WDNR Lake Superior Lake Trout Spawning Survey 2019

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March 13, 2020

Introduction

Recovery of historical spawning populations has been an essential component of Lake Trout rehabilitation in the Wisconsin waters of Lake Superior. Wild Lake Trout abundance in management unit WI-2 (i.e., Apostle Islands) has increased dramatically since the 1960's, and stocking was ceased in 1995. Managers agree that maintaining or continuing to increase spawner biomass is essential to a self-sustaining Lake Trout population that supports both commercial and recreational fishery interests. This assessment is the longest-running Lake Trout survey in the Great Lakes; it was initiated in 1951, but was standardized in its current form in 1985. The objective of this assessment is to monitor Lake Trout population characteristics on historically important spawning shoals and to collect Lake Trout eggs for the Bayfield Fish Hatchery for Lake Trout (WI-1) and Splake stocking programs.

Methods

Gill nets were set on the bottom for one night (24 hr) using the R/V Hack Noyes. The 2019 spawning Lake Trout Survey was conducted in the Apostle Islands region of Lake Superior (Figure 1) between October 17 and October 30. Gull Island Shoal (GIS) was sampled with a 823 m monofilament gillnet. The net was composed of alternating 140 and 152 mm mesh (stretch measure) panels arranged using the following sequence; 152, 140, 152, 140, 152, 140, 152, 140, 152. Both Gull Island (GI) and Michigan Island (MI) were sampled by dividing the standard GIS gillnet. Gull Island was sampled with a 366 m gillnet that used the following sequence of meshes; 152, 140, 152, 140. Michigan Island was sampled with a 457 m gillnet that used the following sequence of meshes; 152, 140, 152, 140, 152. Both GI and MI were combined to generate a single estimate (GI/MI). Sand Cut Reef (SCR) was sampled with a 1,189 m monofilament gillnet that was divided between two humps (i.e., 549 m on the west hump and 640 m on the east hump). The meshes were arranged using the following sequence; 152, 140, 178, 114, 165, 127, 152, 127, 165, 114, 178, 140, 152. This same net was used on Devils Island Shoal (DIS) and Cat Island Shoal (CIS) as one net.

Biological information (e.g., total length, weight, sex, gonad status, fin clips, etc.) was collected from fish using standardized protocols. Otoliths were extracted from deceased individuals, and ages were estimated using cross-sections. All live Lake Trout were given external Floy tags with unique numbers, and tag information was recorded from all recaptured fish.

Assessing relative abundance (CPE) during spawning assessments is not recommended due to the variable nature of sampling spawning aggregations, and CPE trends in this assessment do not reflect other surveys/estimates (e.g., stock assessment model estimates, Spring Lake Trout Survey, etc.). Thus, relative abundance was not assessed with this survey; however, numerous other population characteristics were summarized. Length and age frequency plots were used to compare size and age structure among the five Apostle Islands spawning shoals, and median length was used to look at trends in size structure through time. Presence or absence of a fin clip was used to determine native (i.e., not hatchery-origin) and hatchery origins through time. Recapture histories were assessed with number of years at large calculated for both the most recent capture (i.e., number of years since most recent capture of that individual) and the original capture event (i.e., number of years since the original capture of that individual). Mean annual growth increment was calculated by grouping individual Lake Trout into 20 mm length bins based on the observed total length at the most recent capture. Growth increment was then computed as the difference between the observed total length and the total length at the most recent capture event divided by the number of years at large since most recent capture. Growth was also assessed by fitting von Bertalanffy growth functions to length and age data. Lastly, a transition plot was constructed to visualize Lake Trout movement patterns among the five Apostle Islands spawning shoals sampled in this survey. Analyses were conducted using Program R, and this report was formatted with the package rmarkdown.

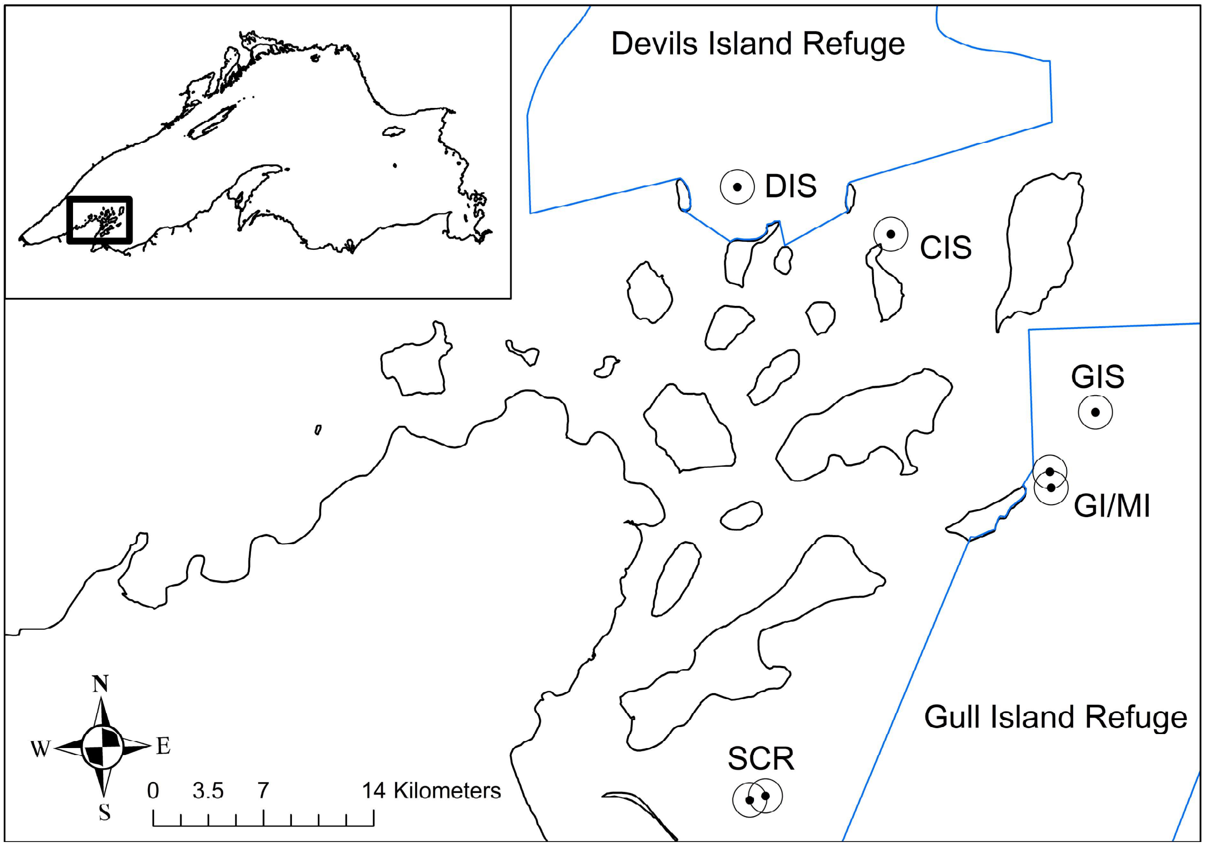

Figure 1. Map of WDNR fall Lake Trout spawning shoal assessment in the Apostle Islands region of Lake Superior. DIS = Devils Island Shoals, CIS = Cat Island Shoals, GIS = Gull Island Shoals, GI/MI = Gull Island/Michigan Island, SCR = Sand Cut Reef.

Results

Lake Trout spawning stock at GI/MI and GIS had larger size structure than other spawning shoals, likely due to using larger mesh sizes at these shoals (Figure 2). CIS, DIS, and SCR were fished using the same gear and are thus comparable. In 2019 DIS had larger male and female size structure than CIS and SCR, while SCR had the smallest size structure of these three shoals (Figure 2). Median total length of both spawning male and female Lake Trout has declined in the last decade at all spawning shoals, but median total length has increased at CIS and DIS in the last few years (Figure 3). The proportion of native (non-hatchery origin) Lake Trout spawning stock was greater than 96% at all spawning shoals in 2019 (Figure 4). Proportion of native Lake Trout has increased substantially in the Apostle Islands since restoration efforts began and WDNR ceased stocking Lake Trout in WI-2 (Figure 4.)

Overall, males reach sexual maturity (i.e., appear in the spawning stock) a couple years earlier than females (Figure 5). The oldest Lake Trout age estimate from this survey since 2010 was 49 years old (sampled in 2019). Lake Trout spawning stock from SCR had a younger age structure than Lake Trout from CIS and DIS (Figure 5). GIS and GI/MI Lake Trout had much older age structure than the other three spawning shoals, but again this is likely biased due to the use of different gears. SCR and CIS Lake Trout spawning stock also had a smaller median number of years at large since most recent capture and original capture compared to all other spawning shoals (Figure 6). GIS Lake Trout had the largest median number of years at large since recent capture and original capture. These results indicate Lake Trout captured on spawning shoals outside the two refuges (SCR and CIS; Figure 1) have smaller size structure (Figure 2), younger age structure (Figure 5), and shorter recapture histories (Figure 6) than those inside the refuges, potentially suggesting a higher mortality rate within these population subsets (especially SCR) due to sport and commercial harvest allowances.

Subsequent recaptures of tagged Lake Trout allowed us to measure growth with a known number of years between the original capture event and recapture events. Smaller male Lake Trout (520-539 mm) on average grew 31 mm per year, but annual growth declined to an average of 17 mm per year for 620-639 mm male Lake Trout and evened out around an avearge of 7-10 mm per year for Lake Trout between 680 and 919 mm (Figure 7). On average, female Lake Trout grow slightly faster than male Lake Trout through the first 20 years of life (i.e., higher K value), but average maximum lengths near the end of life are similar (i.e., similar Linf values; Figure 8, Table 1).

Lake Trout captured on Apostle Islands spawning shoals displayed a relatively large degree of homing back to the same spawning shoal during subsequent recapture events (Figure 9). In other words, a Lake Trout tagged on a particular spawning shoal was likely recaptured on the same shoal. However, there was some degree of mixing among the five spawning shoals assessed from 2010 to 2019. Spawning Lake Trout captured on GI/MI were recaptured on GIS in a subsequent year 29% of the time and vice versa occuring 13% of the time, suggesting the two shoals act more as a "spawning reef complex." Likewise, to a lesser degree, spawning Lake Trout captured on CIS were recaptured on DIS in a subsequent year 11% of the time and vice versa occuring 8% of the time, suggesting these two shoals also act more as a reef complex together. Movement outside of these spawning reef complexes was much more rare; all other transitions occured less than 3% of the time. Interestingly, CIS-DIS spawning Lake Trout were rarely captured in the GIS-GI/MI complex and vice versa, and SCR was realtively isolated from both other complexes.

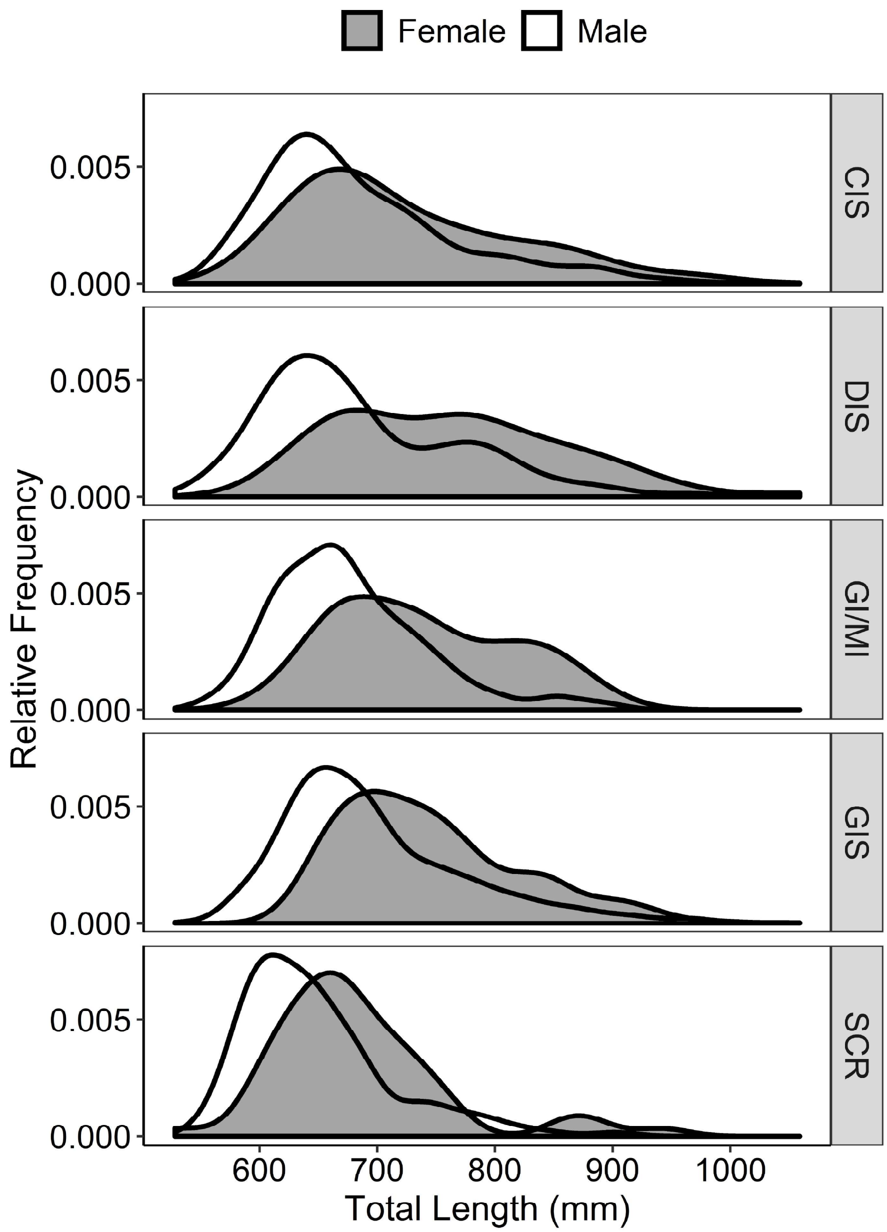

Figure 2. Density plots of male (white) and female (grey) Lake Trout length frequency on five Apostle Islands spawning shoals in 2019.

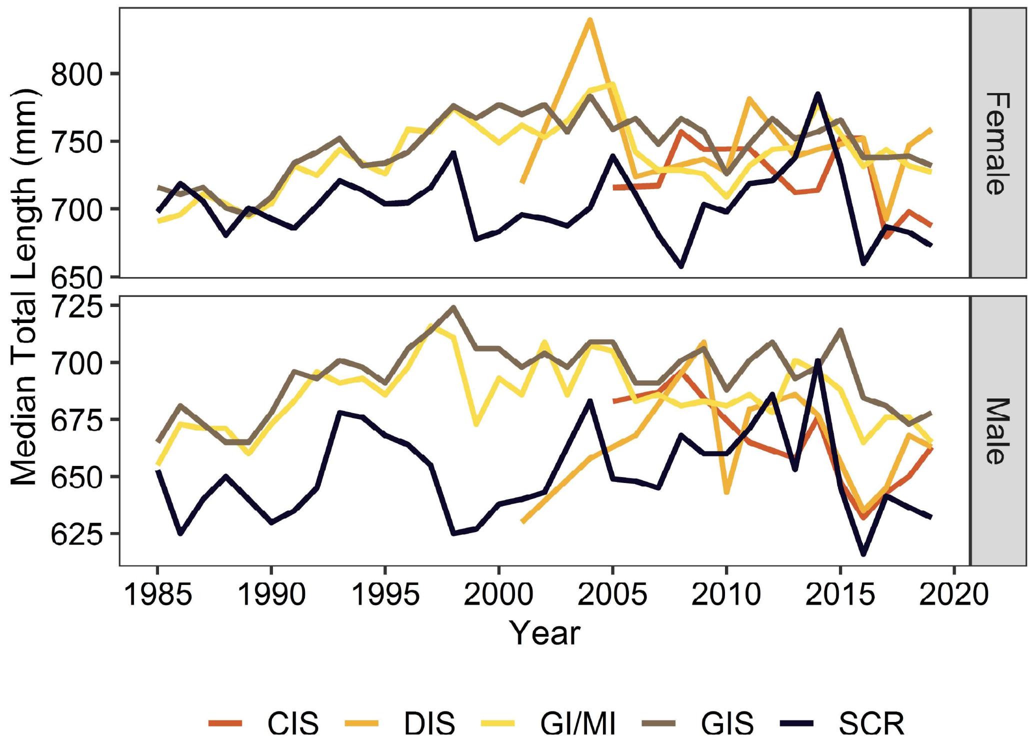

Figure 3. Time series of native female (top) and male (bottom) Lake Trout median total length (mm) captured on five Apostle Islands spawning shoals from 1985 to 2019. Note the differing y-axis scales among grids.

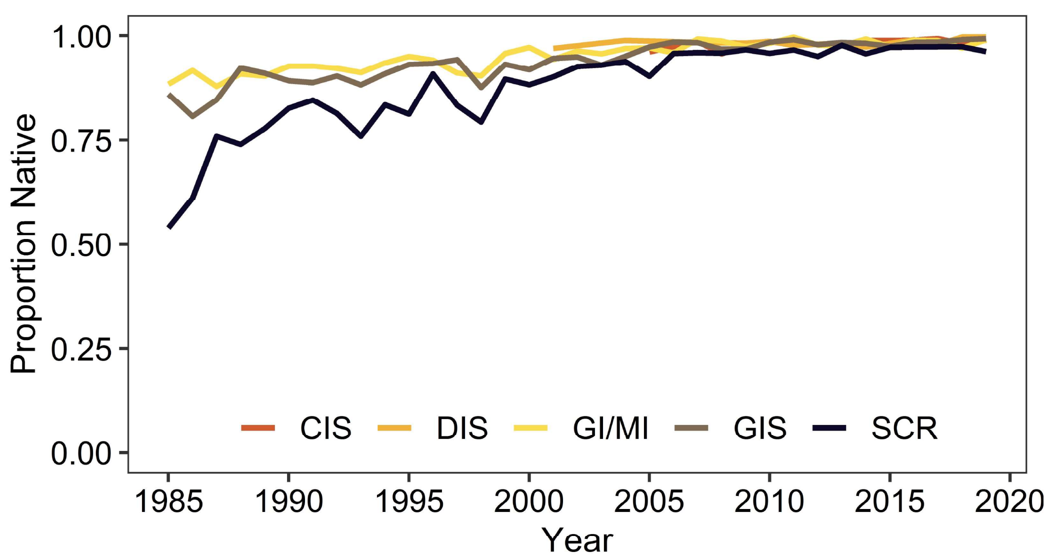

Figure 4. Time series of the proportion of native (non-hatchery origin) Lake Trout among five Apostle Islands spawning shoals from 1985 to 2019.

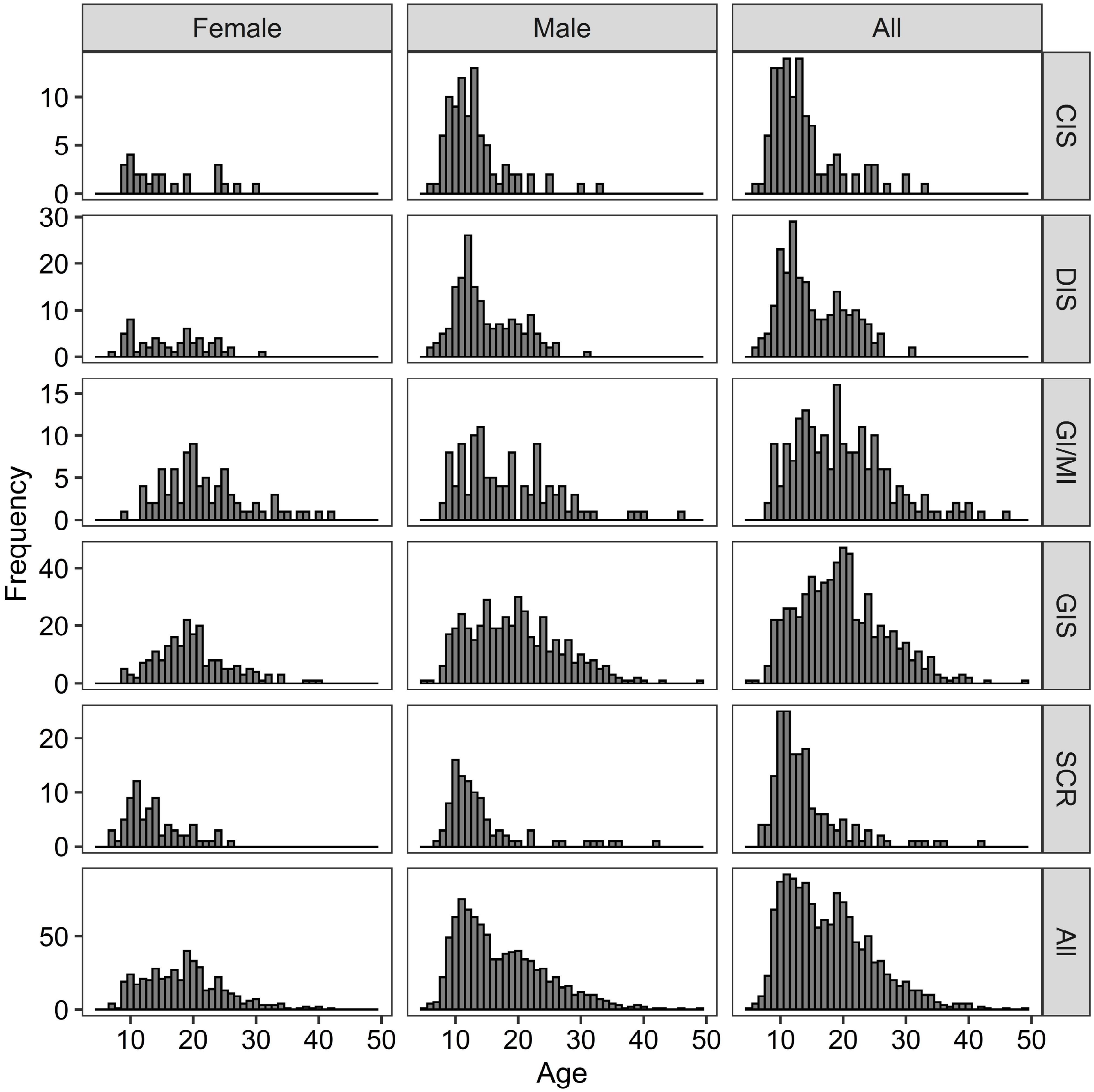

Figure 5. Age frequency plots for male, female, and all sexes of Lake Trout combined that were captured among five Apostle Islands spawning shoals. Data include age estimates from the spawning survey from 2010 to 2018. Note the differing y-axis scales among grids.

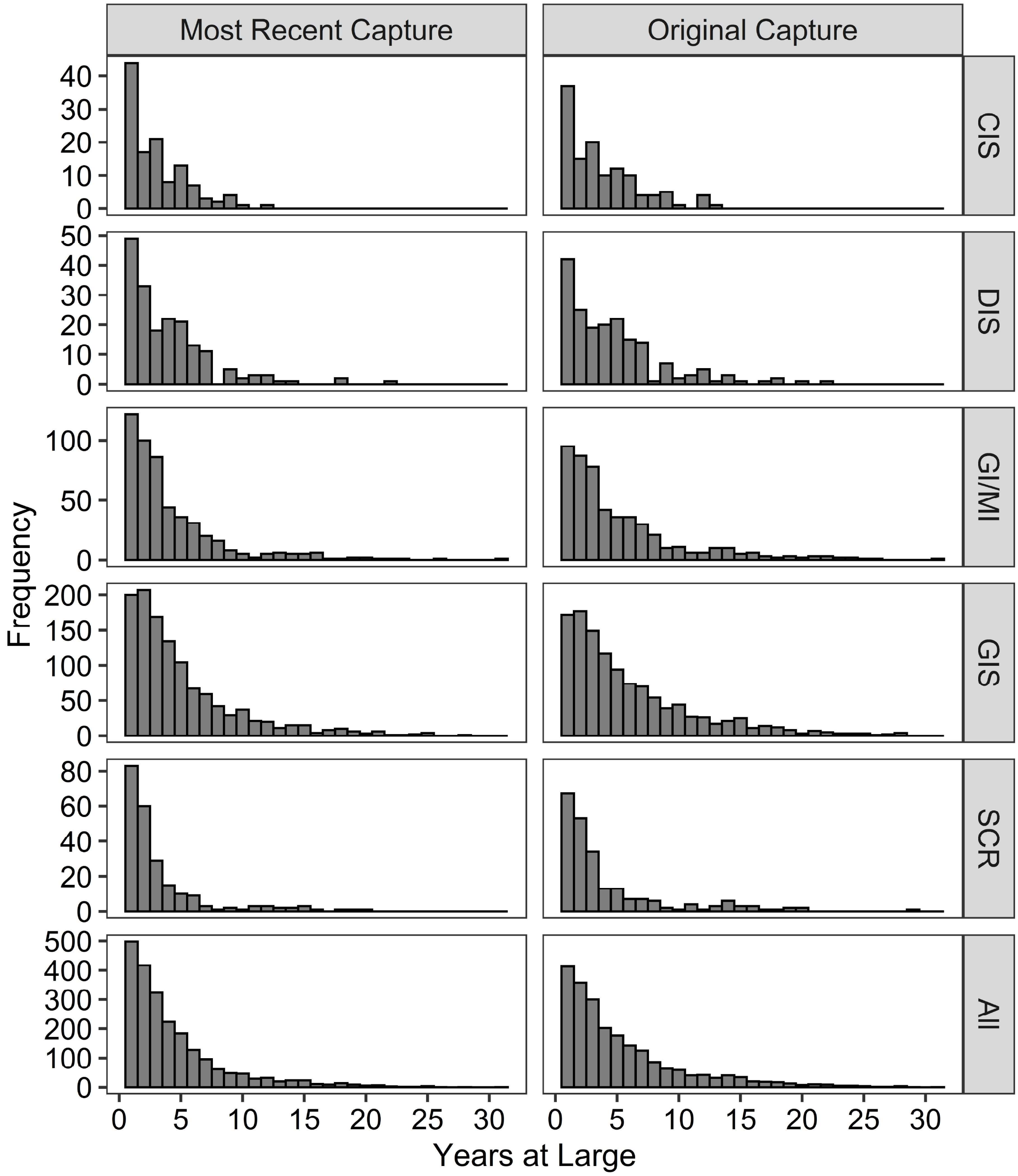

Figure 6. Frequency of the number of years at large since the most recent capture event (left) and the original capture event (right) for all individual recaptured Lake Trout during the fall spawning survey from 2010 to 2019 from each individual spawning shoal and all shoals combined (All).

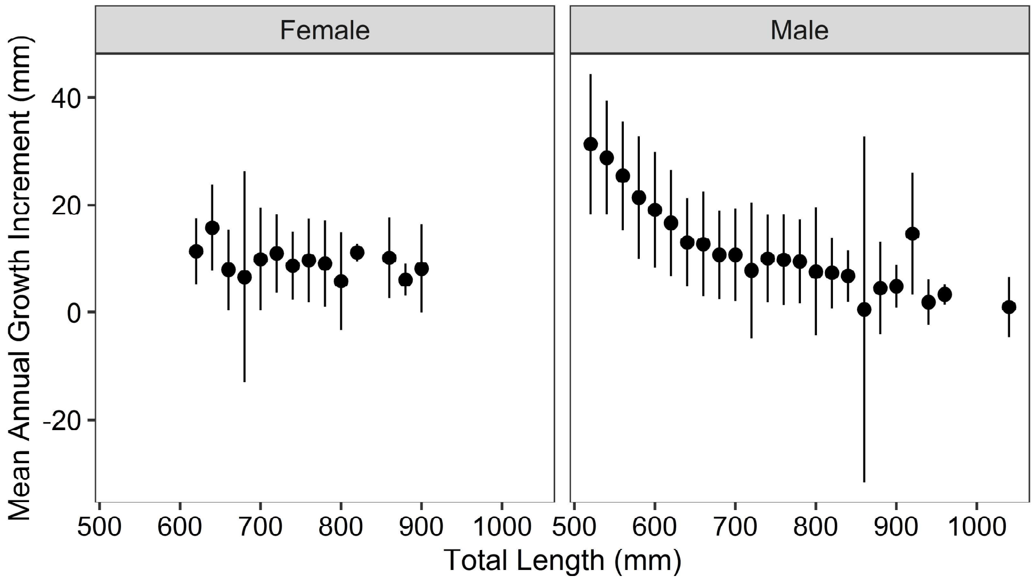

Figure 7. Mean annual growth increment (mm) of female (left) and male (right) recaptured native Lake Trout during the WDNR spawning survey using data from 2010 to 2019. Vertical bars represent +/- one standard deviation. Individual Lake Trout were grouped into 20 mm length bins based on the observed total length at the most recent capture. Growth increment was computed as the difference between the observed total length and the total length at the most recent capture event divided by the number of years since the most recent capture event.

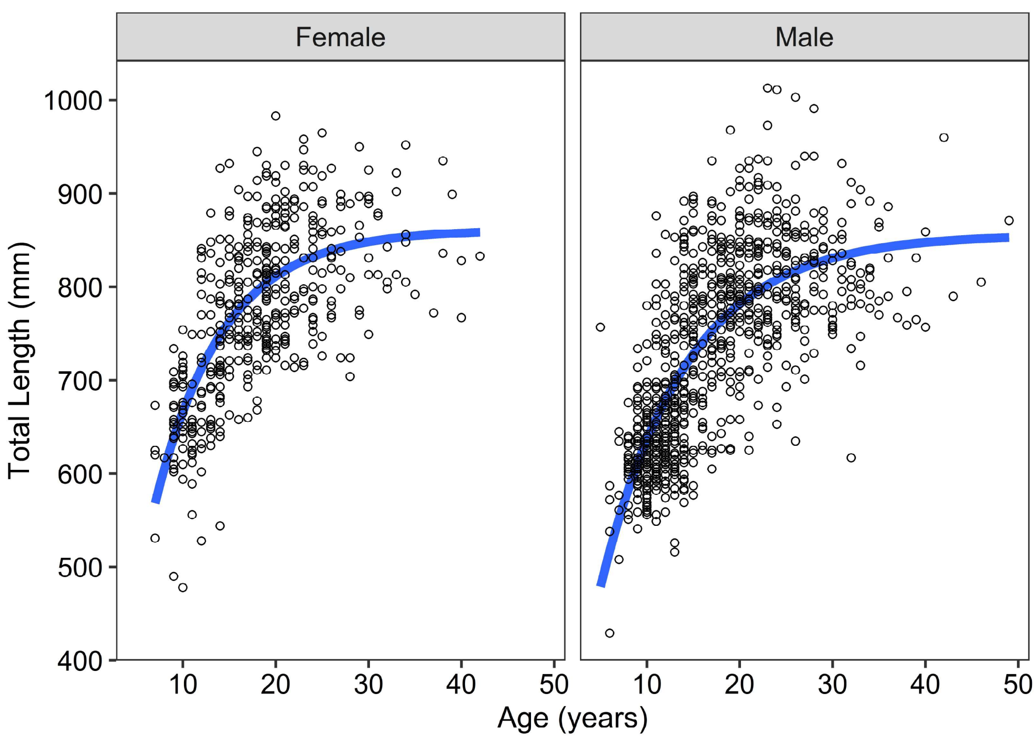

Figure 8. von Bertalanffy growth functions of both female (left) and male (right) Lake Trout from the Spawning Lake Trout Survey from 2010 to 2019.

Table 1. von Bertalanffy growth function coefficients for female and male Lake Trout from the Spawning Lake Trout Survey from 2010 to 2019.

	Female			Male		
	Coefficient	**L 95% CI**	**U 95% CI**	**Coefficient**	**L 95% CI**	**U 95% CI**
Linf	861.089	842.558	885.514	856.190	839.603	876.314
K	0.136	0.105	0.171	0.108	0.091	0.126
t0	-0.903	-3.647	1.053	-2.574	-4.393	-1.119

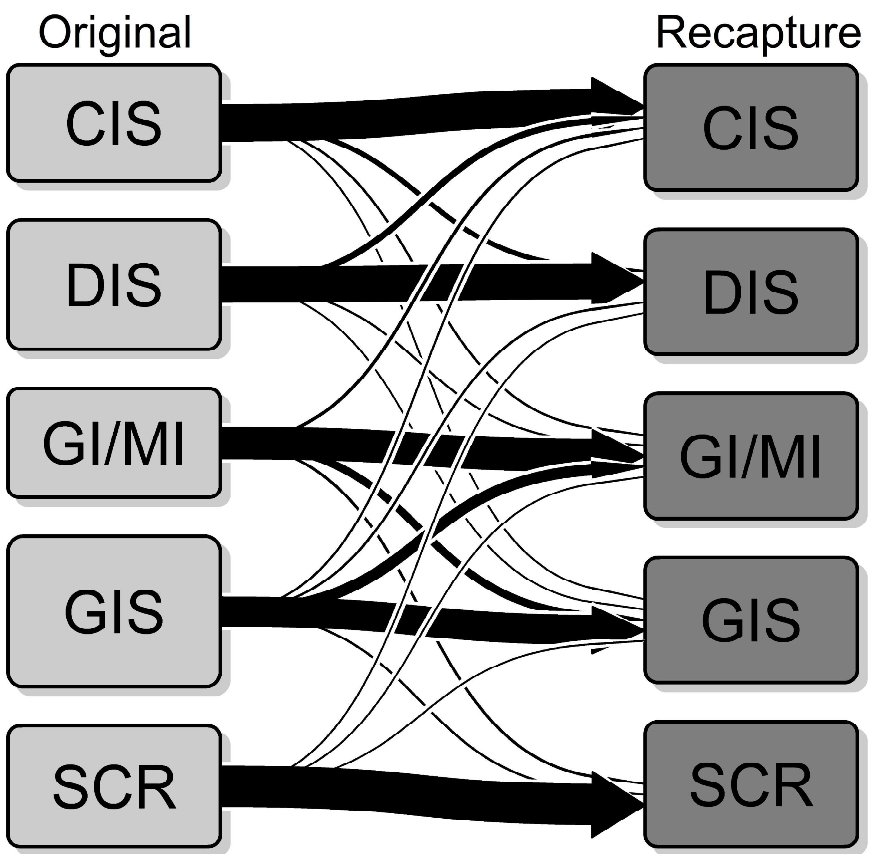

Figure 9. Transition plot representing trends of individual Lake Trout movement from its original capture location (light grey) to its next encounter location (dark grey). Arrow thickness represents proportions of total Lake Trout recaptured within each original capture location. All recaptures from the fall spawning survey from 2010 to 2019 were used in this analysis.