Great Lakes Mass Marking Program

2019 Result Updates

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. It is fully funded by the U.S. EPA's Great Lakes Restoration Initiative.

2018 Tagging and marking activities

- 3.7 million lake trout, 2.9 million steelhead, & 2.4 million Chinook salmon were fin clipped in 2017; most of the lake trout and steelhead, and 1.0 million of the Chinook salmon, were also coded-wire tagged.
- < 0.6 million each of Atlantic salmon, brown trout, brook trout, and splake were also marked in 2017
- ≥ 98.5% of Chinook salmon, lake trout, and steelhead were successfully clipped or tagged in the hatcheries
- Throughputs averaged 8,764, 7,564, and 7,424 fish/hr for Chinook salmon, lake trout and steelhead respectively.

2018 Data and tag recovery activities

- Fish and Wildlife Service bio-technicians stationed on Lakes Michigan and Huron, working with the states, sampled 44 ports and examined 13,422 salmonines, including 4,577 Chinook salmon and 4,501 lake trout.
- About 101,000 coded-wire tags have been recovered since the inception of the project.

2018 Estimated contributions of wild lake trout to fisheries in Lakes Michigan and Huron

- 65% of lake trout recovered in Lake Huron had no fin clip and were presumed wild (Fig. 1).
- 30% of lake trout recovered in Lake Michigan had no fin clip and were presumed wild, and comprised a greater percentage of the catch in southern and central areas (Fig. 1).
- Catch per unit effort of wild lake trout increased over time in Lake Huron and southern Lake Michigan (Fig. 2)

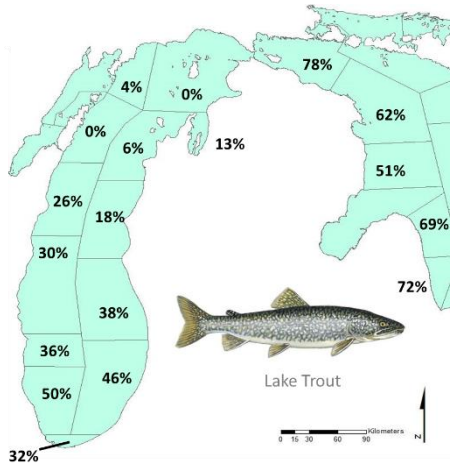

Fig. 1: Percent of lake trout recovered without a fin clip and presumed wild in each statistical district in 2018.

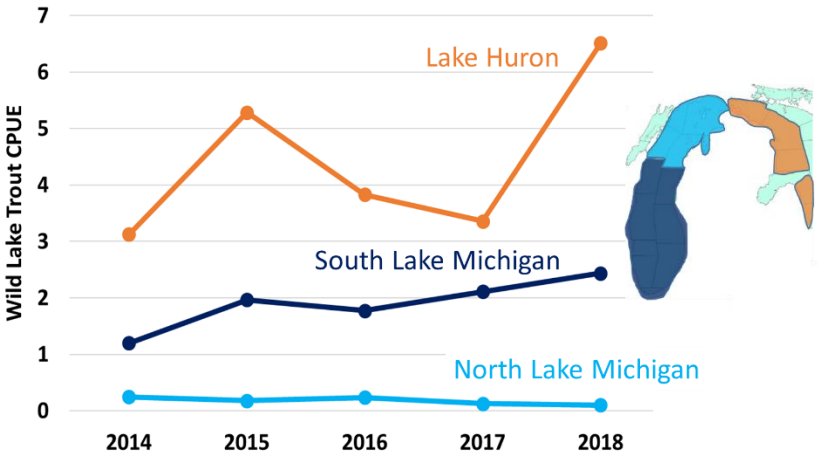

Fig. 2: Catch per unit effort (fish per sampling day) of wild lake trout collected by FWS biotechs in Lake Huron (orange), southern Lake Michigan (dark blue) and northern Lake Michigan (light blue).

2018 Estimated contributions of wild Chinook salmon to fisheries in Lakes Michigan and Huron

- 68% of Chinook salmon (all ages) recovered in Lake Michigan and 68% recovered in Lake Huron were without a fin clip and presumed to be wild (Fig. 3), consistent with values from the past several years.
- Estimated production of wild Chinook salmon from the 2017 year class was greater than the weak 2013 and 2015 year classes and was just below the level observed from most year classes from the mid- to late- 2000s (Fig. 4; blue bars are wild fish).

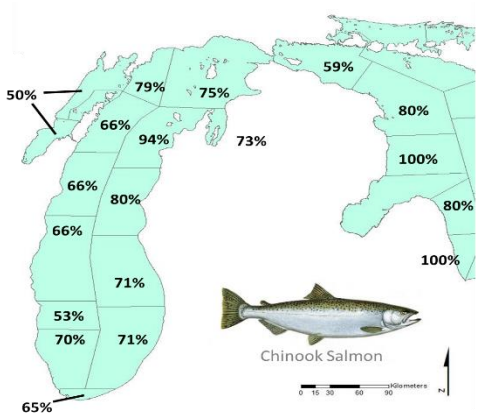

Fig. 3: Percent of Chinook salmon recovered without a fin clip and presumed wild in lakes Michigan and Huron.

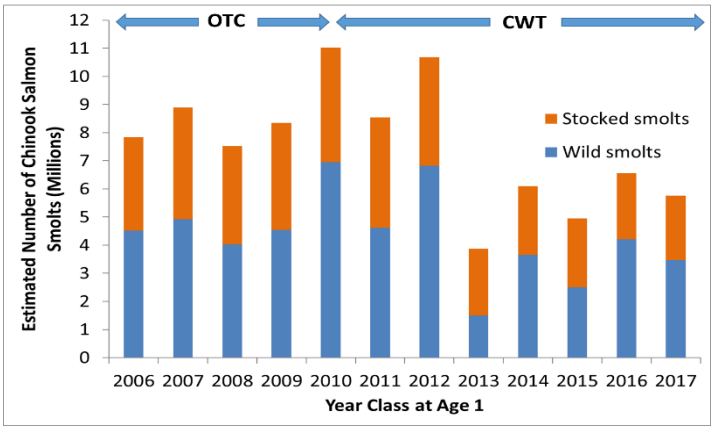

Fig. 4: Estimated number of wild and stocked Chinook salmon in the 2006 – 2017 year classes in Lake Michigan.

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 after stocking than those stocked on the eastern shore and in Green Bay (Fig. 5). Even at eastern ports, fish stocked on the west shore tended to be caught the most (e.g., Frankfort, MI in Fig. 8).

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

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 mixing due to lake wide salmon movement after stocking.

- Annual variability in Chinook salmon growth mirrored year-and-older alewife density (Fig. 6), indicative of a limited food supply.

Chinook salmon movements between lakes Huron and Michigan

- During April – August 2018, 88% of the recovered Chinook salmon that were stocked in Lake Huron were captured in Lake Michigan at age 1, consistent with values from prior years. However, fewer Lake Huron fish were captured in Lake Michigan at Age 2 (68%) and Age 3 (23%) than in prior years. 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, a portion of 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.

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

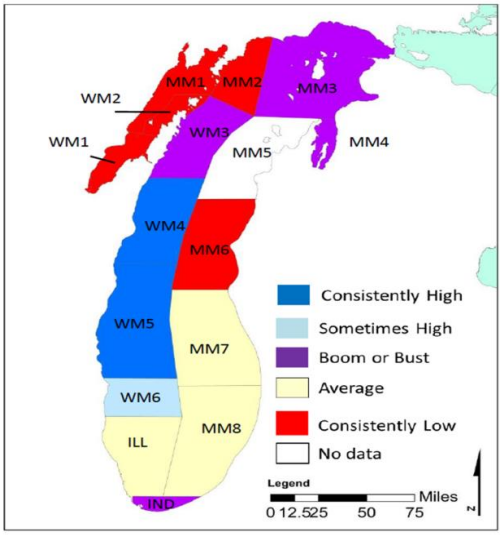

Fig. 5: Districts where year classes (2011 – 2016) consistently had high survival (dark blue); sometimes had high survival (light blue); consistently average survival (yellow); highly variable survival depending on year class (purple); and consistently low survival (red).

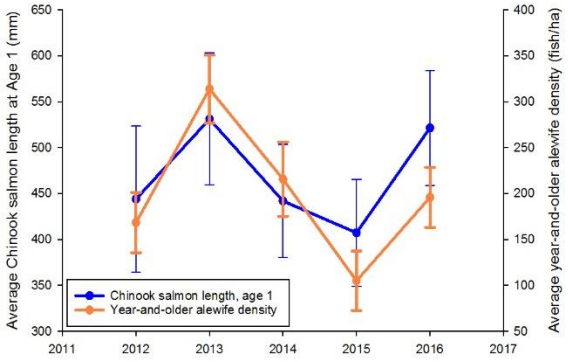

Fig. 6: Chinook salmon length at age 1 (blue line, left axis) tracks year-and-older alewife density (orange line, right axis)

Chinook salmon movement 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. 7). August was a transitional month.
- Mean distance between the centers of stocking and recovery districts during the open-water fishery was 73 - 94 miles depending on age, with recoveries up to 323 miles away from stocking location
- Fishing quality in spring and summer is not dependent on local stocking numbers, but may be affected in the fall.
- 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).

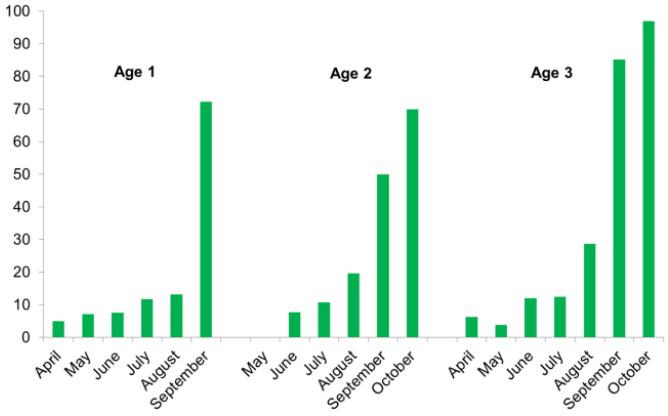

Fig. 7: Percent of Chinook from the 2011 year class recovered in the statistical district where they were stocked, by age and by recovery month. Patterns for later year classes were similar.

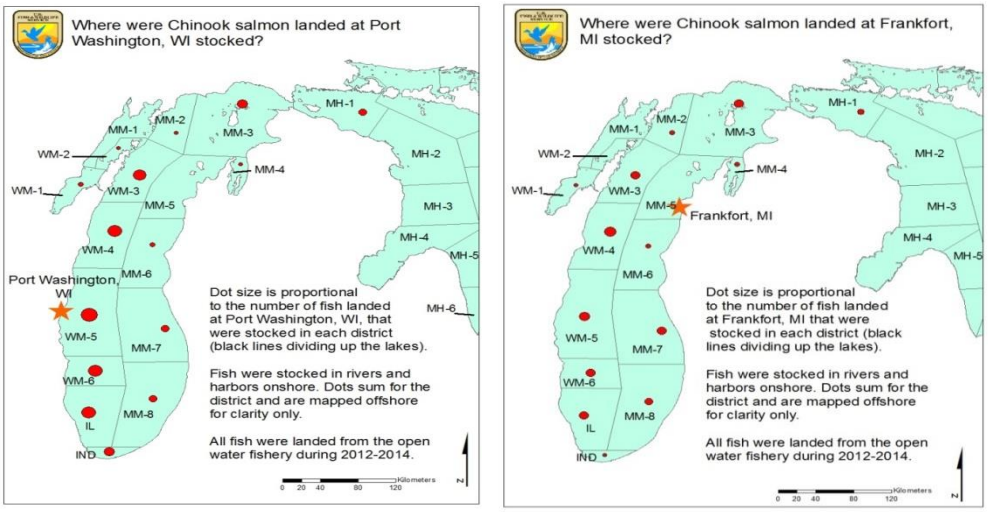

Fig. 8: Origin of stocked Chinook salmon captured at Port Washington, WI (left) and Frankfort, MI (right) from 2012 – 2014 during the open water fishery. The size of each red circle corresponds with the number of fish per 100,000 stocked recovered at the identified harvest location (gold star).

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 rates (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).

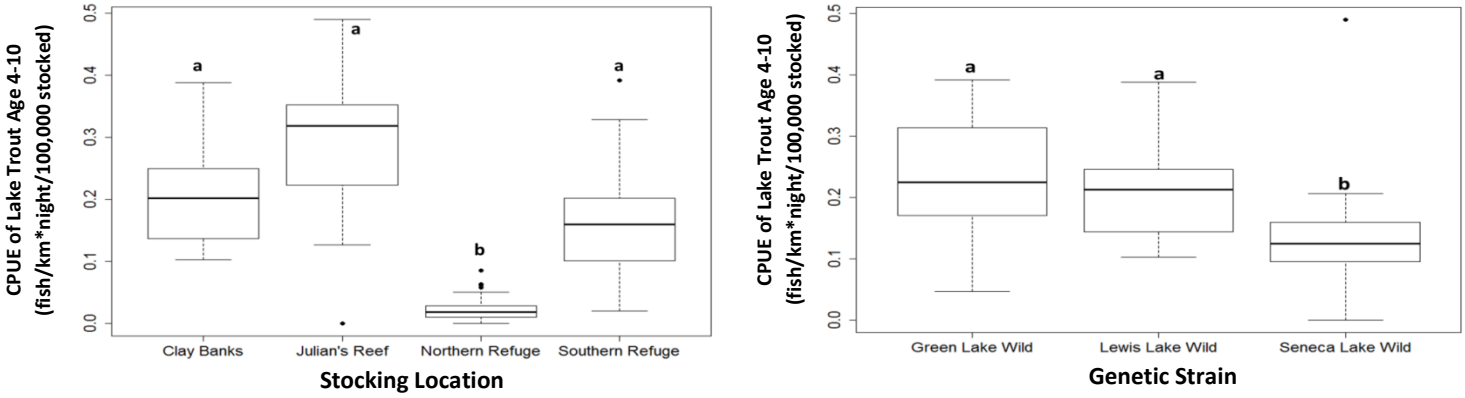

Fig. 9: Effect of stocking location (left) and genetic strain (right) on lake trout CPUE. Northern Refuge fish had low CPUE across all strains and were excluded from the right panel. Different letter codes indicate statistically significant differences ($p < 0.05$).

- 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 2012-2018 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 contradicts the belief that lake trout must be stocked nearshore to benefit anglers.

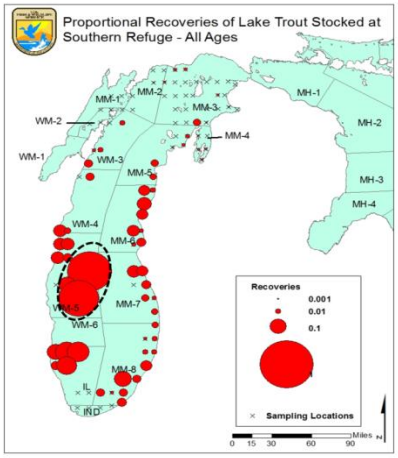

Fig. 10: Catch rate (CPUE) of lake trout stocked offshore at the Southern Refuge (dashed black oval). Dot size is proportional to CPUE. X's are sampling sites.

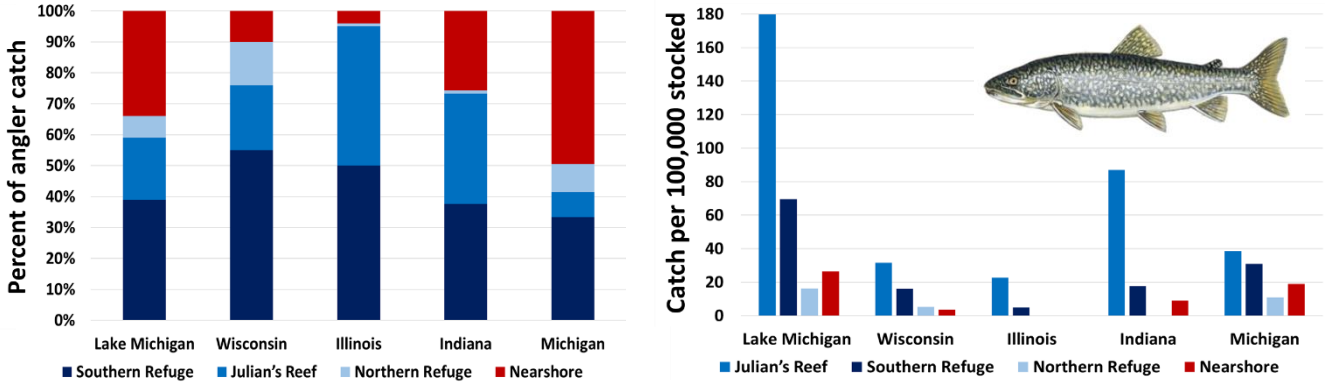

Fig. 11: Percent of angler catch (left) and return rates corrected for number of fish stocked (right) of lake trout from offshore (blue bars) and nearshore (red bars) stocking locations in Lake Michigan.

Diets 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 diet and 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 (goby, bloater, sculpin; Table 1).
- Pacific salmon species (Chinook salmon, coho salmon, and steelhead) were very similar isotopically, suggesting similar diet.
- Results suggest competition for declining alewives and rainbow smelt will be highest among Chinook salmon, coho salmon, and steelhead.

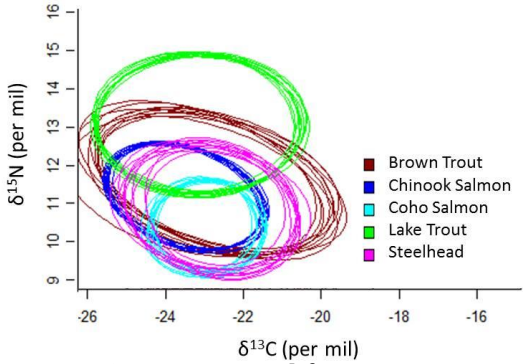

Fig. 12: Potential for competition among salmon and trout, based on overlap of trophic niche (ellipses).

Predator	Alewife & Smelt	Bloater	Sculpin	Round Goby	Stickleback
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 isotope mixing models. Values are lake-wide averages; diets vary among regions, seasons, and individual fish. Numbers may not add to 100% due to rounding.