FISHERY RESEARCH

STEELHEAD VOLITIONAL RELEASE EXPERIMENT

SQUAW CREEK POND, IDAHO

1998 Project Progress Report

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IDFG Report Number 00-18
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By

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Cooperative Agreement
1448-14110-98-J003

IDFG Report Number 00-18
October 1999

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ABSTRACT

We evaluated a new release strategy for hatchery steelhead, *Oncorhynchus mykiss,* intended to reduce the number of residual steelhead entering the Salmon River, Idaho. Residual steelhead could negatively impact ESA-listed salmon, steelhead, and resident fish stocks inhabiting the same waters. The release strategy included pond acclimation, volitional release, and the retention of steelhead that failed to emigrate from the pond. The use of Squaw Creek Pond meets the guidelines for reducing risks to Snake River listed species caused by Columbia Basin hatchery programs noted by National Marine Fisheries Service in several documents, including their predecisional recovery plan for Snake River salmon and the 1994-1998 Biological Opinion for hatcheries in the Columbia basin.

In 1998, 52,800 hatchery steelhead were stocked into Squaw Creek acclimation pond and permitted to volitionally immigrate into the Salmon River. The number of fish that emigrated from the pond was determined by using a fish counter and by conducting a mark-recapture estimate. According to the fish counter, 37,431 fish emigrated between April 20 and May 18, 1998. A total of 20,349 fish emigrated during the night time period, whereas 17,082 emigrated during the day time period. Fish emigration was not correlated with water temperature. Using the mark-recapture method, we determined that 45,159 steelhead emigrated from the pond.

The sex composition of the fish that failed to emigrate (nonmigrants) was not significantly different from the prestocking population. Mean fork length, weight, and condition factor of nonmigrant steelhead collected for sex composition sampling were 237 mm, 118.54 g, and 0.87, respectively. Of the 197 nonmigrants sampled, 193 were classified as smolts and four were classified as transitional.

A total of 298 early migrant, 301 late migrant, and 300 nonmigrant (these fish were force released) steelhead were tagged with passive integrated transponder (PIT) tags to evaluate juvenile migration success and timing. Mean fork lengths of PIT-tagged steelhead classified as early migrants, late migrants, and nonmigrants were 238 mm, 228 mm, and 244 mm, respectively. A total of 221 (74.2%) early migrants, 110 (36.5%) late migrants, and 125 (41.7%) nonmigrants were interrogated at downstream dams. PIT tag interrogation rates and travel times to Lower Granite Dam were not significantly different between late migrants and nonmigrants.

The release strategy we tested was unsuccessful at separating smolts from residual steelhead in 1998. Based on the PIT tag interrogation rate of nonmigrant steelhead and the number of fish remaining in the pond (calculated from the fish counter counts), we estimated that a maximum of 58.3% (8,926) of the steelhead remaining in the pond were residual steelhead. Conversely, by detaining all nonmigrants and using them in resident fishing ponds, a minimum of 41.7% (6,385) of the steelhead smolts that would have emigrated, at least to the downstream dams, were sacrificed. Fishery managers must determine if retaining a population comprised of up to 40% smolts for this release site will impede efforts to sustain fishing opportunity on hatchery B-run steelhead in the upper Salmon River. Managers must also determine whether this strategy is worth expanding to benefit listed species.

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INTRODUCTION

In 1991, the National Marine Fisheries Service (NMFS) listed Snake River sockeye salmon *Oncorhynchus nerka* as endangered under the Endangered Species Act, and in 1992 listed Snake River spring, summer and fall chinook *O. tshawytscha* as threatened (NMFS 1995). Snake River steelhead *O. mykiss* were listed as threatened in 1997. Sockeye, spring, and summer chinook salmon are present in the upper Salmon River drainage upstream of the Pahsimeroi River where the Idaho Department of Fish and Game (IDFG) stocks hatchery steelhead annually. The stocking of hatchery fish in waters inhabited by listed species warrants evaluation to ensure negative interactions such as competition for food and space, predation (Miller 1958, Bachman 1984, Vincent 1987), and the spread of disease (Ratliff 1981) are minimized.

One way to limit the effects of hatchery steelhead on listed species is to reduce the number of nonmigrating (residual) steelhead released. Viola and Schuck (1995) developed a fish stocking technique that was effective in significantly reducing the number of hatchery steelhead residuals released into the Tucannon River, Washington. They found that steelhead smolts and residuals segregated themselves if liberated into an acclimation pond and then permitted to emigrate volitionally. Steelhead that failed to emigrate, defined as residuals by Viola and Schuck, were not released into the river. A majority of the residuals were precocial males. Viola and Shuck (1995) reported that the proportion of the fish released into the Tucannon River from the Curl Lake acclimation pond that were residuals (3.1%) was significantly lower than the proportion which resulted from a direct stream release (14.0%).

In Idaho, Rhine et al. (2000) applied a variation of the stocking technique mentioned above to hatchery steelhead acclimated in raceways at Sawtooth Fish Hatchery. Raceways at Sawtooth Fish Hatchery are constructed in a series; the water flows from upper raceways to lower raceways. Acclimated steelhead that volitionally emigrated from upper raceways were recaptured and detained in lower raceways. Some of the steelhead that emigrated (migrants) from upper raceways were detained until May 15, when the study was terminated. At that time, migrants and nonmigrants (steelhead that had failed to emigrate from upper raceways) were tagged with passive integrated transponder (PIT) tags and released into the Salmon River. Rhine et al. (2000) found that the PIT tag interrogation rate at downstream dams for migrant steelhead was significantly higher than for nonmigrant steelhead. However, about 30% of the nonmigrants tagged with PIT tags were still interrogated at downstream dams. Rhine et al. (2000) suggested that volitionally releasing steelhead from ponds, rather than raceways, may provide a better separation of true smolts and residual steelhead.

This study evaluated the volitional release of hatchery steelhead from Squaw Creek acclimation pond. We hoped that we could duplicate Viola and Schuck's (1995) results and thereby reduce the number of residual steelhead entering the Salmon River where they could potentially have a negative impact on listed salmon and steelhead. Residual steelhead would be detained in the pond to provide fishing opportunity for the public. The use of Squaw Creek Pond meets the guidelines for reducing risks to Snake River listed species caused by Columbia Basin hatchery programs noted by NMFS in several documents, including their predecisional recovery plan for Snake River salmon and the 1994-1998 Biological Opinion for hatcheries in the Columbia basin.

GOAL

The goal of this study was to determine if the number of residual hatchery steelhead entering the Salmon River could be reduced by utilizing a release strategy that included volitional release, acclimation, and the retention of nonmigrant steelhead.

OBJECTIVES

The objectives of this study were to:

1. Describe the characteristics of the population before emigration.
2. Describe the characteristics of migrant steelhead.
3. Describe the characteristics of nonmigrant steelhead.
4. Evaluate the interrogation rates and migration timing of migrant and nonmigrant steelhead.
5. Evaluate emigration timing in relation to water temperature.
6. Compare two different methods of estimating the number of emigrants from Squaw Creek Pond—electronic fish counter and a mark-recapture estimate.

STUDY AREA

The steelhead used for this study were reared at Magic Valley Fish Hatchery and trucked to Squaw Creek Pond. Magic Valley Fish Hatchery is located in southeast Idaho, approximately 12 km northwest of Filer. Squaw Creek Pond is a man-made, earthen pond located adjacent to Squaw Creek, approximately 1 km upstream from its confluence with the Salmon River (Figure 1). Squaw Creek joins the Salmon River approximately 5 km west of Clayton, Idaho. Idaho Department of Fish and Game constructed the pond in 1997 as an acclimation pond for steelhead smolts and as a fish-out pond for stocked rainbow trout, using monies from NMFS award #NA67FH0092 and the IDFG salmon and steelhead tag fund. Squaw Creek Pond has a surface area, mean depth, and volume of approximately 4,047 m^2, 1.2 m, and 4,934 m^3, respectively. Water is supplied to the pond from Squaw Creek via a 38 cm, valved, polyvinyl chloride pipe. The outlet structure and tailrace are constructed of cement. A two-inch channel, recessed in the concrete walls of the outlet channel, supports screens and dam boards.

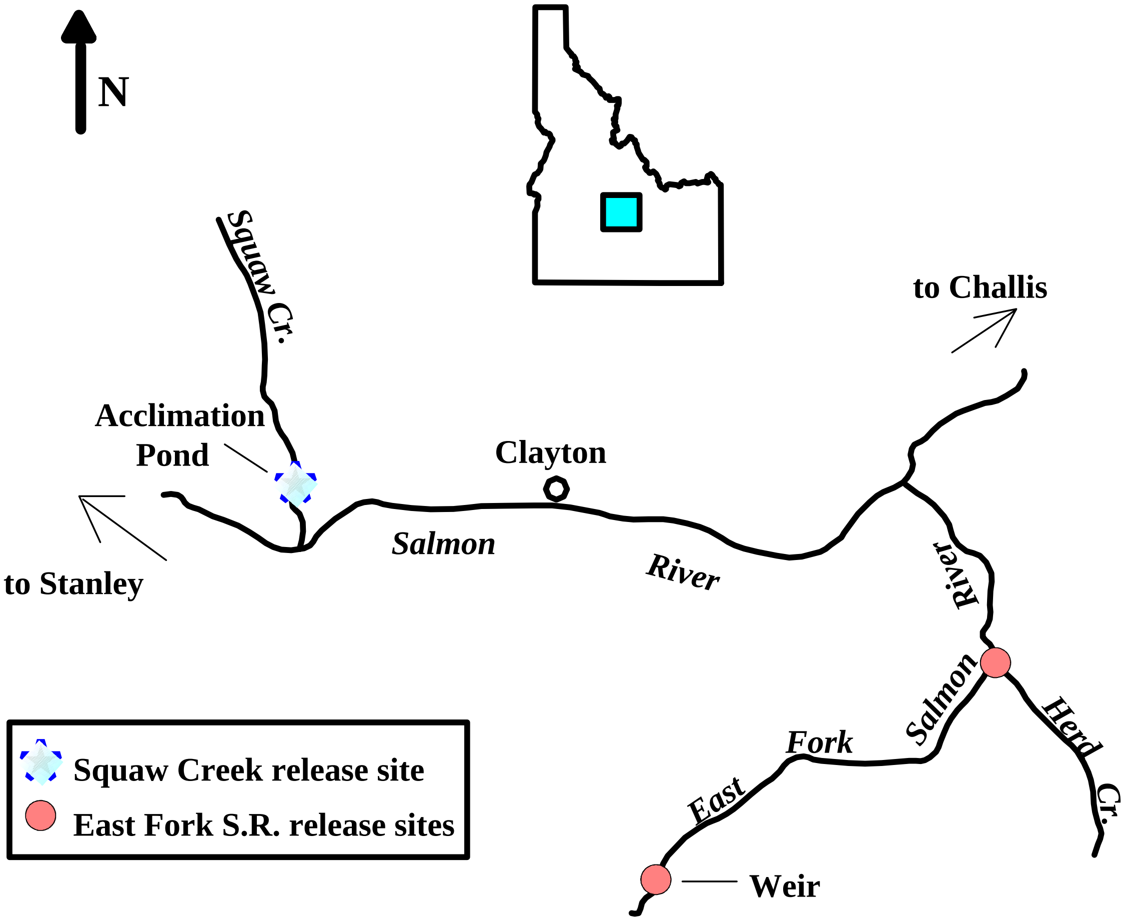

Figure 1. Location of hatchery steelhead smolt release sites on Squaw Creek and the East Fork Salmon River, Idaho.

METHODS

Pre-emigration Data

Dworshak B-stock steelhead from the 1997 brood were used for the study. Eggs were collected at Dworshak National Fish Hatchery, Idaho, located on the North Fork of the Clearwater River, and shipped to Magic Valley Fish Hatchery as eyed eggs in June 1997. Fish were reared in raceways until April 1998. Prior to being trucked to Squaw Creek Pond (April 8), steelhead were crowded and a random sample was collected using a dip net. Fish were taken off feed two days prior to sampling. Sampled fish were euthanized, measured (FL, mm), weighed (g), sexed, and examined for smolt characteristics (parr, transitional, smolt), and sexual maturity. Fish classified as smolts were silver in coloration and had faint, or nonexistent, parr marks. Parr were dark in coloration and exhibited very distinct parr marks. Transitional steelhead showed characteristics of both smolts and parr (i.e., silver in coloration with distinct parr marks). Steelhead with enlarged gonads were classified as sexually mature (precocious). Means for length, weight, and condition factor (K = weight/length^3 x 100,000) were calculated for the population.

Squaw Creek Pond Operations

A total of 52,800 steelhead were stocked into the pond—15,180 on April 10 and 37,620 on April 13. A screen was placed in front of the outlet to prevent fish from immediately exiting the pond. The water flow was set at 2.2 cubic feet per second and held constant throughout the entire study except for several high water periods. Water temperatures at the inlet and outlet were recorded each morning and afternoon. An average daily water temperature was calculated for each location. Daily record keeping for the pond included the number of mortalities, weather conditions, presence of predators, and the presence of ice on the pond. Steelhead were fed a maintenance diet of Rangen and Bioproducts™ commercial fish food until May 5. Feeding was discontinued on May 6 to stimulate fish to emigrate from the pond.

On April 20 the outlet screen was removed and the fish counting system was activated. The water level of the pond remained the same for the first five days that emigration was permitted (April 20-April 24). On April 25, the water level was lowered four inches by removing one dam board from the outlet channel. One dam board was removed every five days until May 5 (April 25, April 30, May 5) and each day thereafter until May 7 (May 6, May 7). On May 18, the outflow screen was installed to stop all emigration.

Fish Emigration

Fish Counter

A Model SR-1601 Smith-Root fish counter, (Smith-Root, Inc., Vancouver, WA 98686), was installed in the outflow channel of Squaw Creek Pond and tested before stocking. Counting tubes were attached through an aluminum dam board, which was placed into slots in the tailrace walls. Each aluminum dam board contained four 3-inch counting tubes; the entire board is referred to as a bank of counters. Counters were checked for accuracy by forcing a known number of fish through the counters before starting the experiment. To further test the accuracy of the counters, two banks of counters were placed in a series in the tailrace to double count the number of emigrating fish. That is, fish traveling through the first bank of counters would be counted a second time as they passed through the second bank of counters.

The number of fish counted by each counting tube was recorded twice in each 24-hour period (approximately 0900 hours and 1700 hours). The number of fish emigrating at night (defined as the period of time between the morning count and the evening count of the previous day) was compared to the number of fish that emigrated during the day (defined as the period of time between the morning count and the evening count of the same day). Fish counters were reset after each count was recorded. The total number of fish that emigrated from Squaw Creek Pond was calculated for each bank of counters by summing the diel counts for each counting tube. Fish that were diverted and collected in the holding area for PIT-tagging were enumerated and added to the emigration total for that day. The percentage of fish that emigrated from the pond was calculated by dividing the number of fish that emigrated by the number of fish that were stocked, multiplied by 100. Linear regression was used to identify correlations between fish emigration and average overall water temperature, average inflow water temperature, and average outflow water temperature. The number of fish counted by the fish counter tunnels was compared to the population estimate from the mark-recapture study.

Mark-Recapture Study

A direct sampling mark-recapture estimate (Scheaffer et al. 1990) was used to estimate the number of nonmigratory steelhead remaining in Squaw Creek Pond on May 19, the date the study was terminated. Based on observations of other Snake River stocks, we assumed a 15% residualism rate (Kent Ball, IDFG, personal communication). Therefore, approximately 7,900 fish were expected to be in the pond on May 19. To ensure an estimate within 80% of the population, IDFG personnel collected 2,100 steelhead from the pond using a beach seine and marked each fish with an upper caudal fin clip. Marked fish were returned to the pond, and the population was resampled. The estimated number of fish remaining in the pond was compared to the number calculated using the fish counter method.

PIT Tagging of Migrant and Nonmigrant Steelhead

PIT tags were used to evaluate emigration success to dams located on the Snake and Columbia rivers. Three different groups of steelhead were PIT tagged. Two of the groups were steelhead that emigrated from the pond; these were defined as early or late migrants based on the time of emigration. The other group of tagged fish were steelhead that did not volitionally emigrate from the pond by May 19; these were defined as nonmigrants.

During evenings before collecting migrant steelhead for PIT tagging (April 28 and May 18 for the early and late migrant groups, respectively), the fish counting banks were removed from the outflow channel and replaced by screens. Fish were allowed to migrate at night into a holding area via a diversion pipe. A total of 300 fish were collected on April 29 (early migrants) and 301 fish were collected on May 19 (late migrants) from the holding area with a dip net. They were then transported to the PIT-tagging station in buckets where they were anesthetized and PIT tagged (Prentice et al. 1990). Fork length (mm), weight (g), smolt stage (parr, transitional, smolt), and other pertinent information, such as precocity, were recorded for each fish that was tagged. The PIT-tagged fish were allowed to recover in fresh water before being released into the outflow channel immediately downstream of the screen. All migrant steelhead remaining in the holding area after tagging were enumerated and released in the outflow channel immediately downstream of the screen. All mortalities were scanned for PIT tags. PIT tag files were submitted to the Columbia River Basin PIT Tag Information System (PTAGIS) (Pacific States Marine Fisheries Commission 1998).

On May 19, a screen was placed in the outflow channel upstream of the diversion pipe to stop all emigration from the pond. Steelhead remaining in the pond at that point were classified as nonmigrants. On May 19, a random sample of nonmigrant steelhead was collected from the pond using a beach seine. Three hundred fish were randomly selected from the seine and transported to the PIT-tagging station in buckets. PIT tagging, data collection, and fish release methods for nonmigrants were as described above. PIT tag files were submitted to PTAGIS.

The number of fish interrogated for each group (e.g., early migrants, late migrants, nonmigrants) and for each smolt stage category (e.g., parr) was determined by querying the PTAGIS database in August. Interrogation systems for PIT-tagged fish are located at Lower Granite, Little Goose, and Lower Monumental dams on the lower Snake River and at McNary Dam on the Columbia River. The rate at which PIT-tagged steelhead were interrogated was calculated by dividing the total number of unique interrogations at Lower Granite, Little Goose, Lower Monumental, and McNary dams by the number of PIT-tagged fish released, multiplied by 100. Median travel time to Lower Granite Dam was calculated for each group (early and late migrants, nonmigrants). All data analyses were performed using SYSTAT (SYSTAT 1996) and tested at the 0.05 significance level. Chi-square test of independence with the Yates correction for continuity (Zar 1984) was used to determine if there was a significant difference in interrogation rates between late migrants and nonmigrants. The Mann-Whitney test was used to test for a significant difference in travel time to Lower Granite Dam between late migrants and nonmigrants.

For PIT-tagged fish, mean fork length, weight, and condition factor (K) were calculated for each group (early and late migrants, nonmigrants) and for each smolt stage category. Data were examined for normality. Significant differences in fork length, weight, and condition factor between late migrants and nonmigrants were tested using a t-test or the Mann-Whitney test, depending on normality. Differences in fork length, weight, and condition factor among smolt stage categories, within groups, were determined using the General Linear Models Procedure or the Kruskal-Wallis one-way analysis of variance, depending on normality. The Tukey test was used to separate means if data were normally distributed; if data were not normally distributed the Mann-Whitney test using the Bonferroni adjustment was used. Smolt stage categories with less than five fish were not included in the analyses.

Nonmigrant Data

On May 19, a random sample of nonmigrant steelhead was collected from the pond using a beach seine. A total of 197 steelhead were randomly selected and euthanized. Descriptive data for nonmigrant steelhead were collected and analyzed as described for pre-emigration data. For each smolt stage category, length, weight, and condition factor data were tested for normality. Data normally distributed were tested for significant differences among smolt stage categories using the General Linear Models Procedure. Tukey's post hoc comparison test was used to separate means. Data not normally distributed were tested using the Kruskal-Wallace test. The Mann-Whitney test using the Bonferroni adjustment was used to detect significant differences among smolt stage categories. The chi-square test of independence with the Yates correction for continuity (Zar 1984) was used to test for differences between the sex composition of fish classified as nonmigrants and the prestocking population. The chi-square test was also used to determine if the number of precocial males differed significantly between the prestocking population and fish classified as nonmigrants.

RESULTS

Pre-emigration Data

On April 8, 202 juvenile steelhead were collected at Magic Valley Fish Hatchery. All of the fish sampled were classified as smolts; therefore, no statistical comparisons were made among smolt stages. Mean length, weight and condition factor were 220 mm, 111 g, and 1.03, respectively (Table 1). Appendix A shows the length frequency distribution of steelhead sampled from Magic Valley Fish Hatchery on April 8. The sample was comprised of 51.5% (104) males and 48.5% (98) females (Table 1). Precocious males (n=3) made up 1.5% of the total sample (males and females, n=202) and 2.9% of the male component of the sample (n=104) (Table 1). Mean length, weight, and condition factor for the precocial males (n=3) in the sample were 247 mm, 165 g, and 1.21, respectively. Mean length, weight, and condition factor for the nonprecocial males (n=101) in the sample were 220 mm, 112 g, and 1.02, respectively.

Fish Emigration

Fish Counter

The first bank of counters in the tailrace counted 37,431 steelhead, while the second bank of counters counted 38,750 steelhead. We chose to use the number from the first bank of counters, since the second bank of counters was located in an area which was subject to more turbulence and thus more likely to include false counts due to air bubbles.

A total of 37,431 steelhead (70.9%) emigrated from Squaw Creek Pond between April 20 and May 18, 1998. A total of 20,349 fish emigrated during the night time period, whereas 17,082 emigrated during the day time period (Figure 2). Diel fish emigration ranged from 24 fish on April 25 to 5,708 fish on May 9 (Figure 3).

No correlation was found between diel fish emigration and average overall water temperature (r^2=0.001, P=0.896), average inflow water temperature (r^2=0.033, P=0.346), or average outflow water temperature (r^2=0.033, P=0.348). Figure 4 shows diel fish emigrated in relation to the intake and outflow water temperatures between April 20 and May 18.

Mark-Recapture Study

We estimated using the mark-recapture technique that 4,848 ± 286 (95% C.I.) steelhead did not emigrate from Squaw Creek Pond. In comparison, we calculated (using counts from the first bank of counters) that 12,576 steelhead had not emigrated from the pond at the time that the mark-recapture estimate was performed (Table 2).

Table 1. Summary statistics and sex characteristics for steelhead[a] sampled at Magic Valley Fish Hatchery, April 8, 1998.

SAMPLE STATISTICS

Variable	n	Mean	SD
Fork Length (mm)	202	220.34	22.18
Weight (g)	199	111.42	30.51
Condition Factor (K)	199	1.03	0.07

SEX COMPOSITION

Sex	n	Percent
Female	98	48.5
Male	104	51.5

PRECOCITY

Sample	Number Sampled	Number Precocial[b]	Percent Precocial

Total (Males + Females)	202	3	1.5
Males Only	104	3	2.9

[a] All steelhead were classified as smolts
[b] All precocial fish were males

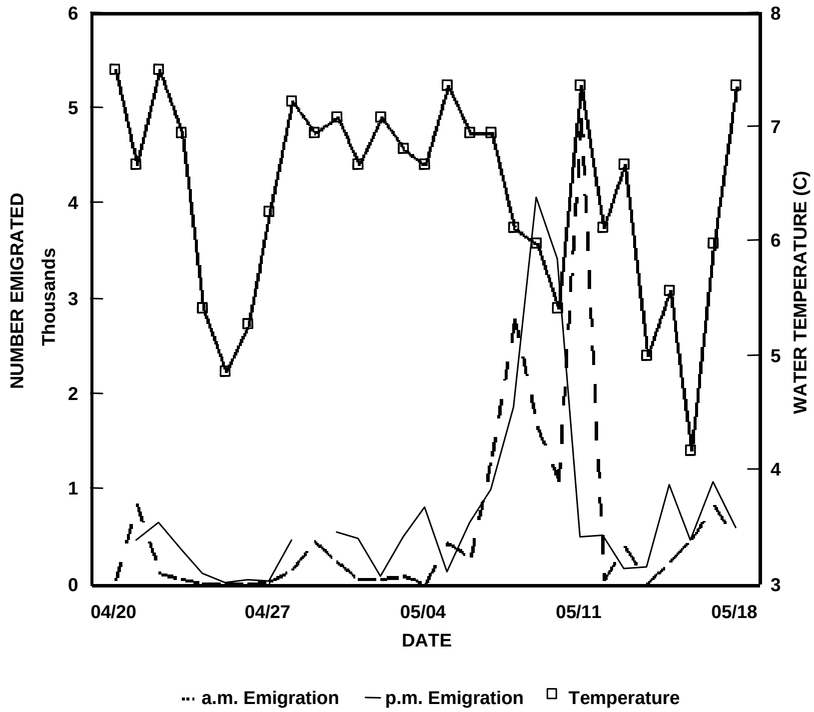

Figure 2. Fish emigration during the day (the period of time between the morning count and the evening count of the same day) and night (the period of time between the morning count and the evening count of the previous day), plotted with average daily water temperature of Squaw Creek Pond between April 20 and May 18, 1998.

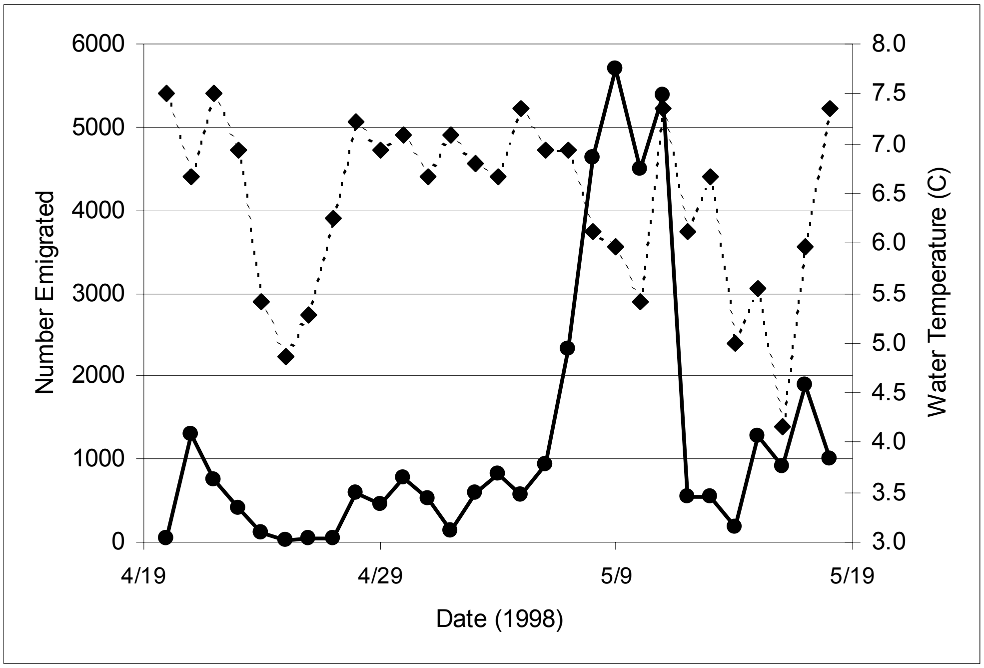

Figure 3. Diel fish emigration (solid line), plotted with average daily water temperature (dashed line) of Squaw Creek Pond between April 20 and May 18, 1998.

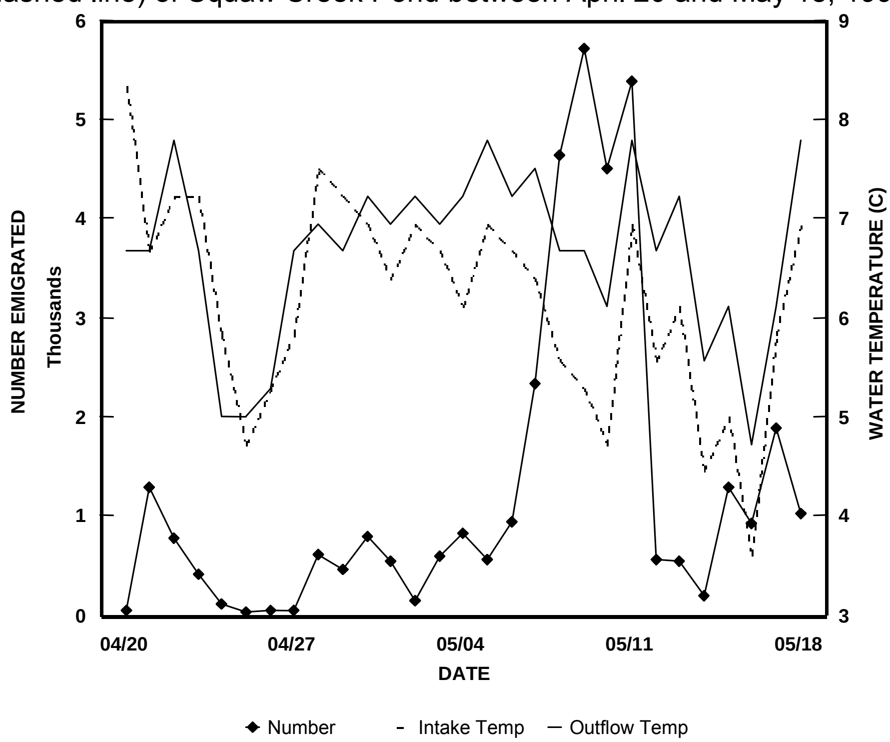

Figure 4. Diel fish emigration, plotted with average intake and outflow water temperature of Squaw Creek Pond between April 20 and May 18, 1998.

PIT Tagging of Migrant and Nonmigrant Steelhead

A total of 298 early migrant, 301 late migrant, and 300 nonmigrant steelhead were PIT tagged and released into the outflow channel below Squaw Creek Pond. A total of 300 early migrant steelhead were PIT tagged; however, two fish possessed PIT tags with identical identification numbers and were dropped from the analyses. Fish classified as early migrants were released on April 29, and fish classified as late migrants and nonmigrants were released on May 19. A total of 222 (74.5%) early migrants, 110 (36.5%) late migrants, and 125 (41.7%) nonmigrants were interrogated at downstream dams (Table 3). Interrogation rates for late migrants and nonmigrants were not significantly different (χ^2 =1.45, P = 0.229). The PIT tag interrogation rate of early migrants was not tested against interrogation rates of other groups, since these fish were released at a different time and, thus, experienced different migration conditions. Travel times to Lower Granite Dam were not significantly different (P=0.772) between late migrants and nonmigrants. Mean daily inflow of the Snake River at Lower Granite Dam ranged from approximately 80 thousand cubic feet per second (kcfs) to 130 kcfs during emigration of the early migrant group and from 120 kcfs to 220 kcfs during emigration of the late migrant and nonmigrant groups (Figure 5). Table 4 summarizes interrogations, by group and smolt stage), of PIT-tagged steelhead released from Squaw Creek Pond.

Descriptive statistics for length, weight, and condition factor of PIT-tagged fish from the early migrant, late migrant, and nonmigrant groups are shown in Table 5. Length frequency distributions of PIT-tagged steelhead from the early migrant, late migrant, and nonmigrant groups are shown in Appendix B, Appendix C, and Appendix D, respectively. Fish from the nonmigrant group were significantly longer (P<0.001) and heavier (P<0.001) than fish from the late migrant group. However, mean condition factor for fish from the later migrant group was significantly higher (P=0.004) than for the nonmigrant group. Table 6 shows descriptive statistics, by smolt stage, of PIT-tagged steelhead released from Squaw Creek Pond. Steelhead from the early migrant group were PIT tagged 16 days earlier than steelhead from the late migrant and nonmigrant groups. Thus, early migrants were not tested against late migrants or nonmigrants in terms of length, weight, and condition factor. For late migrants, fish classified as smolts did not differ from those classified as transitional in terms of mean length (P=0.131), weight (P=0.271), or condition factor (P=0.631). For early migrants, smolts were significantly longer (P<0.001) and heavier (P<0.001) than fish classified as transitional. Precocial males (n=2) comprised <1% of the early migrant PIT tag group. No precocial fish were identified from the late migrant and nonmigrant PIT tag groups.

Table 2. Chronological comparison of two methods used to inventory fish emigration from Squaw Creek Pond.

EVENT	FISH COUNTER	MARK-RECAPTURE
# Stocked (April 10-14)	52,800	52,800
# Mortalities	- 58	- 58
	52,742	52,742
# Emigrated (April 20 to May 18)	- 37,431	*- 45,159*[a]
# Nonmigrants (May 18)	15,311	*7,583*[a]
# Hauled to area ponds (May 19)	- 2,735	- 2,735
# Remaining in Squaw Pond[b] (May 19)	**12,576**	**4,848**
# Hauled to area ponds (May 19)	- 2,649	- 2,649

# Remaining in Squaw Creek Pond at start of catch-out fishery (May 23)	**9,927**	**2,199**

[a] These numbers were derived following the mark-recapture study (52,742 - (2,735 + 4,848) = 45,159 and 52,742 - 45,159 = 7,583).

[b] Estimated number at the time of the mark-recapture study. A total of 2,735 fish were removed from the pond before the mark-recapture study.

Table 3. PIT tag interrogation results for three groups of steelhead released from Squaw Creek Pond in 1998. The PIT tag interrogation sites are Lower Granite (LGR), Little Goose (LGO), Lower Monumental (LMN), and McNary (MCN) dams. Median travel time is to Lower Granite Dam only.

				Number (No.) / Percent (%) Interrogated										
				LGR		LGO		LMN		MCN		TOTAL		Median Travel Time
Group / Tagging File	Release Site	Release Date	Number Released	No.	%	No.	%	No.	%	No.	%	No.	%	(days)
Squaw Creek Pond Steelhead Acclimation Study														
EARLY MIGRANTS														
TSC98119.SQP	Squaw Pond	4/29/98	298	163	54.7	33	11.1	25	8.4	1	0.3	222	74.5	11.7
LATE MIGRANTS														
TDR98139.SQ2	Squaw Pond	5/19/98	301	52	17.3	32	10.6	22	7.3	4	1.3	110	36.5	11.5
NONMIGRANTS														
TDR98139.SQ3	Squaw Pond	5/19/98	300	53	17.7	39	130	28	9.3	5	1.7	125	41.7	12.2

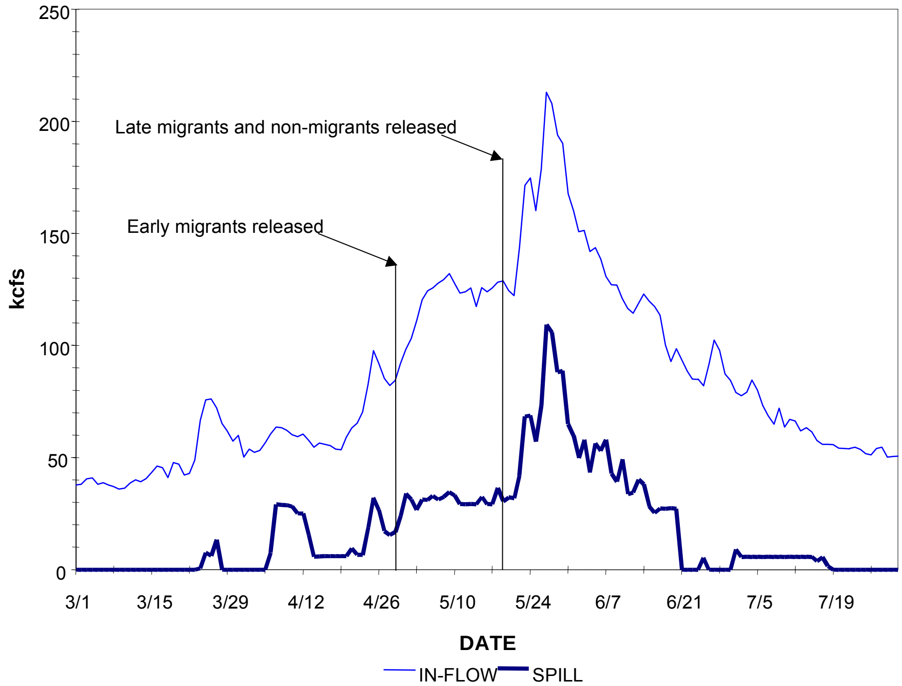

Figure 5. Mean daily in-flow and spill of the Snake River at Lower Granite Dam, Washington, between March 1 and July 31, 1998. Steelhead from the early migrant group were PIT tagged and released on April 29, whereas steelhead from the late migrant and nonmigrant groups were PIT tagged and released on May 19.

Table 4. PIT tag interrogation results, by group and by smolt stage, for steelhead released from Squaw Creek Pond in 1998.

Group/ Release Date	Smolt Stage	Number Released	Number Interrogated	Interrogation Rate (%)
Early Migrants	Smolt	290	220	75.9
April 29	Transitional	6	2	33.3
	Parr	2	0	0.0
Late Migrants	Smolt	295	110	37.3
May 19	Transitional	5	0	0.0
	Parr	1	0	0.0
Nonmigrants	Smolt	300	125	41.7
May 19	Transitional	0	0	--
	Parr	0	0	--

Table 5. Descriptive statistics, by group, of PIT-tagged steelhead released from Squaw Creek Pond in 1998.

	Fork Length (mm)	Weight (g)	Condition Factor (K)
Early Migrants			
n	296.00	296.00	296.00
Mean	238.54	125.77	0.91
SD	20.91	32.57	0.07
Late Migrants			
n	287.00	287.00	287.00
Mean	228.62	106.57	0.87
SD	22.60	32.10	0.08
Nonmigrants			
n	299.00	299.00	299.00
Mean	244.47	127.18	0.85
SD	19.99	32.39	0.05

Table 6. Descriptive statistics, by smolt stage, of PIT-tagged steelhead released from Squaw Creek Pond in 1998. All PIT-tagged nonmigrants were classified as smolts.

	Fork Length (mm)	Weight (g)	Condition Factor (K)
Early Migrants			
Smolt			
n	288.00	288.00	288.00
Mean	239.54	127.01	0.91
SD	20.01	31.80	0.07
Transitional			
n	6.00	6.00	6.00
Mean	193.33	67.82	0.93
SD	11.04	14.45	0.09
Parr			
n	2.00	2.00	2.00
Mean	231.00	121.35	0.98
SD	26.87	32.74	0.08
Late Migrants			
Smolt			
n	281.00	281.00	281.00
Mean	229.25	107.23	0.87
SD	22.09	31.63	0.08
Transitional			
n	5.00	5.00	5.00
Mean	206.00	83.52	0.89
SD	27.41	41.50	0.11
Parr			
n	1.00	1.00	1.00
Mean	167.00	37.70	0.81
SD	--	--	--
Nonmigrants			
Smolt			
n	299.00	299.00	299.00
Mean	244.47	127.18	0.85

SD	19.99	32.39	0.05

Nonmigrant Data

On May 19, juvenile steelhead (n=197) were collected from Squaw Creek Pond—193 smolts and 4 fish classified as transitional. Mean length, weight, and condition factor for the smolts were 238 mm, 119 g, and 0.87, respectively (Table 7). Mean length, weight and condition factor for transitional fish were 224 mm, 114 g, and 0.93, respectively (Table 7). Appendix E shows the length frequency distribution of nonmigrant steelhead sampled at Squaw Creek Pond on May 19, 1998. The sample was comprised of 60.9% (120) males and 39.1% (77) females (Table 7). The sex composition of the nonmigrant steelhead did not differ significantly (χ^2=3.228, P=0.072) from the prestocking population sampled at Magic Valley Fish Hatchery on April 8. Precocial males (n=13) made up 6.6% of the total sample (males and females, n=197) and 10.8% of the male component of the sample (n=120) (Table 7). Fish classified as nonmigrants had a significantly higher (χ^2=4.177, P=0.041) proportion of precocial males than the prestocking population at Magic Valley Fish Hatchery. Mean length, weight, and condition factor for the precocial males in the sample (n=13) were 249 mm, 148 g, and 0.94, respectively. Mean length, weight, and condition factor for the nonprecocial males in the sample (n=107) were 237 mm, 116 g, and 0.86, respectively.

Nonmigrant Steelhead Disposition

A total of 5,384 fish were collected from Squaw Creek Pond and transported to Mosquito Flat Reservoir, Kelly, Hayden, and Hyde lakes, and Kids Pond. The remaining nonmigrant steelhead were retained in the pond for a catch-out fishery.

Table 7. Summary statistics and sex characteristics for nonmigrant steelhead sampled at Squaw Creek Pond, May 19, 1998.

SAMPLE STATISTICS

Stage	Variable	n	Mean	SD
Smolt	Fork Length (mm)	193	237.96	19.84
	Weight (g)	193	118.64	28.63
	Condition Factor (K)	193	0.87	0.08
Transitional	Fork Length (mm)	4	223.75	50.82
	Weight (g)	4	113.83	68.24
	Condition Factor (K)	4	0.93	0.11
TOTAL	Fork Length (mm)	197	237.68	20.71
	Weight (g)	197	118.54	29.57
	Condition Factor (K)	197	0.87	0.08

SEX COMPOSITION

Sex	n	Percent
Female	77	39.1
Male	120	60.9

PRECOCITY

	Number	Percent

Sample	Number Sampled	Precocial[a]	Precocial
Total (Males + Females)	197	13	6.6
Males Only	120	13	10.8

[a] All precocial fish were males

DISCUSSION

Passive integrated transponder tags were used as our main tool to evaluate the effectiveness of this acclimation/volitional release strategy. We failed to reject the null hypothesis—there is no significant difference in PIT tag interrogation rates between steelhead that emigrated from the pond and steelhead that did not emigrate (late migrant group versus nonmigrant group). Descriptive statistics for each group, particularly the sex composition sampling and the smolt stage classification data, were expected to add supporting evidence to our inference, and in fact they do. Viola and Schuck (1995) defined the steelhead that failed to volitionally emigrate from Curl Lake acclimation pond in Washington as residuals and described them as being larger than average, dark in color, and primarily males. Although the nonmigrant steelhead in Squaw Creek Pond were significantly longer and heavier than late migrants, which concurs with Viola and Schuck, they were almost all classified as smolts. Moreover, we found that the sex composition of the nonmigrant population was not significantly different than that of the prestocking population. These data add some support to the results obtained from PIT tags, that interrogation rates of late migrants and nonmigrants were not different. However, it is not overwhelming evidence, particularly when the precocity rate of the nonmigrants is considered.

The rate of precocity was significantly lower in the prestocking population as compared to the population of nonmigrants. This suggests that the release technique did work and that precocial males were detained in the pond. However, a contrary explanation of these data would be that precocial development was incomplete on April 8 (the date baseline data were collected) and that more fish became precocial by May 19 (the end of the study). That is, the proportion of precocial males in the population changed not due to emigration, but rather to the timing of precocial development in conjunction with sample date.

The evidence presented above shows that migration performance was not significantly different between the late migrant and nonmigrant groups, and this finding is supported by some morphological statistics. However, the high PIT tag interrogation rate of the early migrant group (74.5%) could suggest that the technique was initially effective at separating true smolts from residuals but became less effective over time. Since the three groups were not released at the same time and thus experienced different migration conditions, it was inappropriate to test interrogation data for differences among groups. To explore the plausibility of this idea, we examined the migration conditions of the early migrant group with the late migrant and nonmigrant groups, and we contrasted interrogation data of the early migrant group to two other releases of PIT-tagged fish reared at Magic Valley Fish Hatchery.

Snake River flow measured at Lower Granite Dam and the amount of water spilled over the dam were substantially higher during the emigration of the late migrant and nonmigrant groups as compared to the early migrant group (Figure 5). This may explain the relatively low interrogation rates of the late migrant and nonmigrant groups. That is, the difference in interrogation rates between the early and late groups may be due to PIT tag interrogation efficiencies related to water flow and dam operations (i.e., spill) rather than migration performance.

We compared the PIT tag interrogation rate of the early migrant group to the interrogation rates of two general production groups of steelhead reared at Magic Valley Fish Hatchery and released in the East Fork Salmon River, located 13 river kilometers downstream from Squaw Creek. If migration behavior was truly an indicator of whether the fish was a true smolt or residual, one would expect the interrogation rate of the Squaw Creek Pond early migrant group to be higher than that of a general production steelhead release where the PIT-tagged fish were randomly selected from the population. In fact, tagged early migrants had a higher interrogation rate than the PIT-tagged fish in either production group, but narrowly in one case. East Fork B-stock steelhead were released at the East Fork Salmon River weir (approximately 29 river kilometers upstream of the stream mouth) on April 30 and had an interrogation rate of 74.0%. Dworshak B-stock steelhead were released at Herd Creek (approximately 14 river kilometers upstream of the Salmon River confluence) on April 25 and had an interrogation rate of 63%. In contrast, the early migrant group released from Squaw Creek Pond on April 29 had an interrogation rate of 74.5%. We expected the early migrant group to vastly outperform the two general production releases, but these results add to our suspicions that the technique was ineffective in separating smolts from residuals. However, additional factors, such as stock performance (stock effect), time of tagging (tagging effect), acclimation effect, and size-at-release, should be investigated before placing too much weight on this contrast.

Rhine et al. (In Press) and Bigelow (1995) reported that larger size steelhead smolts were interrogated at higher rates than the smaller size fish. Our findings concur with those of Rhine et al. (In Press) and Bigelow (1995). Steelhead from the early migrant group were significantly longer and had higher interrogation rates than fish released at Herd Creek. Another factor that may have influenced our results is cold water acclimation. Steelhead used in this study were reared in 15ºC water at Magic Valley Fish Hatchery until April 8. Fish were then transported to Squaw Creek Pond, where they remained up to four weeks in water ranging from 4ºC-8ºC. Schuck et al. (1998) suggested that, in some cases, holding juvenile steelhead in cold water acclimation ponds might delay the smolting process and decrease juvenile survival. Fish released into the East Fork Salmon River were not acclimated in cold water, but were kept in 15ºC water until release. Finally, steelhead released into the East Fork Salmon River were PIT tagged on February 23, whereas the steelhead in the early migrant group were PIT tagged on April 29. We are unaware of any data that quantifies the effect of PIT tagging fish in relation to time of release. However, Sharpe et al. (1998) found that fish handling procedures, such as fin clipping and coded-wire-tagging, induce short-term stress in chinook salmon and recommend a recovery period of at least 24 h before release for fish that have been stressed, especially if being released into a more physically demanding environment.

A total of 37,431 steelhead emigrated from the pond according to the fish counter, whereas the number derived by the mark-recapture estimate was 45,159. Appleby and Tipping (1991) used a Smith-Root Model SR-1600 fish counter (an older model of the counter we used) to count steelhead and sea-run cutthroat trout *O. clarki* and found the accuracy to be within 1.5% of hand counts. The discrepancy between the two inventory methods may be explained, in part, by predator loss (i.e., birds and otters) and an unknown number of fish that escaped under the outlet screen. Prior to the installation of the fish counter, personnel at Squaw Creek Pond observed fish in the outlet channel and discovered that the outlet screen was not totally secured to the channel floor. The counts on the two banks of counters were fairly close—37,431 for the first bank and 38,750 for the second, which adds support for the accuracy of counters. We chose to use the data from the counters so we could examine emigration timing in relation to water temperature and photoperiod. Steelhead emigration was not correlated with water temperature, but more steelhead emigrated during the night time period.

If we assume that 47,431 steelhead emigrated from the pond, then 15,311 fish remained in the pond at the end of the study (May 19). Based on the 41.7% interrogation rate of the nonmigrants that were PIT tagged, a minimum of 6,385 of the fish were actually smolts that may have emigrated had they been released. At an average smolt-to-adult return rate of 0.174% for B-strain steelhead (brood years 1988-1992) reared at Magic Valley Fish Hatchery and released into the East Fork Salmon River, these fish may have returned nine adults.

Conversely, a maximum of 8,926 of the 15,311 steelhead remaining in the pond were residual steelhead (58.3% of the PIT-tagged nonmigrants were not interrogated) and were prevented from entering the Salmon River. Fishery managers must determine if retaining a population comprised of up to 40% smolts is warranted to remove residuals and whether this strategy is worth expanding to benefit listed species.

The release strategy tested was unsuccessful at separating smolts from residuals as evaluated in 1998 using PIT tag interrogation rates. This does not diminish the other benefits of using Squaw Creek Pond as a release site for hatchery steelhead. For instance, returning adult steelhead could be collected at the pond, which would reduce adult straying, improve hatchery documentation and evaluation, and provide an additional egg source. In addition, using Squaw Creek Pond as a release site may provide some operational benefits by providing a back-up rearing location in case of disease outbreaks or catastrophic events at the hatchery.

RECOMMENDATIONS

1. Collect morphological data for future studies before removing nonmigrants for catch-out fisheries.

2. Record daily emigration counts at 0800 hours and 2000 hours to more accurately quantify emigration during each day and night time period.

3. Reduce sources of error in data collection operations by maintaining consistent personnel duties.

4. Temper pond with well water in order to lengthen acclimation period before volitional release.

5. Schedule releases of production steelhead in the outlet channel of Squaw Creek Pond and in Squaw Creek proper so that comparisons can be made between the study and production groups under similar migration conditions.

6. Document precocial development over time in a captive population of steelhead to ensure initial sample data are representative.

ACKNOWLEDGMENTS

We would like to thank the personnel at Magic Valley Fish Hatchery for rearing the fish for this study and for their assistance with data collection. We would also like to thank Kent Ball, Tom Curet, Mike Larkin, and Sawtooth Fish Hatchery personnel for their pond operation and data collection efforts. A word of thanks is also extended to the personnel from the Nampa Research Office for helping PIT tag fish for this study. We express our appreciation to the United States Fish and Wildlife Service, Lower Snake River Compensation Plan Office, for providing funding for this study.

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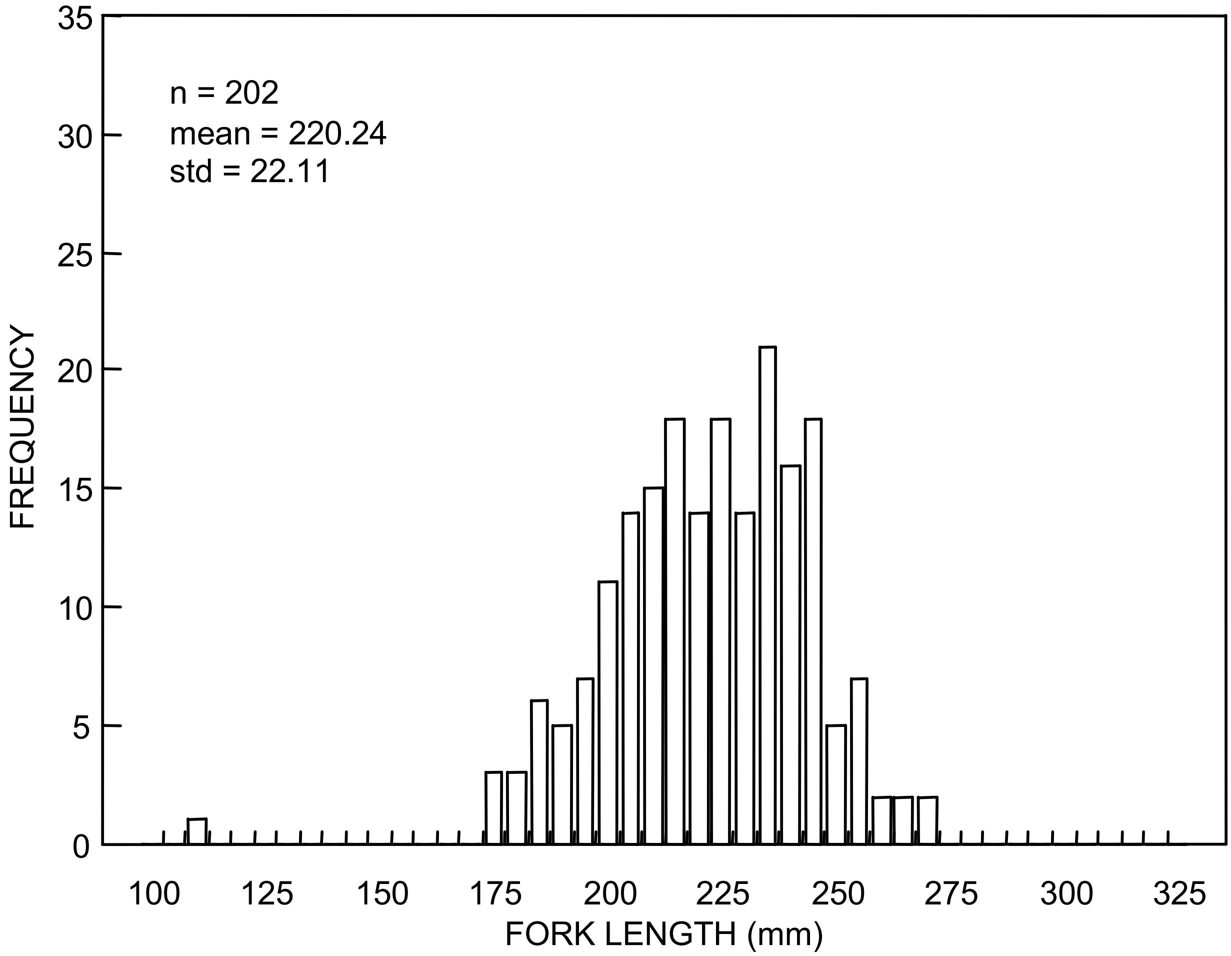
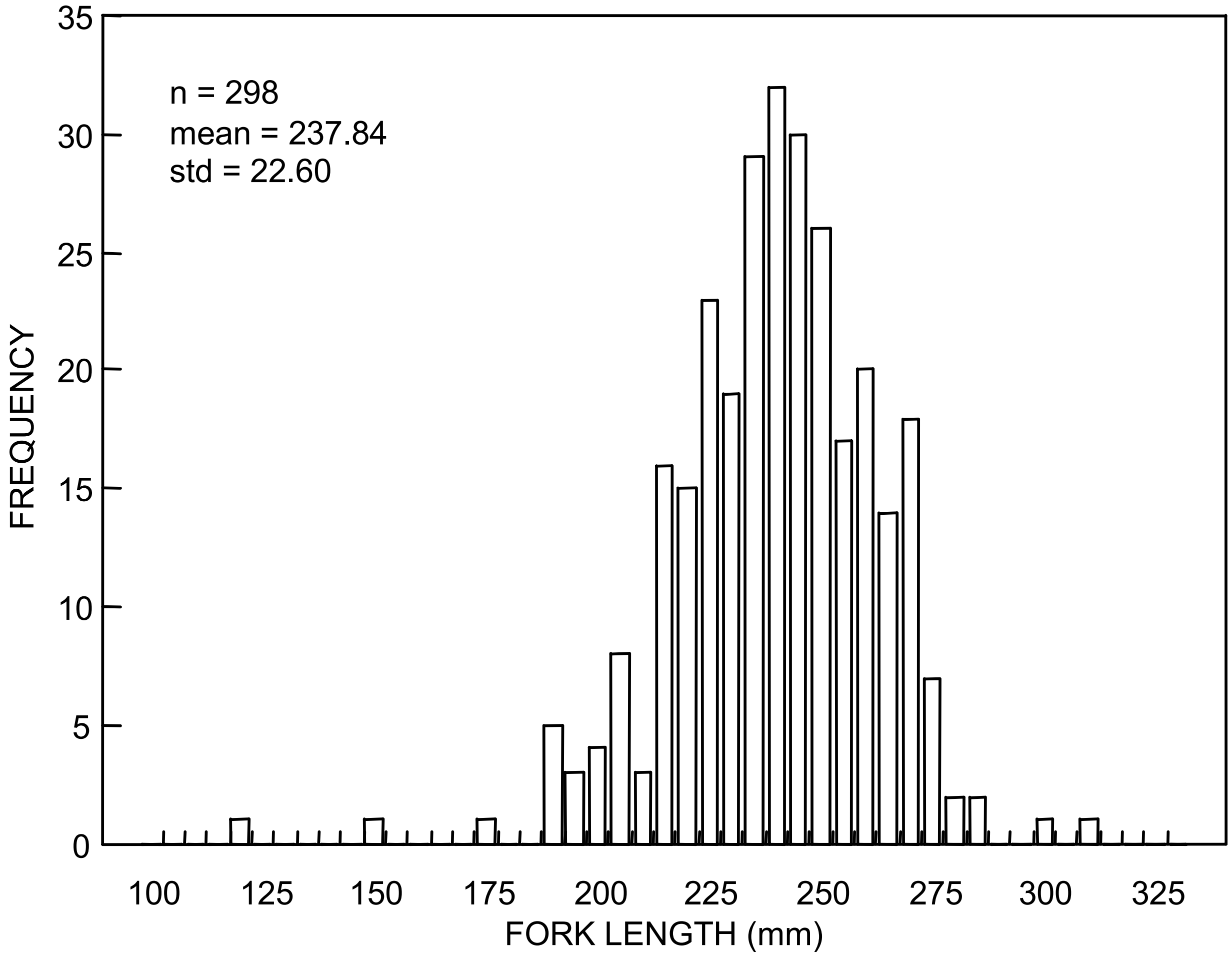
APPENDICES

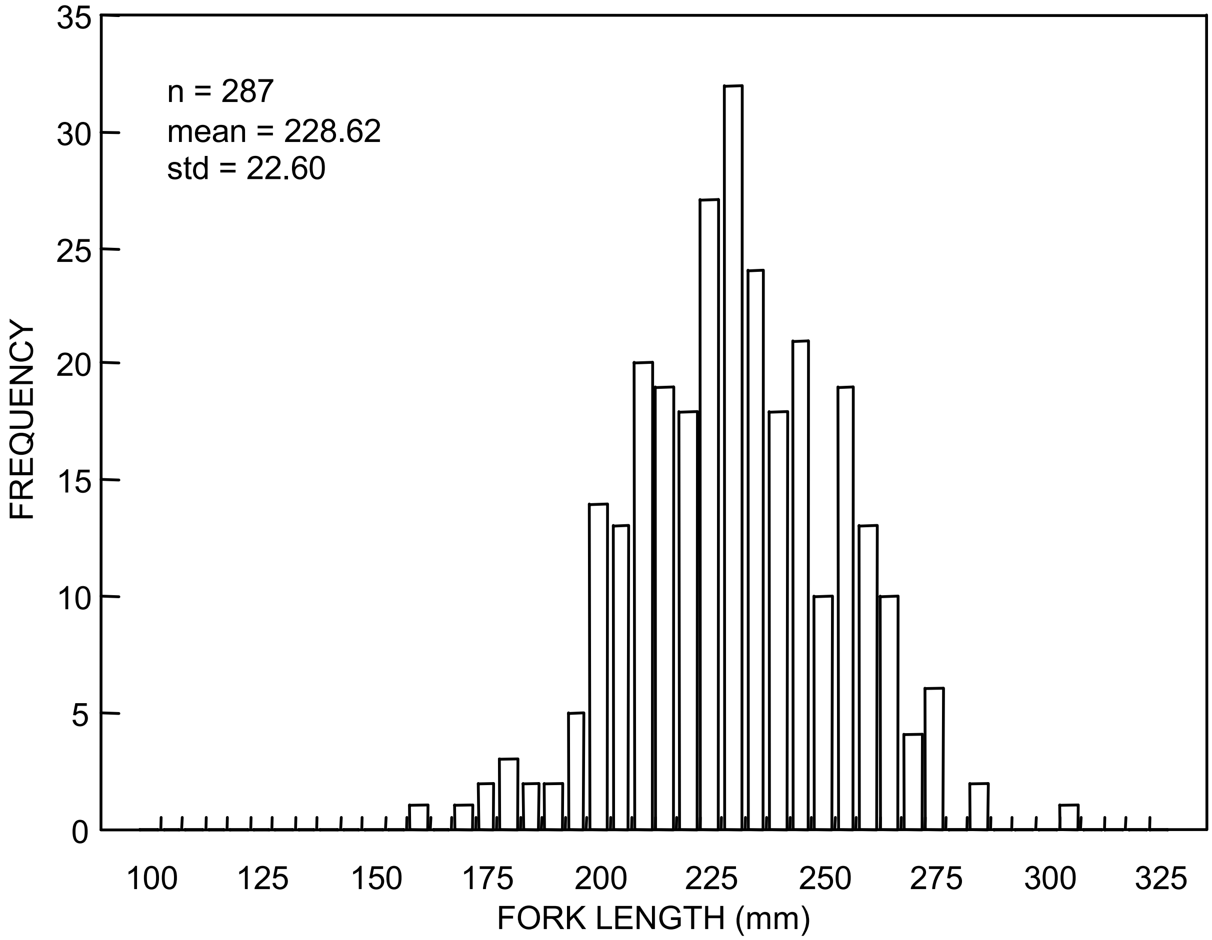
Appendix A. Length frequency distribution of steelhead sampled at Magic Valley Fish Hatchery, April 8, 1998. All fish were classified as smolts.



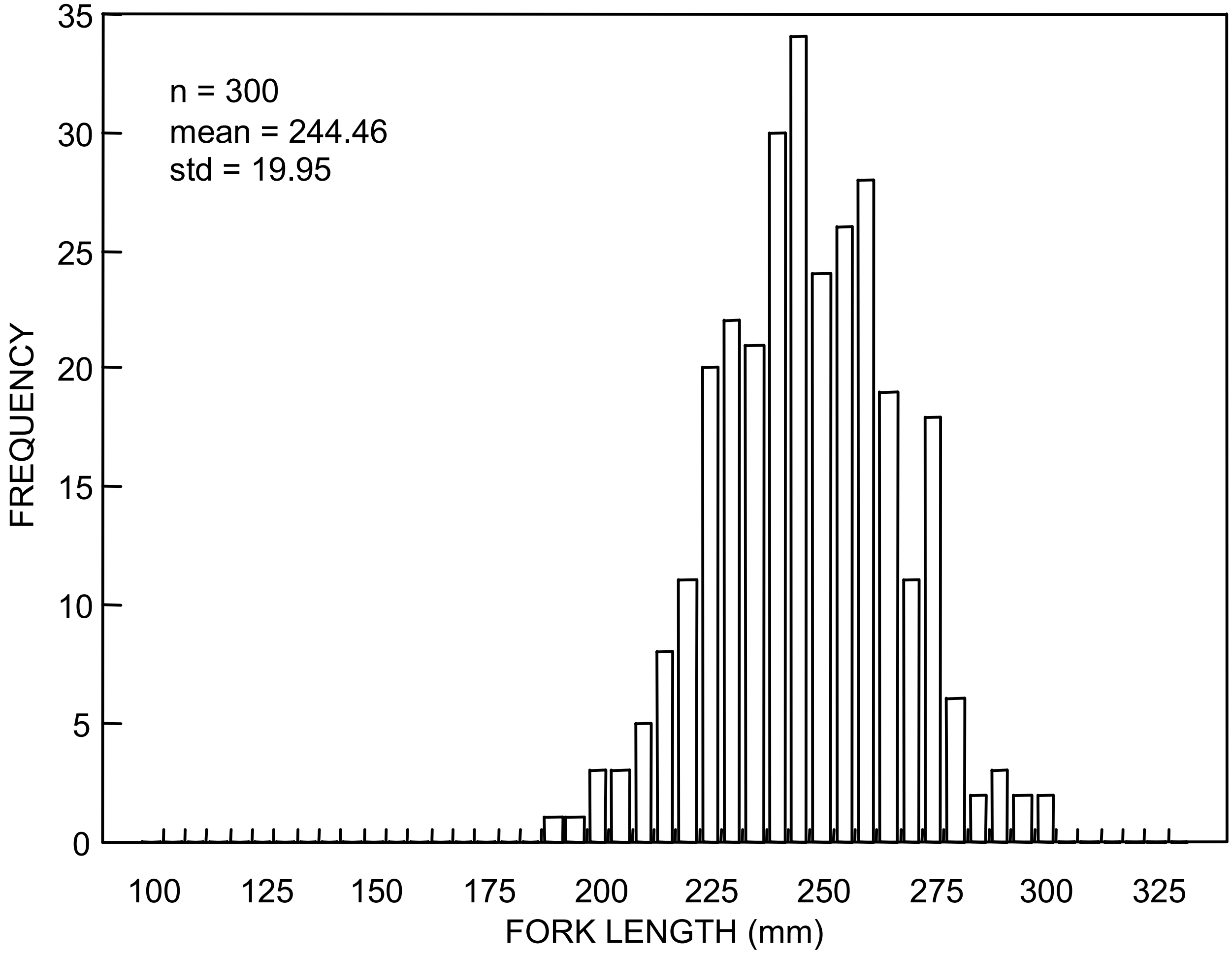
Appendix B. Length frequency distribution of steelhead from the early migrant group, PIT tagged and released at Squaw Creek Pond on April 29, 1998.



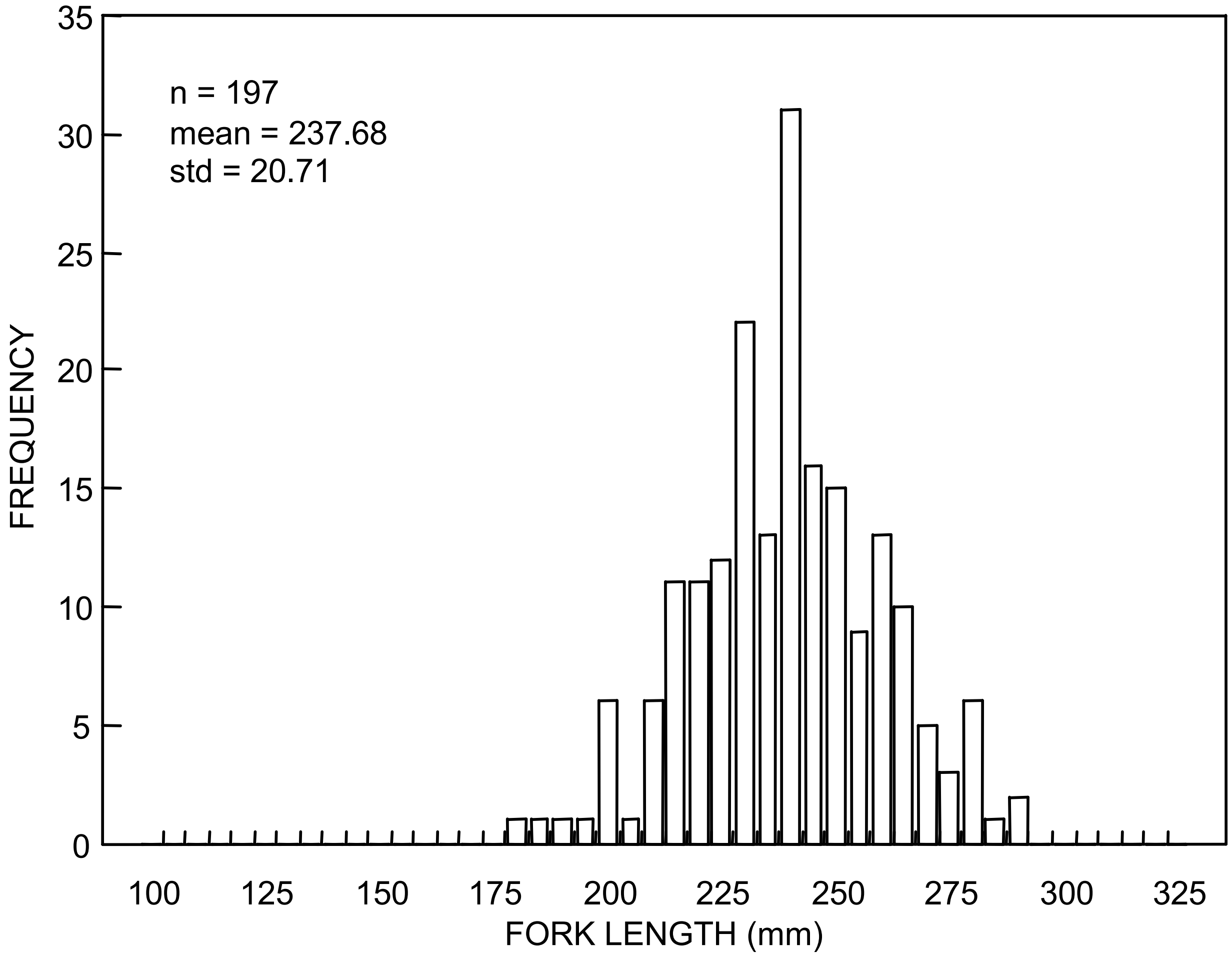
Appendix C. Length frequency distribution of steelhead from the late migrant group, PIT tagged and released at Squaw Creek Pond on May 19, 1998.



Appendix D. Length frequency distribution of steelhead from the nonmigrant group, PIT tagged and released at Squaw Creek Pond on May 19, 1998.



Appendix E. Length frequency distribution of nonmigrant steelhead sacrificed for sex composition information at Squaw Creek Pond, May 19, 1998



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