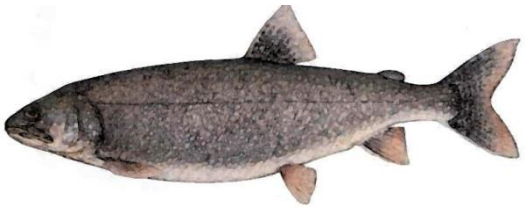
Technical Fisheries Committee Administrative Report 2019: Status of Lake Trout and Lake Whitefish Populations in the 1836 Treaty-Ceded Waters of Lakes Superior, Huron, and Michigan, with Recommended Yield and Effort Levels for 2019



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

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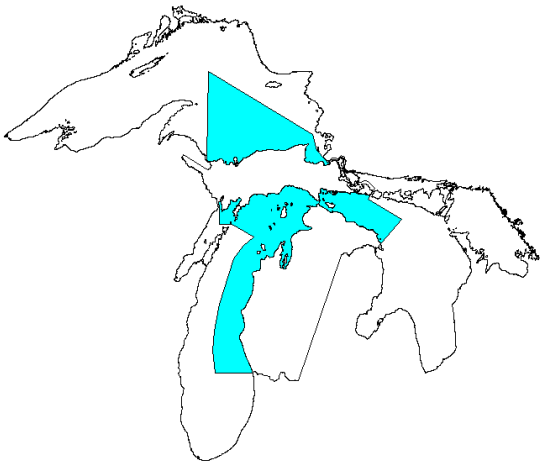

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EXECUTIVE SUMMARY

Prepared by David C. Caroffino and Nathan T. Barton

This document outlines the status of Lake Trout and Lake Whitefish stocks in the 1836 Treaty (hereafter "Treaty") waters of the Great Lakes as assessed by the 2000 Consent Decree's (Decree) Modeling Subcommittee (MSC). The main purposes of this report are to 1) describe the status of each managed stock in the context of establishing harvest limits according to the terms of the Decree; and 2) document important technical changes in the stock assessment process. For more in-depth technical detail on stock-assessment structure, see the 2012 version of this report available at https://www.michigan.gov/documents/dnr/2012StatusStocksReport_403608_7.pdf

Except in a few cases, statistical catch-at-age (SCAA) models have been developed for each management unit where the provisions of the Decree apply. Estimates from the SCAA models are used in projection models that incorporate the mortality target and allocation rules of the Decree to calculate model-recommended yield limits for these units. Annual mortality rate targets for Lake Trout are either 40 or 45%, depending on the area, and a 65% annual mortality target has been established for Lake Whitefish, though a complementary rule reduces mortality below the target rate if the spawning potential ratio (SPR) falls below 0.2. Model-derived yield limits, along with the actual yield and effort limits for 2019, are provided in Table 1.

Table 1. 2019 yield and effort limits

Species	Lake	Management unit	Model-generated yield limit (lb)	Actual yield limit (lb)	Gill net limit (ft)
Lake Trout	Superior	MI-5	114,224	144,678	NA
		MI-6	215,808	215,808	2,971,000
		MI-7	140,323	146,993	9,480,000
	Huron	MH-1	358,201	TBD	TBD
		MH-2	280,136	190,110	NA
	Michigan	MM-123	503,089	630,000	7,893,000
		MM-4	130,326	171,500	1,023,000
		MM-5	112,212	112,212	290,000
		MM-67	194,677	195,683	NA
Lake Whitefish	Superior	WFS-04	118,000	118,000	NA
		WFS-05	201,700	201,700	NA
		WFS-06	NA	174,300	NA
		WFS-07	571,000	571,000	NA
		WFS-08	87,000	221,025	NA
	Huron	North Huron	446,000	379,900	NA
		WFH-05	394,000	394,000	NA
	Michigan	WFM-01	2,177,000	2,177,000	NA
		WFM-02	985,000	271,725	NA
		WFM-03	988,000	600,300	NA
		WFM-04	460,000	320,400	NA
		WFM-05	352,200	264,150	NA
		WFM-06	171,000	125,000	NA
		WFM-07	NA	250,000	NA
		WFM-08	768,000	500,000	NA

In instances where the actual yield limit for a Lake Trout or shared-allocation Lake Whitefish unit (WFS-04, WFS-05, WFM-01, WFM-06 and WFM-08) differs from model-generated yield limit, a brief explanation is provided below. For non-shared-allocation whitefish units, where the tribes have exclusive commercial fishing opportunities, harvest regulation guidelines (HRGs), as established by the Chippewa-Ottawa Resource Authority (CORA), serve as final yield limits - these may differ from the model-generated limits. SCAA models for Lake Whitefish are on a one-year lag, so estimates reported here are derived from data through 2017. Estimates from SCAA models for Lake Trout are derived from data through 2018.

Lake Trout

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). There has been no effort to construct an assessment model for Lake Trout in unit MI-8 due to its status as a deferred area. Unit MI-5 spans waters in both 1836 and 1842 Treaty areas - to date, commercial harvest of Lake Trout from unit MI-5 has occurred exclusively in 1842 Treaty waters.

Biomass in the modeled Lake Superior units has been stable for nearly two decades. Recent patterns in recruitment, however, have begun to deviate. In MI-5, the 2011-year class of Lake Trout appears to be nearly as large as any produced in the last 25 years. Conversely, in MI-6, the 2013- and 2014-year classes are estimated to be the 25% higher than any other year in the modeled time series. These year classes are present in the fishery and in independent survey catches, but their absolute magnitude will be refined in the coming assessment years. If the year classes are as strong as presently predicted, growth rates have the potential to be impacted. Yield in Lake Superior is well below established limits and mortality is approximately 30%. Sea lamprey-induced mortality (SLIM) remains the largest source of mortality in all three of the modeled units.

Wild Lake Trout continue to recruit to the adult stock in Lake Huron and all cohorts since 2006 have had more wild fish than hatchery fish recruit to the adult population. Presently, the proportion of wild fish exceeds 50% in all three data sources (recreational, commercial, survey) and is about 60% overall. A change in the data used for modeling the stock occurred in 2019, which had large impacts on estimated recruitment and stock size. There is a fall spawning survey conducted within the Drummond Island refuge, and age composition data (female only, but not catch rates) from that survey had been used within the stock assessment model in prior years. In the most recent 5 years, it was discovered that data from a small-mesh gill net set off the spawning reef during the fall survey was also being included. By fitting the age compositions from this survey data, the model was greatly inflating estimates of recruitment. The MSC determined that this data source should not be included in the assessment model, and it was removed. Age compositions without a corresponding catch rate can be problematic, and catch rates from fall spawning surveys can be biased. The survey was also conducted in a refuge, where no fishing could occur, and the single site likely would not represent characteristics of an entire stock that spans more than one million hectares. Removing this data source from the assessment model reduced the estimates of recruitment and scaled stock size substantially lower. Estimates of mortality for this stock remain low (27%) but are higher than what had been estimated in the prior two years (22%). Recruitment estimates have been scaled downward between 25 and 60% over the past decade, resulting in biomass estimates slowly declining by 20% from a peak in 2010. Estimates of stock size are still high with approximately one million pounds of spawning stock biomass present in the modeled unit. The MSC had documented concerns over the magnitude of the estimated stock in the most recent two years, as well as the low rates of mortality. The present assessment retains a low rating, as transitions from a stock based on hatchery fish to one based on wild fish are difficult to monitor; however, the comfort level with the scaling has increased. As of this writing, 2019 harvest limits for MH-1 were in their final stages of negotiation by the Executive Council.

The Lake Michigan Lake Trout SCAA models apply only to stocked fish, although wild

fish are becoming more abundant in parts of the lake and will likely be assessed in the future. As a whole, Lake Trout recovery in Lake Michigan is behind that of the other lakes. In the northern portion of the lake (unit MM-123), mortality has been high, averaging 53% over the modeled time series. Commercial mortality has often been the highest source; however, SLIM exceeded 0.20 for 12 consecutive years during the 2000 Consent Decree. Since 2014, SLIM has been at or below 0.10, but overall mortality still exceeds the 40% target.

In MM-4, mortality has only been below the target rate once in the modeled time series. Consistent and high levels of stocking have allowed the population to persist without substantial reductions in spawning stock biomass over the recent 15 years. As in the north, SLIM has declined, and it is presently at the lowest levels in the time series. Recreational fishing mortality exceeded commercial mortality in 2018, and the recreational fishery exceeded its harvest limit to the point of a penalty in 2018. A 2009 amendment to the Decree establishes base harvest limits in this unit, and it includes a transfer provision that increases CORA's harvest limit by the amount that the state remained below its harvest limit the prior year.

Mortality rates in units MM-5 and MM-67 are below target and natural mortality is the largest individual source of mortality in these units; however, this parameter warrants further review in future years. The commercial fishery did not operate in MM-5 during 2018, and all harvest was from the state recreational fishery. Projecting a harvest limit from the assessment model resulted in higher values than were included in the 2009 stipulation for MM-5. This is the first time this occurred since 2012. In MM-67 the recreational fishery has harvested more fish in recent years, likely in response to lower populations of Chinook Salmon. Recreational yield increased to 169k lb in 2018, the highest level since 2001. The commercial fishery in MM-67 has largely been absent since 2012, although 26 trap-net lifts in 2018 produced 724 lb of Lake Trout. After increases in the early 2000s, the spawning stock biomass of Lake Trout in MM-67 has largely remained stable over the past decade.

The Consent Decree's 15% rule for limiting harvest limit changes from the prior year was implemented in MI-5, MI-7, MH-2, and MM-67 for fishing year 2019.

Lake Whitefish

Lake Whitefish populations are supported by natural reproduction throughout the Treaty-ceded waters and projected harvest limits are allocated to CORA- and, where applicable, State-licensed commercial fisheries. The assessment model for Lake Superior unit WFS-06 has not been updated since the mid- 2000s due to the small fishery and a lack of commercial monitoring data. There has been no attempt to fit an assessment model for Lake Michigan unit WFM-07, where no harvest has occurred in the past five years. No information is provided for these units in the section that follows. Lake Superior unit WFS-04 spans waters in both 1836 and 1842 Treaty areas – most of the commercial harvest of Lake Whitefish occurs in the latter. In contrast to Lake Trout mortality rates referenced in the preceding section, mortality rates that follow are for the age class most vulnerable to fisheries.

Lake Whitefish populations in Lake Superior are among the most stable in 1836 Treaty waters, primarily as a result of more consistent recruitment relative to lakes Michigan and Huron. Fishery yields in western Lake Superior Treaty units (WFS-04 and WFS-05) have generally remained in the 50-100K lb range throughout the Decree and recent fishing mortality rates on the most vulnerable age class have been below 0.3 y^{-1}. Estimated annual mortality (average across ages) was nearly identical (33%), and well below target, in these units during 2017. Fishery catch rates are generally stable in these units, although patterns in adult biomass are presently dissimilar. While the adult population in WFS-05 remains stable, a very large year class of whitefish produced in 1998 in WFS-04 is working its way out of the fishery and adult population, leading to declines. Recruitment has been stable since that peak and declines in biomass should subside in the coming years. In eastern Lake Superior (WFS-07 and WFS-08), fisheries are more intense, and mortality is higher. Yields from WFS-07 have ranged between 400-500K lb since 2010 and fishing mortality has increased during this period. The 2017 estimate was >0.6 y^{-1} on the most vulnerable age class. Yields had been similarly

consistent, though lower in scale, in adjacent WFS-08 during 2010-2015, but in 2016 and 2017 yield exceeded 175K lb in back-to-back years for the first time in the modeled time series. Annual mortality during these years averaged 87%. It is possible that nuances in sampling data were responsible for the model estimating values of that magnitude; however, mortality on the whitefish stock in WFS-08 is of great concern and has exceeded the target rate. Fishery monitoring data suggest potential strong year classes in each of the eastern units (2010- and 2012- year classes), which are buffering the high mortality and reducing negative trends in biomass. Further monitoring in future years will reveal how strong these year classes may be.

In northern Lake Huron Treaty waters (WFH-01 thru WFH-04), dramatic declines in recruitment that commenced in the early 2000s and substantial sea lamprey and fishing mortality have combined to drive Lake Whitefish stocks down to their lowest levels since the late 1970s. This area produced an average of 1.71M lb of yield during the 1990s, and as recently as 2006, yield exceeded 1M lb. Roughly 210K lb of whitefish were harvested from northern Lake Huron in 2017 and catch rates are approximately 10% of those observed during the peak of the fishery. The latest version of the assessment suggests that annual mortality has exceeded the 65% target through much of the modeled time series, although in recent years, mortality is below target. The model also suggests that recruitment has increased in the past four years, resulting in a slight increase in biomass of whitefish. The fishery in the adjacent unit (WFH-05) has declined to a point where minimal biosampling occurs resulting in an unstable model, lacking sufficient data to estimate population parameters. Trends in biomass and sea lamprey mortality are similar, and should the population increase to a point where the fishery becomes viable, increasing monitoring will allow for model estimates of key parameters. Trap-net effort was only 108 lifts in 2017, a time series low.

Lake Whitefish recruitment patterns in northern Lake Michigan (WFM-01 thru WFM-04) are fairly synchronous and similar to those in Lake Huron, with similarly predictable consequences: declining abundance, fishery yields and catch rates. Less than 800k lb of whitefish were harvested in these four northern units combined during 2017, the lowest yield since the late 1970s. Unlike northern Lake Huron, recruitment has not shown signs of increasing, nor have declines in biomass ceased. These declines have occurred despite mortality rates remaining well below the target rate of 65%.

Recruitment patterns in unit WFM-05 are similar to those in the north, and although some strong year classes have been produced, an overall pattern of decline followed the peak in 1997. Biomass declines have been muted due to increased growth and low overall fishing mortality through time. Harvest was less than 30k lb in this unit in 2017. Total mortality was estimated to be only 22% in this unit over the past 7 years. Similarly low mortality rates were estimated in unit WFM-06, but here recruitment patterns suggest the presence of a strong 2003-year class, which was not as evident in the northern units. Yield of whitefish from WFM-06 in 2017 was only 13k lb. Two year classes appear to be continuing to carry the fishery in WFM-08, those being fish produced in 1998 and 2003. Recruitment and biomass have declined sharply since the late 2000s and the fishery is made up of very few fish younger than age 10. Fishery yield and catch rates have both increased since 2014, but those are likely due to changes in catchability, not an increasing stock. Total mortality in WFM-08 was only 25% and has been less than 30% for more than a decade, signaling why the fishery has been able to continue to harvest the 1998- and 2003-year classes. The TFC recommended continuance of the conditional constant catch policy for units WFM-06 and WFM-08 in 2019, with harvest limits consistent with the reduced levels established during 2017.

Technical Changes

Information in this section is generally reserved for technical changes that were implemented across multiple assessments. The individual unit summaries provide detail on major structural changes or assumptions that affect a particular assessment; for this reason, certain individual unit summaries provide more detail than others.

Natural Mortality estimation in Lake Whitefish assessments

In 2018, the MSC began exploring alternative ways for estimating Lake Whitefish natural mortality (*M*). A subgroup was charged with conducting a thorough literature review and providing justification for a uniform method of estimating this population parameter. As that work has continued, some assessments for fishing year 2019 included larger standard deviations around the Pauly (1980) prior for *M*, and others used a value of 0.20 for *M*. The MSC continues to discuss a path forward for the 2020 assessments.

Effective Sample Size

In both the Lake Trout and Lake Whitefish assessments, the model fit to the age compositions is impacted by the effective sample size (ESS) provided. For example, an ESS of 100 would provide the model with more freedom to deviate when fitting the age compositions, compared to an ESS of 200. The ESS has been set for each age-data source (commercial – by gear type, survey, and recreational) as equal to the number of actual samples taken in a given year, up to a maximum (traditionally 100 or 200). Typically, the raw number of samples collected exceeded the maximum ESS, meaning the weighting of the age compositions was equal between years, even if the number of samples or the number of trips sampled were substantially different. Published literature has suggested that sampling during fishery-monitoring efforts and even fishery-independent surveys is not truly random, but fish tend to cluster with those of similar size or age, leading to substantial autocorrelation in the biodata collected from sampling a given trip. Methods have been derived to minimize that autocorrelation and provide a better means of evaluating the quality (and independence) of the age composition data collected each year from each source (see Truesdell et al. 2016). For the 2019 assessments, the ESS was estimated outside of the assessment models using an iterative, linear model approach, which provided a proportional adjustment to the vector of the number of samples collected for each data source in each year. This reduced vector was used to weight the age compositions and resulted in ESS values substantially lower than had been previously used. This change altered model fit in some cases, and in some management units it altered the scaling of recruitment and overall biomass (WFS-05 and MI-5, for example). This approach suggests that maximizing the number of trips sampled is preferred over maximizing the number of samples collected per trip. These methods will be used moving forward to collect and fit age composition data.

MANAGEMENT UNIT DESCRIPTIONS

The Great Lakes are divided into spatially explicit 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 either partially or wholly contained within the 1836 Treaty-ceded (Treaty) waters of the Great Lakes. What follows are descriptions of the nine Lake Trout management units (Figure 1) and 15 Lake Whitefish management units (Figure 2) that are assessed by the Modeling Subcommittee, with an emphasis on major physical features and landmarks. Table 2 provides area estimates for each management unit as derived from spatial analysis of available shapefile layers in ArcGIS™ (ESRI).

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). 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.

MI-6: Lake trout management unit MI-6 extends from Laughing Fish Point (east of Marquette) to Au Sable Point (east of Munising). 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.

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). This management unit has complex bathymetry with many lacustrine ridges, trenches, and slopes.

MH-12: Lake trout assessment unit MH-12 comprises Lake Huron statistical districts MH-1 and MH-2 and includes biological data from adjacent Ontario quota management areas 4-1, 4-2, and 4-3. MH-1 is located in northern Lake Huron and extends from the Mackinac Bridge south to the border between grids 607 and 608. The management unit has a wide bathymetric range with areas in grids 407 and 408 as deep as 130 m. This statistical district lies completely within 1836 Treaty waters. On the Michigan shore this district 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 waters. Retention of Lake Trout in the refuge is prohibited. Statistical district MH-2 lies directly to the south of MH-1 and includes both 1836 Treaty waters and non-treaty waters, divided by a NE line running near the tip of Thunder Bay's North Point to the international border. The Michigan ports of Presque Isle and Alpena are contained in this statistical district. MH-2 also has a wide bathymetric range, with areas in grids 714 and 814 deeper than 210 m. District MH-2 contains a limited number of historically important nearshore Lake Trout spawning reefs and shoals. These reefs are located near Middle Island and along Thunder Bay's North and South Points. Six Fathom Bank, a large offshore reef complex, 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. Water depths in the northern portion of the unit are generally less than 45 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 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). 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 includes 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. 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 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 deep-water 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 the 1836 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 the 1836 Treaty area in the unit. Management unit MM-67 contains a portion of the 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 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 1836 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. 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. 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. 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 (WFH-01 thru WFH-04): Management unit WFH-01 is located in the northwest portion of the main basin of Lake Huron. 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. 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. WFH-04 is the largest whitefish management unit in the 1836 Treaty waters of Lake Huron. 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 waters. WFH-05 contains multiple spawning aggregates, most of which are likely associated with the numerous islands (Crooked, Gull, Middle, Sugar and Thunder Bay) or small embayments that are found in the southern part of 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. 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 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. Only grids 308, 309, 407 and 408 are entirely within 1836 Treaty waters

WFM-02: WFM-02 is located in the northwest portion of Lake Michigan. 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.

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-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. 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. 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. 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; only those waters north of the Grand River lie within 1836 Treaty waters. 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.

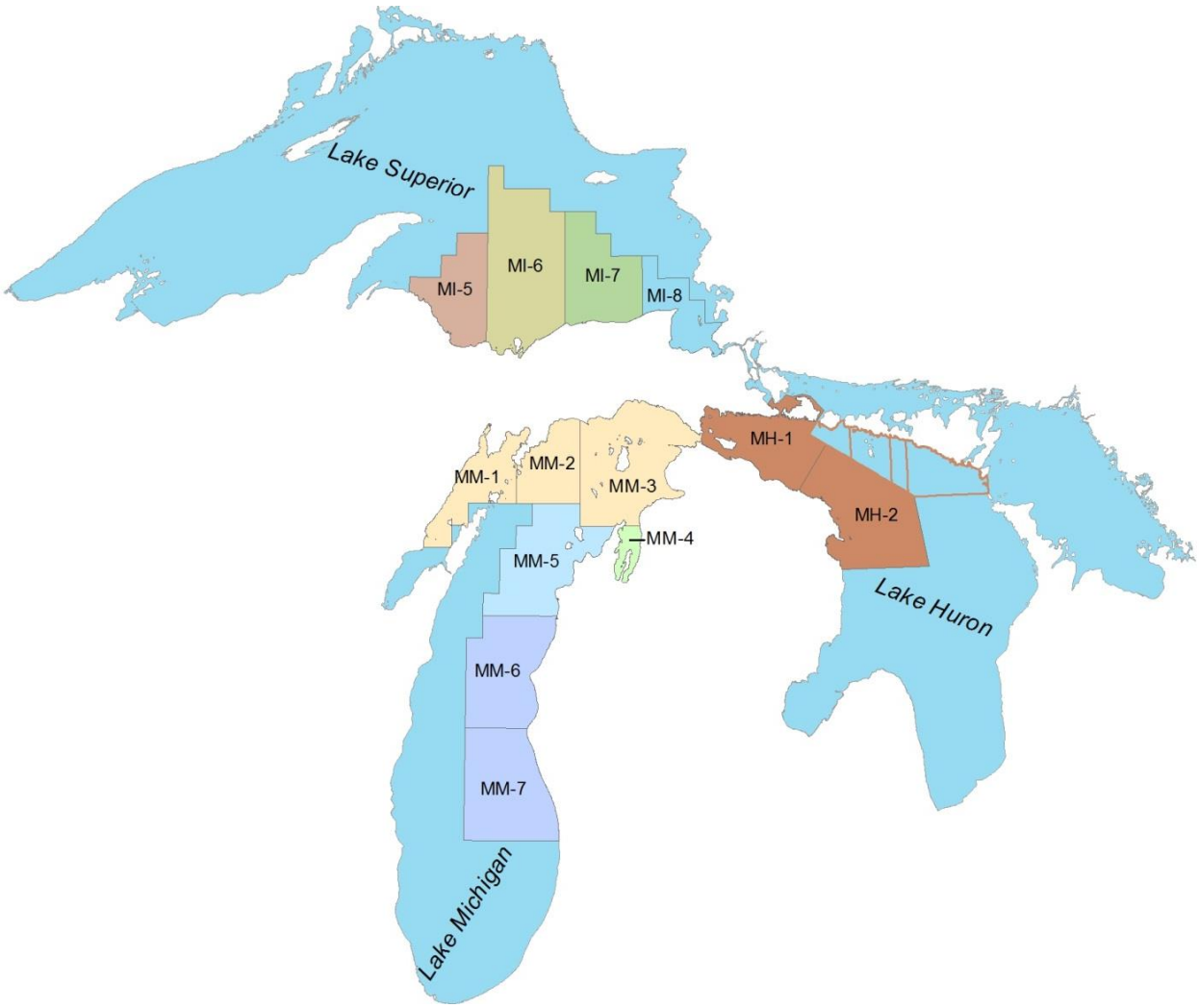


Figure 1. Lake Trout Management Units. Shading denotes units subject to provisions of the 2000 Consent Decree. Like shading indicates where statistical districts have been combined into a single management unit for stock assessment purposes. In the case of Lake Huron, outlined areas adjacent to statistical districts MH-1 and MH-2 denote where fishery data from Ontario waters are included in the stock assessment for Lake Huron. No stock assessment has been developed for Lake Superior unit MI-8.

Figure 2. Lake Whitefish Management Units. Shading denote units 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. No stock assessment model has been developed for Lake Michigan unit WFM-07 and the stock assessment model for Lake Superior unit WFS-06 has not been populated since 2006 due to a paucity of available data.

Table 2. Surface area estimates for Lake Trout and Lake Whitefish management units associated with 1836 waters of the Great Lakes.

Species	Lake	Management unit	Total Area (ha)	Area<= 80m (ha)
Lake Trout	Superior	MI-5	374,100	117,000
		MI-6	803,300	105,100
		MI-7	459,300	157,800
	Huron	MH-12	1,073,800	563,000
		OH-1*	353,800	196,300
	Michigan	MM-123	1,293,200	910,200
		MM-4	66,100	50,200
		MM-5	548,000	125,400
		MM-67	1,155,500	270,200
Lake Whitefish	Superior	WFS-04	396,300	116,800
		WFS-05	730,000	96,400
		WFS-06	416,900	123,200
		WFS-07	239,200	148,800
		WFS-08	78,200	70,400
	Huron	North Huron	677,300	385,700
		WFH-05	262,700	86,300
	Michigan	WFM-01	190,700	190,700
		WFM-02	293,000	146,800
		WFM-03	200,500	200,500
		WFM-04	259,200	228,900
		WFM-05	366,100	174,100
		WFM-06	475,300	116,600
		WFM-07	643,800	117,800
		WFM-08	656,800	145,700

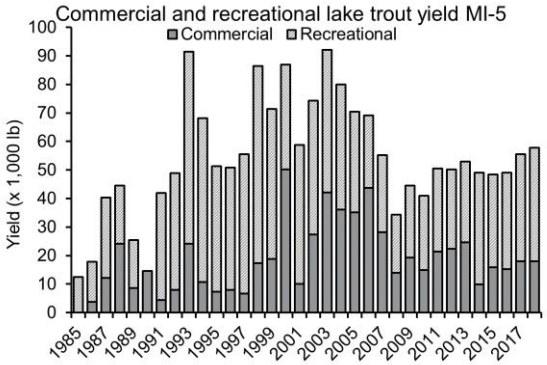
*Ontario statistical district OH-1 presented as a surrogate for the three Ontario quota-management areas (4-1, 4-2 and 4-3) included in the North-Central Lake Huron (MH-12) model.

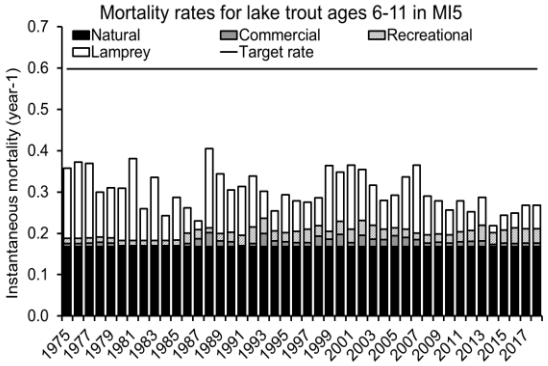
STATUS OF LAKE TROUT POPULATIONS

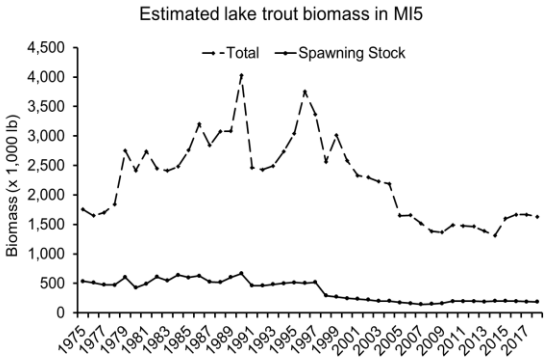
Lake Superior

MI-5 (Marquette)

Shawn Sitar

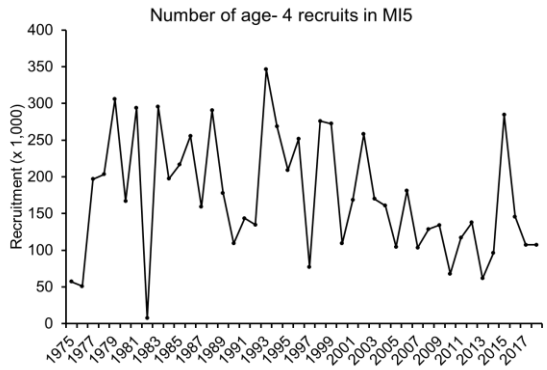






Parameter[(1)]	Value
Base SSBR	4.61 lb
Current SSBR	1.55 lb
Target SSBR	0.36 lb
Current SPR	0.34
M	0.17 y^{-1}
F, Commercial (2016-2018)	0.01 y^{-1}
F, Recreational (2016-2018)	0.04 y^{-1}
Sea Lamprey Mort (2015-2017)	0.05 y^{-1}
Z (2018)	0.27 y^{-1}
Recommended Limit	114,224 lb
Actual Limit	144,678 lb
Model Rating	Medium

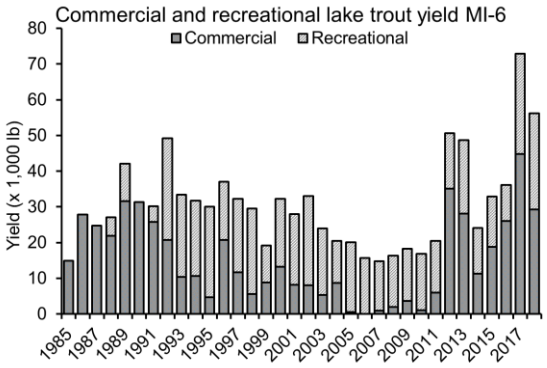
(1) For this table and all subsequent tables in this section, mortality rates represent averages for Lake Trout ages 6-11.

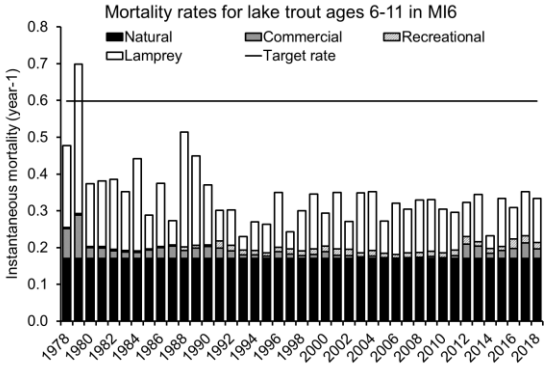


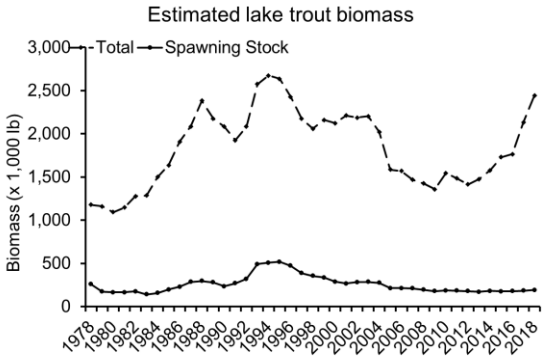
<u>Notable Stock Dynamics and Model Changes:</u>

Since 2007, the Lake Trout population has remained stable and mortality is well below the target level. Although increasing the past three years, sea lamprey-induced mortality has declined from the high levels observed from 1999-2009. Commercial fishery data were not provided for 2018, it was thus assumed to be equal to 2017. The harvest limit declined 33% from 2018, as a result of the population estimate rescaling from using an improved approach to weighting age compositions.

MI-6 (Munising) Shawn Sitar





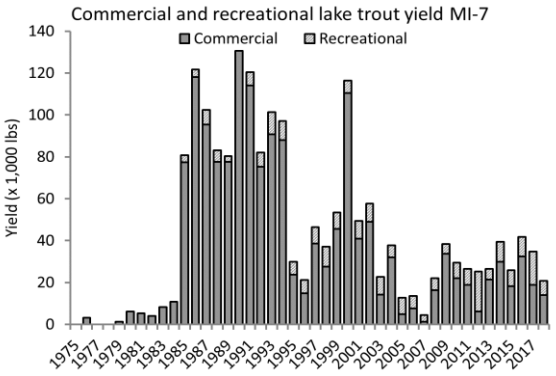


Parameter	Value
Base SSBR	4.36 lb
Current SSBR	1.15 lb
Target SSBR	0.56 lb
Current SPR	0.27
M	0.17 y^{-1}
F, Commercial (2016-2018)	0.03 y^{-1}
F, Recreational (2016-2018)	0.02 y^{-1}
Sea Lamprey Mort (2015-2017)	0.11 y^{-1}
Z (2018)	0.33 y^{-1}
Recommended Limit	215,807 lb
Actual Limit	215,807 lb
Model Rating	High

Notable Stock Dynamics and Model Changes:

After declines in the late 1990s and a period of relative stability from 2004 to 2012, population abundance has increased in recent years due to surges in recruitment. Sea lamprey remain the primary source of mortality, outside of natural causes. Yield remains higher than the time series average, but it is not approaching calculated harvest limits. Total annual mortality for age 6-11 lake trout averaged 28% in the last three years. The 2019 harvest limit for MI-6 increased by 10% from last year due to recent increases in abundance. The model was also updated with an improved approach to weighting age compositions from each data source.

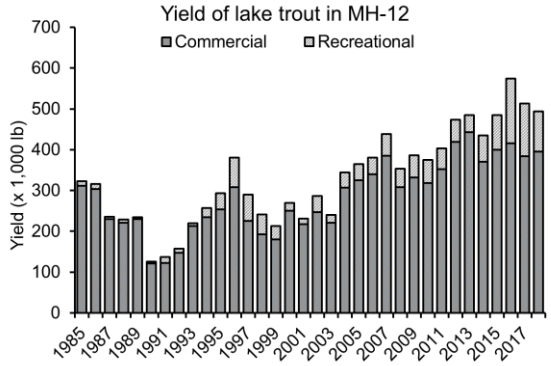
MI-7 (Grand Marais) Shawn Sitar

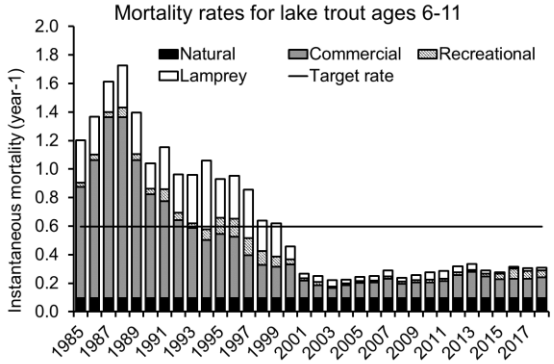


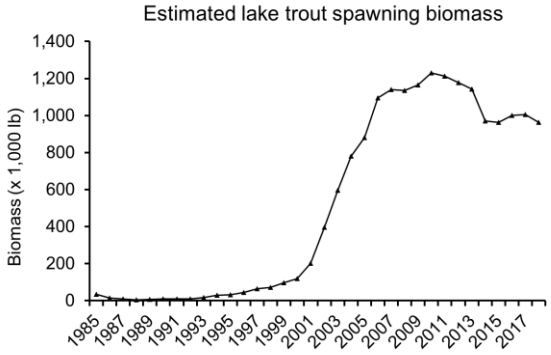
Notable Stock Dynamics and Model Changes:

This model was in rotation status for 2019 and the harvest limit was projected based on 2018 model estimates of abundance and recruitment with updated fishing and sea lamprey mortality rates. The limits declined by 19% because of lower estimates of abundance driven by lower estimates of recruitment in the last model and increases in sea lamprey induced mortality.

Lake Huron
MH-1 and MH-2 (Northern and North-central Lake Huron) Ji He







Parameter	Value
Base SSBR	29.49 lb
Current SSBR	5.03 lb
Target SSBR	n/a*
Current SPR	0.17
M	0.09 y^{-1}
F, Commercial (2016-2018)	0.14 y^{-1}
F, Recreational (2016-2018)	0.06 y^{-1}
Sea Lamprey Mort (2015-2017)	0.02 y^{-1}
Z (2018)	0.31 y^{-1}
Recommended Limit	638,337 lb
Actual Limit	N/A
Model Rating	Low

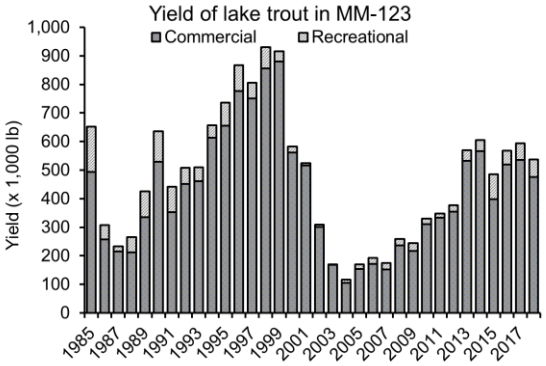
**Target mortality rates differ between MH-1 and MH-2. Target SSBR in MH-1 is 1.57 lb and in MH-2 it is 2.09 lb.*

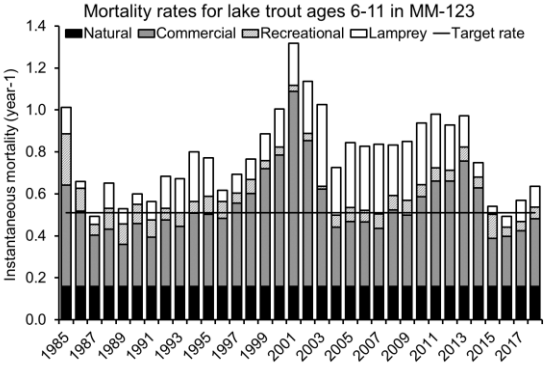
<u>Notable Stock Dynamics and Model Changes:</u>

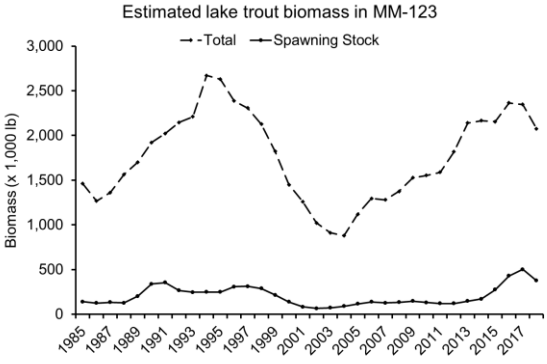
In both 2017 and 2018 the MSC noted uncertainty with the scaling of population size and mortality rates in the northern Lake Huron Lake Trout model. An investigation during fall 2018 uncovered one primary reason why. Fall survey age compositions had been included in the assessment model since 2011. After extensive discussion and analysis, it was determined that the fall data were misleading and uninformative beginning with the 2014 data year. The MSC decided to remove the fall data from the assessment model (and informed the TFC as such in fall 2018). This resulted in a rescaling of recruitment, primarily in the last 6 years, and higher estimates of mortality, leading to

a lower estimate of population biomass, when compared to prior models constructed during the most recent two cycles. The trends in biomass now better mirror those as estimated through the fishery-independent survey since 2006, and rather than a continual increase, spawner biomass is estimated to be largely stable and only slightly lower than its peak in 2010. Mortality rates are still estimated to be low (27%), but much more plausible than in prior years (~20%). Implementing the iterative effective sample size approach to weighting age compositions caused some instability, similar to MM-123. As a result, the IESS approach was not adopted; however, weighting of various data sources was updated based on MSC discussions. Harvest limits for 2019 are not comparable to prior years, given the structural changes to the assessment model. The MSC believes this model is improved over prior years; however, its convergence is still sensitive to starting values and assumptions, so it retains a low rating.

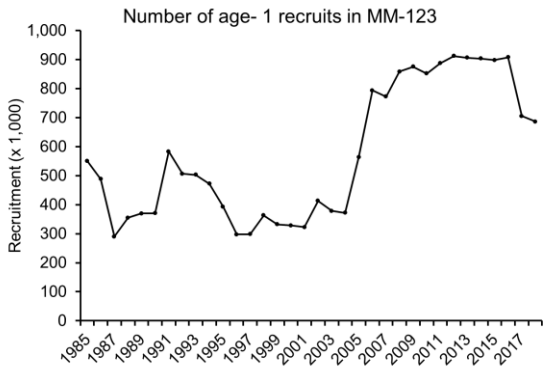
Lake Michigan
MM-123 (Northern Treaty Waters) Ted Treska







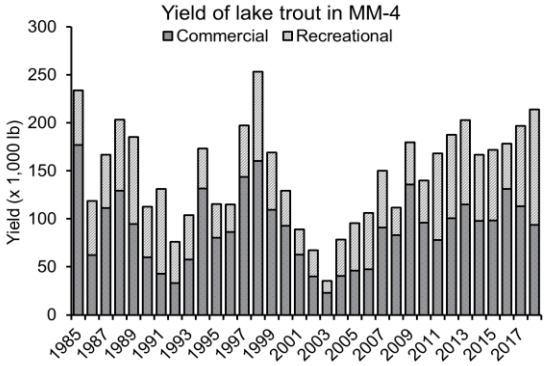
Parameter	Value
Base SSBR	3.56 lb
Current SSBR	0.47 lb
Target SSBR	0.75 lb
Current SPR	0.13
M	0.16 y^{-1}
F, Commercial (2016-2018)	0.28 y^{-1}
F, Recreational (2016-2018)	0.05 y^{-1}
Sea Lamprey Mort (2015-2017)	0.06 y^{-1}
Z (2018)	0.64 y^{-1}
Recommended Limit	503,088 lb
Actual Limit	630,000 lb
Model Rating	Medium

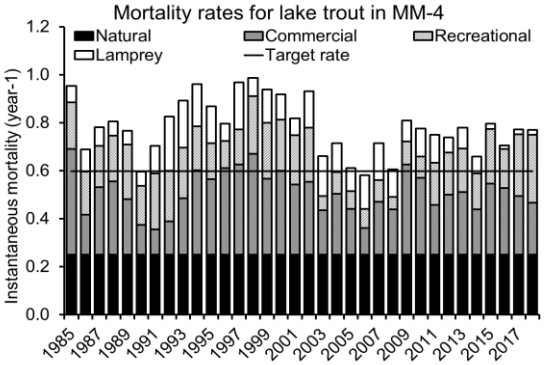


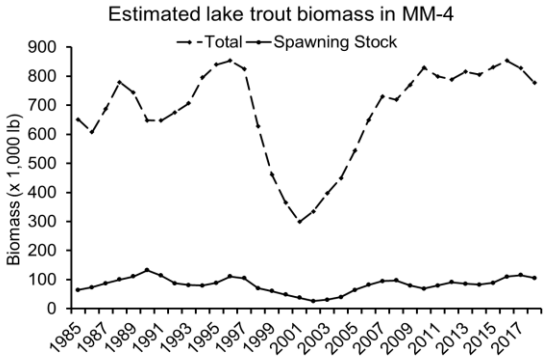
Notable Stock Dynamics and Model Changes:

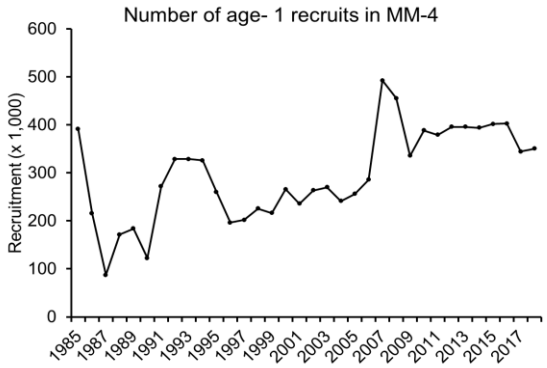
Implementing the IESS approach to weighting age compositions was unsuccessful with this assessment, as it resulted in unrealistic values for survey selectivity. Slight modifications were made to increase the weighting of survey data and equalize the weighting of the commercial and recreational fishery data. Commercial harvest in 2018 was very similar to 2017, although effort was less than half of what it was in the previous year. All data suggest a strong 2011 cohort. A sustained reduction in sea lamprey mortality has also benefited the stock. The model-based harvest limit has increased to 503,000 lb, but the signal for younger cohorts is less clear, despite sustained, elevated levels of stocking.

MM-4 (Grand Traverse Bay) Stephen Lenart







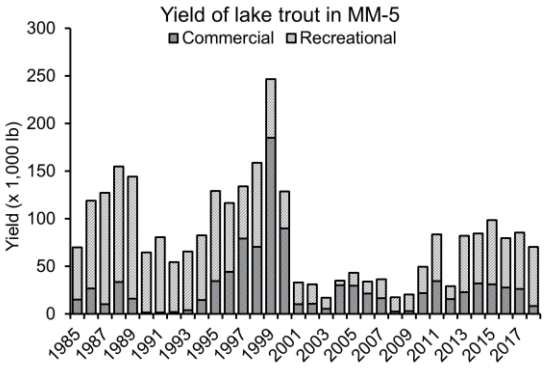


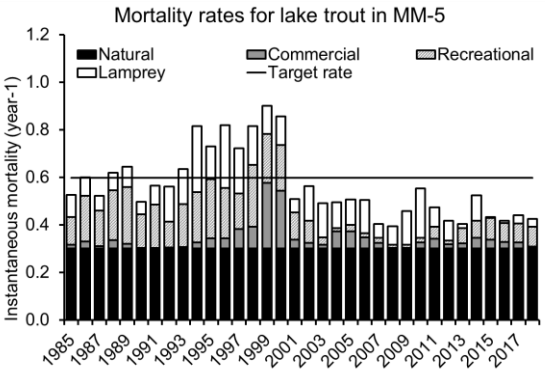
Parameter	Value
Base SSBR	1.51 lb
Current SSBR	0.28 lb
Target SSBR	0.36 lb
Current SPR	0.19
M	0.25 y^{-1}
F, Commercial (2016-2018)	0.25 y^{-1}
F, Recreational (2016-2018)	0.23 y^{-1}
Sea Lamprey Mort (2015-2017)	0.02 y^{-1}
Z (2018)	0.77 y^{-1}
Recommended Limit	130,326 lb
Actual Limit	171,500 lb
Model Rating	Medium

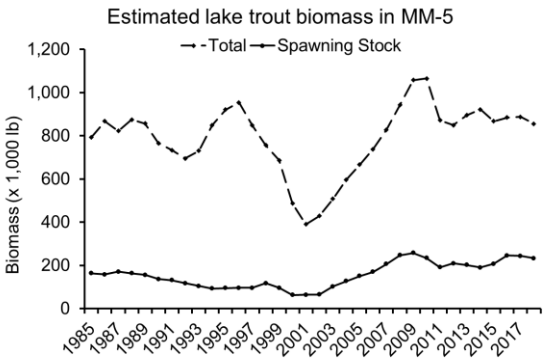
Notable Fishery Dynamics and Model Changes:

Two changes were implemented during this year's assessment: starting the model time series in 1985 and instituting the IESS approach to weighting age compositions. The addition of 2018 data scaled abundance higher during the latter part of the time series, primarily due to a very modest expansion of the age structure that resulted in higher survival estimates for certain fishable cohorts. Estimated sea lamprey-induced mortality remained around 0.02 yr^{-1} for the third consecutive year yet total mortality was well above the target rate (54%) during 2018 and yield was the highest observed since 1998. The increase in the projected harvest limit was due to lower sea lamprey mortality and higher abundance of some year classes (2011 and 2014). A substantial portion of the harvest limit is composed of immature fish.

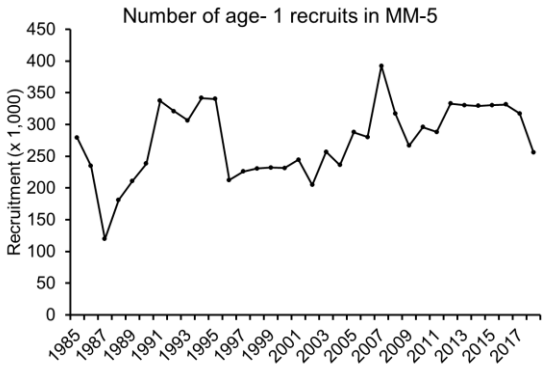
MM-5 (Leelanau Peninsula to Arcadia) Stephen Lenart







Parameter	Value
Base SSBR	1.38 lb
Current SSBR	0.81 lb
Target SSBR	0.57 lb
Current SPR	0.59
M	0.30 y^{-1}
F, Commercial (2016-2018)	0.02 y^{-1}
F, Recreational (2016-2018)	0.08 y^{-1}
Sea Lamprey Mort (2015-2017)	0.02 y^{-1}
Z (2018)	0.43 y^{-1}
Recommended Limit	112,167 lb
Actual Limit	112,167 lb
Model Rating	Low

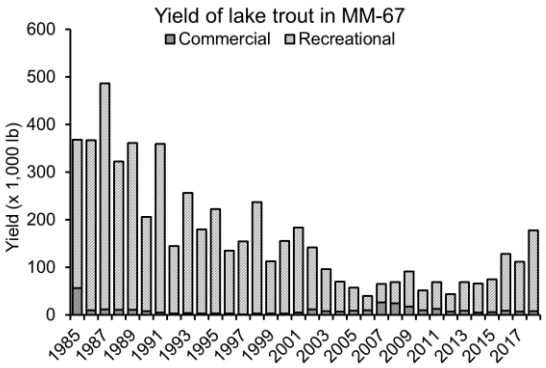


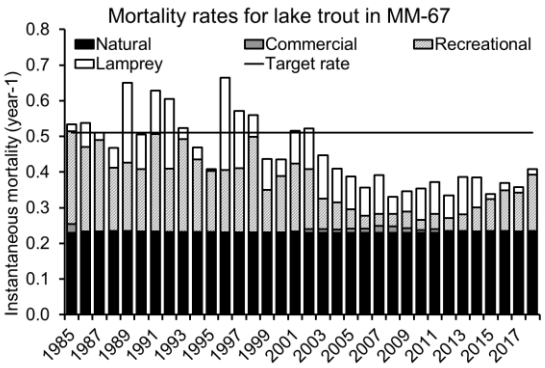
Notable Fishery Dynamics and Model Changes:

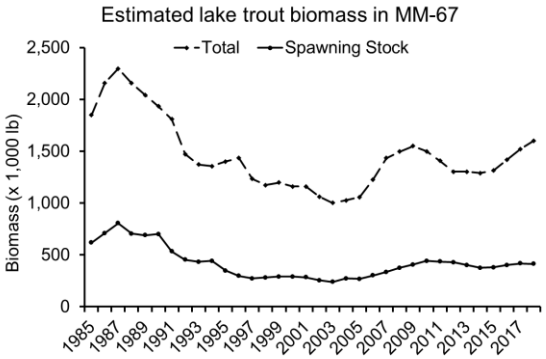
The only structural change made to the MM-5 assessment was to start the model time series in 1985 to bring it in alignment with the remaining Lake Michigan units (IESS was integrated last year). As in MM-4, sea lamprey mortality remained quite low (0.035 yr^{-1}) despite the increase observed over 2016-2017 levels (< 0.01 yr^{-1}). Ignoring scaling differences between the two units, patterns in spawning biomass are remarkably similar in MM-4 and MM-5 since 2002, although mortality is much lower (*A*=35%) in MM-5. Since 2008, estimated biomass has only deviated more than 10% year-to-year on two occasions. This is a product of consistent stocking and below target mortality rates. The model-generated harvest limit increased

35% from 2018 and is above the stipulated level for the first time since 2012, in part (30% of increase) due to lower projected sea lamprey mortality. Despite the low rating (instability when certain initial conditions are changed), the performance of the assessment is nonetheless improved over prior versions and stock size estimates did not diverge widely among versions. Estimated *M* is considerably higher here than in adjacent areas, a situation that will be investigated during the coming assessment cycle.

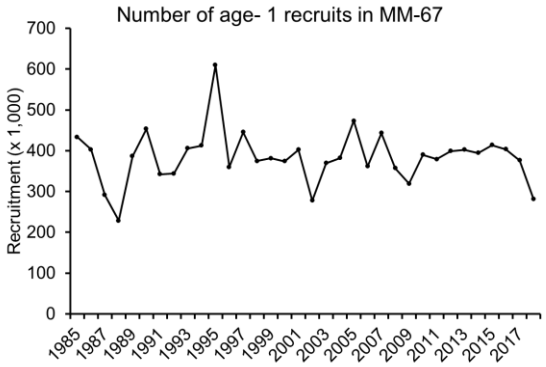
MM-67 (Southern Treaty Waters) Stephen Lenart







Parameter	Value
Base SSBR	2.62 lb
Current SSBR	1.24 lb
Target SSBR	0.77 lb
Current SPR	0.47
M	0.23 y^{-1}
F, Commercial (2016-2018)	0.01 y^{-1}
F, Recreational (2016-2017)	0.13 y^{-1}
Sea Lamprey Mort (2015-2017)	0.02 y^{-1}
Z (2018)	0.41 y^{-1}
Recommended Limit	194,677 lb
Actual Limit	195,683 lb
Model Rating	Medium



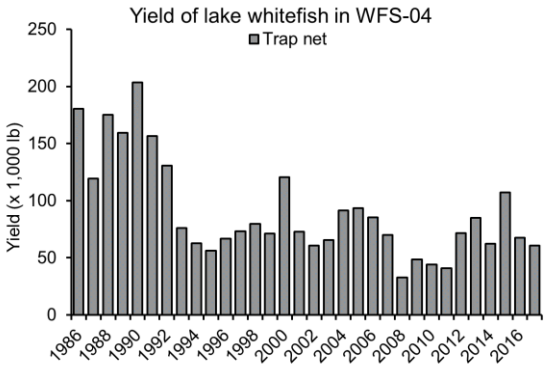
<u>Notable Fishery Dynamics and Model Changes:</u>

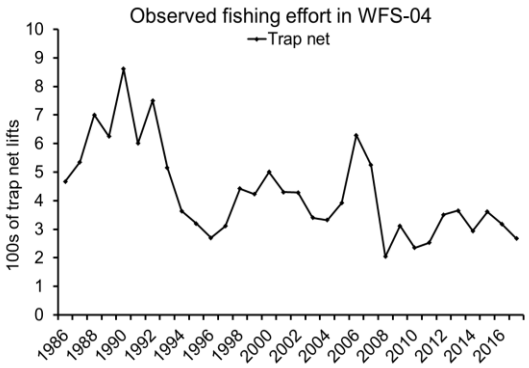
This unit has less of a truncated age structure compared to northern areas and mortality rates that have been below target for much of the time series. Mortality averaged 34% on fish ages 6-11 during 2018 and spawning biomass has been markedly stable since 2009. The 2018 recreational yield was the highest observed since 2001 and was near the model-generated limit for the unit. Sea lamprey mortality has been around 0.02 yr^{-1} for the past three years and about 80% of the increase in the harvest limit from 2018 to 2019 is attributable to lower projected sea lamprey mortality. Model performance has substantially improved in recent years. The only substantive change implemented during this assessment cycle was the integration of IESS.

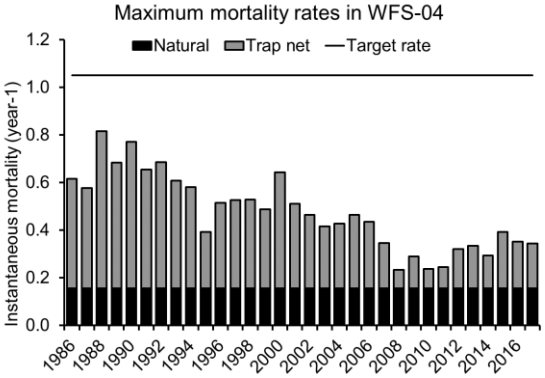
STATUS OF LAKE WHITEFISH POPULATIONS

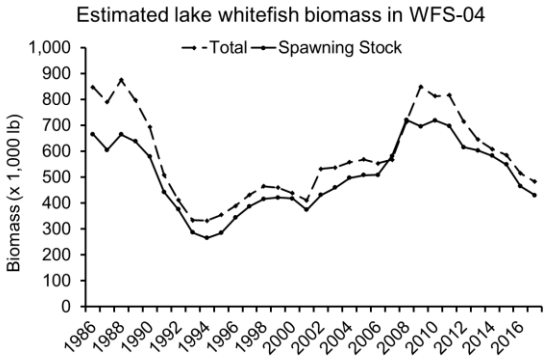
Lake Superior

WFS-04 (Marquette-Big Bay) Mike Seider









Parameter[(2)]	Value
Base SSBR	8.21 lb
Current SSBR	1.64 lb
Target SSBR	1.32 lb
Current SPR	0.20
M	0.16 y^{-1}
F, trap net (2015-2017)	0.18 y^{-1}
Z (2017)	0.33 y^{-1}
Recommended Limit	118,000 lb
Actual Limit	118,000 lb
Model Rating	Medium

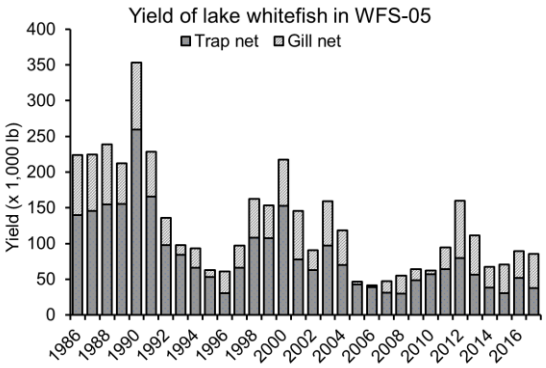
(2) For this table and all subsequent tables in this section, mortality rates represent averages for Lake Whitefish ages 6-11.

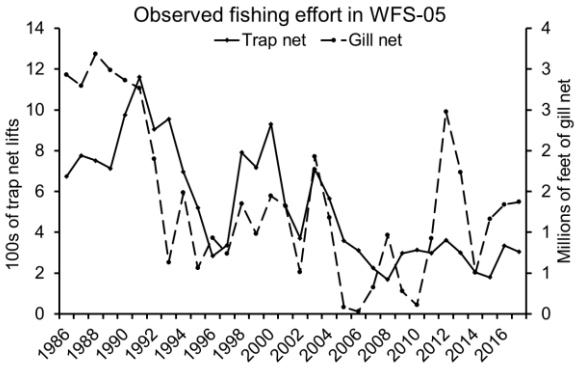
Notable Fishery Dynamics and Model Changes:

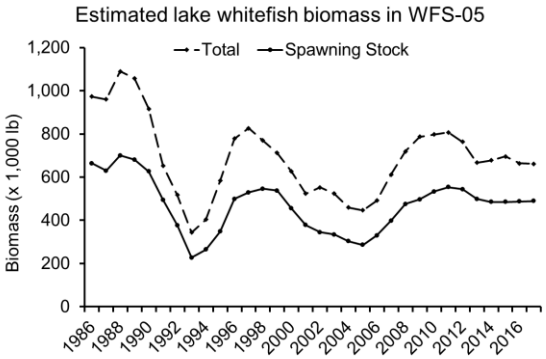
Lake whitefish biomass in WS-04 has declined since the late-2000s, due to declining abundance and weight at age. Fishing mortality has increased gradually since 2008, however maximum total

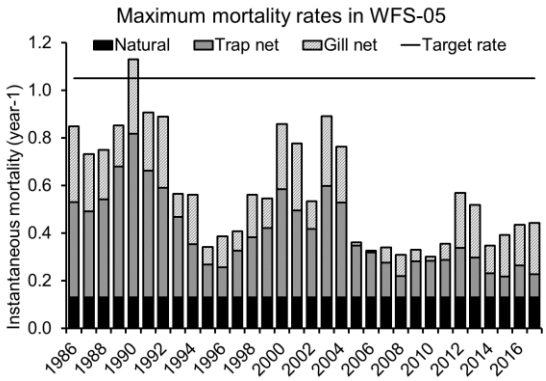
mortality rates were well below the target value. Annual mortality rate (*A*) for the most vulnerable age class was 29% in 2017. Estimated recruitment has been generally stable since about 2010. Due to lack of biological data collected from the gill-net fishery, gill-net harvest was again combined with the trap-net fishery. Unfortunately, by combining gill- and trap-net harvest we can only track changes in total fishing mortality and not mortality from the two fisheries independently. For the 2019 assessment model, annual effective sample size for trap-net age composition was adjusted via an iterative approach adopted by the MSC. The resulting lower effective sample sizes (and lower model weighting), produced higher estimated recruitment since 2010 than in prior assessments. Model diagnostics did not indicate any concerning problems and the assessment continues to provide stable results regardless of structural changes, thus the assessment received a medium rating. The yield limit calculated for the entire WFS-04 management unit is 168,000 lb. After applying the prescribed reduction to reflect the proportion of this management unit that is outside the Consent Decree, the 2019 yield limit for lake whitefish in 1836 Treaty Waters is 118,000 lb.

WFS-05 (Munising) Shawn Sitar







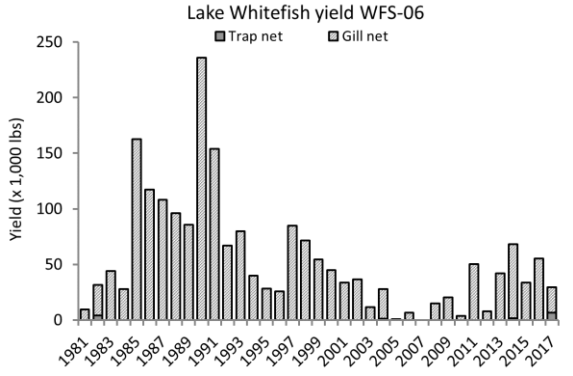


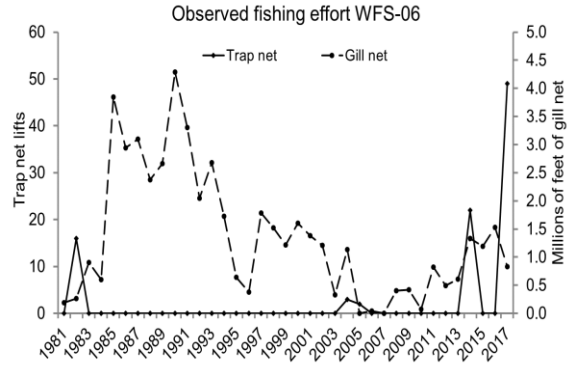
Parameter	Value
Base SSBR	4.66 lb
Current SSBR	1.28 lb
Target SSBR	1.28 lb
Current SPR	0.28
M	0.13 y^{-1}
F, trap net (2015-2017)	0.08 y^{-1}
F, gill net (2015-2017)	0.09 y^{-1}
Z (2017)	0.44 y^{-1}
Recommended Limit	201,700 lb
Actual Limit	201,700 lb
Model Rating	Medium

Notable Fishery Dynamics and Model Changes:

The 2019 Lake Whitefish harvest limit was 201,700 lb and decreased from the 2018 amount by 30%. The decline was due to overall lower stock size estimate due to improvements made to the model in terms of effective sample size for age compositions. The average total annual mortality rate (*A*) experienced by ages 4-12 during 2015-2017 was 26%. Trap-net yield in 2017 was 32,280 lb (28% lower than in 2016) and gill-net yield was 48,200 lb (28% increase from 2016). The model rating for WFS-05 remains at medium because the model has consistent performance with prior models which have had good diagnostics.

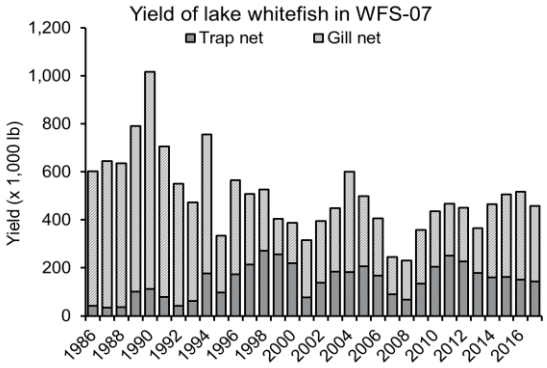
WFS-06 (Grand Marais)

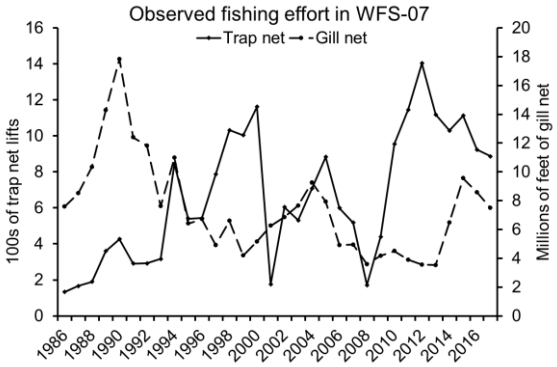


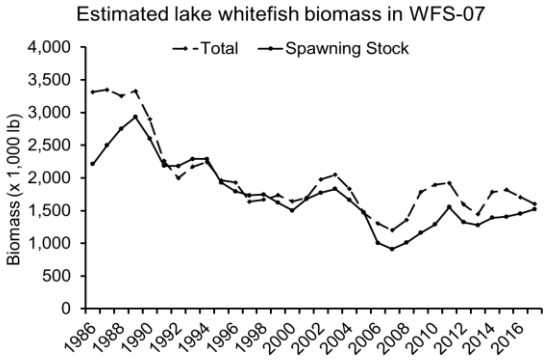


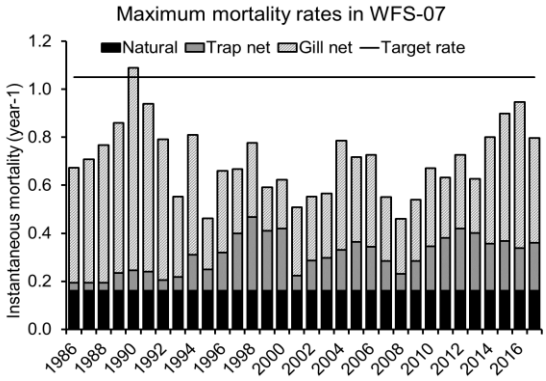
There is no current stock assessment model for WFS-06. Low levels of effort and harvest and a lack of fishery monitoring data since the early 2000s limit the ability to produce an assessment model for this unit. The HRG for this unit was reduced to 174,300 lb for 2019.

WFS-07 (Tahquamenon Bay) Jack Tuomikoski









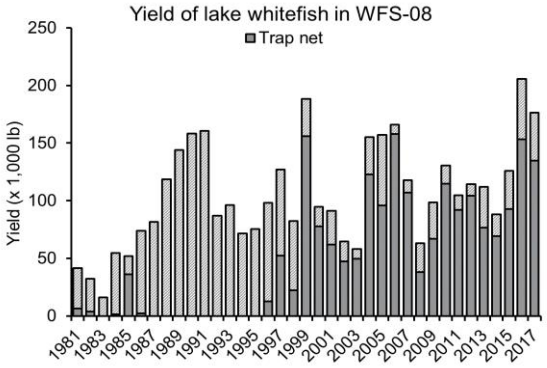
Parameter	Value
Base SSBR	4.51 lb
Current SSBR	0.98 lb
Target SSBR	0.44 lb
Current SPR	0.22
M	0.16 y^{-1}
F, trap net (2015-2017)	0.20 y^{-1}
F, gill net (2015-2017)	0.53 y^{-1}
Z (2017)	0.80 y^{-1}
Recommended Limit	571,000 lb
Actual Limit	571,000 lb
Model Rating	Medium

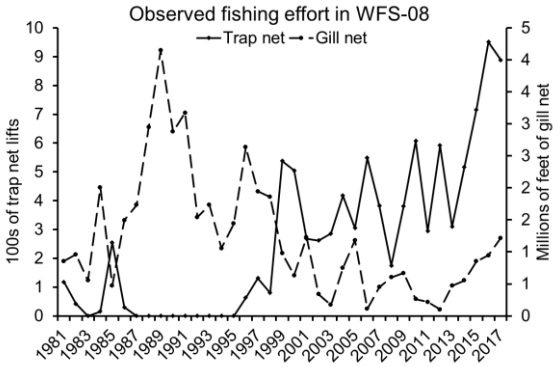
Notable Fishery Dynamics and Model Changes:

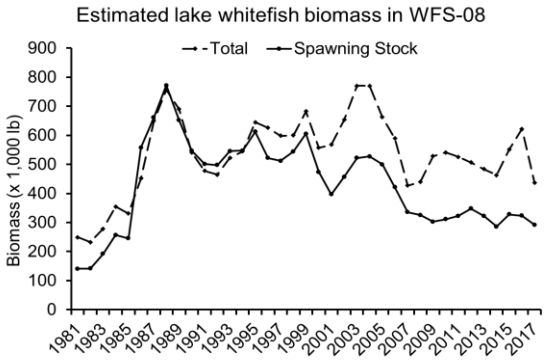
The model recommended harvest limit for 2019 is 571,000 lb, down 17% from 2018. The maximum mortality rate estimated for 2017 was 55%. Some corrections to historical commercial catch and effort were made, with most values being ± 3% of those previously used. These data changes had minor influences on model predictions. Three changes were made to last year's model structure, including using age-based rather than length-based selectivity (improved model stability), allowing time-varying catchability, and using a single logistic function rather than double-logistic for describing trap-net selectivity. Harvest has generally been increasing in WFS-07 since 2008, although harvest in 2017 was 81% of the 2016 harvest. In the context of historical catches, 2017 was 45% of the 1990 harvest

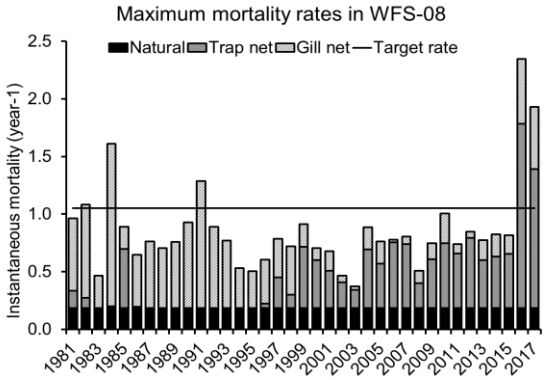
(the highest in the time series). The gill-net fishery has been the predominant fishery for 27 out of 32 years (1986-2017) and constitutes 68% of the 2017 catch. Fishing effort for the gill-net fishery decreased slightly from 2015 to 2017 but generally has been increasing since 2008. Gill-net effort in 2018 was 39% of the maximum effort which occurred in 1990 in this unit. Fishing effort by the trap-net fishery increased from 2009 to the second highest trap net effort on record in 2011, then has generally decreased through 2017. The estimated number of age-4 recruits in 2014 was among the highest in the time series (1986-2017). This cohort can be seen in the fishery as a large proportion of age-4 fish in 2014, age-5 fish in 2015, and age-6 fish in 2016. However, the annual estimate of age-4 recruits has declined each year since 2014. Total biomass in 2017 is 48% of the maximum total annual biomass estimated for this unit. Fit to catch, fit to age, effort residuals, MCMCs, and retrospective analyses ranged from moderate to good for this model, which was rated medium.

WFS-08 (Brimley) Jack Tuomikoski









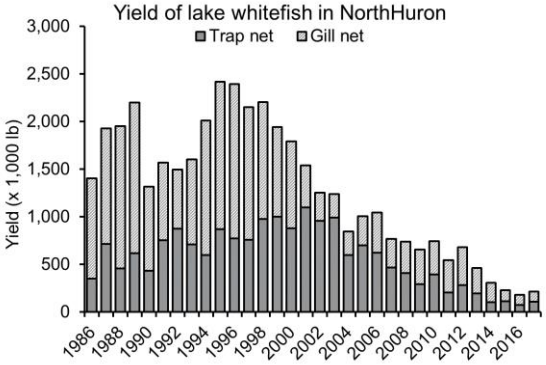
Parameter	Value
Base SSBR	2.48 lb
Current SSBR	0.66 lb
Target SSBR	0.66 lb
Current SPR	0.27
M	0.18 y^{-1}
F, trap net (2015-2017)	1.09 y^{-1}
F, gill net (2015-2017)	0.42 y^{-1}
Z (2017)	1.93 y^{-1}
Recommended Limit	87,000 lb
Actual Limit	221,025 lb
Model Rating	Medium

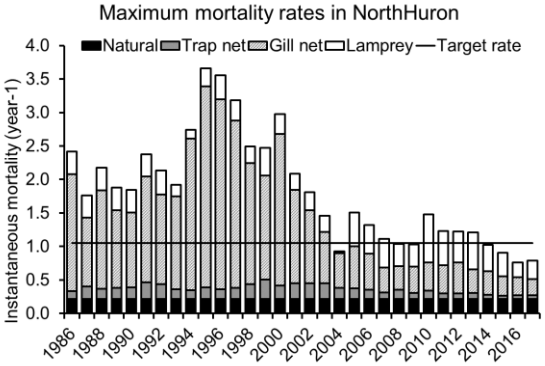
Notable Fishery Dynamics and Model Changes:

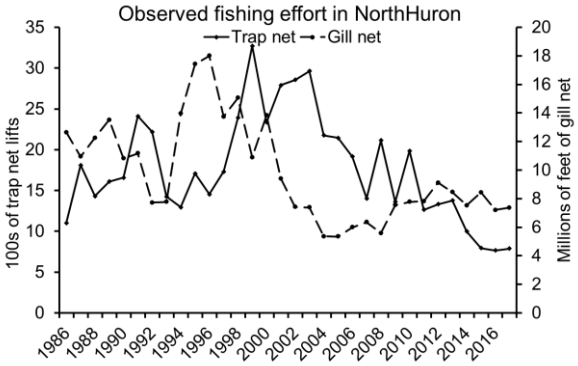
The model recommended harvest limit for 2019 is 87,000 lb, down 61% from 2017. The maximum mortality rate estimated for 2017 was 85%. Some corrections to historical commercial catch and effort were made, with most values being ± 3% of those previously used. The largest change was correcting the 1983 trap-net fishery which should have been zero effort and catch. These data changes had a minor influence on model predictions. Two changes were made to last year's model structure. The first was allowing catchability to vary across years. The second change was to model trap-net selectivity with a single logistic instead of a double-logistic function. Harvest has generally increased in WFS-08 since 2007. Harvest in 2016 and 2017 were the 1st and 3rd highest on record respectively. The trap-net fishery has been the

predominant fishery since the late 1990s and therefore composes most of the total harvest. Trap-net fishery effort has generally increased since 2007 and effort in 2016 and 2017 were the two highest on record. Fishing effort within the gill-net fishery has been increasing since 2012, but effort in 2017 is still only 27% of the maximum gill net effort that was observed in 1989. The estimates of age-4 recruits had been increasing since 2012 but showed a sharp decline for 2017. Population estimates for age-5 fish in 2017 are still relatively high due to strong (age-4) recruitment in 2016. Both spawning and total biomass have been decreased in 2017. Fit to catch, fit to age, effort residuals, MCMCs, and retrospective analyses ranged from moderate to good for this model, which was rated medium.

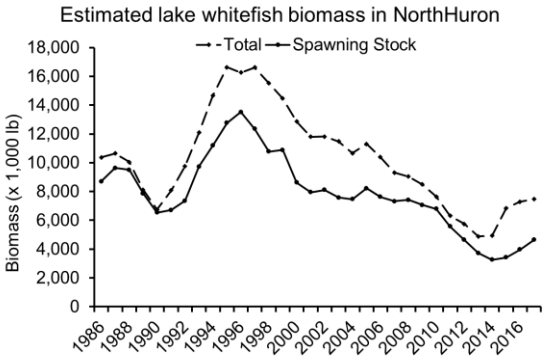
Lake Huron
Northern Huron (WFH-01 to WFH-04) Stephen Lenart







Parameter	Value
Base SSBR	2.70 lb
Current SSBR	0.98 lb
Target SSBR	1.22 lb
Current SPR	0.36
M	0.22 y^{-1}
F, trap net (2015-2017)	0.05 y^{-1}
F, gill net (2015-2017)	0.27 y^{-1}
Z (2017)	0.51 y^{-1}
Recommended Limit	495,600 lb
Actual Limit	379,900 lb
Model Rating	Medium

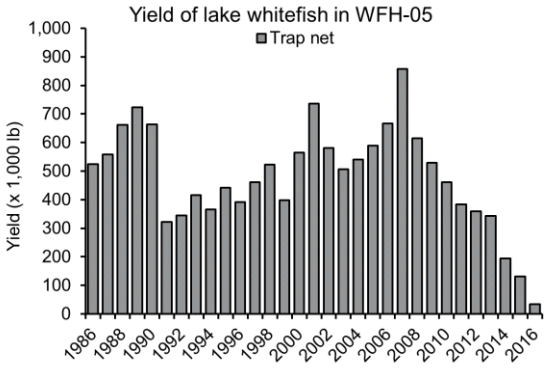


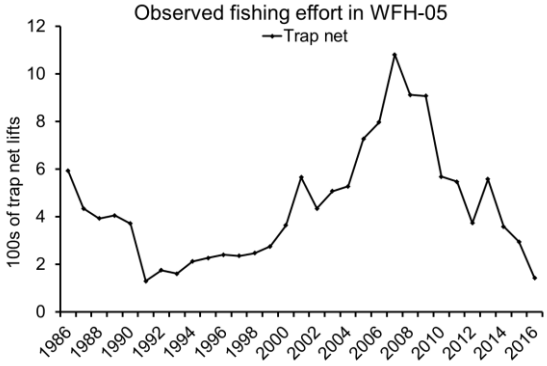
Notable Fishery Dynamics and Model Changes:

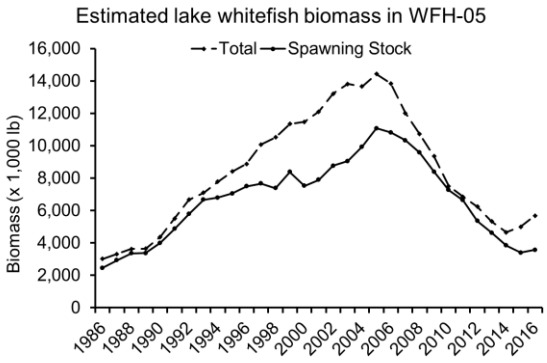
After a nearly two-decade decline, estimated spawning biomass increased modestly from the historic low of 3.5M lb observed in 2014. This increase is mostly attributed to a large (by recent standards) 2010 cohort that entered the fishery in 2016. Estimated mortality on the most vulnerable age class remains high at 54% and sea lamprey is still a significant source of mortality in this unit. Most versions of the model produce limits in the range of 400,000 to 500,000 lb, depending on assumptions related to catchability. Other versions produce limits closer to 1M lb, though these were discarded as unrealistic. The only change to the model structure was to implement a more standardized approach to weighting of the

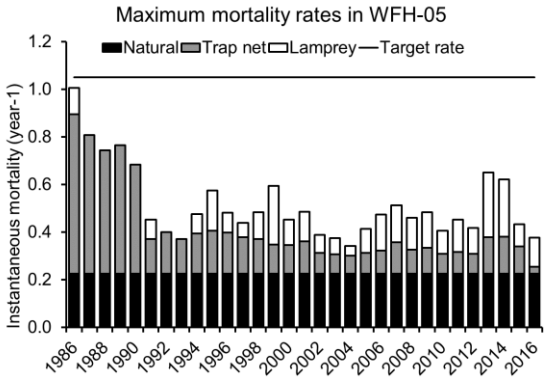
age composition data, though the switch in aging structures to otoliths, resulting in larger contributions of older fish for which there is no earlier signal, remains a problematic issue. The scale of sea-lamprey mortality seems questionable given the number of older fish that persist in the age composition data. Although the scaling of the population remains somewhat uncertain, diagnostics are all in the acceptable range and the model is insensitive to initial start values, suggesting stability. The 446,000 lb limit represents a 2% increase from the 2017 model limit.

WFH-05 (Alpena) Stephen Lenart







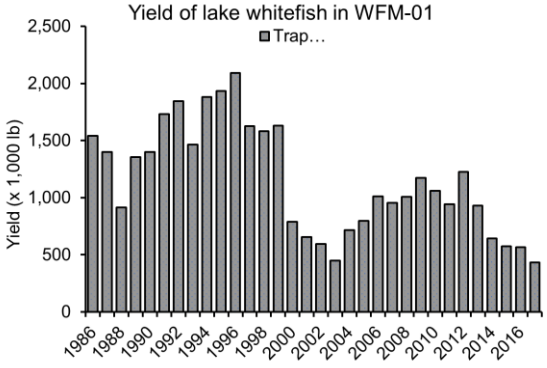


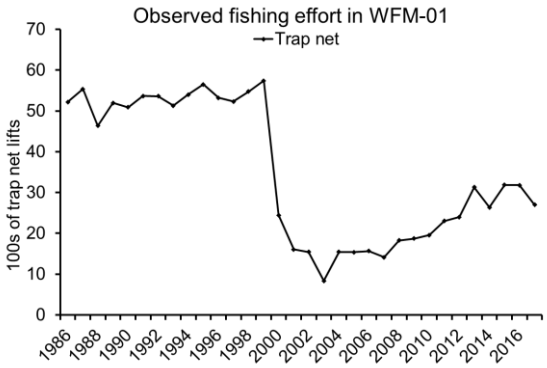
Parameter	Value
Base SSBR	2.97 lb
Current SSBR	1.06 lb
Target SSBR	1.47 lb
Current SPR	0.36
M	0.23 y^{-1}
F, trap net (2015-2017)	0.10 y^{-1}
Z (2017)	0.38 y^{-1}
Recommended Limit	393,500 lb
Actual Limit	394,000 lb
Model Rating	Low

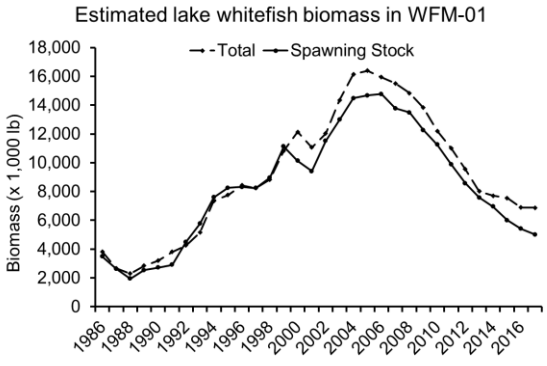
Notable Fishery Dynamics and Model Changes:

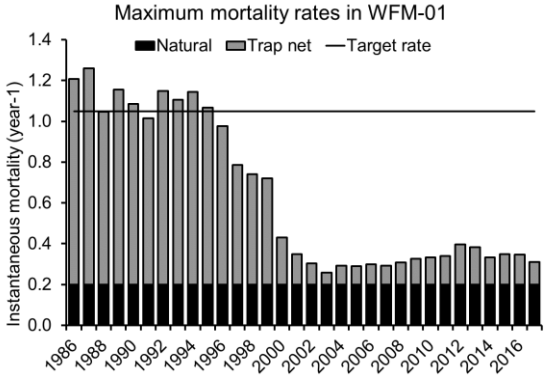
Diagnostics for WFH-05 remain problematic and the issues that plague the North Huron model (influence of the change to otoliths as the primary aging structure and the scaling of sea-lamprey induced mortality) appear to be the driving factors behind our ability to produce an assessment that reaches stable convergence without bounding of certain parameters. There were two changes to the assessment structure this year: the model starts at age-4 versus age-3 and the weighting of age composition data composition followed the procedures adopted in North Huron. These changes brought the WFH-05 assessment into structural alignment with North Huron, but no version would reach convergence without parameter bounding. Reasonable performance for the revised assessment structure occurred if the last year of data were not used to fit the assessment

model (in fact, there were no age composition data for 2017, only harvest and effort). For this reason, the model limit was calculated by using the revised model structure with data through 2016 and then projecting the population forward an additional year after updating the fishery harvest and sea lamprey mortality data in the projection. The resulting harvest limit of 394,000 lb is more reasonable given the dynamics of the stock, which mirror those in North Huron (long term decline in recruitment, fishery cpe, etc.), than those produced in previous assessments, which often exceeded peak yield (800K lb) for this stock. Mortality on the most vulnerable age classes was fairly low (36%) but stock size remains depressed compared to the early 2000s peak due to the decline in recruitment that occurred since then. Model performance is rated as low.









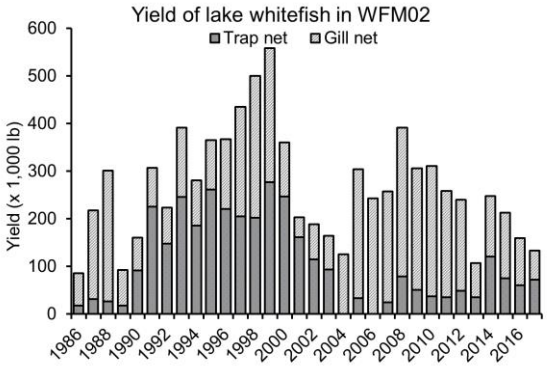
Parameter	Value
Base SSBR	3.14 lb
Current SSBR	0.63 lb
Target SSBR	0.56 lb
Current SPR	0.20
M	0.20 y^{-1}
F, trap net (2015-2017)	0.14 y^{-1}
Z (2017)	0.31 y^{-1}
Recommended Limit	2,177,000 lb
Actual Limit	2,177,000 lb
Model Rating	Low

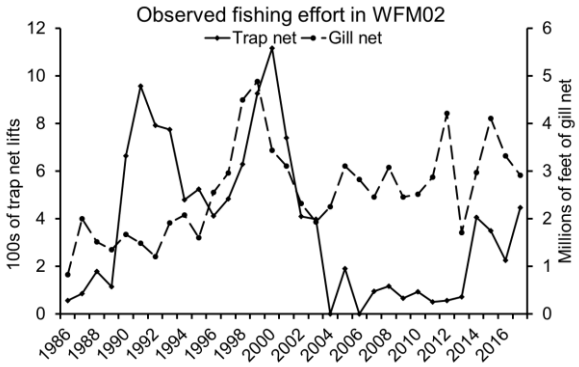
Notable Fishery Dynamics and Model Changes:

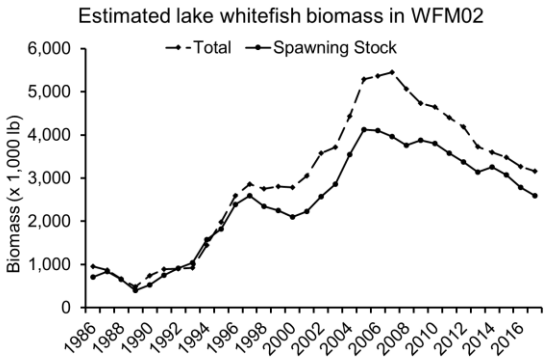
This model maintains the changes made in recent years, but it includes modifications this year to the effective sample size for age compositions (uses an iterative approach to remove autocorrelation), an expansion of the age composition, incorporating lognormal selectivity, and using different models for estimating length and weight at age. The annual mortality rate experienced by the most vulnerable age was 27%. The fishery monitoring data from 2017 tell two different stories. Trap-net monitoring data suggest that 88% of the fish are less than age 12; whereas, purse seine monitoring data suggest that 89% of the fish are older than age 12. There are clear differences in the selectivity of the gears and their respective catchability. Given the change to otolith aging for the

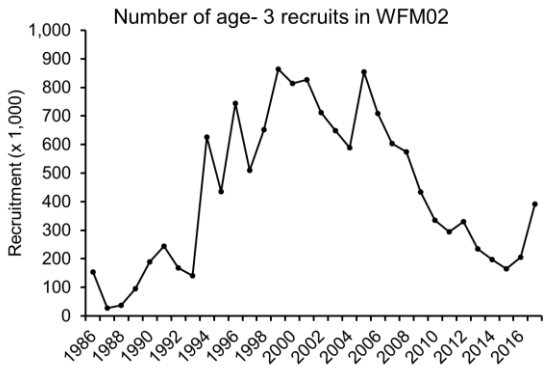
purse seine fish in 2015, there is not yet enough data to model these two fisheries separately. The model is a blend of the two, but also includes data from the permitted gill-net assessment fishery. The present version of the model functions acceptably, meets gradients, is stable to changes in start values, has predictable diagnostics given the noise in the data, and is thus rated medium. The harvest limit has increased by 2% over the prior year's value.

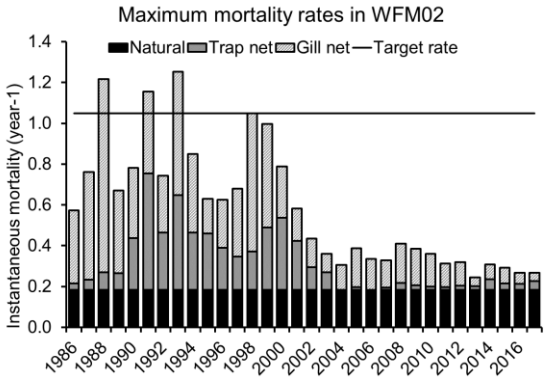
WFM-02 (Manistique) Ted Treska











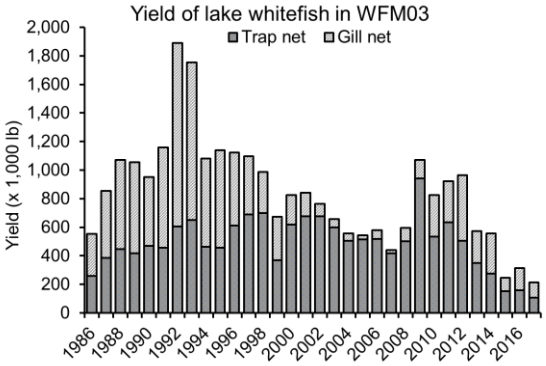
Parameter	Value
Base SSBR	3.97 lb
Current SSBR	0.80 lb
Target SSBR	0.82 lb
Current SPR	0.20
M	0.18 y^{-1}
F, trap net (2015-2017)	0.03 y^{-1}
F, gill net (2015-2017)	0.06 y^{-1}
Z (2017)	0.27 y^{-1}
Recommended Limit	984,914 lb
Actual Limit	271,725 lb
Model Rating	Low

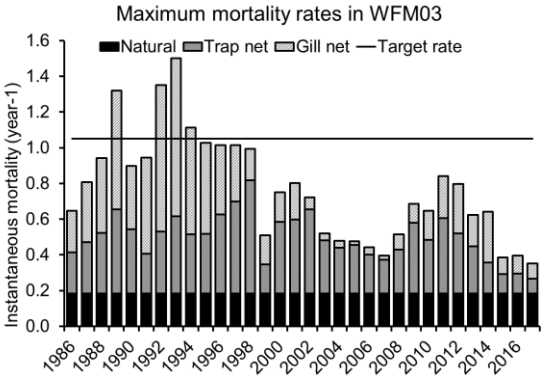
Notable Fishery Dynamics and Model Changes:

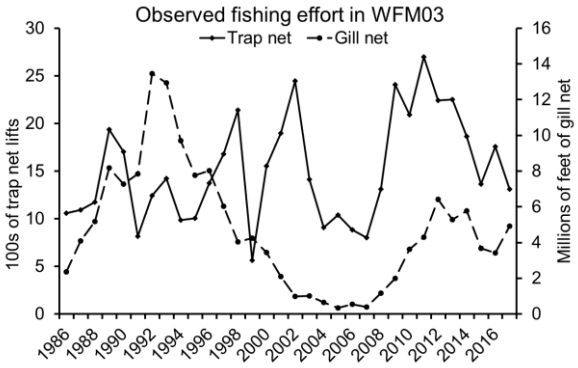
The model estimates a harvest limit of 985,000 lb in this unit for 2019, a 41% increase from the previous year. This year saw a substantial change to the model in a reduction in the effective sample size (ESS) for both fisheries from 50 to values dictated by the new ESS calculation methods. The biomass trend continues to decline from a peak in the mid to late 2000s and is at levels similar to the beginning years of the Consent Decree. Harvest in 2017 was very similar to 2016, with the trap-net fishery taking approximately 60% of the harvest. The CPE for the trap-net and gill-net fisheries both declined, with the gill-net value being the second lowest in the time series, and the trap net approaching historical lows. Effort for the gill-net fishery declined in 2017 while trap-net effort almost doubled from the

previous year. Recruitment seems to have leveled off in recent years, but at a very low level, not seen since the early 1990s. The highest annual mortality rate of 23% was experienced by the age 14 in 2017, continuing to be the lowest value in the time series. The average age of a harvested fish in this unit seems to have leveled off for the gill-net fishery, with a value of 10-11, while the trap-net fishery harvested fish that were 1.5 years younger in 2017 than in previous years. The model is having trouble matching data from recent years which is very erratic and drawn out over many age classes, which is difficult for the model to handle, and it is thus rated low.

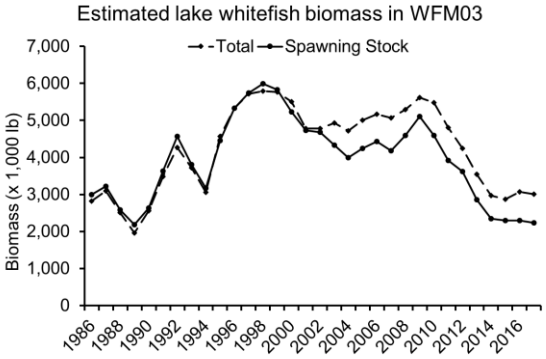
WFM-03 (Naubinway) Ted Treska







Parameter	Value
Base SSBR	3.56 lb
Current SSBR	0.94 lb
Target SSBR	0.96 lb
Current SPR	0.26
M	0.18 y^{-1}
F, trap net (2015-2017)	0.10 y^{-1}
F, gill net (2015-2017)	0.09 y^{-1}
Z (2017)	0.35 y^{-1}
Recommended Limit	987,589 lb
Actual Limit	600,300 lb
Model Rating	Medium

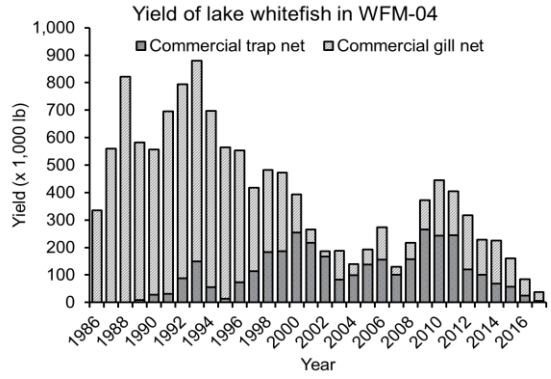


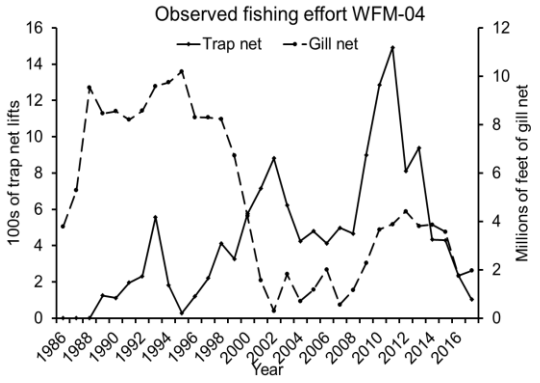
Notable Fishery Dynamics and Model Changes:

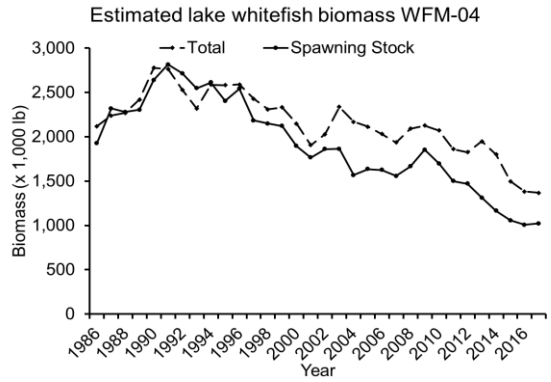
The model recommended harvest level of 988,000 lb is a 23% increase over last year's value. This year saw a substantial change to the model in the reduction in the effective sample size (ESS) for both fisheries from 50 to values dictated by the new ESS calculation methods. Biomass trends seem to be leveling, being consistent for the last 4 years and similar to those of the late 1980s. The model still indicates a sharp decline in recruitment from an overall high in 2005 to the present, though there is a signal that the recruitment class of 2015 (age 4) may be stronger than those of adjacent years. The maximum annual mortality rate of 30% was experienced by the age 15 and older fish (plus group) in 2017. The average age of fish harvested in the fisheries has increased from about 5 or 6 from 1986-1997, to 8-9 years old

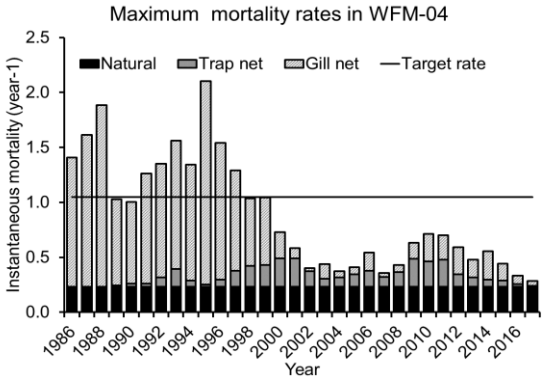
since late 2000s, though there some indication that this might be declining again. Harvest in 2017 was similar to 2015 and 2016, all of which are less than half of the total in 2014. Trap-net CPE continued to decline, and gill-net CPE declined to less than half the value in 2016. Both CPE values are at the lowest value in their respective time series, as declines continue since roughly 2006. Gill-net effort increased to nearly 5 million feet, while trap-net effort saw a decrease of almost 400 lifts. Issues with covariance persist from the previous year and could not be remedied. Improved diagnostics and performance earned this model a medium rating.

WFM-04 (Beaver Island) Kevin Donner









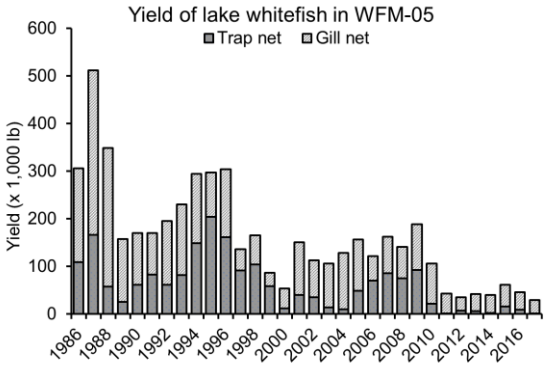
Parameter	Value
Base SSBR	3.35 lb
Current SSBR	0.67 lb
Target SSBR	0.64 lb
Current SPR	0.20
M	0.23 y^{-1}
F, trap net (2015-2017)	0.09 y^{-1}
F, gill net (2015-2017)	0.09 y^{-1}
Z (2017)	0.28 y^{-1}
Recommended Limit	459,724 lb
Actual Limit	320,400 lb
Model Rating	Medium

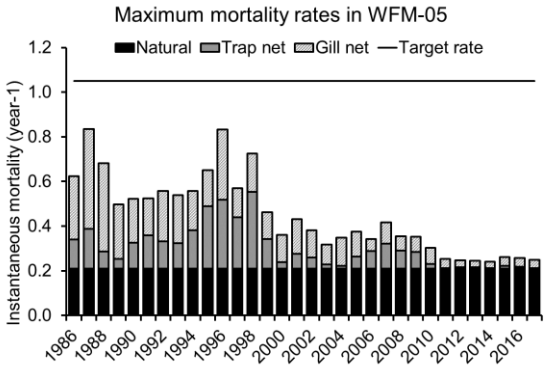
Notable Fishery Dynamics and Model Changes:

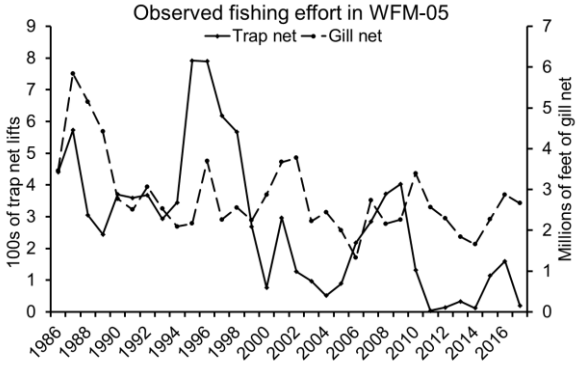
The 2019 model-generated harvest limit for WFM-04 is 460,000 lb. This estimate is 8% higher than the 2018 model estimated limit; an unexpected result given continued lack of young age classes and generally poor CPE. Gill-net selectivity is estimated using a lognormal function, selectivity is now fixed to address scaling issues that were estimating abundances beyond reasonable bounds. Effective sample size was reduced to 15 following MSC conversation. Population trends (declining biomass, abundance, etc) estimated in past years and observed in adjacent management units are similar to those observed in the current model. The maximum total annual mortality rate during 2017 was 28% at age 15. Yield declined to the lowest on record in 2017, surpassing historical low yield observed in 2016. Catch-

per-effort declined in both the gill-net and trap-net fisheries to all-time lows; however, these values are likely complicated by increasing lake trout abundances in the unit and management actions to reduce lake trout catch. Gill-net fisheries account for the majority of yield (70%) for the sixth year running and the target proportion of yield was adjusted to reflect the more recent trends. The model was rated medium and exhibited good fit and almost no retrospective patterns. Biological data is becoming scarce for this unit and the scale of the fishery may soon cause the model to "lose the signal" of the whitefish population.

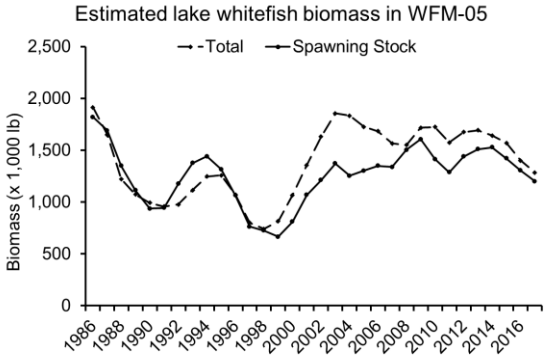
WFM-05 (Grand Traverse Bay) Nathan Barton

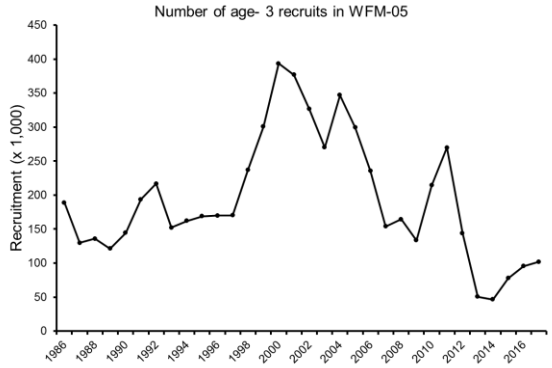






Parameter	Value
Base SSBR	3.52 lb
Current SSBR	0.70 lb
Target SSBR	0.48 lb
Current SPR	0.21
M	0.21 y^{-1}
F, trap net (2015-2017)	0.01 y^{-1}
F, gill net (2015-2017)	0.04 y^{-1}
Z (2017)	0.25 y^{-1}
Recommended Limit	352,307 lb
Actual Limit	264,150 lb
Model Rating	Medium

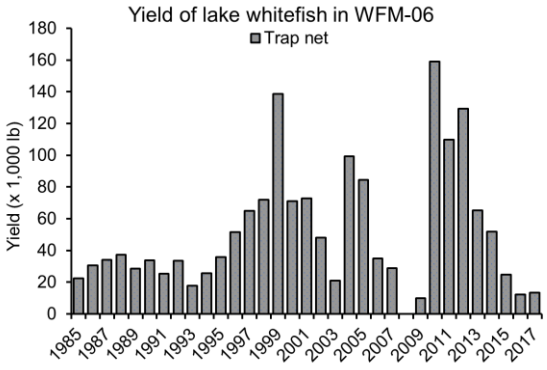


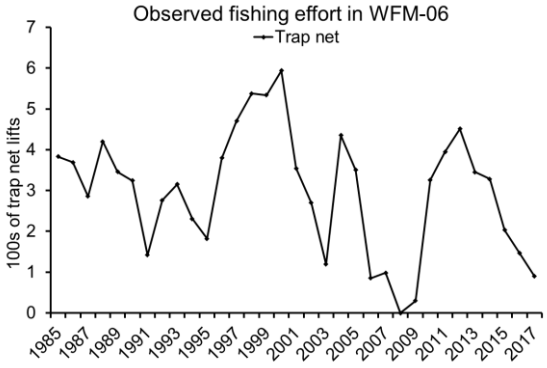


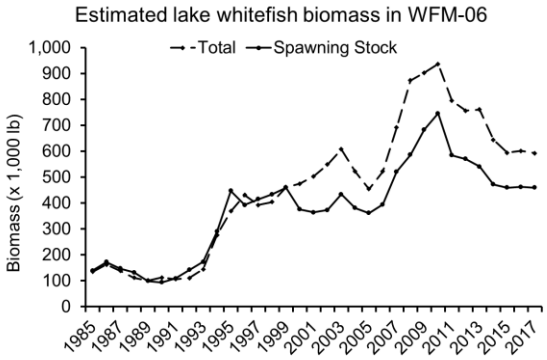
Notable Fishery Dynamics and Model Changes:

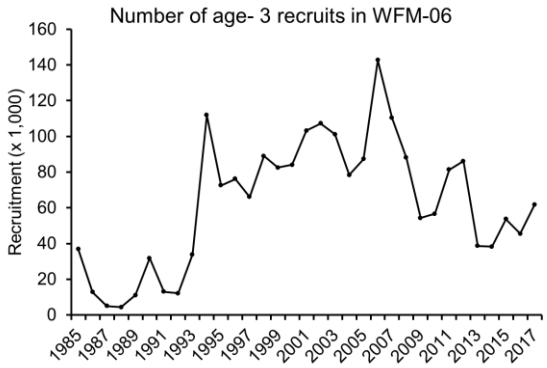
The 2019 model-generated harvest limit for WFM-05 is 352,000 lb, which is essentially unchanged from 2018. There were no structural modifications made to this model for the 2019 run. Francis' linear method for estimating effective sample size was applied to better capture the effective sample size for each fishery included in this model. This allowed the model to deviate age compositions in each respective fishery when sample sizes were low, and to allow for better model performance. In keeping with the recent transition in this unit from scales to otoliths as the major aging structure, the last three years of age composition data were again skewed toward older ages, causing a divergence in the last three years of retrospective patterns. The model was rated medium.

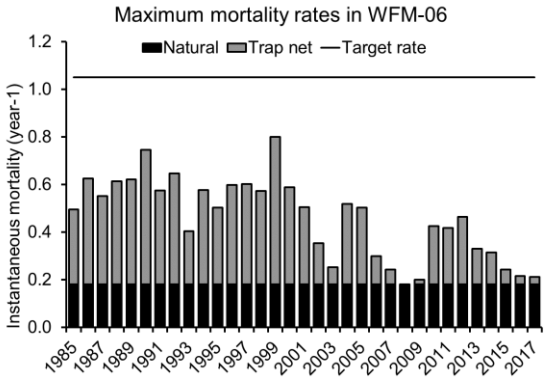
WFM-06 (Leland) Dave Caroffino









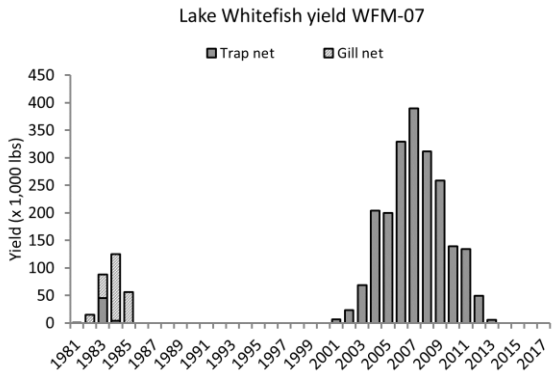


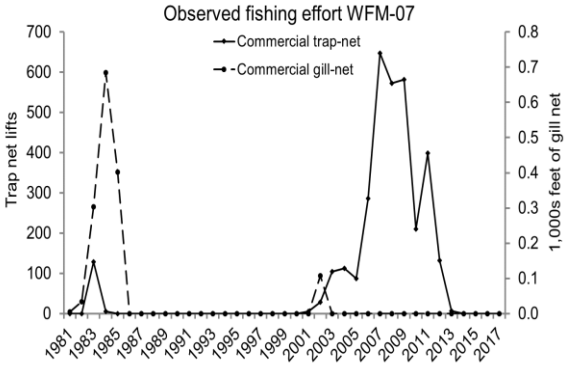
Parameter	Value
Base SSBR	4.92 lb
Current SSBR	0.98 lb
Target SSBR	0.56 lb
Current SPR	0.20
M	0.18 y^{-1}
F, trap net (2015-2017)	0.04 y^{-1}
Z (2017)	0.21 y^{-1}
Recommended Limit	171,000 lb
Actual Limit	125,000 lb
Model Rating	Medium

Notable Fishery Dynamics and Model Changes:

The changes to the WFM-06 model were consistent with others including updating the process by which the effective sample size for age compositions is estimated. This unit has a small population and a small fishery and has been data limited at various points throughout the time series. Recent data suggest recruitment is occurring as young fish have been present in trap-net monitoring for multiple years. The present version of the model suggests that biomass has declined from its peak in 2010, but it has remained stable over the past four years. Mortality is low in this unit, barely reaching 20% on the most vulnerable age in 2017. Catch rates increased in 2017 for the first time since 2010. It was recommended that the constant catch level of 125,000 be adopted as the limit for 2019. Model performance was consistent with past assessments and rated medium.

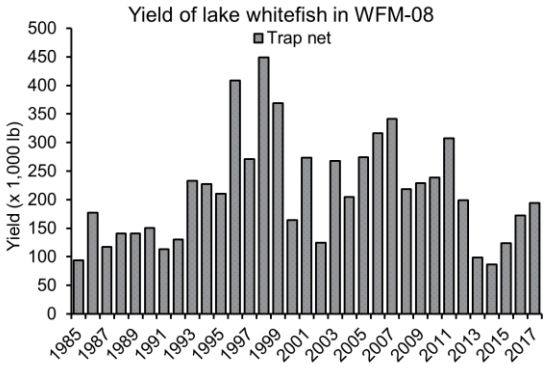
WFM-07 (Manistee to Pentwater)

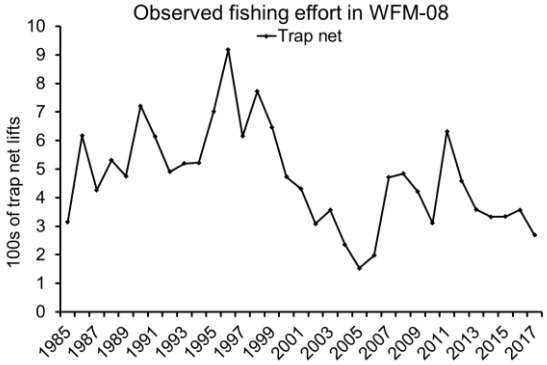


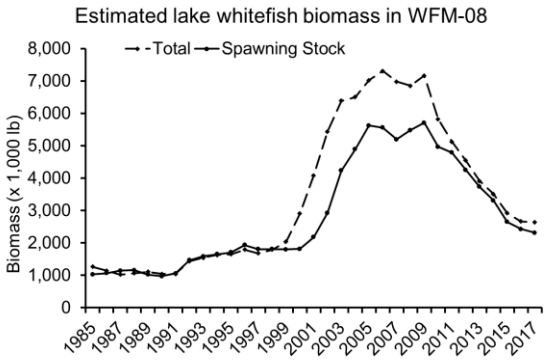


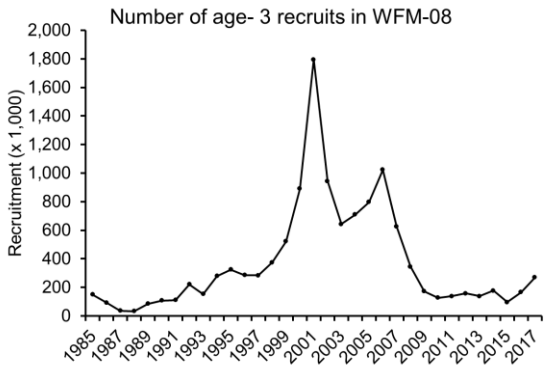
No stock assessment model has been developed for WFM-07. When the Consent Decree was initially signed, this unit lacked the necessary time series of data to populate a model. Fishing effort and yield in this unit peaked in 2007 and ceased in 2013. The HRG was reduced from 350,000 lb to 250,000 lb in 2019.

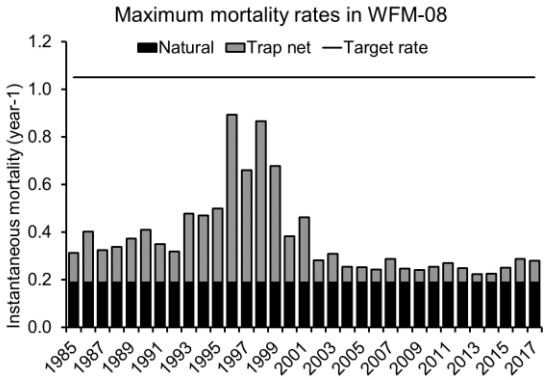
WFM-08 (Muskegon) Dave Caroffino











Parameter	Value
Base SSBR	4.51 lb
Current SSBR	1.24 lb
Target SSBR	1.24 lb
Current SPR	0.27
M	0.19 y^{-1}
F, trap net (2014-2016)	0.08 y^{-1}
Z (2016)	0.28 y^{-1}
Recommended Limit	768,000 lb
Actual Limit	500,000 lb
Model Rating	Medium

Notable Fishery Dynamics and Model Changes:

The changes to the WFM-08 model were consistent with those made for other units, including updating the process for estimating effective sample size. This unit is fished by a single operation, and both fishery monitoring data and model results suggest recruitment has been consistently low since 2009. The total proportion of the catch less than age 10 has not exceeded 15% in the past three years. Yield has increased the past four years, as have catch rates, which now equal their 2010 level (720 lb/lift). Mortality is still estimated to be low, not exceeding 25% on the most vulnerable ages, which is why the fishery can continue to persist on the high recruit classes of the late 90s and early 2000s. The constant catch level of 500,000 lb was recommended for a harvest limit in 2019. Model performance was consistent with past assessments and rated medium.