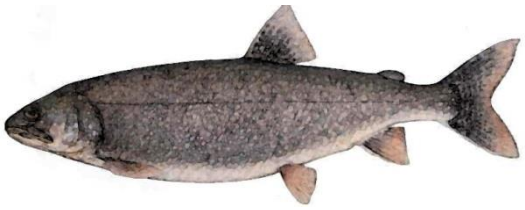
Technical Fisheries Committee Administrative Report 2020: Status of Lake Trout and Lake Whitefish Populations in the 1836 Treaty-Ceded Waters of Lakes Superior, Huron, and Michigan, with Recommended Yield and Effort Levels for 2020



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

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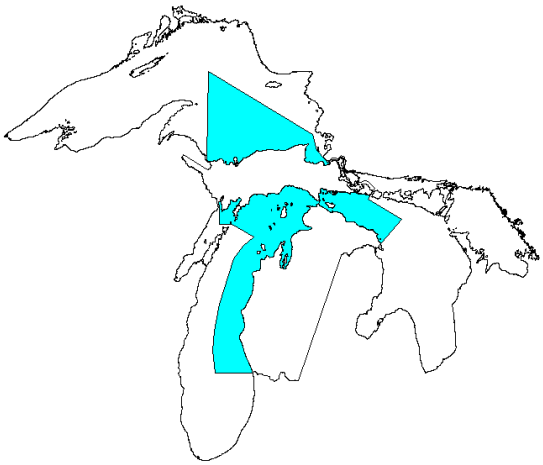

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EXECUTIVE SUMMARY

Prepared by David C. Caroffino and Michael J. Seider

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 2020, are provided in Table 1.

Table 1. 2020 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	124,571	124,571	NA
		MI-6	278,104	248,180	3,067,000
		MI-7	94,329	124,944	8,953,000
	Huron	MH-1	357,856	556,681	13,394,000
		MH-2	284,405	218,627	NA
	Michigan	MM-123	629,400	630,000	7,423,000
		MM-4	161,163	185,465	903,000
		MM-5	121,592	121,592	314,000
		MM-67	445,244	445,244	NA
Lake Whitefish	Superior	WFS-04	105,000	105,000	NA
		WFS-05	208,000	208,000	NA
		WFS-06	NA	137,700	NA
		WFS-07	451,400	451,000	NA
		WFS-08	71,600	165,800	NA
	Huron	North Huron	478,600	379,000	NA
		WFH-05	NA	295,500	NA
	Michigan	WFM-01	1,524,000	1,524,000	NA
		WFM-02	620,700	204,000	NA
		WFM-03	906,900	450,225	NA
		WFM-04	467,500	240,300	NA
		WFM-05	183,000	198,000	NA
		WFM-06	83,900	125,000	NA
		WFM-07	NA	225,000	NA
		WFM-08	390,200	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 2018. Estimates from SCAA models for Lake Trout are derived from data through 2019.

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.

In Lake Superior, Lake Trout have experienced low mortality and population trends have been driven by recruitment. In MI-5, the 2011-year class of Lake Trout (age 9 in 2020) remains one of the strongest recorded over the past 40 years. The 2019 recruitment survey had the second highest catch rate ever observed, suggesting that recruitment of the 2014- and 2015-year classes may also be particularly strong. In MI-6, the present assessment model suggests the 2013-2015 year classes are the strongest on record; however, in both units these year classes have not yet recruited to the spawning population, and more data will be useful to gauge their absolute magnitude. However, the present trajectories of both units are positive. The harvest limit in MI-6 was set using the 15% rule as described in the 2000 Consent Decree. The TFC did not reach consensus to increase the limit up to the model recommendation as some uncertainty exists with regard to the size of the incoming year classes. The Lake Trout population in MI-7 has not experienced the same levels of recruitment, but rather it has remained stable, as has the estimated population size. The 15% rule was also used in this unit to keep the harvest limit from being reduced by more than that level. The decline in model-estimated limit was not due to a negative trajectory in population status, rather the model has suffered from a lack of recreational and commercial monitoring data in recent years, which has caused some instability in model scaling. Yield in all of the Lake Superior units has consistently been well below the maximum levels established by the 2000 Consent Decree. The most recent estimates of Sea Lamprey induced mortality are all lower than the previous year and all below 0.08.

After years of changes to account for a shifting population from one dominated by hatchery fish to one dominated by wild fish, the Lake Huron assessment model was structurally unchanged in 2020. Biomass of the spawning population has been estimated to be constant for nearly a decade and scaling issues that have plagued this model for a decade have more recently begun to improve. Mortality rates in Lake Huron are low, estimated to be less than 30% for the last two decades, which is much more similar to Lake Superior than Lake Michigan. Recruitment of stocked fish has continued to decline, but uncertainties about wild fish remain for the year classes produced since 2013. The harvest limits produced from the Lake Huron assessment model come from calculating population size for each geographic area (Ontario, MH-1, and MH-2) within the overall assessment, according to the area of Lake Trout habitat (surface acres of water less than 240 feet deep). The limits produced by the projection model in 2020 were less than 2% different than those produced in 2019. The actual limit for 2020 in MH-1 was set by a stipulation to the Consent Decree, which was agreed to by the Parties in August of 2019. The limit in MH-2 was set using the 15% rule, which limited the increase from 2019 to only that amount.

The dynamics of Lake Trout populations in Lake Michigan continue to vary based on location. Mortality has been above target in MM-123 and MM-4 for nearly every year of the 2000 Consent Decree. High levels of stocking have sustained populations. An adjustment to natural

mortality in MM-5 (setting to 0.2) has brought overall mortality in this unit in line with MM-67 and in both units, it has averaged less than 30% for the majority of the Decree. Estimates of Sea lamprey induced mortality are highest in MM-123, but nearly non-existent in the rest of Treaty waters in Lake Michigan. Natural reproduction of Lake Trout continues to increase in Lake Michigan, although most of the gains are coming in the southern portion of the lake. Recent cohorts that are beginning to recruit to survey and fishing gear in MM-67 are made up of at least 25% wild fish, and the youngest cohorts captured may be as high as 75% wild fish, although more observations in future years will refine the estimates. In MM-123, the proportion of wild fish remains at background levels. Yield has largely remained stable in Lake Michigan in recent years, although a regulation change in MM-4 as a result of the State of Michigan exceeding the 2018 harvest limit, substantially reduced the 2019 recreational harvest in Grand Traverse Bay. The 2020 harvest limits for Lake Michigan were set by stipulation of the parties in MM-123 and MM-4, but the model-estimated values were used in MM-5 and MM-67.

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 Lake Superior unit WFS-04 spans both the 1836 and 1842 Treaty areas, with more harvest coming from the 1842 area in the western portion of the unit. Recruitment has declined in this unit over the past decade, which has resulted in a commensurate decline in biomass. Young fish remain a part of the commercial catch, and more sampling data would help refine estimates of population size and trends in this unit. Similarly, in the adjacent WFS-05 unit, data have been lacking in recent years. The estimates of recruitment remain stable; however, more sampling of fish in this unit is necessary to increase confidence in population trends. Mortality in the western portion of the 1836 Treaty waters is low.

Further east in Lake Superior, in WFS-06, an assessment model has not been updated in more than a decade. This area (Grand Marais) has a small and sporadic fishery that is difficult to sample and the lack of monitoring data has been prohibitive.

In eastern Lake Superior, fisheries are more intense, and mortality is higher than in the western treaty waters. In WFS-07, the current assessment model estimates that recruitment has largely been stable since the early 1990s, but growth rates have declined, leading to some declines in biomass. Mortality has not exceeded target levels during the present Consent Decree, but it has exceeded 50% in each of the last five years. In WFS-08, recruitment has been increasing in the recent decade, and a strong 2012 year class is helping to maintain population biomass. However, increased yield has resulted in mortality rates that have far exceeded the target levels. While in many areas within the 1836 Treaty waters the age composition of Lake Whitefish populations has been expanding, in this unit, less than 1% of sampled fish have exceeded age 8 since 2016. More commercial monitoring data is required to better refine the scale of mortality.

In northern Lake Huron Treaty waters (WFH-01 thru WFH-04), the long-term declines in recruitment and biomass appear to have ceased. Based on recent data, recruitment has stabilized, with the same holding true for biomass. The stable levels of recruitment observed in recent years are only about 15% of the peak observed in the mid-1990s. The recent level of biomass is estimated to likewise be about 85% lower than the mid-1990s peak. Each additional year of yield continues to be near the lowest recorded in the modern era; however, declines should cease, as the population appears to have stabilized at its present level. Commercial monitoring data suggests the age composition of the population is a balanced mix of young and old fish, although the strong year classes produced on the downward trend of the early 2000s have largely worked their way out of the fishery. Fishery yield from WFH-05 increased more than two-fold from 2016 to 2018; however, commercial monitoring data remain lacking, which has prevented completion of an assessment model with satisfactory diagnostics. The population in this area can only be assessed if data collection consistently improves in the years to come. Some attempts were made to

incorporate the harvest and effort data from WFH-05 into the assessment model for northern Lake Huron. This presents an alternative way to evaluate Lake Whitefish throughout the Treaty waters of Lake Huron, and this model is described in this report; however, it is still in development.

Lake Whitefish recruitment patterns are similar throughout Lake Michigan. Declines from all-time highs began in the late 1990s and early 2000s and continued until recent years. In many areas, recruitment appears to have stabilized at levels approximately 25% of the highs of two decades ago. Trends in biomass follow those of recruitment. As a result of lower abundance, yield is at the lowest level in the modern era. In some areas, smaller population sizes have allowed growth rates to improve over those observed a decade ago. Mortality rates in Lake Michigan are well below the 65% target prescribed by the Consent Decree. The TFC recommended continuance of the conditional constant catch policy for units WFM-06 and WFM-08 in 2020, 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.

Lake Trout movement matrix in Lake Michigan

Lake Trout assessment models in Lake Michigan use the number of fish stocked as a data input for recruitment. However, fish do not necessarily recruit to populations in the same location that they are stocked. Since 2011, all Lake Trout stocked in Lake Michigan have had a coded wire tag that denotes their stocking location. The USFWS has collected tags from captured fish to determine movement from the locations of stocking to the locations of capture. This analysis has resulted in an adjustment to what the MSC refers to as the "movement matrix," which helps improve estimates of recruitment to each management unit, beyond what would occur if only the number stocked in each unit were used. This movement matrix had not been updated since its original creation in the late 1990s. Significant efforts by Matt Kornis (USFWS) have allowed for the creation of a new matrix that was used for the 2020 Lake Michigan Lake Trout assessments. The movement patterns observed two decades ago have generally remained to the present day; however, one deviation was that fewer Lake Trout from MM-3 moved into other management units. This new matrix will continue to be used moving forward.

Wild Lake Trout in Lake Michigan assessments

Given the increasing presence of wild Lake Trout in portions of Lake Michigan, the SCAA models for MM-4, MM-5, and MM-67 have been adjusted in a manner similar to the way a transition from stocked to wild fish was initially handled in Lake Huron. The wild fish have been removed from the data sources that are used to populate the SCAA models. The result is that population dynamics are only being assessed for hatchery fish. Prior to the projection of a harvest limit, the estimates of hatchery-fish abundance at each age are adjusted based on the proportion of wild fish observed within each cohort.

Stock boundaries

In past years, the MSC has combined some assessment models in Lake Huron for both Lake Whitefish and Lake Trout. In Lake Michigan, data analysis has suggested that management unit MM-5 may not be a discrete unit. Movement of Lake Trout stocked within MM-5 differs by stocking location. Fish stocked in the southern portion of the unit move south and mix with fish from MM-67. Those stocked in the northern portion of the unit, remain in place, or to a lesser extent move north into MM-123. The MM-5 assessment model has routinely been a poor performer, and this discovery of movement differences could be a contributing factor. Preliminary analysis of an assessment including MM-67 and data from the southern portion of MM-5 has shown promise and should be considered in the future. Further scrutiny of stock boundaries of other units in all three lakes is warranted to ensure assessment boundaries accurately reflect populations, to the extent possible.

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 SO-11. 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 SO-11 and SO-12. 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 SO-12, 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.

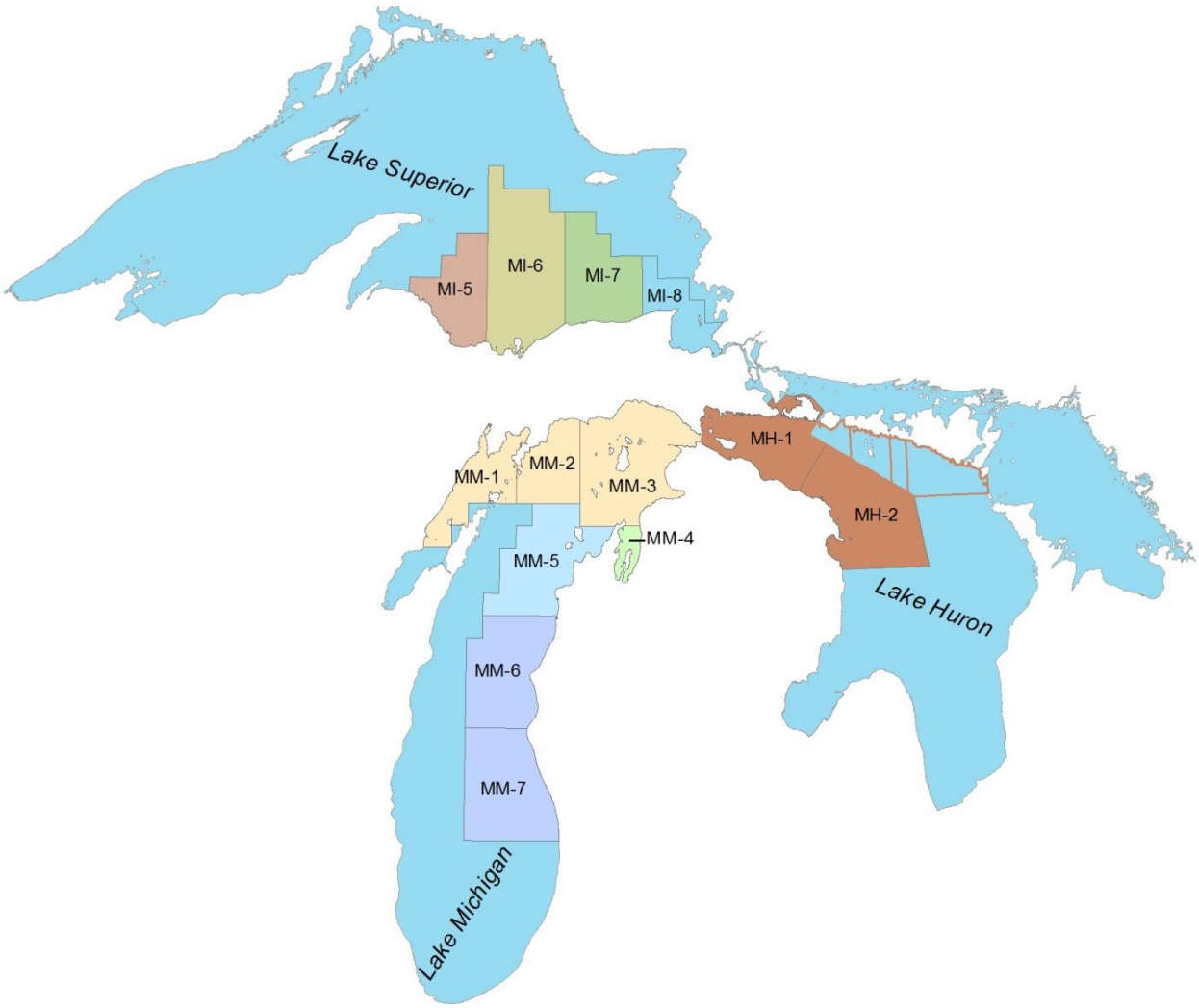


Figure 1. Lake Trout Management Units. Shading denotes units subject to provisions of the 2000 Consent Decree. Like shading indicates where statistical districts have been combined into a single management unit for stock assessment purposes. In the case of Lake Huron, outlined areas adjacent to statistical 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.

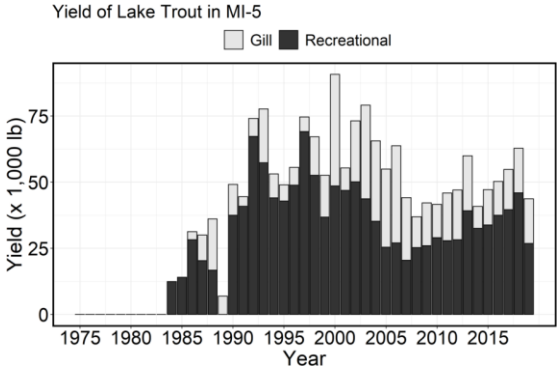
Species	Lake	Management unit	Total Area (ha)	Area<= 80m (ha)
Lake Trout	Superior	MI-5	374,100	117,000
		MI-6	803,300	105,100
		MI-7	459,300	157,800
	Huron	MH-12	1,073,800	563,000
		OH-1*	353,800	196,300
	Michigan	MM-123	1,293,200	910,200
		MM-4	66,100	50,200
		MM-5	548,000	125,400
		MM-67	1,155,500	270,200
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

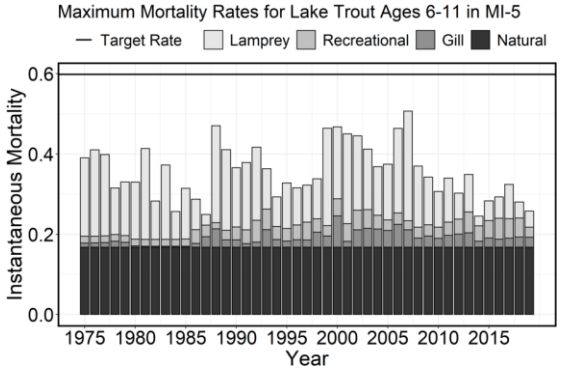
*Ontario statistical district OH-1 presented as a surrogate for the three Ontario quota-management areas (4-1, 4-2 and 4-3) included in the North-Central Lake Huron (MH-12) model.

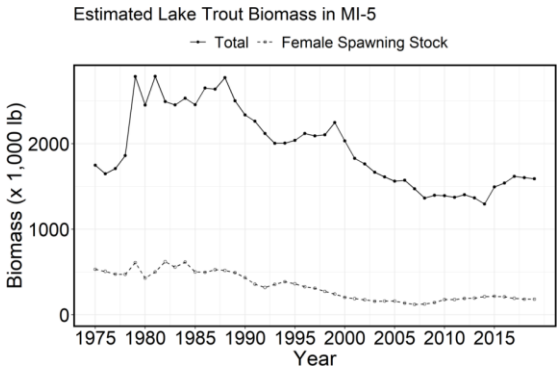
STATUS OF LAKE TROUT POPULATIONS

Lake Superior

MI-5 (Marquette) **Shawn Sitar**

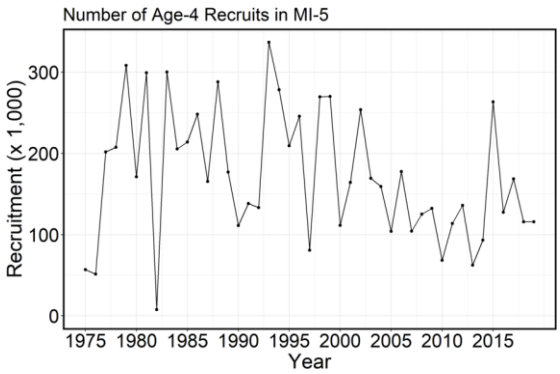






Parameter[(1)]	Value
Base SSBR	4.72 lb
Current SSBR	1.73 lb
Target SSBR	0.34 lb
Current SPR	0.37
M	0.17 y^{-1}
F, Commercial (2017-2019)	0.01 y^{-1}
F, Recreational (2017-2019)	0.03 y^{-1}
Sea Lamprey Mort (2016-2018)	0.04 y^{-1}
Z (2019)	0.22 y^{-1}
Recommended Limit	124,571 lb
Actual Limit	124,571 lb
Model Rating	Medium

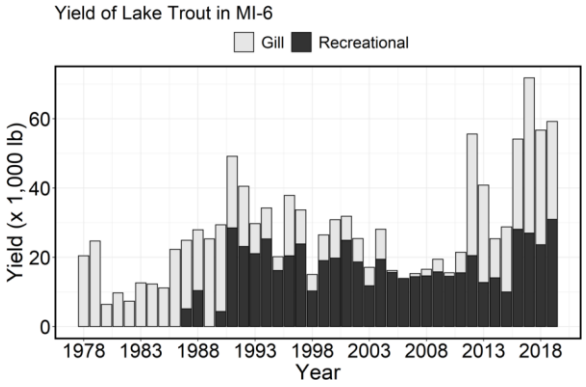
(1) For this table and all subsequent tables in this section, mortality rates represent averages for Lake Trout ages 6-11.

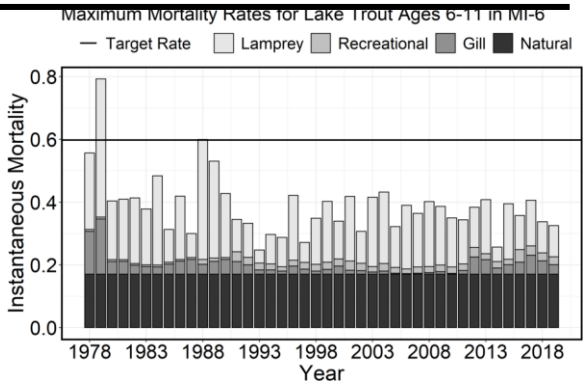


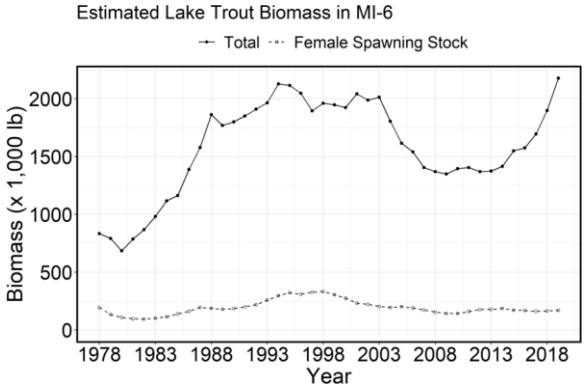
Notable Stock Dynamics and Model Changes:

Lake trout abundance has progressively declined since the late 1990s but has resurged since 2015. The decline and resurgence in abundance was driven by recruitment. Sea lamprey-induced mortality has declined since 2007 and remains at a low rate similar to the mid-1990s. Recreational harvest averaged 9,100 fish during 2017-2019. Commercial yield averaged 16,300 lb during 2016-2018 and has declined by over 60% since 2006. Total annual mortality averaged 22% in the last three years. The model harvest limit in 2020 increased by 8% from 2019 due to a slight increase in abundance.

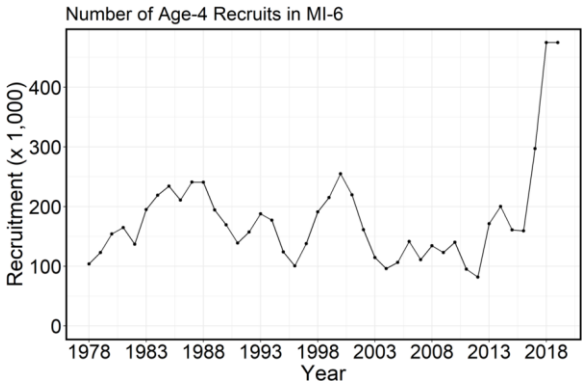
MI-6 (Munising) — Shawn Sitar







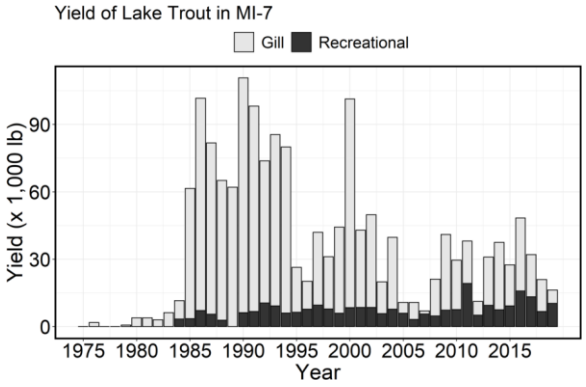
Parameter	Value
Base SSBR	4.14 lb
Current SSBR	1.25 lb
Target SSBR	4.59 lb
Current SPR	0.30
M	0.17 y^{-1}
F, Commercial (2017-2019)	0.03 y^{-1}
F, Recreational (2017-2019)	0.02 y^{-1}
Sea Lamprey Mort (2016-2018)	0.09 y^{-1}
Z (2019)	0.29 y^{-1}
Recommended Limit	278,104 lb
Actual Limit	278,104 lb
Model Rating	Medium

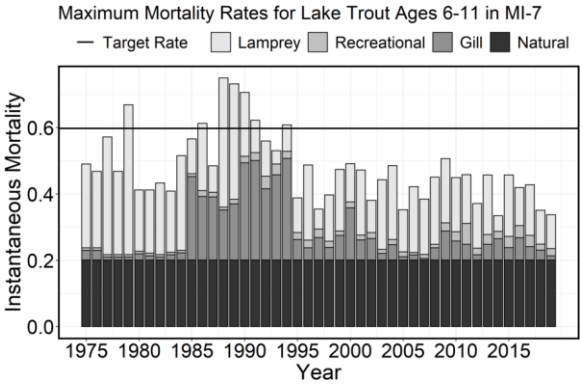


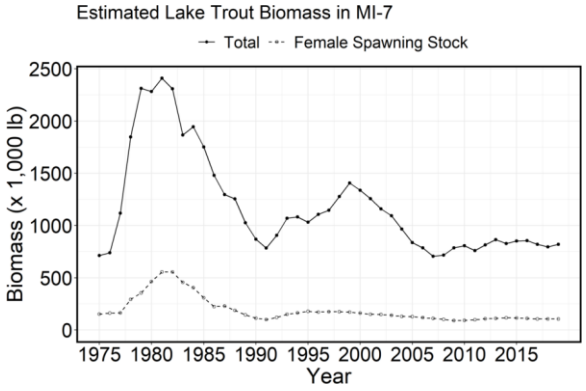
Notable Stock Dynamics and Model Changes:

Recent abundance has increased due to surges in recruitment starting with the 2012-year class. More data are needed to scale the most recent estimates of recruitment. Sea lamprey predation remains the dominant source of mortality. Total annual harvest has increased in the last four years with recreation harvest averaging 5,900 fish and the commercial yield averaging 35,400 lb. Total annual mortality averaged 27% in the last three years. The 2020 harvest limit for MI-6 increased by 29% from last year due to recent increases in abundance.

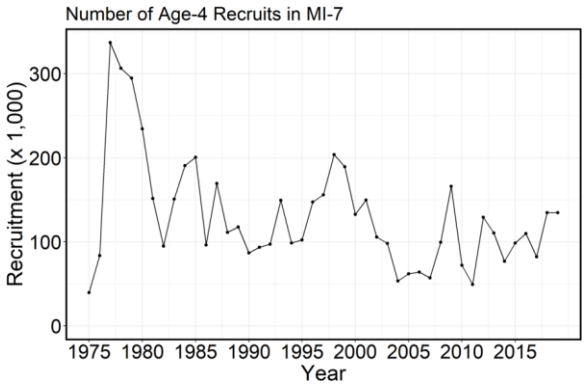
MI-7 (Grand Marais) Shawn Sitar







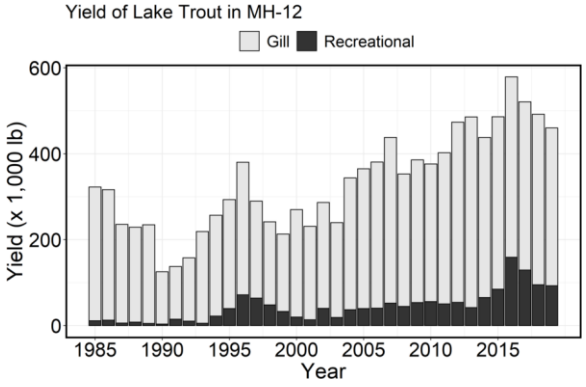
Parameter	Value
Base SSBR	2.81 lb
Current SSBR	1.17 lb
Target SSBR	0.64 lb
Current SPR	0.41
M	0.20 y^{-1}
F, Commercial (2017-2019)	0.02 y^{-1}
F, Recreational (2017-2019)	0.01 y^{-1}
Sea Lamprey Mort (2016-2018)	0.09 y^{-1}
Z (2019)	0.30 y^{-1}
Recommended Limit	94,329 lb
Actual Limit	124,944 lb
Model Rating	Low

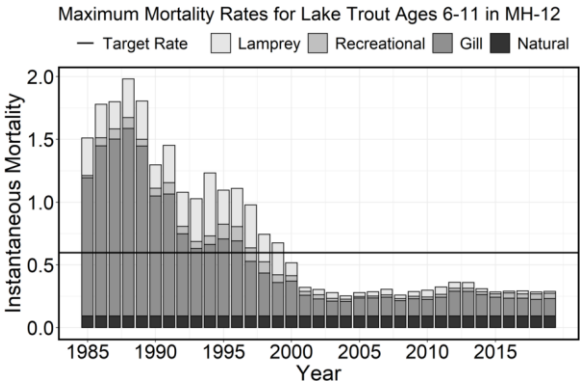


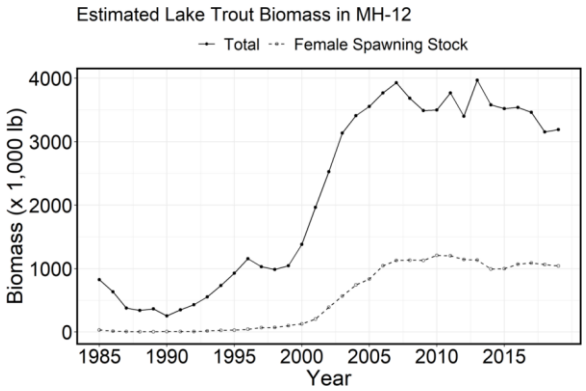
Notable Stock Dynamics and Model Changes:

The 2020 harvest limit for MI-7 was based on a full run of the assessment model. The harvest limit declined by 33% because the current model estimated overall lower abundance than had been estimated in previous models. Data are lacking for this unit and increasing the quality and quantity of data will improve the assessment. Commercial yield averaged 12,700 lb during 2017-2019. Average recreational harvest in the last three years was 2,500 fish. Sea lamprey predation remains the highest mortality source since 2001. Total mortality is low and averaged 28% between 2017 and 2019.

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

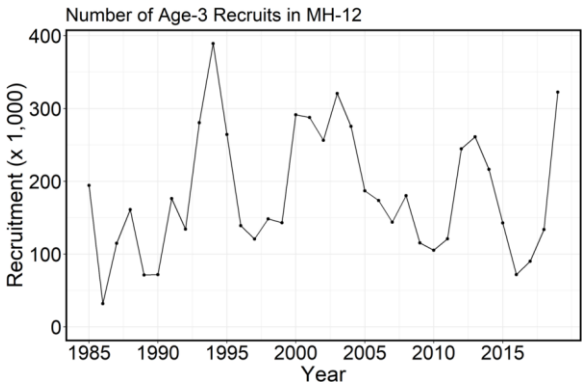






Parameter	Value
Base SSBR	30.72 lb
Current SSBR	5.94 lb
Target SSBR	n/a*
Current SPR	0.19
M	0.09 y^{-1}
F, Commercial (2017-2019)	0.13 y^{-1}
F, Recreational (2017-2019)	0.04 y^{-1}
Sea Lamprey Mort (2016-2018)	0.02 y^{-1}
Z (2019)	0.27 y^{-1}
Recommended Limit	642,261 lb
Actual Limit	775,308 lb
Model Rating	Medium

**Target mortality rates differ between MH-1 and MH-2. Target SSBR in MH-1 is 1.51 lb and in MH-2 it is 2.02 lb.*

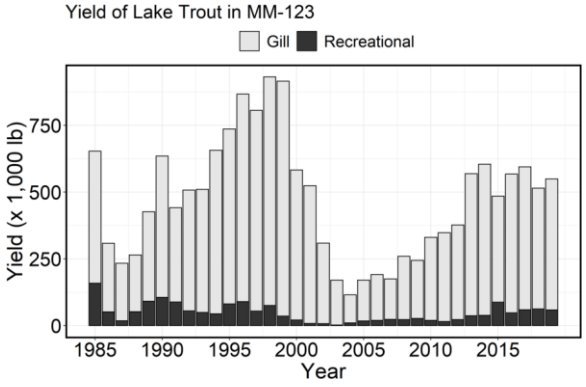


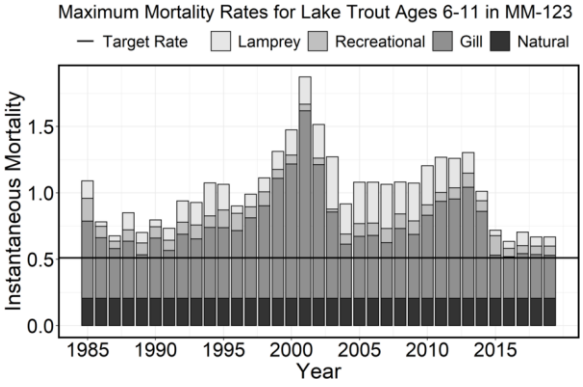
<u>Notable Stock Dynamics and Model Changes:</u>

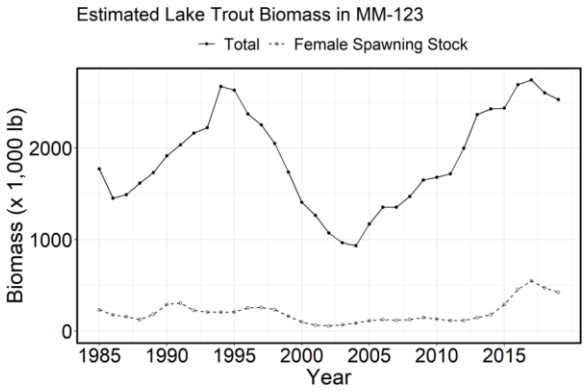
No changes were made to the model structure that was used in 2019. Ontario data (harvest, effort, and biological data) were not provided for the 2020 model run. Wild and hatchery recruits were estimated separately using the wild ratio for each year class, which was calculated based on observations of wild fish at age from all data sources. Female spawning biomass has been steady, even though total biomass has slightly declined. The decline in total biomass appears to be due to a reduction in recruitment of hatchery fish. Wild recruitment has increased from 7,200 fish to over 160,000 fish between 2002 and 2013. The observed maximum age in the population expanded from age 11 in 1995 to 29 in 2019, indicating that annual mortality

has been consistently low in the past two decades. Model performance has improved, and retrospective patterns in the most recent three years show very little pattern. Harvest limits from the assessment model are very similar to 2019.

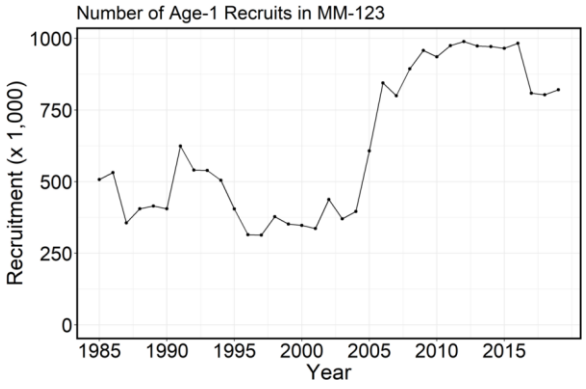
Lake Michigan
MM-123 (Northern Treaty Waters) Ted Treska







Parameter	Value
Base SSBR	4.44 lb
Current SSBR	0.80 lb
Target SSBR	1.27 lb
Current SPR	0.18
M	0.21 y^{-1}
F, Commercial (2017-2019)	0.24 y^{-1}
F, Recreational (2017-2019)	0.05 y^{-1}
Sea Lamprey Mort (2016-2018)	0.07 y^{-1}
Z (2019)	0.57 y^{-1}
Recommended Limit	629,400 lb
Actual Limit	630,000 lb
Model Rating	Medium

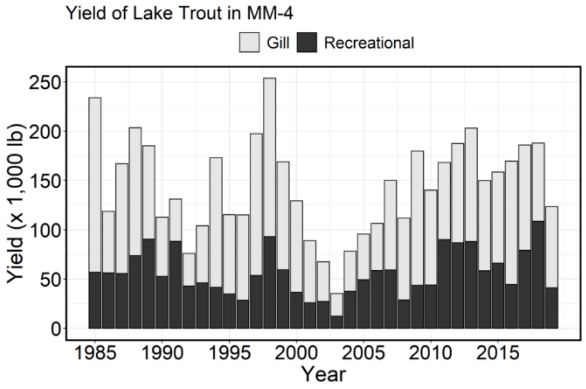


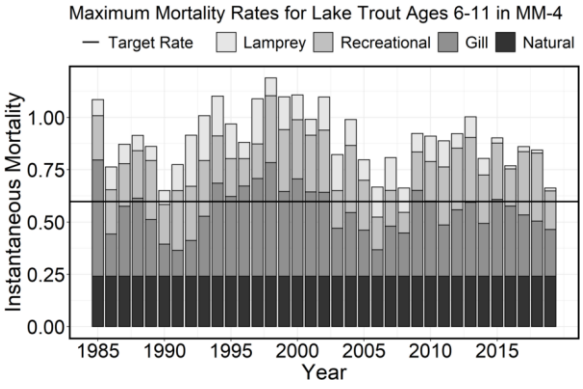
Notable Stock Dynamics and Model Changes:

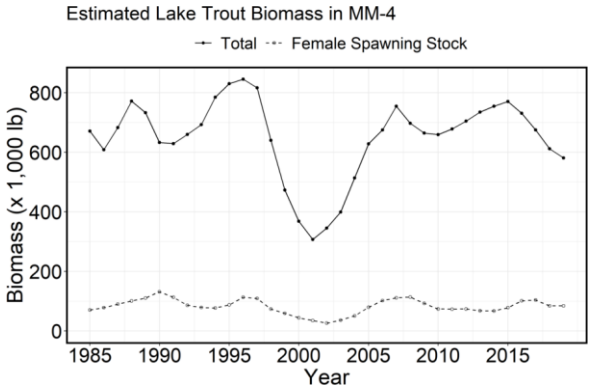
This unit has undergone minor changes since last year and most improvements were consistent with the other Lake Michigan models. The iterative process was used to set the effective sample size, and the survey selectivity was changed to a gamma (lognormal was producing linear relationships that were not logical). The model resulted in an increase in the recommended harvest limit to 629,400 lb. A sustained reduction in estimated sea lamprey mortality over the last few years has resulted in increases in estimated Lake Trout numbers. All fisheries indicate the continuation of the previously very strong 8-year-old cohort along with better representation of younger age classes

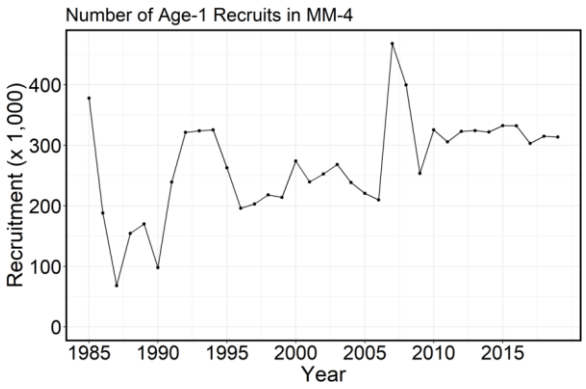
pushing up biomass estimates. Last year's concern over the lack of signal of any younger cohorts is somewhat allayed by increased presence of two- and three-year old fish in 2019, at levels much higher than the previous years. Overall, commercial yield in 2019 was very similar to 2016-2018, while effort in commercial fishery increased slightly. Effort in the recreational fishery declined slightly and recreational harvest was essentially the same as 2017-18. Model performance was similar to the prior year, although diagnostics continue to improve.

MM-4 (Grand Traverse Bay) Stephen Lenart









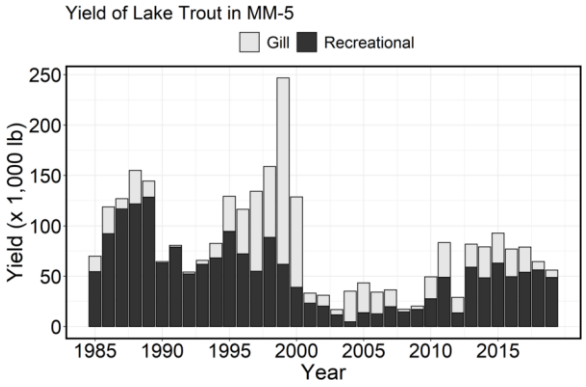
Parameter	Value
Base SSBR	1.54 lb
Current SSBR	0.26 lb
Target SSBR	0.31 lb
Current SPR	0.17
M	0.24 y^{-1}
F, Commercial (2017-2019)	0.22 y^{-1}
F, Recreational (2017-2019)	0.24 y^{-1}
Sea Lamprey Mort (2016-2018)	0.01 y^{-1}
Z (2019)	0.60 y^{-1}
Recommended Limit	161,163 lb
Actual Limit	185,465 lb
Model Rating	Medium

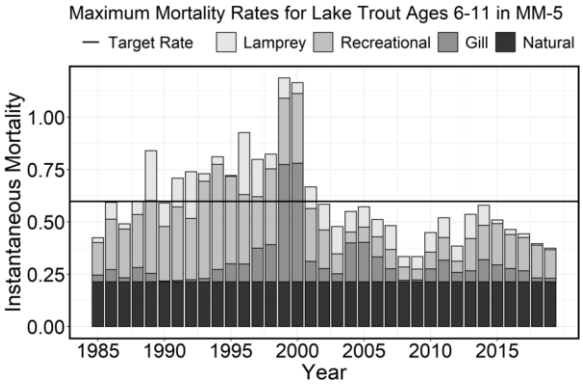
Notable Fishery Dynamics and Model Changes:

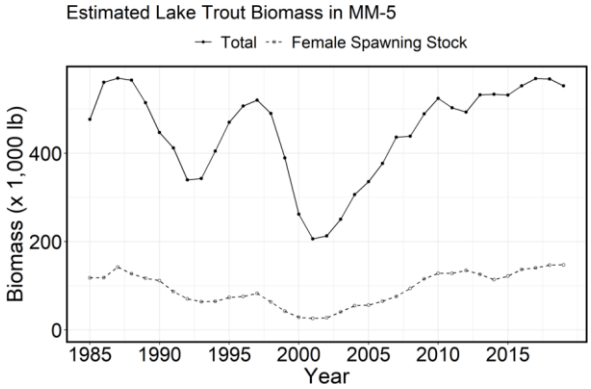
Most data sources indicate that the Lake Trout population in Grand Traverse Bay has been fairly stable for the last decade, a result of consistent stocking and consistent fishery yields that had ranged between 150,000 lb and 200,000 annually for all but one year during 2009-2018. Such yield levels, however, are associated with mortality that is above the target rate. Yield declined in 2019 to the lowest value observed since 2008 due to a regulation change that reduced the recreational fishery bag limit from two to one fish. The average mortality rate for fish ages 6-11 was right at the target rate (45%) in 2019, despite sea lamprey induced mortality being the lowest in the time series - remaining below 0.05 yr^{-1} for the fourth consecutive year. Despite this, the population age structure has expanded only modestly during

this time period. Due to an increasing incidence of unclipped fish in the population, data streams for the 2020 assessment data cycle were updated to include only hatchery fish beginning with the 2014 data year, the year that coincided with consistent observation of unclipped fish across all data sources. In addition, the 2020 assessments for Lake Michigan incorporated revised movement estimates for stocked fish based on analyses of CWT tag returns since the inception of the mass marking program. The model generated harvest limit for 2020 is 161,163 lb, after inflating the numbers at age in the projection model to account for the incidence of wild fish. This represents a 25% increase in the model-generated limit.

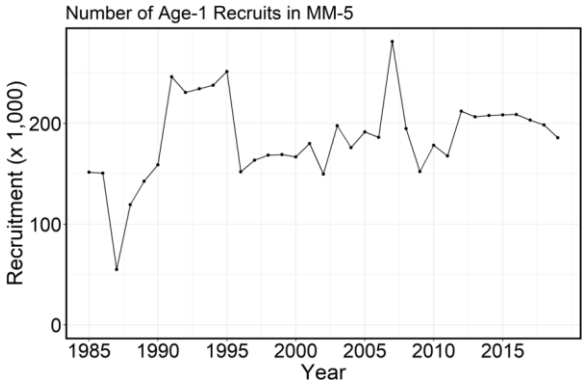
MM-5 (Leelanau Peninsula to Arcadia) Stephen Lenart







Parameter	Value
Base SSBR	1.76 lb
Current SSBR	0.77 lb
Target SSBR	0.34 lb
Current SPR	0.43
M	0.21 y^{-1}
F, Commercial (2017-2019)	0.02 y^{-1}
F, Recreational (2017-2019)	0.10 y^{-1}
Sea Lamprey Mort (2016-2018)	0.01 y^{-1}
Z (2019)	0.33 y^{-1}
Recommended Limit	121,592 lb
Actual Limit	121,592 lb
Model Rating	Low

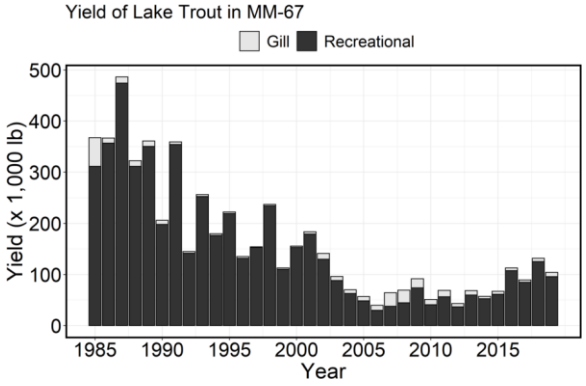


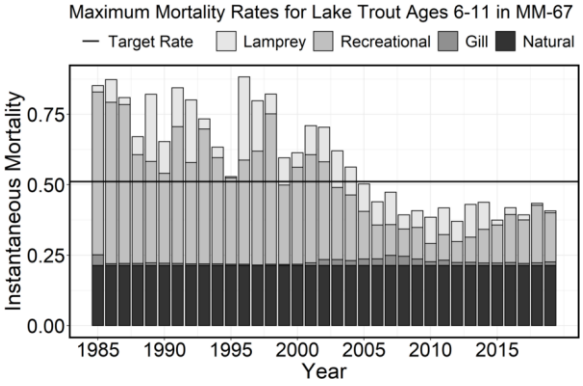
Notable Fishery Dynamics and Model Changes:

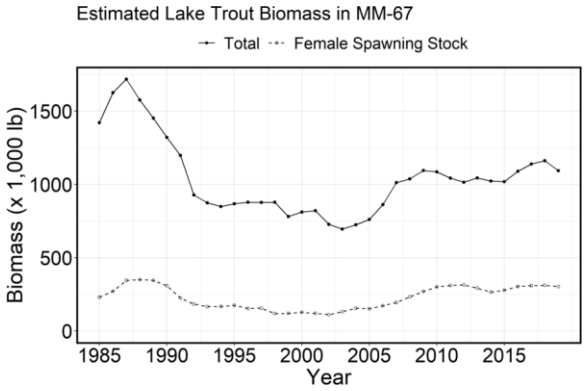
The most recent assessment for unit MM-5 suggests spawning biomass is near the highest in the time series, the result of low estimated mortality over the past nearly fifteen years (28% in 2019), including a dramatic decline in sea-lamprey-induced mortality over the past five years (to <0.01 yr^{-1} in 2018). Total annual yield, which had been stable around 75,000 lb during 2013-2017, declined for the second consecutive year to just over 50,000 lb in 2019. This reduction can be attributed to the absence of a commercial fishery during 2018-2019. Recreational fishery harvests have been fairly stable since 2013, despite declining effort, indicating an increase in catch rates. These increasing catch rates can be attributed to

both a higher abundance of Lake Trout, as well as more fishing effort being allocated toward Lake Trout as the abundance of Chinook Salmon has declined. The MM-5 stock assessment is characterized by being unstable, with uncertain scaling (low rating), a likely product of combining information from two areas (Frankfort and Leland) with quite different dynamics when it comes to Lake Trout. As was the case in MM-4, model changes include the use of hatchery-only fish as well as the new movement matrix for the recruitment of stocked fish. Unlike MM-4, the MM-5 model uses a hard-coded prior for natural mortality (0.2) and a fixed parameter for survey selectivity, both of which could be considered strong assumptions. The model-generated harvest limit increased by 8% (to 121,591 lb) after adjusting for wild fish in the population.

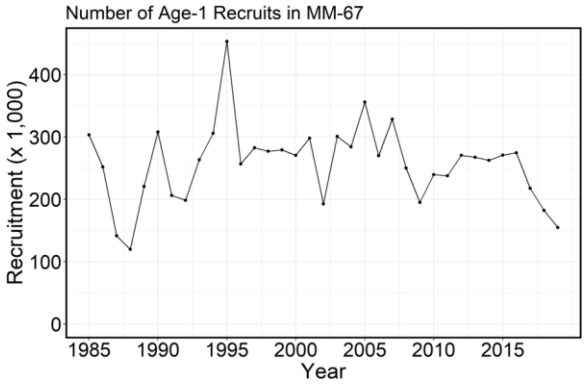
MM-67 (Southern Treaty Waters) Stephen Lenart







Parameter	Value
Base SSBR	2.69 lb
Current SSBR	1.18 lb
Target SSBR	0.31 lb
Current SPR	0.44
M	0.21 y^{-1}
F, Commercial (2017-2019)	0.01 y^{-1}
F, Recreational (2017-2019)	0.14 y^{-1}
Sea Lamprey Mort (2016-2018)	0.01 y^{-1}
Z (2019)	0.36 y^{-1}
Recommended Limit	445,244 lb
Actual Limit	445,244 lb
Model Rating	Medium



Notable Fishery Dynamics and Model Changes:

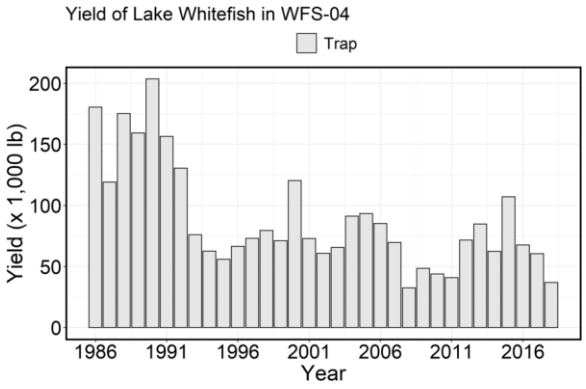
Certain patterns described for unit MM-5 are similar in MM-67 (declining recreational fishing effort but increased catch rates, recent low mortality, and spawning biomass near the time-series high), but ports in this management area are more intensely sampled and model stability is generally higher. The incidence of unclipped fish is higher here than units to the north (33% of both fishery and survey samples came from unclipped fish) and the youngest observed cohorts appear to be dominated by unclipped fish. The age composition is also broader here than in northern areas of the lake. Average mortality on fish ages 6-11 was 31% in 2019. As in units MM-4 and MM-5 the model was populated with only hatchery fish beginning with the 2014 data year and the new post-stocking movement estimates were applied

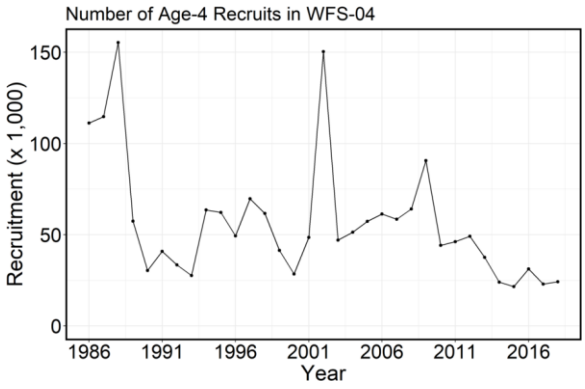
for estimating recruitment of stocked fish. As is the case with MM-5, the spatial scale of the assessment(s) in south-central treaty waters should be revisited, as should the modeling of commercial extractions (fishery has been inactive since early 2010s) given the sensitivity of the assessment to how fishing intensity is estimated. Of note to managers, stocking reductions that began in 2017 will begin to show an impact on the fishable stock within the next few years unless there is a commensurate increase in wild recruitment. The model-generated harvest limit increased by 42% (to 445,244 lb) after adjusting for wild fish in the population and correcting a technical error in the projection sheet that was traced back to 2011.

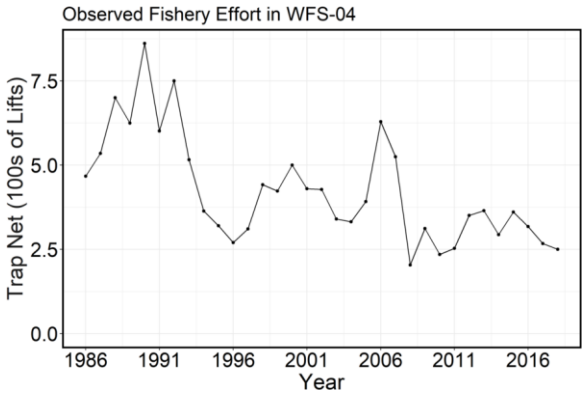
STATUS OF LAKE WHITEFISH POPULATIONS

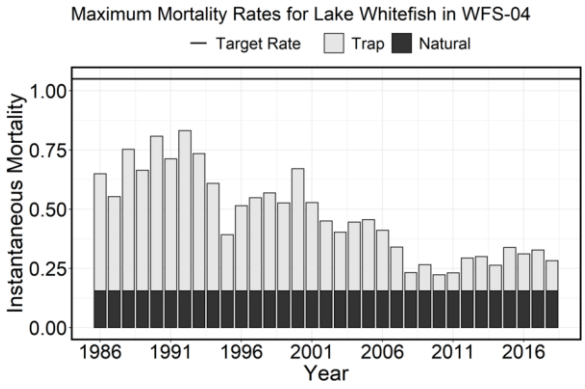
Lake Superior

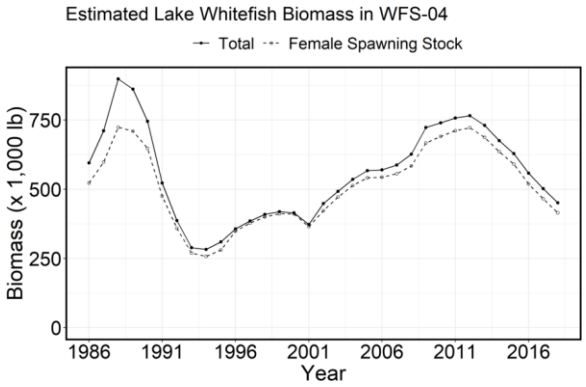
WFS-04 (Marquette-Big Bay) — Mike Seider











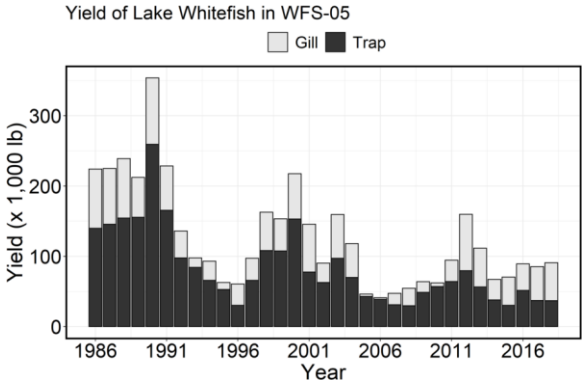
Parameter[(2)]	Value
Base SSBR	8.86 lb
Current SSBR	1.77 lb
Target SSBR	1.10 lb
Current SPR	0.20
M	0.15 y^{-1}
F, trap net (2016-2018)	0.15 y^{-1}
Z (2018)	0.28 y^{-1}
Recommended Limit	105,000 lb
Actual Limit	105,000 lb
Model Rating	Medium

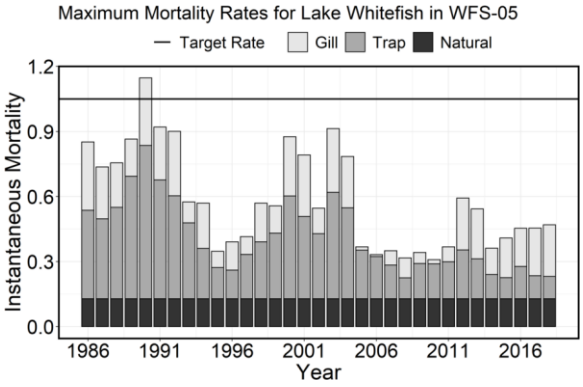
(2) For this table and all subsequent tables in this section, mortality rates represent averages for Lake Whitefish ages 6-11.

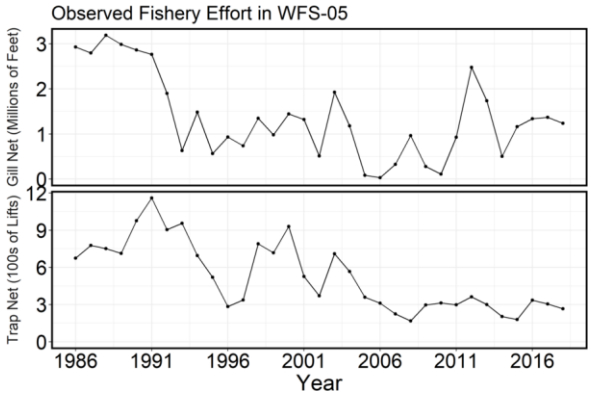
Notable Fishery Dynamics and Model Changes:
Lake whitefish biomass in WFS-04 increased steadily from the early 1990s to the late-2000s. Since about 2012, Lake Whitefish biomass has dropped due to declining

abundance and lower mean weight at age for older fish. Fishing mortality has slightly increased in recent years, but maximum total mortality rates have remained lower than in previous decades and well below the target value. Annual mortality rate (*A*) for the most vulnerable age class was 25% in 2018. The decline in abundance has been due to lower recruitment in recent years. Although estimated recruitment has been generally stable since 2014, it has been lower than in the 1990s and 2000s. There appear to be recent signs of higher recruitment, but those year classes are just becoming vulnerable to the trap net fishery. This assessment relies on the signal of the trap net only, thus there continues to be great uncertainty at the end of the time series. No structural changes were made to the model, but weight-at-age and length-at-age were re-estimated in 2018 with the R-based cohort growth model. Model diagnostics did not indicate any concerning problems and the assessment continues to provide stable results; thus, the assessment received a medium rating. The yield limit calculated for the entire WFS-04 management unit is 149,000 lb. After applying the prescribed reduction to reflect the proportion of this management unit that is outside of Consent Decree waters, the 2020 yield limit for Lake Whitefish in 1836 Treaty waters is 105,000 lb.

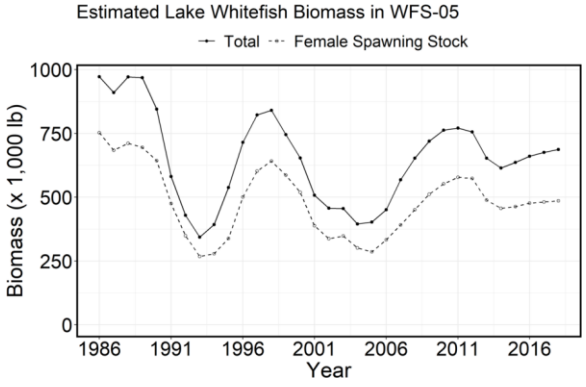
WFS-05 (Munising) Shawn Sitar

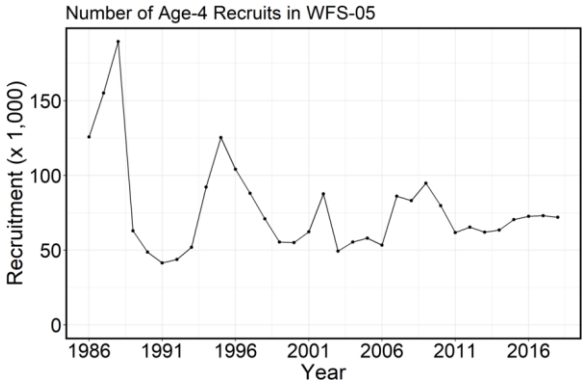






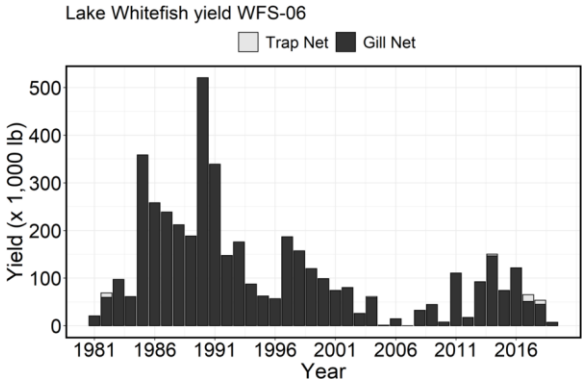
Parameter	Value
Base SSBR	4.50 lb
Current SSBR	1.25 lb
Target SSBR	1.25 lb
Current SPR	0.27
M	0.13 y^{-1}
F, trap net (2016-2018)	0.10 y^{-1}
F, gill net (2016-2018)	0.15 y^{-1}
Z (2018)	0.38 y^{-1}
Recommended Limit	208,000 lb
Actual Limit	208,000 lb
Model Rating	Medium

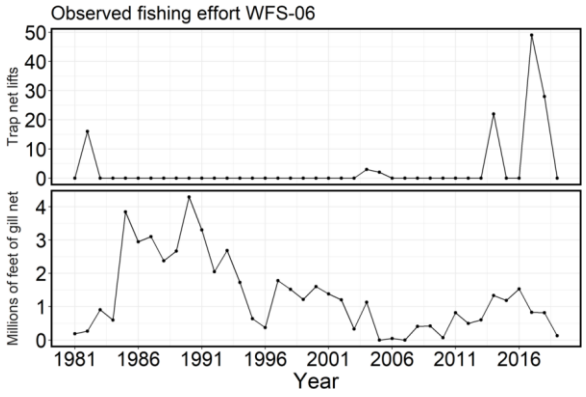




<u>Notable Fishery Dynamics and Model Changes:</u>
The 2020 Lake Whitefish harvest limit is 208,000 lb, a modest 3% increase from 2019. Total abundance has increased slightly in recent years due to slightly higher recruitment. The most vulnerable age experienced a mortality rate (*A*) of 37% in 2018. Trap-net yield in 2018 was 37,100 lb (1% increase from 2017) and gill-net yield was 53,800 lb (25% increase from 2017). There are concerns about the quantity of data being collected from both the trap-net and gill-net fisheries. The model rating for WFS-05 remains at medium because the model has consistent performance with prior models, which have had good diagnostics.

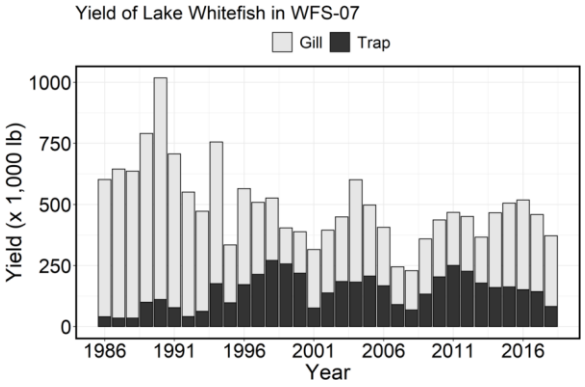
WFS-06 (Grand Marais)

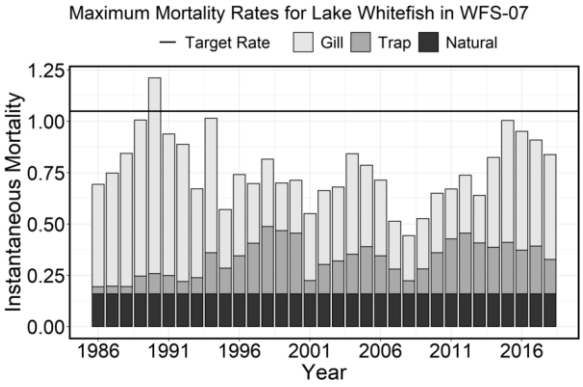


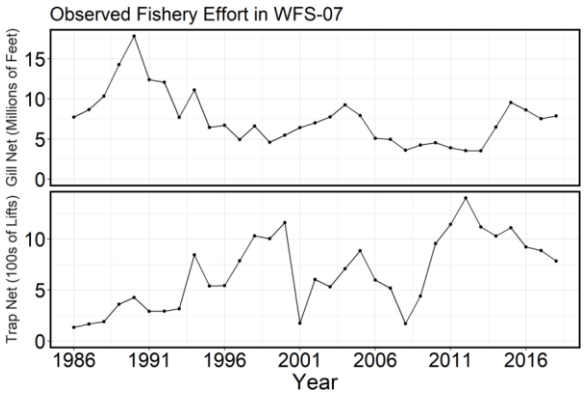


There is no current stock assessment model for WFS-06. Low levels of effort and harvest and a lack of fishery monitoring data since the early 2000s limit the ability to produce an assessment model for this unit. The HRG for this unit was reduced to 137,700 lb for 2020.

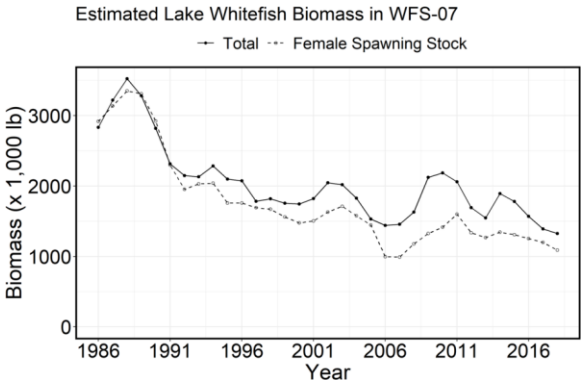
WFS-07 (Tahquamenon Bay) Jack Tuomikoski

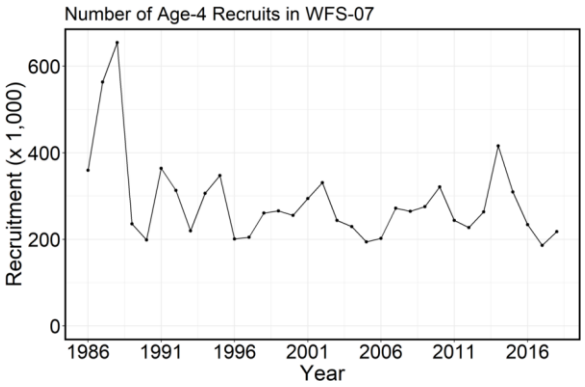






Parameter	Value
Base SSBR	4.66 lb
Current SSBR	0.96 lb
Target SSBR	0.94 lb
Current SPR	0.20
M	0.16 y^{-1}
F, trap net (2016-2018)	0.20 y^{-1}
F, gill net (2016-2018)	0.42 y^{-1}
Z (2018)	0.73 y^{-1}
Recommended Limit	451,400 lb
Actual Limit	451,000 lb
Model Rating	Medium



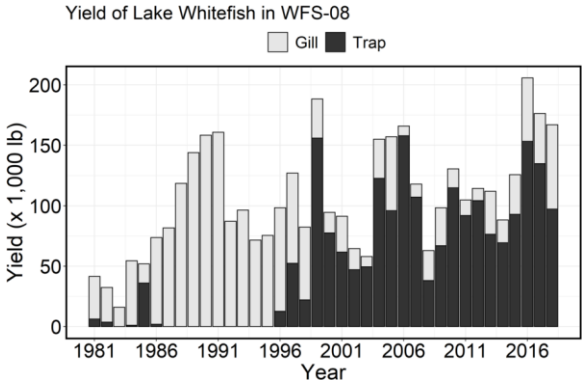


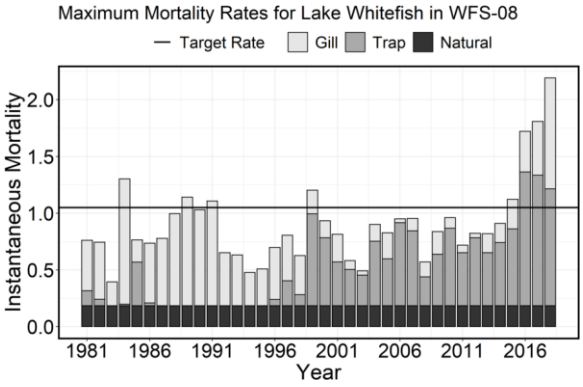
<u>Notable Fishery Dynamics and Model Changes:</u>

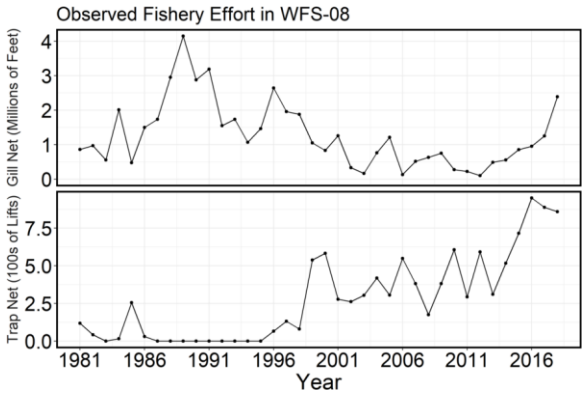
The model recommended harvest limit for 2020 is 451,400 lb, down 21% from 2019. This harvest limit was set using the total annual mortality limit, which resulted in a SPR for the target stock of 0.20. There have been few age-4 fish in the data over 2016-2018 but the proportion of older fish have been more consistent over this same period. Mortality rates over 2015-2018 have decreased slightly. The total yield in WFS-07 has decreased since 2016 along with a decrease in effort (although gill-net effort increased slightly in 2018). Estimates for both the total and spawning biomass decreased from 2014-2018 and are now at (for total biomass) or near (for spawning biomass) their lowest estimated values in the time-series. Estimates of age-4 recruitment

have decreased over 2014-17 with a small increase in 2018. Over 2016-2018 although mortality estimates have decreased slightly, catches have not decreased as fast as effort and recruitment estimates have generally decreased. This caused the projection for 2020 to be lower than the projection for 2019 from last year's model. Some refinements were made to model inputs, but retrospective patterns remained similar to last year's model (moderate). Other indicators of model fit could be improved (MCMC's and the variance of the stock recruitment function). There were no patterns in the fit to catch, fit to age, or fit to effort residuals.

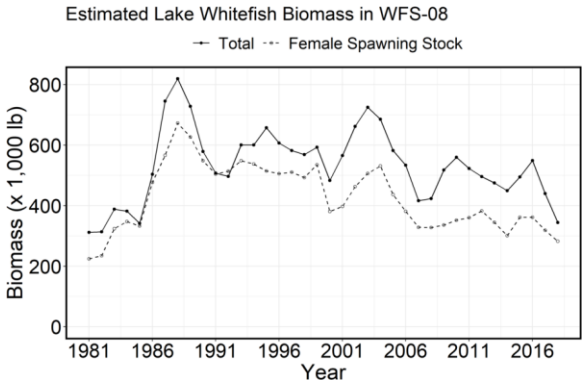
WFS-08 (Brimley) Jack Tuomikoski

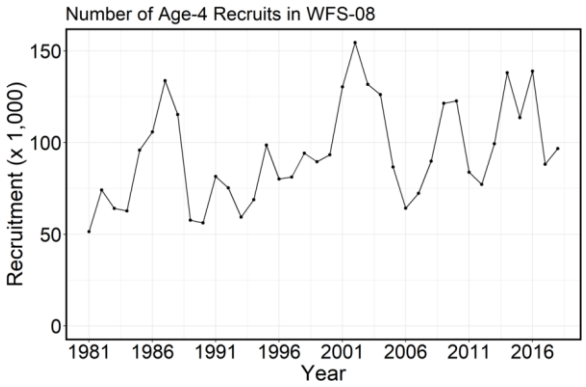






Parameter	Value
Base SSBR	3.55 lb
Current SSBR	0.80 lb
Target SSBR	0.79 lb
Current SPR	0.22
M	0.18 y^{-1}
F, trap net (2016-2018)	1.03 y^{-1}
F, gill net (2016-2018)	0.44 y^{-1}
Z (2018)	1.86 y^{-1}
Recommended Limit	71,600 lb
Actual Limit	165,800 lb
Model Rating	Medium

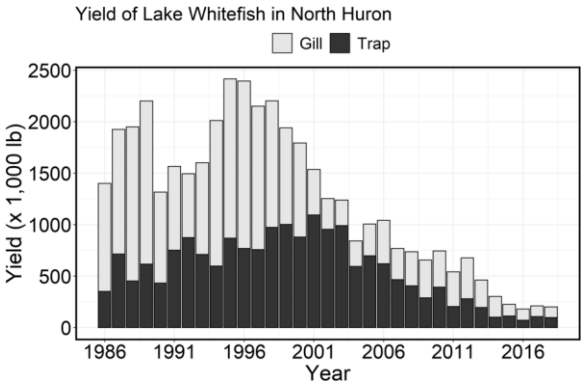


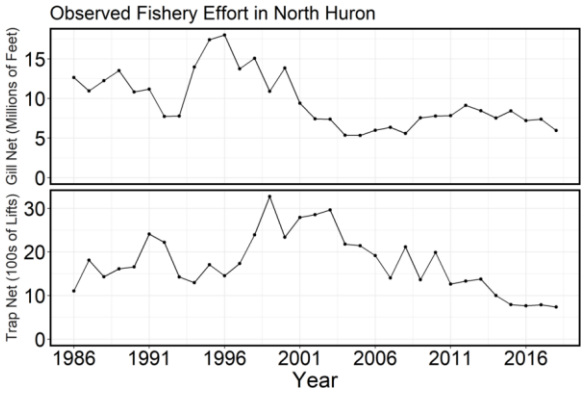


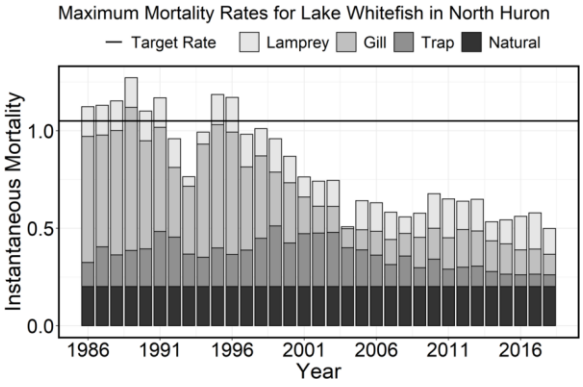
<u>Notable Fishery Dynamics and Model Changes:</u>

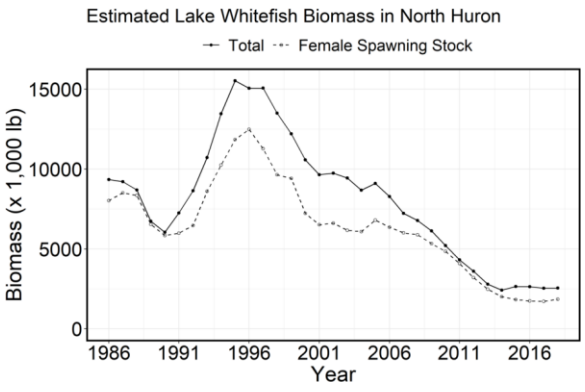
The model recommended harvest limit for 2020 is 71,600 lb, down 18% from 2019. The age structure for this unit has been truncated during the last two years of data collection with few old fish and mortality rates over 2016-2018 have been estimated to be the highest on record. Catches over 2016-2018 are all in the top four since 1981, while model estimates of spawning and total biomass as well as recruitment of age-4 fish have all decreased since 2016. Some refinements were made to model inputs and retrospective patterns were improved over last year's model (indicating a better fit) but remain moderate. Other indicators of model fit could be improved (MCMC's and the variance of the stock recruitment function). There were no patterns in the fit to catch, fit to age, or fit to effort residuals.

Lake Huron
North Huron (WFH-01-WFH-04) Stephen Lenart









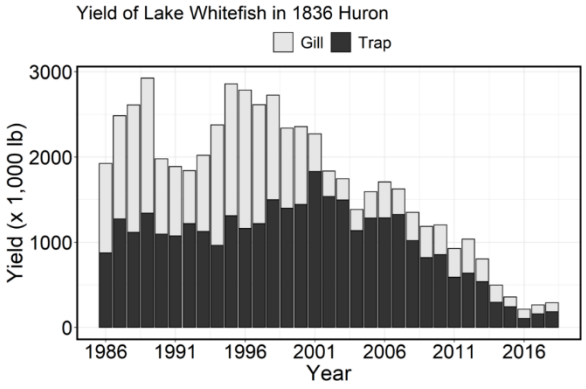
Parameter	Value
Base SSBR	3.53 lb
Current SSBR	0.71 lb
Target SSBR	0.58 lb
Current SPR	0.20
M	0.20 y^{-1}
F, trap net (2016-2018)	0.05 y^{-1}
F, gill net (2016-2018)	0.08 y^{-1}
Z (2018)	0.41 y^{-1}
Recommended Limit	478,600
Actual Limit	379,000
Model Rating	High

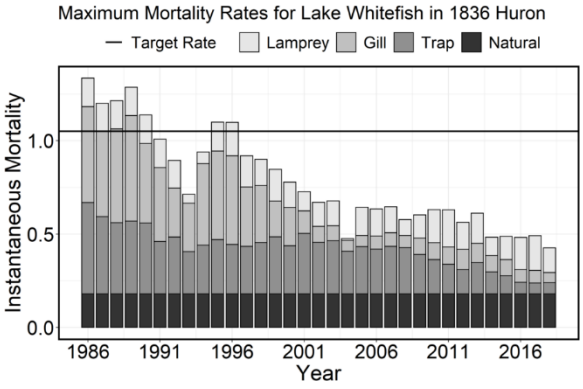
<u>Notable Fishery Dynamics and Model Changes:</u>

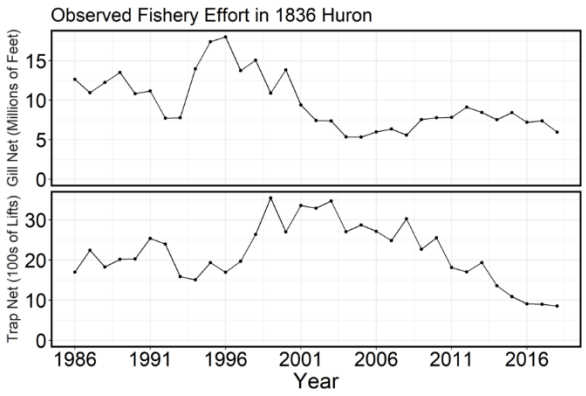
After experiencing a precipitous, nearly two-decade decline, estimated spawning biomass of Lake Whitefish in northern Lake Huron has largely remained stable since 2014. Fishing effort and catch rates have demonstrated patterns similar to biomass, resulting in yields that declined dramatically through time – total yields

have not exceeded 300,000 lb since 2014. Estimated mortality on the most vulnerable age class has been below 50% for the last eight years (40% in 2018), but stock sizes are now constrained by a lower recruitment regime than was present in the 1990s and early 2000s. Sea lamprey is still a significant source of mortality in this unit (avg 0.11 yr^{-1} in 2018), but the overall scale of sea lamprey has been reduced substantially compared to previous versions of the model. This was brought about by a change in a calculation methodology (use of A1/2 vs A1/2/3 wounds) that is now more consistent with the underlying approach used in the estimation of the probability of a whitefish surviving an attack. The calculated harvest limit of 478,600 lb for 2020 is within 3% of last year's model, the solution was stable, and diagnostics were favorable. The "SPR rule" was invoked in the harvest limit calculation, restricting target mortality to 53% during the projection in order to preserve spawning potential to 20% of the unfished state.

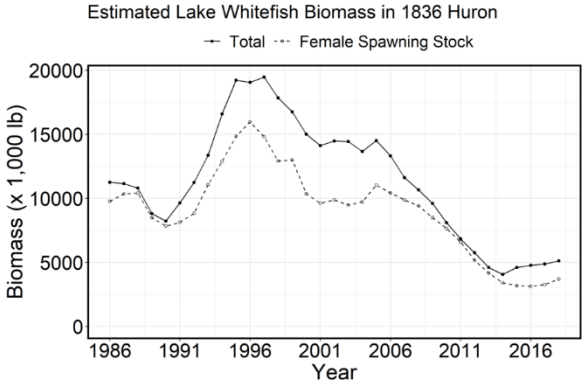
methodology (use of A1/2 vs A1/2/3 wounds) that is now more consistent with the underlying approach used in the estimation of the probability of a whitefish surviving an attack. The calculated harvest limit of 478,600 lb for 2020 is within 3% of last year's model, the solution was stable, and diagnostics were favorable. The "SPR rule" was invoked in the harvest limit calculation, restricting target mortality to 53% during the projection in order to preserve spawning potential to 20% of the unfished state.

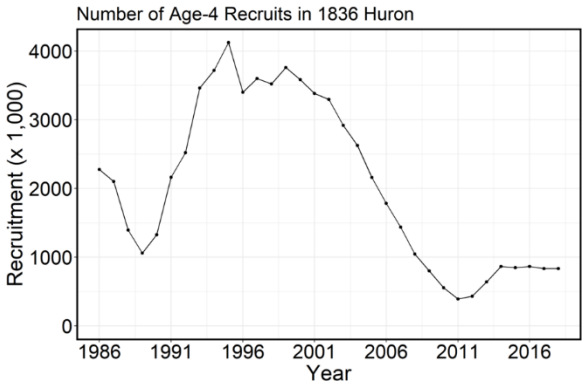






Parameter	Value
Base SSBR	4.09 lb
Current SSBR	0.82 lb
Target SSBR	0.65 lb
Current SPR	0.20
M	0.18 y^{-1}
F, trap net (2016-2018)	0.04 y^{-1}
F, gill net (2016-2018)	0.04 y^{-1}
Z (2018)	0.34 y^{-1}
Recommended Limit	1,050,000 lb
Actual Limit	NA
Model Rating	Medium



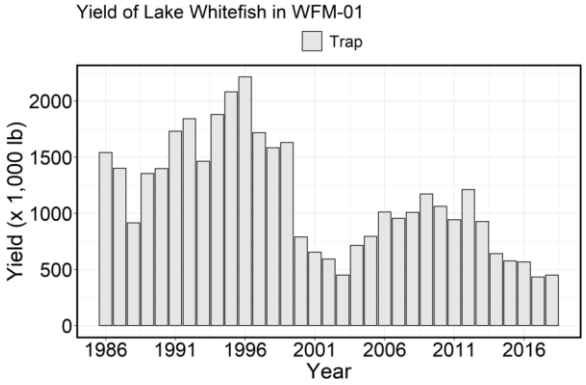


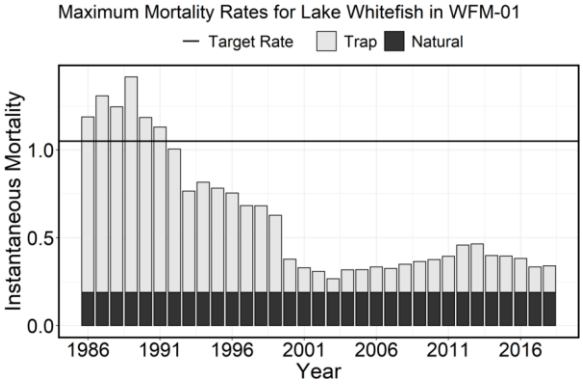
<u>Notable Fishery Dynamics and Model Changes:</u>

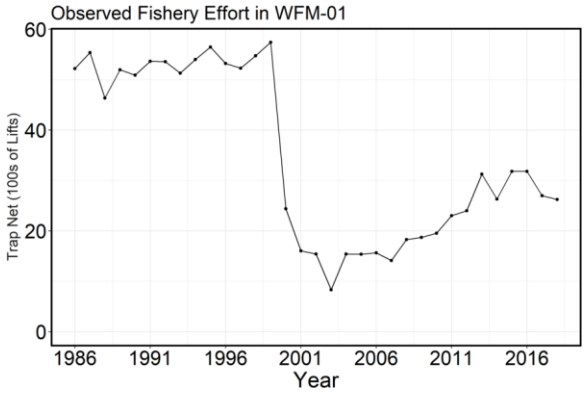
When viewed through an appropriate lens, most of the available science (movement, genetics, trophic) argue for a broader scale of Lake Whitefish stock delineations, further suggesting a north-south gradient within the main basin. As is the case with Lake Trout, the available data suggest a north-south gradient in the main basin, with a "dividing line" around Thunder Bay (Alpena). Based on both published (Ebener 2010) and unpublished information, the Alpena stock is highly mobile, dispersing widely throughout Lake Huron after spawning, including the northern waters, where it is vulnerable to fisheries. Although movement from the north to the WFH-05 area is apparently less prevalent, fish tagged at northern sites (e.g., Cheboygan) were represented in the Alpena fishery. These are clearly mixed-stock fisheries and stock simulations (Li 2017) suggest that combining spatial units (proposed state) when mixing rates are unknown, but mixing occurs, is preferable to

retaining separate stock boundaries, but ignoring mixing (current state). To this end, a combined 1836 Huron model was developed, using fishery information from all 1836 waters of Lake Huron. Because the trap-net fisheries in these two areas indeed operate differently and harvest different fractions of the population, the two trap-net fisheries (North Huron and WFH-05) are modeled separately, but within the combined model framework. The addition of the WFH-05 fishery to that of WFH-01 to WFH-04 resulted in a model with similar diagnostic characteristics to that of North Huron, and a model-generated harvest limit of 1,050,000 lb.

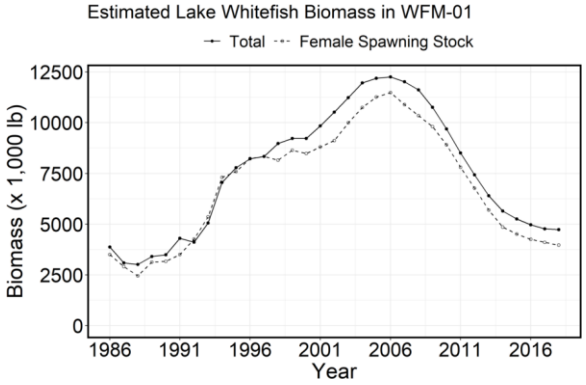
Lake Michigan
WFM-01 (Bays De Noc) Dave Caroffino







Parameter	Value
Base SSBR	3.52 lb
Current SSBR	0.70 lb
Target SSBR	0.66 lb
Current SPR	0.20
M	0.19 y^{-1}
F, trap net (2016-2018)	0.14 y^{-1}
Z (2018)	0.33 y^{-1}
Recommended Limit	1,524,000 lb
Actual Limit	1,524,000 lb
Model Rating	Medium

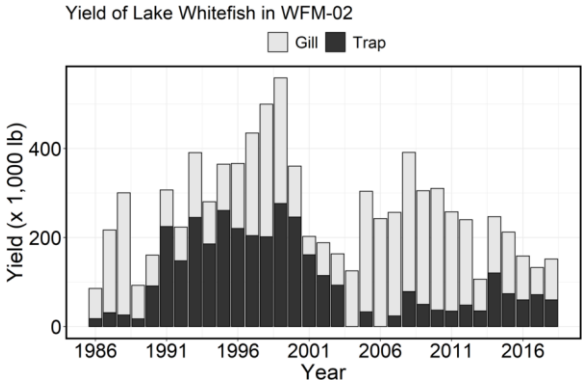


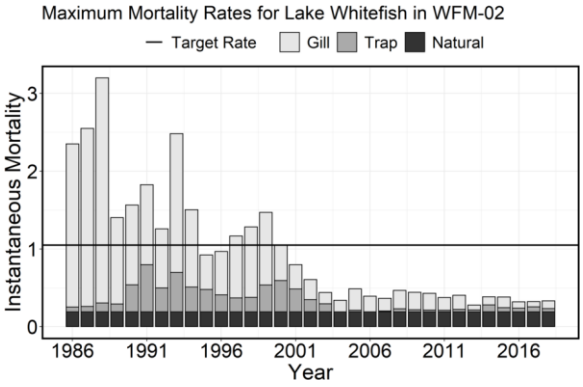
Notable Fishery Dynamics and Model Changes:

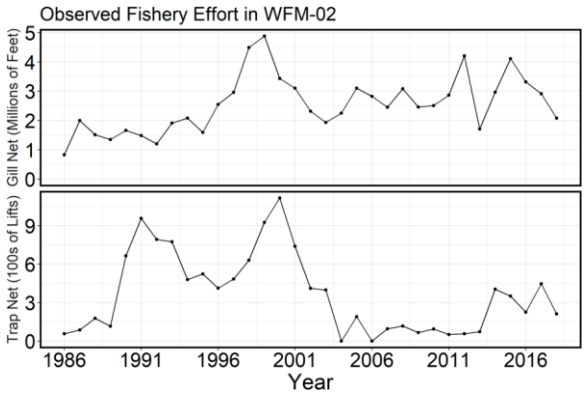
The 2020 version of this assessment includes slight revisions to age compositions during the 2000 Consent Decree era and a revised methodology for estimating recruitment. The trap-net age compositions from the CORA fishery were updated for 2001-2012. Since 2013, the age compositions represent a weighted average harvest (number of fish) from CORA trap nets, State trap nets, State purse seine, and LTBB gill nets. Recruitment was also modified to include a deviation vector, rather than directly estimating stock recruitment parameters. This change better restricted recruitment estimates in the last few years of the time series that were unsupported by data. The population in Bay de Noc appears to be beginning to stabilize after a decade-long decline. Biomass is estimated to be approximately equal to values in the early 1990s but only about 40% of the peak in 2006. The fisheries that presently operate in this unit

continue to have divergent data, as trap nets suggest mostly younger, smaller fish, and the purse seine and gill nets suggest larger, older fish. Mortality remains well-below the present target level. The harvest limit produced by the model is lower than recent years, due to declining stock size and the new methodology for estimating recruitment.

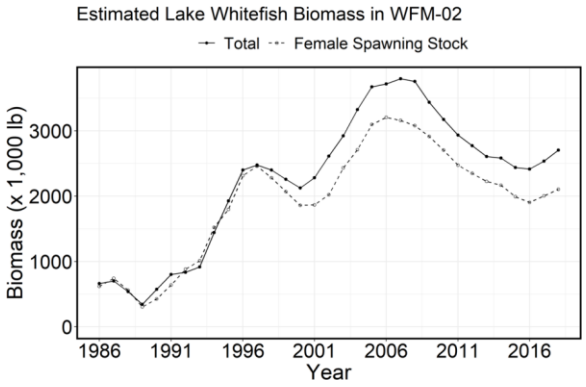
WFM-02 (Manistique) Ted Treska







Parameter	Value
Base SSBR	3.19 lb
Current SSBR	1.19 lb
Target SSBR	1.22 lb
Current SPR	0.37
M	0.19 y^{-1}
F, trap net (2016-2018)	0.04 y^{-1}
F, gill net (2016-2018)	0.04 y^{-1}
Z (2018)	0.26 y^{-1}
Recommended Limit	620,700 lb
Actual Limit	204,000 lb
Model Rating	Medium

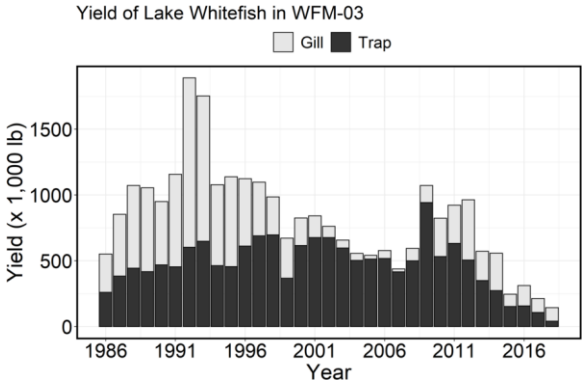


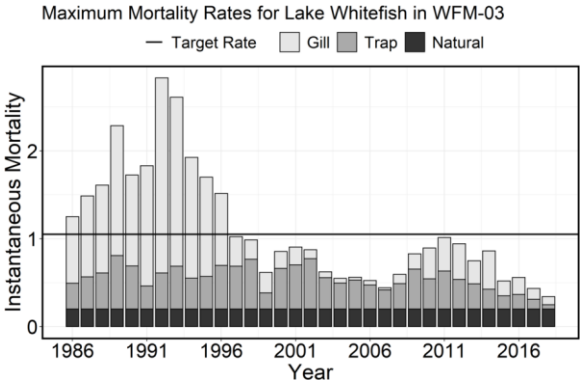
<u>Notable Fishery Dynamics and Model Changes:</u>

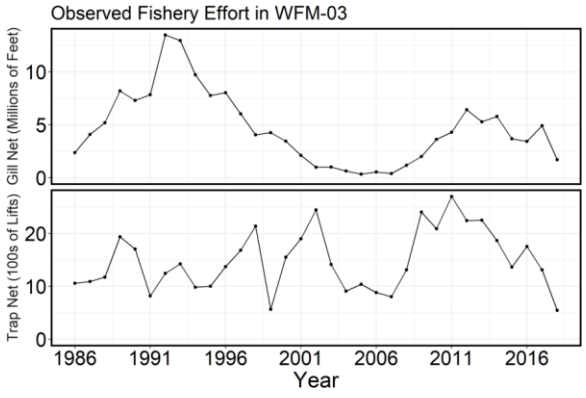
The model estimated harvest limit for 2020 is 620,700 lb, a 37% decrease from the previous year. There were slight increases in biomass at the end of the time series due to young fish showing up in the trap-net fishery that had recently been absent. Subsequent years will confirm whether these cohorts are as strong as estimated in model. Harvest in 2018 was slightly higher than 2017, with the gill-net fishery accounting for the majority of the yield, similar to 2016 proportions. The catch rate for the trap-net and gill-net fisheries both increased to almost twice the 2017 levels. Effort for both fisheries declined in 2018. Recruitment suggested an increase over the last 4 years, but it appears that this is driven by the catch proportions from 2018 trap-net data, as the signal is absent in previous years and in the gill-net fishery. Although the model is predicting that the average age of a Lake Whitefish in this population is beginning to decline, biomonitoring data suggests the average

age continues to increase. The model estimates a low effective sample size, which produces a poor fit to the age compositions, as expected. This unit has not had consistent biosampling from both of the fisheries (trap net and gill net), which has contributed to model instability.

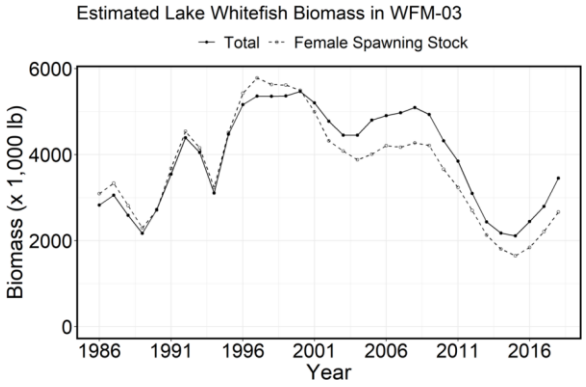
WFM-03 (Naubinway) Ted Treska

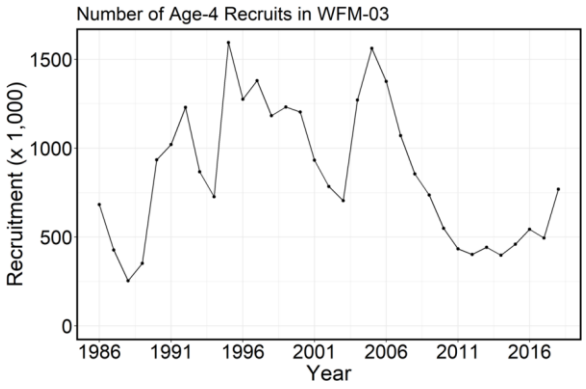






Parameter	Value
Base SSBR	3.40 lb
Current SSBR	1.25 lb
Target SSBR	1.29 lb
Current SPR	0.37
M	0.20 y^{-1}
F, trap net (2016-2018)	0.08 y^{-1}
F, gill net (2016-2018)	0.08 y^{-1}
Z (2018)	0.28 y^{-1}
Recommended Limit	906,900 lb
Actual Limit	450,225 lb
Model Rating	Medium

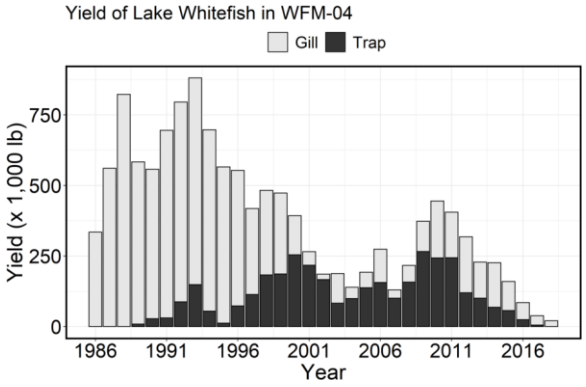


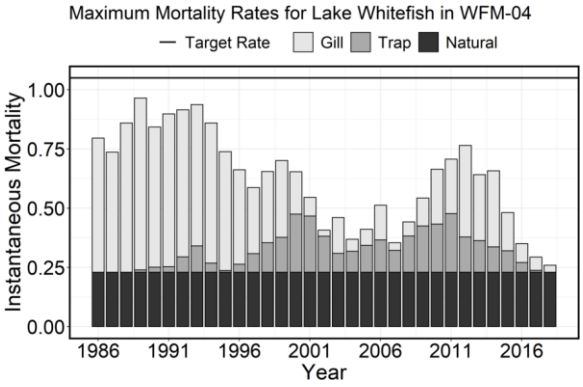


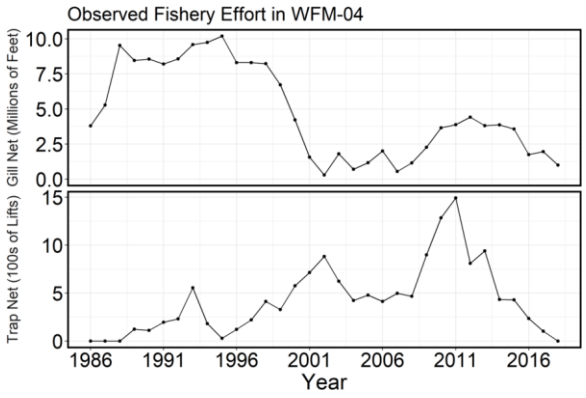
<u>Notable Fishery Dynamics and Model Changes:</u>
The recommended harvest level of 907,000 lb is an 8% decrease over last year's value. Biomass has begun to trend upward due to slight increases in recruitment and increases in weight-at-age. The model still indicates nearly a 65% decline from peak recruitment in 2005 to present; however, recruitment has been stable or trending upward since 2011. The average age of fish harvested in the fisheries has increased from 5-6 from 1986-1997, to nearly 8-9 years old since the late 2000s. There is some indication that the average age of a harvested fish might be declining again in the gill-net fishery, although trap-net data does not show the same trend. The average age of harvest in WFM-03 is considerably lower than that of its neighboring unit WFM-02. Harvest in 2018 was the lowest observed during the time series with trap-net yield declining more than gill-net yield between 2017 and 2018. Trap-net CPE continued to decline, while the gill-net CPE rebounded to three times the value in 2017.

Gill-net effort was reduced from 4.5 million feet to only 1.6 million feet, while trap-net effort decreased by almost 800 lifts. These changes in effort and catch rate are likely reflective of regulatory changes in licensing, rather than specific trends in the Lake Whitefish population. Like WFM-02, the model estimates a low effective sample size, which produces a poor fit to the age compositions, as expected. Issues with covariance persist from the previous years and could not be remedied, but other diagnostics are acceptable.

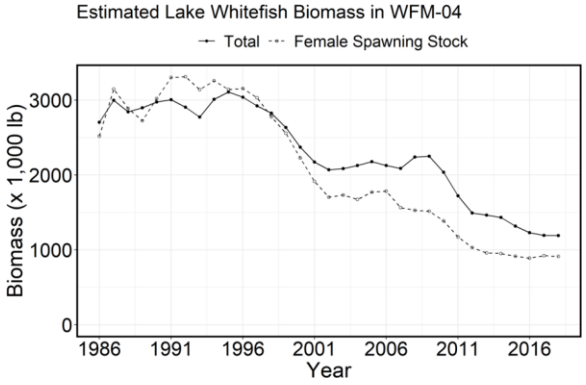
WFM-04 (Beaver Island) Kevin Donner

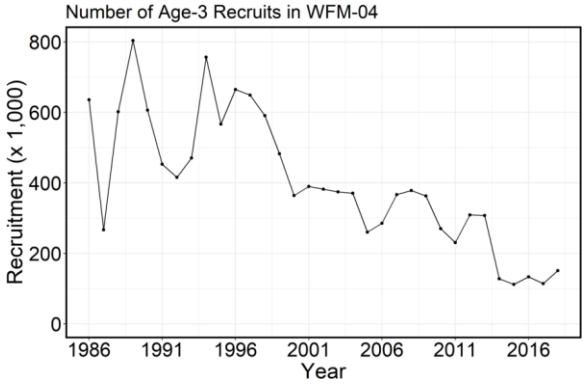






Parameter	Value
Base SSBR	3.04 lb
Current SSBR	0.64 lb
Target SSBR	0.62 lb
Current SPR	0.21
M	0.23 y^{-1}
F, trap net (2016-2018)	0.02 y^{-1}
F, gill net (2016-2018)	0.05 y^{-1}
Z (2018)	0.25 y^{-1}
Recommended Limit	467,500 lb
Actual Limit	240,300 lb
Model Rating	Low

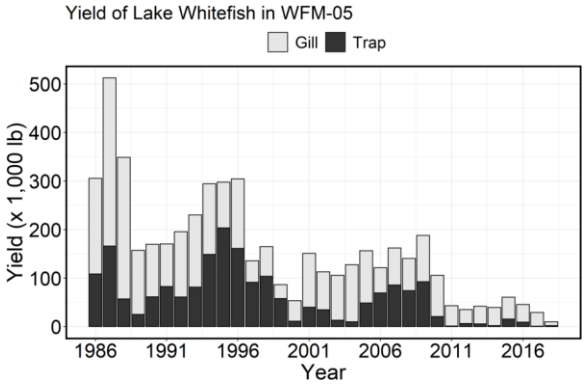


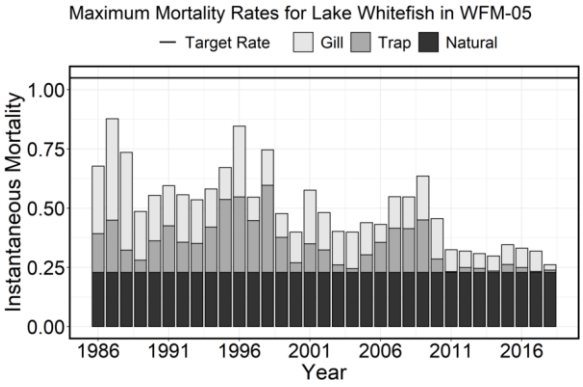


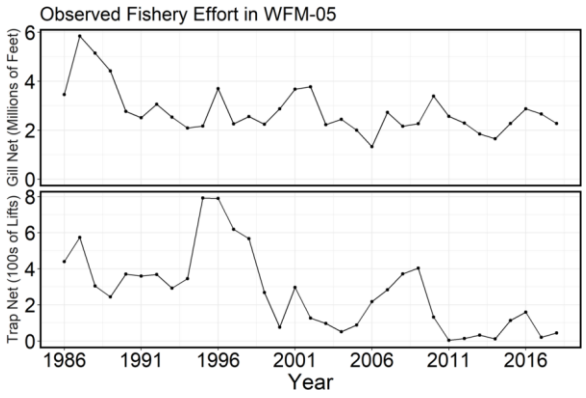
<u>Notable Fishery Dynamics and Model Changes:</u>

None provided.

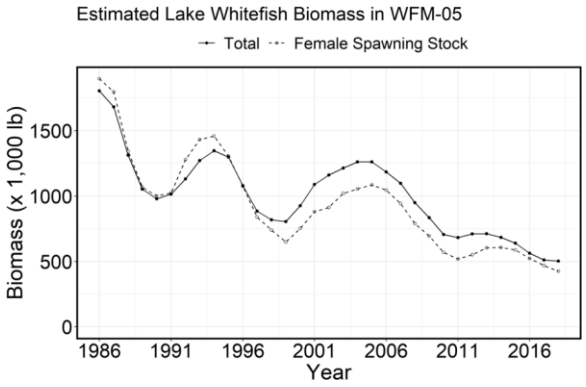
WFM-05 (Grand Traverse Bay) Nathan Barton

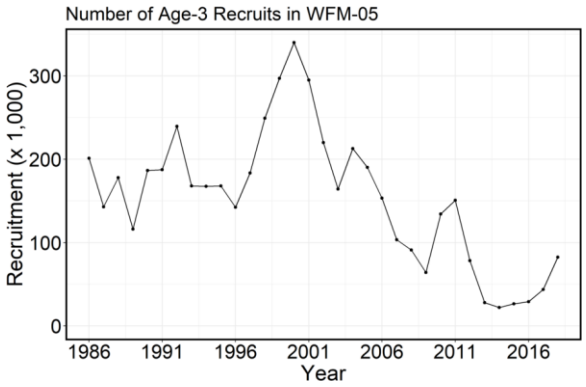






Parameter	Value
Base SSBR	3.54 lb
Current SSBR	0.70 lb
Target SSBR	0.59 lb
Current SPR	0.20
M	0.23 y^{-1}
F, trap net (2016-2018)	0.01 y^{-1}
F, gill net (2016-2018)	0.06 y^{-1}
Z (2018)	0.26 y^{-1}
Recommended Limit	183,000 lb
Actual Limit	198,000 lb
Model Rating	Low



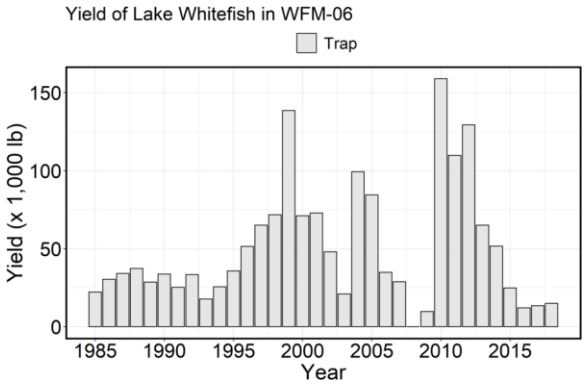


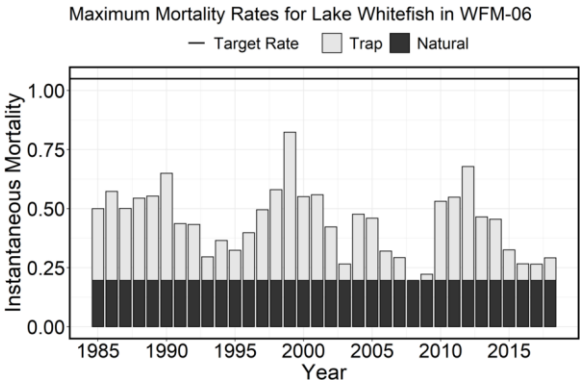
<u>Notable Fishery Dynamics and Model Changes:</u>

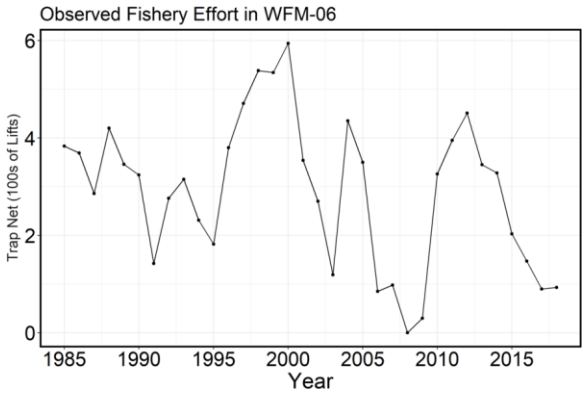
The 2020 model-generated harvest limit for WFM-05 is 183,000 lb, which is down 48% from 2019. There were no major structural changes made to the model for the 2020 update; however, the variance associated with catchability was adjusted and the model was sensitive to the change. There has been a trend from this model over the past few years to continue to drive catchability lower, while expanding the population over time. Multiple factors could have contributed to this; however, the recent transition in aging structure in this unit is likely one key element. In this assessment, catchability was constricted, allowing less freedom to estimate low values and expand the population. This forced the model to alternate between two solutions, one where catchability was low and survival and recruitment were higher, and another the inverse of that, which seems more realistic given the nature of the recent fishery in this unit. Natural mortality was also re-evaluated by a

subgroup of the MSC, and this model was run according to those new standards, which is more constricted than the prior year, but better informed from the literature.

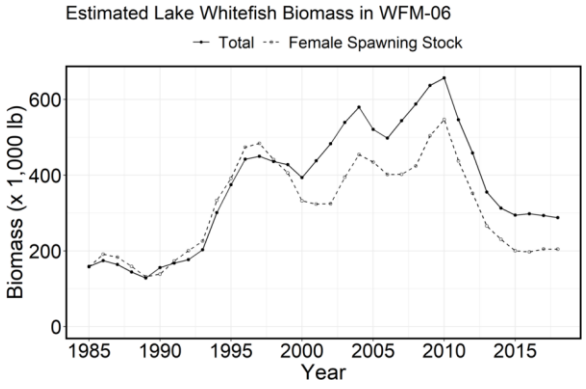
WFM-06 (Leland) Dave Caroffino

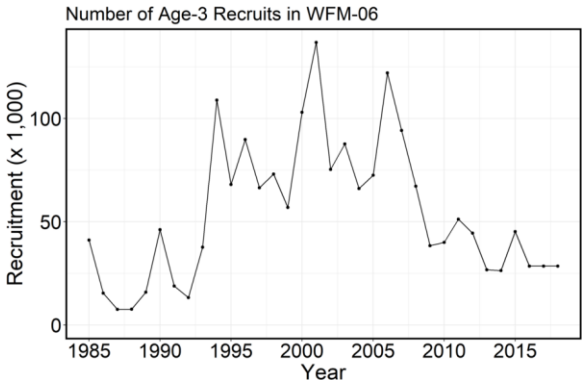






Parameter	Value
Base SSBR	4.17 lb
Current SSBR	0.83 lb
Target SSBR	0.59 lb
Current SPR	0.20
M	0.20 y^{-1}
F, trap net (2016-2018)	0.07 y^{-1}
Z (2018)	0.28 y^{-1}
Recommended Limit	83,900 lb
Actual Limit	125,000 lb
Model Rating	Medium

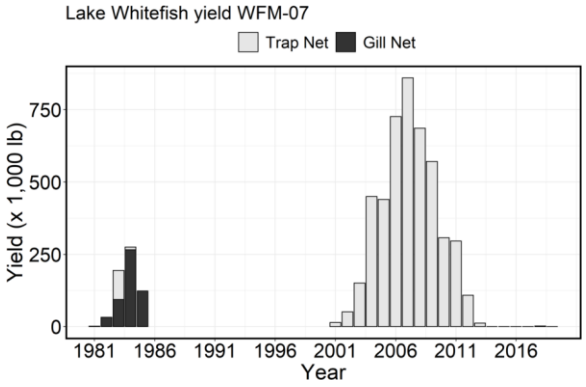


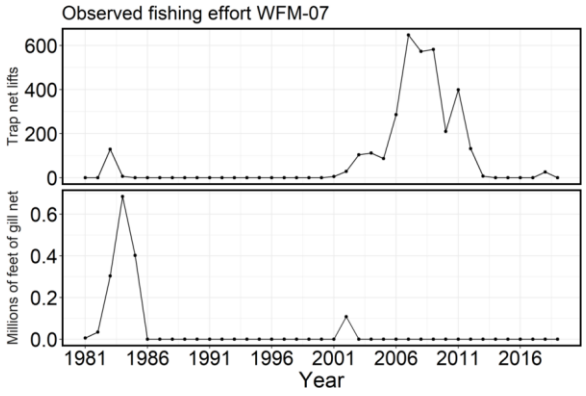


<u>Notable Fishery Dynamics and Model Changes:</u>

The changes to the WFM-06 model for the 2020 cycle included the growth model used to estimate length and weight-at-age as well as modeling recruitment as a deviation vector, rather than estimating specific stock recruitment parameters. The impact of the growth model change was minimal, but the revised method for estimating recruitment resulted in lower stock sizes than previous model runs. This population is the smallest in Lake Michigan, and while recruitment has been reduced from past highs, young fish are present in monitoring data. The gill-net fishery did not operate in either 2018 or 2019. Biomass has been stable for the past four years and is estimated to be approximately half its peak in 2010. Mortality is low, as only a single trap-net operation is presently fishing in the unit. Model performance was consistent with past assessments.

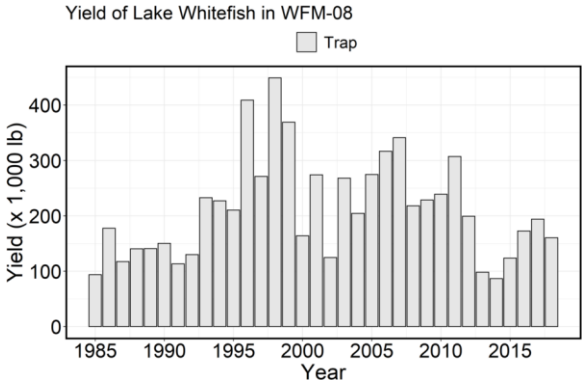
WFM-07 (Manistee to Pentwater)

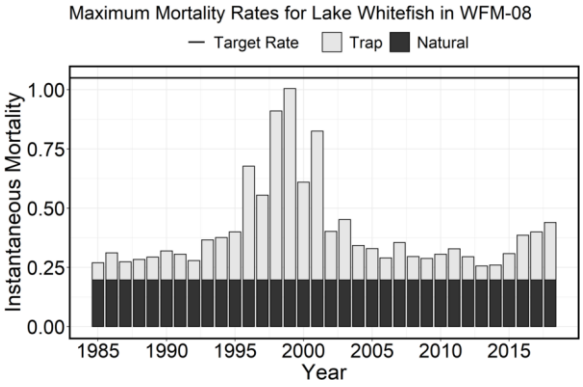


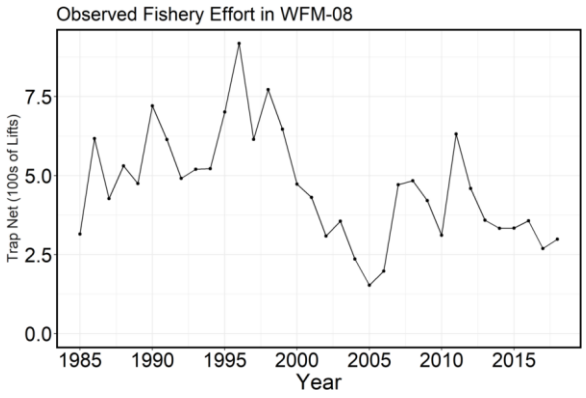


No stock assessment model has been developed for WFM-07. When the Consent Decree was initially signed, this unit lacked the necessary time series of data to populate a model. Fishing effort and yield in this unit peaked in 2007, ceased from 2013-2017, and was minimal in 2018 (1,174 lb). The HRG was reduced to 225,000 lb in 2020.

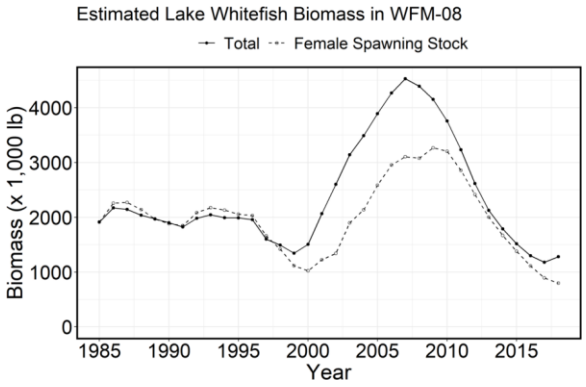
WFM-08 (Muskegon) Dave Caroffino

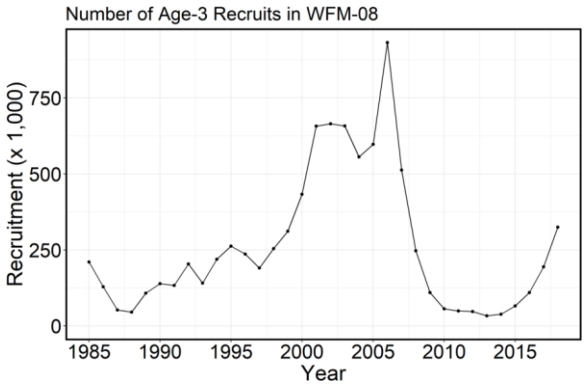






Parameter	Value
Base SSBR	4.15 lb
Current SSBR	0.83 lb
Target SSBR	0.73 lb
Current SPR	0.20
M	0.20 y^{-1}
F, trap net (2016-2018)	0.18 y^{-1}
Z (2018)	0.41 y^{-1}
Recommended Limit	390,200 lb
Actual Limit	500,000 lb
Model Rating	Low





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

The changes to the WFM-08 model for the 2020 cycle included the use of the R-based cohort growth model and a reassessment of age compositions. For the most recent years with otolith ages (2015-2018), the age compositions constructed from commercial sampling were weighted by season according to actual fishery harvest. In addition, for years when older fish were present in the population, but fin rays were the basis of age compositions (2008-2014), the number of samples collected was down weighted, allowing the model more freedom to deviate from the age compositions. The recent years of monitoring data all consistently suggest recruitment in this unit is extremely low. Only 15% of the total catch is of fish less than age 11. Mortality remains low, but the large year classes of the early 2000s are working their way out of the fishery, and the model is beginning to predict a lower average age in the fishery. Model performance is worse than recent years with both MCMCs and retrospective analysis providing

poor results. Alternative model structures to correct some of the outstanding issues were unsuccessful, although more time would be required to fully evaluate some of the patterns observed.