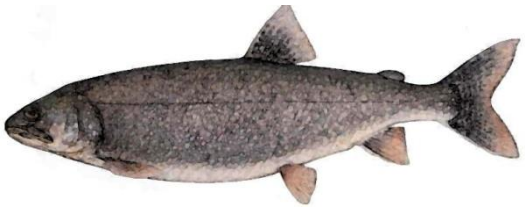
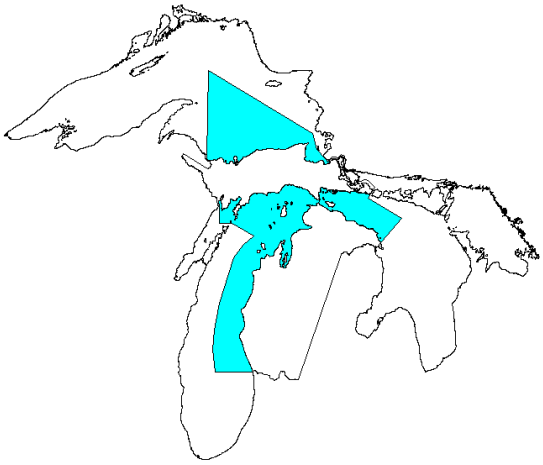
Technical Fisheries Committee Administrative Report 2013: Status of Lake Trout and Lake Whitefish Populations in the 1836 Treaty-Ceded Waters of Lakes Superior, Huron, and Michigan, with Recommended Yield and Effort Levels for 2013



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

D.C. Caroffino (Michigan Department of Natural Resources)
S.J. Lenart (United States Fish and Wildlife Service)

Editors



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EXECUTIVE SUMMARY

Prepared by David C. Caroffino and Stephen J. Lenart

This document outlines the status of lake trout and lake whitefish stocks as assessed by the 2000 Consent Decree's Modeling Subcommittee. The format of this report has been substantially altered from all previous annual reports. The objective was to provide a more succinct, consistent summary without losing focus on the primary purposes, which are to 1) briefly describe the status of each stock in the context of establishing harvest limits according to the terms of the Consent Decree and 2) document important technical changes in the stock assessment process. The most substantive changes include:

- reduced narratives within each individual unit summary;
- standardized graphical output;
- shortened summary tables;
- management unit descriptions included in a stand-alone section;
- removal of the *Stock Assessment Models* and *Priority Work for Future Assessments* sections. These will be periodically updated and included in future versions of this report. The most recent version of these sections are available in the 2012 report: http://www.michigan.gov/greatlakesconsentdecree

Table 1. Yield and effort limits for 2013.

Species	Lake	Management unit	Model-generated yield limit (lb)	Actual yield limit (lb)	Gill net limit (ft)
Lake trout	Superior	MI-5	133,196	133,196	NA
		MI-6	162,548	162,548	4,131,000
		MI-7	73,990	73,990	2,988,000
	Huron	MH-1	485,163	471,500	13,100,000
		MH-2	131,191	131,191	NA
	Michigan	MM-123	0	503,000	15,729,000
		MM-4	91,696	177,853	1,248,000
		MM-5	67,214	98,000	192,000
		MM-67	465,272	465,272	NA
Lake whitefish	Superior	WFS-04	112,000	112,000	NA
		WFS-05	437,000	437,000	NA
		WFS-06	No model estimate	210,000	NA
		WFS-07	376,900	376,900	NA
		WFS-08	262,600	262,600	NA
	Huron	Northern Huron	356,400	485,730	NA
		WFH-05	768,300	768,300	NA
	Michigan	WFM-01	1,716,000	2,000,000	NA
		WFM-02	494,700	494,700	NA
		WFM-03	1,598,500	1,598,500	NA
		WFM-04	634,000	634,000	NA
		WFM-05	365,000	365,000	NA
		WFM-06	132,200	250,000	NA
		WFM-07	No model estimate	500,000	NA
		WFM-08	492,200	1,400,000	NA

Lake Trout

In 2013, the MSC continued the lake trout model rotation strategy first implemented in 2009. Full stock assessments were not completed for lake trout units MI-7 and MM-67. Instead, output from the 2012 assessment was used along with current harvest and sea lamprey mortality information to project the population forward another year. The mortality provisions of the Consent Decree were then applied to the projected population to calculate harvest limits for 2013. Full stock assessments for these units are next scheduled for 2015. Due to significant changes in both model structure and stock dynamics, a full assessment was conducted for lake trout unit MH-2, a unit which had previously been included in the rotation strategy. This unit will be evaluated on an annual basis for inclusion in the rotation plan.

In Lake Superior, lean lake trout are self-sustaining, and the SCAA models and target mortality rates apply to these wild fish in three management areas (MI-5, MI-6, and MI-7). Declines in population abundance and biomass have occurred since the late 1990s, likely as a result of density dependent mechanisms affecting both growth and recruitment. Aside from natural mortality, sea lamprey-induced mortality (SLIM) represents the greatest individual source of mortality in all modeled Superior units and current average SLIM estimates range between 0.08 to 0.10 y^{-1}. These most recent estimates are generally lower than those observed in the middle 2000s, when SLIM rates were generally above 0.14 y^{-1}.

Commercial mortality in Lake Superior remains low (generally below 0.05 y^{-1}), though commercial yield from unit MI-6 in 2012 (38,634 lb) was the highest in the modeled time series. Whether the fishery continues to operate at this level remains uncertain. The recreational fishery has operated at a fairly consistent level throughout Lake Superior in recent years, though the 2011 sport harvest in MI-7 had nearly tripled (19,000 lb) from that observed in 2010. MI-7 sport harvest declined in 2012 to a level more consistent with the long-term average. Current recreational fishery mortality rates are below 0.03 y^{-1} in all management units.

Mortality and harvest of lean lake trout remain below targets throughout Lake Superior, thus our projections suggest yield could be increased in all modeled Lake Superior stocks in 1836 waters. There have been no efforts to fit a stock assessment model for lake trout in MI-8 of Lake Superior because this is a deferred area.

Widespread natural reproduction of lake trout continues to be evident in all Lake Huron data sources. In 2012, unclipped fish represented 23% of the commercial fishery in the U.S. waters of northern Lake Huron and approximately 40% of the recreational lake trout fishery. In the Canadian commercial fishery the proportion of unclipped fish exceeded 60%. Since these wild fish are predominately younger than age 8, hatchery fish still represent the largest proportion of the adult stock, particularly in US waters. To account for the continued presence of wild fish in the population, the Lake Huron assessments are now structured to include both wild and hatchery fish (see *Technical Changes* section for details).

Commercial fishing is the largest source of mortality in northern Lake Huron (unit MH-1), where total yield exceeded 300,000 lb in 2012, a 16% increase from 2011. Commercial yield in the Ontario waters of north-central Lake Huron (unit MH-2) increased nearly 50% to 60,000 lb in 2012, though the fishery is smaller than the north. The sport fishery harvested approximately 20,000 lb of lake trout from each unit during 2012 and recreational fishery mortality rates are below 0.05 y^{-1}. Increased sea lamprey mortality remains a concern in northern Lake Huron, where SLIM has increased to approximately 0.14 y^{-1} in recent years. Rates in north-central Huron have generally remained below 0.10 y^{-1} over the past ten years.

Spawning biomass in northern Lake Huron has declined approximately 28% from the 2007 peak, while the lower overall mortality rates in north-central Lake Huron have allowed spawning biomass to continue to increase there. Overall mortality rate estimates remain below target throughout the treaty waters of Lake Huron. Pre-recruit surveys have documented the presence of additional cohorts of wild fish, suggesting that mechanisms that favored natural reproduction remain in place.

In Lake Michigan treaty waters, where wild fish are scarce, the assessment models and target mortality rates apply only to stocked fish. In unit

MM-123 total mortality is well above target. Substantial sea lamprey-induced mortality (0.27 y^{-1}) and commercial fishing mortality (0.66 y^{-1}) continue to contribute to excessive total mortality rates. Recreational fishery mortality rates have remained below 0.03 y^{-1} since the onset of the Consent Decree. Biomass of young fish is growing due to increased stocking; however, few fish survive past age 7. A Consent Decree Amendment dated 4 April 2007 set the harvest limit in MM-123 at 453,000 lb for CORA and 50,000 lb for the State. These limits were imposed because the current rates of sea lamprey mortality would prevent any harvest under the original terms of the Consent Decree. The stipulated limits will remain in place until conditions of the amendment are met.

Estimated biomass has declined in unit MM-4 after the marked increase observed in the middle 2000s. Mortality from sea lamprey (0.11 y^{-1}), commercial fishing (0.21 y^{-1}), and recreational fishing (0.08 y^{-1}) are factors in this unit, though current total mortality rates remain just below target. Total harvest increased by 15% to 171,000 in 2012, the highest level observed since the Decree was implemented. There is a Consent Decree stipulation for MM-4, which establishes the 2013 harvest limit at 177,853 lb, nearly double the model-recommended value. Actual harvest has been well above the model-generated limit for the past three years, yet model estimates of mortality remain below target. Recent analyses by the MSC suggest that the application of certain rules in the TAC projection process may help explain this apparent disconnect. Nonetheless, the decline is adult biomass remains a concern.

Mortality rates in units MM-5 and MM-67 remain below target. Natural mortality is currently the largest source of mortality in these units, although SLIM had recently shown a marked increase in MM-5 for a two year period (2009-2010). The most recent estimates suggest that SLIM is below 0.10 y^{-1} in both of these management areas. In 2011, harvests for both the MM-5 commercial and sport fisheries were the highest observed since the Consent Decree was implemented. In 2012, total fishery harvest in MM-5 declined by 64% and the fisheries operated at a level much closer to their 2000-2010 averages. Fisheries are now a minor component in unit MM-67, where harvest has typically been less than 20% of the harvest limit for the past decade. The relatively low mortality rates in these southernmost Lake Michigan units have allowed adult biomass to build over the past decade.

Lake Whitefish

In Lake Superior, commercial harvest of lake whitefish has declined over time in the western units (WFS-04 and WFS-05) as a result of declining effort. Stable recruitment, combined with low mortality rates, has resulted in stable to increasing biomass in the west. Effort, and hence yield, has been more variable in the eastern units (WFS-07 and WFS-08) and mortality rates are higher overall. A long-term decline in recruitment is evident in unit WFS-07 and biomass has predictably declined in concert with recruitment. Biomass appears to be more stable in WFS-08, where estimated recruitment has been more favorable. The small, variable fishery in WFS-06 precludes development of an SCAA assessment. As a result, only fishery harvest and effort data are presented in this report.

In northern Lake Huron treaty waters (WFH-01-WFH-04), whitefish biomass peaked in the mid to late 1990s, as did commercial yield, which has declined by more than 50% in the last decade. Although similar patterns in biomass are evident in unit WFH-05, commercial yield peaked there in 2007, following substantial increases in effort since the late 1990s. Effort and yield have since declined. As is the case with all whitefish stocks, these biomass patterns are driven by recruitment, which has demonstrated a steep decline since the early 2000s. Catch rates, which are at their lowest point in the time series, have followed suit. Sea lamprey-induced mortality on lake whitefish has increased over the past decade and is a significant mortality source in the Lake Huron management areas, particularly on the older age classes. Certain classes in northern Lake Huron are experiencing mortality above the 65% annual target. High adult mortality, coupled with low recruitment, presents a troubling scenario for Lake Huron lake whitefish stocks.

Northern Lake Michigan whitefish stocks had, in recent years, provided a contrast to those in northern Lake Huron- strong recruitment in the late 1990s and early 2000s and relatively low mortality allowed stocks to build through the middle 2000s. The most recent assessments from northern Lake Michigan (WFM-01 to WFM-04) suggest that recruitment and biomass have declined from those peaks. Yields have remained stable to increasing, thus mortality rates have generally increased across most northern Lake Michigan stocks, though peak mortality rates remain well below targets. Model structure changed significantly for many of the northern Lake Michigan assessments (see *Technical Changes* section). In certain units, such as WFM-01, the new structure estimated fundamentally different stock dynamics when compared to the previous assessment. The 2013 model-generated harvest limit for unit WFM-01 declined 56% from the model-generated limit of 2012. The uncertainty associated with model estimates of stock size, coupled with the low performance rating, resulted in the TFC adopting a harvest limit of 2 million lb for WFM-01 in 2013.

Although estimated recruitment has declined in unit WFM-05, fishing effort and mortality have declined as well; as a result biomass has remained fairly stable in recent years. The trap-net fishery was inactive in this unit for the first time in the modeled time series. In contrast, trap-net fishery effort increased dramatically in unit WFM-06 during 2010 and 2011, mainly due to the entrance of a State-licensed commercial operation. As a result, trap-net yield was higher than it had been since the Decree was implemented. The dramatic shift in the trap-net fishery dynamics and the sporadic nature of the gill-net fishery has impacted model performance. As a result, the Parties have agreed to a constant harvest limit in unit WFM-06 until model performance improves.

Trap-net fishery effort and yield in unit WFM-07 has declined since reaching a peak in 2007. The limited time series available has precluded development of a SCAA model and the HRG for this unit has remained at a constant level since 2007. The MSC will continue to evaluate the available data to ascertain whether it is feasible to develop a model in the future.

Trap-net fishery yield has remained fairly stable in unit WFM-08, though model estimates indicate that recruitment and biomass have been in decline since the early 2000s. Natural mortality is the largest source of mortality in this unit and historical model-generated harvest limits suggest that fishery yield is small relative to stock size. This unit has been plagued with highly variable estimates of stock size, which appear to be driven by in part by the dynamics of the single active fishery operation. The uncertainty associated with model estimates of stock size (and thus highly variable harvest limits) led to the development of a constant harvest limit of 1.4 million lb. The development of a constant harvest limit was done in accordance with a long-term effort by the MSC to develop a Conditional Constant Catch policy for this unit. As part of the policy, the MSC will continue to run the stock assessment and evaluate a suite of stock parameters when making a recommendation to the TFC for continuance of the constant catch policy.

Technical Changes

In response to the growing contribution of wild lake trout to the populations in Lake Huron treaty waters, the MSC adopted a new structure for the Lake Huron lake trout assessments. Beginning with the 2013 assessments, each model is now estimating age-specific abundances of wild and hatchery fish by year, with recruitment now occurring at age 4. Observed age- and year-specific wild ratios are now input for each data source (survey and fisheries) and the model estimates a single ratio of wild fish for each age and year as part of the fitting process. The ratios are then applied in the calculation of numbers-at-age to derive the abundances of wild fish. Mortality components are assumed to be the same for wild and hatchery fish, as are selectivity and catchability. The abundance of wild fish thus remains linked to the abundance of hatchery fish. This assumed relationship will likely continue until a separate stock-recruit relationship for wild fish can be estimated.

In the lakes Michigan and Superior lake trout assessment models, the maturity matrices were updated for 2013. In Lake Superior maturity is estimated based on a logistic function

of length. The parameters for this function were assumed constant across the units and had not been updated since 1998. In 2013, they were updated based on data from 2008-2012, and a separate function was developed for each management unit. In Lake Michigan, maturity was assumed constant across the lake and through time. In 2013, it was updated to be unit-specific and time-blocked based on the age of 50% maturity observed in survey data. In both lakes fish are now maturing at younger ages than they did in the late 1990s.

In recent years, two substantive structural changes have been incorporated into many of the whitefish assessments. The first relates to the estimation of variance components. Historically, the use of assumed-known priors for the catch and effort deviations was standard in the lake whitefish assessments. These priors were often consistent across assessments and remained unchanged from year to year. Furthermore, for recruitment deviations, an iterative process was used during model optimization to achieve a ratio of near 1 for the prior-to-calculated (by the stock-recruit function) standard deviation. Based on published work conducted at the Quantitative Fisheries Center at Michigan State University, most of the assessments (the exception being certain Lake Superior and Lake Michigan whitefish units) now incorporate a variance-ratio approach, whereby a base variance component is estimated by the model and individual variance components, including that for recruitment, are calculated as the product of a pre-assigned ratio (rho) and the base variance (sigma). The MSC continues to evaluate this structural change, but this approach reduces our reliance on the presumptive assignment of known priors for the variance components. A similar variance-ratio approach has been incorporated into the Lake Huron lake trout assessments, though, in this case, the base variance is not calculated, but is instead assigned as the time-series mean standard deviation for survey catch-per-effort, as estimated by the mixed model.

A second structural change that has been incorporated into the structure of many of the whitefish assessments and the Lake Huron lake trout assessments is the use of a size-based (versus age-based) selectivity function. The estimation of age-based selectivity function parameters had long been problematic, particularly where substantial changes in growth had occurred through time, which is particularly the case in Lake Michigan and Lake Huron whitefish stocks. As growth declined, age was no longer an appropriate surrogate for size or vulnerability to fishing gear. This is true even though the standard approach was to allow one (or more) of the selectivity parameters to vary through time. The use of mean lengths-at-age in the calculation of selectivity function parameters has appeared to improve the models' ability to track changes in selectivity through time, though we remain somewhat cautious about the sensitivity of the estimates to annual changes in size-at-age, which may be influenced by small sample sizes, particularly for the youngest age classes.

The implementation of these structural changes was a potential factor in the substantial changes that occurred in the model-based estimates of stock size and recruitment in certain Lake Michigan whitefish units during 2013, though we note that a trend toward declining recruitment and stock size was evident even in certain Michigan units that retained the old model structure. The MSC will continue to rely on accepted model performance criteria to evaluate the appropriateness of future changes to model structure.

MANAGEMENT UNIT DESCRIPTIONS

The Great Lakes are divided into management units, which differ for lake trout and lake whitefish. The provisions of the 2000 Consent Decree apply to each of the individual management units. What follows are descriptions of the nine lake trout management units (Figure 1) and 15 lake whitefish management units (Figure 2), which are assessed by the Modeling Subcommittee.

Lake Trout Management Units

MI-5: Lake trout management unit MI-5 extends from Pine River Point (west of Big Bay) to Laughing Fish Point (east of Marquette) covering 374,000 ha. This management unit includes Stannard Rock, an offshore shoal about 72 km north of Marquette, and is in both the 1836 (250,000 ha) and 1842 Treaty waters (124,000 ha). The 1836 Treaty area extends east from the north-south line established by the western boundaries of grids 1130, 1230, 1330, 1430, and 1530. This unit has a wide bathymetric range with depths beyond 235 m, and with 117,000 ha shallower than 80 m.

MI-6: Lake trout management unit MI-6 extends from Laughing Fish Point (east of Marquette) to Au Sable Point (east of Munising), encompassing 728,000 ha. This management unit includes Big Reef, an offshore reef complex about 32 km northeast of Munising. This management unit contains the deepest waters of Lake Superior with soundings deeper than 400 m, and only 105,000 ha of the total area is shallower than 80 m.

MI-7: Lake trout management unit MI-7 extends from Au Sable Point (west of Grand Marais) to Little Lake Harbor (east of Grand Marais), encompassing 457,000 ha. This management unit has complex bathymetry with many lacustrine ridges, trenches, and slopes. There is approximately158,000 ha of lean lake trout habitat (depth less than 80 m).

MH-1: 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. For stock assessment purposes, biological data from waters in adjacent Ontario management area 4-1 are included. The management unit has a wide bathymetric range with areas in grids 407 and 408 as deep as 130 m. The Michigan portion of this unit lies completely within 1836 Treaty-ceded waters, covering 437,000 ha, of which approximately 308,000 ha are less than 80 m in depth. The Ontario portion, which lies outside 1836 Treaty waters, covers approximately 124,000 ha, of which approximately 69,000 ha is less than 80 m 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 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 72,000 ha of 1836 Treaty-ceded waters. Retention of lake trout in the refuge is prohibited.

MH-2: Lake trout management unit MH-2 is located in north-central Lake Huron. It includes statistical district MH-2 (approximately 640,000 ha) as well as adjacent Canadian waters (areas 4-2, 4-3, and 4-7 for a total of approximately 546,000 ha). Michigan waters of the MH-2 unit include both 1836 Treaty-ceded waters (304,000 ha) and non-treaty waters (336,000 ha), 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 management unit has a wide bathymetric range with areas in grids 714 and 814 deeper than 210 m, and a total of approximately 255,000 ha of the Michigan portion has bottom depths less than 80 m. A similar area (257,000 ha) in the Ontario portion contains waters less than 80 m. 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, a large offshore reef complex that bisects districts MH-2 and MH-3. A portion of the Six Fathom Bank Refuge is contained in unit MH-2,

covering the eastern half of grid 913 grid 914 and Michigan waters of grid 915. Retention of lake trout is prohibited in the refuge. Canadian waters adjacent to the refuge are a commercially protected area where commercial fishers are prohibited from fishing in waters shallower than 40 fathoms.

MM-123: Management unit MM-123 is made up of statistical districts MM-1, MM-2 and MM-3 and encompasses Michigan's waters of northern Lake Michigan and northern Green Bay, covering 1.29 million ha. Water depths in the northern portion of the unit are generally less than 45 m, and approximately 911,000 ha are less than 80 m. In southern portions of the unit, depths can be greater than 170 m. Most of the historically important lake trout spawning reefs in Lake Michigan are located in MM-123. The unit contains many islands including the Beaver Island complex (Beaver, Hat, Garden, Whiskey, Trout, High and Squaw Islands), North and South Fox Islands, and Gull Island in Lake Michigan. Another series of islands form a line separating Green Bay from Lake Michigan; these include Little Gull, Gravely, St. Martins, Big and Little Summer and Poverty Islands. Except for the southern one-half of MM-1 in Green Bay, this management unit is entirely in 1836 Treaty-ceded waters, and contains a lake trout refuge. The "northern refuge" is nearly 233,000 ha and occupies the southern ½ of grids 313 and 314, grids 413, 414, 513-516, the northwest quarter of grid 517, grid 613, and the northern ½ of grid 614. Retention of lake trout by sport or commercial fisheries is prohibited in the refuge. Both commercial and subsistence gill-net fishing are prohibited in the refuge, while commercial trap-net operations are permitted to harvest lake whitefish.

MM-4: 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 85 m. However, waters on either side of the peninsula are much deeper, ranging to 134 m in the west arm and 195 m 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 66,000 ha of which 50,000 ha are less than 80 m 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.

MM-5: 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 546,000 ha 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 250 m and for the most part are greater than 120 m. Only 125,000 ha (23%) of the unit are at depths less than 80 m. 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.

MM-67: Lake trout management unit MM-67 is located in eastern central Lake Michigan, comprising 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 1,157,000 ha, of which 241,000 ha are less than 80 m in depth. The northern section of the region (MM-6) is deeper, with depths up to 275 m, and is characterized by greater slope than the southern section (MM-7). For the most part, water depths in MM-7 are less than 122 m. 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. 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 179,000 ha in the unit are

outside treaty waters. A line running parallel to the northern side of the Grand River (located approximately ¾ of the way through grids in the 1900 series) out to the state line in the middle of the lake delineates the southern boundary of treaty territories in the unit. Management unit MM-67 contains a portion of the deepwater mid-lake lake trout refuge, which comprises 850 square miles of the unit (grids 1606, 1607, 1706, 1707, 1806, 1807, 1906 and 1907). It is illegal for recreational, commercial and subsistence fishers to retain lake trout when fishing in the refuge area. Gill-net fishing (both commercial and subsistence) is prohibited in the refuge, State- and Tribal-licensed commercial trap-net operations are permitted to fish in the refuge; however, the retention of lake trout is prohibited.

Lake Whitefish Management Units

WFS-04: Lake whitefish unit WFS-04 (486,000 ha) 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.

WFS-05: 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 747,000 ha. 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.

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

WFS-07: WFS-07 is located in the Whitefish Bay area of Lake Superior and contains 150,000 ha of water less than 80-m 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.

WFS-08: WFS-08 is located in the southeast portion of Whitefish Bay, Lake Superior. WFS-08 is spatially the smallest of the management units in the 1836 ceded waters of Lake Superior, and it contains 65,000 ha of water less than 80-m deep. A substantial commercial fishery targeting whitefish also exists in adjacent Canadian management units 33 and 34. It is thought that four reproductively isolated stocks of whitefish contribute to the commercial fishery in WFS-08. There are two spawning areas in WFS-08, a probable contributing spawning population in Canadian waters of management unit 34, as well as contributions from spawning fish in WFS-07 directly west of WFS-08.

Northern Huron: The catch-at-age model for lake whitefish in Northern Lake Huron was created in 2009 after mark-recapture data showed fluid movement of adult fish between management units WFH-01, WFH-02, WFH-03, and WFH-04. The consolidated stock assessment model was an attempt by the Modeling Subcommittee to estimate population parameters for a mixed stock fishery exploited by only one agency (CORA). Management unit WFH-01 is located in the northwest portion of the main basin of Lake Huron. It is relatively shallow and contains 94,000 ha of water less than 80 m. Management unit WFH-02 is located along the northern shore of the main basin of Lake Huron. Much of WFH-02 is deeper than 45 m and maximum depth is slightly more than 90 m. WFH-02 is a small unit made up of only three statistical grids and contains 50,000 ha of water less than 80-m deep. The unit has an irregular shoreline with many small, rocky points, small bays, and scattered boulders. 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 45 m in depth, whereas the north and west sides of Drummond Island are relatively shallow. WFH-03 contains six statistical grids and less than 40,000 ha of water less than 80-m deep. WFH-04 is the largest whitefish management unit in the 1836 treaty-ceded waters of Lake Huron. The unit contains 153,000 ha of water less than 80-m deep. Spawning concentrations of whitefish are scattered throughout the unit with concentrations being found from Cheboygan to Hammond Bay.

WFH-05: WFH-05 extends 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 85,000 ha of water less than 80-m deep in WFH-05. WFH-05 contains a large spawning stock of whitefish that spawns throughout the unit.

WFM-01: Lake whitefish management unit WFM-01 is located in the 1836 Treaty waters of northern Green Bay. Prominent features of this area include two large bays (Big and Little Bay de Noc), numerous small embayments, several islands (including St. Martins Island, Poverty Island, Summer Island, Little Summer Island, Round Island, Snake Island, and St. Vital Island), as well as various shoal areas (Gravelly Island Shoals, Drisco Shoal, North Drisco Shoal, Minneapolis Shoal, Corona Shoal, Eleven Foot Shoal, Peninsula Point Shoal, Big Bay de Noc Shoal, Ripley Shoal, and shoals associated with many of the islands listed above). Little Bay de Noc is the embayment delineated by statistical grid 306, and its surface area is 16,000 ha. Shallow waters characterize the northern end and nearshore areas, but there is a 12- to 30-m 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 38,000 ha delineated by statistical grids 308 and 309. Big Bay de Noc is relatively shallow with over half the area less than 10-m deep and a maximum depth of 21 m. Rivers that empty into Big Bay de Noc include the Big, Little, Ogontz, Sturgeon, Fishdam, and Little Fishdam.

WFM-02: WFM-02 is located in the northwest portion of Lake Michigan. There are 157,000 ha of water less than 80-m deep in the unit. The only known spawning population of whitefish in the management unit is located in Portage Bay; this population is not as abundant as other stocks in Lake Michigan. Many of the whitefish inhabiting WFM-02 move into the unit from adjacent units.

WFM-03: WFM-03 is located in northern Lake Michigan. The unit extends from the Straits of Mackinac west to Seul Choix Point and is bounded on the south by Beaver Island and a complex of shoals and islands surrounding it. Nearly the entire unit is shallow water less than 27 m deep. There are 195,000 ha of water less than 80-m deep.

WFM-04: 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 2- to 9-m 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 14,245 ha landmass that bisects the unit. These latter reefs are surrounded by deep water. WFM-04 contains 234,000 ha of water less than 80-m deep.

WFM-05: 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 greater than 80-m deep, including both the east and west arms of Grand Traverse Bay. The deepest parts of WFM-05 exceed 183 m, 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 197,000 ha, or 46% of the water in these grids, is less than 80-m deep. Much of the offshore waters of WFM-05 are part of the northern Lake Michigan lake trout refuge.

WFM-06: 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 382,000 ha (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 (greater than 60 m). Bays, islands, and shoal areas offer the best habitat for lake whitefish spawning in this management area.

WFM-07: Lake whitefish management unit WFM-07 is located within the 1836 Treaty Ceded Waters of eastern central Lake Michigan from Arcadia in the north to just south of Stony Lake, and west to the Michigan/Wisconsin state line bisecting the middle of the lake. This lake whitefish management unit includes part or all of grids 1107-1111, 1207-1211, 1306-1310, 1406-1410, 1506-1510 and 1606-1609. The surface area for this unit is 521,000 ha, of which 111,000 ha have bottom depths of 80 m or less, with maximum depths up to 275 m. There are several inflows from the Big Manistee, Little Manistee, Big Sable, Pere Marquette, and Pentwater Rivers, and drowned river mouths at Manistee Lake, Pere Marquette Lake, and Pentwater Lake.

WFM-08: Management unit WFM-08 is the Lake Michigan whitefish zone that extends from Montague south past Port Sheldon. WFM-08 has a surface area of 610,000 ha in Michigan grids 1706-1710, 1806-1810, 1906-1911, and 2006-2011. Apart from the shoreline, and 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 61-m deep or deeper.

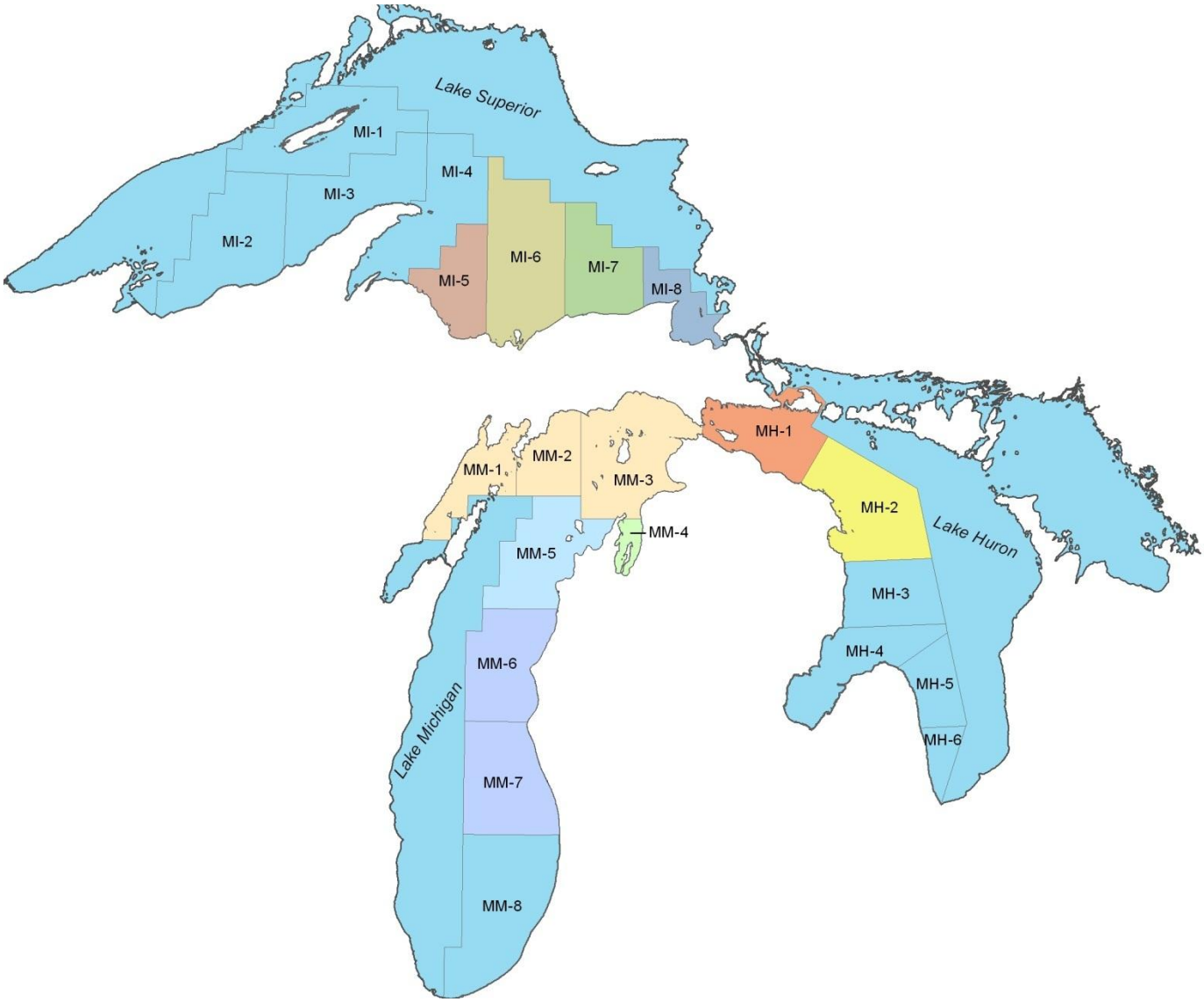


Figure 1. Lake Trout Management Units. Shaded areas denote units which are subject to provisions of the 2000 Consent Decree. Like shading indicates where statistical districts have been combined into a single management unit for stock assessment purposes. No stock assessment has been developed for Lake Superior unit MI-8.

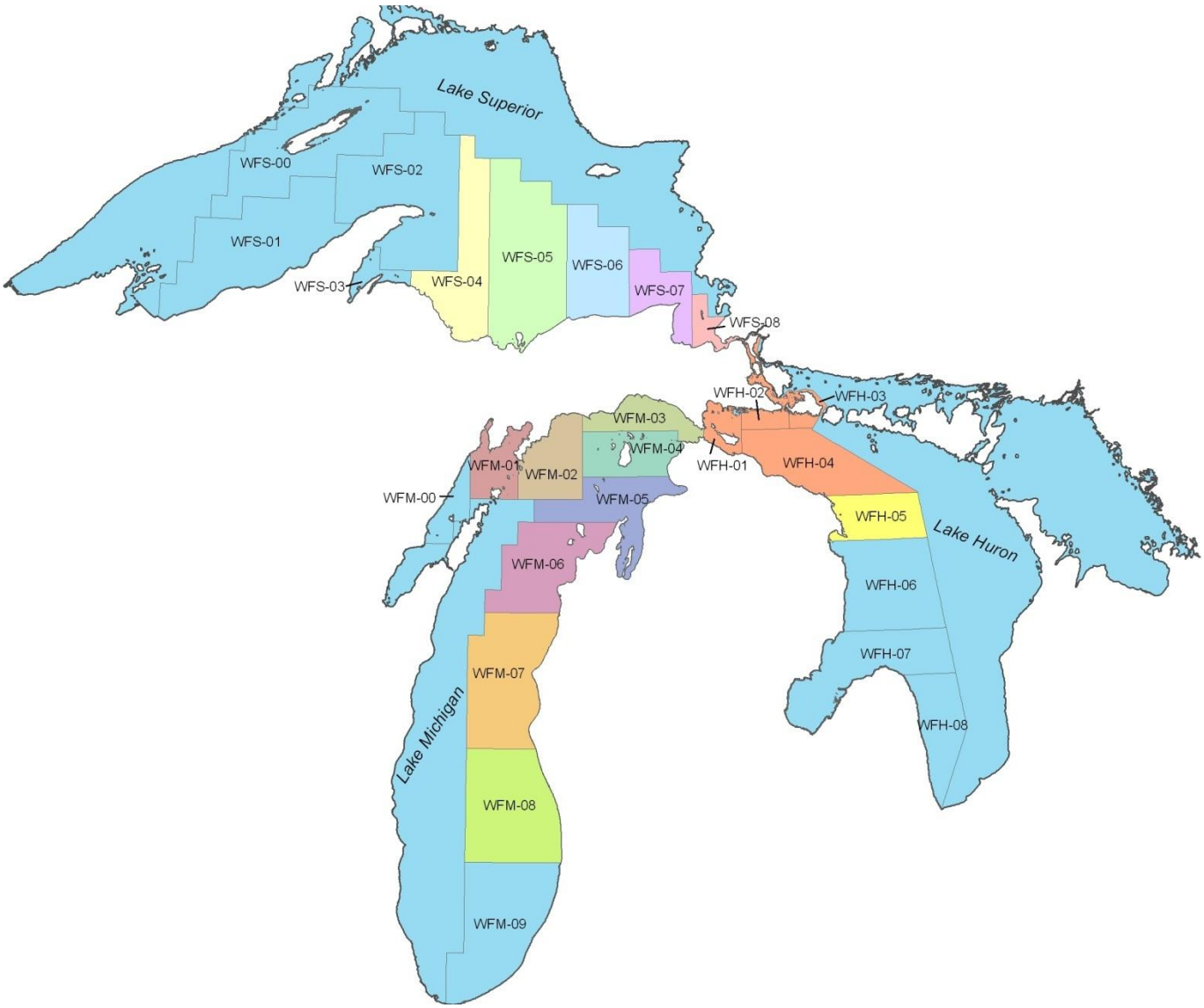


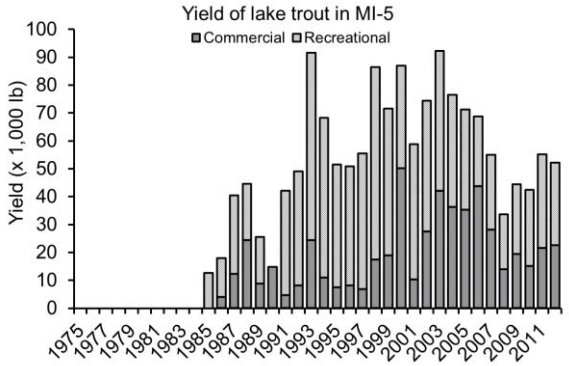
Figure 2. Lake Whitefish Management Units. Shaded areas denote units which are subject to provisions of the 2000 Consent Decree. Like shading indicates where units have been combined into a single management area for stock assessment purposes. Stock assessment models are not currently run for Lake Superior unit WFS-06 or Lake Michigan unit WFM-07.

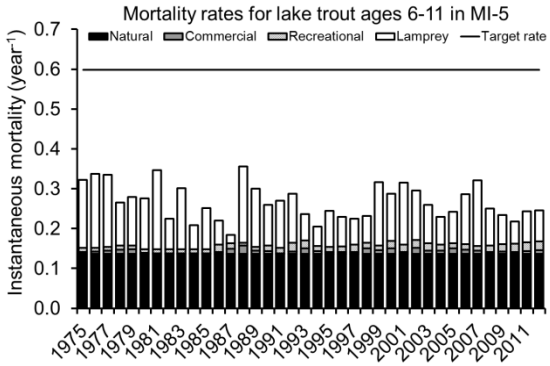
STATUS OF LAKE TROUT POPULATIONS

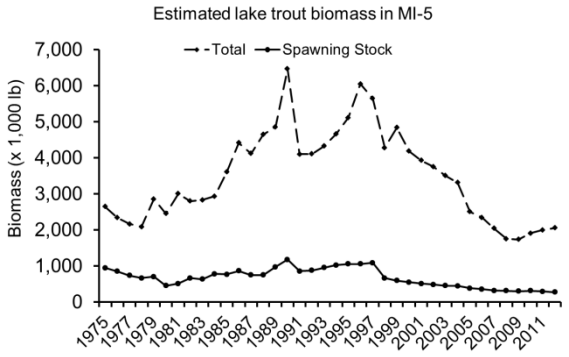
Lake Superior

MI-5 (Marquette)

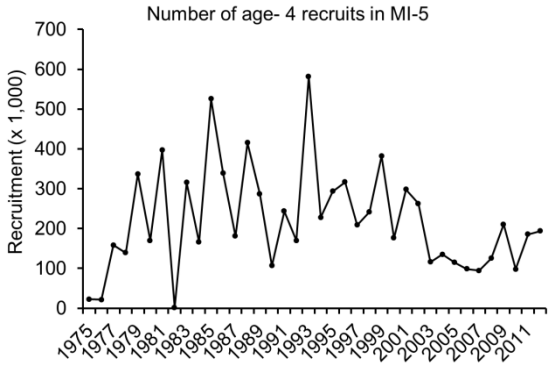
Shawn Sitar







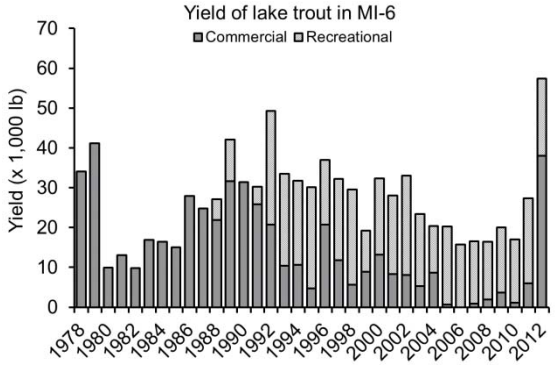
Parameter	Value
Base SSBR	7.09 lb
Current SSBR	1.98 lb
Target SSBR	0.40 lb
Current SPR	0.28
M	0.14 y^{-1}
F, Commercial (2010-2012)	0.01 y^{-1}
F, Recreational (2010-2012)	0.02 y^{-1}
Sea Lamprey Mort (2009-2011)	0.07 y^{-1}
Z	0.25 y^{-1}
Recommended TAC	133,196 lb
Actual TAC	133,196 lb
Model Rating	Medium

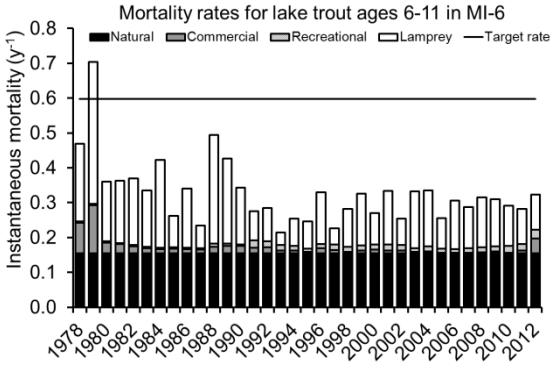


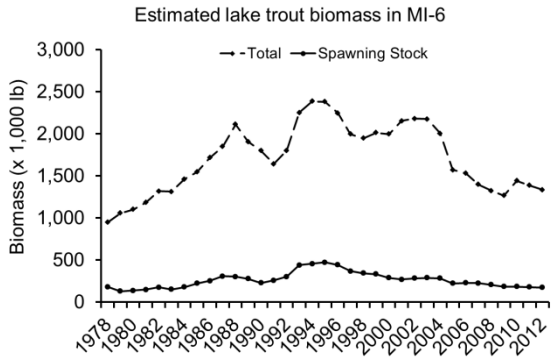
<u>Notable Fishery Dynamics and Model Changes:</u>

Lake trout abundance has progressively declined since the 1990s, driven by reduced recruitment. Total mortality rates have declined since 2007 due to lower sea lamprey-induced mortality. Recreational harvest has been steady in recent years and exceeds commercial landings. Commercial yield increased slightly during 2011-2012. Total annual mortality for ages 6-11 fish averaged 21% in the last three years. The lake trout harvest limit in 2013 declined by 7% from 2012 due to continued declining trends in abundance and recruitment.

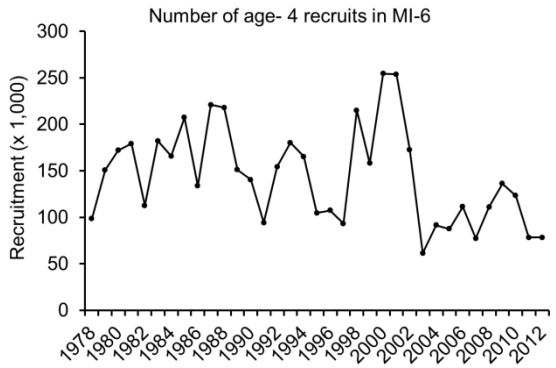
MI-6 (Munising) Shawn Sitar







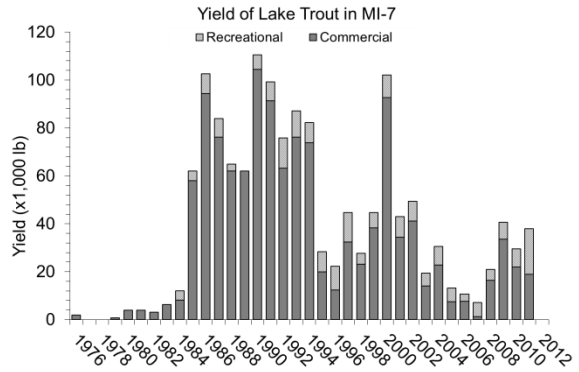
Parameter	Value
Base SSBR	5.33 lb
Current SSBR	1.46 lb
Target SSBR	0.59 lb
Current SPR	0.27
M	0.15 y^{-1}
F, Commercial (2010-2012)	0.02 y^{-1}
F, Recreational (2010-2012)	0.02 y^{-1}
Sea Lamprey Mort (2009-2011)	0.12 y^{-1}
Z	0.32 y^{-1}
Recommended TAC	162,548 lb
Actual TAC	162,548 lb
Model Rating	Low

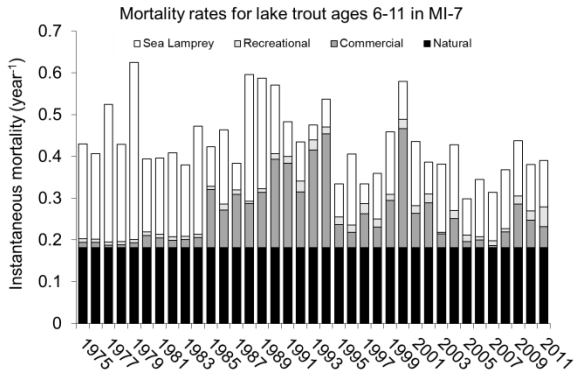


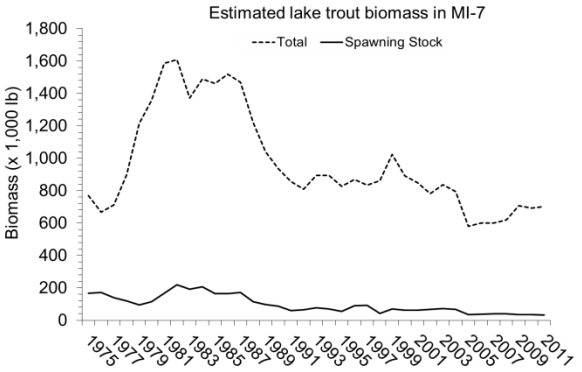
Notable Fishery Dynamics and Model Changes:

Abundance of lake trout continues to decline due to major declines in recruitment since 2001. Total mortality has not varied appreciably in the last 10 years and is mostly driven by sea lamprey predation. Recent commercial landings have been low, however in 2012 landings increased by five-fold to the highest levels since 1980, due to a new fisher entering the area. Total annual mortality for lake trout ages 6-11 averaged 26% in the last three years. The 2013 harvest limit for MI-6 was reduced by 8% from last year's model-generated limit due to declines in stock size. This model retains a low rating because it still relies on a key abundance scaling parameter from the MI-5 model to produce output consistent with our professional perception of stock size in this area.

MI-7 (Grand Marais) Shawn Sitar



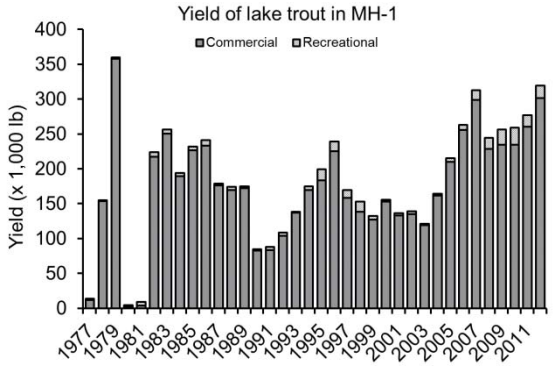


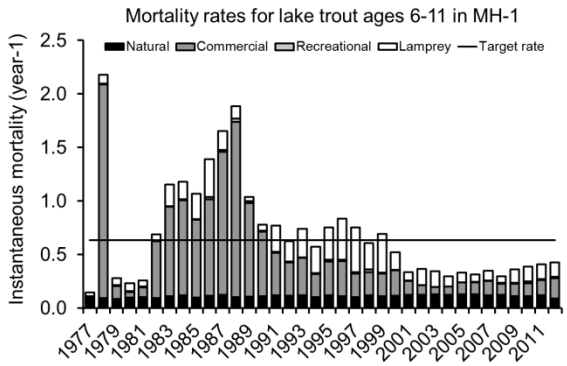


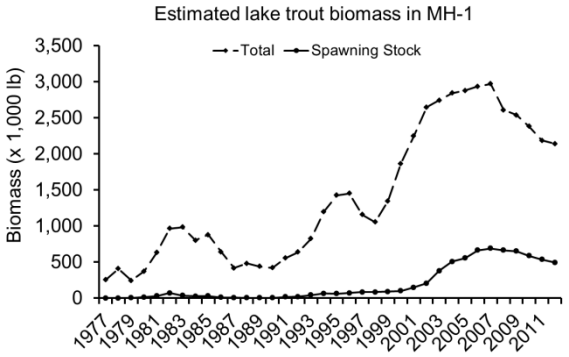
Parameter	Value
Base SSBR	3.08 lb
Current SSBR	0.43 lb
Target SSBR	0.22 lb
Current SPR	0.14
M	0.18
F, Commercial (2009-2011)	0.07
F, Recreational (2009-2011)	0.03
Sea Lamprey Mort (2009-2011)	0.12
Z (2011)	0.39
Recommended TAC	73,990 lb
Actual TAC	73,990 lb
Model Rating	N/A

<u>Notable Fishery Dynamics and Model Changes:</u>
This model was in rotation status for 2013; therefore, the harvest limits were projected from 2012 model estimates of abundance and recruitment, with updated fishing and sea lamprey mortality rates. Average total annual mortality rate for 2010-2012 was 33%. In 2012, recreational harvest decreased by more than 50% and commercial yield decreased by one-third from 2011. The 2013 harvest limit for MI-7 increased 4% from 2012 because of recent slight increases in abundance.

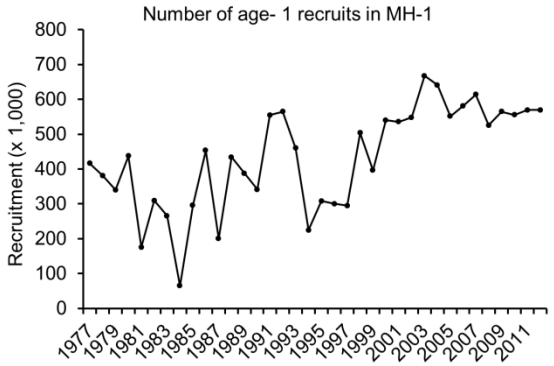
Lake Huron
MH-1 (Northern Lake Huron) Ji He







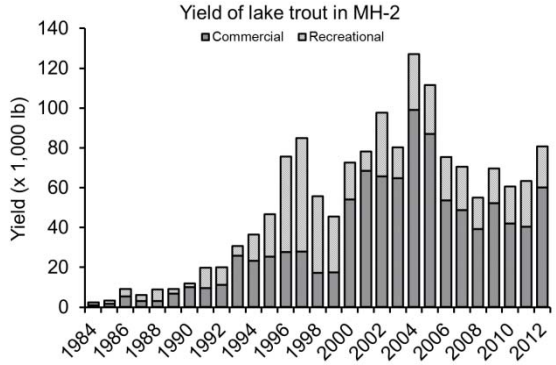
Parameter	Value
Base SSBR	3.94 lb
Current SSBR	0.56 lb
Target SSBR	0.25 lb
Current SPR	0.14
M	0.10 y^{-1}
F, Commercial (2010-2012)	0.15 y^{-1}
F, Recreational (2010-2012)	0.01 y^{-1}
Sea Lamprey Mort (2009-2011)	0.13 y^{-1}
Z	0.43 y^{-1}
Recommended TAC	485,163 lb
Actual TAC	471,500 lb
Model Rating	Low

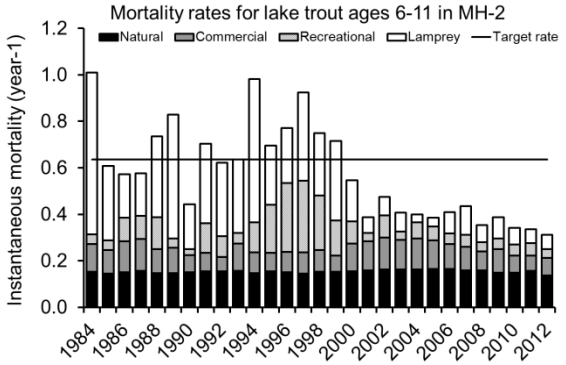


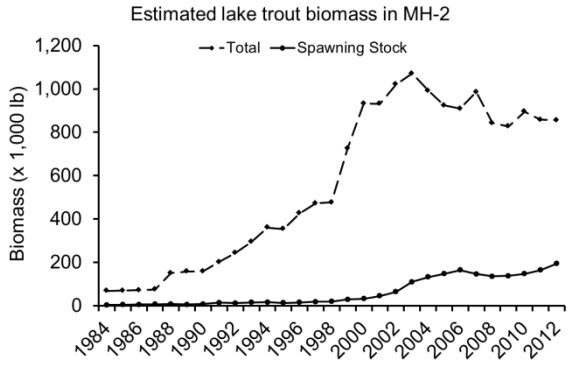
<u>Notable Fishery Dynamics and Model Changes:</u>

Both recreational and commercial yield increased moderately in 2012 from levels observed in 2011. Total yield was approximately 320,000 lb and total annual mortality for lake trout ages 6-11 averaged 35% in 2012. Estimated annual mortality has remained fairly stable (30-35%) over the past four years. In 2012, commercial fishing was the largest mortality source in the unit (0.187 y^{-1}), followed by sea lamprey (0.135 y^{-1}). Total and spawning biomass continue to decline from the 2007 peak, though total abundance increased slightly the past two years. Model estimates suggest that approximately 20% of the adult stock (ages 6+) is now comprised of wild fish, which were incorporated into the assessment for the first time in 2013 (see *Technical Changes* section of the Executive Summary for details).

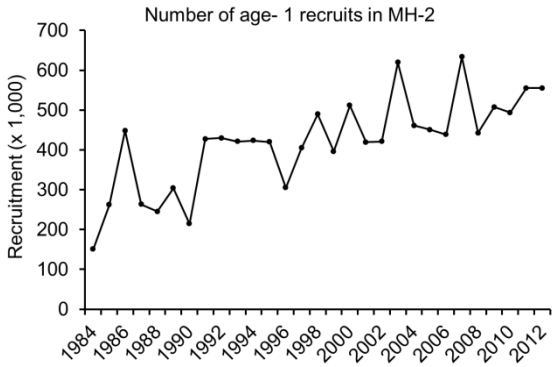
MH-2 (North-Central Lake Huron) Ji He







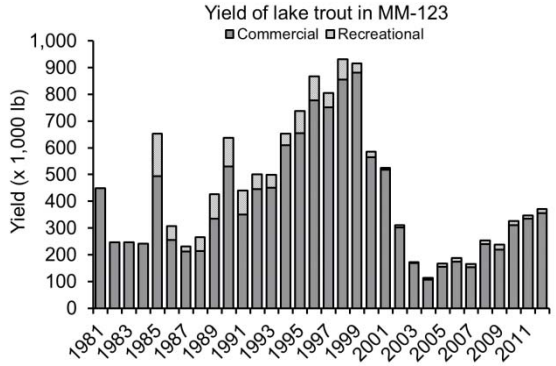
Parameter	Value
Base SSBR	0.08 lb
Current SSBR	0.02 lb
Target SSBR	0.01 lb
Current SPR	0.25
M	0.15 y^{-1}
F, Commercial (2010-2012)	0.07 y^{-1}
F, Recreational (2010-2012)	0.04 y^{-1}
Sea Lamprey Mort (2009-2011)	0.07 y^{-1}
Z	0.31 y^{-1}
Recommended TAC	131,191 lb
Actual TAC	131,191 lb
Model Rating	Low

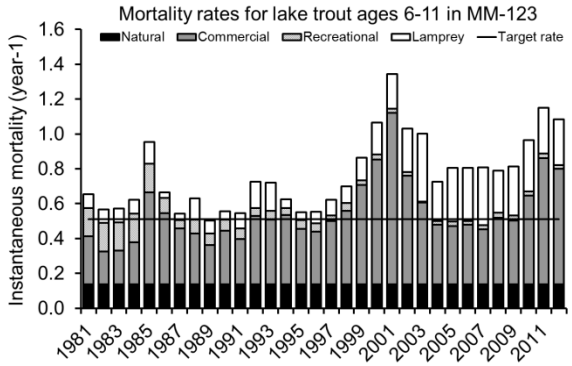


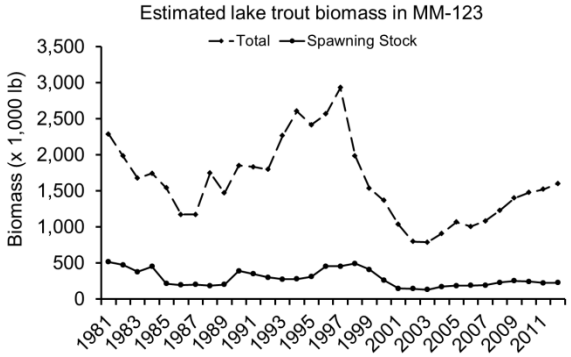
<u>Notable Fishery Dynamics and Model Changes</u>

This structure of this model was updated in 2013, so it was not in rotation. Recreational yield in 2012 was consistent with recent years while commercial yield (Canadian waters) increased 50% in 2012, from 40,000 to 60,000 lb. Estimated sea lamprey mortality remains low (0.07 y^{-1}) and natural mortality is the largest source of mortality in this unit. Total annual mortality for lake trout ages 6-11 averaged 26% in 2012. Model estimates suggest that approximately 44% of the adult stock is now comprised of wild fish, which were incorporated into the assessment for the first time in 2013 (see *Technical Changes* section of the Executive Summary for details). Spawning biomass has recently increased and is now estimated to be at its highest level in the time series.

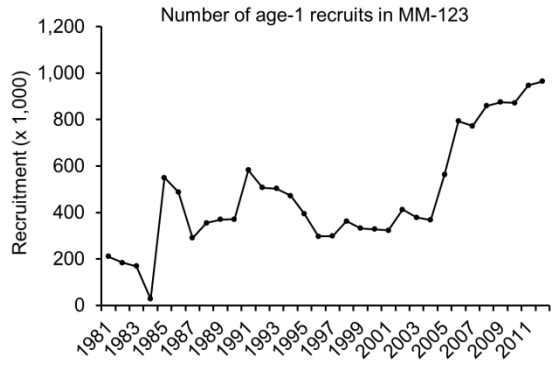
Lake Michigan
MM-123 (Northern Treaty Waters) Jory Jonas





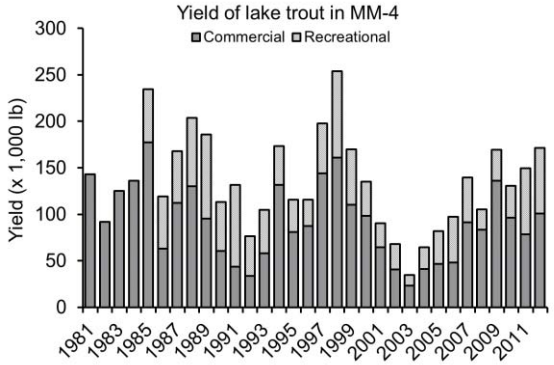


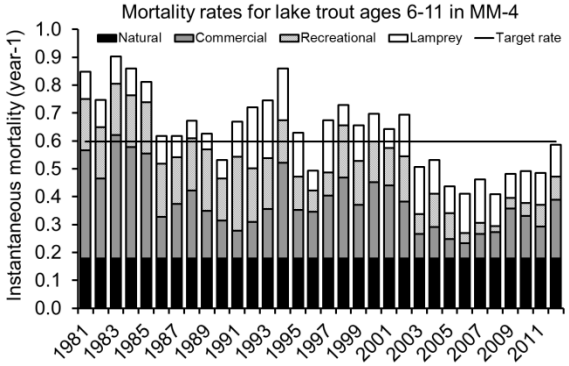
Parameter	Value
Base SSBR	7.10 lb
Current SSBR	0.28 lb
Target SSBR	1.36 lb
Current SPR	0.04
M	0.14 y^{-1}
F, Commercial (2010-2012)	0.63 y^{-1}
F, Recreational (2010-2012)	0.02 y^{-1}
Sea Lamprey Mort (2009-2011)	0.28 y^{-1}
Z	1.08 y^{-1}
Recommended TAC	0 lb
Actual TAC	503,000 lb
Model Rating	Medium

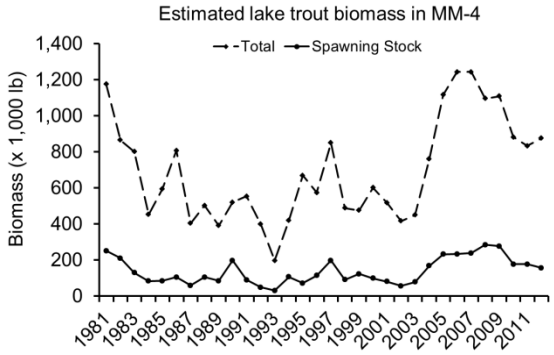


Notable Fishery Dynamics and Model Changes:
The model-generated harvest limit in this unit is zero due to mortality rates which substantially exceed target levels. Sea lamprey mortality remains high (0.28 y^{-1}). Commercial fishing mortality has nearly doubled in the most recent three years (average 0.63 y^{-1}) compared to the prior three-year period (average 0.35 y^{-1}). Each of these mortality sources has killed approximately 90,000 fish in each of the last three years. Total annual mortality for lake trout ages 6-11 averaged 66% in 2012. The harvest limits in MM-123 are set by stipulation and these stipulated limits have not been exceeded since their imposition in 2007. The number of stocked fish recruited to this unit has more than doubled since 2004, from 367,000 to 964,000.

MM-4 (Grand Traverse Bay) Jory Jonas



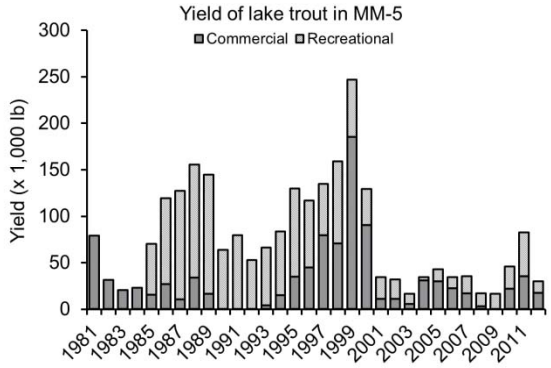


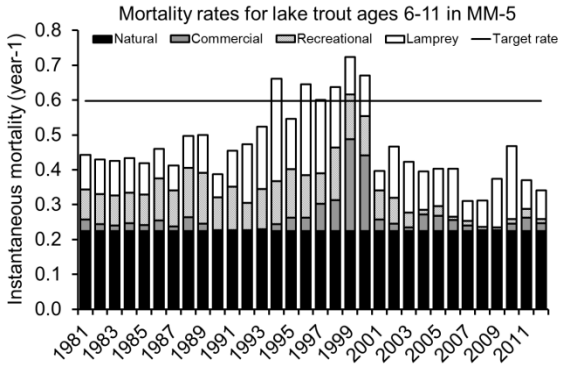


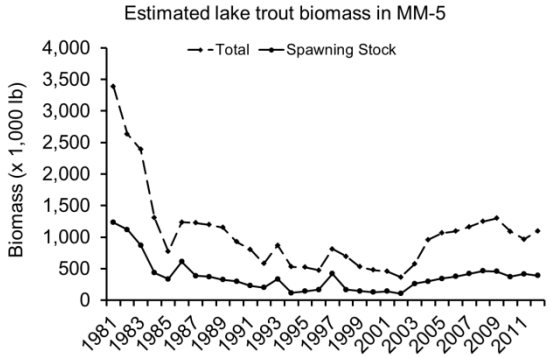
Parameter	Value
Base SSBR	1.98
Current SSBR	0.26 lb
Target SSBR	0.28 lb
Current SPR	0.13
M	0.18 y^{-1}
F, Commercial (2010-2012)	0.16 y^{-1}
F, Recreational (2010-2012)	0.07 y^{-1}
Sea Lamprey Mort (2009-2011)	0.10 y^{-1}
Z	0.59 y^{-1}
Recommended TAC	91,696 lb
Actual TAC	177,853 lb
Model Rating	Low

<u>Notable Fishery Dynamics and Model Changes:</u>
The projected harvest limits for 2013 (41,263 lb state and 50,433 lb tribal) were similar to those estimated for 2012 (41,870 lb state and 51,174 lb tribal). Lamprey mortality rates remain consistent with those observed in the previous year (0.11 y^{-1}). Harvests by recreational and commercial fisheries were higher in 2012 compared to 2011. The number of stocked fish recruited to the unit decreased from 438,637 in 2011 to 407,630 fish in 2012. Total annual mortality for lake trout ages 6-11 averaged 44% in 2012. The actual harvest limits in MM-4 are set by stipulation, which allocates 100,653 lb (94,300 + 6,353 transfer of 2012 unused State limit) to tribal fisheries and 77,200 lb to the state.

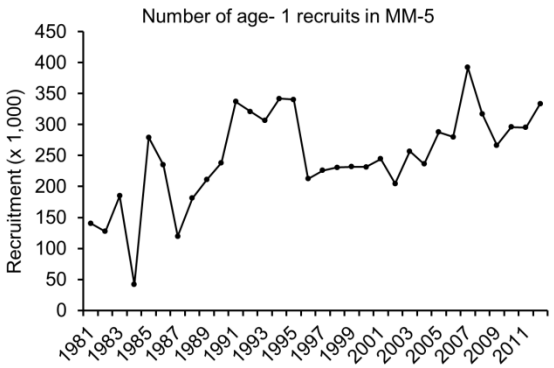
MM-5 (Leelanau Peninsula to Arcadia) Jory Jonas





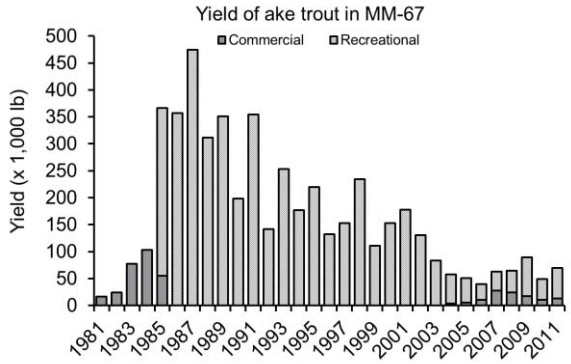


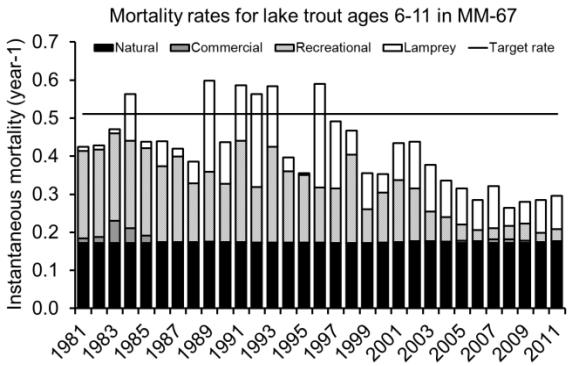
Parameter	Value
Base SSBR	1.98 lb
Current SSBR	0.74 lb
Target SSBR	0.63 lb
Current SPR	0.37
M	0.22 y^{-1}
F, Commercial (2010-2012)	0.03 y^{-1}
F, Recreational (2010-2012)	0.02 y^{-1}
Sea Lamprey Mort (2009-2011)	0.14 y^{-1}
Z	0.34 y^{-1}
Recommended TAC	67,214 lb
Actual TAC	98,000 lb
Model Rating	Medium

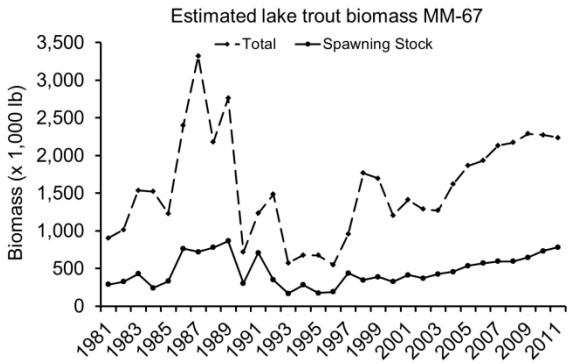


Notable Fishery Dynamics and Model Changes:
The projected harvest limits for 2013 (40,340 lb state and 26,874 lb tribal) were substantially lower than those established in 2012 (61,054 lb state and 40,740 lb tribal). An updated maturity matrix contributed to the lower harvest limits (see *Technical Changes* section of the Executive Summary for details). Lamprey mortality rates were lower than in the previous year (0.08 vs. 0.21 y^{-1}). Mortality rates for recreational and commercial fisheries were also lower in 2012 (0.012 and 0.022 y^{-1}) compared to 2011 (0.025 and 0.039 y^{-1}). Total annual mortality for lake trout ages 6-11 averaged 29% in 2012. The number of stocked fish recruited to this unit has declined from a high of 392,350 yearling equivalents in 2007 to 334,000 in 2012. The harvest limits in MM-5 are set by stipulation, which allocates a minimum of 39,200 lb to tribal fisheries and 58,800 lb to the State recreational fishery.

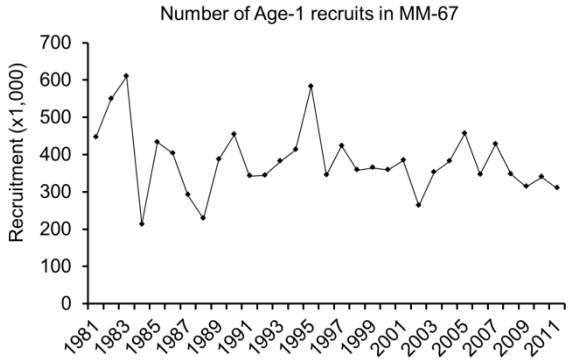
MM-67 (Southern Treaty Waters) Jory Jonas







Parameter	Value
Base SSBR	2.26 lb
Current SSBR	1.09 lb
Target SSBR	0.40 lb
Current SPR	0.48
M	0.17 y^{-1}
F, Commercial (2010-2012)	0.01 y^{-1}
F, Recreational (2010-2012)	0.03 y^{-1}
Sea Lamprey Mort (2009-2011)	0.08 y^{-1}
Z	0.27 y^{-1}
Recommended TAC	465,272 lb
Actual TAC	465,272 lb
Model Rating	N/A



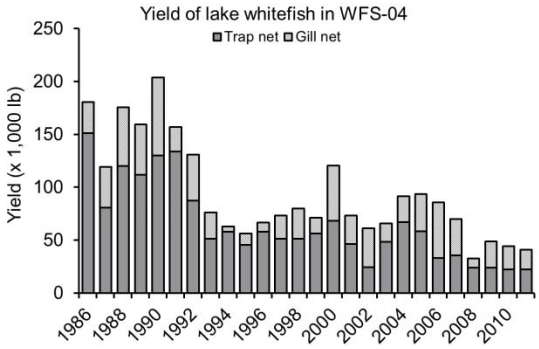
Notable Fishery Dynamics and Model Changes:

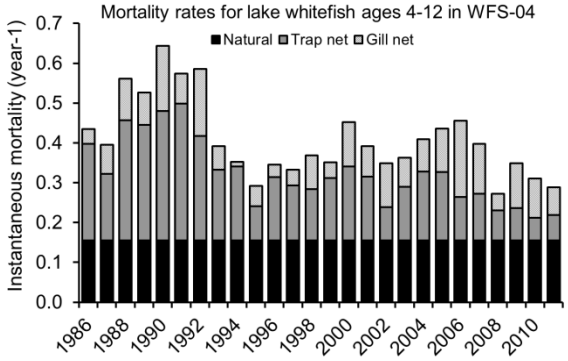
This unit was in rotation for 2013 and a full assessment was not run. Harvest and sea lamprey data were updated to project the 2013 harvest limits. The projected harvest limits for 2013 (418,744 lb state and 46,527 lb tribal) were higher than those established in 2012 (394,844 lb state and 43,871 lb tribal). Recreational harvest in 2012 was about half of the 2011 level despite consistent effort. Commercial harvest was one-third of the 2011 value. The average annual mortality rate for lake trout ages 6-11 in this unit was estimated to be 26% when the last full assessment was run in 2012.

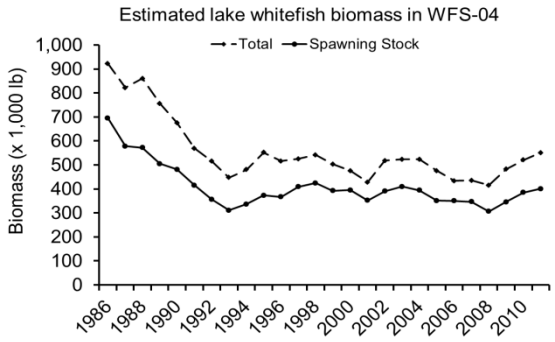
STATUS OF LAKE WHITEFISH POPULATIONS

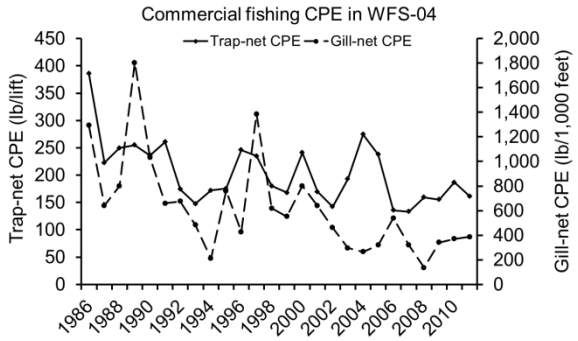
Lake Superior

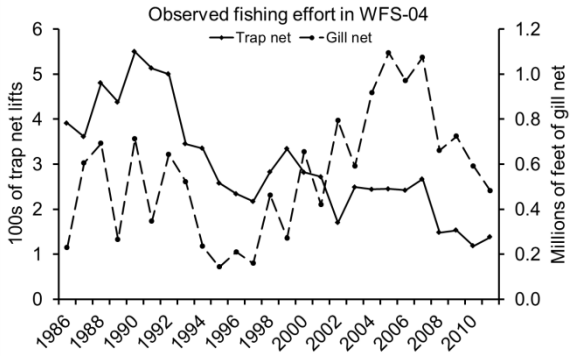
WFS-04 (Marquette-Big Bay) Mike Seider









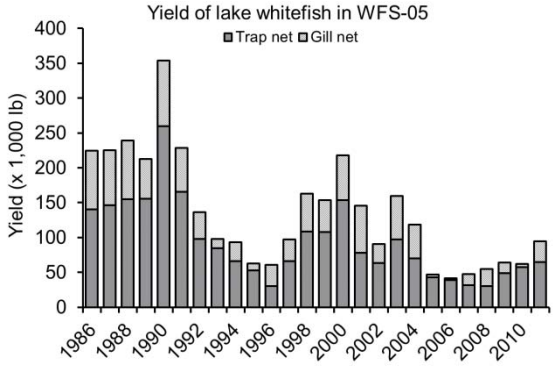


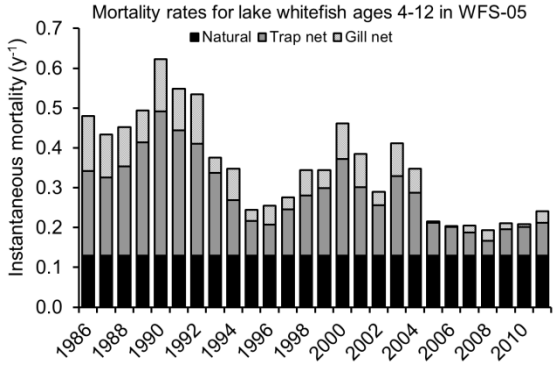
Parameter	Value
Base SSBR	9.87 lb
Current SSBR	3.54 lb
Target SSBR	0.24 lb
Current SPR	0.36
M	0.15 y^{-1}
F, trap net (2009-2011)	0.07 y^{-1}
F, gill net (2009-2011)	0.09 y^{-1}
Z	0.29 y^{-1}
Recommended TAC	112,000 lb
Actual TAC	112,000 lb
Model Rating	Medium

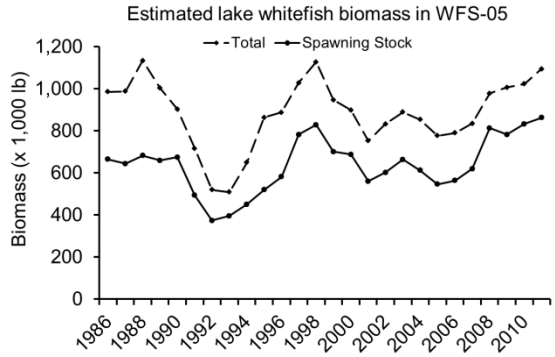
<u>Notable Fishery Dynamics and Model Changes:</u>
No changes were made to the current WFS-04 stock assessment model. The model was not sensitive to parameter starting values and the data fits were good, with no major residual patterns. MCMC distributions were poor, which has been normal for this unit; however, the retrospective analyses showed no troubling

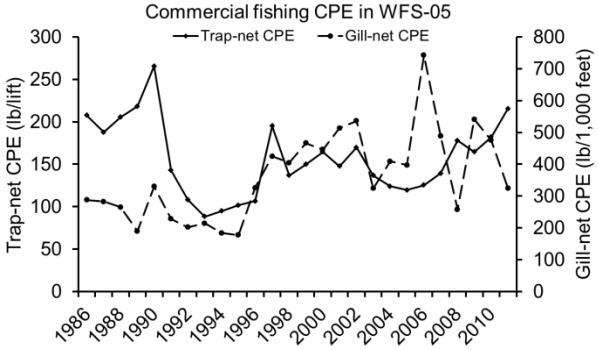
temporal patterns. Estimated total abundance in this management unit has been relatively stable over the last 20 years. Population mean weight-at-age has not changed dramatically for most ages over the entire time series. The estimated number of age-4 whitefish (recruitment) in last three years was higher than in the previous six years. Total mortality rates have gradually declined since 2006 due to declining commercial effort. Trap-net and gill-net effort have declined by 48% and 55%, respectively, since 2007. Commercial CPUE over the same time period has been relatively stable. Total annual mortality for the most vulnerable age class in 2011 was 32%.

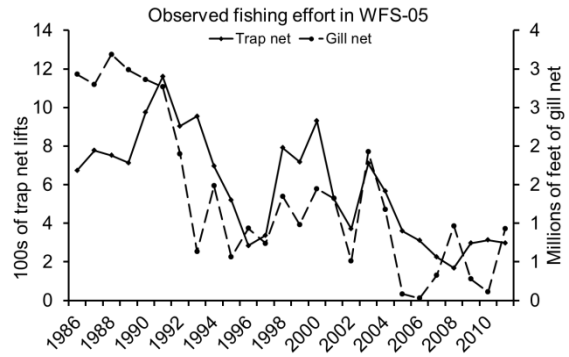
WFS-05 (Munising) — Shawn Sitar

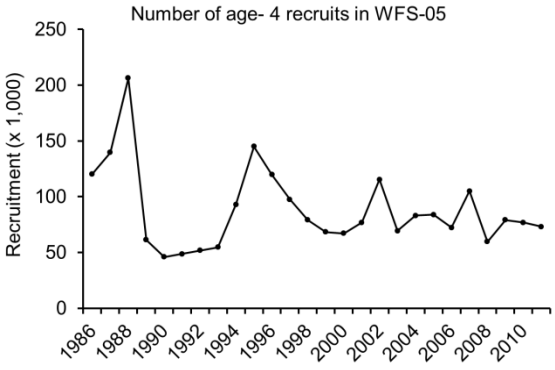










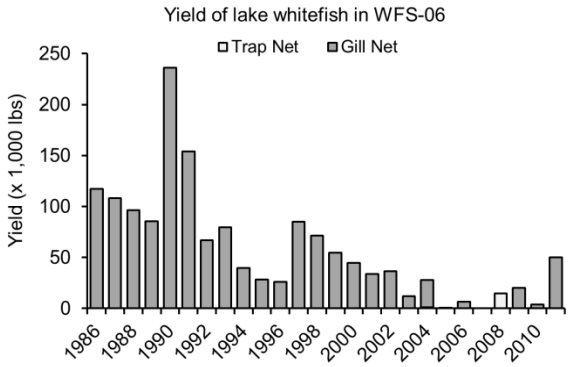


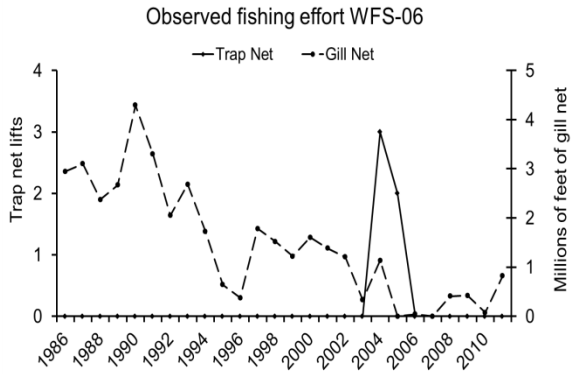
Parameter	Value
Base SSBR	11.02 lb
Current SSBR	4.83 lb
Target SSBR	0.23 lb
Current SPR	0.44
M	0.13 y^{-1}
F, trap net (2009-2011)	0.07 y^{-1}
F, gill net (2009-2011)	0.02 y^{-1}
Z	0.24 y^{-1}
Recommended TAC	437,000 lb
Actual TAC	437,000 lb
Model Rating	Medium

Notable Fishery Dynamics and Model Changes:

The WFS-05 lake whitefish stock biomass has increased since 2005, with total mortality rates far lower than the target maximum. Trap-net yield has increased slightly since 2008 and gill-net yield has increased since 2006. There were no modifications made to the 2013 model for WFS-05. The 2013 harvest limit was 17% lower than the 2012 value. The lower limit is due to a slight decline in abundance of ages vulnerable to the fishery despite overall increases in total stock biomass driven by a buildup of older age classes.

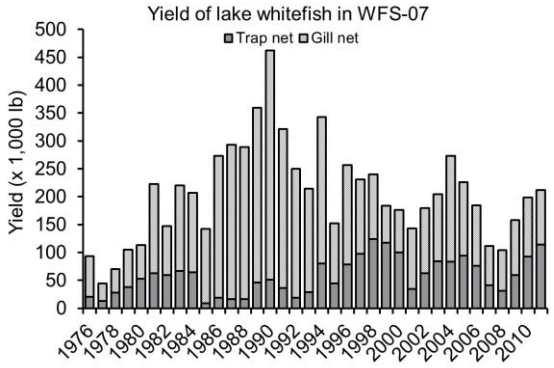
WFS-06 (Grand Marais)

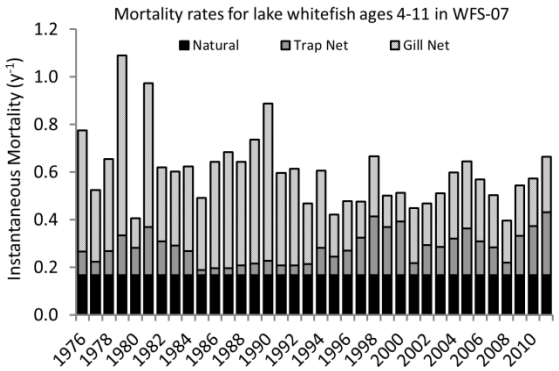


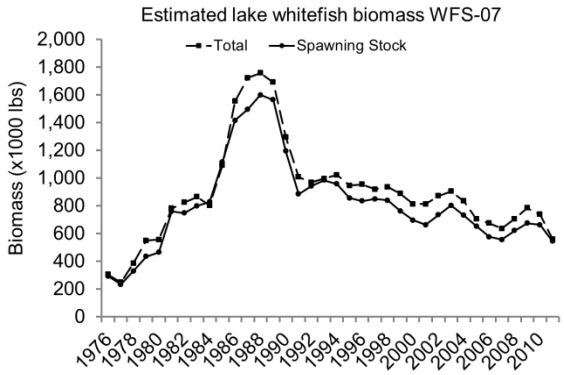


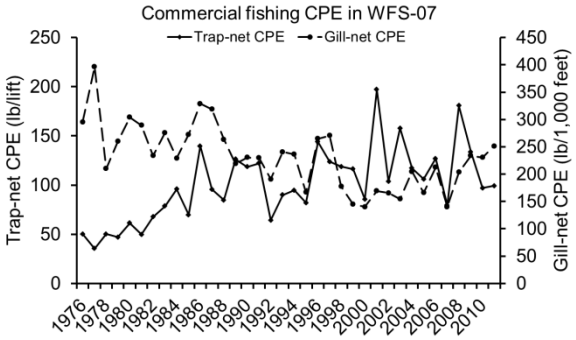
There is no current stock assessment model for WFS-06. Low levels of effort and harvest and a lack of fishery monitoring data since the early 2000s limit the ability to produce a model assessment in this unit.

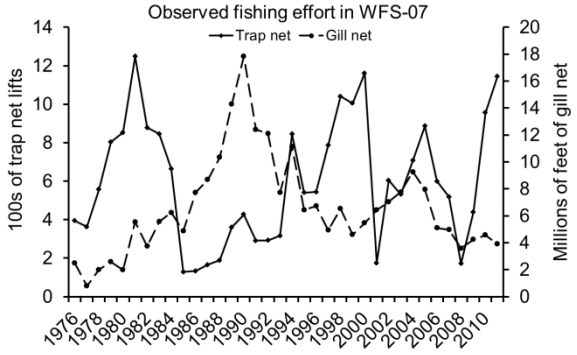
WFS-07 (Tahquamenon Bay) Mark Ebener

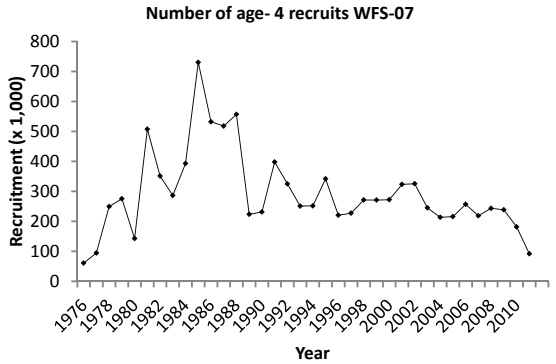










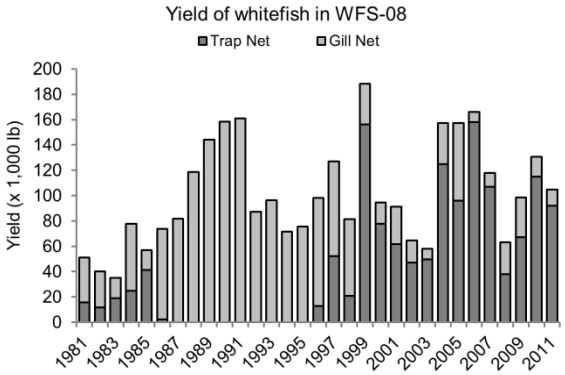


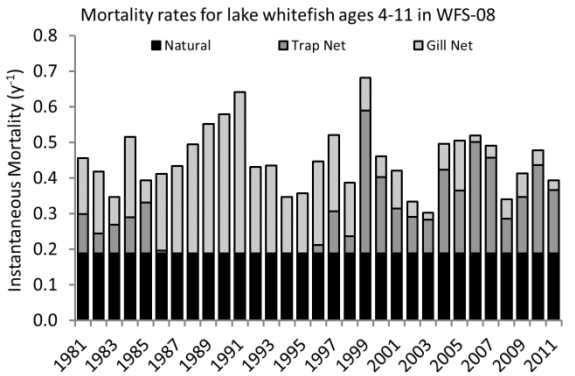
Parameter	Value
Base SSBR	7.12 lb
Current SSBR	1.11 lb
Target SSBR	0.22 lb
Current SPR	0.15
M	0.17 y^{-1}
F, trap net (2009-2011)	0.21 y^{-1}
F, gill net (2009-2011)	0.22 y^{-1}
Z	0.65 y^{-1}
Recommended TAC	376,900 lb
Actual TAC	376,900 lb
Model Rating	Low

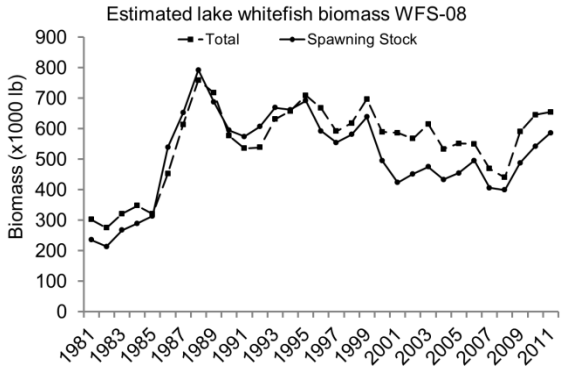
Notable Fishery Dynamics and Model Changes:

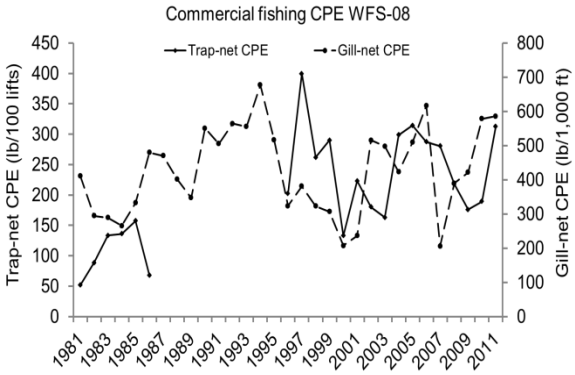
Fishable biomass in WFS-07 continued its two-decade-long decline. Biomass peaked near 3.5 million lb in the late 1980s and has since declined to 1.26 million lb, the lowest level since 1980. Harvest has been reasonably stable despite the declines in biomass, resulting in increasing mortality rates. Annual mortality of the most vulnerable age class was estimated to be 54% in 2011. This model exhibited strong and divergent retrospective patterns in estimated biomass, recruitment, and population size.

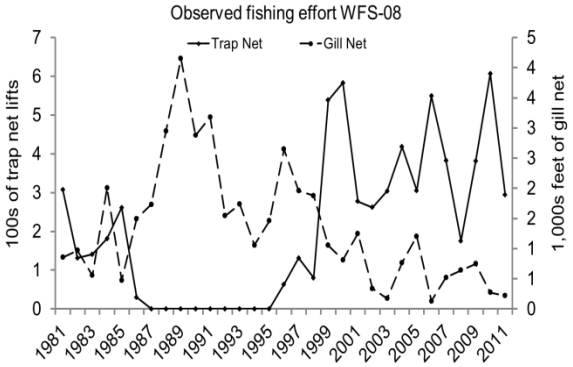
WFS-08 (Brimley) Paul Ripple











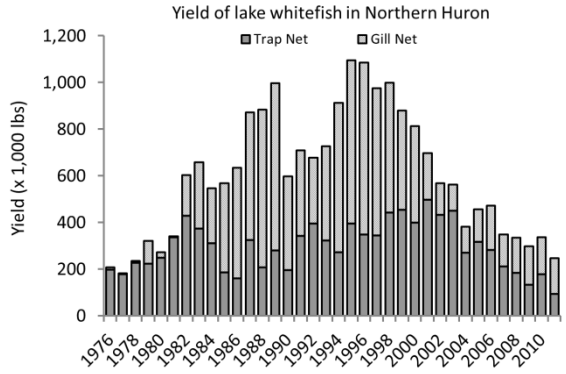
Parameter	Value
Base SSBR	4.56 lb
Current SSBR	1.32 lb
Target SSBR	0.20 lb
Current SPR	0.29
M	0.19 y^{-1}
F, trap net (2009-2011)	0.19 y^{-1}
F, gill net (2009-2011)	0.04 y^{-1}
Z	0.39 y^{-1}
Recommended TAC	262,600 lb
Actual TAC	262,600 lb
Model Rating	Medium

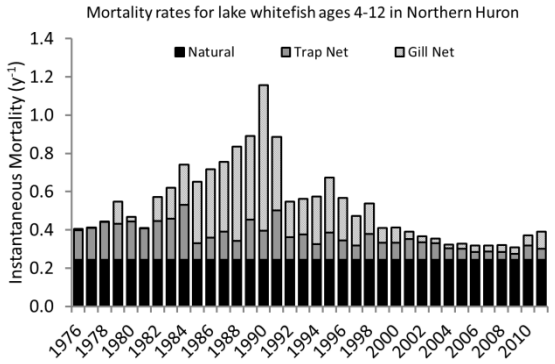
Notable Fishery Dynamics and Model Changes:

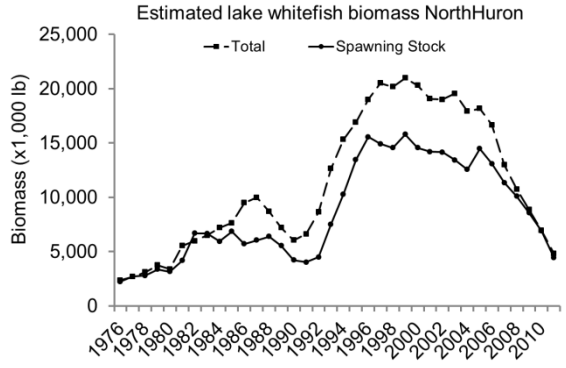
The model-recommended harvest limit for 2013 in WFS-08 is 8.5% higher than the 2012 recommendation. Spawning stock biomass peaked in 1988, slowly decreased until 2008, and has increased since then. Gill-net effort has steadily decreased since 1989. Trap-net effort, while variable, has generally increased since 1995, with a time-series peak reported in 2010. Trap-net effort in 2011 was 294 lifts, about half the effort in 2010. The CPUE for both gears has

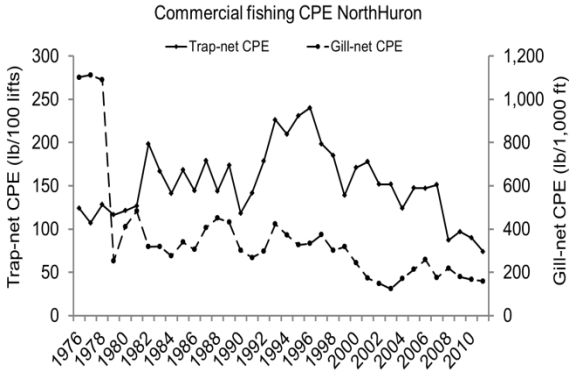
generally been variable over time, though catch rates have shown an increasing trend in the last few years. The annual mortality rate experienced by the most vulnerable age in this population was 35% in 2011. The model did not reach its convergence criterion but was stable with different start values. Other model diagnostics were acceptable.

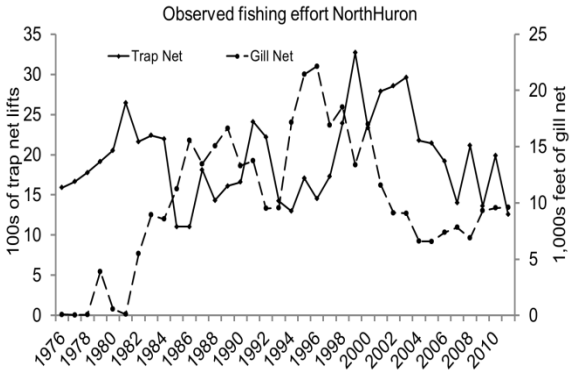
Lake Huron
Northern Huron (WFH-01 to WFH-04) Mark Ebener

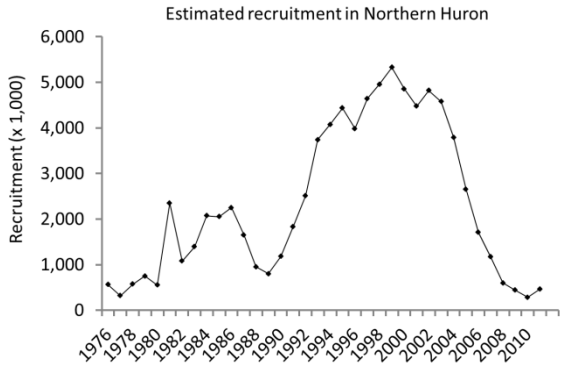












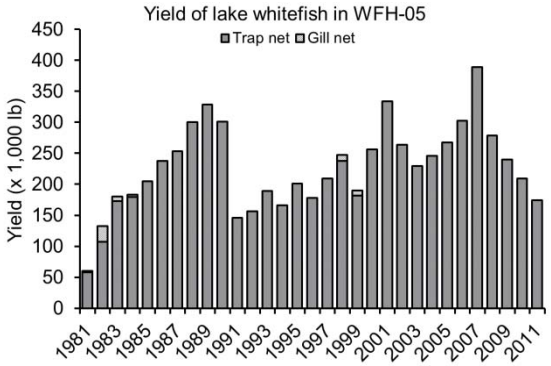
Parameter	Value
Base SSBR	2.40 lb
Current SSBR	0.83 lb
Target SSBR	0.24 lb
Current SPR	0.35
M	0.24 y^{-1}
F, trap net (2009-2011)	0.06 y^{-1}
F, gill net (2009-2011)	0.06 y^{-1}
Z	0.68 y^{-1}
Recommended TAC	356,400 lb
Actual TAC	485,730 lb
Model Rating	High

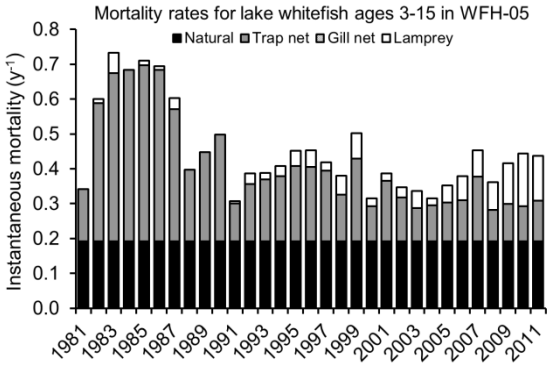
Notable Fishery Dynamics and Model Changes:

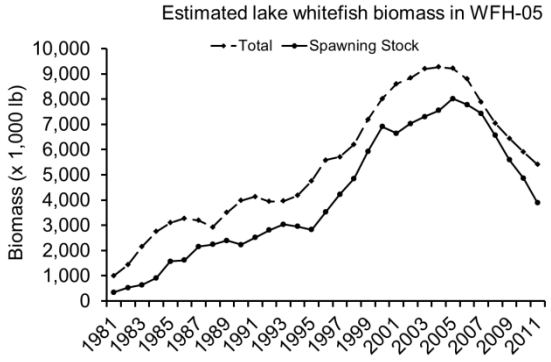
In Northern Lake Huron whitefish biomass peaked in the late 1990s near 21 million lb and has since declined to a near all-time low of only 5 million pounds. The dramatic decline in biomass was due partly to huge declines in recruitment after 2005 and to increased sea lamprey predation over the last few years. Total mortality on the most vulnerable age class was estimated to be 66% ($Z = 1.09\ y^{-1}$) in 2011, with

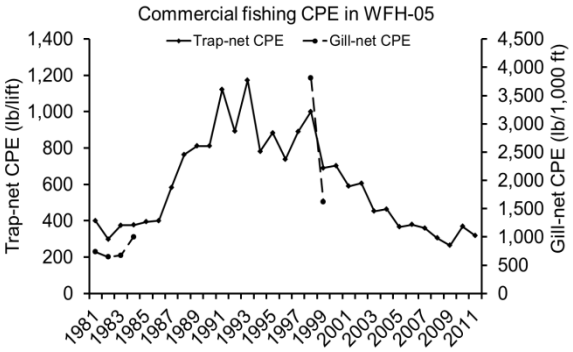
most of this mortality being attributable to sea lamprey (ML = 0.63 y^{-1}). MCMCs were less than optimum, but they were still reasonable. The projection model indicated that the harvest limit could be increased by nearly 50% with a 50% decline in sea lamprey mortality.

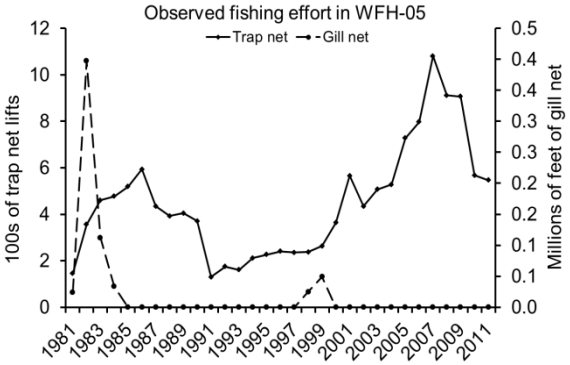
WFH-05 (Alpena) Steve Lenart











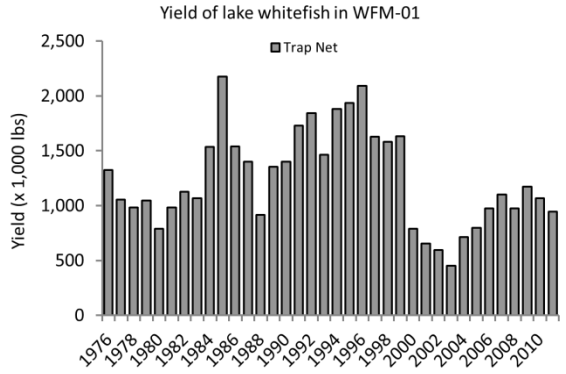
Parameter	Value
Base SSBR	3.17 lb
Current SSBR	1.43 lb
Target SSBR	0.25 lb
Current SPR	0.45
M	0.19 y^{-1}
F, trap net (2009-2011)	0.11 y^{-1}
F, gill net (2009-2011)	0 y^{-1}
Z	0.43 y^{-1}
Recommended TAC	768,300 lb
Actual TAC	768,300 lb
Model Rating	Low

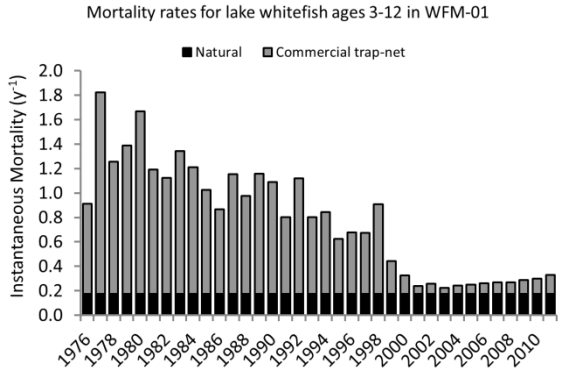
Notable Fishery Dynamics and Model Changes:

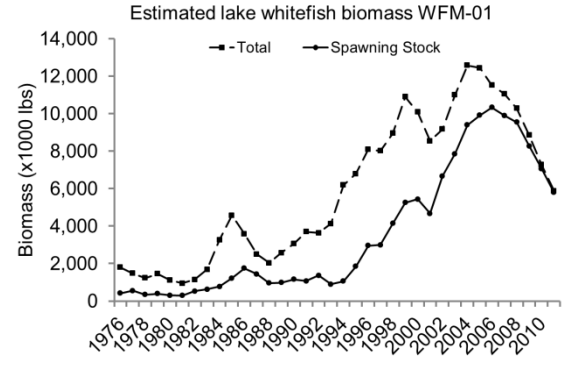
Abundance and biomass have been in sharp decline since an estimated peak in the middle 2000s. Though declining recruitment is the main contributor, increased mortality, primarily from sea lamprey, has played a significant role as well. Each estimated recruit class during 1996-2003 exceeded those from 1981-1995, while more recent estimates (since 2004) were on par with those from the 1980s. Peak

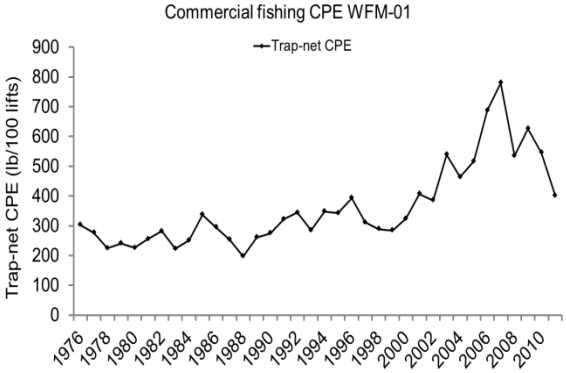
commercial yield occurred in 2007 and has since declined, although catch rates have been declining since 2000. Yield was approximately 390,000 lb in 2011, the lowest since 2000. Maximum total annual mortality in 2011 was 52% (age 13), while maximum annual sea-lamprey induced mortality exceeded 0.30 y^{-1} for the second consecutive year. Despite substantial changes to the structure of the assessment model, the model-derived harvest limit of 768,300 lb is only a modest departure (2.5% decline) from the 2012 model limit. The 2013 assessment incorporates a lognormal function of mean length-at-age to estimate selectivity, the variance-ratio approach, and time blocks for fishery catchability, the latter implemented in an attempt to smooth convergence and retrospective issues. Though convergence can be reached, the assessment is still plagued by retrospective patterns in biomass and sensitivity to initial catchability parameter values. Alternative assessment structures were developed in attempt to address these issues, without success. The output from these alternative structures exhibited population trends that were substantially similar to the selected version, but with very different scaling.

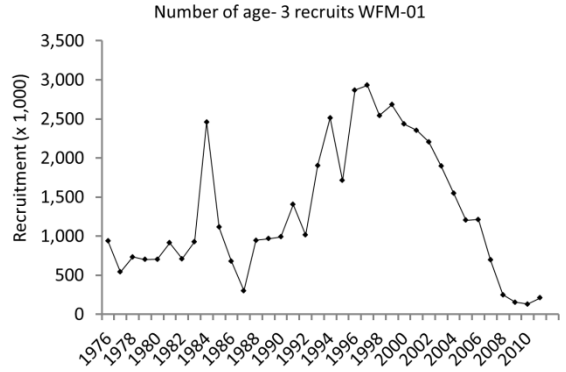
Lake Michigan
WFM-01 (Bays De Noc) — Mark Ebener











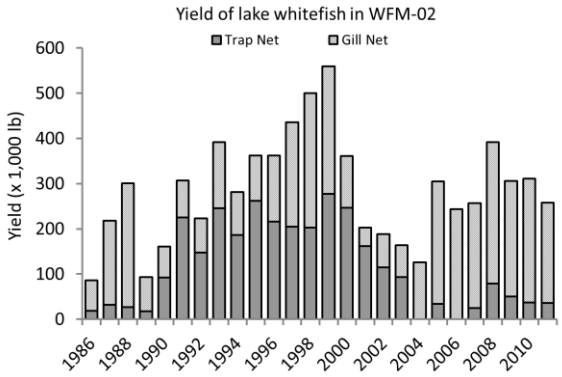
Parameter	Value
Base SSBR	4.14 lb
Current SSBR	1.73 lb
Target SSBR	0.33 lb
Current SPR	0.42
M	0.17 y^{-1}
F, trap net (2009-2011)	0.13 y^{-1}
F, gill net (2009-2011)	0 y^{-1}
Z	0.33 y^{-1}
Recommended TAC	1,716,000 lb
Actual TAC	2,000,000 lb
Model Rating	Low

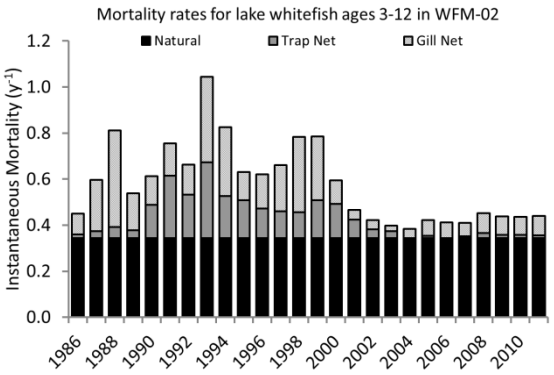
Notable Fishery Dynamics and Model Changes:

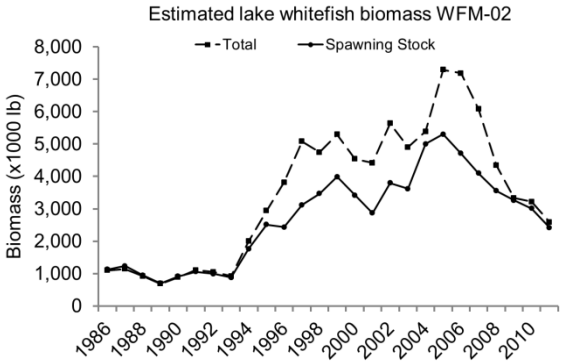
The estimated lake whitefish biomass in WFM-01 peaked near 13 million lb in 2004 and has since declined by 50%. Despite the decline, relative biomass levels remain high and exceed those of the early 1990s. This version of the model incorporated a length-based selectivity function and recent increases in length-at-age have resulted in lower estimates of recruitment. The model estimates that younger age classes should be more selected than they have been in

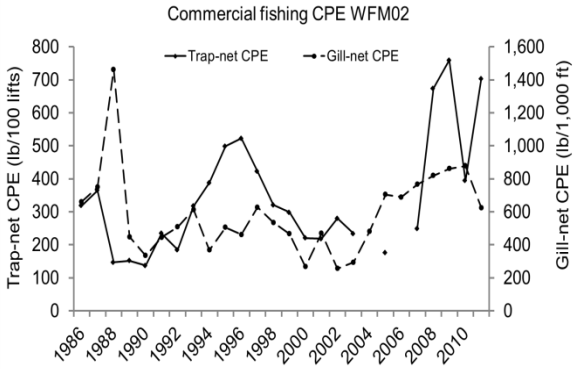
the past. Consequently, selectivity was averaged for the last three years to reduce the model's prediction of declining recruitment, as that trend is not supported by empirical evidence. Age 9 was the most fully vulnerable age class in 2011 with an estimated total annual mortality rate of 32% ($Z = 0.39\ y^{-1}$). In addition to adopting length-based selectivity and a ratio approach to estimating variance, this version of the WFM-01 model also included the following changes: (1) the original 1992 mean weight-at-age data were replaced with the estimated mean for 1991 and 1993 because the 1992 values for each age class were unrealistically larger than values for the same ages in the previous and following years; and (2) increased the standard deviation about the Pauly equation from 0.001 to 0.1. The result was a lower natural mortality rate ($M = 0.17$) than previous versions of this model. MCMC simulations were very poor. Retrospective patterns of biomass, recruitment, and population size were evident, but not all patterns were deemed to be highly problematic.

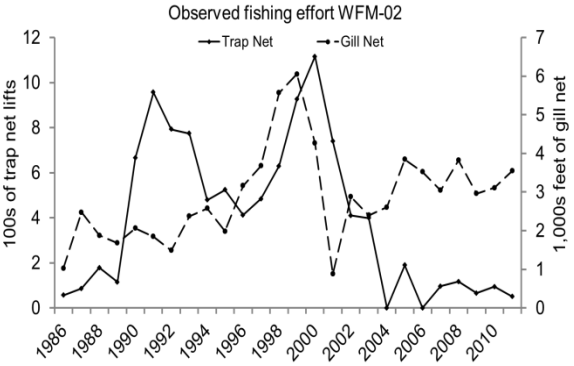
WFM-02 (Manistique) Ted Treska











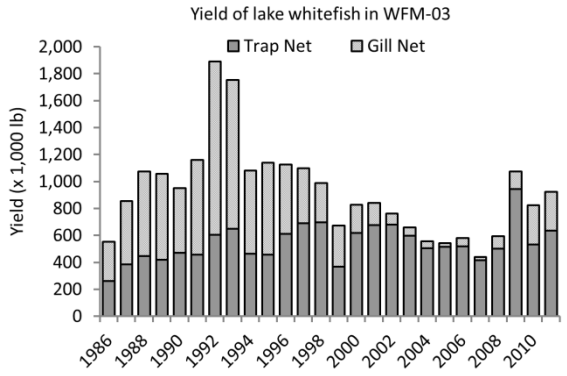
Parameter	Value
Base SSBR	1.27 lb
Current SSBR	0.96 lb
Target SSBR	0.12 lb
Current SPR	0.76
M	0.34 y^{-1}
F, trap net (2009-2011)	0.01 y^{-1}
F, gill net (2009-2011)	0.08 y^{-1}
Z	0.43 y^{-1}
Recommended TAC	494,700 lb
Actual TAC	494,700 lb
Model Rating	Low

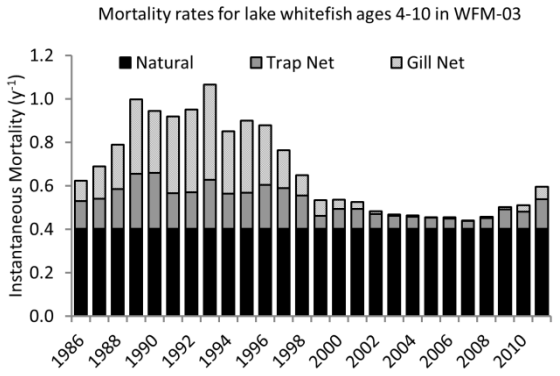
Notable Fishery Dynamics and Model Changes:

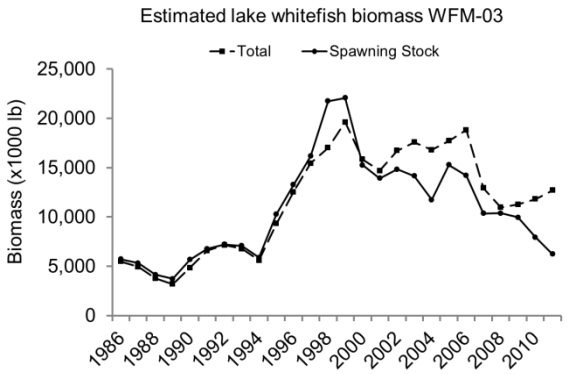
This model incorporated three major updates, a random walk for catchability, a length-based selectivity function, and changes to the calculation of standard deviations for some parameters. These changes were made to improve model performance; however, the rating on this model continues to be low. In the last 3 years, the catch of the 12+ age group has increased from 3% to 28%. The peak annual

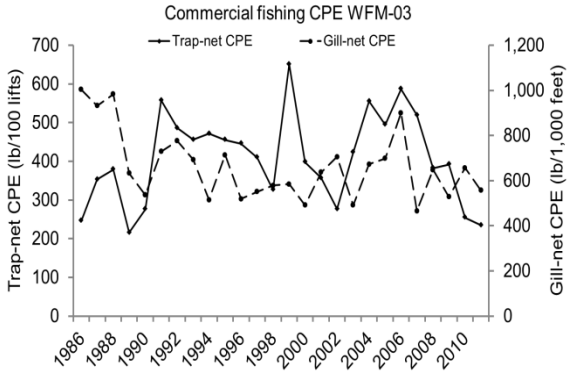
mortality rate in 2011 was 45%, experienced by whitefish ages 11+. We will continue to refine the updates that were made for 2013 in the hope of improving model performance.

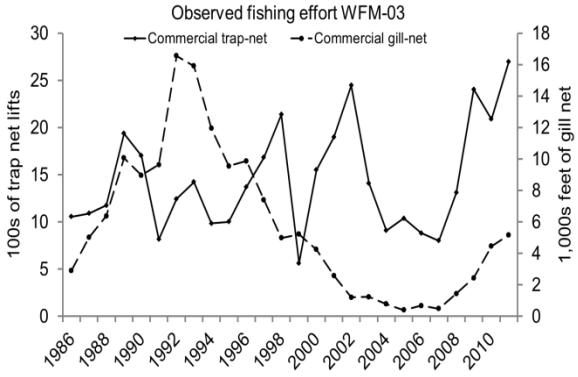
WFM-03 (Naubinway) Ted Treska









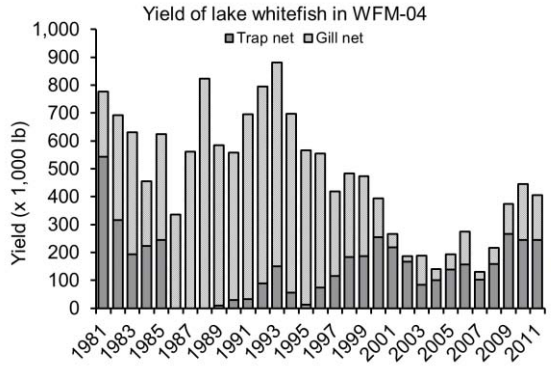


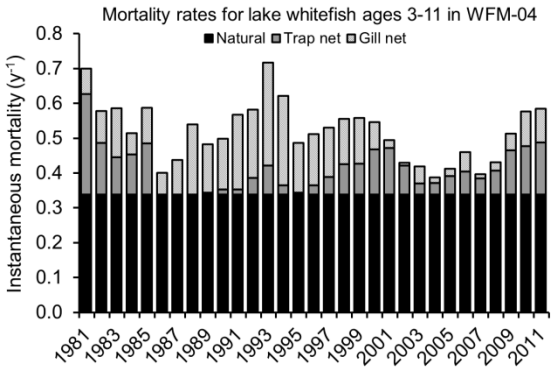
Parameter	Value
Base SSBR	0.92 lb
Current SSBR	0.57 lb
Target SSBR	0.09 lb
Current SPR	0.62
M	0.40 y^{-1}
F, trap net (2009-2011)	0.10 y^{-1}
F, gill net (2009-2011)	0.03 y^{-1}
Z	0.60 y^{-1}
Recommended TAC	1,598,500 lb
Actual TAC	1,598,500 lb
Model Rating	Low

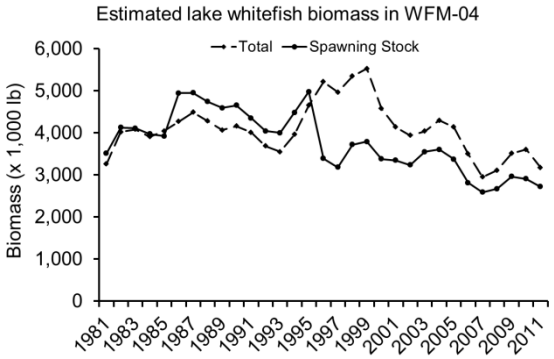
<u>Notable Fishery Dynamics and Model Changes:</u>
This model incorporated three major updates, a random walk for catchability, a length-based selectivity function, and changes to the calculation of standard deviations for some parameters. These changes were made to improve model performance; however, the rating on this model continues to be low. There has been a dramatic change in the age composition in the trap-net fishery, with a

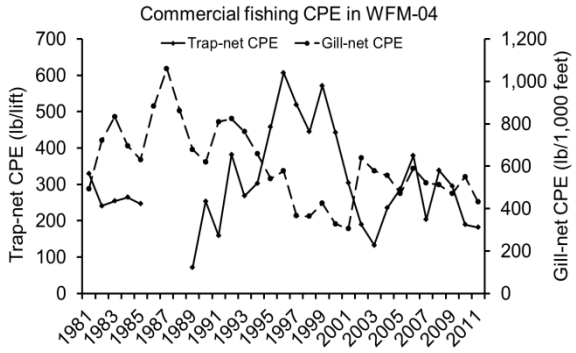
switch from a peak age of 7-8 in 2010 to a large contribution of the 10+ group in 2011(though this trend was not observed in the gill-net fishery). There also was an overall reduction in the percent female observed in the population across most ages. The highest annual mortality rate in 2012 was 56%, experienced by age-7 whitefish. Next year's model will include an expansion of the age classes, as a high number of fish are now moving into the plus age group.

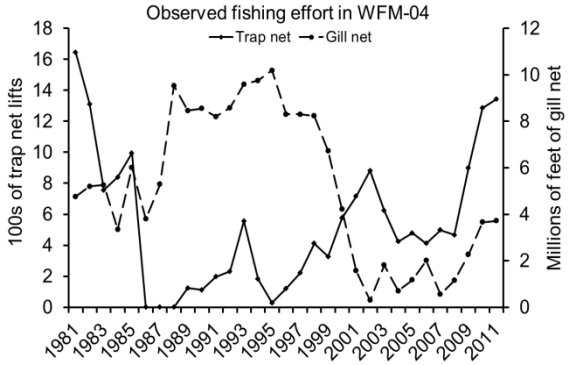
WFM-04 (Beaver Island) Steve Lenart

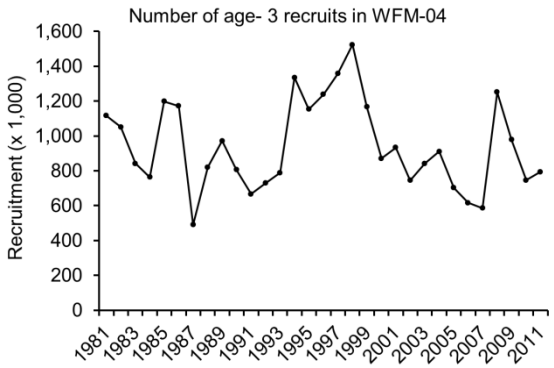












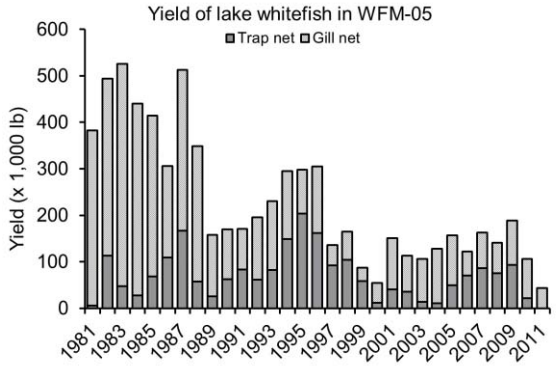
Parameter	Value
Base SSBR	1.60 lb
Current SSBR	0.88 lb
Target SSBR	0.21 lb
Current SPR	0.55
M	0.34 y^{-1}
F, trap net (2009-2011)	0.14 y^{-1}
F, gill net (2009-2011)	0.08 y^{-1}
Z	0.58 y^{-1}
Recommended TAC	634,000 lb
Actual TAC	634,000 lb
Model Rating	Medium

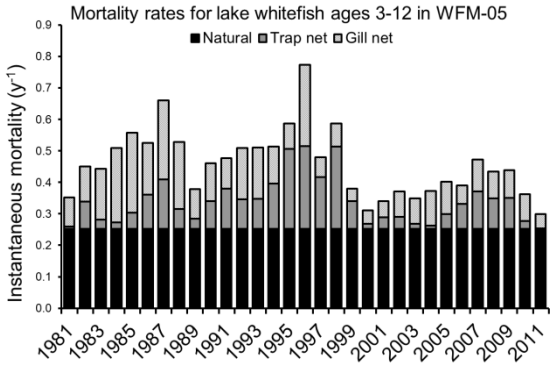
Notable Fishery Dynamics and Model Changes:

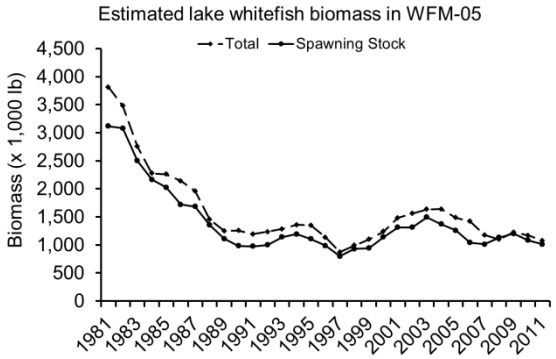
The most recent assessment for this unit suggests a very different pattern in population structure than previous assessments. The most significant feature is that spawning biomass is estimated to have experienced a slow but steady decline since the middle 1990s. This pattern is being driven by estimates of recruitment, since fishing mortality had declined markedly during 2000-2008 compared to the 1990s. During 2009-

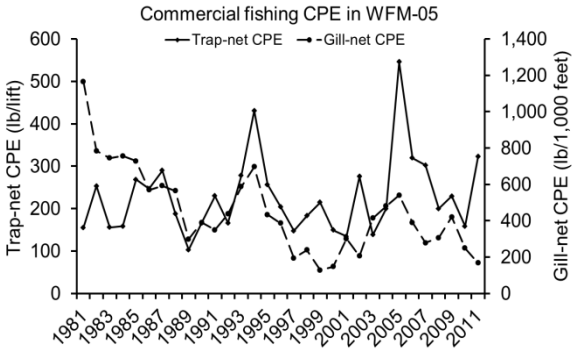
2011, however, average annual yield was over 400,000 lb and total annual mortality rates during 2011 were estimated to be greater than 50% (maximum 54%) for the fully-selected age classes. The recent increase in yield is being driven by increased effort. Approximately 1,300 trap-net lifts were reported during 2010 and 2011; such effort levels have not been recorded since the early 1980s. Trap-net fishery catch rates have declined substantially compared to the middle 1990s and gill-net catch rates show a modest, but steady decline since 2002. The 2013 assessment model structure is not fundamentally different than the 2012 version, except that 1) selectivity is not time-blocked and varies through time via a random walk; and 2) the parameters of the descending limb of the gill-net fishery selectivity curve are fixed. The new assessment suggests higher biomass in the 1980s compared to the base version, though estimates are quite similar for much of the 1990s and early 2000s. The two versions depart after 2008, with the difference largely driven by the estimated abundance of the 2003-2005 cohorts, which are 30-50% lower at age of recruitment in the new version. However, compared to the base version, the new version estimates slightly lower fishing rates for all age classes greater than age 8. The model-generated harvest limit is 6% lower than the 2012 model limit. The model exhibited generally good fit, no troubling retrospective patterns, and reasonable MCMC results.

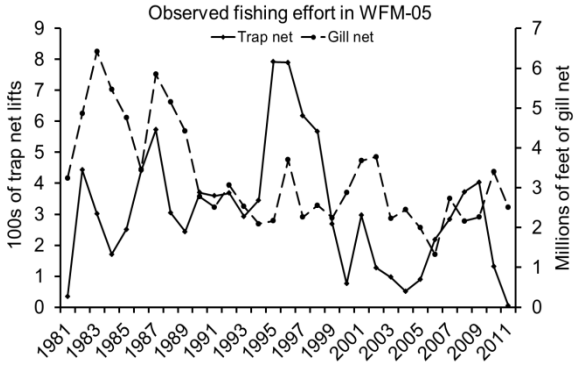
WFM-05 (Grand Traverse Bay) Steve Lenart











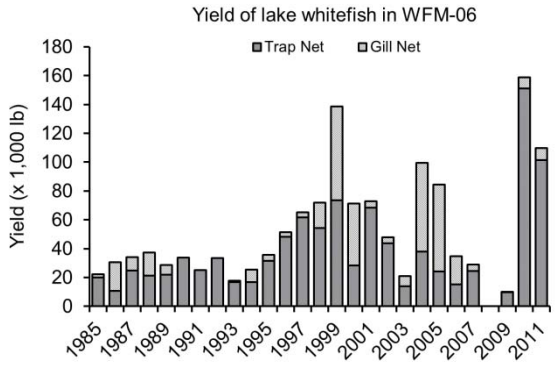
Parameter	Value
Base SSBR	2.88 lb
Current SSBR	1.69 lb
Target SSBR	0.17 lb
Current SPR	0.59
M	0.25 y^{-1}
F, trap net (2009-2011)	0.04 y^{-1}
F, gill net (2009-2011)	0.07 y^{-1}
Z	0.30 y^{-1}
Recommended TAC	365,000 lb
Actual TAC	365,000 lb
Model Rating	Medium

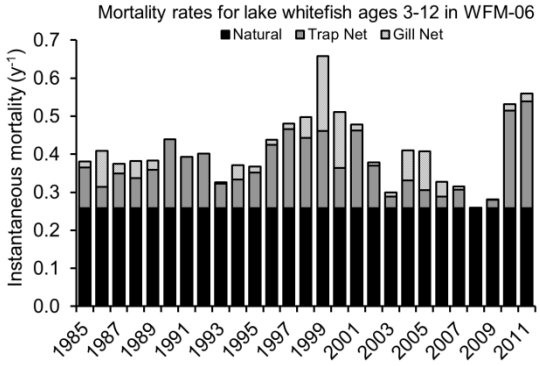
Notable Fishery Dynamics and Model Changes:

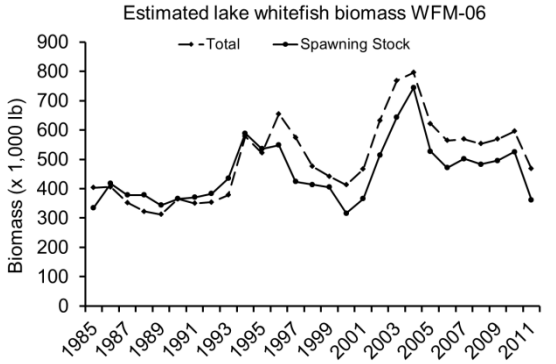
Biomass has remained fairly stable in WFM-05 since the substantial decline that took place during the 1980s. Mortality rates have remained well below target since the late 1990s and fishery extractions were quite steady during the 2000s. Fishery yield in 2011, however, was the lowest in the time series. The decline was driven by a trap-net fishery that recorded only four lifts during 2011. Gill-net effort declined by approximately 25% from 2010 to 2011, yet

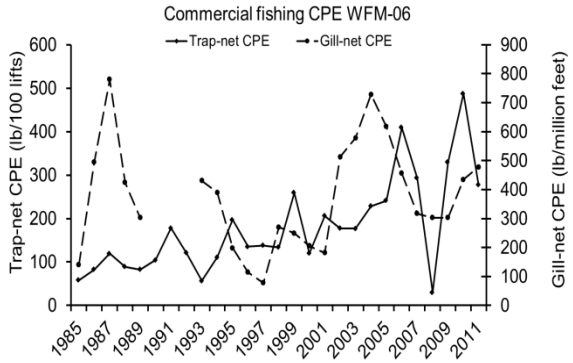
was near the average value for the last decade. Gill-net harvest, however, declined by 50%. The decline in total harvest resulted in mortality rates that are quite low; the estimated maximum annual mortality was 28% in 2011. The decline in the fishery in the past two years helped offset declines in estimated recruitment that, like in adjacent WFM-04, began in the early 2000s. Weight-at-age has stabilized in the past two years, though at higher values than was evident during the middle 2000s. The WFM-05 model structure was brought in line with adjacent WFM-04: selectivity is now size based (though the quadratic component for time-varying selectivity was retained), the descending limb of the selectivity curve is fixed, and the variance-ratio approach is being used. The new assessment model performed reasonably well, with acceptable fit, few retrospective concerns, and acceptable MCMC output. The 2013 model-generated harvest limit represents an 8% decline from the 2012 model limit.

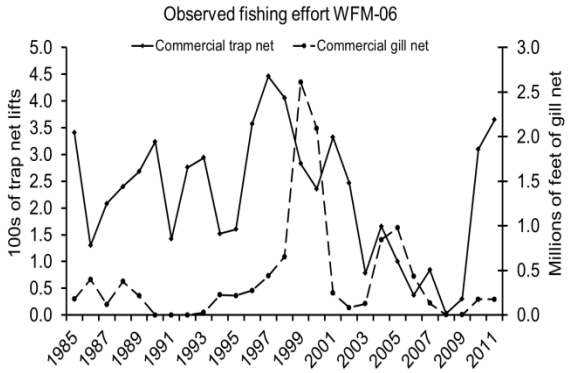
WFM-06 (Leland) Randy Claramunt

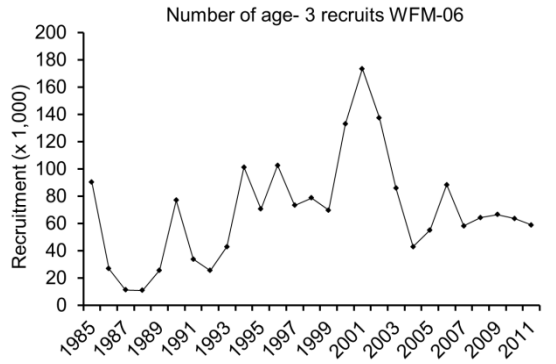












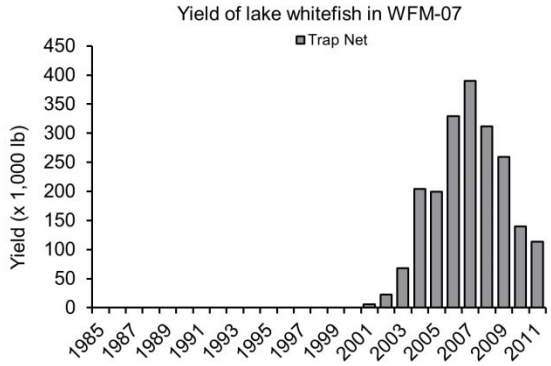
Parameter	Value
Base SSBR	3.26 lb
Current SSBR	1.51 lb
Target SSBR	0.39 lb
Current SPR	0.46
M	0.26 y^{-1}
F, trap net (2009-2011)	0.19 y^{-1}
F, gill net (2009-2011)	0.01 y^{-1}
Z	0.56 y^{-1}
Recommended TAC	250,000 lb
Actual TAC	250,000 lb
Model Rating	Low

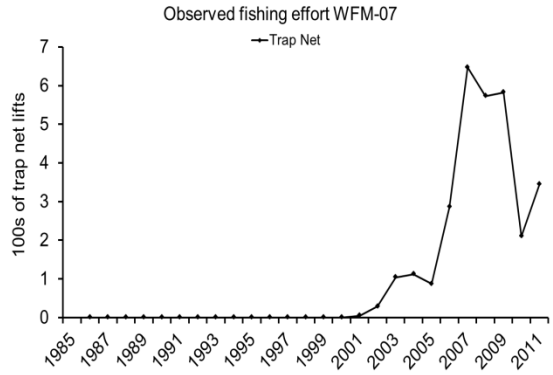
Notable Fishery Dynamics and Model Changes:

The model-generated harvest limit for this unit was 132,200 lb and was well below the model-generated limit of 540,600 lb for 2012. The model fit to the data was satisfactory; whereas, the diagnostics (e.g., retrospective patterns and MCMC distributions) suggest that the estimates of stock size from this model may be suspect. Although there were minor changes in growth (e.g., slight increases in size-at-age) and a modest decrease in yield from 2011 to 2012 of

159,000 to 110,000 lb, the decline in the model generated TAC is a result of updated growth parameters for the stock and its influence on the estimate of natural mortality. In the past, the MSC had modified the methods for estimating growth parameters as inputs into the calculation of natural mortality by using all of the data in the time series (versus using recent averages), fixing size-at-age for young age classes (i.e., 0-2 years old), and using various software packages for estimating growth. The updated approach that was used for this unit and other whitefish management units included using size-at-age data for the entire time series, not including size-at-age for early age classes, and a standard code for estimating growth parameters in the R software package. The result was a very different estimate of *M* that produced a lower stock size than in past years. Given the uncertainty surrounding *M* and its impact on stock size, the MSC recommended continuation of the constant-catch policy of 250,000 lb that has been used in this unit the previous two years.

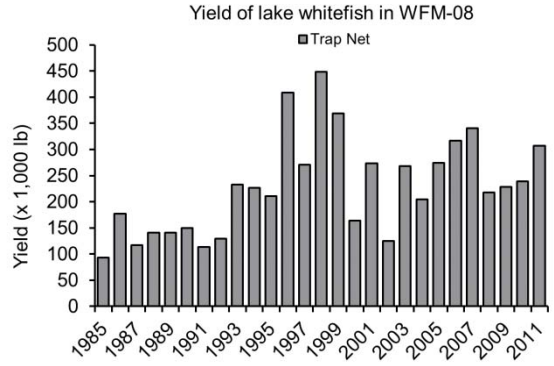
WFM-07 (Manistee to Pentwater)

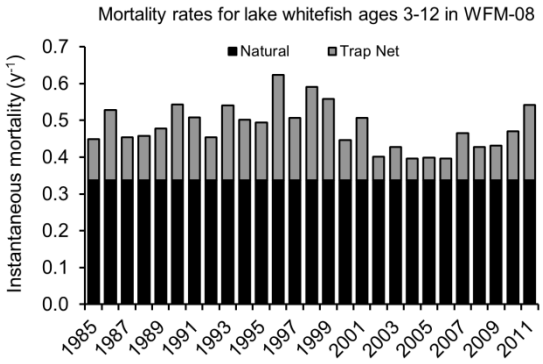


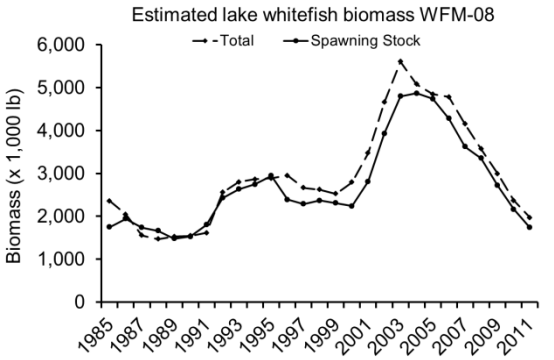


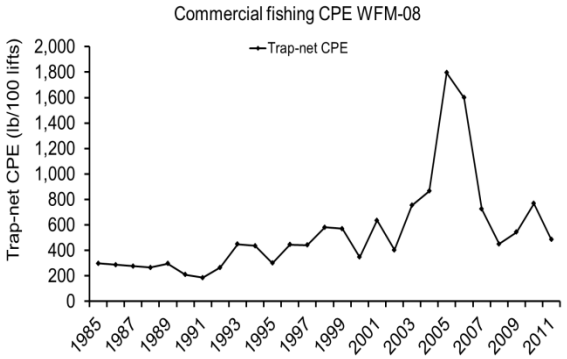
No stock assessment model has been developed for WFM-07. When the Consent Decree was initially signed, this unit lacked the necessary time series of data to populate a model. This time series continues to build as the fishery is executed under the terms of the Consent Decree and biological data continues to be collected from this whitefish stock.

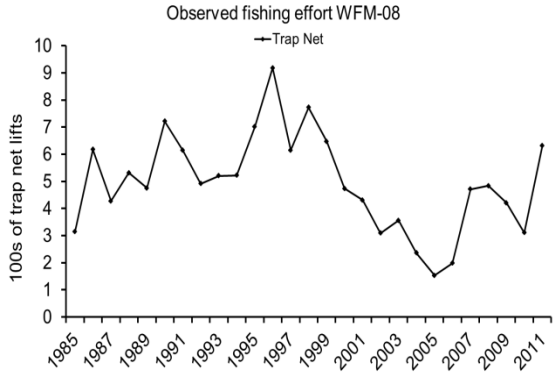
WFM-08 (Muskegon) Randy Claramunt











Parameter	Value
Base SSBR	2.20 lb
Current SSBR	1.46 lb
Target SSBR	0.40 lb
Current SPR	0.66
M	0.34 y^{-1}
F, trap net (2009-2011)	0.14 y^{-1}
F, gill net (2009-2011)	0 y^{-1}
Z	0.54 y^{-1}
Recommended TAC	1,500,000 lb
Actual TAC	1,500,000 lb
Model Rating	Low

Notable Fishery Dynamics and Model Changes:

The model-generated harvest limit for this unit was 492,200 lb, less than one-third of the 2012 model-estimated harvest limit. The model fit to the data was satisfactory and many of the stock parameters from the empirical data (e.g., yield, size-at-age, age compositions) were relatively unchanged from 2011-2012. Model diagnostics were similar to previous years with some deviation in the retrospective patterns at the end of the time series and a few MCMC distributions

that were problematic. However, the decline in the model generated harvest limit is a result of updated growth parameters for the stock and its influence on the estimate of natural mortality. In the past, the MSC has modified the methods for estimating growth parameters as inputs into the calculation of natural mortality (see unit WFM-06). The result was a very different estimate of *M* that produced a lower stock size than in past years. Given the uncertainty surrounding *M* and its impact on stock size, the MSC recommended that the TFC adopt a conditional constant catch policy for WFM-08. The TFC approved a constant limit of 1.5 million lb, which represented an average of previous harvest limits from 2002-2012.