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FISHERIES DIVISION

TECHNICAL REPORT

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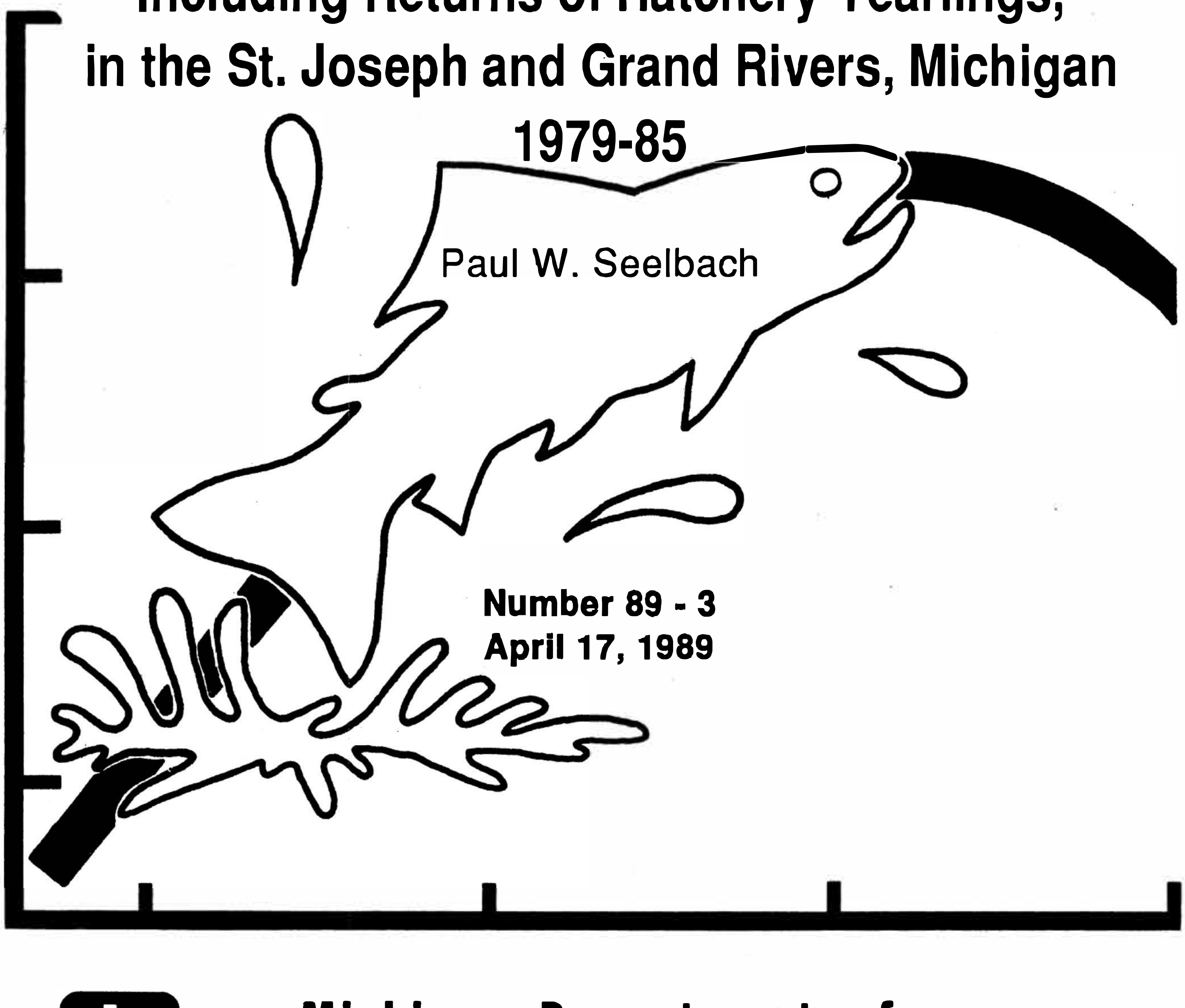

Paul W. Seelbach

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CHARACTERISTICS OF ADULT STEELHEAD POPULATIONS, INCLUDING RETURNS OF HATCHERY YEARLINGS, IN THE ST. JOSEPH AND GRAND RIVERS, MICHIGAN 1979–85[1]

Paul W. Seelbach

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[1]Contribution from Dingell-Johnson Project F-35-R, Michigan.

ABSTRACT

Adult steelhead *Oncorhynchus mykiss* (formerly *Salmo gairdneri*) populations returning to the St. Joseph and Grand rivers were monitored from 1979 to 1985. These populations were fairly large; minimum estimates of abundance averaged approximately 4,000 and 14,000 fish for the two respective rivers. Both populations were similar to the Little Manistee River steelhead population, the parent stock of Michigan's hatchery fish, in terms of lake-age structure (although more age-.4 and age-.5 fish were found in the study populations), percent repeat spawners, length at lake age, length-weight relationship, and sex ratio. The similarities in lake growth parameters indicated fish from all three populations had experienced similar growth regimes while in Lake Michigan. Hatchery-raised yearling parr were marked and stocked in the study rivers during 1979–81. These made up only 26% and 5% of the adults returning from the 1979–82 smolt year classes in the two respective rivers. Nearly all of the remaining fish were unmarked. Percent survival for the hatchery parr was low; minimum estimates were 2%–7% for the St. Joseph River and <1%–2% for the Grand River. Approximately 53% of those fish which returned had spent an additional year or two in the river following stocking, indicating percent smolting at age 1 was quite poor. This analysis showed that past releases of yearling parr have not been the main source of adult steelhead populations returning to the study rivers. The contributions of wild fish and strays from distant sources need to be determined in order to optimally manage the fishery.

INTRODUCTION

The St. Joseph and Grand rivers are large warmwater rivers located in the southwestern portion of Michigan's Lower Peninsula. These rivers had negligible to no steelhead *Oncorhynchus mykiss* (formerly *Salmo gairdneri*) fisheries prior to the 1970s, but following improvements in water quality in the 1970s and the stocking of hatchery-raised fish by the Michigan Department of Natural Resources (MDNR) in 1969, significant steelhead fisheries have developed in both. These fisheries have been erratic; however, in their better years they have ranked among the most attractive in the state, due to large numbers of fish and the rivers' close proximity to large population centers in Michigan, Indiana, and Illinois. The erratic nature of the fisheries on both rivers eventually led to questions concerning the contributions being made by Michigan's hatchery fish and how stocking could be better managed to produce consistently good steelhead fishing.

To examine the contribution of hatchery fish, yearling parr (the primary age group stocked in Michigan) were marked and stocked by the MDNR during 1979–81. From 1979 to 1985 a variety of information on returning adult steelhead populations was collected by MDNR biologists, including creel census data on the major fisheries which occurred below and at the first dam on each river and data on fish which ascended fish ladders located at these dams. The objective of this report is to summarize the characteristics of the steelhead populations and the returns of hatchery yearling parr for these two rivers during 1979–85.

Study rivers

The St. Joseph and Grand rivers are generally characterized by low-to-moderate drought flow levels, low-to-moderate flow stability (Velz and Gannon 1960), and high-summer water temperatures (Anonymous 1968). These rivers are influenced primarily by surface runoff, as they generally lie above relatively impervious soil and rock types which produce little groundwater, and because of the heavy use of existing groundwater by the concentrated population centers which have developed along the rivers' banks (Veatch 1933; Anonymous 1968; Ball et al. 1973). Both rivers contain a variety of substrate types—gravel and cobble being common in flowing water portions, and sand and silt in the slower sections. Resident fish communities are characterized by smallmouth bass *Micropterus dolomieui*, rock bass *Ambloplites rupestris*, walleye *Stizostedion vitreum*, northern pike *Esox lucius*, and a variety of abundant catostomids, cyprinids, and ictalurids. Anadromous salmonids, notably steelhead, provide seasonal fisheries in the downstream reaches. Land in the drainage basins of these rivers is primarily used for intensive agriculture and concentrated municipal-industrial complexes. On both rivers water quality was seriously degraded by agricultural and industrial development; however, significant improvements occurred following the passage of clean water legislation in the late 1960s. Local water quality problems still exist below some major municipal-industrial complexes. Numerous dams have been built along the rivers which have created impoundments and blocked fish movements.

The St. Joseph River begins in Michigan near Hillsdale, winds southwest into Indiana through Elkhart and South Bend, flows northwest back into Michigan through Niles, and enters Lake Michigan near St. Joseph (Figure 1). The river has 306 miles of mainstream and drains an area of 4,285 square miles (Brown 1944). At Niles, width is 200–300 feet and depth ranges from 3 to 18 feet. Discharge at Niles averages 3,044 cfs and ranges from 400 to 19,400 cfs (Knutilla 1970). A number of tributaries enter the lower St. Joseph River, some of which are cold-water streams that support resident trout populations. There are three dams on the Michigan portion of the lower river, the first one located at Berrien Springs, approximately 23 miles upstream from the river mouth. Fish passage is available at the Berrien Springs dam and is planned for the Buchanan and Niles dams (Figure 1).

The Grand River begins near Jackson, flows north through Lansing, then west through Grand Rapids, entering Lake Michigan at Grand Haven (Figure 1). The Grand River has 478 miles of mainstream and drains 5,544 square miles, the second largest drainage basin in Michigan (Brown 1944). At Grand Rapids, the river is 200–300 feet wide and 1 to 7 feet deep. Discharge averages 3,353 cfs and ranges from 380 to 54,000 cfs (Knutilla 1970). Most tributaries to the river are sizable warmwater streams, however, several are coolwater streams, marginal for trout. The mainstream of the Grand River has eight dams, the first one being located at Grand Rapids, approximately 40 miles upstream from the river mouth. The most downstream six dams have fish ladders in operation (Figure 1). Several of the larger tributaries also have dams which block fish movements.

METHODS

Yearling steelhead were raised at the MDNR's Platte River State Fish Hatchery, marked with a fin clip distinct for each year, and stocked in the St. Joseph and Grand rivers during 1979–81. The St. Joseph received 30,000 fish per year and the Grand, 55,000 fish per year, numbers typical of releases in these rivers. All steelhead stocked by Michigan during 1970–84 were Michigan strain fish; these are the first-generation offspring of wild adults collected in the Little Manistee River, a tributary to central Lake Michigan.

Returning adult populations were monitored by estimating catch just below the first dam which was a barrier to fish migration on each river (Grand River catch estimates also included the catch in the Rogue River, a tributary above Grand Rapids) and by estimating the numbers of fish passing these dams via fish ladders. Random creel surveys were typically run at the dam in Berrien Springs and in an area 7 miles downstream on the St. Joseph River during fall

(September-December) and spring (March-April), and at the 6th St. dam in Grand Rapids on the Grand River, and on the Rogue River from the Rockford dam downstream to the mouth, during fall (September-November) and spring (March-April). Estimates or counts of fish moving through the ladders were also made during fall and spring census periods. Returns of fin-clipped hatchery steelhead were expected primarily from fall 1979 through spring 1985 and monitoring of adult populations was carried out through this period by MDNR personnel, with the exception of fall 1982 through spring 1985 on the Grand River, which was monitored as a part of Ryckman's (1986) study of fish ladders. Catch and ladder counts which were estimated based on creel census and actual counts are listed in Appendix 1. Monitoring was not entirely consistent through this period, however, and in many seasons either no data or incomplete data were collected (Table 1). Catch and ladder counts were estimated for these seasons based on relationships developed from existing data; for example, missing spring data were estimated from the previous fall's data and a fall-spring ratio developed from existing data from other years. Estimates of the total catch at or just below each dam and of the number of fish which passed each dam via the fish ladders were used as minimum estimates of adult returns and as an index of abundance each season. These estimates were low during the springs of 1983 and 1985 due to high water conditions which made both angling and counting difficult. Fish which entered the river in the fall were considered a part of the subsequent spring's spawning population.

Biological data were collected on the two rivers during creel surveys and at the fish ladders during 1980–85; scale samples were taken, and sex, total length (in inches), weight (in pounds), and fin clips recorded. Similar to the above, no data were collected during some seasons (Table 1). The number of fish sampled per season for length and fin clip averaged 442 on the St. Joseph River and 129 on the Grand River. A portion of these were also sampled for weight. Scale samples and sex data were only available from 413 fish sampled during 1982–85 for the St. Joseph River and from 135 fish sampled during 1981 and 1983 from the Grand River. The following analyses of biological data were performed for each river, except where noted otherwise.

Percent age structure (percent of the total population made up by each lake-age group) was determined for each season using total length data and a length-age key developed from scale samples. Length-age relationships were identical between the two study rivers and among several years during this period (see Results). Accordingly, all samples were pooled and used to formulate the length-age key. Age was recorded as "stream age.lake age", for example, age 2.2; however, where stream age was irrelevant, this fish was designated age .2 (Seelbach and Beyerle 1984). Fish which returned during the fall were considered part of the following spring's spawning cohort and were assigned an additional annulus. An overall age structure for each spawning season was calculated by combining data from one fall and the following spring.

An estimate of the percentage of repeat spawners was determined by examining the scales of fish from each lake age. Only clearly visible spawning checks were recorded.

A minimum estimate of adult returns for each age group was calculated each season by multiplying the minimum estimated total number returning by the percent age structure for each age group. Percent age structure by smolt year class was determined by examining numbers returning in successive lake-age groups .1–.4.

Mean total lengths were calculated for each age group for each season and spawning year, and for each sex and for maiden- and repeat-spawning fish (all data combined). A length-weight regression was calculated for each river (all data combined) using the formula $W = aL^b$, where W denotes weight and L, length. Sex ratios were calculated for each age group (all data combined).

The proportions of the population made up by various fin-clip groups were determined for each age group for each season, spawning year, and smolt year class. The total number of Michigan yearlings which returned from each release was estimated by first calculating the minimum estimated total number of each fin-clip group returning for each age group and season, and then summing the appropriate numbers over successive lake-age groups .1–.4.

Catch estimates from the Michigan Sport Fishing Survey (Michigan Department of Natural Resources, 1969–81, Lansing), an annual statewide mail survey, were used as indicators of abundance during 1969–81.

RESULTS AND DISCUSSION

Abundance

Since the initial stocking of hatchery fish in 1969, numbers of adult steelhead in the St. Joseph and Grand rivers have increased from negligible levels in the early 1970s to levels which have supported significant, though erratic, fisheries since the mid- to late-70s (Figures 2 and 3). Numbers in the St. Joseph River increased gradually during the 1970s and have averaged approximately 4,400 fish per year during 1980–85 (a minimum estimate from this study). Numbers of adult steelhead returning to the Grand River increased to a peak of approximately 34,000 fish per year during 1979–80 and then decreased sharply to average approximately 8,700 fish per year by 1982–85 (minimum estimates from this study). Population abundance in these rivers was comparable to that for some of Michigan's well-known steelhead rivers tributary to central and northern Lake Michigan. Weir counts (minimum estimates of the total run) on the Little Manistee River have ranged from 5,800 to 19,800 during 1971–86 (Seelbach 1986). From these figures, it can be reasoned that an annual run of 10,000–20,000 steelhead would provide an excellent fishery in a river the size of these northern rivers. The St. Joseph and Grand rivers are much larger; however, based on the historical evidence, it appears that 10,000–20,000 fish also create excellent fisheries on these rivers.

Adult steelhead were present in similar numbers in both fall and spring in both rivers. For years when both fall and spring data were available, fall returns averaged 64%±10% of the yearly total on the St. Joseph River and 41%±5% of the total on the Grand River. Fall returns have been found to make up only 5% to 30% of the yearly total on some other Michigan rivers, however, in some (for example the Little Manistee River) many fall migrants remained in river mouth lakes and were thus not included in the fall counts (Seelbach 1986).

For years when both ladder and catch estimates were available, catch made up 89%±16% and 71%±18% of the yearly returns for the two respective rivers.

Age structure

For the St. Joseph River, age structure of the adult steelhead population during the spawning years 1980–85 averaged 6% age .1, 33% age .2, 43% age .3, 18% age .4, and 1% age .5 (Table 2). Age structure analyzed by smolt year class was fairly similar to this (Table 2), indicating no major, consistent changes in year-class strength during this period. For the Grand River, age structure of the adult population analyzed by smolt year class was similar to that analyzed by year, and this averaged (similar to the St. Joseph River) 9% age .1, 28% age .2, 41% age .3, 21% age .4, and 2% age .5 (Table 3). Age structures for these populations were quite similar to that reported for the population of the Little Manistee River, a tributary of central Lake Michigan, which was 5% age .1, 24% age .2, 58% age .3, and 13% age .4 (Seelbach 1986). The study populations differed in that they had a higher percentage of age-.4 and age-.5 fish. This could have been a reflection of some component of the population having a later mean age at return; for example, the Skamania strain, which is stocked by Indiana and which comprised a portion at least of the St. Joseph River run, has a mean age of return of age .4. Alternatively, as most age-.4 and age-.5 fish were repeat spawners (see below), the higher percentages of older fish could have been due to a higher survival to repeat spawning for these populations.

For years when fall and spring data were available, age structures of fall and spring populations were similar (Table 4). In the Little Manistee River, fall populations had more age-.1 and fewer age-.4 fish than spring populations, however, it was possible that this was a result of differences in seasonal migration patterns (involving Manistee Lake, as described above) which biased the fall samples.

Years spent in the stream (or hatchery), as inferred from adult scales, varied between the two rivers, with the St. Joseph having 71% age-1. and 29% age-2. fish, and the Grand having nearly the inverse, 26% age-1. and 74% age-2. fish. Most wild Great Lakes populations have over 80% age-2. fish, with the population of the Little Manistee having a stream age structure of 27% age-1. and 73% age-2. (Seelbach 1986). The St. Joseph River population thus appeared to have a large component which had come from hatchery-yearling smolts, while interestingly, the Grand River population appeared more influenced by either wild fish, or hatchery parr or fall fingerlings which had lived in the river until age 2.

Information on percent repeat spawners was available only from the St. Joseph River, where 12% of age-.2 fish, 17% of age-.3 fish, 65% of age-.4 fish, and 100% of age-.5 fish were found to have spawned previously (Table 5). These figures were similar to those from the Little Manistee River population, where 6% of age-.2 fish, 18% of age-.3 fish, and 48% of age-.4 fish were repeat spawners (Seelbach 1986). Survival to repeat spawning could not be calculated, as insufficient annual data were available, so no conclusions could be reached as to whether this contributed to the high percentage of older fish found in the study rivers.

The maiden percent-age structure for the St. Joseph River, analyzed by smolt year class was 4%, 40%, 45%, 11%, and 0%, for ages .1, .2, .3, .4, and .5, respectively. This differed slightly from that of the overall population, having fewer older fish. Maiden percent-age structure was fairly similar to that of the Little Manistee River population which was 5%, 27%, 58%, 10%, and 0% for the five respective age groups (Seelbach 1986).

Length

Mean lengths at age were not significantly different between the two study rivers or between maiden and repeat spawners (Table 6). Some significant differences were found between fall and spring fish, between fish of stream ages 1. and 2., and between males and females (Table 6). The same results were found for the Little Manistee population—length at age was slightly affected by stream age, season, and sex, but not by repeat spawning (Seelbach 1986, unpublished data).

Lengths for the predominant age-.2 and age-.3 groups remained quite constant throughout 1980–85 (Figure 4). Similarly, length at age remained constant on the Little Manistee River during 1979–85 (Seelbach 1986) and mean steelhead length in Wisconsin waters was consistent during 1969–84 (Hansen 1986). Data from the study rivers lend additional support to Hansen's (1986) conclusion that steelhead numbers in Lake Michigan have reached some stable equilibrium point as indexed by growth.

Using all the data pooled, mean lengths at age for the study rivers for this period are shown in Figure 5. These are quite similar to mean lengths at age for the Little Manistee River during 1981–85 (Figure 5).

Length-weight relationships calculated for the two rivers were not significantly different (Table 7). These also were not significantly different from a length-weight relationship calculated for the Little Manistee River population (Table 7) (Seelbach, unpublished data). Interestingly, all growth parameters examined were very similar between the two southern study rivers and the more northern Little Manistee River, indicating that fish from both regions had experienced strikingly similar growth regimes in Lake Michigan.

Sex ratio

Using all the data pooled, the sex ratios (male:female) for age-.2, age-.3, and age-.4 fish averaged 1:1.85, 1:1.63, and 1:1.57, respectively. Most Great Lakes steelhead populations have likewise been found to have a female dominated sex ratio (Biette et al. 1981; Seelbach 1986).

Population proportions of fin-clip groups

Unclipped fish made up the bulk of the steelhead populations returning from the 1979–82 smolt year classes in both the St. Joseph and Grand rivers: 65% ± 5% and 94% ± 13% of the total populations in the two respective rivers. Unclipped fish could have been hatchery fall fingerlings, naturally produced fish, or strays from distant sources. Returns from stocked hatchery yearlings contributed only 26% ± 2% and 5% ± 1%, respectively. Fin-clipped fish which had strayed from Indiana and Wisconsin (many of these were Skamania strain fish) made up 4% ± 0% and 2% ± 1% for the two respective rivers. Of these, approximately 27% were from Indiana. Fish with miscellaneous clips made up 6% ± 1% and 0% of the two respective populations. Only a portion of the steelhead stocked in Indiana and Wisconsin during 1979–82, 51.0% and 0.1%, respectively, were fin clipped (Great Lakes Fishery Commission, 1979–82, Annual Reports, Ann Arbor). Thus, the actual proportions of stray fish present were somewhat higher than those found for fin-clipped fish. It is difficult to extrapolate using the above numbers and determine the actual number of strays present in the study rivers due to our lack of understanding of the differential survival rates, movement patterns, and quality of fin clips for various groups of stocked fish. In the Little Manistee River during 1980–85, unclipped fish made up 98% of the population, and at least 70% of the population was shown to be naturally produced (Seelbach 1986).

Returns of hatchery yearlings

Returns of hatchery yearlings to the St. Joseph River ranged from 2% to 7%, while returns to the Grand River ranged from <1% to 2% (Table 8). The better returns to the St. Joseph River could have been due to a number of factors, including: a shorter distance for smolts to migrate to the lake, which might lessen predation on these by river resident fish; or some other aspects of riverine living conditions which were better (possibly cooler water temperatures or fewer predators). Also, fish from both rivers were marked with the same fin clip each year, so the higher return rates to the St. Joseph River could have been a reflection of preferential straying into this river. On both rivers a substantial portion (the mean for six estimates was 53%) of the returns came from fish which had not smolted until ages 2 or 3 (Table 8), suggesting that percent smolting at age 1 was actually quite poor (this is in line with the small size at stocking of these fish—see below). In fact, given their size at stocking, returns from age-1. fish were surprisingly good, suggesting that perhaps the early warming of water temperatures which occurs in southern Michigan rivers allowed for significant growth to occur between stocking and smolting, allowing some fish to grow to smolt size. In contrast, large smolt-size yearlings (200 mm) which were stocked in the Little Manistee River in 1983 showed a 16+% return to the river and over 99% of the returns were from age-1. fish (Seelbach, unpublished data).

The mean percent-age structure of the returning hatchery fish, analyzed by smolt year class, was 4% age .1, 32% age .2, 51% age .3, and 12% age .4. This was quite similar to that for the overall population (Table 2). These fish were the offspring of wild fish from the Little Manistee River and, taking into account that the above hatchery age structure was not adjusted for repeat spawners, it was quite similar to that of the Little Manistee population.

Nearly equal numbers of hatchery yearlings returned in the fall and spring (53% and 47%, respectively). The parents of these fish were all collected in the spring, however, which implies either: (1) that fall- and spring-run groups are all part of one large stock which shows two peaks in migration timing or (2) that the early spring time of parent collection is a time of overlap of the spawning periods of a fall-winter run stock and a spring-run stock and some of each were collected. Skamania steelhead were more prevalent in the fall (69% of returns were in the fall), reflecting their summer-fall migratory patterns.

Abundance relative to stocking densities

The stocking histories of yearling and fall fingerling steelhead and the available data on numbers of returning adults in the St. Joseph and Grand rivers for the period 1969–85 are given in Figures 2 and 3. Data on numbers of returning adults must be viewed with caution, as: (1) the mail survey estimates for each river were based on small sample sizes; (2) the mail survey estimates are believed to be biased high and thus are not strictly comparable with those provided by this study (J. R. Ryckman, personal communication, 1988, MDNR, Ann Arbor); (3) catch and ladder estimates in some years were estimates based on partial data; and (4) catch and ladder estimates in some years were reduced due to high water conditions. Use of these data for interpretation of the relationships between adult abundance and previous stockings is therefore tenuous. Several noteworthy points, however, can be drawn from Figures 2 and 3. As mentioned above, adult abundance in both rivers rose from zero to substantial levels with the initiation of stockings during the 1970s. On the St. Joseph River, the stocking of large numbers of fall fingerlings during 1978–81 did not produce a noticeable increase in adult abundance (the lag between fall fingerling stocking and adult returns is 4–6 years). On the Grand River, both data sets showed a peak in adult abundance in 1980; this appeared closely related to a large stocking of fall fingerlings made in 1974 in conjunction with rotenone (a fish toxicant) treatment of the Rogue River.

No published information is presently available on the survival of steelhead parr stocked in warmwater rivers. Most studies of survival for stocked steelhead have been in cold-water rivers and these have shown that survival is related to size at stocking (Chrisp and Bjornn 1978; Seelbach 1987). Within a cohort, fish which reach the minimum size of approximately 150–160 mm in 1 year will smolt, while the smaller fish will remain in the river for an additional year or more. In the ideal cold-water program, the river should provide a homing imprint and then serve as access to the lake for smolts. Fish which do not smolt and remain for a long time in the river face competition with wild trout and are typically subjected to high mortalities. Most of the small yearlings and fall fingerlings which were stocked in the St. Joseph and Grand rivers would likely not have smolted immediately and would have remained in the river until at least age 2. These would not have encountered competition from wild trout, but would have faced potentially high mortalities due to predation by, and competition with, abundant warmwater fishes, and warm summer temperatures. Based on this line of reasoning, adult abundance would not be expected to relate well to stocking densities. In addition to returns from stocked fish, adult populations could have contained fish which were produced naturally in the study rivers or fish which had strayed in from distant sources. No information is available on the extent of natural reproduction in the study rivers or their tributaries. The contribution of strays is not well understood, although the results of this study show significant contributions of both Indiana- and Wisconsin-stocked fish, in particular to the St. Joseph River. Indeed, the contribution of Indiana fish alone could have caused the river populations to increase during the late 1970s, as mean annual steelhead stockings in this nearby state rose from 31,000 in 1969–74 to 144,000 in 1975–80 (Great Lakes Fishery Commission, 1975–1980, Annual Report, Ann Arbor; D. Brazo, personal communication, 1988, Indiana Department of Natural Resources, Michigan City). The above line of reasoning may also explain the apparent relationship between the 1974 rotenone treatment and stocking of fall fingerlings in the Rogue River and the large 1979–80 peak in adult abundance in the Grand River. The Rogue River has water temperatures which are adequate for trout habitation. The rotenone treatment removed all predators and competitors, allowing the stocked fingerlings to rear to age-2 smolts under good growing conditions (this treatment/stocking was repeated in 1984 and electrofishing surveys in spring 1985 showed that most fish had not reached smolt size by age 1).

Assumptions

The cohort analyses in this study involved the assumption that the sport catch below the first dam, plus the number of fish which ascended the fish ladder at this dam, were related to the population abundance of steelhead in a given river. No actual estimates of population abundance were made.

Management and research implications

This report provides a description of the characteristics of the steelhead populations of the St. Joseph and Grand rivers during 1979–85, and information on the contributions which the stocking of yearling parr has made to these populations. It appears that yearling releases have not been the main source of adults returning to these rivers and, in the case of the Grand River, have not even contributed significantly. Numerous questions remain. For example: What does natural reproduction contribute in each river system? What do stray fish from distant sources contribute? What do releases of fall fingerlings contribute? (The same factors which limit the in-river survival of yearling parr would limit the in-river survival of fall fingerlings, suggesting that these do not contribute a great deal.) What would releases of larger, smolt-size yearlings contribute? Is there preferential straying from one river to the other, and if so, how much? These questions will need to be specifically addressed before management of steelhead in these rivers can be optimized.

Comments on loosely organized studies

This report is a compilation of information collected over a series of years by a variety of persons without centralized responsibility for project definition, data analyses, or report preparation. The results of this loose organization included lost opportunities (for instance much could have been learned by marking the fall fingerlings which were stocked) and a patchy data set (see Table 1). This data set has provided a fair picture of many aspects of steelhead biology in the study rivers; however, a more complete set would have yielded a much more definitive population analysis. If reliable, accurate answers to specific questions are desired, a well-designed, tightly monitored research effort is essential.

ACKNOWLEDGMENTS

Data were collected by numerous MDNR District 9 and 12 fisheries personnel under the supervision of J. T. Trimberger and D. C. Johnson, respectively. J. Clevinger, Sr. monitored both creel and ladder activities on the St. Joseph River during most of the study period. Creel survey data were analyzed by J. R. Ryckman, A. D. Sutton, and R. N. Lockwood. J. R. Ryckman provided thoughtful discussion throughout the project. J. E. Duffy, D. C. Johnson, W. C. Latta, R. P. O'Neal, J. R. Ryckman, and J. T. Trimberger reviewed the manuscript.

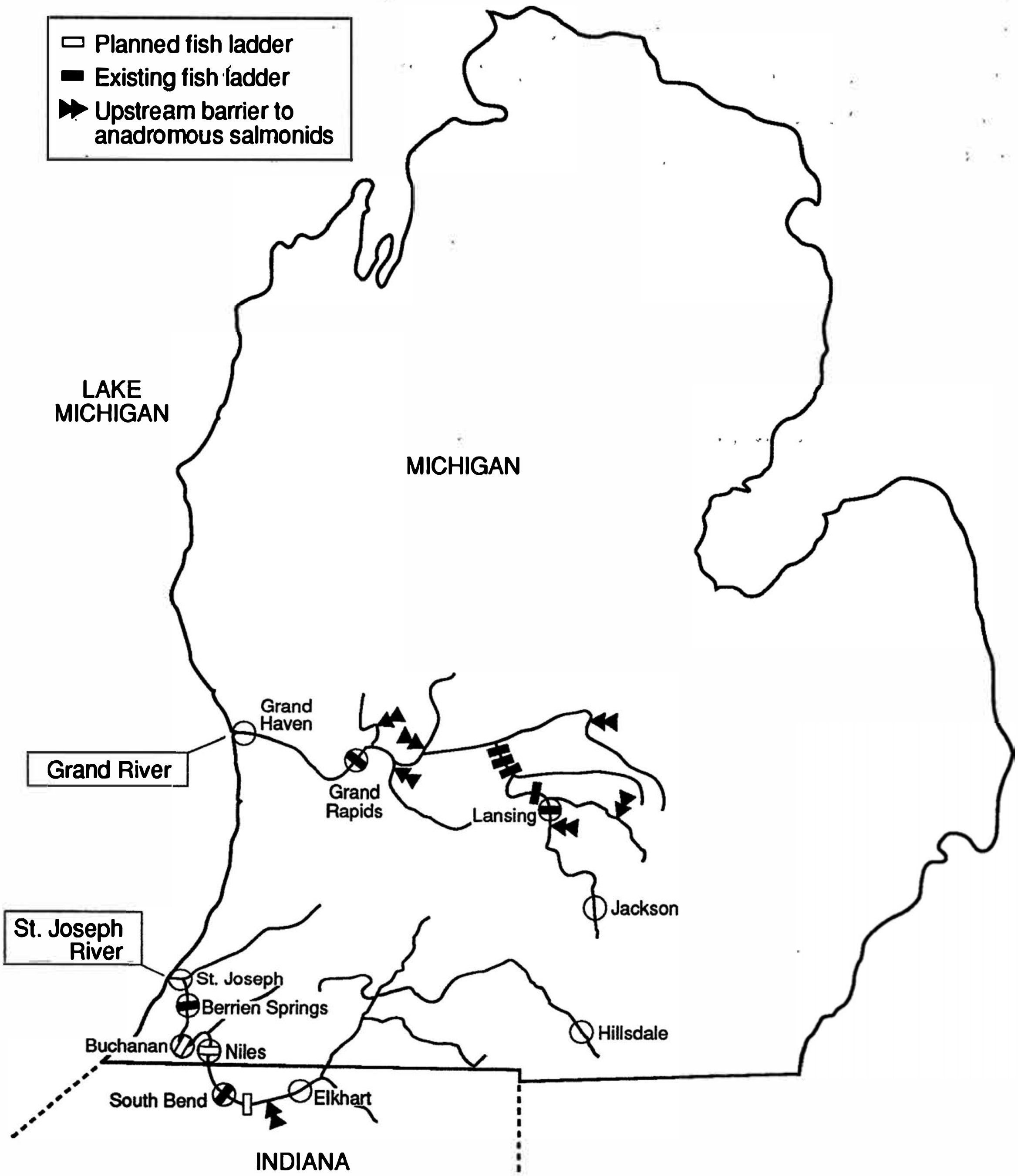

Figure 1. Map of the St. Joseph and Grand rivers, showing major cities, major tributaries, fish ladders (planned and existing), and the upstream barrier to the migration of anadromous salmonids.

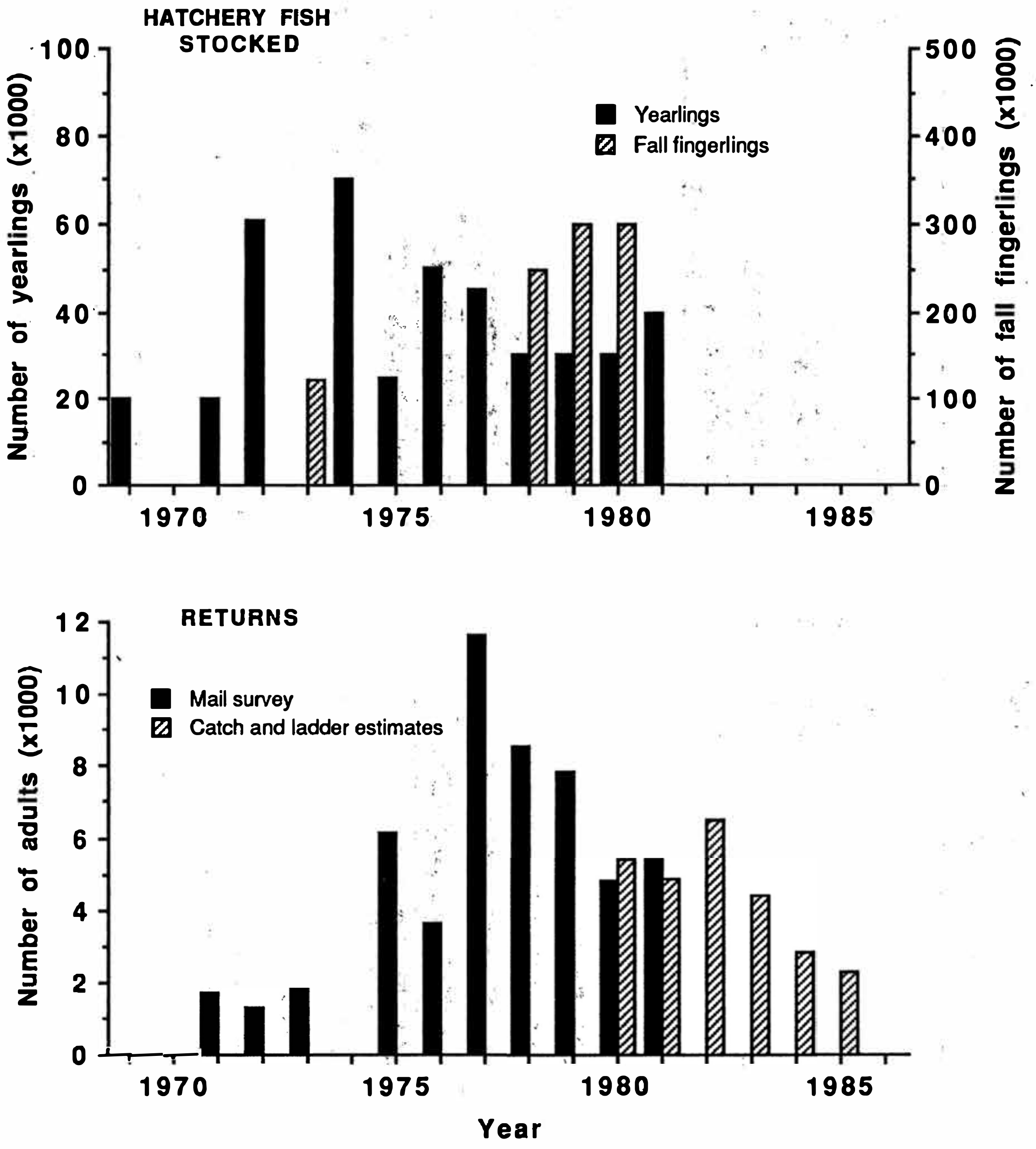

Figure 2. Stocking rates 1969–81 and returns 1969–85 for steelhead in the St. Joseph River. Returns were from Berrien Springs dam to 7 miles below the dam. Mail survey data were adjusted for bias based on 1980–81 catch and ladder estimates.

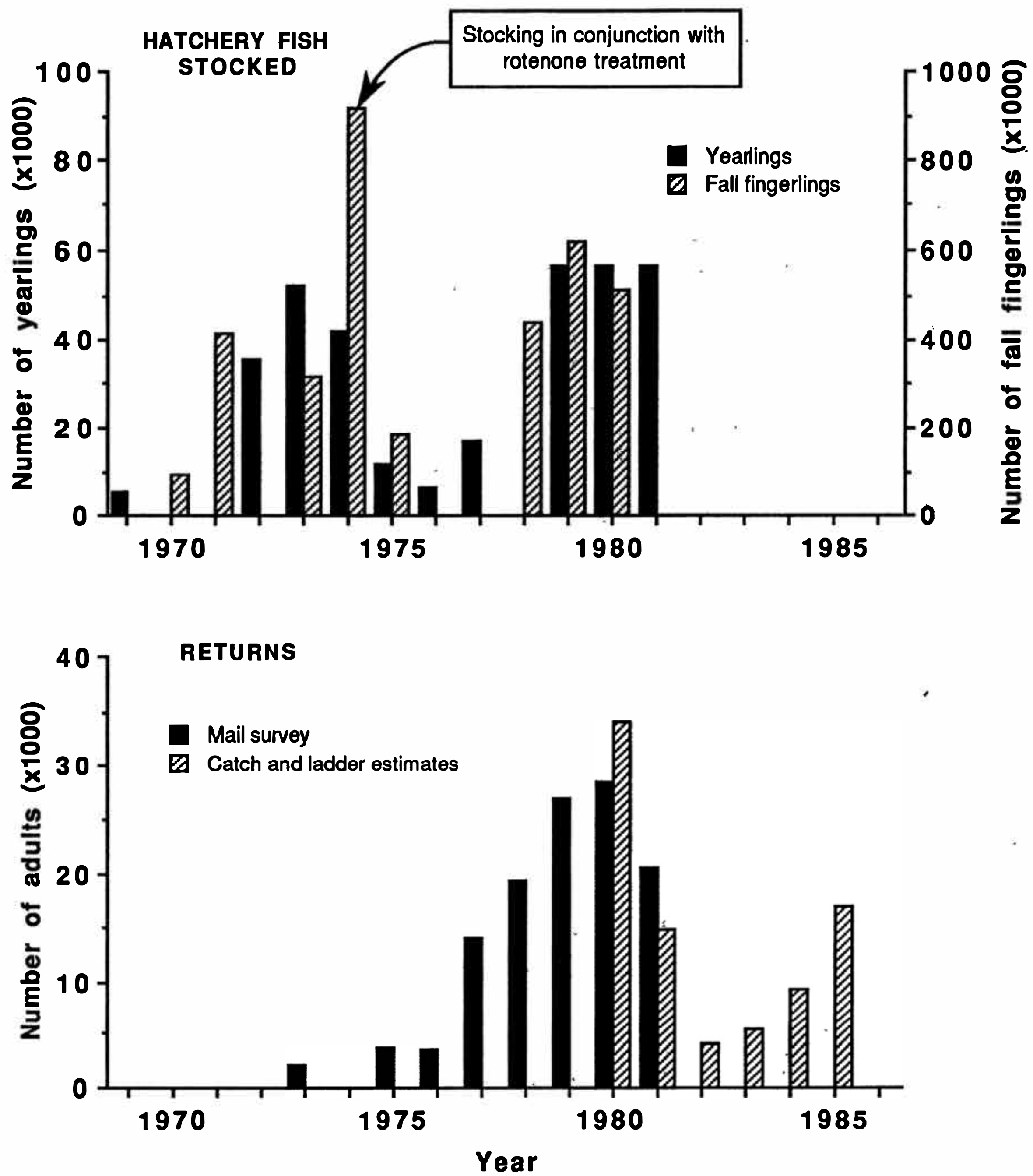

Figure 3. Stocking rates 1969-81 and returns 1969-85 for steelhead in the Grand River. Returns were from the river near Grand Rapids and the Rogue River. Mail survey data are adjusted for bias based on 1980-81 catch and ladder estimates.

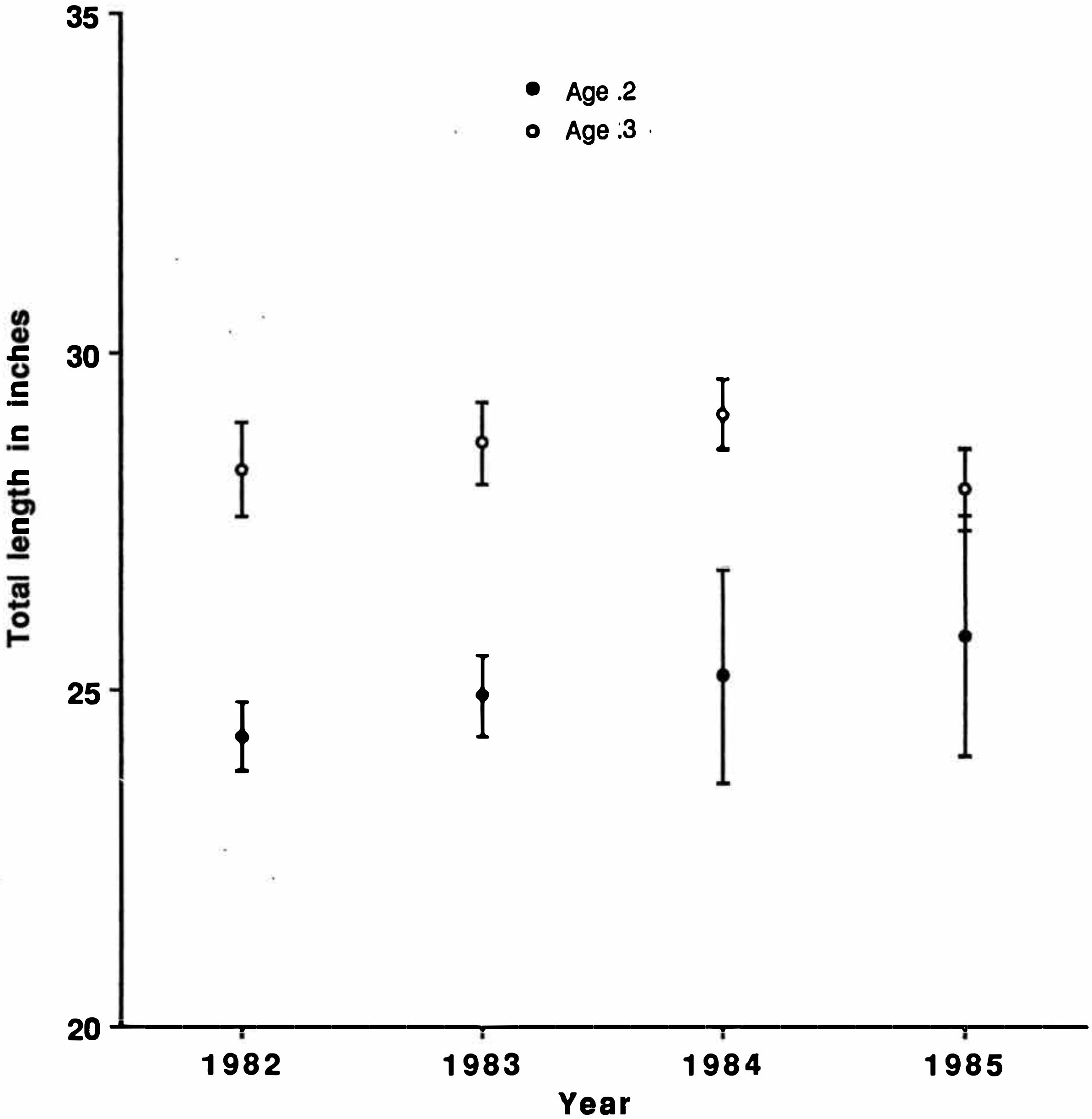

Figure 4. Total length at lake ages .2 and .3 by year for spring steelhead in the St. Joseph River, 1982-85. Error bars denote 95% confidence limits.

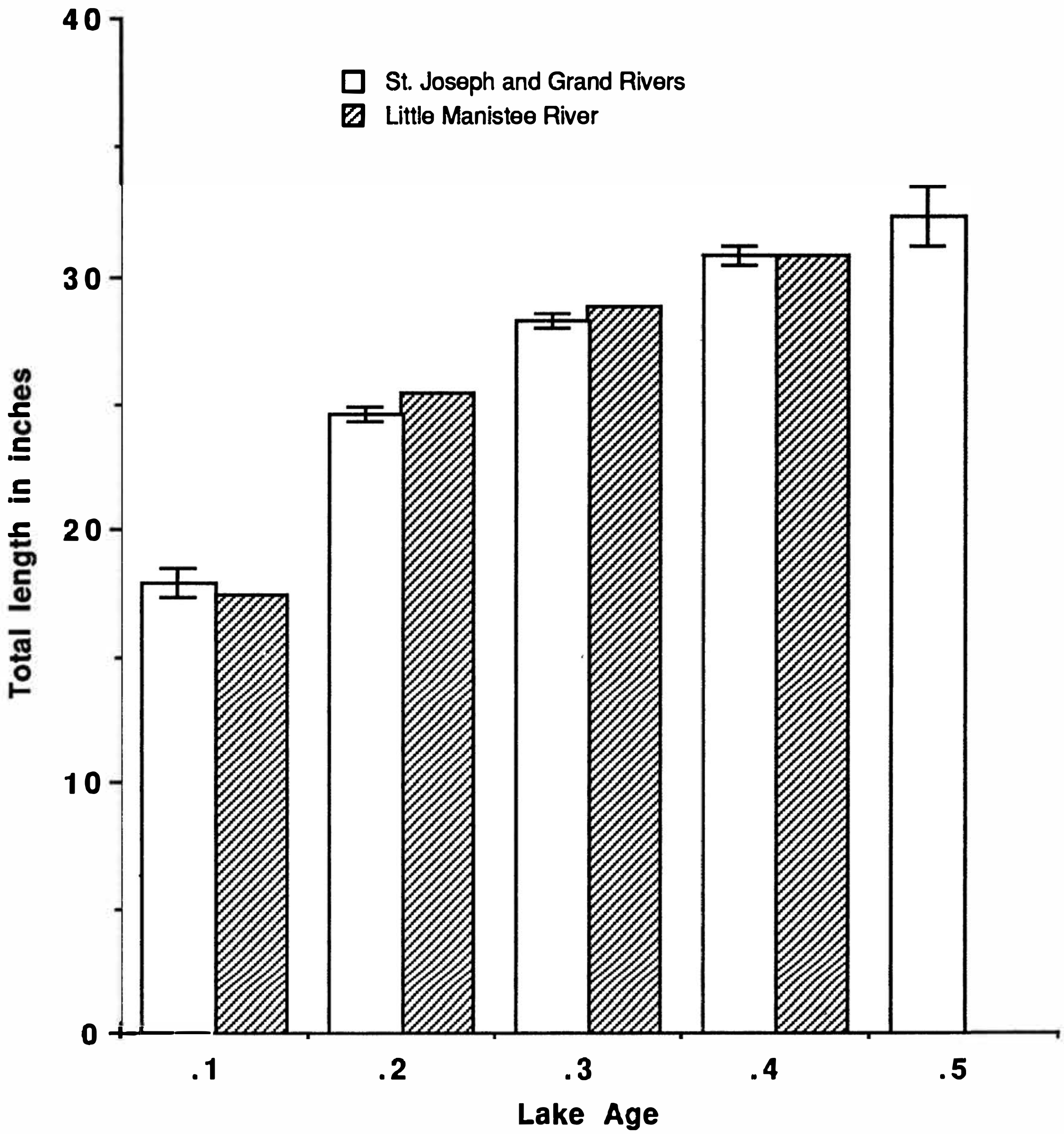

Figure 5. Total length at lake age (with 95% confidence limits) for steelhead for the St. Joseph and Grand rivers (all data combined) and for the Little Manistee River, 1981–85.

Table 1. Matrix of data available for analyses of steelhead populations in the St. Joseph and Grand rivers, fall 1979 through spring 1985. "**" denotes complete data, "*" denotes partial data, and "--" denotes no data.

	St. Joseph River			Grand River		
Season	Census	Ladder	Biological	Census	Ladder	Biological
Fall 1979	--	**	--	--	--	--
Spring 1980	--	**	**	**	--	--
Fall 1980	--	**	--	--	--	--
Spring 1981	--	**	**	*	--	**
Fall 1981	**	**	**	**	--	**
Spring 1982	**	**	**	--	--	**
Fall 1982	*	**	**	**	**	**
Spring 1983	**	**	**	**	**	**
Fall 1983	*	**	**	**	**	**
Spring 1984	**	**	**	**	**	**
Fall 1984	*	**	**	**	**	**
Spring 1985	*	**	**	**	**	**

Table 2. Age structure in percent of the adult steelhead population in the St. Joseph River during 1978–85 analyzed by year and by smolt year class.

	Lake age				
	.1	.2	.3	.4	.5
Year					
1980	2	33	45	19	1
1981	3	24	51	21	1
1982	4	44	39	12	1
1983	4	28	49	18	1
1984	8	25	44	22	1
1985	14	40	30	15	1
Mean	6	32	43	18	1
Smolt year class					
1978	2	34	48	15	1
1979	2	25	54	18	1
1980	2	48	39	11	0
1981	8	42	39	10	1
Mean	3	37	45	14	1

Table 3. Age structure in percent of the adult steelhead population in the Grand River during 1978–85 analyzed by year and by smolt year class.

	Lake age				
	.1	.2	.3	.4	.5
Year					
1981	0	13	53	31	3
1982	13	39	33	13	2
1983	7	29	40	22	2
1984	9	18	47	22	4
1985	15	39	30	15	1
Mean	9	28	40	21	2
Smolt year class					
1978	3	20	71	5	1
1979	3	40	26	24	7
1980	0	26	36	35	3
1981	5	17	47	28	3
Mean	3	26	45	23	3

Table 4. Spring and fall age structure in percent for adult steelhead populations in the St. Joseph and Grand rivers, 1982-85.

River	Season	Lake age .1	.2	.3	.4	.5
St. Joseph	Fall	4	41	40	14	1
	Spring	9	28	43	19	1
Grand	Fall	13	33	35	17	2
	Spring	12	31	37	18	2

Table 5. Percent of the adult steelhead population in the St. Joseph River during 1982-85 which had previously spawned.

Lake age	Sample size	Number of previous spawnings 1	2	3
.2	147	11.6	—	—
.3	146	15.7	0.8	—
.4	54	61.1	3.7	0.0
.5	5	60.0	20.0	20.0

Table 6. Comparisons of total lengths (in inches) between various population subgroups for steelhead from the St. Joseph and Grand rivers during 1981-85. Significant differences between subgroups were determined using 95% confidence intervals and are denoted by an "*".

Comparison by	Subgroup	Lake age .2	Lake age .3	Lake age .4
River	St. Joseph	24.5±0.3	28.3±0.3	—
	Grand	25.3±0.8	28.6±0.4	—
Season	Fall	24.0±0.3*	27.8±0.3*	—
	Spring	25.3±0.3	28.6±0.2	—
Sex	Male	24.3±0.5	28.9±0.2*	32.0±0.5*
	Female	24.9±0.3	28.1±0.3	30.1±0.2
Stream age	Age 1.	24.3±0.3*	28.1±0.3	—
	Age 2.	25.3±0.5	28.6±0.4	—
Previous spawnings	Maiden	24.6±0.3	28.4±0.2	30.7±0.4
	Repeat	23.6±0.8	28.1±0.5	30.7±0.4

Table 7. Length-weight regression parameters for adult steelhead from the St. Joseph, Grand, and Little Manistee rivers during 1980–85. Length and weight were measured in inches and pounds. Sample sizes were 1,500, 732, and 1,961 for the three rivers, respectively.

River	Regression parameter	
	Constant	Slope
St. Joseph	−6.8982 ± 0.1997	2.7035 ± 0.06424
Grand	−6.9095 ± 0.2295	2.7045 ± 0.06961
Little Manistee	−6.9371 ± 0.0827	2.7066 ± 0.02535

Table 8. Number of fish stocked, size at stocking, numbers of fish returning, and percent returns (with 95% confidence limits) for yearling hatchery steelhead stocked in the St. Joseph and Grand rivers during 1979–81.

River	Year stocked	Number stocked	Size at stocking (mm)	Number of fish returning				
				Stream age				
				1.	2.	3.	Total	Percent
St. Joseph	1979	30,000	116	1,287	731	109	2,127	7±1
	1980	30,000	96	647	507	55	1,207	4±1
	1981	30,000	100	345	248	63	656	2±0
Grand	1979	55,000	120	324	268	3	595	1±1
	1980	55,000	96	41	151	0	192	<1
	1981	55,000	100	323	148	355	826	2±1

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Appendix 1. Numbers of adult steelhead estimated to have been caught just below the dam and numbers estimated to have ascended the fish ladder at the dam for Berrien Springs dam on the St. Joseph River and the 6th Street dam on the Grand River during 1980–85.

	Ladder		Catch		
Spawning year	Previous fall	Spring	Previous fall	Spring	Total
St. Joseph River					
1980	64	1,016	—	—	—
1981	33	933	—	—	—
1982	57	204	5,330	882	6,473
1983	128	151	3,015[1]	1,116	4,410
1984	111	510	624[1]	1,573	2,818
1985	157	285	739[1]	1,081[1]	2,262
Grand River					
1980	—	—	—	23,841	—
1981	—	—	—	10,185[1]	—
1982	—	—	1,201	—	—
1983	297	308	3,748	743	5,096
1984	1,281	2,496	2,123	3,124	9,024
1985	915	3,708	4,172	7,869	16,664

[1]Estimates based on partial data.

Report approved by W. C. Latta

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