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EVALUATION OF JUVENILE STEELHEAD INDEX STATIONS ON THE MINNESOTA SHORE OF LAKE SUPERIOR 1973-2010

by

Matt Ward and Donald Schreiner

Minnesota Department of Natural Resources
Lake Superior Area Fisheries
5351 North Shore Drive
Duluth, MN 55804

INTRODUCTION

Anadromous rainbow trout (steelhead) from the west coast of North America were introduced into the Minnesota waters of Lake Superior in 1895 (Hassinger et. al. 1974). The species has become naturalized and supports an important recreational fishery. Minnesota has approximately 180 miles of tributaries accessible to steelhead, of which a more limited portion is suitable for spawning and nursery habitat. Based on angler reports, Minnesota supported a good fishery from the 1940s through the 1960s. Starting in the 1970s, anglers indicated that fishing pressure and harvest increased and the number of steelhead declined. Anglers state steelhead abundance remained low throughout the 1980s. In response to concerns of anglers and biologists, the Minnesota Department of Natural Resources (MN DNR) established the North Shore Steelhead Plan (Schreiner 1992). The goal of the 1992 plan was to stop the decline of adult steelhead and to gather the information necessary to rehabilitate stocks. Several programs to monitor and enhance steelhead abundance were outlined in the plan. One of the programs was to establish designated juvenile steelhead index stations along the Minnesota shore of Lake Superior. Index stations were selected between Duluth and Canada that included small, medium, and large tributaries that represented the range of tributaries on the Minnesota shore. Several of the tributaries selected had previously established index stations, with some having a sampling history that dated back to 1973. Selected tributaries were evenly distributed along the shore and varied in size so rehabilitation measures could be assessed.

The topic of low adult steelhead numbers was revisited again in 1995 during the development of the *Fisheries Management Plan for the Minnesota Waters of Lake Superior* (LSMP) (Schreiner ed. 1995). A question posed by anglers at this time was: “At what minimum level of juvenile abundance should rehabilitation of wild steelhead be abandoned and the 1992 North Shore Steelhead Plan be modified in favor of a major stocking program?” This question was addressed in the 1995 LSMP - Rainbow Trout chapter – Appendix 1 (Schreiner ed. 1995). The basis of the criteria to modify the 1992 North Shore Steelhead Plan was summarized as “a decline in adult steelhead that leads to inadequate recruitment of juvenile steelhead, measured by comparing the current juvenile abundance to historical juvenile abundance at pre-selected index stations”.

The 1992 North Shore Steelhead Plan was revised in 2003 and became the Rainbow Trout Management Plan for the Minnesota Waters of Lake Superior (Schreiner ed. 2003). After more than a decade of sampling the index stations annually, age-0 steelhead abundance increased shorewide. Index station criteria outlined in the 1995 LSMP that would have resulted in rehabilitation of wild steelhead being abandoned in favor of a major stocking program, were never met. Therefore rehabilitation measures that included conservative regulations, habitat protection, and population assessments were continued. The topic of juvenile steelhead abundance was again discussed in 2006 during the process of revising the *Fisheries Management Plan for the Minnesota Waters of Lake Superior* (Schreiner et al. 2006). At that time age-0 steelhead abundance continued to increase at index stations shorewide, which indicated rehabilitation measures were working. Additional evidence of continued rehabilitation was reinforced by a substantial increase in adult steelhead catch rate reported in the spring creel survey. Because criteria for rehabilitation success were no longer required, use of index stations for this purpose was discontinued in the 2006 LSMP. Since 1992, when more index stations became formalized and sampled on an annual basis, two status reports have been produced summarizing sampling efforts. The 1996 report (Jones 1996) described the rationale for establishing index stations and outlined the decision flow chart to modify the 1992 Steelhead Plan in favor of stocking if rehabilitation criteria were not met. The report also summarized how the criteria were tested at individual tributaries and from a shorewide perspective. After four years of data collection (1992–1995) the criteria to abandon the 1992 Steelhead Management Plan in favor of stocking were not met so the plan continued to be implemented as written. The 2000 report (Morse 2000) examined both individual tributaries and all tributaries combined to determine if criteria to abandon the plan in favor of stocking were not met after eight years of data collection (1992-1999). He found juvenile abundance continued to increase so the 1992 Steelhead Plan remained in place. Morse (2000) also compared age-0 and age-1 steelhead catch rates to adult steelhead catch rates in the spring creel, and assessed survival of juvenile steelhead at all index stations by comparing catch rates of age-1 steelhead to catch rates of age-0 steelhead the previous summer.

The present report summarizes and assesses: (1) how the abundances of juvenile steelhead at index stations have changed over time, (2) if relationships are present between spring creel survey data and index station data, and (3) if relationships are present between the Knife River fish trap data and the index stations on the Knife River. We also discuss if sampling all or any of the index stations annually continues to be necessary given the increase in steelhead abundance, and conclude with some recommendations for continuing or discontinuing this assessment.

METHODS

The data used in this report were derived from three sources. The first source of data was from the juvenile steelhead index stations; the second source was from a spring creel survey that has occurred on a subset of tributaries that have both index stations and spring creel census stations; and the third source was from an anadromous fish trap on the Knife River (Figure 1).

Electrofishing Index Stations

Numerous juvenile steelhead index stations on tributaries along the Minnesota shore between Duluth and the Canadian border have been sampled over time (Figure 1, Table 1). The Minnesota shore of Lake Superior is divided into two regions. The area from the Talmadge River to the Split Rock River is referred to as the lower shore and contains seven tributaries with index stations. The area from the Baptism River to Carlson Creek is referred to as the upper shore and also contains seven tributaries with index stations. When all tributaries are considered collectively the term shorewide was used. All index stations are located below natural barriers so they are accessible to anadromous adults.

The number of index stations that have been sampled annually has varied throughout time. The average number of stations sampled annually in the 1970’s was 4 (range 3-6), in the 1980’s was 8 (range 4- 11), in the 1990’s was 12 (range 9-14), and 2000’s was 14 (range 11- 14). The number of stations sampled annually was 14 from 1996 through 2008; however, that number dropped to 11 in 2009 due to insufficient personnel to conduct all surveys on the lower shore. Stations were sampled between late-July and mid-September when low, clear flows were present. Station length was dependent on tributary size and ranged between 300 and 1,500 feet. Station length was determined by protocols established in the Lake Superior Tributary Sampling Guide (Pitman and Wingate 1986). Over the years, crews have used different types of electrofishing gear and estimated abundance in various ways. Despite these changes, all crews have conducted a least a single pass and measured the stations length at the time of sampling. Therefore, all index station data within this report will be summarized and compared as the number of age-0 or age-1 juveniles sampled in a single pass and standardized to a length of 1,000 feet. All juvenile steelhead sampled were measured to the nearest millimeter (mm) and scale samples were collected from a subsample of individuals so age assignments could be made. Index station criteria from the 1995 LSMP (Schreiner ed. 1995) were as follows. Baseline values for age-0 steelhead at each station were established. For tributaries sampled starting in the 1970s, the first seven years of data were averaged to determine baseline values. For tributaries sampled starting in the 1980s, the first four years of data were averaged. Starting with 1992, the estimated number of age-0 juveniles present per 1,000 feet at each index station was averaged over three year time periods (92-94, 93-95, 94-96, etc.). Next, the three year average was compared to the established baseline to determine if it was greater than or less than 70% of baseline values. If it was greater, then it passed individual station criteria. If it was less, then it failed individual station criteria. Next, the percentage of individual stations that passed or failed criteria within specified three-year time periods were determined on a lower shore, upper shore, and shorewide basis. If shorewide average age-0 abundance at 70% of the index stations (10 or more of the 14 stations) was greater than 70% of the baseline values for any three year time periods, the rehabilitation criteria would be met and modification of the 1992 North Shore Steelhead Plan in favor of a major stocking program would not be considered.

Spring Creel Survey

Seventeen tributaries along the Minnesota shore between Duluth and the Canadian border are included in a spring creel survey. Of the seventeen spring creel stations, seven also contain juvenile steelhead index stations (Figure 1). Four of these tributaries that contain both are on the lower shore, while three are on the upper shore.

A stratified random creel survey has been conducted annually since 1992 from ice out (early-April) through late-May (Ostazeski and Morse 2002, Ward 2010a). The survey was designed to target anglers fishing for anadromous trout and salmon, which includes steelhead. Creel clerks interviewed anglers fishing between Lake Superior and the barrier waterfall on tributaries, and anglers fishing within close proximity to the mouths of tributaries along the lake. The creel survey provides annual estimates of both catch and catch rate for steelhead 16 inches and greater at individual tributaries. Those are combined to give estimates for upper shore stations collectively, lower shore stations collectively, and all stations shorewide collectively. Catch and catch rate are compared to the estimated number of age-0 and age-1 juvenile steelhead per 1,000 feet by year-class to determine whether one is an adequate predictor of the other.

Knife River Fish Trap

A permanent fish trap is located on the Knife River 0.5 miles upstream of the mouth with Lake Superior, and has been operational since the spring of 1996 (Figure 1). The fish trap sampled individuals migrating both upstream and downstream (Dexter and Schliep 2007, Ward 2010b). Trap data is used to determine the number of spawning females of an individual year-class. Female abundance will then be compared to the estimated number of age-0 and age-1 juveniles per 1,000 feet at the two Knife River index stations. In addition, the number of age-0 and age-1 juveniles sampled at the two Knife River index stations will be compared to the number of smolts of that year-class captured in the Knife River juvenile trap.

RESULTS

Electrofishing Index Stations

Rehabilitation criteria using results from the index stations were tested at each station over three-year time periods starting in 1992 (Table 2). Shorewide, the average number of age-0 steelhead was greater than 70% of baseline values during all three-year time periods. The average number of age-0 steelhead was also greater than 70% of baseline values during all but one three-year time period, when data was looked at from either an upper or lower shore perspective. The single time period when criteria were not met was 1993-1995 in the lower shore stations. On average, 43% of stations (6 of 14 stations) failed to meet criteria during the first five three-year time periods, while only 10% of stations (1.4 of 14 stations) failed to meet criteria during the last six three-year time periods.

The mean number of age-0 steelhead per 1,000 feet on pass one per decade at all index stations combined, has increased over each of the past four decades. The mean number has increased from 111 in the 1970s to 239 in the 2000s (Figure 2). However, the same trend has not occurred for age-1 juveniles. The mean number has remained between 40 and 50 per 1,000 feet, three of the past four decades (Figure 3). The number of age-0 and age-1 juvenile steelhead sampled at each of the index stations from 1973 through 2010 are shown in Appendix 1 and 2.

When index stations are sampled in consecutive years, a juvenile survival rate from age-0 to age-1 can be estimated by dividing the number of age-1 individuals sampled in one year by the number of age-0 individuals of the same year-class sampled the previous year. When averaging all individual station data from 1973 through 2010 at individual tributaries, this ratio has varied from 0.05 on Carlson Creek to 0.56 on the West Branch of the Knife River (Figure 4). The average ratio at all index stations combined is 0.26, inferring an annual survival rate of 26% shorewide between age-0 and age-1 within index stations.

The mean number of age-0 steelhead sampled per 1,000 feet over time has ranged between 50 on the Split Rock River and 469 on Carlson Creek (Figure 5), while the mean number of age-1 steelhead sampled per 1,000 feet has ranged between 15 on the Split Rock River to 89 on the West Branch of the Knife River (Figure 6).

Spring Creel Survey

Weak relationships were present between either catch or catch rate in the spring creel (early-April through mid-May time period) and the number of age-0 or age-1 juvenile steelhead per 1,000 feet (late-July through mid-September time period) at any of the seven tributaries that contained both spring creel surveys and juvenile steelhead index stations (Table 3). Weak or no relationships were also present between these variables on the lower shore, upper shore, or shorewide (Table 3). Relationships are stronger, relatively speaking, when catch data was used instead of catch rate data, and when age-0 data was used instead of age-1 data (Table 3). Age-1 juvenile comparisons were offset by one year, so year-classes could be compared directly.

Knife River Fish Trap

Weak relationships were present between Knife River trap data and data from the two index stations on the Knife River (Table 4). Weak relationships were present between number of females that spawned upstream and the number of age-0 juveniles sampled per 1,000 feet approximately four months later at the two Knife River index stations individually or collectively. No relationships were present when that same relationship was assessed a year later when the juveniles were age-1. Weak relationships were present between the mean number of age-0 juveniles sampled per 1,000 feet at the two Knife River index stations individually or collectively and the number of smolts of that year-class that emigrated two years later. Interestingly, relationships were no longer present between the mean number of age-1 juveniles sampled per 1,000 feet at the two Knife River index stations individually or collectively and the number of smolts of that year-class that emigrated one year later.

DISCUSSION

Electrofishing Index Stations

Baseline values for index stations were derived from a time period that anglers indicated abundances of adults were insufficient; however, sufficient recruitment was still occurring to sustain the steelhead population at low levels. Biologists established criteria based on the percentage of juveniles they thought were necessary to sustain the population. Index station criteria were met from a shorewide perspective during all three year time periods assessed. Therefore, overall rehabilitation criteria have been met and modification of the 1992 North Shore Steelhead Plan in favor of a major stocking program was not considered. The percentage of individual stations that have failed to meet criteria has decreased three fold over the past twenty years, and all index stations shorewide have met criteria two of the past three time periods assessed (Table 2).

Evidence that age-0 abundance has increased over time has been shown by the increasing number of age-0 steelhead sampled per 1,000 feet at all index stations combined over each of the past four decades (Figure 2). The number of age-0 steelhead has likely increased over time due to the increase in abundance of adult steelhead, which is supported by both creel survey and trap data (Ward 2010a, Ward 2010b). Adult steelhead numbers have likely increased due to restrictive harvest regulations first introduced in 1992, and habitat protection.

Age-1 abundance has not increased over time like that of age-0 individuals. Likely reasons include habitat limitations in the stream and environmental bottlenecks that age-1 juveniles have always experienced in tributaries on the Minnesota shore of Lake Superior. Minnesota tributaries have minimal groundwater inputs that commonly result in summertime water temperatures exceeding the thermal threshold of trout, and stream reaches freezing solid in the winter. Also, due to the steep gradient of Minnesota tributaries, there is a disproportionate percentage of riffles when compared to that of runs and pools. This results in adequate spawning and age-0 juvenile habitat, but, insufficient deep water habitat for age-1 individuals. If age-1 juvenile habitat is limited, they will likely emigrate prematurely in late-spring/early-summer as flows decrease and temperatures increase. This is routinely documented at both the French and Knife River juvenile traps (Ward 2010b, Blankenheim 2010). Therefore carrying capacity of age-1 juveniles is largely influenced by precipitation and temperature during critical periods in both summer and winter. Currently there are more spawning adults producing more age-0 individuals than at any time in the past thirty years; however, due to habitat limitations and ecological bottlenecks age-1 abundance remains similar to historical levels.

When sampling index stations in consecutive years, each year-class is sampled twice so survival from age-0 to age-1 can be estimated. The two smallest tributaries sampled were Carlson Creek and the Talmadge River. Carlson Creek had the lowest survival rate between age-0 and age-1 at 5%, followed by the Talmadge River at 13% (Figure 4). Due to the small watershed size and tributary length, these tributaries lack sufficient habitat and flows to retain many age-1 juveniles in the stream in the summer. Therefore, they are likely not present when index station assessments are conducted, in late-summer/early-fall. The four index stations that had the highest survival rates between age-0 and age-1 were the three stations in the Knife River watershed and the Sucker River station. These four stations are all located on the largest tributaries sampled, and possess substantially larger watersheds and stream miles. These four stations had survival rates between 32% and 66% (Figure 4).

Spring Creel

The spring anadromous creel survey and juvenile steelhead index stations were not designed with the objective that the two would be directly compared on an annual basis, but determining if a relationship exists is of interest. When examined, the relationship between age-0 steelhead and the catch rate of adult steelhead in the spring creel was present, but weak (Table 3). There are two likely reasons for this weak relationship. The first is related to the design of the spring creel survey, while the second is related to the annual in-stream environmental variability.

The spring creel uses a stratified random design that results in the most accurate individual station data that can be determined given the limited amount of effort expended. However, catch and catch rate at individual tributaries should be viewed cautiously due to variability in random creel schedules, timing of fish runs, and in-stream environmental conditions. Therefore, lower shore, upper shore, and shorewide estimates are viewed as more accurate when creel data is assessed. Although lower shore, upper shore, and shorewide estimates are viewed as more accurate, these relationships are still weak when spring creel and index station data is compared. It is understood that the spring creel is not an accurate predictor of adult spawner abundance in an individual stream in a given year because individual adults are likely caught multiple times, and the spring creel is not meant to provide point in time estimates. The spring creel information is most valuable when viewed as trend through time and compared to other streams on a relative basis.

In addition, there are many environmental variables that affect year-class survival between spring spawning and when juveniles are sampled as age-0 in late summer. The relationship between spring creel catch or catch rate and age-1 juveniles was even weaker than for age-0 steelhead because the age-1 juveniles have to survive an additional year in the stream under, at times, extreme environmental conditions.

Knife River Fish Trap

The Knife River watershed is a complex and variable system with tributaries ranging from those that become dry in the summer to those that have adequate shade and groundwater inputs. Similar to the spring creel, the Knife River fish trap was not specifically designed with the objective that fish trap data and index station data would be directly compared. Weak relationships were found between females captured at the Knife River trap and age-0 catch at the two juvenile steelhead index stations on the Knife River. The same relationship for age-1 juveniles was worse (Table 4). Based on these findings it is apparent that environmental conditions that affect survival between egg deposition/fertilization and survival four (age-0) or sixteen (age-1) months later were highly variable.

The relationship between number of either age-0 or age-1 juveniles sampled at index stations in the Knife River and the number of smolts that emigrated is also weak. These findings indicate that instream environmental conditions are annually highly variable. Factors that result in survival rates being highly variable in Minnesota tributaries to Lake Superior include inconsistent flows, high sedimentation, limited groundwater, periods of lethal water temperatures late in the summer, and tributary reaches freezing to the bottom in the winter if sufficient snow is not present to insulate them.

Future of Index Stations

The index station data proved very useful in providing the information required by the criteria established in the 1995 LSMP. Without this important information, and measure of rehabilitation success, it is very likely a major stocking program would have been implemented at a great cost both financially and ecologically. Overall, the index station data are valuable and continue to show population trends over the past four decades for both age-0 and age-1 individuals.

Despite the weak relationships found between annual index station data and annual data from the spring creel and Knife River trap, these relationships were important to explore. Index stations are one of only a few methods biologists have to assess steelhead populations in Minnesota. The only other tools present are the spring anadromous creel survey and the Knife River fish trap. The traps and creel provide different information than the index stations and taken together give a good indication on the status of the steelhead population. However, in an era of shrinking state budgets and staff, the spring creel survey and the operation of the Knife River fish trap are the most expensive of the three methods to assess the steelhead population, and effort in these areas could potentially be reduced. Index stations are the less expensive ‘canary in the coal mine’ and provide information on juvenile population trends that influence the adult steelhead population four or five years into the future.

An unanticipated benefit of the index station time series was realized in 2010 to justify the Section of Fisheries position against further modification of the second falls in the Knife River, as requested by an influential steelhead angling group. By comparing the abundance of age-0 steelhead sampled at three Knife River index stations in 2010 to the long-term mean at these same stations, we could demonstrate that the second falls was not an impediment to upstream migration of adult steelhead as the group claimed. In fact, the 2010 sample of age-0 juvenile steelhead was one of the highest on record, far surpassing the long-term mean. This issue would have been extremely difficult to address without the index station data.

In addition, as interest in global climate change and its effects on fisheries increases, the importance of relatively long-term consistent data sets becomes extremely valuable. This is especially true for tributaries that appear to be currently on a thermal threshold for an important species such as steelhead in Lake Superior. Data generated from continuing to monitor index stations could prove very useful as an important indicator of climate change in the near future.

SUMMARY

The initial reason index station criteria were established is no longer relevant, as adult steelhead populations have rebounded to their highest levels in the last thirty years. Rehabilitation criteria were met and modification of the 1992 North Shore Steelhead Plan in favor of a major stocking program was not considered during the process of revising the Rainbow Trout Management Plan in 2003 or the Lake Superior Management Plan in 2006. The number of age-0 steelhead sampled at index stations shorewide has increased each of the past four decades, while the number of age-1 juveniles has remained fairly consistent. A shorewide juvenile survival rate between age-0 and age-1 appears to average approximately 26% at the index stations, but ranges between 5 and 66%. Weak relationships are present between the spring creel and index station data, or between Knife River trap data and index station data on an annual basis. Despite index station data not being highly correlated to spring creel or Knife River trap data on an annual basis, long term shorewide trend data of juvenile steelhead abundance has proven useful. This type of long-term monitoring may prove to be extremely valuable in the future, especially in the face of global climate change, and should be continued at some level if funds are available.

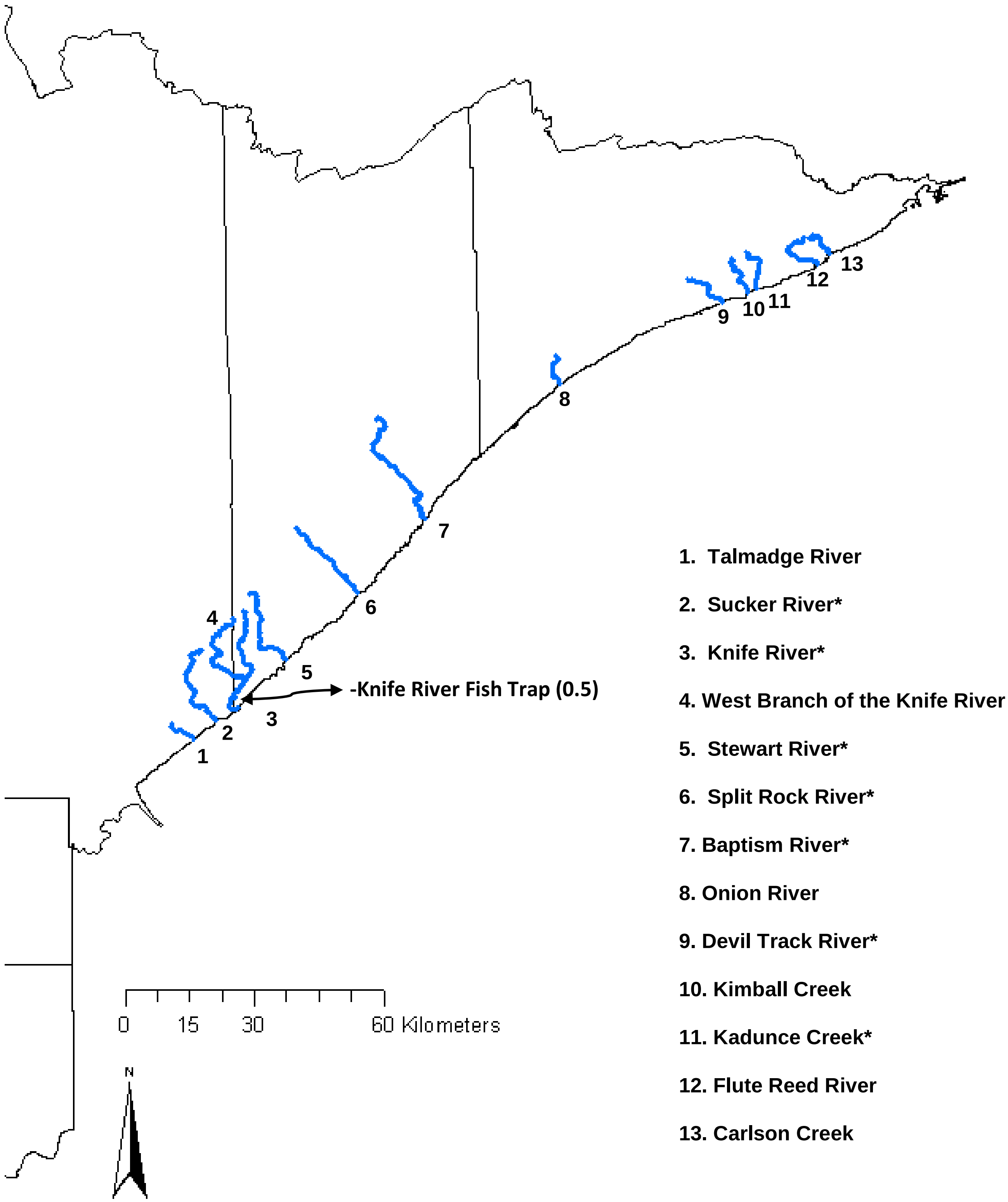

FIGURE 1. Tributaries that contain juvenile steelhead index stations along Minnesota shoreline of Lake Superior. Tributaries that are also included in the spring creel survey have an asterisk (*) after them and the location of the Knife River fish trap is also indicated.

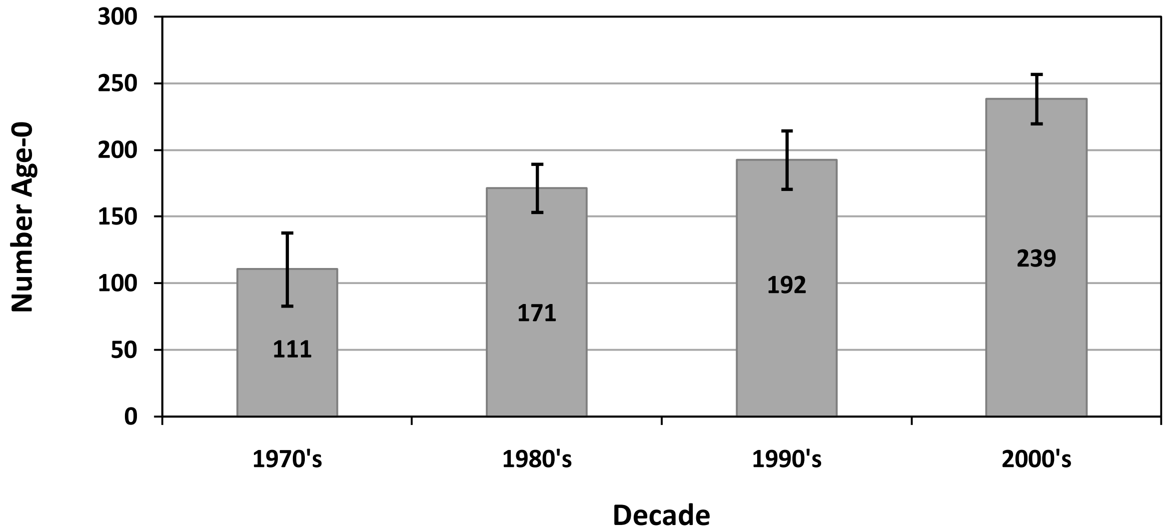

FIGURE 2. The mean number (with standard error) of age-0 steelhead per 1,000 feet on pass 1 per decade on all juvenile steelhead index stations combined.

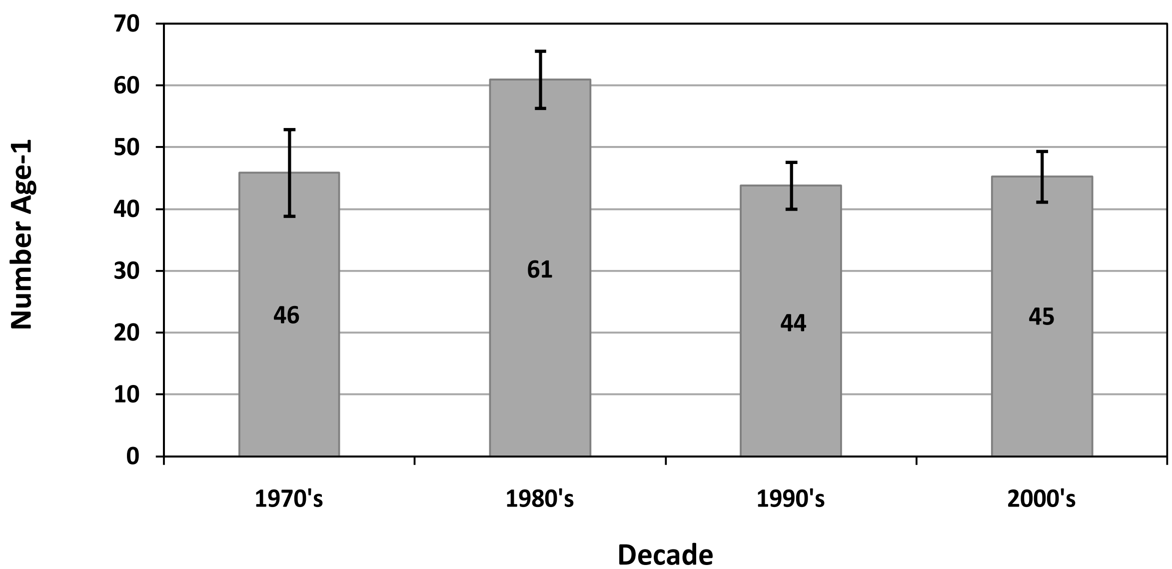

FIGURE 3. The mean number (with standard error) of age-1 steelhead per 1,000 feet on pass 1 per decade on all juvenile steelhead index stations combined.

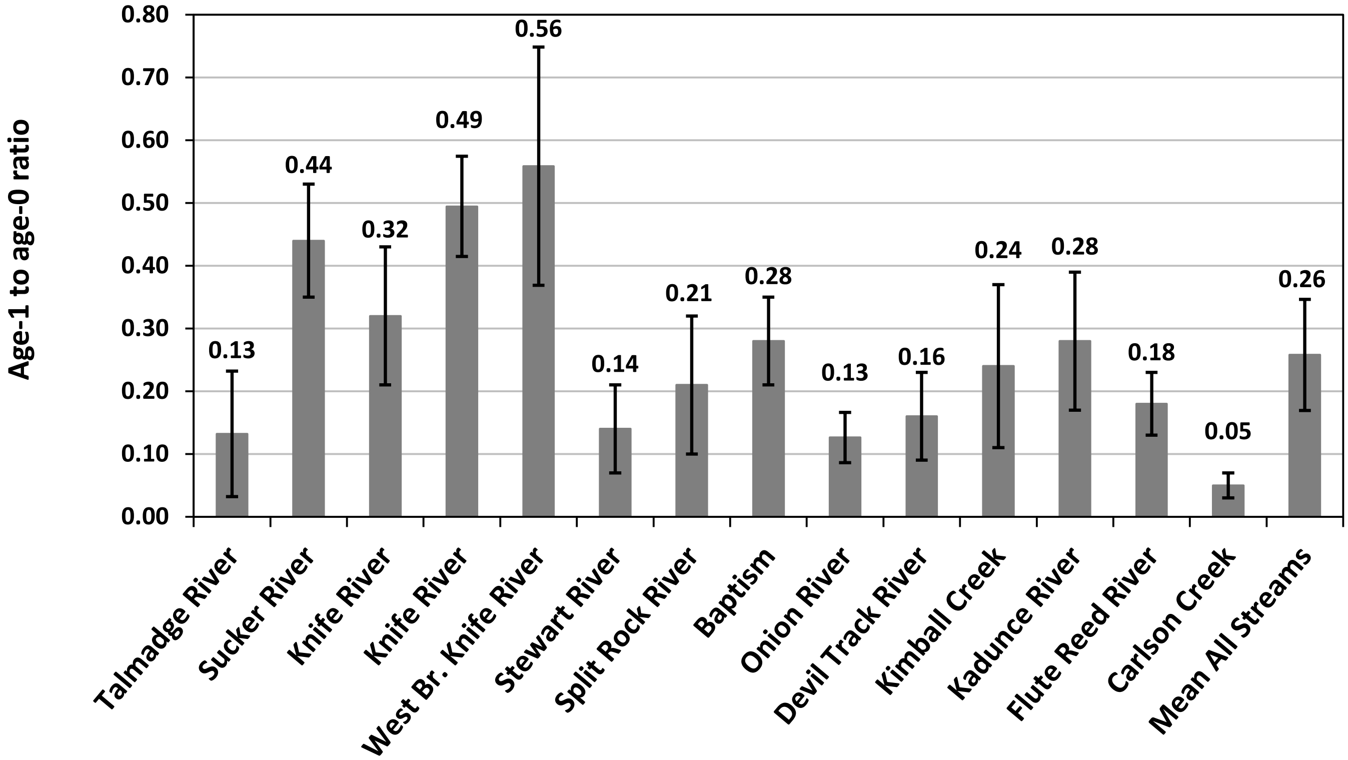

FIGURE 4. Steelhead survival index as the ratio of the number of age-1 sampled from a year-class to the number sampled at age-0 the previous year. Data from all index stations was combined for each station from 1973 through 2010.

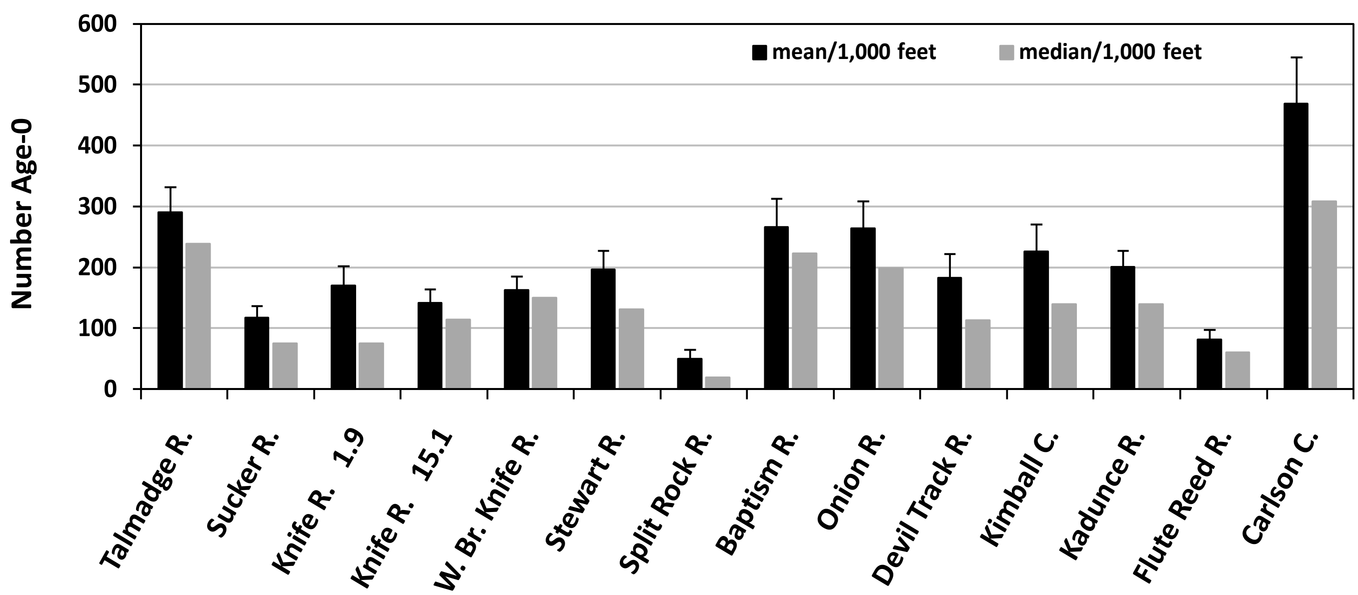

FIGURE 5. The mean and median number of age-0 steelhead per 1,000 feet at the steelhead index stations along the Minnesota waters of Lake Superior. Standard error of the mean is displayed. Figure includes all years a station was sampled from 1973 to present.

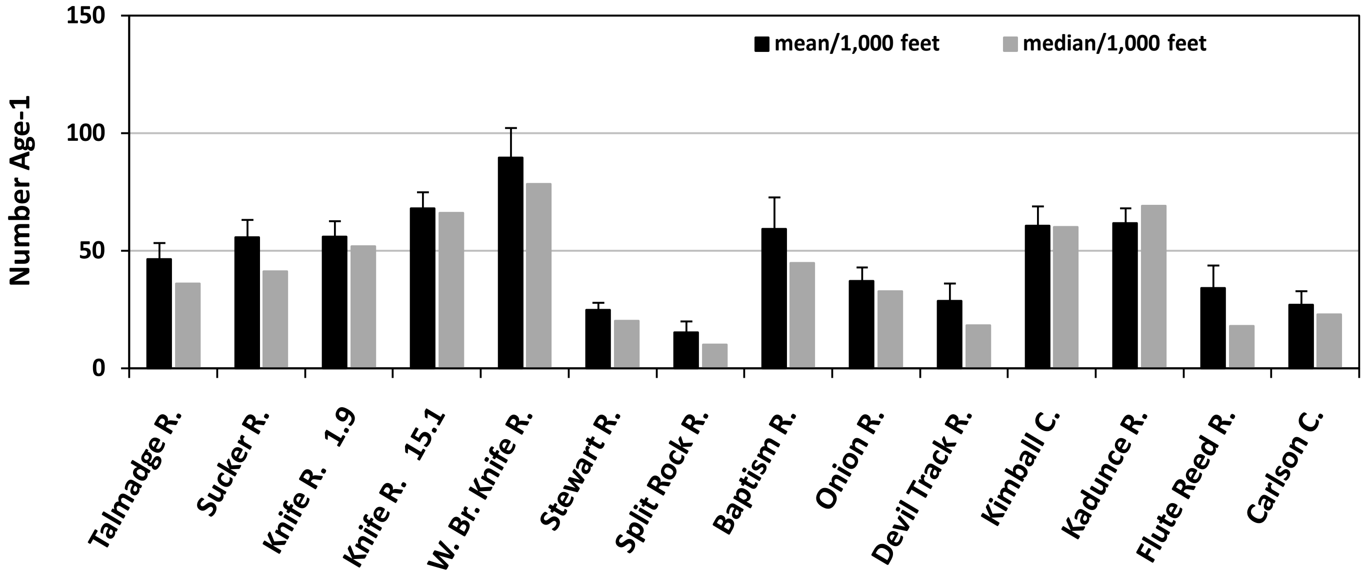

FIGURE 6. The mean and median number of age-1 and older juvenile steelhead per 1,000 feet at the steelhead index stations along the Minnesota waters of Lake Superior. Standard error of the mean is displayed. Figure includes all years a station was sampled from 1973 to present.

TABLE 1. Locations of juvenile steelhead index stations.

Stream	Kittle number	Fisheries Area	County	Station length (ft)	Starting location upstream from mouth (miles)
Talmadge River	S-7	Duluth	St. Louis	480	0.1
Sucker River	S-15	Duluth	St. Louis	649	1.0
Knife River 1.9	S-17	Duluth	St. Louis	985	1.9
Knife River 15.1	S-17	Duluth	Lake	660	15.1
W. Branch, Knife River	S-17-4	Duluth	St. Louis	543	3.7
Stewart River	S-19	Duluth	Lake	852	0.0
Split Rock River	S-29	Finland	Lake	1,500	0.5
Baptism River	S-38	Finland	Lake	1,500	0.7
Onion River	S-56	Grand Marais	Cook	538	0.1
Devil Track River	S-67	Grand Marais	Cook	528	0.1
Kimball Creek	S-70	Grand Marais	Cook	550	0.1
Kadunce Creek	S-72	Grand Marais	Cook	589	0.0

TABLE 2. Tests of index station criteria established in the 1995 Fisheries Management Plan for the Minnesota Waters of Lake Superior (Schreiner 1995). For individual tributaries, P denotes the mean number of age-0 steelhead was greater than 70% of the baseline value (Pass), while F denotes the mean number of age-0 steelhead was less than 70% of the baseline value (Fail). The percentage of lower shore, upper shore, and shorewide stations that failed is also indicated.

Index stations	92-94	93-95	94-96	95-97	96-98	97-99	98-00	99-01	00-02	01-03	02-04	03-05	04-06	05-07	06-08	07-09	08-10
Lower shore stations																	
Talmadge River	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	F
Sucker River	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
Knife River, mile 1.9	F	F	F	F	F	F	P	P	P	P	P	P	F	F	P	P	P
Knife River, mile 15.1	P	F	F	F	P	P	P	P	F	F	F	P	P	P	P	P	P
West Branch Knife River	P	F	F	F	P	P	P	P	P	F	P	P	P	P	P	P	P
Stewart River	F	F	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
Split Rock River	F	F	F	F	F	F	P	P	P	P	P	P	P	P	P	P	P
Percent that failed	43%	71%	57%	57%	29%	29%	0%	0%	14%	29%	14%	0%	14%	14%	0%	0%	14%
Upper shore stations																	
Baptism River	P	F	F	F	P	P	P	F	F	F	P	P	P	P	P	P	F
Onion River	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
Devil Track River	F	F	F	P	P	P	P	P	P	P	P	P	P	P	P	P	P
Kimball Creek	F	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
Kadunce Creek	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
Flute Reed River	F	F	F	F	F	P	P	P	P	P	P	F	F	P	P	P	P
Carlson Creek	P	P	P	P	P	P	P	P	P	P	P	P	F	P	P	P	F
Percent that failed	43%	43%	43%	29%	14%	0%	0%	14%	14%	14%	0%	14%	29%	0%	0%	0%	29%
Shorewide																	
Percent that failed	**43%**	**57%**	**50%**	**43%**	**21%**	**14%**	**0%**	**7%**	**14%**	**21%**	**7%**	**7%**	**21%**	**7%**	**0%**	**0%**	**21%**

TABLE 3. R-squared values from assessing the relationships between spring creel catch and catch rate, and the number of age-0 and age-1 juvenile steelhead sampled at index stations.

Station	Creel catch vs. age-0 electrofishing	Creel catch rate vs. age-0 electrofishing	Creel catch vs. age-1 electrofishing	Creel catch rate vs. age-1 electrofishing
Sucker 1.0	0.2404	0.1132	0.1731	0.0299
Knife 1.9	0.0246	0.0638	0.0763	0.0067
Knife 15.1	0.0000	0.0105	0.0002	0.0166
Stewart 0.2	0.0000	0.0066	0.0466	0.0249
Split Rock 0.5	0.3785	0.1543	0.0274	0.0247
Baptism 0.7	0.0161	0.0126	0.0009	0.0096
Devil Track 0.1	0.4471	0.1641	0.0551	0.0058
Kadunce 0.0	0.0091	0.0210	0.0004	0.0100

TABLE 4. R-squared values from assessing the relationships between Knife River trap data and Knife River index station data.

Station	Number females spawning vs. age-0 electrofishing	Number females spawning vs. age-1 electrofishing	Age-0 electrofishing vs. age-2 and -3 smolts	Age-1 electrofishing vs. age-2 and -3 smolts
Knife 1.9	0.0814	0.0197	0.2480	-0.0370
Knife 15.1	0.0405	0.0622	0.0566	0.1435
Average of 1.9 and 15.1	0.1384	0.0345	0.1684	-0.6770

APPENDIX 1. Number of age-0 steelhead electrofished per 1,000 feet at the juvenile steelhead index stations from 1973 through 2010.

Year	Talmadge River 0.1	Sucker R. River 1.0	Knife River 1.9	Knife River 15.1	West Branch Knife River 3.7	Stewart River 0.2	Split Rock River 0.5	Baptism River 0.7	Onion River 0.1	Devil Track River 0.1	Kimball Creek 0.1	Kadunce Creek 0.0	Flute Reed River 0.0	Carlson Creek 0.1
73	267	43	16			20								
74		22	75			33								
75	260	2	8			27							80	
76	107	25	183			300			20				180	
77	17	53	732			235								
78	0	7	55			3								
79	107	15	267			160								
80	110	97	228			247								
81	613	200	278	65		8			77	42	100	67	20	134
82	597	78	28	27		118				156	65	92	42	312
83	383	83	55	227	83	328			364	18	226	61		
84	190	282	155	319	237	135			64				60	
85	727	50	770	130	137	100			108					
86	157	185	12	110	150	290				0	18	28	22	628
87	263	37	117	157	280	100								
88	33	60	25	17	0	502					98			220
89		12	250	197	260			368		136	80	138		357
90			561	407	127		0	667	366		430	580		796
91			11	141	71		138		538	233	36	186	136	248
92	380	39	53	271	285	52		232	171	27		104	80	812
93			69	69	125	4	14		78	9	58	49	2	928
94		37	21	35	114	104			229	23	70	102	50	305
95	377	6	0	38	0	54	2	3	572		248	153		
96	37	55	12	52	32	163	0	76	116	2	19	61	4	1480
97	191	86	0	28	142	48	10	124	426	125	210	468	48	518
98	485	111	279	549	164	748	24	497	191	273	246	362	63	875
99	157	217	55	94	189	126	27	132	20	42	22	68	128	294
00	682		242	222	324	716	105	149	112	70	740	232	102	278
01	129	177	187	52	11	334	25	192	204	36	55	342	172	133
02	226	30	9	0	7	62	4	168	56	316	274	258	82	373
03	230	167	270	49	14	171	90	232	387	525	492	332	72	1171
04	731	408	276	164	335	131	18	770	28	670	43	138	40	204
05	598	143	45	138	173	86	19	247	121	100	51	83	14	270
06	248	183	39	67	309	89	11	90	411	356	316	140	56	133
07	396	316	316	164	250	279	237	482	325	455	658	70	139	671
08	27	72	428	279	193	347	82	237	752	40	179	299	18	36
09		384		68		238	140	223	893	381	849	480	385	69
10		310	153	118	385	496	7	174	237	360	282	319	38	
Baseline	124	33	196	159	152	128	39	317	131	54	102	62	81	324
70% Baseline	87	23	137	111	106	90	27	222	92	38	72	43	56	227
73-10 Mean	291	117	170	142	163	196	50	266	264	183	226	200	81	469
73-10 Median	239	75	75	114	150	131	19	223	198	113	139	139	60	309

APPENDIX 2. Number of age-1 steelhead electrofished per 1,000 feet at the juvenile steelhead index stations from 1973 through 2010.

Year	Talmadge River 0.1	Sucker R. River 1.0	Knife River 1.9	Knife River 15.1	West Branch Knife River 3.7	Stewart River 0.2	Split Rock River 0.5	Baptism River 0.7	Onion River 0.1	Devil Track River 0.1	Kimball Creek 0.1	Kadunce Creek 0.0	Flute Reed River 0.0	Carlson Creek 0.1
73	7	18	24			7								
74		22	44			16								
75	40	43	23			22							120	
76	30	12	92			50			10				20	
77	17	140	15			28								
78	43	22	52			48								
79	17	75	68			33								
80	33	50	168			23								
81	43	35	47	97		15			24	12	106	80	120	34
82	90	98	57	67		7				6	38	83	12	40
83	103	93	33	73	130	42			66	4	74	89		
84	37	87	67	104	87	33			42				32	
85	107	207	67	53	43	58			40					
86	160	93	123	70	157	20				19	30	61	200	108
87	17	92	75	27	40	12								
88	30	30	45	60	0	2					60			28
89		35	10	20	7			108		9	84	95		16
90			92	97	50		87	79	4		38	112		41
91			67	77	206		11		47	27	112	93	52	10
92	80	39	67	66	78	43		98	125	47		53	88	8
93			60	167	214	9	0		63	0	10	55	20	91
94		20	102	66	157	2			13	2	120	72	36	35
95	90	19	7	31	36	4	12	5	59		116	74		
96	68	0	5	28	21	9	10	3	37	2	41	38	8	0
97	34	20	18	28	50	72	0	19	11	2	22	81	2	24
98	19	53	37	35	64	0	7	46	28	11	70	66	6	22
99	22	33	7	66	78	43	4	27	28	25	14	14	0	6
00	71		120	115	103	20	13	49	6	30	34	24	34	69
01	45	47	141	115	110	37	19	19	11	4	2	6	18	2
02	17	3	25	52	46	28	9	27	17	21	17	22	8	0
03	0	27	5	14	4	0	0	11	0	11	7	12	0	0
04	92	80	76	29	42	74	50	162	28	68	128	28	8	52
05	42	123	95	136	265	25	23	239	56	57	79	83	28	24
06	35	39	25	121	110	18	9	41	56	70	63	14	0	6
07	2	49	44	91	123	4	0	52	0	17	2	44	0	0
08	0	46	56	59	112	33	6	45	74	40	130	88	13	30
09		32		29		13	11	29	55	27	60	119	5	0
10		106	12	48	81	14	18	63	66	174	116	93	18	
73-10 Mean	46	56	56	68	89	25	15	59	37	29	61	62	34	27
73-10 Median	36	41	52	66	78	20	10	45	33	18	60	69	18	23

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