Great Lakes Mass Marking Program

2017 Update and Result Highlights

The Great Lakes Mass Marking Program is a collaboration between federal, state and tribal fisheries agencies, coordinated by the U.S. Fish and Wildlife Service, to answer questions critical for Great Lakes fisheries management.

2016 Tagging and marking activities

- 2.77 million Chinook salmon and 4.92 million lake trout were coded-wire tagged in 2016
- < 0.4 million each of Atlantic salmon, brown trout, and brook trout were also marked in 2016
- Average final % tagged and clipped rates were 97.5% for Chinook salmon and 97.1% for lake trout
- Average throughput was 8,435 and 7,705 fish per hour for Chinook salmon and lake trout, respectively.

2016 Data and tag recovery activities

- In 2016, Fish and Wildlife Service bio-technicians stationed on Lakes Michigan and Huron, working with the states, sampled 47 ports and examined 22,213 salmonines, including 7,449 Chinook salmon and 6,350 lake trout.
- Over 75,000 coded-wire tags have been recovered since the inception of the project.

2016 Estimated contributions of wild lake trout to fisheries in Lakes Michigan and Huron

- In 2016, 54.7 % of lake trout recovered in Lake Huron had no fin clip and were presumed wild (Fig. 1).
- 17.1 % of lake trout recovered in Lake Michigan had no fin clip, with higher no-clip rates in southern Lake Michigan (Fig. 1).

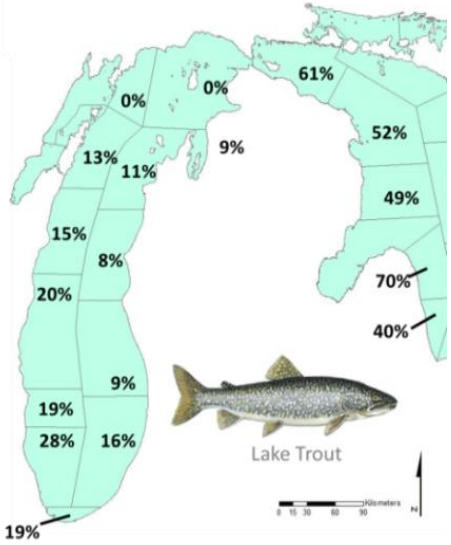


Fig. 1: Percent of lake trout recovered without a fin clip and presumed wild in each statistical district of Lakes Michigan and Huron in 2016.

2016 Estimated contributions of wild Chinook salmon to fisheries in Lakes Michigan and Huron

- In 2016, 64% of Chinook salmon (all ages) recovered in Lake Michigan and 40% recovered in Lake Huron were without a fin clip and CWT and presumed to be wild (Fig. 2).
- Estimated production of wild Chinook salmon from the 2015 year class was greater than the weak 2013 year class, but lower than from year classes 2006 – 2012 and 2014 (Fig. 3). Lower number of spawning Chinook salmon returning from the 2013 year class may have contributed to relatively weak 2015 year class (Fig. 3).

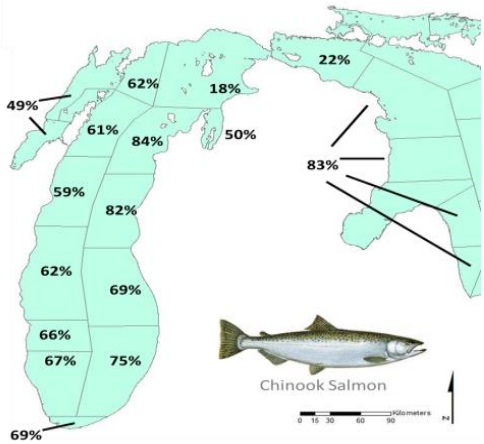


Fig. 2: Percent of Chinook salmon recovered without a fin clip and presumed wild in Lakes Michigan and Huron.

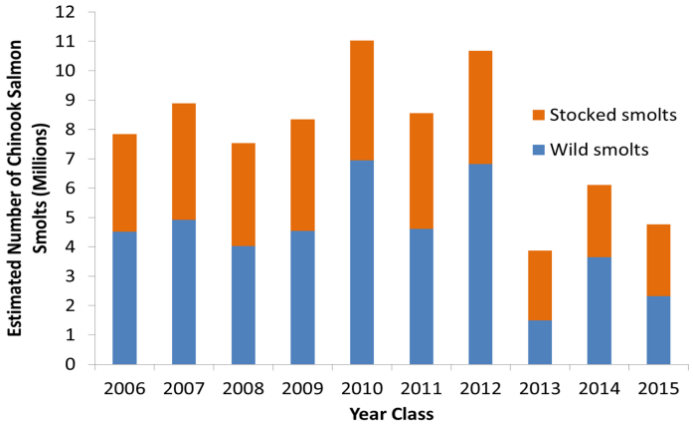


Fig. 3: Estimated number of wild and stocked Chinook salmon in the 2006 – 2015 year classes in Lake Michigan.

Estimated contribution of stocked Chinook salmon to the fishery by stocking district

- Chinook salmon stocked along the western shore of Lake Michigan have greater survival post-stocking than those stocked on the eastern shore and in Green Bay (Fig. 4). Even at eastern ports, fish stocked on the west shore tended to be caught the most (e.g., Frankfort, MI in Fig. 7).
- The analysis was based on the catch of Age 2 and Age 3 Chinook salmon from each stocking location, corrected for recovery district-specific effort. Each Chinook salmon year class (2011 – 2014, total of 10,399fish) was analyzed separately. Fig. 4 shows patterns across all four year classes.
- Underlying mechanisms are unknown, but could include differences in habitat (e.g., water temperature, food availability) that make western shore locations more favorable for young Chinook salmon; differences in rearing or release practices; or greater competition with wild Chinook salmon on the eastern shore.

Contributions of Chinook Salmon to the Lake Michigan Open-Water Fishery

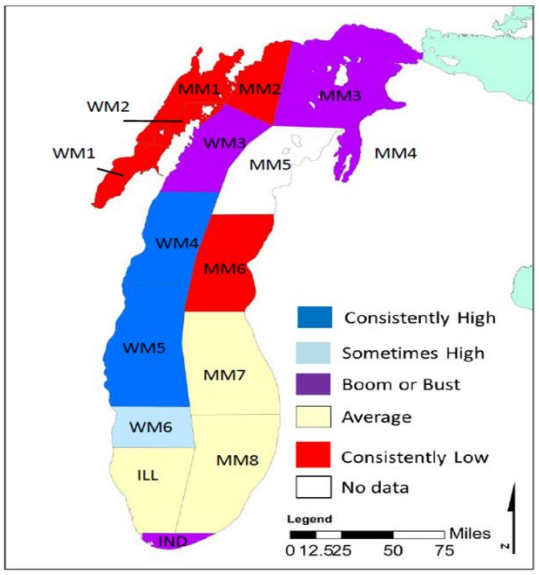


Fig. 4: Map showing districts in which year classes consistently had high survival (dark blue), districts with high survival of some year classes (light blue), districts with consistently average survival (yellow), districts where survival was high or low depending on year class (purple), and a districts where all year classes had low survival (red).

Chinook salmon movement patterns - between basins

- During April – August 2016, 95% of Chinook stocked in Lake Huron were recovered in Lake Michigan. 0% of Chinook stocked in Lake Michigan were recovered in Lake Huron over the same time period. Most mature Huron-stocked fish returned to Lake Huron in autumn to spawn.
- Chinook salmon move from Huron to Michigan with little reciprocal movement. Thus, we consider most Chinook stocked in Lake Huron as part of the Lake Michigan population for the purposes of the predator-prey ratio model, which is used to help maintain balance between predator and prey biomass in Lake Michigan.

Chinook salmon movement patterns – within Lake Michigan

- In the open-water fishery, over 90% of Chinook salmon were harvested in a different statistical district then where they were stocked during April – July. During Sept.-Oct., most (50-95% depending on age) were harvested in their stocking district. (Fig. 5). August was a transitional month.
- Mean distance between the centers of stocking and recovery districts during the open-water fishery was 117-151 km (73-94 mi), dependent on age. The distribution of distances travelled was a long right tail for all ages (Fig. 6), with recoveries up to 520 km (323 mi) away from stocking location.

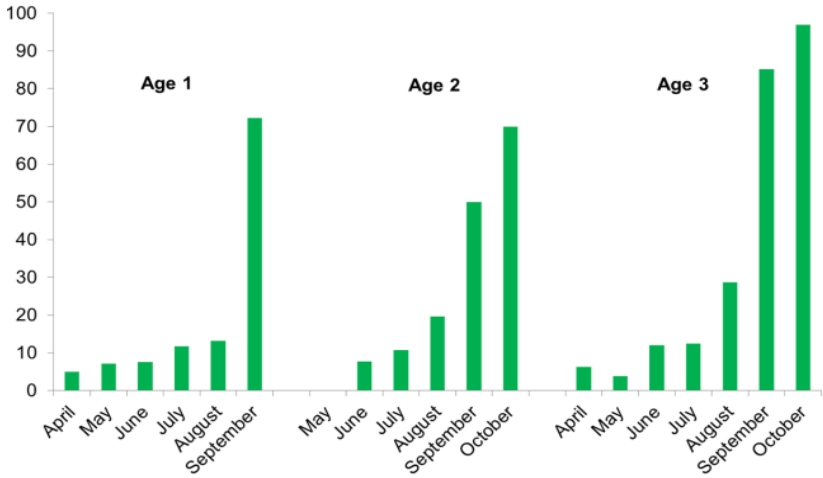


Fig. 5: Percent of Chinook from the 2011 year class recovered in the statistical district where they were stocked, by age and by recovery month.

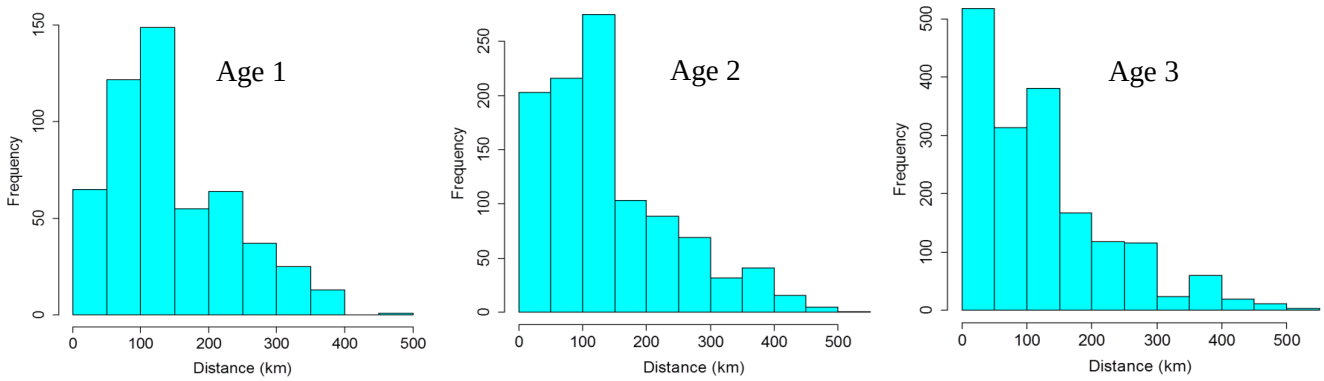


Fig. 6: Distance-frequency distributions of Chinook salmon from the 2011 year class, recovered at Ages 1- 3. Distance is measured as a straight line between the center points of the stocking and recovery districts. 62 miles = 100 km.

- Maps showing the stocking locations of coded-wire tagged Chinook landed at specific ports (31 in Lake Michigan, 11 in Huron, e.g., Fig. 7) are available upon request (matthew_kornis@fws.gov).

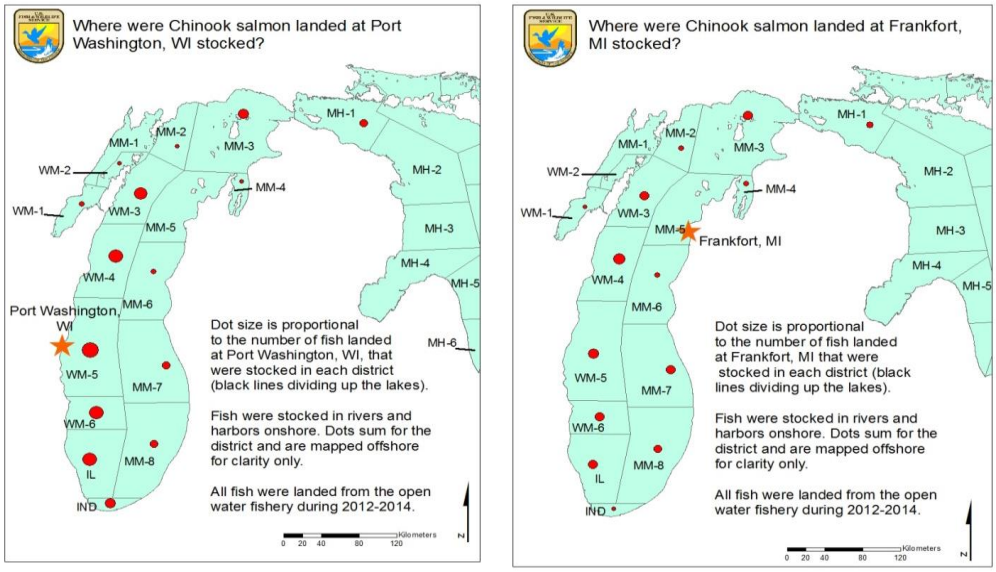


Fig. 7: Origin of stocked Chinook salmon captured from 2012 – 2014 during the open water fishery at Port Washington, WI (left) and Frankfort, MI (right). The size of each circle corresponds with the number of fish per 100,000 stocked.

Post-release survival of lake trout stocked at historical spawning reefs

- Analysis of coded-wire tagged lake trout recovered by spring gill net assessment surveys showed that lake trout catch-per-unit-effort (CPUE, corrected for number of fish stocked and a proxy for survival) was primarily affected by stocking location, genetic strain and length-at-stocking.
- Lake trout CPUE was lowest from fish stocked in the Northern Refuge due to mortality from sea lamprey and commercial fishing, and highest from fish stocked at Julian's Reef (Fig. 8, left panel).

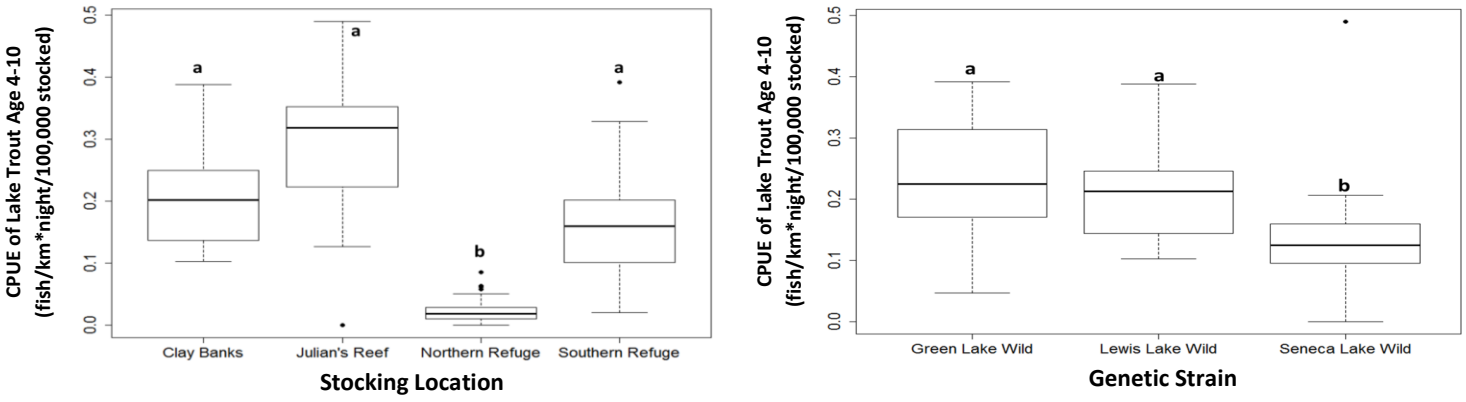


Fig. 8: Effect of stocking location (left) and genetic strain (right) on lake trout CPUE. Northern Refuge fish had low CPUE across all strains and were excluded from that panel. Different letter codes indicate statistically significant differences ($p < 0.05$).

- In stocking locations with low lake trout mortality, Lake Michigan remnant genetic strains (Lewis Lake and Green Lake) had higher CPUE than Seneca Lake strain (Fig. 8, right panel). Fish with greater body length also enjoyed a modest increase in survival at these locations.
- High CPUE of lake trout stocked in southern Lake Michigan may have contributed to increased recoveries of wild lake trout recently reported from that area by building spawning stock biomass.

Post-release movement of lake trout stocked at offshore reefs

- Over 50% of lake trout stocked offshore in southern Lake Michigan were recovered in nearshore waters accessible to the recreational fishery (Fig. 9). Spread of lake trout from northern Lake Michigan was more limited.
- Analysis of angler-caught lake trout from 2012-2016 suggested lake trout stocked offshore contributed more to angler catches (Fig. 10, left) and had greater returns per number stocked (Fig. 10, right) than those stocked nearshore.
- This may be due to better survival of lake trout stocked at offshore locations, and counters the perception that lake trout must be stocked nearshore to benefit anglers.

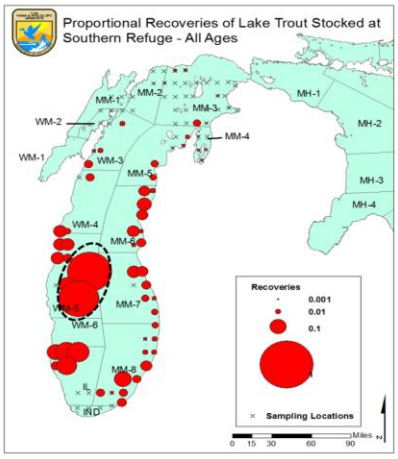
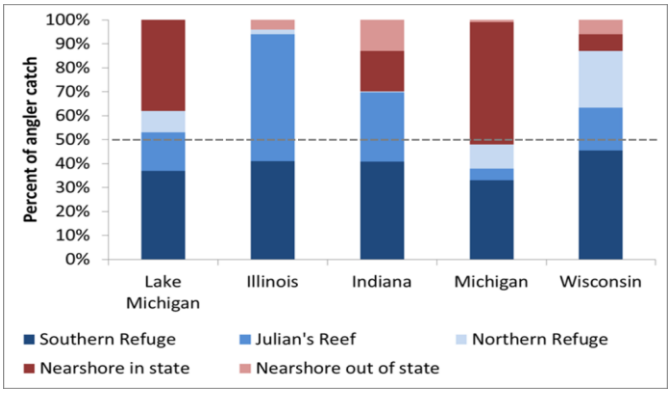


Fig. 9: CPUE of lake trout stocked offshore at the Southern Refuge (dashed black oval). Dot size is proportional to CPUE. X's are sampling sites.



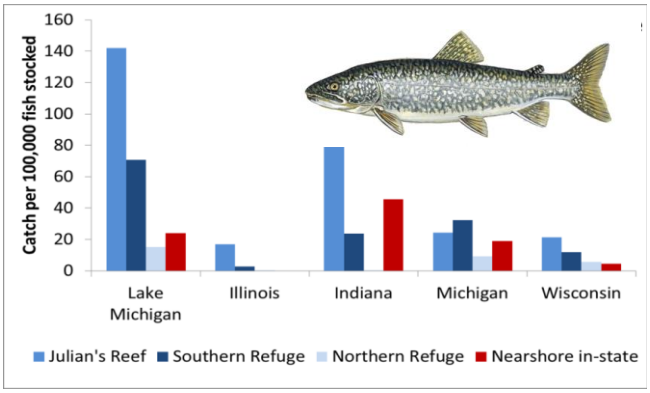


Fig. 10: % of angler catch (left) and return rates corrected for number of fish stocked (right) of lake trout from offshore (blue bars) and nearshore (red bars) stocking locations in Lake Michigan.

Stable isotopes of Lake Michigan salmon and trout

- Stable isotopes of carbon ($\delta^{13}C$, indicates offshore vs. nearshore foraging) and nitrogen ($\delta^{15}N$, indicates food web position) were analyzed to assess potential for competition.
- Lake trout were unique, with <25% overlap with Chinook salmon, coho salmon and steelhead (Fig. 11) and a greater reliance on bottom-oriented and offshore prey (e.g., bloater, sculpin; Table 1).
- Pacific salmon species (Chinook salmon, coho salmon, and steelhead) were very similar isotopically.
- Niche overlap (Fig. 11) and diet mixing models (Table 1) suggest competition for declining alewives and rainbow smelt will be highest among Chinook salmon, coho salmon, steelhead, and brown trout.

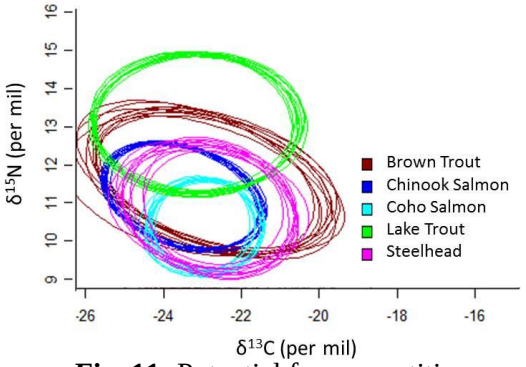


Fig. 11: Potential for competition among salmon and trout, based on overlap of trophic niche (ellipses).

Predator	Alewife & Rainbow Smelt	Bloater	Sculpin spp.	Round Goby	Stickleback spp.
Lake Trout	54	15	15	10	6
Chinook Salmon	85	1	0	6	8
Coho Salmon	80	1	1	12	6
Rainbow Trout	78	1	1	15	6
Brown Trout	72	2	2	13	10

Table 1: Percentage of fish prey in Lake Michigan salmon and trout diets, as estimated by stable C and N isotope mixing models. Values are lake-wide averages; variability is likely among regions, seasons, and individual fish. Numbers may not add to 100% due to rounding.