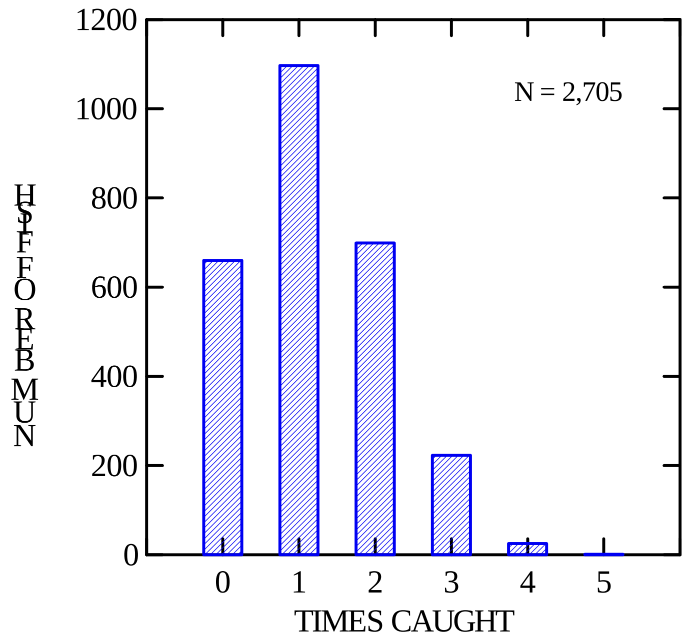
FISHERY RESEARCH

# JOB PERFORMANCE REPORT

## Grant F-73-R-22

### Report Period July 1, 1999 to June 30, 2000




**Project 4—Hatchery Trout Evaluations**
**Subproject 1: Improving Catchability of Rainbow Trout—A Selective Breeding Experiment**
**Subproject 2: Sterile Trout Investigations**


**David Teuscher**
**Senior Fishery Research Biologist**



**IDFG Report Number 00-34**
**March 2000**

# Annual Performance Report

**July 1, 1999 to June 30, 2000**

**Grant F-73-R-22**

**Project 4—Hatchery Trout Evaluations**
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**By**

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**IDFG Report Number 00-34**
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**JOB PERFORMANCE REPORT**
**SUBPROJECT #1: IMPROVING CATCHABILITY OF RAINBOW TROUT: A SELECTIVE BREEDING EXPERIMENT**

State of: Idaho
Grant No.: F-73-R-22, Fishery Research
Project No.: 4
Title: Hatchery Trout Evaluations
Subproject #1: Improving Catchability of Rainbow Trout: A Selective Breeding Experiment
Contract Period: July 1, 1999, to June 30, 2000

## ABSTRACT

The objective of the broodstock selection experiment was to determine if angling vulnerability varied among individual hatchery rainbow trout and if so, is that trait heritable. In 1999, 2,705 age-2 rainbow trout were exposed to 94 h of fishing. The fishing trials were completed in three raceways at the Hayspur State Fish Hatchery. Fish were caught using flies and spinners. PIT tags were used to identify each fish and track their recapture history.

During the fishing experiment, 3,269 catches were recorded. Forty-one percent of the rainbow trout were caught one time. About 26% of the fish were caught two times, and 9% were caught three or more times. Twenty-four percent of the fish were never caught. The capture frequencies were compared to those expected using random recapture probabilities. The null hypothesis of random recaptures was rejected ($\chi^2 = 95.6$, $p < 0.001$). These results demonstrated that individual fish in the R9 broodstock population varied in their susceptibility to hook and line angling. To determine if that trait is heritable, fish caught two or more times were held for spawning. Offspring from those fish will be tested for angling vulnerability at age-1 in 2001.

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## INTRODUCTION

The Idaho Department of Fish and Game (IDFG) plants about 3 million put-and-take rainbow trout annually. Approximately 60% of the catchables are released in lakes, reservoirs, and ponds, and the remaining fish are stocked in streams and rivers. The major objective of the put-and-take program is to provide increased angling opportunity and harvest. Of the 3 million catchables stocked every year, about 1 million (<40%) are harvested by anglers (Teuscher et al. 1998). Assuming an optimistic 40% of the catchables are harvested, where do the other 60% go and what are the associated costs of producing fish that are not caught? In pure economic terms, the losses account for about $660,000 and make up 30% of the total resident hatchery budget (IDFG 1998). Fish losses also impact anglers by lowering harvest and catch rates. The substantial loss of catchable trout begs the question: can we improve returns?

IDFG has completed a number of research projects directed at improving return-to-creel of hatchery rainbow trout. Many of the studies focused on what size rainbow trout to stock (Teuscher 1999; Mauser 1992; Mauser 1994; Cuplin 1958). Other studies evaluated fish behavior (Dillon and Alexander 1996), stocking time, release methods, and fish condition (Welsh et al. 1970; Casey et al. 1968). The above research has benefited IDFG stocking programs, but substantial room for improvement still exists. This report initiates a study that describes the possibility of increasing returns by selecting broodstock that exhibit high levels of angling vulnerability. The success of this project depends on meeting two assumptions. First, individual trout in the Hayspur strain (R9) broodstock population must demonstrate varying degrees of angling vulnerability. Secondly, angling vulnerability must be heritable.

Individual fish exhibit varying degrees of hook-and-line vulnerability. Burkett et al. (1986) reported that largemouth bass in Ridge Lake, Illinois demonstrated “high” and “low” angling vulnerability. In the four-year study, 26% of the bass were never caught, compared to 62% of the fish being caught six or more times. Hackney and Linkous (1978) also reported that largemouth bass have easily harvestable segments. Individuality of angling vulnerability has also been shown for rainbow trout. Lewynsky (1986) observed that during a nine-week fishing trial in a raceway, captures ranged from zero to five times per individual trout. About 37% of the fish were caught more than one time, and 21% were never caught. These studies indicate that some individual fish are more likely than others to be caught by hook-and-line methods, but they give no indication as to the heritability of that trait.

Angling vulnerability may be heritable. Perhaps the most commonly cited studies that link genetic contribution and angling vulnerability are strain evaluations. Strain effects on angling vulnerability have been demonstrated for largemouth bass (Kleinsasser et al. 1990; Burkett et al. 1986; Zolczynski and Davies 1976), rainbow trout (Dwyer and Piper 1984; Brauhn and Kincaid 1982; Moring 1982; Hudy and Berry 1983), cutthroat trout (Dwyer 1990), brook trout (Nuhfer and Alexander 1994), Tilapia (Yoneyama et al. 1997), and blue catfish (Tave et al. 1981). A common theme among the strain studies is that faster growing strains are more vulnerable to angling, and that growth in field tests was generally higher for domesticated and (or) hybrid stocks (Dwyer and Piper 1984; Brauhn and Kincaid 1982; Nuhfer and Alexander 1994; Yoneyama et al. 1997; Tave et al. 1981). Moreover, Umino et al. (1997) determined that genetic factors controlled aggressive feeding behavior and competitive advantage in larval crucian carp, *Carassius langsdorfii*. Similar mechanisms likely pattern the growth and ultimately the catchability of hatchery rainbow trout. If angling vulnerability is heritable, then it should be possible to increase returns by selecting broodstock that are vulnerable to hook-and-line sampling.

## MANAGEMENT GOAL

To increase return-to-creel of hatchery rainbow trout through selective breeding in the Hayspur broodstock population.

## OBJECTIVES

1. Test for individuality of angling vulnerability for Hayspur R9 Broodstock

2. Complete field performance evaluations using offspring from selected broodstock that exhibit high angling vulnerability

## METHODS

Fish used for the vulnerability experiment were Hayspur strain rainbow trout. In April 1998, a random sample of about 2,750 fingerling R9 fish was taken from the 1998 replacement broodstock population. A year later, at age-1, the fish were anesthetized, measured, PIT tagged, and released in three outside raceways at the Hayspur State Fish Hatchery. All of the sorting (fishing) for vulnerability took place in those raceways. Initial mean length and weight of the experimental trout was 284 mm (SE = 1 mm) and 251 g (SE = 8 g), respectively.

Artificial flies and lures were used to complete the fishing trials. Three fly patterns (Adams, Royal Wulff, and Renegade, all of which were size #10 hooks) and three spinners (black and silver #0 Mepps and a gold #4 Panther Martin) were used. To equalize fishing pressure and lure exposure, we employed a systematic design to fishing trials. Each raceway was fished for one h using one gear type. After completing a one-h fishing trial, the angler moved to the next raceway. Once all three raceways were fished with the same fly or lure, the gear type was changed. This procedure assured equal effort and gear exposure for each raceway. A round of fishing was completed when all three raceways were fished with all six-gear types. Several rounds of fishing were completed using the above method. After several rounds, however, catch rates with spinners declined markedly (<10 fish / hr). Therefore, spinners were dropped from the rotation for the last few rounds. Fishing trials began on June 2, 1999 and were terminated on September 1, 1999.

Effort was made to minimize handling stress. Hooked fish were netted, scanned for PIT tag numbers, placed back in the water during hook removal, and immediately released. Hook location and PIT tag numbers were recorded. The angler also recorded if a fish was bleeding at the time of release. Average handling time (initial strike to release) was less than 20 seconds.

The null hypothesis of random recaptures or equal angling vulnerability for all fish was tested using a Poisson distribution (Zar 1984). At the end of the fishing trials, every fish in the population was assigned to one of four categories. Fish in category “0” where never caught. Fish in the category “1” had been caught one time, and so on. The observed frequencies were compared to the Poisson distribution derived using the observed : of 1.2 catches per fish. The observed and expected frequencies were compared using the chi-square statistic (Zar 1984).

## RESULTS AND DISCUSSION

During 94 one-h fishing trials, 3,269 catches were recorded. Forty-one percent of the rainbow trout were caught one time. About 26% of the fish were caught two times and 9% were caught three or more times (Figure 1). The most aggressive fish was caught five times. Twenty-four percent of the fish were never caught, which mirrored results from the bass and earlier rainbow trout fishing experiments (Burkett et al. 1986; Lewynsky 1986).

Table 1 shows the expected and observed catch frequencies. There was a detectable difference between expected and observed capture frequencies ($\chi^2 = 95.6$, $p < 0.001$). Therefore, the null hypothesis of equal capture probabilities was rejected. The greatest negative contributor to the chi-square test was the "0" category, indicating that there was a strong tendency for fish to strike at least one time (Table 1). Conversely, the next largest contributor to the chi-square test was the "4" and "5" categories, which suggested that once a fish was caught three times they learned to avoid recapture.

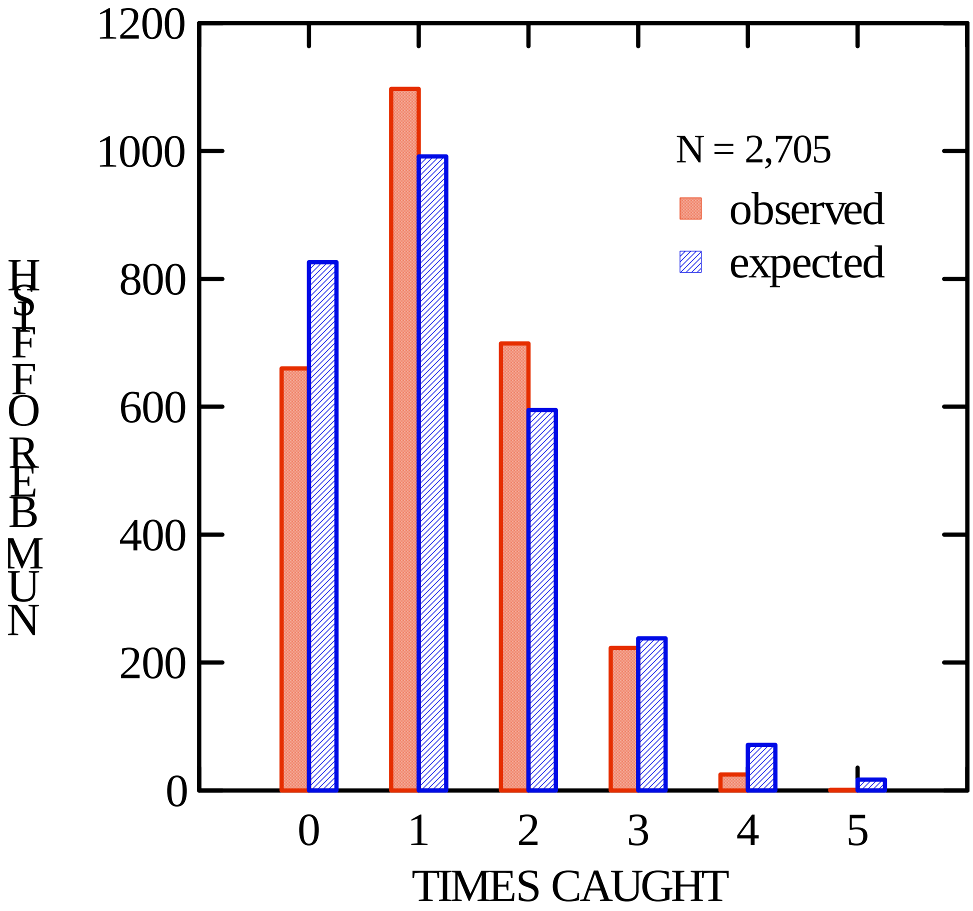

Figure 1. Observed and expected capture frequencies for hatchery rainbow trout caught in three raceways.

Table 1. Capture frequencies for Hayspur strain rainbow trout ($F_i$) and Poisson distribution frequencies (E) for random capture probabilities. The difference between the distributions was statistically significant (*P* <0.001).

| Number of times caught | Observed catch $F_I$ | Expected catch (E) | Deviation (D) | Contribution to the chi-square ($D^2/E$) |
|---|---|---|---|---|
| 0 | 660 | 826 | -166 | 33.4 |
| 1 | 1097 | 991 | 106 | 11.2 |
| 2 | 699 | 595 | 104 | 18.2 |
| 3 | 223 | 238 | 15 | 0.9 |
| 4 | 25 | 71 | -46 | 30.1 |
| 5 | 1 | 17 | -16 | 15.2 |
| | | | | $\chi^2$ = 109.2[a] |

[a] Critical value for $\chi^2_{,\,0.05,4}$ = 9.5

Catch rates and average size of fish caught varied for flies and lures. Total catch was 2,796 (42 fish / hr) for flies and 473 (17 fish / hr) for spinners. The difference in total catch was partly due to effort. Because of a marked decline in catch rates over time, spinners were not used after day 50 of the experiment. The decline also occurred using flies, but catch rates remained well above those for spinners (Figure 2). Mean length of fish caught with flies was 283 mm (SE = 0.5 mm) and 291 mm (SE = 1.3) for lures. The difference was significant (t-value = -6.114, *P* <0.001).

Hooking mortality was minor. A total of 27 dead fish were removed from the raceways. Of those fish, eight were never caught, 15 were caught once, and four were caught twice. Mortality rates were 1.2% for fish never caught, 1.4% for fish caught one time, and 0.6% for fish caught twice. All of the fish caught three or more times survived the experiment. From the 3,269 total catches, about 8% of the fish were hooked in the gill arches and 1% in the esophagus. The more benign areas (upper jaw and roof) made up 75% of hook locations.

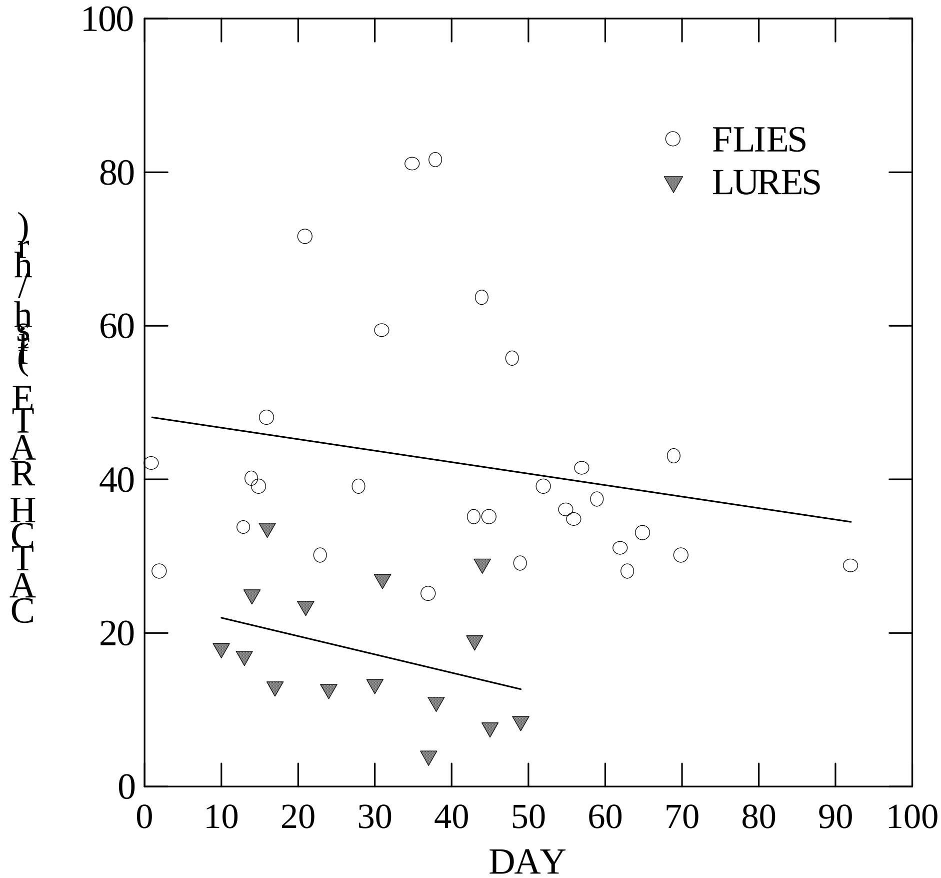


Figure 2. Catch rates plotted against day of the experiment. Neither slope was significantly different from zero (P >0.05).

**RECOMMENDATION**

1 Complete the second stage of the study to determine if angling vulnerability is heritable.

## ACKNOWLEDGMENTS

I would like to thank Ryan Hillyard for his dedication to this project. Ryan was the lead technician responsible for data collection and entry. Bob Esselman, Doug Young, and Russ Wood helped tag and sort the broodstock population as well as fed and maintained them. Doug Megargle, Heather Ray, and Jeremy Mayhew also assisted with fieldwork.

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**JOB PERFORMANCE REPORT**
**SUBPROJECT #2: STERILE TROUT EVALUATIONS**

State of: Idaho — Grant No.: F-73-R-22, Fishery Research

Project No.: 4 — Title: Hatchery Trout Evaluations

Subproject #1: Sterile Trout Evaluations

Contract Period: July 1, 1999, to June 30, 2000

## ABSTRACT


Triploid rainbow trout *Oncorhynchus mykiss* may have important applications in fishery management programs. Triploids are functionally sterile and do not pose genetic risks to indigenous populations. Triploid fish may also grow faster and live longer than normal diploid fish. In 1999, we developed methods to mass-produce triploid rainbow trout and continued monitoring the performance of triploid trout stocked in recreational fisheries.

The 1998-99 spawning season was the first attempt at mass producing triploid Hayspur strain (R9) rainbow trout. A heat shock treatment of 26°C at 20 min after fertilization for a 20-minute duration was administered to 1.2 million eggs. The recipe produced a mean induction rate of 98%. That induction rate is as good or better than triploid egg lots available from commercial producers. The extra cost for treating 1.2 million eggs was minor. Equipment costs were about $500 for the water heating and circulation pumps. The egg treatments required one extra person to monitor water temperatures and treat the eggs. Producing triploids increased the cost of egg production by 1% to 2%. As many as 500,000 eggs can be treated in four hours.

Triploid female rainbow trout stocked in Treasureton and Daniels reservoirs have demonstrated higher survival rates but had no significant differences in growth compared to diploid fish. In 1999, 72 triploid and 31 control rainbow trout were sampled. The differences in relative survival were significant and increased with fish age. Although ontogenetic growth patterns varied, mean lengths and weights of age-3 triploid and diploid rainbow trout were similar. Results from the reservoir evaluations are preliminary and monitoring will continue as long as fish persist in good numbers.

## INTRODUCTION

Over the last decade, the production and use of triploid fish as a fishery tool has received increasing attention. Rationale for using sterile fish in stocking programs is generally based on two distinct and separate needs: 1) the desire for a longer-lived, faster growing hatchery product, and 2) protecting the genetic integrity of indigenous stocks. Although early researchers focused on the predicted growth, longevity benefits, and the trophy potential of sterile fish, such benefits have not been documented in recreational fisheries.

With or without growth benefits, sterile fish represent a fishery management tool with potentially broad applications. For example, the demand for consumptive stream trout fishing in Idaho is largely met by stocking hatchery rainbow trout *Oncorhynchus mykiss* catchables in selected waters. Despite emphasis on wild trout management over the last two decades, about 40% of stream plants occur in waters with viable trout populations (J. Dillon, Idaho Department of Fish and Game, unpublished data). Using sterile rainbow trout catchables to meet these demands would minimize concerns for genetic impacts on indigenous rainbow and cutthroat trout *O. clarki*.

Techniques to produce sterile salmonids are well developed, particularly within the aquaculture industry, and triploid rainbow trout eggs are available from many commercial egg suppliers. The most widely used approach is chromosome manipulation, specifically for induction of triploidy. Triploidy is induced by thermal, pressure, or chemical shock of eggs shortly after fertilization. This causes retention of the second polar body of the egg and results in an embryo with two sets of maternal and one set of paternal chromosomes. Triploid salmonids are functionally sterile, although males can develop secondary sex characteristics and exhibit spawning behavior (Benfey 1999; Feist et al. 1996; Inada and Taniguchi 1991).

Although production techniques are fairly well developed, information on performance of triploid salmonids in recreational fisheries is lacking (Simon et al. 1993). Sterile fish must survive, grow, and return to anglers at rates similar to or better than normal fish if they are to be useful in stocking programs (Dillon et al. 2000).

## MANAGEMENT GOAL

To minimize genetic risks to indigenous rainbow trout and cutthroat trout in Idaho streams from hatchery trout and enhance hatchery-supported lake and reservoir fisheries.

## OBJECTIVES

1 Develop methods and evaluate costs of producing sterile rainbow trout.

2 Evaluate relative survival and growth of triploid rainbow trout in lakes and reservoirs.

# METHODS

## Production of Sterile Rainbow Trout

In 1998, several experiments were completed to determine the best time and temperature to heat shock Hayspur R9 rainbow trout. The optimal temperature and time that produced normal egg survival and consistent induction rates was 26°C at 20 min after fertilization for a 20-min duration (Teuscher 1999). The same recipe was used for mass production, but egg handling procedures and treatment tubs were modified.

Male and female fish were spawned in separate containers. After taking spawn from the desired number of fish (≤10 females or 30,000 eggs), eggs and milt were mixed and fresh water added. The time of fertilization began with the addition of the fresh water. At 20 min after fertilization (MAF), the eggs were poured into heath trays and submersed in the heated water bath. The container used for the water bath was 221 X 40 X 12 cm (length X width X height) and was filled with 26.5 L of ambient hatchery water and 0.27 L of argentine. The argentine disinfected the eggs and is the normal protocol for treating eggs at the Hayspur Hatchery. The desired water temperature was maintained using a recirculating heat pump (Polyscience, model 210). The heat pump capacity was 6.3 L / min. Three Fisher Scientific thermometers tracked water temperature at both ends and near the middle of the heated water bath. After the first two treatments, it was determined that water circulation from the heat pump was insufficient to equalize temperatures throughout the treatment tray. To facilitate water movement, the egg treatment tray was fitted with a perforated plastic pipe and a bilge pump. The bilge pump was fixed in the corner of the treatment tank and pushed water through the perforated pipe down the entire length of the treatment tank. The bilge pump capacity was 32 L / min, a rate that would exchange all the water in the tank once every two min. The bilge pump was turned on once or twice during egg treatments for about 10 sec or until the temperature readings from all three thermometers stabilized.

Heat shocked eggs were delivered to six hatcheries. When the fish reached about 75 mm, we sacrificed 30-60 fish to confirm ploidy. Blood samples were taken by severing the caudal peduncle. The samples were fixed in Alsever's solution and shipped on ice to the Washington State University Veterinary Sciences Lab, where each sample was evaluated for ploidy level using flow cytometry.

## Sterile Fingerlings in Lakes and Reservoirs

In April 1996, IDFG received 60,000 all-female triploid (sterile) rainbow trout eggs from Trout Lodge and an equal number of all-female diploids (control). The eggs were scheduled for use as fall 1996 fingerling plants in lakes and reservoirs statewide. They were hatched and reared at the Nampa State Fish Hatchery. Prior to release, we differentially marked the sterile and control groups with fluorescent grit dye (Nielson 1990). Sterile fish were dyed red, and control fish were dyed green. In October 1996, the fingerlings were stocked in roughly equal proportions in seven waters (Table 2). To assess relative survival and growth, staff from this project and regional management personnel completed a combination of gillnetting and electrofishing surveys.

Table 2. Study waters and stocking dates for sterile and control fingerling rainbow trout stocked in seven Idaho lakes and reservoirs.

| | | | Stocked | | |
|---|---|---|---|---|---|
| **System** | **Acres** | **Harvest Regulations** | **Date** | **Sterile** | **Control** |
| Daniels Reservoir | 375 | 2 (20" minimum) | Oct. 15, 1996 | 7,965 | 7,938 |
| Treasureton Reservoir | 143 | 2 (12"-16" slot) | Oct. 15, 1996 | 5,900 | 6,030 |
| Brundage Reservoir | 340 | 2 (12" –20" slot) | Oct. 15, 1996 | 1,003 | 1,016 |
| Little Payette Reservoir | 1,450 | 2 (20" minimum) | Oct. 15, 1996 | 5,015 | 5,080 |
| Lost Valley Reservoir | 750 | General | Oct. 16, 1996 | 12,980 | 12,700 |
| Warm Lake | 640 | General | Oct. 16, 1996 | 5,015 | 5,080 |
| Tule Lake | 7 | 2 (20" minimum) | Oct. 16, 1996 | 100 | 100 |

Relative survival data were compared using a chi-square test. The goal was to sample a minimum of 172 grit-marked fish per water. Data that passed a standard chi-square test of homogeneity were pooled (i.e., sample periods and gear types; Elrod and Frank 1990). A sample of 172 fish allowed us to detect a 20% change from a stocking ratio of 50:50 ($\forall$ = 0.10, 1 - $\exists$ = 0.80). Growth comparisons (length and weight) will be made using t-test statistics.

## RESULTS

### Production of Sterile Rainbow Trout

A total of 1.2 million eggs were heat shocked. The mean triploid induction rate for R9 rainbow trout was 98% (Table 3). Egg lots ranged in size from 15,000 to 500,000. Induction rates for Kamloops eggs were lower. The recipe developed for R9 rainbow trout induced triploidy in only 67% of the Kamloops eggs (Table 3). One additional lot of Kamloops eggs was treated with the standard heat shock recipe, but the eggs were mixed with R9 eggs and could not be used as a true replicate for Kamloops eggs.

Survival of the heat shocked eggs declined during the second half of the spawning run. Eyed egg survival dropped from 86% on October 29, 1998 to 11% on May 12, 1999 (Table 3). Eyed egg survival plotted against spawning date resulted in a Pearson correlation coefficient of 0.97 ($P < 0.001$). Reduced eyed egg survival is normal for R9 eggs taken late in the spawning run (Bob Esselman, personal communication).

Table 3. Mean induction rates and eyed egg survival of heat shocked egg lots. The strain abbreviations are Hayspur strain (R9) and Kamloops (K1).

| Treatment Date | Strain | Eyed eggs Live | Dead | Total | Survival eyed eggs | % triploid | Shipped to |
|---|---|---|---|---|---|---|---|
| 29-Oct-98 | R9 | 138,295 | 23,249 | 161,544 | 0.86 | | Clark Fork |
| 05-Nov-98 | R9 | 101,697 | 26,695 | 128,392 | 0.79 | 75%[a] | Hagerman |
| 25-Nov-98 | R9 | 115,542 | 27,750 | 143,292 | 0.81 | | Clearwater |
| 23-Dec-98 | R9 | 43,617 | 17,647 | 61,264 | 0.71 | 100% | Nampa/Mackay |
| 07-Jan-99 | R9 | 56,838 | 26,111 | 82,949 | 0.69 | 98% | Grace |
| 25-Feb-99 | R9 | 7,142 | 8,023 | 15,165 | 0.47 | 100% | Grace |
| 04-Mar-99 | R9 | 35,448 | 35,854 | 71,302 | 0.50 | | Hagerman |
| 12-May-99 | R9 | 3,050 | 24,186 | 27,236 | 0.11 | 100% | Nampa |
| 25-Feb-99 | K1 | 29,000 | 22,093 | 51,093 | 0.57 | 67% | Grace |
| 24-Mar-99 | R9 & K1 mix | 280,850 | 223,189 | 504,039 | 0.56 | 92% | Nampa |
| **Grand Totals** | | **811,479** | **434,797** | **1,246,276** | | | |

[a] Water circulation pump was not installed.

## **Sterile Fingerlings in Lakes and Reservoirs**

In Treasureton Reservoir, on June 8, 1999, 20 (71%) sterile and eight (29%) control rainbow trout were caught in 10 h of electrofishing. Mean total lengths were 498 mm (SE = 6 mm) for the sterile group and 488 mm (SE = 7 mm) for the controls. Statistical comparisons for mean length and weight are shown in Table 4. During the spring sample period, most of the females from the control group were sexually mature. Conversely, none of the sterile fish showed any signs of maturation. Two of the sterile females were sacrificed and no mature oocytes were visually present (Figure 3). Gamete weight in the sterile females was less than 2 g (<0.1% of total body weight). In October, 5.5 h of electrofishing produced 29 (69%) sterile fish and 13 (31%) control fish. Similar to spring samples, the sterile fish were slightly longer than the controls. Mean total length was 496 mm (SE = 4 mm) for sterile and 483 mm (SE = 7 mm) for control fish. The small difference in mean length was significant (t-value = -1.65, $P$ = 0.05).

In Daniels Reservoir, on June 9, 1999, 14 (78%) sterile and four (22%) control rainbow trout were caught in 10 h of electrofishing. Mean total lengths were 521 mm (18 mm) for sterile and 508 mm (SE = 9 mm) for controls. The difference in mean length was not statistically significant (t-value = -0.66, $P$ = 0.26). Similar to Treasureton Reservoir, most of the female control fish were sexually mature. For the control females, egg weight averaged 7.5% of total body mass. Ovaries of the sterile fish were not developed and made up less than 0.1% of total body mass (Figure 3). Flesh color for the sterile trout was bright red, compared with a paler appearance for controls. In October, 5.5 h of electrofishing produced nine (60%) sterile and six (40%) control fish. Mean lengths were identical for sterile and control fish at 527 mm. Figures 4 and 5 show the trends in sterile and control growth from their initial release date in October of 1996.

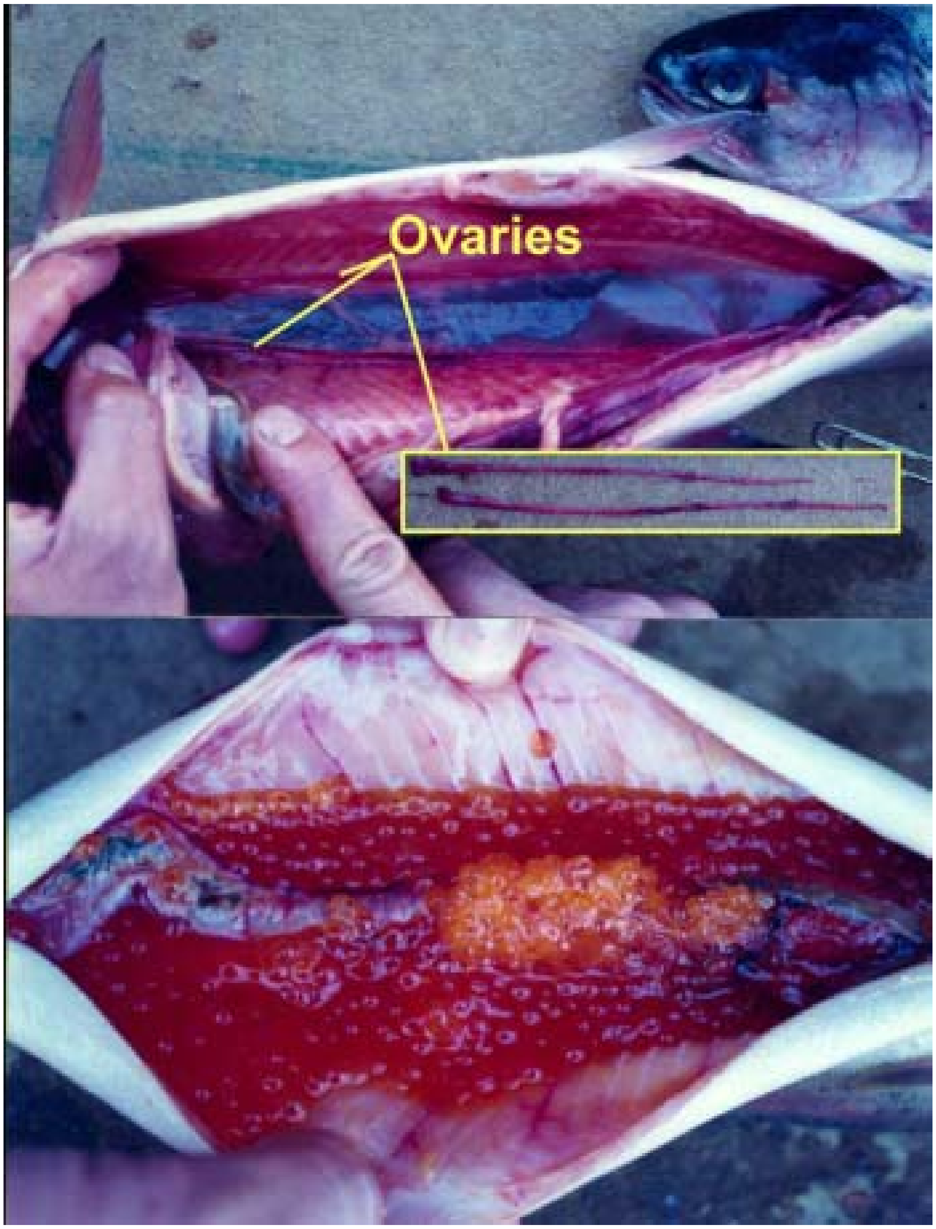


Figure 3. Comparison of sexual maturity for age-3 triploid (top) and diploid (bottom) rainbow trout caught in Daniels Reservoir on June 9, 1999. Gonad mass made up 10% of the control fish weight compared to less than 0.1% for the sterile trout.

Pooled catch results show that relative survival was higher for sterile rainbow trout compared to the diploid controls. In both waters, the data collected since 1997 met the homogeneity assumptions (Treasureton $\chi^2$ = 7.98, df = 4, $P$ >0.05; Daniels $\chi^2$ = 3.81, df = 4, $P$ >0.25). Therefore, catch results were pooled and one chi-square value was used to test the null hypothesis that relative survival was similar for triploid and diploid rainbow trout. In both reservoirs, the null was rejected because more sterile fish were caught than expected. Pooled chi-square values are shown in Table 4.

Table 4. Comparisons of relative survival (catch) and growth of sterile and control rainbow trout stocked on October 10, 1996, in Treasureton and Daniels reservoirs. Chi-square statistics were calculated to test if the ratio of caught fish was significantly different from their stocked proportions. Two sample t-tests were used to compare average lengths and weights.

| | Catch | | | | Length (mm) | | Weight (g) | |
|---|---|---|---|---|---|---|---|---|
| | **Sterile** | **Control** | $\chi^2$ | ***P*** | **Sterile** | **Control** | **Sterile** | **Control** |
| **Treasureton** | | | | | | | | |
| At release | | | | | 157 | 150 | 38 | 36 |
| June 1997 | 19 | 23 | 0.38 | >0.50 | 266 | 267 | 243 | 245 |
| May 1998 | 29 | 18 | 2.57 | >0.10 | 396 | 401 | 708 | 812[c] |
| Oct 1998 | 25 | 24 | 0.02 | >0.90 | 446 | 448 | 904 | 1,005[c] |
| June 1999 | 20[S] | 8 | 5.14 | <0.03 | 498 | 488 | 1,260 | 1,376 |
| Oct 1999 | 29[S] | 13 | 6.10 | <0.03 | 496[T] | 483 | 1,134 | 1,170 |
| Pooled | 122[S] | 86 | 6.23 | <0.03 | | | | |
| **Daniels** | | | | | | | | |
| At release | | | | | 157 | 150 | 38 | 36 |
| April 1997 | 21 | 16 | 0.68 | >0.25 | 187 | 183 | 70 | 68 |
| May 1998 | 1 | 2 | 0.33 | >0.50 | 418 | 429 | 950 | 647[N] |
| Oct 1998 | 19[S] | 8 | 4.48 | <0.05 | 475 | 501[c] | 1,166 | 1,428[c] |
| June 1999 | 14[S] | 4 | 5.56 | <0.03 | 521 | 508 | 1,398 | 1,293 |
| Oct 1999 | 9 | 6 | 0.60 | >0.50 | 527 | 527 | 1,346 | 1,433 |
| Pooled | 64[S] | 36 | 7.84 | <0.01 | | | | |

[C] Indicates that the control fish were significantly larger than sterile fish on that date
[T] Indicates that the sterile fish were significantly larger than the control fish on that date
[S] Indicates that significantly more fish that were sterile were caught
[N] Indicates that samples size was too small to complete statistics

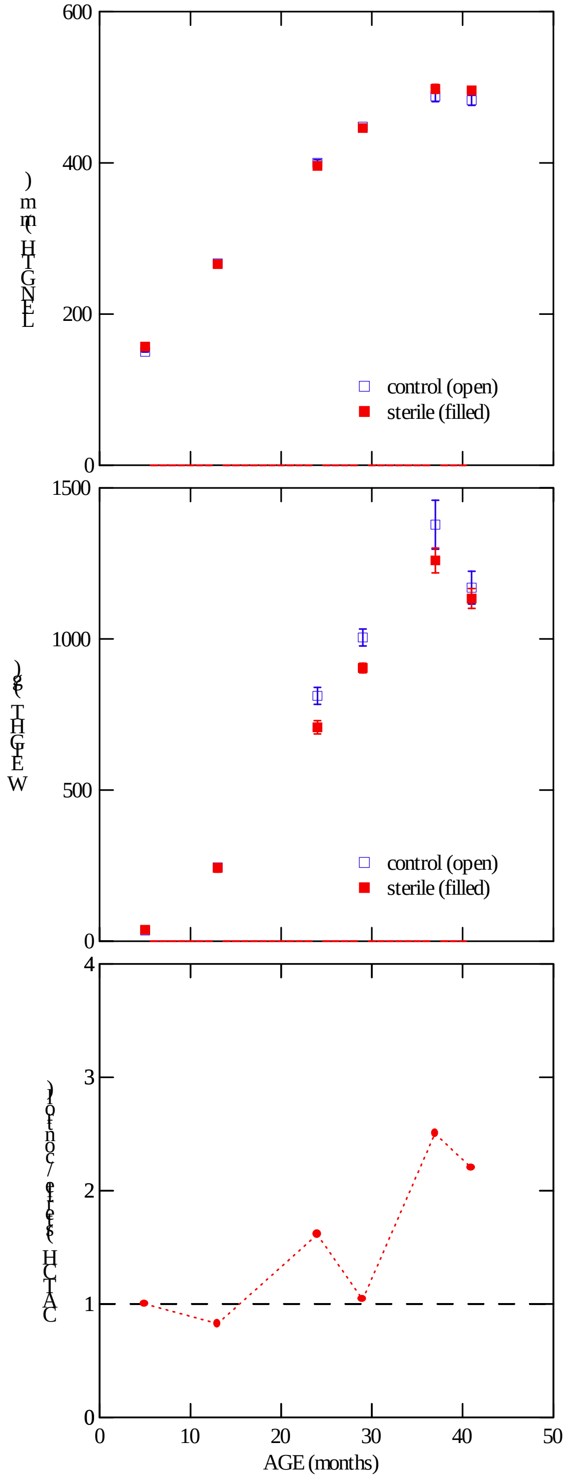


Figure 4. Relative survival (catch) and growth of sterile and control rainbow trout in Treasureton Reservoir. Error bars represent one standard error.

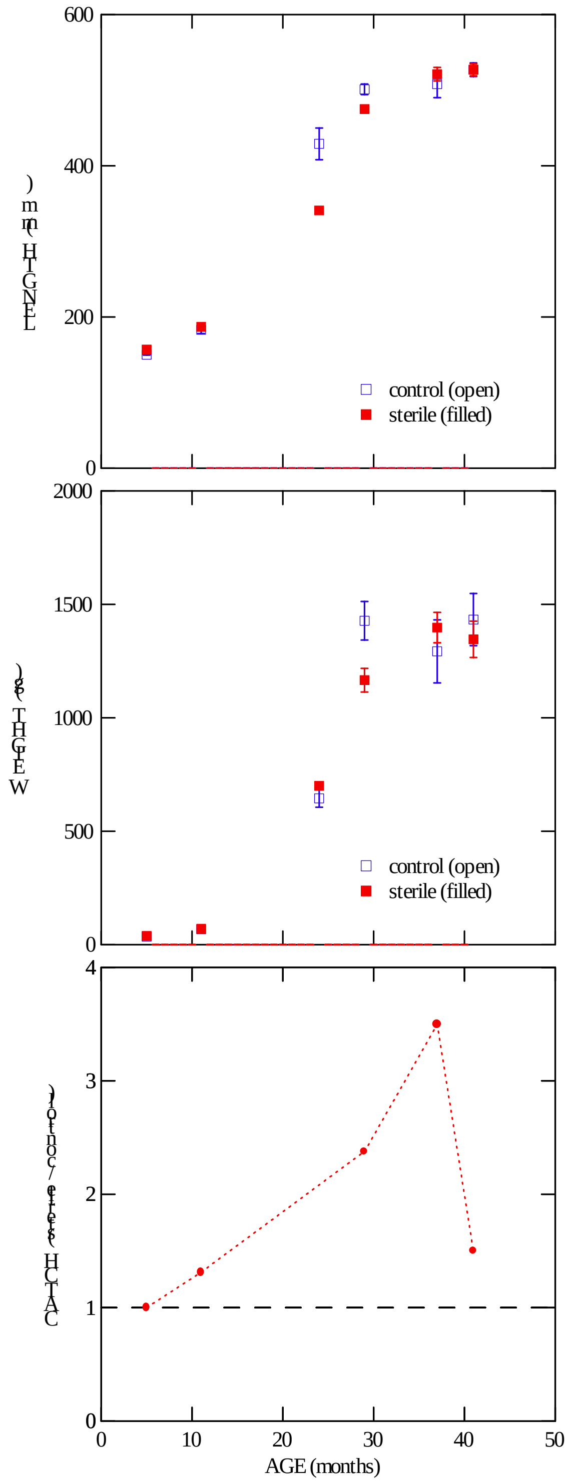


Figure 5. Relative survival (catch) and growth of sterile and control rainbow trout in Daniels Reservoir. Error bars represent one standard error.

## DISCUSSION

Mass production of triploid R9 rainbow trout is cost effective and more reliable than commercially available products. In 1999, triploid eggs cost between one-quarter and two times more than normal eggs when purchased from commercial producers. The increase in cost to produce triploid eggs at Hayspur is substantially lower. Personnel costs for treating the 1.2 million eggs was about $282 (40 h X $7.05 h). Assuming R9 eggs cost about $15 / 1,000, the total cost to produce 1.2 million normal eggs would be $18,000. The cost of producing the same number of triploid eggs would be about $18,282 or an increase of only 1.6%. Even with the heat pump cost added (prorated over a 5-year period), production costs would only increase by 2%, which is substantially lower than commercial values (25% to 200% the normal egg price). Moreover, the commercial producers do not guarantee induction rates, and IDFG received a commercial lot in 1998 that was only 78% triploid.

Benfey (1999) summarized the physiology and behavior of sterile fishes. In that summary, over 200 sterile fish papers were cited and the following conclusions made: 1) male triploid fish pair with ripe diploid females and demonstrate normal spawning behavior; 2) the survival of triploid fish may be lower than diploid fish in stressful environments - i.e., in waters with high water temperatures or low oxygen levels; 3) triploid salmonids have better muscle pigmentation than diploids prior to spawning; 4) growth rates are the same for triploid and diploid fish; and 5) because some species exhibit high spawning mortality, triploid fish may live longer and obtain a larger size. The results from three years of monitoring sterile fish plants in Idaho reservoirs support the above review. The triploid fish have not demonstrated a consistent growth advantage. Secondly, post-spawning mortality or out-migration loss may explain the relative survival advantage observed for the all-female triploid rainbow trout. Because data collection is ongoing, these conclusions should be considered preliminary.

Grit mark retention is a potential limitation in the reservoir evaluations. We assumed that mark retention was similar for red and green grit mark dye. If retention was not similar, our results could be biased in favor of sterile or control fish. Nielson (1990), however, observed similar retention of green and red grit dye colors during a 12-year study. Nielson (1990) also reported that after six years, mark retention was 86% for grit-dyed fingerlings. Additionally, directly monitoring impacts to the fishery like collecting catch rate data for sterile and control fish would bolster the performance evaluations.

## RECOMMENDATIONS

1 Because of economic benefits and high induction rates, produce triploid rainbow trout using Idaho’s R9 rainbow trout.

## ACKNOWLEDGEMENTS

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