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Martin K. Koenig [a] & Kevin A. Meyer [a]
[a] Idaho Department of Fish and Game, 1414 East Locust Lane, Nampa, Idaho, 83686, USA

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ARTICLE

Relative Performance of Diploid and Triploid Catchable Rainbow Trout Stocked in Idaho Lakes and Reservoirs

Martin K. Koenig* and Kevin A. Meyer
Idaho Department of Fish and Game, 1414 East Locust Lane, Nampa, Idaho 83686, USA

Abstract
Idaho Department of Fish and Game hatcheries stock predominantly sterile triploid (3n) rainbow trout *Oncorhynchus mykiss* to provide sportfishing opportunities while minimizing the genetic risks to wild stocks. Triploid catchable-sized rainbow trout are stocked in over 500 water bodies across Idaho annually, but there remains some uncertainty regarding the performance of triploid rainbow trout relative to their diploid (2n) counterparts. We examined the relative survival, growth, and returns of diploid and triploid all-female catchable rainbow trout across 13 lakes and reservoirs. Most reservoirs showed higher returns of 2n rainbow trout to anglers. In 2008, 3n rainbow trout returned on average at only 72% and 81% of the rates of 2n trout in gill nets and snout collection boxes, respectively, and the difference for both methods was statistically significant. Carryover of marked rainbow trout from 2008 was low or zero in most reservoirs. Where there was carryover, snout collection boxes suggested that 3n rainbow trout returned to anglers at 71% of the rate of 2n rainbow trout in the second year after planting, but the difference was not statistically significant. Triploid rainbow trout did not show any growth advantages over 2n rainbow trout but were similar in length, weight, and dressed weight. The disparity in returns between 2n and 3n trout varied across reservoirs but was more pronounced in locations subjected to greater drawdown and with greater species diversity. While 2n rainbow trout may grow and survive better in reservoirs subject to low water levels, triploid rainbow trout may perform equally well under good habitat conditions while not having genetic impacts on native stocks. These findings are rather fortuitous for fisheries managers, as triploids probably perform better in higher-quality habitats where native trout often exist, whereas diploids are better suited to reservoirs with degraded habitats where native stocks have usually been extirpated.

To meet the demands on recreational trout fisheries, many fish and game agencies have funded hatchery programs to maintain fishing quality, often consuming large portions of annual fisheries budgets (Hartzler 1988; Johnson et al. 1995). In 1983, rainbow trout *Oncorhynchus mykiss* made up 77% of all catchable-sized trout stocked in the USA, 50 million being stocked in over 500,000 ha of impoundments (Hartzler 1988). Stocking practices in the USA have trended towards stocking fewer, larger individuals that are immediately available to anglers, with catchables now being the most commonly stocked size of rainbow trout (Halverson 2008). In fact, Halverson (2008) reported that while rainbow trout made up only 5% of fish stocked in the USA by numbers, they made up 50% of fish stocked by weight in 2004. A large portion of the cost and production capacity of Idaho Department of Fish and Game (IDFG) resident hatcheries is associated with producing catchable-sized triploid (3n) rainbow trout. In 2008, IDFG hatcheries raised and stocked approximately 2.4 million catchable trout across more than 500 water bodies, requiring approximately one-half of the annual resident hatchery system budget (IDFG 2008). Since 2001, IDFG has established a policy to stock only sterile (i.e., triploid) rainbow trout in systems where stocked rainbow trout pose a genetic risk to native trout populations (IDFG 2001). Triploid salmonids, created by heat or pressure shock, are functionally sterile. In this respect, 3n trout provide a valuable tool for conservation while managing for recreational trout fisheries.

In addition to protecting native stocks from genetic introgression, sterile fish could theoretically provide fishery benefits

*Corresponding author: martin.koenig@idfg.idaho.gov
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such as increased growth (Thorgaard 1986; Boulanger 1991; Teuscher et al. 2003) or longevity (Parkinson and Tsumura 1988; Johnston et al. 1993; Warrillow et al. 1997). Survival, longevity, and growth of 3n salmonids in natural environments are inconsistent relative to diploid (2n) fish (Parkinson and Tsumura 1988; Simon et al. 1993; Brock et al. 1994; Warrillow et al. 1997; Teuscher et al. 2003) and may be species dependent (Ihssen et al. 1990). Despite the uncertainty around their performance, triploid salmonids are still incorporated into hatchery programs of many western states (Kozfkay et al. 2006).

Relative return to creel—the proportion of stocked marked fish caught by anglers—is often used to compare the performance of diploid and triploid salmonids. Previous IDFG evaluations of sterile salmonids have examined relative survival and returns of 3n rainbow trout, including catchables in streams (Dillon et al. 2000), fingerlings in high-desert reservoirs (Teuscher et al. 2003), and fingerlings in alpine lakes (Koenig et al. 2011). Dillon et al. (2000) found no difference in return-to-creel rates of 3n and 2n catchable rainbow trout stocked together in 18 Idaho streams. Mean time to harvest was not different for sterile fish, as most trout in the study were caught in less than 30 d. Teuscher et al. (2003) evaluated all-female 3n and 2n fingerling rainbow trout in two productive Idaho reservoirs. Overall, the total electrofishing catch of triploids over several years was higher than for diploids, but 3n trout did not show any advantage in length or weight over 2n trout. In high alpine lakes, mixed-sex 2n rainbow trout returned to gill nets at almost twice the rate as mixed-sex 3n trout 3 and 4 years after stocking (Koenig et al. 2011). However, catch of the all-female 3n group was significantly higher than mixed-sex 2n and 3n groups 3 and 4 years after stocking (Koenig et al. 2011). As with other evaluations, no significant differences in length or weight were found between 2n and 3n test groups. Although these studies evaluated the performance of 3n salmonids in natural environments, the low number of studies available, limited scope, and contradictory results do not fully elucidate the performance of 3n hatchery trout, specifically in the context of put-and-take fisheries.

Despite the high costs associated with stocking catchable-sized trout, poststocking evaluations to assess the performance of catchables are rare, despite the large number of water bodies and rainbow trout stocked each year (Hartzler 1988; IDFG 2008). Given the limited research on 3n rainbow trout performance in natural settings and the contradictory results even among Idaho waters, there remains considerable uncertainty as to whether stocking 3n rainbow trout produces satisfactory fisheries in Idaho waters. Additional research on the performance of 3n catchable rainbow trout would allow fisheries managers to adjust stocking strategies and evaluate the utility of stocking sterile trout within their jurisdiction. Such research could also identify opportunities to increase hatchery efficiency by examining returns on different hatchery products. The objective of this study was to compare growth, relative survival, and relative return to creel of catchable-sized 2n and 3n rainbow trout stocked in lakes and reservoirs in Idaho.

STUDY SITE

We chose 13 lakes and reservoirs across Idaho representing the range of sizes, habitats, and elevations of those typically stocked with catchable rainbow trout by IDFG (Table 1). Study lakes were selected from those having a history of catchable rainbow trout stocking and were scheduled to receive plants in 2008 from Hagerman State Hatchery. Stocked lakes had an average elevation of 1,388 m, ranging from 547 to 1,922 m.

TABLE 1. Location, surface area, stocking date, size at stocking, and quantities of marked trout planted during 2008 in 13 Idaho lakes and reservoirs to assess the relative performance of diploid (2n) and triploid (3n) catchable-sized rainbow trout.

Water body	Size (ha)	Elevation (m)	Stocking date	Total 2n	2n weight (fish/kg)	2n length (mm)	Total 3n	3n weight (fish/kg)	3n length (mm)
Devil’s Creek Reservoir	35	1,571	Apr 29, 2008	5,405	1.04	257	5,355	0.95	265
Horsethief Reservoir	101	1,541	May 14–Jun 4, 2008	15,126	1.03	258	15,593	1.02	259
Island Park Reservoir	2,947	1,922	Jun 2–3, 2008	16,800	1.07	332	17,465	1.11	255
Little Camas Reservoir	391	1,502	Apr 30, 2008	3,776	1.07	255	3,885	1.01	260
Lost Valley Reservoir	211	1,454	May 29, 2008	7,590	1.04	257	7,557	1.04	257
Mann Lake	55	547	May 1, 2008	5,063	1.12	251	5,040	1.09	253
Oakley Reservoir	407	1,435	Apr 7, 2008	4,995	1.22	244	4,950	1.25	242
Paddock Reservoir	482	979	Apr 1, 2008	4,988	1.29	239	4,930	1.32	238
Roseworth Reservoir	393	1,594	Apr 8, 2008	4,995	1.22	244	4,950	1.25	242
Soldier’s Meadow Reservoir	45	1,388	May 20, 2008	4,700	1.07	255	4,540	1.03	258
Stone Reservoir	50	1,402	Apr 28, 2008	5,040	1.09	253	5,040	1.27	241
Thorn Creek Reservoir	45	1,679	May 16, 2008	2,520	1.09	253	2,573	1.11	252
Waha Reservoir	38	1,034	May 20, 2008	3,525	1.07	255	3,405	1.03	258

Most lakes had a surface area between 35 and 482 ha, except for Island Park Reservoir (2,947 ha). Other than Horsethief Reservoir (which remains near full pool for most of the year), these reservoirs are used for irrigation purposes and are subject to drawdown, which can be substantial in some years. Species composition varied between reservoirs and ranged from simple trout-only lakes (Horsethief Reservoir) to more-complex, mixed fisheries containing rainbow trout, white crappie *Pomoxis annularis*, largemouth bass *Micropterus salmoides*, and channel catfish *Ictalurus punctatus* (Mann Lake). All study lakes were managed under the year-round "general" trout harvest regulation of 6 fish/d with no length restrictions.

METHODS

All-female 2n and 3n rainbow trout eggs were obtained from Troutlodge, Inc. (Sumner, Washington) and reared to "catchable" size at Hagerman State Hatchery until the time of stocking. This stock of rainbow trout is commonly raised and stocked by IDFG hatcheries. Using all-female trout eliminated the confounding effect that sex may have on the comparative performance of diploids and triploids. According to their technical literature, Troutlodge, Inc. reports typical triploid induction rates of greater than 95%, most egg lots showing 100% triploidy (Troutlodge 2011). Even though small numbers of diploid fish are not likely to be detected by small-scale testing (Devlin et al. 2010), we wanted to confirm the ploidy level of test groups prior to stocking using blood samples and flow cytometry. Confidence intervals (CIs) around the proportion triploid/diploid were calculated according to Fleiss et al. (2003). The 3n induction rate (with 95% confidence bounds) was estimated at 100% (91–100%, $n = 49$), while results from the 2n group indicated 100% diploid (91–100%, $n = 50$).

Marking and stocking.—Diploid and triploid groups were marked in identical fashion with both adipose fin clips and coded wire tags (CWTs). Adipose fin clips were used to distinguish experimental fish from other rainbow trout when collected in the field, while wire tag codes identified ploidy level. A total of 110,485 2n and 109,885 3n rainbow trout were tagged in fall 2007. Most trout (65%) were tagged using the Northwest Marine Technologies (NMT) AutoFish system in a mobile tagging trailer, while the remainder was hand-tagged using scissors and Mark IV Automatic Tag Injectors (NMT). At the time of tagging, the 3n and 2n groups were 92 mm ($n = 110{,}113$, coefficient of variation, the ratio of the SD to the mean [CV] = 13.7) and 102 mm ($n = 75{,}260$, CV = 14.7) in total length, respectively. Average tag retention was monitored by examining pooled incidental mortalities weekly over the hatchery rearing phase and was not estimated separately for 2n and 3n groups. Collected mortalities were examined for CWTs using a V-Detector (NMT) antenna. Tags were dissected with the aid of the V-Detector and tag codes read using a compound microscope. Confidence intervals around the proportion marked were calculated according to methods of Fleiss et al. (2003). Tag retention across the 30 weeks in-hatchery after tagging was 95 ± 1% (95% CI about the mean; $n = 1{,}181$).

Marked trout were stocked between April 1 and June 3, 2008, depending on water conditions and access availability. The total numbers of marked trout planted varied among study locations, but each reservoir received approximately equal numbers of 2n and 3n test fish (Table 1). At stocking, the mean length of 2n and 3n marked fish was 251 and 252 mm, respectively, averaging 252 mm overall (Table 1). A total of 84,523 2n and 85,283 3n catchable-sized rainbow trout were planted across the 13 locations as part of the normal stocking requests.

Sample collection.—Rainbow trout were sampled using floating monofilament experimental gill nets measuring 48 m long × 1.8 m deep. Nets were composed of six panels consisting of 19-, 25-, 32-, 38-, 51-, and 64-mm-bar mesh, placed in random order when manufactured. Gill nets were set at sunset and fished overnight for a minimum of 8 h. During each sampling event, 5–15 gill nets were fished at each reservoir from one to three nights, depending on catch rates. Gill nets were set in a variety of locations to include both pelagic and littoral zones, but locations were not standardized across reservoirs. Sampling typically yielded enough marked fish so that most reservoirs were only sampled on one occasion during each sampling season. Most sites were first sampled during September and October 2008. However, due to low water conditions, some locations were sampled earlier. Paddock Valley Reservoir was subjected to early drawdown and therefore sampled in July 2008. Little Camas Reservoir and Thorn Creek Reservoir were also drawn low and were sampled from August 19–21, 2008. Reservoirs were also sampled in spring (April–May) 2009, and again in fall (September–October) 2009. Some reservoirs were not sampled on multiple occasions after low initial catches of marked fish. All adipose-clipped rainbow trout were measured (total length) to the nearest millimeter and weighed to the nearest gram. Dressed weight was collected on a subsample of the marked rainbow by removing entrails, gonads, and gills, but leaving the pectoral fins and kidney intact. Snouts of marked fish were then removed and frozen for tag recovery later. Coded wire tags were removed from snouts by manual dissection using a V-Detector antenna (NMT) and read using a compound microscope.

In addition to gill netting, in 2008 and 2009 we collected tags from fish caught by anglers. Snouts of adipose-clipped rainbow trout were collected passively using "snout collection boxes" installed at boat ramps and other access locations such as docks and intersections of access roads around study locations. Snout boxes and the associated signs were installed on or before the day of stocking. Signs described the goals of the research program and invited anglers to participate in the study by depositing snouts of adipose-clipped rainbow trout that they planned to harvest. Boxes were filled part way with a mixture of rock salt and borax (to act as a desiccant and preservative) and were checked from weekly to monthly, depending on anticipated fishing pressure and crew availability. Recovered snouts were stored frozen until tags could be dissected. Snout boxes were dismantled in the fall during September and October, towards the end of the typical fishing season.

Data analysis.—Mean length, weight, and dressed weight between 2n and 3n marked trout were examined by sampling occasion (fall 2008, spring 2009, or fall 2009) using mixed-model two-way analysis of variance (ANOVA) with repeated measures (PROC MIXED, SAS 2004). Ploidy level and sampling occasion were treated as fixed effects, while lakes were treated as a random effect. Lakes were sampled repeatedly in sequential events, so the analysis used an autoregressive covariance structure, which showed improved results to those using compound symmetry (according to model Akaike information criterion scores). The analysis was weighted by the total number of marked fish caught at each lake and performed using a significance level of $\alpha = 0.05$.

The total catches of 2n and 3n marked trout were compared for each sampling period using a nonparametric Wilcoxon paired-sample test (T) with $\alpha = 0.05$. Differences of zero were ignored in the analysis (Zar 1999), which reduced sample size in some cases. We performed separate analyses for gill net (by sampling event) and angler-caught data (by fishing season). Since we were only interested in comparing relative returns for 2n and 3n trout, we did not correct for nonresponse bias in the number of tags returned.

The relationships between the relative catch of 3n marked trout and other biological and habitat variables were examined by means of correlation analysis. Variables were generally not normally distributed and did not meet the assumptions necessary for ordinary least-squares regression analysis. Because of this and the relatively small sample size ($n = 28$), we used nonparametric Spearman rank correlation coefficients to test single-variable relationships between several variables and the proportion of marked trout caught that were triploid (H_0: $\rho = 0$). Each sampling occasion was used as one observation in the data set. Variables included the reservoir volume (percent full) in fall 2008, total species count sampled with gill nets, and the catch per unit effort (CPUE, total fish/h netting) of all nontrout bycatch. Correlations were calculated using a significance level of $\alpha = 0.05$. Confidence intervals were calculated around mean length, weight, dressed weight, and catch per unit effort.

RESULTS

Sampling in 2008 yielded a combined total 2,270 rainbow trout across all reservoirs. Of these rainbow trout captured, 1,212 (53%) were marked with adipose fin clips. During the first season fish were planted, 2n trout on average were captured by gill nets at a higher rate than 3n trout ($T_{0.05(2),\,12} = 10$, $P = 0.028$). Gill-net CPUE for 2n and 3n trout in fall 2008 was 0.43 ± 0.24 and 0.31 ± 0.18 fish/h, respectively. Six hundred thirty-five total 2n and 456 total 3n marked rainbow trout were sampled, indicating that on average 3n rainbow trout returned to gill nets at 72% of 2n rainbow trout, 2n rainbow trout being caught in higher numbers in 9 of 13 reservoirs (Table 2).

The snout recovery boxes yielded results similar to those of the gill-net surveys. Of the 2,533 snouts returned during the 2008 fishing season, tag codes indicated 1,215 (55%) as 2n and 989 as 3n (45%). This indicated that 3n rainbow trout

TABLE 2. Total counts of diploid (2n) and triploid (3n) rainbow trout tags recaptured, by method and year. Catch per unit effort by gill nets is shown in parentheses. Trout were stocked in spring 2008 and recaptured in fall 2008, spring 2009, and fall 2009.

	Gill nets						Voluntary creel			
	Fall 2008		Spring 2009		Fall 2009		2008		2009	
Water body	2n	3n	2n	3n	2n	3n	2n	3n	2n	3n
Devil's Creek Reservoir	33 (0.35)	36 (0.38)	3 (0.01)	1 (0.003)	0	1 (0.01)	47	39	6	1
Horsethief Reservoir	98 (0.75)	118 (0.90)	10 (0.07)	16 (0.11)	0	2 (0.01)	442	454	11	14
Island Park Reservoir	46 (0.10)	30 (0.06)	17 (0.04)	6 (0.01)	1 (0.003)	0	56	28	16	14
Little Camas Reservoir	85 (0.40)	46 (0.22)	0	0			46	44		
Lost Valley Reservoir	144 (1.12)	94 (0.73)	31 (0.25)	20 (0.16)	13 (0.04)	25 (0.09)	66	70	31	18
Mann Lake	6 (0.05)	6 (0.05)					57	55		
Oakley Reservoir	5 (0.04)	5 (0.04)	2 (0.005)	0			65	26	2	1
Paddock Reservoir	10 (0.09)	1 (0.01)					5	4		
Roseworth Reservoir	16 (0.06)	2 (0.01)	0	1 (0.001)			82	44	0	0
Soldier Meadow Reservoir	35 (0.30)	33 (0.28)	13 (0.05)	11 (0.04)	0	0	59	35	11	9
Stone Reservoir	70 (0.71)	27 (0.28)					81	41		
Thom Creek Reservoir	30 (1.23)	20 (0.82)	0	0			111	89		
Waha Lake	57 (0.43)	38 (0.29)	62 (0.44)	62 (0.44)	0	0	98	60	13	7
Grand total	635 (0.43)	456 (0.31)	138 (0.09)	117 (0.08)	14 (0.01)	28 (0.02)	1,215	989	90	64
Total percent	58%	42%	54%	46%	33%	67%	55%	45%	58%	42%

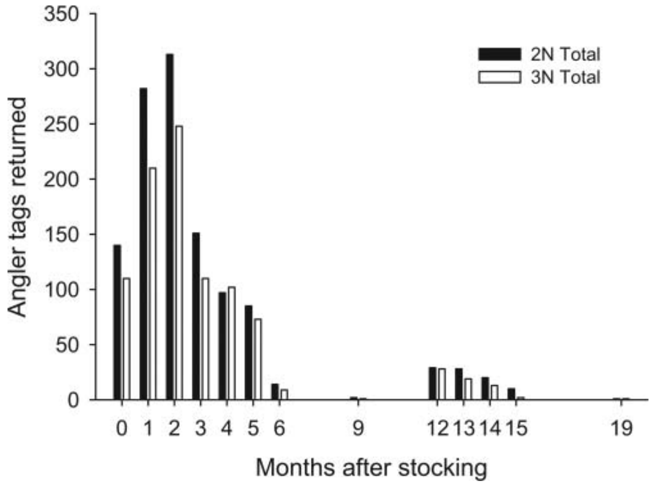

FIGURE 1. Total diploid and triploid rainbow trout tags returned by anglers from 13 Idaho reservoirs stocked in spring 2008, by month after stocking.

returned to anglers at 81% of 2n rainbow trout during 2008. The proportion of 2n and 3n tags recovered varied between lakes, but angler-caught tag returns in 2008 were on average significantly higher for 2n trout than for 3n trout ($T_{0.05(2),\ 13} = 17$, $P = 0.015$). When angler-caught tags were compared by month, paired differences were also significant ($T_{0.05(2),\ 7} = 2$, $P = 0.043$), and differences in angler returns were apparent almost immediately after planting but decreased over time (Figure 1).

Gill-net sampling in spring 2009 included 10 of 13 reservoirs and captured 303 marked rainbow trout, of which 255 contained tags. Catch of marked fish was again highly variable and much lower than in the previous fall, with most marked rainbow trout being caught at Lost Valley Reservoir and Waha Lake (Table 2). No marked trout were caught at Little Camas and Thorn Creek reservoirs, suggesting poor overwinter survival probably due to low water levels at the end of the previous year. The gill-net CPUE for 2n and 3n trout was 0.09 ± 0.01 and 0.08 ± 0.09 fish/h, respectively. Tag codes indicated 138 (or 54%) 2n rainbow trout and 117 (or 46%) 3n rainbow trout were caught in spring 2009, but the paired comparisons of gill-net returns were not significantly different between 2n and 3n rainbow trout ($T_{0.05(2),\ 7} = 2$, $P = 0.28$).

Six of the 13 reservoirs were again sampled with gill nets in fall 2009. Catch rates of marked fish were low, yielding only 67 adipose-clipped rainbow trout, of which 42 contained tags. The total fall 2009 gill-net sample was composed of 33% (14) 2n rainbow and 67% (28) 3n rainbow trout. The vast majority of marked trout were recaptured at Lost Valley Reservoir (38 of 42), no marked fish being recaptured in two of the six reservoirs sampled; this suggests very few marked trout survived beyond the second summer. Limited sample size for paired comparisons of gill-net returns from fall 2009 ($n = 4$) precluded meaningful statistical analysis.

Angler-caught returns of marked fish were less variable across reservoirs in 2009 than in 2008. The voluntary creel yielded 470 snouts, snouts having been collected from all seven of the reservoirs surveyed (Table 2). As with the gill-net data, Lost Valley Reservoir provided the majority of returned tags. Overall, 2n trout made up 58% (90) of tags recovered, while 3n comprised 42% (64), suggesting 3n rainbow trout returned to anglers at only 71% of 2n trout. However, paired differences in the total number of 2n and 3n tags returned by anglers were not statistically significant ($T_{0.05(2),\ 7} = 2$, $P = 0.15$, $n = 7$), probably because of limited sample size. The total returned tags (154) over the 2009 season compared with 2008 (2,204) suggests the vast majority of fish stocked in 2008 were caught that same year. Regardless of ploidy level, few fish survived as holdovers into the next fishing season.

Triploid rainbow trout did not show any growth advantages over diploid trout in terms of length or weight (Figure 2). In fall 2008 2n and 3n rainbow trout were of similar length (321 ± 3 mm and 317 ± 3 mm, respectively), and increased in length in spring 2009 (340 ± 8 mm and 329 ± 8 mm, respectively) and again in fall 2009 (438 ± 21 mm and 435 ± 11 mm, respectively), but differences were not statistically significant ($F = 0.03$, df = 27, $P = 0.86$). In fall 2008, 2n and 3n rainbow trout were of similar weight (357 ± 10 g and 328 ± 11 g, respectively). Marked 2n and 3n trout increased in weight in spring 2009 (470 ± 43 g and 378 ± 38 g, respectively) and again in fall 2009 (883 ± 167 g and 829 ± 68 g, respectively), but differences were not statistically significant ($F = 0.56$, df = 27, $P = 0.46$). Dressed weight was also similar between 2n and 3n marked trout in fall 2008 (348 ± 10 g and 327 ± 11 g, respectively), and increased in spring 2009 (406 ± 36 g and 338 ± 35 g, respectively) and again in fall 2009 (772 ± 152 g and 727 ± 57 g, respectively), but differences were not statistically significant ($F = 0.19$ df = 22, $P = 0.67$). In comparing length, weight, and dressed weight between groups, the interaction of ploidy level and sampling occasion was not significant ($F = 0.25$, df = 27, $P = 0.78$).

The Spearman rank correlation coefficients suggested that the 3n proportion of marked trout caught was related to reservoir volume and the number of other species captured, but not to nontrout bycatch. Reservoir volume (percent pool remaining) in the fall after planting was positively correlated to the proportion of triploid rainbow trout ($r_s = 0.42$, $P = 0.026$), suggesting 3n rainbow trout performance was more similar to 2n rainbow trout in reservoirs with more water (higher percent full) than those with lower pools. The proportion of 3n rainbow trout was negatively correlated with number of species sampled ($r_s = -0.33$, $P = 0.08$), suggesting fewer 3n rainbow trout were caught in reservoirs with greater species diversity. The CPUE of bycatch species was not significantly correlated to the proportion of 3n rainbow trout caught ($r_s = -0.22$, $P = 0.26$).

DISCUSSION

When reared separately from diploids under good conditions, triploid salmonids can perform similarly to diploids in aquaculture settings (Habicht et al. 1994; Sheehan et al. 1999;

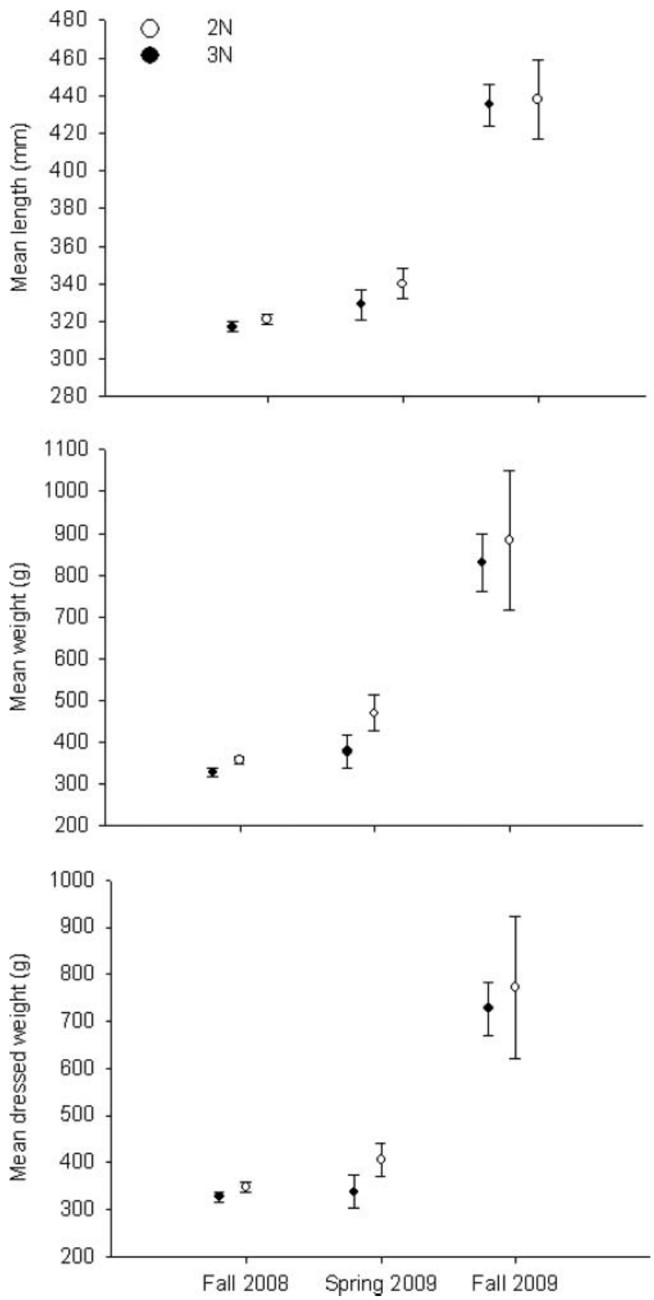

FIGURE 2. Mean length, weight, and dressed weight of diploid and triploid rainbow trout across all reservoirs by sampling season. Error bars indicate 95% CIs. No statistically significant differences were found between groups.

Piferrer et al. 2009), but their performance in natural environments after stocking can be variable (Simon et al. 1993; Dillon et al. 2000; Teuscher et al. 2003). Brock et al. (1994) found the cumulative catch of 3n rainbow trout (age 1 and age 2) to be 39% lower than 2n trout in six Alaska lakes. Similarly, 3n rainbow trout in our study did not survive as well as 2n rainbow trout over the period of two fishing seasons. Disparities in returns from 2n and 3n rainbow trout varied across reservoirs, but 2n trout provided higher returns in most locations. When interpreting these results, we assumed that 2n and 3n marked trout were equally susceptible to gill nets. While we expect this to be true, it remains largely untested. However, the relative proportions of 2n and 3n rainbow trout collected were similar between the snout return boxes (angler harvest) and active sampling with gill nets. This suggests that 2n rainbow trout were either more catchable both by gill nets and by anglers, or (more likely) that differences in catch were actually a result of lower 3n survival and not an artifact of differing catchability.

Gill-net surveys only provided a snapshot sample, while the snout return boxes provided return-to-angler data across much of the fishing season, allowing comparison of returns over time. In many locations—such as Devils Creek, Island Park, Oakley, Roseworth, Soldier Meadow, Stone, and Thorn Creek reservoirs—differences in return to anglers between 2n and 3n appeared early in the fishing season (Figure 1). Simon et al. (1993) reported similar findings, with lower survival of 3n rainbow trout becoming apparent shortly after planting. Considering the relatively brief window of time that catchable trout are typically available for harvest (Johnson et al. 1995), differences in survival of 2n and 3n trout soon after planting would directly translate to changes in angler success for put-and-take fisheries typical of this study.

One reason for using 3n trout in sport fisheries is the potential for faster growth rates and larger ultimate size (Brock et al. 1994). Several authors have reported growth advantages of 3n salmonids over their 2n counterparts (Thorgaard 1986; Ihssen et al. 1990; Boulanger 1991; Galbreath et al. 1994; Sheehan et al. 1999). However, these studies were conducted with treatments reared separately in hatchery environments, and any growth advantage of 3n fish seems only to materialize at larger sizes (500–700 g) after the fish have passed the normal size of sexual maturity. Growth advantages of 3n salmonids tend to reverse or disappear when reared in sympatry, in natural environments with 2n conspecifics, or when examined at earlier life stages (Simon et al. 1993; Brock et al. 1994; Galbreath et al. 1994). During the length of our study, 3n rainbow trout did not show any growth advantages over 2n rainbow trout. While mean length between the groups was similar, 2n fish tended to be heavier in weight and dressed weight in the first two sampling events, although differences were not statistically significant (Figure 2). Ojolick et al. (1995) studied growth patterns of rainbow trout and found that 2n fish had higher girth, while 3n fish tended to grow longer and leaner with lower condition factor. Teuscher et al. (2003) reported similar findings in Daniels and Treasureton reservoirs in Idaho, where 3n rainbow trout did not show any growth advantages over 2n rainbow up to 4 years of age. We expected dressed weights of 3n rainbow trout to surpass those of 2n trout after sexual maturity (Boulanger 1991). However, the put-and-take fisheries in this evaluation had little carryover, so any long-term growth advantages of 3n rainbow trout may be of little benefit to anglers given the short life expectancy typical of a catchable trout.

Habitat conditions varied across the study reservoirs and probably affected the survival and returns of stocked trout. Correlation coefficients showed the disparity in catch between 2n and 3n rainbow trout was usually greatest in reservoirs that experienced low water conditions in the fall when the first sampling occurred. Many of the study sites are irrigation reservoirs that are subject to drawdowns after mid-June when spring runoff ends and irrigation season begins. Little Camas, Paddock, Roseworth, Stone, and Thorn Creek reservoirs were drawn down by fall of 2008, Little Camas and Stone reservoirs becoming so low that these fisheries were opened to public salvage. These reservoirs probably experienced high summer water temperatures and low dissolved oxygen levels. While returns of 3n rainbow trout were on average lower than those of 2n trout, our results indicate that performance differences were less pronounced (higher proportion of 3n trout caught) at sites with less reservoir drawdown, suggesting 3n trout are more comparable to 2n trout in reservoirs where water levels might remain closer to full pool throughout the season. Despite this negative correlation of 3n catch and low reservoir levels in the fall, angler-returned tags indicate disparities in 2n and 3n catch appeared early in the season soon after stocking (Figure 1). Therefore, there may be factors inherent to these reservoirs that affected 3n trout performance rather than the level of drawdown itself.

Low reservoir levels from drought and drawdown (and the associated stressful habitat conditions and limited food supplies for salmonids) are commonly implicated in the poor survival and returns of stocked trout (Wiley et al. 1993; Dillon and Alexander 1996). Triploid salmonids are disproportionately affected by poor water quality such as low dissolved oxygen (Simon et al. 1993), elevated water temperatures (Ojolick et al. 1995; Hyndman et al. 2003; Atkins and Benfey 2008), and chronic environmental stress (see Maxime 2008 and Piferrer et al. 2009 for reviews). Research shows 3n rainbow trout have higher mortality than 2n controls at water temperatures above 17°C (Myers and Hershberger 1991; Blanc et al. 1992). Ojolick et al. (1995) reported 69% of 3n rainbow trout died within 3 weeks while reared at 21°C compared with 39% for 2n fish, 50% of the cumulative mortality occurring 20 d earlier for 3n than for 2n fish. Hyndman et al. (2003) found even higher mortality (9 of 10) in triploid brook trout *Salvelinus fontinalis* during 4 h of recovery after exhaustive exercise at 19°C, compared with no mortality in exercised diploids. Triploid salmonids may have lower hemoglobin : loading ratios that reduce maximum blood oxygen capacity (Ojolick et al. 1995) and may have difficulty restoring muscle metabolites after exercise (Hyndman et al. 2003). Yamamoto and Iida (1994) suggested 3n rainbow trout experienced more severe hypoxia under low dissolved oxygen conditions than diploids when infected with bacterial gill disease. More recently, Atkins and Benfey (2008) concluded triploid Atlantic salmon *Salmo salar* and brook trout had a lower optimum temperature for metabolic processes, which might explain higher mortality of 3n salmonids at temperatures not lethal to diploids. Regardless of underlying physiological mechanisms, earlier mortality of 3n trout could subsequently reduce return to creel by reducing the amount of time that trout are available to anglers. Simon et al. (1993) found low survival rates of triploid rainbow trout began shortly after stocking, suggesting that 3n rainbow trout may be a poor choice for even short-term fishing opportunities in waters with poor habitat conditions.

Correlation coefficients showed that the disparity in catch between 2n and 3n rainbow trout increased in reservoirs with higher numbers of fish species present, a higher number of species being correlated with a lower proportion of 3n trout in the total catch of marked trout. For example, the fish communities of Devils Creek, Horsethief, and Lost Valley reservoirs consisted almost exclusively of trout, and triploids made up an average of 51, 56, and 43% of the marked trout sampled, respectively. In these locations, triploids performed similar to diploids in terms of the total catch of marked trout. In contrast, Island Park, Paddock, and Stone reservoirs contained six different species. In these locations, triploids made up an average of 36, 9, and 28% of the marked trout sampled, respectively. Regardless of fishing pressure, low survival of stocked trout is common where established populations of competing nongame and predatory species exist and in locations with low water levels (Wiley et al. 1993; Dillon and Alexander 1996). Poor competitive ability of triploid fishes has been demonstrated for Atlantic salmon (Galbreath et al. 1994), saugeye (sauger *Sander canadensis* × walleye *S. vitreus*; Czesny et al. 2002), and small brook trout (O'Keefe and Benfey 1997), which could exacerbate low return-to-creel rates of triploid rainbow trout in locations with diverse species assemblages.

Several authors have suggested that the benefits of sterile trout—such as increased growth rates, larger ultimate sizes, and increased longevity—do not begin until the species reaches the normal age of sexual maturity (Ihssen et al. 1990; Sheehan et al. 1999; Teuscher et al. 2003). Our results suggest these advantages may never be realized in many put-and-take fisheries, especially in reservoirs subject to drawdown, high summer temperatures, or intense fishing pressure where carryover may be limited. In fact, some have reported catchable trout are caught as quickly as 7–10 d after stocking in streams (Butler and Borgeson 1965; Johnson et al. 1995) and within 2 months (more than 83% being harvested in the first year) in lakes and reservoirs (Wiley et al. 1993). On average, 3n rainbow trout did not grow or survive as well as 2n rainbow trout over the period of this evaluation (two fishing seasons). High exploitation rates (although rarely achieved), combined with lower survival (and return to creel) during the fishing season, could negate any long-term benefits associated with triploidy. However, in lakes with good habitat conditions, 3n rainbow trout may perform well while preventing genetic impacts to native trout.

Stocking strategies for managing catchable trout are highly site specific (Hartzler 1988), and fisheries managers should decide on an individual-lake basis whether the protection of native fish outweighs the potential for reduced survival and return to creel of 3n trout. Fortunately in Idaho, most reservoirs with lower quality habitat and mixed-species assemblages (where 3n trout would perform poorly) also tend to have few native salmonid populations nearby, thus stocking 2n trout poses little genetic risk in these water bodies. In reservoirs dominated by trout that maintain good water quality and are less subject to drawdown, native salmonids are more frequently found nearby, and continuing to use 3n trout in these locations will help protect native genotypes.

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