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Study 3

MINNESOTA DEPARTMENT OF NATURAL RESOURCES
DIVISION OF FISH AND WILDLIFE
SECTION OF FISHERIES

Status of Coaster Brook Trout in Minnesota Waters of Lake Superior 2018

Nick R. Peterson

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Background

Brook Trout *Salvelinus fontinalis* is one of two charr native to the Minnesota waters of Lake Superior. The migratory life-history variant of stream resident Brook Trout, referred to as 'Coasters', will spend all or a portion of their life in Lake Superior and can grow to a size that exceeds 20 inches and 5 pounds (Becker 1983). Coasters were once widely distributed among Lake Superior tributaries (Newman and Dubois 1997), and historic angling records document abundant populations of large Brook Trout (likely Coasters) in many North Shore streams (Smith and Moyle 1944). In the late-1800s, the reports of abundant Brook Trout populations on the North Shore spread quickly. A multitude of anglers traveled to the North Shore throughout the late-1800s and early-1900s to catch and harvest Coasters. By the 1920s, angler diaries already began to document significant declines of Coaster populations in Minnesota streams. These early declines were almost entirely due to overfishing because they occurred prior to the peak of excessive logging on the North Shore. Extensive harvest of old growth conifers, mostly white pine, throughout the mid-1900s changed the landscape, altered the hydrology of North Shore streams, and degraded stream habitats utilized by Brook Trout and other aquatic species (Horns et al. 2003). Coaster populations continued to decline throughout the late-1900s (Smith and Moyle 1944).

In response to population declines, the Minnesota Department of Natural Resources (MNDNR) and many other jurisdictions in Lake Superior began to stock various life stages of Brook Trout. Brook Trout were extensively stocked in Minnesota waters throughout the mid-1900s, but stocking was ultimately deemed unsuccessful. The MNDNR discontinued their Coaster stocking program after 1987 (Schreiner et al. 2006), but stocking has continued in other jurisdictions. Today, the Grand Portage Band of Lake Superior Chippewa has a Coaster stocking program within Grand Portage Reservation waters, immediately adjacent to the waters managed by the MNDNR.

Interest in coaster rehabilitation intensified among biologists and anglers over the past few decades (Schreiner et al. 2008). In 1999, the Great Lakes Fishery Commission produced "*A Brook Trout Rehabilitation Plan for Lake Superior*", which provided a framework for Brook Trout rehabilitation efforts in Lake Superior (Newman et. al 1999). A number of agencies have attempted to protect remnant stocks, primarily through harvest regulation. In 1997, the MNDNR implemented a conservative regulation for the Minnesota waters of Lake Superior and the below-barrier portions of Lake Superior tributaries. The regulation was an open season from the inland Trout opener in mid-April through Labor Day, with a bag limit of one fish and a minimum size limit of 20 inches. A standardized fall spawning assessment in tributaries was added to the MNDNRs Lake Superior Management Plan (Schreiner et al. 1996) to better assess the status of Coaster populations and to evaluate progress of the conservative regulations implemented in 1997. Five spawning assessments have been completed since 1997 (Tillma 1999; Pranckus and Ostazeski 2003; Ward 2007; Ward 2008; Blankenheim 2013). These assessments have provided valuable information to support management and rehabilitation efforts for Coasters in Minnesota waters (Miller et al. 2016), and support research, coordination and management efforts to rehabilitate coaster Brook Trout populations throughout Lake Superior.

Conservative regulations implemented by MNDNR have improved size and abundance of Coasters in Minnesota waters over time (Miller et al. 2016), but size and abundance could be affected by straying of stocked fish from other jurisdictions. Brook Trout and Splake (Brook Trout x Lake Trout cross) are currently stocked in Lake Superior by other jurisdictions and

tribes, and these fish have been captured in Minnesota waters throughout the open water fishing season. Genetic introgression of stocked Splake into Lake Trout and Brook Trout populations is a growing concern among Lake Superior management agencies (Feringa et al. 2016). Contrary to what many believe, some stocked Splake in Lake Superior are fertile. Feringa et al. (2016) found that 56% of Splake captured at several Lake Trout spawning reefs in Lake Superior were sexually mature. Fertile Splake have been captured among spawning Brook Trout in Minnesota streams during the MNDNRs fall spawning assessments (Ward 2007; Ward 2008; Blankenheim 2013), and captured while trying to ascend the Knife River fish trap in the fall (Peterson 2018). Stocked Splake may pose a threat to the genetic integrity of spawning Brook Trout and Lake Trout populations where they occur (Feringa et al. 2016), however this assumption needs further evaluation. The MNDNR initiated a genetics monitoring program to determine the genetic contribution from hatchery strains of Brook Trout and Splake (Brook Trout x Lake Trout hatchery hybrid) in Minnesota waters (Goldsworthy et al. 2016).

Genetic analysis of Coasters previously sampled by the MNDNR found that substantial genetic diversity still exists within Coaster populations in Minnesota, and that native Brook Trout populations suffered no significant genetic impact from previous stockings (Burnham-Curtis 2000). Genetic analysis of all Coasters captured in fall spawning assessments between 1997 and 2013 showed that the vast majority of fish were Minnesota strain and few were Isle Royal strain or stocked hatchery strain fish (Miller et al. 2016). This suggested that most Coasters, particularly large sized fish, captured in recent years were the result of conservative regulations rather than stocking efforts by other agencies or strays from other jurisdictions.

This report summarizes the results of the 2018 fall spawning assessment for Coasters in Minnesota waters of Lake Superior. Genetics results were not available at the time of this report, but will be analyzed and reported at a later date. The fall spawning assessment will now be completed every 3 years, with the next assessment in 2021 (Goldsworthy et al. 2016).

Environmental Conditions

Environmental conditions were relatively good for stream backpack electrofishing in the fall of 2018, and streams were able to be sampled for 4 out of 5 weeks of the survey season. The crew was sidelined the week of October 8-14 due to consistent rains that made streams too high and turbid to sample. Monthly precipitation totals during the 2018 survey period were similar to other years with the exception of 2007. Mean monthly precipitation totals in Grand Marias were 3.6 inches in September, 4.5 inches in October, and 1.9 inches in November (Figure 1). Snow and ice appeared during the end of the last week of October throughout the first week of November.

Study Area and Methods

Stream sampling protocols were reanalyzed prior to the 2018 fall spawning assessment. Given resource constraints, the 2018 survey refocused efforts on streams that 1) had captured 10 or more Brook Trout in previous surveys, 2) provided suitable habitat conditions (upstream and downstream of barriers) that would support Brook Trout, 3) were in close proximity to the Grand Portage Reservation waters where Coasters are currently stocked, and 4) provided stream conditions that could safely and adequately be sampled via backpack electrofishing. Twelve streams were chosen based on these criteria, which included streams from the Gooseberry River,

north to Carlson Creek, located near the Grand Portage Reservation boundary (Figure 2, Table 1).

The MNDNR and 21 public volunteers sampled Coasters from October 2 through November 1, 2018. A total of 9.5 miles of stream were sampled in 2018, which was slightly lower than the historic average (11.5 miles) (Table 2). All streams, except for the Cascade River, were sampled multiple times in a total of 23 total sampling events (Table 3). Fish were sampled with 1-pass backpack electrofishing from the lake to the first natural barrier, or to a previously established landmark if a barrier falls was not present. Field crews consisted of three or four individuals on small to medium sized streams, and five or six individuals on larger streams. At least two ETS Electrofishing ABP-3 electrofishing packs were used at each stream, and a Smith Root model LR-24 was also used when more than two electrofishing packs were required to adequately sample a stream. Electrofishing settings (volts, frequency, and duty cycle) were recorded during all sampling events, but effort (on time in seconds) was not recorded due to a timer malfunctions on multiple packs. Water temperature (°C), conductivity (µs), dissolved oxygen (mg/L) and discharge (m^3/s) were measured during every survey, and a water sample was collected to measure alkalinity (meq $liter^{-1}$) and pH, on each stream on each sample date.

Brook Trout were captured, measured, weighed, and sex was determined, if possible. Maturity status was determined for each fish (ripe, green, or spent [for females]), and all young-of-the-year (age-0) were considered immature. Scale samples were collected for estimating age and to evaluate length at age at time of capture. A piece of tissue was removed from the right rear pelvic fin for genetic analyses and to provide a 'mark' so that recaptured fish could be recognized in subsequent sampling events. Tissue samples were placed in individually numbered vials of 95% ethanol solution. All Brook Trout were released immediately after workup. The presence of other species observed during sampling was recorded as either present, common, or abundant, but not enumerated.

Multiple passes to estimate population abundance was not used due to the general low abundance of Brook Trout and time constraints. Migration into and out of the study streams between sampling events was apparent based on low number of recaptures among sampling events throughout the season. Immigration or emigration during sampling period violates mark-recapture assumptions and limits the utility of mark-recapture estimates. Therefore, relative abundance based on catch from 1-pass electrofishing was used to compare catch within and among streams, and among years.

Genetics will be evaluated for all Brook Trout captured this fall to determine if they were stocked or naturally produced fish. Procedures followed those used for a similar analysis of 2007, 2008 and 2013 samples of North Shore Brook Trout (Miller et al., 2016). Tissue samples were sent to the genetics lab of Loren Miller, MNDNR Fish Geneticist. Samples will be genotyped using microsatellite DNA markers previously developed for Brook Trout (King et al., 2012). Ancestry will be assessed using the program Structure (Pritchard et al., 2000) and baseline data for potential source populations of stocked fish (Nipigon, Isle Royale) available from the prior study. Individuals will be classified as stocked fish if their estimated ancestry from one of these source populations exceeded criteria established by simulations (Miller et al., 2016).

Results

Catch and Catch-Rates

A total of 263 Brook Trout (includes within-year recaptures, potential Splake, and fish captured in a second pass) were captured in 2018, which was higher than all previous surveys except for 1997 (*N*=382) and 2013 (*N*=264). Twenty-one Brook Trout were within-year recaptures (possessed a fin clip from a previous sampling event), 9 were recaptured at the Gooseberry River, 7 at the Onion River, 3 at Kimball Creek, and 1 at both the Flute Reed and Little Marias rivers. One fish captured at the Flute Reed River was identified as a either a Splake or Lake Trout (pending genetic analysis). Eight Brook Trout were captured on a second pass at the Cross River on October 31, 2018. All within-year recaptures, potential Splake, and Brook Trout captured in a second pass were excluded from most data summaries in this report to allow valid comparisons of catch and catch rates among years.

More Brook Trout (*N*=233) were captured in pass-1 in 2018 than the historic average (*N*=200). The overall mean catch per unit effort (CPUE; # in pass 1) in 2018 was 24.6 Brook Trout per mile, which was the highest catch rate among all previous years. Catch rates of Brook Trout (all sizes) has steadily increased from 2002 (12.4 per mile) to 2018 (24.6 per mile), and catch rates for Brook Trout 12 inch and larger has steadily increased from 1997 (0.2 per mile) to 2018 (2.7 per mile) (Table 2, Figure 3).

Catch rates were higher than the historic average at 5 of 12 rivers sampled in 2018. Catch rates per stream ranged from 3.9 per mile in the Devil Track River to 114.5 fish per mile in the Onion River (Table 4). Catch and catch rates were higher than average at middle shore rivers and lower than average at many upper shore rivers. Significant increases in catch and catch rates were observed at the Onion (114 per mile), Poplar (91.4 per mile), Gooseberry (68 per mile), and Cross (57 per mile) rivers. Significant reductions in catch and catch rates were observed at Kadunce (24 per mile), Kimball (8 per mile), and Spruce (43 per mile) creeks (Table 5; Figure 4).

Sex was recorded for almost all Brook Trout (*N*=257) captured in 2018. Sex ratios were 61% (*N*=156) females, 23% (*N*=58) males, and 17% (*N*=43) were unknown sex. Maturity status for females was 68% (*N*=106) green (mature, not yet ready to spawn), 11% (*N*=17) ripe (mature, ready to spawn), 17% (*N*=106) spent (already spawned), and 4% (*N*=6) unknown maturity. All males were ripe and all fish with unknown sex were immature.

Size and Age Structure

The average size of Brook Trout captured in 2018 was 8.6 inches, which was higher than the average size in previous surveys (7.4 inches). Approximately 58% (*N*=134) of Brook Trout were 8 inches or larger, 11% (*N*=26) were 12 inches or larger, 2% (*N*=6) were 16 inches or larger, and no fish exceeded 20 inches. More Brook Trout that measured 12 inches or larger were captured in 2018 (26) than all previous years (Table 6; Figure 5). Mean total length per stream ranged from 3.4 inches at the Cascade River to 10.8 at the Devil Track River. In general, mean total length was higher at middle shore streams than upper shore streams (Table 7). Mean total length was slightly higher for males (9.9 inches) than females (9.1 inches). The largest Brook Trout captured was a male that measured 17.4 inches.

Five age classes were found among Brook Trout captured in 2018. Approximately 9% (*N*=21) were age-0, 26% (*N*=61) were age-1, 51% (*N*=119) were age-2, 10% (*N*=24) were age-3, and 3% (*N*=8) were age-4 (Table 8, Figure 6).

Run Timing and Water Temperatures

Approximately 90% (*N*=237) of all Brook Trout were captured in October and 10% (*N*=26) were captured in November. Approximately 81% (*N*=213) of all Brook Trout were captured in the third week of October or later, and most (57% of total; *N*=149) were captured during the third week of October. More Brook Trout (*N*=50) were captured in the first week of October than all previous assessments; the historic mean catch the first week of October from 1997 through 2013 was 4 (Table 9; Figure 7).

Fifty-one percent (*N*=133) of Brook Trout and Splake were captured when water temperatures were less than 40^{o}F, and 49% (*N*=130) at 40 to 49 ^{o}F. No surveys happened when water temperatures were 50 ^{o}F or higher (Table 10; Figure 8).

Genetics

Genetics results from fish captured in 2018 were not available at the time of this report. This information will be shared on the MNDNR Lake Superior Area Fisheries website as soon as data is available.

Other Fish Species

Nineteen fish species were present among the 12 streams sampled in 2018. Rainbow Trout, Coho salmon and Pink salmon were the most common species present after Brook Trout. For Rainbow Trout, young-of-year (age-0) were present in 10 rivers and age-1 and older were present at 7 rivers. Adult Coho and Pink salmon were found in 9 and 6 streams, respectively (Table 11).

Discussion

Coaster populations on the North Shore have maintained their abundance over the past 2 decades. Overall catch and catch rates have continued to increase over time, with the highest catch rates observed in 2018. A relatively high overall catch rate was somewhat expected in 2018 due to changes in survey methods (streams sampled); only the streams with the highest catch rates in previous years were sampled in 2018. Regardless, the higher catch rate in 2018 followed the increasing trend in catch rates that have been observed in Minnesota waters since 1997 (Miller et al 2016). The same 12 streams should be sampled in future years to standardize survey protocols and maintain comparable data among years.

The capture efficiency and abundance of Coasters in each stream is influenced by the daily stream and environmental conditions. Relative abundance and catch rates within streams have fluctuated, sometimes significantly, between sampling events within the same year (Tillma 1999, Ward 2007, Blankenheim 2013). The variation in catch rates is influenced by environmental and stream conditions, immigration from stream resident Brook Trout populations, migratory behaviors among life history types (stream resident, lacustrine or adfluvial), individual energetics, and a number of other factors. Environmental and stream conditions (precipitation, water discharge and temperature) largely influence catch and catch rates in the fall spawning assessments, and could also influence which streams Coasters utilize for spawning in a given year. In years when conditions allowed large and small streams to be effectively sampled (e.g., 2008 and 2018), larger streams tended to capture larger Coasters than smaller streams. Coasters are known to sporadically utilize both streams and Lake Superior

throughout the year (Huckins et al. 2008, Robillard et al. 2011a), and protracted spawning runs have been documented in Lake Superior (Huckins and Baker 2008); however, habitat use and periodicity of spawning is not well understood in Minnesota waters. Delineating the diversity in habitat use could improve sampling efficiencies for Coasters in Minnesota, and help develop science-based ideas to better conserve and restore Coasters and their habitats lakewide.

Overall, size structure of Coasters captured in the fall spawning assessment has increased, albeit only slightly, over time. Although the majority of Coasters captured in fall assessments were relatively small (overall, annual mean length of approx. 8 inches), more large fish have been captured in recent years (Miller et al. 2016). The catch and catch rates for Coasters 12 inches or larger was the highest on record in 2018, and the two largest fish were captured in 2013 (Blankenheim 2013). The increased catch of large Brook Trout in the 2018 was likely not influenced by changes to the sampling protocols. Fish size was not a criteria for selecting streams to sample in 2018, and there was almost no difference in the size structure of Brook Trout captured at 26 streams in 2013 versus at 12 rivers in 2018; the streams that were not sampled in 2018 routinely caught few, small Brook Trout and contributed little to the overall size structure in previous years (MNDNR unpublished data). Also, there seems to be more large Brook Trout (presumed to be Coasters) captured by anglers in below barrier sections of Minnesota streams in recent years. In 2018, many pictures were posted on a variety of social media sites of large-sized Coasters caught in a number of larger North Shore streams. Many of these fish were caught in the spring and summer, prior to the fall spawning assessment, and in streams that were too big or hazardous to effectively sample with backpack electrofishing gear in the fall. Furthermore, anglers fishing North Shore streams in the spring caught over 1,000 Brook Trout in 2016 and 2017, which was over double the historic average (443) (Peterson 2017). Given the number and size of Coasters captured by anglers each year, anglers and angling should be considered as a supplemental tool for evaluating Coaster populations in future assessments.

More Coasters were older ages in recent fall spawning assessments compared to the first assessments. The older age-structure of Brook Trout sampled in 2018 corresponded to the increased presence of large Brook Trout captured in 2018. The improved size and age structure observed in recent years suggests that the conservative harvest regulation implemented in 1997 appears to be working. Support and compliance of the regulation is essential for its success. Anglers seem content with the regulation, and angler compliance has been good in recent years. Few illegally harvested Brook Trout have been reported in recent spring creel surveys (Peterson 2017).

Catch and catch-rates at some streams were likely influenced by stream resident Brook trout that emigrated from upstream of barriers. The highest overall catch rates in the fall assessments have been at Spruce Creek (87 per mile), Kadunce Creek (80 per mile), and the Onion River (67 per mile) (Figure 9). These streams are similar in many ways. All three streams typically have consistently high catch rates of Brook Trout (presumed Coasters) below barriers in the fall, however, very few (or zero) of the fish captured at these streams have exceeded 12 inches. All three of these streams also abundant stream resident Brook Trout populations upstream of barriers. One Brook Trout captured in the Onion River in the 2018 fall assessment measured 4.5 inches and was a ripe female, which was a length at maturity more similar to a stream resident Brook Trout than a migratory Coaster. Large-type Brook Trout are generally lake-specialists, whereas small-type Brook Trout are stream specialists, stream-lake generalists, or some mixture of the two (Robillard et al. 2011b). The total length and length-at-maturity of this fish indicated that it had likely immigrated downstream from the upstream resident

population within a week of being captured, and had not yet entered Lake Superior. By definition, a Coaster is a Brook Trout that has utilized Lake Superior at some stage of their life. If significant emigration from upstream populations occurred during the fall spawning assessment, the assessment may not accurately index Coasters that have previously utilized Lake Superior at some time in their life. The migration patterns of stream resident Brook Trout and their contributions to Coaster populations in Minnesota is not well understood and should be explored in future assessments.

The fall spawning assessment protocols should be standardized as much as possible so that data collected can provide an accurate index of population trends over time. The timing of all previous fall spawning assessments appears to have effectively captured Coasters throughout the entire spawning season; the catch rates peaked in the middle of the assessment and were low at the beginning and end of the assessment. Some previous fall spawning assessments have started in September, but very few fish were captured that early in the season. The majority of Coasters have entered streams to spawn in early-October, or when water temperatures drop below 50°F, and the peak of spawning activity (based on highest abundance of Coasters captured in the streams) occurred in late-October, when water temperatures are below 45°F. In the future, fall spawning assessments should start on October 1 (or from when stream temperatures drop below 50°F) and end no earlier than November 1 (or when ice begins to form on streams).

The best action to protect and sustain Coasters in Minnesota streams is to protect and sustain good stream habitat, both upstream and downstream of barriers. Coasters are a life history variant of a stream resident Brook Trout, not a separate strain or subspecies, and there is little evidence of genetic differentiation between the two types (Elias et al. 2018). In general, MNDNR data shows that streams with the best Coaster populations also provide the abundant stream resident Brook Trout populations upstream of barriers. Stream resident Brook Trout that migrate downstream over a barrier do not have access back upstream. Stream conditions in below barrier reaches of North Shore streams are often harsh and not ideal for Brook Trout and most (or all) Brook Trout captured below barriers will have to use Lake Superior when stream conditions become poor, or when their curious intuition leads them there. Therefore, a stream Brook Trout captured below barriers will inevitably become a Coaster, at least by definition. Even though the exact contributions of stream resident Brook Trout to Coaster populations are unknown, it seems apparent that Brook Trout populations upstream have helped to sustain Coaster populations below barriers.

Watershed protection and restoration to improve stream conditions is also a critical component of Coaster rehabilitation. Coaster populations are not as abundant in Lake Superior as they were in the late-1800s, and will likely not be given the current stream habitat conditions, competition with non-native species, and many other factors they face today. The lack of suitable stream spawning and rearing habitat, volatile stream flow regimes and lack of groundwater, impacts from other species, and projected increases in stream water temperatures due to climate change are all obstacles for Coaster rehabilitation that are extremely difficult to address, if at all. Therefore, agencies and anglers must maintain realistic expectations for the fishery and continue to address obstacles to Coaster rehabilitation, whenever possible.

Acknowledgements

We really appreciate all the volunteers who helped with the coaster Brook Trout survey in 2018. The survey required more time and effort than was often available from MNDNR staff, and we could not have done it without you. Our efforts this fall show how MNDNR and

stakeholders can work together to improve our understanding of our fisheries, and our cooperative efforts will a lasting impact on the rehabilitation and management of Coasters. We look forward to working with volunteers again in 2021. We appreciate Phil Kunze who helped survey all season and shared his delicious smoked salmon sandwiches with the crew. Many MNDNR staff also sacrificed their time to help with the survey. This survey could not have been completed without the collective efforts of all involved.

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Prepared by:
Nick R. Peterson

Edited by:
Cory Goldsworthy

Area Fisheries Supervisor: _____ Date: 5/29/2019

Regional Fisheries Supervisor: _____ Date: 6/2/19

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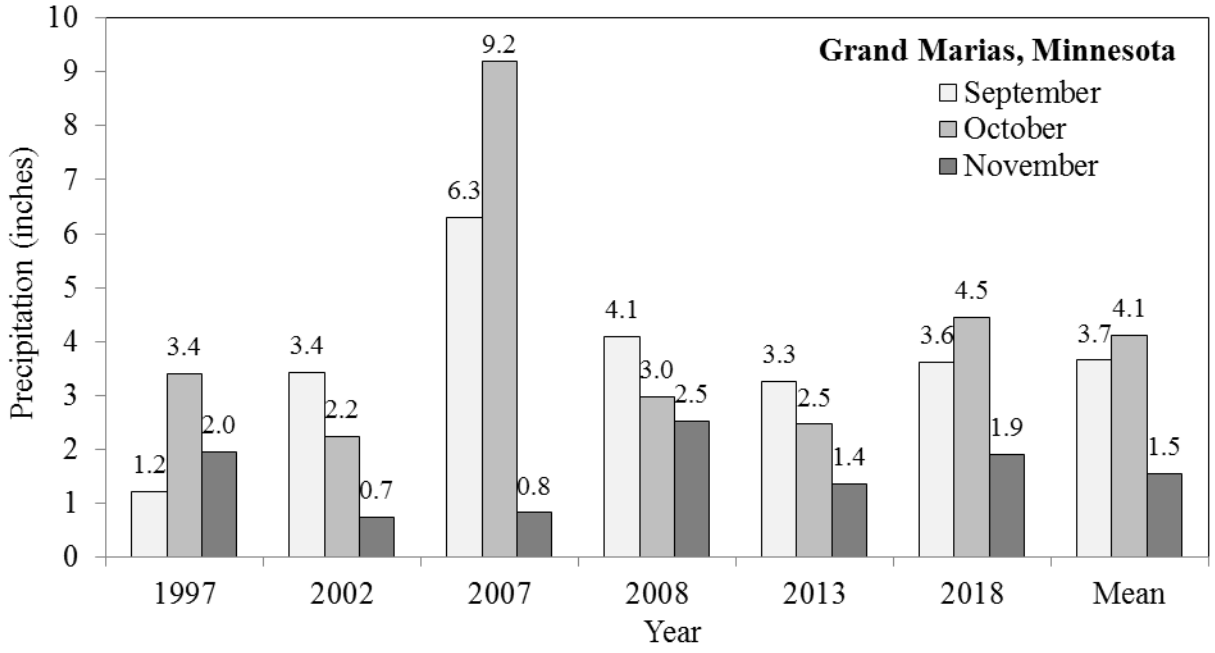

Figure 1. Monthly precipitation totals (inches) and the historic average (Mean) in Grand Marais during years with a Coaster Brook Trout survey.

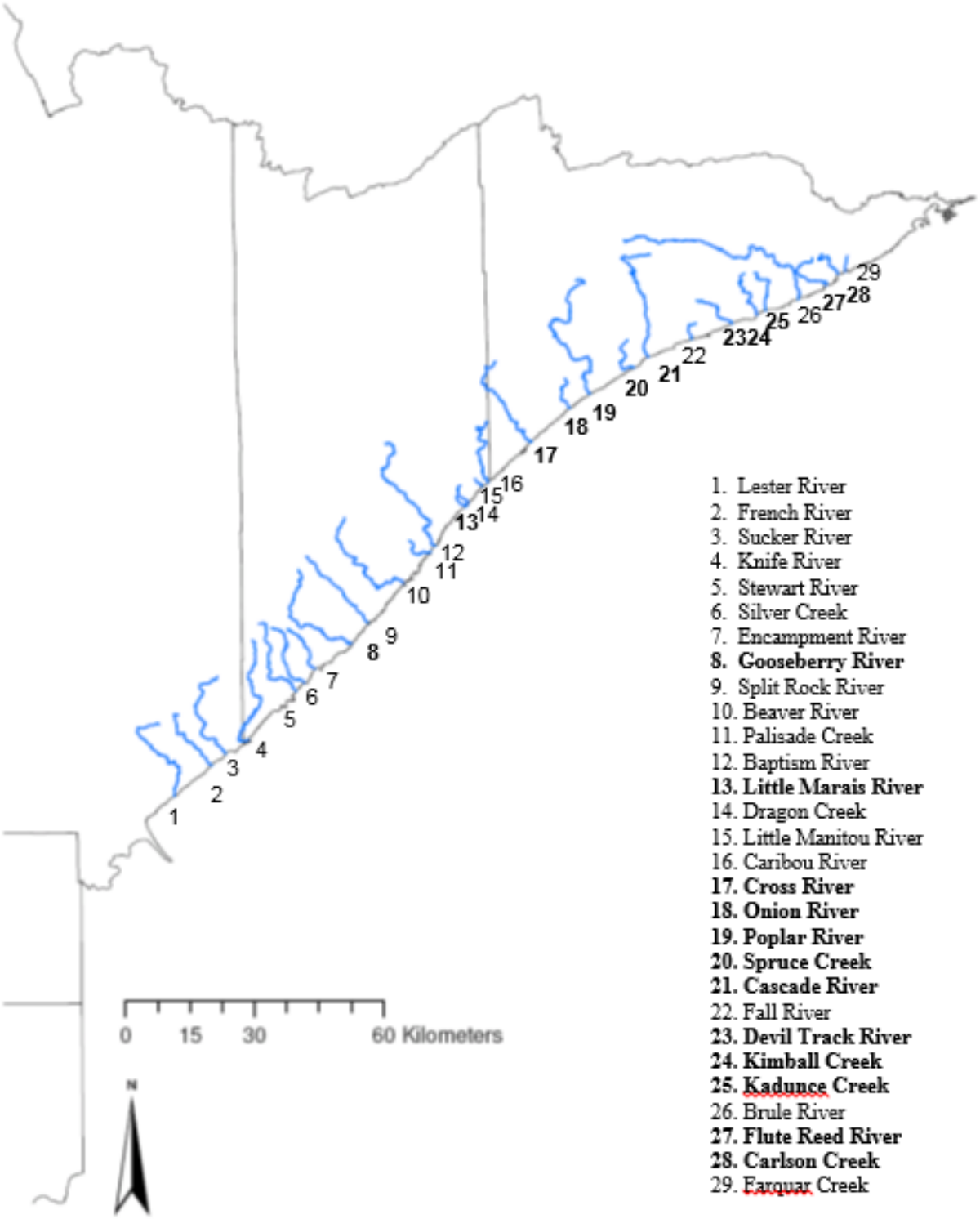

Figure 2. Streams on the Minnesota shore of Lake Superior sampled for coaster Brook Trout in the 1997, 2002, 2007-2008, 2013, or 2018. Not all streams were sampled every year. Streams sampled in 2018 are bold.

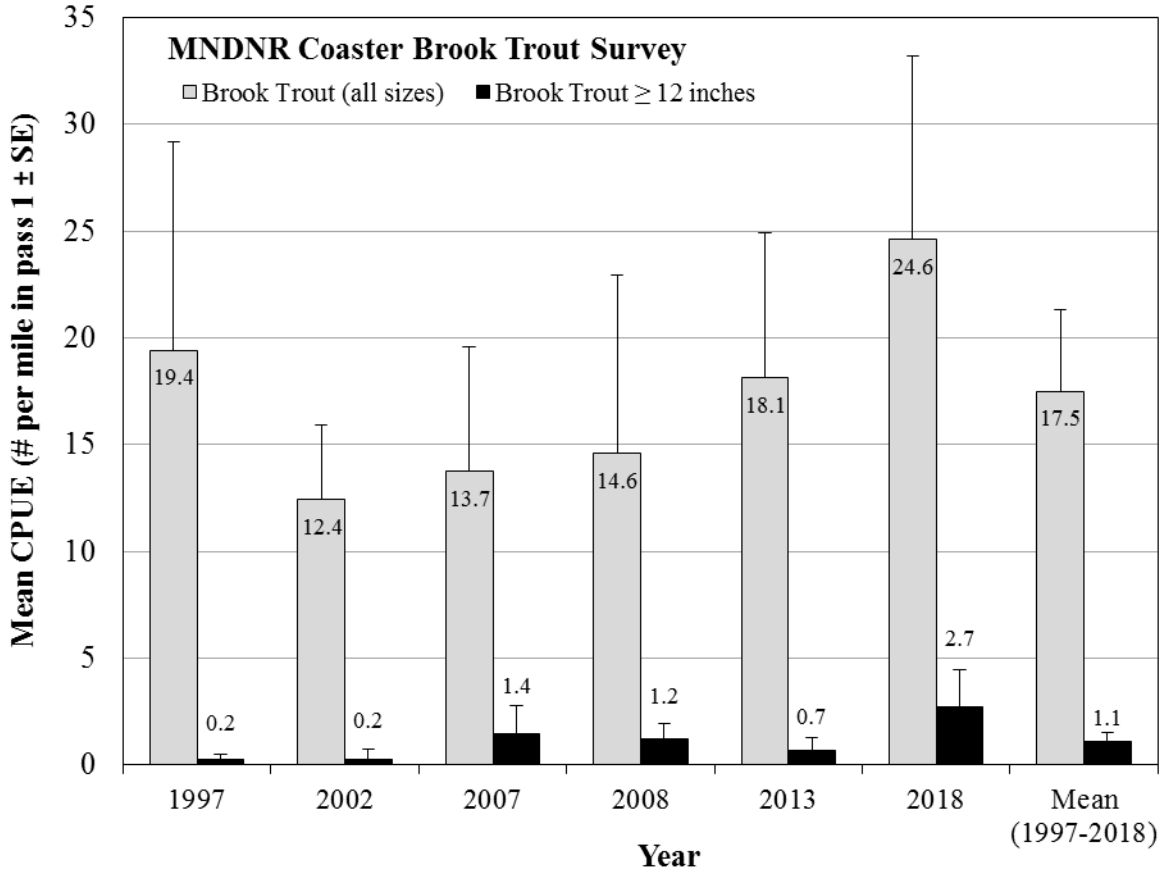

Figure 3. Shorewide mean catch per unit effort (number per mile in pass 1 ± standard error) for Brook Trout of all sizes and 12 inches or larger captured by year.

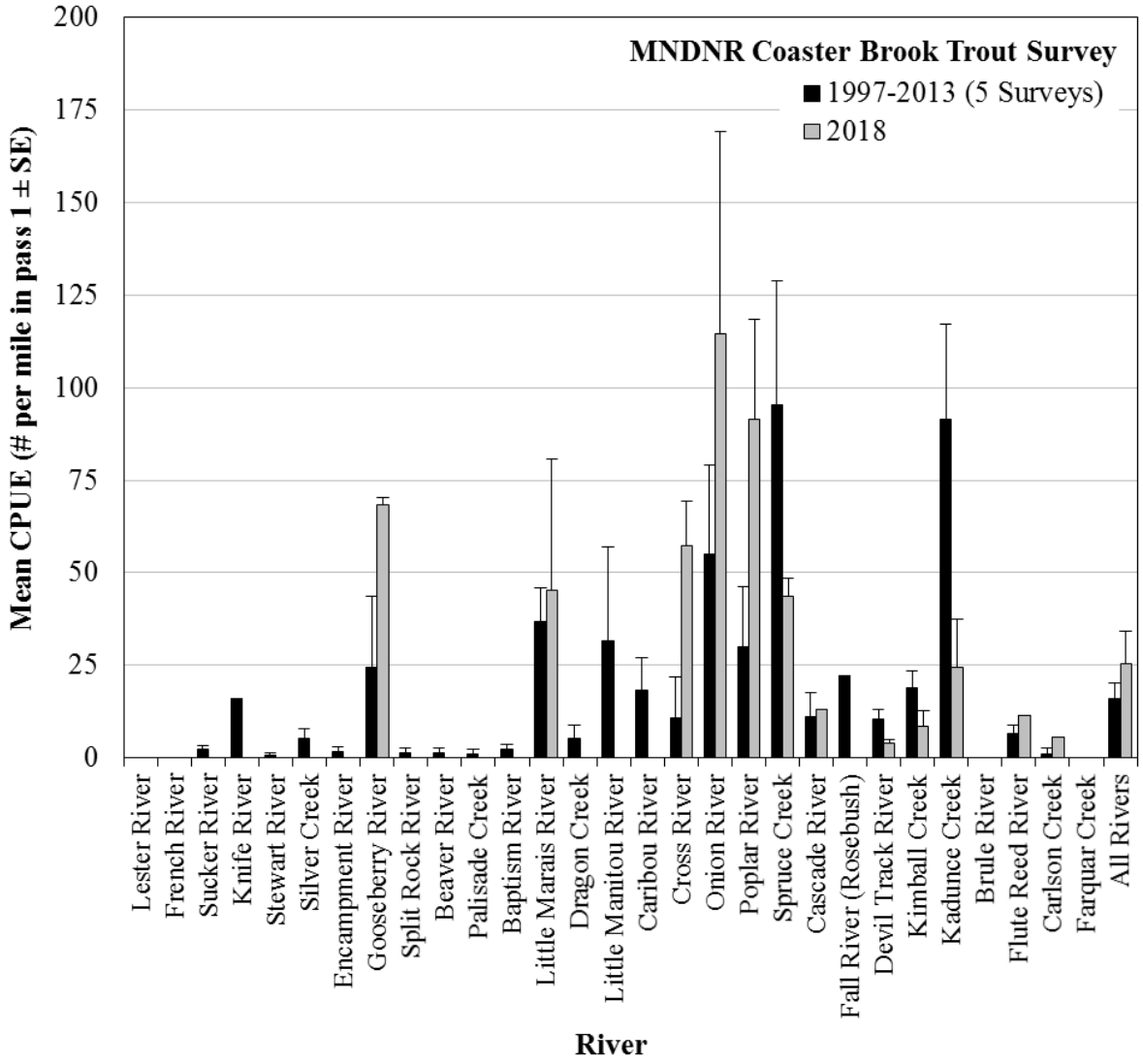

Figure 4. Mean catch per unit effort (number per mile in pass 1 ± standard error) for Brook Trout of all sizes captured by river in 2018 compared to the historic mean catch per unit effort of five assessments completed between 1997 and 2013.

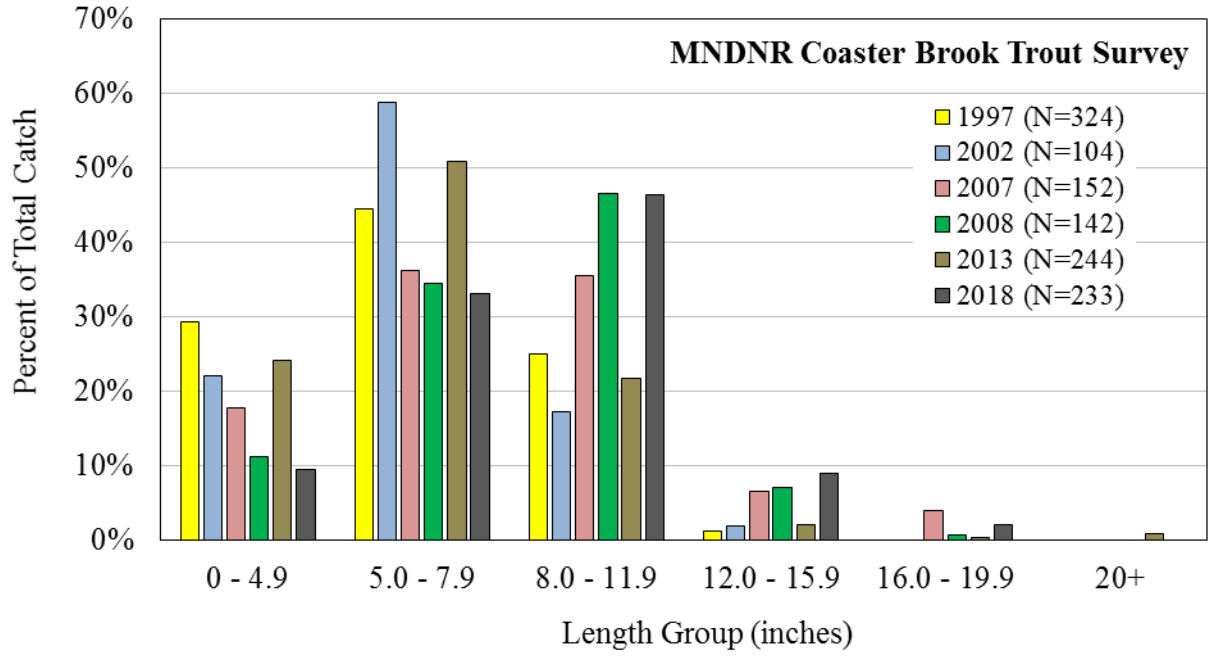

Figure 5. Percent of total catch by length group (inches) for coaster Brook Trout captured by year.

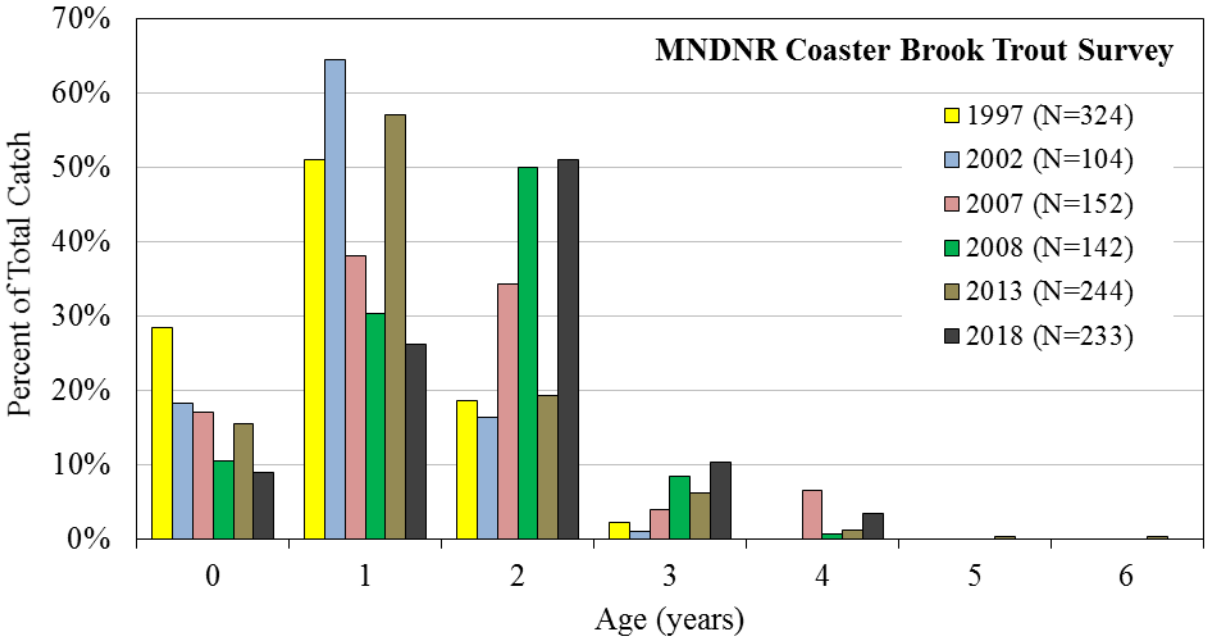

Figure 6. Percent of total catch by age (years) for coaster Brook Trout captured by year.

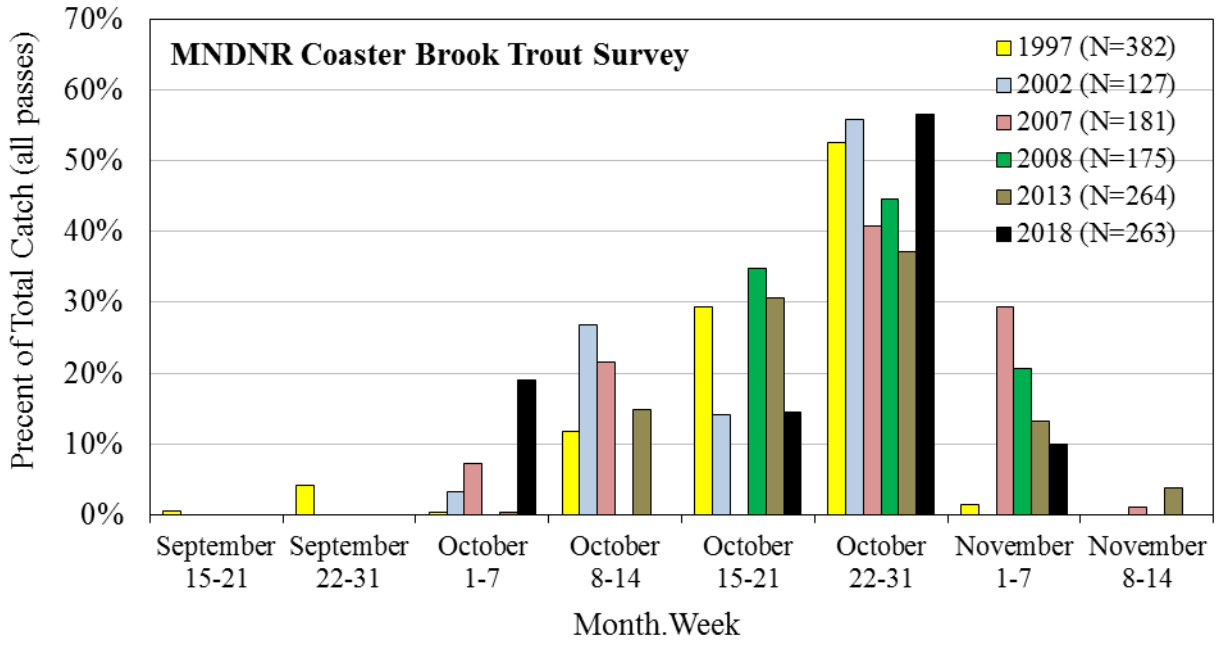

Figure 7. Percent of total catch by time period (Month.Week) for coaster Brook Trout captured by year. These numbers include all fish captured in all passes including within year recaptures and Splake.

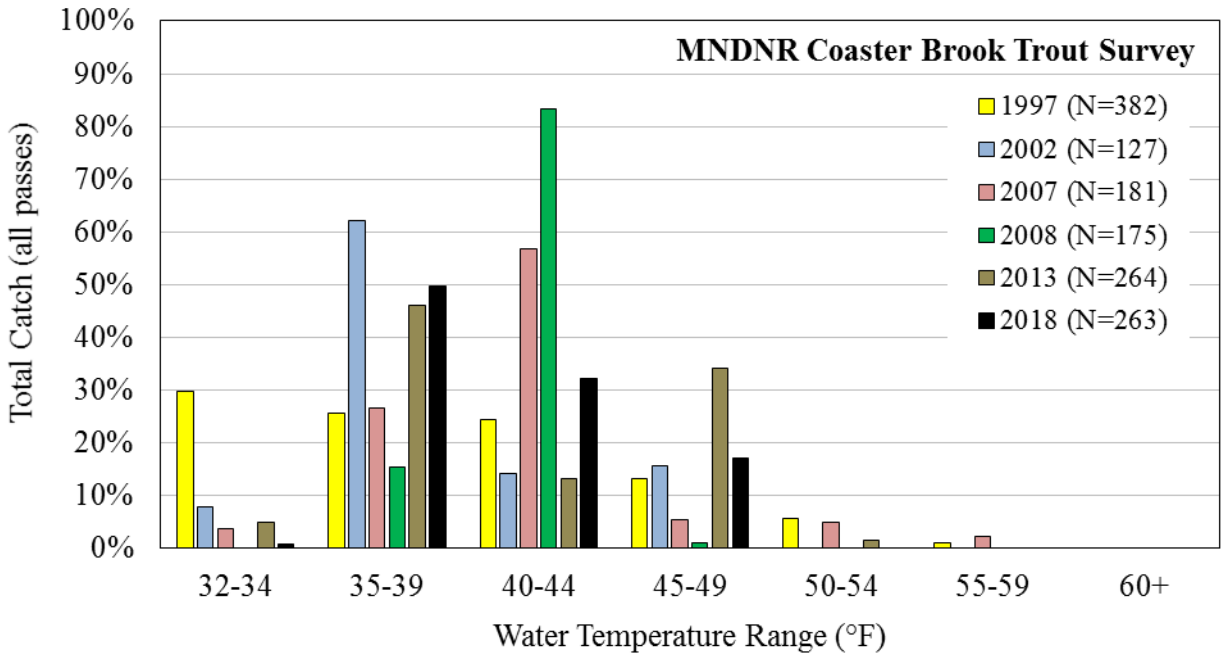

Figure 8. Percent of total catch by water temperature range (°F) for coaster Brook Trout captured by year. These numbers include all fish captured in all passes including within year recaptures and Splake.

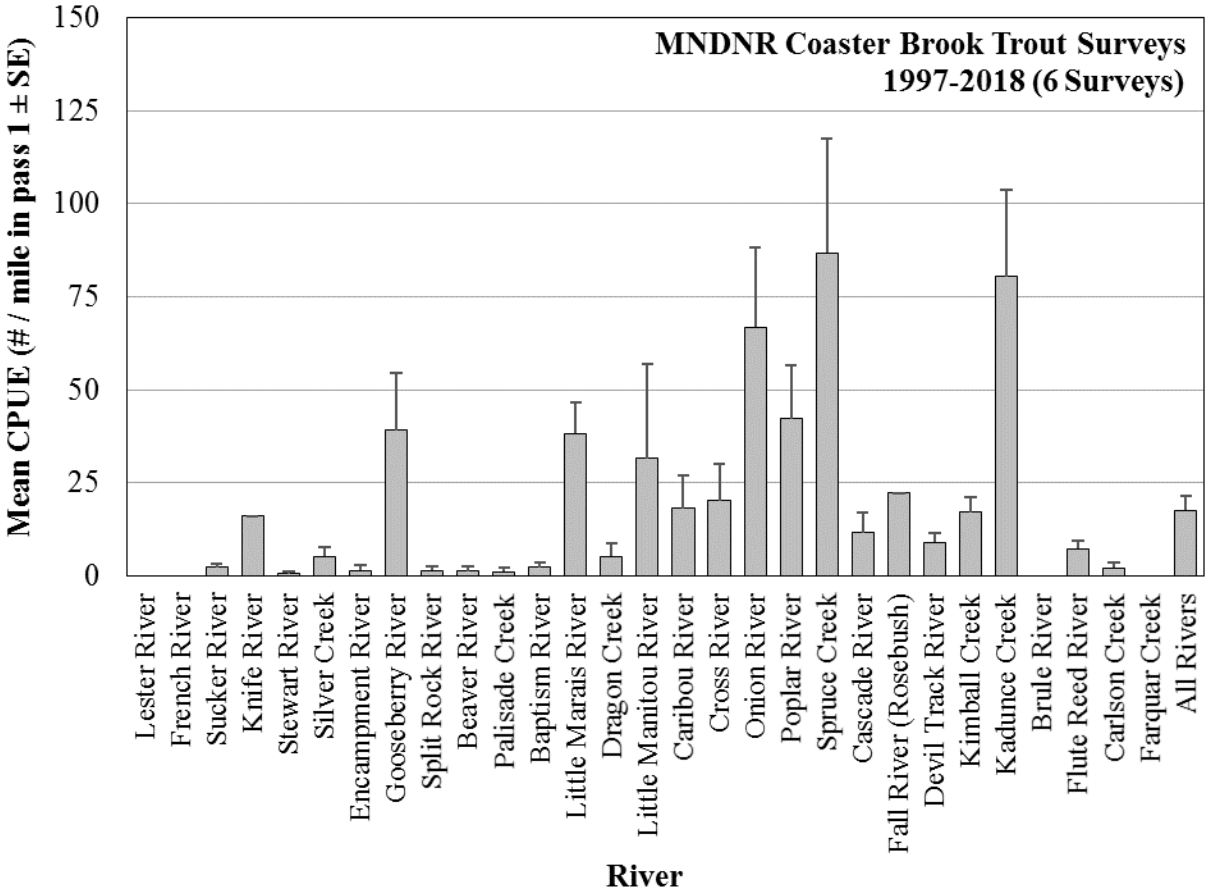

Figure 9. Mean catch per unit effort (number per mile in pass 1 ± standard error) for Brook Trout of all sizes captured by river in five assessments completed between 1997 and 2013.

Table 1. Site descriptions for all rivers sampled in MNDNR coaster Brook Trout surveys. Rivers sampled in 2018 are bold. Map ID corresponds to locations shown on Figure 2.

							Downstream UTM		Upstream UTM	
Map ID	Stream	MNDNR Stream ID	Site Description	Station Length (miles)	Fisheries Area	County	Easting	Northing	Easting	Northing
1 .	Lester River	S-005	Lake to barrier falls in park	0.66	Duluth	St. Louis	575800	5187457	575967	5188347
2 .	French River	S-11	Fish captured in adult trap	0.06	Duluth	St. Louis	584367	5194564	584316	5194642
3 .	Sucker River	S-15	Lake to barrrier downstream of Hwy. 61	0.44	Duluth	St. Louis	587728	5197133	587250	5197478
4 .	Knife River	S-17	fish captured in adult trap	0.56	Duluth	Lake	592613	5200190	591799	5199926
5 .	Stewart River	S-19	Lake to barrier falls below powerline	0.97	Finland	Lake	604026	5211375	603134	5212110
6 .	Silver Creek	S-21	Lake to first falls	0.25	Finland	Lake	605933	5213130	605759	5213410
7 .	Encampment River	S-22	Partial barrier at first falls by cabin	0.22	Finland	Lake	608426	5216296	608262	5216471
8 .	**Gooseberry River**	**S-26**	**Upstream of lagoon to middle falls & side channel**	**0.44**	**Finland**	**Lake**	**616307**	**5221832**	**616194**	**5222175**
9 .	Split Rock River	S-29	Upstream end of Hwy 61 culvert to falls	0.75	Finland	Lake	620699	5226668	619884	5227453
10 .	Beaver River	S-35	Upstream end of lagoon to barrier falls	0.12	Finland	Lake	629055	5235430	628894	5235516
11 .	Palisade Creek	S-37	Lake to slides at Hwy 61	0.45	Finland	Lake	635391	5242825	634840	5242557
12 .	Baptism River	S-38	Under Hwy 61 bridge to barrier falls	0.74	Finland	Lake	636200	5244098	635475	5244772
13 .	**Little Marais River**	**S-44**	**Lake to barrier falls**	**0.10**	**Finland**	**Lake**	**643395**	**5252959**	**643266**	**5253019**
14 .	Dragon Creek	S-44.1	Lake to falls downstream of highway	0.34	Finland	Lake	643454	5252979	643589	5253457
15 .	Little Manitou River	S-46	Lake to Hwy 61	0.16	Finland	Lake	647181	5257598	647017	5257794
16 .	Caribou River	S-47	Lake to barrier falls	0.10	Finland	Lake	648611	5258373	648499	5258431
17 .	**Cross River**	**S-52**	**Lake to barrier falls/Hwy 61**	**0.29**	**Finland**	**Cook**	**658611**	**5267664**	**658304**	**5267757**
18 .	**Onion River**	**S-56**	**Lake to barrier falls**	**0.18**	**Grand Marais**	**Cook**	**667540**	**5275151**	**667412**	**5275386**
19 .	**Poplar River**	**S-58**	**Lake to barrier falls by Lutsen Resort**	**0.09**	**Grand Marais**	**Cook**	**672197**	**5278391**	**672214**	**5278520**
20 .	**Spruce Creek (Deer Ya**	**S-62**	**Lake to barrier falls**	**0.10**	**Grand Marais**	**Cook**	**682558**	**5284293**	**682495**	**5284431**
21 .	**Cascade River**	**S-64**	**Lake to falls**	**0.15**	**Grand Marais**	**Cook**	**685831**	**5286704**	**685747**	**5286879**
22 .	Fall River (Rosebush)	S-66	Lake to barrier falls	0.04	Grand Marais	Cook	695798	5290809	695780	5290871
23 .	**Devil Track River**	**S-67**	**Lake upstream end of fish sanctuary**	**1.40**	**Grand Marais**	**Cook**	**705201**	**5294213**	**703939**	**5295231**
24 .	**Kimball Creek**	**S-70**	**Lake to slides**	**1.02**	**Grand Marais**	**Cook**	**711077**	**5296144**	**710869**	**5297194**
25 .	**Kadunce Creek**	**S-72**	**Lake to barrier falls**	**0.27**	**Grand Marais**	**Cook**	**713093**	**5297256**	**712926**	**5297612**
26 .	Brule River	S-75	Lake to falls	1.44	Grand Marais	Cook	720723	5299860	720785	5301585
27 .	**Flute Reed River**	**S-77**	**Lake to Hwy 61**	**0.35**	**Grand Marais**	**Cook**	**727007**	**5302855**	**727256**	**5303343**
28 .	**Carlson Creek**	**S-79**	**Lake to barrier falls**	**0.53**	**Grand Marais**	**Cook**	**729975**	**5305452**	**729501**	**5305977**
29 .	Farquar Creek	S-80	Lake to Hwy 61	0.11	Grand Marais	Cook	731537	5305987	731486	5306144

Table 2. Survey start date, survey end date, season length (days), number of rivers sampled, number of surveys completed, total distance sampled (miles), number of Brook Trout captured, and mean catch per-unit-effort (Mean CPUE; number per mile in pass 1) for coaster Brook Trout surveys completed in Minnesota from 1997 to 2018.

							Brook Trout (all sizes)				Brook Trout ≥ 12 inches			
Year	Survey Start Date	Survey End Date	Season Length (days)	Rivers Sampled (#)	Total Surveys (#)	Total Distance Sampled (miles)	Mean CPUE (#/mile in pass 1)	N	*SD*	*SE*	Mean CPUE (#/mile in pass 1)	N	*SD*	*SE*
1997	9/17/1997	11/4/1997	48	19	41	16.7	19.4	324	*62.6*	*9.8*	0.2	4	*1.6*	*0.3*
2002	10/7/2002	10/30/2002	23	9	23	8.4	12.4	104	*16.8*	*3.5*	0.2	2	*2.3*	*0.5*
2007	9/28/2007	11/8/2007	41	17	38	11.1	13.7	152	*35.9*	*5.8*	1.4	16	*8.4*	*1.4*
2008	10/21/2008	11/5/2008	15	16	21	9.7	14.6	142	*38.3*	*8.3*	1.1	11	*3.3*	*0.7*
2013	10/7/2013	11/8/2013	32	26	39	13.5	18.1	244	*42.3*	*6.8*	0.6	8	*3.8*	*0.6*
2018	10/2/2018	11/1/2018	30	12	23	9.5	24.6	233	*41.1*	*8.6*	2.7	26	*8.4*	*1.7*
Mean	10/3	11/3	32	17	31	11.5	17.5	200	*38.0*	*3.8*	1.1	11	*3.9*	*0.4*

** Data excludes fish recaptured within the same year, fish captured in French or Knife River Traps, Splake (Lake Trout x Brook Trout hybrids), or questionable Splake.*

Table 3. Dates that each survey was completed at each river sampled for the MNDNR coaster Brook Trout survey by year, including the total number of surveys completed at each river for all surveys between 1997 and 2018.

	1997						2002				2007				2008		2013			2018			Total Surveys
River / Survey Number	**#1**	**#2**	**#3**	**#4**	**#5**	**#6**	**#1**	**#2**	**#3**	**#4**	**#1**	**#2**	**#3**	**#4**	**#1**	**#2**	**#1**	**#2**	**#3**	**#1**	**#2**	**#3**	**(1997-2018)**
Lester River															11/5								1
Sucker River	9/17	10/3									11/8				10/31		10/9						5
Knife River																	11/7						1
Stewart River	9/24	10/15									10/29	11/8					10/25						5
Silver Creek	9/17	10/14									9/28	10/29					10/7	10/22					6
Encampment River	10/7										9/28	10/29					10/7						4
Gooseberry River															10/31		10/28	11/6		10/4	10/23		5
Split Rock River	9/24	10/10	10/21	10/28											10/24	10/30	10/23						7
Beaver River	9/26										10/2	11/6					10/11						4
Palisade Creek											10/4	11/7					10/11						3
Baptism River	9/26	10/22													10/23		11/1						4
Little Marais River	10/14						10/7				10/2	10/17	10/31	11/6	10/28		10/8	10/22		10/5	10/30		11
Dragon Creek															10/28		10/8	10/22					3
Little Manitou River															10/28		10/22						2
Caribou River	10/7	10/21									10/4	10/31			10/24		10/31						6
Cross River	9/23	10/8	10/15	10/22	10/28	11/4	10/7	10/16	10/24						10/20	11/3	10/14	10/31		10/2	10/22	10/31	16
Onion River	10/14	10/26	10/31				10/9	10/16	10/24	10/30	10/15	10/31					10/14	10/24		10/15	10/25		13
Poplar River							10/10	10/16	10/24		11/2				10/20	11/3	10/10	10/24	11/5	10/15	10/24		11
Spruce Creek	10/17	10/31					10/21				10/17	10/26	11/6		10/28	11/3	10/10	10/24	11/5	10/5	10/24		13
Cascade River	10/19	10/25					10/21										11/5			10/24			5
Fall River											10/16	10/25	11/1				11/5						4
Devil Track River	10/18	10/24	10/29				10/10	10/22							10/22	11/4	10/29			10/16	11/2		10
Kimball Creek	10/18	10/25					10/11	10/22	10/25	10/30	10/15	11/1			10/29		10/17	11/8		10/17	11/1		13
Kadunce Creek	10/18	10/25					10/11	10/21	10/25	10/30	10/1	10/16	10/30	11/5	10/21		10/16	10/30		10/17	10/30		15
Brule River																							0
Flute Reed River	10/17	10/19									10/26	11/7			10/21		10/16	10/30		10/18	11/1		9
Carlson Creek	10/17										10/1	10/25					10/17			10/18			5
Farquar Creek	10/17										10/8	10/25					10/30						4

Table 4. Total catch and mean catch per effort (number per mile in pass 1) of Brook Trout in 2018. Mean catch per-unit-effort (Mean CPUE) with standard deviation (*SD*) and standard error (*SE*) are also shown for each river sampled and overall for all surveys completed in 2018. Fish recaptured within the same year, fish captured in French or Knife River Traps, Splake (Lake Trout x Brook Trout hybrids), or questionable Splake are excluded from the data.

				Number Captured				Catch Per Effort (#/Mile)					
Stream	Station Length (miles)	Surveys (#)	Total Distance Sampled (miles)	Survey #1	Survey #2	Survey #3	All Surveys	Survey #1	Survey #2	Survey #3	Mean CPUE (#/mile)	*SD*	*SE*
Lester River	0.66	0	--	--	--	--	--	--	--	--	--	--	--
French River	0.06	0	--	--	--	--	--	--	--	--	--	--	--
Sucker River	0.44	0	--	--	--	--	--	--	--	--	--	--	--
Knife River	0.56	0	--	--	--	--	--	--	--	--	--	--	--
Stewart River	0.97	0	--	--	--	--	--	--	--	--	--	--	--
Silver Creek	0.25	0	--	--	--	--	--	--	--	--	--	--	--
Encampment River	0.22	0	--	--	--	--	--	--	--	--	--	--	--
Gooseberry River	0.44	2	0.88	29	31	--	60	65.9	70.5	--	68.2	*3.2*	*2.3*
Split Rock River	0.75	0	--	--	--	--	--	--	--	--	--	--	--
Beaver River	0.12	0	--	--	--	--	--	--	--	--	--	--	--
Palisade Creek	0.45	0	--	--	--	--	--	--	--	--	--	--	--
Baptism River	0.74	0	--	--	--	--	--	--	--	--	--	--	--
Little Marais River	0.10	2	0.20	1	8	--	9	10.1	80.6	--	45.3	*49.9*	*35.3*
Dragon Creek	0.34	0	--	--	--	--	--	--	--	--	--	--	--
Little Manitou River	0.16	0	--	--	--	--	--	--	--	--	--	--	--
Caribou River	0.10	0	--	--	--	--	--	--	--	--	--	--	--
Cross River	0.29	3	0.87	16	11	15	42	55.0	37.8	51.6	48.1	*9.1*	*5.3*
Onion River	0.18	2	0.37	11	31	--	42	60.0	169.1	--	114.5	*77.1*	*54.5*
Poplar River	0.09	2	0.19	6	11	--	17	64.5	118.3	--	91.4	*38.0*	*26.9*
Spruce Creek	0.10	2	0.21	4	5	--	9	38.7	48.4	--	43.5	*6.8*	*4.8*
Cascade River	0.15	1	0.15	2	--	--	2	13.2	--	--	13.2	--	--
Fall River (Rosebush)	0.04	0	--	--	--	--	--	--	--	--	--	--	--
Devil Track River	1.40	2	2.80	7	4	--	11	5.0	2.9	--	3.9	*1.5*	*1.1*
Kimball Creek	1.02	2	2.03	4	13	--	17	3.9	12.8	--	8.4	*6.3*	*4.4*
Kadunce Creek	0.27	2	0.53	3	10	--	13	11.3	37.6	--	24.4	*18.6*	*13.2*
Brule River	1.44	0	--	--	--	--	--	--	--	--	--	--	--
Flute Reed River	0.35	2	0.71	4	4	--	8	11.3	11.3	--	11.3	*0.0*	*0.0*
Carlson Creek	0.53	1	0.53	3	--	--	3	5.7	--	--	5.7	--	--
Farquar Creek	0.11	0	--	--	--	--	--	--	--	--	--	--	--
All Rivers (N=12)	**4.93**	**23**	**9.47**	**90**	**128**	**15**	**233**	**18.3**	**30.1**	**51.6**	**24.6**	**41.1**	**8.6**

Table 5. Total catch and mean catch per effort (number per mile in pass 1) of Brook Trout in all coaster Brook Trout surveys. Mean catch per-unit-effort (Mean CPUE) with standard deviation (*SD*) and standard error (*SE*) are also shown for each river sampled and overall for all surveys and years. Fish recaptured within the same year, fish captured in French or Knife River Traps, Splake (Lake Trout x Brook Trout hybrids), or questionable Splake are excluded from the data.

	Total Number Captured							Mean CPUE (#/mile in pass 1)							
Stream / Year	1997	2002	2007	2008	2013	2018	All Years	1997	2002	2007	2008	2013	2018	*All Years*	*SE*
Lester River	--	--	--	0	--	--	0	--	--	--	0.0	--	--	*0.0*	*0.0*
French River	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sucker River	0	--	2	1	1	--	4	0.0	--	4.5	2.3	2.3	--	*2.3*	*0.9*
Knife River	--	--	--	--	9	--	9	--	--	--	--	16.1	--	*16.1*	*0.0*
Stewart River	2	--	0	--	0	--	2	2.0	--	0.0	--	0.0	--	*0.7*	*0.7*
Silver Creek	2	--	5	--	1	--	8	4.0	--	10.0	--	2.0	--	*5.3*	*2.4*
Encampment River	1	--	0	--	--	--	1	4.5	--	0.0	--	0.0	--	*1.5*	*1.5*
Gooseberry River	--	--	--	4	18	60	82	--	--	--	15.1	33.9	68.2	*39.1*	*15.5*
Split Rock River	11	--	--	1	0	--	12	3.7	--	--	0.7	0.0	--	*1.4*	*1.1*
Beaver River	0	--	1	--	0	--	1	0.0	--	4.0	--	0.0	--	*1.3*	*1.3*
Palisade Creek	--	--	0	--	1	--	1	--	--	0.0	--	2.2	--	*1.1*	*1.1*
Baptism River	3	--	--	0	3	--	6	3.0	--	--	0.0	4.1	--	*2.4*	*1.2*
Little Marais River	5	1	19	6	3	9	43	50.4	10.1	47.9	60.5	15.1	45.3	*38.2*	*8.4*
Dragon Creek	--	--	--	3	1	--	4	--	--	--	8.9	1.5	--	*5.2*	*3.7*
Little Manitou River	--	--	--	1	9	--	10	--	--	--	6.3	56.8	--	*31.6*	*25.2*
Caribou River	0	--	2	2	4	--	8	0.0	--	10.4	20.7	41.4	--	*18.1*	*8.8*
Cross River	35	4	--	2	9	42	92	20.1	4.6	--	3.4	15.5	48.1	*18.1*	*8.1*
Onion River	66	33	4	--	16	42	161	120.0	45.0	10.9	--	43.6	114.5	*66.8*	*21.5*
Poplar River	--	2	5	5	9	17	38	--	7.2	53.8	26.9	32.3	91.4	*42.3*	*14.3*
Spruce Creek	48	2	25	16	21	9	121	232.1	19.3	80.6	77.4	67.7	43.5	*86.8*	*30.6*
Cascade River	8	1	--	--	0	2	11	26.4	6.6	--	--	0.0	13.2	*11.5*	*5.6*
Fall River (Rosebush)	--	--	3	--	1	--	4	--	--	22.3	--	22.3	--	*22.3*	*0.0*
Devil Track River	55	3	--	35	18	11	122	13.1	3.0	--	12.5	12.9	3.9	*9.1*	*2.3*
Kimball Creek	32	45	16	26	36	17	172	32.0	11.1	7.9	25.6	17.7	8.4	*17.1*	*4.1*
Kadunce Creek	54	13	64	35	81	13	260	101.5	12.2	60.1	131.5	152.2	24.4	*80.3*	*23.4*
Brule River	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Flute Reed River	2	--	3	5	3	8	21	2.9	--	4.2	14.1	4.2	11.3	*7.4*	*2.2*
Carlson Creek	0	--	3	--	0	3	6	0.0	--	2.8	--	0.0	5.7	*2.1*	*1.4*
Farquar Creek	0	--	0	--	0	--	0	0.0	--	0.0	--	0.0	--	*0.0*	*0.0*
All Rivers	**324**	**104**	**152**	**142**	**244**	**233**	**1,199**	**19.4**	**12.4**	**13.7**	**16.5**	**18.1**	**24.6**	***17.5***	***3.8***

Table 6. Total catch (number captured in pass-1) by length-group (inches) and mean total length (Mean TL; inches) of Brook Trout captured by year.

	Year						
Length-Group (inches)	1997	2002	2007	2008	2013	2018	All Years
1	0	0	0	0	0	0	0
2	24	5	4	0	25	10	68
3	53	13	7	1	13	4	91
4	18	5	16	15	21	8	83
5	51	15	14	11	42	18	151
6	53	31	23	12	43	29	191
7	40	15	18	26	39	30	168
8	41	5	21	20	16	31	134
9	15	11	12	23	15	34	110
10	18	1	14	11	10	23	77
11	7	1	7	12	12	20	59
12	3	0	1	7	2	15	28
13	1	1	1	2	1	3	9
14	0	1	2	0	1	1	5
15	0	0	6	1	1	2	10
16	0	0	3	0	0	3	6
17	0	0	3	0	1	2	6
18	0	0	0	1	0	0	1
19	0	0	0	0	0	0	0
20	0	0	0	0	1	0	1
21	0	0	0	0	1	0	1
22+	0	0	0	0	0	0	0
Total	324	104	152	142	244	233	1,199
Mean TL (inches)	6.4	6.5	8.2	8.4	6.8	8.6	7.4

Table 7. Mean total length at capture of Brook Trout by age and river in 2018.

			Mean TL by Age (years)				
River	N	Mean TL	0	1	2	3	4
Gooseberry River	60	9.6	--	6.7	9.3	12.2	--
Little Marais River	9	9.4	--	6.6	9.9	12.0	--
Cross River	42	9.8	4.2	6.9	9.4	12.2	17.1
Onion River	42	7.1	2.9	6.2	8.9	12.3	--
Poplar River	17	10.5	--	6.4	10.4	12.2	15.6
Spruce Creek	9	6.0	3.0	5.9	10.0	--	--
Cascade River	2	3.4	3.4	--	--	--	--
Devil Track River	11	10.8	--	6.3	8.9	11.5	16.0
Kimball Creek	17	5.8	4.5	5.7	8.1	--	--
Kadunce Creek	13	5.9	2.8	6.1	10.5	--	--
Flute Reed River	8	8.8	--	7.0	9.6	13.9	--
Carlson Creek	3	7.2	--	6.9	8.0	--	--
All Rivers	233	8.6	3.4	6.3	9.4	12.3	16.3

Table 8. Total catch (number captured in pass-1) of Brook Trout by age and year.

	Year						
Age (years)	1997	2002	2007	2008	2013	2018	Total
0	92	19	26	15	38	21	211
1	165	67	58	43	139	61	533
2	60	17	52	71	47	119	366
3	7	1	6	12	15	24	65
4	0	0	10	1	3	8	22
5	0	0	0	0	1	0	1
6	0	0	0	0	1	0	1
Total	324	104	152	142	244	233	1,199

Table 9. Total catch (all passes) of Brook Trout by time period (Month.Week) and year.

	Year						
Month.Week	1997	2002	2007	2008	2013	2018	All Years
September 15-21	2	--	--	--	--	--	2
September 22-31	16	--	0	--	--	--	16
October 1-7	1	4	13	--	1	50	69
October 8-14	45	34	39	--	39	--	157
October 15-21	112	18	--	61	81	38	310
October 22-31	201	71	74	78	98	149	671
November 1-7	5	--	53	36	35	26	155
November 8-14	--	--	2	--	10	--	12
Total	382	127	181	175	264	263	1,392

**Includes all Brook Trout, recaps, and Splake captured in all passes.*

Table 10. Water temperature ranges when Brook Trout were captured by year.

Water Temperature		1997		2002		2007		2008		2013		2018		Total	
°F	°C	*N*	*%*	*N*	*%*	*N*	*%*	*N*	*%*	*N*	*%*	*N*	*%*	*N*	*%*
32-34	0.0-1.4	114	30%	10	8%	7	4%	0	0%	13	5%	2	1%	146	10%
35-39	1.4-4.2	98	26%	79	62%	48	27%	27	15%	122	46%	131	50%	505	36%
40-44	4.2-6.9	93	24%	18	14%	103	57%	146	83%	35	13%	85	32%	480	34%
45-49	6.9-9.7	51	13%	20	16%	10	6%	2	1%	90	34%	45	17%	218	16%
50-54	9.7-12.5	22	6%	0	0%	9	5%	0	0%	4	2%	0	0%	35	3%
55-59	12.5-15.0	4	1%	0	0%	4	2%	0	0%	0	0%	0	0%	8	1%
60+	15.1+	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
Total		382		127		181		175		264		263		1392	

**Includes all Brook Trout, recaps, and Splake captured in all passes.*

Table 11. All fish species present in the 2018 coaster Brook Trout survey by river.

River / Species	Blacknose Dace	Brook Trout	Brown Trout	Burbot	Chinook Salmon	Central Mudminnow	Coho Salmon	Common Shiner	Creek Chub	Finescale Dace	Longnose Dace	Northern Redbelly Dace	Pearl Dace	Pink Salmon	Rainbow Trout (age-0)	Rainbow Trout (age-1+)	Rock Bass	Sculpin spp.	Walleye (age-0)	White Sucker
Gooseberry River	X	X					X	X	X		X			X	X	X	X	X		X
Little Marais River	X	X					X					X			X					
Cross River		X	X	X				X	X		X			X	X	X			X	X
Onion River		X					X		X	X				X	X	X				
Poplar River		X					X	X	X					X						X
Spruce Creek		X					X							X	X			X		
Cascade River		X																		
Devil Track River		X			X		X		X					X	X	X		X		
Kimball Creek		X					X						X		X			X		
Kadunce Creek	X	X		X		X	X				X				X	X		X		
Flute Reed River		X					X		X						X	X		X		
Carlson Creek		X													X	X				