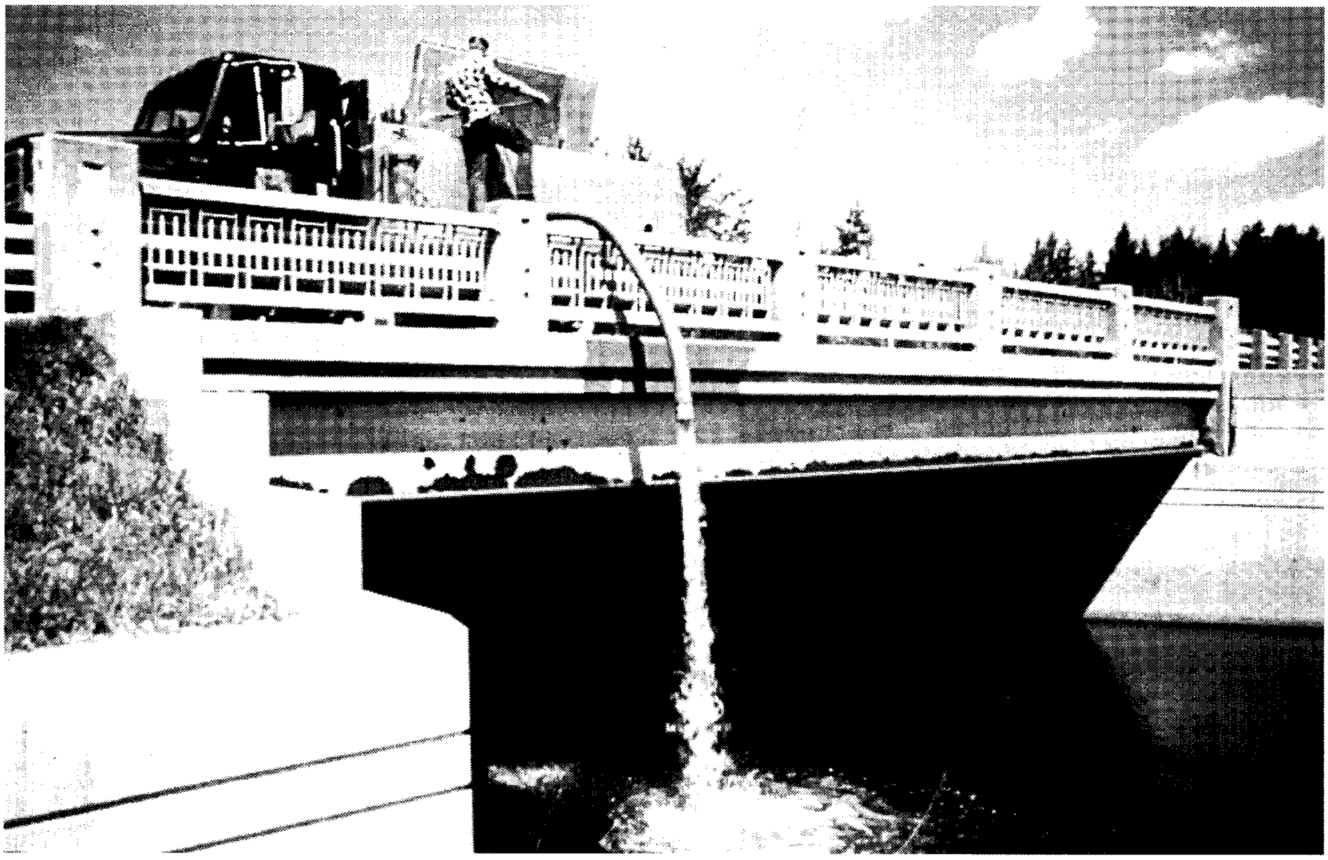
FISHERIES DIVISION

RESEARCH REPORT

Number 2012 July 1, 1994

Rehabilitation of a Lake Superior Steelhead Population by Stocking Yearling Smolts

James W. Peck



DNR

STATE OF MICHIGAN
DEPARTMENT OF NATURAL RESOURCES

MICHIGAN DEPARTMENT OF NATURAL RESOURCES
FISHERIES DIVISION

Fisheries Research Report 2012
July 1, 1994

REHABILITATION OF A LAKE SUPERIOR STEELHEAD POPULATION BY STOCKING YEARLING SMOLTS

James W. Peck

PRINTED BY AUTHORITIY OF:Michigan Department of Natural Resources
TOTAL NUMBER OF COPIES PRINTED: 300 TOTAL COST: $263.98 COST PER COPY: $ .87p
Michigan Department of Natural Resources

Michigan Department of Natural Resources
Fisheries Research Report No. 2012, 1994.

Rehabilitation of a Lake Superior Steelhead Population by Stocking Yearling Smolts

James W. Peck

Michigan Department of Natural Resources
Marquette Fisheries Station
484 Cherry Creek Road
Marquette, Michigan 49855

Abstract.–The steelhead *Oncorhynchus mykiss* population in the upper Chocolay River was successfully rehabilitated in the 1980s after being below carrying capacity for around 30 years. Rehabilitation was accomplished by stocking large (175-184 mm), yearling Michigan-strain steelhead smolts in 1983, 1984, and 1985 at an upstream location with good spawning substrate. Most adult steelhead sampled in the 1986-88 spawning runs were hatchery fish, and all of these were the Michigan strain stocked in 1983-85. The composition of steelhead spawning runs in the upper Chocolay River changed from mostly hatchery to all wild during 1986-92. Steelhead spawning activity stabilized at about 0.9 adults and 0.6-0.8 redds per 100 m of stream. Juvenile steelhead abundance in the upper Chocolay River increased in 1985 and 1986, then leveled off between 1986 and 1992 at what appeared to be carrying capacity. Numbers of age-0 steelhead in one 305-m section of the Chocolay River increased from less than 50 to more than 1,900 between 1984 and 1985, then stabilized at just over 1,200 during 1986-92. Numbers of age-1 steelhead in this section increased from 79 to 273 between 1985 and 1986, then stabilized at just over 200 during 1987-92. A similar increase in juvenile abundance was observed in another Chocolay River section sampled during 1983-86, and constant abundance was recorded for a third section during 1986-92. Densities of age-0 steelhead in the Chocolay River sections were lower than in two nearby Lake Superior tributaries (the Little Garlic River and Chinks Creek), but were less variable. Densities of age-1 steelhead in the Chocolay River sections were as high and more stable than in the two Lake Superior tributaries, and comparable to density in a Lake Michigan tributary (Little Manistee River). No further steelhead stocking should be done in the upper Chocolay River unless juvenile populations decrease substantially, and future stocking of hatchery fish should only be done in streams with steelhead populations below carrying capacity.

The Chocolay River, a Lake Superior tributary in Marquette County, Michigan, historically had sizable population of naturally-reproducing steelhead (anadromous rainbow trout *Oncorhynchus mykiss*). Michigan Department of Natural Resources (MDNR) stream surveys during 1950-51 indicated an abundance of juvenile steelhead in the upper river and tributaries (Unpublished data, Marquette Fisheries Station, Marquette). However, the increased abundance of sea lamprey *Petromyzon marinus* later in the 1950s resulted in reduced abundance of steelhead and other large salmonine fishes throughout Lake Superior and its tributaries (Smith and Tibbles 1980). Electrical barrier weirs were installed on the Chocolay

River and other Lake Superior tributaries in the early 1950s to stop spawning runs of sea lamprey, and chemical treatments of tributaries with 3-trifluoromethyl-4-nitrophenol (TFM) began in the 1960s to reduce populations of sea lamprey ammocetes. The control measures, especially TFM treatments, effectively reduced sea lamprey populations in Lake Superior, which resulted in increased survival of large salmonines. Steelhead spawning runs increased during the 1960s in most tributaries, as indicated by the total catch of adult steelhead in barrier traps (Dahl and McDonald 1980). However unlike steelhead populations in other streams with sea lamprey electrical weirs, the Chocolay River population did not recover. Trap records for the Chocolay River indicated a decrease in the number of adult steelhead from over 100 during the mid-1950s to less than 10 by the mid-1960s (Unpublished data, U.S. Fish and Wildlife Service, Marquette, Michigan). Catches increased slightly in the early and late 1970's but never exceeded 17 fish. Juvenile steelhead captured in the downstream trap at the weir decreased in number sharply from 1,200 in 1955 to about 100 by 1957, then decreased gradually to less than 10 by the late 1960s. Catch of juveniles increased to over 100 in the early 1970s, then decreased to less than 20 by the late 1970s.

The electrical barrier weir on the Chocolay River during 1954-79 (Figure 1) may have been the primary reason why the steelhead population did not recover during the 1960s and 1970s. The weir on the Chocolay River, like those on other tributaries, was located below most suitable spawning habitat; thus, upstream- migrating adult steelhead and downstream- migrating juveniles had to pass the weir. Traps were installed at the weirs to capture these migrants and transfer them safely around the electrical field. A direct-current field was also used to divert fish away from the lethal alternating-current field and into the traps. Mortality of adult steelhead caused by the Chocolay River weir was estimated in 1956 at only about 5%, but mortality of downstream migrating juveniles was estimated at nearly 45% (McLain 1957). McLain (1957) blamed the mortality on various factors including low water velocity, flooding, and malfunction of the direct-current diversion field. McLain did not observe mortality of this magnitude in the other stream with a barrier weir examined in his study. If such mortality was an annual occurrence in the Chocolay River, it may explain why steelhead populations did not recover there as they did in other tributaries. The weir may also have blocked adult steelhead from spawning in the upper river. Results from this study indicated that spawning steelhead did not migrate to the spawning area in the upper river until mid-April and early May, which coincided with operation of the weir during 1954-79. Dahl and McDonald (1980) believed that the number of rainbow trout captured at the weir trap was not indicative of the total population utilizing the stream, and additional fish were reluctant to enter the trap and may spawn below the weir or migrate to other streams.

Rehabilitation of the Chocolay River steelhead population was initiated by MDNR with the stocking of yearling steelhead in 1980. The MDNR has stocked yearling steelhead annually since then, using several strains, sizes, and stocking sites. However, stocking hatchery steelhead in Lake Superior and tributaries has not been a successful management practice in recent years. Returns to the sport fishery from the number of steelhead stocked in the Chocolay River and in various other tributaries and sites in Lake Superior have been less than 2% (Hansen and Stauffer 1971; Wagner and Stauffer 1978; Peck 1992). Seelbach and Miller (1993) estimated the total return to a Lake Superior tributary (Huron River) was about 3% of the number planted. There had been no previously documented contribution of hatchery steelhead to natural reproduction in Lake Superior tributaries.

The objectives of this study were to determine if steelhead stocked as hatchery yearlings during the 1980s contributed to spawning runs in an upstream area of the Chocolay River, and if natural reproduction increased as a result.

Methods

The Chocolay River flows through mostly-wooded terrain and enters Lake Superior near Marquette. The main stream is 26 km long, has 208 km of tributaries, and drains about 412 km^2 (Brown 1944). According to Zimmerman (1968), flow of the main stream at the US 41 highway bridge (Figure 1) generally ranged from 0.8 to 2.0 m^3/sec, total alkalinity was 22 to 74 ppm, total hardness was 34 to 80 ppm, and temperatures ranged from 0° to 18° C. The Chocolay River has resident populations of brook trout *Salvelinus fontinalis* and brown trout *Salmo trutta*, and most anadromous salmonines in Lake Superior use the Chocolay River for reproduction. Most of the good steelhead spawning substrate (gravel-cobble) is located in the upper 8 km of the main stream, and in the tributaries above US 41 (Unpublished data, Marquette Fisheries Station, Marquette). Substrate in the lower main stream and associated tributaries is typified by that in Cherry Creek which is described as mainly sand (Hendrickson et al. 1973). Cherry Creek is almost entirely groundwater fed and has a constant discharge (Hendrickson et al. 1973), whereas the upper river receives a greater proportion of surface runoff and fluctuates seasonally and during snow-melt and rain events (Zimmerman 1968).

Yearling steelhead of varying numbers and strains were stocked in the Chocolay River at three sites during 1980-92 (Table 1; Figure 1). About 10,000 Michigan-strain yearlings of parr size (93-125 mm total length) yearlings were stocked annually in the lower Chocolay River about 3 km upstream from the mouth at the M-28 highway bridge from 1980 through 1982. Just under 20,000 yearling Michigan-strain steelhead of smolt-size (175-184 mm total length) were stocked in the upper Chocolay River in 1983, 1984, and 1985 at the US 41 highway bridge about 20 km upstream from the river mouth. The Michigan-strain hatchery steelhead originated from gametes of wild steelhead collected in the Little Manistee River, a Lake Michigan tributary. Other hatchery steelhead yearlings stocked in the Chocolay River included 26,000 Skamania steelhead at the US 41 site in 1986, 20,000 Siletz steelhead in Cherry Creek in 1984, and 11,000-20,000 Skamania steelhead in Cherry Creek annually from 1987-92. The Skamania and Siletz are West Coast strains that enter tributaries during the summer months prior to spawning and are referred to as summer steelhead (Fielder 1987). Steelhead stocked during 1983-89 were marked with a fin clip to identify strain and year stocked.

The contribution of hatchery steelhead to natural reproduction in the Chocolay River was determined by assessing abundance and origin (hatchery versus wild) of adult steelhead in spawning runs, as well as estimating abundance of juvenile steelhead in sections of the stream. Steelhead spawning activity was assessed by counting adult fish and redds in a 1,700-m section on the main stream at Beckman road, and in a 1,400-m section on the East Branch at County Road 460 during 1986-92 (Figure 1). Adult fish were collected with pulsed-DC electrofishing units to determine age and hatchery or wild origin. Age was determined by counting the number of annuli on scale samples and from age-specific fin clips. Origin was based on the presence (hatchery) or absence (wild) of a fin clip. Circuli spacing before and after the first annulus on scales was qualitatively examined for additional evidence of origin for fish lacking a fin clip. Hatchery fish typically exhibit uniform circuli spacing immediately before and after the first annulus, whereas wild fish exhibit narrow spacing before the first annulus immediately followed by wide spacing (Seelbach and Whelan 1988). Juvenile populations were estimated by Petersen (Bailey modification) single-census mark-and-recapture population estimates (Ricker 1975) in 305-m long sections during late August to early September each year on the main stream at US 41 in 1983-86, at Beckman Road in 1984-92, and at County Road 460 in 1986-92 (Figure 1). Separate estimates were made for age-0 and for older juveniles. Practically all of the older juveniles were age 1 (96-98%), with the remainder being age 2. These older juveniles are referred to as age 1 in this report. Juvenile steelhead estimates were discontinued in the US 41 section after 1986 because of the lack of rocky-riffle habitat (commonly used by age-0 fish, Hartman 1965), and because the pools in this section were too deep to sample older juvenile steelhead effectively. The Beckman Road section was shallower and contained much more age-0 steelhead habitat (40-50% riffle area). More age-0 steelhead habitat was available in the County Road 460 section (60-70% riffle area). Total stream substrate area was estimated annually in each 305-m section so that density of juveniles (number per m^2) could be determined. Densities of age-0 and -1 steelhead in the Chocolay River sections were compared to density in two other Lake Superior tributaries assessed during 1982-92.

Results

The number of adult steelhead collected annually at Beckman Road and County Road 460 ranged from 6 to 26, and the number of adult steelhead observed per 100 m was consistently around 0.9 (Table 2). The number of adults collected was influenced by both water conditions and number of adults available on the days collections were made. Redd counts were probably the better method of assessing spawning activity. The number of redds counted per 100 m of stream was 0.4 in 1986, 0.6 in 1987-88, and 0.8 in 1990-92. Only a small amount (700 m) of the Beckman Road section was sampled in 1986 and this may have influenced the low number of redds and high number of adults per 100 m recorded. The origin of the spawning runs changed from 83% hatchery in 1986 to all wild fish in 1992 (Table 2, Figure 2). All hatchery fish identified in the 1986-91 spawning runs were Lake Michigan strain steelhead planted in 1983, 1984, or 1985. The hatchery steelhead sampled in 1986 were all fish that had been stocked in 1983, while most of those sampled in 1987 and 1988 had been stocked in 1984, and most or all of the hatchery fish sampled in 1989-91 were those stocked in 1985 (Figure 2). All of the non-clipped steelhead captured during 1986-92 exhibited the narrow pre-annulus and wide post-annulus circuli spacing around the first annulus typical of wild fish. Hatchery steelhead ranged in lake age from 3 to 6, and wild steelhead ranged in lake age from 1 to 5. Most steelhead spawning in these sections of the Chocolay River took place from mid-April through the first week of May during 1986-92. No fish or redds were observed prior to 15 April and no spawning activity (new redds) was noted after May.

Numbers and density of age-0 steelhead in the Chocolay River increased substantially in 1985 at both US 41 and Beckman Road, and a similar increase was noted for the age-1 steelhead in 1986 (Table 3; Figures 3 and 4). The number of age-0 steelhead at US 41 increased from 16 to 856 between 1983 and 1986, and the number at Beckman Road increased from 47 to 1,924 between 1984 and 1985. There were no population estimates at County Road 460 prior to 1986. Age-0 steelhead populations at both Beckman Road and County Road 460 have fluctuated without trend with a mean population of about 1,300 during 1986-92.

Numbers of age-1 steelhead increased 2- to 4-fold at US 41 and Beckman Road by 1986. Abundance of these older juvenile steel-head fluctuated without trend at just over 200 fish at Beckman Road during 1986-92. At County Road 460, abundance of age-1 steel-head averaged just over 100 during 1986-92.

Discussion

The Lake Michigan strain steelhead yearlings planted at the US 41 site during 1983-85 appeared to be responsible for the increased steelhead production at this site and upstream in the Chocolay River since 1985. Although a few more years of pre-stocking data would have been desirable, an additional year of low age-0 steelhead numbers at US 41 in 1982 and at Beckman Road in 1983 can be inferred from the low numbers of age-1 steelhead at the two sites in 1983 and 1984, respectively. These low numbers indicate that the steelhead stocked in 1980-82 made little or no contribution to spawning runs prior to 1985. It is also doubtful that they contributed to the 1985 spawning run because none were found in the 1986-92 spawning runs. Since hatchery steelhead stocked during 1983-85 made up a majority of adult steelhead in spawning runs sampled during 1986-88, it seems likely that they were most responsible for the increase in juvenile steelhead production. No comparable increase in steelhead natural reproduction occurred in the Little Garlic River and Chinks Creek, two Lake Superior tributaries with good wild steelhead populations (Figures 3 and 4). Age-0 and age-1 steelhead densities (number per m^2) in these two streams were much higher and increasing between 1983-84, while densities in the US 41 and Beckman Road sections of the Chocolay River were near zero. While age-0 and age-1 steelhead density was increasing many fold in the Chocolay River, density in Little Garlic River and Chinks Creek was fluctuating without trend.

In order for Lake Michigan strain hatchery steelhead to have contributed to increased production of age-0 juveniles in 1985, males and females from the 1983 plant would have to have spawned in 1985 at lake-age 2. About 11% of the adult steelhead I sampled in 1986-92 at Beckman Road and County Road 460 were lake-age 2, but none of these were hatchery fish. However, lake-age 2 steelhead made up 25% of adult steelhead sampled in the creel survey in the lower Chocolay River during 1984-87, and many of these were hatchery fish (Peck 1992). The average contribution of lake-age 2 wild steelhead to spawning populations in Lake Superior and the other Great Lakes was also 25% (Biette et al. 1981). Seelbach and Miller (1993) found that the contribution of lake-age 2 Lake Michigan strain hatchery steelhead to maiden spawning runs in a Lake Superior tributary (Huron River) was about 30-40%. Seelbach (1993) reported that the contribution of lake-age 2 maiden spawning wild steelhead in the Little Manistee River, which was the source of the Lake Michigan strain hatchery steelhead, was 44% for males and 17% for females. My sampling was apparently inadequate to detect the generally low percentage of Lake Michigan strain steelhead that spawned at lake-age 2. However, I believe that some of these lake-age 2 fish were present in the 1985 spawning run in the upper Chocolay River, and because of the low number of wild spawners, were mainly responsible for the increase in age-0 steelhead abundance in 1985.

I believe the Lake Michigan strain of steelhead stocked in 1983-85 was successful in rehabilitating the steelhead population in the upper Chocolay River because juvenile steelhead abundance prior to 1985 was below the river's carrying capacity and there was room for the reproductive contribution from these hatchery fish. This was indicated in stream surveys conducted on the Chocolay River in the early 1950s and 1970s, and by comparison with abundance in other Lake Superior tributaries. Age-0 and age-1 steelhead were found throughout the upper Chocolay River during surveys in 1951, but surveys in the 1970's indicated no age-0 fish and only a few older fish of unspecified age (Unpublished data, Marquette Fisheries Station, Marquette, MI). These surveys were qualitative, so a quantitative comparison with the population estimates from this study was not possible. Juvenile steelhead abundance in the Chocolay River in 1983 and 1984 was many times less than in other Lake Superior tributaries sampled during 1967-74 (Stauffer 1977) and in the two of these five that were sampled during 1982-92 (Figure 4). As pointed out by Seelbach (1987), hatchery steelhead survive better in streams with few steelhead, but rarely contribute substantially when introduced to streams with good numbers of steelhead. The latter case was demonstrated by two studies in a Lake Superior tributary with a good steelhead population (Huron River) where the contribution of hatchery steelhead to adult spawning runs ranged from practically nil (Wagner and Stauffer 1978) to 3% (Seelbach and Miller 1993). The contribution of hatchery steelhead in Lake Michigan tributaries was much better in streams with marginal steelhead populations than in streams with good steelhead populations (Seelbach and Whelan 1988).

I believe the steelhead population in the upper Chocolay River was restored to carrying capacity because abundance during 1986-92 was similar to wild steelhead abundance in other Great Lakes streams. Age-0 steelhead density in the Chocolay River was generally lower than in the Little Garlic River and Chinks Creek, but density of age-1 steelhead was comparable, indicating either better survival to age 1, or better habitat for age-1 steelhead in the Chocolay. Densities of age-0 and age-1 steelhead in the Chocolay River fluctuated much less from year to year than in the Little Garlic River and Chinks Creek. The greater stability of age-0 and age-1 steelhead production and the greater recruitment to age 1 in the Chocolay River was typical of steelhead populations in stable-flow streams (Seelbach 1993). Flow variation in the Chocolay River at US 41 was only 50% of that reported for the Little Garlic River (Zimmerman 1968). Densities of age-0 steelhead in the Chocolay River were greater than in a stable-flow Lake Michigan tributary (Little Manistee River), and densities of age-1 fish were comparable (Seelbach 1993). However, age-0 production in the Little Manistee was less than most other steelhead streams which Seelbach (1993) blamed on a scarcity of spawning substrate.

The successful rehabilitation of the steelhead population in the upper Chocolay River demonstrated the importance of size and stocking location of hatchery fish. Steelhead yearlings stocked in 1983-85 averaged larger than 160 mm. This was the threshold size for early smolting, early outmigration, and high survival to smolt in Lake Michigan tributaries (Seelbach 1987). Seelbach and Miller (1993) reported size-dependent survival in a Lake Superior tributary (Huron River) where larger hatchery yearlings provided a better return of adults. The yearlings stocked in the Chocolay River in 1980-82 were smaller than 160 mm, so their survival to smolt was likely much lower than those stocked in 1983-85. Even if these small yearlings survived, they were not imprinted to the upstream portion of the river that contained most of the good spawning area. Any survivors may have contributed to spawning runs in the mainly sand-bottom tributaries near the stocking site in the lower river.

The absence of summer steelhead in Chocolay River spawning runs may indicate the importance of stocking site and strain for rehabilitating steelhead populations. Summer steelhead yearlings stocked in the Chocolay River were larger than the Lake Michigan strain steelhead yearlings, so survival should have been at least as good. Adult Siletz and juvenile Skamania summer steelhead were well represented in the sport catch in the lower Chocolay during 1986-87 (Peck 1992). However, no Siletz or Skamania were found in the spring spawning assessments at Beckman Road or County Road 460 during 1986-92, nor were any found during spawning assessments for coho salmon *Oncorhynchus kisutch* at these two sites during October-November 1990-92. The stocking site for Siletz and Skamania since 1986 has been in the lower river, so these fish may have been poorly imprinted and strayed to other Great Lakes tributaries. Those that were imprinted and returned to the Chocolay apparently remained in the lower river, similar to the fate of Lake Michigan steelhead stocked in the lower river in 1980-82. However, Skamania stocked at the US 41 site in 1986 should have imprinted similar to the Lake Michigan strain stocked in 1983-85, which contributed substantially to the spawning runs. These fish should have returned to the Chocolay River by 1990. Perhaps these Skamania did not imprint well or their survival was poor. Skamania steelhead were selectively bred to return to spawn at an older age (Fielder 1987), and this extra time in Lake Superior would expose them to more sea lamprey and fishing mortality. On the other hand, summer steelhead tend to spawn during winter months on the West Coast (Fielder 1987), so the Skamania may have spawned between our fall and spring surveys. High water during the spring could have destroyed any evidence of these redds. There was no increase in juvenile steelhead abundance during 1990-92, but if the population was at carrying capacity, additional spawning by summer steelhead would produce no detectable increase in juvenile abundance.

This study demonstrated the ability of the Lake Michigan strain of steelhead to rehabilitate a depleted steelhead population in a Lake Superior tributary in a relatively short period of time. The increase in juvenile abundance that occurred between 1984-86 and subsequent stability indicated that the steelhead population in the upper Chocolay River was brought up to carrying capacity by just two years of enhanced spawning runs (1985 and 1986), produced by only two years of stocking (1983 and 1984). Fish stocked in 1985 apparently were not needed, and rehabilitation may even have been accomplished without those fish stocked in 1984. There certainly appears to be no further need for stocking hatchery steelhead in the upper Chocolay River.

Although the Lake Michigan strain of steelhead successfully rehabilitated the Chocolay River steelhead population, it may have a detrimental effect on wild steelhead populations. The Lake Michigan strain of hatchery steelhead are progeny of wild broodstock in the Little Manistee River spawning run. Chilcote et al. (1986) indicated that although adult steelhead that are hatchery-reared progeny of wild broodstocks may have higher reproductive success than progeny of cultured broodstocks, their progeny have lower survival than those produced by natural spawning of naturally produced fish. Chilcote et al. (1986) warned that stocking large numbers of hatchery progeny even from wild broodstocks could ultimately threaten the genetic integrity of the wild population and lead to a decrease in the natural productivity of the stream.

The MDNR management practice of annually stocking Lake Michigan strain steelhead yearlings into Lake Superior tributaries with wild steelhead populations should be re-evaluated. Genetically differentiated steelhead populations have become established in Lake Superior (Krueger and May 1987, Krueger et al. 1994). Rehabilitation or enhancement of steelhead populations without harming their genetic integrity may be possible, but may require strategies different from those currently in use. Seelbach and Miller (1993) suspected that the Lake Michigan strain steelhead may be inappropriate for stocking Lake Superior streams and have recommended research to evaluate the use of a local genetic stock to enhance spawning runs. Until new enhancement strategies are developed that will protect the genetic integrity of the wild populations, the most prudent use of the Lake Michigan strain hatchery steelhead would be to stock at low numbers and only in streams with below-capacity steelhead populations.

Acknowledgments

Paul Hannuksela provided much of the expertise and effort on the juvenile and adult steelhead assessments. He was ably assisted by other Marquette Fisheries Station personnel. Richard G. Schorfhaar, Wilbert C. Wagner, Philip J. Schneeberger, and Paul W. Seelbach edited the manuscript. This documentation of steelhead rehabilitation was supported by funds from the Federal Aid in Fish Restoration Act, Michigan, F-53-R, studies 419 and 461.

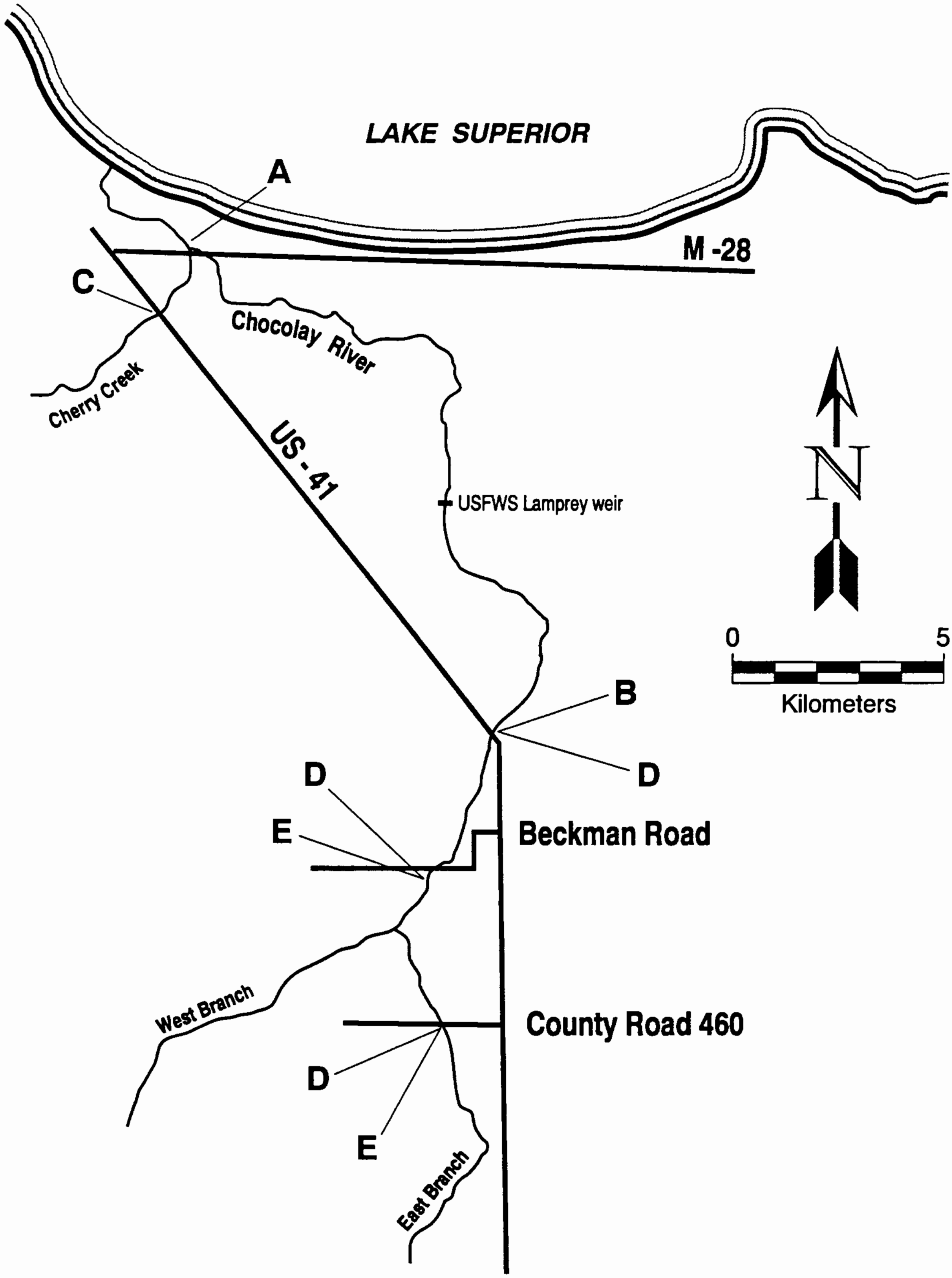


Figure 1.—Chocolay River, Marquette County, sites where yearling steelhead were stocked (Lake Michigan strain in 1980-1982 [A] and 1983-1985 [B], Siletz strain in 1984 [C], Skamania strain in 1986 [B] and 1987-1992 [C]) and where juvenile (D) and adult (E) populations were assessed.

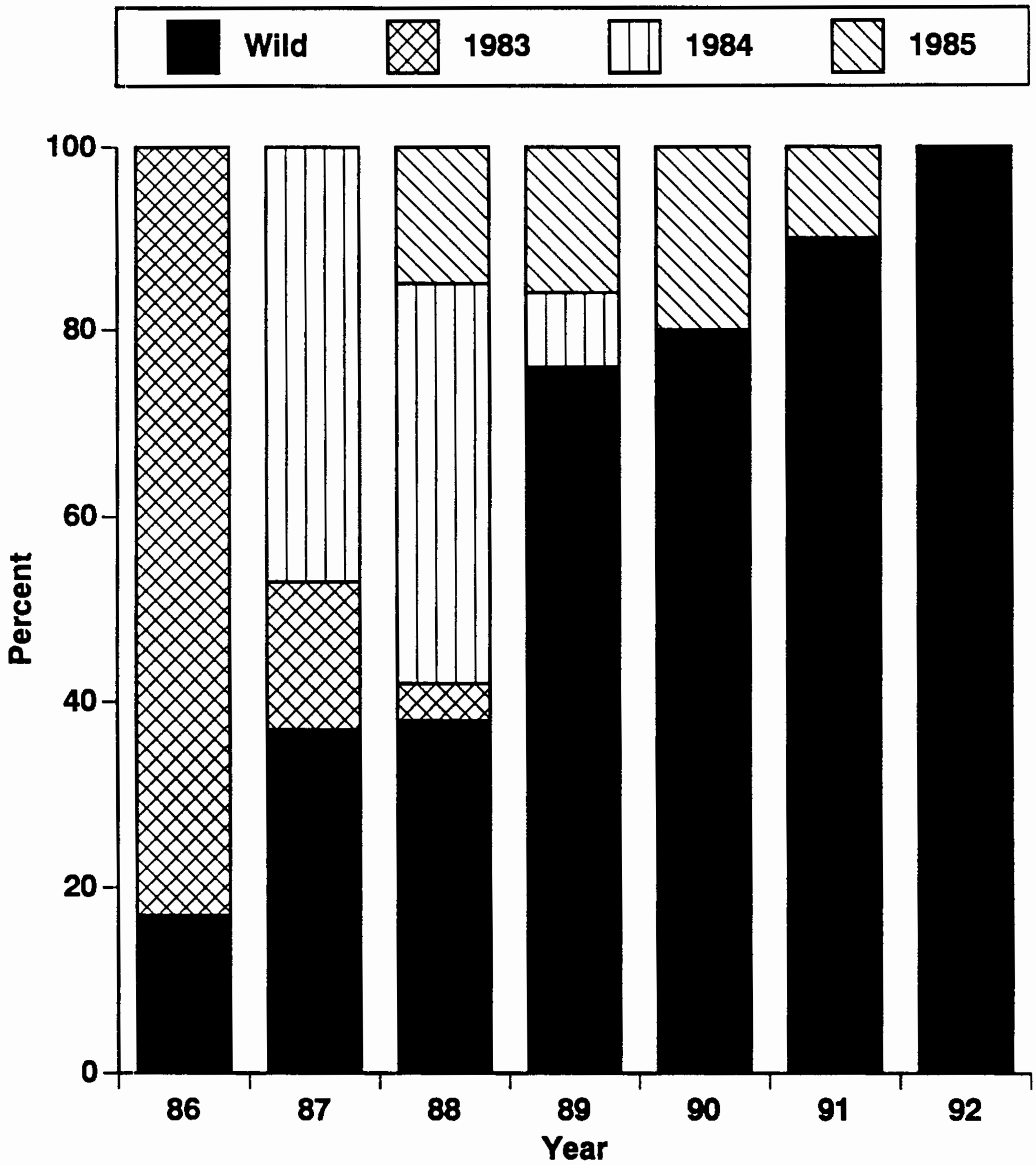


Figure 2.—Annual percentage of steelhead in the Chocolay River originating from Lake Michigan strain steelhead stocked in 1983-1985 or wild steelhead. Steelhead spawning runs were sampled at Beckman Road and County Road 460.

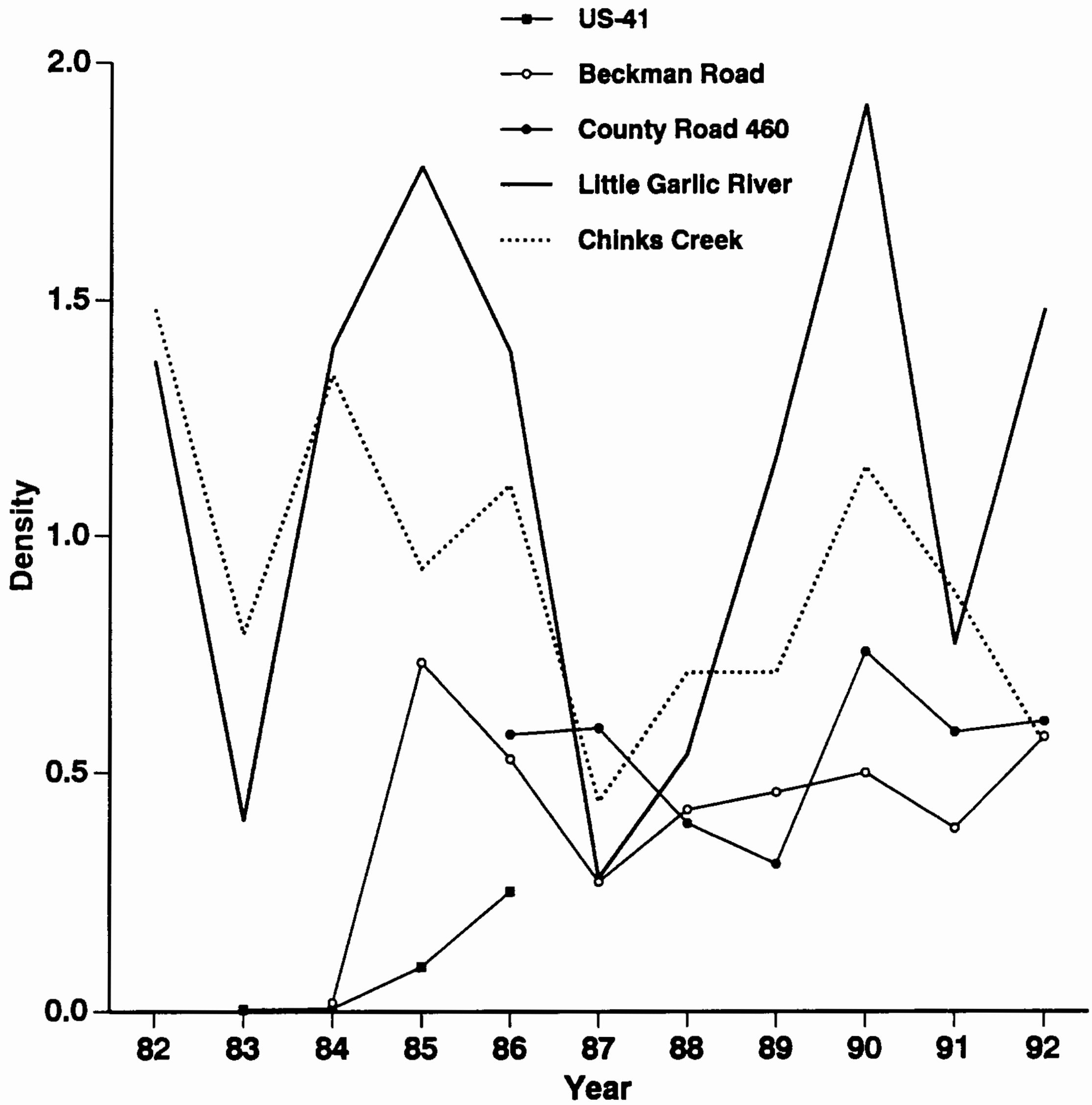


Figure 3.—Density (number/m^2) of age-0 steelhead in 305-m linear sections of Little Garlic River, Chinks Creek, and Chocolay River at US-41, Beckman Road, and County Road 460 during 1982-1992.

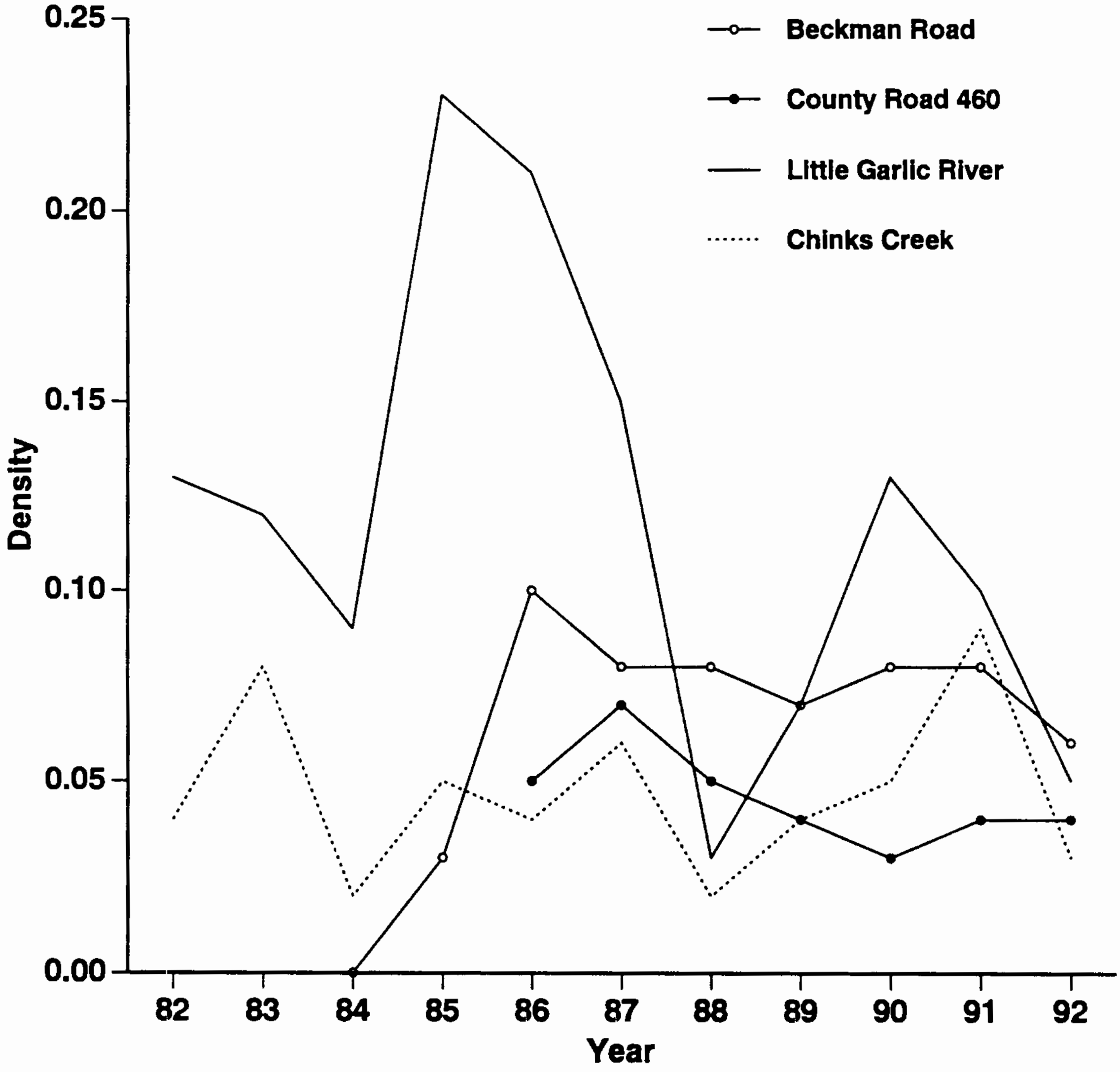


Figure 4.—Density (number/m^2) of age-1 steelhead in 305-m linear sections of Little Garlic River, Chinks Creek, and Chocolay River at Beckman Road and County Road 460 during 1982-1992.

Table 1.–Hatchery steelhead yearlings planted in Chocolay River and a tributary (Cherry Creek), Marquette County, 1980-92.

Planting site	Year	Strain	Number	Mean total length (mm)	Mark
Main stream at M-28					
	1980	L. Michigan	10,000	99	None
	1981	L. Michigan	10,000	125	None
	1982	L. Michigan	10,000	93	None
Main stream at US 41					
	1983	L. Michigan	19,400	176	Yes
	1984	L. Michigan	17,400	184	Yes
	1985	L. Michigan	19,300	175	Yes
	1986	Skamania	26,200	221	Yes
Cherry Creek at US 41					
	1984	Siletz	18,400	194	Yes
	1987	Skamania	17,100	211	Yes
	1988	Skamania	15,000	202	Yes
	1989	Skamania	15,000	198	Yes
	1990	Skamania	11,000	201	No
	1991	Skamania	18,000	200	No
	1992	Skamania	20,000	210	No

Table 2.–Visual and electrofishing assessment of steelhead spawning activity in two sections of the Chocolay River, Marquette County, Michigan, 1986-92.

				Number of adults		
Year	Stream section	Section length (m)	Number of redds (per 100 m)	Observed (per 100m)	Collected	Percent hatchery
1986	Beckman Road	700	3 (0.4)	9 (1.3)	6	83
1987	Beckman Road	1,700	7	20	14	79
	County Road 460	1,400	12	5	5	20
	Total	3,100	19 (0.6)	25 (0.8)	19	63
1988	Beckman Road	1,700	15	27	21	67
	County Road 460	1,400	4	5	5	40
	Total	3,100	19 (0.6)	32 (1.0)	26	62
1989	Beckman Road	1,700	–[a]	26	20	30
	County Road 460	1,400	–	5	5	0
	Total	3,100		31 (1.0)	25	24
1990	Beckman Road	1,700	3	13	2	50
	County Road 460	1,400	21	9	3	0
	Total	3,100	24 (0.8)	22 (0.7)	5	20
1991	Beckman Road	1,700	9	17	11	9
	County Road 460	1,400	15	15	9	11
	Total	3,100	25 (0.8)	32 (1.0)	20	10
1992	Beckman Road	1,700	10	22	11	0
	County Road 460	1,400	16	4	2	0
	Total	3,100	26 (0.8)	26 (0.8)	13	0

[a] No redd counts made in 1989.

Table 3.—Estimated[a] number (±2 SE) of naturally-produced juvenile steelhead in 305-m linear sections of the Chocolay River, 1983-92.

	Estimated number of juvenile steelhead					
	US 41		Beckman Road		County Road 460	
Year	Age-0	Age-1[b]	Age-0	Age-1[b]	Age-0	Age-1[b]
1983	16 ±16	24 ±29	–	–	–	–
1984	20 ±14	26 ±19	47 ±39	69 ±40	–	–
1985	345 ±91	24[c]	1,924 ±362	79 ±33	–	–
1986	856 ±508	159 ±55	1,499 ±539	273 ±84	1,433 ±143	113 ±14
1987	–	–	739 ±100	226 ±31	1,301 ±147	149 ±28
1988	–	–	1,164 ±136	209 ±23	963 ±84	116 ±15
1989	–	–	1,231 ±219	185 ±35	729 ±63	107 ±13
1990	–	–	1,472 ±172	221 ±42	1,475 ±87	57 ±7
1991	–	–	1,178 ±206	232 ±45	1,421 ±192	95 ±19
1992	–	–	1,657 ±211	181 ±43	1,493 ±145	89 ±22

[a] Petersen (Bailey modification) single-census mark-and-recapture population estimate.
[b] Mostly age 1 (96-98%), and the remainder age 2.
[c] Wild yearlings separated from hatchery yearlings based on percentage in recapture run, no SE determined.

References

Brown, C.J.D. 1944. Michigan streams–their lengths, distribution, and drainage areas. Michigan Department of Conservation, Institute for Fisheries Research, Miscellaneous Publication 1.

Biette, R.M., D.P. Dodge, R.L. Hassinger, and T.M. Stauffer. 1981. Life history and timing of migrations and spawning behavior of rainbow trout (*Salmo gairdneri*) population of the Great Lakes. Canadian Journal of Fisheries and Aquatic Sciences 38:1759-1771.

Chilcote, M.W., S.A. Leider, and J.J. Loch. 1986. Differential reproductive success of hatchery and wild summer-run steelhead under natural conditions. Transactions of the American Fisheries Society 115:726-735.

Dahl, F.H., and R.B. McDonald. 1980. Effects of control of the sea lamprey (*Petromyzon marinus*) on migratory and resident fish populations. Canadian Journal of Fisheries and Aquatic Sciences 37:1886-1894.

Fielder, D.G. 1987. An assessment of the introduction of summer steelhead into Michigan. Michigan Department of Natural Resources, Fisheries Research Report 1948, Ann Arbor.

Hansen, M.J., and T.M. Stauffer. 1971. Comparative recovery to the creel, movement and growth of rainbow trout stocked in the Great Lakes. Transactions of the American Fisheries Society 100:336-349.

Hartman, G.F. 1965. The role of behavior in the ecology and interaction of under-yearling coho salmon (*Oncorhynchus kisutch*) and steelhead trout (*Salmo gairdneri*). Journal of the Fisheries Research Board of Canada 22:1035-1081.

Hendrickson, G.E., R.L. Knutilla, and C.J. Doonan. 1973. Hydrology and recreation on the cold-water rivers of Michigan's Upper Peninsula. U.S. Geological Survey, Water Information Series Report 4, Okemos, Michigan.

Krueger, C.C., and B. May. 1987. Genetic comparison of naturalized rainbow trout populations among Lake Superior tributaries: differentiation based on allozyme data. Transactions of the American Fisheries Society 116:795-806.

Krueger, C.C., D.L. Perkins, R.J. Everett, D.R. Schreiner, and B. May. 1994. Genetic variation in naturalized rainbow trout (*Oncorhynchus mykiss*) from Minnesota tributaries to Lake Superior. Journal of Great Lakes Research 20:299-316.

McLain, A.L. 1957. The control of upstream movement of fish with pulsated direct current. Transactions of the American Fisheries Society 86:269-284.

Peck, J.W. 1992. The sport fishery and contribution of hatchery trout and salmon in Lake Superior and tributaries at Marquette, Michigan, 1984-1987. Michigan Department of Natural Resources, Fisheries Research Report 1975, Ann Arbor.

Ricker, W.E. 1975. Computation and interpretation of biological statistics of fish populations. Fisheries Research Board of Canada, Bulletin 191, Ottawa.

Seelbach, P.W. 1987. Smolting success of hatchery-raised steelhead planted in a Michigan tributary of Lake Michigan. North American Journal of Fisheries Management 7:223-231.

Seelbach, P.W. 1993. Population biology of steelhead in a stable-flow, low-gradient tributary of Lake Michigan. Transactions of the American Fisheries Society 122:179-198.

Seelbach, P.W., and B.R. Miller 1993. Dynamics in Lake Superior of hatchery and wild steelhead emigrating from the Huron River, Michigan. Michigan Department of Natural Resources, Fisheries Research Report 1993, Ann Arbor.

Seelbach, P.W., and G.E. Whelan. 1988. Identification and contribution of wild and hatchery steelhead stocks in Lake Michigan tributaries. Michigan Department of Natural Resources, Fisheries Research Report 1950, Ann Arbor.

Smith, B.R., and J.J. Tibbles. 1980. Sea lamprey (*Petromyzon marinus*) in Lakes Huron, Michigan, and Superior: history of invasion and control, 1936-1978. Canadian Journal of Fisheries and Aquatic Sciences 37:1780-1801.

Stauffer, T.M. 1977. Numbers of juvenile salmonids produced in five Lake Superior tributaries and the effect of juvenile coho salmon on their numbers and growth, 1967-1974. Michigan Department of Natural Resources, Fisheries Research Report 1846, Ann Arbor.

Wagner, W.C., and T.M. Stauffer. 1978. Survival of rainbow trout stocked in a Lake Superior tributary, 1971-1973. Michigan Department of Natural Resources, Fisheries Research Report 1859, Ann Arbor.

Zimmerman, J.W. 1968. Water quality of streams tributary to lakes Superior and Michigan. U.S. Fish and Wildlife Service, Special Scientific Report- Fisheries 559, Washington, D.C.

Report approved by Paul W. Seelbach
James S. Diana, Editor
Paul W. Seelbach, Editorial Board Reviewer
Alan D. Sutton, Graphics
Kathryn L. Champagne, DTP