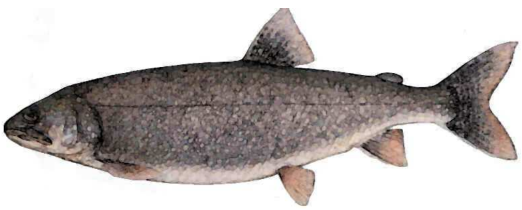
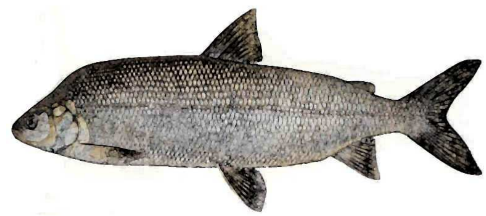
Technical Fisheries Committee Administrative Report 2009: Status of Lake Trout and Lake Whitefish Populations in the 1836 Treaty-Ceded Waters of Lakes Superior, Huron and Michigan, with recommended yield and effort levels for 2009

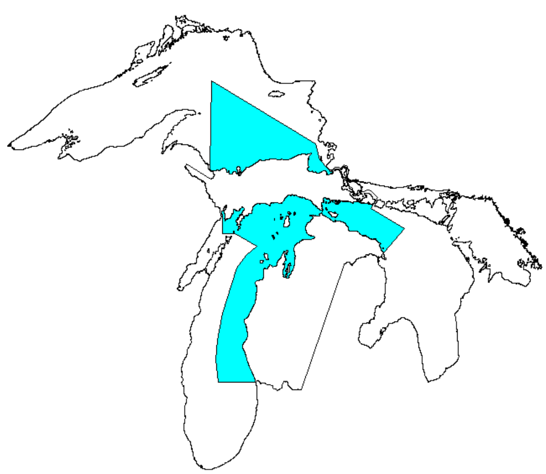




A Report Submitted by the
Modeling Subcommittee
to the
Technical Fisheries Committee

D.C. Caroffino (Michigan Department of Natural Resources),
S.J. Lenart (Little Traverse Bay Band of Odawa Indians),

Editors



Recommended Citation formats:

Entire report: Modeling Subcommittee, Technical Fisheries Committee. 2009. Technical Fisheries Committee Administrative Report 2009: 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 2009. http://www.michigan.gov/documents/dnr/2009-status-report_303561_7.pdf

Section: Caroffino, D.C., and S.J. Lenart. 2009. Executive Summary in Caroffino, D.C., and S.J. Lenart (eds.). Technical Fisheries Committee Administrative Report 2009: 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 2009. http://www.michigan.gov/documents/dnr/2009-status-report_303561_7.pdf

Table of Contents

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 2009, the MSC assessed population status and mortality rates of 18 different stocks of lake whitefish and nine stocks of lake trout that are within 1836 Treaty-ceded waters. The MSC developed and fit statistical catch-at-age (SCAA) models using a nonlinear modeling and statistics program (AD Model Builder, Otter Research Ltd.) to estimate age- and year-specific population abundance and mortality rates. Insufficient data prevented development of reliable SCAA models in three lake whitefish units, so an alternative, descriptive approach was used. 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 2009 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%. 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 2009 specified in the Consent Decree.

The 2009 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). Details are given in the text of reports for units where recommended and actual harvest limits differ.

Species	Lake	Management unit	MSC recommended yield limit (lb)	Actual yield limit (lb)	Gill net limit (ft)
Lake trout	Superior	MI-5	97,900	126,944	NA
		MI-6	148,000	148,000	6.18 million
		MI-7	99,000	111,482	4.26 million
	Huron	MH-1	203,000	230,000	7.69 million
		MH-2	87,660	87,660	NA
	Michigan	MM-1,2,3	*26	503,000	9.36 million
		MM-4	104,974	201,059	0.64 million
		MM-5	154,028	154,028	0.85 million
		MM-6,7	420,612	420,612	NA
Lake whitefish	Superior	WFS-04	81,000	92,000	NA
		WFS-05	412,000	412,000	NA
		WFS-06	no estimate	210,000	NA
		WFS-07	636,000	535,000	NA
		WFS-08	132,000	132,000	NA
	Huron	WFH-01	467,000	467,000	NA
		WFH-02	500,000	500,000	NA
		WFH-03	no estimate	150,000	NA
		WFH-04	289,000	546,000	NA
		WFH-05	962,000	962,000	NA
	Michigan	WFM-01	3,044,000	3,044,000	NA
		WFM-02	797,000	558,000	NA
		WFM-03	2,820,000	2,820,000	NA
		WFM-04	846,000	846,000	NA
		WFM-05	282,000	282,000	NA
		WFM-06	207,000	207,000	NA
		WFM-07	no estimate	500,000	NA
		WFM-08	1,126,000	1,126,000	NA

*Calculated based on fully-phased mortality, for comparison only

For the fourth consecutive year, the TFC could not reach consensus on MSC recommended lake trout harvest limits for MM-4 and MM-5. However, in August 2009, the parties agreed to a stipulation to the Consent Decree which established harvest limits in these two units. Agreed upon harvest limits will remain in effect until sea lamprey mortality is significantly below 1998 levels for three consecutive years. In MM-4 the parties agreed to a minimum Tribal TAC of 94,300 lb and a minimum State TAC of 63,000 lb for 2007-2009. For 2010 and thereafter, the minimum State harvest limit will be 77,200 lb. If the State does not harvest its full TAC, which it did not in 2008, the unharvested portion will be transferred to the Tribal TAC for the following year. In all cases, if the model generated harvest limit is higher than these negotiated minimums, the model generated limit will apply. In MM-5 the parties agreed to a minimum TAC for the Tribal fishery of 39,200 lb; however, no minimum was established for the State fishery. The model generated harvest limit will be used for the State fishery each year and for the Tribal fishery when it exceeds the established floor.

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). For all lake trout units, the mixed model analysis of survey CPE was conducted in R in 2009, rather than in SAS, as it had been previously. In unit MI-6, this change resulted in improved fit between observed and predicted CPEs. As a consequence, the model rescaled to a larger stock size, closer to what researchers expect from this stock. Although direct harvest of spawning lake trout has impacted the MI-5 stock, total mortality rates in all modeled Lake Superior stocks have been below targets, and increases in yield are possible. There have been no efforts to fit a stock assessment model for lake trout in MI-8 of Lake Superior because this is a deferred area. However, the MSC plans to write a summary of this unit and the fishery there for the 2010 report. Weight-at-age of lake trout has declined since the 1970s and 1980s in Lake Superior, and tied to this is a shift toward later maturity. These changes in growth and maturation likely reflect increases in predator fish abundance and declines in the prey fish, most of which are less abundant than 20 years ago. Competitive effects of the abundant siscowet lake trout also likely play a role. Lower growth rates, and in some cases declining recruitment, have led to decreases in lake trout biomass in all modeled Lake Superior units. Commercial fishery harvests in the modeled Lake Superior units continue to be low. As a result, commercial monitoring data is often lacking for these units. This paucity of data has the potential to cause convergence issues for the Lake Superior models. Sea lamprey-induced mortality continues to climb in Lake Superior and is now the greatest individual source of mortality.

In the Lake Huron and Lake Michigan management areas wild lake trout are scarce, and the assessment models and target mortality rates apply to stocked fish. In Lake Huron, lake trout mortality rates remain below target in MH-2, while the maximum mortality target was met in MH-1 in 2008. Estimated mortality has now increased in MH-1 for four consecutive years. Although commercial harvest by Tribal fishers in MH-1 declined in 2008, recreational harvest increased again as anglers continued to target lake trout. The recreational harvest was only 471 lb below the harvest limit in 2008. 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 allowed stocks to increase in these units through the middle part of the decade. However, recent declines in growth have helped contribute to declining estimates of adult biomass in the past few years. Continued control of sea lamprey in MH-1 and MH-2 is necessary to keep mortality rates below target and allow potential increases in lake trout yield in Lake Huron. The MSC is concerned with its ability to accurately estimate survival and abundance of juvenile lake trout in Lake Huron based on survey catches. Analysis of survey data through 2008 suggests that survival of stocked fish has been poor since 2002, and recruitment concerns may soon impact the fishery, as the strong year classes of 1997-2001 work their way out of the fishery. In 2010, the MSC will be exploring methods to better estimate juvenile lake trout survival by evaluating the use of the summer lake whitefish fishery independent survey in the stock assessment models for lake trout.

In Lake Michigan 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 to catchable size. 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 this species were managed according to the original Consent Decree mortality limits. This unit will remain in a state of excessive mortality until rates of sea lamprey mortality are controlled.

Total mortality rates are below target for MM-4, MM-5 and MM-67. In MM-4, lamprey mortality is above 1998 levels and overall harvest in 2008 declined from the 2007 peak, primarily due to a reduced recreational fishery. As previously described a Consent Decree Amendment now governs harvest limits in this unit as well as MM-5. In MM-5 commercial harvest declined in 2008 to only 300 lb, due to a lack of effort. Lamprey mortality in this unit continues to be below 1998 baseline levels, but the potential for harvest is more dependent upon behavior of the fishers rather than availability of the resource. The 2008 commercial harvest of lake trout in MM-67 was the highest on record under the Consent Decree. Overall mortality in this unit remains low and lamprey mortality is below baseline. In the 2009 Lake Michigan model assessments, a revised methodology was employed to estimate first-year survival of stocked fish. Abundance of age-1 fish can no longer exceed the number stocked and recruited into a unit, bringing the Lake Michigan units in line with the methodology that has been employed in Lake Huron since 2007.

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, others experiencing either low or stochastic recruitment. Nonetheless, lakewide or regional patterns are often 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.

Most whitefish stocks in Lake Michigan exhibited a marked increase in biomass through the middle part of this decade, a result of strong recruitment events in the late 1990s and early 2000s and a general decline in fishing mortality. In most Lake Michigan units, commercial effort and yield has declined since the Decree was implemented. In some units, yield has stabilized at lower levels, while in others (eg WFM-01 and WFM-02), yield has begun to rebound as stocks have increased. Natural mortality remains the largest mortality source in nearly every Lake Michigan unit.

Modeling efforts to describe the lake whitefish stocks in WFS-06, WFH-03, 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 2009, the WFS-06 HRG was set equal to its 2008 level. The 2009 HRG for WFH-03 was set at 150,000 lb, the second consecutive year that it was reduced from its 2003-2007 level of 306,000 lb. CORA implemented this change in order to be conservative in the face of potential increases in sea lamprey induced mortality on whitefish in this unit and concerns about recruitment. The HRG in WFM-07 remained consistent with previous levels.

In addition to providing assessments for each stock, the MSC also provides recommendations to the TFC to improve both data collection and the SCAA models. These recommendations include gathering accurate data on all forms of fishery extractions, continuing to implement fishery-independent surveys to assess abundance of lake whitefish, better delineating stock boundaries and movement patterns of lake whitefish, improving natural mortality estimates, refining estimates of hooking mortality on lake trout, improving the estimation of selectivity, refining our methods of estimating lake trout recruitment, developing methods of estimating time-varying catchability, and evaluating alternate harvest policies. The implementation of all these recommendations is not imminent and will require a significant and increased investment in staff, time, and other resources. The MSC continues to make progress by estimating throwbacks in the commercial fishery (e.g. MH-1), measuring and adding hooking mortalities from the recreational fishery into the models as harvest, continuing to conduct and expand the time series of fishery-independent lake whitefish surveys, performing sensitivity analyses of stock assessment models, performing retrospective analyses of stock assessment models, and applying the results of studies in lakes Huron and Michigan that assessed lake whitefish stock boundaries, movement, and mortality. The MSC has also improved and standardized the flow of information to the TFC.

The MSC continues to recommend a process that will allow us to provide timely stock assessment results and meet the strict deadlines imposed by the Consent Decree. The TFC has approved use of projected commercial fishery yield for the last few months of the year based on historic patterns. This has helped the MSC meet deadlines, but further steps are necessary. The idea of a lake trout model rotation has been discussed for many years, and a resolution was agreed upon in late 2009. Three units, MI-7, MH-2, and MM-67 will be rotated beginning in 2010. Full stock assessments will not be completed in these units, rather sea lamprey and harvest information will be updated and the harvest limit will be projected from the previous stock assessment model. Full stock assessment models will be run for these units again for 2012, and every three years thereafter. These units were chosen for their current lack of management or allocation issues and concerns. Reports on the status of these stocks will still be completed each year; however, this process will save the modelers some time and allow the effectiveness of a rotation plan to be fully evaluated.

STOCK ASSESSMENT MODELS

Prepared by Shawn P. Sitar, James R. Bence, and Aaron P. Woldt

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 2008 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 asympototic 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:

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

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

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

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

Movement Matrices and the calculation of yearling equivalents stocked

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

The observation sub-model

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

Fishery kill was predicted using Baranov's catch equation:

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

note that no additional parameters needed to be estimated.

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

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

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

The Likelihood (defining the best fit)

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

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

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

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

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

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

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

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

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

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

Target Mortality Rates

The Consent Decree specifies a "fully-phased in" upper bound target for total mortality (i.e., A = the proportion of the population that dies in a year). These rates were either 40-45% (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 2009 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 2009 Fishing Season

Starting with the estimates or projections of age-specific abundance at the start of 2009, 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 2009, but did not in 2009, 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 2009

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 MM-67 the target mortality rate was 40% and the allocation was 90% state, 10% Tribal. Although a stipulation governed the TAC in MH-1, the model calculated TAC was based on an interim target mortality rate of 47%, and the allocation was 9% state and 91% Tribal. In MH-2 the target mortality rate was 40% and the allocation was 95% state and 5% Tribal. In MI-5 the target mortality rate was 45% and the allocation was 95% state and 5% Tribal. In MI-6 the target mortality rate was 45% and the allocation was 50% state and 50% Tribal. In MI-7, the target mortality rate was 45% and the allocation was 30% state and 70% Tribal.

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 2009 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 2009 TACs for MI-5 and MI-7 were calculated per the Consent Decree. However, the 2009 TACs for these units decreased by more than 15% compared to the 2008 TACs. The TFC agreed to accept higher estimated TACs for these units in 2009 limited by a 15% decline from the 2008 TACs. In MM-67 and MI-6, the TAC increased by more than 15% over the 2008 limit. The TFC waived the 15% rule, and allowed the harvest limit in these units to increase up to the model recommendation.

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 as follows: in WFM-01 the State receives 10% of the harvest limit or 200,000 lb, whichever is less; in WFM-06 the State receives 30% of the harvest limit or 65,000 lb, whichever is less; in WFM-08 the State receives 45% of the harvest limit or 500,000 lb, whichever is less, provided that in any year in which only one State licensee participates in the fishery the State's share shall be 22.5% of the harvest limit or 250,000 lb, whichever is less; in WFS-04 the State shall be entitled to harvest 10% of the harvest limit or 25,000 lb, whichever is less; and in WFS-05 the State shall be entitled to harvest 16% of the harvest limit or 130,000 lb, whichever is less. In each of the shared units, the Tribes are allocated the remainder of the harvest limit, provided that in any year in which no State licensee participates in the fishery the Tribes are allocated the entire whitefish harvest limit. 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.

References cited:

Bence, J.R. 2002. Stock Assessment Models *in* Bence J.R. and Ebener, M.P. (eds.). Summary Status of Lake Trout and Lake Whitefish Populations in the 1836 Treaty-Ceded Waters of Lakes Superior, Huron and Michigan in 2000, with recommended yield and effort levels for 2001. Technical Fisheries Committee, 1836 Treaty-Ceded Waters of Lakes Superior, Huron and Michigan.

Pauly, D. 1980. On the interrelationships between natural mortality, growth-parameters, and mean environmental-temperature in 175 fish stocks. *Journal du Conseil* 39:175-192.

Rutter, M.A., and Bence, J.R. 2003. An improved method to estimate sea lamprey wounding rate on hosts with application to lake trout in Lake Huron. *J. Gr. Lak. Res*. 29(Supplement 1):320-331.

Sitar, S.P., Bence, J.R., Johnson, J.E., Ebener, M.P., Taylor, W.W. 1999. Lake trout mortality and abundance in southern Lake Huron. *N. Am. J. Fish. Manage*. 19:881-900.

Spangler, G.R., Robson, D.S., and Reiger, H.A. 1980. Estimates of lamprey-induced mortality in whitefish, *Coregonus clupeaformis*. *Can. J. Fish. Aquat. Sci.* 37:2146-2150.

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. Items that we consider high priority are noted.

Data collection and processing

- Accurate and complete data on extractions and other deaths caused by fishing is essential if SCAA models are to produce reliable estimates. We assigned a HIGH priority to determining the following:

  i. Evaluating the importance of including recreational harvest of whitefish in the stock assessment models

     Harvest is large enough in WFM-05, WFS-05, and WFS-06 to warrant inclusion into the assessment models. In addition, harvest in WFH-03 is highly variable, but in years of good ice conditions, extractions in this unit can also be large. The State of Michigan should plan and execute winter creel surveys in these units to ensure an accurate estimate of lake whitefish harvest and we need to evaluate if adding these extractions to the model improves its performance. The current creel budget precludes such winter creels from taking place, but in the event of funding availability these surveys will be pursued.

  ii. the magnitude of hooking mortality from recreational catch and release fishing

     Currently the models use a hooking mortality rate of 15%, based on a 1986 study. The State of Michigan creel program quantifies released lake trout of both legal and non-legal size. In 2003, an MSC subcommittee drafted a study design to quantify hooking mortality in the recreational fisheries in lakes Superior and Huron. This project was approved for MDNR funding, but due to budget reductions, it has been placed on hold in past fiscal years. However, it is currently scheduled to begin in 2010. If completed, this study would allow us to better estimate hooking mortality rates.

- Accurate prior estimates of M (natural mortality) are essential in SCAA models. Existing tagging information and current estimates of natural mortality for lake trout and lake whitefish need to be reviewed and revised as necessary. We assigned a HIGH priority to this recommendation.

Two basin-wide lake whitefish tagging studies in lakes Michigan and Huron were conducted between 2003 and 2005. Empirical estimates of natural mortality, derived from these results, indicated that natural mortality may be higher than what is currently estimated by the Pauly equation in the whitefish SCAA models. The empirically derived estimates of natural mortality have been incorporated into some assessment models and their use may be expanded in future assessments.

- The basis for stock boundaries and assumed movement or lack of movement between stocks needs further study. For lake trout the assumption that stocked fish move to an area and then become resident needs to be evaluated. We assigned a HIGH priority to this recommendation.

  The lake whitefish tagging studies conducted in lakes Michigan and Huron demonstrated that current stock boundaries likely do not contain discrete populations of whitefish, as movement across management units was common. A new Lake Huron assessment model incorporating multiple management units has been developed for the 2010 assessment.

  For lake trout, the movement matrix, which represents assumed movement of hatchery lake trout from stocking sites to their resident location may soon be updated. Researchers from the University of Michigan are evaluating juvenile and adult lake trout movement in Lake Michigan. Once available, these results will be evaluated for their utility as an update to the current methodology.

- Summer lake whitefish surveys

  i. The lake whitefish models continue to need "indices of abundance" based on fishery independent survey data. A sampling protocol for lake whitefish was implemented on all lakes in 2002 and has been carried out each year since. These data were not immediately incorporated into the stock assessment models because of the short time series available; however, as that time series lengthens their inclusion should be evaluated. This continues to be a HIGH priority for us.

  ii. The lake whitefish summer surveys in Lake Huron may have value for the lake trout models. Their use as a separate index of abundance or as a source for population age composition data is being evaluated for the 2010 assessment.

- 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. This is an ongoing Dingell-Johnson funded project within MDNR. We assigned a HIGH priority to this recommendation.

- The lake trout relative abundance indices (CPUE) used in SCAA models are pre-processed outside the models using mixed-model analysis. The current models and alternatives have been evaluated by a student at Michigan State University, and an MDNR Research Report that describes the evaluation is in press. As a result, changes to the mixed model methodology were implemented in 2009, details of which will be described in the modeling section of the 2010 Status of the Stocks Report.

Models

- Estimates of uncertainty for data used in the models and our assumptions about uncertainty should be evaluated when possible. The way uncertainty is used in model fitting needs to be reviewed based upon research completed at Michigan State University. We assigned a HIGH priority to this recommendation.

- The need to assess fishery selectivity has been recognized since early in this modeling process. Such an evaluation has been completed by researchers at Michigan State University, and changes to selectivity (e.g., utilizing a random walk) will be implemented in the near future.

- The assumption that fishery and survey catchability is constant in the SCAA models needs to be changed. Based on research completed at Michigan State University, fishery catchability should be allowed to vary over time following a random walk. This change represents a small task but is a HIGH priority.

- Current approaches to modeling and estimating recruitment need to be reviewed, including how we project recruitment forward into the future. We should also evaluate adding environmental variables that could influence recruitment based on research completed at Purdue University.

- Current harvest policies and possible alternatives have been evaluated for general lake whitefish stocks. Results from this work need to be considered on a unit specific basis to determine if an alternate policy will better meet the needs of both managers and the fishery.

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 lake whitefish quotas is a year longer than for lake trout and is sufficient. The timing of data availability and target dates for delivery can be summarized as:

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 numbers need to be made available in a more timely fashion.

   b. Recreational harvest – the State can provide these data by February 15.

2. Biological data-commercial:
   a. These data can be available by February 15. We use age composition, mean weight in harvest, mean length at age, and composition of siscowets, wild, and hatchery fish.

   b. Biological data from the Canadian commercial fisheries is not readily available, and better access to these data 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 ready by March 1 we will proceed without it and use the data the next year. We use age composition, mean weight of harvested fish, and composition of wild and hatchery fish.

3. Biological data-recreational:
   These data are available by the February 15 deadline.

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

5. Survey data:
   a. Survey CPUE – These data can be ready by February 15. Often

the mixed model analysis can be completed by February 15.

b. Age composition – These data can be ready by February 15, except occasionally in Lake Superior. If not ready by February 15, we will proceed without the most recent year's data.

c. Mean length and weight at age – These data can be ready by February 15 and the estimates of von Bertalanffy model can be updated by February 15.

d. Sea lamprey marking – These data can be ready by February 15 and estimates of mortality, processed outside of the model, should be ready by February 15.

e. Maturity at age – These data can be ready by February 15. These are constants in lakes Huron and Michigan and vary in Lake Superior.

Lake whitefish

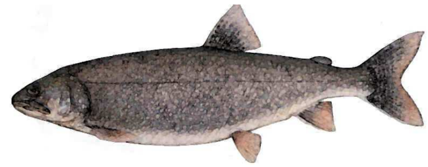
The Consent Decree sets October 1 as the deadline for the previous year's data. We moved this deadline to August 1 to allow additional time for calculating harvest limits. Because of the one year time lag, data should be available by the data submission deadline, although some parties continue miss it. 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.

More general comments

- Alternative harvest policies have been evaluated by a graduate student at Michigan State University. We, in conjunction with the QFC and TFC, have begun evaluating their implementation in WFM-06 and WFM-08. The evaluation will be completed in 2010. If implemented, these policies may provide some stability in the annual harvest limit while still providing protection for the stock. There are currently no plans to apply these policies to lake trout management.

- We continue to receive and review fall lake trout data from multiple agencies. The utility of these data for inclusion in the stock assessment models should be carefully evaluated. Fall age composition data may be particularly useful in characterizing population age structure. The MSC briefly discussed these data at the fall 2009 meeting and decided that exploration of their use will be postponed until other issues such as selectivity and catchability are resolved.

STATUS OF LAKE TROUT POPULATIONS



Lake Superior

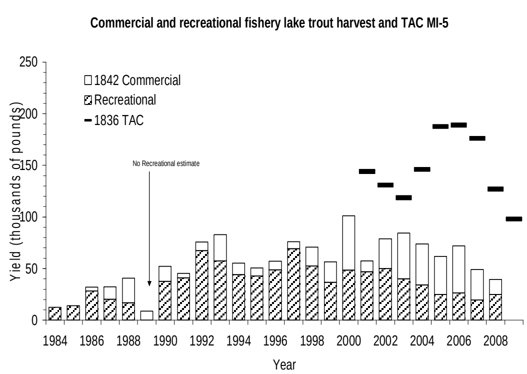
MI-5 (Marquette - Big Bay)

Prepared by Shawn P. Sitar and John K. Netto

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.

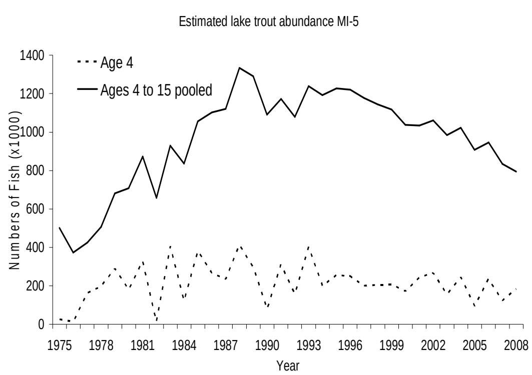
The only tribal commercial fishery is a large mesh gill net fishery that is centered around Marquette and Big Bay in 1842 Treaty waters. This fishery mainly targets lake whitefish with lake trout as bycatch. However, lake trout have been targeted near spawning reefs in Marquette during recent fall fisheries. 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 $ft \bullet y^{-1}$.

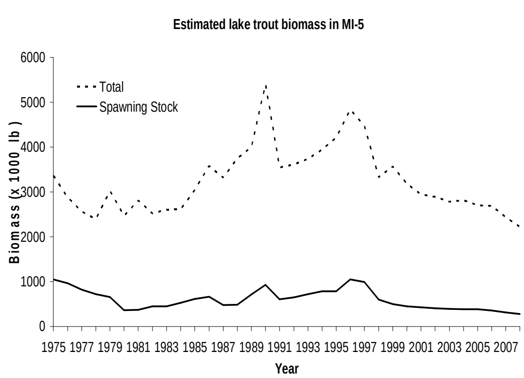
Generally, the commercial fishery is conducted from late winter through early October, with a dome shaped selectivity with peak age between 7 and 10. The commercial fishery operates in various grids near Marquette, and the overall impacts on the MI-5 population are nominal. However, in 2000, and 2003 through 2008, 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.



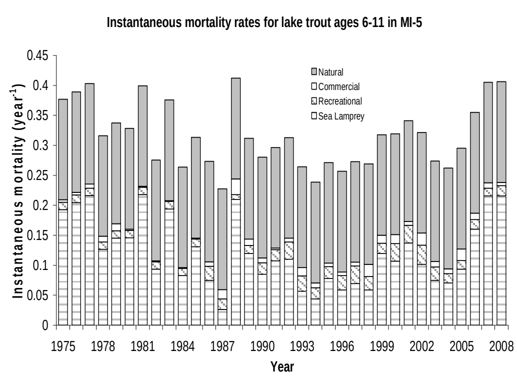
Recreational harvest of lake trout comprises both charter and sport angler fisheries. Most of this activity is centered around the port of Marquette, though some lake trout are harvested at Stannard Rock, an offshore reef. There are no seasonal restrictions on the sport fishery, though most of the fishery occurs during the months of May through October. 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 2004 to 2008 was 7,100 fish (26,000 lb) • y^{-1}. Recreational effort has declined from 146,000 angler hours in 1986 to 37,900 angler hours in 2008.

Abundance of wild lake trout increased more than two-fold since 1975 and has averaged about 974,000 fish (age 4 and older) during 1999 to 2008. Total biomass of age-4 and older lake trout averaged 2.8 million lb during 1998-2007. Lake trout biomass declined from 4.8 million lb in 1996 to 2.2 million lb in 2007. Spawning stock biomass averaged 389,000 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 2008 the highest level on record was observed. With the exception 1988 and 2005, recreational fishing mortality has been higher than commercial fishing mortality for ages 6-11 lake trout. However, commercial fishing mortality on older lake trout, due to harvest during the spawning season, is higher than recreational fishing (see 2006 Status of MI-5 lake trout report). Average total annual mortality (*A*) for lake trout age 6 to 11 averaged 32% during 2006 to 2008, which has increased since the 1990s due to increases in sea lamprey mortality. Spawning stock biomass produced per recruit during 2006 to 2008 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 2009 in 1836 Treaty waters is 97,900 lb, allocated as 93,800 lb for the state recreational fishery and 4,100 lb for the tribal fishery. The recommended yield limit for 1842 Treaty waters is 136,300 lb.

The 2009 TAC is lower than the 2008 because 1) declining abundance of lake trout, 2) higher mortality, and 3) the 2009 model estimated lower stock sizes in recent years than the 2008 model.

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

Notable stock dynamics

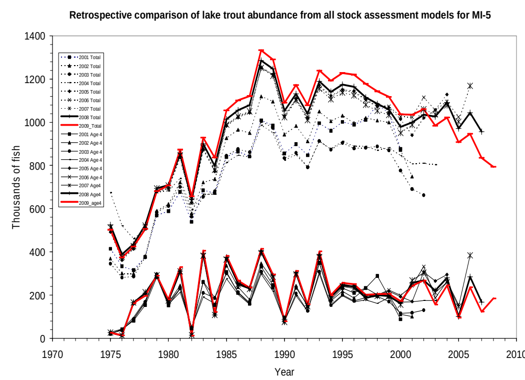
Commercial yield declined by more than 50% from 2007 to 2008 in MI-5. Furthermore, spring survey CPUE in 2008 also declined by more than 50% from 2007. This may be due to reduced sampling effort in the last 5 years of the survey in MI-5. Summer survey CPUE has declined since 2004.

Model diagnostics

The 2009 model's survey CPUE data were based on estimates generated from R software as opposed to SAS. The survey CPUE mixed effects model had fixed effects of year and depth strata and random effects of grid and year-grid interaction term. The model included autocorrelation of year effects, and heterogeneous variances of observation errors among depth strata. The year effects from the R software were consistent with the least square means of year effects from the SAS model used in previous years.

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 2009 model was generally consistent with those estimated by the 2008 model. The recent assessment models (2005 through 2009) 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	4.908 lb (SE 0.485)
Current SSBR	0.95 lb (SE 0.07)
SSBR at target mortality	0.443 lb (SE 0.011)
Spawning potential reduction	
At target mortality	0.193 (SE 0.008)
Average yield per recruit	0.229 lb (SE 0.028)
Natural mortality (M)	0.168 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)	0.008 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)	0.156 y^{-1}
Total mortality (Z)	
(average ages 6-11, 2006-2008)	0.316 y^{-1} (SE 0.009)
Recruitment (age 4)	
(average 1999-2008)	193,070 fish (SE 27,813)
Biomass (age 4+)	
(average 1999-2008)	2,823,100 lb (SE 331,640)
Spawning biomass	
(average 1999-2008)	389,320 lb (SE 48,936)
MSC recommended yield limit in 2009	97,900 lb
Actual yield limit in 2009	126,944 lb

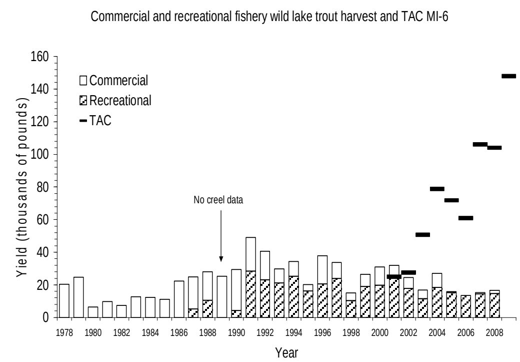
MI-6 (Au Train - Munising)

Prepared by Shawn P. Sitar and John K. Netto

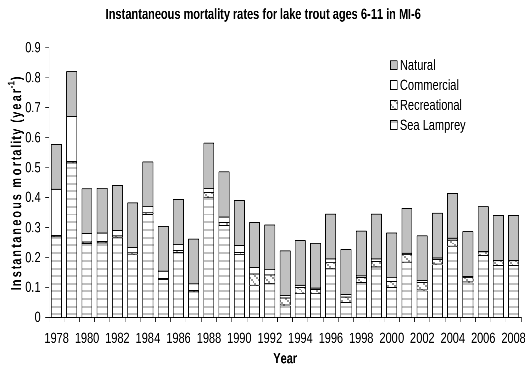
Lake trout management unit MI-6 extends from Laughing Fish Point (east of Marquette) to Au Sable Point (east of Munising), encompassing 1.8 million acres. This management unit includes Big Reef, an offshore reef complex about 20 miles northeast of Munising. This management unit contains the deepest waters 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 1,000 lb during 2006 to 2008. Total effort averaged 262,000 ft during the last three years.

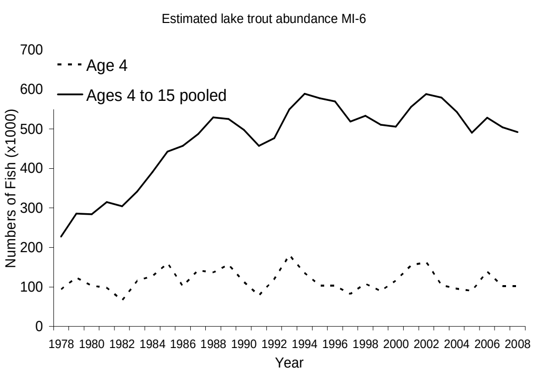
Recreational harvest of lake trout comprises fish caught by both charter and sport angling. Most of the recreational harvest was from the Au Train Bay and Grand Island areas, although some harvest was also from Big Reef. Recreational harvest of wild lake trout has increased through the late 1980s and peaked at 6,300 fish (28,500 lb) in 1991. Harvest has steadily declined since 2001 and corresponded to declines in effort. During 2006 to 2008, recreational fishery harvest and effort averaged 3,700 fish (14,100 lb) and 14,300 angler hours. In the last five years, wild fish composed nearly all (> 98%) of the total recreational and commercial harvest of lean lake trout.

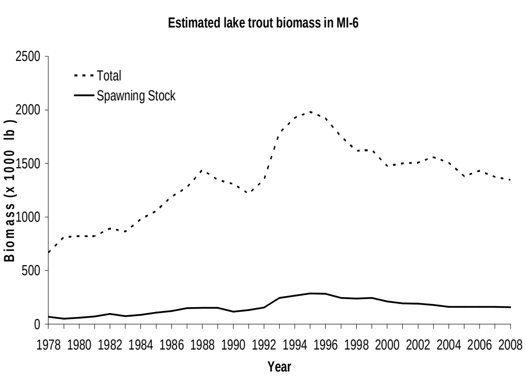


Sea lamprey mortality has been increasing since 1997, and in recent years it has been the highest mortality source for age 6 to 11 lake trout in MI-6. Sea lamprey mortality estimates during the last five years are at their highest levels since 1989. Recreational fishing mortality has been higher than 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 29.5% during 2006 to 2008, 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 530,000 fish • y^{-1}, while population biomass trended downward in this unit due to declines in somatic growth. During 1999-2008, population biomass averaged 1.4 million lb per year while average annual spawning stock biomass was 183,000 lb. Recruitment of age-4 lake trout in the last 10 years averaged 115,000 fish.





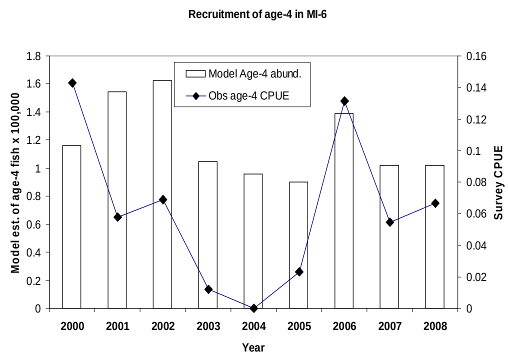
The recommended yield limit for 2009 is 148,000 lb, of which 74,000 lb is allocated to the state recreational fishery and 74,000 lb to the tribal commercial fishery. The 2009 TAC is slightly higher than the 2008 TAC because the 2009 model estimated: 1) higher abundances, 2) slightly lower mortality rates, and 3) improved estimates of recruitment.

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 0.6% 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.

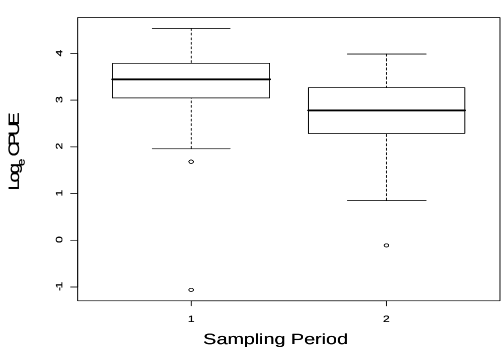
Notable stock dynamics

The commercial fishery for lake trout in this unit has declined to near zero harvest levels. Consequently, no commercial monitoring data for age and size structure of harvest have been available since 2001.

Previous SCAA models for MI-6 estimated very steep population declines in recruitment since 2002 which was not reflected in the observed data sources. However, the 2009 model, using the R-based mixed model survey CPUEs yielded improved model estimates of age-4 abundance that better matched observed age-4 summer survey CPUEs.



Spring survey lean lake trout catch per unit effort (CPUE) in 2008 declined by more than 50% from the previous few years. 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. Based on a review of the MI-6 spring survey CPUEs during 1999-2008, lean lake trout CPUE from samples collected in June (period 2, calendar week 21 and later) was lower than survey CPUE from samples collected during period 1 (April and May, calendar week 20 and earlier).

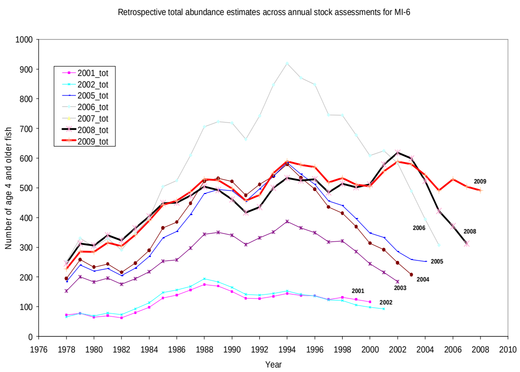


In the late spring, lean lake trout become less demersal as water temperatures increase and may either become more broadly distributed in the water column (pelagic) or move into shallower waters (outside the survey target minimum depth) perhaps in response to rainbow smelt spawning aggregations near shore.

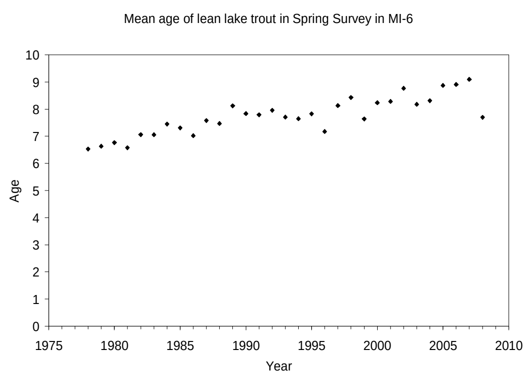
These data indicate that the spring survey in MI-6 should be conducted prior to June to avoid low survey CPUEs that are due to sampling outside optimal sampling period rather than indicating true declines in population abundance.

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. The spring and summer gill-net surveys do not indicate any major decrease in the adult population.



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.

The 2009 model's survey CPUE data were based on estimates generated from R software as opposed to SAS. The survey CPUE mixed effects model had fixed effects of year and depth strata and random effects of grid and year-grid interaction term. The model included autocorrelation of year effects, and heterogeneous variances of observation errors among depth strata. The year effects from the R software were consistent with the least square means of year effects from the SAS model used in previous years.

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	5.961 lb (SE 0.55)
Current SSBR	1.22 lb (SE 0.08)
SSBR at target mortality	0.429 lb (SE 0.009)
Spawning potential reduction	
At target mortality	0.205 (SE 0.007)
Average yield per recruit	0.116 lb (SE 0.016)
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)	0.002 y^{-1} (SE 0.0)
Sport fishing mortality (F)	
(average 2006-2008, ages 6-11)	0.014 y^{-1} (SE 0.002)
Sea lamprey mortality (ML)	
(average ages 6-11, 2006-2008)	0.147 y^{-1}
Total mortality (Z)	
(average ages 6-11, 2006-2008)	0.313 y^{-1} (SE 0.008)
Recruitment (age 4)	
(average 1999-2008)	115,640 fish (SE 14,995)
Biomass (age 4+)	
(average 1999-2008)	1,470,200 lb (SE 109,880)
Spawning biomass	
(average 1999-2008)	182,890 lb (SE 14,040)
MSC recommended yield limit in 2009	148,000 lb
Actual yield limit in 2009	148,000 lb

MI-7 (Grand Marais)

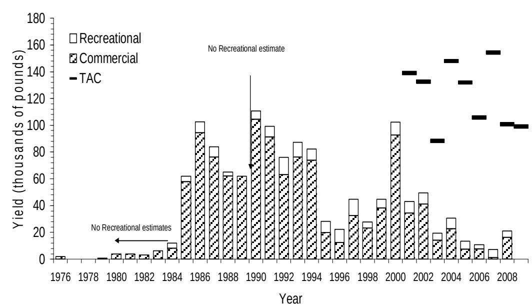
Prepared by Shawn P. Sitar and John K. Netto

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 8,500 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 2006 to 2008 has averaged 770,000 ft. Presently, there is only one commercial operator in MI-7.

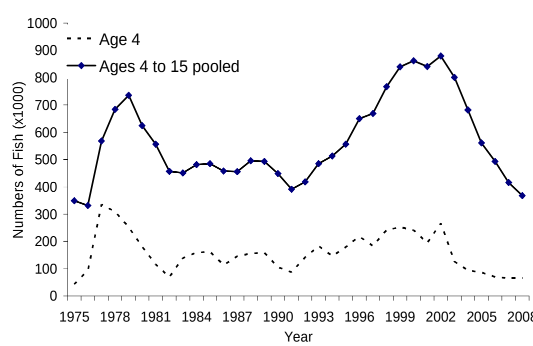
The standardized creel survey began at Grand Marais in 2001. Sport harvest and effort in MI-7 prior to 2001 were estimated using the average sport CPUE and effort index ratio between MI-7 and MI-5 (from MIDNR creel mail survey data from 1971 to 1982) applied to MI-5 sport harvest and effort during 1984 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 2006 to 2008 was 1,000 fish (4,500 lb). The average sport effort for the same time period was 9,500 angler hours.

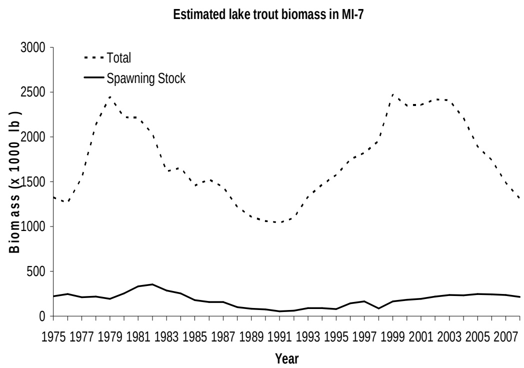
Commercial and recreational fishery lake trout harvest and TAC MI-7



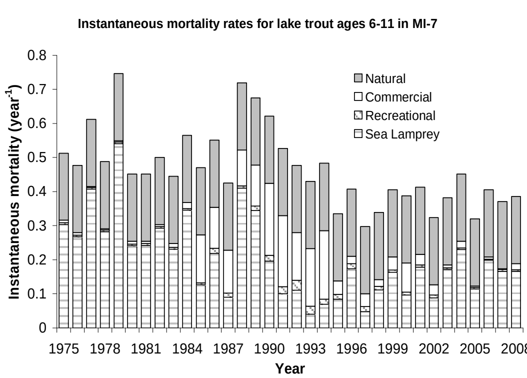
Abundance of age-4 and older wild lake trout averaged 674,000 fish • y^{-1} during 1999 to 2008. In the same time period, recruitment at age 4 averaged 146,000 fish per year. Stock size increased steadily between 1992 and 2002. Abundance has declined since 2002 due to the combination of increases in sea lamprey-induced mortality, which doubled between 2002 and 2008, and declines in recruitment since 2002. Spawning stock biomass averaged 216,600 lb during the last ten years.

Estimated lake trout abundance MI-7





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. The most recent estimate of sea lamprey mortality for this unit is more than triple the 1997 level. During 1975 to 1979, total annual mortality (*A*) for ages 6 to 11 lake trout averaged 43%. During the last five years, average *A* was 32%. The current estimate of spawning stock biomass per recruit (SSBR) for MI-7 is above the target value, indicating that mortality rates are not exceeding the target.



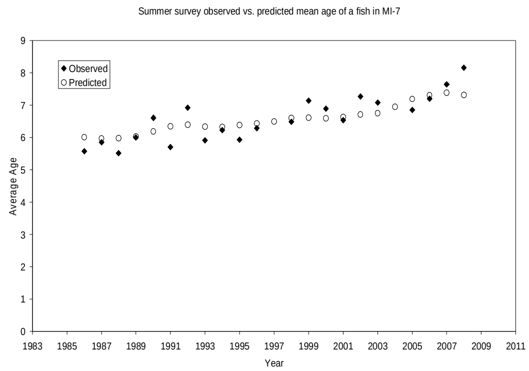
The recommended yield limit for 2009 is 99,000 lb with 29,700 lb allocated to the state recreational fishery and 69,300 lb to the tribal commercial fishery. These limits were calculated on the basis of the target mortality rate (*A*) of 45% and an allocation of 30% to the state and 70% to the tribes, 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.

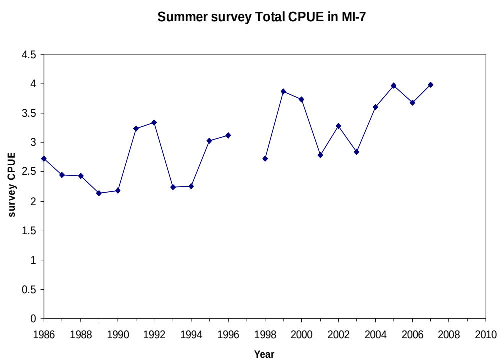
The 2009 TAC is only 1,700 lb less than the 2008 TAC generated by the quota projection model. However, it is a larger departure from the actual 2008 TAC issued because of the 15% rule. Overall, stock abundance has been on the decline since 2002, primarily due to declines in recruitment and increases in sea lamprey-induced mortality.

Notable stock dynamics

No commercial monitoring data were available for 2004-2008. Total commercial yield declined to near zero in 2005 and 2006. 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 CPUEs which have 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.





There were an unusually high number of sport fishery releases of lean lake trout estimated in 2008 compared to previous years. Total lean lake trout harvest in 2008 was 837 fish, and releases were estimated at 293 fish (26%).

Model diagnostics

The 2009 model's spring survey CPUE data were based on estimates generated from R software as opposed to SAS. The spring survey CPUE mixed effects model had fixed effect of year and random effects of grid and year-grid interaction term. The model included autocorrelation of year effects, and heterogeneous variances of observation errors among depth strata. The year effects from the R software were consistent with the least square means (LSM) of year effects from the SAS model used in previous years. There were extremely poor estimates of summer (pre-recruit) survey CPUEs and associated standard errors using R software. As an interim solution, the SAS LSM year effect estimates of summer survey CPUE from the 2008 assessment were used in this year's catch-at-age model. The SAS model did not have a summer survey CPUE estimate for 2008, which does not significantly influence overall model fit to the data or estimated quantities.

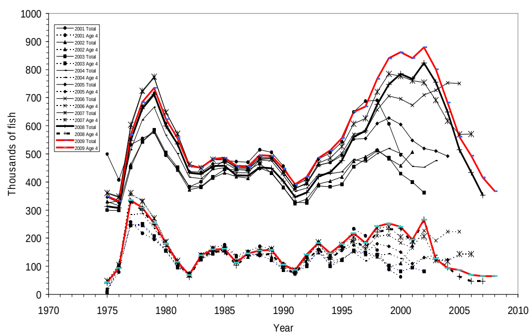
The 2009 model reached convergence with acceptable maximum gradient components, and reasonable asymptotic standard errors on parameter estimates. The model under-predicted summer survey CPUE in the last five years of the model, which also occurred in the 2008 assessment model. No other major patterns in residuals were observed for fit to observed data sources. The MCMC simulations yielded good results without autocorrelations. Summary table quantities are reported with 95% probability intervals.

There were retrospective patterns observed in the 2009 assessment model (within model evaluation). Although not systematic, the biomass estimates differed with each iteration of removing a year from the data series. For example, the largest difference in total biomass in 2000 was 27%.

Retrospective estimates of total biomass for 2009 MI-7 model

The 2009 assessment had higher abundance estimates than prior year assessments. There were no systematic patterns in changes in the abundance estimates from various stock assessments (among model comparison). However, there were major departures in abundance estimates among the assessments.

Retrospective abundance estimates across annual stock assessments for MI-7



Summary Status MI-7 Lake Trout	Value (95% probability interval)
Female maturity	
Size at first spawning	2.75 lb
Age at first spawning	6 y
Size at 50% maturity	4.96 lb
Age at 50% maturity	10 y
Spawning biomass per recruit	
Base SSBR	4.138 lb (3.229-5.048)
Current SSBR	1.08 lb (0.905-1.244)
SSBR at target mortality	0.537 lb (0.501-0.566)
Spawning potential reduction	
At target mortality	0.261 (0.243-0.283)
Average yield per recruit	0.096 lb (0.052-0.138)
Natural mortality (M)	0.197 y^{-1}
Fishing mortality	
Age of full selection	
Commercial fishery (2006-2008)	8
Sport fishery (2006-2008)	7
Commercial fishing mortality (F)	
(average 2006-2008, ages 6-11)	0.009 y^{-1} (0.005-0.013)
Sport fishing mortality (F)	
(average 2006-2008, ages 6-11)	0.004 y^{-1} (0.002-0.006)
Sea lamprey mortality (ML)	
(average ages 6-11,2006-2008)	0.148 y^{-1}
Total mortality (Z)	
(average ages 6-11,2006-2008)	0.344 y^{-1} (0.326-0.366)
Recruitment (age 4)	
(average 1999-2008)	146,330 fish (106,973-264,417)
Biomass (age 4+)	
(average 1999-2008)	2,064,700 lb (1,479,540-3,681,530)
Spawning biomass	
(average 1999-2008)	216,660 lb (146,040-401,454)
MSC recommended yield limit in 2009	99,000 lb
Actual yield limit in 2009	111,482 lb

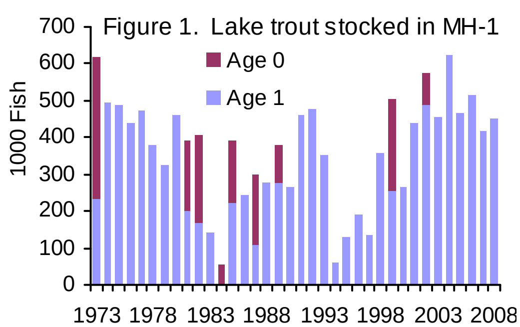
Lake Huron

MH-1 (Northern Lake Huron)

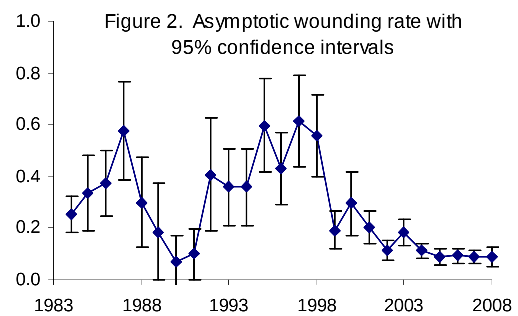
Prepared by Ji X. He, Aaron P. Woldt, Mark P. Ebener, and Adam Cottrill

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 no-fishing zone of Drummond Island Refuge. In 2008, non-clipped lake trout made up 5.6% of the total survey and fishery catch. The percentage of unclipped fish actually exceeded 20% in spring surveys along the north-east shore of the unit and in commercial biological samples from Ontario QMA4-1.

The total number of age-1 lake trout stocked into MH-1 in 2008 was 449,373 (Figure 1), of which 120,755 were planted in the Drummond Island Refuge. The average number of yearling equivalents stocked during 2003-2007 was 504,263. After adjusting the number stocked to account for movement among the three management units of Lake Huron's main basin, including 2007 stocked fall fingerlings immigrating from Six Fathom Bank, total 2008 age-1 lake trout in MH-1 was 525,716.



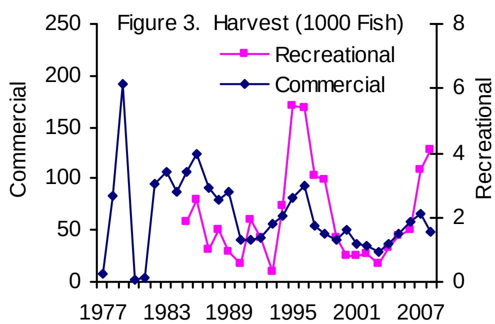
Sea lamprey induced mortality at each lake trout age was based on fitting wounding rate as a logistic function of body length (TL, mm), and length distribution at age. The wounding rate in a given year was based on biological samples from the spring (April-June), and reflected sea lamprey induced mortality in the previous year. These biological samples were from spring gill-net surveys by MDNR during 1977-2008, CORA during 1991-2008, and a summer gill-net survey by USFWS in June 2002-2008. Asymptotic wounding rate decreased after 1998, and has been significantly lower than the 1998 level since 2001 (Figure 2). At age 7, average sea lamprey induced instantaneous mortality was estimated to be 0.396 y^{-1} during 1993-1997, and was only 0.075 y^{-1} during 2003-2007. At age 15, average sea lamprey mortality was estimated to be 0.408 y^{-1} during 1993-1997, and was only 0.076 y^{-1} during 2003-2007.



Total commercial harvest in 2008 in MH-1 and neighboring QMA4-1 was 245,598 lb, of which tribal fisheries accounted for 224,492 lb. The yearly average commercial harvest from 2003 through 2007 was 207,208 lb, of which tribal fisheries accounted for 184,162 lb. The commercial harvest by tribal fishers included both the reported value and estimated discards after 2001.

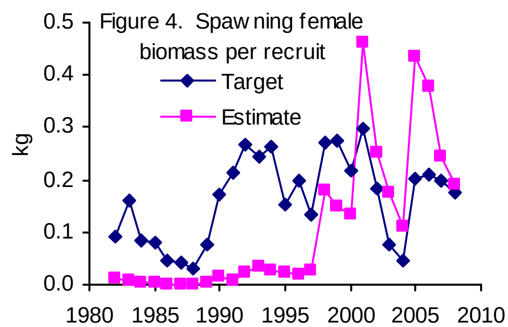
On average, tribal large-mesh gill nets accounted for 83% of annual total commercial harvest in 2003 through 2007, which slightly increased to 89% in 2008. Ontario large-mesh gill-net fisheries accounted for 9% of the total commercial harvest in 2008, which was lower than the 2003-2007 average of 12.4%. Tribal trap nets accounted for 2% of total commercial harvest in 2008, which was lower than the 2003-2007 average of 5%. Tribal small-mesh gill nets (2.5-3.0 inch stretch) accounted for less than 1% of total commercial harvest in 2008 and in all previous years.

Recreational harvest only represents a small portion of the total lake trout harvest in MH-1 (Figure 3). The estimate includes discards after 2002. Recreational harvest averaged 6,600 lb from 2003-2007 but increased to 19,529 lb in 2008.

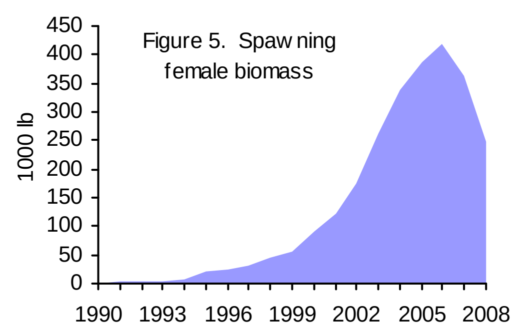


Target spawning stock biomass per recruit (SSBR) was based on a limit of 47% annual mortality (*A*) for age 5 and older lake trout, and was in the range of 0.03-0.30 (Figure 4). The large variation in target SSBR was mostly due to the variation in the survival from age 1 to age 2, while body weight and 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 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. After 2000, estimated SSBR was higher than the target each year, suggesting that over-all-age annual mortality was below the mortality limit of 47%.



As a result, spawning stock biomass (SSB) was almost negligible until the late 1990s, and steadily increased from 1998 to 2006 (Figure 5). In the most recent two years, however, SSB decreased by more than 40%, from the high of 417,000 lb in 2006 to 247,000 lb in 2008. Such a decline in SSB was inconsistent with the estimated SSBR that was always higher than the target in each of the 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-1, lake trout were fully recruited by age 5 before 2006, but were not fully recruited until age 7 after 2006. From 2002 to 2005, average proportions of age 4 and 5 lake trout in survey catches were 0.26 and 0.31 respectively, and in commercial catches were 0.16 and 0.31, respectively. In 2007 and 2008, average proportions of age 4 and 5 in survey catches were only 0.05 and 0.08, respectively, and in commercial catches were only 0.02 and 0.09 respectively. 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 47% to pre-recruit ages might have led to underestimation of target SSBR and allocation of very high fishing mortality to spawning stock.

The Modeling Subcommittee (MSC) will further clarify potential technical issues with the determination of target SSBR. In calculating total allowable catch (TAC) for 2009, however, the MSC followed a policy that prohibits technical changes immediately prior to TAC determination. The MSC continued the calculation of target SSBR based on the limit of 47% annual mortality (A) for age 5 and older lake trout. The recommended harvest limit was 185,347 lb for the tribes, and 17,653 lb for the state. The allocation percentage is 91% for the tribes and 9% for the state, based on the Section VII.A.7.d of the 2000 Consent Decree. For the first time, the 2009 TAC calculation did not use the under reporting proportion of 0.16, otherwise the recommended 2009 TAC would be further reduced.

The MSC has informed the TFC in previous reports that it was unusual to see the magnitude of harvest limit increasing rapidly in just a few years and staying high. Now the technical concern can be better stated: the recommended harvest level in recent years appeared to assume pre-recruitment abundances that were not supported by survey and fisheries data yet, and continued to use an age at full recruitment that was no longer supported by recent new data from both the survey and fisheries.

For the 2008 TAC year the MH-1 catch-at-age model did not fully converge. The problem was that the model was coded to estimate age-1 survival for the most recent year classes but there was no survey and fishery data in which they were represented. For the 2009 TAC year, we coded yearling survival in the model for 2007 and 2008 to be the same as in 2006, the last year for which age-1 survival could be estimated.

Additional refinement to the model for 2009 included an expansion of commercial age structure from ages 2-9 to ages 1-15, and a similar expansion of survey age structure from ages 2-10 to ages 1-15. These expansions were long overdue, given the apparent increases in the catch of lake trout older than age 9. Correspondingly, boundary parameters were modified for estimating the vectors determining time-varying selectivity in fishery independent survey, and in commercial and recreational fisheries.

The year by age matrix of body weight at age was updated for TAC year 2009. This matrix was not updated with the 2006 and 2007 data due convergence issues with the time-varying growth and length-weight models. Thus, the TAC calculations for 2007 and 2008 did not consider the continuous declines in weight at age that was occurring in MH-1 lake trout.

Finally, TAC year 2009 was the first time that survey abundance indices were estimated using the R software program. They were estimated using a mixed effect model, including fixed effect of year and random effect of locations (grids). The model included ARMA(1,1) autocorrelation of year effects, and heterogeneous variances of observation errors among depth strata. The abundance indices were year effects on log scale catch per unit effort, rather than least square means (LSM) for log scale CPUE. The year effects from the R model agreed with LSM from the SAS model used in previous years.

With all of the above refinements, the MH-1 catch-at-age model converged in 2009 TAC year, although the maximum gradient component of 0.00046 was not as low as desired. Age-specific selectivity in commercial and recreational fisheries, and in fishery independent surveys, appeared to be sensitive to initial values for the double logistic functions parameters. Such sensitivity only influenced the estimates of abundance and mortality at age 10 and older, and 10% changes in those initial parameter values produced less than 5% changes in the calculation of the TAC. The model fit the data well, including the total numbers harvested by commercial and recreational fisheries, age structures for the survey and for the commercial and recreation fisheries. No apparent residual patterns were identified. The fit of the catch-at-age model to survey abundance indices was improved substantially in comparison with previous years.

The highest uncertainty in the MH-1 model was with the estimates of time-varying survival from age 1 to age 2. Retrospective patterns were apparent in estimates of survival rates for the most recent five year classes. This was expected because those estimates were based on insufficient observations when the year classes were still young, and recruitment to the fisheries was delayed from ages 4-5 to ages 7-8. Markov Chain Monte Carlo simulation identified the same concerns about the uncertainty in the vector of time-varying mortality of age 1 lake trout, which to some degree was associated with the uncertainty in time-varying selectivity of the survey, commercial, and recreational fisheries.

Future improvement of the MH-1 model may include the following. (1) Expand the age structure of recreational fisheries from ages 2-9 to ages 1-15 to adequately reflect the increasing catch of older lake trout. (2) Update the year by age matrix of maturity at age through modeling maturity schedules as time-varying, which will improve SSB and SSBR related model calculations. (3) Estimate time-varying standard errors for length at age that varies among years, and thereby improve the calculation of sea lamprey induced mortality. (4) Replace the double logistic functions for gear selectivity with gamma functions to reduce sensitivity of model estimates to initial parameter values. (5) Evaluate using summer survey abundance indices and age composition in the model to improve estimation of survival from age 1 to age 2. Finally, (6) improve survey abundance indices, by evaluating the impact of depth as a continuous variable rather than a factor of strata, and by evaluating the potential impact of age composition on catch rate.

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	3.445 lb (SE 1.361)
Current SSBR	0.570 lb (SE 0.260)
SSBR at target mortality	0.474 lb (SE 0.182)
Spawning potential reduction	
At target mortality	0.164 (SE 0.024)
Average yield per recruit	0.517 lb (0.195)
Natural mortality (M)	0.197 y^{-1}
Fishing mortality	
Age of full selection	
Commercial fishery (2006-2008)	7 y
Sport fishery (2006-2008)	7 y
Commercial fishing mortality (F) (average 2006-2008, ages 6-11)	0.262 y^{-1} (SE 0.043)
Sport fishing mortality (F) (average 2006-2008, ages 6-11)	0.017 y^{-1} (SE 0.004)
Sea lamprey mortality (ML) (average 2005-2007, ages 6-11)	0.072 y^{-1}
Total mortality (Z) (average 2006-2008, ages 6-11)	0.547 y^{-1} (SE 0.048)
Recruitment (age 1) (average 1999-2008)	559,810 fish (SE 23,836)
Biomass (age 3+) (average 1999-2008)	1,762,600 lb (SE 124,160)
Spawning biomass (average 1999-2008)	244,800 lb (SE 22,791)
MSC recommended yield limit for 2009	203,000 lb
Actual yield limit (based on August 2007 Decree amendment)	230,000 lb (plus estimated throwbacks)

MH-2 (North-central Lake Huron)

Prepared by Ji X. He, Aaron P. Woldt, Adam Cottrill, and Mark P. Ebener

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, non-clipped lake trout accounted for more than 22% of biological samples from Ontario commercial fisheries in this unit.

Total age-1 lake trout stocked in 2008 was 470,240, including 9,644 in Ontario QMA 4-3 (Figure 1). The average number of age-1 lake trout stocked between 2003 and 2007 was 492,664. After accounting for movement among the three management units of Lake Huron's main basin, and the addition from 2007 stocked fall fingerlings in Six Fathom Bank and Yankee Reef, the total number of age-1 lake trout in MH-2 was estimated to be 442,495 fish in 2008.

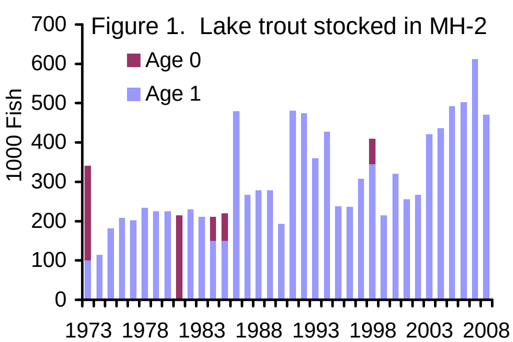


Figure 1. Lake trout stocked in MH-2

Sea lamprey induced mortality at age was based on fitting wounding rate as a logistic function of body length (TL, mm), and length distribution at age. The wounding rate in a given year was based on biological samples from the spring (April-June), and reflected sea lamprey induced mortality in the previous year. These biological samples were from spring gill-net surveys by MDNR during 1984-2008, and a summer gill-net survey by USFWS in June 2003-2008. Asymptotic wounding rate decreased after 2000, and has been significantly lower than the 1998 level since 2001 (Figure 2). At age 7, average sea lamprey induced instantaneous mortality was estimated to be 0.332 y^{-1} during 1993-1997, and only 0.077 y^{-1} during 2003-2007. At age 15, the average was estimated to be 0.352 y^{-1} during 1993-1997, and only 0.079 y^{-1} during 2003-2007.

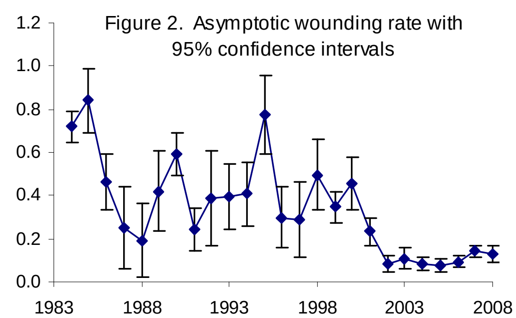
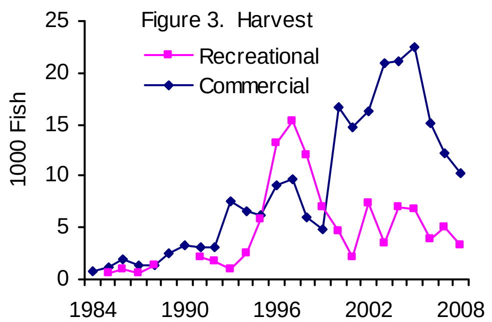


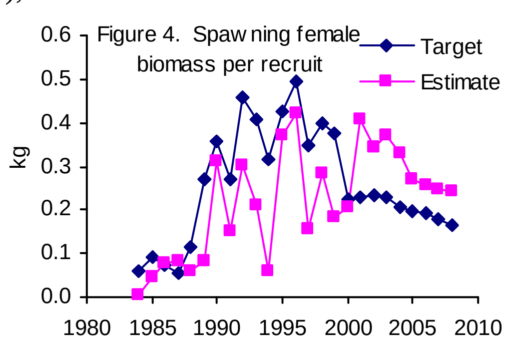
Figure 2. Asymptotic wounding rate with 95% confidence intervals

Both commercial and recreational harvests were substantial in this region of Lake Huron (Figure 3). The majority of commercial harvest came from Ontario large-mesh gill nets, and there was no commercial fishery in Michigan waters. Total commercial harvest in 2008 was 41,119 lb, compared with yearly average of 69,948 lb from 2003 through 2007. The reported recreational harvest included both retention of fish caught and an estimate of discard after 2002. On average, recreational harvests during 2003-2007 were 26,900 lb, and in 2008 the harvests decreased to 20,991 lb.



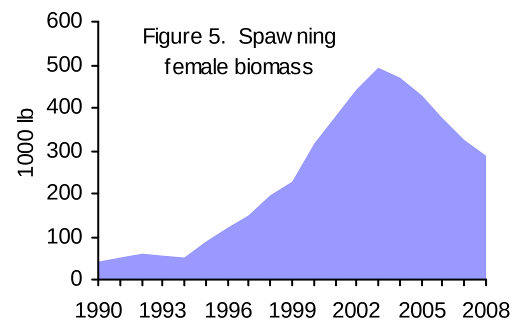
Target spawning stock biomass per recruit (SSBR) was based on a limit of 40% annual mortality (*A*) for age-5 and older lake trout, and was in the range of 0.06-0.48 (Figure 4). The large variation in target SSBR was mostly due to the variation in the survival from age 1 to age 2, although body weight 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 the target before 2000 (Figure 4), and the dominant source of lake trout



mortality was sea lamprey. After 2000, estimated SSBR was higher than the target, so over-all-age annual mortality should be lower than the mortality limit of 40%. Sea lamprey induced mortality was still higher than commercial and recreational fishing mortality combined in the recent three years including 2008, although the treatment on the St. Marys River since 1998 substantially reduced sea lamprey abundance and sea lamprey wounding rates (Figure 2).

Spawning stock biomass (SSB) was very low until the late 1990s, and 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 a decline in SSB was inconsistent with the estimated SSBR that 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.

The Modeling Subcommittee (MSC) will further clarify potential technical issues with the determination of target SSBR. In calculating total allowable catch (TAC) for 2009, however, the MSC followed a policy that prohibits technical changes immediately prior to TAC determination. The MSC continued the calculation of target SSBR based on the limit of 40% annual mortality (*A*) for age-5 and older lake trout. The recommended harvest limit was 83,277 lb for the state, and 4,383 lb for the tribes. The allocation percentage is 95% for the state and 5% for the tribes, as outlined in Sections VII.A.3 and VII.A.4 of the 2000 Consent Decree.

The recommended TAC for 2009 was much higher than the 2008 level of 46,000 lb. Such a rapid change does not reflect a change in the MH-2 lake trout stock but is another example of the uncertainty in model parameters. The highest uncertainty in the MH-2 model was with estimates of time-varying survival from age 1 to age 2. Retrospective patterns in the estimates were apparent. In fact, with the addition of 2008 data, the model could not fully converge until age-1 survival in the recent seven years were coded as equal to the survival in 2000. This was expected because the oldest fish in those year classes were rarely captured in the survey and recreational fishery, and they were not sufficiently represented by 2008. Over the years, the commercial fishery in Ontario waters continued to catch age-4 and age-5 lake trout, but biological samples from the commercial fishery were often very small, and the commercial age structure was inconsistent with recreational and survey age structures in recent years. MCMC simulations identified the same concerns about uncertainty in the vector of time-varying mortality of age-1 lake trout, which in turn was associated with uncertainty in time-varying selectivity of the survey, and commercial and recreational fisheries.

The MSC has informed the TFC in previous reports that it was unusual to see the harvest limit increasing rapidly in just a few years and staying high. Now the technical concern can be better stated: the recommended harvest level in recent years appeared to assume pre-recruitment abundances that were not yet supported by survey and fisheries data and continued to use an age at full recruitment that was no longer supported by recent new data from both the survey and fisheries.

The MH-2 model converged in 2009 TAC year. The maximum gradient component was 0.00025. The model fit data well, including harvest numbers of commercial and recreational fisheries, age structures for the survey, and for the commercial and recreation fisheries. No apparent residual pattern was identified. The fit of catch-at-age model to survey abundance indices was improved substantially, in comparison with the fits of previous years.

Refinements to the MH-2 model were similar as in MH-1 model this year, including an expansion of commercial age structure from ages 2-8 to ages 1-15, and a similar expansion of survey age structure from ages 2-10 to ages 1-15. These expansions were long overdue, given the apparent increases in the catch of lake trout older than ages 9 and 10. Correspondingly, boundary parameters were modified for estimating the vectors determining time-varying selectivity in fishery independent survey, and in commercial and recreational fisheries.

The year by age matrix of body weight at age was updated this year. This matrix was not updated in 2006 and 2007 due to the difficulty at the time of getting time-varying growth and length-weight models to converge. Thus, the TAC calculation for 2007 and 2008 did not consider the continuous declines in weight at age that was occurring in MH-2 lake trout.

Finally, this year was the first time that survey abundance indices were estimated using the R software program. The model included year effects, ARMA(1,1) autocorrelation of year effects, and heterogeneous variances of observation errors among years. The abundance indices were year effects on log scale catch per unit effort, rather than least square means (LSM) for log scale CPUE. The year effects from the R model agreed with LSM from the SAS model as used in previous years. Model comparison based on AIC criteria did not support inclusion of any random effects.

Future model improvement may include the following. (1) Expand the age structure of recreational fisheries from ages 2-9 to ages 1-15, and adequately reflect the increasing catch of older lake trout. (2) Evaluate the difference of commercial age structure from the recreational and survey age structures, and increase sample size of biological data from Ontario commercial fishery. (3) Update the year by age matrix of maturity at age, by modeling maturity schedules as time-varying, and thereby improve SSB and SSBR related model calculations. (4) Estimate time-varying standard errors for length at age that varies among years, and improve the calculation of sea lamprey induced mortality at ages. (5) Evaluate potential replacement of double logistic functions by using gamma functions for describing age-specific selectivity patterns, and reduce sensitivity of model estimates to initial parameter values. (6) Evaluate use of summer survey abundance indices and age composition in the model, and improve estimation of survival from age 1 to age 2. (7) Further improve survey abundance indices, by (a) evaluating the impact of depth as a continuous variable rather than a factor of strata, and (b) evaluating the potential impact of age composition on catch rate.

Summary Status MH-2 Lake Trout	**Value (Standard Error)**
Female maturity	
Size at first spawning	1.16 lb
Age at first spawning	3 y
Size at 50% maturity	3.58 lb
Age at 50% maturity	6 y
Spawning stock biomass per recruit	
Base SSBR	1.410 lb (SE 0.120)
Current SSBR	0.520 lb (SE 0.050)
SSBR at target mortality	0.363 lb (SE 0.021)
Spawning potential reduction	
At target mortality	0.371 (SE 0.011)
Average yield per recruit	0.128 lb (SE 0.008)
Natural mortality (M)	0.228 y^{-1}
Fishing mortality	
Age of full selection	
Commercial fishery (2006-2008)	9 y
Sport fishery (2006-2008)	8 y
Commercial fishing mortality (F) (average 2006-2008, ages 6-11)	0.055 y^{-1} (SE 0.007)
Sport fishing mortality (F) (average 2006-2008, ages 6-11)	0.029 y^{-1} (SE 0.004)
Sea lamprey mortality (ML) (average 2005-2007, ages 6-11)	0.099 y^{-1}
Total mortality (Z) (average 2006-2008, ages 6-11)	0.412 y^{-1} (SE 0.014)
Recruitment (age 1) (average 1999-2008)	479,690 fish (SE 26,359)
Biomass (age 3+) (average 1999-2008)	1,973,700 lb (SE 91,831)
Spawning biomass (average 1999-2008)	375,240 lb (SE 25,520)
MSC recommended yield limit for 2009	87,660 lb
Actual yield limit for 2009	87,660 lb

Lake Michigan

MM-123 (Northern Treaty Waters)

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

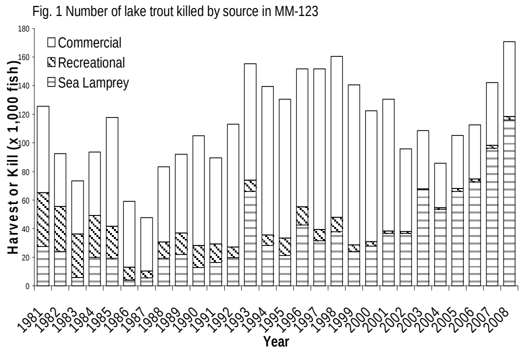
Management unit MM-123 is made up of statistical districts MM-1, MM-2 and MM-3 and encompasses Michigan's waters of northern Lake Michigan and northern Green Bay, covering 5,000 square miles. Water depths in the northern portion of the unit are generally less than 150 feet, and approximately 3,800 square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

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

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

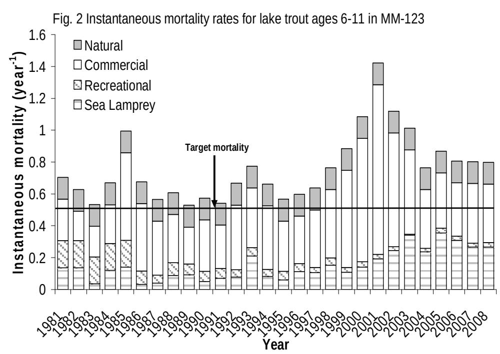
Recruitment of lake trout in MM-123 is currently based entirely on stocking. In each of the last ten years, on average, 851,656 yearling lake trout have been stocked into MM-123 and approximately 63 percent of these fish were stocked into the northern refuge. To more accurately estimate recruitment in the model, the number of fish stocked is adjusted to account for movement among the various regions in the lake. Coded-wire tag returns were used to assign movement of stocked fish into different management units. After adjustments, the resulting estimates of age-1 recruitment in MM-123 have averaged 513,313 fish from 1999-2008.

Both state and tribal commercial fisheries operate in MM123. State-licensed commercial fisheries target lake whitefish primarily with trap nets in Green Bay. The tribal commercial gill net and trap net fishery primarily targets lake whitefish, lake trout are harvested as by-catch. From 1981 until 2001, commercial fishing accounted for most of the lake trout mortality in northern Lake Michigan (Figure 1). In 2001, sea lamprey abundance began to increase and in the most recent 5 years (average 80,920 fish•y^{-1}) sea lamprey-induced mortality of lake trout peaked at an estimated 115,980 fish in 2008. Prior to the year 2000, sea lamprey killed an average of 23,000 fish•y^{-1}.



The tribal commercial fishers in MM-123 use large- and small-mesh gill nets as well as trap nets. The large-mesh gill-net fishery accounts for the majority of the lake trout yield. Total commercial yield increased from 350,685 lb in 1991 to 880,257 lb in 1999. After the implementation of the 2000 Consent Decree, the tribal commercial yield of lake trout decreased to a low of 105,746 lb in 2004. Since then, harvest has been gradually increasing and was 247,345 lb in 2008. Large-mesh gill-net effort declined from 23 million feet in 1992 and 1993 to 4.2 million feet in 2004. During the most recent 3 years large-mesh gill-net effort has averaged 5.3 million feet. The number of lake trout harvested from MM-123 by the commercial fishery increased from 66,000 fish in 1991 to 145,300 fish in 1997. More recently, following implementation of the 2000 Consent Decree, the number of lake trout harvested by the commercial fishery declined to an all time low of 29,000 fish in 2004, before increasing to 50,800 fish in 2008 (Figure 1).

The recreational fisheries for lake trout are comprised of both charter and sport anglers. Since 1986, recreational fishing mortality of lake trout in MM-123 has been significantly lower than commercial fishing or sea lamprey predation (Figure 2). In 1991, the minimum size limit for sport fishing in MM-123 was increased from 10 to 24 inches and a decline in recreational yield resulted. In 2003, the bag limit was raised from 2 to 3 fish, and appears to have had little effect on harvest. The 24-inch minimum size limit and 3 fish bag limit remained in effect through 2008. The recreational yield of lake trout declined by over 97 percent from 1998 (75,820 lb) to 2003 (2,300 lb). Recreational fishery yield has declined further averaging 13,800 lb during the most recent 3 years. The numbers of lake trout harvested fell to just under 400 fish in 2003 and has averaged 2,100 fish from 2006 to 2008. Recreational fishing effort is relatively low in this unit, averaging 95,300 angler hours during 1988-2008.



Sea lamprey mortality rates in northern Lake Michigan have averaged 0.15 fish•y^{-1} from 1981-2008. With the exception of 1993 lamprey induced mortality has 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 and exceeded all other sources of mortality at 0.35 • y^{-1} in 2005. Lamprey mortality has since declined slightly reaching 0.26 • y^{-1} in 2007 (Figure 2).

In northern Lake Michigan, 50 percent of lake trout are spawning by age 6. Lake trout are fully-recruited into commercial fisheries at age 8 and recreational fisheries at age 7. The biomass of lake trout in northern Lake Michigan nearly tripled, increasing from 1.2 to 2.9 million pounds from 1986 to 1997. The biomass of lake trout then steadily declined to 0.7 million pounds by 2003 (Figure 3). More recently, the estimated biomass has increased, reaching 1.5 million pounds in 2008 most of which is accounted for by young fish. Spawning biomass experienced similar though less pronounced patterns, with only a slight increase in recent years.

The spawning stock biomass produced per recruit (including the refuge population) during 2008 was substantially below the target value indicating that mortality rates for the combined refuge/non-refuge population are above the 40% mortality target for this area (Figure 2).

The yield limit for 1836 Treaty waters in 2009 is 50,000 pounds for the state recreational fishery and 453,000 pounds 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 extremely low because the combination of sea lamprey and natural mortality are above the mortality limit and few fish are available to allocate to fisheries.

Fig. 3 Estimated lake trout biomass in MM-123

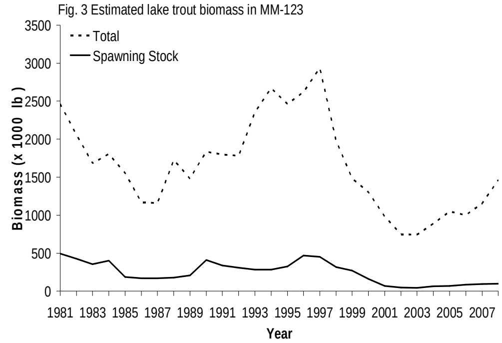
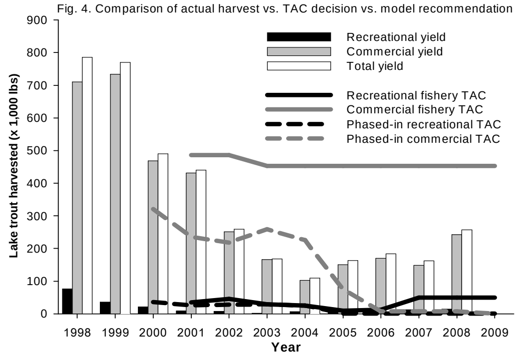


Fig. 4. Comparison of actual harvest vs. TAC decision vs. model recommendation



Model evaluation and changes:

The 2009 SCAA model reached convergence with acceptable maximum gradient components and reasonable asymptotic standard errors on parameter estimates. All parameters were estimated except ages 13, 14 and 15 for the starting population vector (ln-initial). The MCMC simulations yielded good results generally without autocorrelations and no drift in the trace plots. We did not observe any major patterns in residuals that were fit to observed data sources. Recreational harvest residuals did show some trending, likely because this comprises only a small component of the harvest and data are limited. The retrospective analysis of this year's model did not show any systematic temporal patterns in estimates of biomass, spawning biomass, Z or N.

Changes to the model in 2009 include a revision of the estimation process for first year survival. Values were fixed so they can no longer be greater than the number of fish stocked and recruited into the unit. The result was a higher level of mortality assigned to the fisheries. In the past survival of young fish was over-estimated and mathematically more fish were allowed to exist than were stocked and recruited into the unit. By fixing the recruitment of young fish, mortality rates of both recreational and commercial fisheries increased substantially relative to previous years. Additionally, total instantaneous mortality (Z) increased considerably for age-1 fish. A second change involved selectivity. A double logistic function has traditionally been used to estimate selectivity and all parameters were estimable for all fishery types. Some parameter values were not estimable and had been fixed in the past.

Summary Status MM-123	Value (95% probability interval)
Female maturity	
Size at first spawning	2.36 lb
Age at first spawning	3 y
Size at 50% maturity	5.56 lb
Age at 50% maturity	6 y
Spawning stock biomass per recruit	
Base SSBR	7.01 lb (5.59 – 8.59)
Current SSBR combined w/ refuge	0.34 lb (0.25 – 0.44)
SSBR at target mortality	1.07 lb (0.88 – 1.27)
Spawning potential reduction	
At target mortality	0.153 (0.141 – 0.166)
Average yield per recruit	0.510 lb (0.440 – 0.586)
Natural mortality (M)	0.233 y^{-1}
Fishing mortality	
Age of full selection	
Commercial fishery (2006-2008)	8 y
Sport fishery (2006-2008)	7 y
Commercial fishing mortality (F)	
Average 2006-2008, ages 6-11	0.364 y^{-1} (0.299 – 0.442)
Sport fishing mortality (F)	
Average 2006-2008, ages 6-11	0.028 y^{-1} (0.022 – 0.035)
Sea lamprey mortality (ML)	
Average 2005-2007, ages 6-11	0.280 y^{-1}
Total mortality (Z)	
Average 2006-2008, ages 6-11	0.840 y^{-1} (0.769 – 0.923)
Recruitment (age 1)	
Average 1999-2008 (± SE)	513,313 fish (± 68,493)
Biomass (age 3+)	
Average 1999-2008	1,081,176 lb (1,013,920 - 1,151,000)
Spawning biomass	
Average 1999-2008	98,189 lb (87,663 – 109,260)
MSC Recommended yield limit for 2009	26 lb
Actual Yield Limit for 2009	503,000 lb

MM-4 (Grand Traverse Bay)

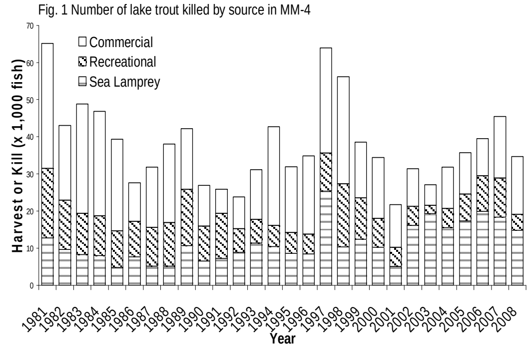
Prepared by Jory L. Jonas, and Erik J. Olsen

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

The recruitment of lake trout in Grand Traverse Bay is based entirely on stocking. The U.S Fish and Wildlife Service is the primary agency responsible for stocking lake trout in Lake Michigan. In each of the last ten years, on average, 278,744 yearling lake trout have been stocked into Grand Traverse Bay. To more accurately estimate recruitment in the model, the number of fish stocked is adjusted to account for movement among the various regions in the lake. Over the last 10 years (1999-2008) recruitment to age one has averaged 298,181 fish in the Grand Traverse management unit.

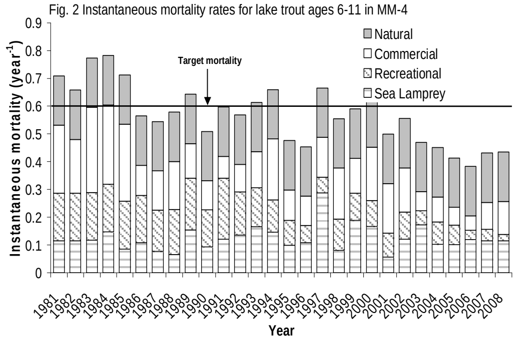
From 1993 until 2001 more lake trout were killed by commercial fishing than by either sea lamprey or sport fishing, averaging 19,800 fish • y^{-1} (Figure 1). By 2003, the number of lake trout killed by commercial fishing had declined to less than 5,600 fish • y^{-1}. The harvest of lake trout has increased in recent years and was 15,500 fish in 2008. Commercial fishing mortality rates in Grand Traverse Bay peaked in 1983 (0.31 • y^{-1}). The lowest mortality rate occurred in 2006 and was 0.05 • y^{-1}. Since this time, mortality rates have increased to 0.12 • y^{-1} in 2008 (Figure 2).

Fig. 1 Number of lake trout killed by source in MM-4



Only Chippewa Ottawa Resource Authority licensed tribal fishermen 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 a low of 6,300 fish in 1991 to 33,300 fish harvested in 1998. Harvest again declined to 5,000 fish in 2003, and has been increasing, averaging 16,000 fish in 2007 and 2008. Accordingly, the yield of lake trout captured in tribal commercial fisheries peaked in 1998 at 161,000 lb and declined by nearly 86% to 23,000 lb in 2003. Yield has increased in recent years and averaged 87,000 lb annually in 2007 and 2008. Large-mesh gill-net effort in tribal fisheries had declined from 2 million feet in 1996 to only 0.3 million feet in 2006. Effort in 2008 was higher at 0.5 million feet of net.

Fig. 2 Instantaneous mortality rates for lake trout ages 6-11 in MM-4

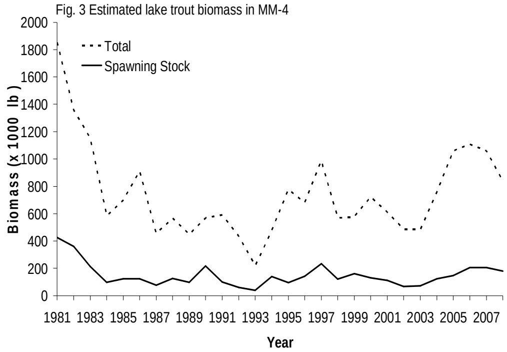


The recreational fisheries for lake trout are comprised of both charter and sport anglers. The sport fishing harvest regulations in the Grand Traverse Bay management unit have changed significantly over the last 15 years, affecting recreational fishing mortality rates and harvest levels. From 1992-1996, 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. An inverted slot limited was adopted where anglers are only allowed to keep fish between 20 and 25 inches, and are allowed one trophy fish greater than 34 inches. The mortality rates of lake trout resulting from recreational fishing had been declining from 1991 (0.22 fish•y^{-1}) to 1997 (0.06 fish•y^{-1}). Recreational fishing mortality was relatively consistent from 1998 to 2002 averaging 0.10 • y^{-1} and has been declining in recent years to 0.02 • y^{-1} in 2008 (Figure 2). The estimated recreational yield of lake trout in Grand Traverse Bay had been reasonably stable during the years 1992-1996 averaging 39,000 lb. In response, at least in part to reductions in size limits, the recreational yield of lake trout from 1996 to 1998 increased reaching 93,000 lb by 1998. Yield then declined to an all time low of 12,000 lb in 2003. Yield was up to 48,300 lb in 2007 and declined to 19,000 lb in 2008. The numbers of lake trout harvested followed patterns similar to yield. Numbers were reasonably consistent from 1992 through 1996 averaging 9,600 fish and had increased to 17,000 fish in 1998. Harvest numbers declined steadily to 2,200 fish in 2003 increased to an estimated 10,500 fish harvested in 2007 and were down to 4,300 fish in 2008 (Figure 1). From 1991 to 2007 fishing effort had been relatively consistent averaging 197,000 angler hours per year (range=155,000 - 238,000 angler hours).

From 1981-1988, sea lamprey-induced mortality was the lowest source of mortality in the Grand Traverse Bay management unit with instantaneous rates averaging $0.10 \bullet y^{-1}$. Wounding mortality increased to $0.29 \bullet y^{-1}$ in 1997 and declined to $0.06 \bullet y^{-1}$ by 2001. In the past four years (2004-2007) lamprey mortality has averaged $0.11 \bullet y^{-1}$. In 2001, lampreys were estimated to have killed just over 5,000 lake trout. The estimated numbers of lake trout killed by lamprey increased to 19,900 in 2006 and was down to 14,800 by 2008.

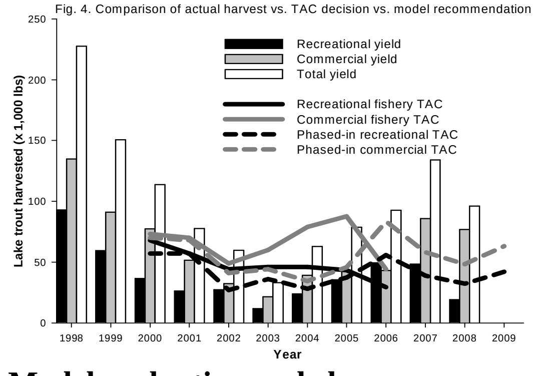
In the Grand Traverse Bay management unit, lake trout are recruited into sport and commercial fisheries by age 6. Female lake trout first spawn at age 3 and 50 percent or more are spawning by age 6. The total biomass of lake trout over age 3 peaked in 1981 at 1.9 million pounds. More recently, biomass has increased from a low of 218,700 pounds in 1993 to 1.0 million pounds in 1997. From 1998 to 2003 lake trout biomass averaged 575,000 lbs, increased to 1.2 million lbs in 2007, and was lower in 2008 at 839,000 lbs.

Fig. 3 Estimated lake trout biomass in MM-4



The spawning stock biomass produced per recruit is slightly above the target value indicating that total mortality rates are close to and below target rates for Grand Traverse Bay. The model recommended harvest limit for 2009 in the Grand Traverse Bay management unit is 104,974 pounds of which 41,990 pounds was allocated to the state recreational fishery and 62,984 pounds to the tribal commercial/subsistence fishery. In August 2009 a stipulation to the 2000 Consent Decree was agreed to by the Parties that 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. This stipulation stated that the Tribal harvest limit will not be less than 94,300 lb, and the State harvest limit will not be less than 63,000 lb for 2009. 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 2008 did not reach the limit of 63,000 lb, the actual Tribal harvest limit in 2009 was 94,300 lb plus the leftover amount from the State, 43,759 lb, for a total of 138,059 lb.

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



Model evaluation and changes:

The 2009 SCAA model reached convergence with acceptable maximum gradient components and reasonable asymptotic standard errors on parameter estimates. All parameters were estimated except ages 13, 14 and 15 for the starting population vector (ln-initial).

The MCMC simulations yielded good results generally without autocorrelations and no drift in the trace plots. We did not observe any major patterns in residuals for fit to observed data sources. The retrospective analysis of this year's model did not show any systematic temporal patterns in estimates of biomass, spawning biomass, Z or N.

Changes to the model in 2009 include a revision of the estimation process for first year survival. Values were fixed so they can no longer be greater than number of fish stocked and recruited into the unit. A second change involved estimation of selectivity parameters. A double logistic function was used to estimate selectivity and all parameters were estimable for all fishery types. Some parameter values were not estimable and had been fixed in the past.

Summary Status MM-4	Value (95% probability interval)
Female maturity	
Size at first spawning	2.44 lb
Age at first spawning	3 y
Size at 50% maturity	4.84 lb
Age at 50% maturity	6 y
Spawning stock biomass per recruit	
Base SSBR	1.438 lb (1.024 – 1.946)
Current SSBR	0.277 lb (0.183 – 0.394)
SSBR at target mortality	0.202 lb (0.147 – 0.267)
Spawning potential reduction	
At target mortality	0.142 (0.128 – 0.157)
Average yield per recruit	0.137 lb (0.101 – 0.179)
Natural mortality (M)	0.178 y^{-1}
Fishing mortality	
Age of full selection	
Commercial fishery (2006-2008)	6 y
Sport fishery (2006-2008)	6 y
Commercial fishing mortality (F)	
Average 2006-2008, ages 6-11	0.096 y^{-1} (0.073 – 0.129)
Sport fishing mortality (F)	
Average 2006-2008, ages 6-11	0.035 y^{-1} (0.028 – 0.045)
Sea lamprey mortality (ML)	
Average 2005-2007, ages 6-11	0.116 y^{-1}
Total mortality (Z)	
Average 2006-2008, ages 6-11	0.425 y^{-1} (0.389 – 0.472)
Recruitment (age 1)	
Average 1999-2008 (± SE)	298,181 fish (30,046)
Biomass (age 3+)	
Average 1999-2008	757,118 lb (680,254 – 840,595)
Spawning biomass	
Average 1999-2008	133,674 lb (108,729 – 160,753)
MSC recommended yield limit for 2009	104,974 lb
Actual yield limit for 2009	201,059 lb

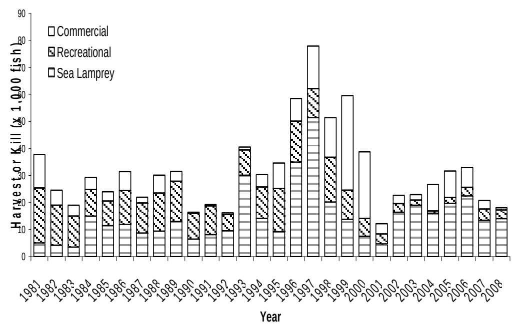
MM-5 (Leelanau Peninsula to Arcadia)

Prepared by Jory L. Jonas and Erik J. Olsen

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

The recruitment of harvestable lake trout in the MM-5 management unit of Lake Michigan is based entirely on stocking. The U.S. Fish and Wildlife Service is the primary agency responsible for stocking lake trout in Lake Michigan. Over the last ten years, on average, 220,599 yearling lake trout were stocked into the MM-5 management unit annually. To more accurately estimate recruitment in the model, the number of fish stocked is adjusted for movement among the various regions in the lake. Over the last 10 years (1998-2007) the recruitment to age one has averaged 269,045 fish in MM-5.

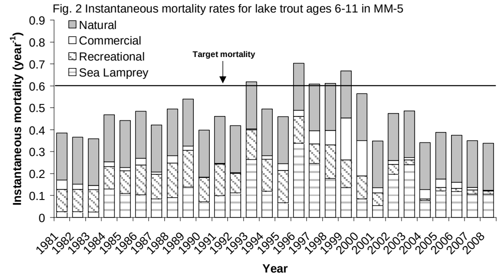
Fig. 1 Number of lake trout killed by source in MM-5



Although both State and Tribal commercial fishermen harvest fish in the management unit, state-licensed commercial fisheries are primarily trap-net operations targeting lake whitefish. State-licensed fishermen are not permitted to harvest lake trout, and as a result, are not included in lake trout harvest allocations. The Chippewa Ottawa Resource Authority oversees three types of tribal commercial fisheries in this area including large-mesh gill net, small-mesh gill net, and trap net. The 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. In 2008, commercial fishing mortality was a mere $0.003 \cdot y^{-1}$. To place this in perspective, from 1990 to 1993, mortality from commercial fishing was also extremely low averaging $0.002 \cdot y^{-1}$. Mortality rates then increased to their highest levels in 1999 and 2000 at 0.19 and 0.16 • y^{-1} respectively. In 1999 nearly 35,000 fish were harvested in commercial fisheries. Where in contrast, after the year 2000, commercial harvest decreased considerably and only 1,900 lake trout were harvested in 2003. In 2008, a mere 570 lake trout were harvested in commercial fisheries and surveys (Figure 1). The yield of lake trout in commercial fisheries rose precipitously from 3,800 lb in 1993 to 184,900 lb in 1999. From 2001 to 2003, the yield was extremely low, averaging 8,800 lb. Yield increased to 29,700 lb in 2005 and has steadily declined to 3,000 lb in 2008. Large-mesh gill-net effort in Tribal fisheries reflected patterns similar to those observed in mortality, harvest, and yield. Gill-net effort rose from 22,000 feet in 1993 to 2 million in 1999. After implementation of the 2000 Consent Decree, gill-net effort declined considerably and in 2008 was 18,500 feet of net.

Recreational fisheries for lake trout are primarily managed by the State of Michigan and include both charter and sport anglers. In the MM-5 management unit from 1986 until 1991, recreational fishing mortality (averaged over ages 6-11) exceeded commercial fishing averaging 0.14 • y^{-1}. Mortality from recreational fishing declined since 1998 from 0.15 • y^{-1} to 0.01 • y^{-1} in 2004. Recreational fishing mortality rates have remained low averaging 0.02 • y^{-1} during the recent four years (2005 to 2008). Recreational fishery yields declined from 88,500 lb in 1998 to 3,800 lb in 2004. Yield had been increasing reaching 18,700 lb in 2007, but had declined in 2008 to 13,700 lb. The numbers of lake trout harvested also dropped between 1998 (16,500 fish) and 2004 (785 fish) declining by nearly 95 percent. In 2008, 3,200 fish were harvested. Recreational fishing effort had been relatively consistent from 1995 to 1999 averaging 279,000 angler hours. In 2008, angler effort wad down to 156,000 angler hours. The sport fishing 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 below 24 inches and one trophy fish greater than 34 inches.

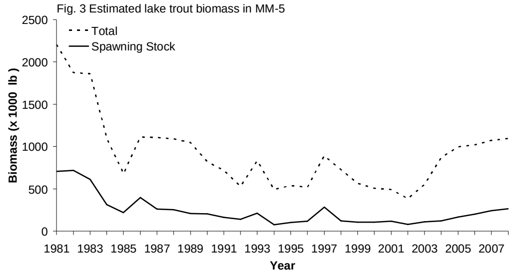
Fig. 2 Instantaneous mortality rates for lake trout ages 6-11 in MM-5



From 1984-1992 sea lamprey mortality rates were relatively consistent averaging 0.10 • y^{-1}. Mortality rates increased to 0.26 • y^{-1} in 1993, declined over the next two years to 0.07 • y^{-1}, and rose to an all time high of 0.34 • y^{-1} in 1996. During the last three years (2005-2007) lamprey mortality rates have averaged 0.11 • y^{-1} (Figure 2). Sea lamprey killed only 4,700 lake trout in 2001 and the number killed has increased to 22,400 by 2006. In 2007 13,400 lake trout were killed by sea lamprey.

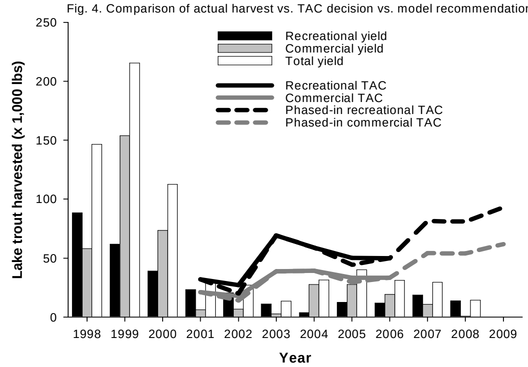
Fifty percent of lake trout are spawning by age 6 in MM-5 and they are fully recruited into commercial fisheries and recreational fisheries. The biomass of lake trout older than age 3 was 891,000 lb in 1997, declined to 386,000 lb in 2002 and has since increased to 1.1 million lb in 2008 (Figure 3). The biomass of spawning age lake trout increased from 81,300 lb in 2002 to 265,000 lb in 2008.

Fig. 3 Estimated lake trout biomass in MM-5



The spawning stock biomass produced per recruit is substantially above the target value, indicating that mortality is at acceptable levels in MM-5. The recommended yield limit for 2008 in unit MM-5 is 154,028 pounds, and is based on a target mortality rate of 45%. Of this yield, 92,430 pounds were allocated to the state recreational fishery and 61,598 pounds 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 related to this unit. The stipulation established a floor for the Tribal harvest limit, and until sea lamprey mortality rates are significantly below 1998 levels for three consecutive years, the Tribal harvest limit cannot be less than 39,200 lb.

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



Model evaluation and changes:

The 2009 SCAA model reached convergence with acceptable maximum gradient components and reasonable asymptotic standard errors on parameter estimates. All parameters were estimated except ages 13, 14 and 15 for the starting population vector (ln-initial). The MCMC simulations yielded poor results with autocorrelations and drift in the trace plots. We did not observe any major patterns in residuals for fit to observed data sources. The retrospective analysis of this year's model did not show any systematic temporal patterns in estimates of biomass, spawning biomass, Z or N.

Changes to the model in 2009 include a revision of the estimation process for first year survival. Values were fixed so they can no longer be greater than number of fish stocked and recruited into the unit. A second change involved the estimation of selectivity parameters. A double logistic function was used and most parameters were estimated. Exceptions include the p2 parameter for the survey which was set equal to 2 due to a knife-edge patterns expressed in the data. The p4 parameters for the second and fourth recreational fishery selectivity curves were fixed at -0.2 to provide a signal for the descending limb of the double logistic.

Summary Status MM-5	Value (95% probability interval)
Female maturity	
Size at first spawning	2.00 lb
Age at first spawning	3 y
Size at 50% maturity	5.10 lb
Age at 50% maturity	6 y
Spawning stock biomass per recruit	
Base SSBR	2.510 lb (2.242 – 2.704)
Current SSBR	0.955 lb (0.852 – 1.025)
SSBR at target mortality	0.495 lb (0.448 – 0.532)
Spawning potential reduction	
At target mortality	0.198 (0.192 – 0.206)
Average yield per recruit	0.109 lb (0.098 – 0.131)
Natural mortality (M)	0.214 y^{-1}
Fishing mortality	
Age of full selection	
Commercial fishery (2006-2008)	6 y
Sport fishery (2006-2008)	6 y
Commercial fishing mortality (F)	
Average 2006-2008, ages 6-11	0.011 y^{-1} (0.010 – 0.013)
Sport fishing mortality (F)	
Average 2006-2008, ages 6-11	0.018 y^{-1} (0.014 – 0.025)
Sea lamprey mortality (ML)	
Average 2005-2007, ages 6-11	0.115 y^{-1}
Total mortality (Z)	
Average 2006-2008, ages 6-11	0.358 y^{-1} (0.349 – 0.372)
Recruitment (age 1)	
Average 1999-2008 (± SE)	269,045 fish (± 17,492)
Biomass (age 3+)	
Average 1999-2008	787,151 lb (741,039 – 815,431)
Spawning biomass	
Average 1999-2008	162,159 lb (144,155 – 172,919)
MSC recommended yield limit for 2009	154,028 lb
Actual yield limit in 2009	154,028 lb

MM-67 (Southern Treaty Waters)

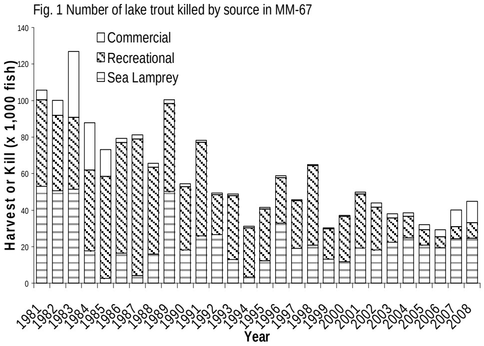
Prepared by Jory L. Jonas and Archie W. Martell Jr.

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

The recruitment of lake trout in the southern treaty waters of Lake Michigan is based entirely on stocking. During the past ten years, an average of 188,500 yearling lake trout have been stocked into non-refuge southern treaty waters, while an additional 319,000 fish were stocked into the mid-lake refuge area, much of which is in Wisconsin' waters. To more accurately estimate recruitment in the model, the number of fish stocked is adjusted to account for movement among the various regions in the lake. Over the last 10 years (1998-2007), the recruitment of lake trout to age one has averaged 371,558 fish in the southern treaty management unit of Lake Michigan.

Since 1986, commercial fishing has killed fewer lake trout of harvestable size in the southern unit (MM-67) than either recreational fishing or sea lamprey (Figure 2). In 2008, the State's commercial fishery in southern treaty waters of Lake Michigan was comprised of two trap-net operations and one small-mesh gill-net chub operation. The 2008 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 pounds 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 9,500 pounds over the last 20 years (1988-2008). During the recent three years the harvest in commercial fisheries has been increasing, from 1,900 fish • y^{-1} in 2004 to 11,600 fish • y^{-1} in 2008. As a result of the 2000 Consent Decree, this unit is experiencing increased Tribal commercial fishing effort.

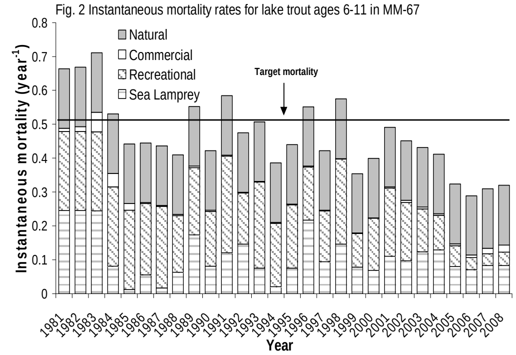
Fig. 1 Number of lake trout killed by source in MM-67



State recreational fisheries for lake trout are comprised of both charter and sport anglers. Recreational fishing mortality is generally higher than commercial fishing mortality (Figure 2). During the last five years, observed recreational fishing mortality rates have been declining from 0.20 • y^{-1} in 2001 to 0.04 • y^{-1} in 2008. The yield of lake trout in recreational fisheries has also declined from 177,800 lb in 2001 to 42,300 lb in 2008. The highest recreational yield was observed in 1987 at 474,400 lb. The numbers of lake trout harvested have declined by nearly 80 percent in recent years, from 29,500 fish in 2001 to 8,400 fish in 2008 (Figure 1). Effort levels have been relatively consistent since 1990 averaging 1,149,000 angler hours. 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.

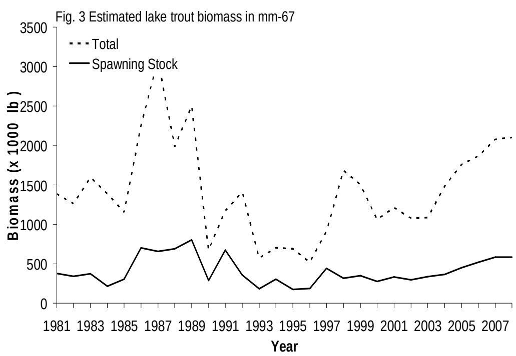
Sea lamprey-induced mortality is lower in southern treaty waters of Lake Michigan relative to the northern management units. Mortality rates have ranged from 0.02 to 0.22 • y^{-1} during the last 20 years (Figure 2). In recent years (2005-2007), the number of lake trout killed by lamprey has averaged 21,600 fish (Figure 1).

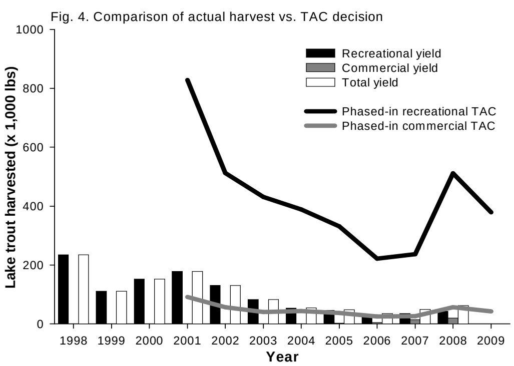
Fig. 2 Instantaneous mortality rates for lake trout ages 6-11 in MM-67



The majority of lake trout in MM-67 are spawning by age 6, have recruited into recreational fisheries by age 7 and commercial fisheries by age 6. The biomass of lake trout age 3 and older is high, and reached 2.1 million lb in 2008 (Figure 3). Spawning lake trout comprise a relatively high proportion of the total biomass in this unit (Figure 3), at over 585,000 lb in 2008.

The spawning stock biomass produced per recruit is substantially greater than the target value indicating that mortality is below the targeted 40% level in MM-67. The model recommended yield limit for MM-67 in 2009 was 420,612 lb and was accepted by the parties. The state recreational fishery is allocated 90 percent or 378,551 pounds and the tribal fishery 10 percent of 42,061 pounds. Both recreational and commercial fisheries are well below established TAC levels (Figure 4).





Model adjustments and changes:

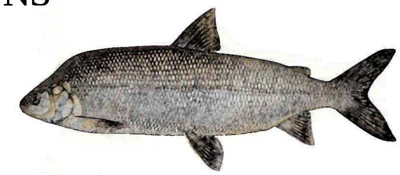
The 2009 SCAA model reached convergence with acceptable maximum gradient components and reasonable asymptotic standard errors on parameter estimates. All parameters were estimated except ages 13, 14 and 15 for the starting population vector (ln-initial). The MCMC simulations yielded poor results with autocorrelations and drift in the trace plots. Residual patterns indicate slight trending. The retrospective analyses of this year's model indicate that we may need to address time varying parameters to improve performance.

Changes to the model in 2009 include a revision of the estimation process for first year survival. Values were fixed so they can no longer be greater than the number of fish stocked and recruited into the unit. A second change involved the estimation of selectivity parameters. A double logistic function was used and most parameters were estimated. Exceptions include the p2 parameter for the survey which was set equal to 2 due to a knife-edge patterns expressed in the data. Commercial fishery selectivity parameters were fixed to values from MM-5, as no bio-data is available to signal estimation for this unit.

Summary Status MM-67	Value (95% probability interval)
Female maturity	
Size at first spawning	1.58 lb
Age at first spawning	3 y
Size at 50% maturity	5.86 lb
Age at 50% maturity	6 y
Spawning stock biomass per recruit	
Base SSBR	3.974 lb (3.014 – 5.206)
Current SSBR combined w/ refuge	1.699 lb (1.276 – 2.219)
SSBR at target mortality	0.775 lb (0.606 – 0.958)
Spawning potential reduction	
At target mortality	0.197 (0.173 – 0.221)
Average yield per recruit	0.204 lb (0.160 – 0.254)
Natural mortality (M)	0.176 y^{-1}
Fishing mortality	
Age of full selection	
Commercial fishery (2006-2008)	6 y
Sport fishery (2006-2008)	7 y
Commercial fishing mortality (F)	
Average 2006-2008, ages 6-11	0.014 y^{-1} (0.006 – 0.021)
Sport fishing mortality (F)	
Average 2006-2008, ages 6-11	0.037 y^{-1} (0.031 – 0.046)
Sea lamprey mortality (ML)	
Average 2005-2007, ages 6-11	0.079 y^{-1}
Total mortality (Z)	
Average 2006-2008, ages 6-11	0.307 y^{-1} (0.285 – 0.331)
Recruitment (age 1)	
Average 1999-2008 (± SE)	371,558 fish (± 16,263)
Biomass (age 3+)	
Average 1999-2008	1,532,020 lb (1,315,990 – 1,785,160)
Spawning biomass	
Average 1999-2008	410,811 lb (330,153 – 511,165)
MSC recommended yield limit in 2009	420,612 lb
Actual yield limit in 2009	420,612 lb

STATUS OF LAKE WHITEFISH POPULATIONS

Lake Superior

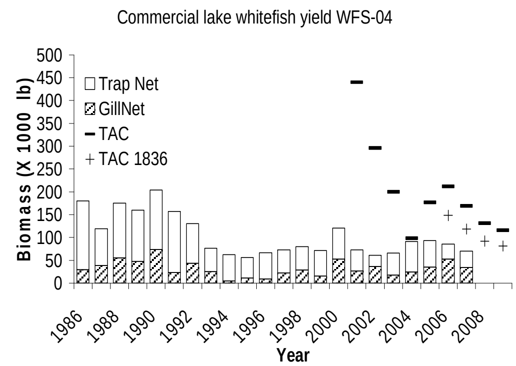


WFS-04 (Marquette - Big Bay)

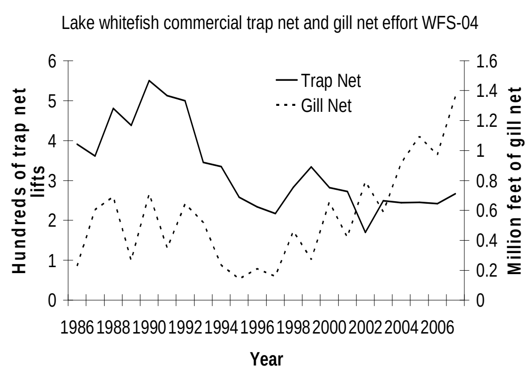
Prepared by Philip J. Schneeberger

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

Overall yield in WFS-04 during 2007 was 69,824 lbs. The overall harvest was divided nearly equally between trap-net (35,529 lbs) and gill-net (34,295 lbs) fisheries. Compared to 2006, trap-net yield increased 8% but gill-net yield dropped 35% in 2007. In 1836 waters of WFS-04, lake whitefish yield (all from trap nets) was 3,050 lbs, or about half the yield taken in 2006, and represented only 4% of the overall yield from the management unit in 2007.

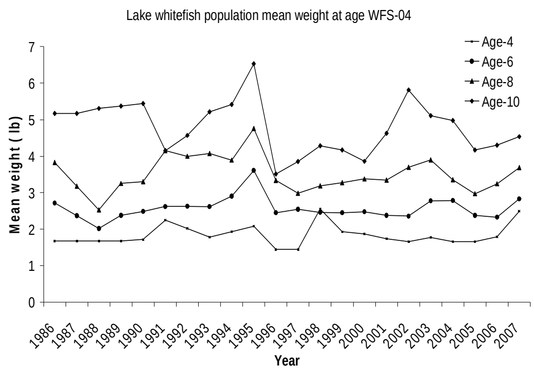


WFS-04 trap-net effort (267 lifts in 2007) has remained stable since 2003, whereas, gill-net effort (1.36 million feet in 2007) continued an increasing trend that began in 1995. Only 13% of the trap-net effort and none of the gill-net effort took place in 1836 Treaty waters during 2007.



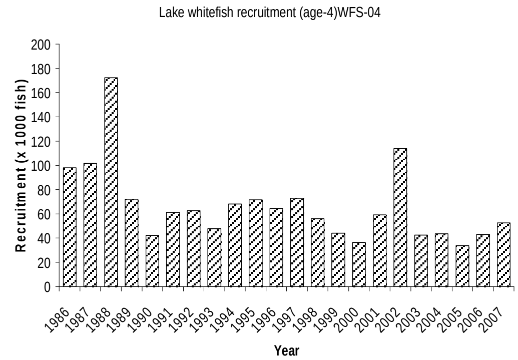
Catch-per-unit effort (CPUE) has declined since 2004 for the trap-net fishery and longer term for gill nets. The two lowest CPUEs during the time series for trap nets occurred in 2006 and 2007, and four of the five lowest gill-net CPUEs were recorded since 2003.

Between 2006 and 2007, calculations of mean weight-at-age tipped higher by an average of 12% for ages 4-12+. This continued an upward trend in weight that began in 2005 for most whitefish age groups.

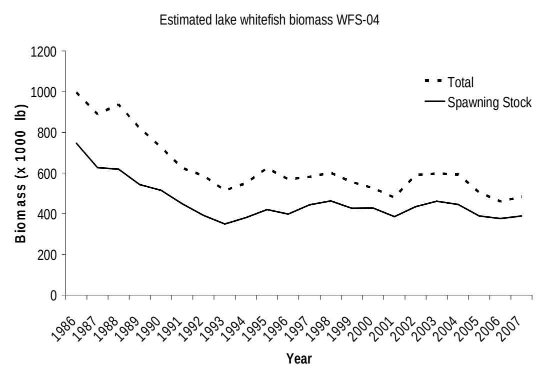


A von Bertalanffy growth model was used to portray individual fish growth as a function of time. Averages for length-at-age, calculated from lake whitefish data pooled for 2005-2007 from state fisheries, were used for model inputs. The model was forced through zero by inserting a data point a length of 0 mm at age 0. Model estimates for growth parameters L ∞, k, and t_0 were 755 mm, 0.178, and -0.18.

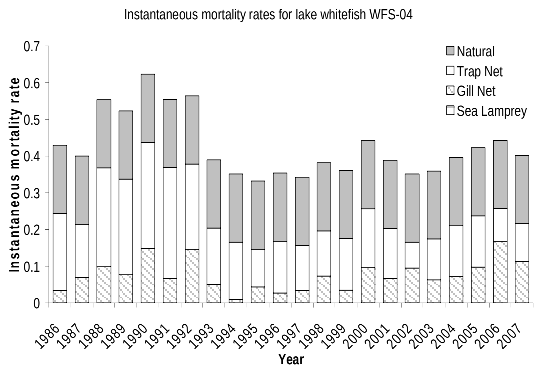
Recruitment (number of age-4 lake whitefish) was estimated at 52,000 in 2007. WFS-04 recruitment estimates have remained relatively stable since 2003. The most recent larger-than-normal year class was produced in 1998, as determined by the estimate of 4-year olds in 2002.



Neither fishable biomass nor spawning stock biomass has exhibited detectable trends for more than ten years. Estimated fishable biomass was 484 thousand lbs and spawning stock biomass was 390 thousand lbs in 2007. The 2007 ratio of spawning stock biomass to fishable biomass was 0.80, and has varied between 0.66 and 0.82 through the time series of the data set.



Total instantaneous mortality rate (Z) for the WFS-04 lake whitefish stock has ranged between 0.33 and 0.44 y^{-1} from 1993 through 2007. The 2007 estimate for Z was 0.40 y^{-1}, down from 0.44 y^{-1} estimated for 2006. Estimated instantaneous fishing mortality rates (F) were 0.11 y^{-1} for gill nets and 0.10 y^{-1} for trap nets in 2007. Instantaneous natural mortality rate was estimated at 0.19 y^{-1}.



The calculated overall 2009 yield limit for lake whitefish in WFS-04 is 116,000 lbs. Applying the reduction to reflect the proportion of this management unit that is outside the Consent Decree, the 2009 yield limit becomes 81,000 lbs for 1836 Treaty waters, a 12% decrease from the limit calculated for the 2008 fishing season and the fourth consecutive drop since 2005. Part of the reduction from 2006 to 2007 was attributed to a recalibration of model inputs for the gill net fishery that resulted from a more precise determination by tribal biologists of yield and effort within the management unit boundaries. The further decline of the yield limit for 2009 makes sense when recent declines in CPUE for both gill nets and trap nets are considered. However, the potential for higher yield limits in the near future can be hoped for based on modestly favorable trends in weight-at-age, recruitment, and mortality.

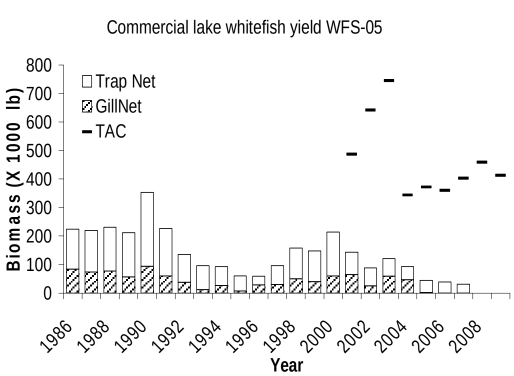
Summary Status WFS-04 Whitefish	**Value (Standard Error)**
Female maturity	
Size at first spawning	1.98 lb
Age at first spawning	4 y
Size at 50% maturity	2.08 lb
Age at 50% maturity	5 y
Spawning biomass per recruit	
Base SSBR	8.798 lb (SE 0.015)
Current SSBR	2.74 lb (SE 0.1)
SSBR at target mortality	0.308 lb (SE 0.000)
Spawning potential reduction	
At target mortality	0.312 (SE 0.011)
Average yield per recruit	1.578 lb (SE 0.009)
Natural mortality (M)	0.186 y^{-1}
Fishing mortality rate 2005-2007	
Fully selected age to gill nets	7
Fully selected age to trap nets	7
Gill net fishing mortality (F)	
Average 2005-2007, ages 4+	0.147 y^{-1} (SE 0.01)
Trap net fishing mortality (F)	
Average 2005-2007, ages 4+	0.113 y^{-1} (SE 0.007)
Sea lamprey mortality (ML)	
(average ages 4+, 2005-2007)	N/A
Total mortality (Z)	
(average ages 4+, 2005-2007)	0.446 y^{-1} (SE 0.015)
Recruitment (age 4)	
(average 1998-2007)	52,461 fish (SE 2,999)
Biomass (age 3+)	
(average 1998-2007)	539,730 lb (SE 21,554)
Spawning biomass	
(average 1998-2007)	420,350 lb (SE 17,284)
MSC recommended yield limit for 2009	81,000 lb
Actual yield limit for 2009	81,000 lb

WFS-05 (Munising)

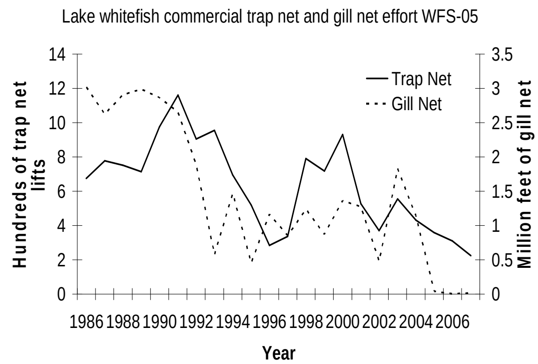
Prepared by Philip J. Schneeberger

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.

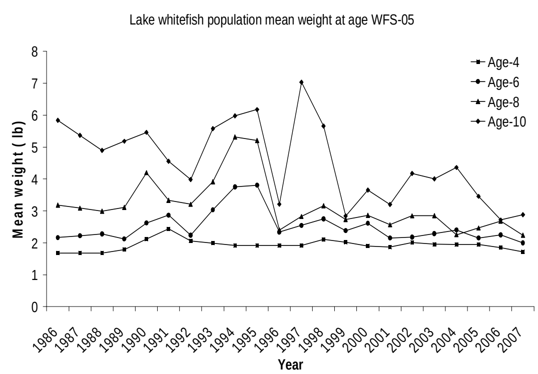
Total yield of lake whitefish in WFS-05 for 2007 was 32 thousand lbs, down 18% from 2006 and the fourth consecutive year of declining yield. Trap nets have accounted for virtually all (>95%) of the lake whitefish yield each year between 2005 and 2007. Yield from gill nets had averaged 32% of the annual total from 1986 through 2004. A peak yield of 354 thousand lbs (73% from trap nets and 27% from gill nets) occurred in 1990.



A decline in fishing effort has continued from 2003 through 2007 and is currently at the lowest point in the data series for both trap nets and gill nets. Fishing effort in 2007 was 225 lifts for trap nets and 19,000 feet for gill nets.

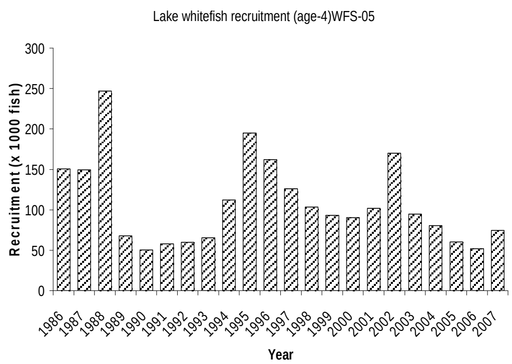


Mean weights at age declined in 2007 for fish of all ages compared to averages calculated for 2000-06. The magnitude of these declines ranged from 2% for age 4 to 55% for ages 12+ and averaged 14% for the 6-9 yr old fish that composed more than three-quarters of the yield.

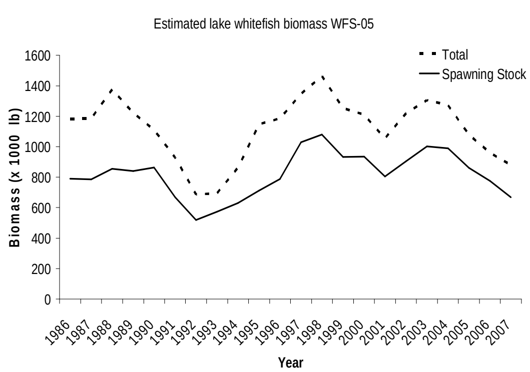


A von Bertalanffy growth model was used to portray individual fish growth as a function of time. Averages for length-at-age, calculated from lake whitefish data pooled for 1986-2007 from state fisheries, were used for model inputs. The model was forced through zero by inserting a data point representing a length of 75 mm at age 0. Model estimates for growth parameters $L \infty$, k, and t_0 were 780 mm, 0.140, and -1.33.

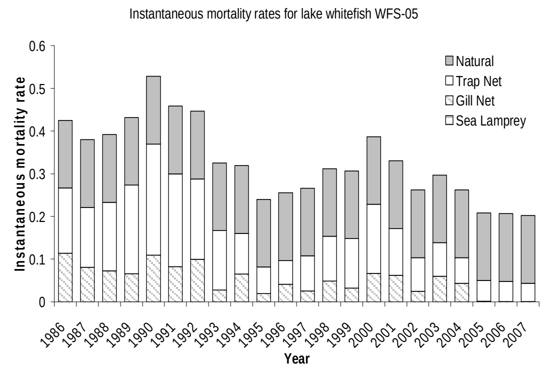
The 2007 estimate of recruitment, reported as annual numbers of age-4 lake whitefish in the population, was 74,000 fish. Based on the current model, this estimate is higher than estimates for the two previous years, though 20% lower than the average for 2000-06. Highest levels of recruitment have occurred within the data series at seven-year intervals with peaks in 1988, 1995, and 2002.



Biomass estimates in 2007 were 880,000 lb for the fishable stock (lake whitefish age-4 and older) and 668,000 lb for the spawning stock. The estimates of biomass using the current model have declined since 2003, and the 2007 values are 25% lower than averages for 2000-06. The 2007 ratio of spawning stock biomass to fishable biomass was 0.76, which was about average for the data series.



Estimates for total instantaneous mortality rate (Z) have remained consistently below 0.4 y^{-1} since 1993. The estimate for Z was 0.2 y^{-1} in 2007. Natural mortality rate (M), estimated at 0.16 y^{-1}, was 78% of the total for Z in WFS-05. Instantaneous fishing mortality (F) rate was 0.0003 y^{-1} for gill nets and 0.0431 y^{-1} for trap nets.



The calculated 2009 yield limit for WFS-05 was 412,000 lb, a 10% decrease from the yield limit for 2008. The decrease in the yield limit seems reasonable considering the estimated decline in fish biomass, tempered by the slight upturn in recruitment and consistently low mortality for lake whitefish in this management unit.

Summary Status WFS-05 Whitefish	Value (Standard Error)
Female maturity	
Size at first spawning	1.84 lb
Age at first spawning	4 y
Size at 50% maturity	2.01 lb
Age at 50% maturity	5 y
Spawning biomass per recruit	
Base SSBR	5.551 lb (SE 0.008)
Current SSBR	3.85 lb (SE 0.1)
SSBR at target mortality	0.205 lb (SE 0.000)
Spawning potential reduction	
At target mortality	0.694 (SE 0.019)
Average yield per recruit	0.528 lb (SE 0.032)
Natural mortality (M)	0.159 y^{-1}
Fishing mortality rate 2005-2007	
Fully selected age to gill nets	7
Fully selected age to trap nets	7
Gill net fishing mortality (F)	
Average 2005-2007, ages 4+	0.001 y^{-1} (SE 0.000)
Trap net fishing mortality (F)	
Average 2005-2007, ages 4+	0.047 y^{-1} (SE 0.004)
Sea lamprey mortality (ML)	
(average ages 4+, 2005-2007)	N/A
Total mortality (Z)	
(average ages 4+, 2005-2007)	0.207 y^{-1} (SE 0.004)
Recruitment (age 4)	
(average 1998-2007)	92,032 fish (SE 6,890)
Biomass (age 3+)	
(average 1998-2007)	1,170,000 lb (SE 76,919)
Spawning biomass	
(average 1998-2007)	895,170 lb (SE 62,324)
MSC recommended yield limit for 2009	412,000 lb
Actual yield limit for 2009	412,000 lb

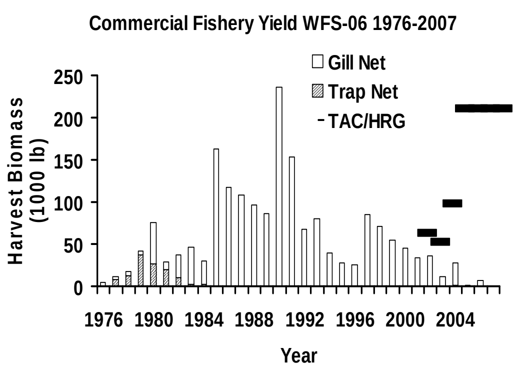
WFS-06 (Grand Marais)

Prepared by Mark P. Ebener

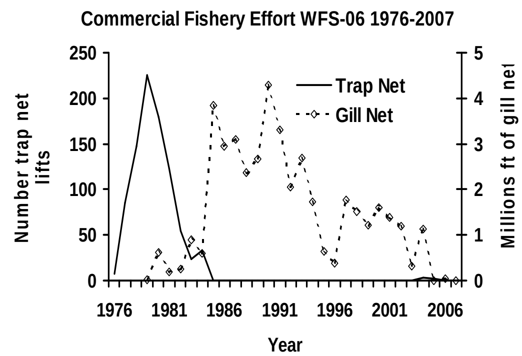
WFS-06 is located in the center of the 1836 treaty-ceded waters of Lake Superior. The unit contains no islands or bays, has 88,600 surface acres of waters less than 240 ft deep and is part of the open water of Lake Superior. There is little habitat for whitefish reproduction in the unit; therefore, it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

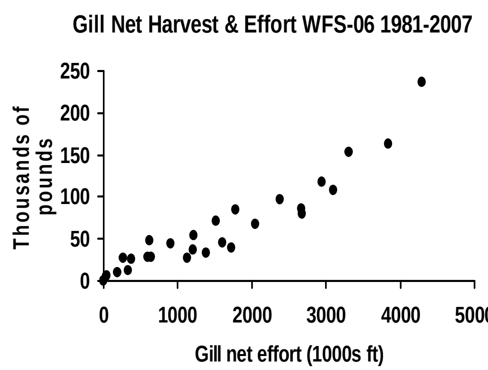
The commercial yield of lake whitefish from WFS-06 has averaged 57,400 lb during 1976-2007 but it has been on a long-term decline. The gill-net fishery has accounted for nearly 100% of the yield during 1976-2007. The peak yield was 236,000 lb in 1990 and there was no yield in 2007.



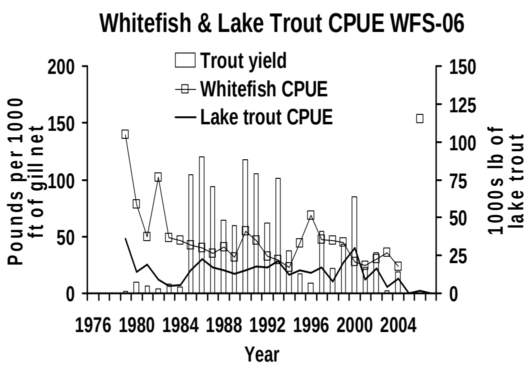
Gill-net effort peaked at 4.3 million ft in 1990 and declined thereafter to zero in both 2005 and 2007. Trap-net effort has always been low in WFS-06 and never exceeded 225 lifts during 1976-2007. There has been no trap net effort in WFS-06 since 2004 and 2005 when effort totaled 5 lifts.



There was a direct linear relationship between gill-net effort and yield of whitefish in WFS-06 during 1976-2007. Gill-net effort explained 88% of the variation in gill-net yield during 1976-2007. Catch per unit effort of whitefish averaged only 42 lb per 1000 ft of gill net during 1976-2007.



The large increase in gill-net effort and its subsequent decline was due to implementation of the 1985 Consent Decree and recovery of lake trout in Lake Superior. The 1985 Consent Decree closed a substantial amount of fishing areas to commercial gill-net fishing. Immediately after the 1985 Consent Decree five large-boat gill-net fisheries, displaced from lakes Michigan and Huron, moved into WFS-06 to target large-sized whitefish. Large incidental catches of lake trout took place during this time period as fishermen learned that WFS-06 was offered better catches of lake trout than whitefish. All but one of these fisheries subsequently moved out of WFS-06 by 1994. As whitefish catch rates declined and incidental catches of lean and siscowet lake trout increased, gill-net effort declined. WFS-06 has never been a productive unit for trap-net fishing, so conversion to trap net fishing was not an option for the gill-net fisheries.



About the only appealing aspect of fishing for whitefish in WFS-06 is their large size. Annual mean weight of whitefish in the commercial fishery from WFS-06 ranged from 3.0 to 5.6 lb and averaged 3.8 lb during 1985-2005. Mean weight averaged 3.2 lb in 2005, the last year commercial harvests were sampled in WFS-06. The proportion of medium (3.0-3.9 lb) and jumbo whitefish (>3.9 lb) in the harvest from WFS-06 was typically greater than nearly all other units in the 1836 ceded waters.

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. The harvest regulating guideline for 2009 was 210,000 lb and represents the same value as in 2004 through 2008.

WFS-07 (Tahquamenon Bay)

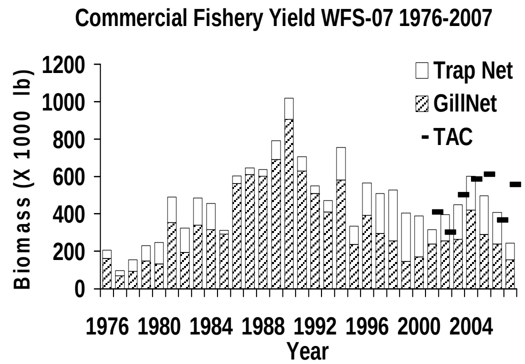
Prepared by Mark P. Ebener

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.

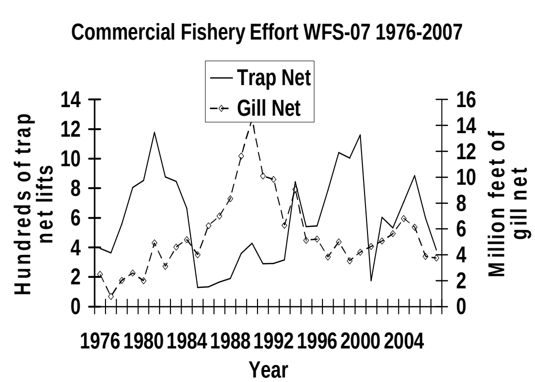
WFS-07 is an important fishing ground for the CORA fishery, and has been an exclusive CORA fishing zone since 1985. Large- and small-boat gill-net fisheries as well as several trap-net fisheries operate in WFS-07. An ice fishery also takes place nearly every winter. There are a large number of relatively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

The commercial yield of whitefish from WFS-07 averaged 493,000 lb during 1976-2007. A peak yield of one million pounds occurred in 1990 and the lowest reported yield was 98,000 lb in 1977. The 2007 yield was 245,000 lb and the TAC was 577,000 lb.

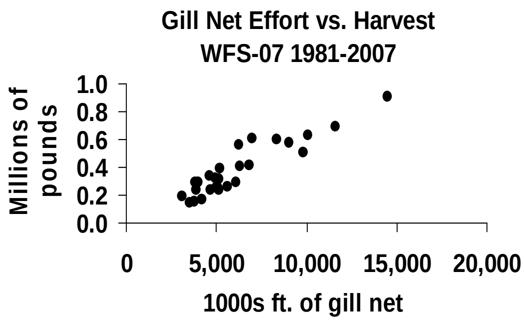


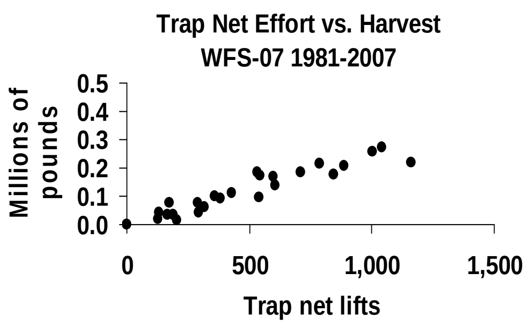
The large-mesh gill-net fishery accounted for 77% of the whitefish yield from WFS-07 during 1976-2007. The trap-net fishery harvested more whitefish from the unit than the gill-net fishery only during 1998-2000. The yield in 2007 was 154,000 lb from the gill-net fishery and 91,000 lb from the trap-net fishery.

Yield of whitefish from WFS-07 has mirrored changes in fishing effort during 1976-2007. After peaking at 17.8 million ft in 1990, large-mesh gill-net effort declined to between 3.5 and 6.8 million ft during 1997-2007. Gill-net effort was 3.8 million ft in 2007. Trap-net effort increased from 128 lifts in 1985 to 1,161 lifts in 2000 before declining to 175 lifts in 2001. Trap net effort was 382 lifts in 2007.



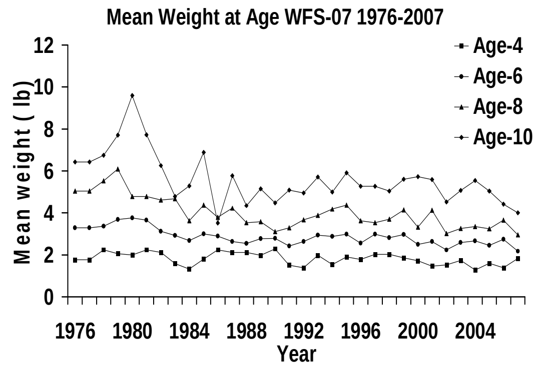
Harvest of whitefish was directly proportional to fishing effort by the CORA fishery. Gill-net and trap-net effort explained 84% and 91%, respectively, of the variation in harvest by each gear during 1981-2007. The average catch-per-unit-effort was 64 pounds per 1,000 ft. in the gill net fishery and 238 pounds per lift in the trap net fishery.





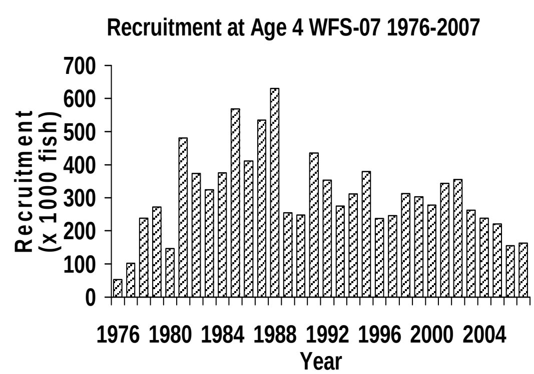
Whitefish caught in WFS-07 are of moderate to large size. Mean weight of a harvested whitefish averaged 3.3 lb in the gill-net fishery and 2.8 lb in the trap-net fishery during 1976-2007. Mean weight of a harvested whitefish in 2007 was 3.7 lb in the gill-net fishery and 2.4 lb in the trap-net fishery.

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.

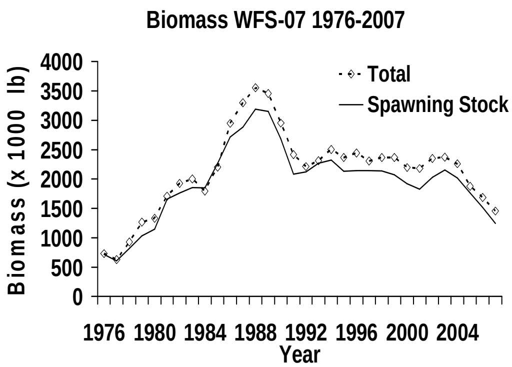


Sexual maturity of whitefish in WFS-07 occurs at a small size and young age, but complete maturity of females occurs at a large size and old age. Female whitefish begin reaching sexual maturity at age 3 and about 15 inches long, and by age 5 over 50% of females are sexually mature. After age 5, however, the rate of sexual maturity slows and complete maturity is not achieved until whitefish reach 26 inches long and age 12.

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 309,000 age-4 whitefish recruited to the fishable population each year during 1976-2007. Recruitment varied from 53,000 fish in 1976 to 663,000 fish in 1988. Recruitment was estimated to be 155,000 and 163,000 whitefish in 2006 and 2007, respectively.

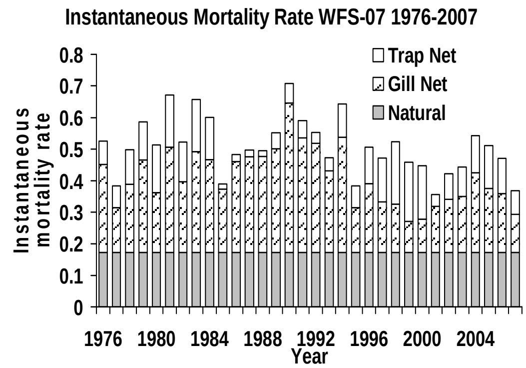


Average total biomass of age-4 and older whitefish peaked at 3.55 million lb in 1988 and has declined ever since. The total biomass was 1.46 million lb in 2007, compared to a spawning biomass of 1.24 million lb. The estimated biomass of whitefish in 2007 was equal to levels observed in the late 1970s.



Using Pauly's relationship between average water temperature occupied by a fish (4°C) and von Bertalanffy growth parameters L∞ (77.3 cm) and k (0.1601) natural mortality was estimated to be 0.17 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 showed little change during 1976-2007. The variations in total mortality were largely driven by changes in gill-net effort. Instantaneous total annual mortality averaged 0.51 y^{-1} during 1976-2007 and ranged from 0.36 y^{-1} in 2001 to 0.71 y^{-1} in 1990. Fishing mortality averaged 0.34 y^{-1} during 1976-2007. Gill-net mortality averaged 0.24 y^{-1} and trap-net mortality 0.10 y^{-1} during 1976-2007. Gill-net fishing mortality in 2007 was 0.12 y^{-1}, and trap-net mortality was 0.08 y^{-1}.



The projection model estimated that fishing mortality could be increased by 2.21 times in 2009 above levels estimated for 2005-2007. As a consequence, the recommended yield limit was estimated to be 636,000 lb in 2009. Previous recommended yield limits were 535,000 lb in 2008, 557,000 lb in 2007, 367,000 lb in 2006, 611,000 lb in 2005, 585,000 lb in 2004, 502,000 lb in 2003, 302,000 lb 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	1.61 lb
Age at first spawning	4 y
Size at 50% maturity	2.04 lb
Age at 50% maturity	5 y
Spawning biomass per recruit	
Base SSBR	7.163 lb (SE 0.001)
Current SSBR	1.53 lb (SE 0.09)
SSBR at target mortality	0.271 lb (SE 0.000)
Spawning potential reduction	
At target mortality	0.214 (SE 0.012)
Average yield per recruit	1.466 lb (SE 0.008)
Natural mortality (M)	0.172 y^{-1}
Fishing mortality rate 2005-2007	
Fully selected age to gill nets	6
Fully selected age to trap nets	6
Gill net fishing mortality (F)	
Average 2005-2007, ages 4+	0.017 y^{-1} (SE 0.012)
Trap net fishing mortality (F)	
Average 2005-2007, ages 4+	0.108 y^{-1} (SE 0.007)
Sea lamprey mortality (ML)	
(average ages 4+, 2005-2007)	N/A
Total mortality (Z)	
(average ages 4+, 2005-2007)	0.450 y^{-1} (SE 0.018)
Recruitment (age 4)	
(average 1998-2007)	263,140 fish (SE 8,441)
Biomass (age 3+)	
(average 1998-2007)	2,111,500 lb (SE 83,444)
Spawning biomass	
(average 1998-2007)	1,866,700 lb (SE 77,936)
MSC recommended yield limit for 2009	636,000 lb
Actual yield limit for 2009	535,000 lb

WFS-08 (Brimley)

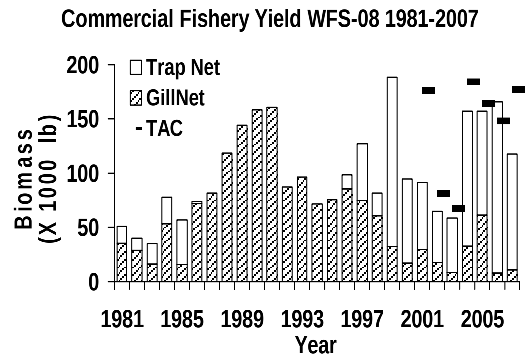
Prepared by Mark P. Ebener

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.

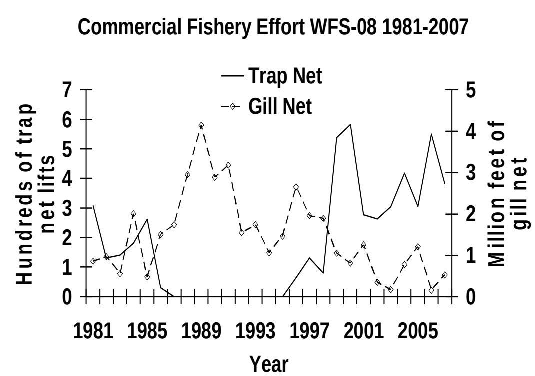
There are probably four reproductively isolated stocks of whitefish that contribute to the commercial fishery in WFS-08. Whitefish that spawn in WFS-07, two areas of WFS-08, and a fourth population that spawns in Canadian waters of management unit 34 all contribute to the fishery.

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.

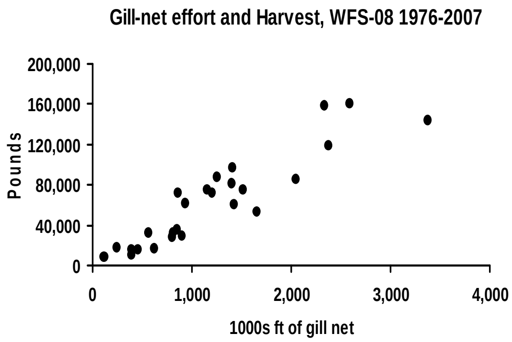
The commercial yield of whitefish from WFS-08 has averaged 101,100 lb during 1981-2007. Annual yields ranged from 35,000 lb in 1983 to 188,000 lb in 1999. The peak yield of 195,000 lb occurred in 1979, just prior to the creation of CORA. The large-mesh gill-net fishery accounted for 62% of the yield from WFS-08 during 1981-2007. There was no trap-net yield from WFS-08 during 1987-1995. The trap-net yield in 2007 was 107,000 lb, while the gill-net yield was 10,700 lb.

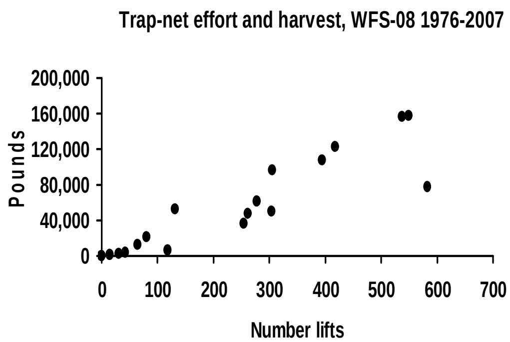


Gill-net effort has been declining in WFS-08 while trap-net effort has increased tremendously. Peak gill-net effort was 3.4 million ft in 1989, but it had declined to 0.12 million ft by 2006. Trap-net effort peaked at 738 lifts in 1979, declined to zero during 1987-1995, increased to 583 lifts in 2000, then declined somewhat before increasing again to 549 lifts in 2006. Fishing effort in 2007 was 0.40 million ft of gill net and 395 trap net lifts.



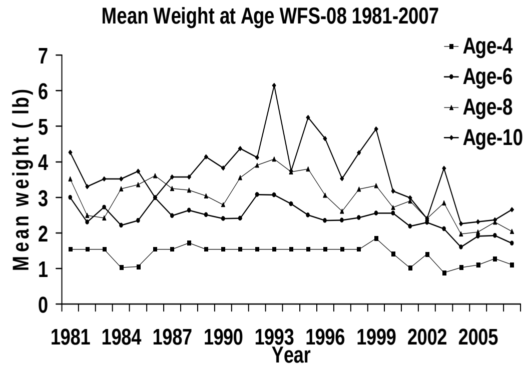
Both gill net and trap net harvest was linearly related to their respective fishing efforts. Fishing effort explained 85% of the variation in gill-net harvest and 87% of the variation in trap net harvest. Average gill net CPUE was 61 lb per 1000 ft. and average trap net CPUE was 240 lb per lift during 1981-2007.





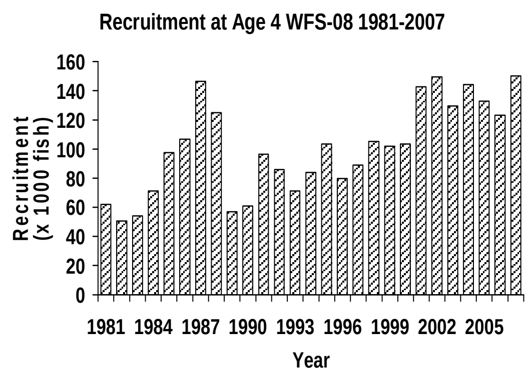
Whitefish in WFS-08 are of moderate to large size. Mean weight of a harvested whitefish in the gill-net fishery averaged 3.0 lb and mean weight in the trap-net fishery averaged 2.2 lb during 1981-2007. Mean weight of a harvested whitefish in 2007 was 1.9 lb in the trap-net fishery and 2.6 lb in the gill-net fishery.

Growth in of whitefish in WFS-08 remained fairly stable during 1981-1993, but has generally declined since then. Weight of age-10 and older whitefish increased from 1981-1993 then declined thereafter. Mean weight of age-6 whitefish has been declining continually since the early 1980s.

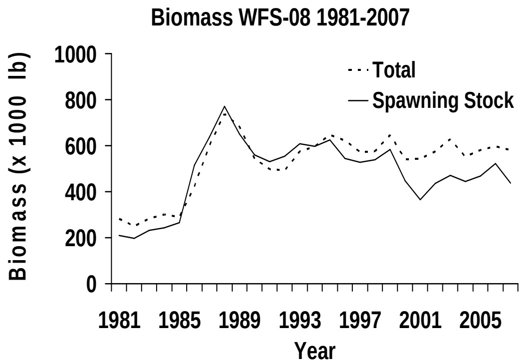


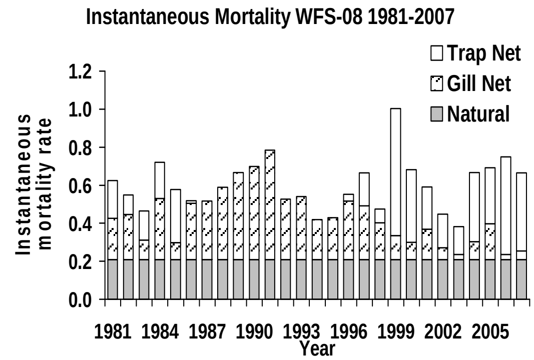
Female whitefish in WFS-08 begin maturing at 15 inches total length and at age 3. Two-thirds of whitefish in WFS-08 are sexually mature by age 4. Complete maturity is reached at 23 inches total length and age 11.

Recruitment of age-4 whitefish in WFS-08 has been less variable than in adjacent unit WFS-07, and has increased continually since 1989. The stock assessment model estimated that an average of 100,900 age-4 whitefish recruited to the population each year during 1981-2007. Recruitment peaked at 150,000 age-4 whitefish in 2007.



Spawning biomass has been declining somewhat since 1999 despite increasing recruitment over the last decade and stable total biomass of age-4 and older fish. Total biomass has averaged about 600,000 lb in WFS-08 during 1987-2007 while spawning biomass has declined from 771,000 lb in 1988 to 438,000 lb in 2007.





Using Pauly's relationship between average water temperature occupied by a fish (4^{o}C) and von Bertalanffy growth parameters L∞ (69.6 cm) and k (0.1747), natural mortality was estimated to be 0.21 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. In the 2007 stock assessment model only mean length data from fish collected during 2002-2006 was used in the von Bertalanffy growth model. 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. Annual instantaneous total annual mortality of age-4 and older whitefish averaged 0.60 y^{-1} during 1981-2007 and was 0.66 y^{-1} in 2007. Fishing mortality averaged 0.39 y^{-1} during 1981-2007 and was 0.46 y^{-1} in 2007. Trap-net mortality was 0.41 y^{-1} and gill-net mortality 0.05 y^{-1} in 2007.

Total annual mortality on age-4 and older whitefish was slightly less than the target rate of 1.05 y^{-1} during 2005- 2007. The SPR value at the target mortality rate was 0.37 and greater than the target SPR value of 0.20. Thus the projection model estimated that fishing mortality rate in 2009 could be increased 1.15 times from levels experienced during 2005-2007. The recommended yield limit at this rate of fishing was estimated to be 132,000 lb in 2009. Recommended yield limits in WFS-08 were 195,000 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	1.16 lb
Age at first spawning	4 y
Size at 50% maturity	1.53 lb
Age at 50% maturity	5 y
Spawning biomass per recruit	
Base SSBR	2.805 lb (SE 0.004)
Current SSBR	0.77 lb (SE 0.03)
SSBR at target mortality	0.162 lb (SE 0.000)
Spawning potential reduction	
At target mortality	0.275 (SE 0.010)
Average yield per recruit	0.905 lb (SE 0.008)
Natural mortality (M)	0.208 y^{-1}
Fishing mortality rate 2005-2007	
Fully selected age to gill nets	10
Fully selected age to trap nets	10
Gill net fishing mortality (F)	
Average 2005-2007, ages 4+	0.087 y^{-1} (SE 0.008)
Trap net fishing mortality (F)	
Average 2005-2007, ages 4+	0.406 y^{-1} (SE 0.026)
Sea lamprey mortality (ML)	
(average ages 4+, 2005-2007)	N/A
Total mortality (Z)	
(average ages 4+, 2005-2007)	0.701 y^{-1} (SE 0.031)
Recruitment (age 4)	
(average 1998-2007)	128,270 fish (SE 6,081)
Biomass (age 3+)	
(average 1998-2007)	581,930 lb (SE 20,253)
Spawning biomass	
(average 1998-2007)	471,250 lb (SE 16,263)
MSC recommended yield limit for 2009	132,000 lb
Actual yield limit for 2009	132,000 lb

Lake Huron WFH-01 (St. Ignace)

Prepared by Mark P. Ebener

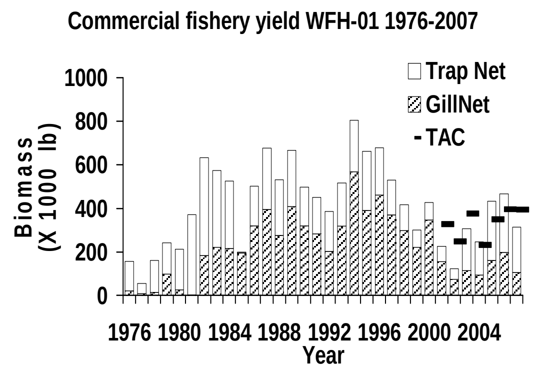
Management unit WFH-01 is located in the northwest portion of the main basin of Lake Huron. The unit is relatively shallow and contains 232,275 surface acres of water less than 240 ft deep.

There are multiple reproductively isolated stocks of lake whitefish that inhabit WFH-01. One stock is located near Cheboygan, MI, another stock spawns north of St. Ignace, MI, a third stock spawns in St. Martin Bay, and a fourth stock spawns near Cedarville, MI.

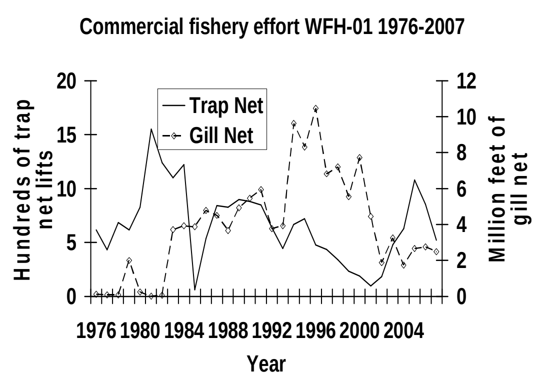
WFH-01 has been an exclusive fishing zone for the CORA fishery since 1985 and is a favored fishing area for small-boat gill-net fishers, especially during the early spring and fall. In most years some gill-net fishing occurs under the ice in St. Martin Bay.

Commercial fishery yield has ranged from a low of 46,000 lb in 1977 to a high of 806,000 lb in 1994 and averaged 407,000 lb during 1976-2007. The commercial yield was 313,000 lb in 2007 compared to 466,500 lb in 2006. The yield in 2007 was slightly less than the recommended harvest limit of 394,000 lb.

The large-mesh gill-net fishery has accounted for the majority of the commercial yield from WFH-01 during 1976-2007. From 1976-1984 large-mesh gill nets accounted for 0-41% of the annual yield, while after 1985 gill nets accounted for 34-81% of the annual yield. The gill-net fishery harvested 105,600 lb in 2007 compared to 207,400 lb for the trap-net fishery.

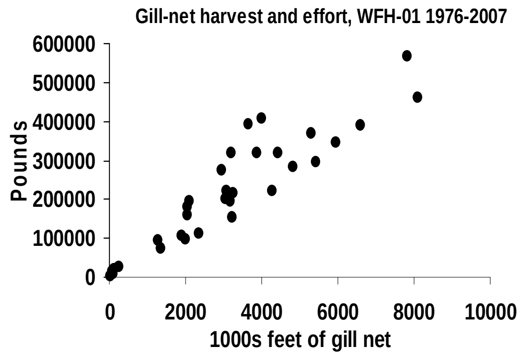


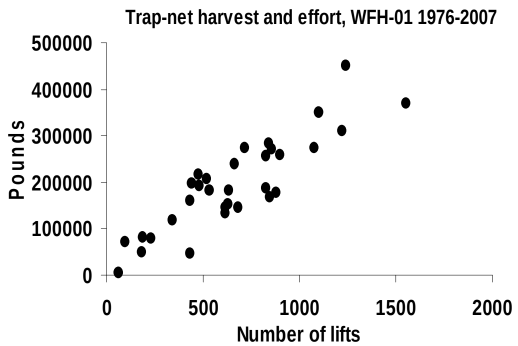
Gill-net effort continued to be much lower than the long-term average in WFH-01 in 2007, while trap-net effort approached the long-term average for the unit. Gill-net effort was stable at about 3.6 million ft from 1983 to 1993, increased to 8.1 million ft in 1996, and then declined to between 1.2 and 2.1 million ft during 2002-2007. Gill-net effort was 1.9 million feet in 2007. Trap-net effort peaked at 1,357 lifts in 1981 and declined to only 98 lifts in 2001 before increasing to 1,078 lifts in 2005. Trap net effort was 520 lifts in 2007.



Harvest of whitefish was directly proportional to fishing effort in WFH-01. Gill net and trap net effort explained

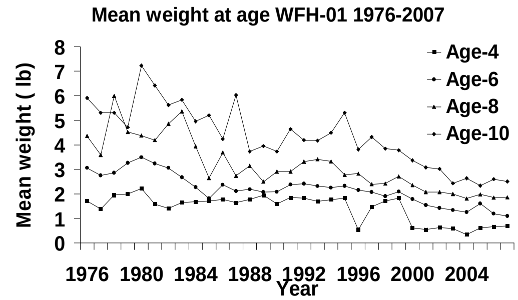
85% and 76%, respectively, of the variation in harvest by each gear during 1976-2007. The average catch-per-unit-effort was 62 pounds per 1,000 ft. in the gill net fishery and 251 pounds per lift in the trap net fishery.



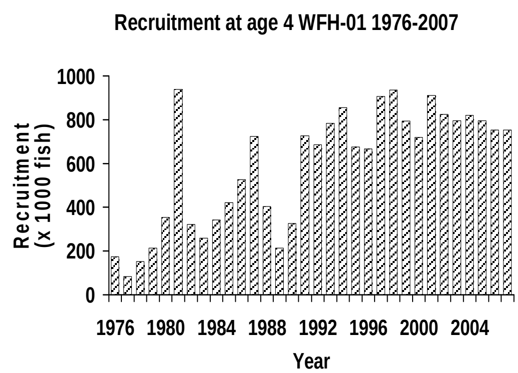


Whitefish in WFH-01 are of small size with over 90% of the harvest by weight being made up of No1 fish that weigh less than 3 lb. Mean weight of whitefish in the trap-net and gillnet fisheries ranged from 2.1 to 2.3 lb and 2.2 to 3.0 lb, respectively, during 1980-2007. Mean weight of a harvested whitefish was 2.8 lb in the gill-net fishery and 2.2 lb in the trap-net fishery in 2007.

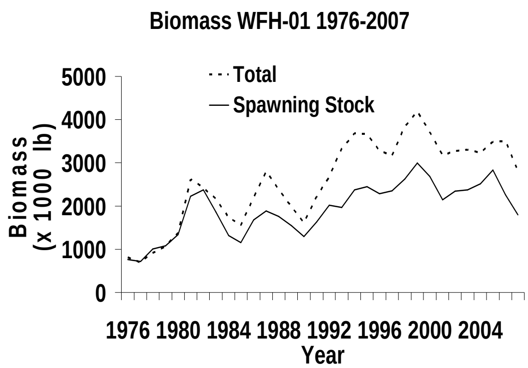
The declines in growth of lake whitefish, expressed as mean weight at age, that were ongoing for several decades appear to have stabilized since 2004. In 2007, mean weight of nearly all age classes of whitefish either increased or remained the same as previous years.



Large year-classes of whitefish were produced during 1987-2003 in WFH-01. These large year-classes produced the highest yield of 806,000 lb in 1994 and probably suppressed growth. An estimated average of 588,000 age-4 whitefish recruited the population each year during 1976-2007. Recruitment varied from a low of 82,000 fish in 1977 (1973 year class) to a high of 934,000 fish in 1998 (1994 year class). The 1987-2003 year classes averaged 788,000 fish. Recruitment was estimated to be 751,000 age-4 whitefish in 2007.

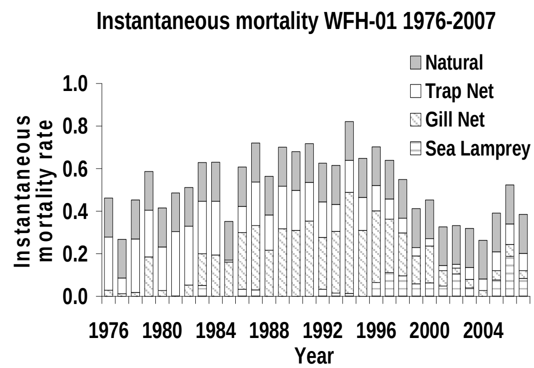


Fishable and spawning stock biomass have been stable over the last decade but declined somewhat from 2005 to 2007. Total biomass of age-4 and older whitefish averaged 2.6 million lb from 1976-2007 and was 2.8 million lb in 2007. Spawning stock biomass averaged 1.9 million lb during 1976-2007 and was 1.8 million lb in 2007.



Using Pauly's relationship between average water temperature occupied by a fish (5.3°C) and von Bertalanffy growth parameters L∞ (61.7 cm) and k (0.1602), natural mortality was estimated to be 0.21 y^{-1} in the WFH-01 stock assessment model. The von Bertalanffy growth model for WFH-01 was updated using mean length at age data collected during 2003-2007 from commercial trap and gill nets and survey gill nets.

Total instantaneous mortality of whitefish in WFH-01 has been substantially lower since the 2000 Consent Decree due primarily to a two-thirds reduction in fishing mortality. Average instantaneous total mortality was 0.53 y^{-1} during 1976-2007 and fishing mortality was 0.31 y^{-1}. Since 2000 total instantaneous mortality has averaged 0.36 y^{-1} and fishing mortality 0.10 y^{-1}. Gill net mortality was 0.04 y^{-1} and trap net mortality 0.08 y^{-1} in 2007.



The current spawning potential reduction value of 0.50 in WFH-01 during 2005-2007 was greater than the minimum value of 0.20 as defined by the modeling subcommittee. Thus, the projection model estimated that fishing mortality rate could be increased 1.74 times above the 2005-2007 values. The increase in fishing effort produced a recommended yield limit of 467,000 lb for 2009. Previous harvest limits were 235,000 for 2008, 394,000 lb for 2007, 395,000 lb in 2006, 348,000 lb in 2005, 232,000 lb in 2004, 375,000 in 2003, 248,000 lb in 2002, and 327,000 lb in 2001.

Convergence criteria were not met for the WFH-01 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 WFH-01 Whitefish	Value (Standard Error)
Female maturity	
Size at first spawning	0.66 lb
Age at first spawning	4 y
Size at 50% maturity	1.57 lb
Age at 50% maturity	7 y
Spawning biomass per recruit	
Base SSBR	2.08 lb (SE 0.004)
Current SSBR	0.58 lb (SE 0.01)
SSBR at target mortality	0.061 lb (SE 0.000)
Spawning potential reduction	
At target mortality	0.278 (SE 0.006)
Average yield per recruit	0.374 lb (SE 0.012)
Natural mortality (M)	0.209 y^{-1}
Fishing mortality rate 2005-2007	
Fully selected age to gill nets	9
Fully selected age to trap nets	9
Gill net fishing mortality (F)	
Average 2005-2007, ages 4+	0.052 y^{-1} (SE 0.004)
Trap net fishing mortality (F)	
Average 2005-2007, ages 4+	0.100 y^{-1} (SE 0.007)
Sea lamprey mortality (ML)	
(average ages 4+, 2005-2007)	0.134 y^{-1}
Total mortality (Z)	
(average ages 4+, 2005-2007)	0.495 y^{-1} (SE 0.01)
Recruitment (age 4)	
(average 1998-2007)	809,410 fish (SE 66,125)
Biomass (age 3+)	
(average 1998-2007)	3,448,900 lb (SE 167,720)
Spawning biomass	
(average 1998-2007)	2,455,000 lb (SE 111,590)
MSC recommended yield limit for 2009	467,000 lb
Actual yield limit for 2009	467,000 lb

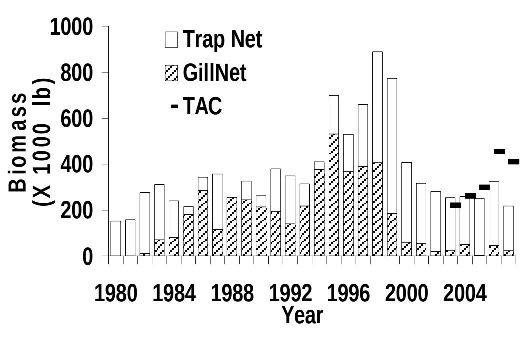
Prepared by Mark P. Ebener

Management unit WFH-02 is located along the northern shore of the main basin of Lake Huron. Much of WFH-02 is deeper than 150 ft and maximum depth is slightly more than 300 ft. WFH-02 is a small unit made up of only three statistical grids that contain 122,562 surface acres of water less than 240 ft deep. The unit has an irregular shoreline with many small rocky points, small bays, and islands.

Because the shoreline of WFH-02 is highly irregular and rocky, nearly the entire unit contains habitat suitable for whitefish reproduction. Spawning concentrations of whitefish can be found throughout the unit. A large aggregation of spawning whitefish can be found in the area from Albany Island to Saddle Bag Islands.

WFH-02 has been an exclusive CORA fishing zone since the 1985. The commercial yield of whitefish averaged 372,000 lb during 1980-2007 and ranged from a low of 152,000 lb in 1980 to a high of 888,000 lb in 1998. The fishery yield was 218,000 lb in 2007.

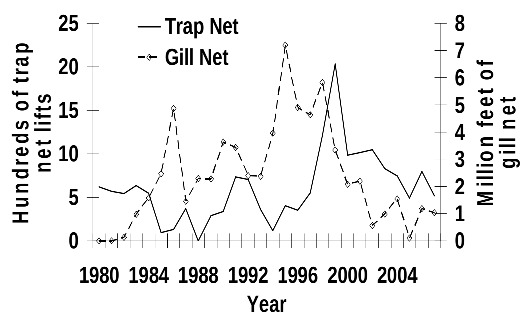
Commercial fishery yield WFH-02 1980-2007

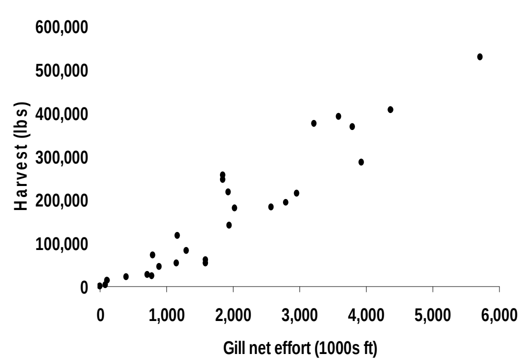


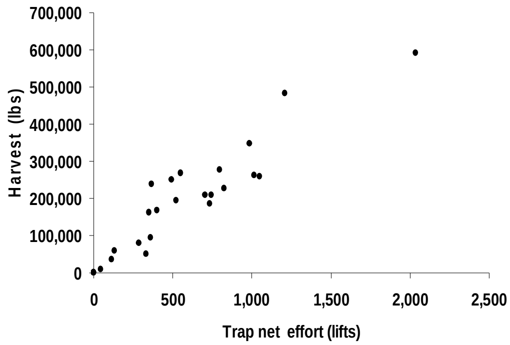
The allocation of the harvest among fishing gears has changed dramatically in WFH-02 since implementation of the 2000 Consent Decree. During 1985-1999 the large-mesh gill-net fishery accounted for the majority of harvest. After 2000 the trap-net fishery accounted for the largest proportion of the harvest and the total harvest declined from 888,000 lb to less than 300,000 lb. The trap-net fishery harvested 194,000 lb in 2007, while the gill-net fishery harvested 24,000 lb.

The changes in commercial yield were directly related to changes in fishing effort. Gill-net effort peaked at 7.5 million ft in 1995 and declined thereafter to very low levels. Gill-net effort was only 0.775 million ft in 2007. Trap-net effort peaked at 2,033 lifts in 1999 but has declined continually since then to 520 lifts in 2007.

Commercial fishery effort WFH-02 1980-2007

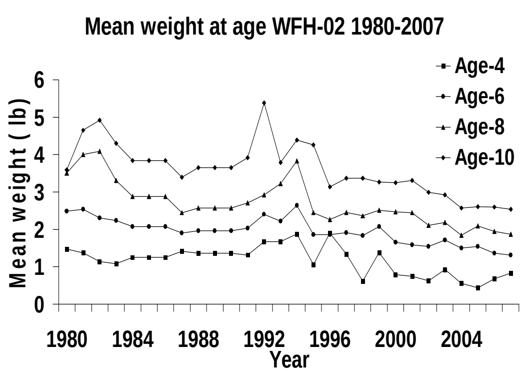




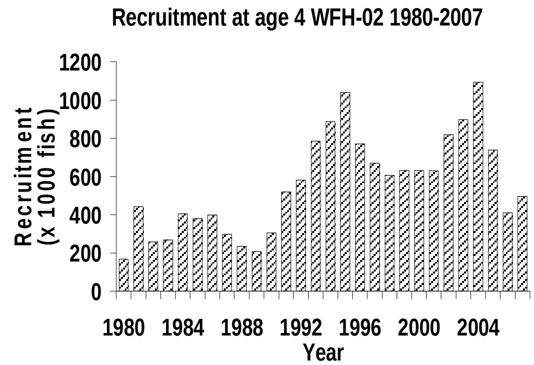


Whitefish in WFH-02 have always been of small size. No1 fish of less than 3 pounds made up 90% of the harvest from the unit during 1980-2007. Mean weight in the trap-net harvest has ranged from 2.0 to 2.3 lb and mean weight in the gill-net harvest ranged from 1.9 to 2.8 lb during 1980-2007. Mean weight of a harvested whitefish was 2.1 lb in the trap-net fishery and 2.4 lb in the gill-net fishery in 2007.

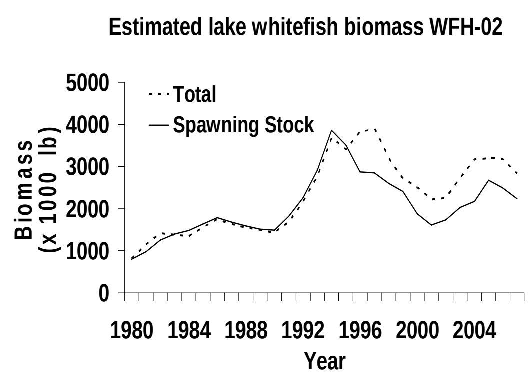
Unlike other units in Lake Huron, growth of whitefish in WFH-02 remained stable through 2000. There was a slight decline in mean weight at age from 1980 to 1984, but it was not as steep as in other Lake Huron management units. After 2000 mean weight at age declined across nearly all age classes and was lower in 2007 than nearly all other years.



Recruitment of age-4 whitefish increased substantially in WFH-02 beginning in 1991. Annual recruitment to the fishery prior to 1991 ranged from 167,000 to 441,000 fish. During 1991-2007 annual recruitment ranged from 519,000 to 1,091,000 fish and averaged 718,000 fish.

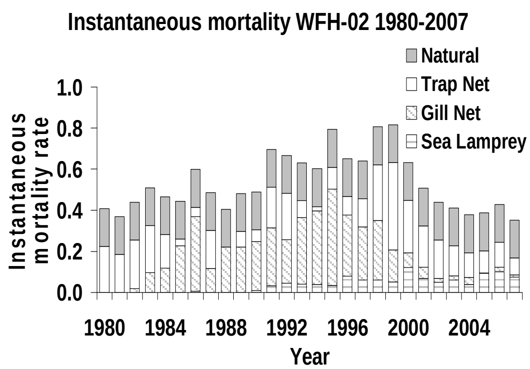


The large increase in recruitment during the mid 1990s nearly tripled biomass of whitefish in WFH-02. Total biomass of age-4 and older whitefish increased from 1.42 million lb in 1990 to 3.9 million lb in 1997. Total and spawning biomass were nearly equivalent in WFH-02 through 1994 because the fish matured at such a small size and because growth had not declined much. With the decline in growth that began after 2000 the difference between total and spawning biomass became much larger. Total biomass was estimated to be 2.87 million lb and spawning biomass 2.2 million lb in 2007.



Using Pauly's relationship between average water temperature occupied by a fish (5.3°C) and von Bertalanffy growth parameters L∞ (62.1 cm) and k (0.1625), natural mortality was estimated to be 0.21 y^{-1} in the WFH-02 stock assessment model. The von Bertalanffy growth model for WFH-01 were updated using mean length at age data collected during 2003-2007 from commercial trap and gill nets and survey gill nets.

Total instantaneous mortality rate of age-4 and older whitefish averaged 0.53 y^{-1} in WFH-02 during 1980-2007. Total mortality peaked at 0.81 y^{-1} during 1998 and 1999 then declined continually through 2007. Total mortality rate was 0.35 y^{-1} in 2007. Fishing mortality averaged 0.31 y^{-1} during 1980-2007 and was only 0.09 y^{-1} in 2007. Sea lamprey mortality peaked at 0.12 y^{-1} in 2000, averaged 0.06 y^{-1} during 1991-2007, and increased from 1991 to 2007.



Spawning potential reduction at the target mortality rate was estimated to be 0.55 and considerably greater than the target of 0.20. The projection model estimated that fishing mortality rate could be increased 2.25 times to achieve the target mortality rate. As a consequence, the projection model estimated a yield limit of 500,000 lb for 2009. Previous recommended harvest limits were 432,000 lb for 2008, 410,000 lb for 2007, 454,000 lb in 2006, 298,000 lb in 2005, 261,000 lb in 2004 and 221,000 lb in 2003.

Convergence criteria were not met for the WFH-02 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 WFH-02 Whitefish	**Value (Standard Error)**
Female maturity	
Size at first spawning	0.65 lb
Age at first spawning	4 y
Size at 50% maturity	1.17 lb
Age at 50% maturity	5 y
Spawning biomass per recruit	
Base SSBR	2.48 lb (SE 0.004)
Current SSBR	0.88 lb (SE 0.02)
SSBR at target mortality	0.081 lb (SE 0.000)
Spawning potential reduction	
At target mortality	0.356 (SE 0.007)
Average yield per recruit	0.392 lb (SE 0.013)
Natural mortality (M)	0.210 y^{-1}
Fishing mortality rate 2005-2007	
Fully selected age to gill nets	9
Fully selected age to trap nets	9
Gill net fishing mortality (F)	
Average 2005-2007, ages 4+	0.012 y^{-1} (SE 0.001)
Trap net fishing mortality (F)	
Average 2005-2007, ages 4+	0.120 y^{-1} (SE 0.008)
Sea lamprey mortality (ML)	
(average ages 4+, 2005-2007)	0.103 y^{-1}
Total mortality (Z)	
(average ages 4+, 2005-2007)	0.445 y^{-1} (SE 0.009)
Recruitment (age 4)	
(average 1998-2007)	694,890 fish (SE 53,810)
Biomass (age 3+)	
(average 1998-2007)	2,797,300 lb (SE 149,740)
Spawning biomass	
(average 1998-2007)	2,180,200 lb (SE 110,180)
MSC recommended yield limit for 2009	500,000 lb
Actual yield limit for 2009	500,000 lb

WFH-03 (Drummond Island)

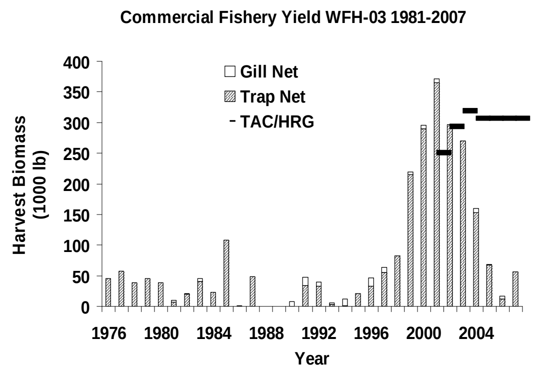
Prepared by Mark P. Ebener

Management unit WFH-03 is small and encompasses only the area around Drummond Island. A lake trout refuge is located along the south shore of the Island where large-mesh gill-net fishing and retention of lake trout by trap-net fisheries is prohibited. The south side of WFH-03 is deep with much of the water exceeding 150 ft deep, whereas the north and west sides of Drummond Island are relatively shallow. The unit contains six statistical grids containing less than 100,000 surface acres of water less than 240 ft deep.

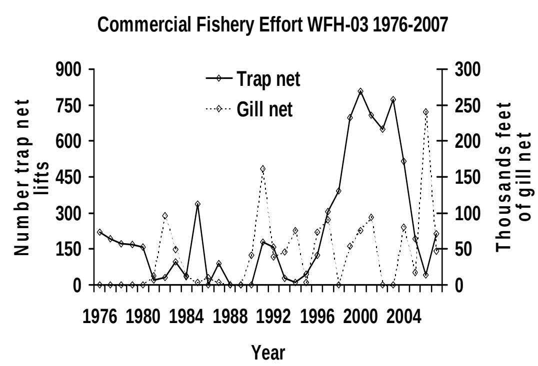
The spawning shoals for lake whitefish in WFH-03 are located primarily along the south shore of Drummond Island in the main basin of Lake Huron. Adult whitefish in spawning condition have been caught primarily on reef located in the center of the island during gill-net surveys in October and early November of 1991-2007.

WFH-03 has been an exclusive CORA fishing zone since 1985. The unit is primarily a trap-net fishery because retention of lake trout is prohibited in the refuge, but a winter gill-net fishery takes place under the ice in the North Channel from January through March of some years. The trap-net fishery takes place year-round along the south shore of Drummond Island since ice seldom forms here.

The commercial yield of lake whitefish from WFH-03 increased tremendously during the late 1990s, peaked in 2001, and since then has declined annually. Prior to 1998 the commercial yield of lake whitefish exceeded 100,000 lb only in 1985. After 1998 the commercial yield increased from 229,000 lb in 1999 to 371,000 lb in 2001, but then declined to only 17,000 lb in 2006. Ninety-eight percent of the yield was taken with trap-nets during 1999-2007. The commercial harvest was only 56,600 lb in 2007.

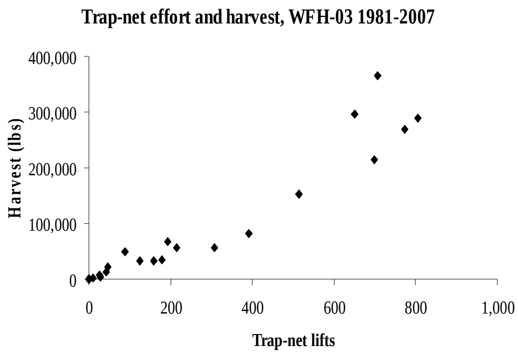


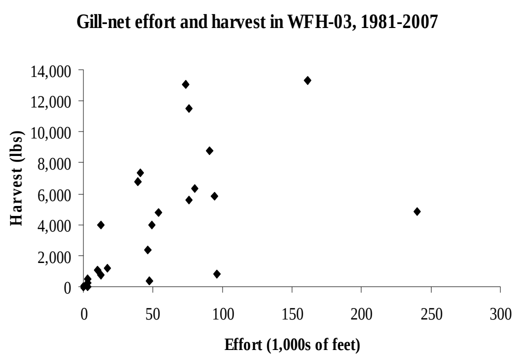
The large-increase in harvest during 1999-2003 was directly related to increased trap-net effort. Trap-net effort ranged from 0 to 337 lifts during 1976-1997, thereafter trap-net effort increased to between 307 and 806 lifts. Gill-net effort was highly variable and low in WFH-03 ranging from 0 to 240,000 ft. during 1976-2007. Gill-net effort was only 47,000 ft in 2007, while trap-net effort was 214 lifts.



There is a direct linear relationship between trap-net effort and subsequent yield but not gill net effort in the commercial fishery of WFH-03 during 1976-2007. Fishing effort explained

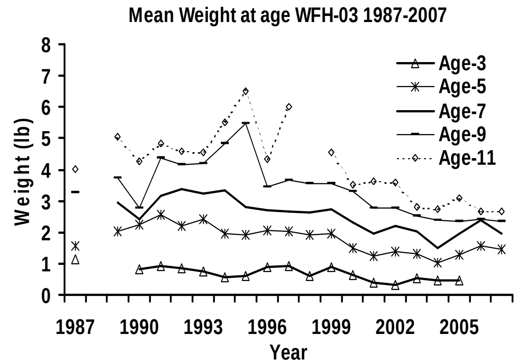
91% of the variation in trap-net yield of whitefish from WFH-03 during 1976-2007, while gill-net effort explained only 41% of the variation in gill net yield.





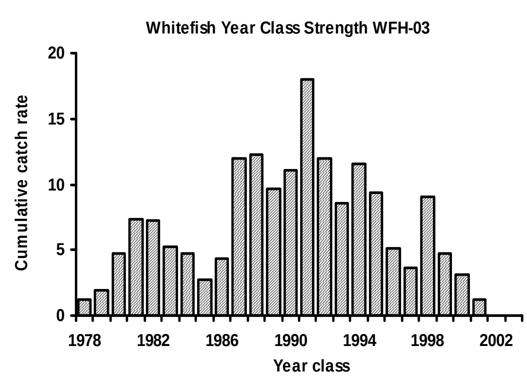
Whitefish caught in the fishery of WFH-03 are of moderate size. During 1987-2007 70% of the whitefish harvested were No1 fish, 23% were mediums and 7% were jumbos. Mean weight of whitefish in the trap-net harvest ranged from 2.0 to 2.8 lb during 1991-2007. Mean weight in the gill-net fishery ranged from 2.3 to 3.0 lb during 1976-2007. Mean weight of a harvested whitefish was 2.4 lb in the trap-net fishery in 2007.

The declines in growth exhibited in Lake Huron also occurred in WFH-03, but the greatest declines occurred on older whitefish. The weight of age-5 whitefish declined from between 0.6 and 1.1 lb during 1987-1999 to between 0.3 and 0.6 lb during 2000-2007. In comparison, mean weight of age-11 whitefish declined from between 4.0 and 6.5 lb during 1987-1999 to between 2.7 and 3.5 lb during 2000-2007.

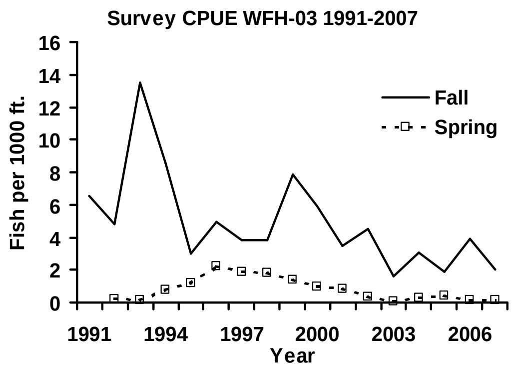


Average mean total length of ages 2-19 whitefish captured in all gear types during 1989-2007 was used to estimate von Bertalanffy growth parameters. L-infinity and k were estimated to be 599 mm total length and 0.2394. These parameters were combined with an average water temperature occupied by whitefish in Lake Huron of 5.3°C to estimate a natural mortality rate of 0.27 y^{-1} using Pauly's equation.

Recruitment of whitefish in WFH-03 has declined in recent years and is probably contributing to the reduced catches and fishing effort. Relative abundance of the 1987-1995 year classes was substantially greater than for the 1996-2000 year classes. The last relatively abundant year class was produced in 1998 based on gill-net survey catches in WFH-03 during May and October of 1991-2007.



Relative abundance of lake whitefish has been declining in WFH-03 since at least 1996 based on survey catches. Graded-mesh gill net surveys have been conducted in WFH-03 every October since 1991 and every May/early June since 1992. Abundance in the October survey has been declining since the early 1990s, whereas abundance in the spring survey peaked in 1996 and declined thereafter. Abundance has stabilized at low levels in both surveys since about 2003.



No attempt was made to develop a stock assessment of whitefish this unit because past attempts to do so were unsuccessful. Reasonable and consistent estimates of abundance and mortality could not be produced with the stock assessment model because they would change, by an order of magnitude in some cases, after only small changes were made to starting values of the input parameters.

A harvest regulating guideline of 150,000 lb was established for WFH-03 in 2009.

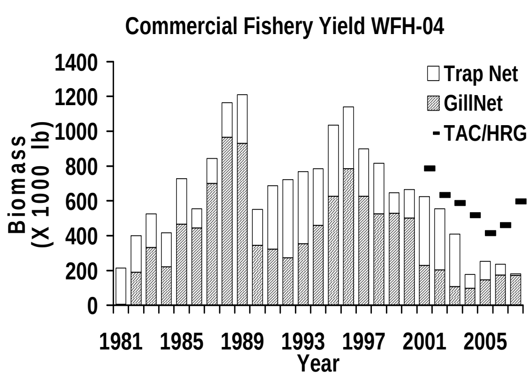
WFH-04 (Hammond Bay)

Prepared by Mark P. Ebener and Aaron P. Woldt

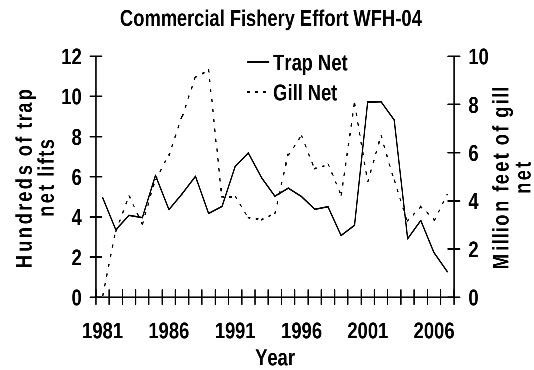
WFH-04 is the largest whitefish management unit in the 1836 treaty-ceded waters of Lake Huron. The unit contains 377,567 surface acres of water less than 240 ft deep. Spawning concentrations of whitefish are scattered throughout the unit with concentrations being found from Cheboygan, MI to Hammond Bay.

In August 2000 WFH-04 became an exclusive CORA commercial fishing zone. Prior to 2000 the area south of 40 Mile Point was an exclusive commercial fishing zone for state-licensed trap-net fisheries, while the area north of 40 Mile Point was an exclusive CORA commercial fishing zone since 1985.

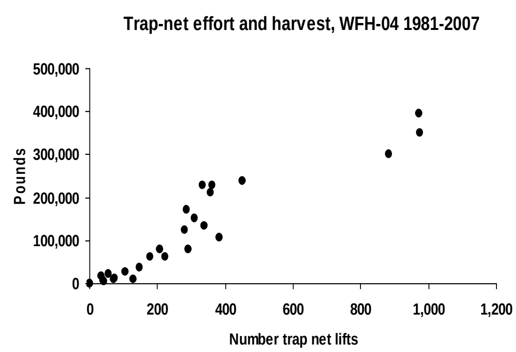
The CORA large-mesh gill-net fishery accounted for 78% of the whitefish harvest from WFH-04 during 1981-2007. The annual yield from WFH-04 ranged from a high of 1.2 million lb in 1989 to a low of 186,200 lb in 2004. The annual yield of whitefish from the unit averaged 511,000 lb during 1981-2007. The trap-net fishery harvested only 9,350 lb of whitefish in 2007 compared to 172,000 lb for the gill-net fishery.

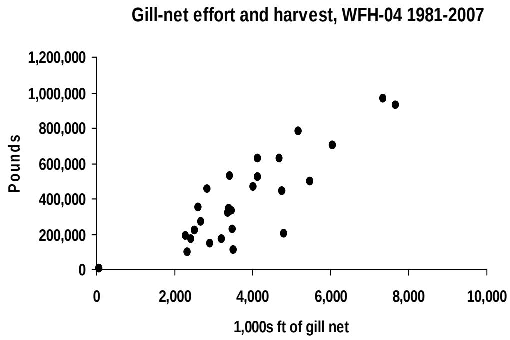


Trap-net effort reached it lowest level in WFH-04 in 2007 since the late 1980s, while gill-net effort increased 33% from 2006 to 2007. Trap-net effort peaked at 719 lifts in 1992, declined to 308 lifts in 1999, increased to 974 lifts in 2002, but then declined to only 128 lifts in 2007. Large-mesh gill-net effort peaked at 7.7 million ft in 1989 and 5.2 million ft in 2000, and was 3.211 million ft in 2007.



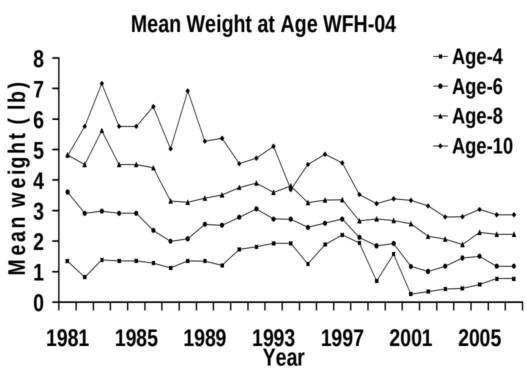
There was a direct linear relationship between fishing effort and catch in WFH-04 during 1981-2007. Trap-net effort explained 88% of the variation in trap-net harvest and average catch per unit effort was 398 lb per trap net lift. Gill net effort accounted for 72% of the variation in gill net harvest and average catch rate was 134 lb per 1000 ft.





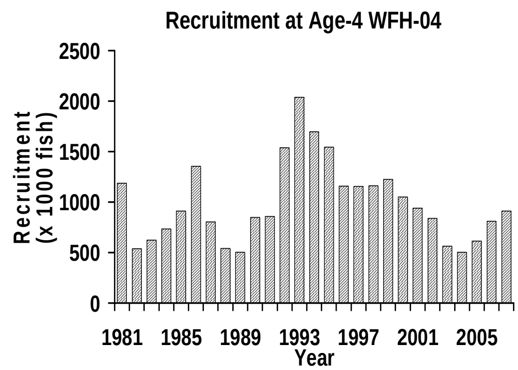
Whitefish from WFH-04 are of moderate size. The commercial harvest from WFH-04 was composed of 64% No1 whitefish, 27% mediums, and 9% jumbos during 1982-2007. Annual mean weight of whitefish caught in the gill-net fishery ranged from 2.5 to 3.0 lb during 1982-2007, while mean weight in the trap-net fishery ranged from 2.4 to 3.6 lb during 1982-2007. Mean weight in the trap-net fishery was 2.9 lb in 2006 and mean weight in the gill-net fishery was 2.7 lb in 2007.

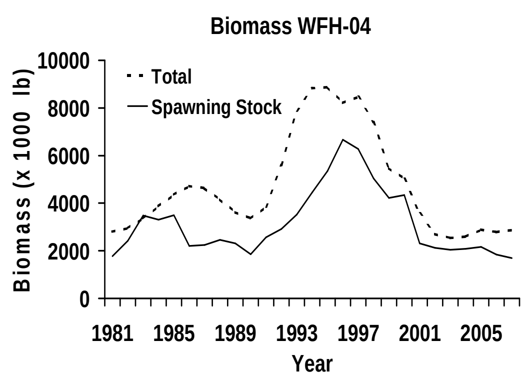
Growth of whitefish in WFH-04 continued to stabilize and increase slightly among most age classes from 2006 to 2007. Mean weight at age of ages 4-6 has been increasing since 2001, while weight at age of older fish has stabilized since about 2003.



The declines in harvests from WFH-04 that occurred after 1996 were largely being driven by declines in both mean weights at age and recruitment. The 1988-1991 year classes of whitefish were very abundant ranging from 1.5 to 2.0 million fish at age 4. The 1999 and 2000 year classes were the least abundant at 562,000 and 502,000 fish, respectively, during 1981-2007. The 2003 year class was estimated to contain 909,000 fish at age 4 in 2007.

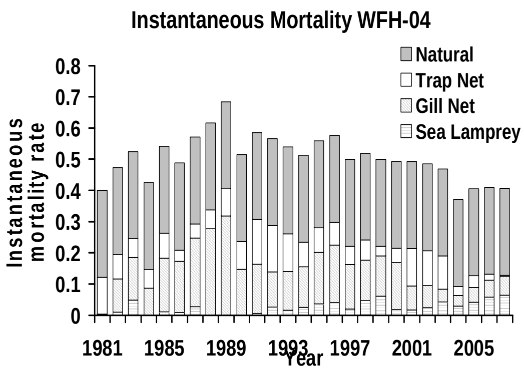
The combined effects of reduced recruitment and growth drove biomass of whitefish in WFH-04 to low levels during 2001-2007. After peaking at 8.9 million lb in 1995, total biomass declined nearly annually to 2.6 million lb in 2004. Biomass was 2.9 million lb in 2007. Spawning stock biomass declined from 6.7 million lb in 1996 to 1.7 million lb in 2007.





Using Pauly's relationship between average water temperature occupied by a fish (5.3°C) and von Bertalanffy growth parameters $L\infty$ (58.2 cm) and k (0.2426), natural mortality was estimated to be 0.279 y^{-1} in the WFH-04 stock assessment model. The von Bertalanffy growth model for WFH-04 was updated using mean length at age data collected during 1989-2007 from commercial trap nets and gill nets, and survey gill nets.

Total annual mortality of age-4 and older whitefish averaged 0.407 y^{-1} during 2005-2007. Gill-net mortality averaged 0.054 y^{-1}, trap-net mortality 0.020 y^{-1}, and sea lamprey mortality 0.055 y^{-1} during 2005-2007. In 2007 gill-net mortality was 0.059 y^{-1}, trap-net mortality 0.004 y^{-1}, and sea lamprey mortality 0.064 y^{-1} on age-4 and older whitefish.



Since total annual mortality on all age classes of whitefish was less than the target of 1.05 y^{-1}, the projection model estimated that fishing mortality could be increased 1.70 times in 2009 over that experienced during 2005-2007. The SPR value at the target-fishing rate was 0.61. The model estimated total allowable catch for WFH-04 in 2009 was 289,000 lb but the model quality was rated as low because of poor Markov Chain Monte Carlo simulation results. Consequently, the recommended harvest level for WFH-04 in 2009 was 546,000 lb compared to 546,000 lb in 2008, 597,000 lb in 2007, 460,000 lb in 2006, 415,000 lb in 2005, 518,000 lb in 2004, 588,000 lb in 2003, 634,000 lb in 2002, and 787,000 lb in 2001.

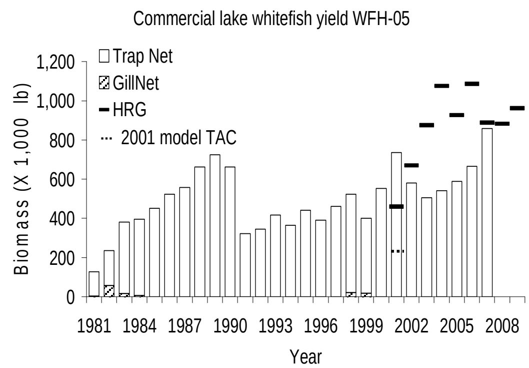
Summary Status WFH-04 Whitefish	Value (Standard Error)
Female maturity	
Size at first spawning	0.71 lb
Age at first spawning	4 y
Size at 50% maturity	2.03 lb
Age at 50% maturity	7 y
Spawning biomass per recruit	
Base SSBR	1.312 lb (SE 0.00)
Current SSBR	0.63 lb (SE 0.02)
SSBR at target mortality	0.083 lb (SE 0.000)
Spawning potential reduction	
At target mortality	0.482 (SE 0.012)
Average yield per recruit	0.280 lb (SE 0.017)
Natural mortality (M)	0.279 y^{-1}
Fishing mortality rate 2005-2007	
Fully selected age to gill nets	9
Fully selected age to trap nets	9
Gill net fishing mortality (F)	
Average 2005-2007, ages 4+	0.061 y^{-1} (SE 0.007)
Trap net fishing mortality (F)	
Average 2005-2007, ages 4+	0.023 y^{-1} (SE 0.002)
Sea lamprey mortality (ML)	
(average ages 4+, 2005-2007)	0.062 y^{-1}
Total mortality (Z)	
(average ages 4+, 2005-2007)	0.426 y^{-1} (SE 0.009)
Recruitment (age 4)	
(average 1998-2007)	861,440 fish (SE 72,977)
Biomass (age 3+)	
(average 1998-2007)	3,780,500 lb (SE 210,580)
Spawning biomass	
(average 1998-2007)	2,784,600 lb (SE 153,690)
MSC recommended yield limit for 2009	289,000 lb
Actual yield limit for 2009	546,000 lb

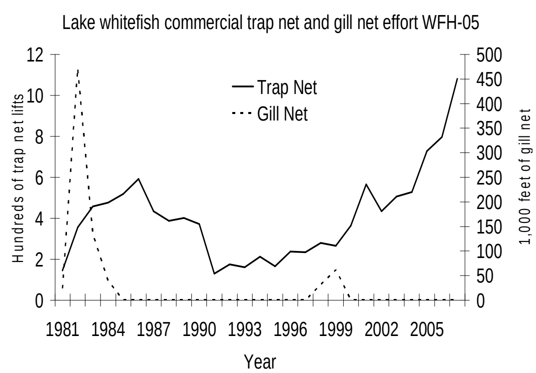
Prepared by Aaron P. Woldt and Mark P. Ebener

WFH-05 runs from Presque Isle south to the southern end of grids 809-815 in US waters and includes some waters of Lake Huron that lie outside the 1836 Treaty-ceded waters. There are an estimated 209,000 surface acres of water < 240 ft deep in WFH-05. WFH-05 contains a large spawning stock of whitefish that spawns throughout the unit.

The 2000 Consent Decree converted WFH-05 from an exclusive State zone to an exclusive CORA trap-net fishing zone beginning in August 2000. There are 2 areas open to tribal trap-net fishing in WFH-05: 1) the Southern Lake Huron Trap Net (SLHTN) Zone, and 2) Michigan waters south of the SLHTN Zone and north of a line from the tip of North Point on Thunder Bay in a straight line northeast to the international border. Only four CORA trap-net operations from two tribes can fish the SLHTN Zone, and each operation can fish no more than 12 trap nets. The CORA fishery in this zone has a 17-inch minimum length limit, and there is no limit on the depth of water in which trap nets can be fished. In the area south of the SLHTN Zone and north of North Point, the 4 tribal fishers fishing the SLHTN Zone can apply for State permits to fish up to 16 total trap nets (4 each). In this zone, there has been a 19-inch minimum length limit set by the State, and trap nets can only be fished in waters < 90 ft deep.

Annual commercial trap-net yield has ranged from 124,000 lb in 1981 to a high of 858,000 lb in 2007 and averaged 492,000 lb during 1981-2007. In general, trap-net harvest and effort have been directly related over the modeled time series and have been especially linked since 1991. As trap-net effort increased from 130 lifts in 1991 to 566 lifts in 2001, the yield increased from 322,000 lb in 1991 to 736,000 lb in 2001. Trap-net effort and yield both declined in 2002. Since 2003, trap-net effort and yield have increased annually. Trap-net effort increased from 507 lifts in 2003 to 1,081 lifts in 2007, and trap-net yield increased from 506,000 lb in 2003 to 858,000 lb in 2007.

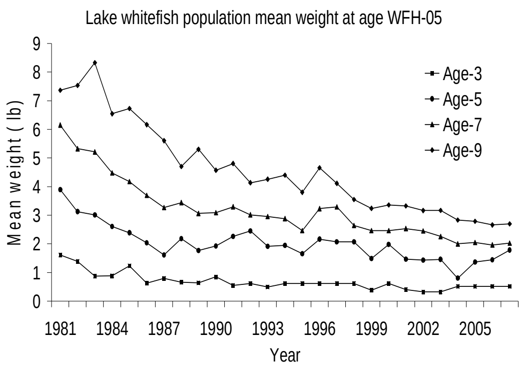




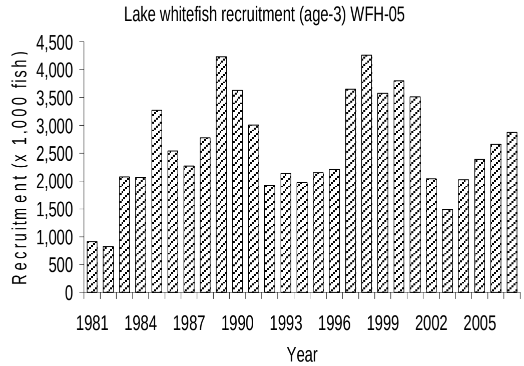
Whitefish in WFH-05 are of similar size to those in WFH-04. Mean weight of a harvested whitefish has been steadily decreasing since 1998 (3.5 lb), but seems to have leveled off from 2004 to 2007. Mean weight of a harvested whitefish was 2.6 lb in WFH-05 in 2007. The weight of harvested lake whitefish averaged 3.2 lb over the modeled time series (1981-2007).

Weight-at-age of whitefish in WFH-05 has stabilized over the last few years after continually declining from 1981 to

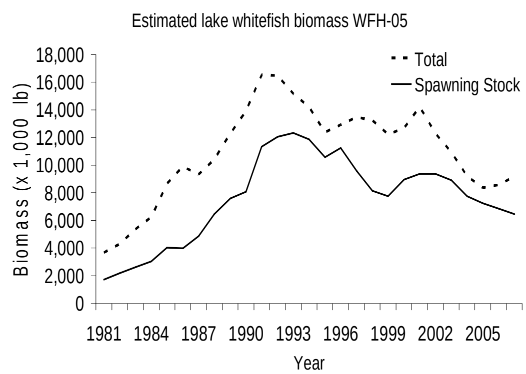
1999. Prior to 1984, age-9 and older whitefish weighed between 7 and 8 lb, but by 2007 they weighed about 2.7 lb. This large decrease in average weight for older fish is likely due to decreased growth rates and concurrent changes in the whitefish forage base. Mean weight of all age classes in 2007 was similar to mean weight-at-age from 1999 to 2006. Mean weight-at-age of age-5 fish increased slightly in 2007, for the third year in a row, to a level nearly equal to mean weight-at-age in 2000.



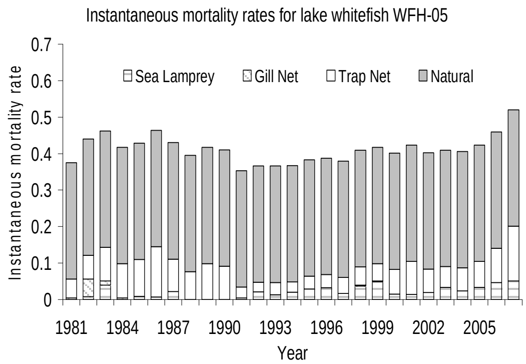
Recruitment of age-3 whitefish to the fishable population in WFH-05 has been cyclical since 1981. Recruitment peaked at 4.2 million age-3 whitefish in 1989, and then declined annually to about 2.2 million age-3 whitefish in 1996 (1993 year class). Recruitment then peaked again in 1998 at 4.3 million age-3 whitefish, before declining annually to about 1.5 million age-3 whitefish in 2003. From 2004 through 2007, estimated recruitment increased and averaged about 2.49 million age-3 whitefish. The stock assessment model estimated that 2.87 million age-3 whitefish were present in the population during 2007.



Both fishable and spawning stock biomass has been declining in WFH-05 since the early 1990s, primarily because of low recruitment in the early and mid-1990s and declining weight-at-age. Fishable stock size peaked at 16.5 million lb in 1991 and has since declined to 9.2 million lb in 2007. Spawning stock biomass peaked at 12.3 million lb in 1993 and then declined to 6.5 million lb in 2007. Total biomass did increase slightly in 2007 relative to 2006, but spawning stock biomass decreased.



Natural mortality has consistently been the most significant source of mortality affecting age-4 and older whitefish in WFH-05. Natural mortality was greater than fishing and sea lamprey mortality combined in all years in WFH-05 and was estimated to be 0.319 y^{-1}. In general, trap-net fishing mortality has been increasing in WFH-05 over the last decade and was estimated to be 0.150 y^{-1} in 2007. Sea lamprey-induced mortality had been cyclical but low in WFH-05 over the last decade, peaking in 1999 at 0.048 y^{-1} and peaking again in 2007. Since 2002, sea lamprey-induced mortality estimates have been increasing, reaching an all time high for the modeled time series of 0.051 y^{-1} in 2007.



Total annual mortality was estimated to be 0.459 y^{-1} on age-4 and older whitefish in WFH-05 during 2005-2007. Total mortality was estimated to be 0.520 y^{-1} in 2007. Because total mortality was less than the target rate of 1.05 y^{-1}, the projection model estimated that trap-net fishing effort could be increased 2.61 times over the 2005-2007 levels. The recommended yield limit at this increased rate of fishing was estimated to be 962,000 lb in WFH-05 for 2009. The recommended yield limit in 2008 was 883,000 lb. In general, the harvest limit in this unit has been steadily increasing under the 2000 Consent Decree. However, the yield limit seems to have stabilized since 2004, oscillating around an average of 971,000 lb from 2004 to 2009. Total tribal trap-net harvest was below the HRG in 2007.

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	1.53 lb
Age at 50% maturity	5 y
Spawning biomass per recruit	
Base SSBR	1.110 lb (1.110 – 1.111)
Current SSBR	0.650 lb (0.615 – 0.698)
SSBR at target mortality	0.229 lb (0.229 – 0.229)
Spawning potential reduction	
At target mortality	0.585 (0.585 – 0.585)
Average yield per recruit	0.238 lb (0.185 – 0.275)
Natural mortality (M)	0.319 y^{-1}
Fishing mortality rate 2005-2007	
Fully selected age to gill nets	8
Fully selected age to trap nets	8
Average gill-net F, ages 4+	N/A
Average trap-net F, ages 4+	0.090 y^{-1} (0.061 – 0.117)
Sea lamprey mortality (ML)	
(average ages 4+, 2005-2007)	0.058 y^{-1}
Total mortality (Z)	
(average ages 4+, 2005-2007)	0.459 y^{-1} (0.430 – 0.485)
Recruitment (age 3)	
(average 1998-2007)	2,862,100 fish (2,363,550 – 3,999,940)
Biomass (age 3+)	
(average 1998-2007)	11,094,000 lb (9,161,910 – 15,294,900)
Spawning biomass	
(average 1998-2007)	8,078,500 lb (6,622,150 – 11,208,300)
MSC recommended yield limit for 2009	962,000 lb
Actual yield limit for 2009 (HRG)	962,000 lb

Lake Michigan

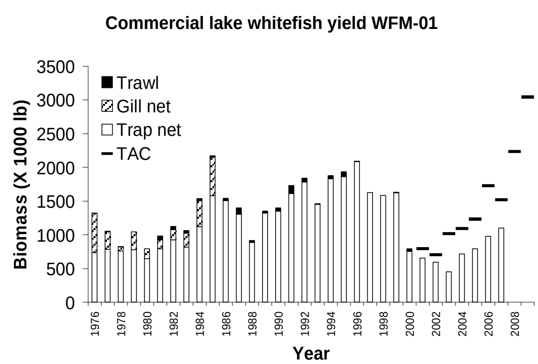
WFM-01 (Bays de Noc)

Prepared by Philip J. Schneeberger

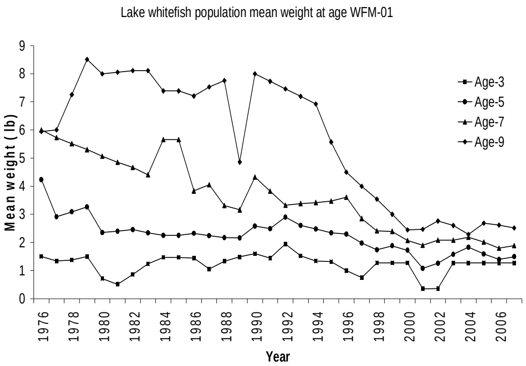
Lake whitefish management unit WFM-01 is located in 1836 Treaty waters of northern Green Bay. Prominent features of this area include two large bays (Big and Little bays de Noc), numerous small embayments, several islands (including St. Martins Island, Poverty Island, Summer Island, Little Summer Island, 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 1.101million lbs during 2007, up 13% from 2006. Fishing effort was almost identical in 2006 and 2007 at just a little over 1,400 lifts per year. Yields have increased steadily between 2003 and 2007. There has also been a fairly consistent climb in catch-per-unit effort starting in 1999 at a level of 284 lbs/lift and culminating nearly three times higher at a current peak of 780 lbs/lift in 2007. Commercial gill netting in this management zone ceased after 1985. Trawl yield was basically negligible through 2000 and has been non-existent thereafter.

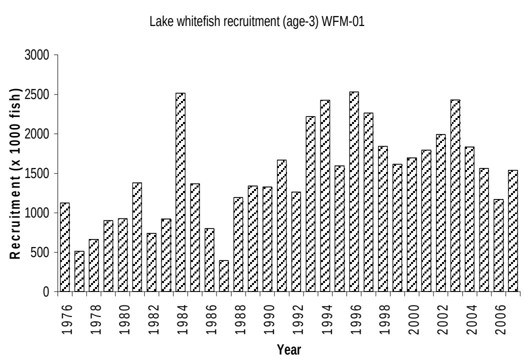


There was little change in weight-at-age for WFM-01 lake whitefish between 2006 and 2007. Weight-at-age values have been relatively stable since 2003 following declines in the 1990s and early 2000s.

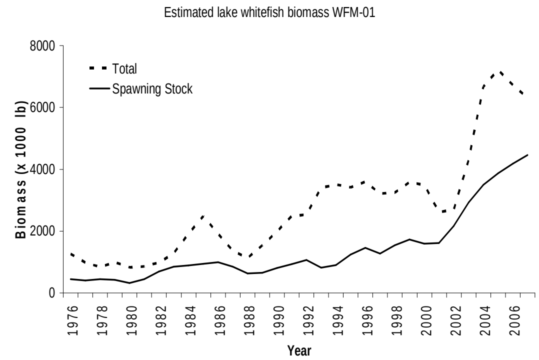


A von Bertalanffy growth model was used to portray individual fish growth as a function of time. Averages for length-at-age, calculated from lake whitefish data pooled for 2005-2007 from state and tribal fisheries, were used for model inputs. Model estimates for growth parameters L ∞, k, and t_0 were 604 mm, 0.172, and -0.97.

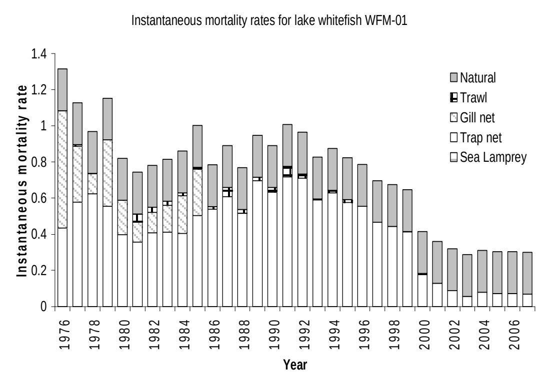
Estimated recruitment (numbers of age-3 fish) increased 32% in 2007 compared to 2006. The recruitment estimate for 2007 (representing the 2004 year class) was 1,540,000. Recruitment estimates have been higher than 1 million fish (with a high estimate of 2.5 million fish in 1996) every year since 1988 in WFM-01.



Based on the latest model estimates, fishable biomass was 6.3 million lbs in 2007 and of this total, spawning stock biomass (4.5 million lbs) composed 71% of the total. Considering the entire data set, fishable biomass estimates have been highest during the years from 2003 through 2007. 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 2007 estimate was 0.30 y^{-1} with 0.23 y^{-1} assigned to instantaneous natural mortality rate (M) and 0.07 y^{-1} attributable to instantaneous fishing mortality rate (F).



The projected 2009 yield limit for WFM-01 is 3.04 million lbs. This value is a 36% increase from the 2008 yield limit of 2.24 million lbs. Although the 2009 yield limit is high, an increase from the 2008 limit seems reasonable based on favorable estimates of biomass, catch-per-unit effort, recruitment, and mortality.

Summary Status WFM-01 Whitefish	Value (95% Probability Interval)
Female maturity	
Size at first spawning	1.44 lb
Age at first spawning	4 y
Size at 50% maturity	1.49 lb
Age at 50% maturity	5 y
Spawning biomass per recruit	
Base SSBR	2.3 lb (2.29 – 2.31)
Current SSBR	1.32 lb (1.25 – 1.39)
SSBR at target mortality	0.2731 lb (SE 0.2729 – 0.2734)
Spawning potential reduction	
At target mortality	0.572 (0.543 – 0.606)
Average yield per recruit	0.510 lb (0.475 – 0.539)
Natural mortality (M)	0.231 y^{-1}
Fishing mortality rate 2005-2007	
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 2005-2007, ages 4+	0.0 y^{-1}
Trap net fishing mortality (F)	
Average 2005-2007, ages 4+	0.095 y^{-1} (0.081 – 0.110)
Trawl fishing mortality (F)	
Average 2005 – 2007, ages 4+	0
Sea lamprey mortality (ML)	
(average ages 4+, 2005-2007)	N/A
Total mortality (Z)	
(average ages 4+, 2005-2007)	0.326 y^{-1} (0.313 – 0.341)
Recruitment (age 4)	
(average 1998-2007)	2,655,363 fish (1,864,580 – 3,943,560)
Biomass (age 3+)	
(average 1998-2007)	10,840,049 lb (8,805,690 – 13,745,200)
Spawning biomass	
(average 1998-2007)	6,214,979 lb (5,395,260 – 7,257,350)
MSC recommended yield limit for 2009	3,040,000 lb
Actual yield limit for 2009	3,040,000 lb

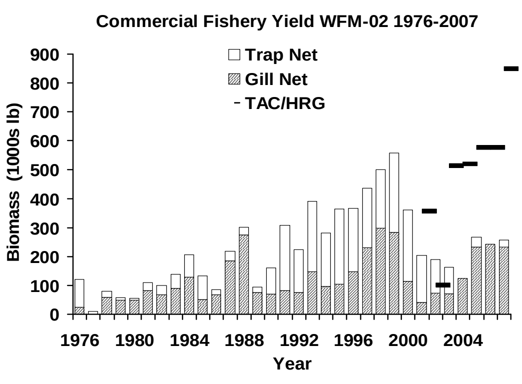
WFM-02 (Manistique)

Prepared by Mark P. Ebener

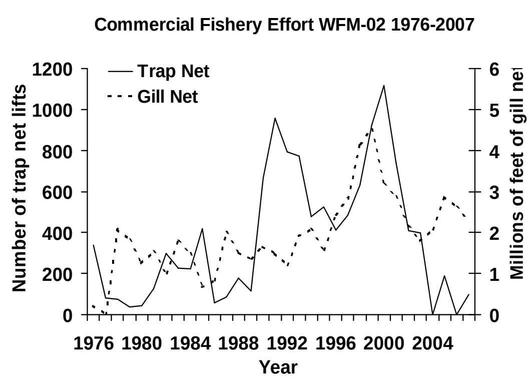
WFM-02 is located in the northwest portion of Lake Michigan. There are 387,000 surface acres of water less than 240 ft deep in the unit. The only known spawning population of whitefish in WFM-02 is located in Portage Bay; this population is not as abundant as other stocks in Lake Michigan. Many of the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

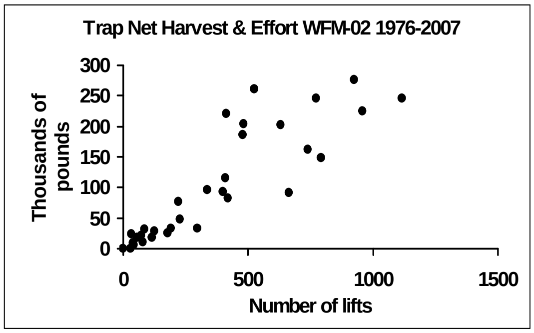
Commercial fishery harvests have averaged 222,000 lb per year from WFM-02 during 1976-2007. The lowest harvest was 11,000 lb in 1977 and the peak harvest was 558,000 lb in 1999. The large-mesh gill-net fishery accounted for 54% of the total harvest during 1976-2007, but since 2004 the gill net fishery has accounted for 97% of the harvest. The commercial harvest was 257,000 lb in 2007.

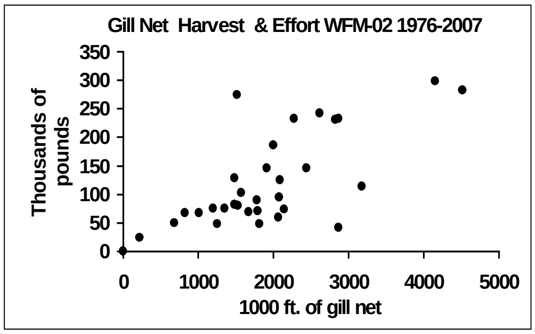


Trap-net effort has been highly variable, while gill-net effort has generally been increasing in WFH-02 since 1976. Trap-net effort was less than 400 lifts annually during 1976-1989, increased to between 400 and 1,110 lifts during 1990-2002, and since 2002 has not exceeded 200 lifts. Peak trap-net effort was 1,116 lifts in 2000 and the effort in 2007 was 96 lifts. Gill-net effort increased from 1,200 ft in 1977 to a peak of 4.5 million ft in 1999 and since then has ranged from 1.8 to 3.2 million feet. Gill-net effort was 2.2 million ft in 2007.

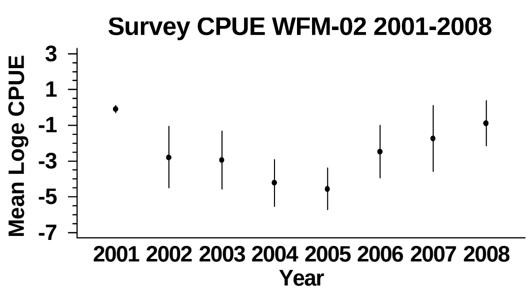


The relationship between fishing effort and harvest was linear and positive for the trap-net fishery, but relationship between effort and harvest was much less clear for the gill-net fishery. Trap-net effort explained 76% of the variation in trap-net catch during 1976-2007 in WFM-02 and catch per unit effort averaged 258 lb per lift. Gill-net effort explained only 48% of the variation in gill-net harvest during 1976-2007 and catch per unit effort averaged 60 lb per 1000 ft.





Fishery independent surveys have been conducted in WFM-02 during July through early September of 2001-2008. The gill-net surveys were conducted 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 then increased thereafter. Relative abundance was greater in 2006-2008 than during the lower periods of 2004-2005.



The stock assessment model projected a total allowable catch of 921,000 lb from WFM-02 for 2009, but given that the peak historic harvest was 558,000 lb, a harvest regulating guideline of 558,000 lb was established for the unit in 2009. Previous HRGs were 357,000 lb in 2001, 100,000 lb in 2002, 514,000 lb in 2003, 520,000 lb in 2004, 577,000 lb in 2005 and 2006, 849,000 lb in 2007, and 558,000 lb in 2008.

Summary Status WFM-02 Whitefish	Value (Standard Error)
Female maturity	
Size at first spawning	0.39 lb
Age at first spawning	3 y
Size at 50% maturity	1.81 lb
Age at 50% maturity	5 y
Spawning biomass per recruit	
Base SSBR	2.112 lb (SE 0.038)
Current SSBR	1.29 lb (SE 0.04)
SSBR at target mortality	0.127 lb (SE 0.000)
Spawning potential reduction	
At target mortality	0.612 (SE 0.019)
Average yield per recruit	0.495 lb (SE 0.025)
Natural mortality (M)	0.244 y^{-1}
Fishing mortality rate 2005-2007	
Fully selected age to gill nets	8
Fully selected age to trap nets	8
Gill net fishing mortality (F)	
Average 2005-2007, ages 4+	0.087 y^{-1} (SE 0.008)
Trap net fishing mortality (F)	
Average 2005-2007, ages 4+	0.01 y^{-1} (SE 0.001)
Sea lamprey mortality (ML)	
(average ages 4+, 2005-2007)	N/A
Total mortality (Z)	
(average ages 4+, 2005-2007)	0.34 y^{-1} (SE 0.009)
Recruitment (age 3)	
(average 1998-2007)	701,210 fish (SE 74,084)
Biomass (age 3+)	
(average 1998-2007)	2,621,800 lb (SE 201,800)
Spawning biomass	
(average 1998-2007)	1,934,200 lb (SE 140,010)
MSC recommended yield limit for 2009	797,000 lb
Actual yield limit for 2009	558,000 lb

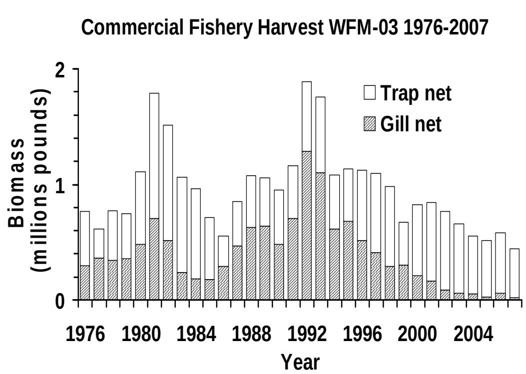
WFM-03 (Naubinway)

Prepared by Mark P. Ebener

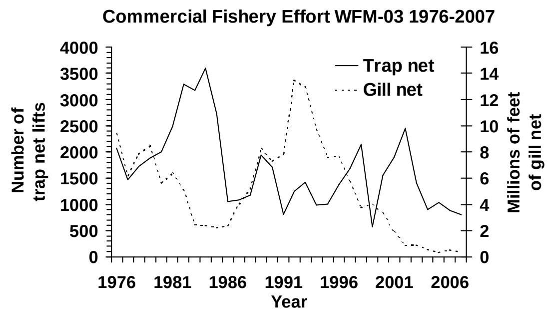
WFM-03 is located in northern Lake Michigan. The unit extends from the Straits of Mackinaw west to Seul Choix Point and is bounded on the south by Beaver Island and complex of shoals and islands that surround the island. Nearly the entire unit is shallow water less than 90 ft deep. There are 483,000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

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

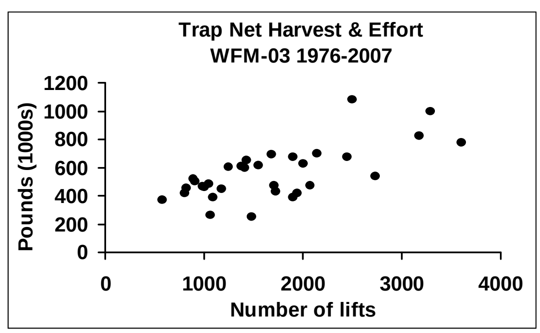
The commercial fishery harvest from WFM-03 averaged 957,000 lb during 1976-2007. The trap-net fishery accounted for 58% of the harvest during 1976-2007. Peak harvests of 1.5-1.8 million lb occurred in 1981-1982 and 1.8-1.9 million lb in 1992-1993. Commercial fishery harvest declined nearly annually after 1993 primarily because of large reductions in gill-net harvest. The commercial harvest of 439,000 lb in 2007 was the lowest ever during 1976-2007.

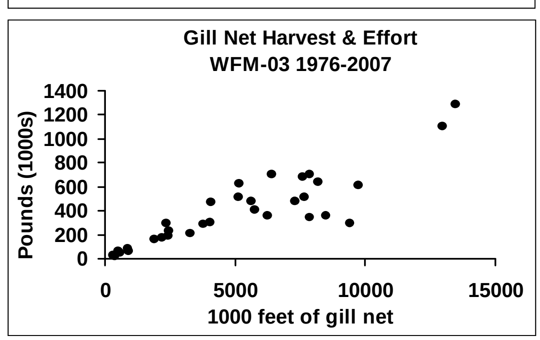


Both gill-net and trap-net effort has been declining in WFM-03 over the last 32 years. Gill-net effort peaked at 13.5 million ft in 1992 and declined thereafter. Gill-net effort in 2007 was 366,000 ft. Trap-net effort declined from a peak of 3,597 lifts in 1984 to only 571 lifts in 1999 and was 802 lifts in 2007.



The relationship between fishing effort and harvest in WFM-03 is not as clear as in some other units. Trap-net effort explained only 45% of the variation in trap-net catch, whereas gill-net effort explained 76% of the variation in gill-net harvest during 1976-2007. Average trap-net catch rate was 165 lb per lift and average gill-net catch rate

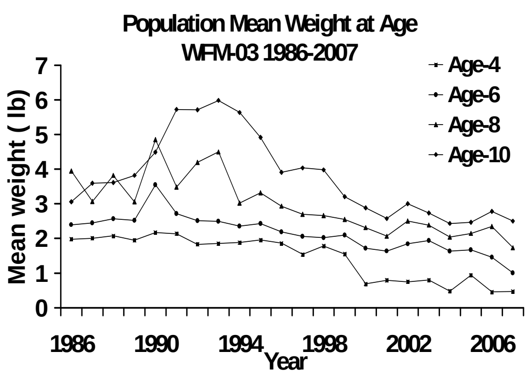




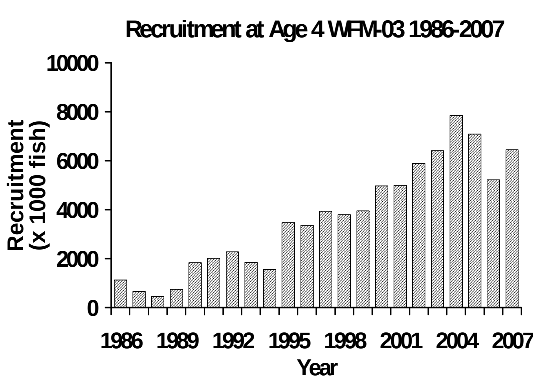
was 73 lb per 1000 ft. during 1976-2007.

Whitefish in WFM-03 are of small size. During 1986-2007 No1 whitefish made up 85%, mediums 12%, and jumbos 3% of the harvest from this unit. Mean weight of a harvested whitefish in 2007 was 2.4 lb in the gill-net fishery and 2.3 lb in the trap-net fishery.

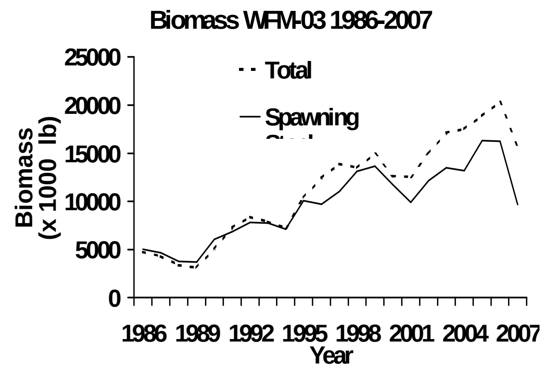
Mean weight at nearly all ages continued to decline in 2007 from 2006 levels. Mean weight at age declined by 8-48% among age-3 to age-10+ fish from 2006 to 2007. Only age-4 whitefish showed an increase in mean weight at age from 2006 to 2007. All ages weighed less in 2007 than nearly any other year during 1986-2007.



Estimated recruitment of age-4 whitefish to the fishable populations continued to be high in WFM-03 during 2007. Recruitment averaged 3.6 million age-4 whitefish during 1986-2007. The lowest recruitment was 452,000 fish for the 1984 year class in 1988, while the highest recruitment was 7.8 million fish for the 2000 year class in 2004. The 2003 year class was estimated to contain 6.4 million fish when it recruited in 2007.



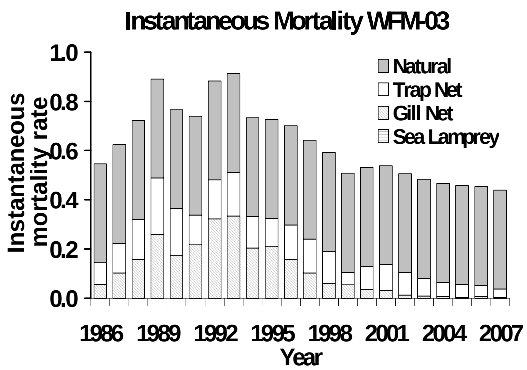
Biomass of age-4 and older whitefish appeared to finally stabilize in WFM-03 during 2007. Fishable biomass averaged 11.2 million lb during 1986-2007, while spawning stock biomass averaged 9.7 million lb during the same time period. Fishable biomass peaked at 20.3 million lb in 2006. Spawning stock biomass peaked at 16.3 million lb in 2005. Fishable and spawning stock biomasses were 15.7 and 9.7 million lb, respectively, in 2007.



Von Bertalanffy growth parameters for $L\infty$ and k and an average water temperature of 6^{o}C were used in 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 rate averaged 0.62 y^{-1} in WFM-03 during 1986-2007. Gill-net and trap-net mortality both averaged 0.11 y^{-1} in WFM-03 during 1986-2007. Gill-net mortality peaked at 0.33 y^{-1} in 1993 then continually declined to only 0.002 y^{-1} in

2007. Trap-net mortality peaked at 0.29 y^{-1} in 1989 and since then has fluctuated between 0.03 y-1 and 0.19 y^{-1}. Trap-net mortality was estimated to be 0.04 y^{-1} in 2007.



Total annual mortality on fully vulnerable age-classes was less than the target rate during 2005-2007 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 4.62 times. The projected harvest limit for 2009 under this increased fishing rate was estimated to be 2.82 million pounds. Total allowable catch/HRG for previous years were 953,000 lb in 2001, 1,313,000 lb for 2002, 1,462,000 lb for 2003, 1,938,000 lb for 2004, 1,970,000 lb for 2005-2007, and 2,551,000 lb for 2008.

Summary Status WFM-03 Whitefish	**Value (Standard Error)**
Female maturity	
Size at first spawning	0.62 lb
Age at first spawning	4 y
Size at 50% maturity	1.37 lb
Age at 50% maturity	6 y
Spawning biomass per recruit	
Base SSBR	0.783 lb (SE 0.002)
Current SSBR	0.63 lb (SE 0.01)
SSBR at target mortality	0.60 lb (SE 0.000)
Spawning potential reduction	
At target mortality	0.8 (SE 0.013)
Average yield per recruit	0.12 lb (SE 0.007)
Natural mortality (M)	0.402 y^{-1}
Fishing mortality rate 2005-2007	
Fully selected age to gill nets	9
Fully selected age to trap nets	9
Gill net fishing mortality (F)	
Average 2005-2007, ages 4+	0.004 y^{-1} (SE 0.00)
Trap net fishing mortality (F)	
Average 2005-2007, ages 4+	0.051 y^{-1} (SE 0.004)
Sea lamprey mortality (ML)	
(average ages 4+, 2005-2007)	N/A
Total mortality (Z)	
(average ages 4+, 2005-2007)	0.457 y^{-1} (SE 0.005)
Recruitment (age 3)	
(average 1998-2007)	5,655,281 fish (SE 415,708)
Biomass (age 3+)	
(average 1998-2007)	15,813,259 lb (SE 831,721)
Spawning biomass	
(average 1998-2007)	12,949,000 lb (SE 979,710)
MSC recommended yield limit for 2009	2,820,000 lb
Actual yield limit for 2009	2,820,000 lb

WFM-04 (Beaver Island)

Prepared by Stephen J. Lenart

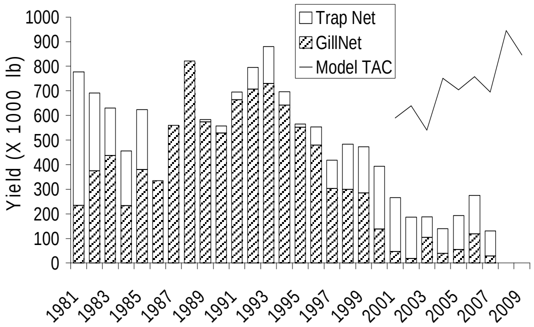
WFM-04 is located in central northern Lake Michigan and contains a very diverse range of habitat. The Beaver Island archipelago, which consists of eight named islands, is the dominant feature of the unit. These islands, located mainly along the northern edge of the unit, are associated with a large, 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.

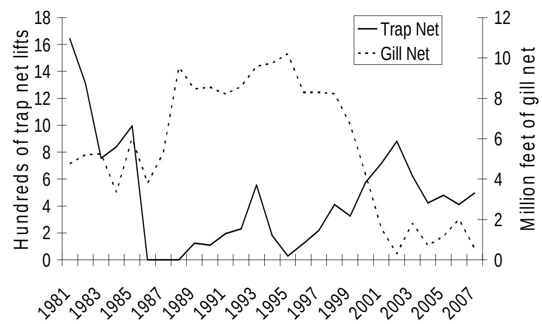
In the four years prior to implementation of the 1985 Agreement between the State and the three COTFMA tribes, the trap-net fishery accounted for a substantial proportion (30–70%) of the total commercial yield. Average commercial yield was 636,000 lb during this period. After 1985, the gill-net fishery 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 steadily declined since. The commercial yield recorded in 2007 (130,000 lb) was the lowest in the entire time series. The steady decline in overall yield can be attributed to a shrinking gill-net fishery, which has harvested, on average, 69,000 lb of whitefish per year during 2000 to 2007. By comparison, average gill-net harvest was 524,000 lb during 1985 to 1999. Only in 2004 was the gill-net harvest lower than the 29,000 lb recorded in 2007. The trap-net fishery yielded approximately 100,000 lb of whitefish in 2007, slightly lower than the 2000 to 2006 average (159,000 lb).

Commercial lake whitefish yield WFM-04



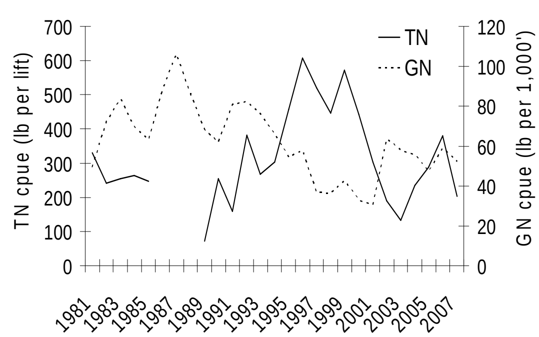
Fishing effort in WFM-04 has been quite variable through the years. After averaging more than 1,100 lifts per year during 1981 to 1985, the trap-net fishery was inactive for a three-year period. Effort remained low through the mid-1990s (average of 200 lifts during 1989 to 1996). During the period 1997 to 2002, trap-net effort steadily increased, reaching 881 lifts in 2002. Trap-net effort then declined to 623 lifts in 2003, a 29% decrease. Reported effort during 2004 to 2007 has been fairly stable, ranging from 412 to 498 lifts. By contrast, gill-net effort has progressively declined since 1995, when more than 10 million ft of gill-net effort was reported. The decline in gill-net effort in recent years followed as a consequence of the 2000 Consent Decree with the conversion of gill-net fisheries to trap-net fisheries. During 1985 to 1999, average gill-net effort was approximately 8 million feet per year, more than five times higher than the average reported since the Decree was implemented in 2000. In 2007, just over 500,000 feet of effort was reported in WFM-04.

Commercial trap net and gill net effort WFM-04



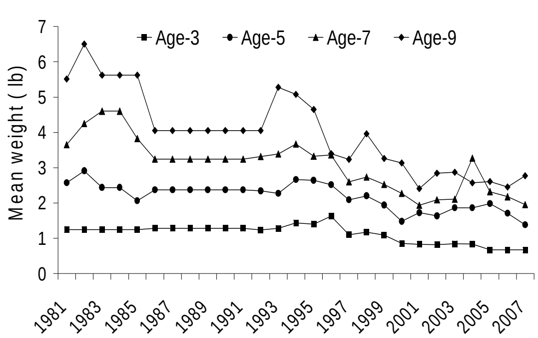
Since declining through much of the 1990s, catch-per-unit-effort (cpue) in the gill-net fishery has been quite stable in recent years, averaging 56 lb per 1,000 feet of effort during 2002 to 2007 (range 47 to 64 lb). Prior to the peak of gill-net fishery effort in the early 1990s, gill-net cpue was generally higher. The highest gill-net cpue was recorded during 1986 to 1988 (average 93 lb), when the trap-net fishery was inactive. Trap-net cpue has been more variable, but has generally increased throughout the 1990s as CORA trap-net operations became more established. However, effort was generally low during this period. Since 2000, trap-net cpue has ranged between 133 and 379 lb per lift. 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.

Commercial trap net and gill net CPUE WFM-04



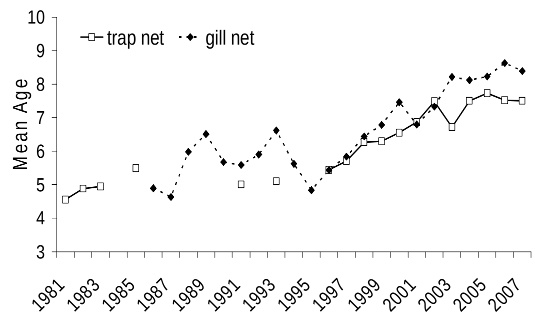
Growth of whitefish in WFM-04 has followed the long-term trend evident across all of northern Lake Michigan- fish are much smaller at a given age than they were during the late 1980s and early 1990s. For example, age-9 whitefish weighed, on average, 5.8 lb during the 1980s. This declined to an average of 4.1 lb in the 1990s and then to 2.71 lb during 2001 - 2007. While a similar long-term decline was evident in younger age classes, growth had appeared to stabilize during the early 2000s. However, weight-at-age for age-5 and age-7 fish declined in 2006 and then again in 2007, a trend that bears watching in the future. 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. Annual mean weight of a whitefish harvested in the trap-net fishery ranged from 2.0 to 3.3 lb during 1981 to 2007. The mean weight of whitefish harvested in the 2007 trap-net fishery was 2.4 lb. The mean weight of a whitefish harvested in the gill-net fishery ranged from 2.6 to 3.5 lb during 1981 to 2007. Since 1995, the mean weight of whitefish in the gill-net fishery has remained relatively constant (2.6 to 2.8 lb).

Lake whitefish population mean weight at age WFM-04

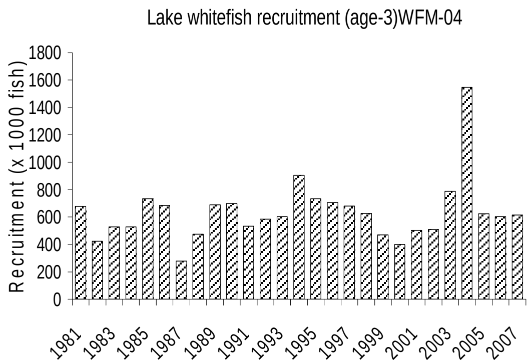


Further indicators of the long-term change in growth can be gleaned from the fishery. During the 1980s, the mean age of a whitefish harvested in the trap-net fishery was approximately 5 years. By 2002, the mean age in the trap-net fishery had increased to approximately 7.5 years, with little increase since that time. Mean age continues to increase in the gill-net fishery, reaching 8.7 years in 2006.

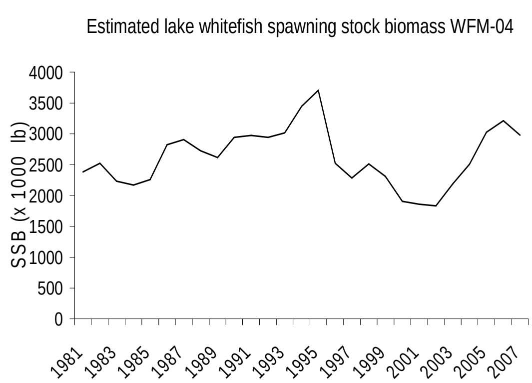
Mean age in the WFM04 commercial fishery



Recruitment of age-3 whitefish to the population in WFM-04 is quite stable. During the period 1981 to 2002, average estimated recruitment of age-3 whitefish was 590,000 fish (range 280,000 to 900,000). The catch-at-age model estimates that two of the largest recruitment events occurred in successive years (2003 and 2004) corresponding to the 2000 and 2001 year classes. Of particular interest is the estimate for the 2001 year class (age-3 fish in 2004). This estimate (1.55 million fish) is more than 70% greater than the next largest in the time series and is more than double the long-term average for the unit. Although a strong signal for this year class exists in the age composition of both fisheries, these fish have not yet fully recruited to the fishery, so the true magnitude of this estimate remains uncertain. However, estimates from adjacent management units in northern Lake Michigan suggest similar trends and the survey data, though limited, provides support for a very strong 2001 cohort.



Spawning stock biomass (SSB) has generally been fairly stable in WFM-04, a consequence of the consistent recruitment. From 1981 to its peak in 1996, estimated spawning stock biomass increased from 2.4 to 3.7 million pounds. The relatively high overall mortality rates in the early 1990s, coupled with declining growth, resulted in declining SSB estimates during 1997 to 2002, when estimated SSB fell to a low of 1.8 million pounds, half that of the 1996 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 million pounds, on par with estimates from the early 1990s.

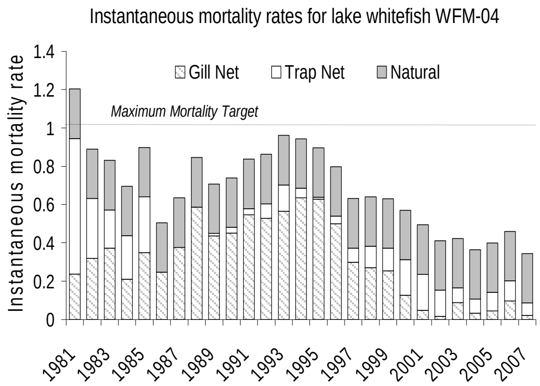


A significant factor in this increase in spawning stock biomass was the general decline in fishing mortality rates since the mid-1990s, particularly in the gill-net fishery. During 1987 to 1996, instantaneous gill-net mortality on ages-4+ ranged between 0.37 and 0.63 yr^{-1} (average 0.53). After 1996, gill-net mortality declined for six consecutive years, reaching its lowest point in the time series in 2002 (0.015 yr^{-1}). During 2005 to 2007, average instantaneous gill-net mortality was 0.054 yr^{-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 0.039 yr^{-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 0.089 y^{-1} during 2005 to 2007. Total mortality (Z) of age-4 and older whitefish in WFM-04 has steadily declined since 1993 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. Growth parameters are 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).

Table 1. Growth parameters and estimates of M from WFM04 model assessments

TAC Year	Linf	K	M
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.



The average total mortality rate of age-4 and older whitefish was 0.401 y^{-1} during 2005 to 2007, well below the maximum target rate of 1.05 y^{-1}. The spawning potential reduction was estimated at 0.604 indicating that the fishery could support an increase in effort during 2009 (effort multipliers are 2.3 for the trap-net fishery and 4.3 for the gill-net fishery). The 2009 model-generated yield limit of 846,000 lb represents a 10% decrease over the 2008 mode-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 will be determined by CORA according to the process detailed in the Tribal Management Plan for the 1836 Treaty waters.

Model Changes and Diagnostics

After updating the source file to include 2007 data, two separate models were evaluated during the 2009 TAC assessment: (1) last year's model with no changes (gill-net selectivity modeled as a double logistic function); and (2) a model in which gill-net selectivity was modeled as a simple logistic function. As in years past, the most problematic parameters continue to be those associated with gill-net selectivity. This was the primary reason why model 2 was evaluated. As was the case in prior assessments, modeling gill-net selectivity as a simple logistic function resulted in convergence issues (selectivity parameters at bounds) and a poor fit to the observed fishery age composition. It is worth noting that model 2 produced much smaller biomass estimates (35-55% of the estimates produced by model 1). Furthermore, biomass estimates from model 2 were sensitive to changes in the bounds of the selectivity parameters. Model 1 reached minimum convergence criteria, provided a reasonable fit to the observed fishery age composition, and biomass estimates were insensitive to changes in the bounds of the selectivity parameters; therefore this model was retained. One structural change was made to the model prior to running final diagnostics. The relative population scaler used in estimating age-specific abundance in the first year of the model has been a problematic parameter (bounding issues) since the plus group was expanded (from 9+ to 11+) during the 2007 TAC assessment. Since these older age classes (particularly the last three) were not represented in the fishery in the early part of the time series, the model code was changed so that the population scaler was not used in estimating initial abundance for the last three age classes (ages 9-11+). This alleviated the bounding issues without impacting biomass estimates. The MCMC simulations produced reasonable results (some stickiness in the trace plots) and retrospective analyses of SSB and recruitment did not produce any problematic temporal patterns. The final model rating was “medium” due to the fact that the MCMC diagnostics were not optimal.

In the future, the MSC has decided that growth parameters for each stock will be derived using all historical data, not just recent time blocks. The approach used to date was not necessarily consistent across stocks and, furthermore, the use of all historical data is thought to be more appropriate for use with the Pauly equation in estimating natural mortality. This change will be implemented during the 2010 TAC assessment.

Summary Status WFM-04 Whitefish	Value (95% Probability Interval)
Female maturity	
Size at first spawning	0.67 lb
Age at first spawning	3 y
Size at 50% maturity	1.69 lb
Age at 50% maturity	5 y
Spawning biomass per recruit	
Base SSBR	2.465 lb (2.456 – 2.474)
Current SSBR	1.490 lb (1.428 – 1.551)
SSBR at target mortality	0.210 lb
Spawning potential reduction	
At target mortality	0.604 (0.579 – 0.629)
Average yield per recruit	0.460 lb (0.437 – 0.482)
Natural mortality (M)	0.258 y^{-1}
Fishing mortality rate 2005-2007	
Fully selected age to gill nets	10
Fully selected age to trap nets	10
Gill net fishing mortality (F)	
Average 2005-2007, ages 4+	0.054 y^{-1} (0.048 – 0.061)
Trap net fishing mortality (F)	
Average 2005-2007, ages 4+	0.089 y^{-1} (0.078 – 0.101)
Sea lamprey mortality (ML)	
(average ages 4+, 2005-2007)	N/A
Total mortality (Z)	
(average ages 4+, 2005-2007)	0.401 y^{-1} (0.385 – 0.418)
Recruitment (age 3)	
(average 1998-2007)	668,880 fish (558,588 – 818,366)
Biomass (age 3+)	
(average 1998-2007)	3,089,000 lb (2,734,000 – 3,588,000)
Spawning biomass	
(average 1998-2007)	2,434,000 lb (SE 2,173,000 – 2,775,000)
MSC recommended yield limit for 2009	846,000 lb
Actual yield limit for 2009	846,000 lb

WFM-05 (Grand Traverse Bay)

Prepared by Erik J. Olsen

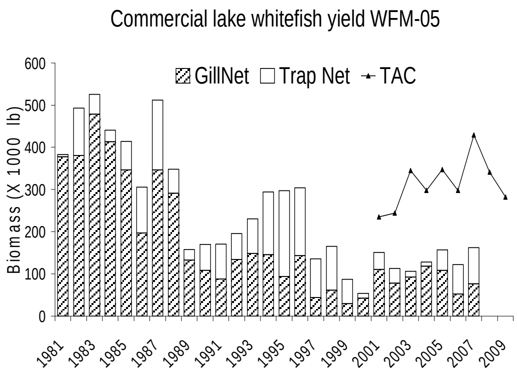
Management unit WFM-05 encompasses the area from Little Traverse Bay through Grand Traverse Bay and offshore waters of Lake Michigan north and west of the Leelanau Peninsula. Much of WFM-05 contains water >240 ft. deep including the both the east and west arms of Grand Traverse Bay. The deepest parts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

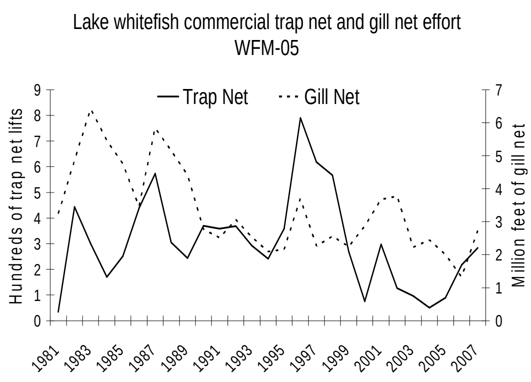
WFM-05 has been an important tribal fishing area since the 1970s. Much of the tribal fishing activity that occurred prior to and immediately after re-affirmation of treaty-reserved fishing rights took place in Grand Traverse Bay. Tribal small-boat fishers relied on Grand Traverse Bay as an important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

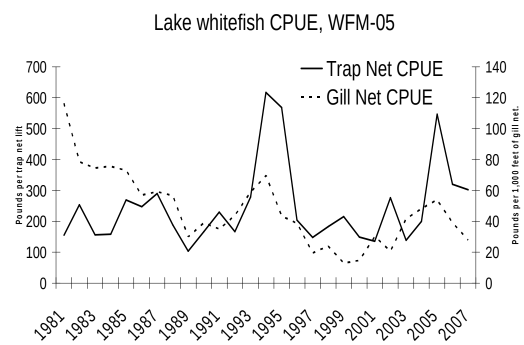
Commercial yields of lake whitefish during the 1990s were substantially less than during the 1980s. The commercial yield averaged 383,000 lb from 1980 to 1989 and 205,000 lb during 1990 to 1999. The fishery declined through the late 1990s, with the lowest recorded yield coming in 2000 at 53,000 lb. The fishery has rebounded slightly through 2007, averaging 134,000 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. Increased trap-net effort in 2006 and 2007 resulted in trap-net yield again surpassing that of gill net.



Large-mesh gill-net effort in WFM-05 declined from 1984-1989 and has held relatively stable since; whereas, trap-net effort has varied, but with a downward trend since 1996. Gill-net effort declined from an average of 6.4 million ft. from 1983 through 1990. Since then, the large-mesh gill-net fishery has averaged 2.6 million feet annually, with an all-time low of 1.3 million feet in 2006. Trap-net effort has varied annually between 200 and 800 lifts during 1982-1999. Through the 1990s, trap-net effort averaged 423 lifts per year, peaking at 790 lifts in 1996. Trap-net effort has declined since, averaging 166 lifts since 2000, with an all-time low of 51 lifts in 2004.



The decline in yield of whitefish in WFM-05 has generally mirrored the decline in lake whitefish recruitment within this management unit. CPUE of whitefish in the large-mesh gill-net fishery declined from 153 lb per 1,000 ft. of gill net in 1979 to a low of 13 lb per 1000 ft. in 1999. Since 2000, gill-net CPUE has been increasing, before appearing to decline during the past two years. 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 per lift. From 2000-2004, trap-net CPUE averaged 183 lb, but jumped significantly to 546 lbs per lift 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.



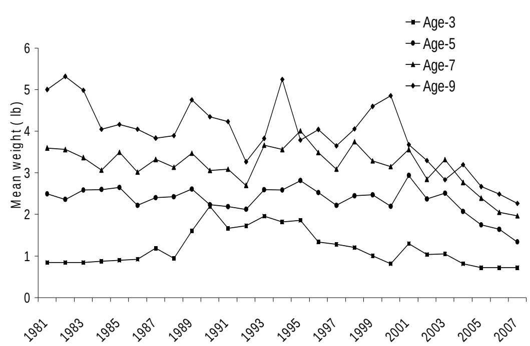
Whitefish from WFM-05 are currently of small to moderate size. Mean weight at age is trending down in recent years. From 2000 to 2007, the proportion of the yield made up of the three size classes of whitefish were 77% No.1 (< 3 lb), 18% mediums (3-4 lb), and 5% jumbos (≥ 4 lb). In comparison, from 1980 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 (2005-2007). Annual mean weight of whitefish in the gill-net harvest ranged from 2.4 to 3.5 lb since 1979 and averaged 2.7 lb during the last three years (2005-2007).

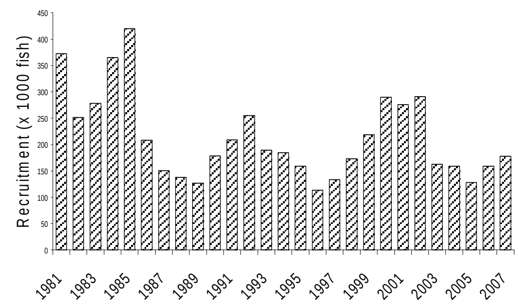
Mean weights of lake whitefish (ages 3-9) from WFM-05 have been slowly declining since 1981. This pattern of declining growth is also being observed in other areas of Lakes Michigan and Huron, including substantial declines in areas adjacent to this management unit.

Lake whitefish population mean weight at age WFM-05



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

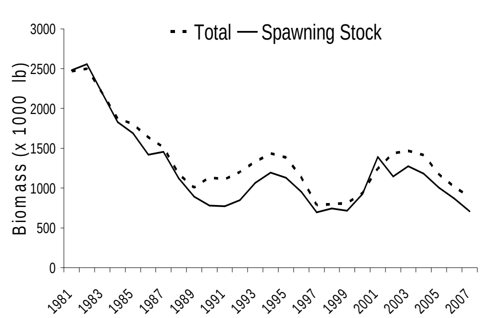
Lake whitefish recruitment (age-3) WFM-05



During 1981-1985 average estimated recruitment was 337,000 fish (range 277,000 to 420,000). Since then, estimates have ranged between 113,000 and 290,000, with an average of 186,000 age-3 fish entering the fishery annually.

Biomass of whitefish estimated with the stock assessment model declined in response to decline in recruitment since the early 1980s. Annual biomass of whitefish ≥ age 3 (calculated at the beginning of each year) peaked at the beginning of the 1981-2007 timeframe with 2.5 million lb. Biomass steadily declined to 1.0 million lb in 1989 and has ranged from 789,000 to 1.5 million lb from 1990 to 2007. Spawning stock biomass followed the same trend, peaking at 2.5 million lb in 1981 before declining through the remainder of the decade. Since 1990 spawning stock biomass has ranged between 697,000 and 1.4 million lb since.

Estimated lake whitefish biomass WFM-05



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

Since l998, F has decreased below natural mortality. Fishing mortality within this unit has been dominated by gill nets; however, during the late 1990s (1995-1998) 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 in 2006 and 2007. Instantaneous fishing-induced mortality on whitefish ≥ age 4 averaged 0.099 for the large-mesh gill-net fishery and 0.09 for the trap-net fishery during 2005-2007. Gill net-induced fishing mortality ranged from 0.39 in 1983 to 0.06 in 2006, while trap-net-induced fishing mortality ranged from 0.01 in 1981 to 0.32 in 1998. The gill-and trap-net mortality level has declined from a combined rate of 0.64 in 1996 to a low of 0.13 in 2000.

Total instantaneous mortality on the fishable stock in WFM-05 during 2005-2007 was substantially less than the target rate of 1.05. Total instantaneous mortality was estimated to be 0.42 during 2005-2007 and the spawning potential reduction value was 0.47.

Stock Assessment Model

To generate the 2009 yield limit, the model .dat file was updated with biological data through 2007. Due to low sample size, weight-at-age for age-2 and age-3 fish in the population was based on a three-year average of survey data. Female maturity-at-age and von Bertalanffy growth parameters were calculated from running, five-year time blocks, the most recent being 2003-2007. No substantive changes were made to the model code during the 2009 TAC 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). MCMC simulations revealed good results for all variables ($SSBR_{(base,\ target,\ current)}$, AvgF, AvgZ, AvgRecruitment, AvgBiomass, AvgSSB, YPR, and SPR). The model generally fit the data well, except perhaps for some disagreement between observed and predicted age in the 2007 trap-net fishery.

A retrospective analysis of biomass suggests 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.

The 2009 model-generated yield limit of 282,000 lb represents a 18% decline from the 2008 limit. This decline can likely be attributed to a period of lower recruitment in recent years. A continued decline in weight-at-age is another contributing factor. However, since overall mortality is well below target, the projection model estimated that fishing effort could be increased 3.2 times in WFM-05 during 2009 from the average during 2005-2007. The projected yield associated with this level of fishing is 282,000 lb, which was accepted as the HRG for 2009.

Summary Status WFM-05 Whitefish	Value (95% Probability Interval)
Female maturity	
Size at first spawning	0.72 lb
Age at first spawning	3 y
Size at 50% maturity	1.22 lb
Age at 50% maturity	4 y
Spawning biomass per recruit	
Base SSBR	2.739 lb (2.730 – 2.749)
Current SSBR	1.30 lb (1.216 – 1.381)
SSBR at target mortality	0.218 lb
Spawning potential reduction	
At target mortality	0.474 (0.444 – 0.504)
Average yield per recruit	0.536 lb (0.511 – 0.558)
Natural mortality (M)	0.231 y^{-1}
Fishing mortality rate 2005-2007	
Fully selected age to gill nets	11
Fully selected age to trap nets	11
Gill net fishing mortality (F)	
Average 2005-2007, ages 4+	0.099 y^{-1} (0.087 – 0.111)
Trap net fishing mortality (F)	
Average 2005-2007, ages 4+	0.09 y^{-1} (0.078 – 0.102)
Sea lamprey mortality (ML) (average ages 4+, 2005-2007)	N/A
Total mortality (Z) (average ages 4+, 2005-2007)	0.42 y^{-1} (0.04 – 0.044)
Recruitment (age 3) (average 1998-2007)	203,510 fish (182,501 – 234,697)
Biomass (age 3+) (average 1998-2007)	1,119,000 lb (1,034,000 – 1,228,000)
Spawning biomass (average 1998-2007)	996,500 lb (922,618 – 1,089,000)
MSC recommended yield limit for 2009	282,000 lb
Actual yield limit for 2009	282,000 lb

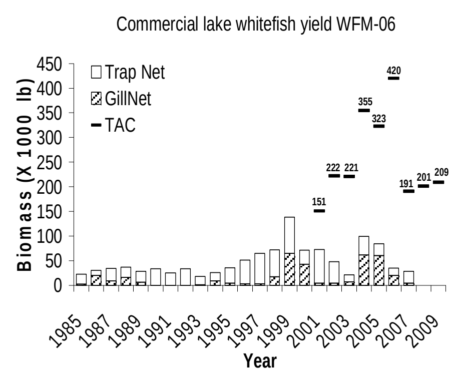
WFM-06 (Leland - Frankfort)

Prepared by Randall M. Claramunt, Philip J. Schneeberger, and Erik Olsen

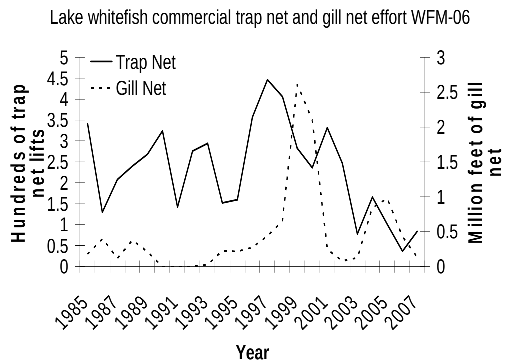
Lake whitefish management unit WFM-06 is located in 1836 Treaty waters west of the Leelanau Peninsula from about Cathead Point south to Arcadia. Surface area for this unit is 945,156 acres (including part or all of grids 709-714, 808-814, 908-912, and 1008-1011). These waters of Lake Michigan include 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.

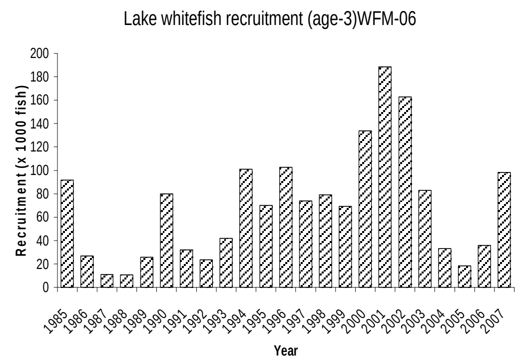
WFM-06 was reserved for state licensed commercial trap-net fishing operations from 1985 through 1999, except that tribal gill netting was allowed in grid 714. Most state licensed trap-net effort and harvest is reported from grids 812-814 and 912. Beginning in 2000, WFM-06 became a shared zone in a truer 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.

Yield for 2007 was 29,000 lb in WFM-06, down from 35,000 lb in 2006, and down from the 1985-2006 average of 49,000 lb. Of the total yield in 2007, trap-net yield was 24,700 lb (85.5 %) and gill-net yield was 4,200 lb (14.5 %). Proportions of yield by gear type have varied considerably from year to year with an average split of 73.1 % from trap nets and 26.9 % from gill nets between 1985 and 2007.

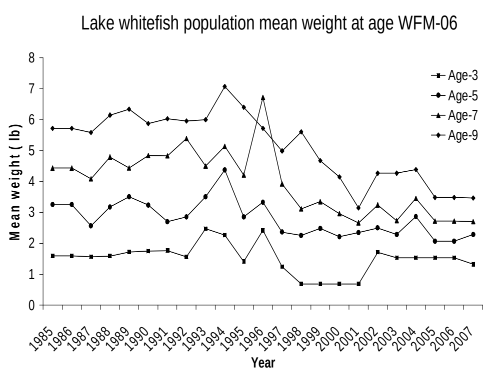


Trap-net effort increased from 38 lifts in 2006 to 84 lifts in 2007. However, trap-net effort in 2007 was the third lowest recorded level for the 1985-2006 series (average of 237 lifts). Similarly, gill-net effort in 2007 (132,310 ft) decreased from 2006 (432,300 ft), and was slightly lower than the 1985-2006 average of 478,500 ft.



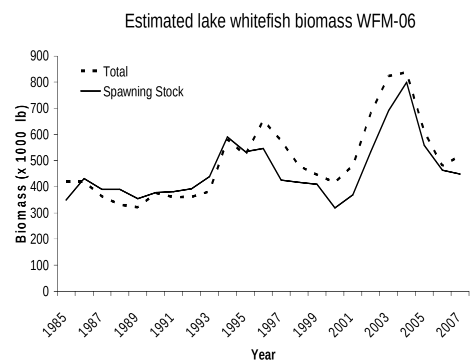


Lake whitefish weight-at-age in 2007 was relatively unchanged for most age groups from the 2006 values. Weight-at-age during 2004 and 2005 appeared to have stabilized from observed declines during 1996 to 2001 for most ages. However, weight-at-age values in 2007 were not available because trap-net biodata samples were not collected. Based on samples for fish aged 5-12+, weight-at-age values were still 30% lower than the 1985-2006 averages.



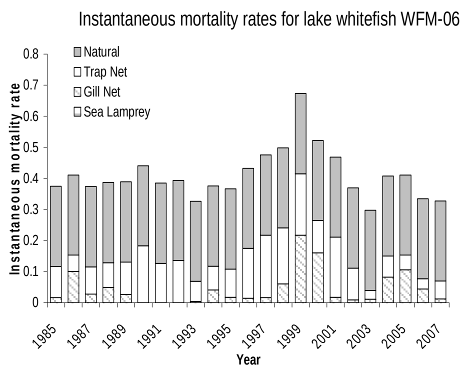
Recruitment, based on estimated numbers of age-3 fish, increased from 36,000 fish in 2006 to 98,000 fish in 2007. Recruitment in 2007 was above the long-term average of 69,000 fish. Periods of high recruitment were observed during 1994-98 and 2000-2002, and low recruitment was observed during 1987-88 and 2004 and 2005.

Estimates of total biomass and spawning stock biomass have roughly paralleled each other from 1985 through 2007, and reflect changes in recruitment estimates. Biomass values estimated for 2007 were 518,000 lb for total and 480,000 lb for spawning stock biomass. The ratio of spawning stock biomass to total biomass was 0.87 in 2007 and unchanged from 2006.



Total instantaneous mortality rate (Z) in 2007 was 0.33 y^{-1}, showing a slight decrease in the rate from 0.34 y^{-1} in 2006. Based on current estimates, the 2007 rate for Z is lower than the average of 0.41 y^{-1} for 1985-2006. Instantaneous fishing mortality rates (F) have varied considerably for trap nets and gill nets throughout the time series. During 2007, F was slightly higher for the trap-net fishery. Estimates for F were 0.057 y^{-1} for trap nets and 0.012 y^{-1} for gill nets.

The 2007 estimate for instantaneous natural mortality rate was 0.258 y^{-1}, still the largest source of lake whitefish mortality in WFM-06. Natural mortality (M) is estimated using the Pauly equation based on growth parameters (K, L-infinity) 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 2007, the growth parameters were estimated at 60.1 for L-infinity and 0.20 for K based on survey data for the most recent three-year time block (2005-2007). Per MSC recommendations future growth parameters will be based on data from the entire time series (1985-present) to better represent growth conditions for this stock.



The 2009 yield limit is 207,000 lb, which is a slight increase from the limit calculated for 2007 of 201,000 lb. Moreover, based on current fishing mortality and 2009 yield-limit and projection model, the level of commercial fishing effort inWFM-06 could increase from the 2008 levels.

Summary Status WFM-06 Whitefish	Value (95% Probability Interval)
Female maturity	
Size at first spawning	1.47 lb
Age at first spawning	3 y
Size at 50% maturity	1.80 lb
Age at 50% maturity	4 y
Spawning stock biomass per recruit	
Base SSBR	4.215 lb (4.201 – 4.230)
Current SSBR	2.58 lb (2.409 – 2.772)
SSBR at target mortality	0.410 lb (0.410 – 0.411)
Spawning potential reduction	
At target mortality	0.612 (0.571 – 0.657)
Average yield per recruit	0.601 lb (0.536 – 0.659)
Natural mortality (M)	0.258 y^{-1}
Fishing mortality rates	
Age of full selection	
Fully selected age to gill nets	8 y
Fully selected age to trap nets	8 y
Gill net fishing mortality (F)	
Average 2005-2007, ages 4+	0.049 y^{-1} (0.040 – 0.058)
Trap net fishing mortality (F)	
Average 2005-2007, ages 4+	0.042 y^{-1} (0.035 – 0.050)
Sea lamprey mortality (ML)	
(average 2005-2007, ages 4+)	N/A
Total mortality (Z)	
(average 2005-2007, ages 4+)	0.349 y^{-1} (0.333 – 0.365)
Recruitment (age 3)	
(average 1998-2007)	99,195 fish (78,741 – 112,660)
Biomass (age 3+)	
(average 1998-2007)	577,360 lb (506,058 – 682,243)
Spawning biomass	
(average 1998-2007)	501,230 lb (435,461 – 595,158)
Recommended yield limit in 2009	207,000 lb
Actual yield limit in 2009	207,000 lb

WFM-07 (Ludington)

Prepared by Archie W. Martell Jr.

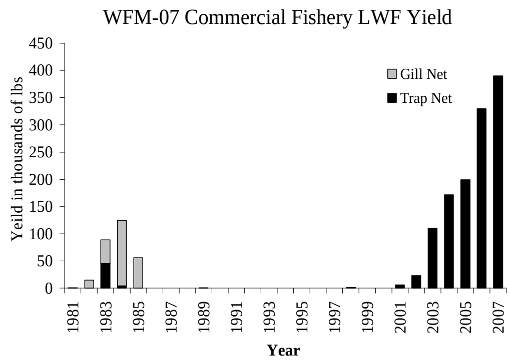
Lake whitefish management unit WFM-07 is located within the 1836 Treaty Ceded Waters of eastern central Lake Michigan from Arcadia in the north to just south of Stony Lake, and west to the state line bisecting the middle of the lake. This lake whitefish management unit includes part or all of grids 1107-1111, 1207-1211, 1306-1310, 1406-1410, 1506-1510 and 1606-1609. The surface area for this unit is 1,286,940 acres (2,011 square miles) of which 274,943 acres (430 square miles) have bottom depths of 240 feet or less, with maximum depths up to 900 feet. There are no islands or bays and apart from the shoreline 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.

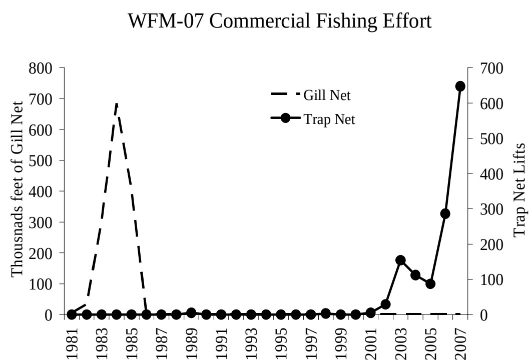
Since 2000, WFM-07 has been a Tribal commercial fishing zone for lake whitefish, part of the Little River Zone with tribal fishing regulated under permitting control of the Little River Band of Ottawa Indians (LRBOI). From 1985 through 2000, there was no significant State commercial fishing effort and 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.

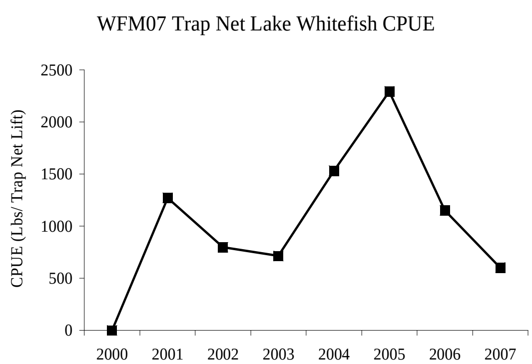
There has been no statistical catch at age modeling of the lake whitefish stock in WFM-07 due to a lack of long-term commercial catch-at-age information. Pursuant to the 2000 Consent Decree, the tribes had three years of allowable commercial fishing without harvest limits in this unit during 2001-2003.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

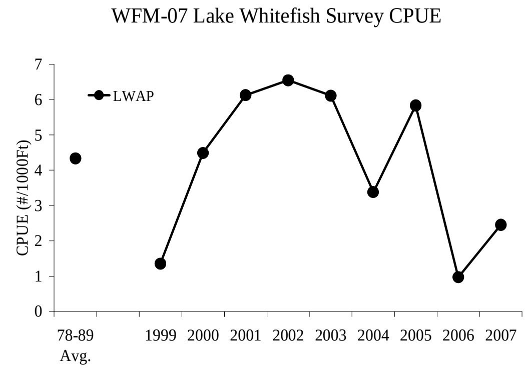
At the conclusion of the 2003 fishing season, three years of commercial trap net fishing activity for lake whitefish was completed by Tribal fishers within this unit. Following the 2000 Consent Decree and the Tribal Management Plan, an annual Harvest Regulation Guideline (HRG) for lake whitefish was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

The 2001-2007 average lake whitefish commercial harvest within this unit has been 175,750 lb. In 2001 Tribal commercial fishing activities began, with effort only occurring in October and November with 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 fishing was distributed across the fishing season and harvest and effort increased to 110,080 lb and 154 trap net lifts, respectively. Commercial lake whitefish activity continued to increase in 2004 with a harvest of 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. Commercial lake whitefish fishing harvest of within WFM-07 reached 389,997 lb in 2007 represented by 647 trap-net lifts.







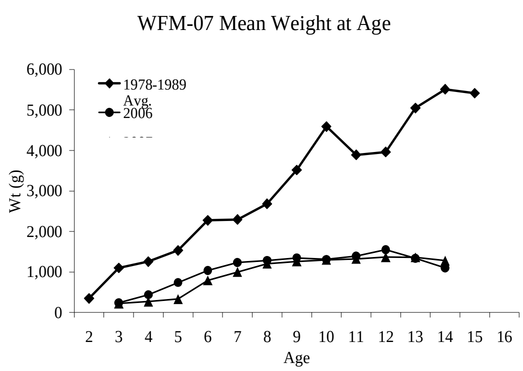


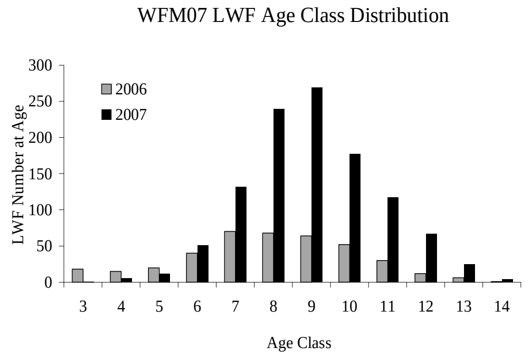
Fishery-independent surveys were conducted following the Lakewide Assessment Plan LWAP using graded-mesh gill nets (GMGN). From 1999 through 2007, GMGN catch-per-unit-effort (CPUE; number per 1,000 feet of GMGN) for lake whitefish in spring assessments have been 1.4, 4.5, 6.1, 6.5, 6.1, 4.3, 5.8, 0.97,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

The mean length of lake whitefish sampled in spring GMGN surveys in 2007 increased to above 20 inches, and is larger than seen in the previous year's survey. The 2004-2007 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 samples. The mean length of the lake whitefish within this unit are still below those of the 1978-1989 survey average. For example, lake whitefish collected from 1983 commercial samples averaged over 23 inches.

Similar to average length, the mean weight of lake whitefish from both the GMGN surveys (3.12 lb) and commercial samples (2.65 lb) in 2007 are currently lower than the 1978-1989 survey average (6.84 lb) and the 1983 commercial samples (5.54 lb). The mean age of lake whitefish from the 2007 GMGN survey is 8.8 y and 9.0 y from the commercial samples. 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 sample of 7.3 y.

Lake whitefish mean weight at age from 2006 and 2007 survey and commercial samples was substantially lower as compared to 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.





The instantaneous total annual mortality rates for WFM-07 lake white fish 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 instantaneous total annual mortality rate (Z) from all assessment GMGN surveys and commercial samples combined was estimated to be 0.339 y^{-1} for ages 7-13. The instantaneous total annual mortality rate (Z) for 2007 lake whitefish from all assessment GMGN surveys and commercial samples combined was estimated to be 0.386 y^{-1} for ages 7-14. The estimated total annual mortality rates calculated for this lake whitefish stock has been below the target maximum total annual mortality rate of Z = 0.65 y^{-1} as outlined in the 2000 Consent Decree.

The lake whitefish stocks within WFM-07 have relatively low exploitation rates as compared to other management zones in northern Lake Michigan. With the development of the tribal commercial fishery, however, there are indications that the abundance of lake whitefish is relatively stable and may be decreasing slightly within this management unit as compared to recent and historical observations. 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 2009 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

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

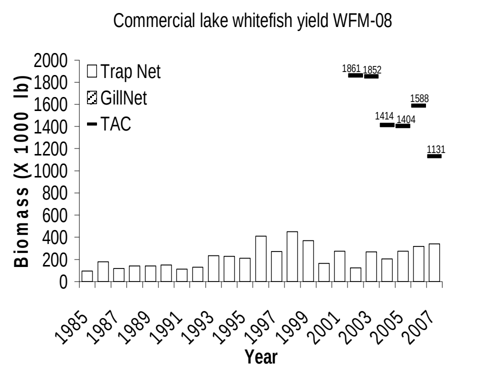
WFM-08 (Muskegon)

Prepared by Randall M. Claramunt, Philip J. Schneeberger, and Archie W. Martell Jr

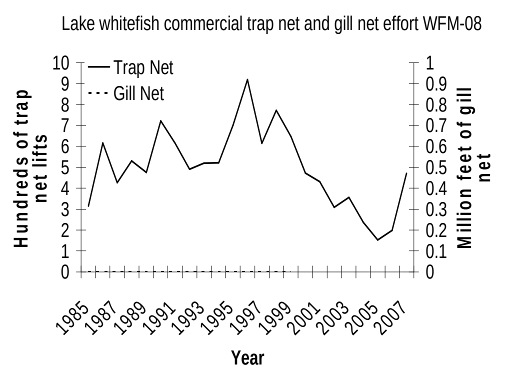
Management unit WFM-08 is the Lake Michigan whitefish zone from about Montague south past Port Sheldon. WFM-08 has a surface area of 1,506,880 acres in Michigan grids 1706-1710, 1806-1810, 1906-1911, and 2006-2011. Apart from the shoreline, inflows from the White, Muskegon, and Grand rivers, and drowned 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 restricted to 90 feet).

Lake whitefish yield from WFM-08 in 2007 was 341,000 lb. In 2007, yield increased from 2006 (317,000 lb), and was higher than the 1985-2006 average of 221,000 lb. Trap-net effort increased considerably from 198 lifts in 2006 to 471 lifts in 2007.

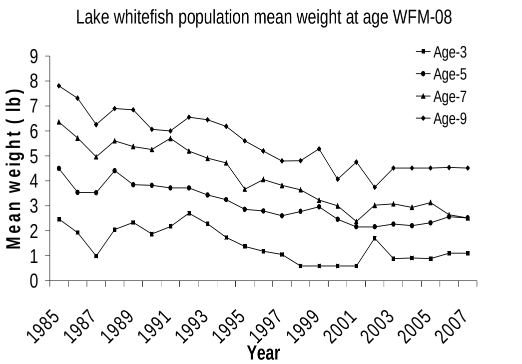


Although trap-net effort increased in 2007, the current level of commercial effort remains lower than the long-term average for this unit of 502 lifts from 1985-2006.

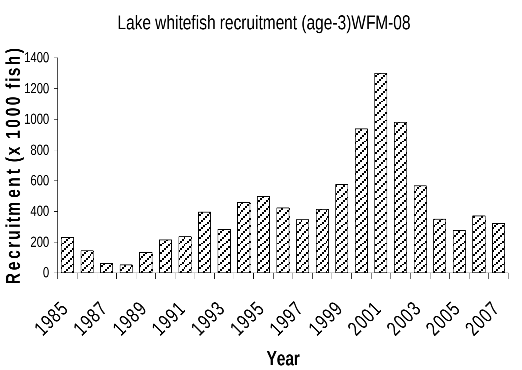


Weight-at-age data have trended downward from 1985 through 2003. After 2003, weight-at-age increased or appeared to have stabilized for most of the age groups, although biological data for the larger age groups is limited.

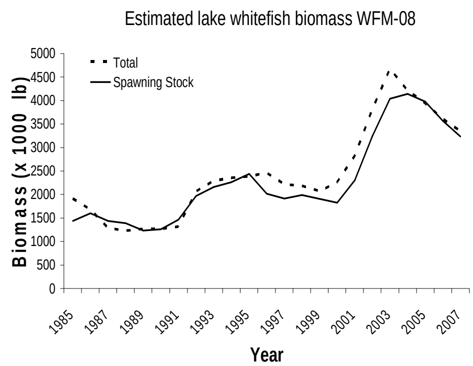
Overall, weight-at-age values in 2007 are relatively unchanged from 2006 and approximately 25 % lower than the long-term average for ages 4-9 from 1985 - 2006.



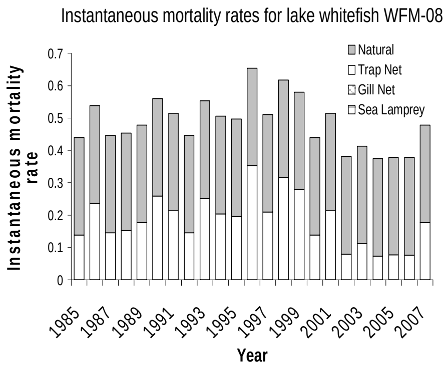
Recruitment, based on the estimated number of age-3 fish, was 322,940 in 2007. Estimates of recruitment were considerably higher during 1999-2003 (averaged 871,387 and peaked at 1,299,800), but the estimate for 2007 was slightly lower than the 1985-2006 average of 419,786 age-3 fish.



Up to 2003, estimates of total fishable biomass and spawning stock biomass continued 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 4.7 million lb in 2003 to an estimated 3.3 million lb in 2007. Spawning stock biomass followed a similar decline from 4.1 million lb in 2003 to 3.2 million lb in 2007. The ratio of spawning stock biomass to fishable biomass was close to 1.0 in 2007 (0.97), slightly higher than the 1985-2005 average ratio of 0.94.

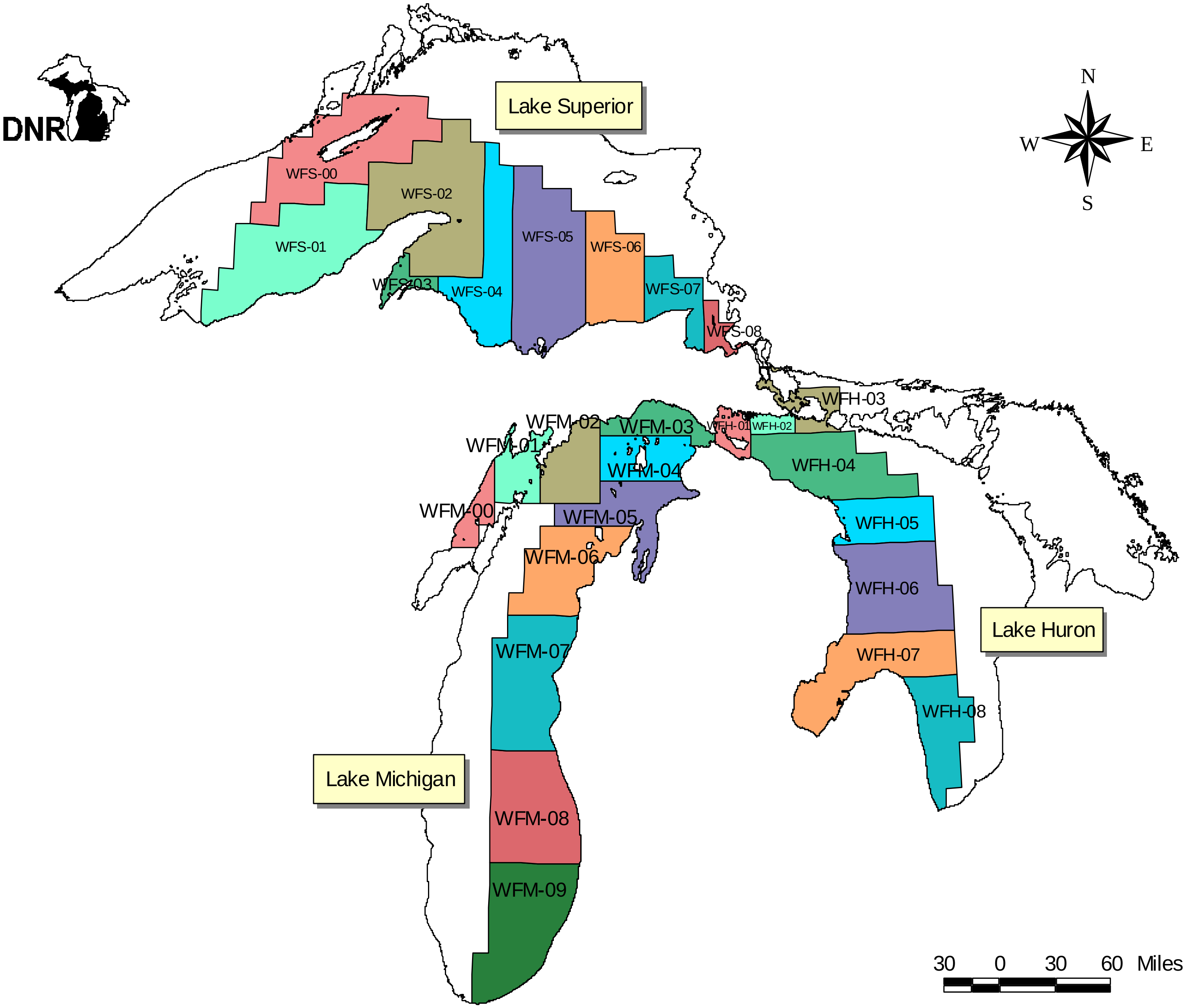


Mortality rates have been relatively stable throughout the time series. Instantaneous total mortality rate (Z) was estimated at 0.48 y^{-1} during 2007. Components of the total rate consisted of 0.18 y^{-1} for instantaneous trap-net-fishing mortality (F) and 0.30 y^{-1} for instantaneous natural mortality (M). Estimates of mortality have been very consistent from 1985-2006 and the ratio of F to Z averaged 0.39 from 1985 through 2007. 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-infinity) 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 2007, the growth parameters were estimated at 57.5 for L-infinity and 0.39 for K based on survey data for the most recent three-year time block (2005-2007). Per MSC recommendation future growth parameters will be based on data from the entire time series (1985-present) to better represent growth conditions for this stock.

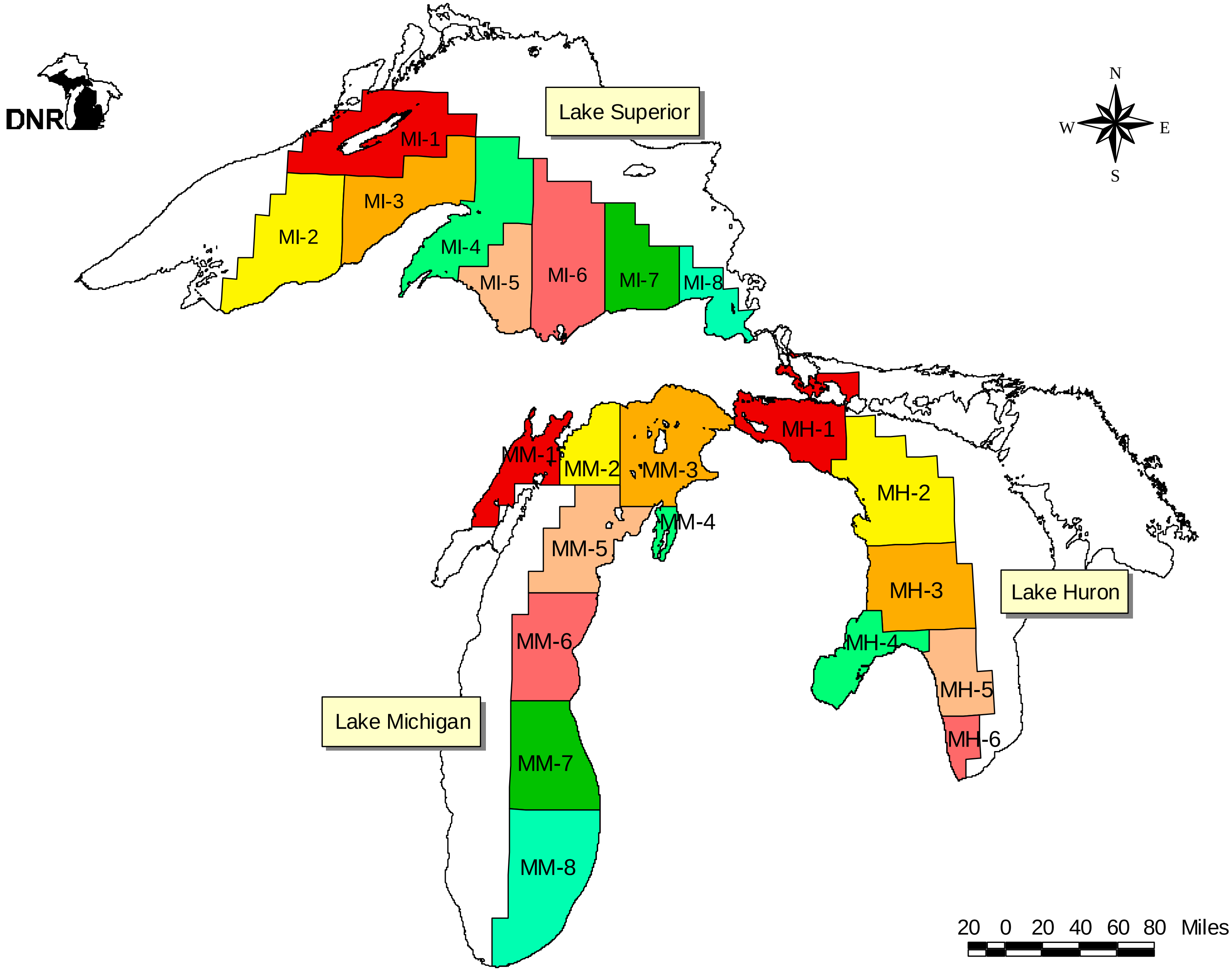


The 2009 yield limit for WFM-08 was 1.126 million lbs (500,000 for state-licensed fishers and 626,000 for tribal fishers), calculated using the projection model. This projected yield is close to the limit calculated for 2008 (1.335 million lb).

Summary Status WFM-08 Whitefish	**Value (95% Probability Interval)**
Female maturity	
Size at first spawning	1.03 lb
Age at first spawning	3 y
Size at 50% maturity	2.04 lb
Age at 50% maturity	4 y
Spawning stock biomass per recruit	
Base SSBR	3.22 lb (3.21 – 3.23)
Current SSBR	2.04 lb (1.89 – 2.27)
SSBR at target mortality	0.38 lb (0.36 – 0.44)
Spawning potential reduction	
At target mortality	0.63 (0.59 – 0.70)
Average yield per recruit	0.51 lb (0.42 – 0.56)
Natural mortality (M)	0.301 y^{-1}
Fishing mortality rates	
Age of full selection	
Fully selected age to gill nets	N/A
Fully selected age to trap nets	10 y
Gill net fishing mortality (F)	
Average 2005-2007, ages 4+	0 y^{-1}
Trap net fishing mortality (F)	
Average 2005-2007, ages 4+	0.102 y^{-1} (0.07 – 0.12)
Sea lamprey mortality (ML)	
(average 2005-2007, ages 4+)	N/A
Total mortality (Z)	
(average 2005-2007, ages 4+)	0.403 y^{-1} (0.38 – 0.43)
Recruitment (age 3)	
(average 1998-2007)	609,070 fish (556,276 – 829,697)
Biomass (age 3+)	
(average 1997-2006)	3,293,200 lb (2,913,950 – 4,178,590)
Spawning biomass	
(average 1998-2007)	3,022,800 lb (2,641,450 – 3,810,830)
Recommended yield limit in 2009	1,126,000 lb
Actual yield limit in 2009	1,126,000 lb



Appendix 1. Lake whitefish management units.



Appendix 2. Lake trout management units.