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Smolting Success of Hatchery-Raised Steelhead Planting in a Michigan Tributary of Northern Lake Michigan

Paul W. Seelbach

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SMOLTING SUCCESS OF HATCHERY-RAISED STEELHEAD PLANTED IN A MICHIGAN TRIBUTARY OF NORTHERN LAKE MICHIGAN[1]

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

Abstract

Four groups of hatchery-raised steelhead, Salmo gairdneri, were marked and released in a Michigan tributary of northern Lake Michigan. The groups were spring yearlings, fall fingerlings, fall yearlings, and large spring yearlings. I examined smolting patterns, residual stream populations, survival from planting to smolting, and cost-to-smolting for each group. Smolting was monitored using traps installed near the mouth of the river. Estimates of residual stream populations were obtained by electrofishing. Most fish in three of the planting groups (spring yearlings, fall fingerlings, and fall yearlings) remained in the river until age 2. A significant number of the fourth group (large spring yearlings) smolted at age 1 within 2 months of planting. The majority of hatchery-raised and wild steelhead smolted during the period mid-April to mid-June, with peak migrations occurring in mid-May. Most hatchery-raised fish showed little dispersal, with 90–100% consistently found within 1.75 miles of the planting site. Planting groups which remained in the river for extended time periods suffered high losses. Only 1–2% of both the spring yearlings and the fall fingerlings survived to smolt; 7% of the fall yearlings survived to smolt. In contrast, nearly 50% of the large spring yearlings, which did not remain long in the river, survived to smolt. These large spring yearlings were by far the most economical and practical group considered, in terms of both cost-to-smolting and numbers needed to reasonably supplement a river's smolt production.

Introduction

Great Lakes steelhead, Salmo gairdneri, populations are maintained by a combination of natural reproduction and supplemental plantings of hatchery-raised fish. The extent of the contribution made by hatchery-raised fish has long been questioned. Several investigators have examined tag returns from hatchery-raised steelhead planted in the Great Lakes and concluded that their contribution to adult stocks was negligible (Hansen and Stauffer 1981; King and Swanson 1973; Wagner and Stauffer 1978). In addition, results from Pacific Coast studies suggest that Great Lakes steelhead were being planted at too small a size to assure significant returns (see Chrisp and Bjornn 1978). This conclusion, however, has not been widely accepted, either by management agencies or the fishing public. The reasons for this include (1) the spectacular success of planting hatchery-raised salmon, Oncorhynchus sp., in the Great Lakes; (2) a few localized, successful plantings of hatchery-raised steelhead (John Trimberger, Fisheries District Biologist, Michigan Department of Natural Resources, Grand Rapids, Michigan, personal communication, February 1985); (3) a lack of detailed research on the survival of hatchery-raised steelhead following their release in the Great Lakes system; and (4) a reluctance to apply the findings of research done on the Pacific Coast to the Great Lakes (Wagner and Stauffer 1978). As a result, the planting of hatchery-raised steelhead continues as a major management program for the Great Lakes (nearly 2 million spring yearlings were planted in Lake Michigan in 1981 according to the Great Lakes Fishery Commission (1981) report). Approximately one-half of the hatchery-raised steelhead planted in Michigan are released in rivers at sites at least 1 mile upstream from the river mouth (Michigan Department of Natural Resources 1981–84) based on the idea that the fish will imprint to the planting site, migrate from the river, and subsequently return to the river as adults. Studies of hatchery-raised steelhead on the Pacific Coast show that survival between planting and smolting can be the critical factor determining the success or failure of a riverine planting program (Bjornn et al. 1979; Chrisp and Bjornn 1978; Wagner et al. 1963). Clearly, if most fish do not survive to smolt, then very few will survive to return as adults. The purpose of this study was to examine smolting patterns, residual stream populations, survival from planting to smolting, and cost-to-smolting for various age and size groups of hatchery-raised steelhead planted in a Michigan tributary of northern Lake Michigan.

Materials and Methods

Study site and planting groups

This study was conducted on the Little Manistee River, a cold-water trout stream which flows through gently rolling, forested areas of Michigan's northwestern lower peninsula before emptying into Lake Michigan near Manistee, Michigan (Fig. 1). The Little Manistee River is approximately 107 km long, with an average width of 13 m, and an average depth of less than 1 m (although pools up to 2 m deep are common). Flow is fairly stable, averaging 5–6 m^3, with peak flows reaching 12–14 m^3. The primary bottom type is sand, although long stretches of gravel and rubble exist. Spring seepage occurs along most of the main stream, maintaining water temperatures below 13 C throughout the year. The river provides excellent spawning, rearing, and adult residence habitat for abundant anadromous and resident salmonids, the most common of which are steelhead and resident brown trout, Salmo trutta. The Michigan Department of Natural Resources (MDNR) operates a fish weir 7 km upstream from the mouth of the river to collect anadromous salmonids for hatchery purposes.

Hatchery-raised steelhead were obtained from MDNR fish hatcheries. These fish were first-generation offspring of adults captured in the Little Manistee River. The four planting groups were (1) spring yearlings (age 14 months post-fertilization), the most common age and size group planted in Michigan prior to 1983; (2) fall fingerlings (age 6 months post-fertilization), the second most common group planted; (3) fall yearlings, an experimental group which were larger and older at release than typical and were thought to be potentially more successful; and (4) large spring yearlings, the most common group planted beginning in 1983. All fish were planted in the Little Manistee River. The site, magnitude, and timing of each plant were chosen so as to be representative of MDNR steelhead plants in rivers (Michigan Department of Natural Resources 1981–82)(Fig. 1, Table 1).

Marking of fish

Each group of hatchery-raised steelhead was distinctly marked before planting. The large spring yearlings were marked using fin clips. The remaining groups of fish were marked using pressure-sprayed fluorescent pigment (Phinney 1966). A sample of each group was examined for marking efficiency (percentage of fish with marks) and this figure was used to calculate the total number of marked fish in that group (Table 1). Values for short-term mark retention were obtained by holding a sample of fish from each marking group in an aquarium for several months and also from the literature (Table 2).

Smolting

Smolting was monitored using two traps installed at the MDNR fish weir. A modified fyke-net trap (Davis et al. 1980) was used in April-May 1981, and modified inclined-screen traps (Seelbach et al. 1985) were used in June-July 1981, April-July 1982, March-June 1983, and April-June 1984. Traps were checked daily, with the total number captured being recorded for each species. Steelhead trapped each day were anesthetized and checked for fluorescent marks and fin clips (up to 400 fish per day). All fish with fluorescent marks or fin clips were scale sampled and measured. Scale sampling of marked fish was terminated each year after 100 fish per planting group were sampled.

I calculated the total number of smolts produced by each planting group. Each day trapped fish were sorted into the proper planting groups by mark color, fin clip, and age, which was determined using length frequency and scale analyses. For days when data were missed (due to debris-laden traps, vandalism, or sampling limitations), the missing data were estimated using catch data from a period of several days before and after the period of missing data (the percentage of the total steelhead catch which was estimated averaged 21% per year for 3 years, 1982–84). The total number of smolts trapped from each planting group was calculated by summing the daily catch totals. The total number of smolts from each planting group was corrected for marking efficiency (Table 1), but not for mark retention, as this was considered to be 100% (Table 2). The total number of smolts produced by each planting group was estimated by dividing the total number trapped from each group by the estimated trapping efficiency. Trap efficiency was measured by trapping and fin clipping smolts, and releasing them 100 m above the traps; the percentage subsequently recaptured was the trap efficiency (efficiency was 42% in 1982 and 1983 and 8% in 1984, Seelbach et al. 1985). In 1981 a quantitative trapping system had not been fully developed. I estimated that the number of age-1 smolts produced from the 1981 spring-yearling plant was 14, based on the replicate planting of spring yearlings in 1982 and on the fact that no hatchery fish were captured in the traps in 1981. The mean total length of smolts in each planting group was calculated using weekly weighted mean total lengths (weighted by the number of smolts captured during each week). The mean total length for each planting group was compared with the mean total length of wild smolts of the same age and year to check for significant differences.

A weighted-mean migration date was calculated for each group (weighted by the number of smolts captured each day). Smolt migration patterns were similar to a normal curve, and the mean plus the confidence band (± 2 standard deviations) were good descriptors of the peak migration date and of the period in which 95% of the smolts migrated (Brown and Hollander 1977).

My examination of smolting patterns involved several assumptions. The smolt traps were run only during the spring months, based on the assumption that few, if any, fish smolted at other times of the year. Numerous authors have defined spring as the major period of smolting activity (Chrisp and Bjornn 1978; Hallock et al. 1961; Wagner 1968). Ruggles (1980), Sopuck (1978), and Youngson et al. (1983) describe fall emigrant steelhead and Atlantic salmon, Salmo salar; however, these fish are considered to be pre-smolts, migrating for reasons other than smolting. Wild steelhead smolts in the Little Manistee River showed a clearly defined smolting peak (Fig. 2), suggesting that smolting is confined to this period.

The three assumptions of testing trap efficiency were (1) that fish survived the handling process; (2) that fish did not avoid the traps on their second migration; and (3) that fish resumed their smolting migration following release. Handling mortality was tested by simultaneously holding 30 handled and 30 control fish in an enclosure for 15 days. No difference in mortality was found and handling mortality was assumed to be negligible. Trap avoidance was tested and found to be negligible (Seelbach et al. 1985). Changes in smolting behavior remain untested, however, T. C. Bjornn (Idaho Cooperative Fisheries Research Unit, Moscow, Idaho, personal communication, December 1984) has found that some handled smolts may never resume smolting. If this were true, my estimates of smolt survival would increase, but the relationships between groups would remain the same.

Residual stream population

Population estimates were obtained for juvenile steelhead during August and September 1981–83, at 14–16 stations on the Little Manistee River (stations 6 and 7 were discontinued after 1981 due to the scarcity of steelhead at these sites)(Fig. 1). These stations were selected so as to cover the range of habitat types which occur along the length of the river. Juvenile steelhead were captured using dc electrofishing equipment. Two consecutive runs were made at each station, removing all steelhead as they were captured. All juvenile steelhead were measured and those of appropriate lengths were anesthetized and examined for fluorescent marks. Fish were sorted into age groups using length frequency and scale analyses. Fish were sorted into planting groups according to mark color, fin clip, and age. Population estimates were calculated for each site for each planting group using the two-run removal method (Zippin 1958). An estimate of the total number of fish remaining in the river from each planting group was calculated. Stream sections for population estimates were approximately 100 m long. Population estimates were calculated for each site as number of trout per hectare. The river, from the weir to Luther (see Fig. 1), was stratified by habitat type. The total area of each stratum was determined using measurements of aerial photographs combined with on-site measurements. Population estimates for each site were then expanded using stratified sampling equations (Schaeffer et al. 1979) to estimate the total number of fish in each planting group in the river from the weir to Luther.

Several assumptions are inherent in the removal method of population estimation (1) the population must be stationary; (2) the probability of capture must be the same for each animal; and (3) the probability of capture must remain constant from trapping to trapping (Zippin 1958). Electrofishing in small rivers is generally believed to satisfy these assumptions, although Bohlin (1982) points out that assumption (2) is questionable, and that this problem, plus often inadequate sample sizes, can affect the accuracy of estimates. I assumed that the basic assumptions were met and gathered as large a sample as was possible.

Survival from planting to smolting

Percent survival from planting to smolting was calculated as the total number of smolts divided by the total number planted. The total number of large spring yearlings planted was corrected for what was considered an unusually high fishing mortality (see Table 1). These fish were planted prior to the opening day of trout season and many were caught during the first few weeks of the season. A conservative estimate of this fishing mortality was made based on daily observations and on angler interviews.

Cost-to-smolting

Information on the cost per pound of raising steelhead to various ages and sizes in Michigan hatcheries was obtained from Harry Westers (Hatchery Planning Specialist, Michigan Department of Natural Resources, Lansing, Michigan). The cost per fish planted was calculated as cost per pound (for each group) divided by the number of fish per pound (for the appropriate group). This figure was then divided by the proportion surviving to smolt to give the cost per smolt.

Results

Smolting patterns

Most fish in three of the planting groups (spring yearlings, fall fingerlings, and fall yearlings) remained in the river following planting and smolted at ages 2 and 3 (Table 3). Less than 5% of the spring-yearling and fall-fingerling smolts were age 1, the remainder being ages 2 and 3. All of the fall-yearling smolts were age 2. In contrast, 98% of the large spring-yearling smolts were age 1, with the remainder being age 2. Hatchery-raised smolts of both age 1 and age 2 migrated at similar times to their wild counterparts, although this timing was affected slightly by fish length, with larger fish migrating earlier than smaller fish (Fig. 2). Age-1 smolts of the spring yearlings were similar in size to wild age-1 smolts (Table 4), but migrated slightly later (an exception). Both age-2 and age-3 smolts of the spring yearlings were smaller than their wild counterparts, and migrated slightly later. In general, both age-1 and age-2 smolts of the fall fingerlings were similar in size and migration time to wild fish, although age-2 smolts of the 1982 plant were smaller than wild age-2 smolts. Smolts of the fall yearlings were larger than wild age-2 smolts and migrated earlier. Both age-1 and age-2 smolts of large spring yearlings were larger than wild smolts of comparable age and migrated earlier.

Residual stream populations

Moderate numbers of fish of two planting groups (spring yearlings and fall fingerlings) were found in the river during the first fall following planting (age-1 fish). Very few fish of either group were found during subsequent falls (Table 5). None of the fall yearlings or large spring yearlings was found remaining in the river. Hatchery-raised fish generally remained within 1.75 miles of the planting site (100% of the spring-yearlings and 86% of the fall-fingerlings).

Survival from planting to smolting

Survival from planting to smolting was very low for three of the planting groups (spring yearlings, fall fingerlings, and fall yearlings), and fairly high for the fourth group (large spring yearlings), and was inversely related to the length of time that each group spent in the river before smolting (Fig. 3).

Most spring yearlings remained an additional year in the river, where approximately 1% survived to smolt. Fall fingerlings spent an additional 20 months in the river, and 2% survived to smolt. Fall yearlings spent 8 months in the river and only 7% survived to smolt. Large spring yearlings, however, smolted almost immediately, with 48% surviving to smolt.

Cost-to-smolting

The cost of producing one smolt was lowest for the fall fingerlings and large spring yearlings at $0.69 and $1.11, respectively. A spring yearling cost approximately $4.00, while a fall yearling cost nearly $9.00.

Discussion

It has consistently been demonstrated that there are two major factors which affect smolting in hatchery-raised steelhead (1) size at release and (2) time of release (Chrisp and Bjornn 1978; Bjornn et al. 1979; Hallock et al. 1961; Wagner 1968; Wagner et al. 1963). Size at release is critical because smolting in steelhead is strongly size related. Within a cohort, the fish which reach the "minimum smolting size" of approximately 150–160 mm in 1 year will smolt, while the smaller members will remain in the river for an additional year or more (Chrisp and Bjornn 1978; Wagner et al. 1963; Wallis 1968). In most wild steelhead populations, fish need 2 or more years to grow to this minimum size (Biette et al. 1981; Maher and Larkin 1955; Withler 1966). Hatchery-raised steelhead, however, are typically planted at age 1, and if they are smaller than the minimum smolting size, and do remain an additional year or two in the river, are subject to the high mortalities which have been well documented for hatchery-raised trout planted in rivers (90% mortality within the first few months—see Bjornn et al. 1979; Chrisp and Bjornn 1978; Cooper 1959; Cresswell 1981; Wallis 1968). Hatchery-raised trout have a bell-shaped length-frequency distribution, often with a fairly large variance; and in order to assure that most of the fish in a planting group are above the minimum smolting size, the mean length of fish in the planting group needs to be well above this minimum size. Along these lines, Bjornn et al. (1978) argue that hatchery-raised steelhead should average approximately 200 mm in length at planting. Time of release is important because both the physiological mechanisms (Hoar 1976) and the external cues (Chrisp and Bjornn 1978), which regulate smolting, act to restrict the smolting of both wild and hatchery-raised steelhead to a 3-month period in the spring, with peak activity taking place within a 1- or 2-week period (Chrisp and Bjornn 1978; Hallock et al. 1961; Wagner 1968). Early planting subjects fish to the high mortalities associated with river residence and possibly to a period of slower-than-hatchery growth, resulting in fewer fish reaching smolt size that season. Late planting may result in fish losing their smolt characteristics and remaining in the stream or in fish reaching the sea (or lake) at less than optimal times (Ruggles 1980; Wagner 1968; Wilder 1952). Stress from handling and transportation can cause fish to spend up to 2 weeks "recovering" in the stream before they resume smolting so, ideally, fish should be planted a week or two prior to the peak smolting period.

The findings of this study are in complete agreement with the literature on factors which affect smolting and survival in hatchery-raised steelhead. Size at release had a major effect, with 48% of large spring yearlings surviving to smolt, compared with 1% for smaller spring yearlings. Apparently 50–55% survival-to-smolting is as good as can be expected; Bjornn et al. (1978) found similar values of 32–54% smolting at age 1 for fish averaging 190 mm in total length. Time of release was also supported as a major factor as hatchery-raised fish consistently smolted at times similar to wild fish. The mid-May smolting period found here is quite similar to smolting periods reported by the investigators mentioned earlier in this discussion. It is important to note that, although the large spring yearlings were planted 2 months before they smolted in May, cold-water temperatures in the planting river may have affected the timing of smolting. Kerstetter and Keeler (1976) found that elevated temperatures can hasten the onset of steelhead smolting, and it is possible that large spring yearlings planted in warmer rivers might smolt earlier than those in this study. A third factor which may significantly affect survival was identified as winter harshness. Harsh winter conditions are suspected to have caused high mortalities among wild steelhead populations in the study river during the 1981–82 winter. Fish from the replicate plantings of spring yearlings and fall fingerlings were in the river both during this winter and the following milder winter, however, no effect of varying winter harshness was seen. The single planting of fall yearlings was in the river during the harsh 1981–82 winter, and the survival value which I recorded may be minimal for this planting group.

The minimal dispersal of residual stream populations is consistent with the findings of other investigators (Bjornn and Mallet 1964; Cooper 1959; Cresswell 1981; Wentworth and Labar 1984). This concentration of fish may have adverse effects both on the survival of hatchery-raised trout and on local wild trout populations. Hatchery-raised steelhead which survived to smolt grew to sizes generally comparable to those of wild smolts of similar age. At planting, both fall fingerlings and spring yearlings were similar in size to wild fish of comparable ages. Those fall fingerlings which survived apparently adjusted well to natural feeding conditions. Once planted, spring yearlings, however, grew more slowly than wild fish. This is consistent with the finding of Hochachka (1961), Reimers (1963), and Sosiak et al. (1979) that hatchery-raised salmonids often do not adjust well to natural feeding conditions. The fact that a fair number of the 1982 spring yearlings did not smolt until age 3 is an indication that they were growing quite slowly.

Fall-fingerling and large spring-yearling smolts were the least expensive to produce. When considering a hypothetical management goal of supplementing the smolt production of a river by 20,000 smolts, the planting of large spring yearlings is the most favorable approach, in terms of cost, numbers needed, and risk (Fig. 4). For fall fingerlings to be comparable, river conditions must be ideal. These fish need (1) rearing habitat suitable for up to 2 year's growth and (2) favorable winter conditions (Wentworth and Labar 1984). Since large spring yearlings leave the river shortly after planting, river conditions are fairly unimportant.

The application of the findings of this study to steelhead plantings in Michigan must be split into two separate time frames, before 1983 and after 1983.

Before 1983

Michigan's hatchery-raised steelhead program has traditionally consisted of raising spring yearlings at a cold-water hatchery, where growth is similar to that of wild trout. These "small" (by smolting standards) fish were typically planted in one of three major habitat types (1) in cold-water rivers which had wild trout populations (most of which are thought to be limited by environmental factors, not reproduction); (2) in large cool-to-warmwater rivers primarily inhabited by large piscivorous fish (non-trout); and (3) at the mouths of rivers or in open waters of the Great Lakes. The results of this study are directly applicable to past plantings in cold-water rivers, and suggest that these efforts probably resulted in the production of very few returning adults. The application to plantings in large, cool-to-warmwater rivers is more difficult. Spring yearlings would certainly not have smolted at age 1, however, it is not clear (1) how warm summer temperatures affect movement of the planted trout or (2) what impact resident fish (particularly the large piscivores) have on the planted trout. The results of this study are not applicable to past plantings at river mouths or in open waters of the Great Lakes.

Most of Michigan's fall-fingerling plants have been in large warmwater rivers or in their cooler tributaries. The length of river residence, and their subsequent survival-to-smolting, are unknown.

After 1983

Beginning in 1982 (for planting in 1983), Michigan began production of large spring yearlings at a coolwater hatchery. To date, the average size at planting has been less than that of the large spring yearlings used in this study (160 mm compared to 200 mm, (Michigan Department of Natural Resources 1984), and less than the desired goal of 180–200 mm. Increased efforts toward raising and planting large spring yearlings hold the potential for significant smolt production and, subsequently, significant contributions to adult populations.

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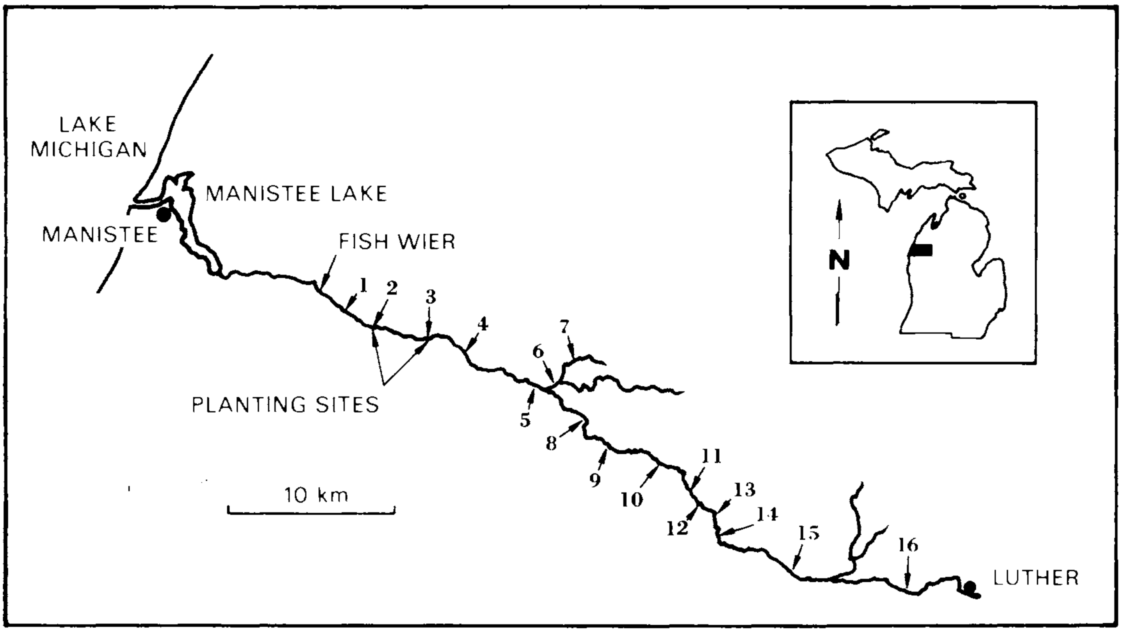

Figure 1. The Little Manistee River, showing the fish weir, planting sites, and population estimates sites.

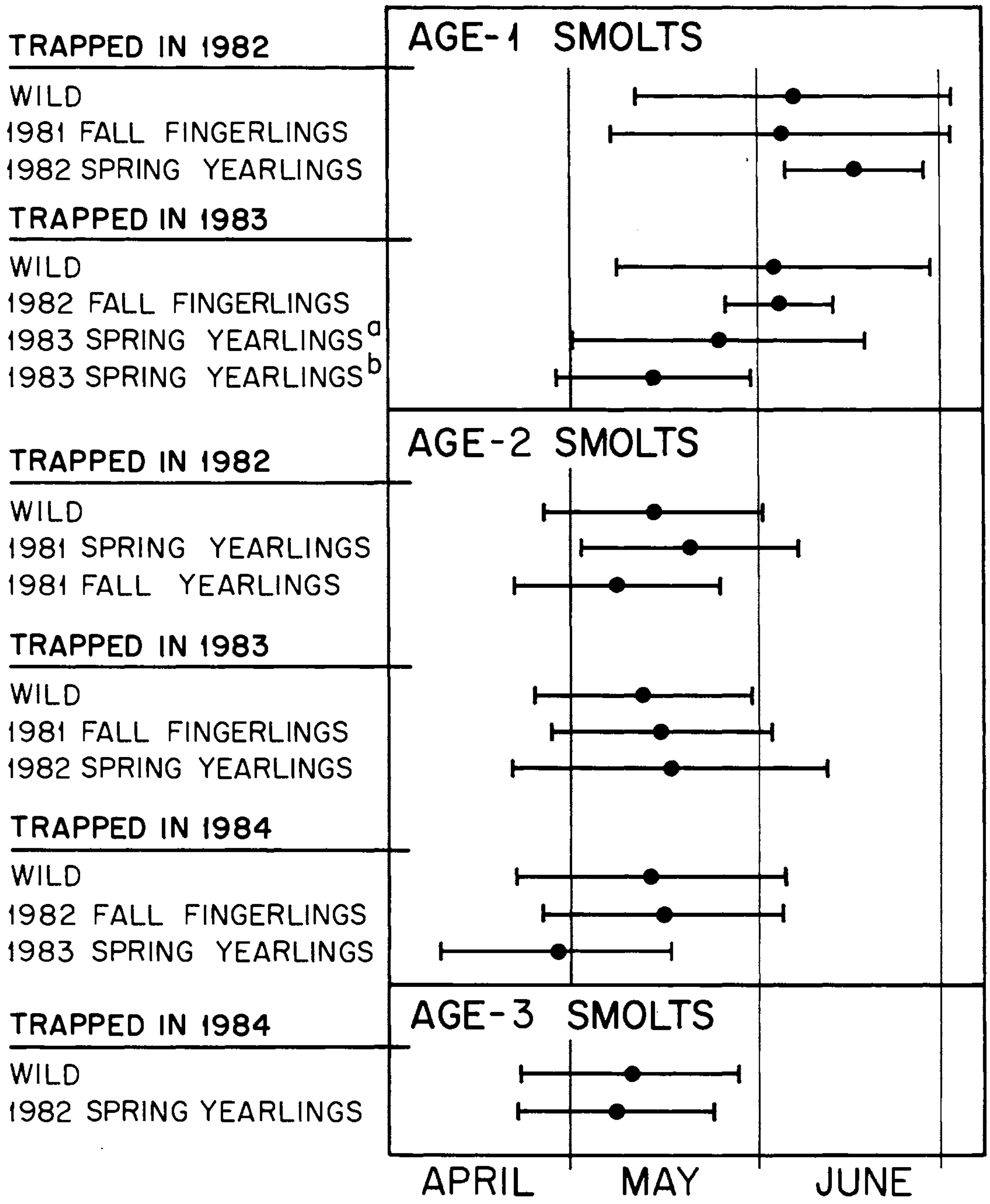

Figure 2. Mean date of migration (with 95% confidence limits) for hatchery-raised and wild steelhead smolts, Little Manistee River, 1982–84. For 1983 spring yearlings, "a" denotes 12 fish per kg and "b" denotes 5 fish per kg.

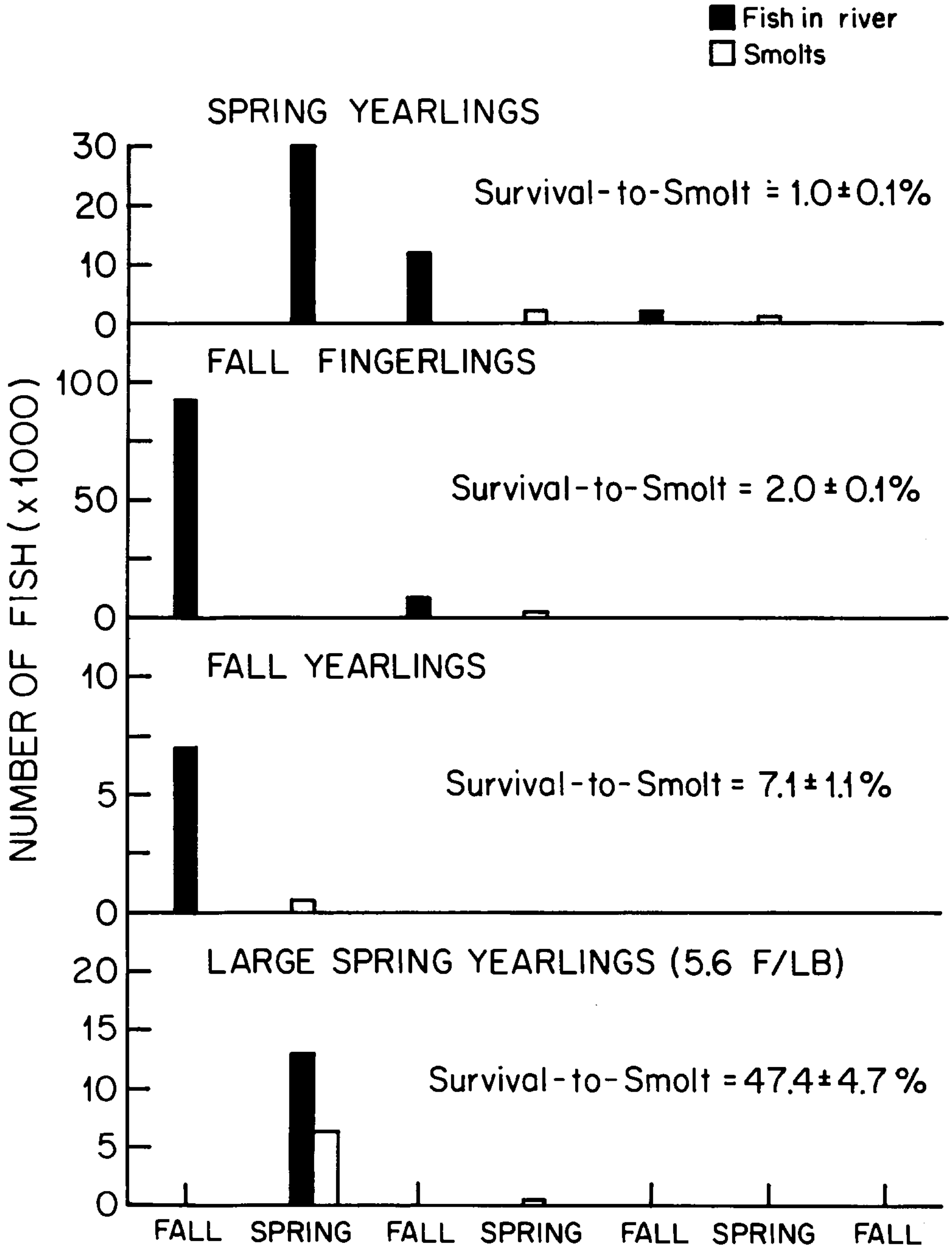

Figure 3. Pattern of smolting and survival-to-smolting for hatchery-raised steelhead planted in the Little Manistee River. Results for the spring yearlings and fall fingerlings are an average of two replicated plantings.

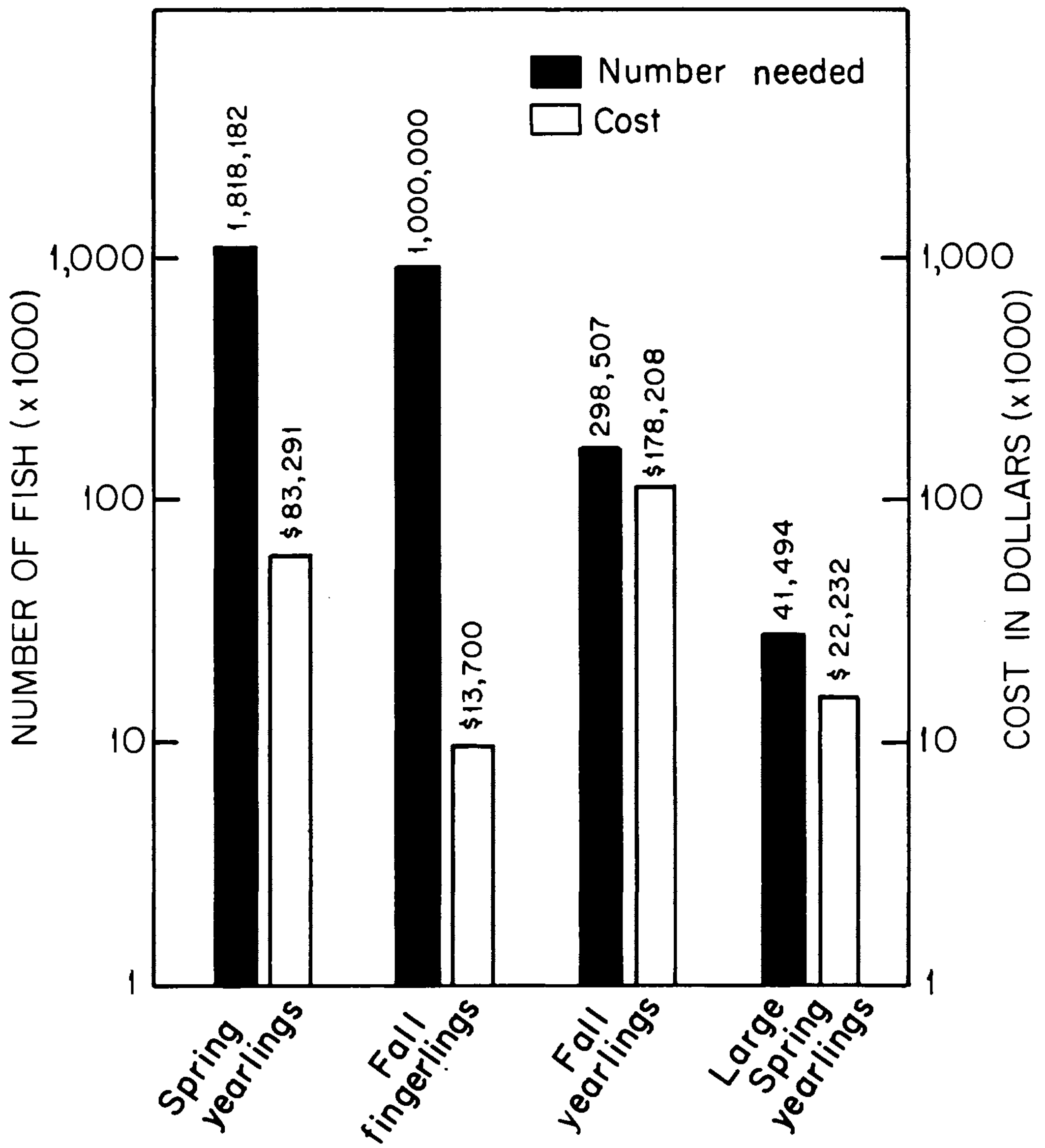

Figure 4. Number of fish needed and cost to produce 20,000 smolts.

Table 1. Numbers, planting groups, weights, mean length, and number marked for hatchery-raised steelhead planted in the Little Manistee River, 1981–83.

Planting date	Planting group (year class)	Number planted	Weight in fish/kg (mean length, mm)	Actual number spray marked (percent efficiency)	Number fin clipped (clip)[1]
May 1981	Spring yearlings (1980)	29,914	88 (110)	18,554 (93)	3,000 (AD-LV)
Sep 1981	Fall fingerlings (1981)	85,257	686 (—)	67,548 (86)	2,005 (D)
Sep 1981	Fall yearlings (1981)	7,050	15 (190)	5,162 (—)[2]	1,500 (D)
May 1982	Spring yearlings (1981)	30,000	200 (80)	22,880 (76)	3,000 (AD-LV)
Sep 1982	Fall fingerlings (1982)	98,000	917 (42)	78,400 (80)	— —
Mar 1983	Large spring yearlings (1982)	13,000[3]	12 (200)	— —	13,000 (D-AD)
Mar 1983	Large spring yearlings (1982)	1,000	5 (240)	— —	1,000 (RP-LV)

[1]AD-L denotes an adipose – left vented clip, D denotes a dorsal clip, D-AD denotes a dorsal-adipose clip, and RP-LV denotes a right pectoral-left ventral clip.

[2]A 93% efficiency was used.

[3]This number is corrected for unusually high fishing mortality.

Table 2. Retention of pressure-sprayed fluorescent pigment by young salmonids.

Species (planting group)	Time period fish were held	Percent retention (number at end of period)	Source
Steelhead (spring yearlings)	3.5 months	99.8 (99)	This study
Steelhead (fall fingerlings)	4 months	95.6 (43)	This study
Steelhead (spring yearlings)	2 months	100.0 (255)	This study
Steelhead (fall fingerlings)	4 months	100.0 (85)	This study
Coho salmon[1] (spring fingerlings)	12 months	100.0	Phinney 1974
Coho salmon (spring fingerlings)	24 months	100.0	Phinney and Mathews 1973

[1]Oncorhynchus kisutch.

Table 3. Total number of smolts produced from hatchery-raised steelhead planted in the Little Manistee River, 1982–84.

Planting group (year planted)	Number planted	Year of smolting 1982	1983	1984
Spring yearlings (1981)	29,914	157±25	—	—
Fall fingerlings (1981)	85,257	7±1	730±72	12±3
Fall yearlings (1981)	7,050	500±81	—	—
Spring yearlings (1982)	30,000	14±2	215±22	214±54
Fall fingerlings (1982)	98,000	—	10±1	2,798±699
Large spring yearlings[1] (1983)	15,000	—	6,144±610	119±30
Large spring yearlings[2] (1983)	1,000	—	485±48	—

[1]12 fish per kg.

[2]5 fish per kg.

Table 4. Mean total length (mm) at smolting (with 95% confidence limits) for hatchery-raised and wild steelhead. An asterisk denotes significant difference between hatchery-raised and wild groups.

Planting group (year planted)	Age at smolting	Hatchery-raised	Wild
Spring yearlings (1981)	2	196.5±14.2	200.5±22.5
Fall fingerlings (1981)	2	200.5±17.4	200.5±22.5
Fall yearlings (1981)	2	202.8±28.1	200.5±22.5
Spring yearlings (1982)	1	162.0±20.0	164.9±17.5
	2	195.3±29.7	219.8±23.3
	3	226.1±27.2	255.8±10.3
Fall fingerlings (1982)	1	175.0±18.0	182.8±17.4
	2	191.7±13.3	211.1±32.1
Large spring yearlings[1] (1983)	1	227.2± 3.6	182.8±17.4*
	2	268.7± 0.5	211.1±32.1*

[1]12 fish per kg.

Table 5. Estimates of the number of hatchery-raised steelhead in the Little Manistee River, fall 1981–83.

Planting group (year planted)	Year of estimate		
	1981	1982	1983
Spring yearlings (1981)	11,477±394	242±0	—
Fall fingerlings (1981)	—	7,613±382	449±167
Fall yearlings (1981)	—	—	—
Spring yearlings (1982)	—	11,420±333	236±0
Fall fingerlings (1982)	—	—	8,529±540
Large spring yearlings[1] (1983)	—	—	—

[1]12 fish per kg.

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