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PROJECT 4: HATCHERY TROUT EVALUATIONS

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Douglas J. Megargle
Senior Fishery Research Biologist

David Teuscher
Senior Fishery Research Biologist

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By

Douglas J. Megargle
Senior Fishery Research Biologist

David Teuscher
Senior Fisher Research Biologist

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

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ABSTRACT

Increased growth rates, improved survival, and genetic protection of wild stocks have been suggested as possible benefits of stocking triploid fish. Despite exhaustive comparison between diploid and triploid fish in aquaculture, conclusive field investigations are lacking. This study monitored the long-term growth and relative survival of triploid rainbow trout stocked in two Southeast Idaho reservoirs. In October 1996, triploid and diploid rainbow trout were differentially marked and stocked in equal proportions. Growth and relative survival were monitored using gillnet and electrofishing samples collected through October 2000. In both reservoirs, relative survival (total catch) was significantly higher for triploid fish. The final catch proportions (triploid:diploid) were 1.4:1 in Treasureton (X^2 = 6.08, P <0.03) and 1.9:1 in Daniels reservoirs (X^2 = 10.91, P <0.01). We observed ontogenetic difference in growth. At age-1, mean length and weight values were similar for the triploid and diploid fish. During the second year, however, diploid growth was significantly higher than triploids. The trend reversed as the diploid fish reach sexual maturity. Age-3 and older triploids caught or exceeded diploid fish in length but not weight. Our findings suggest that managers considering the use of triploid rainbow trout for trophy management should not expect a growth advantage but may extend the period that a specific plant of fish is susceptible to anglers. The all-female triploids provide an enticing management option when considering their ability to maintain hatchery-supported fisheries while protecting the genetic integrity of wild populations.

Author:

David Teuscher
Senior Fishery Research Biologist

INTRODUCTION

Physiology, hatchery performance, and production techniques for triploid (3N) salmonids are widely published. Benfey (1999) reviewed the available literature on 3N fish and cited over 200 publications. The popularity of the subject stems from the common assertion that 3N fish are functionally sterile, and that sterility provides a fisheries or aquaculture benefit. In aquaculture, research has focused on survival, growth, dress-out weights, conversion efficiencies, flesh quality, hybrid vigor, and physiological responses to acute stressors. Results of those experiments have been mixed. In general, 3N salmonids produced by temperature or pressure shock suffer increased mortality and reduced growth during early life stages (Solar et al. 1984; Happe et al. 1988; Guo et al. 1990; Oliva-Teles and Kaushik 1990; Galbreath et al. 1994; McCarthy et al. 1996). Despite early rearing disadvantages, 3N performance appears to improve with age. Several investigators reported enhanced rearing performance in terms of growth and food conversion for age-1 and older triploids (Sheehan et al. 1999; Habicht et al. 1994; Boulanger 1991; Bye and Lincoln 1986; Lincoln and Scott 1984). Recent aquaculture research addressed feeding behavior (O'Keefe and Benfey 1999), handling stress (Benfey and Biron 2000; Sadler et al. 2000), tumor suppression (Thorgaard et al. 1999), and survival of hybrid crosses (Blanc et al. 2000; Galbreath and Thorgaard 1997).

Unlike the breadth of review in aquaculture, published literature on the performance of 3N salmonids in natural environments is sparse. We found only six studies that addressed the topic. Those studies evaluated growth, relative survival, longevity, return-to-creel, and genetic protection of wild stocks. Brock et al. (1994) and Simon et al. (1993) reported lower growth and survival for 3N rainbow trout compared to diploid (2N) controls. In contrast, 3N brook trout and kokanee demonstrated the potential for increased longevity in lake habitats (Warrillow et al. 1997; Parkinson and Tsumura 1988). Return-to-creel was similar for 3N and 2N rainbow trout stocked in 18 Idaho streams (Dillon et al. 2000). Lastly, Cotter et al. (1999) argued that stocking 3N Atlantic salmon reduced genetic impacts to wild populations because fewer 3N fish returned to spawning habitats. These studies provided an important framework for evaluating the performance of 3N salmonids in natural environments. However, the limited number, contradicting results, and diversity of questions fail to fully address the performance of 3N salmonids stocked for trophy angling opportunity or genetic protection issues.

The genetic conservation of wild populations is a management priority for the Idaho Department of Fish and Game (IDFG). The IDFG recently established a goal to stock only 3N rainbow trout in systems where reproduction between wild and hatchery fish was possible. As part of that plan, it is important to evaluate the performance of 3N rainbow trout so that fisheries managers can adjust stocking strategies if necessary. In this study, we compared long-term survival and growth of 3N and 2N rainbow trout stocked in two Southeast Idaho reservoirs. Additionally, we evaluated efforts to produce triploid trout at Hayspur and Henrys Lake hatcheries in 2000.

RESEARCH GOAL

1. 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 at the production scale.

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

METHODS

Sterile Fingerlings in Lakes and Reservoirs

On April 18, 1996, IDFG received approximately 60,000 2N rainbow trout eggs from Trout Lodge, Inc., Summer, Washington. The eggs were all-female and half were heat shocked to induce triploidy. Thereafter, husbandry and rearing protocols for both groups of fish were similar. The fish were reared for seven months at the IDFG fish hatchery in Nampa, Idaho. Two weeks prior to release, we differentially marked the 3N and 2N groups with fluorescent grit dye. Grit dyeing procedures were completed as described by Nielson (1990). Triploid fish were marked with red grit dye and 2N fish with green.

On October 15, 1996, equal proportions of 2N and 3N rainbow trout were stocked in Daniels and Treasureton reservoirs. The reservoirs were built for irrigation purposes and are located in the Southeast corner of Idaho. Daniels Reservoir (144 ha) is twice as large as Treasureton Reservoir (61 ha). Both reservoirs reside approximately 1525 m above sea level. The reservoirs are relatively small, shallow (mean depth <15 m), and have restrictive harvest regulations. Harvest limits are two fish with a 508 mm minimum length restriction on Daniels Reservoir and a 305 to 406 mm protected slot limit on Treasureton Reservoir.

Gillnets and shoreline electrofishing were used to monitor relative survival and growth. In both reservoirs, experimental gillnets were set in the spring of 1997. Boat electrofishing equipment was used to sample fish in 1998, 1999, and 2000. Captured fish were anesthetized and held under a black light to check for grit dye markings. Total lengths (mm) and weights (g) were measured for all grit marked fish. A subsample of fish was collected to estimate the gonadosomatic index (GSI). The GSI was calculated as:

$$(\text{Gonad weight (g)} / \text{Body weight (g)}) \times 100.$$

Fish not sacrificed for GSI comparisons were given a caudal punch and released. The fin punch ensured that grit marked fish released back to the reservoir were not resampled during the same sampling effort.

Relative survival was compared based on comparative catches of 3N and control fish in each reservoir. Survival data were evaluated using a chi-square goodness-of-fit test. To obtain sufficient power for the chi-square test (1 - ß = 0.80), a minimum of 172 grit marked fish had to be sampled. A sample of 172 fish provided a detectible difference of a 20% change from a stocking ratio of 50:50 (Elrod and Frank 1990). Data collected within a reservoir that met a standard chi-square test of homogeneity were pooled (Zar 1984). Data collected from different reservoirs were not pooled. Two sample t-tests were used to compare length and weight measurements. Additional growth comparisons were made by modeling growth using the Von Bertalanffy equation:

$$L(age) = L\infty (1 - Exp(-K(age - T_o))),$$

where $L\infty$ is the maximum obtainable size, K is the growth coefficient, and T_o is the age at which length would be theoretically zero. The Von Bertalanffy equations were estimated using QWKVON 1.0 (Beamesderfer 1988). A significance level of $P \leq 0.1$ was accepted for all statistical tests.

Production of Sterile Rainbow Trout

In 2000, several experiments were completed to determine the best method to produce 3N Kamloop rainbow trout at Hayspur Hatchery. A reliable thermal treatment has been determined for the Hayspur R9 rainbow trout, but to date an acceptable thermal treatment has not been developed for Kamloop strain rainbow trout. A variety of heat shock treatments were used to treat Kamloop eggs and compared with controls at Hayspur. Fertilized Kamloop eggs were exposed to various temperatures, incubation periods, and durations of heat shock treatments. The eggs were heat shocked, incubated, hatched, and subsequently reared at Hayspur Hatchery. Eggs were enumerated at eyed and hatch stages to determine survival. An automated egg counter was used at first but found to be inaccurate; therefore, a second round of treatments was conducted and eggs were hand counted. Blood samples were collected from each treatment group and ploidy levels were determined using flow cytometry at Washington State University by Paul Wheeler.

Mass production of sterile triploid rainbow trout began at Hayspur Hatchery in 2000. A new heat shock water bath was designed, built, and placed into production in October 2000. Two water bath tables were built, which allowed Hayspur personnel to heat shock their entire production. Some production occurred before the construction of the new water bath tables; therefore, some diploid production occurred. We sampled the sterile lots of rainbow trout (T9 strain) produced at Hayspur and evaluated induction rates.

The influence egg quality had upon triploid induction rates of Henrys Lake hybrids was examined. In 1999, it was suspected that poor egg quality might have negatively impacted efforts to produce triploid Henrys Lake hybrid trout. In 2000, heat shock treatments were scheduled during the peak in the spawn run when it was suspected that egg quality was optimal. Eggs were heat shocked [10 minutes after fertilization (MAF); 27°C; 20 min], incubated to eyed stage and shipped to McCall Hatchery for rearing. Sixty blood samples were randomly collected from fingerlings and ploidy levels were determined at Washington State University by Paul Wheeler.

RESULTS

Sterile Fingerlings in Lakes and Reservoirs

Relative survival was higher for sterile rainbow trout compared to the 2N controls. In both waters, the data collected since 1997 met the homogeneity assumptions (Treasureton X^2 =

8.20, df = 6, P >0.10; Daniels X^2 = 5.41, df = 5, P >0.25); therefore, catch results were pooled. In Treasureton Reservoir, a total of 131 3N and 94 2N fish was sampled. The difference in total catch was significant (X^2 = 6.08, P <0.03). In Daniels Reservoir, a total of 70 3N and 36 2N fish was sampled (X^2 = 10.91, P <0.01). The ratios of total catch (3N/2N) were 1.4:1 in Treasureton and 1.9:1 in Daniels Reservoir. Individual and pooled chi-square statistics are shown in Table 1.

Ontogenetic growth patterns varied between 3N and 2N rainbow trout. Growth was similar for the first 13 months of life. In both reservoirs, mean lengths and weights varied by less than 3% between the stocking groups. However, growth for 2N rainbow trout exceeded 3N fish during their second year in the reservoir. By the 29th month of the experiment, the mean 2N weight was 11% and 22% higher than 3N weight in Treasureton and Daniels reservoirs, respectively. Table 1 shows mean length, weight, and sample size for each sample period. In the spring of 1999, the age-3 2N rainbow trout reached sexual maturity, and from that point forward Triploids demonstrated a growth advantage. The ontogenetic differences in growth were evident in the Von Betallanfy growth models (Figure 1). At age-3, the Von Bertalanffy growth functions crossed in Treasureton and converged in Daniels Reservoir. The maximum length predictions (L_∞) of the growth model were the same (545 mm) for 2N and 3N fish in Daniels Reservoir. In Treasureton, L_∞ was 532 mm for 2N and 591 mm for the 3N model (Figure 1).

The 3N rainbow trout did not reach sexual maturation (Figure 2). At age-2, GSI was estimated for 14 3N and seven 2N rainbow trout. The mean GSI for 2N fish at age-2 was 1.5%. The gonadosomatic index for age-2 triploids was <0.1%. For age-3 and older fish, the mean GSI remained 0.1% (n = 6) for triploids and increased to 12.1% (n = 7) for diploids. The GSI index indicated that dress-out weights for triploids would exceed diploids in age-3 and older fish.

Production of Sterile Rainbow Trout

Our attempt to produce triploid Kamloop rainbow trout at high induction rates was successful. Triploid induction rates ranged from 27-100% (Table 2). Eggs shocked 20 min after fertilization (MAF) in 26°C water showed good eye-up and high induction rates. The survival advantage found with this treatment was also evident in the survival from eye-up to sac fry (Table 3).

General production of Hayspur T9 rainbow trout (T9 = triploid R9 strain) was successful. On average 95% of the T9's sampled were indeed triploid (Table 4). Due to technical difficulties at the WSU lab, some samples produced no results because samples were not evaluated before they decomposed. Although there is no reason to suspect a bias in decomposition among triploid and diploid samples, some error in the triploidy evaluation was possible.

Efforts to produce Henrys Lake hybrid triploid trout with high induction rates were less successful. Sixty samples were taken from the production lot, and only 65% of the treated eggs were triploid. Selection for better egg quality did not improve overall triploid induction rates.

Table 1. Comparisons of relative survival (catch), Chi-square statistics, length, and weight of 3N and 2N rainbow trout sampled from Treasureton and Daniels reservoirs. Values in parenthesis are one SE. Asterisks indicate significance difference from t-test statistics.

	Age	Catch				Length (mm)		Weight (g)	
Reservoir	(months)	Triploid	Diploid	X^2	*P*	Triploid	Diploid	Triploid	Diploid
Treasureton	5					157 (-)	150 (-)	38 (-)	36 (-)
	13	19	23	0.38	>0.50	266 (5)	267 (4)	243 (14)	245 (9)
	24	29	18	2.57	>0.10	398 (4)	401 (4)	708 (22)	812 (28)*
	29	25	24	0.02	>0.90	446 (3)	448 (3)	904 (16)	1,005 (28)*
	37	20	8	5.14	<0.03	498 (6)	488 (7)	1,260 (41)	1,376 (81)
	41	29	13	6.10	<0.03	496 (4)*	483 (7)	1,134 (33)	1,170 (54)
	47	8	7	0.07	>0.75	528 (8)	501 (16)	1,469 (66)	1,550 (122)
	51	1	1	0.00	=1.00	535 (-)	465 (-)	1,400 (-)	800 (-)
	Pooled X^2	131	94	6.08	<0.03				
Daniels	5					157 (-)	150 (-)	38 (-)	36 (-)
	11	21	16	0.68	>0.25	187 (6)	183 (5)	70 (6)	68 (5)
	24	2	2	0.00	=1.00	380 (39)	429 (30)	825 (125)	1000 (300)
	29	19	8	4.48	<0.05	475 (5)	501 (7)*	1,166 (52)	1,428 (85)*
	37	14	4	5.56	<0.03	521 (9)	508 (18)	1,398 (67)	1,293 (139)
	41	9	6	0.60	>0.50	527 (9)	527 (8)	1,346 (80)	1,433 (115)
	47	5	0	5.00	<0.05	510 (9)	-	1,117 (104)	-
	Pooled X^2	70	36	10.91	<0.01				

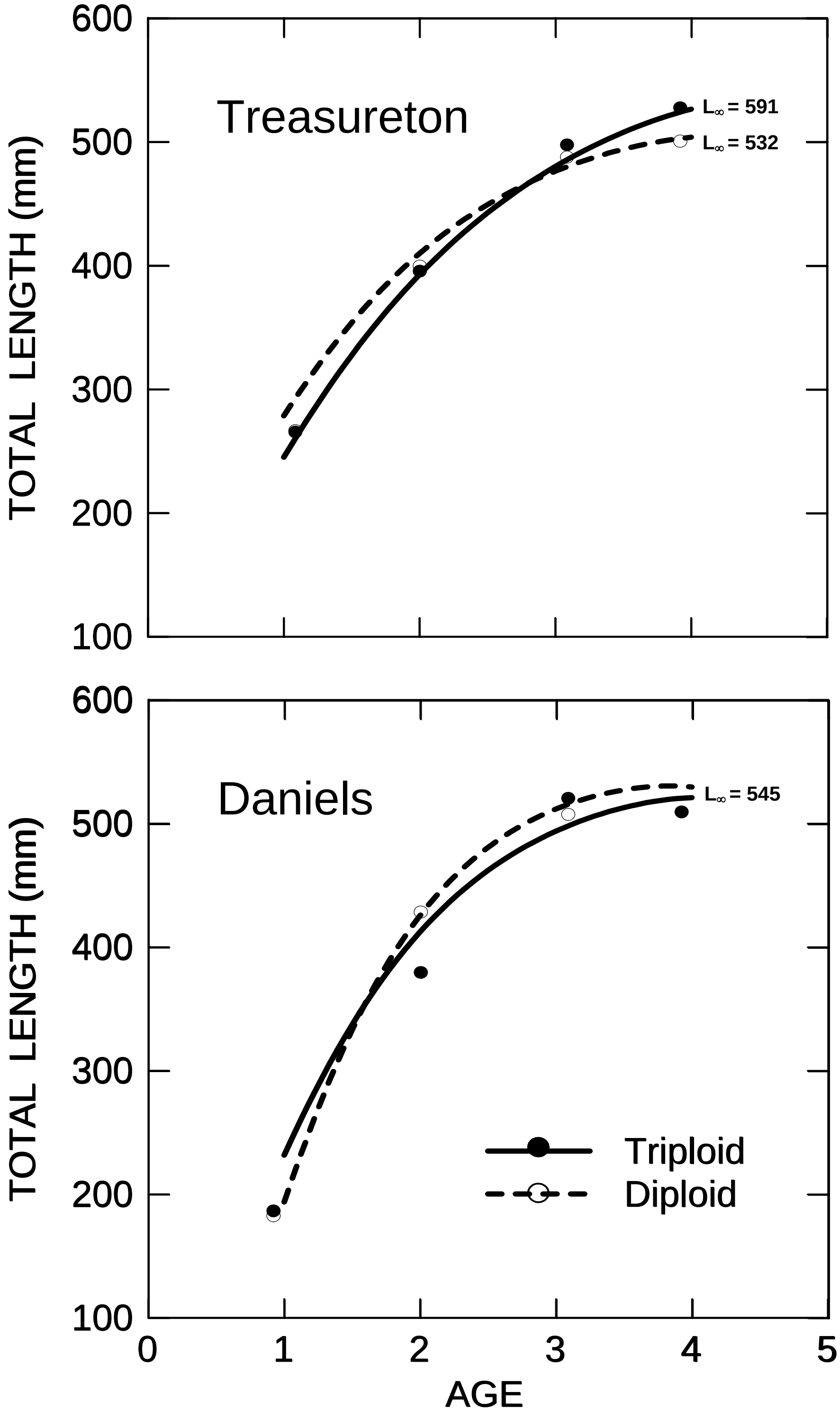

Figure 1. Von Bertalanffy growth functions for 3N and 2N rainbow trout stocked in Daniels and Treasureton reservoirs. Maximum theoretical length ($L\infty$) predictions are shown. The coefficient of determination (r^2) for all of the growth models exceeded 0.95.

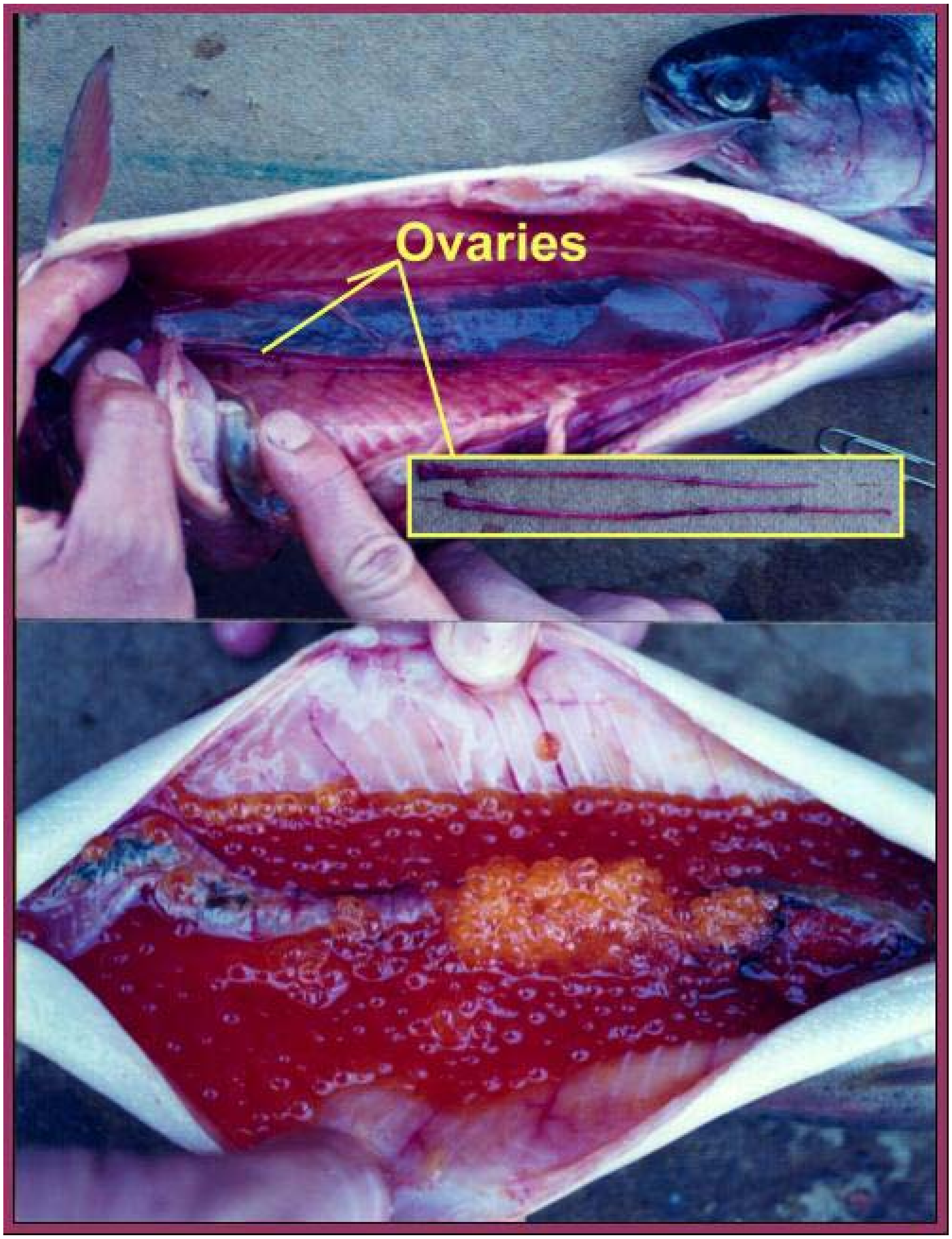

Figure 2. Comparison of sexual maturity for age-3 3N (top) and 2N (bottom) rainbow trout caught in Daniels Reservoir on June 9, 1999. The gonadosomatic index was 10% for the 2N fish and less than 0.1% for the 3N fish.

Table 2. Survival to eyed eggs stage and triploid induction rates of Kamloop rainbow trout that were heat shocked at Hayspur Hatchery in April 2000.

			10 MAF			15 MAF			20 MAF			
Trial	**Temp (C)**	**Batch**	**Survival (%)**	**Relative survival (%)[a]**	**Induction (%)**	**Survival (%)**	**Relative survival (%)[a]**	**Induction (%)**	**Survival (%)**	**Relative survival (%)[a]**	**Induction (%)**	**Average relative survival (%)**
1[b]	26[c]	Cont	- na -			- na -			- na -			
		Treat	- na -	- na -	93.0	- na -	- na -	93.0	- na -	- na -	93.0	- na -
	27[c]	Cont	- na -			- na -			- na -			
		Treat	- na -	- na -	100.0	- na -	- na -	100.0	- na -	- na -	97.0	- na -
	28[d]	Cont	- na -			- na -			- na -			
		Treat	- na -	- na -	100.0	- na -	- na -	93.0	- na -	- na -	97.0	- na -
	29[d]	Cont	- na -			- na -			- na -			
		Treat	- na -	- na -	100.0	- na -	- na -	93.0	- na -	- na -	27.0	- na -
2	26[c]	Cont	37.1			24.9			40.8			
		Treat	31.3	84.3	- na -	35.9	144.1	- na -	35.0	85.7	100.0	104.7
	27[c]	Cont	24.1			24.5			21.8			
		Treat	16.1	66.6	100.0	17.1	69.9	100.0	15.8	72.5	100.0	69.7
	28[d]	Cont	12.4			2.1			33.7			
		Treat	15.3	123.0	100.0	0.2	8.4	100.0	30.0	88.9	95.0	73.4
	29[d]	Cont	26.8			8.4			27.5			
		Treat	6.8	25.3	100.0	0.8	9.8	100.0	4.8	17.5	100.0	17.5

[a] Relative survival = (Treatment survival / Control survival) *100
[b] Errant counts were produced from an automated egg counter; therefore, no survival estimates could be generated
[c] Duration of heat shock treatment was 20 min
[d] Duration of heat shock treatment was 10 min

Table 3. Survival from eyed egg to sac fry stage and triploid induction rates of Kamloop rainbow trout that were heat shocked at Hayspur Hatchery in April 2000.

		10 MAF			15 MAF			20 MAF			
Temp (C)	Batch	Survival (%)	Relative survival (%)[a]	Induction (%)	Survival (%)	Relative survival (%)[a]	Induction (%)	Survival (%)	Relative survival (%)[a]	Induction (%)	Average relative survival (%)
26[b]	Cont	77.0			82.0			82.5			
	Treat	70.5	91.6	93.0	84.4	102.4	93.0	81.0	98.2	93.0	97.4
27[b]	Cont	94.0			95.5			89.5			
	Treat	70.5	75.0	100.0	69.2	72.5	100.0	50.3	56.1	97.0	67.9
28[c]	Cont	91.5			79.2			92.0			
	Treat	83.0	90.7	100.0	0.0	0.0	93.0	80.5	87.5	97.0	59.4
29[c]	Cont	96.0			84.4			95.0			
	Treat	76.3	79.4	100.0	50.0	59.2	93.0	43.9	46.2	27.0	61.6

[a] Relative survival = (Treatment survival / Control survival) *100
[b] Duration of heat shock treatment was 20 min
[c] Duration of heat shock treatment was 10 min

Table 4. Triploid induction rates of rainbow trout production (T9) at Hayspur Hatchery from January 1, 2000 to December 31, 2000.

Strain	Hatchery	Raceway population	Sample (n)	Tiploid (n)	Diploid (n)	No Result[a] (n)	Induction rate (%)
T9	American Falls	1	60	54	6	0	90
	Grace	1	60	0	0	60	- na -
	Clearwater	1	60	53	0	7	100
		2	60	52	0	8	100
	Nampa	1	60	54	6	0	90
	TOTAL		**360**	**213**	**12**	**75**	**95**

[a] No results were obtained because samples were held at WSU too long prior to lab processing of samples; samples decomposed.

DISCUSSION

Sterile Fingerlings in Lakes and Reservoirs

Triploid rainbow trout demonstrated a benefit in relative survival, but no consistent growth advantage was found. These results contradict findings from Brock et al. (1994) and Simon et al. (1993). In those experiments, relative survival and growth of 3N rainbow trout was lower than diploids. In Simon et al. (1993), the authors noted that drought conditions increased water temperatures and lowered oxygen levels below those optimal for rainbow trout. The performance of 3N fish in stressful environments such as low oxygen or high water temperatures may be inferior to diploids (Benfey 1999). However, in several stress response experiments, 3N performance mirrored 2N controls (Sadler et al. 2000, Benfey and Biron 2000; O'Keefe and Benfey 1999). The fact that our conclusions contradict Brock et al. (1994) may be explained by the length of evaluation. Brock et al. (1994) monitored growth and relative survival for two years. If we terminated data collection after two years, our conclusions would have been the same. At age-2, 3N lengths and weights were significantly less than 2N fish, and comparisons of relative survival were inconclusive. The length of evaluation is critical given that the potential benefits of triploidy do not manifest before sexual maturation (Benfey 1999).

Angling pressure may have impacted our mean length and weight estimates. In Daniels reservoir, there is a 508 mm minimum length limit for harvest. The largest fish from each population were likely culled from the fishery upon reaching legal harvest length as evident by the decline in mean lengths measured between October 1999 (mean = 525 mm, n = 9) and June 2000 (mean = 510 mm, n = 5). Size-selective harvest may have negatively biased the maximum obtainable size of 3N fish predicted by the Von Bertalanffy growth model (Figure 1). If the last sample period is removed from the Von Bertalanffy equation, growth for 3N trout in Daniels Reservoir appears linear (Figure 1). If the harvest bias is real, both 2N and 3N populations should have been impacted.

Grit mark retention is a potential limitation in the reservoir evaluations. We assumed mark retention was similar for red and green grit mark dye. If retention was not similar, our results could be biased. Nielson (1990) observed similar retention of green and red grit dye colors during a 12-year study, and reported mark retention was 86% after six years for grit-dyed fingerlings.

Our findings provide important management considerations. Managers using 3N fish for trophy management should not expect a substantial growth advantage. Long-term survival of 3N trout appears to be significantly higher than for 2N trout. Stocking 3N rainbow trout will afford genetic protection to wild populations while meeting the demands of sport anglers.

Production of Sterile Rainbow Trout

The triploid trout production at Hayspur Hatchery is effective. High induction rates for T9's indicate the hatchery can successfully provide a quality triploid product. Hayspur produced and shipped approximately 2.8 million T9 eggs in 2000. A thermal treatment was identified and implemented that will likely prove successful in producing triploid Kamloop (KT) rainbow trout in 2001. Kamloop eggs will be shocked with the same thermal treatment as R9 eggs (26°C; 20 MAF; 20 min). The new heat baths built for Hayspur have provided the means to heat shock all production lots without slowing production.

Efforts to improve induction rates at Henrys Lake Hatchery by selecting for high egg quality were unsuccessful. In 2000, Henrys Lake Hatchery produced and shipped approximately 340,000 hybrid eggs of which only 221,000 (65%) were triploid. It is suspected that relatively high genetic variation in the Henrys Lake cutthroat trout females may cause differences in susceptibility to heat shock treatments among egg lots. Wild salmonid populations have shown wide variation in induction rates in past research (Carmen Olita, Alaska Department of Fish and Game, personal communication). In the Alaska study, the induction rates of 1:1 (male:female) salmon crosses that were treated identically showed induction rates that ranged from 0-100%. If genetic variation of the Henrys Lake cutthroat trout population is problematic, then perhaps induction rates higher than 65-70% will not be possible with the current shock treatments. The role of genetic variability in triploid production at Henrys Lake Hatchery can be investigated further by examining induction rates of several female cutthroat trout fertilized by one individual male rainbow trout. If substantial variation is noted, then other options of producing sterile triploid trout should be examined.

One possibility not yet examined at Henrys Lake Hatchery is the use of pressure shock to induce triploidy. Pressure shock treatments are not biased against egg size and are thought to shock egg lots more uniformly than thermal treatments (Tim Yasaki, British Columbia Ministry of Environment, personal communication). Effectiveness of thermal treatments may suffer if large variation in egg size is present, because thermal units are not applied uniformly to large and small eggs.

MANAGEMENT RECOMMENDATIONS

1. Use 3N rainbow trout for lake and reservoir stocking programs where enhanced long-term survival of stocked trout will benefit the fisheries.

2. Produce triploid Kamloop rainbow trout at Hayspur Hatchery with the following heat-shock treatment: 26°C: 20 MAF: 20 min.

3. Investigate how the genetic variation of the cutthroat trout broodstock impacts the production of triploid hybrid trout at Henrys Lake Hatchery.

4. Examine the use of pressure shock treatments to induce triploidy at Henrys Lake Hatchery.

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LITERATURE CITED

Beamesderfer, R. 1988. Quick Von Bertalanffy parameter estimator (QWKVON).

Benfey, T. J. 1999. The physiology and behavior of triploid fishes. Reviews in Fisheries Science 7:39-67.

Benfey, T. J., and M. Biron. 2000. Acute stress response in triploid rainbow trout *Oncorhynchus mykiss* and brook trout *Salvelinus fontinalis*. Aquaculture 184: 167-176.

Blanc, J. M., F. Vallee, and M. Dorson. 2000. Survival, growth and dressing traits of triploid hybrids between rainbow trout and three char species. Aquatic Research 31: 349-358.

Boulanger, Y. 1991. Performance comparison of all-female, diploid and triploid brook trout. Canadian Technical Report in Fisheries and Aquatic Sciences 1789: 111-121.

Brock, I. V., P. A. Hansen, D. N. McBride, and A. C. Havens. 1994. Culture and performance of triploid rainbow trout in Alaska. Transactions of the North American Wildlife and Natural Resource Conference 59: 263-273.

Bye, V. J., and R. F. Lincoln. 1986. Commercial methods for the control of sexual maturation in rainbow trout *Salmo gairdneri R.* Aquaculture 57: 299-309.

Cotter, D., V. O'Donovan, A. O'Maoileidigh, G. Rogan, N. Roche, N. O. Wilkins. 2000. An evaluation of the use of triploid Atlantic salmon *Salmo salar L.* in minimizing the impact of escaped farmed salmon on wild populations. Aquaculture 186: 61-75.

Elrod, J. H. and F. Anthony. 1990. Sample size requirements and analysis of tag recoveries for paired releases of lake trout. North American Journal of Fisheries Management 10: 196-204.

Dillon, J. C., D. J. Schill, and D. M. Teuscher. 2000. Relative return to creel of triploid and diploid rainbow trout stocked in eighteen Idaho streams. North American Journal of Fisheries Management 20:1-9.

Galbreath, P. F., and G. H. Thorgaard. 1997. Saltwater performance of triploid Atlantic salmon *Salmo salar L.* x brown trout *Salmo trutta L*. hybrids. Aquaculture Research 28: 1-8.

Galbreath, P. F., W. St. Jean, V. Anderson, and G. H. Thorgaard. 1994. Freshwater performance of all-female diploid and triploid Atlantic salmon. Aquaculture 128: 41-49.

Guo, X., W. K. Hershberger, and J. M. Meyers. 1990. Growth and survival of intrastrain and interstrain rainbow trout *Oncorhynchus mykiss* triploids. Journal of World Aquaculture Society 21: 250-256.

Habicht, C., J. E. Seeb, R. B. Gates, I. R. Brock, and C. A. Olito. 1994. Triploid coho salmon outperform diploid and triploid hybrids between coho salmon and Chinook salmon during their first year. Canadian Journal of Fisheries and Aquatic Sciences 51: 31-37.

Happe, A., E. Quillet, and B. Chevassus. 1988. Early life history of triploid rainbow trout *Salmo gairdneri Richardson*. Aquaculture 71: 107-118.

Lincoln, R. F., and A. P. Scott. 1984. Sexual maturation in triploid rainbow trout, *Salmo gairdneri Richardson*. Journal of Fish Biology 25: 385-392.

McCarthy, I. D., C. G. Carter, D. F. Houlihan, R. Johnstone, and A. I. Mitchell. 1996. The performance of all-female diploid and triploid Atlantic salmon smolts on transfer together to sea water. Journal of Fish Biology 48: 545-548.

Nielson, B. R. 1990. Twelve-year overview of fluorescent grit marking of cutthroat trout in Bear Lake, Utah-Idaho. American Fisheries Society Symposium 7:42-46.

O'Keefe R. A., and T. J. Benfey. 1999. Comparative growth and food consumption of diploid and triploid brook trout *Salvelinus fontinalis* monitored by radiography. Aquaculture 175: 111-120.

Oliva-Teles, A., and S. J. Kaushik. 1990. Growth and nutrient utilization by 0+ and 1+ triploid rainbow trout, *Oncorhynchus mykiss*. Journal of Fish Biology 37: 125-133.

Parkinson, E. A., and K. Tsumura. 1988. Growth and survival of hormone-sterilized coho *Oncorhynchus kisutch* and kokanee salmon *O. nerka* in a lacustrine environment. Canadian Journal of Fisheries and Aquatic Sciences 45: 1490-1494.

Sadler, J., R. M. G. Wells, P. M. Pankhurst, and N. W. Pankhurst. 2000. Blood oxygen transport, rheology and haematological responses to confinement stress of diploid and triploid Atlantic salmon, *Salmo salar*. Aquaculture 184: 349-361.

Sheehan, R. J., S. P. Shasteen, A. V. Suresh, A. R. Kapuscinski, and J. E. Seeb. 1999. Better growth in all-female diploid and triploid rainbow trout. Transactions of the American Fisheries Society 128: 491-498.

Simon, D. C., C. G. Scalet, and J. C. Dillon. 1993. Field performance of triploid and diploid rainbow trout in South Dakota ponds. North American Journal of Fisheries Management 13: 134-140.

Solar, I. I., E. M. Donaldson, and G. A. Hunter. 1984. Induction of triploid rainbow trout by heat shock, and investigation of early growth. Aquaculture 57: 57-64.

Thorgaard, G. H., D. N. Arbogast, J. D. Hendricks, C. B. Pereira, and G. S. Bailey. 1999. Tumor suppression in triploid trout. Aquatic Toxicology 46: 121-126.

Warrillow, J. A., D. C. Josephson, W. D. Youngs, and C. C. Krueger. 1997. Differences in sexual maturity and fall emigration between diploid and triploid brook trout *Salvelinus fontinalis* in an Adirondack lake. Canadian Journal of Fisheries and Aquatic Sciences 54: 1808-1812.

Zar, J. H. 1984. Biostatistical analysis. Prentice-Hall, Englewood Cliffs, New Jersey.

ANNUAL PERFORMANCE REPORT
SUBPROJECT #3: FISH HEALTH AND PERFORMANCE

State of: Idaho

Grant No.: F-73-R-23, Fishery Research

Project No.: 4

Title: Hatchery Trout Evaluations

Subproject #3: Fish Health and Performance Study

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ABSTRACT

I compared the performance (relative tag returns) of Kamloop rainbow trout catchables from four of Idaho Department of Fish and Game's largest production hatcheries. Additionally, I examined fish health prior to stocking to determine if prestock fish health was related to post-stock performance. Fish health was evaluated using an organismic index and autopsy-based assessment. Jaw-tagged rainbow trout from Nampa, Hagerman-Riley Creek, Hagerman-Tucker Springs, and American Falls hatcheries were stocked concurrently in 16 lakes and reservoirs located throughout south-central Idaho in 1999 and 2000. In all time periods evaluated, returns were significantly different among hatcheries. The disparity of returns among hatcheries suggests the hatchery environment can affect the performance of stocked trout; however, the differences among hatcheries were inconsistent. This suggests some hatchery influences were neither predictable nor hatchery specific. Generally, American Falls Hatchery trout provided relatively high first year returns and exceptionally high carryover. Nampa Hatchery trout performed well in 1999 but relatively poorly in 2000; therefore, the overall comparative performance of Nampa trout was inconclusive. Hagerman trout consistently provided 11-12% returns, which on average, is lower than the other hatcheries. An explicit explanation for this difference was not determined, but rearing trout at low densities may provide better returns of stocked trout. The hatchery source for catchable trout was a significant source of variation in stocked trout returns among the waters examined, but most of the variation in returns was explained by water specific influences. Prestock fish health was unrelated to returns; however, zooplankton abundance may prove useful in predicting the carryover of stocked catchable trout.

Author:

Douglas J. Megargle
Senior Fishery Research Biologist

INTRODUCTION

Each year, Idaho Department of Fish and Game (IDFG) hatcheries stock approximately three million catchable rainbow trout *Oncorhynchus mykiss*, of which about one million are harvested by anglers (Teuscher et al. 1998). The IDFG hatchery program accounts for a large portion of the total fishery budget (IDFG 1995), but it also provides angling opportunity in many waters of the state where yield fisheries cannot be supported with natural production. Given the cost of the hatchery program, every effort should be made to maximize the angling opportunity provided by IDFG hatcheries.

In the past, IDFG has completed numerous studies designed to maximize harvest of hatchery trout. Several studies have investigated the possible relationship between fish size (Mauser 1992, 1994; Teuscher 1999), stocking time, stocking methods, fish conditions (Casey et al. 1968; Welsh et al. 1970), and fish behavior (Dillon and Alexander 1996) to angler success. However, no evaluations have examined the hatchery-to-hatchery variability in fish health, quality, and return-to-creel.

The 1996-2000 management plan provides guidelines to maximize the efficiency of the catchable rainbow trout program. The guidelines include: 1) concentrating releases of catchables in high use areas, 2) timing releases to coincide with fishing pressure, 3) testing strains of rainbow trout which improve returns to creel, 4) publicizing the location of stocked streams, 5) improving habitat to maximize harvest of stocked trout, and 6) producing a consistently high-quality product at the hatcheries (IDFG 1995). One aspect of quality, in terms of IDFG management objectives, would be a stocked trout that provides maximum return-to-creel (harvest). For the purposes of this study, such return rates will subsequently be referred to as performance.

The hatchery environment can affect the post-stock survival of fish stocked in the natural environment. Hatchery environments can influence the expression of behavioral traits (Vincent 1960; Moyle 1969; Swain and Riddell 1990) and post-stock survival. Rearing densities, the quantity and quality of the water supply, and the disease and pathogen prevalence can directly impact fish health of hatchery-reared trout. Idaho Department of Fish and Game hatcheries vary widely in physical design, water source, disease status, and fish culture practices. A range of potential environmental stressors is found among hatcheries, which suggests that post-stock vigor and survival to creel may also vary with the source of stocked trout. For example, anecdotal observations by several IDFG regional fishery managers suggest that some fish provided from Hagerman Hatchery in the 1980's were unhealthy and likely contributed very little to the fishery. Although studies directly linking prestock hatchery conditions to return-to-creel are limited, it can be assumed that hatchery-specific fish performance exists. If IDFG can identify a hatchery facility that consistently produced lower quality trout, focus can be placed on making improvements at that facility. In addition, the recent fiscal situation has resulted in substantial cutting of hatchery budgets. If IDFG budget conditions do not change in the near future, an assessment of hatchery trout performance will be useful if production needs to be cut.

The purpose of this study is to determine if various IDFG hatcheries are providing similar quality products for use in the catchable trout program. This was the final year of a two-year study to determine if the returns of stocked trout differ among hatcheries. Specifically, this research evaluated the relative return-to-creel of catchable rainbow trout (CRBT) from four IDFG hatchery sources. Fish health was also evaluated to determine if fish health at stocking was a useful predictor of return-to-creel.

RESEARCH GOAL

The goal of this research is to maximize the angler harvest of CRBT produced and stocked by IDFG hatcheries.

OBJECTIVES

1. To determine if there are significant differences in the quality of CRBT produced at three IDFG hatcheries: Nampa, Hagerman (both Riley Creek and Tucker Springs sources), and American Falls.

2. If a significant difference is found, determine if prestock fish health can predict subsequent harvest of stocked trout.

3. Determine if the ZPR index can be used to predict relative carryover of stocked CRBT.

DESCRIPTION OF STUDY AREA

Lakes and reservoirs were stocked with tagged trout in 1999 and 2000. Lakes and reservoirs representing a wide range in size, elevation, and productivity were included in the study and were located throughout Southern Idaho (Table 5, 6; Figure 3). Site-specific temperature and dissolved oxygen data are reported in Appendix A. Only sites that were managed with CRBT, were known to have significant fishing pressure, and were easily accessible were considered for this study. Regional fishery managers provided angling effort information for potential study areas. Sites 1-16 were stocked in 1999. Site 2 was eliminated from the study in 2000 due to disease concerns and was replaced with site 17 (Figure 3).

Four IDFG sources of Kamloop CRBT were chosen for this evaluation. The hatchery sources included: 1) Nampa, 2) Hagerman-Riley Creek (Hag-R), 3) Hagerman-Tucker Springs (Hag-T), and 4) American Falls. These hatcheries were selected because they 1) reared sufficient numbers of CRBT, 2) reared a large portion of the CRBT for IDFG, and 3) were centrally located. Although Hag-T and Hag-R were not unique facilities, they will be referred to as hatcheries from this point forward. Two sources of Hagerman CRBT were used because Hagerman Hatchery has two water sources for fish production. The water source for Hag-T and Hag-R is well water (Tucker Springs) and surface water (Riley Creek), respectively. Historically, fish reared in the Hag-R surface water have had acute and chronic health considerations (Doug Burton, IDFG, personal communication). All four hatchery sources were used in 1999, and three were used in 2000. Hag-T was eliminated from the study in 2000 because no catchable-sized trout were available from that water source.

Table 5. Description of study waters.

Study waters	IDFG catalog #	Elevation (m)	Surface area (ha)
Upper Payette Lake	09-00-00-0392	1,701	128
Cove Arm Res.	05-00-00-0168	750	31
Dog Creek Res.	11-00-00-0121	1,100	38
Magic Res.	11-00-00-0131	1,469	1529
Lava Lake	11-00-00-0118	1,570	8
Mann Creek Res.	08-00-00-0003	878	114
Park Center Pond	10-00-00-0117	823	6
Dierkes Lake	05-00-00-0208	1,052	40
Mountain Home Res.	05-00-00-0180	1,000	164
Blair Trail Reservoir	05-00-00-0184	1,058	6
Little Camas Res.	10-00-00-0130	1,500	589
Sublett Reservoir	05-00-00-0228	1,625	46
Deep Creek Res.	14-00-00-0112	1,573	74
Roseworth Res.	05-00-00-0202	1,426	607
Featherville Dredge P.	10-00-00-0161	1,372	1
Hawkins Reservoir	05-00-00-0234	1,567	22

Table 6. Water quality of study waters including pH, ambient conductivity, Secchi disk, and plankton productivity data. Data were collected in August 1999 and 2000. Data are presented as 1999 data/2000 data.

Study waters	PH	Cond.[a]	Secchi (m)	ZPR[b]	ZQI[c]
Upper Payette Lake	9.4/-na-	20/-na-	8.2/-na-	0.1/-na-	0.0/-na-
Cove Arm Res.	8.9/9.2	410/413	2.7/1.5	0.9/0.8	0.9/0.9
Dog Creek Res.	8.5/9.2	350/351	2.7/0.3	0.0/0.0	0.0/0.0
Magic Res.	8.8/9.0	185/219	4.5/3.5	0.5/0.9	0.1/0.5
Lava Lake[e]	10.4/-na-	600/-na-	1.0/-na-[d]	-na-/-na-	-na-/-na-
Mann Creek Res.	8.8/8.6	160/174	1.9/1.5	0.3/0.8	0.1/0.3
Park Center Pond	9.2/8.7	140/118	1.1/1.0	0.0/0.0	0.0/0.0
Dierkes Lake	9.4/9.2	700/700	1.8/1.3	0.0/0.0	0.0/0.0
Mountain Home Res.[e]	9.3/9.3	70/ 77	1.7/-na-	1.0/-na-	0.6/-na-
Blair Trail Reservoir	9.9/9.5	100/ 46	0.4/0.5	0.0/0.0	0.0/0.0
Little Camas Res.	8.8/9.6	85/ 87	2.2/0.5	0.6/0.4	1.2/1.1
Sublett Reservoir	9.2/8.2	450/460	4.8/3.5	0.1/0.0	0.1/0.0
Deep Creek Res.	8.8/7.8	300/306	4.5/2.5	0.5/0.8	0.5/0.3
Roseworth Res.	8.7/8.5	85/ 86	1.9/1.0	0.5/0.5	0.6/0.6
Featherville Dredge P.	9.1/8.6	80/ 74	5.5/4.0	0.0/0.0	0.0/0.0
Hawkins Reservoir[e]	8.8/9.4	700/335	2.9/2.5	0.8/-na-	1.2/-na-

[a] Conductivity (micro semens / cm)
[b] ZPR = zooplankton biomass (750µ mesh net) / zooplankton biomass (500µ mesh net). The greater the ZPR ratio the more favorable are the forage conditions.
[c] ZQI = ((zooplankton biomass (750µ mesh net) + zooplankton biomass (500µ mesh net))*ZPR. The ZQI is a measure that includes both abundance and zooplankton size.
[d] Secchi reading to bottom; too shallow to sample plankton.
[e] Drought conditions precluded sampling in 2000

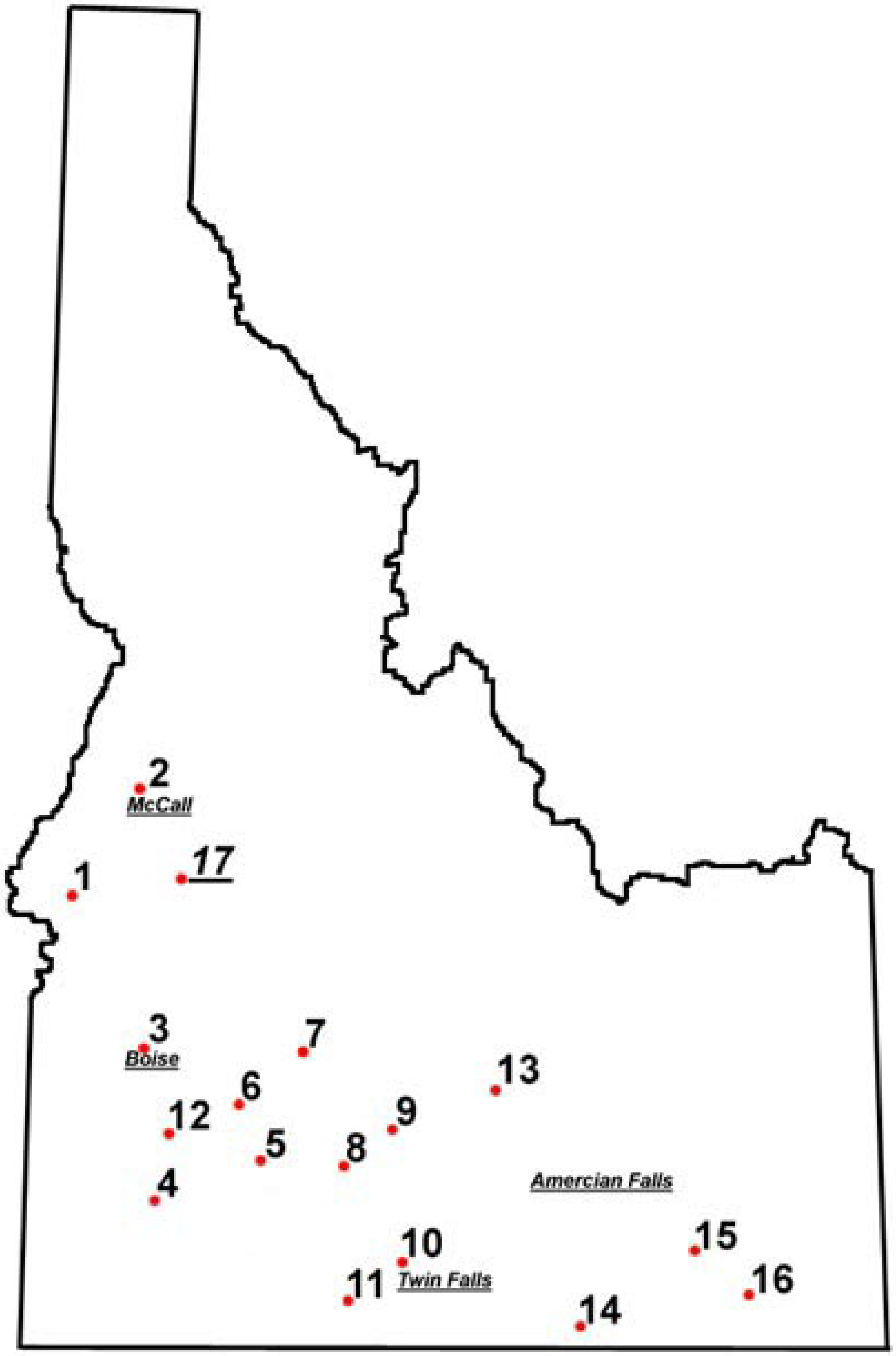

Figure 3. Location of study waters: 1) Mann Creek Res., 2) Upper Payette Lake, 3) Park Center Pond, 4) Cove Arm Res., 5) Blair Trail Res., 6) Little Camas Res., 7) Featherville Dredge Pond, 8) Dog Creek Res., 9) Magic Res., 10) Dierkes Lake, 11) Roseworth Res., 12) Mountain Home Res., 13) Lava Lake, 14) Sublett Res., 15) Hawkins Res., 16) Deep Creek Res., and 17) Horsethief Res. (replaced Upper Payette Lake in 2000).

METHODS

The optimal sample size (study waters) needed for this study was determined in an *a priori* power analysis. Past tag-return data (Teuscher 1999) were used to determine the optimal sample size needed to minimize Type II errors. It was estimated that a sample size of 16 sites would provide adequate protection against Type II errors ($1-\beta = 0.75$) and detect a 20% difference in returns among hatcheries.

Trout used in this study were selected from all raceways that contained catchable-sized (23-25 cm total length) Kamloop rainbow trout. In each hatchery, one raceway containing CRBT was systematically selected once per week to assure all raceways were represented in the analysis. If the selected raceway was partitioned, then fish were stocked from a randomly selected section. Two to five study waters were stocked from each of the selected raceways. Those waters stocked from the same raceway in the same year are hereafter referred to as stock groups.

A total of 3,200 CRBT were tagged at each hatchery in 1999 and 2000. Fish were crowded and randomly removed from the raceway where they were anesthetized, measured for total length (TL mm), jaw tagged (size 8 Monel butt-end tag), and held in holding pens for up to three days. Every fish was measured for length in 1999, but a subsample (n = 100) was taken in 2000. One hundred trout were measured for length per stock group (Table 7). The wooden holding pens were 1.2 X 1.2 X 2.4 m (width X height X length) and were lined with 6 mm plastic hardware-cloth in 1999. However, due to the extreme weight of the wooden pens, they were replaced in 2000 with identical sized pens that were framed with 5.1 cm PVC pipe and lined with nylon netting. Tag loss due to shedding or mortality was monitored to provide an accurate count of tagged fish stocked. Shed tags were reapplied to other trout if they were observed prior to transport. Each hatchery planted 200 tagged trout into each water for a total of 800 and 600 tagged trout being stocked per water in 1999 and 2000, respectively (Table 8; Appendix B).

Transport time for each stock effort was standardized among hatcheries. In most instances, the tagged trout were loaded into fish transport trucks simultaneously at all hatcheries. The travel time discrepancy among hatcheries may have introduced bias if no compensations were made; therefore, transport truck drivers with the shortest drive time were required to hold the fish in the transport truck at the hatchery to standardize the time fish spent in the transports. Minor differences in transport time were made up at the plant site, and each water was usually planted concurrently.

Reward incentives, press releases, and signs were used to encourage angler compliance in returning tags. Anglers that returned tags were entered in site-specific drawings where each winner was awarded $50.00. Newspaper, radio, and television were used to disseminate information regarding the location of the study waters, the reward incentive, and the project goal. Blaze-orange signs with information pertinent to the drawing were posted near access points in all waters. Additionally, data slips with the tag return instructions were affixed to each sign to assist anglers in the tag return process. Jaw-tag data were collected by mail, telephone, and field contacts by IDFG personnel. Tag number, angler address, and date of catch data were entered and compiled in a Microsoft® Access database.

Table 7. Plant group, water, date fish were tagged and stocked, and number of fish tagged and measured for length at Nampa, Hag-R, and American Falls hatcheries in 2000.

Plant group	Water	Tag date	Stock date	No. tagged	No. measured
1	Lava L.	April 24, 2000	April 24, 2000	200	100
	Dierkes L.		April 25, 2000	200	
	Mt. Home Res.		April 26, 2000	200	
2	Dog Creek Res.	April 27, 2000	April 27, 2000	200	100
	Park Center P.		April 28, 2000	200	
3	Blair Trail Res.	May 1, 2000	May 1, 2000	200	100
	Sublett Res.		May 2, 2000	200	
	Cove Arm Res.		May 3, 2000	200	
4	Little Camas Res.	May 4, 2000	May 4, 2000	200	100
	Deep Cr. Res.		May 5, 2000	200	
5	Roseworth Res.	May 8, 2000	May 8, 2000	200	100
	Manns Cr. Res		May 9, 2000	200	
	Hawkins Res.		May 10, 2000	200	
6	Magic Res.	May 11, 2000	May 11, 2000	200	100
	Featherville P.		May 12, 2000	200	
7	Horsethief Res.	May 22, 2000	May 22, 2000	200	100

Returns were stratified arbitrarily. All jaw tags returned before December 31 of the same stock year were considered first year returns, and tags returned from January 1 to December 31 the following year were considered second year returns. The difference in returns among the hatcheries was evaluated for the first year, second year, and the combined first and second year returns.

First year adjusted return-to-creel estimates were made in 1999 and 2000. Methods used to adjust returns for non-compliance differed among years. In 1999, adjusted return-to-creel estimates were made using a 36% compliance rate. This compliance rate represented the average compliance for non-reward (standard) tag and band returns found in past studies (Table 9). In 2000, adjusted return-to-creel estimates were made using $10.00 reward tags. Fifty reward tags were stocked into each water (n = 800). Incentive-based compliance was determined from the literature and used to expand actual reward tag returns to provide an adjusted return-to-creel estimate. The $10.00 reward was adjusted for inflation prior to modeling the return rate (1991 inflation adjustment to $7.90). Using this approach, it was estimated that 55% of $10.00 reward-tagged trout caught were reported to IDFG (Nichols et al. 1991).

Table 8. Hatchery source, water, and numbers of tagged rainbow trout stocked into Idaho waters in 1999 and 2000.

		Tagged fish stocked				
Year	**Site**	**AF**	**Hag-R**	**Hag-T**	**Nampa**	**Total**
1999	Blair Trail Res.	200	200	198	200	798
	Cove Arm Res.	199	200	200	200	799
	Deep Cr. Res.	200	200	199	200	799
	Dierkes L.	196	199	200	199	794
	Dog Creek Res.	200	199	200	200	799
	Featherville P.	200	200	200	200	800
	Hawkins Res.	200	200	198	199	797
	Lava L.	200	200	200	199	799
	Little Camas Res.	200	200	200	200	800
	Magic Res.	200	200	200	200	800
	Mann Creek Res.	199	200	199	199	797
	Mt. Home Res.	198	200	198	200	796
	Park Center P.	200	200	198	199	797
	Roseworth Res.	199	200	200	199	798
	Sublett Res.	200	200	199	198	797
	U. Payette L.	200	200	200	200	800
	Total	**3,191**	**3,198**	**3,189**	**3,192**	**12,770**
2000	Blair Trail Res.	199	200	No fish stocked	200	599
	Cove Arm Res.	200	200		200	600
	Deep Cr. Res.	200	200		200	600
	Dierkes L.	198	200		200	598
	Dog Creek Res.	200	200		200	600
	Featherville P.	---	---		200	600
	Hawkins Res.	200	200		200	600
	Horsethief Res.	200	198		209	607
	Lava L.	199	200		200	599
	Little Camas Res.	200	200		200	600
	Magic Res.	200	200		201	601
	Mann Creek Res.	---	---		200	600
	Mt. Home Res.	200	200		200	600
	Park Center P.	200	200		200	600
	Roseworth Res.	200	200		200	600
	Sublett Res.	200	200		200	600
	Total	**2,796**	**2,798**		**2,810**	**8,404**

The proportion of returned tags was statistically compared among hatcheries. Tag return data were adjusted for both transport-mortality and shed tags. Return data were standardized (# returned / # stocked) and arcsine transformed prior to the statistical analysis. Confidence bounds were assigned to the proportion of tags returned using methods described in Fleiss (1981). Tag returns among hatcheries were compared with a randomized blocked ANOVA ($\alpha = 0.05$) where tag return was the dependent variable and water and hatchery were the independent variables (Zar 1999, SYSTAT 1999). The null hypothesis for each return strata was $Nampa_R$ = $Hag\text{-}R_R$ = $Hag\text{-}T_R$ = American $Falls_R$, where $hatchery_R$ represents the proportion of tag returns from each hatchery. If the null hypothesis were rejected, the interaction among independent variables (study water X hatchery) was examined graphically (Neter et al. 1990). A Tukey's multiple comparison test was used to detect significant differences in returns among hatcheries. The level of influence the independent variables (hatchery and water) had on tag returns was described using one-way ANOVA. A combined model was not possible; therefore, the level of influence of hatchery and water were considered separately. Two study waters were removed from the 2000 analysis. An undetermined number of tagged trout destined for Mann Creek Reservoir and Featherville Dredge Pond escaped from the holding pens before stocking. The proportion of tagged trout returned from those study waters could not be determined.

Table 9. Band or tag reporting rates from past reports. Estimated tag return reporting rates (compliance) are listed for standard (non-reward).

Reference	Species	Incentive ($)	Estimated compliance (%)
Standard tag or band[a]			
Nichols et al. 1991	Duck	None	32
Nichols et al. 1991 – adjusted for bias	Duck	None	26
Henry and Burnham 1976	Duck	None	38
Nichols et al. 1995	Duck	None	38
Conroy and Blandin 1984	Duck	None	43
Reeves 1979	Dove	None	38
Average			**36**

[a] Nonreward tag

The relation between fish health and tag returns was investigated. Each raceway was evaluated separately since fish health may be unique among raceways. An autopsy-based fish health assessment method (HCP) was used to characterize fish health prior to stocking (Goede and Barton 1990). Twenty trout per raceway were randomly collected from each raceway population and subsequently autopsied and evaluated by IDFG fish pathologists. Several raceways were evaluated at Nampa (n = 5), Hag-R (n = 3), Hag-T (n = 2), and American Falls (n = 4). The HCP procedure included the examination of 16 health-related criteria (Table 10). Data were compiled with AUSOM© software program (AUSOM© 1996). The AUSOM© program combines ten criteria to generate the normality index (NI), which reflects the overall health of the hatchery population sampled. Simple linear regression was used to determine if prestock fish health could predict post-stock tag returns. The average return rate (all waters stocked from the same raceway) was regressed against NI.

Basic water quality data were collected to examine the relation between water quality and hatchery specific returns. In mid-August, dissolved oxygen, water temperature, turbidity (Secchi disc), pH, and conductivity data were gathered for the study waters. Additionally, zooplankton samples were taken to characterize productivity at each water. Plankton were collected at two to three locations with three nets of varying mesh size (153, 500, 750 μ mesh). The plankton samples were processed and reported as described in Teuscher (1999). Data are presented in Table 6 and Appendix B. Simple linear regression was used to determine if the ZPR or ZQI index could be used to predict carryover of stocked catchable-rainbow trout.

Table 10. Criteria used to evaluate prestock fish health in 1999 and 2000 (AUSOM© 1996).

Parameter	Evaluation criteria	Data expression
General		
Length	Total length (mm)	Integer
Weight	Weight (g)	Integer
Ktl and Ctl	Ktl = $(W * 10^5) / L^3$; Ctl is converted from Ktl and expressed as Ctl times 10 to the fourth power	Integer
Autopsy		
Eyes	Normal, exopthalmia, hemorrhagic, blind missing, other	% Normal
Gills	Normal, frayed, clubbed, marginate, pale, other	% Normal
Pseudobranch	Normal, swollen, lithic, swollen & lithic, inflamed, other	% Normal
Thymus	No hemorrhage, mild hemorrhage, severe hemorrhage	% Normal
Fins	No active erosion or pervious erosion healed over, mild active erosion with no bleeding, severe active erosion with hemorrhage and / or secondary infection	% Normal
Opercules	No shortening, mild shortening, severe shortening	% Normal
Messentary fat	Internal body fat expressed with regard to amount present	1, 2, 3, or 4
Spleen	Black, red, granular, nodular, enlarged, other	% Normal
Hind gut	No inflammation, mild inflammation, severe inflammation	% Normal
Kidney	Normal, swollen, mottled, granular, urolithic, other	% Normal
Liver	Red, light red, fatty liver, nodules, focal discoloration, general discoloration, other	% Normal
Bile	Yellow: bladder empty or partially full, yellow: bladder full and distended, light green, dark green	Integer
Gender	Male or female	M, F (%)
Blood		
Hematocrit	Volume of red blood cells	% total volume
Leucocrit	Volume of white blood cells	% total volume
Plasma protein	Amount of plasma protein	g / 100 ml
Summary		
Normality index	This index is calculated by averaging the “% Normals”	Percent
Severity index	This index is calculated by averaging the specific percent indices for the thymus, gut, fin, and opercule	Percent
Feeding index	This index is calculated by subtracting the “bile index” from 100	Percent

RESULTS

The first year performance of trout varied among hatcheries. First year returns were not equal among hatcheries in 1999 ($F_{0.05(1),3,45}$ = 6.45, P <0.0005) or in 2000 ($F_{0.05(1),2,26}$ = 14.91, P <0.0005). The relative performance of trout from each hatchery was inconsistent between 1999 and 2000 (Table 11). In 1999, Nampa trout returned at the highest rate (15.4%) followed by American Falls (14.5%), Hag-T (12.1%) and Hag-R (11.2%). In 2000, American Falls trout returned at the highest rate (18.6%) followed by Hag-R (12.2%) and Nampa (11.1%). American Falls first year returns showed a 52% and 68% increase relative to Nampa and Hag-R. In 1999, returns were lowest from Hag-R and Hag-T stocked trout, whereas the lowest returns in 2000 were from Nampa. Specific significant differences among hatcheries are described in Table 12.

Carryover was unequal among hatcheries. Returns of trout stocked in 1999 and returned in 2000 (i.e. carryover) differed significantly ($F_{0.05(1),3,45}$ = 11.40, P <0.0005). On average, <3% of all trout stocked in 1999 were returned in the second year. Second year returns ranged from 1.3-4.5%, with trout from American Falls providing 2-3 times the carryover returns of the other three hatcheries (Table 11).

Overall returns differed among hatcheries. Tags returned between the stock date in 1999 and December 31, 2000 were unequal among hatcheries ($F_{0.05(1),3,45}$ = 11.02, P <0.0005). The combined first and second year returns were similar for American Falls (18.9%) and Nampa (17.5%), both of which differed from Hag-T (13.7%) and Hag-R (12.5%) (Table 11). The higher carryover returns from American Falls trout affected the overall performance ranking and resulted in American Falls trout slightly outperforming Nampa.

There was a wide range of returns among hatcheries within waters. The range in first year return from the 1999 plant was greatest among hatcheries in Roseworth Reservoir (14.6%), Sublett Reservoir (10.2%), and Dierkes Lake (10.1%) (Table 11). Returns were most similar (i.e. small range) in Featherville Dredge Pond (4.0%), Dog Creek Reservoir (4.0%), and Park Center Pond (3.5%). The variation in returns among hatcheries within waters was not consistent between the 1999 and 2000 plants. First year returns from the 2000 plant were most different among hatcheries in Roseworth Reservoir (18.0%), Park Center Pond (13.5%), and Dog Creek Reservoir (13.5%), whereas the returns were most similar among hatcheries in Dierkes Lake (5.7%), Cove Arm Reservoir (2.0%), and Lava Lake (1.1%).

Most of the variation in tag returns can be explained by water-specific influences. ANOVA models including both the 1999 and 2000 plants showed 65-77% of the variation in the performance of stocked rainbow trout was the result of site-specific influences (Table 13). The first year and overall returns from the 1999 plant were independent from hatchery influences; however, carryover from the 1999 plant was significantly impacted by hatchery influences. When significant, hatchery influences upon the returns were relatively small (13-18%) when compared to water-specific influences. Variation in the first year return from the 2000 plant was significantly related to both hatchery and site influences.

Adjusted return-to-creel estimates ranged from 15-73% in the 14 waters examined (Table 14). Thirty-six percent of the stocked waters have met the return goal of 40% returns within the first year. Return-to-creel was highest in Park Center Pond (73%) and Horsethief Reservoir (55%). Relatively low return-to-creel was found in Lava Lake (15%) and Magic Reservoir (15%).

Table 11. Return rate (%) of trout stocked into Idaho waters in 1999 and 2000 from American Falls, Hagerman-Riley, Hagerman-Tucker, and Nampa hatcheries.

Site	AF			Hag-R			Hag-T			Nampa			Total		
	Yr 1	Yr 2	Both	Yr 1	Yr 2	Both	Yr 1	Yr 2	Both	Yr 1	Yr 2	Both	Yr 1	Yr 2	Both
Fish tagged and stocked in 1999															
Hawkins Res.	22.5	6.0	**28.5**	21.0	1.5	**22.5**	29.8	1.0	**30.8**	24.1	2.0	**26.1**	24.3	2.6	**27.0**
Roseworth Res.	20.1	11.1	**31.2**	16.5	4.5	**21.0**	14.0	2.5	**16.5**	28.6	4.0	**32.7**	19.8	5.5	**25.3**
Deep Cr. Res.	23.0	5.5	**28.5**	17.5	2.0	**19.5**	17.1	5.5	**22.6**	17.0	3.5	**20.5**	18.6	4.1	**22.8**
Featherville P.	22.5	1.0	**23.5**	19.0	0.5	**19.5**	21.0	0.0	**21.0**	23.0	0.5	**23.5**	21.4	0.5	**21.9**
Little Camas Res.	15.5	7.5	**23.0**	9.0	5.0	**14.0**	14.0	4.5	**18.5**	17.5	3.0	**20.5**	14.0	5.0	**19.0**
Sublett Res.	18.5	2.0	**20.5**	12.0	0.0	**12.0**	17.6	0.0	**17.6**	22.2	0.0	**22.2**	17.6	0.5	**18.1**
Mt. Home Res.	17.7	9.1	**26.8**	11.5	1.0	**12.5**	9.1	0.0	**9.1**	14.0	2.0	**16.0**	13.1	3.0	**16.1**
Magic Res.	12.0	13.5	**25.5**	5.5	2.0	**7.5**	7.0	3.5	**10.5**	8.5	4.0	**12.5**	8.3	5.8	**14.0**
Mann Cr. Res.	11.1	5.5	**16.6**	7.0	2.0	**9.0**	8.0	1.0	**9.0**	17.1	4.0	**21.1**	10.8	3.1	**13.9**
Blair Trail Res.	14.5	0.0	**14.5**	11.5	0.0	**11.5**	10.6	0.0	**10.6**	17.5	0.5	**18.0**	13.5	0.1	**13.7**
Dierkes L.	8.2	2.0	**10.2**	11.6	0.5	**12.1**	14.0	0.5	**14.5**	17.1	1.0	**18.1**	12.7	1.0	**13.7**
Park Center P.	11.0	0.5	**11.5**	12.5	0.0	**12.5**	10.6	0.5	**11.1**	14.1	0.0	**14.1**	12.0	0.3	**12.3**
Cove Arm Res.	10.1	7.0	**17.1**	5.0	2.5	**7.5**	6.0	5.0	**11.0**	4.0	8.0	**12.0**	6.3	5.6	**11.9**
Lava L.	10.5	1.0	**11.5**	7.5	0.0	**7.5**	6.5	0.0	**6.5**	11.1	1.0	**12.1**	8.9	0.5	**9.4**
Dog Creek Res.	5.5	0.0	**5.5**	6.5	0.0	**6.5**	4.5	1.0	**5.5**	8.5	0.0	**8.5**	6.3	0.3	**6.5**
U. Payette L.	10.0	0.0	**10.0**	5.5	0.0	**5.5**	4.0	0.0	**4.0**	2.0	0.0	**2.0**	5.4	0.0	**5.4**
Total	14.5	4.5	**18.9**	11.2	1.3	**12.5**	12.1	1.6	**13.7**	15.4	2.1	**17.5**	13.3	2.4	**15.3**
95% LCL	13.3	3.8	17.0	10.1	0.9	11.0	11.0	1.1	12.2	14.1	1.6	16.0	12.7	2.1	14.7
95% UCL	15.8	5.2	19.8	12.3	1.8	13.4	13.3	2.0	14.6	16.7	2.6	18.7	13.9	2.6	16.0
Fish tagged and stocked in 2000															
Park Center P.	35.5	---	---	25.5	---	---				22.0	---	---	27.7	---	---
Horsethief Res.	31.5	---	---	20.7	---	---				19.6	---	---	23.9	---	---
Little Camas Res.	23.0	---	---	17.0	---	---				18.5	---	---	19.5	---	---
Hawkins Res.	23.5	---	---	11.5	---	---				15.5	---	---	16.8	---	---
Roseworth Res.	25.5	---	---	9.5	---	---				7.5	---	---	14.2	---	---
Dog Creek Res.	20.0	---	---	13.0	---	---				6.5	---	---	13.2	---	---
Dierkes L.	16.7	---	---	11.5	---	---				11.0	---	---	13.0	---	---
Blair Trail Res.	8.0	---	---	18.0	---	---				12.5	---	---	12.9	---	---
Deep Cr. Res.	15.5	---	---	11.0	---	---	No fish available			9.5	---	---	12.0		
Mt. Home Res.	16.0	---	---	8.0	---	---				6.5	---	---	10.2	---	---
Lava L.	10.6	---	---	9.5	---	---				9.5	---	---	9.8	---	---
Cove Arm Res.	9.0	---	---	7.0	---	---				8.5	---	---	8.2	---	---
Sublett Res.	14.0	---	---	6.0	---	---				3.5	---	---	7.8	---	---
Magic Res.	11.5	---	---	2.0	---	---				5.0	---	---	6.2	---	---
Featherville P.[a]	-na-	-na-	-na-	-na-	-na-	-na-				-na-	-na-	-na-	-na-	-na-	-na-
Mann Cr. Res.[a]	-na-	-na-	-na-	-na-	-na-	-na-				-na-	-na-	-na-	-na-	-na-	-na-
Total	18.6	---	---	12.2	---	---				11.1	---	---	14.0	---	---
95% LCL	17.1			10.9						10.0			13.2		
95% UCL	20.1			13.4						12.3			14.7		

[a] Return rates of stocked fish could not be determined due to escape of tagged trout prior to stocking.

There was no relation between prestock fish health and post-stock returns. Results of the HCP analysis are presented in Table 15. The normality index derived from the HCP evaluation was not a good predictor of returns (n = 7, R^2 = 0.00, P = 0.96) (Figure 4). Healthier fish showed no advantage over less healthy fish in returns.

There was no statistical relation between water productivity (ZPR) and carryover returns. Trout stocked from each hatchery in 1999 showed a positive relationship between carryover and ZPR, but the relationship was not statistically significant (n = 8, R^2 = 0.42, P = 0.08) (Figure 5).

Table 12. Results (P values) from a Tukey's multiple comparison test comparing tag returns among hatcheries. Significant difference (α = 0.05) is denoted with an asterisk (*****).

					Hatchery			
Stock year	**Returns**	**MSE**	**df**	**Hatchery**	**AF**	**Hag-R**	**Hag-T**	**Nampa**
1999	Year 1[a]	0.002	45	AF	1.00			
				Hag-R	0.02*	1.00		
				Hag-T	0.06	0.97	1.00	
				Nampa	0.99	0.01*	0.03*	1.00
	Year 1[b]	0.002	45	AF	1.000			
				Hag-R	0.091	1.000		
				Hag-T	0.023*	0.937	1.000	
				Nampa	0.974	0.034*	0.007*	1.000
	Year 2	0.003	45	AF	1.000			
				Hag-R	0.000*	1.000		
				Hag-T	0.000*	0.989	1.000	
				Nampa	0.006*	0.499	0.321	1.000
	Year 1&2	0.003	45	AF	1.000			
				Hag-R	0.001*	1.000		
				Hag-T	0.000*	0.882	1.000	
				Nampa	0.636	0.023*	0.003*	1.000
2000	Year 1	0.003	26	AF	1.000			
				Hag-R	0.001*	1.000	-- na --	
				Hag-T	-- na --	-- na --	-- na --	-- na --
				Nampa	0.000*	0.847	-- na --	1.000

[a] Data from Megargle 2000 that reported only tagged fish caught and reported by December 31, 1999.
[b] Corrected returns: tagged fish caught in 1999 and reported by December 31, 2000 were added to this comparison (Megargle 2000).

The rate and timing of tag returns varied among hatcheries. Generally, in both the 1999 and 2000 plants, the majority of the tagged trout were caught within the first 100 days after stocking (DAS) (Figure 6). The timing of tag returns was not consistent between the 1999 and 2000 plants. More tags were returned from Nampa Hatchery in the first 100 DAS in 1999 than Hag-R, Hag-T, and American Falls hatcheries. However, in 2000, the trends were reversed and relatively few tags were returned from Nampa Hatchery in the same time period. Additionally, the double pulse of returns found within the first 200 DAS in 1999 was not present in 2000 (Figure 6). The timing of the second year returns for trout stocked in 2000 will be reported in the 2001 report.

Table 13. R square and significance from a one-way ANOVA that examined the variation of tag returns as explained by independent variables. Significance (α = 0.05) is denoted with an asterisk (*).

Year	Time period	Independent variable	R square	P
1999	1st year	Site	0.77	0.000*
		Hatchery	0.06	0.266
	2nd year	Site	0.70	0.000*
		Hatchery	0.13	0.038*
	1st and 2nd year	Site	0.71	0.000*
		Hatchery	0.12	0.048
2000	1st year	Site	0.65	0.001*
		Hatchery	0.18	0.019*

The average size of stocked trout in 2000 varied among hatcheries. Mean lengths stocked were 268 mm (SE = 0.8), 259 mm (SE = 0.8), and 243 mm (SE = 0.8) for American Falls, Hag-R, and Nampa hatcheries, respectively (Figure 7). Fish size differed significantly among hatcheries (F = 224.8; df = 2, 2097; P <0.01), but the maximum difference among hatcheries was small (2.5 cm). The statistical test was highly sensitive and would have determined a significant difference if mean lengths differed by even 1 mm (effect size <1 mm).

DISCUSSION

The performance of trout stocked was variable and inconsistent. Given the two years of stocking, results indicate the number of trout returned was not standard among the hatcheries examined with respect to the first year returns, second year returns, and the overall returns. The disparity of returns among hatcheries suggests the hatchery environment did affect the performance of stocked trout; however, the performance was inconsistent. For example, trout stocked from Nampa were returned at the highest rates in the first year following the 1999 plant, whereas in 2000, American Falls showed substantially better returns. This fact suggests the hatchery environment does affect post-stock performance, but the specific hatchery influence is not identified with this experimental design. Generally, American Falls produced trout that provided relatively high first year returns and exceptionally high carryover. Nampa trout performed well in 1999, but relatively poorly in 2000; therefore, performance is inconclusive. Hagerman trout consistently provided 11-12% returns, which on average is lower than the other hatcheries. However, trout stocked from Hagerman Hatchery outperformed Nampa Hatchery on average in 2000. The past impression held by some IDFG personnel that Hagerman product is consistently inferior is unsubstantiated.

Table 14. First year tag returns, return rate, and adjusted of $10.00 reward tags stocked into Idaho waters in 1999 and 2000. Confidence intervals are enclosed in parenthesis.

Year	Water	Stock	Return-to-creel (tags)	Return-to-creel (%)[a]	Adjusted return-to-creel (%)
1999[b]	Hawkins Res.	797	192	24 (21-27)	67 (58-75)
	Featherville P.	800	172	22 (18-24)	62 (50-67)
	Deep Creek Res.	799	149	19 (15-21)	53 (44-58)
	Roseworth Res.	798	155	19 (17-22)	53 (47-61)
	Sublett Res.	797	140	18 (15-20)	51 (42-56)
	Blair Trail Res.	798	108	14 (11-16)	39 (31-44)
	Little Camas Res.	800	109	14 (11-16)	39 (31-44)
	Mt. Home Res.	796	101	13 (10-15)	37 (28-42)
	Park Center Pond	797	96	12 (10-14)	34 (28-39)
	Dierkes Lake	794	99	12 (10-15)	34 (28-42)
	Mann Creek Res.	797	84	11 (8-13)	31 (22-36)
	Lava Lake	799	69	9 (7-11)	25 (19-31)
	Magic Res.	800	63	8 (6-10)	22 (17-28)
	Cove Arm Res.	799	46	6 (4 - 7)	17 (11-19)
	Dog Creek Res.	799	50	6 (5 - 8)	17 (14-22)
	U. Payette L.	800	43	5 (4 - 7)	14 (11-19)
	Total	**12,770**	**1,676**	**13 (13-14)**	**37 (36-39)**
2000[c]	Park Center P.	50	20	40 (27-55)	73 (49-99)
	Horsethief Res.	50	15	30 (18-45)	55 (33-81)
	Deep Creek Res.	50	12	24 (14-38)	44 (25-70)
	Hawkins Res.	50	11	22 (12-36)	40 (22-66)
	Sublet Res.	50	11	22 (12-36)	40 (22-66)
	Dierkes L.	50	10	20 (11-34)	36 (19-62)
	Roseworth Res.	50	7	14 (6-27)	26 (11-50)
	Dog Creek Res.	50	6	12 (5-25)	22 (9-46)
	Little Camas Res.	50	6	12 (5-25)	22 (9-46)
	Mt. Home Res.	50	6	12 (5-25)	22 (9-46)
	Blair Trail Res.	50	5	10 (4-23)	18 (7-41)
	Cove Arm Res.	50	5	10 (4-23)	18 (7-41)
	Lava L.	50	4	8 (3-20)	15 (5-37)
	Magic Res.	50	4	8 (3-20)	15 (5-37)
	Total	**700**	**122**	**17 (15-20)**	**32 (27-37)**

[a] Confidence intervals (2000 estimate) were derived from a ratio: # return/# stock (Fleiss 1981)
[b] Adjusted using a tag return compliance rate of 36%.
[c] Adjusted using a tag return compliance rate of 55%.

Table 15. Fish health evaluation results of fish sampled from each of the three hatcheries examined in 2000. Data are summarized by raceway.

	Nampa[a]			Riley[b]			American Falls[c]	
	C2	**C3**	**C4**	**18**	**20**	**22**	**12**	**14**
TL (mm)	225.0	230.0	226.0	233.0	247.0	261.0	263.0	266.0
CV (%)	10.1	7.5	7.4	8.2	11.2	8.0	5.8	5.4
Weight (g)	146.0	152.0	141.0	155.0	194.0	216.0	231.0	245.0
CV (%)	28.8	30.1	25.2	28.8	33.6	29.9	17.9	20.1
Ktl	1.2	1.2	1.2	0.8	1.3	1.2	1.3	1.3
CV (%)	6.5	8.9	6.7	6.7	11.4	10.0	8.0	8.8
Ctl	4.5	4.4	4.3	3.0	4.5	4.3	4.6	4.6
Hematocrit	46.3	43.3	38.5	36.8	38.2	32.0	48.5	43.1
CV (%)	13.4	11.7	9.5	12.6	13.3	11.9	13.6	11.8
Leucocrit	1.8	1.4	1.4	2.1	1.6	1.4	1.5	1.6
CV (%)	35.2	42.7	36.2	51.2	37.4	43.5	47.3	51.3
Plasma protein	6.5	6.9	6.1	7.0	6.6	6.1	6.6	6.3
CV (%)	11.1	9.5	10.8	5.5	10.3	9.8	15.5	23.7
Eyes	95.0	95.0	100.0	95.0	100.0	100.0	100.0	100.0
Gills	65.0	80.0	70.0	5.0	15.0	10.0	85.0	100.0
Pseudobranch	95.0	95.0	100.0	90.0	85.0	85.0	100.0	100.0
Thymus	75.0	50.0	80.0	100.0	85.0	80.0	35.0	45.0
Messentary fat	3.2	3.8	2.5	2.1	2.3	2.0	3.7	3.8
Spleen	100.0	100.0	100.0	100.0	90.0	95.0	100.0	95.0
Hind gut	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Kidney	100.0	100.0	100.0	95.0	95.0	100.0	100.0	100.0
Liver	95.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Bile	1.0	1.0	1.0	0.2	0.2	0.8	1.0	2.0
Fin	75.0	40.0	50.0	90.0	70.0	70.0	40.0	30.0
Opercule	100.0	95.0	85.0	90.0	95.0	95.0	100.0	100.0
Percent female	100.0	100.0	100.0	100.0	100.0	100.0	95.0	100.0
Percent male	0.0	0.0	0.0	0.0	0.0	0.0	5.0	0.0
Normality index[d]	90.0	85.5	88.5	86.5	83.5	83.5	86.0	87.0
Severity index[e]	9.4	18.8	13.8	2.5	21.3	8.1	21.3	24.4
Feeding index[f]	66.7	66.7	66.7	95.0	95.0	73.3	66.7	33.3

[a] Raceway C3: Coldwater disease - Flavobacterium psychrophilum (1/12-carrier)
Bacterimia - Pasturella sp. (1/12-carrier)

[b] Raceway 18: MAS - Aeromonas caviae (1/12-carrier)
Raceway 20: Pseudomonas – Pseudomonas mallei (3/12-carrier)

[c] Raceway 12: Coldwater Disease - Flavobacterium psychrophilum (1/12-carrier)
Raceway 14: Coldwater Disease - Flavobacterium psychrophilum (1/12-carrier)

[d] Average of the "percent normals" excluding bile and messentary fat; expressed as percent

[e] Average of the "percent normals" including thymus, gut, fin, and opercule; expressed as percent

[f] Calculated by subtracting the bile index from 100; expressed as percent

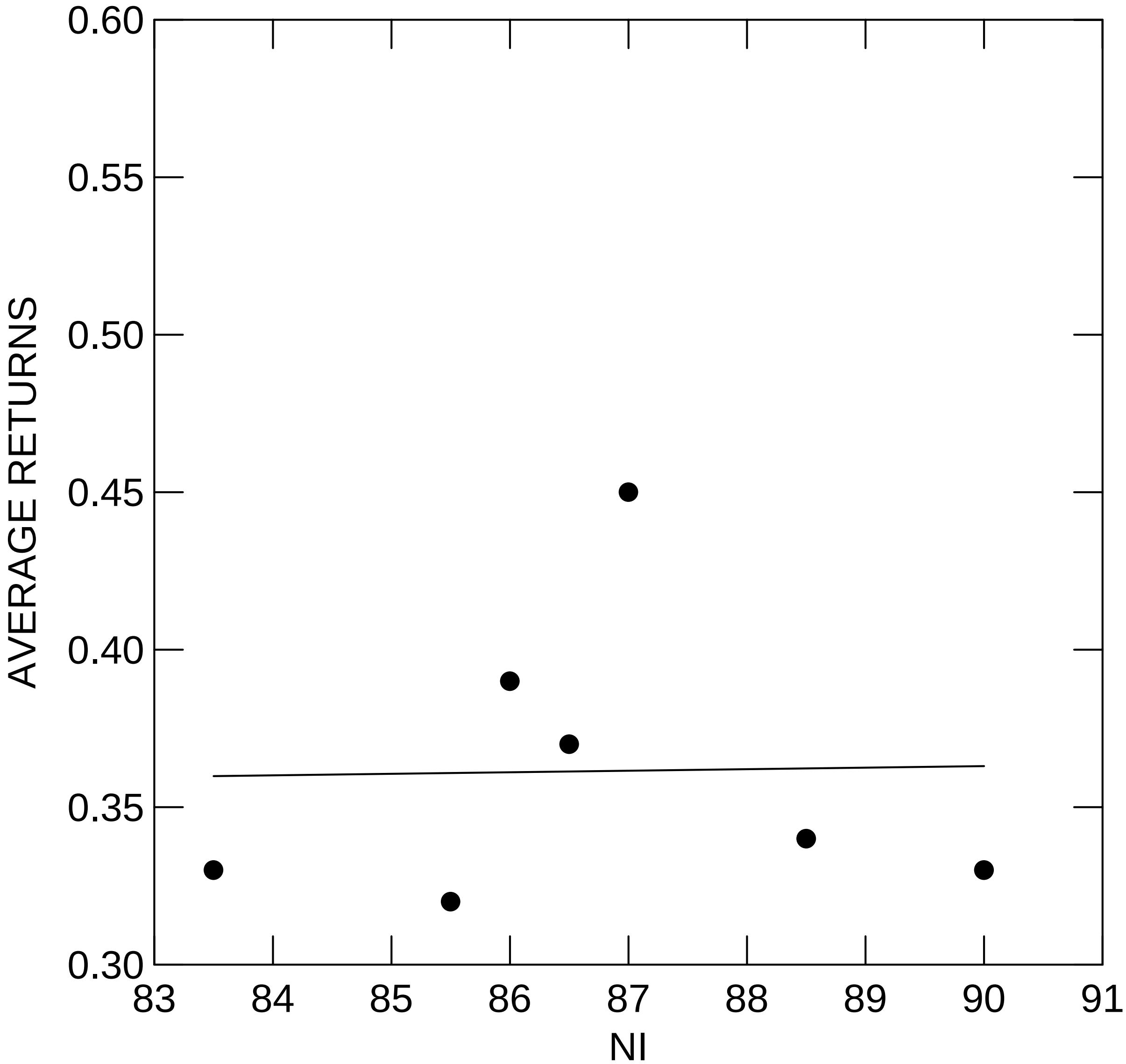

Figure 4. Regression line depicting the relationship between the prestock NI of stocked fish and the associated average returns. Relative returns (%) were arcsine transformed prior to regression.

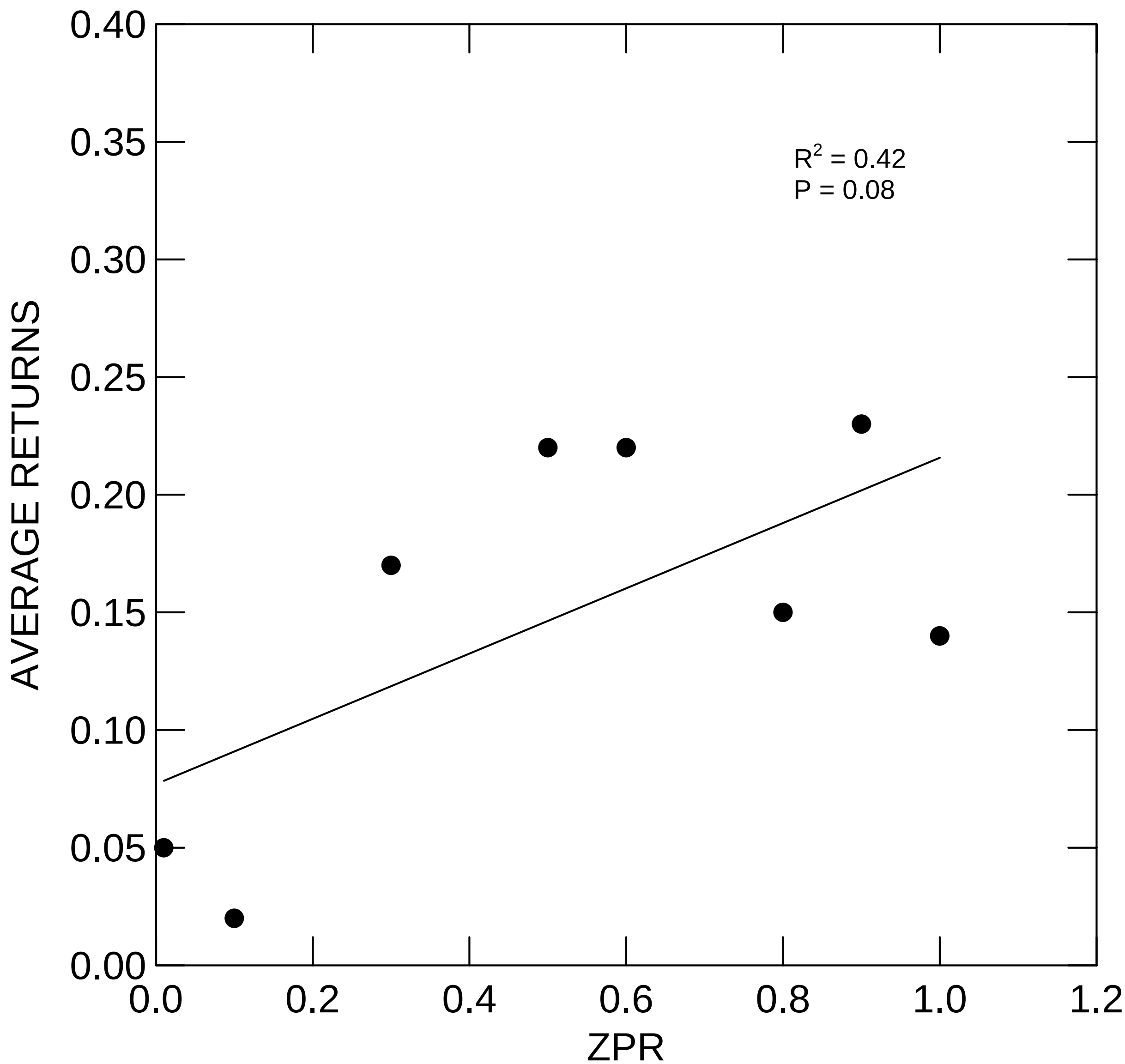

Figure 5. Regression line depicting the relationship between the ZPR of waters and the associated average carryover returns. Returns (%) were arcsine transformed prior to regression.

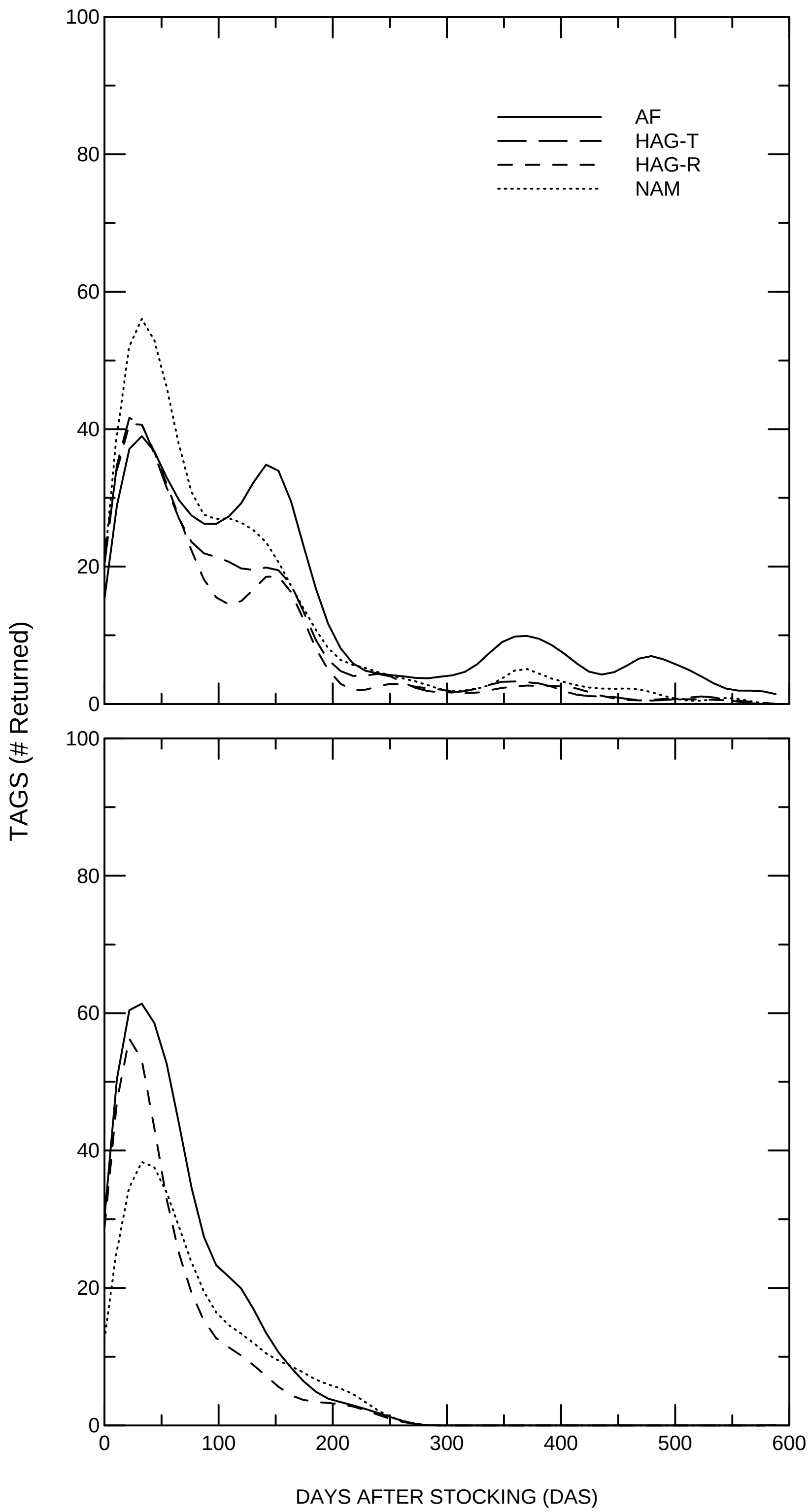

Figure 6. The timing of returns of tagged fish stocked throughout southern Idaho in 1999 (upper graph) and 2000 (lower graph) from Nampa, Hag-R, Hag-T, and American Falls hatcheries. The second year returns for trout stocked in 2000 are not shown in figure.

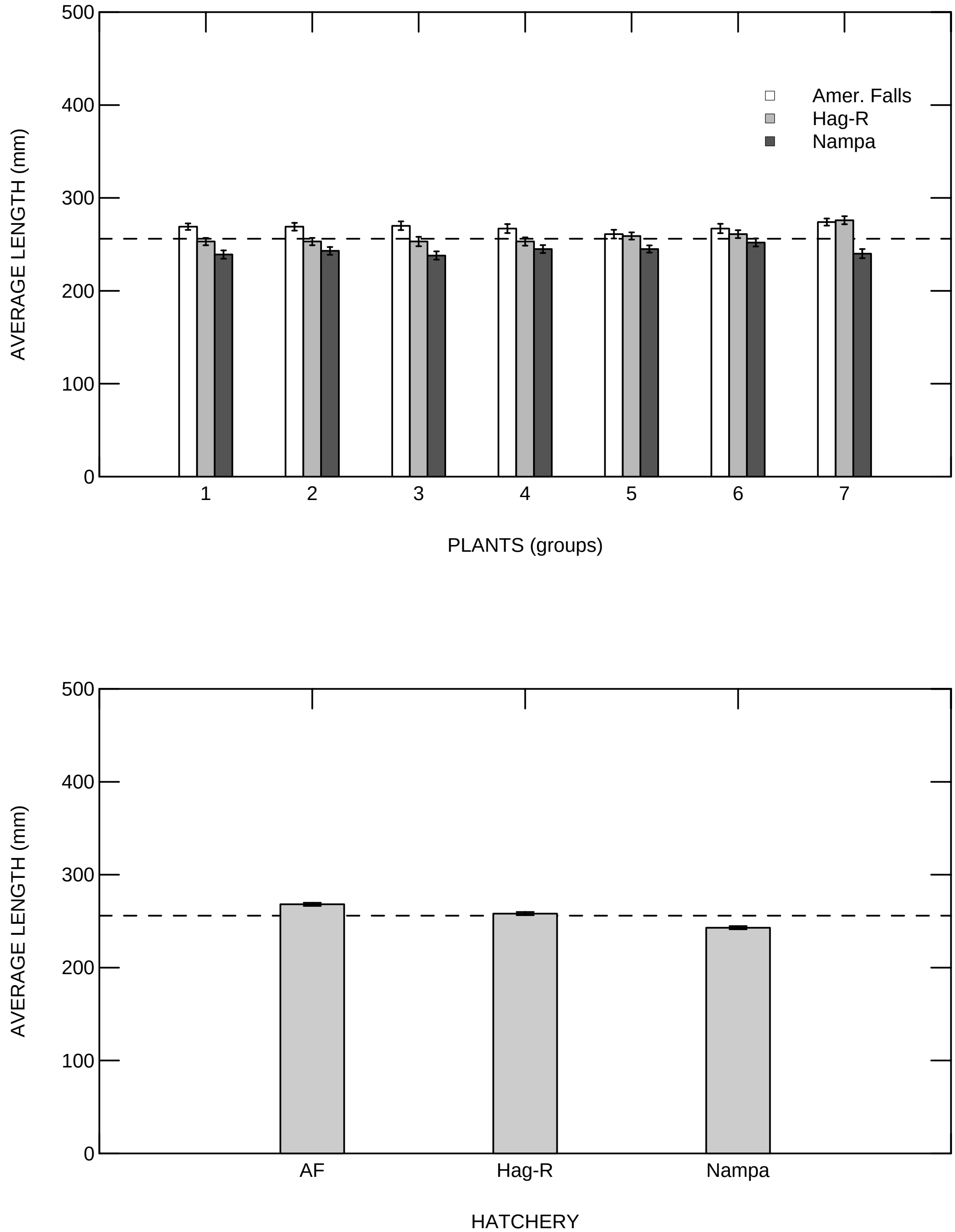

Figure 7. Mean length by hatchery (lower graph) and plant group (upper graph) of trout stocked in 14 lakes and reservoirs by American Falls, Hagerman-Riley (Hag-R), and Nampa hatcheries in 2000. Stock groups are defined in Table 7. Dashed line represents average length of all stocked trout combined.

The differential returns among hatcheries could result in lower quality fisheries in some locations. The hatchery source likely impacts angler success and therefore the efficiency of the put-and-take program. For example, if the first year return rates of the 2000 plants were applied to a water receiving 20,000 catchable trout, returns could range from 2,200 (Hag-R = 11.1%) to 3,700 (American Falls = 18.6%) trout depending upon the hatchery source. The same consideration may be applied to fingerlings if similar performance differences can be applied to the 1.3 million fingerlings reared at Hagerman. Because fingerlings must rear longer in the wild prior to capture by anglers, the potential for magnification of return reductions would seem more probable, if not likely. American Falls trout proved to generally outperform Nampa and Hagerman trout, and if feasible, anglers would benefit if all catchables were provided from American Falls. However, due to production and logistical limitations, that is obviously not an option. Additionally, the inconsistent differences among years limits any predictions as to which hatchery would provide a reliable advantage.

The cause of the discrepancy in catchable returns among hatcheries is unknown. Past research has linked the hatchery environment to post-stock survival, behavior, or the combination (Ginetz and Larkin 1976; Forgerlund et al 1981; Olla and Davis 1989; Ryer and Olla 1991, 1992, 1995a, 1995b; Olla et al. 1995, 1998). Since a fish's hatchery environment is often inconsistent during production, identifying the exact cause would be difficult without directly manipulating the hatchery environment in a controlled evaluation. Additionally, the causative agent may be a combination of influences that may not be apparent; however, some generalizations may be made.

It is possible but unlikely that return-to-creel differences among the hatchery may have been biased by transport vehicle and fish size disparity. Although efforts were made to standardize the stocking protocol among the hatcheries examined, some differences were apparent. In both 1999 and 2000, the average size of fish stocked differed by about 2 cm among hatcheries. The size discrepancy was slightly larger within some waters. However, Teuscher (1999) showed similar returns from trout that differed by 5 cm in length, and it is unlikely the small difference in length in this study substantially impacted returns. American Falls and Nampa hatcheries were able to use one-ton fish transport trucks, but Hagerman fish (Hag-T and Hag-R) were hauled in a dual compartment, two-ton transport. It would have been preferred that each hatchery planted trout with similar transports; however, fish transport densities among the hatcheries were similar. It was more important that the fish were held in the transport for equal periods prior to stocking.

Rearing densities and the amount of handling prior to stocking were different among the hatcheries examined. American Falls produce trout at considerably lower densities than either Nampa or Hagerman. It is not unusual for trout to exceed density index levels of 0.5 several times throughout production in Nampa and Hagerman; however, at American Falls density index levels rarely exceed 0.2 except just prior to stocking (<0.4). In addition to reduced densities, fish are handled or moved less at American Falls than at the other hatcheries. Fish are handled (moved) 3-4 times at Hagerman, 1-2 times at Nampa and once at American Falls. Low densities and reduced handling likely minimize chronic stress levels as evidenced by reduced disease outbreaks. Forgerlund et al. (1981) reported decreased growth and condition, reduced conversion, and increased stress and mortality of salmonids reared at high densities. It may be suggested that a reduction in production and prestock handling might improve returns from Hagerman hatchery, but the 52-68% potential increase in returns may not compensate for lost overall production. Rearing densities at American Falls hatchery were approximately one third of those at Hagerman and Nampa, which would suggest nearly a two-thirds reduction in production would be needed to achieve the potential increase in returns. Chronic stress loads of catchable trout would likely be reduced with any reduction in production, thus improving fish health and reducing disease outbreaks (Patino et al. 1986). In addition, a substantial reduction in production would mean a substantial reduction in overall hatchery expenses. A controlled experiment comparing the return-to-creel of trout reared at current and greatly reduced densities at either Hagerman or Nampa hatchery would be useful to further explore the benefits of low density rearing.

Prestock fish health was unrelated to post-stock returns. A regression model produced a poor fit, neutral-sloped model. In some cases, fish with higher normality index ratings were found to have lower return rates. American Falls and Nampa hatcheries produced trout of similar health according to the HCP evaluation; however, their returns were significantly different. These results suggest that prestock fish health screening would not provide any insight as to the expected performance of hatchery trout. There may be several reasons as to why no statistical relation could be found. First, the normality index values measured at all hatcheries in 1999 and 2000 were never lower than 83%. Perhaps if a greater range in normality index were evaluated (i.e. extremely low values), a better-fit model would be possible. Second, fish were stocked into a wide variety of waters that differed in productivity, thermal and oxygen refugia, depth, and angling pressure (as evidenced by return rates). The heavy influence of the natural environment may have biased, or at least diluted, any potential relationship. Regardless, the use of the HCP evaluation as a predictive management tool does not seem to show promise. Obvious critical health concerns (i.e. symptomatic disease outbreaks) will undoubtedly impact post-stock survival, but the importance of the subtle health differences detected by the HCP evaluation were not shown to be a significant factor in return-to-creel.

Most of the overall tag return variation was due to water-to-water variation; a smaller portion was attributed to hatchery-specific influences. After examining the relation between water, hatchery, and returns, it was obvious that where the fish were stocked exerted greater influence on tag returns than did the hatchery source. In fact, overall returns of the 1999 plant were not significantly influenced by the hatchery source. Overall statewide returns could be better enhanced and stabilized by a reduction (or elimination) of stocking in waters that provide poor fisheries than if the return potential was improved at Hagerman Hatchery. The results of this study emphasize the need to evaluate stocking waters regularly, especially in light of a reduced hatchery budget, and adjust stocking requests accordingly.

Carryover returns of catchable trout were statistically unrelated to plankton productivity (ZPR). High ZPR generally were associated with waters showing higher returns, but returns did not increase linearly with increased ZPR. However, extremely low ZPR waters produced relatively poor returns, which implies there may be a critical threshold when ZPR $\leq$0.3. Plankton productivity and fingerling survival has been shown to have a positive relation, because plankton were likely a major portion of their forage (Teuscher 1999). It would seem logical to assume highly productive waters would provide a survival advantage to catchable trout. Visual inspection of the data shows what appears to be a good relationship between the variables. I suspect an increased sample size and the use of non-linear regression may prove ZPR useful in predicting the carryover potential of catchable trout. This relationship should be further investigated including carryover and ZPR data for trout stocked in 2000.

The adjusted return-to-creel estimates suggest that nearly one third of the stocking waters have already met minimum harvest goals in the first year. Five of 14 waters showed return-to-creel rates $\geq$40% by December 31, 2000. Ten of 30 return-to-creel point estimates were >40% after the second year returns were included in the overall estimate (Table 14). Of those waters with adjusted return-to-creel rates ≤40%, most included the 40% management goal within confidence limits. Some extremely low returns were impacted by drought conditions, and low harvest was expected. It is important to note the harvest estimates in this report do not reflect season-long estimates and should be considered accordingly. In some instances trout were stocked outside of the normal schedule as determined by regional fish managers, and more harvest would likely have resulted with increased angling effort. The addition of second year returns will substantially increase the number of waters reaching the 40% goal. Additionally, further efforts should be made to evaluate return-to-creel by weight.

In conclusion, I found significant differences in the return-to-creel of catchable trout stocked from American Falls, Nampa and Hagerman hatcheries. There is evidence that the source of rainbow trout catchables can impact the post-stock performance of the trout. However, the hatchery specific post-stock performance was not predictable or consistent between years or among stocking waters. An explanation for this inconsistent performance was not determined. Generally, American Falls trout performed best, followed by Nampa and Hagerman. Prestock fish health, as measured using the HCP examination, does not appear to be a useful management tool when evaluating the return-to-creel. The relationship between carryover and ZPR may yet prove to be a useful management tool to understand carryover potential of stocking waters.

MANAGEMENT RECOMMENDATIONS

1. If future budgets required a significant reduction in CRBT stocking, reduction of production at Hagerman would appear to have the least impact on Idaho anglers.

2. Do not use the HCP evaluation as a management tool to predict the return-to-creel of catchable rainbow trout.

3. Continue to evaluate the relationship between carryover and ZPR. The addition of a second year of evaluation may demonstrate a useful relationship.

4. Conduct a controlled study at Hagerman or Nampa to evaluate how a density reduction at those facilities may impact the post-stock returns of catchable trout.

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LITERATURE CITED

AUSOM©. 1996. Utah Division of Wildlife Resources, Fisheries Experiment Station. Logan, Utah.

Casey, O. E., W. E. Webb, R. J. Bell, P. Jeppeson, J. Mallet, T. Holubetz, R. J. Bell, D. R. Corley, R. E. Gray. 1968. Test for increasing the returns of hatchery trout. Job completion report, F-32-R-10. Idaho Department of Fish and Game. Boise, Idaho.

Conroy, M. J, and W. W. Blandin. 1984. Geographic and temporal differences in band reporting rates for American black ducks. Journal of Wildlife Management 48:23-36.

Dillon, J. C., and C. B. Alexander. 1996. Put-and-grow hatchery evaluations. Annual progress report, project F-73-R-17. Idaho Department of Fish and Game. Boise, Idaho.

Fleiss, J. L. 1981. Statistical methods for rates and proportions, second edition. John Wiley and Sons, Inc. New York, New York.

Forgerlund, U. H. M., J. R. McBride, and E. T. Stone. 1981. Stress-related effects of hatchery rearing density on coho salmon. Transactions of the American Fisheries Society 110:644-649.

Ginetz, R. M., and P. A. Larkin. 1976. Factors affecting rainbow trout *Salmo gairdneri* predation on migrant fry of sockeye salmon *Oncorhynchus nerka*. Journal of the Fisheries Resource Board of Canada 33:19-24.

Goede, R. W., and B. A. Barton. 1990. Organismic indices and an autopsy-based assessment as indications of health and condition of fish. American Fisheries Society Symposium 8:93-108.

Henry, C. J., and K. P Burnham. 1976. A reward band study of mallards to estimate band reporting rates. Journal of Wildlife Management 40:1-14.

Idaho Department of Fish and Game. 1995. Fisheries management plan 1996-2000. Boise, Idaho.

Mauser, G. 1992. Hatchery trout evaluations. Job performance report, F-73-R-14. Idaho Department of Fish and Game. Boise, Idaho.

Mauser, G. 1994. Hatchery trout evaluations. Job performance report, F-73-R-15. Idaho Department of Fish and Game. Boise, Idaho.

Moyle, P. B. 1969. Comparative behavior of young brook trout of domestic and wild origin. Progressive Fish Culturist 31:51-56.

Neter, J., W. Wasserman, and M. H. Kutner. 1990. Applied linear statistical models, third edition. Richard D. Erwin, Inc. Boston, Massachusetts.

Nichols, J. D., R. J. Blohm, R. E. Reynolds, R. E. Trost, J. E. Hines, and J. P Bladen. 1991. Band reporting rates for mallards with reward bands of different dollar values. Journal of Wildlife Management 55:119-126

Nichols, J. D, R. E. Reynolds, R. J. Blohm, R. E. Trost, J. E. Hines and J. P Bladen. 1995. Geographic variation in band reporting rates for mallards based on reward banding. Journal of Wildlife Management 59:697-708.

Olla, B. L., and M. W. Davis. 1989. The role of learning and stress in predator avoidance of hatchery-reared coho salmon *Oncorhynchus kisutch* juveniles. Aquaculture 76:209-214.

Olla, B. L., M. W. Davis, and C. B Schreck. 1995. Stress-induced impairment of predator evasion and nonpredator mortality in Pacific salmon. Aquaculture Research 26:393-398.

Olla, B. L., M. W. Davis, and C. H. Ryer. 1998. Understanding how the hatchery environment represses or promotes the development of behavioral survival skills. Bulletin of Marine Science 62:531-550.

Patino, R., C. B. Schreck, J. L. Banks, and W. S. Zaugg. Effects of rearing conditions on the developmental physiology of smolting coho salmon. Transactions of the American Fisheries Society 115:828-837.

Reeves, H. M. 1979. Estimates of reporting rates for mourning dove bands. Journal of Wildlife Management 43:36-42.

Ryer, C. H., and B. L. Olla. 1991. Information transfer and the facilitation and inhibition of feeding in schooling fish. The Environmental Biology of Fishes 30:317-323.

Ryer, C. H., and B. L. Olla. 1992. Social mechanisms facilitating exploitation of sparially variable ephemeral food patches in a pelagic marine fish. Animal Behavior 44:69-74.

Ryer, C. H., and B. L. Olla. 1995a. The influence of food distribution upon the development of aggressive and competitive behavior in juvenile chum salmon, *Oncorhynchus keta*. Journal of Fish Biology 46:264-272.

Ryer, C. H., and B. L. Olla. 1995b. Influences of food distribution on fish foraging behavior. Animal Behavior 49:411-418.

Swain, D. P., and B. E. Riddell. 1990. Variation in agnostic behavior between newly emerged juveniles from hatchery and wild populations of coho salmon, *Oncorhynchus kisutch*. Canadian Journal of Fisheries and Aquatic Sciences 47:566-571.

SYSTAT. 1999. SYSTAT statistical software, version 9.0. SPSS, Inc.

Teuscher, D. M., C. B. Alexander, J. C. Dillon, and D. J. Schill. 1998. Hatchery trout evaluations. Job performance report, F-73-R-20. Idaho Department of Fish and Game. Boise, Idaho.

Teuscher, D. M. 1999. Hatchery trout evaluations. Job performance report, F-73-R-22. Idaho Department of Fish and Game. Boise, Idaho.

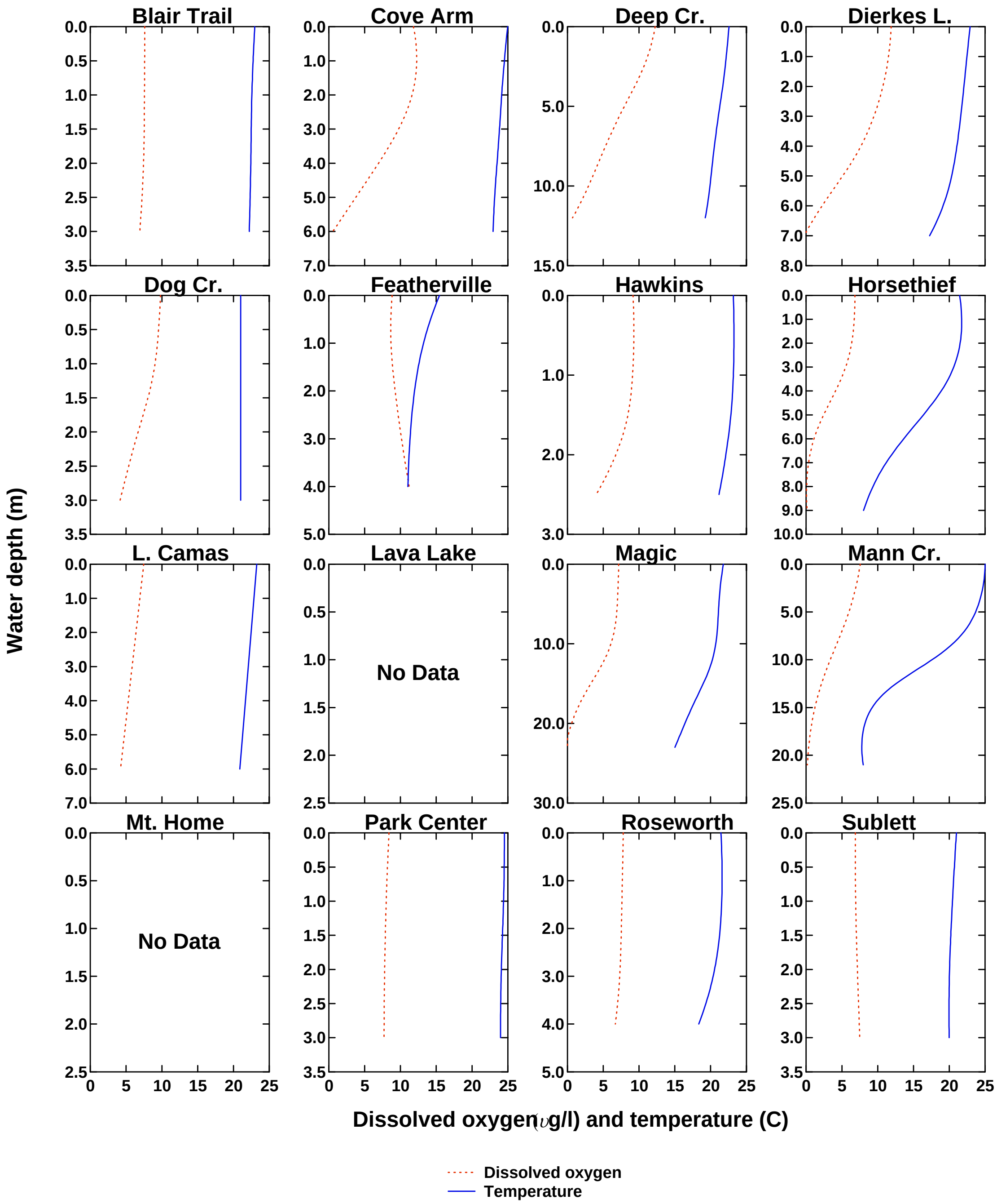
Vincent, R. E. 1960. Some influences of domestication upon three stocks of brook trout *Salvelinus fontinalis Mitchill*. Transactions of the American Fisheries Society 89:35-52.

Welsh, T., O. E. Casey, W. E. Webb, R. J. Bell, P. Jeppson, D. Corley, H. T. Heimer. 1970. Test for increasing the returns of hatchery trout. Job completion report, F-32-R-12. Idaho Department of Fish and Game. Boise, Idaho.

Zar, J. H. 1999. Biostatistical analysis, fourth edition. Upper Saddle River, New Jersey.

APPENDICES

Appendix A. Temperature and dissolved oxygen profiles for each of the study water stocked in August 2000.



Appendix B. Tag numbers, hatchery source, water, and stock date of tagged trout stocked in south-central Idaho in 1999 and 2000.

Year	Tag series[a]	Hatchery	Water	Date
1999	00001 - 00200	American Falls	Mountain Home Reservoir	May 19, 1999
	00201 - 00400	American Falls	Lava Lake	May 17, 1999
	00401 - 00600	American Falls	Dierkes Lake	May 18, 1999
	00601 - 00800	American Falls	Dog Creek Reservoir	May 20, 1999
	00801 - 01000	American Falls	Park Center Pond	May 21, 1999
	01001 - 01200	American Falls	Sublett Reservoir	May 24, 1999
	01201 - 01400	American Falls	Blair Trail Reservoir	May 25, 1999
	01401 - 01600	American Falls	Cove Arm Reservoir	May 26, 1999
	01601 - 01800	American Falls	Deep Creek Reservoir	May 27, 1999
	01801 - 02000	American Falls	Roseworth Reservoir	June 2, 1999
	02001 - 02200	American Falls	Little Camas Reservoir	June 1, 1999
	02201 - 02400	American Falls	Mann Creek Reservoir	June 3, 1999
	02401 - 02600	American Falls	Magic Reservoir	June 7, 1999
	02601 - 02800	American Falls	Hawkins Reservoir	June 8, 1999
	02801 - 03000	American Falls	Featherville Dredge Pond	June 14, 1999
	03001 - 03200	American Falls	Upper Payette Lake	June 21, 1999
	03201 - 03400	Hagerman (Riley Creek)	Lava Lake	May 17, 1999
	03401 - 03600	Hagerman (Riley Creek)	Dierkes Lake	May 18, 1999
	03601 - 03800	Hagerman (Riley Creek)	Mountain Home Reservoir	May 19, 1999
	03801 - 04000	Hagerman (Riley Creek)	Dog Creek Reservoir	May 20, 1999
	04001 - 04200	Hagerman (Riley Creek)	Park Center Pond	May 21, 1999
	04201 - 04400	Hagerman (Tucker Springs)	Sublett Reservoir	May 24, 1999
	04401 - 04600	Hagerman (Riley Creek)	Blair Trail Reservoir	May 25, 1999
	04601 - 04800	Hagerman (Riley Creek)	Cove Arm Reservoir	May 26, 1999
	04801 - 05000	Hagerman (Riley Creek)	Deep Creek Reservoir	May 27, 1999
	05001 - 05200	Hagerman (Riley Creek)	Roseworth Reservoir	June 2, 1999
	05201 - 05400	Hagerman (Riley Creek)	Little Camas Reservoir	June 1, 1999
	05401 - 05600	Hagerman (Riley Creek)	Mann Creek Reservoir	June 3, 1999
	05601 - 05800	Hagerman (Riley Creek)	Magic Reservoir	June 7, 1999
	05801 - 06000	Hagerman (Riley Creek)	Hawkins Reservoir	June 8, 1999
	06001 - 06200	Hagerman (Riley Creek)	Featherville Dredge Pond	June 14, 1999
	06201 - 06400	Hagerman (Tucker Springs)	Upper Payette Lake	June 21, 1999
	06401 - 06600	Hagerman (Tucker Springs)	Lava Lake	May 17, 1999
	06601 - 06800	Hagerman (Tucker Springs)	Dierkes Lake	May 18, 1999
	06801 - 07000	Hagerman (Tucker Springs)	Mountain Home Reservoir	May 19, 1999
	07001 - 07200	Hagerman (Tucker Springs)	Dog Creek Reservoir	May 20, 1999
	07201 - 07400	Hagerman (Tucker Springs)	Park Center Pond	May 21, 1999
	07401 - 07600	Hagerman (Riley Creek)	Sublett Reservoir	May 24, 1999
	07601 - 07800	Hagerman (Tucker Springs)	Blair Trail Reservoir	May 25, 1999
	07801 - 08000	Hagerman (Tucker Springs)	Cove Arm Reservoir	May 26, 1999
	08001 - 08200	Hagerman (Tucker Springs)	Deep Creek Reservoir	May 27, 1999
	08201 - 08400	Hagerman (Tucker Springs)	Roseworth Reservoir	June 2, 1999
	08401 - 08600	Hagerman (Tucker Springs)	Little Camas Reservoir	June 1, 1999
	08601 - 08800	Hagerman (Tucker Springs)	Mann Creek Reservoir	June 3, 1999
	08801 - 09000	Hagerman (Tucker Springs)	Magic Reservoir	June 7, 1999
	09001 - 09200	Hagerman (Tucker Springs)	Hawkins Reservoir	June 8, 1999

Appendix B. Continued.

Year	Tag series[a]	Hatchery	Water	Date
	09201 - 09400	Hagerman (Tucker Springs)	Featherville Dredge Pond	June 14, 1999
	09401 - 09600	Hagerman (Riley Creek)	Upper Payette Lake	June 21, 1999
	09601 - 09800	Nampa	Lava Lake	May 17, 1999
	09801 - 10000	Nampa	Dierkes Lake	May 18, 1999
	10001 - 10200	Nampa	Mountain Home Reservoir	May 19, 1999
	10201 - 10400	Nampa	Dog Creek Reservoir	May 20, 1999
	10401 - 10600	Nampa	Park Center Pond	May 21, 1999
	10601 - 10800	Nampa	Sublett Reservoir	May 24, 1999
	10801 - 11000	Nampa	Blair Trail Reservoir	May 25, 1999
	11001 - 11200	Nampa	Cove Arm Reservoir	May 26, 1999
	11201 - 11400	Nampa	Deep Creek Reservoir	May 27, 1999
	11401 - 11600	Nampa	Roseworth Reservoir	June 2, 1999
	11601 - 11800	Nampa	Little Camas Reservoir	June 1, 1999
	11801 - 12000	Nampa	Mann Creek Reservoir	June 3, 1999
	12001 - 12200	Nampa	Magic Reservoir	June 7, 1999
	12201 - 12400	Nampa	Hawkins Reservoir	June 8, 1999
	12401 - 12600	Nampa	Featherville Dredge Pond	June 14, 1999
	12601 - 12800	Nampa	Upper Payette Lake	June 21, 1999
	18602	American Falls	Dierkes Lake	May 18, 1999
	18603	American Falls	Mountain Home Reservoir	May 19, 1999
	18604	American Falls	Mountain Home Reservoir	May 19, 1999
	18605	American Falls	Cove Arm Reservoir	May 26, 1999
	18606	American Falls	Mann Creek Reservoir	June 3, 1999
	18615	American Falls	Roseworth Reservoir	June 2, 1999
	19001	Hagerman (Riley Creek)	Hawkins Reservoir	June 8, 1999
2000	20001 - 20200	American Falls	Lava Lake	April 24, 2000
	20201 - 20400	American Falls	Dierkes Lake	April 25, 2000
	20401 - 20600	American Falls	Mountain Home Reservoir	April 26, 2000
	20601 - 20800	American Falls	Dog Creek Reservoir	April 27, 2000
	20801 - 21000	American Falls	Park Center Pond	April 28, 2000
	21001 - 21200	Hagerman (Riley Creek)	Deep Creek Reservoir	May 5, 2000
	21201 - 21400	Hagerman (Riley Creek)	Roseworth Reservoir	May 8, 2000
	21401 - 21600	Hagerman (Riley Creek)	Mann Creek Reservoir	May 9, 2000
	21601 - 21800	American Falls	Little Camas Reservoir	May 4, 2000
	21801 - 22000	American Falls	Deep Creek Reservoir	May 5, 2000
	22001 - 22200	American Falls	Roseworth Reservoir	May 8, 2000
	22201 - 22400	American Falls	Mann Creek Reservoir	May 9, 2000
	22401 - 22600	American Falls	Hawkins Reservoir	May 10, 2000
	22601 - 22800	American Falls	Magic Reservoir	May 11, 2000
	22801 - 23000	American Falls	Featherville Dredge Pond	May 12, 2000
	23001 - 23200	American Falls	Horsethief Reservoir	May 23, 2000
	23201 - 23400	Hagerman (Riley Creek)	Lava Lake	April 24, 2000
	23401 - 23600	Hagerman (Riley Creek)	Dierkes Lake	April 26, 2000
	23601 - 23800	Hagerman (Riley Creek)	Mountain Home Reservoir	April 27, 2000
	23801 - 24000	Hagerman (Riley Creek)	Dog Creek Reservoir	April 28, 2000
	24001 - 24200	Hagerman (Riley Creek)	Park Center Pond	April 29, 2000
	24201 - 24400	Hagerman (Riley Creek)	Blair Trail Reservoir	May 1, 2000

Appendix B. Continued.

Year	Tag series[a]	Hatchery	Water	Date
	24401 - 24600	Hagerman (Riley Creek)	Sublett Reservoir	May 2, 2000
	24601 - 24800	Hagerman (Riley Creek)	Cove Arm Reservoir	May 3, 2000
	24801 - 25000	Hagerman (Riley Creek)	Little Camas Reservoir	May 4, 2000
	25001 - 25200	American Falls	Sublett Reservoir	May 2, 2000
	25201 - 25400	American Falls	Cove Arm Reservoir	May 3, 2000
	25401 - 25600	Hagerman (Riley Creek)	Hawkins Reservoir	May 10, 2000
	25601 - 25800	Hagerman (Riley Creek)	Magic Reservoir	May 11, 2000
	25801 - 26000	Hagerman (Riley Creek)	Featherville Dredge Pond	May 12, 2000
	26001 - 26200	Hagerman (Riley Creek)	Horsethief Reservoir	May 23, 2000
	26299	American Falls	Roseworth Reservoir	May 8, 2000
	26300	American Falls	Little Camas Reservoir	May 4, 2000
	26301 - 26400	American Falls	Blair Trail Reservoir	May 1, 2000
	26401 - 26600	Nampa	Lava Lake	April 24, 2000
	26601 - 26800	Nampa	Dierkes Lake	April 25, 2000
	26801 - 27000	Nampa	Mountain Home Reservoir	April 26, 2000
	27001 - 27200	Nampa	Dog Creek Reservoir	April 27, 2000
	27201 - 27400	Nampa	Park Center Pond	April 28, 2000
	27401 - 27600	Nampa	Blair Trail Reservoir	May 1, 2000
	27601 - 27800	Nampa	Sublett Reservoir	May 2, 2000
	27801 - 28000	Nampa	Cove Arm Reservoir	May 3, 2000
	28001 - 28200	Nampa	Little Camas Reservoir	May 3, 2000
	28201 - 28400	Nampa	Deep Creek Reservoir	May 5, 2000
	28401 - 28600	Nampa	Roseworth Reservoir	May 8, 2000
	28601 - 28800	Nampa	Mann Creek Reservoir	May 9, 2000
	28801 - 29000	Nampa	Hawkins Reservoir	May 10, 2000
	29001 - 29200	Nampa	Magic Reservoir	May 11, 2000
	29201 - 29400	Nampa	Featherville Dredge Pond	May 12, 2000
	29401 - 29600	Nampa	Horsethief Reservoir	May 23, 2000
	32701 - 32800	American Falls	Blair Trail Reservoir	May 1, 2000

[a] All tag numbers are preceded by the prefix “TR” (e.g. TR 00001)

Prepared by:

Douglas J. Megargle
Senior Fishery Research Biologist

David Teuscher
Senior Fishery Research Biologist

Approved by:

IDAHO DEPARTMENT OF FISH AND GAME

Virgil K. Moore, Chief
Bureau of Fisheries

Steve Yundt
Fishery Research Manager