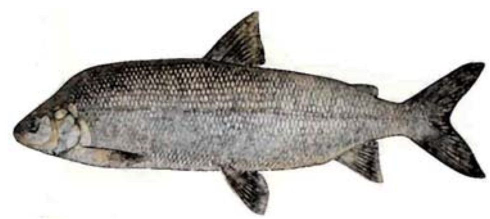
Technical Fisheries Committee Administrative Report 2007: Status of Lake Trout and Lake Whitefish Populations in the 1836 Treaty-Ceded Waters of Lakes Superior, Huron and Michigan in 2006, with recommended yield and effort levels for 2007



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

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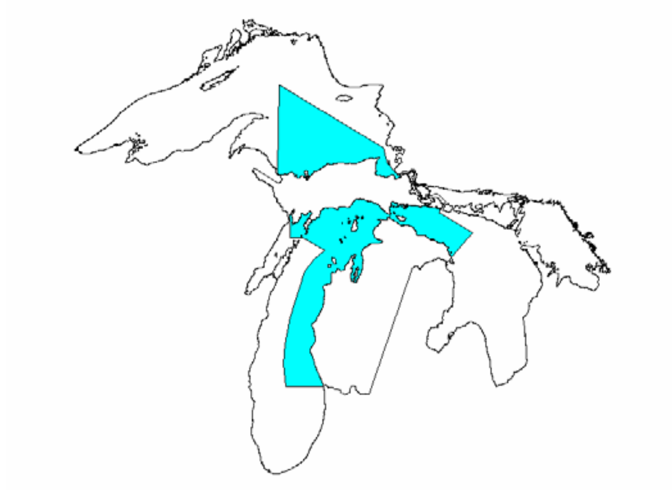
Editors



Recommended Citation formats:

Entire report: Modeling Subcommittee, Technical Fisheries Committee. 2009. Technical Fisheries Committee Administrative Report 2007: Status of Lake Trout and Lake Whitefish Populations in the 1836 Treaty-Ceded Waters of Lakes Superior, Huron and Michigan in 2006, with recommended yield and effort levels for 2007. http://www.michigan.gov/documents/dnr/2007-status-report_275666_7.pdf

Section: Woldt, A.P., Bence, J.R., and Ebener, M.P. 2008. Executive Summary in Woldt, A.P., and Caroffino, D.C. (eds.). Technical Fisheries Committee Administrative Report 2007: Status of Lake Trout and Lake Whitefish Populations in the 1836 Treaty-Ceded Waters of Lakes Superior, Huron and Michigan in 2006, with recommended yield and effort levels for 2007. http://www.michigan.gov/documents/dnr/2007-status-report_275666_7.pdf

Table of Contents

EXECUTIVE SUMMARY

Prepared by Aaron P. Woldt, James R. Bence, and Mark P. Ebener

In August 2000 the State of Michigan's Department of Natural Resources (MDNR), five tribes of the Chippewa/Ottawa Resource Authority (CORA), and United States Department of Interior's U.S. Fish and Wildlife Service negotiated an 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 Consent Decree states that mortality of lake trout shall be regulated with yield and effort limits in 1836 Treaty-ceded waters. In management units where the state and tribes both have commercial whitefish fisheries, the mortality of whitefish shall be regulated with yield limits. The Consent Decree provides specific guidelines on how these yield and effort limits should be calculated. A Modeling Subcommittee (MSC) of the Technical Fisheries Committee (TFC) was established and charged with developing the yield and effort limits required in the Consent Decree.

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. Where feasible we 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 us from developing reliable SCAA models in three lake whitefish units, so an alternative, descriptive approach was used. SCAA models resulted in estimates of abundance and mortality which were combined with growth and maturity data for whitefish and lake trout in each stock or management unit to project recommended yield levels for calendar year 2007. Recommended yield limits were obtained by either limiting mortality to a maximum rate, achieving a minimum spawning potential reduction, or projecting harvest for a specified level of fishing effort. The maximum allowable mortality rate (*A*) on whitefish was 65%, while the maximum mortality rate on lake trout was either 40 or 45%. In some areas the mortality rate was not considered for lake trout, and yields were instead tied to levels of fishing effort as part of a process for "phasing in" total mortality rate targets as specified in the Consent Decree. The target spawning potential reduction for whitefish ranged from 20 to 35%. Harvest limits were allocated to State and CORA fisheries for each stock following the percentages specified in the Consent Decree.

The 2007 MSC recommended harvest and effort 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. The two estimates marked with asterisks in the table below are based on 2007 fully-phased-in mortality rates and are included for comparison only.

Species	Lake	Management unit	MSC recommended yield limit (lb)	Actual yield limit (lb)	Gill net limit (ft)
Lake trout	Superior	MI-5	175,700	175,700	NA
		MI-6	106,000	106,000	4.43 million
		MI-7	154,300	154,300	23.29 million
	Huron	MH-1	190,900 (No TFC Consensus)	230,000	7.65 million
		MH-2	91,817	100,934	NA
	Michigan	MM-1,2,3	*8,400	503,000	9.36 million
		MM-4	*96,900 (No TFC Consensus)	Not finalized	0.53 million
		MM-5	135,400 (No TFC Consensus)	Not finalized	0.60 million
		MM-6,7	263,600	265,425	NA
Lake whitefish	Superior	WFS-04	119,000	119,000	NA
		WFS-05	403,000	403,000	NA
		WFS-06	no estimate	210,000	NA
		WFS-07	551,000	551,000	NA
		WFS-08	177,000	177,000	NA
	Huron	WFH-01	394,000	394,000	NA
		WFH-02	410,000	410,000	NA
		WFH-03	no estimate	306,000	NA
		WFH-04	597,000	597,000	NA
		WFH-05	889,000	889,000	NA
	Michigan	WFM-01	1,518,000	1,518,000	NA
		WFM-02	849,000	849,000	NA
		WFM-03	4,145,000	1,970,000	NA
		WFM-04	695,000	695,000	NA
		WFM-05	429,000	429,000	NA
		WFM-06	191,000	191,000	NA
		WFM-07	no estimate	500,000	NA
		WFM-08	1,131,000	1,131,000	NA

In April 2007, the TFC could not reach consensus on MSC recommended lake trout harvest limits for MH-1, MM-4, and MM-5. A final harvest limit for MH-1 was later set by the parties via Executive Council agreement (August 2007). To date, harvest limits have not been finalized for MM-4 and MM-5, and negotiations between the parties are ongoing. This is the second time under the 2000 Consent Decree that harvest limits for all lake trout units were not finalized by the parties prior to the end of a fishing season. In 2006, no final lake trout harvest limits were approved by the parties for MM-4 or MM-5.

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). Stability of the MI-6 model was increased in recent years by borrowing catchability parameters for the large-mesh survey in MI-5 due to lack of survey data in MI-6. In MI-5 and MI-7 recent mortality rates 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. There has been a general decline in size-at-age of lake trout across Lake Superior over the past 20 years, and tied to this is a shift toward later maturity. These changes in growth and maturation probably reflect increases in predator fish abundance and declines in the abundance of prey fish, most of which are less abundant than 20 years ago. Competitive effects of siscowet lake trout may also play a role. Lower growth rates have led to decreases in lake trout biomass in all modeled Lake Superior units. Commercial fishery harvests in MI-5 and MI-7 continue to be low. As a result, commercial monitoring data is scant or completely lacking for these units. This lack of data may soon cause convergence issues for the Lake Superior models. Sea lamprey-induced mortality continues to edge up in Lake Superior as well.

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. Lake trout mortality rates remain below target in both MH-1 and MH-2; however, rates have recently increased in MH-1. Reductions in fishing mortality resulting from reduced commercial effort and an effective size limit in the recreational fishery, coupled with sea lamprey control, should allow spawning stocks to continue to build in MH-1. A drastic decline in sea lamprey-induced mortality since 2000 in MH-2 is the main reason total mortality remains below target in this area. 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. Lake trout growth rates remain stable, but low. Also, the MSC is concerned with its abilities to accurately estimate survival and abundance of juvenile lake trout in Lake Huron based on survey catches. The MSC will explore methods to better estimate juvenile lake trout survival, and these alternative methods may impact harvest limits in future years.

In Lake Michigan units MM-1,2,3 and MM-4 lake trout mortality rates are above target rates due to recent substantial increases in sea lamprey-induced mortality. Biomass and spawning stock biomass in both units continue to increase in the face of high total mortality rates, but the majority of harvestable size fish are consumed by sea lampreys. A Consent Decree Amendment dated 4 April 2007 set the harvest limit in MM-1,2,3 at 453,000 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. Harvest limits are still being negotiated for MM-4.

In MM-5, mortality rates are less than the target rates for the fourth year in a row, indicating acceptable mortality levels despite a slight increase in sea lamprey-induced mortality. In MM-6,7, lake trout mortality rates continue to be well below target rates, and a slight decline in sea lamprey-induced mortality has also occurred.

In general, fishery exploitation in recent years has not been excessive on lake whitefish stocks, and total mortality is below target rates in all 15 units with functioning stock assessment models. However even though size-at-age stabilized or increased for many stocks in recent years, it has declined for most stocks over the past two decades. In a number of stocks this has been accompanied by a decline in fish condition (weight for a given length). These patterns are most evident in the Lake Michigan and Lake Huron management areas. Many stocks also experienced a decline in recruitment near the end of the time series used in the assessments, although recruitment levels seemed to stabilize for some stocks.

Although current total mortality is below target for all whitefish units, mortality rates may become excessive and decrease population abundance if harvest is maintained at recent levels in the face of declining or stable but low recruitment and growth. In addition, widespread declines in growth rates of lake whitefish are a concern, and further research on this is important for supporting management strategies.

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 the lack of available data. However, summaries for these units are still included in this document. In 2007, the WFH-03 and the WFS-06 HRGs were set equal to their respective 2006 levels. WFM-07 was not fished commercially between 1985 and 2000, but there has been a small amount of tribal commercial harvest in WFM-07 by the Little River Band of Ottawa Indians since 2001. In 2007 the WFM-07 HRG was based on the 2004 HRG which was calculated as the approximate average of the 2004 model-generated harvest limit for WFM-06 and WFM-08.

In addition to providing assessments for each stock, we also provide recommendations to the TFC to improve data collection and to improve the SCAA models. These recommendations include 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 curves, refining our methods of estimating lake trout recruitment, and developing methods of estimating time-varying catchability. The implementation of all these recommendations will take several years and will involve a significant and increased investment in staff, time, and other resources. The MSC continues to make progress by estimating throwbacks in the commercial fishery where appropriate (e.g. MH-1), measuring and adding hooking mortalities from the recreational fishery into the models as harvest, conducting fishery-independent lake whitefish surveys, performing sensitivity analyses of stock assessment models, performing retrospective analyses of stock assessment models, and completing studies in lakes Huron and Michigan to assess lake whitefish stock boundaries and movement.

The MSC also 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. Past

TFC approved use of projected commercial fishery yield for the last few months of the year based on historic patterns of the yield has helped the MSC meet deadlines, but more is needed. The MSC will again ask the TFC to consider a proposal for rotation of lake trout stock assessment models. Under this plan, the MSC would rotate updates of stock assessment models by lake on a 3-year cycle. We would still produce harvest limits for each unit in each year, but the stock assessment models would only be updated once every 3 years and annual harvest limits would be based on multiyear projections in 2 of 3 years. The time savings from not annually updating all stock assessment models could be used to make improvements to models, verify model performance, and conduct adequate model diagnostics. The proposed rotation techniques might also result in more stable harvest limit estimates from year to year.

We also want to urge parties to meet Consent Decree mandated data submission deadlines. Some parties have repeatedly missed data deadlines in the past. Doing so makes it nearly impossible for the MSC to provide yield and effort limits to the TFC and the parties by already short Consent Decree deadlines.

Finally, the MSC hopes to avoid going through another fishing season without finalized harvest limits for all lake trout stocks. Parties were able to finalize harvest limits for most lake trout stocks in 2007, but the fishing season was completed without final harvest limits for 2 Lake Michigan stocks. This process may lead to the unintentional overharvest of stocks if continued in the future.

STOCK ASSESSMENT MODELS

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

Overview

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.

The second task built from the first, by projecting the estimated fish population forward through the 2007 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-age model was fit to 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.

Sea lamprey mortality rates were not estimated during model fitting. Instead they were calculated based on observed wounding (sum of A1-A3 marks), as was done by Sitar et al. (1999). For a given size of lake trout, sea lamprey mortality was calculated by:

$$ML = w\frac{(1-p)}{p},$$

where w was the mean wounds per fish and p was an estimate of the probability of surviving an attack. Length-specific wounding rates were converted to age-specific rates using an age-length key.

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

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

where m is the average number of sea lamprey marks per fish, a is age class, t is year, and y is the time series under consideration. The time series varied somewhat by management unit but typically covered 1980-2003 in Lake Huron units. Essentially, the average marking rate on an age class was a function of the annual deviation in sea lamprey marking in a management 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 a probability of survival of 0.25 from 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. For stocked lake trout stocks, 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. 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, with deviations from recruitment expected based on a Ricker stock-recruit function (with parameters estimated during model fitting) being 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 not already needed for the population sub-model 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 2007 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 2007 Fishing Season

Starting with the estimates or projections of age-specific abundance at the start of 2007, 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 2007, but did not in 2007, 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 2007

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-5, 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-5 the target mortality rate was 45% and the allocation was 60% state and 40% tribal. In MM-67 the target mortality rate was 40% and the allocation was 90% state, 10% tribal. In MH-1, the interim target mortality was 47%, and the allocation was 8% state and 92% 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 portion of the reported yields. 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 2007 TACs for MH-1 and MM-1,2,3 were set in accordance with Court Orders and agreements between the Parties reached at Executive Council Meetings or other negotiations. Final harvest limits for MM-4 and MM-5 were not set and negotiations are ongoing.

The Final 2007 TACs for MM-6,7 and MH-2 were calculated per the Consent Decree. However, the 2007 TACs for these units decreased by more than 15% compared to the 2006 TACs. The TFC agreed to accept higher estimated TACs for these units in 2007 limited by a 15% decline from the 2006 TACs.

Lake whitefish recommended yields were calculated generally following the approach used for fully phased-in lake trout areas. Details differed because of the different way that target mortality was defined for whitefish, and because for most areas there was no specified allocation between state and tribal fisheries (WFS-05 was an exception). 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 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.

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.

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 Aaron P. Woldt, James R. Bence, and Mark P. Ebener

The MSC annually revises its list of recommendations to improve stock assessments. The revised list reflects improvements made since the assessments used to determine 2006 harvest limits, ongoing work to address assessment needs, and a prioritized ranking (HIGH, MEDIUM, LOW) of recommendations.

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. The MSC assigned a HIGH priority to determining the following:

   i. the significance of subsistence fishery harvests

   Tribes have made strides in tracking this harvest, but more work is needed to better quantify this for models/management units where subsistence fishing is significant.

   ii. the extent of discarding by commercial fisheries

   In 2002, CORA submitted a study plan to the TFC for calculating the number of lake trout discards in the commercial fishery in MH-1. This plan could be used for other management units where necessary.

   iii. the significance of recreational fishing for lake whitefish

   In 2002, Michigan compiled data showing yearly recreational harvest of lake whitefish in Treaty waters. After reviewing these data, the MSC determined that harvest was large enough in WFH03, WFM05, WFS05, and WFS06 to include in assessment models. At the MSC's request, the state of Michigan planned winter creel surveys in some of the above units to estimate lake whitefish harvest in the ice fishery. Continued assessment is needed.

   iv. the magnitude of recreational catch and release and associated hooking mortality

   The state of Michigan creel program now 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. Once implemented, this study design will allow the MSC to better estimate a hooking mortality rate. Currently the models use a rate of 15% based on Loftus (1986).

- 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 new tagging studies designed as needed. The MSC assigned a HIGH priority to this recommendation.

  Two basin-wide lake whitefish tagging studies in lakes Michigan and Huron began in 2003 and will help yield estimates of *M*. Tagging for these studies finished in fall 2005.

- 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. The MSC assigned a HIGH priority to this recommendation.

  Two basin-wide lake whitefish tagging studies in lakes Michigan and Huron began in 2003 and will help delineate lake whitefish stock boundaries. Tagging for these studies finished in Fall 2005.

- The lake whitefish models continue to need "indices of abundance" based on fishery independent survey data. The MSC developed a sampling protocol for lake whitefish that was implemented on all lakes in 2002. Conducting this survey and incorporating its results into the lake whitefish models continues to be a HIGH priority for the MSC.

- Improved approaches for estimating the most recent year's lake trout yield need to be investigated. At the time assessment models are constructed, final yearly harvest estimates are not available because commercial catch reports have not all been turned in. In 2002, CORA began providing the MSC with projected year end lake trout harvest for the most recent year based on patterns in historic harvest data. The reliability of this approach needs to be evaluated. The MSC assigned a HIGH priority to this recommendation.

  Both CORA and Michigan are exploring ways to speed up the processing of commercial catch reports.

- Currently lake trout relative abundance indices (CPUE) used in SCAA models are pre-processed outside the models using mixed-model analysis. The assumptions underlying these mixed-models need to be reviewed and improvements made when appropriate. The MSC assigned a MEDIUM priority to this recommendation.

A graduate student at Michigan State University (MSU) continues to explore this issue.

- Estimates of uncertainty for all data used in models should be estimated when possible. The MSC assigned a MEDIUM priority to this recommendation.

- 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. The validity of this assumption needs to be assessed. The MSC assigned a LOW priority to this recommendation.

Models

- The overall approach in the SCAA models to estimate fishery selectivity needs to be evaluated, and alternative approaches should be considered. Currently the models use either a single or double logistic function of age. Alternative age-specific functions should be considered. Furthermore, some of the SCAA models have time-varying selectivity by assuming that one of the selectivity parameters varies over time following a polynomial function. Alternative approaches (such as using a random walk for this variation) should be evaluated. The MSC assigned a MEDIUM priority to this recommendation.

  A graduate student at MSU is currently exploring this issue.

- The assumption that fishery and survey catchability is constant in the SCAA models needs to be evaluated. Alternatives include allowing catchability to vary over time following a random walk or in response to population density. The MSC assigned a MEDIUM priority to this recommendation.

  A graduate student at MSU is currently exploring this issue

- Alternative approaches to weighting likelihood components needs to be reviewed. It is possible that some weighting factors could be improved using other statistical approaches. The MSC assigned a MEDIUM priority to this recommendation.

  A graduate student at MSU is currently exploring this issue

- Current approaches to modeling and estimating recruitment need to be reviewed. The MSC assigned a MEDIUM priority to this recommendation.

- The procedures to convert fishery yield to numbers of fish harvested for comparison with SCAA model predictions needs to be reviewed. The current approach is to divide annual reported fishery yield by the annual average weight of a harvested fish. The average weight of a harvested fish is poorly estimated in some years. An alternative is to convert predicted numbers harvested to yield based on weight-at-age data, which may be a better estimate. The MSC assigned a MEDIUM priority to this recommendation.

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. The MSC moved this date to February 15 to allow additional time to run the SCAA models and calculate harvest limits. The MSC also set the second full week in March for its 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 - Currently CORA cannot be ready by February 15. These numbers need to be made available in a more timely and accurate fashion.

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

2. Biological data-commercial: 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.

3. Biological data-recreational: These data can be available by February 15. Occasionally Lake Superior data 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.

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. We will use a general linear model to estimate CPUE.

   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 can 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. The MSC moved this deadline to August 1 to allow additional time for calculating harvest limits. Because of the one year time lag, data are usually available by the data submission deadline. The MSC also set the third full week in September for its 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

- The MSC recommends that in addition to this status of the stocks report (termed short report), a second report for the 2001 assessments be written that documents and describes in detail the modeling methods used (termed long report). The 2001 long report is currently being written. We recommend the short report be produced annually and include text describing any changes in the modeling process for a given management unit and species. The long report will be produced periodically following substantial changes in methods used to produce harvest limits.

- The MSC continues to be concerned about the short time frame between data availability and the deadline for lake trout harvest and effort limits. The time period between the data submission deadline and the deadline for preliminary harvest limits is too narrow to allow sufficient model analysis, diagnostics of model convergence, and estimation of harvest limits. Given the life history of lake trout, it may be reasonable to either update the lake trout models every 2-3 years or update them with a one-year lag for some data sources.

- In the future, the MSC may need to consider alternative harvest limit setting policies (e.g. conditional constant catch) for some units in 1836 Treaty waters. There are a number of alternative policies that could be evaluated that might help stabilize year-to-year variation in harvest limits while still protecting the biological integrity of stocks, especially for units where stock assessment models are currently problematic for the MSC.

Alternative harvest limit policies will be evaluated by a graduate student at MSU.

- The MSC will review fall lake trout data available from all agencies and determine the utility of including these data in the lake trout catch-at-age models. Fall age composition data may be particularly useful in characterizing the age structure of modeled populations.

- Age composition and commercial yield are the data that generally limit producing timely results. Above we have suggested an approach for providing commercial yield data sooner. In some areas age compositions may not be available when harvest limit calculations begin; we recommend proceeding without the most recent year's data in these cases.

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STATUS OF LAKE TROUT POPULATIONS

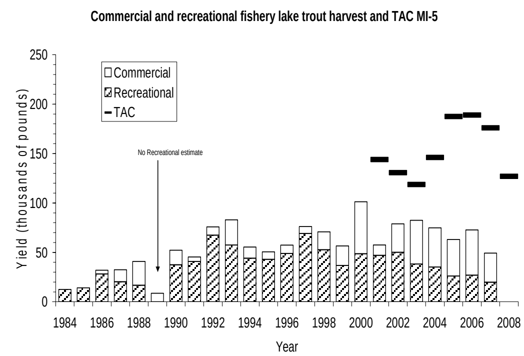
Lake Superior

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 down past 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 2002 to 2006, tribal yield averaged 39,000 round lb and tribal large mesh gill net effort averaged 657,000 ft per year.

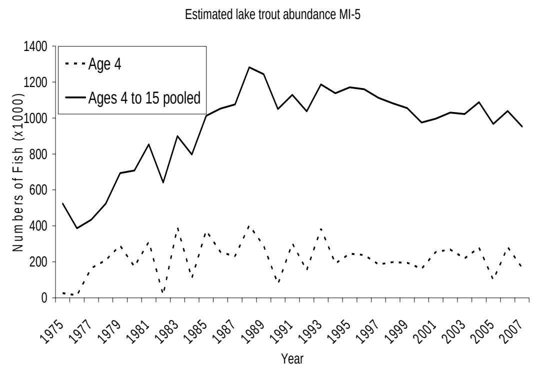


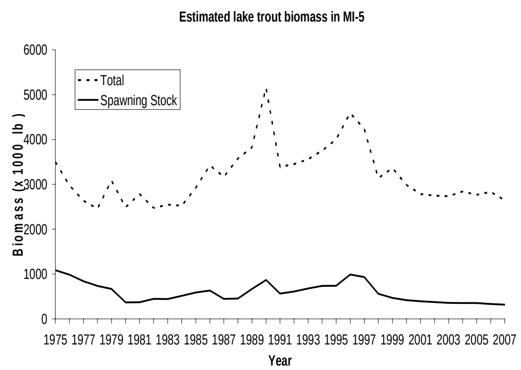
Generally, the fishery is conducted from late winter through early October, with a dome shaped selectivity with peak age between 7 and 10. The commercial fishery operates in various grids near Marquette, and the overall impacts on the MI-5 population are nominal. However, in 2000 and from 2003 through 2006, 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.

The commercial fishery age composition during the years that spawning lake trout were allowed to be harvested was skewed right with peak age being 15 years or older. During the years with commercial harvest during the spawning season at this site, instantaneous commercial fishing mortality rates (F_C) on age 15 and older fish ($F_{C,2000}$=0.21 year^{-1}; $F_{C,2003}$=0.12 year^{-1}; $F_{C,2004}$=0.12 year^{-1}; $F_{C,2006}$=0.15 year^{-1}) were higher than all younger ages and were more than 10-fold higher than all other years. The increased fishing mortality on spawners has affected the size-structure of the Presque Isle Harbor reefs lake trout. The proportion of large lake trout (> 700 mm) collected in MDNR fall surveys at the Presque Isle Harbor reefs has progressively declined from 44% in 2003 to 30.8% in 2006. Furthermore, relative abundance based on sampling of spawning lake trout by the MDNR has declined since 2000 in Presque Isle Harbor.

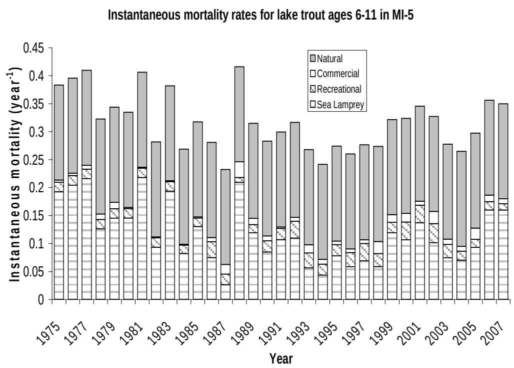
Recreational harvest of lake trout comprises both charter and sport angler fisheries. Most of this activity is centered around the port of Marquette, though some lake trout are harvested at Stannard Rock, an offshore reef. There are no seasonal restrictions on the sport fishery, though most of the fishery 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 and has been declining since 2002. Average harvest during 2002 to 2006 was 10,000 fish (35,300 lb) per year. Recreational effort has declined from 146,000 angler hours in 1986 to 37,000 angler hours in 2006.

Abundance of wild lake trout increased more than two-fold since 1975 and has averaged about 1 million fish (age 4 and older) during 1997 to 2006. Total biomass of age 4 and older lake trout averaged 3 million lb during 1997-2006. Lake trout biomass declined from 4.4 million lb in 1996 to 3 million lb in 2006. Spawning stock biomass averaged 437,000 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.



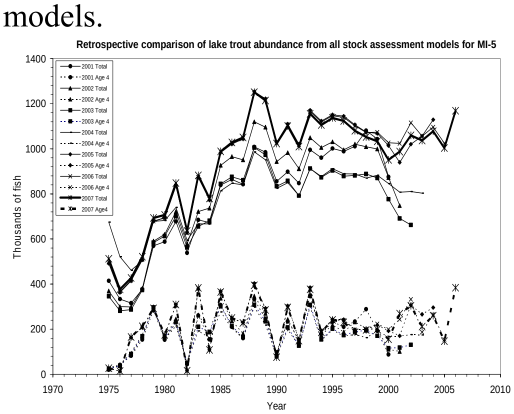


Apart from background natural mortality, sea lamprey-induced mortality was the dominant mortality source since 1975, although mortality from this source has declined since the late-1980s. With the exception of 1988 and 2005, recreational fishing mortality has been higher than commercial fishing mortality. Average total annual mortality (A) for age 6 to 11 lake trout has declined from 33% during 1975 to 1977 to 25% during 2004 to 2006. Spawning stock biomass produced per recruit during 2004 to 2006 has been above the target minimum value indicating that mortality rates are not excessive and there is good population reproductive potential.



Model changes

No major changes were made from last year's SCAA model. As with last year's model, probability intervals were not able to be calculated because of poor results from Markhov Chain Monte Carlo (MCMC) simulations. Further work is underway to improve the MCMC results. Summary table quantities are reported with asymptotic standard errors. The 2007 model had consistent abundance estimates when compared to the 2006 model estimates. However, the 2005, 2006, and 2007 models had higher abundance estimates than earlier assessment models. However, there were no systematic temporal patterns in estimates of abundance across stock assessment models.



The recommended yield limit for 2007 in 1836 Treaty waters is 175,700 lb, allocated as 168,200 lb for the state recreational fishery and 7,500 lb for the tribal fishery. This recommended yield limit was based on the target mortality rate of 45% defined in the Consent Decree, allocating 40% of the total yield 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 90% of the total yield.

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	4.636 lb (SE 0.471)
Current SSBR	1.69 lb (SE 0.15)
SSBR at target mortality	0.437 lb (SE 0.011)
Spawning potential reduction	
At target mortality	0.366 (SE 0.017)
Average yield per recruit	0.519 lb (SE 0.059)
Natural mortality (M)	0.173 y^{-1}
Fishing mortality	
Age of full selection	
Commercial fishery (2004-2006)	15
Sport fishery (2004-2006)	8
Commercial fishing mortality (F)	
Average 2004-2006, ages 6-11	0.014 y^{-1} (SE 0.002)
Sport fishing mortality (F)	
Average 2004-2006, ages 6-11	0.015 y^{-1} (SE 0.002)
Sea lamprey mortality (ML)	
Average 2004-2006, ages 6-11	0.068 y^{-1}
Total mortality (Z)	
Average 2004-2006, ages 6-11	0.268 y^{-1} (SE 0.009)
Recruitment (age-4)	
Average 1997-2006	231,120 fish (SE 32,928)
Biomass (age 3+)	
Average 1997-2006	3,008,600 lb (SE 351,490)
Spawning biomass	
Average 1997-2006	437,130 lb (SE 54,845)
Recommended yield limit in 2007	175,700 lb

MI-6 (Au Train - Munising)

John K. Netto

The model generated harvest limit for MI-6 was 106,000 lb, with 53,000 lb each being allocated to CORA and the State. A complete description of the status of the lake trout stock and the modeling process used to generate the TAC is not available as the author did not submit the required report.

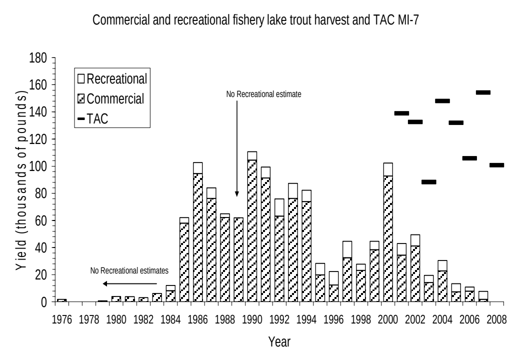
MI-7 (Grand Marais)

Prepared by Shawn P. Sitar and John K. Netto

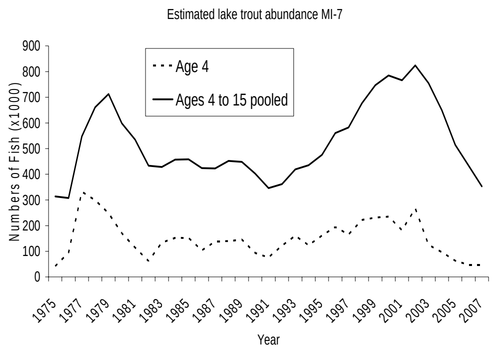
Lake trout management unit MI-7 extends from Au Sable Point (west of Grand Marais) to Little Lake Harbor (east of Grand Marais), encompassing 987,000 acres. This management unit has complex bathymetry with many lacustrine ridges, trenches, and slopes. There is approximately 92,000 acres of lean lake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

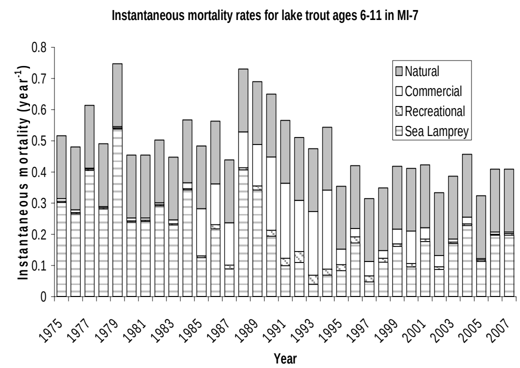
The commercial fishery that harvests lake trout is a tribal large-mesh gill-net fishery that is mostly based out of Grand Marais. This fishery mainly targets lake whitefish with lake trout as bycatch. Between 1976 and 2005, tribal commercial yield of wild lake trout peaked in 1990 at 104,400 lb and declined to 12,400 lb in 1996. In the last three years, average yield was 12,700 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 2004 to 2006 has averaged 1.8 million ft. Presently, there is only one commercial operator in MI-7.

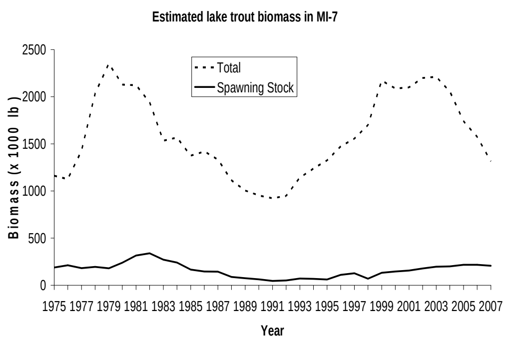
The standardized creel survey began at Grand Marais in 2001. Sport harvest and effort in MI-7 for years prior to 2001 were estimated using the average sport CPUE and effort index ratio between MI-7 to MI-5 from MIDNR creel mail survey data from 1971 to 1982 applied to MI-5 sport harvest and effort during 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 harvest of wild lake trout during 2004 to 2006 was 1,500 fish (5,500 lb). The average sport effort for the same time period was 18,700 angler hours.



Abundance of age-4 and older wild lake trout averaged 687,000 fish during 1997 to 2006. In the same time period, recruitment at age 4 averaged 178,000 fish. Stock size increased steadily between 1992 and 2000. Abundance has declined since 2003 due to the combination of increases in sea lamprey-induced mortality, which doubled between 2002 and 2004 and declines in recruitment since 1999. Both sea lamprey-induced and commercial-fishing mortality declined significantly in the first half of the 1990s. However, in recent years sea lamprey mortality has increased. Spawning stock biomass averaged 167,000 lb during the last ten years and represented 8.5% of total stock biomass.







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 during 1990 to 1994. Commercial fishing mortality declined during 1995 to 1998, and increased between 1999 and 2002. In recent years, commercial fishing has declined to very low levels. Sea lamprey mortality has increased by more than two fold since 1997 and has nearly tripled in 2004. During 1975 to 1979, total annual mortality (*A*) for age 6 to 11 lake trout averaged 44%. During the last five years, average *A* was 31%. The current spawning stock biomass per recruit (SSBR) estimate for MI-7 is above the target value, indicating that mortality rates are not exceeding the target.

<u>Notable stock dynamics</u>

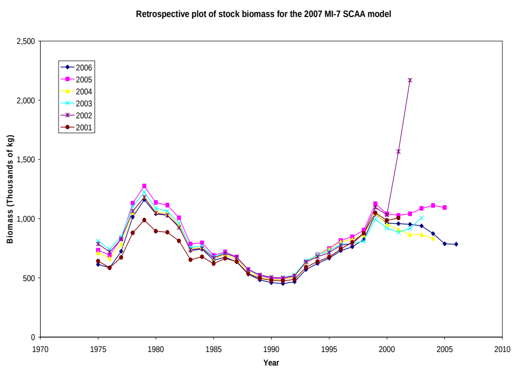
No commercial monitoring data were available for 2004-2006. Total commercial yield declined to near zero in 2005 and 2006. Recent increases in sea lamprey-induced mortality have caused the reduction in stock size and TAC. Furthermore, there was a 40% decline in recruitment at age-4 between 2002 and 2003.

<u>Model changes</u>

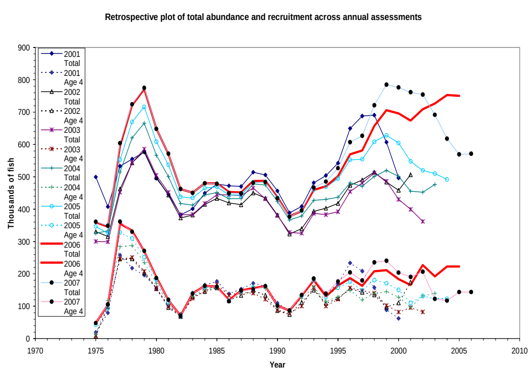
No structural changes were made to the MI-7 SCAA model for the 2007 assessment.

<u>Diagnostics and uncertainty</u>

The final 2007 model reached convergence with acceptable maximum gradient components, and reasonable asymptotic standard errors on parameter estimates. No major patterns in residuals were observed for fit to observed data sources. The MCMC simulations yielded good results without autocorrelations and no drift in the trace plots for all variables evaluated. In the retrospective analysis of the 2007 model, there were no systematic temporal patterns in biomass estimates, though there were some differences in biomass estimates for recent years.



There were no systematic patterns when comparing year 2000 abundance estimates from the past six stock assessments. However, there were major departures in abundance estimates across the 2005 through 2007 assessments.



The recommended yield limit for the year 2007 is 154,300 lb with 46,300 lb allocated for state recreational yield and 108,000 lb for tribal commercial yield. 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 3% 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.

Summary Status MI-7 Lake Trout 2007	Value (Standard Error)
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	3.582 lb (SE 0.442)
Current SSBR	1.1 lb (SE 0.1)
SSBR at target mortality	0.516 lb (SE 0.018)
Spawning potential reduction	
At target mortality	0.307 (SE 0.013)
Average yield per recruit	0.118 lb (SE 0.027)
Natural mortality (M)	0.210 y^{-1}
Fishing mortality	
Age of full selection	
Commercial fishery (2004-2006)	8
Sport fishery (2004-2006)	8
Commercial fishing mortality (F)	
Average 2004-2006, ages 6-11	0.012 y^{-1} (SE 0.003)
Sport fishing mortality (F)	
Average 2004-2006, ages 6-11	0.005 y^{-1} (SE 0.001)
Sea lamprey mortality (ML)	
Average 2004-2006, ages 6-11	0.127 y^{-1}
Total mortality (Z)	
Average 2004-2006, ages 6-11	0.355 y^{-1} (SE 0.012)
Recruitment (age-4)	
Average 1997-2006	178,430 fish (SE 39,178)
Biomass (age 4+)	
Average 1997-2006	1,957,600 lb (SE 398,330)
Spawning biomass	
Average 1997-2006	167,210 lb (SE 38,477)
Recommended yield limit in 2007	154,300 lb

Lake Huron

MH-1 (Northern Lake Huron)

Prepared by Aaron P. Woldt and Ji X. He

Lake trout management unit MH-1 is located in northern Lake Huron and extends from the Mackinac Bridge south to the border between grids 607 and 608, encompassing statistical district MH-1 and adjacent Canadian waters (Canadian management area 4-1). The management unit has a wide bathymetric range with areas in grids 407 and 408 as deep as 426 ft. The Michigan portion of this unit lies completely within 1836 Treaty-ceded waters, covering 1,017,640 acres of which approximately 681,720 acres are less than 240 ft in depth. On the Michigan shore this unit encompasses the ports of Saint Ignace, Mackinaw City, Cheboygan, Hammond Bay, and Rogers City. The St. Marys River, connecting Lakes Superior and Huron, flows into Lake Huron in grid 306. The St. Marys River had supported large spawning runs of sea lamprey, and until the late 1990s the resulting larval populations were untreated and contributed substantial numbers of parasitic-phase sea lamprey to the lake. Comprehensive treatment of the river by the Great Lakes Fishery Commission's control agents has reduced the number of sea lamprey produced in the St. Marys River, and decreases in lake trout wounding and sea lamprey-induced mortality rates are being documented in northern Lake Huron. The majority of Lake Huron's historically important lake trout spawning reefs and shoals are located in MH-1. The Drummond Island Refuge is located in grids 307, the northern ½ of grid 407, and Michigan waters of grids 308, 408, 409, and 410, and covers 177,840 acres of 1836 Treaty-ceded waters. Retention of lake trout in the refuge is strictly prohibited.

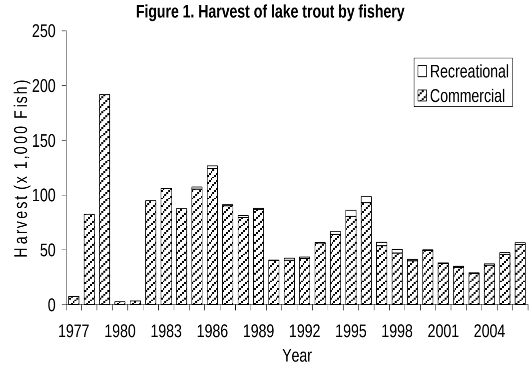
There is little or no natural recruitment of lake trout in northern Lake Huron, although recent indicators (increased trawl catches of age-0, increased CPUE's of unclipped, spawning adults) suggest natural recruitment may be on the rise. As a result, nearly all of the lake trout harvest is comprised of hatchery fish. The United States Fish and Wildlife Service annually plants lake trout in MH-1. From 2002 to 2006, approximately 511,000 yearling lake trout were planted annually in MH-1. Under the 2000 Consent Decree, stocking was increased in MH-1 to levels prescribed in the Lake Huron Committee's Lake Trout Rehabilitation Guide. In 2006, approximately 517,000 yearling lake trout were stocked into MH-1. After adjusting for post stocking survival and immigration and emigration based on coded-wire-tag data, the MH-1 model estimated 581,000 yearling lake trout recruits in MH-1 for 2006.

Both commercial and recreational lake trout fisheries exist in MH-1. Tribal commercial fishers deploy trap nets and large-mesh gill nets (4.5 inch stretch) that target lake whitefish and salmon, and small-mesh gill nets (2.5-3.0 inch stretch) that target bloater chubs. Lake trout are caught in these fisheries as bycatch and can be marketed by tribal fishers under CORA regulations. No State-licensed commercial fishers operate in MH-1. The Consent Decree prohibits State-licensed commercial fishing north of the 45th parallel in Lake Huron. Previous to August 2000 one State-licensed fisher operated a trap-net operation in MH-1. This operation targeted lake whitefish and was not allowed to market lake trout bycatch. All lake trout were returned to the water, regardless of condition.

Although few lake trout have been stocked in Canadian waters adjacent to MH-1, this region was included in the assessment model because there is a substantial commercial fishery for lake trout. This means that lake trout extractions from Canadian management area 4-1 were included in the data, and estimates of yields and recruitment into this area (primarily the result of movement from other areas) were also included. From 2002 to 2006, tribal commercial yield of lake trout averaged 149,000 lb, while Canadian commercial yield averaged 23,000 lb. Because CORA implemented a 400 lb daily bag limit (later changed to 500 lb) in 2002 for tribal large-mesh gill-net fishers in US waters of MH-1, the tribal harvest from 2002 to 2006 includes an estimate of throwback mortality (i.e. fish that were thrown back but later died due to handling). The majority of tribal lake trout yield (94%) came from the large-mesh gill-net fishery. Tribal large-mesh gill-net effort averaged 6.1 million ft from 2002 to 2006, while Canadian large-mesh gill-net effort averaged 1.7 million ft. With the implementation of the 2000 Consent Decree, tribal large-mesh gill-net effort has declined in MH-1. Large-mesh gill-net effort in 2006 dropped by 7.3 million ft (54%) from the 2000 effort level. Lake trout harvest in large-mesh gill-nets initially dropped under the Decree, but the 2004, 2005, and 2006 large-mesh gill-net harvests exceeded the 2000 harvest.

The State-licensed recreational fishery in MH-1 is composed of both charter and non-charter anglers. Lake trout are caught as bycatch by salmon anglers, but some anglers target lake trout by fishing the lower parts of the water column. A limited number of subsistence fishing permits are also issued to tribal members in 1836 Treaty-ceded waters. Recreational harvest represents a small portion of the total fishery harvest in MH-1 (Figure 1). From 2002 to 2006, recreational yield of lake trout averaged 3,900 lb. In 2006, recreational harvest was 7,000 lb in MH-1. Starting in 2001, the State of Michigan raised the minimum size limit for lake trout in the recreational fishery from 10 inches to 20 inches in areas north of 44° 50’ N latitude. Starting in 2003, the State of Michigan imposed a 15 - 19 inch slot limit in MH-1. All fish outside the slot were non-legal, except for one fish daily that may be 34 inches or larger. In 2006, the State of Michigan imposed a 22 inch minimum size limit for lake trout in the recreational fishery. These regulations are intended to keep harvest below the State share of the MH-1 harvest limit. Due to these more restrictive State regulations, 2003-2006 State harvest includes an estimate of throwback mortality.

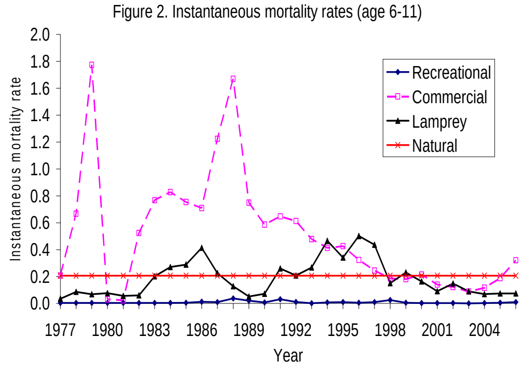
Figure 1. Harvest of lake trout by fishery



Instantaneous mortality rates have been variable and relatively high in northern Lake Huron (Figure 2). From

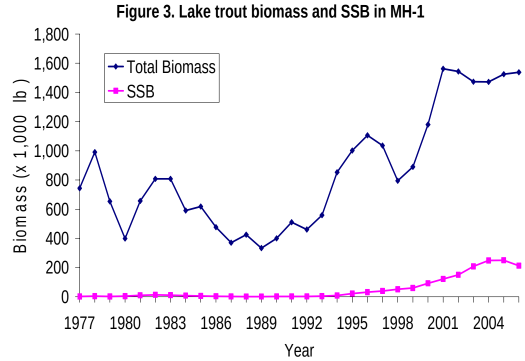
1977 to 1993, commercial fishing mortality was the leading source of lake trout mortality. After 1993, commercial fishing mortality decreased as sea lamprey-induced mortality increased. Sea lampreys were the largest source of lake trout mortality in the 1990s, until 1998 when sea lamprey-induced mortality decreased. From 2002 to 2006 sea lamprey-induced instantaneous mortality averaged 0.09 y^{-1}, and commercial fishing instantaneous mortality averaged 0.17 y^{-1}. Sea lamprey-induced mortality rates for age-6 to 11 lake trout in 2006 decreased 76% from the average of 1994-1998 levels. This decline is due to the treatment of the St. Marys River and subsequent reduction in parasitic phase sea lamprey. Recreational fishing mortality was low in all years relative to commercial fishing mortality in northern Lake Huron (Figure 2).

Figure 2. Instantaneous mortality rates (age 6-11)



In the 1980s and early 1990s, high rates of both sea lamprey-induced and commercial fishing mortality caused the age structure in northern Lake Huron to be truncated just before the age of first maturity. As a result, spawning stock biomass (SSB) has been extremely low in northern Lake Huron (Figure 3). However, since 1998 total lake trout biomass and SSB have been steadily increasing. Total biomass seems to have leveled off since 2001, but its current value is higher than any in the modeled time series. Much of this increase is due to lower rates of commercial and sea lamprey-induced mortality and increased stocking in MH-1. Total 2006 lake trout biomass was 1.54 million lb, well above the most recent 20-year average of 952,000 lb, and one of the highest levels in the modeled time series. However, total 2006 SSB was only 213,000 lb indicating the majority of lake trout biomass in MH-1 is composed of young fish. Increases in abundance of older age classes will be needed to create a naturally-producing, self-sustaining stock.

Figure 3. Lake trout biomass and SSB in MH-1



The Modeling Subcommittee of the TFC recommends a lake trout harvest limit of 190,900 lb for MH-1 in 2007. This harvest was calculated using the interim target total annual mortality rate of 47% and 2007 allocation percentage (92% for tribal harvest and 8% for the State) as outlined in Section VII.A.7.d of the Consent Decree. Based on these calculations, the total yield was allocated 15,300 lb to the State and 175,600 lb to the tribes.

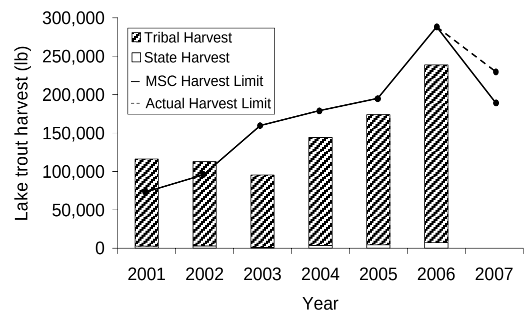
In 2001 the MH-1 harvest limit was calculated based on the phase-in requirements of the Consent Decree. In particular, it was based on the average effort from 1997 to 1999, either adjusted for gill-net operations converted to trap nets under provisions of the Consent Decree (tribal commercial fishery) or changes in regulations (State recreational fishery). The Consent Decree states that this technique should be used to calculate the MH-1 harvest limit through 2005. However, due to changes in lake trout stock dynamics in MH-1 caused by larger than expected decreases in sea lamprey-induced mortality, calculating the 2002 to 2005 harvest limits using the phase-in method described in the Decree results in projected total annual mortality rates that fall below the target specified in the Decree.

In February 2003 the Executive Council of the 2000 Consent Decree instructed the MSC to calculate lake trout harvest limits using interim total annual mortality rates in units where conformity to Consent Decree provisions resulted in harvest limits based on total annual mortality rates below target. As a result, since February 2003 MH-1 harvest limits have been calculated using the Consent Decree specified interim target mortality rate for 2006-2011 of 47%, and the 2006 allocation percentage of 92% Tribal 8% State.

Current spawning stock biomass per recruit (SSBR) is above SSBR at target mortality, indicating total annual mortality rates are below the interim target of 47% total annual mortality. This is due to harvest reductions along with reductions in sea lamprey mortality due to the treatment of the St. Marys River. If mortality rates remain low, stock biomass and spawning stock biomass should continue to increase.

Both tribal and State harvests were lower than their respective harvest limits in 2006 (Figure 4). In general, total harvest in this unit has increased under the 2000 Consent Decree, as has the total harvest limit. This is due to increased lake trout biomass due to reductions in total annual mortality and increased stocking. In 2007 for the first time under the Decree, the MSC recommended harvest limit dropped relative to the previous year. The total MSC recommended harvest limit dropped 99,300 lb from 2006 to 2007.

Figure 4. Yearly harvest and harvest limits



Last year, the MSC informed the TFC and the parties that it was not comfortable with the magnitude of the harvest level increase from 2005 to 2006 in MH-1, especially after a period of relative stability from 2003 to 2005 and given that a harvest limit increase of similar magnitude did not occur in MH-2 in 2006. For the 2007 harvest limit model, the MSC implemented methods (described below) in the model to better estimate survival and abundance of juvenile lake trout and more realistically match relative abundances seen in survey catches. The MSC felt that it might have been overestimating survival of age 1 to 2 lake trout in previous model runs.

Due to concerns over the drop in the MSC recommended harvest limit and concerns about juvenile lake trout survival, in August 2007 the Executive Council of the 2000 Consent Decree amended the Decree and set the 2007-2009 MH-1 harvest limit as follows:

> *The Tribes' lake trout harvest limit for unit MH-1 (including the Bay Mills Small Boat Zone) shall be 210,000 pounds plus estimated throwback mortality, and the State's*

lake trout harvest limit shall be <u>20,000</u> pounds.

As part of this amendment, the parties also agreed to improve data collection and methodologies to better estimate throwback mortalities and juvenile lake trout survival during 2007-2009.

<u>Model changes</u>

To address the estimated juvenile survival issues described above, we coded this year's assessment model to estimate time varying survival from age 1 to 2 as a bounded vector. We stopped using the post stocking survival vector as in previous model runs. Also, in 2007 we modeled time varying selectivity in the commercial and recreational fisheries as a random walk function and set maximum age specific selectivity as 1 for each year.

Changes made for past TAC-year models were maintained in the current model. These changes include modeling time varying selectivity in the spring survey as a random walk function starting with the 2006 TAC-year model, introducing time-varying maturity and weight-at-age in the model input data starting with the 2005 TAC-year model, and allowing the model to select the peak age of fishery selectivity, setting the under-reporting vector for the tribal commercial fishery to zero, and including release mortalities from the recreational fishery in harvest totals starting with the 2004-TAC year model.

Summary Status MH-1 Lake Trout	**Value (Standard Error)**
Female maturity	
Size at first spawning	1.27 lb
Age at first spawning	3 y
Size at 50% maturity	3.94 lb
Age at 50% maturity	6 y
Spawning stock biomass per recruit	
Base SSBR	3.799 lb (SE 0.624)
Current SSBR	0.660 lb (SE 0.150)
SSBR at target mortality	0.483 lb (SE 0.071)
Spawning potential reduction	
At target mortality	0.173 (SE 0.026)
Average yield per recruit	0.506 lb (0.080)
Natural mortality (M)	0.206 y^{-1}
Fishing mortality	
Age of full selection	
Commercial fishery (2004-2006)	7 y
Sport fishery (2004-2006)	7 y
Commercial fishing mortality (F)	
Average 2004-2006, ages 6-11	0.240 y^{-1} (SE 0.044)
Sport fishing mortality (F)	
Average 2004-2006, ages 6-11	0.007 y^{-1} (SE 0.002)
Sea lamprey mortality (ML)	
Average 2004-2006, ages 6-11	0.072 y^{-1}
Total mortality (Z)	
Average 2004-2006, ages 6-11	0.498 y^{-1} (SE 0.048)
Recruitment (age-1)	
Average 1997-2006	525,730 fish (SE 0)
Biomass (age 3+)	
Average 1997-2006	1,198,800 lb (SE 58,087)
Spawning biomass	
Average 1997-2006	116,680 lb (SE 11,166)
MSC recommended yield limit for 2007	190,900 lb
Actual yield limit for 2007 (Based on August 2007 Decree amendment)	230,000 lb (plus est. tribal throwbacks)

MH-2 (North-central Lake Huron)

Prepared by Aaron P. Woldt and Ji X. He

Lake trout management unit MH-2 is located in north-central Lake Huron. It includes statistical district MH-2 (grids 409-410, 509-512, 608-614, 709-715, 809-815, and 909-915 for a total of 1,521,520 acres) as well as adjacent Canadian waters (areas 4-2, 4-3, and 4-7 for a total of 1,526,460 acres). Michigan waters of the MH-2 unit include both 1836 Treaty-ceded waters (723,710 acres) and non-treaty waters (797,810 acres), divided by a line running north-east from the tip of North Point to the international border. The Michigan ports of Presque Isle and Alpena are contained in this unit. The St. Marys River, connecting Lakes Superior and Huron, flows into northern Lake Huron in grid 306, to the north of this unit. The St. Marys River had supported large spawning runs of sea lamprey, and until the late 1990s the resulting larval populations were untreated and contributed substantial numbers of parasitic-phase sea lamprey to the lake. Comprehensive treatment of the river by the Great Lakes Fishery Commission's control agents has reduced the number of sea lamprey produced in the St. Marys River, and decreases in lake trout wounding and sea lamprey-induced mortality rates are being documented in northern Lake Huron. The management unit has a wide bathymetric range with areas in grids 714 and 814 deeper than 690 feet, and a total of 202,540 acres of 1836 Treaty-ceded waters with bottom depths of 240 ft or less. This management unit contains a limited number of historically important lake trout spawning reefs and shoals. These reefs are located near Middle Island, North Point, and Six Fathom Bank. The Six Fathom Bank Refuge is located in the eastern half of grids 913 and 1013, grids 914 and 1014, and Michigan waters of grids 915 and 1015 covering 251,940 acres. Canadian waters adjacent to the refuge are a commercially protected area where commercial fishers are prohibited from fishing in waters shallower than 40 fathoms. Recreational anglers may harvest lake trout in Canadian waters adjacent to the refuge, but few, if any, travel the long distance offshore. Approximately ½ of the refuge lies in MH-2 (118,560 acres), and retention of lake trout in the refuge is strictly prohibited.

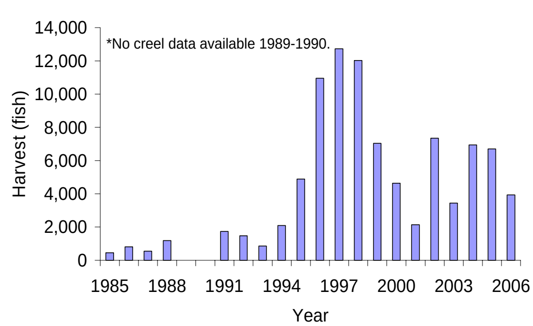
There has been little or no natural recruitment of lake trout in north-central Lake Huron, although recent indicators (increased trawl catches of age-0, increased CPUE’s of unclipped, spawning adults) suggest natural recruitment may be on the rise. As a result, nearly all of the lake trout harvest is comprised of hatchery fish. The United States Fish and Wildlife Service annually plants lake trout in MH-2. From 2002 to 2006, approximately 424,000 yearling lake trout per year were planted annually in near-shore areas of MH-2. No lake trout were planted offshore on Six Fathom Bank/Yankee Reef in 2006. The Six Fathom/Yankee Reef complex was stocked annually from 1985 to 2001, but in 2002 these fish were re-allocated to nearshore stocking sites. In the future, stocked fish will again be planted on the mid-lake reefs. Approximately 47,000 yearling lake trout were planted annually in Canadian management area 4-3 from 2002 to 2006. After adjusting for post stocking survival and immigration and emigration based on coded-wire-tag data, the MH-2 model estimates 446,000 yearling lake trout recruits in MH-2 for 2006.

In contrast to MH-1, there is no commercial harvest of lake trout in Michigan waters of MH-2. As of August 2000, tribal commercial fishers may deploy trap nets that target lake whitefish in 1836 Treaty-ceded waters of MH-2. This fishery is not allowed to market lake trout bycatch. Two State-licensed commercial fishing operations operate trap nets targeting lake whitefish in MH-2 south of the 45th parallel. These operations are also not allowed to market lake trout bycatch. All lake trout are returned to the water, regardless of condition. Prior to the signing of the Consent Decree, both State-licensed fisheries operated trap nets north of North Point. These fisheries were moved south of the 45th parallel to accommodate the new tribal trap-net operations as stipulated in the Consent Decree.

There is a substantial commercial fishery for lake trout in Canadian waters adjacent to MH-2 (areas 4-2, 4-3, and 4-7) that we included in our assessment. From 2002 to 2006, total Canadian commercial lake trout yield in these areas averaged 75,000 lb per year. The majority of this yield came from the large-mesh gill-net fishery. Canadian large-mesh gill-net effort averaged 8.9 million ft per year from 2002 to 2006. Canadian large-mesh gill-net effort in waters adjacent to MH-2 increased substantially starting in 1999, stabilized from 2002-2004, and decreased in recent years. However, Canadian effort is currently near its highest levels during the 1984-2006 modeled time series.

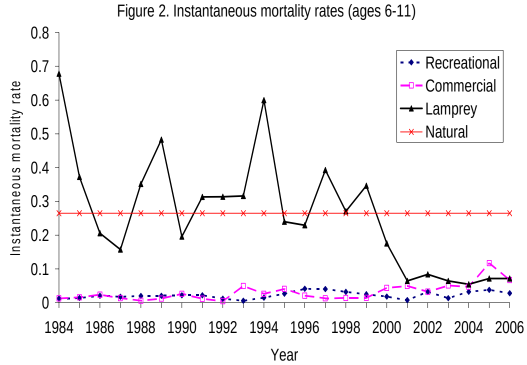
The State-licensed recreational fishery in MH-2 is composed of both charter and non-charter anglers. Lake trout are caught as bycatch by salmon anglers, but some anglers target lake trout by fishing the lower parts of the water column. A limited number of subsistence fishing permits are also issued to tribal members in 1836 Treaty-ceded waters. The magnitude of recreational harvest varies from year to year and has averaged 5,700 fish from 2002 to 2006 (Figure 1). From 2002 to 2006, recreational yield of lake trout averaged 28,900 lb, and in 2006 recreational harvest was 21,200 lb in MH-2. Starting in 2001, the State of Michigan raised the minimum size limit of lake trout in the recreational fishery from 10 inches to 20 inches in areas north of 44° 50’ N latitude. Starting in 2003, the State of Michigan raised the minimum size limit of lake trout in the recreational fishery from 20 inches to 22 inches in MH-2. These new regulations are intended to keep recreational harvest below the State share of the MH-2 harvest limit. Due to these more restrictive State regulations, 2003-2006 State harvest includes an estimate of throwback mortality (i.e. fish that were thrown back but later died due to handling).

Figure 1. Recreational fishery lake trout harvest



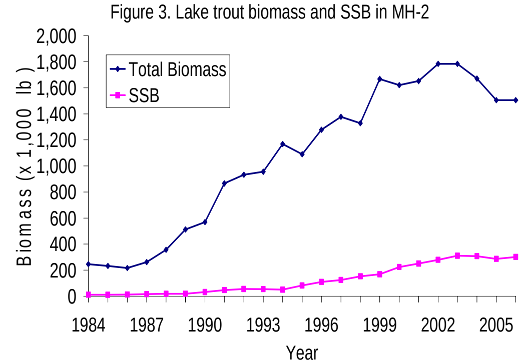
In most years, the dominant source of mortality for lake trout in MH-2 was sea lamprey (Figure 2). Sea lamprey-induced mortality was greater than all other mortality sources from 1984 to 1999 with the exception of 1986, 1987, 1990, 1995, and 1996 when natural mortality was the largest single mortality source (Figure 2). Sea lamprey mortality rates have been cyclic in north-central Lake Huron, reaching peaks in 1984, 1989, 1994, 1997, and 1999 (Figure 2). From 2002 to 2006, sea lamprey-induced mortality averaged 0.07 y^{-1}. From 1999 to 2001 sea lamprey-induced mortality rates declined drastically, and then leveled off in recent years. Sea lamprey-induced mortality rates for age 6-11 lake trout in 2006 decreased 79% from the average of 1994-1998 levels and are now at their lowest levels over the modeled time series. This decline is due to the treatment of the St. Marys River and subsequent reduction in parasitic phase sea lamprey. Recreational and commercial fishing mortality were low in most years relative to sea lamprey-induced mortality; however, increases in commercial harvest of lake trout in Canadian waters have caused the commercial fishing mortality rate to increase since 1999 (Figure 2).

Figure 2. Instantaneous mortality rates (ages 6-11)



Past high rates of sea lamprey-induced mortality in most years caused the age structure in north-central Lake Huron to be truncated just before the age of first maturity. As a result, spawning stock biomass (SSB) is low in north-central Lake Huron (Figure 3). Total lake trout biomass steadily increased from 1984 to 2003, but declined from 2004 to 2006. Total biomass averaged 1.65 million lb from 2002 to 2006. SSB increased every year from 1984 to 2003, and has leveled off since 2004. Both total lake trout biomass and SSB remain at high levels relative to the modeled time series (1984-2006). Much of this increase is due to lower rates of sea lamprey-induced mortality and increased stocking in MH-2. Total 2006 SSB was 296,000 lb (roughly 18% of total biomass) indicating the majority of lake trout biomass in MH-2 is composed of young, immature fish. Increases in abundance of older age classes will be needed to create a naturally-producing, self-sustaining stock.

Figure 3. Lake trout biomass and SSB in MH-2



The Modeling Subcommittee of the TFC recommends a lake trout harvest limit of 91,817 lb for MH-2 in 2007. This harvest limit was calculated using the target total annual mortality rate of 40% and allocating 95% of the harvest to the State and 5% of the harvest to the tribes as outlined in Sections VII.A.3 and VII.A.4 of the Consent Decree. Based on these calculations, the total yield was allocated 87,930 lb to the State and 3,887 lb to the tribes.

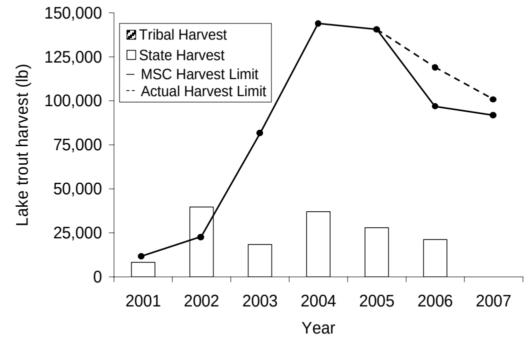
Current spawning stock biomass per recruit (SSBR) is above SSBR at target mortality, indicating total annual mortality rates are below the target of 40% total annual mortality. This is due to the large declines in sea lamprey-induced mortality rates from 2000 to 2006. If sea lamprey-induced mortality remains low, spawning stock biomass and SSBR should continue to increase.

State harvest was significantly lower than the State harvest limit in 2006 (Figure 4). Tribal harvest in this unit was reported to be 324 lb in 2007, despite the requirement that all tribal fishers in MH-2 are required to release all lake trout regardless of condition.

The total 2007 MSC recommended harvest limit decreased significantly from the actual 2006 harvest limit (Figure 4). Section VII.A.6 of the Consent Decree states that for fully phased in units "changes in harvest limits from year to year shall not result in adjustments greater than a fifteen percent (15%) increase or decrease from the previous year in that unit, unless all parties agree that a greater change is appropriate." For MH-2 in 2007, the parties agreed to invoke the 15% rule to limit the harvest limit decline to a level 15% below the actual 2006 harvest limit. Invoking the 15% rule resulted in a 2007 harvest limit of 95,876 lb for the State and 5,058 lb for the tribes.

The large increases in harvest limits from 2001 to 2004 were due to large scale declines in sea lamprey-induced mortality rates during 2000-2004. The plateau and decline in harvest limit from 2005 to 2007 is likely due to declined growth rate and reduced biomass, but could indicate that this unit is approaching an asymptote in its harvest limit. We will continue to monitor the lake trout population dynamics in this unit in the future, especially dynamics of juvenile lake trout which have become less abundant in recent survey catches.

Figure 4. Yearly harvest and harvest limits



Last year, the MSC informed the TFC and the parties that it was not fully comfortable with the magnitude of the harvest level increases over time in MH-2. For the 2007 harvest limit model, the MSC implemented methods (described below) in the model to better estimate survival and abundance of juvenile lake trout and more realistically match relative abundances seen in survey catches. The MSC felt that it might have been overestimating survival of age 1 to 2 lake trout in previous model runs.

Model changes

To address the estimated juvenile survival issues described above, we coded this year's assessment model to estimate time varying survival from age 1 to 2 as a bounded vector. We stopped using the post stocking survival vector as in previous model runs. Also, in 2007 we modeled time varying selectivity in the commercial and recreational fisheries as a random walk function and set maximum age specific selectivity as 1 for each year.

Changes made for past TAC-year models were maintained in the current model. These changes included modeling time varying selectivity in the spring survey as a random walk function starting with the 2006 TAC-year model, introducing time-varying maturity and weight-at-age in the model input data starting with the 2005 TAC-year model, and allowing the model to select the peak age of fishery selectivity, setting the under-reporting vector for the tribal commercial fishery to zero, and including release mortalities from the recreational fishery in harvest totals starting with the 2004 TAC-year model.

Summary Status MH-2 Lake Trout	Value (Standard Error)
Female maturity	
Size at first spawning	0.64 lb
Age at first spawning	3 y
Size at 50% maturity	3.94 lb
Age at 50% maturity	6 y
Spawning stock biomass per recruit	
Base SSBR	0.329 lb (SE 0.661)
Current SSBR	0.140 lb (SE 0.280)
SSBR at target mortality	0.113 lb (SE 0.226)
Spawning potential reduction	
At target mortality	0.422 (SE 0.038)
Average yield per recruit	0.048 lb (SE 0.094)
Natural mortality (M)	0.265 y^{-1}
Fishing mortality	
Age of full selection	
Commercial fishery (2004-2006)	6 y
Sport fishery (2004-2006)	7 y
Commercial fishing mortality (F)	
Average 2004-2006, ages 6-11	0.077 y^{-1} (SE 0.019)
Sport fishing mortality (F)	
Average 2004-2006, ages 6-11	0.033 y^{-1} (SE 0.007)
Sea lamprey mortality (ML)	
Average 2004-2006, ages 6-11	0.066 y^{-1}
Total mortality (Z)	
Average 2004-2006, ages 6-11	0.441 y^{-1} (SE 0.034)
Recruitment (age-1)	
Average 1997-2006	461,530 fish (SE 0)
Biomass (age 3+)	
Average 1997-2006	1,589,600 lb (SE 167,650)
Spawning biomass	
Average 1997-2006	239,890 lb (SE 34,233)
MSC recommended yield limit for 2007	91,817 lb
Actual yield limit for 2007	100,934 lb

Lake Michigan

MM-123 (Northern Treaty Waters-Lake Michigan)

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

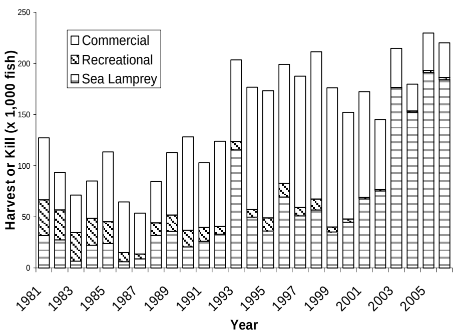
Lake trout management unit MM-123 is made up of statistical districts MM-1, MM-2 and MM-3 and encompasses Michigan's waters of northern Lake Michigan and northern Green Bay. This management unit covers 5,000 square miles. Water depths in more northern waters are mostly less than 150 feet, and approximately 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 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. Gill-net fishing (both commercial and subsistence) is prohibited in the refuge, while commercial trap-net operations are permitted to harvest lake whitefish. Commercial fishing is also prohibited in the innermost area of Little Traverse Bay (grid 519) and portions of grid 306 in northern Green Bay.

Recruitment of lake trout in the MM-123 is currently based entirely on stocking. In each of the last ten years, on average, 700,695 yearling lake trout have been stocked into northern Lake Michigan and approximately 73 percent of these fish were stocked into the northern refuge. To more accurately estimate recruitment to the fishable stock of lake trout in the model, the number of fish stocked is adjusted to account for first year mortality and movement among different management units in the lake. During 1997-2006 the recruitment of stocked lake trout to age one has averaged 570,213 fish in MM-123.

Both state and tribal commercial fisheries operate in MM-123. State-licensed commercial fisheries are primarily trap net operations in Green Bay targeting lake whitefish because possessing lake trout is prohibited. While the current tribal commercial fishery primarily targets lake whitefish, lake trout are harvested as by-catch. From 1981 until 2001, commercial fishing killed more harvestable lake trout (> 17 in.) than other sources of mortality in northern Lake Michigan (Figure 1). In 2001, sea lamprey abundance began to increase and in the recent 4 years sea lamprey-induced mortality of lake trout has reached an all-time high killing an average of 176,000 fish per year compared to an average of 37,000 fish killed per year prior to the year 2000.

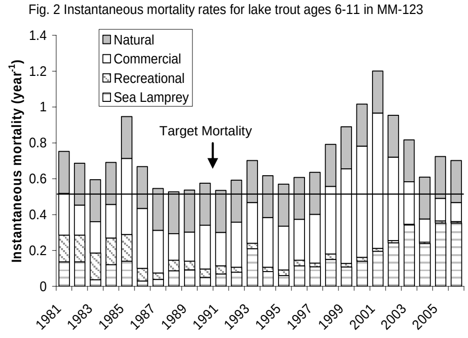
Fig. 1 Number of lake trout killed by source in MM-123



The Chippewa Ottawa Resource Authority oversees three types of commercial fisheries in this area, large-mesh gill net, small-mesh gill net, and trap net. The large-mesh gill-net fishery accounts for the majority of the lake trout yield. Total commercial yield increased from 353,280 lb in 1991 to 880,257 lb in 1999. After the implementation of the 2000 Consent Decree, the commercial yield of lake trout has continuously decreased to a low of 105,491 lb in 2004 and has averaged 152,000 lb during the recent 2 years. Large-mesh gill-net effort in tribal fisheries declined from 23 million feet in 1992 and 1993 to 4.2 million feet in 2005 and rose slightly in 2006 to 5.2 million feet. The number of lake trout harvested from MM-123 by the commercial fishery increased from 1991 (63,000 fish) to 1998 (144,000 fish). More recently, following implementation of the 2000 Consent Decree, the number of lake trout harvested by the commercial fishery has declined to an all time low of 26,000 fish in 2004, and has averaged 35,000 fish during the recent two years (Figure 1). In 2006, the commercial yield of lake trout in this unit was less than the phased-in TAC and greater than the non-phased TAC allocation (Figure 4).

The management of recreational fisheries for lake trout is the primary responsibility of the State of Michigan and fisheries are comprised of both charter and sport anglers. The mortality rate of lake trout resulting from recreational fishing in MM-123 is significantly lower than that associated with 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 recreational yield of lake trout declined by over 97 percent from 1998 (75,820 lb) to 2003 (2,300 lb). Yield was up slightly in 2005 and 2006 averaging 13,300 lb. The numbers of lake trout harvested followed similar patterns to those described for yield. Declines in harvest and yield are in part correlated to declines in recreational fishing effort. The number of angler hours decreased by nearly 40 percent from 116,000 in 1998 to 74,000 in 2003. Since then, effort has been trending upward to 125,000 angler hours in 2006, likely the result of improved fisheries for Chinook salmon in recent years.

Fig. 2 Instantaneous mortality rates for lake trout ages 6-11 in MM-123



From 1989 until 2002 sea lamprey-induced mortality had been the second highest source of mortality for lake trout in northern Lake Michigan. Since 2003, sea lamprey mortality has exceeded other sources and averaged 0.31 $year^{-1}$ during 2003-2005 (Figure 2).

In northern Lake Michigan, lake trout generally are both spawning and recruited into commercial and recreational fisheries by age 7. The biomass of lake trout in northern Lake Michigan had nearly quadrupled from 1986 to 1997 increasing from 1.7 to 4.6 million lb. However, from 1997 to 2002 the biomass of lake trout steadily decreased and was only one-third those observed in 1997 (Figure 3). From 2002 to 2006 the biomass of lake trout has increased to 2.5 million lb. Spawning biomass showed similar though less pronounced patterns in abundance with a slight increase in recent years.

The spawning stock biomass produced per recruit (including the refuge population) during 2006 is 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 model-recommended yield limit for 1836 Treaty waters in 2007 was 8,400 lb total, reflecting the high mortality currently affecting lake trout in this unit. The actual yield limit adopted for 2007 was 50,000 lb for the state recreational fishery and 453,000 lb for the tribal commercial fishery, based on an Executive Council Agreement. These values reflect phase-in requirements extended 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 below the 1998 baseline for three consecutive years. Phase-in options allows for temporary increases in mortality above the 40% target (Figure 4). When fully phased in, yield allocations in this management unit will be 10% to the State of Michigan and 90% to tribal fisheries, while meeting the 40% mortality target. The model generated harvest recommendations are extremely low because the combination of sea lamprey and natural mortality are so close to the mortality limits that there is little left to allocate to either the commercial or recreational fishery.

Fig. 3 Estimated lake trout biomass in MM-123

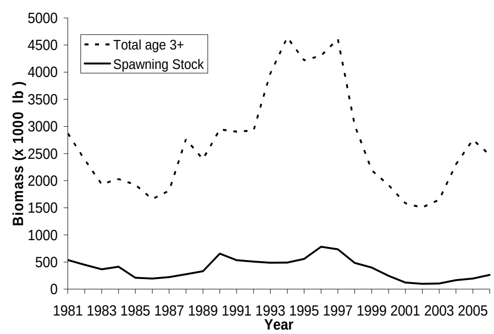
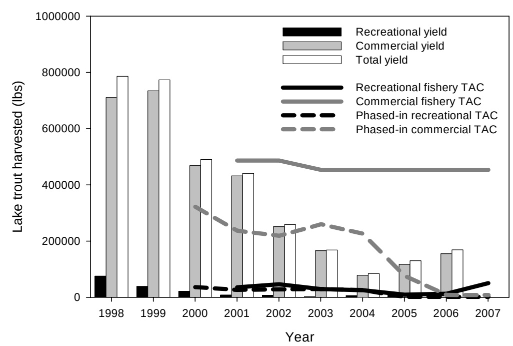


Fig. 4. Comparison of actual harvest vs. TAC decision vs. model recommendation



Model evaluation and changes

For this year's assessment, the SCAA model reached convergence with acceptable maximum gradient components and reasonable asymptotic standard errors on parameter estimates. We did not observe any major patterns in residuals for fit to observed data sources. The MCMC simulations yielded good results without autocorrelations and no drift in the trace plots for all quantities evaluated. The retrospective analysis of this year's model did not show any systematic temporal patterns in biomass estimates, although modest differences in biomass estimates for recent years exist.

Summary Status MM-123	Value (95% probability interval)
Female maturity	
Size at first spawning	2.20 lb
Age at first spawning	3 y
Size at 50% maturity	5.89 lb
Age at 50% maturity	6 y
Spawning stock biomass per recruit	
Base SSBR	5.62 lb (4.86 – 6.41)
Current SSBR combined w/ refuge	0.78 lb (0.65 – 0.92)
SSBR at target mortality	1.74 lb (1.53 – 1.97)
Spawning potential reduction	
At target mortality	0.310 (0.279 – 0.345)
Average yield per recruit	0.276 lb (0.229 – 0.328)
Natural mortality (M)	0.234 y^{-1}
Fishing mortality	
Age of full selection	
Commercial fishery (2004-2006)	7 y
Sport fishery (2004-2006)	7 y
Commercial fishing mortality (F)	
Average 2004-2006, ages 6-11	0.126 y^{-1} (0.091 – 0.172)
Sport fishing mortality (F)	
Average 2004-2006, ages 6-11	0.010 y^{-1} (0.007 – 0.014)
Sea lamprey mortality (ML)	
Average 2003-2005, ages 6-11	0.312 y^{-1}
Total mortality (Z)	
Average 2004-2006, ages 6-11	0.683 y^{-1} (0.644 – 0.733)
Recruitment (age-1)	
Average 1997-2006	570,213 fish (410,582 – 787,429)
Biomass (age 3+)	
Average 1997-2006	2,380,841 lb (2,031,110 - 2,803,960)
Spawning biomass	
Average 1997-2006	270,890 lb (231,678 – 319,808)
Recommended yield limit in 2007	503,000 lb phase-in; 8,400 lb model

MM-4 (Grand Traverse Bay)

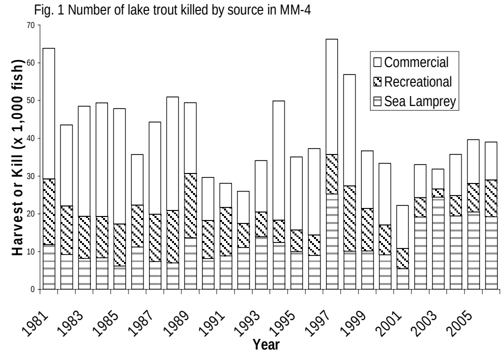
Prepared by Jory L. Jonas, John K. Netto, and Erik J. Olsen

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, 233,000 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 variations in mortality and movement among the various regions in the lake. Over the last 10 years (1997-2006) the recruitment to age one has averaged 224,106 fish in the Grand Traverse management unit.

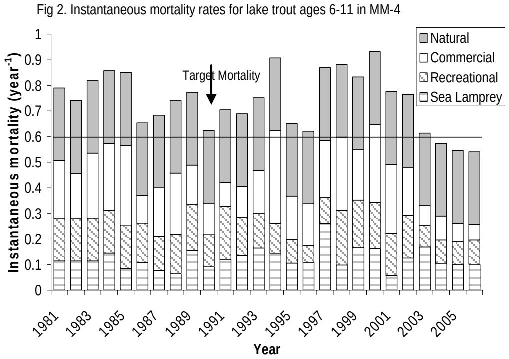
From 1994 until 2001 more lake trout were killed by commercial fishing than by either sea lamprey or sport fishing, averaging 22,000 fish (Figure 1). By 2003, the number of lake trout killed by commercial fishing had declined to less than 5,300 fish y^{-1}. The harvest of lake trout has increased in recent years to slightly above 10,400 fish y^{-1}. Commercial fishing mortality in Grand Traverse Bay peaked in 1994 (0.36 y^{-1}), and remained relatively stable through 2002 averaging 0.22 y^{-1}. Mortality has been significantly lower during the last three years (2004 to 2006) averaging 0.07 y^{-1} (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 6,000 fish in 1991 to 33,000 fish harvested in 1998. Harvest declined dramatically to 5,000 fish in 2003, and has averaged 10,800 fish in the recent three years (2004–2006). Accordingly, 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 increased slightly in recent years to 45,500 lb in 2006. Large-mesh gill-net effort in tribal fisheries has declined from 2 million feet in 1996 to only 0.26 million feet in 2006. Reduced levels of commercial lake trout harvest in the Grand Traverse Bay management unit had been expected due to conversion of the regions largest gill-net fishers to trap-net operations.

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



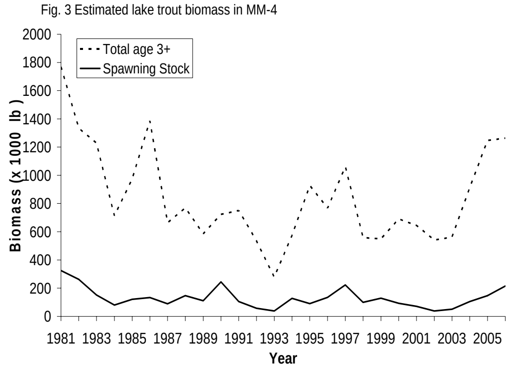
The management of recreational fisheries for lake trout is the primary responsibility of the State of Michigan and fisheries are comprised of both charter and sport anglers. The sport fishing harvest regulations in the Grand Traverse Bay management unit have changed significantly over the last 10 years, affecting recreational fishing mortality rates and harvest levels. From 1992-1996, the minimum size limit for lake trout harvest increased from 10 to 24 inches. In 1996, the season for harvesting lake trout was lengthened, so that it extended from Jan 1 through September 30 in contrast to the previous season of May 1 through Labor Day. Mid-way through the year in 1997 the minimum size limit was decreased to 20 inches and remained so through 2002. In 2003, the bag limit was raised from 2 to 3 fish and the minimum size limit increased to 22 inches. In 2006, regulations were again changed to protect larger spawning lake trout. A harvest slot limit 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 steadily declined from 1991 (0.21 y^{-1}) to 1996 (0.07 y^{-1}). Recreational fishing mortality averaged 0.18 y^{-1} from 1998 to 2002, and has been consistently lower during the last four years (2003-2006) averaging 0.09 y^{-1} (Figure 2). The estimated recreational yield of lake trout in Grand Traverse Bay had been steady 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. After which, yield declined each year to an all time low of 12,000 lb in 2003. Yield has been steadily increasing and was 49,500 lb in 2006. The numbers of lake trout harvested followed similar patterns, remaining stable from 1992 through 1996 averaging 6,000 fish. Harvest increased through 1998 peaking at 19,000 fish, steadily declined to 2,000 fish in 2003, and rose to 9,700 fish in

2006 (Figure 1). Effort levels have remained relatively stable over the last 10 years (1997-2006) averaging 198,000 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 y^{-1}. Wounding mortality increased to 0.26 y^{-1} in 1997 and declined to 0.06 y^{-1} by 2001. In the past three years (2003-2005) lamprey mortality has averaged 0.125 y^{-1}. In 2003, lampreys were estimated to have killed over 24,000 lake trout whereas during the past three yrs, on average, 20,000 lake trout have been killed.

In the Grand Traverse Bay management unit, lake trout are recruited into sport fisheries by age 6 and commercial fisheries by age 7. Some 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 1986 at 1.4 million lb. Biomass increased from a low of 278,000 lb in 1993 to 1.1 million lb in 1998. From 1998 to 2003 biomass averaged 590,000 lb and has increased in recent years to a level of 1.3 million lb in 2006.

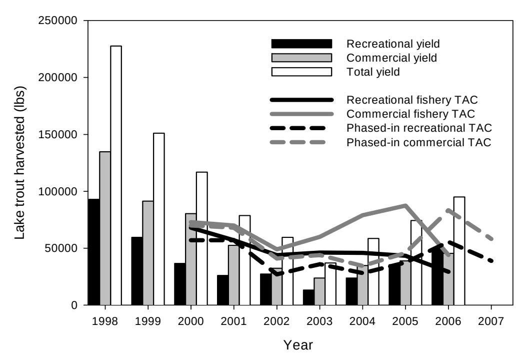
Fig. 3 Estimated lake trout biomass in MM-4



The spawning stock biomass produced per recruit is below the target value indicating that mortality rates exceeded targets in Grand Traverse Bay. The model recommended harvest limit for 2007 in the Grand Traverse Bay management unit is 96,900 lb of which 38,800 lb was allocated to the state recreational fishery and 58,100 lb to the tribal commercial/subsistence fishery.

Grand Traverse Bay represents an area of unique phase in requirements defined in the 2000 Consent Decree. From 2006 to 2009, yield and effort limits are to meet the target mortality rate for the management unit of 45%, with a 40 percent allocation to the state of Michigan and a 60 percent allocation to tribal fisheries. By decision of the parties, phase-in practices will continue to be used in 2007; however, an agreement upon specific harvest limits has yet to be reached.

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



Model evaluation and changes

For this year's assessment, the SCAA model reached convergence with acceptable maximum gradient components and reasonable asymptotic standard errors on parameter estimates. We did not observe any major patterns in residuals for fit to observed data sources. The MCMC simulations yielded good results without autocorrelations and no drift in the trace plots for all quantities evaluated. The retrospective analysis of this year's model did not show any systematic temporal patterns in biomass estimates, although modest differences in biomass estimates for recent years exist. Retrospective patterns in recruitment indicate that year class strength of a cohort does not stabilize until around age 5 in this SCAA model.

A report of the changes to the structure of the model used to generate the 2007 TAC was not provided by John Netto.

Summary Status MM-4	Value (95% probability interval)
Female maturity	
Size at first spawning	2.39 lb
Age at first spawning	3 y
Size at 50% maturity	6.53 lb
Age at 50% maturity	6 y
Spawning stock biomass per recruit	
Base SSBR	2.363 lb (2.091 – 2.673)
Current SSBR	0.591 lb (0.511 – 0.677)
SSBR at target mortality	0.779 lb (0.713 – 0.847)
Spawning potential reduction	
At target mortality	0.331 (0.297 – 0.364)
Average yield per recruit	0.519 lb (0.468 – 0.573)
Natural mortality (M)	0.284 y^{-1}
Fishing mortality	
Age of full selection	
Commercial fishery (2004-2006)	7 y
Sport fishery (2004-2006)	6 y
Commercial fishing mortality (F)	
Average 2004-2006, ages 6-11	0.075 y^{-1} (0.057 – 0.098)
Sport fishing mortality (F)	
Average 2004-2006, ages 6-11	0.093 y^{-1} (0.072 – 0.117)
Sea lamprey mortality (ML)	
Average 2003-2005, ages 6-11	0.125 y^{-1}
Total mortality (Z)	
Average 2004-2006, ages 6-11	0.576 y^{-1} (0.536 – 0.622)
Recruitment (age-1)	
Average 1997-2006	224,106 fish (200,509 – 250,990)
Biomass (age 3+)	
Average 1997-2006	714,030 lb (630,392 – 804,831)
Spawning biomass	
Average 1997-2006	118,362 lb (102,092 – 136,781)
Recommended yield limit in 2007	No consensus on phase-in; 96,900 lb model

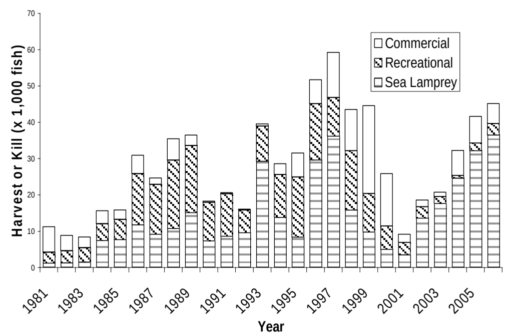
MM-5 (Leelanau Peninsula to Arcadia)

Prepared by Jory L. Jonas, John K. Netto, 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, 207,300 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 to account for variations in mortality and for movement among the various regions in the lake. Over the last 10 years (1997-2006) the recruitment to age one has averaged 330,270 fish in MM-5.

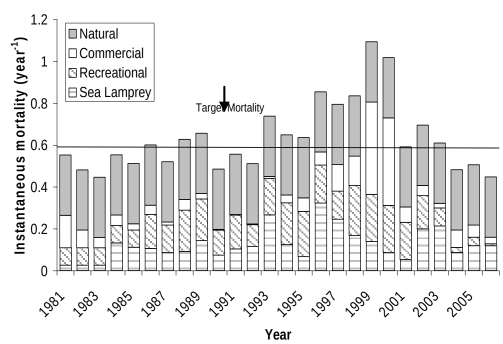
Fig 1. Number of lake trout killed by source in MM-5



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. From 1990 to 1993, mortality from commercial fishing was extremely low averaging $0.005y^{-1}$. Mortality rates increased over the next seven years; the highest commercial fishing mortalities were observed in 1999 and 2000 at 0.44 and 0.42y^{-1} respectively. In 1999 nearly 25,000 fish were harvested in commercial fisheries. After the year 2000, the commercial harvest decreased and only 1,100 lake trout were harvested in 2003 resulting in a low mortality rate of 0.02y^{-1}. Harvest increased averaging 6,600 fish during the last three years (2004-2006; Figures 1 and 2). 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. In the most recent three years (2004-2006), yield has increased averaging 27,200 lb. 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. From 2001 to 2003 gill-net effort averaged 115,000 feet of net and has increased averaging 570,000 feet from 2004 to 2006.

Recreational fisheries for lake trout are primarily managed by the State of Michigan and include both charter and sport anglers. From 1986 until 1999, recreational fishing mortality exceeded or equaled commercial fishing mortality in the MM-5 management unit. Mortality (averaged over ages 6-11) from recreational fishing has been declining since 1998 from 0.24y^{-1} to 0.01y^{-1} in 2006. The recreational fishery yield declined from 88,500 lb in 1998 to 3,800 lb in 2004. Yield has increased slightly averaging 12,200 lb in the last two years. The numbers of lake trout harvested had also dropped between 1998 (18,100 fish) and 2004 (765 fish) declining by nearly 96 percent. In 2006, the number of fish harvested had increased to 3,100. Recreational fishing effort had been relatively consistent from 1995 to 1999 averaging 279,000 angler hours. By 2001, angler effort increased to 370,000 angler hours declined to 180,000 hours in 2003 and has been increasing since to 327,000 hours in 2006. 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.

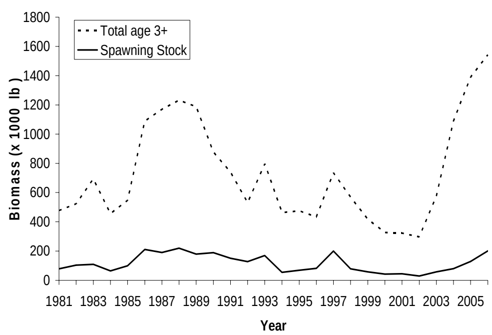
Fig. 2 Instantaneous mortality rates for lake trout ages 6-11 in MM-5



From 1984-1992 sea lamprey mortality rates were relatively consistent averaging 0.11y^{-1}. Rates increased to 0.27y^{-1} in 1993 declining over the next two years to 0.07y^{-1}. Rates increased again in 1996 to 0.32y^{-1} and steadily declined to 0.05y^{-1} in 2001. During the last four years (2002-2005) lamprey mortality rates have averaged 0.16y^{-1} (Figure 2). Sea lamprey killed only 3,000 lake trout in 2001 and numbers killed have increased to 36,500 in 2006.

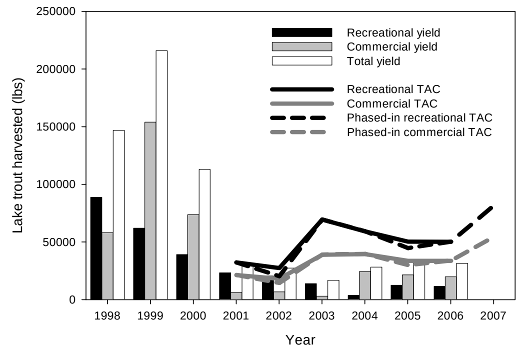
Fifty percent of lake trout are spawning by age 6 in MM-5. By age 7 they are fully recruited into commercial fisheries and age 5 into recreational fisheries. The biomass of lake trout older than age 3 was 736,000 lb in 1997, declined to 297,000 lb in 2002 and has since increased to 1.5 million lb in 2006 (Figure 3). The biomass of spawners has increased from 29,600 lb in 2002 to 200,600 lb in 2006.

Fig. 3 Estimated lake trout biomass in MM-5



The spawning stock biomass produced per recruit has been improving in this unit and is now above the target value, indicating that mortality is at acceptable levels in MM-5. The recommended yield limit for 2007 in unit MM-5 is 135,400 lb, and is based on a target mortality rate of 45%. Of this yield, 81,300 lb were allocated to the state recreational fishery and 54,100 lb to the tribal commercial and subsistence fisheries. Allocations were based on a 60 percent allotment for the state of Michigan and 40 percent to tribal fisheries. Parties are contesting the model based TAC for this unit, and negotiations are ongoing.

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



<u>Model evaluation and changes</u>

For this year's assessment, the SCAA model reached convergence with acceptable maximum gradient components and reasonable asymptotic standard errors on parameter estimates. We did not observe any major patterns in residuals for fit to observed data sources. The MCMC simulations yielded good results without autocorrelations and no drift in the trace plots for all quantities evaluated. The retrospective analysis of this year's model did not show any systematic temporal patterns in biomass estimates, although modest differences in biomass estimates for recent years exist. Retrospective patterns in recruitment indicate that year class strength of a cohort does not stabilize until around age 5 in this SCAA model.

A report of the changes to the structure of the model used to generate the 2007 TAC was not provided by John Netto.

Summary Status MM-5	Value (95% probability interval)
Female maturity	
Size at first spawning	2.75 lb
Age at first spawning	3 y
Size at 50% maturity	6.78 lb
Age at 50% maturity	6 y
Spawning stock biomass per recruit	
Base SSBR	2.244 lb (1.952 – 2.565)
Current SSBR	0.828 lb (0.680 – 0.985)
SSBR at target mortality	0.704 lb (0.631 – 0.782)
Spawning potential reduction	
At target mortality	0.314 (0.288 – 0.342)
Average yield per recruit	0.181 lb (0.148 – 0.220)
Natural mortality (M)	0.288 y^{-1}
Fishing mortality	
Age of full selection	
Commercial fishery (2004-2006)	7 y
Sport fishery (2004-2006)	5 y
Commercial fishing mortality (F)	
Average 2004-2006, ages 6-11	0.059 y^{-1} (0.041 – 0.082)
Sport fishing mortality (F)	
Average 2004-2006, ages 6-11	0.025 y^{-1} (0.017 – 0.036)
Sea lamprey mortality (ML)	
Average 2003-2005, ages 6-11	0.141 y^{-1}
Total mortality (Z)	
Average 2004-2006, ages 6-11	0.497 y^{-1} (0.470 – 0.529)
Recruitment (age-1)	
Average 1997-2006	330,270 fish (268,156 – 405,556)
Biomass (age 3+)	
Average 1997-2006	736,796 lb (595,506 – 901,997)
Spawning biomass	
Average 1997-2006	93,789 lb (76,392 – 114,340)
Recommended yield limit in 2007	no consensus on phase-in; 135,400 lb model

MM-67 (Manistee-Ludington-Muskegon)

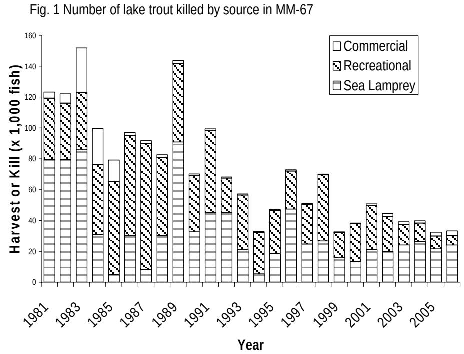
Prepared by Jory L. Jonas, John K. Netto, and Archie W. Martell Jr.

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, some state and tribal licensed commercial trap net operations are permitted; however, the retention of lake trout is prohibited. In 2006 tribal commercial fishing effort increased over previous years in MM-6, but there was no effort in management unit MM-7.

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 204,200 yearling lake trout have been stocked into non-refuge southern treaty waters, while an additional 282,000 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 varying mortality and for movement among the various regions in the lake. Over the last 10 years (1997-2006), the recruitment of lake trout to age one has averaged 315,216 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 2006, 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 2006 tribal commercial fishery within this area consisted of two permitted trap net operations, of which only one operation was actively fishing and three permitted tribal small-mesh gill-net operations of which only two actively fished. State and tribal commercial fisheries primarily target lake whitefish and chubs, and while state-licensed operations are not permitted to harvest lake trout, tribal trap net operations are allowed 100 lb per day lake trout bycatch. As a result, state commercial fishermen are not included in lake trout harvest allocations. The yield of lake trout in commercial fisheries has averaged 2,800 lb over the last 20 years (1986-2006). During the recent three years the harvest in commercial fisheries has been increasing, from 1,500 fish year^{-1} in 2004 to 3,200 year^{-1} in 2006. As a result of stipulations of the 2000 Consent Decree, this area may experience greater commercial fishing effort from tribal interests in the future.

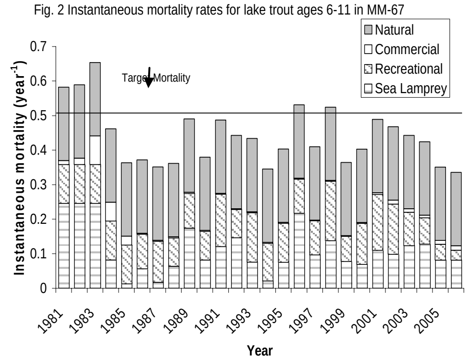
Fig. 1 Number of lake trout killed by source in MM-67



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 0.16y^{-1} in 2001 to 0.03y^{-1} in 2006. The yield of lake trout in recreational fisheries has also declined from 177,800 lb in 2001 to 29,700 lb in 2006. 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 28,200 fish in 2001 to 5,600 fish in 2006, a trend which has been occurring since recreational harvest peaked in 1987 (81,200 fish; Figure 1). Effort levels have been relatively consistent since 1990 averaging 1,174,000 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 15, 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 when compared with rates observed in the northern units. Mortality rates have ranged from 0.01 to 0.24 y^{-1} during the last 20 years (Figure 2). In recent years (2003-2005), the number of lake trout killed by lamprey has averaged 24,100 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 8. The biomass of lake trout age 3 and older is high averaging over 1.5 million lb during the recent ten years (1997-2006; Figure 3). Spawning lake trout comprise a relatively high proportion of the total biomass in this unit (Figure 3), averaging over 422,900 lb from 1997-2006.

The spawning stock biomass produced per recruit is above the target value indicating that target mortality rates have been achieved in MM-67. The model recommended yield limit for MM-67 in 2007 was 263,600 lb and was adjusted by the Technical Fisheries Committee to accommodate the 15% rule resulting in a yield limit of 265,400 lb accepted by the parties. Of the 265,400 lb allocated, the state recreational fishery receives 238,895 lb and the tribal fishery 26,530 lb. The yield limit and allocations in this management unit are set to achieve a total mortality rate target of 40% and establish a 90 percent allocation to the state of Michigan and a 10 percent allocation to tribal fisheries. Both recreational and commercial fisheries are well below established TAC levels (Figure 4).

Fig. 3 Estimated lake trout biomass in MM-67

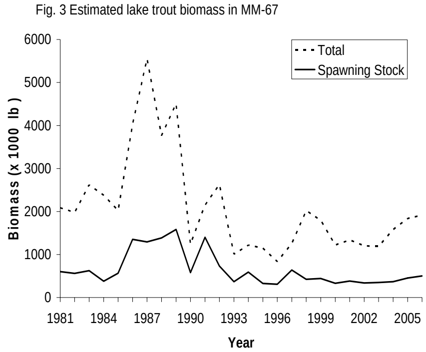
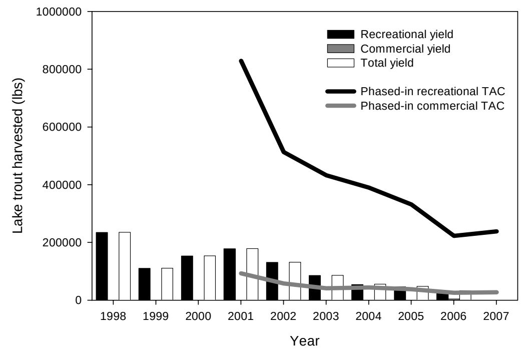


Fig. 4. Comparison of actual harvest vs. TAC decision



<u>Model adjustments and changes</u>

For this year's assessment, the SCAA model reached convergence with acceptable maximum gradient components and reasonable asymptotic standard errors on parameter estimates. We did not observe any major patterns in residuals for fit to observed data sources. The MCMC simulations yielded good results without autocorrelations and slight drift in the trace plots for all quantities evaluated. Retrospective patterns for MM67 indicate that we need to address time varying parameters in the models to improve performance.

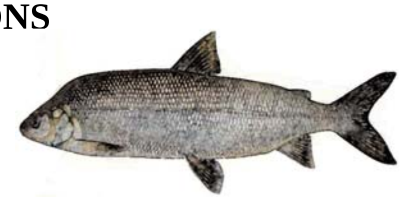
A report of the changes to the structure of the model used to generate the 2007 TAC was not provided by John Netto.

Summary Status MM-67	Value (95% probability interval)
Female maturity	
Size at first spawning	1.79 lb
Age at first spawning	3 y
Size at 50% maturity	6.38 lb
Age at 50% maturity	6 y
Spawning stock biomass per recruit	
Base SSBR	4.939 lb (3.714 – 6.366)
Current SSBR combined w/ refuge	1.850 lb (1.269 – 2.467)
SSBR at target mortality	1.211 lb (0.978 – 1.439)
Spawning potential reduction	
At target mortality	0.247 (0.212 – 0.284)
Average yield per recruit	0.305 lb (0.264 – 0.353)
Natural mortality (M)	0.212 y^{-1}
Fishing mortality	
Age of full selection	
Commercial fishery (2004-2006)	8 y
Sport fishery (2004-2006)	7 y
Commercial fishing mortality (F)	
Average 2004-2006, ages 6-11	0.011 y^{-1} (0.008 – 0.017)
Sport fishing mortality (F)	
Average 2004-2006, ages 6-11	0.055 y^{-1} (0.037 – 0.088)
Sea lamprey mortality (ML)	
Average 2003-2005, ages 6-11	0.111 y^{-1}
Total mortality (Z)	
Average 2004-2006, ages 6-11	0.392 y^{-1} (0.355 – 0.442)
Recruitment (age-1)	
Average 1997-2006	315,216 fish (297,419 – 334,777)
Biomass (age 3+)	
Average 1997-2006	1,487,592 lb (1,047,200 – 1,964,010)
Spawning biomass	
Average 1997-2006	404,460 lb (252,503 – 576,823)
Recommended yield limit in 2007	265,425 lb 15% rule; 263,600 lb model

STATUS OF LAKE WHITEFISH POPULATIONS

Lake Superior

WFS-04 (Marquette - Big Bay)

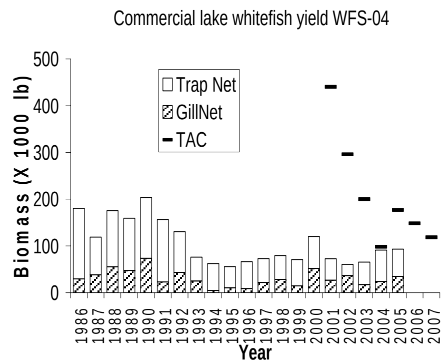


Prepared by Philip J. Schneeberger

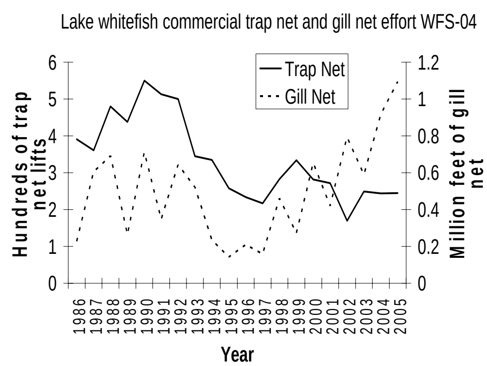
Lake whitefish unit WFS-04 (1,201,498 surface acres) is located in Lake Superior near Marquette roughly between Big Bay and Laughing Fish Point. Near shoreline features of this zone include many points, bays, islands, and in-flowing rivers. Habitat suitable for lake whitefish growth and reproduction 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, but 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.)

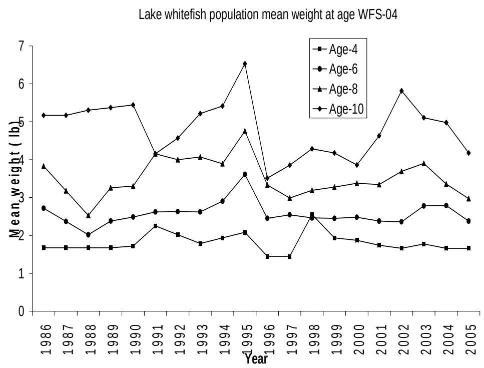
Overall yield in WFS-04 during 2005 was 93,396 lb with 58,310 lb (62%) caught in trap nets and 35,087 lb (38%) harvested in gill nets. Lake whitefish yield was 7,935 lb in 1836 waters of WFS-04, all taken in trap nets, and representing 8% of the overall yield in the management unit.



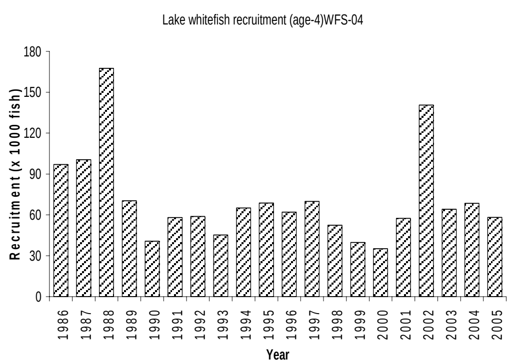
The 2005 trap net effort in WFS-04 was 245 lifts, nearly identical to the number in 2004 as well as to the 2000-04 average. Gill net effort (1,094,340 ft of net) was 62% higher in 2005 than the 2000-04 average. Only 7% of the trap-net effort and none of the gill-net effort took place in 1836 Treaty waters during 2005.



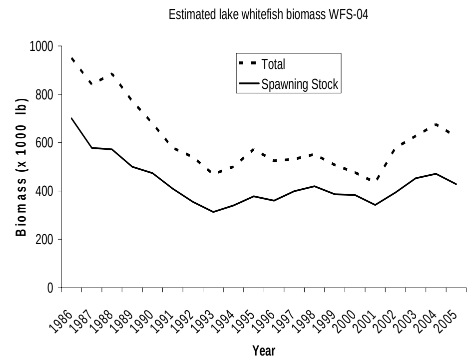
Between 2004 and 2005, calculations of mean weight-at-age decreased by an average of 9% for ages 5-12+. In general, weight-at-age data have exhibited declines in WFS-04 during the last 2-4 years.



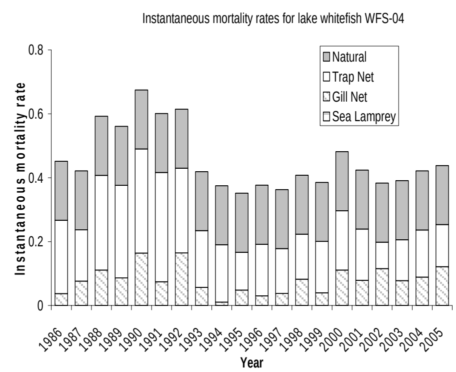
Recruitment (number of age-4 lake whitefish) was estimated at 58,000 in 2005. Highest estimated recruitment during the last 10 years was 140,000 in 2002 (fish produced in the 1998 year class). The 2005 recruitment estimate was 12% below the 10-year average for 1995-2004.



Both fishable biomass and spawning stock biomass declined in 2005 following three consecutive years of increase during 2001 - 2004. Estimated fishable biomass was 624,000 lb and spawning stock biomass was 428,000 lb in 2005. The 2005 ratio of spawning stock biomass to fishable biomass was 0.69, close to the same as values during the last several years.



Total instantaneous mortality rate (Z) for the WFS-04 lake whitefish stock has been below 0.45 y^{-1} in all years but one (2000) since 1993. The 2005 estimate for Z was 0.44 y^{-1}, up slightly from the 0.42 y^{-1} value for 2004. Estimated instantaneous fishing mortality rates (F) were 0.12 y^{-1} for gill nets and 0.13 y^{-1} for trap nets in 2005. Instantaneous natural mortality rate was estimated at 0.18 y^{-1}.



The calculated overall 2007 yield limit for lake whitefish in WFS-04 is 169,000 lb in WFS-04. Applying the reduction to reflect the proportion of this management unit that is outside the Consent Decree, the 2007 yield limit becomes 119,000 lb for 1836 Treaty waters, a 20% decrease from the limit calculated for the 2006 fishing season. Part of this reduction was caused by 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. In addition, the 2005 decline in estimated biomass, decreased weight-at-age, and increased mortality rate all contributed to the decreased yield limit.

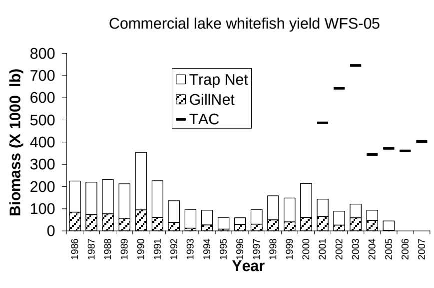
Summary Status WFS-04 Whitefish	**Value (95% Probability Range)**
Female maturity	
Size at first spawning	1.70 lb
Age at first spawning	4 y
Size at 50% maturity	2.05 lb
Age at 50% maturity	5 y
Spawning biomass per recruit	
Base SSBR	6.975 lb (6.952 - 6.999)
Current SSBR	2.11 lb (1.94 - 2.28)
SSBR at target mortality	0.217 lb
Spawning potential reduction	
At target mortality	0.302 (0.278 - 0.326)
Average yield per recruit	1.364 lb (1.347 - 1.379)
Natural mortality (M)	0.185 y^{-1}
Fishing mortality rate 2003-2005	
Fully selected age to gill nets	9
Fully selected age to trap nets	7
Average gill net F, ages 4+	0.112 y^{-1} (0.097 - 0.129)
Average trap net F, ages 4+	0.142 y^{-1} (0.125 - 0.162)
Sea lamprey mortality (ML)	
Average ages 4+, 2003-2005	N/A
Total mortality (Z)	
Average ages 4+, 2003-2005	0.438 y^{-1} (0.409 - 0.471)
Recruitment (age-4)	
Average 1996-2005	65,133 fish (57,189 - 74,515)
Biomass (age 3+)	
Average 1996-2005	556,034 lb (508,896 - 607,749)
Spawning biomass	
Average 1996-2005	405,766 lb (372,361 - 441,638)
Recommended yield limit in 2007	119,000 lb

WFS-05 (Munising)

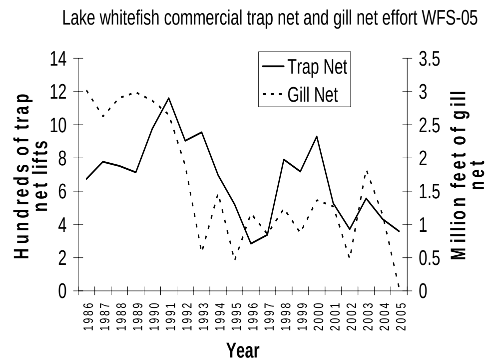
Prepared by Philip J. Schneeberger

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.

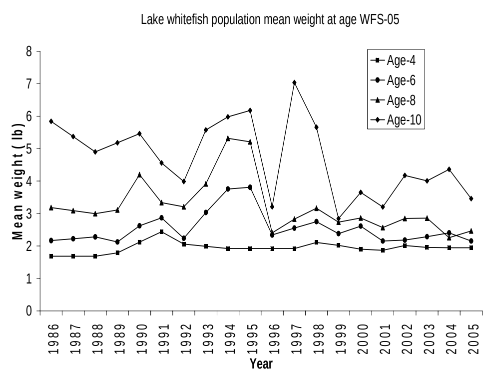
Total yield of lake whitefish in WFS-05 for 2005 was 45,000 lb, down 52% from 93,000 lb in 2004. The 2005 yield was 66% less than the average for 2000-2004. Trap nets accounted for 96% of the lake whitefish yield during 2005, and gill nets took the remaining 4%. Trap-net and gill-net yields in 2005 were 60% below and 96% below the 1986-2004 averages for each gear type, respectively.



Fishing effort decreased 17% for trap nets and 96% for gill nets between 2004 and 2005. Fishing effort in 2005 was lower than 1986-2004 averages for trap nets (-48%), and gill nets (-97%).

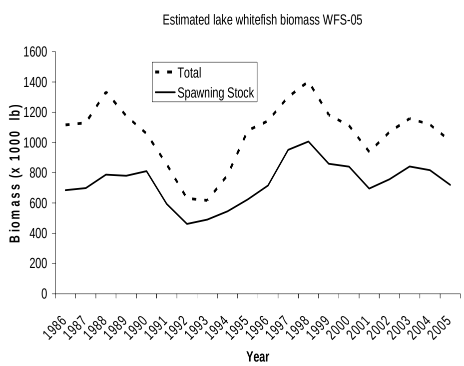


Mean weight-at-age declined in 2005 compared to 2000-04 averages for most fish ages 5 and older. The magnitude of these declines ranged from 8 to 17% and averaged 12% for ages 5-12+.

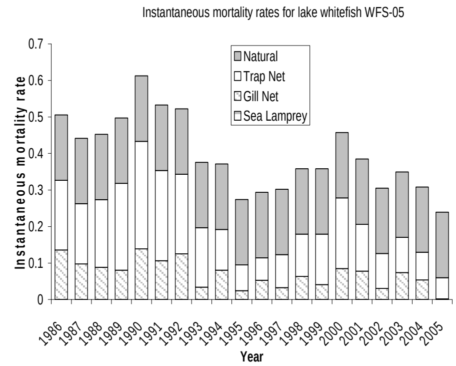


The 2005 estimate of recruitment, reported as annual numbers of age-4 lake whitefish in the population, was 97,000 fish, similar to estimates for six of the last seven years, but lower than the 2002 recruitment estimate of 168,000 (representing a strong 1998 year class).

Biomass estimates in 2005 were 1.01 million lb for the fishable stock (lake whitefish age-4 and older) and 720,000 lb for the spawning stock. Both of these values were just slightly lower than 2004 estimates. Spawning stock biomass was 71% of fishable biomass in 2005, nearly the same as the 1986-2004 average of 70%.



Estimates for total instantaneous mortality rate (Z) have remained consistently below 0.45 y^{-1} during 1993-2005 with the exception of the 2000 estimate. The estimate for Z was 0.24 y^{-1} in 2005. Natural mortality rate (M) was the largest component (18%) of Z in WFS-05. Instantaneous fishing mortality (F) rate was 0.002 y^{-1} for gill nets and 0.058 y^{-1} for trap nets.



The calculated 2007 yield limit for WFS-05 was 403,000 lb, a 12% increase from the yield limit for 2006. The combination of a slight increase in recruitment and a drop in mortality apparently counteracted the downturns in biomass and weight-at-age for the 2007 yield limit calculation.

Summary Status WFS-05 Whitefish	Value (Standard Error)
Female maturity	
Size at first spawning	1.95 lb
Age at first spawning	4 y
Size at 50% maturity	2.05 lb
Age at 50% maturity	5 y
Spawning biomass per recruit	
Base SSBR	7.128 lb (SE 0.012)
Current SSBR	2.95 lb (SE 0.12)
SSBR at target mortality	0.211 lb (SE 0.000)
Spawning potential reduction	
At target mortality	0.413 (SE 0.016)
Average yield per recruit	1.064 lb (SE 0.021)
Natural mortality (M)	0.179 y^{-1}
Fishing mortality rate 2003-2005	
Fully selected age to gill nets	11
Fully selected age to trap nets	11
Average gill net F, ages 4+	0.045 y^{-1} (SE 0.003)
Average trap net F, ages 4+	0.081 y^{-1} (SE 0.006)
Sea lamprey mortality (ML)	
Average ages 4+, 2003-2005	N/A
Total mortality (Z)	
Average ages 4+, 2003-2005	0.305 y^{-1} (SE 0.008)
Recruitment (age-4)	
Average 1996-2005	115,980 fish (SE 7,011)
Biomass (age 3+)	
Average 1996-2005	1,143,700 lb (SE 51,926)
Spawning biomass	
Average 1996-2005	820,440 lb (SE 39,582)
Recommended yield limit in 2006	403,000 lb

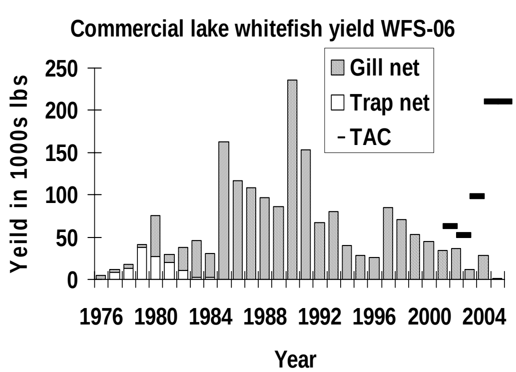
WFS-06 (Grand Marais)

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.

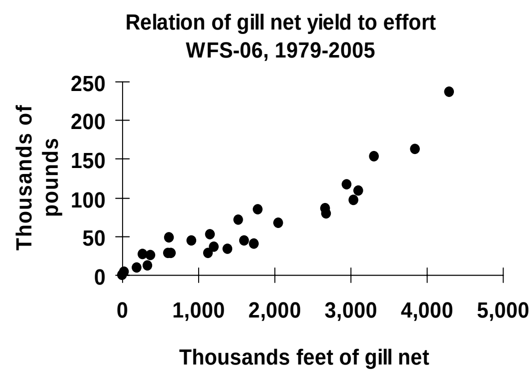
WFS-06 has been an exclusive commercial fishing zone for CORA fishers since 1985. Because the unit is so exposed to the open water of Lake Superior, and because access to the unit is limited mainly to the Grand Marais area, only large-boat gill-net fisheries typically operate here. A sizeable sport fishery targets whitefish off the pier at Grand Marais, but this yield and effort is not included in the stock assessment model.

The commercial yield of lake whitefish from WFS-06 has averaged 62,000 lb during 1976-2005. The peak yield was 236,000 lb in 1990 and the lowest yield was 682 lb in 2005.



The large-mesh gill-net fishery has accounted for 93% of the entire yield from WFS-06 during 1976-2004. Peak gill-net effort was 4.2 million ft in 1990 and there was no gill-net effort in 2005.

There was a direct linear relationship between gill-net effort and yield of whitefish in WFS-06 during 1976-2005. Gill-net effort explained 87% of the variation in gill-net yield during 1976-2005.



No stock assessment was conducted on whitefish in WFS-06 for 2004 because the small size of the yield from the area makes it difficult to collect biological data. The harvest regulating guideline for 2007 was 210,000 lb and represents the same value as in 2006.

WFS-07 (Tahquamenon Bay)

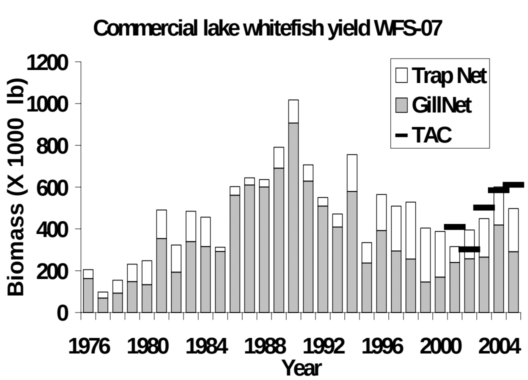
Prepared by Mark P. Ebener

WFS-07 is located in the Whitefish Bay area of Lake Superior and contains 371,000 surface acres of water less than 240 ft deep. There is a substantial commercial fishery in adjacent Canadian management unit 33.

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.

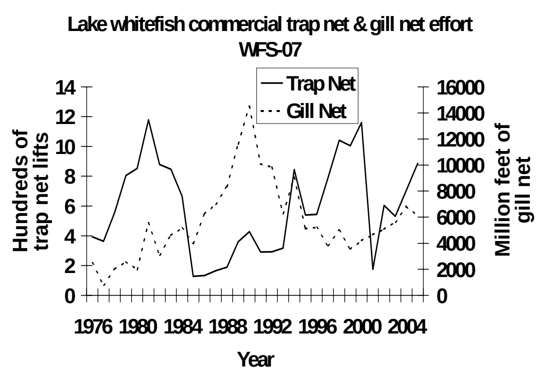
WFS-07 is an important fishing ground for the CORA fishery, and has been an exclusive CORA fishing area since 1985. Large- and small-boat gill-net fisheries as well as several trap-net fisheries operate in WFS-07. An ice fishery also takes place nearly every winter. There are a large number of relatively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

The commercial yield of whitefish from WFS-07 has averaged 472,000 lb during 1976-2005. A peak yield of one million lb occurred in 1990 and the lowest reported yield was 98,000 lb in 1977. The 2005 yield was 498,000 lb and the TAC was 611,000 lb.

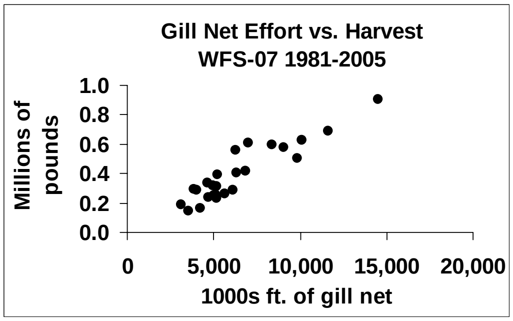


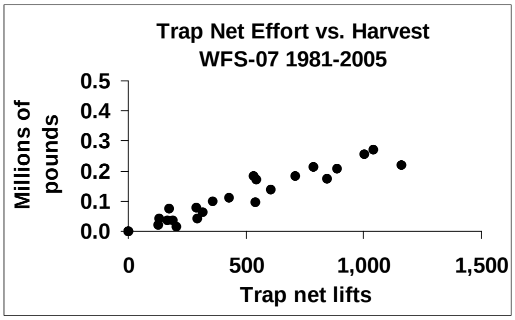
The large-mesh gill-net fishery accounted for 75% of the whitefish yield from WFS-07 during 1976-2005. The trap-net fishery harvested more whitefish from the unit than the gill-net fishery only during 1998-2000. The yield in 2005 was 290,800 lb from the gill-net fishery and 207,200 lb from the trap-net fishery.

Yield of whitefish from WFS-07 has mirrored changes in fishing effort during 1976-2005. After peaking at 17.8 million ft in 1990, large-mesh gill-net effort declined to between 3.8 and 6.8 million ft during 1995-2005. Gill-net effort was 6.1 million ft in 2005. Trap-net effort increased from 128 lifts in 1985 to 1,161 lifts in 2000, declined to 175 lifts in 2001, and then increased to 886 lifts in 2005.



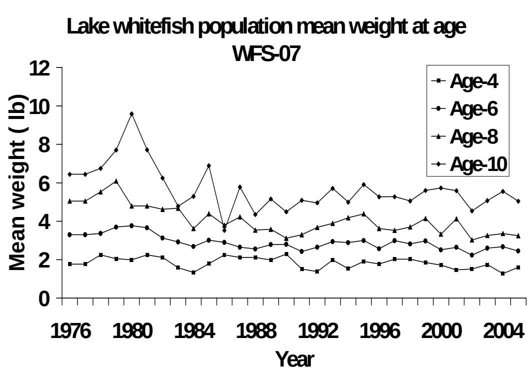
Harvest of whitefish was directly proportional to fishing effort by the CORA fishery. Gill net and trap net effort explained 87% and 91%, respectively, of the variation in harvest by each gear during 1981-2005. The average catch-per-unit-effort was 63 lb per 1,000 ft. in the gill-net fishery and 237 lb per lift in the trap-net fishery.





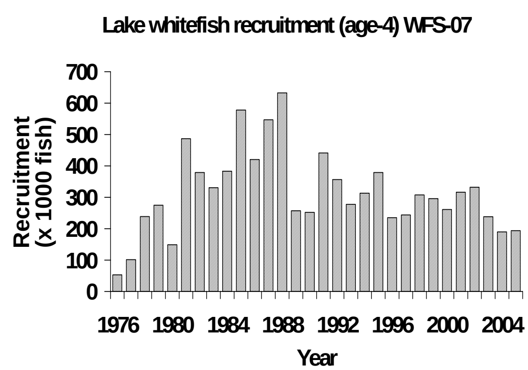
Whitefish caught in WFS-07 are of moderate to large size. Mean weight of a harvested whitefish averaged 3.3 lb in the gill-net fishery and 2.8 lb in the trap-net fishery during 1976-2005. Mean weight of a harvested whitefish in 2005 was 3.3 lb in the gill-net fishery and 2.6 lb in the trap-net fishery.

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

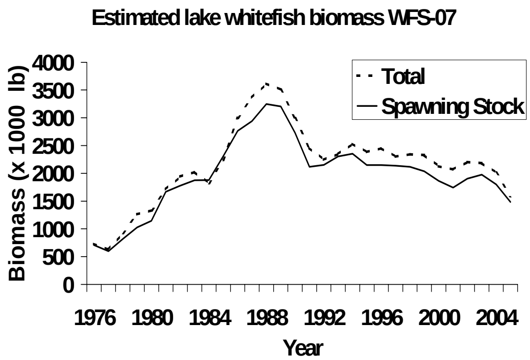


Sexual maturity of whitefish in WFS-07 occurs at a small size and young age, but complete maturity of females occurs at a large size and old age. Female whitefish begin reaching sexual maturity at age 3 and about 15 inches long, and by age 5 over 50% of females are sexually mature. After age 5, however,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

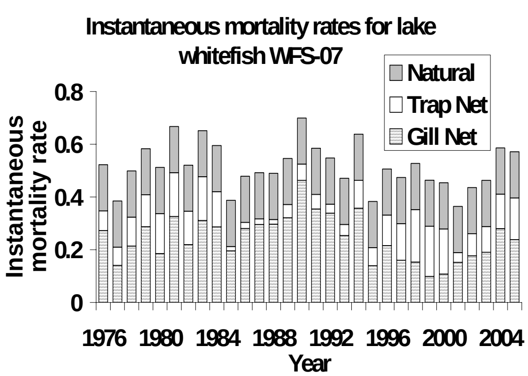
Estimated recruitment of age-4 whitefish to the fishable population peaked in 1988 and has declined slowly thereafter. The stock assessment model estimated that an average of 316,000 age-4 whitefish recruited to the fishable population each year during 1976-2005. Recruitment varied from 53,000 fish in 1976 to 663,000 fish in 1988. Recruitment was estimated to be 189,000 and 194,000 whitefish in 2004 and 2005, respectively.



Average total biomass of age-4 and older whitefish peaked at 3.61 million lb in 1988 and has declined ever since. The total biomass was 1.59 million lb in 2005, compared to a spawning biomass of 1.48 million lb. The estimated biomass of whitefish in 2005 was equal to levels observed in the early 1980s.



Instantaneous total annual mortality of age-4 and older whitefish showed little substantial change during 1976-2005. The variations in total mortality were driven largely by changes in large-mesh gill-net effort. Instantaneous total annual mortality on age-4 and older fish averaged 0.52 y^{-1} during 1976-2005 and ranged from 0.36 y^{-1} in 2001 to 0.70 y^{-1} in 1990. Fishing mortality averaged 0.34 y^{-1} during 1976-2005, while natural mortality was estimated to be 0.18 y^{-1}. Gill-net mortality averaged 0.24 y^{-1} and trap-net mortality 0.09 y^{-1} during 1976-2005. Fishing mortality in 2005 was 0.40 y^{-1}, with gill-net mortality being 0.24 y^{-1} and trap-net mortality 0.16 y^{-1}. Sea lamprey mortality is not estimated for whitefish in any Lake Superior management unit.



The projection model estimated that fishing mortality could be increased by 1.56 times in 2007 above levels estimated for 2003-2005. As a consequence, the recommended yield limit was estimated to be 551,000 lb in 2007. For the years 2001-2006, the recommended yield limits for this unit were 409,000 lb, 302,000 lb, 502,000 lb, 585,000 lb 611,000 lb, and 367,000 lb, respectively.

Summary Status WFS-07 Whitefish	Value (Standard Error)
Female maturity	
Size at first spawning	1.54 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	7.383 lb (SE 0.001)
Current SSBR	1.26 lb (SE 0.08)
SSBR at target mortality	0.256 lb (SE 0.000)
Spawning potential reduction	
At target mortality	0.171 (SE 0.011)
Average yield per recruit	1.570 lb (SE 0.004)
Natural mortality (M)	0.175 y^{-1}
Fishing mortality rate 2003-2005	
Fully selected age to gill nets	6
Fully selected age to trap nets	6
Average gill net F, ages 4+	0.236 y^{-1} (SE 0.018)
Average trap net F, ages 4+	0.129 y^{-1} (SE 0.009)
Sea lamprey mortality (ML)	
Average ages 4+, 2003-2005	N/A
Total mortality (Z)	
Average ages 4+, 2003-2005	0.54 y^{-1} (SE 0.025)
Recruitment (age 4)	
Average 1996-2005	261,380 fish (SE 9,303)
Biomass (age 3+)	
Average 1996-2005	2,161,500 lb (SE 86,386)
Spawning biomass	
Average 1996-2005	1,921,600 lb (SE 81,198)
Recommended yield limit in 2007	551,000 lb

WFS-08 (Brimley)

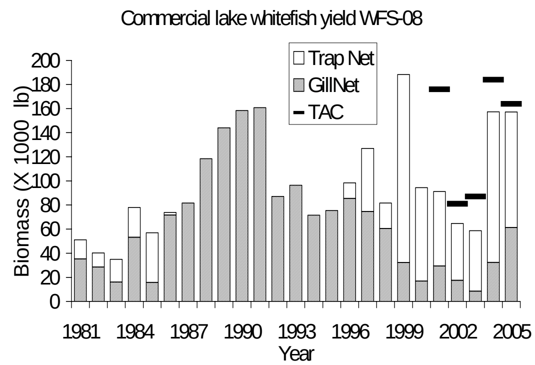
Prepared by Mark P. Ebener

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.

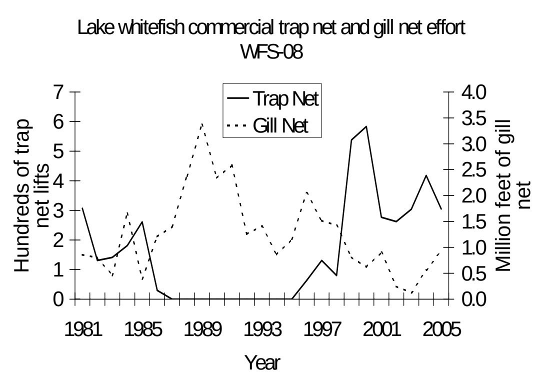
There are probably four reproductively isolated stocks of whitefish that contribute to the commercial fishery in WFS-08. Whitefish that spawn in WFS-07 are caught in the commercial fishery of WFS-08. The areas off Birch Point and Iroquois Island are both whitefish spawning grounds that contribute to the fishery in WFS-08. A fourth spawning population located in Canadian waters off Gros Cap also contributes whitefish to the fishery in WFS-08.

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 seven or eight undeveloped landing sites that are commonly used by the CORA small-boat fishery during the open-water fishing season. A commercial trap-net fishery and a sport fishery for whitefish also occur in the unit.

The commercial yield of whitefish from WFS-08 has averaged 97,900 lb during 1981-2005. 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 67% of the yield from WFS-08 during 1981-2005. There was no trap-net yield from WFS-08 during 1987-1995. The trap-net yield in 2005 was 95,900 lb, while the gill-net yield was 61,200 lb.

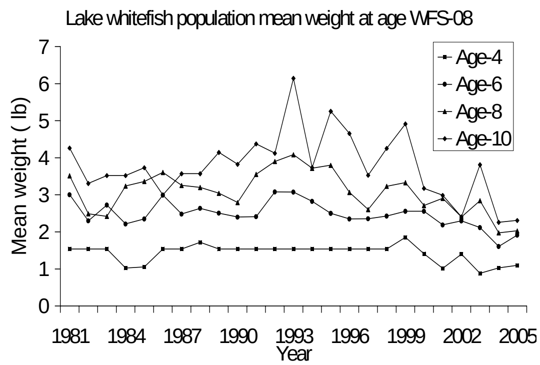


Gill-net effort has been declining in WFS-08 while trap-net effort has increased tremendously. Peak gill-net effort was 4.1 million ft in 1989, but it declined to 0.94 million ft in 2005. Trap-net effort peaked at 738 lifts in 1979, declined to zero during 1987-1995, and increased to 583 lifts in 2000. Trap-net effort was 305 lifts in 2005.



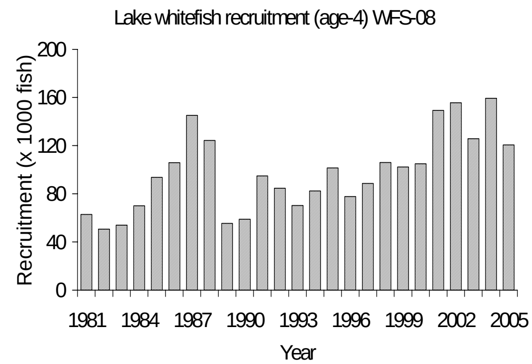
Whitefish in WFS-08 are of moderate to large size. Mean weight of a harvested whitefish in the gill-net fishery averaged 3.0 lb and mean weight in the trap-net fishery averaged 2.2 lb during 1981-2005. Mean weight of a harvested whitefish in 2005 was 2.0 lb in the trap-net fishery and 2.6 lb in the gill-net fishery.

Growth in weight of whitefish in WFS-08 has remained fairly stable during 1981-1993, but has declined over the period of 1994-2005 unlike in adjacent WFS-07. Mean weight of age-5 and older whitefish was about the same in 2005 as in 2004.

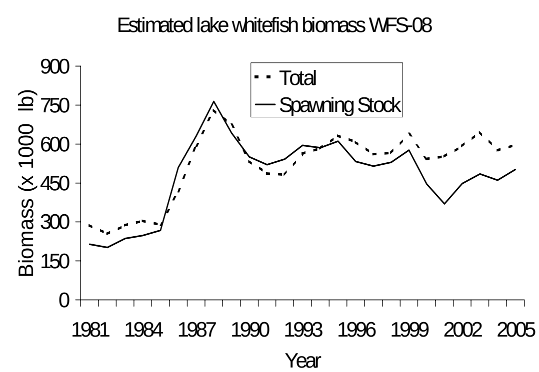


Whitefish in WFS-08 mature at smaller sizes and ages than in WFS-07. Female whitefish in WFS-08 begin maturing at 15 inches total length and at age 3. Two-thirds of whitefish in WFS-08 are sexually mature by age 4. Complete maturity is reached at 23 inches total length and age 11.

Recruitment of age-4 whitefish to the fishable population in WFS-08 has been less variable than in adjacent unit WFS-07, and has increased during the last decade unlike in WFS-07. The stock assessment model estimated that an average of 98,000 age-4 whitefish recruited to the fishable population in WFS-08 each year during 1981-2005. Recruitment peaked in 2004 at 149,000 age-4 whitefish. Recruitment was estimated to be 121,000 age-4 whitefish in 2005.

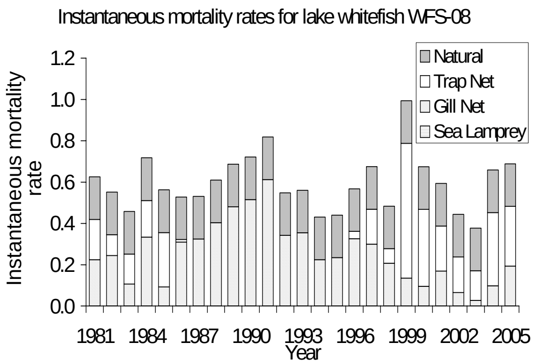


Because of the decline in mean weight-at-age, spawning stock biomass of whitefish in WFS-08 has declined faster than total biomass. Total biomass of age-4 and older whitefish averaged 520,000 lb during 1981-2005 and ranged from 254,000 lb in 1982 to 731,000 lb in 1988. Total and spawning biomass were nearly equal through 1995, thereafter the disparity between total and spawning biomass increased. Total biomass was estimated to be 597,000 lb and spawning biomass was estimated to be 502,000 lb in 2005.



Total annual mortality of age-4 and older whitefish increased slightly from 2004 to 2005 in WFS-08. Total instantaneous mortality of age-4 and older whitefish averaged 0.60 y^{-1} during

1981-2005. Estimated total annual mortality of whitefish in WFS-08 was 0.69 y^{-1} in 2005. The trap-net fishery has inflicted the majority of fishing mortality on whitefish in WFS-08 since 1999. Trap-net mortality was 0.29 y^{-1}, gill-net mortality 0.21 y^{-1}, and natural mortality 0.26 y^{-1} in 2005.



Total instantaneous mortality on age-4 and older whitefish was less than the target rate of 1.05 y^{-1} during 2003- 2005. The SPR value at the target mortality rate was 0.36 and greater than the target SPR value of 0.20. Thus the projection model estimated that fishing mortality rate in 2006 could be increased 1.52 times from levels experienced during 2003-2005. The recommended yield limit at this increased rate of fishing was estimated to be 177,000 lb in 2007. For the years 2001-2006, the recommended yield limits for this unit were 176,000 lb, 81,000 lb, 67,000 lb, 184,000 lb, 164,000 lb, and 148,000 lb, respectively.

Summary Status WFS-08 Whitefish	Value (Standard Error)
Female maturity	
Size at first spawning	1.00 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	2.446 lb (SE 0.003)
Current SSBR	0.89 lb (SE 0.03)
SSBR at target mortality	0.146 lb (SE 0.000)
Spawning potential reduction	
At target mortality	0.362 (SE 0.013)
Average yield per recruit	0.889 lb (SE 0.014)
Natural mortality (M)	0.206 y^{-1}
Fishing mortality rate 2003-2005	
Fully selected age to gill nets	10
Fully selected age to trap nets	10
Average gill net F, ages 4+	0.106 y^{-1} (SE 0.01)
Average trap net F, ages 4+	0.262 y^{-1} (SE 0.017)
Sea lamprey mortality (ML)	
Average ages 4+, 2003-2005	N/A
Total mortality (Z)	
Average ages 4+, 2003-2005	0.575 y^{-1} (SE 0.025)
Recruitment (age-4)	
Average 1996-2005	119,000 fish (SE 6,382)
Biomass (age 3+)	
Average 1996-2005	587,960 lb (SE 20,492)
Spawning biomass	
Average 1996-2005	486,590 lb (SE 16,772)
Recommended yield limit in 2007	177,000 lb

Lake Huron

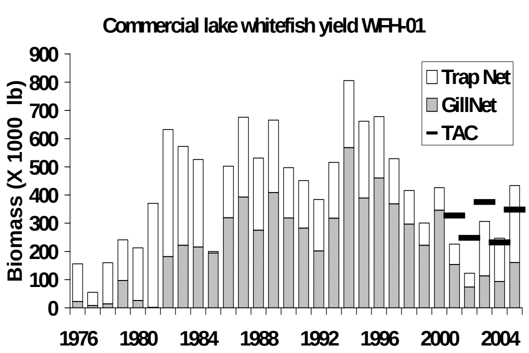
WFH-01 (St. Ignace)

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.

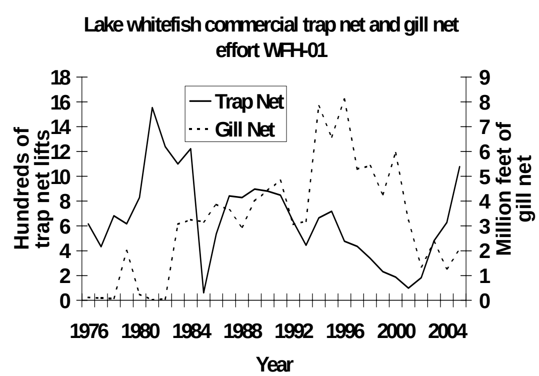
There are probably several reproductively isolated stocks of lake whitefish that inhabit WFH-01. One stock is located near Cheboygan, MI, another stock spawns north of St. Ignace near Rabbitsback and Horseshoe Bay, and a third stock spawns in St. Martin Bay. A fourth stock probably spawns near Hessel, 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 417,000 lb during 1976-2005. The commercial yield was 433,700 lb in 2005 compared to 243,600 lb in 2004. The yield in 2005 was more than the recommended harvest limit of 348,000 lb.



The large-mesh gill-net fishery has accounted for the majority of the commercial yield from WFH-01 during 1976-2005. From 1976-1984 large-mesh gill nets accounted for 0-41% of the annual yield, while after 1985 gill nets accounted for 37-81% of the annual yield. The gill-net fishery harvested 160,900 lb in 2005 compared to 272,800 lb for the trap-net fishery.

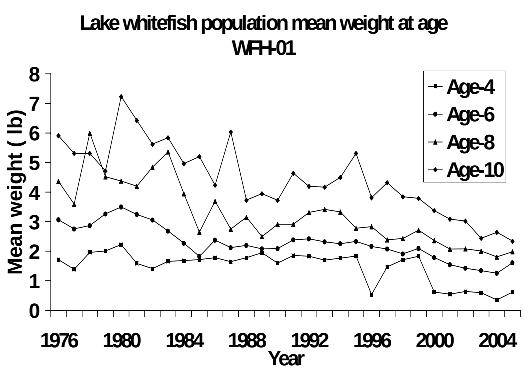
Gill-net effort continued to be much lower than the long-term average in WFH-01 in 2005, while trap-net effort continued to increase. Trap-net effort peaked at 1,357 lifts in 1981 and declined to only 98 lifts in 2001 before increasing to 1,078 lifts in 2005. Gill-net effort was stable at about 3.6 million ft from 1983 to 1993, increased to 8.1 million ft in 1996, and then declined to between 1.3 and 2.3 million ft during 2002-2005. Gill-net effort was 2.0 million feet in 2005.



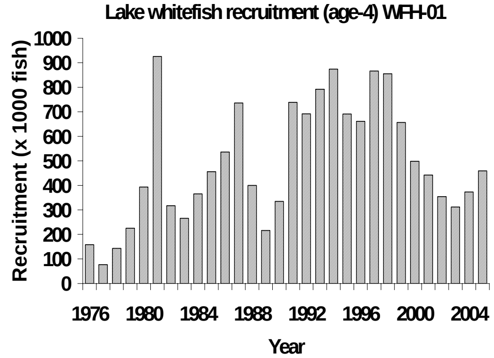
Whitefish in WFH-01 are of small size with over 90% of the harvest by weight being made up of No.1 fish. Mean weight of whitefish in the trap-net fishery ranged from 2.1 to 2.3 lb during

1980-2005. Mean weight of whitefish in the gill-net fishery ranged from 2.2 to 3.0 lb during 1982-2005. Mean weight of a harvested whitefish was 2.4 lb in the gill-net fishery and 2.1 lb in the trap-net fishery in 2005.

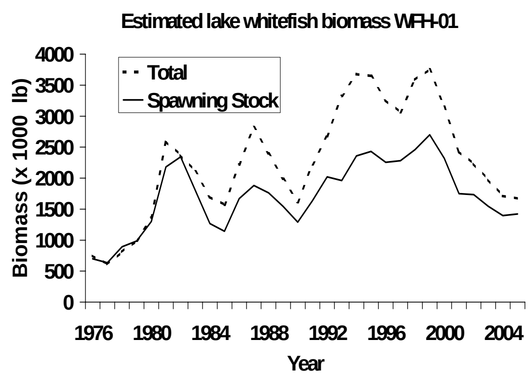
Growth of lake whitefish, expressed as mean weight at age, appears to have stabilized in 2005. Mean weight-at-ages 4-9 stabilized or increased slightly from 2004 to 2005, where as mean weight of age-10 and older fish continued to declines in 2005. Unfortunately, mean weight at all ages in 2005 was still substantially lower than in nearly all previous years.



Large year classes of whitefish were produced during 1987-1995 in WFH-01. These large year classes produced the highest yield of 806,000 lb in 1994 and also probably helped suppress growth of whitefish in the unit. An estimated average of 494,000 age-4 whitefish recruited the population each year during 1976-2005. Recruitment varied from a low of 77,000 in 1977 (1973 year class) to a high of 925,000 age-4 whitefish in 1981 (1977 year class). The 1987-1995 year classes averaged 758,000 fish. Recruitment was estimated to be 459,000 age-4 whitefish in 2005.



Because of the declines in growth and recruitment in WFH-01, biomass declined to a low level in 2004 but appeared to stabilize in 2005 for the first time since the late 1990s. Total biomass of age-4 and older fish declined from 3.4 million lb in 1994 to 1.7 million lb in 2004 and 2005, while spawning biomass declined from 2.3 million lb in 1999 to 1.4 million lb in 2004 and 2005.



Total instantaneous mortality of age-4 and older whitefish in WFH-01 was increased considerably from 2004 to 2005 due to increased fishing and sea lamprey mortality. Total annual mortality ranged from 0.32 y^{-1} to 0.34 y^{-1} during 2001-2004, and was 0.51 y^{-1} in 2005. Gill-net mortality of age-4 and older whitefish increased from 0.04 y^{-1} in 2004 to 0.08 y^{-1} in 2005 and trap net mortality increased from 0.08 y^{-1} to 0.17 y^{-1} from 2004 to 2005. Sea lamprey-induced mortality increased from 0.0 y^{-1}

in 2004 to 0.06 y^{-1} in 2005. Natural mortality was estimated to be 0.19 y^{-1}.

The current spawning potential reduction value of 0.39 in WFH-01 during 2003-2005 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 1.9 times above the 2003-2005 values. The increase in fishing effort produced a recommended yield limit of 394,000 lb for 2007. For the years 2001-2006, the recommended yield limits for this unit were 327,000 lb, 248,000 lb, 375,000 lb, 232,000 lb, 348,000 lb, and 395,000 lb, respectively.

Summary Status WFH-01 Whitefish	Value (Standard Error)
Female maturity	
Size at first spawning	0.52 lb
Age at first spawning	4 y
Size at 50% maturity	1.40 lb
Age at 50% maturity	6 y
Spawning biomass per recruit	
Base SSBR	2.127 lb (SE 0.003)
Current SSBR	0.83 lb (SE 0.03)
SSBR at target mortality	0.076 lb (SE 0.000)
Spawning potential reduction	
At target mortality	0.391 (SE 0.012)
Average yield per recruit	0.587 lb (SE 0.015)
Natural mortality (M)	0.218 y^{-1}
Fishing mortality rate 2003-2005	
Fully selected age to gill nets	9
Fully selected age to trap nets	9
Average gill net F, ages 4+	0.067 y^{-1} (SE 0.005)
Average trap net F, ages 4+	0.127 y^{-1} (SE 0.009)
Sea lamprey mortality (ML)	
Average ages 4+, 2003-2005	0.039 y^{-1}
Total mortality (Z)	
Average ages 4+, 2003-2005	0.451 y^{-1} (SE 0.014)
Recruitment (age-4)	
Average 1996-2005	547,710 fish (SE 34,340)
Biomass (age 3+)	
Average 1996-2005	2,683,400 lb (SE 104,720)
Spawning biomass	
Average 1996-2005	1,985,900 lb (SE 78,379)
Recommended yield limit in 2007	394,000 lb

WFH-02 (Detour)

Prepared by Mark P. Ebener

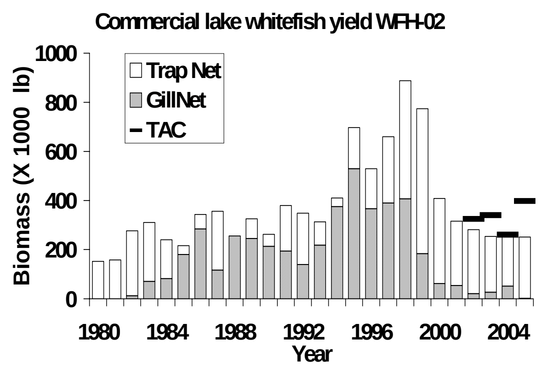
Management unit WFH-02 is located along the northern shore of the main basin of Lake Huron. Much of WFH-02 is deeper than 150 ft and maximum depth is slightly more than 300 ft. WFH-02 is a small unit made up of only three statistical grids and contains 122,562 surface acres of water less than 240 ft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

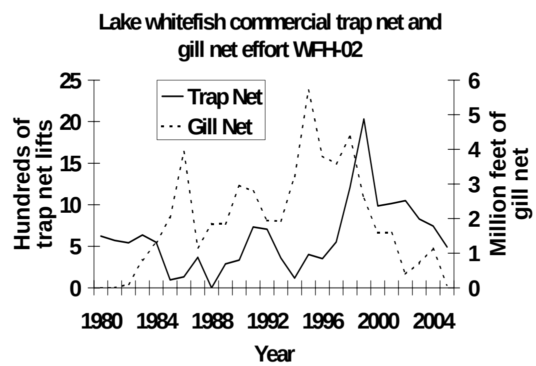
Because the shoreline of WFH-02 is highly irregular and rocky, nearly the entire unit contains habitat suitable for reproduction and survival of young whitefish. Spawning concentrations of whitefish can be found from Beavertail Point in the west portion of the unit to St. Vitals Point in the middle of the unit. This area covers roughly 16 miles or more of shoreline. 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 1980-2005 and ranged from a low of 152,000 lb in 1980 to a high of 888,000 lb in 1998. The fishery yield was 251,000 lb in 2005.

The allocation of the harvest among fishing gears has changed dramatically in WFH-02 over the past few years. During 1985-1997 the large-mesh gill-net fishery accounted for the majority of harvest. After 1997 the trap-net fishery accounted for the largest proportion of the harvest. The trap-net fishery harvested 249,000 lb of whitefish in 2005, while the gill-net fishery harvested only 1,600 lb.

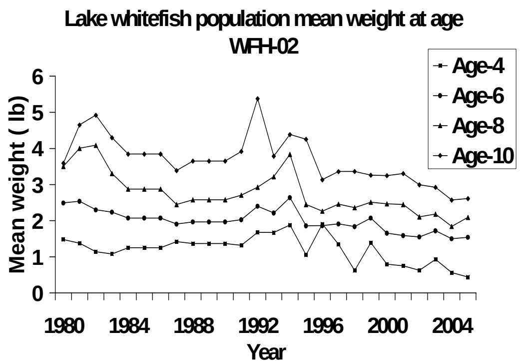
Both large-mesh gill-net and trap-net effort have changed markedly in WFH-02 since 1980. Trap-net effort ranged from 0 to 713 lifts between 1980 and 1997, thereafter effort increased to 2,033 lifts in 1999, then declined almost annually to only 492 lifts in 2005. Large-mesh gill-net effort increased from zero in 1981 to 7.2 million ft in 1995, since then gill-net effort has declined almost annually to 0.08 million ft in 2005.



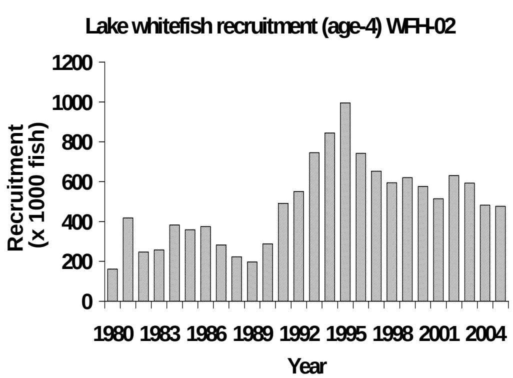


Whitefish in WFH-02 have always been of small size. No.1 fish made up 90% of the harvest from the unit during 1980-2004. Mean weight in the trap-net harvest has ranged from 2.0 to 2.3 lb and mean weight in the gill-net harvest ranged from 1.9 to 2.8 lb during 1980-2005. Mean weight of a harvested whitefish was 2.2 lb in the trap-net fishery and 2.6 lb in the gill-net fishery in 2005.

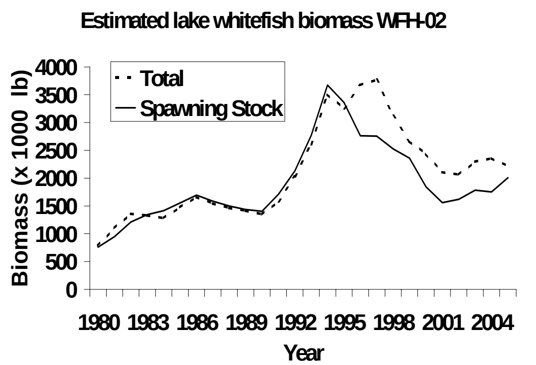
Unlike other units in Lake Huron, growth of whitefish in WFH-02 remained stable through 2000. There was a slight decline in mean weight-at-age from 1980 to 1984, but it was not as steep as in WFH-01, WFH-04, and WFH-05. Mean weight of almost all ages increased from 2004 to 2005 except of age-4 fish.



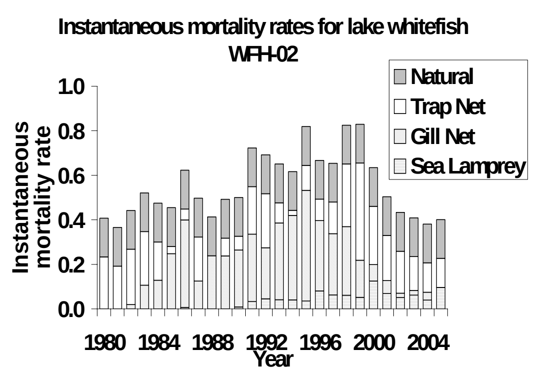
The increase in commercial fishery yield during the mid 1990s was driven largely by increased recruitment. The 1989-1993 year classes of whitefish were substantially larger than preceding and subsequent year classes. The stock assessment model estimated that the 1991 year class contained one million fish when it recruited to the fishery at age 4 in 1995. Recruitment averaged 489,000 fish during 1980-2005 and was estimated to be 476,000 fish in 2005.



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 1.35 million lb in 1990 to 3.8 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 in the mid 1990s the difference between total and spawning biomass became much larger. Total biomass was estimated to be 2.2 million lb and spawning biomass 2.0 million lb in 2005.



Total annual mortality rate on age-4 and older whitefish in WFH-02 increased nearly annually from 1980 to 1999, and declined thereafter. Total instantaneous mortality of age-4 and older whitefish increased from 0.37 y^{-1} in 1981 to 0.83 y^{-1} in 1999, and then declined to 0.38 y^{-1} in 2004. Total mortality of age-4 and older whitefish was 0.40 y^{-1} in 2005.



The increase in total mortality was due to substantial increases in fishing mortality through 1999 and increased sea lamprey mortality since 1990. Fishing mortality increased from 0.19 y^{-1} in 1981 to 0.60 y^{-1} in 1998, then declined to 0.13 y^{-1} in 2005. Gill-net mortality was 0.001 y^{-1} and trap-net mortality was 0.13 y^{-1} in 2005. Sea lamprey mortality of age-4 and older whitefish increased from 0.01 y^{-1} in 1990 to 0.12 y^{-1} in 2000, then stabilized at about 0.03 y^{-1} during 2001-2005.

Total annual mortality of age-4 and older whitefish averaged 0.454 y^{-1} during 2003-2005. Spawning potential reduction at the current mortality rate was 0.36 and considerably greater than the target of 0.20. The projection model estimated that fishing mortality rate could be increased 1.48 times to achieve the target mortality rate. As a consequence, the projection model estimated a yield limit of 410,000 lb for 2007. In comparison, harvest limits were 454,000 lb in 2006, 298,000 lb in 2005, 261,000 lb in 2004 and 221,000 lb in 2003.

Summary Status WFH-02 Whitefish	Value (Standard Error)
Female maturity	
Size at first spawning	0.64 lb
Age at first spawning	4 y
Size at 50% maturity	1.33 lb
Age at 50% maturity	5 y
Spawning biomass per recruit	
Base SSBR	2.961 lb (SE 0.005)
Current SSBR	1.07 lb (SE 0.03)
SSBR at target mortality	0.108 lb (SE 0.000)
Spawning potential reduction	
At target mortality	0.361 (SE 0.009)
Average yield per recruit	0.585 lb (SE 0.016)
Natural mortality (M)	0.199 y^{-1}
Fishing mortality rate 2003-2005	
Fully selected age to gill nets	9
Fully selected age to trap nets	9
Average gill net F, ages 4+	0.022 y^{-1} (SE 0.002)
Average trap net F, ages 4+	0.158 y^{-1} (SE 0.011)
Sea lamprey mortality (ML)	
Average ages 4+, 2003-2005	0.075 y^{-1}
Total mortality (Z)	
Average ages 4+, 2003-2005	0.454 y^{-1} (SE 0.013)
Recruitment (age-4)	
Average 1996-2005	588,450 fish (SE 39,346)
Biomass (age 3+)	
Average 1996-2005	2,670,000 lb (SE 106,830)
Spawning biomass	
Average 1996-2005	2,096,400 lb (SE 81,160)
Recommended yield limit in 2007	410,000 lb

WFH-03 (Drummond Island)

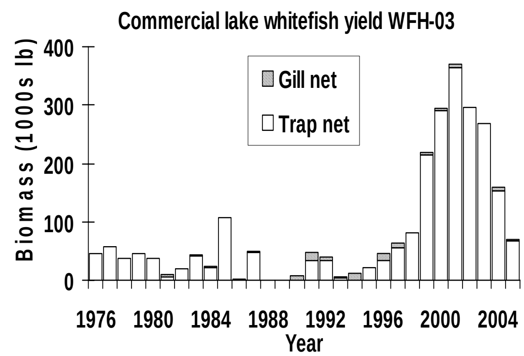
Prepared by Mark P. Ebener

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 Drummond Island where large-mesh gill-net fishing is prohibited 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. WFH-03 contains six statistical grids and less than 100,000 surface acres of water less than 240 ft deep.

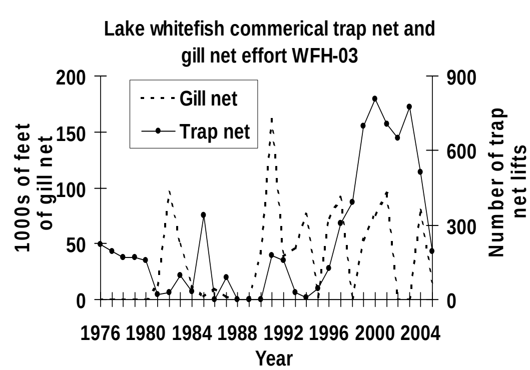
The spawning shoals for lake whitefish in WFH-03 are located primarily along the south shore of Drummond Island in the main basin of Lake Huron. Adult whitefish in spawning condition have been caught primarily between Seaman Point and Big Shoal during gill-net surveys in October and early November of 1991-2004.

WFH-03 has been an exclusive fishing zone for the CORA fishery since 1985. The unit is primarily a trap-net fishery, 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.

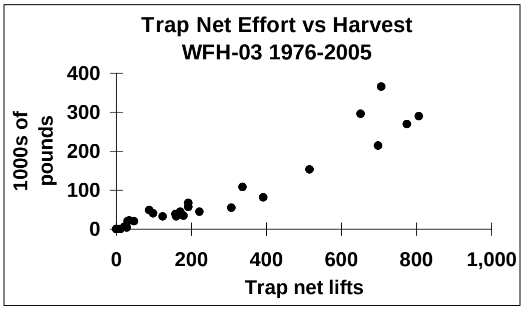
The commercial yield of lake whitefish from WFH-03 increased tremendously during the late 1990s, peaked in 2001, and since then has declined annually. Prior to 1998 the commercial yield of lake whitefish exceeded 100,000 lb only in 1985. After 1998 the commercial yield increased from 82,000 lb in 1999 to 370,000 lb in 2001, but then declined to only 69,000 lb in 2005. Ninety-nine percent of the yield was taken with trap-nets during 1999-2005.

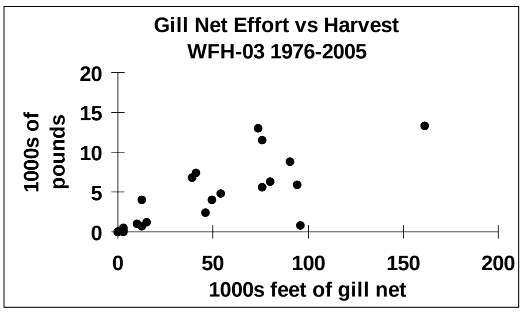


The large-increase in harvest during 1999-2003 was directly related to increased trap-net effort. Trap-net effort ranged from 0 to 337 lifts during 1976-1997, thereafter trap-net effort increased to between 356 and 806 lifts. Gill-net effort was highly variable and low in WFH-03 ranging from 0 to 162,000 ft. during 1976-2004. Gill-net effort was only 15,000 ft in 2005, while trap-net effort was 192 lifts.



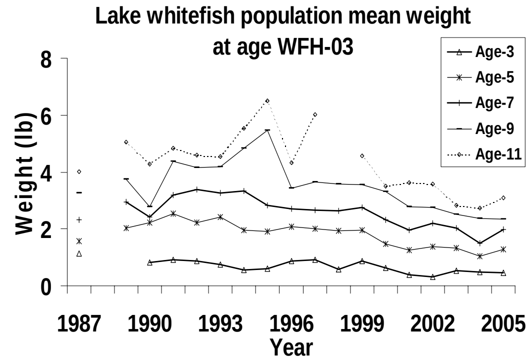
There is a direct linear relationship between fishing effort and subsequent yield in the commercial fishery of WFH-03. Fishing effort explained 91% of the variation in trap-net yield of whitefish from WFH-03 during 1976-2003, while gill-net effort explained only 66% of the variation in gill net yield. Both relationships were linear, positive, and statistically significant.



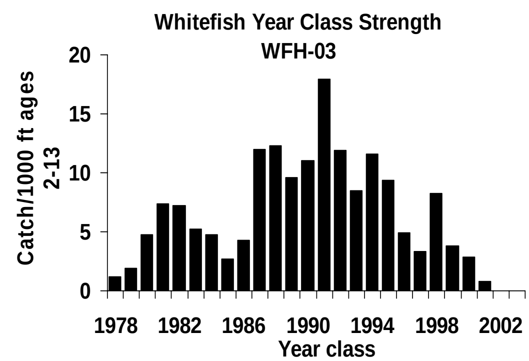


Whitefish caught in the fishery of WFH-03 are of moderate size. During 1987-2005 70% of the whitefish harvested were No.1 fish, 23% were mediums, and 7% were jumbos. Mean weight of whitefish in the trap-net harvest ranged from 2.0 to 2.8 lb and averaged 2.4 lb during 1991-2005. Mean weight in the gill-net fishery ranged from 2.3 to 3.0 lb and averaged 2.6 lb. Mean weight of whitefish was 2.1 lb in the trap-net fishery and 2.9 lb in the gill-net fishery in 2005.

Growth of whitefish, expressed as mean weight-at-age, stabilized in 2005. Mean weight of ages 3-11 increased or remained the same from 2004 to 2005 for the first time since the mid 1990s. Only mean weight of age-3 whitefish did not increased from 2004 to 2005. Mean weight-at-age was still lower in 2005 than in most other years.



Recruitment of whitefish in WFH-03 has declined in recent years and is probably contributing to the reduced catches and fishing effort. The 1987-1995 year classes were abundant in WFH-03, but only the 1998 year class has been abundant since then based upon gill net survey catches in the Refuge during 1991-2005.



No attempt was made to develop a stock assessment of whitefish this unit in 2004 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 306,000 lb was established for WFH-03 in 2007 and is identical to the 2004-2006 values.

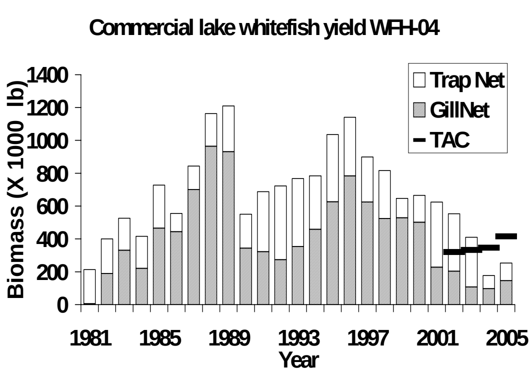
WFH-04 (Hammond Bay)

Prepared by Mark P. Ebener and Aaron P. Woldt

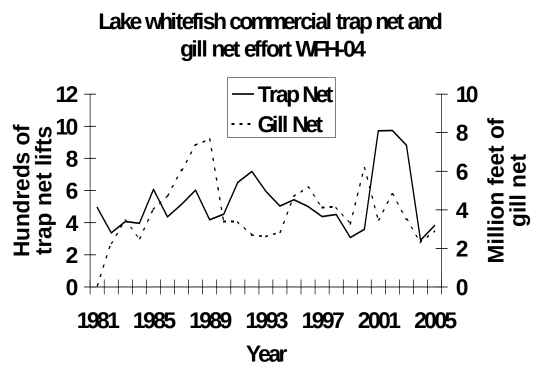
WFH-04 is the largest whitefish management unit in the 1836 treaty-ceded waters of Lake Huron. The unit contains 377,567 surface acres of water less than 240 ft deep. Spawning concentrations of whitefish are scattered throughout the unit with concentrations being found from Cheboygan, MI to Hammond Bay.

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 62% of the whitefish harvest from WFH-04 during 1981-2004. 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 671,000 lb during 1981-2005. The trap-net fishery harvested 107,000 lb of whitefish in 2005 compared to 145,700 lb for the gill-net fishery. The 2005 yield of 253,000 lb was less than the predicted harvest limit of 460,000 lb.



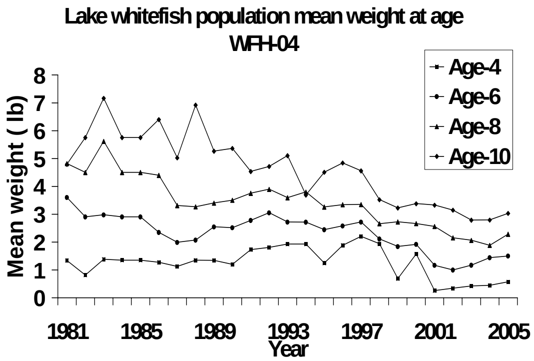
Both trap-net and gill-net effort increased slightly in the unit from 2004 to 2005. Trap-net effort peaked at 719 lifts in 1992, declined to 308 lifts in 1999, increased to 974 lifts in 2002, but then declined to 291 lifts in 2004 and 382 lifts in 2005. Large-mesh gill-net effort peaked at 7.7 million ft in 1989 and 5.2 million ft in 2000, and was only 2.9 million ft in 2005.



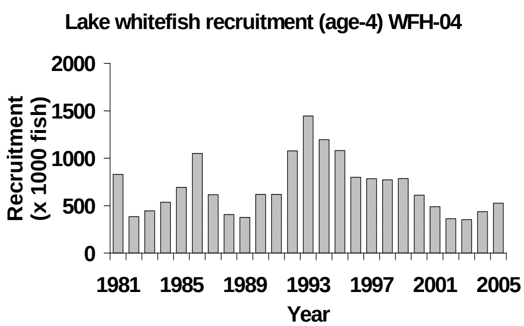
Whitefish from WFH-04 are of moderate size. The commercial harvest from WFH-04 was composed of 64% No.1 whitefish, 27% mediums, and 9% jumbos during 1982-2005. Annual mean weight of whitefish caught in the gill-net fishery ranged from 2.5 to 3.0 lb during 1982-2005, while mean weight in the trap-net fishery ranged from 2.4 to 3.6 lb during 1982-2005. Mean weight in the harvest in 2005 was 2.2 lb for the trap-net fishery and 2.7 lb for the gill-net fishery.

Growth of whitefish in WFH-04 continued to stabilize and increase slightly among most age classes from 2004 to 2005. Mean weight-at-age of ages 4-6 has been increasing since 2001, while weight-at-age of older fish increased only from 2004 to 2005.

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.

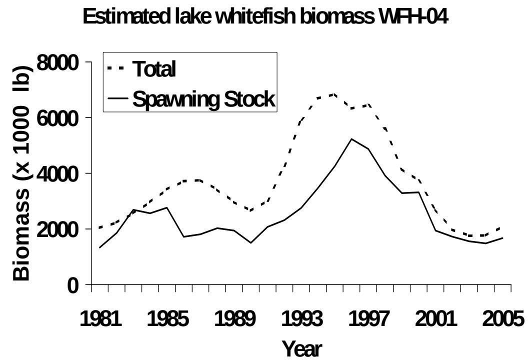


The 1988-1991 year classes of whitefish were very abundant ranging from 1.08 to 1.45 million fish at age 4. The 1998 and 1999 year classes were the least abundant at 364,000 and 353,000 fish, respectively, during 1981-2005. The 2001 year class was estimated to contain 527,000 fish at age 4 in 2005.

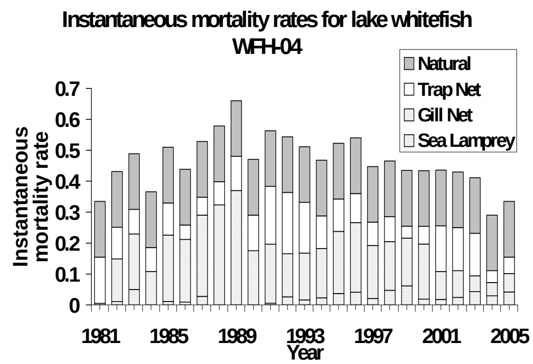


The combined effects of reduced recruitment and growth drove biomass of whitefish in WFH-04 to low levels during 2001-2005. After peaking at 6.8 million lb in 1995, total biomass declined nearly annually to only 1.8 million lb in 2004 and 2.1 million lb in 2005. Spawning stock biomass declined from 5.2 million lb in 1996 to 1.5 million lb in 2004 and 1.7 million lb in 2005.

Total instantaneous mortality of age-4 and older whitefish averaged 0.395 y^{-1} during 2003-2005. Gill-net mortality averaged 0.058 y^{-1}, trap-net mortality 0.087 y^{-1}, and sea lamprey mortality



0.043 y^{-1} during 2003-2005. In 2005 gill-net mortality was 0.06 y^{-1}, trap-net mortality 0.05 y^{-1}, and sea lamprey mortality 0.04 y^{-1} on age-4 and older whitefish. Natural mortality was estimated to be 0.180 y^{-1}.



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 2.30 times in 2007 over that experienced during 2003-2005. The spawning potential reduction value at the target-fishing rate was 0.36. The recommended harvest level for WFH-04 in 2007 was 597,000 lb compared to 460,000 in 2006, and 415,000 lb in 2005.

Summary Status WFH-04 Whitefish	Value (Standard Error)
Female maturity	
Size at first spawning	0.48 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	2.623 lb (SE 0.000)
Current SSBR	0.95 lb (SE 0.04)
SSBR at target mortality	0.127 lb (SE 0.000)
Spawning potential reduction	
At target mortality	0.361 (SE 0.014)
Average yield per recruit	0.655 lb (SE 0.020)
Natural mortality (M)	0.206 y^{-1}
Fishing mortality rate 2003-2005	
Fully selected age to gill nets	9
Fully selected age to trap nets	9
Average gill net F, ages 4+	0.058 y^{-1} (SE 0.006)
Average trap net F, ages 4+	0.087 y^{-1} (SE 0.007)
Sea lamprey mortality (ML)	
Average ages 4+, 2003-2005	0.043 y^{-1}
Total mortality (Z)	
Average ages 4+, 2003-2005	0.395 y^{-1} (SE 0.012)
Recruitment (age-4)	
Average 1996-2005	592,580 fish (SE 36,479)
Biomass (age 3+)	
Average 1996-2005	3,656,400 lb (SE 135,790)
Spawning biomass	
Average 1996-2005	2,901,100 lb (SE 111,910)
Recommended yield limit in 2007	597,000 lb

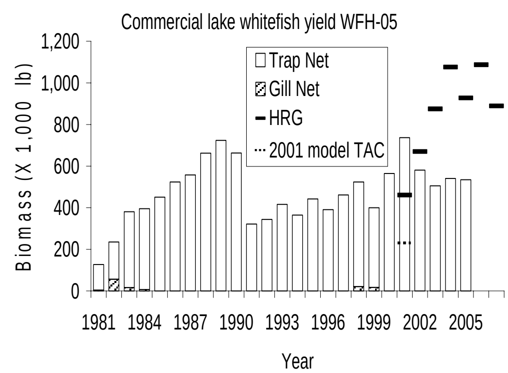
WFH-05 (Alpena)

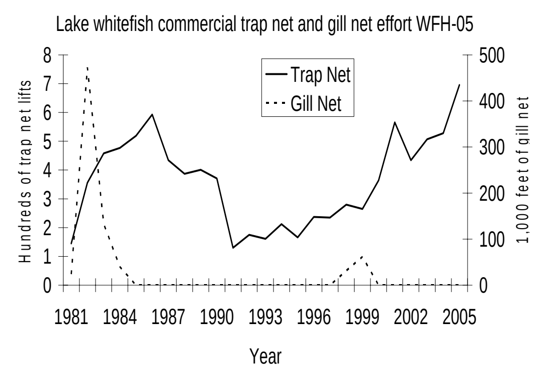
Prepared by Aaron P. Woldt and Mark P. Ebener

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 less than 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.

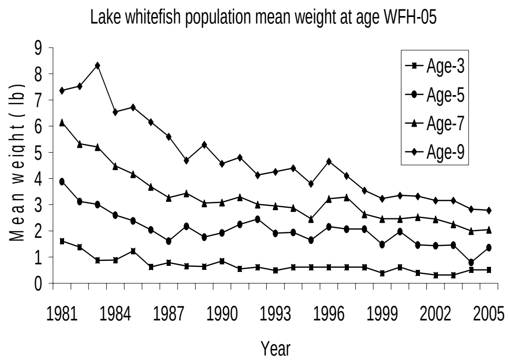
Annual commercial trap-net yield has ranged from 124,000 lb in 1981 to 736,000 lb in 2001 and averaged 469,000 lb during 1981-2005. In general, trap-net harvest and effort have been directly related over the modeled time series and have been especially linked since 1991. As trap-net effort increased 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 2002, trap-net effort has increased annually, but trap-net yield has remained relatively stable. The relatively tight relationship between trap-net effort and yield diverged further in 2005, as trap net effort increased by 32% from 2004 levels, and trap net yield remained stable.



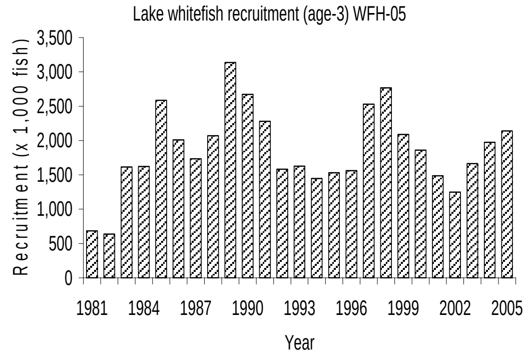


Whitefish in WFH-05 are of similar size to those in WFH-04. The commercial harvest from WFH-05 was made up of approximately 70% No.1 whitefish (< 3 lb), 23% mediums (3-4 lb), and 7% jumbos (≥ 4 lb). Mean weight of a harvested whitefish was 2.5 lb in WFH-05 in 2005. Mean weight of a harvested whitefish has been steadily decreasing since 1998, but increased slightly from 2004 to 2005.

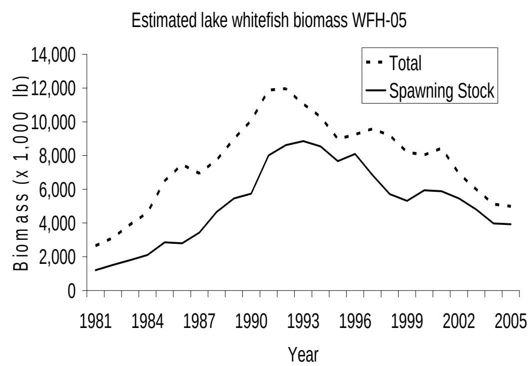
Weight-at-age of whitefish in WFH-05 has stabilized over the last few years after continually declining from 1981 to 1999. Prior to 1984, age-9 and older whitefish weighed between 7 and 8 lb, but by 2005 they weighed about 2.8 lb. This large decrease in average weight for older fish is likely due to decreased growth rates. Mean weight of all age classes in 2005 was similar to mean weight-at-age from 1999 to 2004. Mean weight-at-age of age-5 fish increased slightly in 2005 to a level nearly equal to mean weight-at-age in 2003.



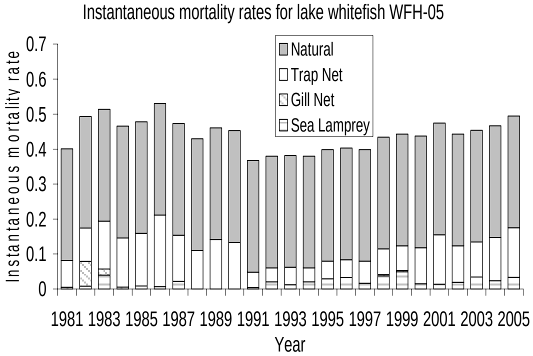
Recruitment of age-3 whitefish to the fishable population in WFH-05 has been cyclical since 1981. Recruitment peaked at 3.1 million age-3 whitefish in 1989, and then declined annually to about 1.6 million age-3 whitefish in 1996 (1993 year class). Recruitment then peaked again in 1998 at 2.8 million age-3 whitefish, before declining annually to about 1.2 million age-3 whitefish in 2002. From 2003 through 2005, estimated recruitment increased and averaged about 1.93 million age-3 whitefish. The stock assessment model estimated that 2.14 million age-3 whitefish were present in the population during 2005.



Both fishable and spawning stock biomass have 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 12.0 million lb in 1992 and has since declined to 5.0 million lb in 2005. Spawning stock biomass peaked at 8.9 million lb in 1993 and then declined to 3.9 million lb in 2005.



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 0.141 y^{-1} in 2005. Sea lamprey-induced mortality had been increasing in WFH-05 over the last decade, but recent estimates have declined and remained low, averaging 0.02 y^{-1} from 2000 to 2005.



Total instantaneous mortality was estimated to be 0.458 y^{-1} on age-4 and older whitefish in WFH-05 during 2003-2005. Total mortality was estimated to be 0.494 y^{-1} in 2005. 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 2.64 times over the 2003-2005 levels. The recommended yield limit at this increased rate of fishing was estimated to be 889,000 lb in WFH-05 for 2007. The recommended yield limit in 2006 was 1,087,000 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 995,000 lb from 2004 to 2007. Total tribal trap-net harvest was below the HRG in 2005.

Summary Status WFH-05 Whitefish	Value (95% probability interval)
Female maturity	
Size at first spawning	0.45 lb
Age at first spawning	3 y
Size at 50% maturity	1.65 lb
Age at 50% maturity	6 y
Spawning biomass per recruit	
Base SSBR	1.028 lb (1.028 – 1.029)
Current SSBR	0.570 lb (0.531 – 0.620)
SSBR at target mortality	0.171 lb (0.171 – 0.171)
Spawning potential reduction	
At target mortality	0.554 (0.554 – 0.554)
Average yield per recruit	0.280 lb (0.231 – 0.316)
Natural mortality (M)	0.319 y^{-1}
Fishing mortality rate 2003-2005	
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+	0.104 y^{-1} (0.075 – 0.132)
Sea lamprey mortality (ML)	
Average ages 4+, 2003-2005	0.041 y^{-1}
Total mortality (Z)	
Average ages 4+, 2003-2005	0.458 y^{-1} (0.429 – 0.486)
Recruitment (age-3)	
Average 1996-2005	1,931,400 fish (1,620,820 – 2,524,340)
Biomass (age 3+)	
Average 1996-2005	7,572,100 lb (6,439,560 – 9,748,690)
Spawning biomass	
Average 1996-2005	5,597,100 lb (4,724,800 – 7,253,400)
Recommended yield limit for 2007	889,000 lb

Lake Michigan

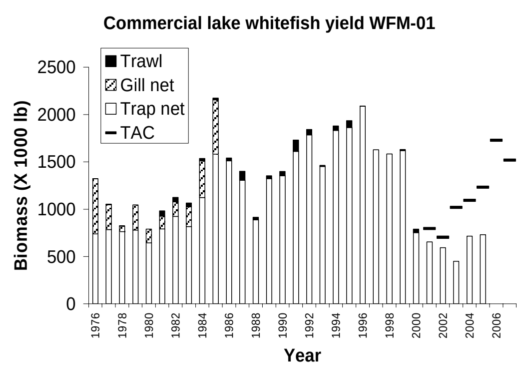
WFM-01 (Bays de Noc)

Prepared by Philip J. Schneeberger

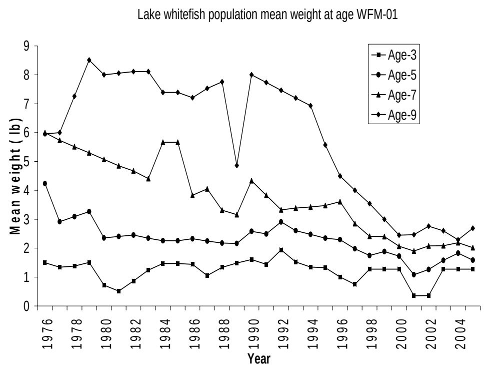
Lake whitefish management unit WFM-01 is located in 1836 Treaty waters of northern Green Bay. Prominent features of this area include two large bays (Big and Little bays de Noc), numerous small embayments, several islands (including St. Martins Island, Poverty Island, Summer Island, Little Summer Island, 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 a very important area for lake whitefish reproduction. Fairly consistent 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 730,000 lb during 2005, up 2% from 2004. Trap-net effort was 1,540 lifts in 2005, compared to 1,541 lifts in 2004. Both yield and effort declined between 1999 and 2003, before rebounding in 2004 and 2005. Catch-per-unit-effort (CPUE) increased slightly from 464 lb lift^{-1} in 2004 to 474 lb lift^{-1} in 2005, and was considerably higher than the 1976-2003 average CPUE of 302 lb lift^{-1}. Commercial gill netting in this management zone ceased after 1985.

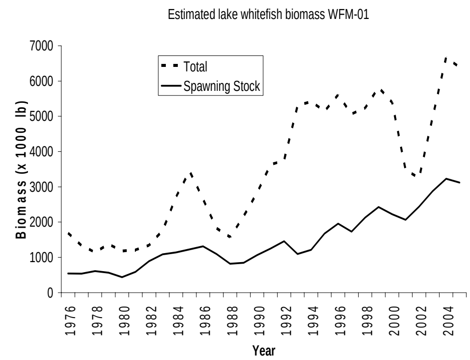


Between 2004 and 2005, weight-at-age for WFM-01 lake whitefish increased for fish 8-years old and older, and decreased for ages 5-7. Weight-at-age values in 2005 were less than 1996-2000 averages for ages 4-9+.

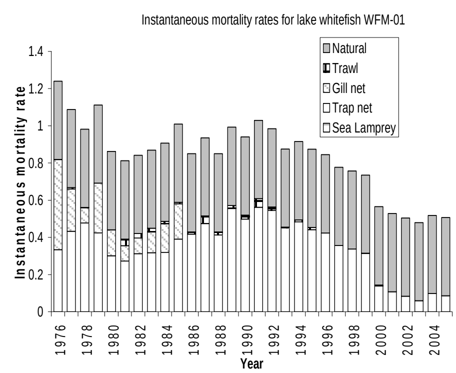


Estimated recruitment (numbers of age-3 fish) increased slightly (2%) from 2004 to 2005. The 2005 recruitment estimate of 3.08 million lake whitefish was 10% less than average recruitment estimated for the previous 5-year period, 2000-04.

Based on the latest model estimates, fishable biomass was 6.4 million lb in 2005 and of this total, spawning stock biomass (3.1 million lb) represented 49%. Fishable biomass fluctuated through the data series, trending steeply upward from 2002 to 2004, then dipping somewhat lower in 2005. Spawning stock biomass has generally shown an increasing trend over the whole time series, but also took a slight downturn in 2005.



Estimates of total instantaneous mortality rate (Z) have remained stable between 0.48 and 0.56 y^{-1} during 2000-2005. The 2005 estimate was 0.51 y^{-1} with 0.42 y^{-1} attributable to instantaneous natural mortality rate (M) and 0.09 y^{-1} attributable to instantaneous fishing mortality rate (F).



The projected 2007 yield limit for WFM-01 is 1.52 million lb. This value is a 12% decrease from the 2006 yield limit of 1.73 million lb. The decrease appeared to be caused by the slight downturn in the 2005 biomass estimates (total and spawning stock).

Summary Status WFM-01 Whitefish	Value (95% Probability Interval)
Female maturity	
Size at first spawning	1.26 lb
Age at first spawning	4 y
Size at 50% maturity	1.54 lb
Age at 50% maturity	5 y
Spawning biomass per recruit	
Base SSBR	0.773 lb (0.770 - 0.777)
Current SSBR	0.56 lb (0.54 - 0.58)
SSBR at target mortality	0.2026 lb (0.2022 - 0.2029)
Spawning potential reduction	
At target mortality	0.727 (0.697 - 0.754)
Average yield per recruit	0.183 lb (0.166 - 0.201)
Natural mortality (M)	0.421 y^{-1}
Fishing mortality rate 2002-2004	
Fully selected age to gill nets	4
Fully selected age to trap nets	5
Fully selected age to trawls	5
Average gill net F, ages 4+	0 y^{-1}
Average trap net F, ages 4+	0.010 y^{-1} (0.086 - 0.116)
Average trawl F, ages 4+	0 y^{-1}
Sea lamprey mortality (ML)	
Average ages 4+, 2003-2005	N/A
Total mortality (Z)	
Average ages 4+, 2003-2005	0.520 y-1 (0.506 - 0.536)
Recruitment (age-3)	
Average 1996-2005	4,542,079 fish (3,504,670 - 6,060,250)
Biomass (age 3+)	
Average 1996-2005	11,990,600 lb (10,049,700 - 14,548,700)
Spawning biomass	
Average 1996-2005	5,452,608 lb (4,776,870 - 6,275,270)
Recommended yield limit in 2007	1,518,000 lb

WFM-02 (Manistique)

John K. Netto

The model generated harvest limit for WFM-02 was 849,000 lb. A complete description of the status of the lake whitefish stock in WFM-02 and the modeling process used to generate the TAC is not available as the author did not submit the required report.

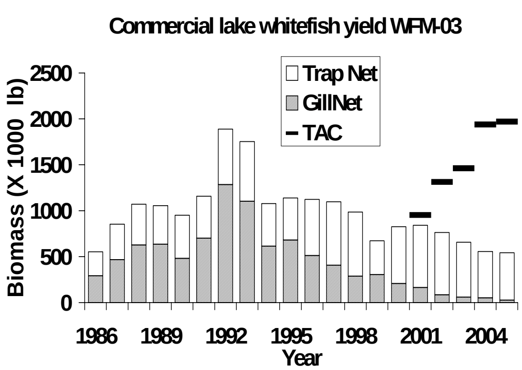
WFM-03 (Naubinway)

Prepared by Mark P. Ebener

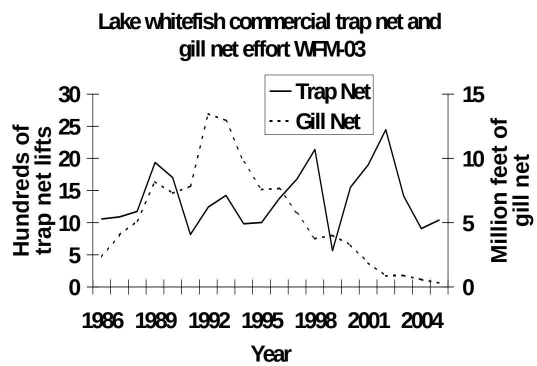
WFM-03 is located in northern Lake Michigan. The unit extends from the Straits of Mackinac west to Seul Choix Point and is bounded on the south by Beaver Island and complex of shoals and islands that surround the island. Nearly the entire unit is shallow water less than 90 ft deep. There are 483,000 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 yield from WFM-03 averaged 0.98 million lb during 1986-2005. The trap-net fishery yield averaged 528,000 lb and the gill-net fishery yield averaged 456,600 lb during 1986-2005. Total fishery yield peaked at 1.89 million lb in 1992 and 1.75 million lb in 1993 and declined slowly thereafter. The trap-net yield was 514,000 lb and the gill-net yield only 28,200 in 2005. The commercial yield in 2005 represented only 28% of the recommended harvest limit.



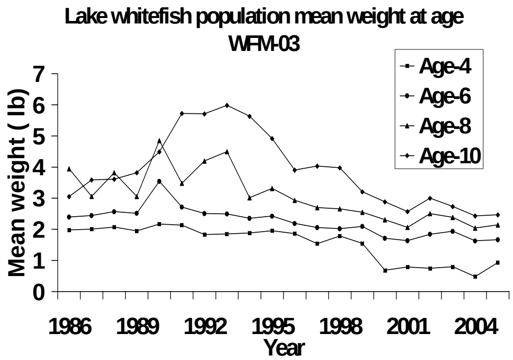
Trap-net fishing effort in WFM-03 has been highly variable yet stable, while gill-net effort has declined tremendously since the early 1990s. Trap-net effort has varied from 565 lifts to 2,447 lifts in WFM-03 during 1986-2005 and averaged 1,372 lifts. Gill net effort increased from 2.3 million ft in 1986 to 13.5 million ft in 1992 before declining to only 0.31 million feet in 2005. Trap net effort was 1,040 lifts in 2005.



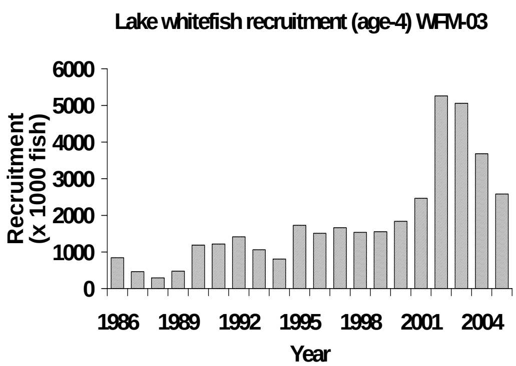
Whitefish in WFM-03 are of small size. During 1986-2005 No.1 whitefish made up 85%, mediums 12%, and jumbos 3% of the harvest from this unit. Mean weight of a harvested whitefish in 2005 was 2.2 lb in the gill-net fishery and 2.3 lb in the trap-net fishery.

Growth of whitefish in WFM-03 appeared to stabilize in 2005 based upon mean weight-at-age. Mean weight-at-age increased for age classes of whitefish in WFM-03 from 2004 to 2005 possibly halting the long-term decline in growth in the unit. Mean weight-at-age in 2005 though continued to be less than during most years since 1986.

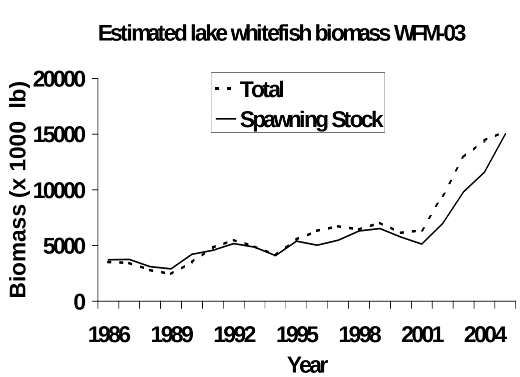
Estimated recruitment of age-4 whitefish was fairly consistent and high in WFM-03. Recruitment increased



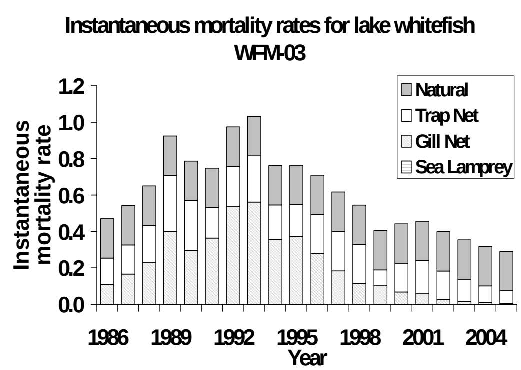
from an average of 1.17 million fish during 1986-2000, to 3.81 million during 2001-2005. Recruitment of age-4 whitefish was estimated to be 2.58 million fish in 2005.



Biomass of age-4 and older whitefish has been fairly stable or increasing in WFM-03 based on the stock assessment model. Total biomass ranged from 2.4 to 7.0 million lb during 1986-2001 and then increased abruptly thereafter due to the estimated large recruitment during 2001-2005. Total biomass and spawning stock biomass were estimated to be 15.2 and 15.0 million lb in WFM-03 in 2005.



Changes in gill-net effort have been primarily responsible for the changes in total annual mortality of whitefish in WFM-03. Total instantaneous mortality of age-4 and older whitefish increased from 0.47 y^{-1} in 1986 to 1.03 y^{-1} in 1993, and then declined to 0.29 y^{-1} in 2005. Gill-net induced mortality increased from 0.11 y^{-1} in 1986 to 0.56 y^{-1} in 1993 then declined to 0.004 y^{-1} in 2005. Trap-net mortality was fairly stable ranging from 0.09 y^{-1} to 0.31 y^{-1} during 1986-2005. Natural mortality was estimated to be 0.22 y^{-1} in WFM-03 and has been greater than total fishing mortality in most years since 1999. Trap-net and gill-net mortality was estimated to be 0.004 y^{-1} and 0.07 y^{-1} in 2005.



Total annual mortality on fully vulnerable age-classes was less than the target rate during 2003-2005 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 2.86 times. The projected harvest limit for 2007 under this increased fishing rate was estimated to be 4.1 million lb. Because the stock assessment model was not very stable, a harvest regulating guideline of 1.97 million lb was adopted for 2007.

Summary Status WFM-03 Whitefish	Value (Standard Error)
Female maturity	
Size at first spawning	0.74 lb
Age at first spawning	4 y
Size at 50% maturity	1.30 lb
Age at 50% maturity	5 y
Spawning biomass per recruit	
Base SSBR	2.8 lb (SE 0.004)
Current SSBR	1.76 lb (SE 0.03)
SSBR at target mortality	0.170 lb (SE 0.000)
Spawning potential reduction	
At target mortality	0.63 (SE 0.012)
Average yield per recruit	0.529 lb (SE 0.014)
Natural mortality (M)	0.247 y^{-1}
Fishing mortality rate 2003-2005	
Fully selected age to Gill Nets	9
Fully selected age to trap nets	9
Average gill net F, ages 4+	0.012 y^{-1} (SE 0.001)
Average trap net F, ages 4+	0.107 y^{-1} (SE 0.007)
Sea lamprey mortality (ML)	
Average ages 4+, 2003-2005	N/A
Total mortality (Z)	
Average ages 4+, 2003-2005	0.367 y^{-1} (SE 0.008)
Recruitment (age-4)	
Average 1996-2005	2,714,100 fish (SE 304,450)
Biomass (age 3+)	
Average 1996-2005	9,117,700 lb (SE 729,070)
Spawning biomass	
Average 1996-2005	7,764,500 lb (SE 575,890)
Recommended yield limit in 2007	1,970,000 lb

WFM-04 (Beaver Island)

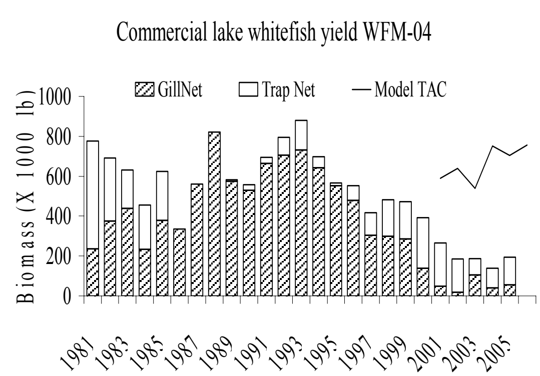
Prepared by Stephen J. Lenart

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.

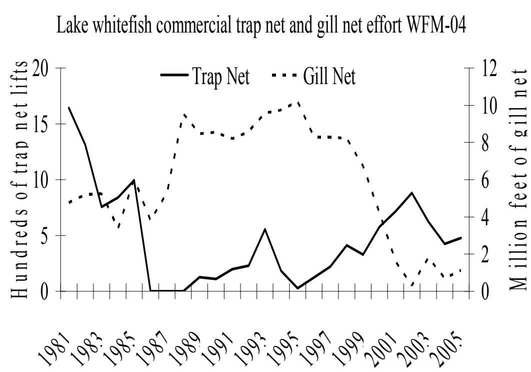
WFM-04 has been an exclusive commercial fishing zone for the CORA fishery since 1985. Much of the western half of the unit is designated as a lake trout refuge where retention of lake trout by recreational or commercial fishers is prohibited. The eastern portion of WFM-04 along the Lower Peninsula of 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, 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 and has steadily declined ever since. This decline can be attributed to a shrinking gill-net fishery, which has harvested, on average, 67,000 lb of whitefish per year during 2000 to 2005. By comparison, average gill-net harvest was 524,000 lb during 1985 to 1999.

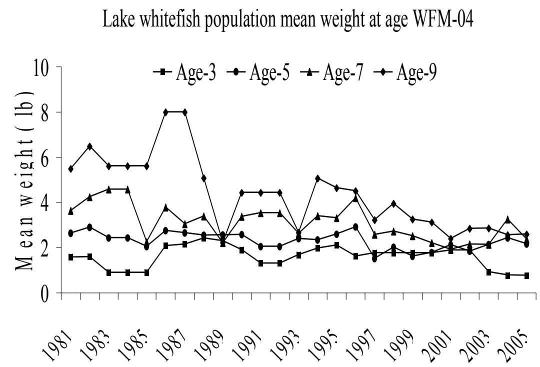


Fishing effort in WFM-04 has been quite variable through the years. After averaging more than 1,100 lifts per year during 1981 to 1985, the trap-net fishery was inactive for a three-year period.

Effort then 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. Since then, trap-net effort has generally declined, and the reported effort of 479 lifts in 2005 was very near the long-term average for the unit (470 lifts). In 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. Since 2000, average effort has declined to 1.6 million feet per year. In 2005 reported gill-net effort was 1.13 million feet, a slight increase from 2004.

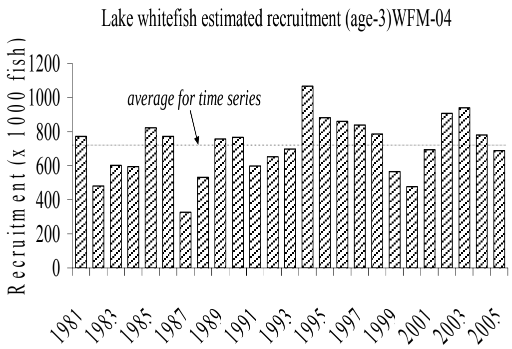


Whitefish in WFM-04 are of moderate size compared to other management units. Annual mean weight of a whitefish harvested in the trap-net fishery ranged from 2.0 to 3.3 lb during 1981 to 2005. The mean weight of whitefish harvested in the 2005 trap-net fishery was 2.5 lb. The mean weight of a whitefish harvested in the gill-net fishery ranged from 2.6 to 3.5 lb during 1981 to 2005. Since 1995, the mean weight of whitefish in the gill-net fishery has remained relatively constant (2.6 to 2.8 lb).

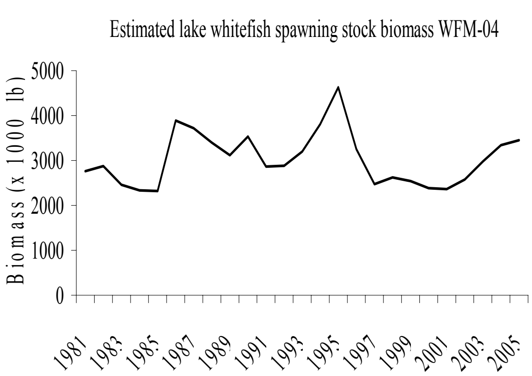


Although growth of whitefish in WFM-04 has not declined to the same extent as in other Lake Michigan units, significant declines are still evident. For example, age-9 whitefish weighed, on average, 5.8 lb during the 1980s. This declined to an average of 4.1 lb in the 1990s and then to 2.7 lb during 2000 - 2005. While a similar long-term decline was evident in younger age classes, growth has stabilized or increased slightly for age-5 and age-7 fish since 2000. Prior to implementation of the whitefish survey in 2001, data on age-3 fish were collected primarily from the fishery, where a bias toward larger fish in this first age class is likely. Thus the recent trend indicating a decline in growth of age-3 fish may be misleading. Furthermore, sample size for this age class tends to be quite small, particularly in recent years.

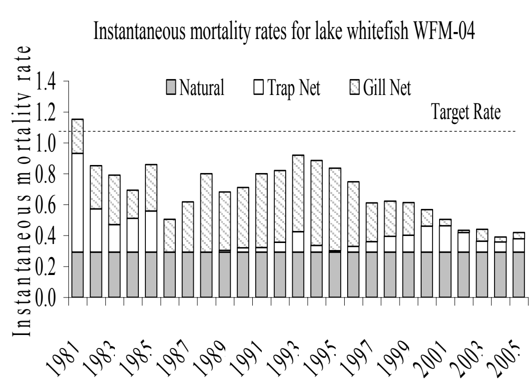
Recruitment of age-3 whitefish to the population in WFM-04 is quite stable, in contrast to other Lake Michigan management units. Average estimated recruitment of age-3 whitefish in WFM-04 was 714,000 fish during 1981 to 2005. Annual estimated recruitment varied from 327,000 to 1,066,000 fish during this time period. Average estimated recruitment during 2000 to 2005 was 747,000 age-3 fish, slightly higher than the long term average for the unit.



Spawning stock biomass has also been quite stable in WFM-04, a consequence of the consistent recruitment. During the period 1981 to 2005, estimated spawning-stock biomass ranged from a low of 2.32 million lb in 1985 to a high of 4.63 million lb in 1995. After declining in the late 1990s from the mid-decade peak, spawning stock biomass has increased annually since 2001. In 2005, estimated spawning-stock biomass was 3.45 million lb.



A significant factor in this increase in spawning stock biomass was the general decline in mortality rates since the mid-1990s, particularly in the gill-net fishery. During the period 1986 to 1996, instantaneous gill-net mortality ranged between 0.21 to 0.55 yr^{-1}. Instantaneous gill-net mortality then declined annually for the next six years, reaching its lowest point in the time series in 2002 (0.013 yr^{-1}). During 2003 to 2005, average instantaneous gill-net mortality was 0.050 yr^{-1}. Trap-net mortality, which was highest early in the time series, was a minor component of the overall mortality during the mid 1980s and most of the 1990s (average 0.035 yr^{-1} during 1986 to 1997). Trap-net mortality increased gradually from 1997 to 2001, but has leveled off in recent years. Total mortality (Z) of age-4 and older whitefish in WFM-04 has steadily declined since 1993 and recent total mortality rates are among the lowest in the time series. Since 2000, natural mortality has been the primary component of overall mortality in this unit. Natural mortality (M) was estimated to be 0.293 y^{-1}. This is markedly higher than the estimate from last year's model assessment. Sea lamprey mortality is not estimated separately in this unit, although a significant increase in the abundance of adult sea lamprey in northern Lake Michigan in recent years may precipitate an evaluation of this mortality component for whitefish.



The average total mortality rate of age-4 and older whitefish was 0.42 y^{-1} during 2003 to 2005, well below the maximum target rate of 1.05 y^{-1}. The spawning potential reduction in 2006 was 0.723. Thus, the projection model estimated that gill-net fishing effort could be increased 4.6-fold and trap-net effort 2.6-fold from the effort levels recorded during 2003 to 2005.

The 2007 model-generated yield limit of 695,000 lb was adopted by CORA as the Harvest Regulation Guideline for management unit WFM04.

Structural changes to the model

Four separate models were evaluated in 2006: last year's model (updated with 2005 data); a model with an expanded plus group (from 9+ to 11+); and each of the former with gill-net selectivity modeled as a double-logistic function (versus the single-logistic as applied in prior assessments). An expansion of the plus group was considered because the 9+ age group was the highest represented group (exceeding 35%) in both fisheries for the third consecutive year. Although the relative strength of these older cohorts obviously would contribute to their prevalence in the fishery, the selectivity curve appears to have shifted towards these older fish (for example, prior to 1996, fish of age 9+ never exceeded 1.5% of the trap-net catch; a similar trend is evident in the gill-net fishery). As in years past, the most problematic parameters continue to be those associated with gill-net selectivity, particularly when attempting to model selectivity using a double-logistic function. In prior assessments, choosing a simple logistic function for gill-net fishery selectivity appeared to stabilize the model and allowed for reasonable MCMC outputs. Although all four models evaluated during the 2006 assessment reached minimum convergence criteria, none yielded acceptable diagnostics. The model with the lowest maximum gradient component was the version with the expanded plus group and gill-net selectivity modeled as a double-logistic function. Furthermore, this method of modeling selectivity in the gill-net fishery is consistent with that used in adjacent units and is likely the most appropriate, given the dynamics of the fishery. Thus, the model with the expanded plus group was chosen. Nonetheless, the model performance was rated as "low" due to the lack of acceptable diagnostics.

The 2007 model-generated yield limit of 695,000 lb represents an 8% decrease from the 2006 model-generated limit of 757,000 lb. However, this decrease can be attributed to the change in model structure (for example, the model-generated yield limit for 2007 using last year's model structure would have been 765,000 lb, a slight increase from 2006). The primary difference is that the 9+ model estimated a higher abundance of older fish compared to the model with the expanded plus group.

Future work should focus on evaluating alternative methods for modeling selectivity that might better account for the changes in growth that have occurred over time.

Summary Status WFM-04 Whitefish	Value (95% probability interval)
Female maturity	
Size at first spawning	0.84 lb
Age at first spawning	3 y
Size at 50% maturity	1.71 lb
Age at 50% maturity	4 y
Spawning biomass per recruit	
Base SSBR	1.756 lb (1.754 - 1.758)
Current SSBR	1.394 lb (1.388 - 1.401)
SSBR at target mortality	0.348 lb
Spawning potential reduction	
At target mortality	0.794
Average yield per recruit	0.242 lb (0.236 - 0.247)
Natural mortality (M)	0.348 y^{-1}
Fishing mortality rate 2003-2005	
Fully selected age to gill nets	10
Fully selected age to trap nets	10
Average gill net F, ages 4+	0.044 y^{-1} (0.041 - 0.046)
Average trap net F, ages 4+	0.067 y^{-1} (0.065 - 0.069)
Sea lamprey mortality (ML)	N/A
Total mortality (Z)	
Average ages 4+, 2003-2005	0.458 y^{-1} (0.454 - 0.462)
Recruitment (age-3)	
Average 1996-2005	1,060,826 fish (1,031,290 - 1,092,350)
Biomass (age 3+)	
Average 1996-2005	4,862,936 lb (4,763,970 - 4,991,230)
Spawning biomass	
Average 1996-2005	3,481,441 lb (3,412,680 - 3,572,230)
Recommended yield limit 2007	695,000

WFM-05 (Grand Traverse Bay)

Prepared by Erik J. Olsen

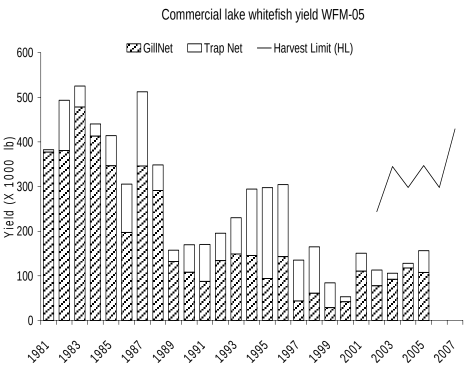
Management unit WFM-05 encompasses the area from Little Traverse Bay through Grand Traverse Bay and offshore waters of Lake Michigan north and west of the Leelanau Peninsula. Much of WFM-05 contains water >240 ft. deep including the both the east and west arms of Grand Traverse Bay. The deepest parts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

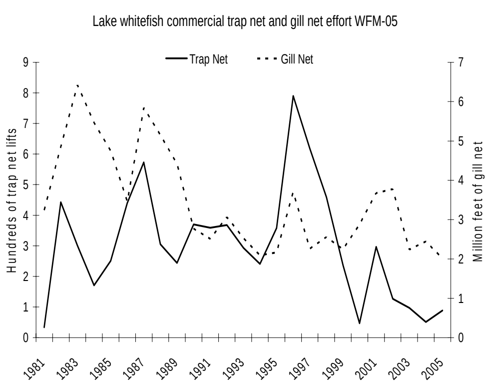
WFM-05 has been an important tribal fishing area since the 1970s. Much of the tribal fishing activity that occurred prior to and immediately after re-affirmation of treaty-reserved fishing rights took place in Grand Traverse Bay. Tribal small-boat fishers relied on Grand Traverse Bay as an important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

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

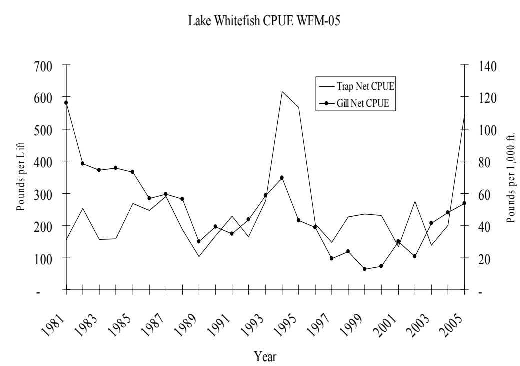
Commercial yields of lake whitefish during the 1990s were substantially less than during the 1980s. The commercial yield averaged 383,000 lb from 1980 to 1989 and 205,000 lb during 1990 to 1999. The fishery declined through the late 1990s with the lowest recorded yield coming in 2000 at 53,000 lb. The fishery has rebounded slightly through 2005, averaging 131,000 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.



Large-mesh gill-net effort in WFM-05 declined from 1984 to 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 2.8 million feet annually. Trap-net effort has varied annually between 200 and 800 lifts during 1982-1999. Through the 1990s, trap-net effort averaged 409 lifts per year, peaking at 790 lifts in 1996. Since reaching a low of 47 lifts in 2000, trap-net effort has averaged 132 lifts through 2005.



The decline in yield of whitefish in WFM-05 has 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 16 lb per 1000 ft. in 1999. Since 2000, gill-net CPUE has steadily increased to 72 lb per 1000 ft. in 2005. In contrast, during 1981-1999 the CPUE of whitefish in the trap-net fishery has been remarkably stable holding between 150 and 300 lb per lift, except for 1994 and 1995. From 2000 to 2004, trap-net CPUE averaged 183 lb lift^{-1}, but jumped significantly to 546 lb lift^{-1} in 2005. Gill-net fishers in WFM-05 claim the long-term decline in catchability 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. Whatever the cause, it is evident that something has reduced catch rates of whitefish to the large-mesh gill-net fishery in the unit.

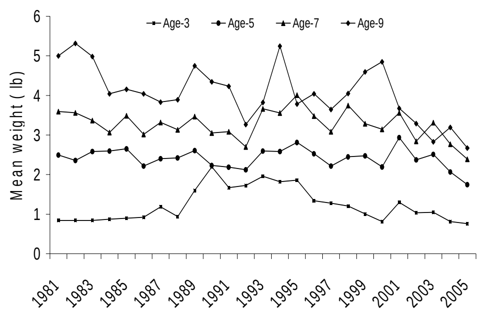


Whitefish from WFM-05 are currently of small to moderate size. From 2000 to 2005, the proportion of the yield made up of the three size classes of whitefish were 74% No.1 (< 3 lb), 20% mediums (3-4 lb), and 6% jumbos (≥ 4 lb). This compares with 65% No.1, 22% mediums, and 13% jumbos from 1980 to 1989 and 65% No.1, 20% mediums, and 15% jumbos from 1990 to 1999.

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 2.3 lb during the last three years (2003-2005). Annual mean weight of whitefish in the gill-net harvest ranged from 2.4 to 3.5 lb since 1979 and averaged 2.9 lb during the last three years (2003-2005).

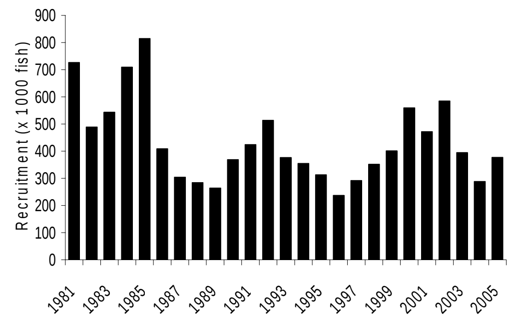
While relatively stable, mean weights of lake whitefish (ages 3-9) from WFM-05 have been slowly declining since 1981. This pattern of declining growth is also being observed in other areas of Lakes Michigan and Huron, including substantial declines in areas adjacent to this management unit.

Lake whitefish population mean weight at age WFM-05



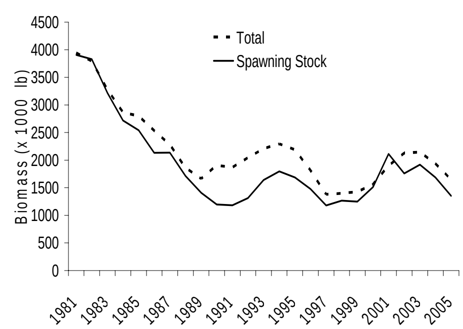
Recruitment of age-3 whitefish to the population in WFM-05 is highly variable and has generally declined since the late 1980s based on estimates from the stock assessment model. The number of age-3 whitefish entering the population has declined significantly over time. Early on (1981-1985) year classes averaged 687,000 fish, ranging from 489,000 to 815,000. Since 1985, estimates have been relatively stable, ranging between 238,000 and 585,000, with an average of 379,000 age-3 fish entering the fishery annually. It is difficult to assess whether the decline in recruitment is real, or an artifact of changing catchability to the gill-net fishery.

Estimated lake whitefish recruitment (age-3)WFM-05



Biomass of whitefish estimated with the stock assessment model declined in response to declines in recruitment. Annual biomass of whitefish ≥ age 3 (calculated at the beginning of each year) peaked at the beginning of the 1981-2005 timeframe with 3.1 million lb. This steadily declined to 1.3 million lb in 1989 and has leveled out at approximately 1.9 million lb from 1990 to 2005. Spawning stock biomass also followed the same trend, peaking at 3.1 million lb in 1981 and holding at about 1.5 million lb since 1990.

Estimated lake whitefish biomass WFM-05



From 1981 to 1989, the combined commercial fishing mortality (F) mortality was comparable to natural mortality in this unit. Overall F has declined since 1990, with a short increase at the end of the 1990s. Fishing mortality within this unit has been dominated by gill nets; however during the late 1990s (1995-1998) trap-net approached or surpassed gill-net mortality. Since then, both gill-net and trap-net mortality has held relatively steady at a reduced level. Average fishing-induced mortality on whitefish ≥ age 4 averaged 0.1 for the large-mesh gill-net fishery and 0.02 for the trap-net fishery during 2003-2005. Gill net induced fishing mortality ranged from 0.28 in 1984 to 0.06 in 1999, while trap net induced fishing mortality ranged from 0.19 in 1996 to 0.01 in 1981. The gill- and trap-net mortality level has declined from a combined rate of 0.42 in 1996 to a low of 0.09 in 2000.

Total annual mortality on the fishable stock in WFM-05 during 2003-2005 was substantially less than the target rate of 65%. Total annual mortality was estimated to be 50% during 2003-2005 and the spawning potential reduction value was 0.73. Consequently, the projection model estimated that fishing mortality could be increased 4.5 times in WFM-05 in 2007 from the average value during 2003-2005. The projected yield associated with this level of fishing is 429,000 lb, which was accepted as the HRG for 2007.

Summary Status WFM-05 Whitefish	Value (95% Probability Interval)
Female maturity	
Size at first spawning	0.87 lb
Age at first spawning	3 y
Size at 50% maturity	1.52 lb
Age at 50% maturity	4 y
Spawning biomass per recruit	
Base SSBR	1.4616 lb (1.4612 - 1.4619)
Current SSBR	1.06 lb (1.012 - 1.064)
SSBR at target mortality	0.283 lb (0.283 - 0.283)
Spawning potential reduction	
At target mortality	0.727 (0.693 - 0.728)
Average yield per recruit	0.253 lb (0.252 - 0.283)
Natural mortality (M)	0.376 y^{-1}
Fishing mortality rate 2003-2005	
Fully selected age to gill nets	11
Fully selected age to trap nets	11
Average gill net F, ages 4+	0.1 y^{-1} (0.10 - 0.12)
Average trap net F, ages 4+	0.022 y^{-1} (0.021 - 0.025)
Sea lamprey mortality (ML)	not estimated
Total mortality (Z)	
Average ages 4+, 2003-2005	0.498 y^{-1}
Recruitment (age-3)	
Average 1996-2005	395,870 fish (345,124 - 411,023)
Biomass (age 3+)	
Average 1996-2005	1,734,100 lb (1,517,940 - 1,757,640)
Spawning biomass	
Average 1996-2005	1,551,200 lb (1,361,560 - 1,572,090)
Recommended yield limit in 2007	429,000 lb

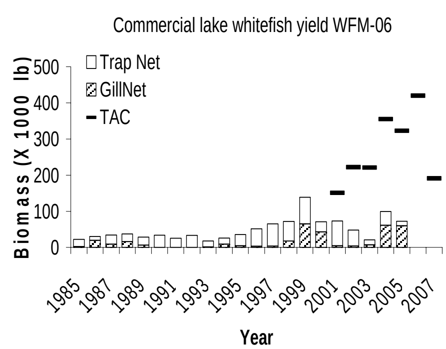
WFM-06 (Leland - Frankfort)

Prepared by Randall M. Claramunt and Philip J. Schneeberger

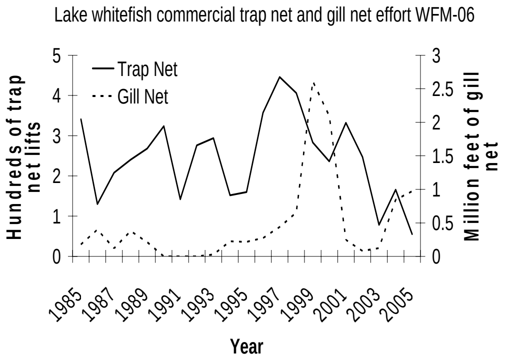
Lake whitefish management unit WFM-06 is located in 1836 Treaty waters west of the Leelanau Peninsula from about Cathead Point south to Arcadia. Surface area for this unit is 945,156 acres (including part or all of grids 709-714, 808-814, 908-912, and 1008-1011). These waters of Lake Michigan include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

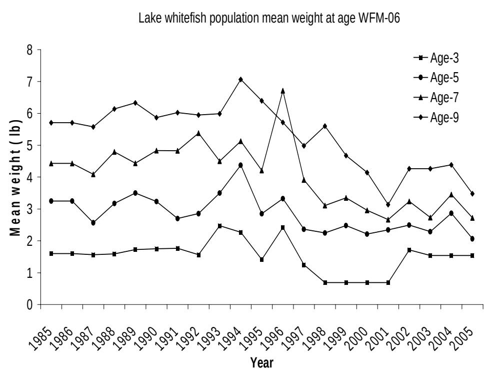
Yield for 2005 was 72,000 lb in WFM-06, down from 99,000 lb in 2004, and up from the 1985-2004 average of 48,000 lb. Of the total in 2005, trap-net yield was 12,400 lb (17.2 %) and gill-net yield was 59,000 lb (82.8%). Proportions of yield by gear type have varied considerably from year to year with an average split of 73% from trap nets and 27% from gill nets between 1985 and 2005.



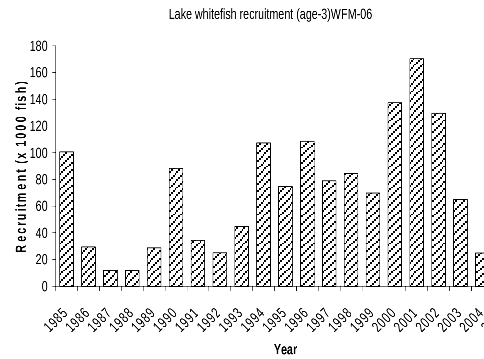
Trap-net effort decreased from 166 lifts in 2004 to 55 lifts in 2005. The 2005 trap-net effort was lowest recorded for the 1985-2004 series (average of 254 lifts). Gill-net effort in 2005 (969,400 ft) increased from 2004 (843,640 ft), and was higher than the 1985-2004 average (455,917 ft).



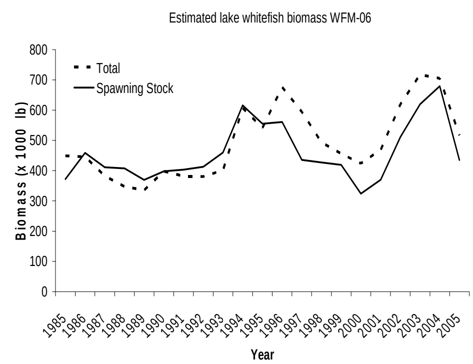
Lake whitefish weight-at-age in 2005 was relatively unchanged for most age groups from the 2004 values. Weight-at-age in 2004 and 2005 appears to have stabilized from observed declines during 1996 to 2001 for most ages. However, weight-at-age values in 2005 for fish aged 5-12+ were still 34% lower than the 1985-2004 averages.



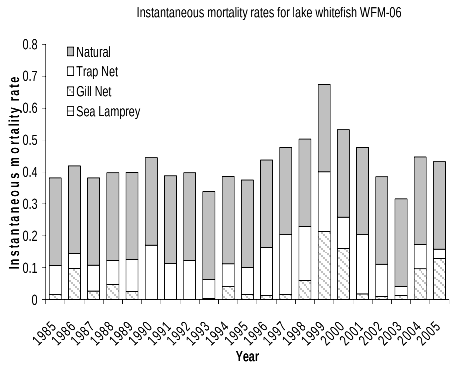
Recruitment, based on estimated numbers of age-3 fish, increased from 25,000 fish in 2004 to 38,000 fish in 2005. However, recruitment in 2005 was lower than the long-term average of 70,000 fish. Estimates of recruitment were highest during 1994-1998 and 2000-2002, and lowest for the time series during 1987-1988 and 2004 and 2005.



Estimates of total biomass and spawning stock biomass have roughly paralleled each other from 1985 through 2005 and reflect changes in recruitment estimates. Biomass values estimated for 2005 were 517,000 lb for total and 435,000 lb for spawning stock biomass. The ratio of spawning stock biomass to total biomass was 0.84 in 2005.



Total instantaneous mortality rate (Z) in 2005 was 0.43 y^{-1}, showing a slight decrease in the rate from 0.45 y^{-1} in 2004. Based on current estimates, the 2005 rate for Z is similar to the average of 0.43 y^{-1} for 1985-2004. Instantaneous fishing mortality rates (F) have varied considerably for trap nets and gill nets throughout the time series. During 2005, F was much higher for the gill net fishery. Estimates for F were 0.029 y^{-1} for trap nets and 0.129 y^{-1} for gill nets. The 2005 estimate for instantaneous natural mortality rate was 0.274 y^{-1}, still the largest source of lake whitefish mortality in WFM-06.



The 2007 yield limit is 191,000 lb, which is a large decrease from the limit calculated for 2006 of 420,000 lb. However, based on the 2007 yield limit and projection model, the level of commercial fishing effort inWFM-06 could still increase from the 2006 levels.

Summary Status WFM-06 Whitefish	Value (95% probability interval)
Female maturity	
Size at first spawning	1.54 lb
Age at first spawning	3 y
Size at 50% maturity	2.18 lb
Age at 50% maturity	4 y
Spawning stock biomass per recruit	
Base SSBR	3.317 lb (3.305 – 3.328)
Current SSBR	1.88 lb (1.731 – 2.049)
SSBR at target mortality	0.360 lb (0.359 – 0.361)
Spawning potential reduction	
At target mortality	0.567 (0.522 – 0.618)
Average yield per recruit	0.583 lb (0.520 – 0.634)
Natural mortality (M)	0.274 y^{-1}
Fishing mortality rates 2003-2005	
Fully selected age to gill nets	8 y
Fully selected age to trap nets	8 y
Average gill net F, ages 4+	0.072 y^{-1} (0.059 – 0.086)
Average trap net F, ages 4+	0.041 y^{-1} (0.033 – 0.049)
Sea lamprey mortality (ML)	
Average ages 4+, 2003-2005	N/A
Total mortality (Z)	
Average ages 4+, 2003-2005	0.387 y^{-1} (0.366 – 0.408)
Recruitment (age-3)	
Average 1996-2005	90,642 fish (81,514 – 104,400)
Biomass (age 3+)	
Average 1996-2005	567,220 lb (495,124 – 669,182)
Spawning biomass	
Average 1996-2005	478,120 lb (413,060 – 569,751)
Recommended yield limit in 2007	191,000 lb

WFM-07 (Ludington)

Prepared by Archie W. Martell Jr.

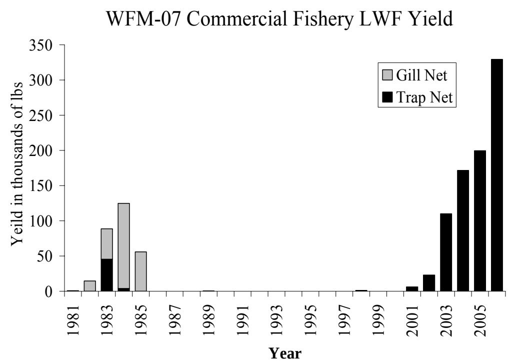
Lake whitefish management unit WFM-07 is located within the 1836 Treaty Ceded Waters of eastern central Lake Michigan from Arcadia in the north to just south of Stony Lake, and west to the state line bisecting the middle of the lake. This lake whitefish management unit includes part or all of grids 1107-1111, 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, relatively few 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.

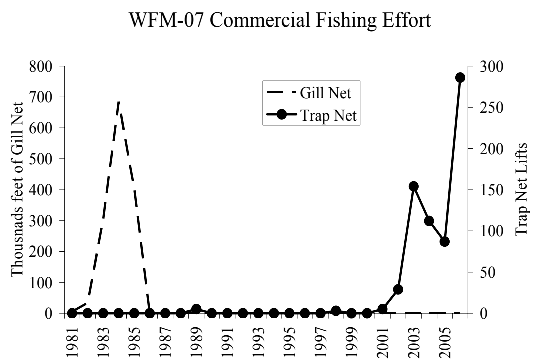
Since 2000, WFM-07 has been a Tribal commercial fishing zone for lake whitefish, part of the Little River Zone with tribal fishing regulated under permitting control of the Little River Band of Ottawa Indians (LRBOI). From 1985 through 2000, there was no significant State commercial fishing effort and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

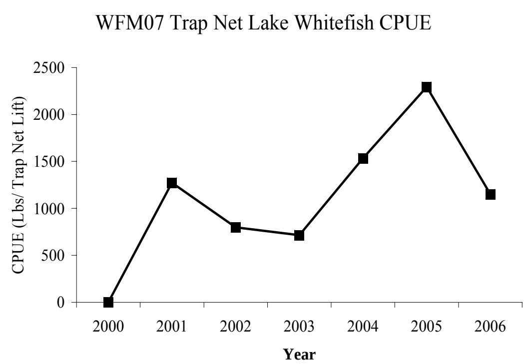
There has been no statistical catch at age modeling of the lake whitefish stock in WFM-07 due to a lack of long-term commercial catch-at-age information. Pursuant to the 2000 Consent Decree, the tribes had three years of allowable commercial fishing without harvest limits in this unit during 2001-2003.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

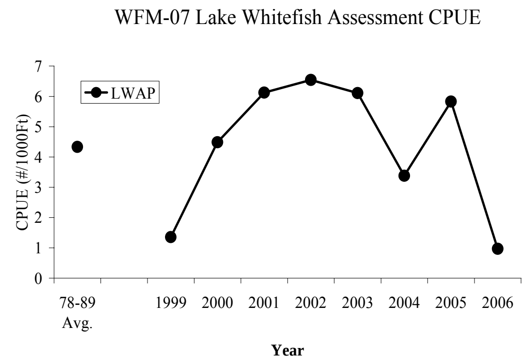
At the conclusion of the 2003 fishing season, three years of commercial trap-net fishing activity for lake whitefish was completed by Tribal fishers within this unit. Following the regulations in the 2000 Consent Decree and the Tribal Management Plan, an annual Harvest Regulation Guideline (HRG) for lake whitefish was developed for this management unit in 2004.

Commercial fishing harvest of lake whitefish within WFM-07 for 2001-2006 peaked at 329,271 lb in 2006 represented by 286 trap-net lifts. In 2001 Tribal commercial fishing activities began and effort was limited to the months of 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 harvest continued to increase in 2004 (171,755 lb), but effort decreased from 154 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 effort and harvest reached all-time high levels for this unit.







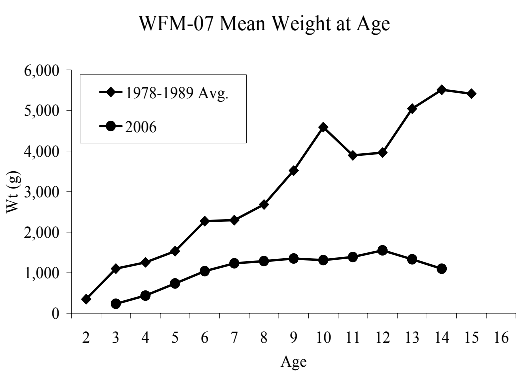


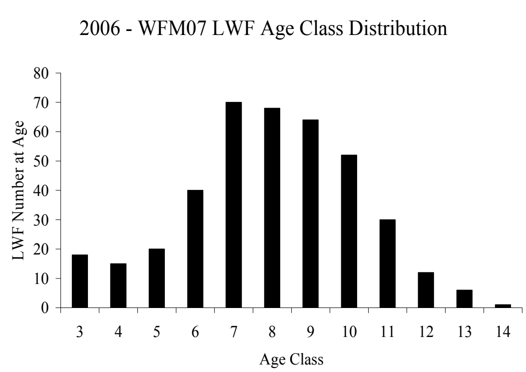
Fishery-independent surveys were conducted using graded-mesh gill nets (GMGN) following the spring Lakewide Assessment Plan (LWAP). Historical gill-net surveys from 1978 to 1989 had an average catch-per-unit-effort (CPUE) of 4.3 fish per 1,000 feet of gill net. The average LWAP survey CPUE of lake whitefish from 2000-2003, and in 2004 was higher than the historical average. However, in 1999, 2004, and 2006 the LWAP CPUE was lower than the historical average. The CPUE for lake whitefish in spring gill-net surveys for the years 1999 through 2006 were 1.4, 4.5, 6.1, 6.5, 6.1, 4.3, 5.8 and 0.97, respectively.

The mean length of lake whitefish sampled in spring GMGN surveys in 2006 increased to just above 19 inches, and was larger than seen in the previous year's survey. The 2004-2006 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 (2.70 lb) and commercial samples (2.58 lb) in 2006 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 2006 GMGN survey is 10.8 years and 7.8 years 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 years and the 1983 commercial sample of 7.3 years.

Lake whitefish mean weight-at-age from GMGN surveys in 2006 was substantially lower compared to the 1978-1989 GMGN survey average. This follows a similar trend that has been observed from 2000 to present. The lower weight-at-age indicates that growth rates are reduced 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 estimated total annual mortality rates calculated for this lake whitefish stock has been below the target maximum total annual mortality rate of $Z = 1.05$ 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. Results from the current 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. These results suggest that this stock may be regulated by density-dependent mechanisms which could improve under higher exploitation rates.

In 2004, LRBOI adopted additional effort limitations of 4 trap-net permits with a maximum of 12 nets per permit for this unit. The lake whitefish HRG of

500,000 lb for WFM-07 in 2007 and is a continuation of the 2004 HRG that was developed and recommended by the LRBOI and adopted by CORA. 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 Sub-Committee 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

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

WFM-08 (Muskegon)

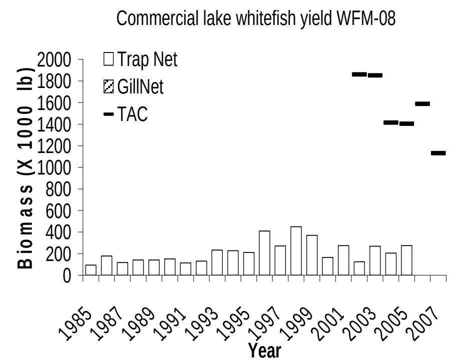
Prepared by Randall M. Claramunt and Philip J. Schneeberger

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.

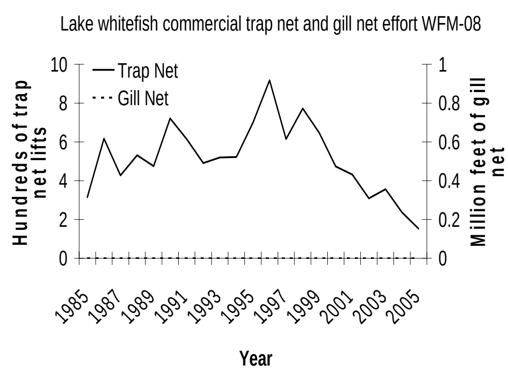
Although commercial exploitation and monitoring have occurred for many years, little is known about reproductive biology of the WFM-08 lake whitefish stock. Fish in this area are near the southern end of the distribution for lake whitefish.

Two state-licensed trap-net fishers operate in WFM-08 where minimum length for whitefish in commercial catches was 19 inches TL through 1999, then changed to 17 inches TL in 2000. Other management zones have had a 17-inch minimum size limit throughout the time series. Through 2005 there has been no gill net harvest of lake whitefish in WFM-08.

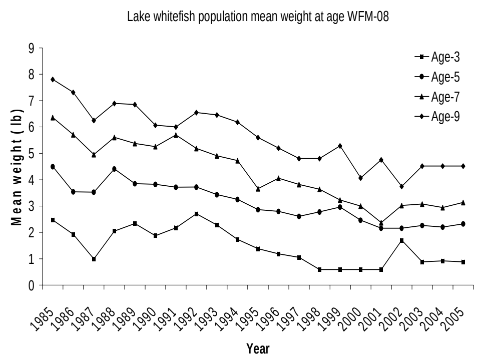
Lake whitefish yield from WFM-08 in 2005 was 275,000 lb. In 2005, yield increased from 2004, and was slightly higher than the 1985-2004 average of 213,000 lb. Trap-net effort decreased from 236 lifts in 2004 to 153 lifts in 2005.



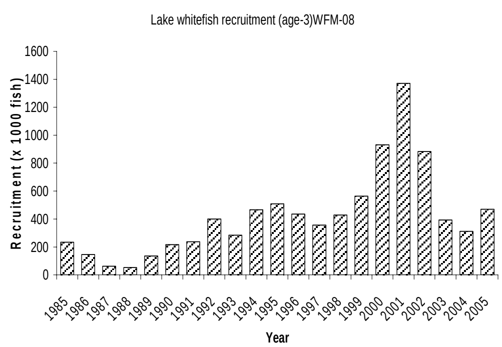
Effort in 2005 remained lower than the average for 1985-2004 of 535 lifts.



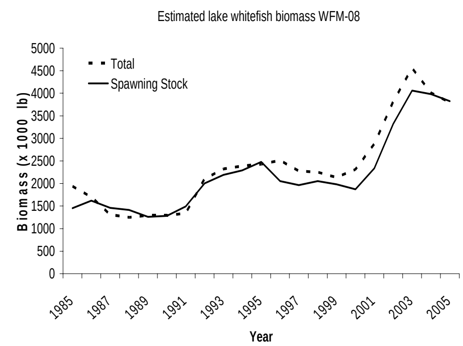
Weight-at-age data have trended downward from 1985 through 2005. From 2003 to 2005, weight-at-age increased or was stable for most of the age groups. Weight-at-age values in 2005 represent a 25.9% decrease from the averages for 1985 to 2004 for ages 4-9.



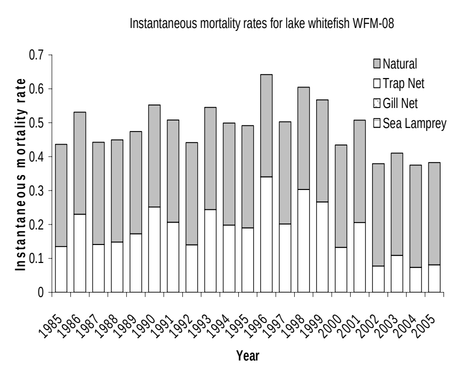
Recruitment, based on the estimated number of age-3 fish, was 469,000 in 2005. Estimates of recruitment were considerably higher (averaged 937,000 and peaked at 1,371,000) during 1999-2002, but the estimate for 2005 was very similar to the 1985-2004 average of 421,000 age-3 fish.



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. Total biomass was estimated at 3.8 million lb and spawning stock biomass was similar at 3.8 million lb in 2005. The ratio of spawning stock biomass to fishable biomass was 1 in 2005, slightly higher than the 1985-2004 average ratio of 0.94.

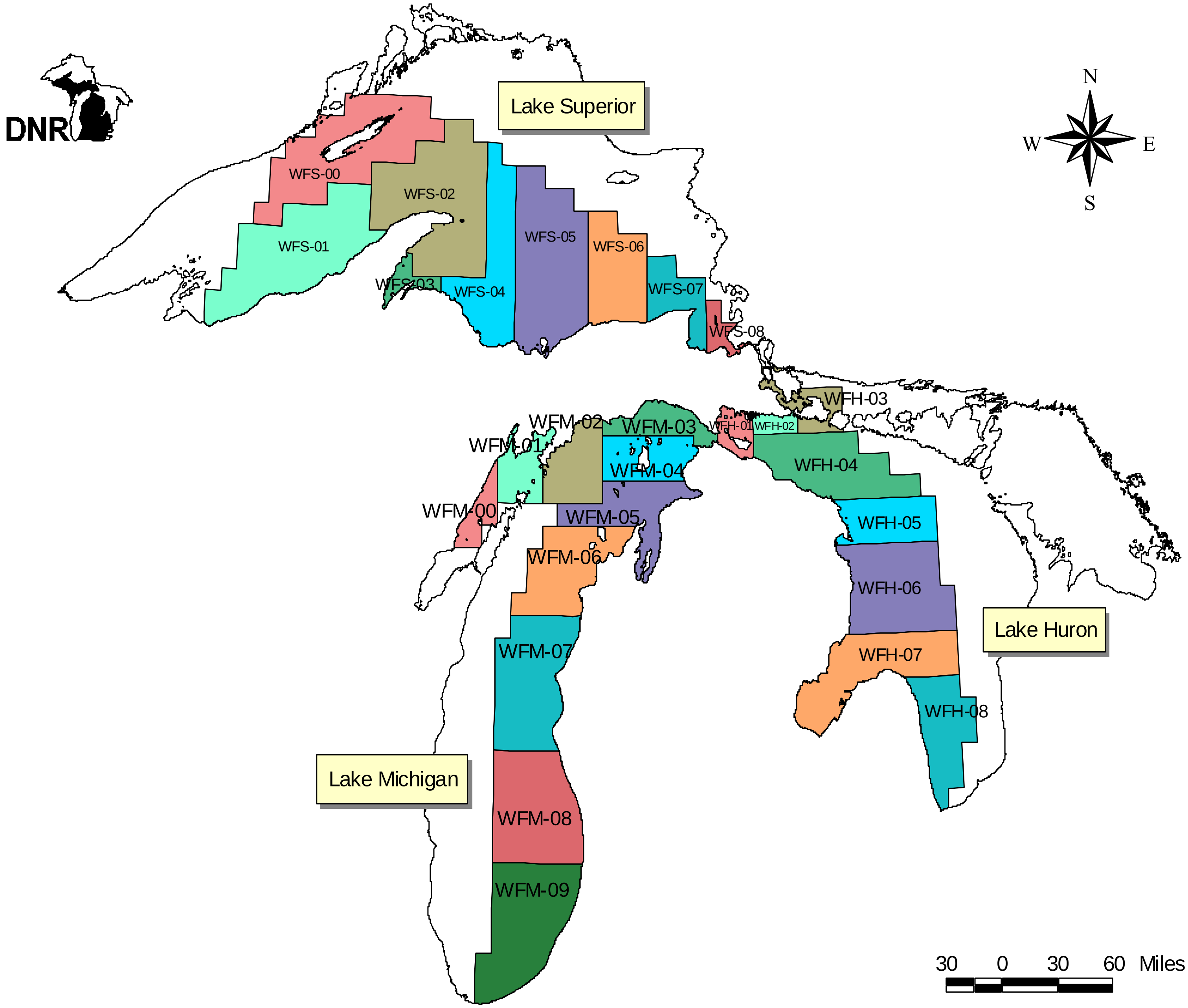


Mortality rates have been relatively stable throughout the time series. Instantaneous total mortality rate (Z) was estimated at 0.38 y^{-1} during 2005. Components of the total rate consisted of 0.08 y^{-1} for instantaneous trap-net-fishing mortality (F) and 0.30 y^{-1} for instantaneous natural mortality (M). Estimates of mortality have been very consistent from 1985-2005 and the ratio of F to Z averaged 0.35 from 1985 through 2005.

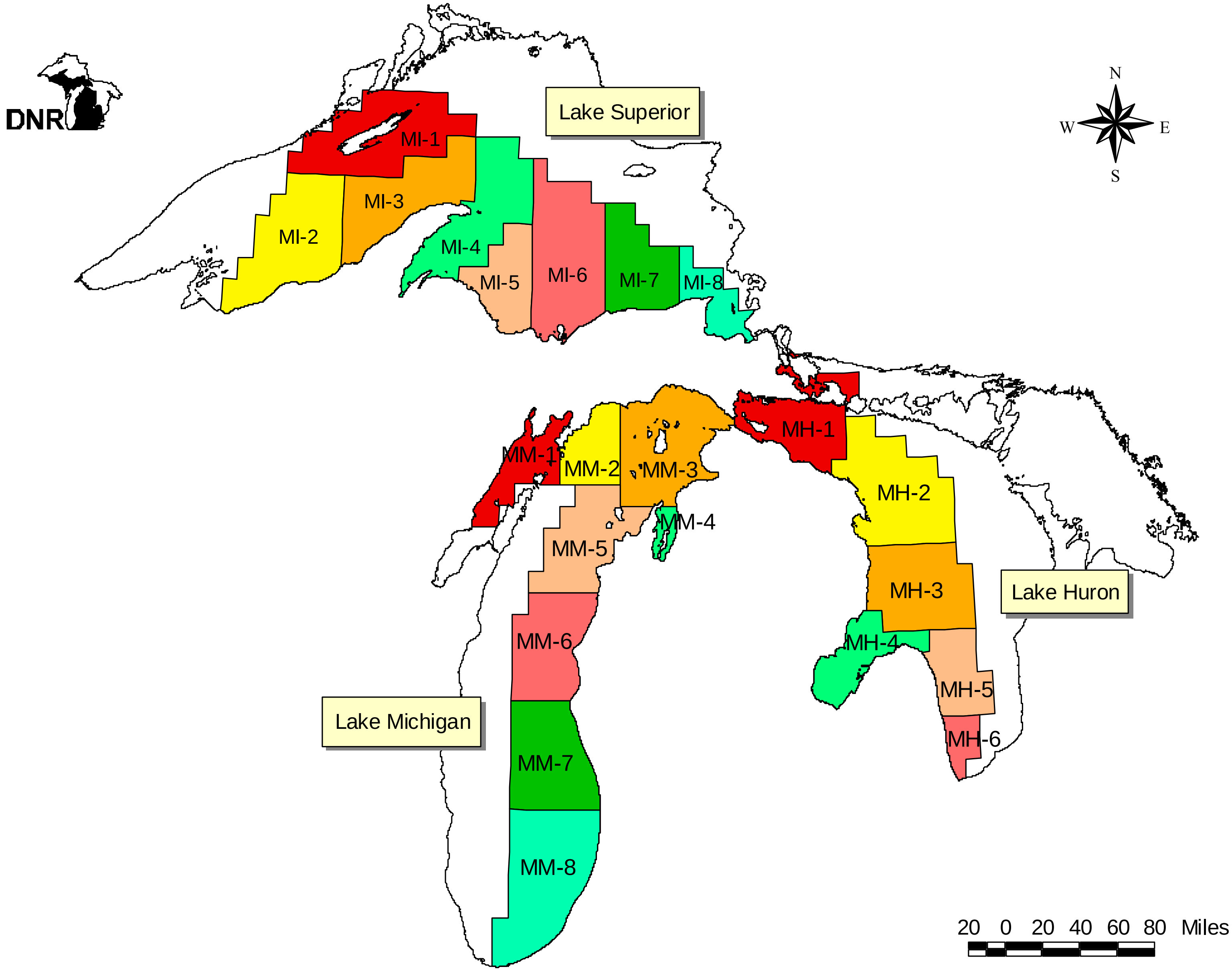


The 2007 yield limit for WFM-08 was 1.131 million lb, calculated using the projection model. This projected yield is close to the limit calculated for 2006 (1.588 million lb).

Summary Status WFM-08 Whitefish	Value (95% probability interval)
Female maturity	
Size at first spawning	0.90 lb
Age at first spawning	3 y
Size at 50% maturity	1.77 lb
Age at 50% maturity	4 y
Spawning stock biomass per recruit	
Base SSBR	3.36 lb (3.35 – 3.38)
Current SSBR	2.32 lb (2.23 – 2.42)
SSBR at target mortality	0.40 lb (0.39 – 0.40)
Spawning potential reduction	
At target mortality	0.69 (0.66 – 0.72)
Average yield per recruit	0.457 lb (0.42 – 0.49)
Natural mortality (M)	0.301 y^{-1}
Fishing mortality rates	
Fully selected age to gill nets	N/A
Fully selected age to trap nets	10 y
Average gill net F, ages 4+	0 y^{-1}
Average trap net F, ages 4+	0.081 y^{-1} (0.05 – 0.09)
Sea lamprey mortality (ML)	
Average ages 4+, 2003-2005	N/A
Total mortality (Z)	
Average ages 4+, 2003-2005	0.382 y^{-1} (0.37 – 0.39)
Recruitment (age-3)	
Average 1996-2005	614,130 fish (553,372 – 708,036)
Biomass (age 3+)	
Average 1996-2005	3,054,000 lb (2,737,940 – 3,431,760)
Spawning biomass	
Average 1996-2005	2,743,700 lb (2,451,070 – 3,083,300)
Recommended yield limit in 2007	1,131,000 lb



Appendix 1. Lake whitefish management units.



Appendix 2. Lake trout management units.