FISHERY RESEARCH

STEELHEAD VOLITIONAL RELEASE EXPERIMENT

SQUAW CREEK POND, IDAHO

2000 Project Progress Report

Ryan L. Newman
Fisheries Research Biologist

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STEELHEAD VOLITIONAL RELEASE EXPERIMENT

SQUAW CREEK POND, IDAHO

2000 Annual Report

By

Ryan L. Newman

Idaho Department of Fish and Game
600 South Walnut Street
P.O. Box 25
Boise, ID 83707

To

U.S. Fish and Wildlife Service
Lower Snake River Compensation Plan Office
1387 S. Vinnell Way, Suite 343
Boise, ID 83709

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ABSTRACT

For the third consecutive year, we evaluated a hatchery steelhead *Oncorhynchus mykiss* release strategy intended to reduce the number of residual steelhead entering the Salmon River in Idaho. Residual steelhead could negatively impact Endangered Species Act (ESA)-listed sockeye salmon *O. nerka*, chinook salmon *O. tshawytscha*, native 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 listed Snake River fish species caused by Columbia River basin hatchery programs. The National Marine Fisheries Service has noted these guidelines in several documents, including their predecisional recovery plan for Snake River salmon and the 1994-1998 Biological Opinion for hatcheries in the Columbia River basin.

In 2000, 110,185 hatchery steelhead were stocked into Squaw Creek acclimation pond and permitted to volitionally emigrate and enter the Salmon River. Steelhead that emigrated from the pond were enumerated using a Smith-Root fish counter. Count data indicate that 106,414 steelhead emigrated between April 25 and June 5, 2000, of which 34% emigrated during the daytime period and 66% emigrated during the nighttime period. A weak correlation was found between steelhead emigration and water temperature.

A total of 4,528 steelhead from the population destined for Squaw Creek Pond were diverted to Sawtooth Fish Hatchery and held as a captive population to determine the increase in precocity over the migration period. The proportion of precocial males in the captive population on May 9 was 5% (n = 4) compared to 2% (n = 1) in the prestocking population on April 12.

The sex composition of the steelhead that failed to emigrate from Squaw Creek Pond (nonmigrants) by June 5 was significantly different from the prestocking population. Mean fork length, weight, and condition factor of nonmigrant steelhead were 228 mm, 108 g, and 0.89, respectively. Of the 28 nonmigrant males sampled, 16 were precocial (35%).

A total of 300 early migrant, 300 captive, 600 general production, 299 late migrant, and 292 nonmigrant (force released) steelhead were tagged with passive integrated transponder (PIT) tags to evaluate juvenile migration success and arrival time to Lower Granite Dam from Squaw Creek Pond. To compare migration success and timing under similar conditions, PIT-tagged steelhead from the early migrant group were compared to the captive and general production groups, and steelhead from the late migrant group were compared to the nonmigrant group. A total of 67 (22%) late migrants and 15 (5%) nonmigrants were interrogated at downstream dams. Using PIT tag interrogations, nonmigrants had a significantly longer travel time to Lower Granite Dam than the late migrants. A total of 60 (20%) early migrants, 135 (45%) captives, 180 (60%) general production East Fork Salmon River B-stock, and 140 (46) general production Dworshak B-stock steelhead were interrogated at downstream dams. The Dworshak B-stock steelhead production group was interrogated at a significantly higher rate than the captive and early migrant groups. Steelhead from the captive group were interrogated at a significantly higher rate than the early migrant group. There were no significant differences in travel time to Lower Granite Dam among the early, captive, and production groups.

Contrary to results of the previous two years, the release strategy we tested was successful at separating smolts from residual steelhead when assessed using PIT-tag data. Based on the PIT tag interrogation rate of nonmigrant steelhead and the number of steelhead

remaining in the pond (calculated from the fish counter), we estimated that a maximum of 51 steelhead smolts were detained in the pond. The remaining 949 fish were residual steelhead. Although the release strategy was successful at separating smolts from residual steelhead, the interrogation rates of the early, late, and control study groups were abnormally low.

Author:

Ryan L. Newman
Fisheries Research Biologist

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 and spring/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 steelhead 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, were not released into the river. A majority of the residuals were precocial males. Viola and Schuck (1995) reported that the proportion of the steelhead 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, might provide a better separation of true smolts and residual steelhead.

This was the third year of a study, initiated in 1998, which evaluated the volitional release of hatchery steelhead from Squaw Creek acclimation pond. We duplicated Viola and Schuck's (1995) study in hopes of identifying a method to 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 opportunities for the public. The use of Squaw Creek Pond meets the guidelines for reducing risks to Snake River listed species caused by Columbia River 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 River basin.

GOAL

1. 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 interrogation rates and migration timing of migrant, nonmigrant, captive, and production steelhead.

5. Evaluate emigration timing in relation to water temperature.

STUDY AREA

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 manmade, 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 steelhead tag fund. Squaw Creek Pond has a surface area of approximately 4,047 m^2, a mean depth of approximately 1.2 m, and an approximate volume of 4,934 m^3, respectively. Water is supplied to the pond from Squaw Creek via a 38 cm, valve regulated, polyvinyl chloride (PVC) pipe. The outlet structure and tailrace are constructed of concrete. Two-inch channels, recessed in the concrete walls of the outlet channel, support screens and dam boards. The outlet channel, which is approximately 300 m long, 3 m wide, and 0.2 m deep, returns water to Squaw Creek from the pond.

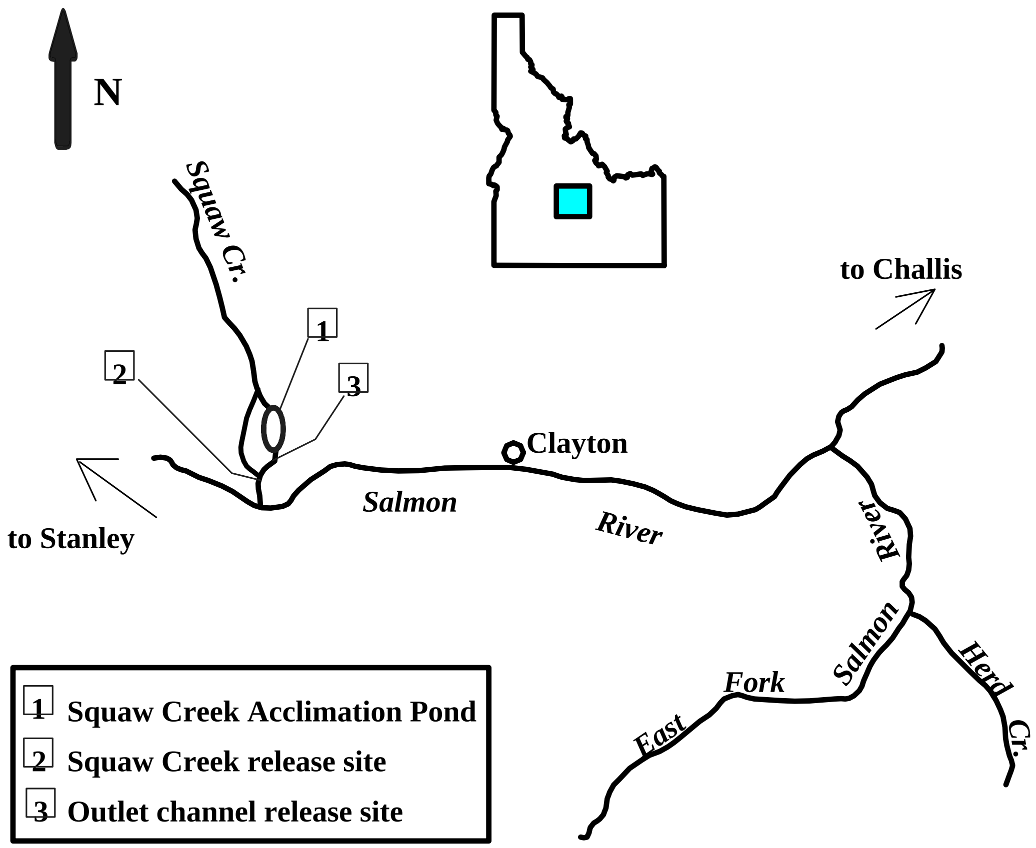

Figure 1. Location of hatchery steelhead release sites on Squaw Creek, Idaho.

METHODS

Prestocking Data

Dworshak B-stock steelhead from the 1999 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 1999. Steelhead were reared in raceways until April 2000. Prior to being released into Squaw Creek Pond (April 10), a random sample was collected from the truck using a dip net. Steelhead were taken off feed two days prior to sampling. Sampled steelhead were euthanized, measured (fork length, mm), weighed (g), sexed, and examined for sexual maturity. Steelhead with enlarged gonads were classified as sexually maturing (i.e., precocious). Mean length, weight, and condition factor ($K = \text{weight}/\text{length}^3 \times 100{,}000$) were calculated for the sample.

Squaw Creek Pond Operations

A total of 110,185 steelhead were stocked into the pond on April 10. A screen was placed in front of the outlet to prevent fish from immediately exiting the pond. The water inflow was initially set at 2.2 cubic feet per second (cfs) but varied throughout the study. Pond inflow was increased on several occasions to stimulate emigration and was decreased during periods of high run-off. 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's dry extruded 3.0 mm commercial fish food until April 22. Feeding was discontinued on April 23 to stimulate steelhead to emigrate from the pond.

On April 25 the outlet screen was removed, and the fish counting system was activated. The water level of the pond remained the same for the first three days that emigration was permitted (April 25-April 28). On April 28, the water level was lowered 10 cm by removing one dam board from the outlet channel. Rather than removing one dam board every five to six days, as in previous years, nine boards were removed in five days in 2000. On April 28, April 30, May 1, May 2, and May 3, one, two, four, one, and one boards were removed, respectively. Data collection for the study concluded on June 5.

Captive Population

A total of 4,528 steelhead from the prestocking population at Magic Valley Fish Hatchery were moved to Sawtooth Fish Hatchery to document precocial development over time in a captive population. Data from the captive population were used to determine whether precocial development was complete on April 10 or if the number of precocial fish increased after that date. This information will be used to determine if an observed change in the precocity rate of nonmigrants in Squaw Creek Pond could be attributed to volitional emigration of smolts or to the temporal aspects of precocial development.

The captive population of steelhead was transported to Sawtooth Fish Hatchery on April 10 and held in raceway 6 until they were transported and released into the outflow channel of Squaw Creek Pond. Data was collected from the captive population on April 12, May 9, and June 5 using the methods described for the prestocking data. Steelhead with enlarged gonads were classified as sexually maturing (i.e., precocious). Means for fork length (mm), weight (g), and condition factor (K) were calculated for the samples. A chi-square test of independence with the Yates correction for continuity (Zar 1984) was used to test for differences between the proportion of precocial males in the prestocking sample collected at Magic Valley Fish Hatchery (raceway 15, April 10) and the final sample collected at Sawtooth Fish Hatchery (June 5).

Fish Emigration

Fish Counter

A Smith-Root fish counter, Model SR-1601, (Smith-Root, Inc., Vancouver, Washington) was used to enumerate fish leaving the pond. Two counters were installed in the outflow channel of Squaw Creek Pond and tested prior to stocking. Counting tubes were attached to 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 was referred to as a bank of counters. System accuracy was checked by forcing a known number of steelhead through the counters prior to starting the experiment. To further test the accuracy of the counters, two banks of counters were placed in series in the tailrace to double count the number of emigrating steelhead. That is, steelhead 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 steelhead counted by each counting tube was recorded two times in each 24-hour period (approximately 0800 hours and 2000 hours). The number of steelhead 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 steelhead 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 steelhead that emigrated from Squaw Creek Pond was calculated for each bank of counters by summing the diel counts for each counting tube. Steelhead that were diverted and held for PIT tagging were enumerated and added to the emigration total for that day. The percentage of steelhead that emigrated from the pond was calculated by dividing the number of steelhead that emigrated by the number of steelhead that were stocked, multiplied by 100. Linear regression was used to identify correlations between steelhead emigration and average water temperature of the pond (Zar 1984).

PIT Tagging of Migrant, Nonmigrant, Captive, and Production Steelhead

Passive integrated transponder tags were used to evaluate emigration success to dams located on the Snake and Columbia rivers. Three different groups of steelhead were PIT tagged at Squaw Creek Pond: early migrants, late migrants, and nonmigrants. Nonmigrants were those fish that did not volitionally emigrate by June 5.

During evenings before collecting migrant steelhead for PIT tagging (May 7 and May 21 for the early and late migrant groups, respectively), the fish counting banks were removed from the outflow channel and replaced by screens. Steelhead were allowed to migrate at night into a holding area via a diversion pipe. A total of 300 steelhead were collected on May 8 (early migrants) and 299 steelhead were collected on May 22 (late migrants) from the holding area with a dip net and transported to the PIT tagging station in buckets. There they were placed in a tricaine methane sulfonate (MS-222) anesthetic bath and PIT tagged. Fork length (mm), weight (g), and other pertinent information, such as precocity, were recorded for each steelhead that was tagged. Tagged steelhead 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, and any tags found were dotted out in the tagging files. Tag files were submitted to the Columbia River Basin PIT Tag Information System (PTAGIS) (Pacific States Marine Fisheries Commission 1998).

Two groups of PIT-tagged production steelhead (East Fork B-stock and Dworshak B-stock; 300 each) were released at the Squaw Creek release site near Squaw Creek Pond (Figure 1) on April 20 to compare emigration rates between the early migrant group and general production releases under similar migration conditions. Dworshak B-stock steelhead were reared at Magic Valley Fish Hatchery and were PIT tagged on February 24, 2000. East Fork B-stock steelhead were reared at Magic Valley Fish Hatchery and were PIT tagged on February 23, 2000. These general production PIT tag groups were part of approximately 100,000 juvenile steelhead released below the outlet channel of Squaw Creek Pond on April 20 and May 1. In addition to these two groups, 300 steelhead from the captive population (described earlier in this report) were tagged with PIT tags and released into the outlet channel of Squaw Creek Pond on May 8. Steelhead PIT tagged from the captive (control) population will be, hereafter, referred to as the captive group.

On June 5, 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 June 5, a random sample of nonmigrant steelhead (n = 292) was collected from the pond using a beach seine and transported to the PIT-tagging station in a live well. The PIT tagging, data collection, and fish release methods for nonmigrants were as described above. The PIT tag files were submitted to PTAGIS.

The number of fish interrogated for each group (early migrants, late migrants, nonmigrants, captive group, and production groups) was determined by querying the PTAGIS database in late 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, John Day, and Bonneville dams 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, McNary, John Day, and Bonneville dams by the number of PIT-tagged steelhead released, multiplied by 100. Median travel time to Lower Granite Dam was calculated for each group (early and late migrant, nonmigrant, captive group, and production groups). All data analyses were performed using SYSTAT (SYSTAT 1996) and tested at the 0.05 significance level. A 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. A Chi-square test of independence with the Yates corrections for continuity was used to test for differences in the interrogation rates of PIT-tagged steelhead in the early migrant, captive, and general production release groups; a Tukey-type multiple comparison was used to detect significant differences between groups (Zar 1984). The Kruskal-Wallis test was used to test for significant differences in the travel time to Lower Granite Dam among PIT-tagged steelhead from the early migrant, captive, and production groups. The PIT tag interrogation rate of the early migrants was not tested against interrogation rates of the late and nonmigrant groups, since these steelhead were released at a different time and, thus, experienced different migration conditions.

Mean fork length (mm), weight (g), and condition factor (K) were calculated for each group of PIT-tagged steelhead (early migrants, late migrants, nonmigrants, and the captive group). Data were checked 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.

Nonmigrant Data

On June 5, a random sample of nonmigrant steelhead was collected from the pond using a beach seine. Forty steelhead were randomly selected and euthanized. Descriptive data for nonmigrant steelhead were collected and analyzed as described for pre-emigration data. A chi-square test of independence with the Yates correction for continuity (Zar 1984) was used to test for differences between the sex composition of steelhead classified as nonmigrants and the prestocking population. The chi-square test was also used to determine if the proportion of precocial males differed significantly between the prestocking population and steelhead classified as nonmigrants.

RESULTS

Prestocking Data

On April 10, 42 juvenile steelhead were collected from the Magic Valley Fish Hatchery stocking truck at Squaw Creek Pond. Mean fork length, weight, and condition factor (n = 42) were 218 mm, 110 g, and 1.17, respectively (Table 1). Appendix A shows the length-frequency distribution of steelhead sampled on April 10. The sample was comprised of 50% (21) females and 50% (21) males (Table 1). Precocious males (n = 1) made up 2.4% of the total sample (males and females; n = 42) and 4.8% of the male component of the sample (n = 21) (Table 1).

Table 1. Summary statistics and sex characteristics for initial pond stock, early migrant, late migrant, and nonmigrant steelhead sampled at Squaw Creek Pond and captive steelhead sampled at Sawtooth Fish Hatchery.

SAMPLE STATISTICS								
Sample Group	**Sample Date**	**Sex Ratio (M:F)**	**Mean Fork Length (mm)**	**Mean Weight (g)**	**Mean Condition Factor (K)**	**Percent Precocial**	**Number Precocial**	**Sample Size**
Initial Pond Stocking	4/10/00	1.0:1	218	109.7	1.17	2.38	1	42
Early Migrants	5/9/00	1.35:1	226	106.8	1.01	10	4	40
Late Migrants	5/22/00	na	na	na	na	na	na	na
Nonmigrants	6/5/00	3.3:1	228	108	0.89	35	14	40
Captive Group	4/12/00	1.32:1	219	108.5	1.12	2.27	1	44
Captive Group	5/9/00	2.35:1	218	93.8	0.89	5	2	40
Captive Group	6/5/00	1.67:1	226	105.95	0.94	10	4	40

Captive Population

On April 12, May 9, and June 5, 44, 40, and 40 juvenile steelhead, respectively, were randomly selected from the captive population at Sawtooth Fish Hatchery and euthanized. Mean fork length, weight, and condition factor are reported in Table 1. Precocious males made up 2.3% (n = 1) of the total sample on April 12, 5.0% (n = 2) of the total sample on May 9, and 10% (n = 4) of the total sample on June 5 (Table 1). The proportion of precocial males in the captive population on June 5 was not significantly different (χ^2 = 0.96, P = 0.327) than the prestocking population on April 10. The proportion of precocial males in the captive population on April 12 was not significantly different (χ^2 = 1.068, P = 0.301) than the number of precocial males in the captive population on June 5.

Fish Emigration

Fish Counter

The first bank of counters in the tailrace counted 112,306 steelhead, while the second bank of counters counted 106,414 steelhead. The study was terminated on May 24, at which time the fish counters were removed. The fish, however, were allowed to volitionally emigrate from the pond until June 5. According to Magic Valley Fish Hatchery stocking records, approximately 110, 185 steelhead at 4.53 fish per pound were stocked into Squaw Creek Pond. Approximately 1,000 juvenile steelhead remained in Squaw Creek Pond following the volitional release, of which 400 were transported to area reservoirs on June 5 (Kurt Schilling, IDFG, personal communication). This is evidence that the numbers recorded by the first bank of counters were not accurate; therefore, we chose to use the number from the second bank of counters. The difference between the number of steelhead counted by the second bank of counters plus the steelhead removed for outplanting and the number of steelhead planted into the pond may be attributed to the 12-day volitional release period following the removal of the counters.

A total of 106,414 steelhead (96.6%) emigrated from Squaw Creek Pond between April 25 and June 5, 2000. A total of 36,181 (34%) steelhead emigrated during the daytime period, whereas 70,233 (66%) emigrated during the nighttime period (Figure 2). Diel steelhead emigration ranged from 17 fish on April 26 to 39,389 fish on May 4 (Figure 3). A weak correlation was found between diel steelhead emigration and average daily water temperature ($r^2 = 0.38$, $P = 0.001$).

PIT Tagging of Migrant, Nonmigrant, Captive, and Production Steelhead

A total of 300 early migrant, 299 late migrant, and 292 nonmigrant steelhead were PIT tagged and released into the outlet channel below Squaw Creek Pond. Steelhead classified as early migrants were released on May 8; steelhead classified as late migrants were released on May 22, and steelhead classified as nonmigrants were released on June 5. In addition, 300 PIT-tagged steelhead from the captive population were released in the outlet channel on May 8, and 600 PIT-tagged general production steelhead were released into Squaw Creek proper (Figure 1) on April 20 and May 1. To compare migration success and timing under similar conditions, PIT-tagged steelhead from the early migrant group were compared to the captive and general production groups, and steelhead from the late migrant group were compared to the nonmigrant group. Twenty percent (60) of the early migrants, 22.4% (67) of the late migrants, 5.1% (15) of the nonmigrants, 45.0% (135) of the captives, 60.0% (180) of the general production steelhead (East Fork B-stock) and 46.7% (140) of the general production steelhead (Dworshak B-stock) were interrogated at downstream dams (Table 2). Interrogation rates of late migrants and nonmigrants were significantly different ($\chi^2 = 35.45$, $P = 0.000$) (Table 3). Steelhead from the late migrant group had significantly ($P < 0.001$) shorter travel times to Lower Granite Dam than steelhead from the nonmigrant group.

Table 2. PIT tag interrogation results for six groups of steelhead released from Squaw Creek Pond or into Squaw Creek in 2000. 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.

Group / Tagging File	Fish Stock	Release Site	Release Date	Number Released	Number (No.) / Percent (%) Interrogated: LGR No.	LGR %	LGO No.	LGO %	LMN No.	LMN %	MCN No.	MCN %	TOTAL No.	TOTAL %	Median Travel time (days)
Squaw Creek Pond Acclimation Study															
EARLY MIGRANTS TSC00129.SQ1	Dwor-B	Squaw Pond	5/8/00	300	50	16.7	7	2.3	2	0.7	1	0.3	60	20.0	15.2
LATE MIGRANTS KEP00143.SQL	Dwor-B	Squaw Pond	5/22/00	299	45	15.1	12	4.0	6	2.0	4	1.3	67	22.4	7.8
NONMIGRANTS KEP00157.SQN	Dwor-B	Squaw Pond	6/5/00	292	10	3.4	4	1.4	1	0.3	0	0.0	15	5.1	23.1
CAPTIVE POPULATION KEP00129.SQC	Dwor-B	Squaw Pond	5/8/00	300	118	39.3	6	2.0	8	2.7	3	1.0	135	45.0	15.3
PRODUCTION GROUP KEP00054.M1W	Efk-B	Squaw Creek	4/20/00	300	164	54.7	7	2.3	6	2.0	2	0.7	180	60.0	15.6
PRODUCTION GROUP KEP00055.10E	Dwor-B	Squaw Creek	5/1/00	300	120	40.0	7	2.3	10	3.3	3	1.0	140	46.7	18.5

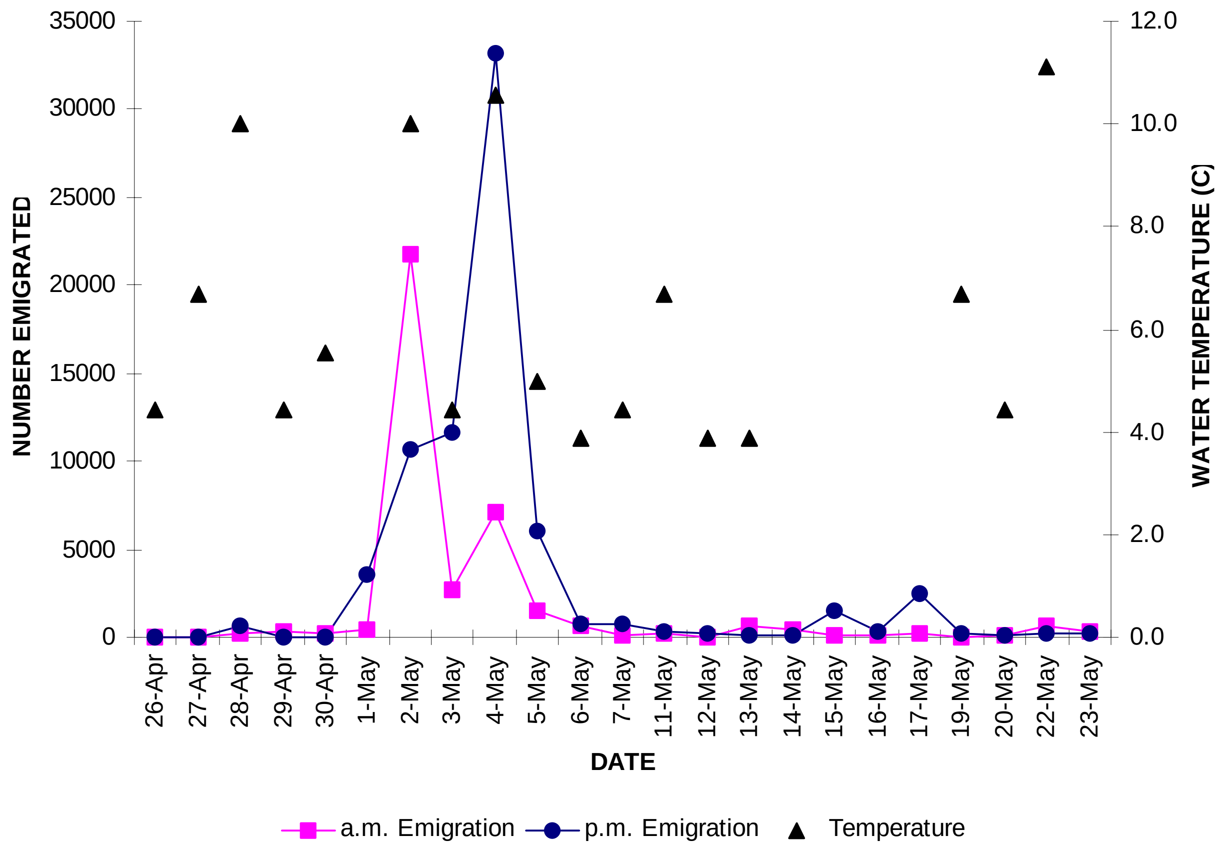

Figure 2. Fish emigration during the day (the period of time between the morning count and the evening count of the same day) and night (the period of time between the morning count and the evening count of the previous day) time periods, plotted with average daily water temperature of Squaw Creek Pond between April 26 and May 23, 2000.

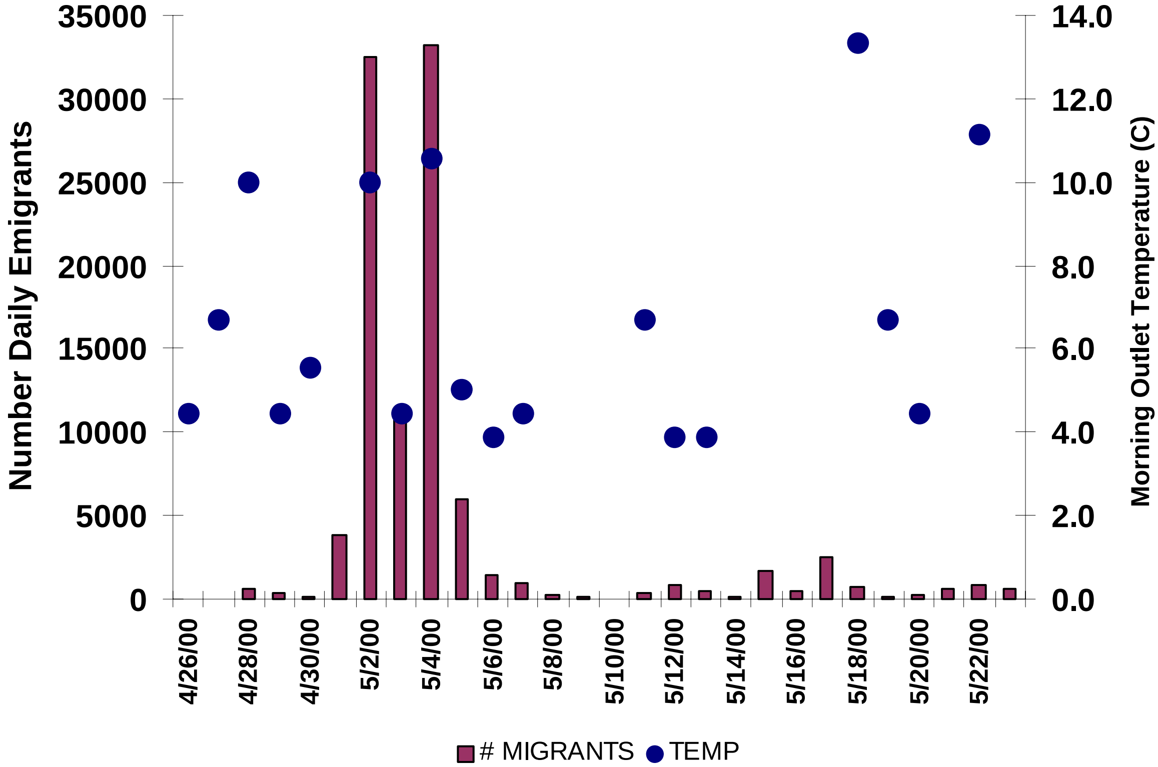

Figure 3. Diel fish emigration (bars), plotted with average daily water temperature (points) of Squaw Creek Pond between April 26 and May 23, 2000.

Table 3. Interrogation rates of five groups of PIT-tagged steelhead released at or near Squaw Creek Pond in 2000. Chi-square analysis was used to identify significant differences in interrogation rates among the early migrant, captive, and production groups (Comparison 1) and between the late migrant and nonmigrant groups (Comparison 2). A Tukey-type multiple comparison was used to identify significant differences between the early migrant, captive, and production groups. Interrogation rates not followed by the same letter indicate a significant ($P \leq 0.05$) difference among groups.

Group	Release Date	Number Released	Number Interrogated	Percent Interrogated
Comparison 1				
Early Migrant	5/8	300	60	20.0 A
Captive	5/8	300	135	45.0 B
Production (EfK–B)	4/20	300	180	60.0 B
Production (Dwor– B)	5/1	300	140	46.7 B
Comparison 2				
Late Migrant	5/22	299	67	22.4 C
Nonmigrant	6/5	292	15	5.1 D

Interrogation rates of steelhead from the early migrant, captive, and production groups were significantly different ($\chi^2 = 102.3$, $P < 0.001$). Steelhead from the captive group were interrogated at a significantly ($P \leq 0.05$) higher rate than steelhead from the early migrant group (Table 3). Steelhead from both production groups were interrogated at significantly ($P \leq 0.05$) higher rates than steelhead from the early migrant group (Table 3). Travel time to Lower Granite Dam was not significantly different among the early migrant, captive, and production groups.

Mean daily inflow and spill of the Snake River at Lower Granite Dam ranged from approximately 83 to 99 thousand cubic feet per second (kcfs) and 21 to 24 kcfs, respectively, during emigration of steelhead in the early migrant and captive groups, respectively (Figure 4).

Fork length, weight, and condition factor of PIT-tagged steelhead from the early migrant, late migrant, nonmigrant, and captive groups are shown in Table 4. Length-frequency distributions of PIT-tagged steelhead from the early migrant, late migrant, nonmigrant, and captive groups are shown in Appendix B, Appendix C, Appendix D, and Appendix E, respectively. Steelhead from the nonmigrant group were significantly longer ($P < 0.001$) and heavier ($P < 0.001$) than steelhead from the late migrant group. Steelhead from the nonmigrant group had a significantly higher ($P < 0.001$) condition factor than did steelhead from the late migrant group. Precocial males comprised 12.3% (n = 37), 2.7% (n = 8), and 3.1% (n = 9) of the early migrant, late migrant, and nonmigrant PIT-tag groups, respectively. Precocial males comprised 0% (n = 0) of the captive PIT tag group.

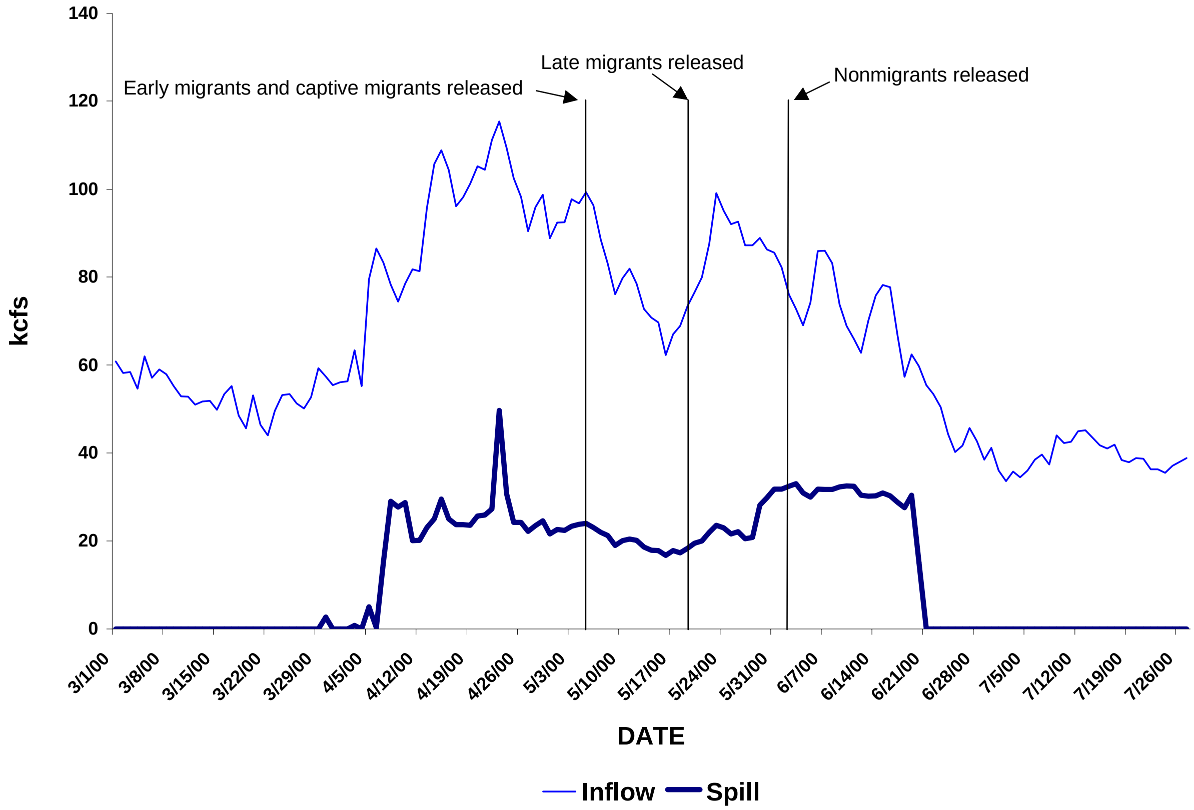

Figure 4. Mean daily inflow and spill of the Snake River at Lower Granite Dam, Washington, between March 1 and July 30, 2000. Steelhead from the early migrant group were PIT tagged and released on May 8, whereas steelhead from the late migrant and nonmigrant groups were PIT tagged and released on May 22 and June 5, respectively.

Table 4. Descriptive statistics by group, of PIT-tagged steelhead released from Squaw Creek Pond in 2000.

	Fork Length (mm)	Weight (g)	Condition Factor (K)
Early Migrants			
n	300	300	300
Mean	210.36	88.17	0.911
SD	29.57	35.82	0.288
Median	212	83.7	0.87
Late Migrants			
n	295	295	295
Mean	214.46	85.88	0.85
SD	24.06	30.43	0.26
Median	214	81	0.84
Nonmigrants			
n	290	290	290
Mean	231.71	116.55	0.59
SD	25.54	35.12	0.48
Median	233	112	0.89
Control Group			
n	300	300	300
Mean	220.24	102.78	0.98
SD	21.33	26.44	0.48
Median	214	91.3	0.93

Nonmigrant Data

On June 5, 40 juvenile steelhead were randomly selected from Squaw Creek Pond and euthanized. Mean length, weight, and condition factor (n = 40) were 228 mm, 108 g, and 0.89, respectively (Table 1). The sample (n = 40) was comprised of 76.7% (31) males and 23.3% (9) females (Table 1). The sex composition of the nonmigrant steelhead did differ significantly ($\chi^2 = 5.546$, P = 0.019) from the prestocking population sampled from the Magic Valley Fish Hatchery stocking truck at Squaw Creek Pond on April 10. Precocial males (n = 14) made up 35% of the total sample (males and females, n = 40) and 45.2% of the male component of the sample (n = 31). Steelhead classified as nonmigrants had a significantly higher (P <0.001) proportion of precocial males than the prestocking population. Mean fork length, weight, and condition factor for the precocial males in the sample (n = 14) were 224.2 mm, 107.5 g, and 0.92, respectively. Mean fork length, weight, and condition factor for the nonprecocial males in the sample (n = 17) were 232 mm, 112 g, and 0.87, respectively. Appendix D shows the length-frequency distribution of PIT-tagged nonmigrant steelhead sampled at Squaw Creek Pond on June 5, 2000 (n = 292).

Nonmigrant Steelhead Disposition

Approximately 400 juvenile steelhead (110 lbs) were collected from Squaw Creek Pond and transported to Mosquito Flat Reservoir by personnel from Sawtooth Fish Hatchery on June 5. The remaining nonmigrant steelhead were retained in the pond for a catch-out fishery.

DISCUSSION

Using PIT tags as our main evaluation tool, we found the volitional release strategy we used was successful at separating smolts from residual steelhead at Squaw Creek Pond. Contrary to previous years results, in 2000 late migrants had significantly higher interrogation rates and significantly shorter travel times than nonmigrants. In 1998 (Osborne and Rhine 2000) and 1999 (Rhine and Osborne 2000), PIT tag interrogation rates between the late migrants and nonmigrants did not differ significantly. Viola and Schuck (1995) defined the steelhead that failed to volitionally emigrate from Curl Lake acclimation pond, Washington, as residuals and described them as being larger than average and predominately males. Similar to Viola and Shuck's findings, in 2000 steelhead classified as nonmigrants in Squaw Creek Pond were significantly longer and heavier than late migrants.

Although the release strategy appeared to be successful at separating smolts from residual steelhead, early and late migrant study groups had very low interrogation rates (20.0% and 22.4%, respectively) compared to previous years results (>50% for all groups). The captive group had a lower interrogation rate (45%) as well. However, of all six PIT tag groups released at Squaw Creek Pond during the course of the study, only one group (E. Fk. B production group) had an interrogation rate consistent with previous years. Spill at Lower Granite Dam was lower in 2000 than in 1999 and 1998 during the smolt emigration period, and no major changes were made at the pond or hatcheries with the exception of Squaw Creek Pond water level management.

In 1998 and 1999, to stimulate emigration, the pond level was decreased by 14 cm (by removing one dam board) every five or six days, until five dam boards had been removed. However, in 2000 one dam board was removed on April 28, two on April 30, four on May 1, one on May 2, and one on May 3, for a total of nine dam boards removed. This sudden reduction in water level and subsequent increase in pond flush rate may have more closely simulated natural flow conditions, resulting in greater emigration of smolts. For example, on May 1, four dam boards were removed, lowering the level of Squaw Creek Pond by 56 cm. The A.M. counter reading at Squaw Creek Pond on May 2 revealed that 23,572 steelhead had volitionally emigrated from the pond, compared to 370 steelhead during the A.M. period on May 1. An additional 7,966 steelhead emigrated during the P.M. emigration period on May 2. Steelhead continued to emigrate from the pond in high numbers through May 5.

One possible explanation for the low steelhead interrogation rates in 2000 may be the timing of precocial development in conjunction with pond water level reduction date and study group release dates. In the present study, the rate of precocity was significantly lower in the prestocking population (2.38%) as compared to the population of nonmigrants (35%), again suggesting that the release technique was effective in detaining precocial male steelhead in the pond. However, precocial development may have been incomplete on April 10, 2000 (the date baseline data were collected), subsequently resulting in more fish becoming precocial by

June 5, 2000 (the end of the study). The precocity rate of steelhead in the captive population at Sawtooth Fish Hatchery increased from 2.27% on April 12 to 5% on May 9 and again to 10% on June 5. The rate of precocity was significantly higher for captive steelhead sampled at Sawtooth Hatchery on June 5 as compared to the initial stocking group and the captive steelhead sampled on April 10. Precocial development may not have been complete by May 2 when large numbers of steelhead emigrated from the pond, resulting in the release of potentially precocial fish. This suggests that the proportion of precocial males in the population at Squaw Creek Pond may have changed due to the timing of precocial development with respect to sample date. Also, as stated earlier, the pond level was decreased a total of 126 cm in a period of only six days (April 29–May 3), resulting in a net water volume reduction of nearly 70%. From May 1 through May 5, 91.2% (97,102) of the total steelhead recorded by the second bank of counters emigrated from the pond, leaving only 9,312 steelhead in the pond. The early migrant group of steelhead was PIT tagged on May 8, three days after the mass emigration of most of the fish in the pond. Therefore, this PIT tag sample misrepresents the true early migrants from the pond. The 9,312 steelhead remaining in the pond apparently resisted emigration during the high spill and high emigration periods, which suggests that both the early and late migrant steelhead PIT tag groups may have consisted of residual steelhead exhibiting localized downstream movement, as opposed to true smolt emigration.

The release strategy tested was successful at separating smolts from residuals as evaluated in 2000, using interrogation data from PIT tags and precocity data. However, due to the timing of the early migrant group release, there is no estimate of minimum survival for 91.2% of the total migrants. The water management strategy was successful at removing steelhead from Squaw Creek Pond; however, it was not evaluated in terms of emigration success. We recommend this study be repeated again in 2001, with no changes in pond operations taking place. PIT tag operations, however, will be adjusted in a manner better suited to represent each migrant group.

ACKNOWLEDGMENTS

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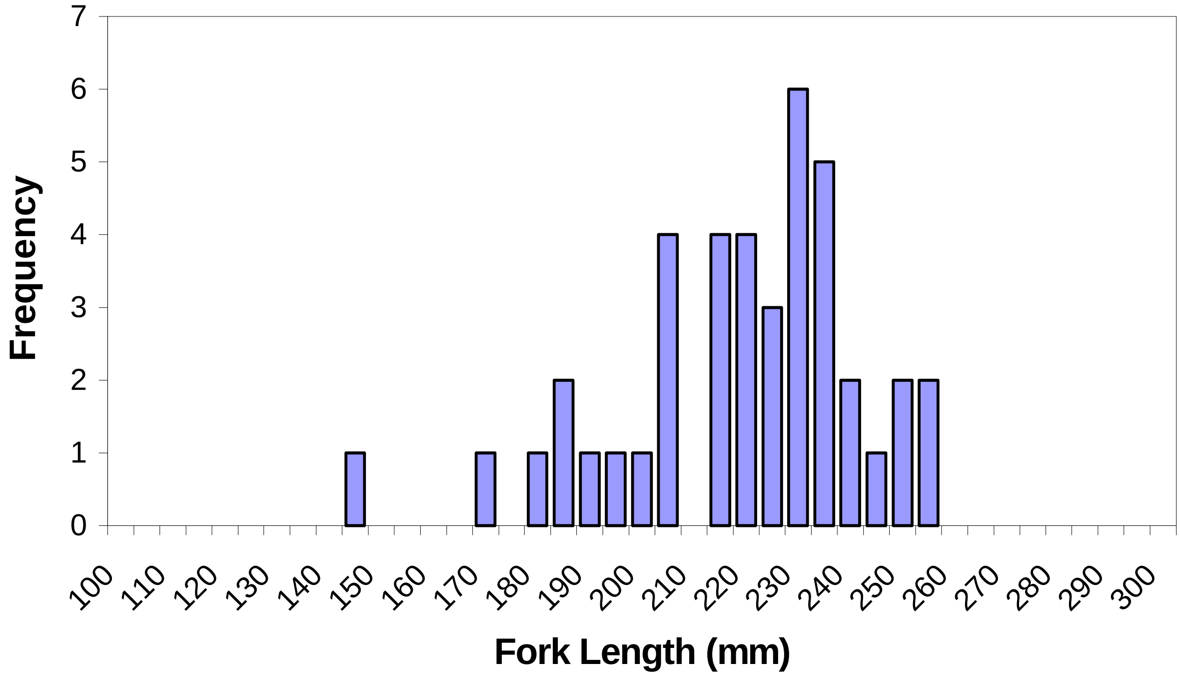
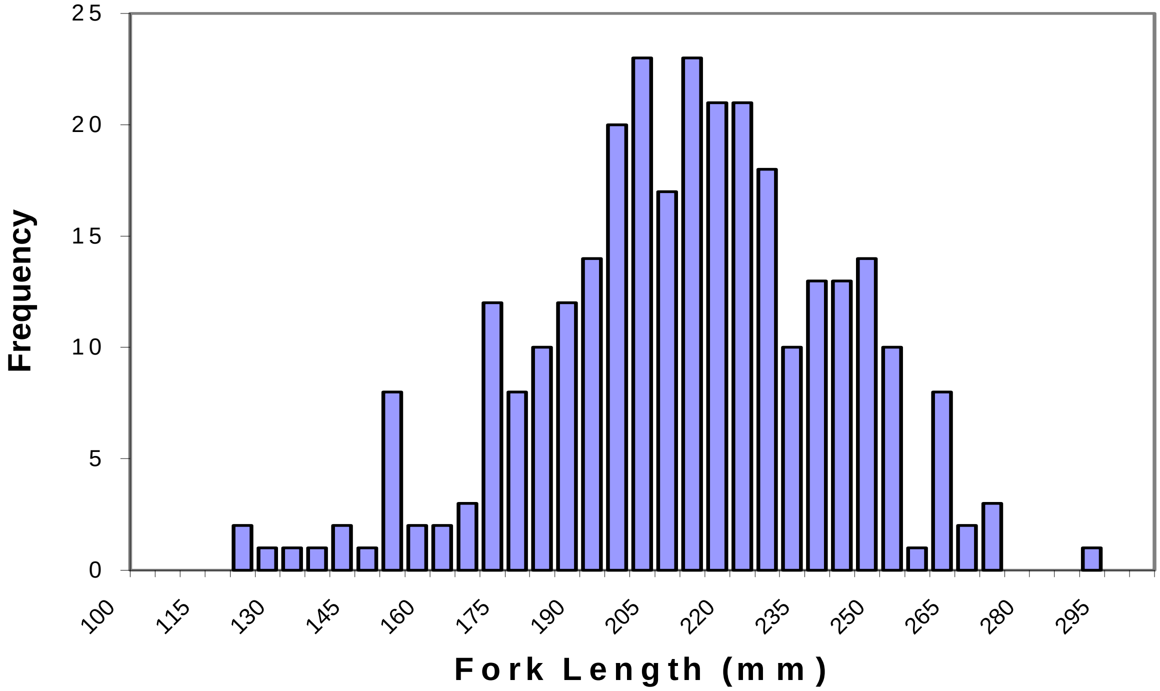
APPENDICES

Appendix A. Length-frequency distribution of steelhead sampled from the Magic Valley Fish Hatchery stocking truck, prior to pond stocking, on April 12, 2000.



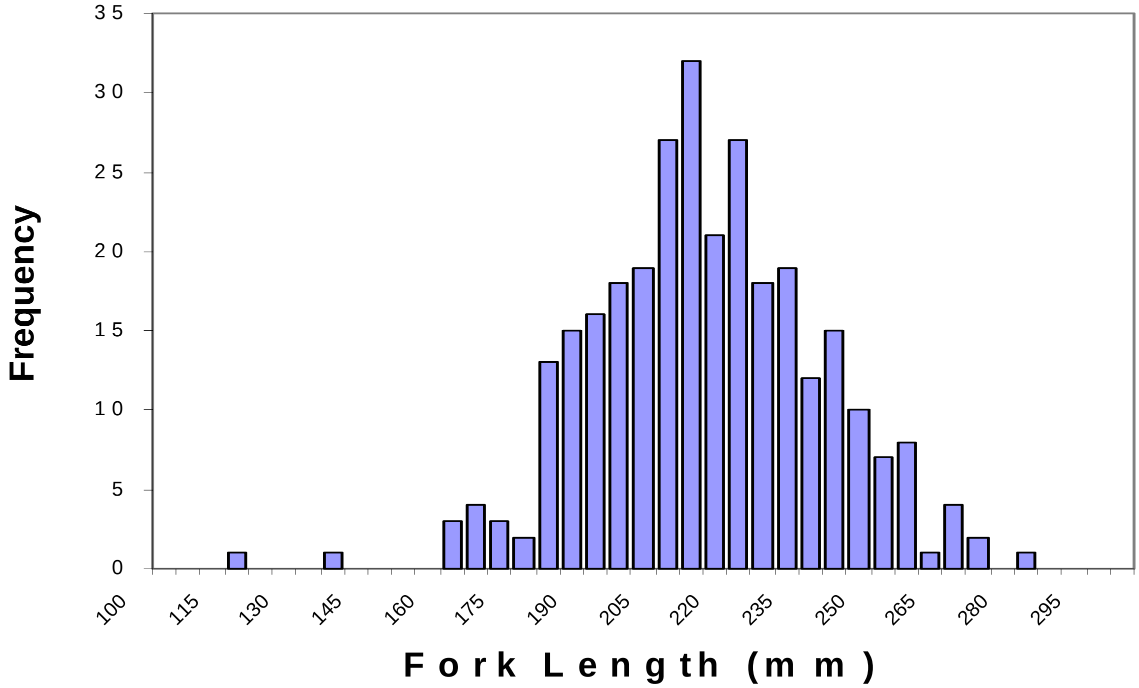
	Fork Length (mm)	Weight (g)	Condition Factor (K)
Mean	218.1	109.7	1.17
Standard Deviation	23.6	29.1	0.46
Median	226	110.6	0.97
n	41	42	41

Appendix B. Length-frequency distribution of steelhead from the early migrant group, PIT tagged and released at Squaw Creek Pond on May 8, 2000.



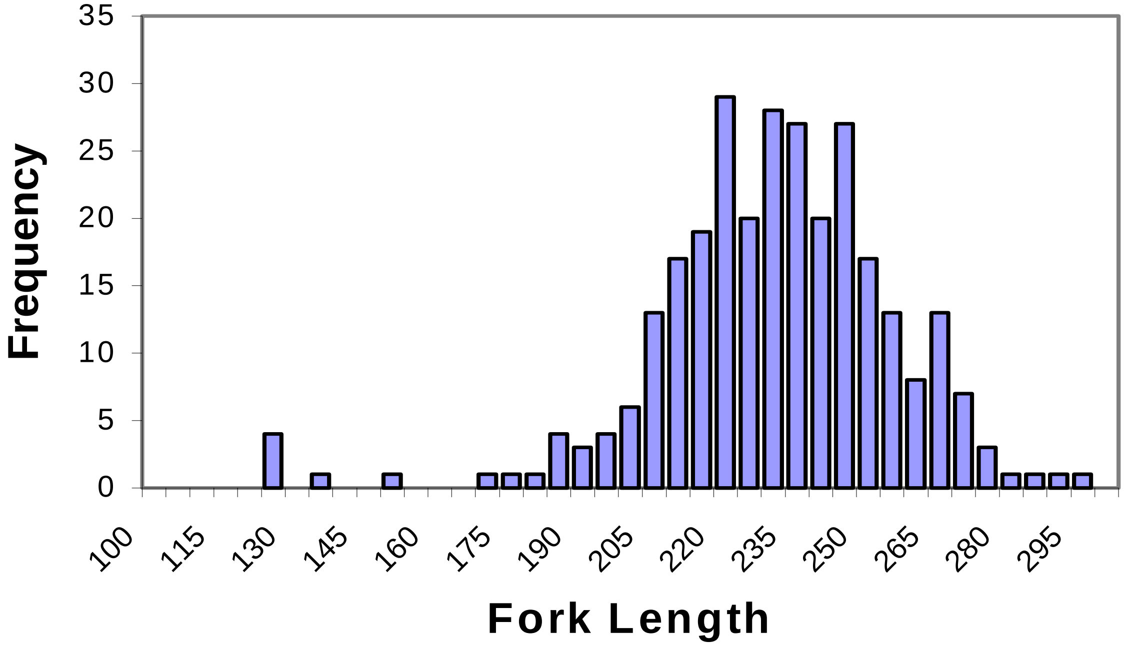
	Fork Length (mm)	Weight (g)	Condition Factor (K)
Mean	210.4	88.2	0.91
Standard deviation	29.6	35.8	0.29
Median	212.0	83.7	0.89
n	300	300	300

Appendix C. Length-frequency distribution of steelhead from the late migrant group, PIT tagged and released at Squaw Creek Pond on May 22, 2000.



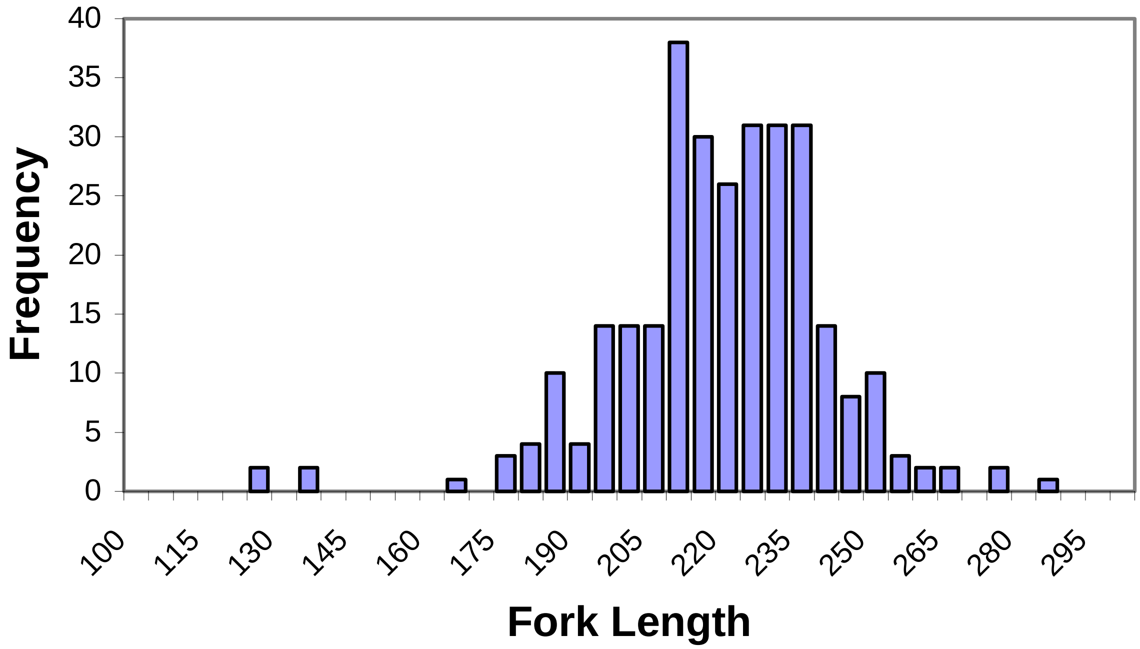
	Fork Length (mm)	Weight (g)	Condition Factor (K)
Mean	214.5	85.9	0.85
Standard deviation	24.1	30.4	0.26
Median	214.0	81.0	0.84
n	299	299	299

Appendix D. Length-frequency distribution of steelhead from the nonmigrant group, PIT tagged and released at Squaw Creek Pond on June 5, 2000.



	Fork Length (mm)	Weight (g)	Condition Factor (K)
Mean	231.7	116.5	0.96
Standard deviation	25.5	35.1	0.48
Median	233.0	112.0	0.89
n	292	292	292

Appendix E. Length-frequency distribution of steelhead from the captive group, PIT tagged and released at Squaw Creek Pond on May 8, 2000.



	Fork Length (mm)	Weight (g)	Condition Factor (K)
Mean	210.0	89.4	1.01
Standard deviation	17.3	17.6	0.58
Median	214.0	91.3	0.93
n	300	300	300

Prepared by:

Ryan L. Newman
Fisheries Research Biologist

Approved by:

IDAHO DEPARTMENT OF FISH AND GAME

Virgil K. Moore, Chief
Bureau of Fisheries

Steve Yundt
Fisheries Research Manager