Great Lakes Mass Marking Program

2018 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.

2017 Tagging and marking activities

- 3.8 million lake trout, 2.8 million steelhead, & 2.1 million Chinook salmon were fin clipped in 2017; most of the lake trout and steelhead, and 0.5 million of the Chinook salmon, were also coded-wire tagged.
- < 0.5 million each of Atlantic salmon, coho salmon, brown trout, and brook trout were also marked in 2017
- ≥ 98.3% of Chinook salmon, lake trout, and steelhead were successfully clipped or tagged in the hatcheries
- Ave. throughputs were 8,361, 7,627, and 7,030 fish/hr for Chinook salmon, lake trout and steelhead respectively.

2017 Data and tag recovery activities

- In 2017, Fish and Wildlife Service bio-technicians stationed on Lakes Michigan and Huron, working with the states, sampled 40 ports and examined 10,474 salmonines, including 3,657 Chinook salmon and 2,819 lake trout.
- Over 90,000 coded-wire tags have been recovered since the inception of the project.

2017 Estimated contributions of wild lake trout to fisheries in Lakes Michigan and Huron

- In 2017, 57% of lake trout recovered in Lake Huron had no fin clip and were presumed wild (Fig. 1).
- 26% of lake trout recovered in Lake Michigan had no fin clip; wild fish comprised a greater percentage of the catch in southern and western areas (Fig. 1).

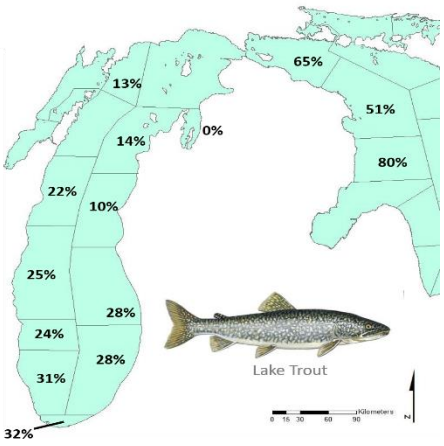


Fig. 1: Percent of lake trout recovered without a fin clip and presumed wild in each statistical district of Lakes Michigan and Huron in 2017.

2017 Estimated contributions of wild Chinook salmon to fisheries in Lakes Michigan and Huron

- 67% of Chinook salmon (all ages) recovered in Lake Michigan and 71% recovered in Lake Huron outside of district MH1 were without a fin clip and presumed to be wild (Fig. 2), consistent with values from the past several years.
- Estimated production of wild Chinook salmon from the 2016 year class was much greater than the weak 2013 and 2015 year classes and on par with most year classes from the mid- to late- 2000s (Fig. 3; blue bars are wild fish).

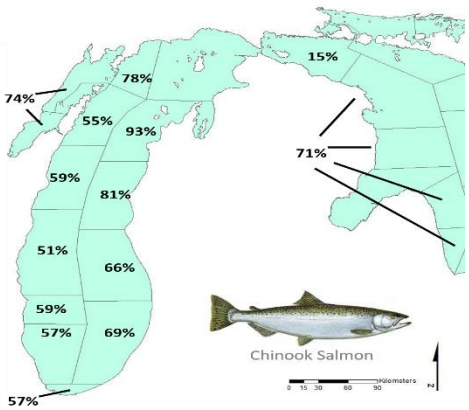


Fig. 2: Percent of Chinook salmon recovered without a fin clip and presumed wild in Lakes Michigan and Huron.

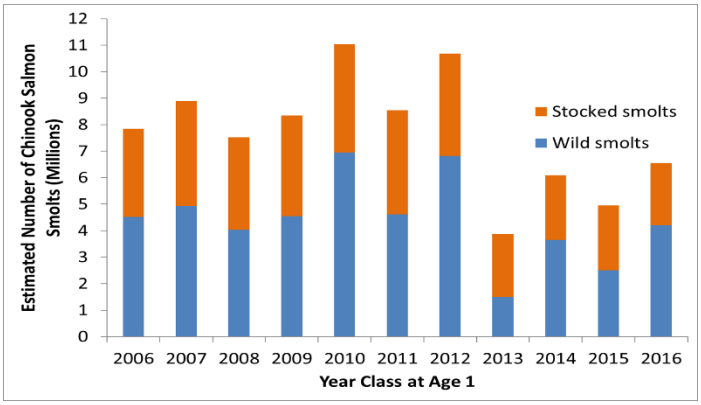


Fig. 3: Estimated number of wild and stocked Chinook salmon in the 2006 – 2016 year classes in Lake Michigan.

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

- Chinook salmon stocked on 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. 8). Analysis was based on Age 2-3 Chinook salmon, separately analyzed for the 2011-2014 year classes and corrected for sampling and stocking effort. Total of 10,399 fish.

- Underlying mechanisms are unknown, but could include differences in habitat (e.g., water temperature, food availability) that make western shore locations favorable for young Chinook salmon; differences in rearing or release practices; or greater competition with wild Chinook salmon on the eastern shore.

Chinook salmon growth patterns

- Chinook salmon stocked on the western shore grew slightly faster than those stocked elsewhere, mirroring survival patterns, but overall growth differences were minor, consistent with lakewide mixing due to salmon movement post-stocking.

- Annual variability in Chinook salmon growth mirrored year-and-older alewife density (Fig. 5), indicative of a limited food supply.

Chinook salmon movement patterns - between basins

- During April – August 2016, 95% of Chinook stocked in Lake Huron were recovered in Lake Michigan, consistent with values from prior years. 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, most Chinook salmon stocked in Lake Huron are considered 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. 6). 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. 7), with recoveries up to 520 km (323 mi) away from stocking location.

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

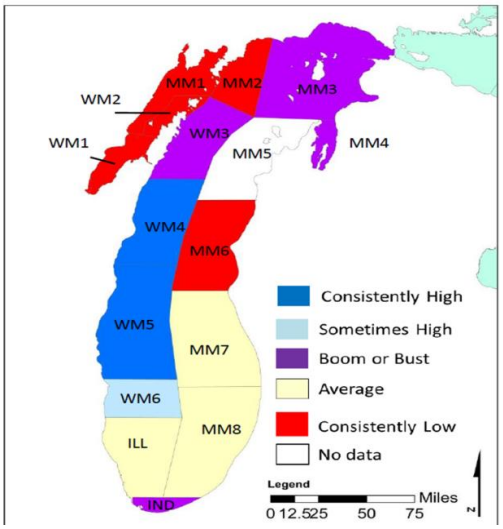


Fig. 4: Map showing districts in which year classes consistently had high survival (dark blue); high survival of some year classes (light blue); consistently average survival (yellow); highly variable survival depending on year class (purple); consistently low survival (red).

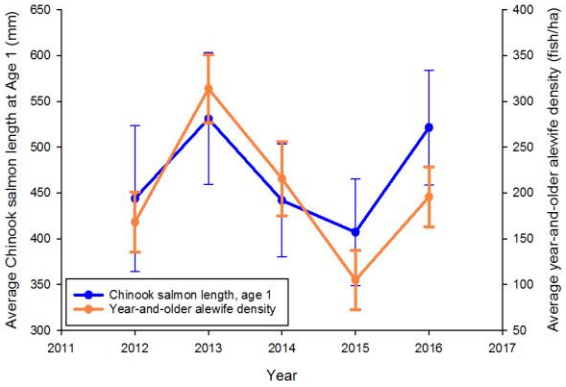


Fig. 5: Similar patterns between Chinook salmon length at age 1 (blue line, left axis) and year-and-older alewife density (orange line, right axis)

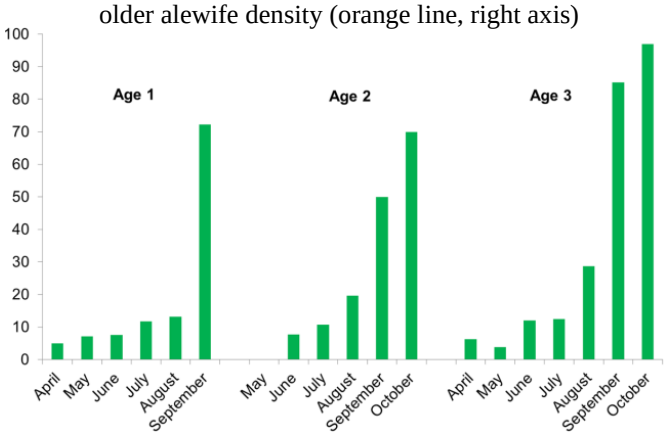


Fig. 6: Percent of Chinook from the 2011 year class recovered in the statistical district where they were stocked, by age and by recovery month. Patterns for later year classes were similar.

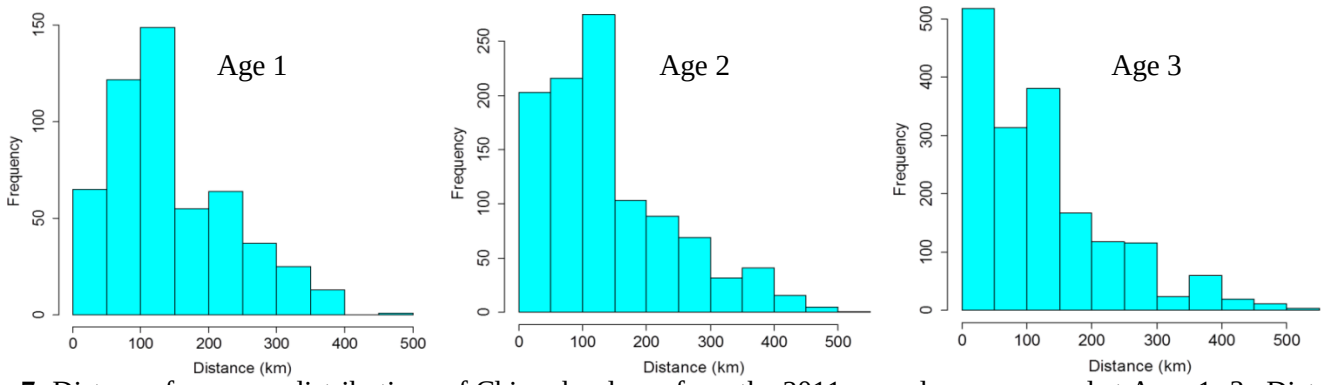


Fig. 7: Distance-frequency distributions of Chinook salmon from the 2011 year class, recovered at Ages 1- 3. Distance is measured as a straight line between the center points of the stocking and recovery districts. 62 miles = 100 km.

- Maps showing the stocking locations of coded-wire tagged Chinook landed at specific ports (31 in Lake Michigan, 11 in Huron, e.g., Fig. 8) are available upon request (matthew_kornis@fws.gov).

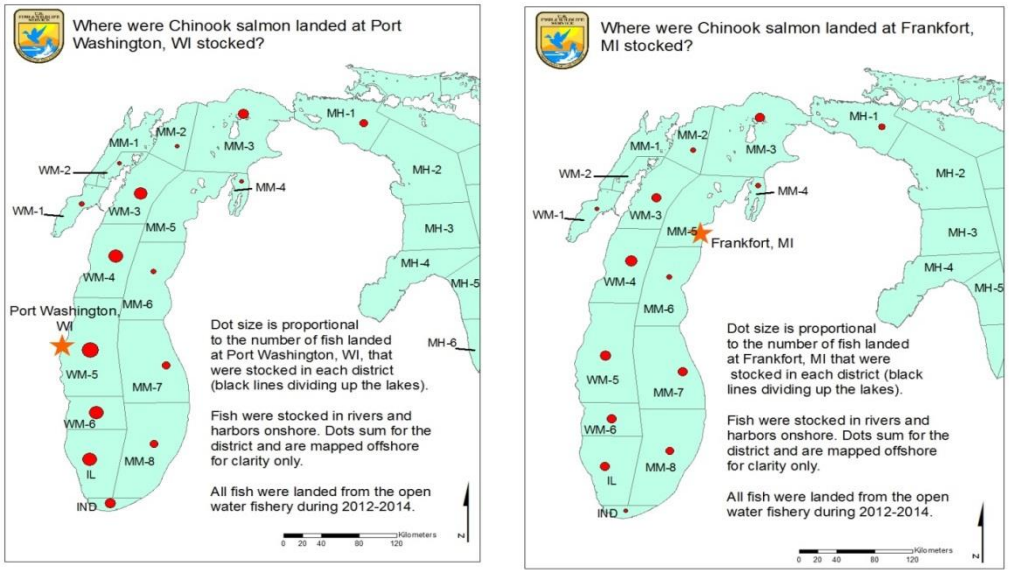


Fig. 8: Origin of stocked Chinook salmon captured at Port Washington, WI (left) and Frankfort, MI (right) from 2012 – 2014 during the open water fishery. The size of each circle corresponds with the number of fish per 100,000 stocked.

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 and genetic strain.
- Lake trout CPUE was lowest from fish stocked in the Northern Refuge, due in part to mortality from sea lamprey and commercial fishing, and highest from fish stocked at Julian's Reef (Fig. 9, left panel).

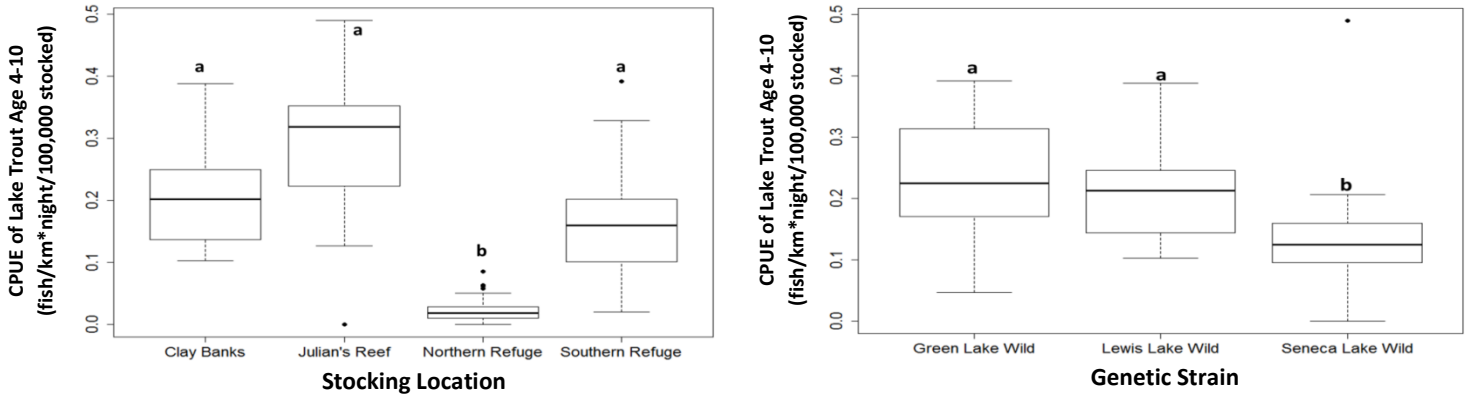


Fig. 9: Effect of stocking location (left) and genetic strain (right) on lake trout CPUE. Northern Refuge fish had low CPUE across all strains and were excluded from the right panel. Different letter codes indicate statistically significant differences ($p < 0.05$).

- 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. 9, right panel).
- 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. 10). 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. 11, left) and had greater returns per number stocked (Fig. 11, 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.

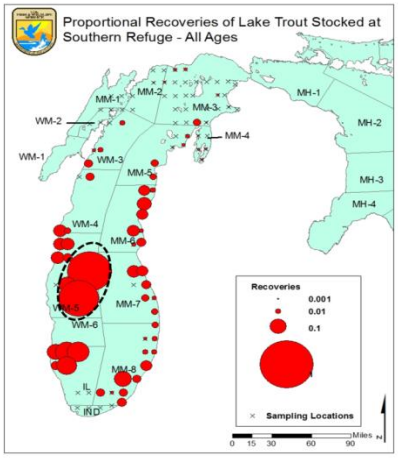
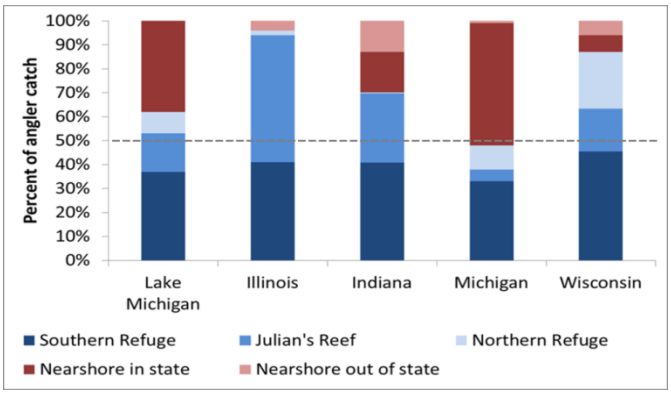


Fig. 10: CPUE of lake trout stocked offshore at the Southern Refuge (dashed black oval). Dot size is proportional to CPUE. X's are sampling sites.



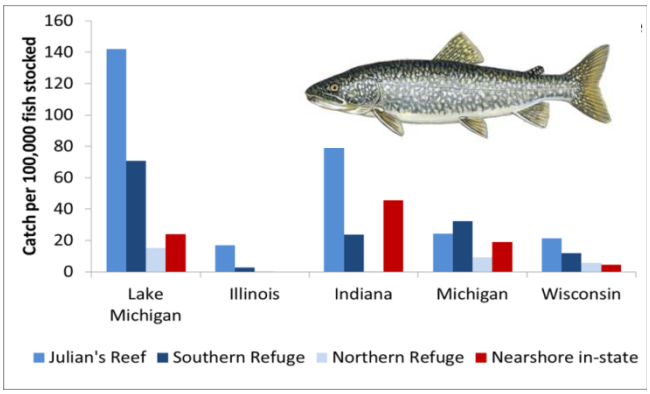


Fig. 11: % of angler catch (left) and return rates corrected for number of fish stocked (right) of lake trout from offshore (blue bars) and nearshore (red bars) stocking locations in Lake Michigan.

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. 12) and had a greater reliance on bottom-oriented and offshore prey (e.g., goby, bloater, sculpin; Table 1).
- Pacific salmon species (Chinook salmon, coho salmon, and steelhead) were very similar isotopically.
- Niche overlap (Fig. 12) and diet mixing models (Table 1) suggest competition for declining alewives and rainbow smelt will be highest among Chinook salmon, coho salmon, and steelhead.

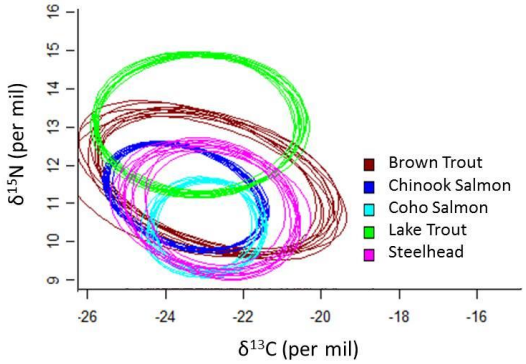


Fig. 12: Potential for competition among salmon and trout, based on overlap of trophic niche (ellipses).

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.

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