FISHERY RESEARCH

Wild Trout Competition Studies

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Wild Trout Competition Studies
Annual Performance Report

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Project 2: Wild Trout Investigations

Subproject #1: Competition between Wild and Hatchery Rainbow Trout

Subproject #2: Fate and Survival of Sterile Hatchery Rainbow Trout in a Stream Environment

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ANNUAL PERFORMANCE REPORT
SUBPROJECT #1: COMPETITION BETWEEN WILD AND HATCHERY RAINBOW TROUT

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Subproject #1: Competition Between Wild and Hatchery Rainbow Trout

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ABSTRACT

Idaho Department of Fish and Game (IDFG) has proactively dealt with potential adverse genetic effects of introduced trout on existing populations by stocking sterile rainbow trout, but concerns about ecological effects of introducing hatchery trout into streams and rivers supporting wild trout still remain. This report summarizes one year of a multiyear study to assess if stocking sterile hatchery rainbow trout *Oncorhynchus mykiss* of catchable size (catchables) in streams in Idaho reduces wild rainbow trout abundance, survival, growth, or recruitment in those streams. Catchables were stocked at a density of 3.8 fish/100 m^2 into treatment reaches on 11 study streams, which were paired with control study reaches where no stocking occurred. Total densities of age 2 or older wild rainbow trout at study reaches stocked with catchables appeared to be unaffected by stocking at 11 of 12 treatments so far. Observed densities of wild rainbow trout in treatment reaches were higher than densities observed the previous year after being corrected by the 2005 to 2006 change in densities at control sites. Treatment reach densities of wild rainbow trout averaged 3.2 fish/100 m^2 greater than 2005 densities. Age-length keys created from assigning age estimates to 3,384 wild rainbow trout suggested age composition was similar among all study sites, averaging 50% age 1, 36% age 2, 12% age 3, and 2% age 4 or older. Growth rates did not differ significantly between treatment and control reaches regardless of management regulations. Total annual mortality rates from catch curve analyses were high, averaging 68% overall, and were variable both within and among study streams. Pretreatment 2005 recruitment, as indicated by abundance of age 1 wild rainbow trout, was also variable among and within streams, ranging from 0.2 to 14.9 trout/100 m^2. With this being the first treatment year of a multiyear project, effects of catchables on wild rainbow trout populations cannot fully be addressed.

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INTRODUCTION

Hatchery trout play an important role in Idaho's stream fisheries but potentially pose a threat to wild trout populations. Maintaining put-and-take fisheries in streams, ponds, lakes, and reservoirs that previously held no game fish is a widely accepted use of hatchery-reared fish (Utter 1994; Epifanio and Nickum 1997). However, supplementing wild trout stream fisheries with hatchery trout raises concern over potential adverse genetic and ecological effects (Krueger and May 1991; Allendorf 1991). Idaho Department of Fish and Game (IDFG) has proactively dealt with potential adverse genetic effects of introduced trout on existing populations by stocking sterile rainbow trout *Oncorhynchus mykiss*, but concerns about adverse competitive interactions in streams and rivers supporting wild trout still remain.

Competition, by definition, causes a reduction in fitness of an organism due to the limited supply of a resource held in common with other organisms, or the limited ability to exploit a resource because of interference by other organisms (Birch 1957). Reduced fitness levels in wild trout populations could translate to decreased survival, growth, and fecundity rates (Moyle and Cech 1982). Most competition studies have indirectly assessed changes in fitness levels, or found evidence of competition by inferring causal relationships between fitness and characteristics such as ability to maintain favorable positions (Griffith 1972; Fausch and White 1986; Peery and Bjornn 1996), win agonistic bouts (Griffith 1972; Mesa 1991; McMichael et al. 1999), gain weight (Dewald and Wilzbach 1992; Harvey and Nakamoto 1996), or survive (Kocik and Taylor 1994). While these studies at the individual scale are much easier to replicate with different manipulations of fish compositions and densities for interspecific competition versus intraspecific competition comparisons, they do not directly address concerns at the population level (Fausch 1998), a scale at which competition investigations are rarely performed (Schoener 1983). More specifically, relatively few experiments of competition between hatchery and wild trout have been conducted despite widespread concern (Weber and Fausch 2003). The two foremost studies conducted with catchables and wild trout have contradicting conclusions. Vincent (1987) concluded catchables decreased the abundance and biomass wild rainbow trout and brown trout *Salmo trutta* in the Madison River and O'Dell Creek, Montana while Petrosky and Bjornn (1988) concluded catchables had little effect on wild cutthroat trout *O. clarkii* in the St. Joe River and wild rainbow trout in Big Springs Creek.

Currently, IDFG stocks more than 500,000 catchable sterile rainbow trout, hereafter called catchables, into streams annually (IDFG unpublished data). In 2005, a total of 2,200,000 catchables were stocked in 123 waters. Most (64%) of these waters were lentic systems, including 60 reservoirs, 67 lakes, and 79 ponds. Most stream stocking locations received catchables multiple times, usually during spring and summer; the median stocking frequency was three events/year/stream. Stocking sites for catchables were not evenly distributed across Idaho's seven regions. The number of stocking sites in Idaho streams ranged from three in Region 1 to 33 in Region 3, with most sites (88%) in regions 3, 4, 5, and 6.

Stocking catchables allows for more angling opportunities for the public without changing seasons or regulations. However, stocking catchables may potentially have adverse effects on wild trout populations through direct or interference competition. The objectives of this study are to assess population-scale competition effects of stocked catchables on wild rainbow trout populations by quantifying changes in wild trout populations' abundance, survival, growth, and recruitment over several years after catchables are stocked in a way similar to IDFG stream stocking practices. In 2005, I calculated stocking densities for two streams representative of most streams in the present study (High 2006). Stocking densities for Silver Creek of the Middle

Fork Payette River drainage was the highest and was used as the target density of catchables for treatment sites in the present study.

OBJECTIVES

1. Determine whether stocking catchables reduces abundance, growth, survival, or recruitment in wild fish populations by 20%.

STUDY AREA

The study area for this investigation is southern Idaho (Figure 1). Eleven study streams spread across the study area are grouped by regulation type. General regulation streams have a fishing season from the Saturday of Memorial Day weekend through November 30 with a six trout limit. Streams with wild trout regulations have the same fishing season but the bag limit is two trout. The final group is the “catch-and-release” group. Again, the fishing season is the same, but bag limits are different. While these streams are not explicitly managed with catch-and-release regulations, they function as such, with slow growth and minimum length limits of 356 mm (14 in) on two of the streams with trophy regulations (2 fish over 356 mm) and very limited public access and fishing pressure on the remaining stream which is technically managed under general regulations except for catch-and-release mandated for cutthroat trout landed.

METHODS

Suitable study streams were selected during 2005, and baseline abundance data were collected (High 2006). Selection criteria were that the stream was not already stocked anywhere nearby (i.e. within 5 km), that 3 km could be established between two study reaches on each stream, rainbow trout dominated salmonid compositions, and harvest was regulated by general, wild trout, or catch-and-release regulations. One study site from each pair on each study stream was randomly assigned as a treatment reach, except at Badger Creek, where logistical constraints of planting catchables required that the upper site on Badger Creek serve as the treatment. The Middle Fork Boise River had two pairs of study sites, and thus two sites were selected as treatment sites.

Catchables ranging in size from 150 to over 300 mm were stocked into treatment reaches to a density of 3.8 fish/100 m^2. Streams were stocked three times during the growing season at monthly intervals. Stocking density was based on rates currently used for Silver Creek, a tributary of the Middle Fork Payette River. Silver Creek is stocked at high rates relative to other streams with a total of over 7,000 catchables/year. Treatment reaches were stocked in the middle as well as upstream and downstream of the reach boundaries with the same density of catchables. Most stocking sites were accessible directly by netting from the hatchery truck or trailer. Some, including the Little Weiser River and Little Lost River required a 300 m in-stream transport downstream from an accessible point to the middle of the treatment reach. Badger Creek was not accessible by truck but was stocked using ATVs and horses.

Trout populations were sampled using backpack and canoe-mounted electrofishing gear for conducting mark-recapture population estimates. All captured salmonids were identified to species, measured to the nearest mm (TL), and weighed to the nearest 0.1 g using a top-loading digital scale. Scale samples were collected from all rainbow trout, or a minimum of 10 individuals from each 10 mm size group. Population estimates and 95% confidence intervals, corrected for size-selectivity, were calculated using modified Peterson mark/recapture models in the Fisheries Analysis Plus (FA+) program (Fisheries Analysis + 2004).

Densities of wild rainbow trout based on abundance estimates were compared between treatment and control sections on each stream after I corrected for annual variability in population abundance by adding the difference from 2006 to 2005 densities at the control reach to the 2006 treatment reach density. Comparisons among streams were performed using 95% confidence intervals around the density estimates. This methodology assumes that within stream rates of recruitment, mortality, emigration, and immigration are consistent for each of the control and treatment reach pairs between years.

Growth of wild rainbow trout, measured in terms of total length, was compared between treatment and control reaches in two ways. First, one-way ANOVA and pairwise comparisons based on 95% confidence intervals were used to compare sizes of cohorts between treatment and control sites. Second, growth was expressed as instantaneous growth rates for each cohort and compared against those rates in corresponding control reaches.

Scales were used to estimate ages of wild rainbow trout and to create an age-length key at each study site. The proportions of different-aged fish within the age-length key were applied to the size interval estimates obtained from FA+ to generate estimates of separate age classes at each study site (Van Den Avyle 1993). Age class abundance estimates were used to draw catch curves for each of the study sites. Ages were estimated by mounting scales between microscope slides and photographing them with a digital camera on a compound microscope at 30 – 40X magnification. Two individuals independently assigned ages to each scale without knowledge of fish length (Devries and Frie 1996). When discrepancies occurred, both individuals assigned an age again. If consensus for an age estimate could not be reached, the sample was not included in the analysis. Age designations for rainbow trout from each of the 24 sites were used to create separate age-length keys. Once catch curves were constructed, the slopes of the best-fit linear line through the natural log of abundance estimates for each age class were used to estimate mortality rates (Ricker 1975). I converted the instantaneous rates to total annual mortality rates. This methodology assumes constant recruitment, equal survival among age groups, and consistent survival from year to year. Density of age 1 rainbow trout was used as to estimate 2005 pre-treatment recruitment.

To control for any affect that angler harvest of wild or catchable trout may have had on competition, modified roving creel surveys were conducted on general regulation and wild trout regulation study streams. Exploitation levels were grouped into three general categories — low, medium, or high. The goal was to survey each stream monthly, once during the week and once during the weekend or holiday, from June through September. Survey dates and time of survey (morning or afternoon) were not randomly selected. Survey reaches encompassed treatment and control sites and were typically less than 10 km. Creel clerks were asked to quickly count anglers within the survey reach initially, and follow up the count with interviews. During interviews, creel clerks asked how many individuals were in the fishing party, how many hours were spent fishing, why the area was selected, and how many fish had been caught. Any harvested fish were inspected to determine origin (hatchery versus wild) and were measured (TL).

RESULTS

Catchables were stocked into treatment reaches of each of the study streams at monthly intervals from June through August (Table 1). Initial stocking events in June were postponed two weeks due to high stream flows from above normal snowpack levels. Differences in effects of competition among the groups of study streams managed by three regulation types were not apparent, so results from all study streams were lumped together.

Average densities of all wild rainbow trout ranged from 0.4 to 29.3 trout/100 m^2 in the South Fork Boise River and Fourth Fork Rock Creek, respectively (Table 2). Capture efficiencies averaged 36%. Age structures within the different populations were somewhat similar, with an average of 50% age 1, 36% age 2, 12% age 3, and 2% age 4 and older (Table 3). The East Fork Weiser River's estimate of wild rainbow trout was the only stream where the corrected density was significantly lower in the treatment reach compared with the control (Figure 2). Densities of catchables in the East Fork Weiser River were more than five times higher than the target stocking rate at the time of sampling at 22.0 catchables/100 m^2.

Growth of wild rainbow trout varied by stream and by location on the stream, with age classes from upper sites having average total lengths typically less than trout from the lower sites (Table 4). All comparisons of age-specific sizes yielded statistically significant results ($p<0.05$) allowing for pairwise comparisons at the $\alpha = 0.05$ level. As expected, when significant differences between lengths of wild rainbow trout cohorts between treatment and control reaches within streams existed, trout from lower study reaches were significantly larger than cohorts from upper reaches. Age 0 and age 2 trout from Medicine Lodge Creek as well as age 1 trout from the upper Middle Fork Boise River were the only exceptions. Comparisons of instantaneous growth rates also indicated that growth rates were similar between treatment and control reaches or slightly faster at the lower reaches (Table 5).

Annual rates of mortality were variable among study streams. Total annual mortality rates for wild rainbow trout varied around an average of 68%, ranging from 43% to 91% at the lower site on Badger Creek and the upper site on Fourth Fork Rock Creek, respectively (Table 4). Catch curves used to estimate mortality were generally similar within study streams (Figure 3). A catch curve with a descending limb could not be constructed for the lower site on Squaw Creek, thus an annual mortality rate could not be estimated.

Relative 2005 recruitment was not only variable among streams, but also within streams. Recruitment of wild rainbow trout appeared to be highest at the lower site on the East Fork Weiser River, with an estimated age 1 trout density of 14.9 fish/100 m^2, and lowest at the upper site of Medicine Lodge Creek and the lower site of Squaw Creek where abundance was only 0.2 fish/100 m^2.

Fishing pressure at all study streams appears to be low. Anglers were observed fishing Fourth Fork Rock Creek, Medicine Lodge Creek, and the Little Lost River during creel surveys, but were most frequently observed at Fourth Fork Rock Creek. No harvest was reported at Medicine Lodge Creek or the Little Lost River. At Fourth Fork Rock Creek, four interviews were conducted during eight surveys, and 64 fish were reportedly caught (84% were released). No anglers were observed during seven surveys on Willow Creek, in four surveys on Clear Creek, or in three surveys on East Fork Weiser River, Little Weiser River, and Squaw Creek. Therefore, all general regulation and wild trout regulation study streams were assigned to the low category of exploitation except Fourth Fork Rock Creek, which was categorized as medium.

DISCUSSION

Preliminary results of this long-term study are more similar to those reported by Petrosky and Bjornn (1988) than Vincent (1987). All of the study streams had total abundance estimates of wild rainbow trout in treatment reaches at or above control levels except at the East Fork Weiser River, where densities of catchables were significantly higher than densities at other streams (Figure 4). Therefore, it appears that competition from catchables is not yet evident in rainbow trout populations, except at a density level higher than what IDFG stocks. This assertion is similar to the findings of Petrosky and Bjornn (1988), who concluded that abundance of cutthroat trout in the St. Joe River, Idaho declined when stocking rates exceeded 3.4 fish/m (500 catchables in 146 m section) but not when catchables were stocked at 0.3 to 2.0 fish/m. The high densities of residual catchables in the East Fork Weiser River were likely caused by low catchable mortality rates, the cause of which cannot be readily explained. I expected fewer catchables in the East Fork Weiser River because the treatment reach had the highest map gradient of all 24 sites, with associated high flow velocities and thus higher metabolic demands. While age 2 and older wild brown trout densities in O'Dell Creek, Montana reportedly decreased 36% in one year and up to 49% in three years after annual catchable stocking was initiated (Vincent 1987), I have not yet observed a similar effect in my study streams. However, this is only the first of at least three years of stocking, so results are obviously preliminary.

Growth rates did not appear to be affected by stocking catchables for one year. Available data is limited to assess differences in growth, but based on comparisons of growth between treatment and control reaches, overlapping 95% confidence intervals resulted in few significant differences (Table 4). In Big Springs Creek, Idaho, a tributary to the Lemhi River, Petrosky and Bjornn (1988) concluded that growth of wild rainbow trot was not affected when similarly sized catchables were used to double the trout abundance in their study reaches. Conversely, Vincent (1987) concluded that catchables significantly decreased the abundance of age 2 and older brown trout. Big Springs Creek was considered a productive system (Petrosky and Bjornn 1988) whereas the majority of the streams used in the present study were not. There were three cases where pairwise comparisons indicated significant differences between cohort sizes between sites, two at Medicine Lodge Creek and one on the Middle Fork Boise River. In all of these cases, competition from catchables does not seem to explain the statistical significance. Medicine Lodge Creek had the highest growth rates observed in 2006, as well as a population oddly comprised of many larger and older individuals (Table 3), and only age 0 and age 2 cohorts had significant size differences. At the Middle Fork Boise River, only one age cohort had significant size differences. Instantaneous growth rates of trout cohorts also did not show a consistent pattern suggesting effects of competition.

Impacts of stocking catchables on wild trout population survival rates could not be assessed at this phase of the study. The best option available for determining survival rates was using catch curves (Ricker 1975). It is unlikely that the limited exposure wild trout populations had to catchables (3 months or less) was sufficient to cause annual mortality rates to shift to the point where a statistically significant change could be detected. However, annual mortality rates estimated for 2006 will be useful for comparison in coming years. Catch curve analysis assumes survival rate is uniform with age, the population is randomly sampled, and recruitment is constant each year. Because of these demanding assumptions, annual mortality estimates based on catch curves have inherent variability (Allen 1997). As the study progresses, I will be able to utilize cohort analyses and multiple mark and recapture robust designs such as Pollock's robust design (Cormack 1964; Jolly 1965; Seber 1965) in combination with catch curve analyses to better estimate and confirm mortality rates.

Recruitment rates during 2005 were highly variable among study streams and sites. Similar to mortality rates, effects of stocking catchables on wild trout population recruitment rates cannot be fully addressed until later during this multiyear study. Reduced levels of recruitment would be a secondary effect of competitive interactions due to reduced fitness levels (Dewald and Wilzbach 1992; Harvey and Nakamoto 1996), suggesting they may be hard to detect if present. Vincent (1987) and Petrosky and Bjornn (1988) concluded that catchables had no effect on yearling trout, the age used in the present study as a surrogate measure of recruitment. Pollock's robust design, which allows for recruitment estimation within the model, may help alleviate the limited precision of using age 1 trout as a surrogate for recruitment, and will provide for an interesting comparison.

Previous population-level competition studies have not incorporated angler exploitation into their study designs. It seems logical that the practice of stocking catchables into a stream would draw anglers. Increased angler effort, therefore, could affect study outcomes by increasing total annual mortality rates, changing the size structure of the population, and reducing the numbers of spawning females. Observed rates of exploitation on study streams managed under general or wild trout regulations was low, perhaps because stocking activities were not publicized, and study streams do not typically receive catchables. The only exception was Fourth Fork Rock Creek, which is a stocked stream downstream of the study area. Age compositions among the three different groups of streams managed under different regulations was surprisingly similar, suggesting that exploitation has not occurred such that the age structure of wild trout populations have been truncated. Field observations confirmed the fact that fishing pressure on study streams is so sporadic that sampling intensities for quantitative surveys would have to be too high to be logistically possible (Heggenes 1987).

In summary, preliminary findings do not indicate measurable impacts of catchables on wild trout populations, except at East Fork Weiser River where catchable densities were almost six times the intended stocking density of 3.8 catchable/100 m^2. However, with impacts potentially taking multiple years to occur, it is too early to conclude that catchables do not adversely impact wild rainbow trout populations' abundance, growth, survival or recruitment. So far, results support the findings of Petrosky and Bjornn (1988), who concluded that catchables had limited effect on wild trout populations because of their choices for stream position and limited persistence times. This project will continue again in 2007, which will enable further investigation into effects of catchables on wild trout populations. This will be particularly beneficial for not only comparing differences in abundance and growth, but for recruitment and survival rates as well.

RECOMMENDATIONS

1. Continue study in 2007 by stocking treatment reaches with catchables at density of 3.8 fish/100 m^2 at 3 monthly intervals during the growing season.

2. Continue monitoring abundance, growth, mortality, and recruitment of wild rainbow trout populations at each site.

3. Apply Pollock's robust design to data with individually marked fish to provide a second estimate of abundance and survival for comparison purposes.

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Table 1. Study reach locations, abiotic descriptions, treatment stocking rates and source of catchables.

Stream	Site	elevation (m)	Conductivity (μS/cm)	Zone	Easting	Northing	Gradient (%)	Order	Ownership	Drainage area (km^2)	Annual rainfall (cm)	Geology	Catchables/plant	Source hatchery
General regulation streams														
Fourth Fork Rock Creek	Lower	1577	50	11	726775	4681619	4.8	3rd	Sawtooth National Forest	25	46	Basalt	51	Hagarman
	Upper	1800	50	11	725117	4678773	3.5	2nd	Sawtooth National Forest	14	46	Basalt	-	-
East Fork Weiser River	Lower	1260	70	11	550180	4961897	3.3	2nd	Payette National Forest	70	91	Basalt	-	-
	Upper	1481	60	11	553858	4962111	5.9	2nd	Payette National Forest	50	91	Basalt	39	Nampa
Little Weiser River	Lower	1163	80	11	555728	4927393	1.8	3rd	Payette National Forest	116	82	Basalt	70	Nampa
	Upper	1306	60	11	560119	4929915	2.2	3rd	Payette National Forest	85	82	Basalt	-	-
Wild trout regulation streams														
Squaw Creek	Lower	1149	30	11	555742	4913591	1.4	3rd	Boise National Forest	96	78	Basalt	-	-
	Upper	1254	30	11	556947	4920060	1.8	3rd	Boise National Forest	66	78	Basalt	88	Nampa
Clear Creek	Lower	1267	50	11	612447	4884548	3.1	3rd	Boise National Forest	136	84	Granite	124	Nampa
	Upper	1562	40	11	615483	4892526	2.5	3rd	Boise National Forest	93	84	Granite	-	-
Little Lost River	Lower	2036	70	12	313446	4909346	6.2	4th	Salmon-Challis National Forest	192	60	Sedimentary	57	Mackay
	Upper	2104	50	12	310744	4914244	6.0	4th	Salmon-Challis National Forest	116	60	Sedimentary	-	-
Willow Creek	Lower	1717	160	11	691836	4817640	2.5	3rd	Sawtooth National Forest	51	67	Basalt/Granite	23	Nampa
	Upper	1790	190	11	690451	4819520	2.9	3rd	Sawtooth National Forest	31	67	Basalt/Granite	-	-
Medicine Lodge Creek	Lower	1737	360	12	380935	4904871	1.6	4th	Bureau of Land Management	409	47	Sedimentary	44	Mackay
	Upper	1806	310	12	376226	4907857	1.7	4th	Bureau of Land Management	394	47	Sedimentary	-	-
Catch-and-release regulation streams														
South Fork Bosie River	Lower	1343	90	11	660998	4827702	1.6	5th	Boise National Forest	917	90	Granite	-	-
	Upper	1604	100	11	664707	4828430	1.7	5th	Boise National Forest	899	90	Granite	227	Hagarman
Middle Fork Boise River	Site 1	1094	50	11	613554	4843073	0.5	5th	Boise National Forest	984	90	Granite	303	Nampa
	Site 2	1171	60	11	618340	4848149	0.5	5th	Boise National Forest	905	90	Granite	-	-
Middle Fork Boise River	Site 3	1269	50	11	626494	4849524	0.4	5th	Boise National Forest	757	90	Granite	270	Nampa
	Site 4	1305	60	11	631618	4852102	1.0	5th	Boise National Forest	647	90	Granite	-	-
Badger Creek	Lower	1646	200	12	477674	4862215	4.4	3rd	Private	150	68	Sedimentary/volcanics	-	-
	Upper	1698	200	12	480530	4863772	0.9	3rd	Private	145	68	Sedimentary/volcanics	181	Ashton

Table 2. Summary of wild rainbow trout abundance in relation to study site area and abundance of other salmonids species present (RBT = rainbow trout, BKT = brook trout, BLT = bull trout, BRN = brown trout, and MWF = mountain whitefish) in 2006.

			Average				Rainbow trout	Salmonid percent composition				
Stream	**Site**	**Length (m)**	**width (m)**	**Area (m^2)**	**Total RBT (95% CI)**	**% Efficiency**	**density (fish/100m^2)**	**RBT**	**BKT**	**BLT**	**BRN**	**MWF**
General regulation streams												
Fourth Fork Rock Creek[a]	Lower	835	3.2	2,672	763 (639-887)	25.4	29.3	0.96	0	0	0.04	0
	Upper	460	2.9	1,334	291 (226-356)	28.5	21.8	0.68	0.32	0	0	0
East Fork Weiser River[b]	Lower	506	5.6	2,834	592 (532-652)	46.7	20.9	1	0	0	0	0
	Upper	515	6.3	3,245	439 (320-557)	32.2	13.5	1	0	0	0	0
Little Weiser River[b]	Lower	640	12.3	7,872	655 (568-742)	45.5	8.3	0.99	0	0	0	0.01
	Upper	586	10.9	6,387	654 (571-737)	56.1	10.2	0.99	0	0.002[d]	0	0.01
Wild trout regulation streams												
Squaw Creek[b]	Lower	1,063	10.3	10,949	189 (118-260)	25	1.7	0.86	0	0	0	0.14
	Upper	845	12.2	10,309	1,113 (1,068-1,158)	20.4	10.8	0.98	0	0	0	0.02
Clear Creek[b]	Lower	536	11.1	5,950	965 (696-1,234)	27.7	16.2	0.99	0	0.01	0	0
	Upper	500	11.4	5,700	682 (558-806)	37.6	12.0	0.99	0	0.01	0	0
Little Lost River[b]	Lower	705	6.2	4,371	816 (763-869)	39.0	18.7	0.95	0.01	0.04	0	0
	Upper	483	6.0	2,898	722 (617-827)	45.4	24.9	0.88	0.11	0.01[d]	0	0
Willow Creek[b]	Lower	500	4.0	2,000	347 (239-455)	33.6	17.4	1	0	0	0	0
	Upper	532	4.1	2,181	170 (110-230)	45.2	7.8	1	0	0	0	0
Medicine Lodge Creek[b]	Lower	634	5.2	3,297	357 (297-417)	65.9	10.8	1	0	0	0	0
	Upper	597	6.3	3,761	108 (81-135)	74.1	2.9	1	0	0	0	0
Catch-and-release regulation streams												
South Fork Bosie River[a]	Lower	1,015	23.8	24,157	455 (364-546)	29.7	1.9	0.54	0	0.06	0	0.4
	Upper	1,479	26.1	38,602	328 (231-425)	24.7	0.8	0.4	0	0.01	0	0.59
Middle Fork Boise River[a]	Site 1	780	28.0	21,840	90 (39-141)	20	0.4	0.37	0	0	0	0.63
	Site 2	974	33.4	32,532	349 (165-533)	10.8	1.1	0.82	0	0	0	0.18
	Site 3	1,021	27.2	27,771	573 (441-705)	32.2	2.1	0.78	0	0	0	0.22
	Site 4	838	24.3	20,363	230 (152-308)	20.6	1.1	0.57	0	0.01	0	0.42
Badger Creek[b,c]	Lower	232	14.0	3,248	465 (391-539)	46.1	14.3	0.89	0.002	0	0	0.11
	Upper	464	16.5	7,656	856 (644-1,068)	29.7	11.2	1	0	0	0	0

[a]Estimate is for wild rainbow trout ≥100 mm
[b]Estimate is for wild rainbow trout ≥75 mm
[c]Estimate includes Yellowstone cutthroat trout and rainbow x cutthroat hybrids
[d]Estimates includes brook x bull trout hybrids

Table 3. Scale-based estimates of wild rainbow trout abundance by age class at each study site in 2006.

Stream	Site	Age 1	Age 2	Age 3	Age 4	Age 5
General regulation streams						
Fourth Fork Rock Creek	Lower	221	397	139	10	0
	Upper	46	180	63	2	0
East Fork Weiser River	Lower	420	103	65	5	0
	Upper	216	148	69	5	0
Little Weiser River	Lower	348	220	17	2	0
	Upper	352	242	44	4	0
Wild trout regulation streams						
Squaw Creek	Lower	23	66	75	0	0
	Upper	550	485	59	2	0
Clear Creek	Lower	723	160	72	9	0
	Upper	254	188	61	22	0
Little Lost River	Lower	69	428	246	65	4
	Upper	335	227	32	14	0
Willow Creek	Lower	216	123	8	0	0
	Upper	79	86	5	0	0
Medicine Lodge Creek	Lower	149	77	90	38	3
	Upper	7	41	33	2	0
Catch-and-release regulation streams						
South Fork Boise River	Lower	163	244	42	6	0
	Upper	113	116	91	6	0
Middle Fork Boise River	1	37	35	14	2	0
	2	180	139	30	0	0
	3	343	181	16	2	0
	4	128	63	30	9	0
Badger Creek	Lower	201	109	66	12	0
	Upper	634	183	38	0	0

Table 4. Estimates of annual growth (mm) and mortality (proportion) of wild rainbow trout at all study sites in 2006. Annual changes in average age class total lengths are indicated with 95% confidence intervals in parentheses.

			Average annual growth (mm)				Annual
Stream	**Site**	**Type**	**Age 1**	**Age 2**	**Age 3**	**Age 4**	**mortality**
		General regulation streams					
Fourth Fork Rock Creek	Lower	Treatment	99 (49.6)	53 (51.0)	48 (45.2)	52 (76.2)	0.84
	Upper	Control	91(47.4)	49 (51.2)	36 (37.0)	NA	0.91
East Fork Weiser River	Lower	Control	103 (31.6)	48 (27.2)	42 (36.2)	64 (113.2)	0.61
	Upper	Treatment	86 (40.0)	55 (41.2)	35 (28.2)	24 (21.2)	0.44
Little Weiser River	Lower	Treatment	124 (42.8)	58 (50.4)	64 (65.2)	21 (77.8)	0.78
	Upper	Control	122 (32.6)	53 (44.2)	30 (21.0)	38 (56.4)	0.65
		Wild trout regulation stream					
Squaw Creek	Lower	Control	107 (31.0)	76 (61.4)	59 (128.0)	NA	NA
	Upper	Treatment	95 (39.8)	53 (49.0)	50 (49.6)	NA	0.67
Clear Creek	Lower	Treatment	112 (37.8)	47 (35.4)	37 (33.8)	14 (27.0)	0.75
	Upper	Control	117 (37.6)	41(46.4)	43 (40.0)	24 (44.4)	0.51
Little Lost River	Lower	Treatment	108 (34.8)	71 (54.2)	55 (58.6)	44 (79.2)	0.61
	Upper	Control	109 (35.6)	60 (52.8)	75 (60.0)	16 (59.0)	0.68
Willow Creek	Lower	Treatment	89 (31.2)	61 (43.0)	59 (57.6)	NA	0.81
	Upper	Control	80 (31.0)	48 (30.4)	59 (33.0)	NA	0.74
Medicine Lodge Creek	Lower	Treatment	192 (49.2)	58 (63.4)	42 (67.8)	NA	0.65
	Upper	Control	193 (34.8)	81 (91.0)	44 (77.6)	NA	0.77
		Catch-and-release regulation streams					
South Fork Boise River	Lower	Control	151 (42.2)	68 (62.2)	56 (64.2)	50 (55.6)	0.85
	Upper	Treatment	128 (34.4)	75 (58.8)	59 (65.6)	NA	0.60
Middle Fork Boise River	1	Treatment	140 (38.0)	56 (62.6)	65 (62.6)	NA	0.60
	2	Control	142 (36.4)	55 (80.6)	53 (35.8)	NA	0.59
	3	Treatment	128 (33.0)	55 (54.8)	64 (47.8)	60 (14.2)	0.78
	4	Control	142 (36.6)	53 (67.4)	37 (86.2)	65 (60.8)	0.58
Badger Creek	Lower	Control	159 (54.4)	66 (41.4)	35 (51.2)	NA	0.43
	Upper	Treatment	169 (70.4)	52 (73.6)	44 (86.8)	NA	0.75

Table 5. Instantaneous growth rates for wild rainbow trout cohorts. Growth rates in bold are rates for treatment reaches which are slower than corresponding control reaches.

Stream	Site	Reach type	Instantaneous growth rates Age 1	Age 2	Age 3
General regulation streams					
Fourth Fork Rock Creek	Lower	treatment	0.43	0.27	0.23
Fourth Fork Rock Creek	Upper	control	0.43	0.23	-
East Fork Weiser River	Lower	control	0.38	0.25	-
East Fork Weiser River	Upper	treatment	0.49	**0.22**	**0.13**
Little Weiser River	Lower	treatment	0.38	0.30	**0.08**
Little Weiser River	Upper	control	0.36	0.16	0.17
Wild trout regulation streams					
Squaw Creek	Lower	control	0.54	0.28	-
Squaw Creek	Upper	treatment	**0.44**	0.29	-
Clear Creek	Lower	treatment	0.35	**0.21**	**0.07**
Clear Creek	Upper	control	0.30	0.24	0.11
Little Lost River	Lower	treatment	0.51	**0.27**	0.17
Little Lost River	Upper	control	0.44	0.37	0.06
Willow Creek	Lower	treatment	0.52	**0.33**	-
Willow Creek	Upper	control	0.47	0.38	-
Medicine Lodge Creek	Lower	treatment	**0.26**	0.16	-
Medicine Lodge Creek	Upper	control	0.35	0.15	-
Catch-and-release regulation streams					
South Fork Boise River	Lower	control	0.37	0.23	0.17
South Fork Boise River	Upper	treatment	0.46	0.26	-
Middle Fork Boise River	1	treatment	0.34	0.29	-
Middle Fork Boise River	2	control	0.33	0.24	-
Middle Fork Boise River	3	treatment	0.36	0.30	**0.22**
Middle Fork Boise River	4	control	0.32	0.17	0.25
Badger Creek	Lower	control	0.35	0.14	-
Badger Creek	Upper	treatment	**0.27**	0.18	-

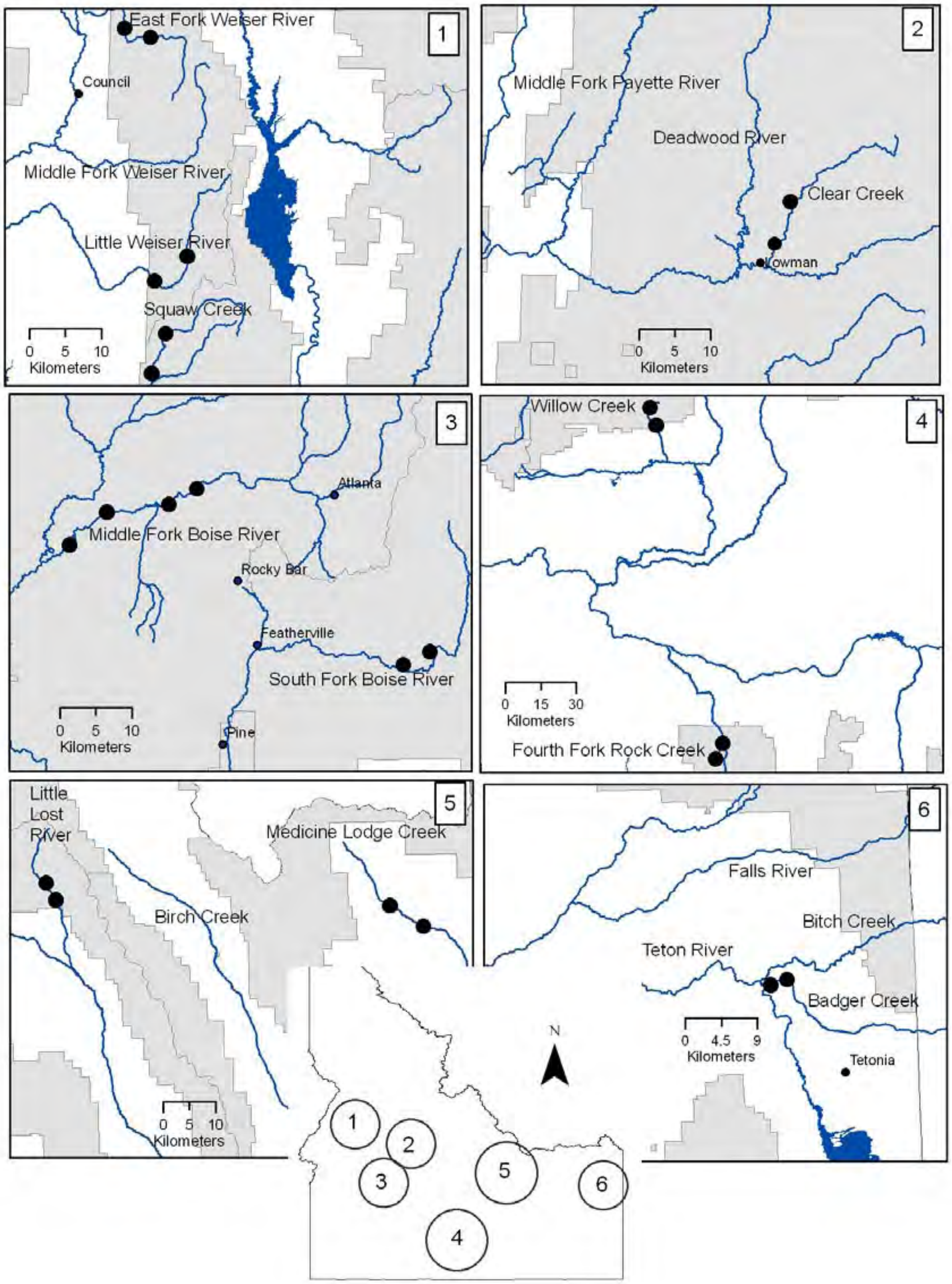

Figure 1. Study streams sampled during 2006 with study areas marked with closed circles.

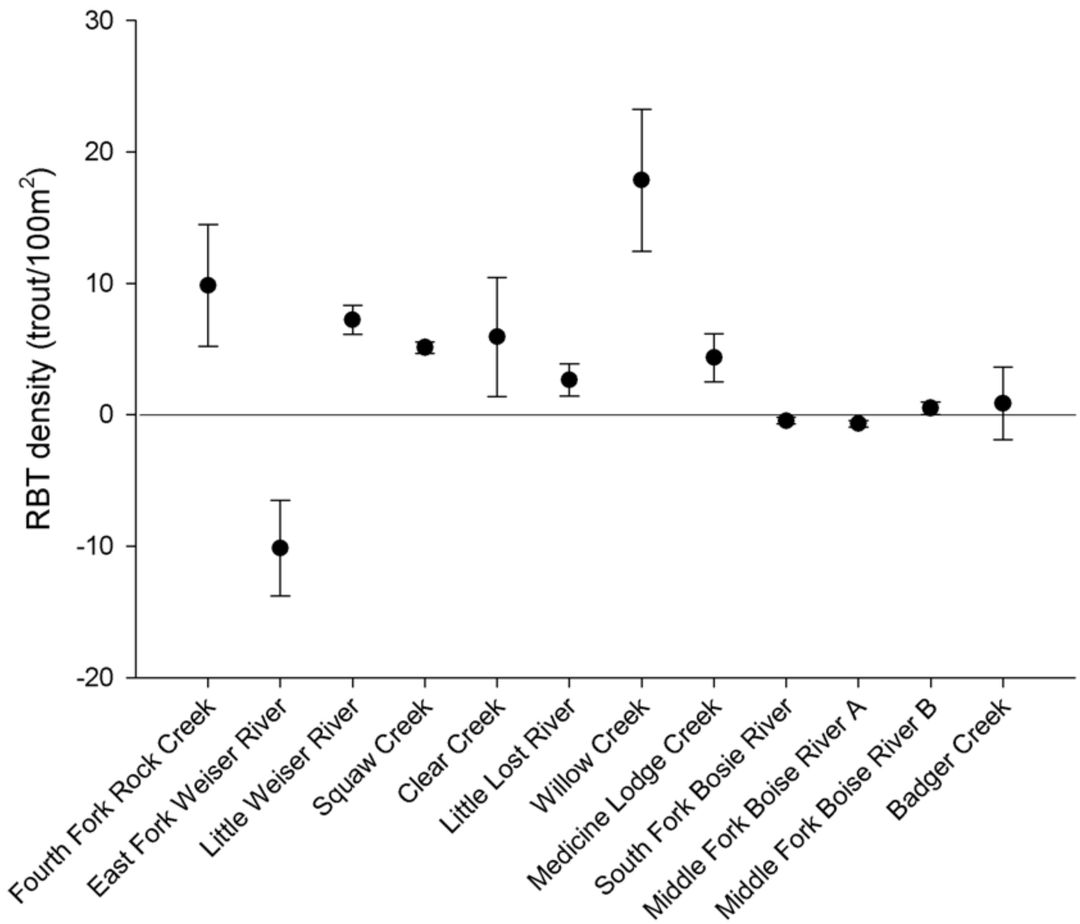

Figure 2. Expected densities of wild rainbow trout in treatment reaches of study streams where hatchery catchables were stocked. Expected densities were calculated by adding the difference of 2005 from 2006 control site densities added to the 2006 density estimate of the treatment site. (RBT = rainbow trout)

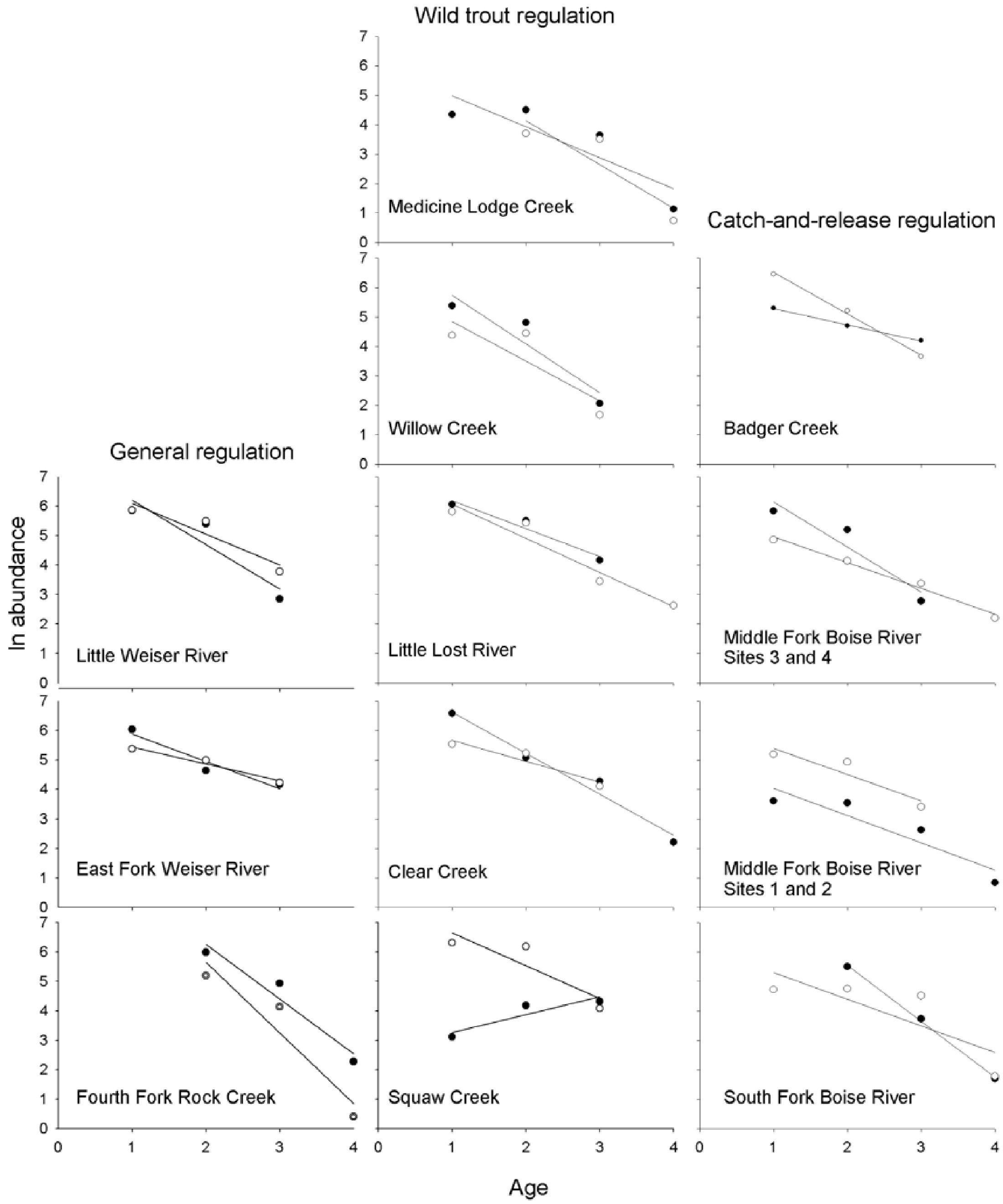

Figure 3. Catch curves for all 24 study sites in 2006. Closed circles represent data from lower sites, and open circles are for data from upper sites.

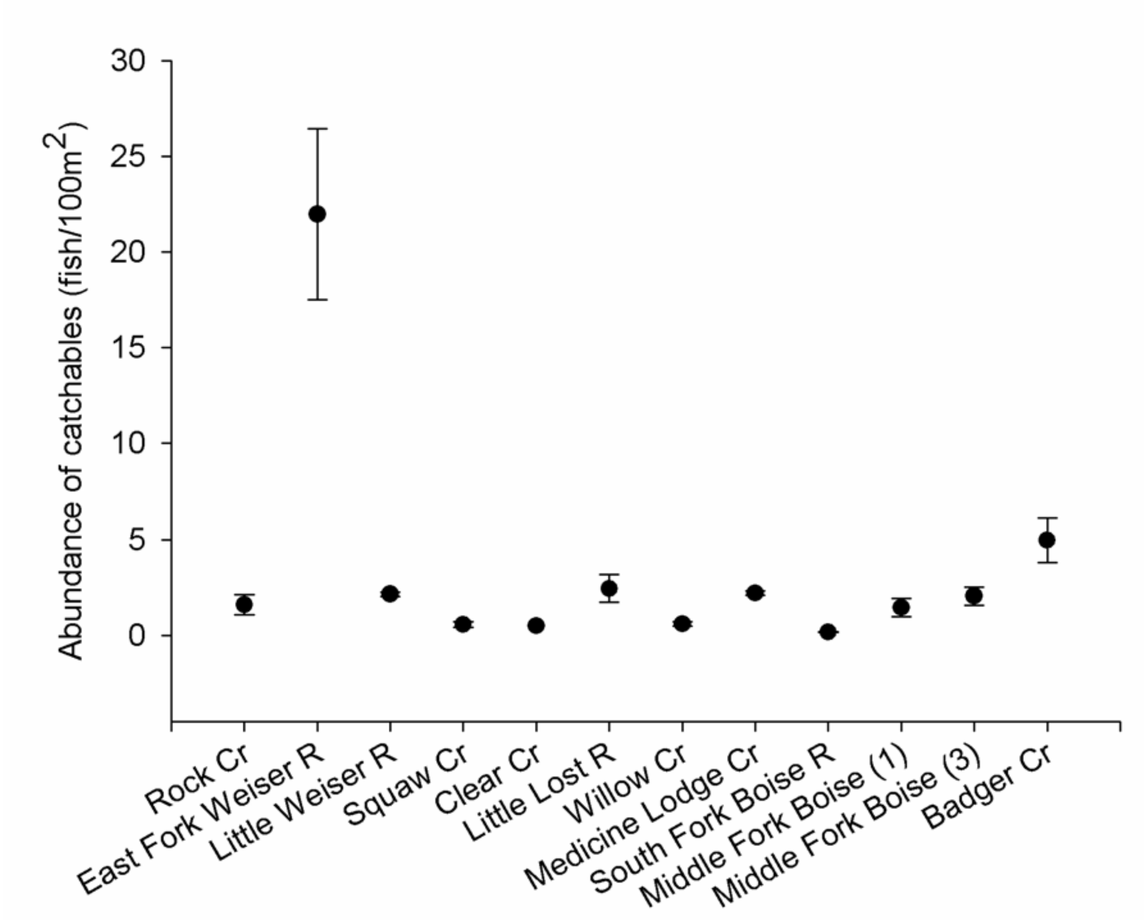

Figure 4. Estimated densities of sterile hatchery rainbow trout of catchable size for study streams in 2006 at the time of electrofishing with 95% confidence intervals.

ANNUAL PERFORMANCE REPORT
SUBPROJECT #2: FATE AND DISPERSAL OF STERILE HATCHERY RAINBOW TROUT AFTER STOCKING IN A RIVERINE ENVIRONMENT

State of: Idaho

Grant No.: F-73-R-27, Fishery Research

Project No.: 2

Title: Wild Trout Competition Studies

Subproject #2: Fate and Dispersal of Sterile Hatchery Rainbow Trout After Stocking in a Riverine Environment

Contract Period: July 1, 2006 to June 30, 2007

ABSTRACT

While over 0.5 million sterile hatchery rainbow trout *Oncorhynchus mykiss* of catchable size (catchables) are annually released into streams in Idaho to improve angler catch and harvest rates, returns from this investment are often much less than 50%, and the fate of unharvested catchables is unknown. Survival and dispersal of catchables was investigated using snorkel and telemetry techniques to quantify the life span and dispersal distances of catchable rainbow trout stocked into streams. Counts of catchables released with Floy®-tags (n = 900) and motion-sensitive radio tags (n = 54) steadily declined throughout the observation period. Dispersal of Floy®-tagged catchables was generally limited to the 1 km upstream and downstream of the stocking point. Median values for maximum known downstream and upstream dispersal distances for radio-tagged catchables ranged from 2.8 to 1.2 km from the stocking point, respectively. Telemetry efforts continued through November 1, 2006, at which time four catchables were still alive as indicated by the motion-sensitive radio tags. Radio signals had been lost from an additional three catchables. All of the remaining 47 catchables had signals changed to mortality (no movement) transmissions, of which 39 tags were recovered. Mortality rates of radio-tagged catchables were higher than expected with an average lifespan of 14.3 d. Radio-tagged catchables stocked into the special regulation section of the Middle Fork Boise River persisted from 1 to 90 d.

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INTRODUCTION

Mortality and dispersal of planted hatchery trout can greatly influence return to creel rates. Several studies have quantified dispersal distances and return rates of hatchery trout harvested by anglers (Trembley 1945; Mauser 1994; Dillon et al. 2000), but little empirical data exists concerning the fate of hatchery trout not harvested. While over 0.5 million hatchery rainbow trout *Oncorhynchus mykiss* of catchable size (hereafter called catchables) are annually released into Idaho streams by the Idaho Department of Fish and Game (IDFG) to improve catch and harvest rates, harvested returns from this investment are usually less than 50%. For example, Heimer et al. (1985) used check stations and creel surveys to estimate a return to creel rate of 40% for catchables released into the Portneuf River in southeastern Idaho. This was slightly higher than the average (34%) of 11 rainbow trout studies summarized by Cresswell (1981), including one of the original return to creel studies for rainbow trout performed by Cobb (1933), who observed a rate of 33%. In 1997, Dillon et al. (2000) estimated return to creel rates for triploid and diploid catchables to be 17%, but did not adjust for nonresponse bias. Such low return to creel rates begs the question: What happens to hatchery catchable trout stocked in streams?

Annual mortality rates of catchables in streams is high. Heimer et al. (1985) reported low (<1%) annual survival rates for catchables in the Portneuf River. Dillon et al. (2000) reported annual survival rates for triploid and diploid catchables as 2-3% in 18 of Idaho's streams. Miller (1952) reported <2% annual survival for cutthroat trout *O. clarkii* stocked in a stream in Alberta, Canada. Cooper (1953) observed annual survival rates <10% for catchable rainbow and brown trout *Salmo trutta* in Michigan. Bettinger and Bettoli (2002) reported low annual survival (2-6%) of catchable rainbow with 50% of the mortality occurring within the first three weeks in Tennessee. In an assessment of stocking practices in Wyoming, Wiley et al. (1993) concluded that few catchable rainbow and cutthroat trout survived to a second fishing season.

Wide dispersal is one logical explanation for low return to creel rates in flowing systems and may explain some of the unaccounted for individuals, as virtually every study has limited scope of coverage. However, most studies indicate that wide roving catchable rainbow trout are the exception to the rule. For example, Heimer et al. (1985) received returned tags from two catchable rainbow trout that were caught by anglers at least 158 river km away from the release point, but most (66%) of the recaptured catchables were caught within a few hundred meters of the stocking point. Cooper (1953) reported that the vast majority (88%) of his stocked rainbow trout exhibited little movement from the stocking point, while 10% moved greater than 1.2 km downstream and 2% moved upstream the same distance. While available literature indicates the majority of catchables do not move far from the stocking point, these studies were performed using diploid fish, and none have been conducted with triploid catchables in streams.

The purpose of this study is to provide fishery managers with information concerning the dispersal distances and fate of stocked sterile catchables in lotic systems so they can make informed decisions when deciding when and where to plant hatchery catchables, the most expensive products of our hatchery system.

OBJECTIVE

1. Quantify dispersal distances and survival of triploid catchables in the Middle Fork Boise River.

STUDY AREA

The Middle Fork Boise River is a sterile 6th order stream covering 984 km^2. Average rainfall in the area is 89.7 cm (Unites States Geological Survey 2004). Conductivities range from 50–60 µS/cm. Average widths and depths of four 1.0 km sample sites ranged from 23 to 35 m and 0.4 to 0.5 m, respectively. Granite dominates the geology of the drainage, consistent with other soils within the Idaho batholith. Elevation ranges from almost 2,600 m at the headwaters to 1,051 m at the mouth of the North Fork Boise River. Gradients measured on 1:24,000 scale topographic maps range from 1–2%. Available water temperatures for the Middle Fork Boise River during the summer of 2006 indicate favorable conditions for rainbow trout, with average monthly maximums less than 16°C, excluding the month of August when data were not available.

The focal point of the current study was the stocking point, which was located approximately 2.1 km upstream of Roaring River at a long run below a swift riffle. Five radio-telemetry stations were installed around the stocking point spanning approximately 38 river km from the confluence of Hot Creek at the upper site downstream to the confluence of the North Fork Boise River at the lower site (Figure 5). Besides these sites, fixed stations were installed near Granite Creek Hot Springs, Roaring River, and Repeat Creek (Figure 5).

METHODS

Eyed triploid rainbow trout eggs from Troutlodge, Inc. were hatched and reared to catchable size (average total length of 281 mm) at IDFG's Nampa Hatchery. Catchables were tagged with either 5 cm Floy® tags or 11 x 41 mm motion-sensitive radio tags (7.7 g weight in air). Three different groups of catchables were tagged: one in June, July, and August. Catchables were netted from a raceway and anaesthetized to minimize handling and tagging stress. Floy® tags were placed just below the dorsal fin on the left side to allow the T-bar to anchor against the opposite side of the dorsal fin bones. Floy® tags were angled back towards the posterior of the fish to reduce resistance. Floy® tags were color-coded according to the month of release: June–yellow, August–green, and September-orange. Catchables were placed in an enclosure submersed in an adjacent, empty raceway after tagging for a 24 hr observation period prior to being loaded into a stocking truck. The holding cage was inspected for shed tags before and after loading tagged fish.

Catchables selected for marking with radio tags were selected based on size in an effort to keep the tag less than 4% of the body weight of the fish (Zale et al. 2005). We anaesthetized selected catchables for four to five minutes before surgically placing the transmitter intraperitoneally using the shielded needle technique (Ross and Kleiner 1982). The gills were continuously ventilated with water mixed with anesthetic using a submersible pump throughout the tagging procedure. Antennas were trimmed to 24 cm to limit antenna trailing distance. Three non-absorbable sutures were used to seal the incision. The sutured incision and the location of the antenna wound were treated with iodine prior to placing the catchable into a recovery bucket. The catchable was placed in the submersed cage in an adjacent raceway with the other radio- and Floy®-tagged fish after regaining its equilibrium. Radio-tag code number, total lengths, weights, anesthetic time, tagging time, and comments were recorded during the radio tagging process. Motion-sensitive transmitters used in this study were coded radio tags (Lotek Wireless).

These 7.7 g tags were the lightest motion-sensitive coded tags available. Tag frequency was 148.380 MHz, and radio tags were programmed with a 24 hr inactivity threshold and a sensitivity level of five. The transmitter added a value of 100 to its unique code once the 24 hr threshold of inactivity had been exceeded. Battery expectancy was 137 d with a 5 s burst rate.

Short-term (24 hr) tag retention and survival for radio tagged-fish was 100%. However, during the August release, one catchable could not maintain equilibrium at the time of release and was removed from the study. No shed radio tags were observed within the holding pen. However, during electrofishing surveys in September a catchable that had expelled a radio transmitter through its body wall was observed within 200 m downstream of the release site.

Mortality of radio-tagged catchables with motion-sensitive tags was monitored with frequent (2 to 3 times weekly) mobile telemetry surveys and fixed receiver stations. Motion-sensitive transmitters were useful for obtaining conservative survival times. Survival was measured in days post stocking. When long downstream movements relative to previous documented activity preceded an inactive code, the date of location of the active code before the downstream movement was determined to be the time and location of death, because fish could have potentially floated downstream after dying, causing an active code transmittal until the carcass or tag lodged itself in the substrate.

The dispersal and relative abundance of Floy®-tagged catchables around the stocking site was monitored by weekly tandem snorkel surveys following the July stocking event and continuing through September. The relative abundances of Floy®-tagged catchables from each stocking event were used as pseudo-control data, which were compared to radio-tagged catchable survival data. Mortality rates of Floy® and radio-tagged catchables were compared using proportions of live fish observed versus time since stocking. Residuals were analyzed to determine how best to transform datasets for simple linear regression. Slope estimates from linear regression models for Floy® and radio-tagged catchables were compared using the method for comparing slope coefficients from two populations explained by Zar (1999).

RESULTS

A total of 275 catchables were Floy®-tagged for each of the three stocking events occurring on June 29, July 20, and August 23, 2006. Short-term (24 hr) tag retention for Floy® tags was high. No shed Floy® tags were observed within the holding pen. However, during the July stocking event, a few (<5) shed Floy® tags were observed while netting fish from the stocking truck.

Snorkel surveys for Floy®-tagged catchables began July 21 and continued through September. Counts steadily declined throughout the observation period. However, the rate of decline was faster for catchables released in August than those released in June or July. By three weeks post-stocking, only 21% of the stocked fish were counted by snorkelers.

Dispersal of Floy®-tagged catchables was generally limited to 1 km upstream and downstream of the stocking point (Figure 6). More than 50% of the counts were made in this 2 km stretch of river for 14 of the 23 release group-specific observation periods. Visual inspection of boxplots suggest upstream dispersal was more apparent for individuals planted early in the summer (18% moved upstream in the June group, compared to 13% and 5% for July and August), little movement was apparent for those planted in midsummer (78% moved less than 1 km for the July group compared with 58% and 73% for the June and August groups), and downstream dispersal was the trend for those planted in late summer with 85% of the August group moving downstream compared with 66% and 75% for June and July (Figure 6).

All radio-tagged catchables were found during mobile tracking surveys. Mobile tracking efforts continued through November 1, 2006, at which time three catchables were still alive, as indicated by the motion-sensitive radio tags. For the remaining 51 catchables, 47 of the signals ended with a change to mortality (no movement) transmission. The fate of the remaining four catchables is unknown, as their last mobile tracking records indicated they were still active. Of the 47 catchables whose last records indicated inactivity, 39 radio tags were recovered while eight were inaccessible. The final locations of these 47 radio tags were as follows: 21 found in the river with no fish, nine found in the river in a dead catchable, nine on the bank (often among large boulders), four in the river at inaccessible places, and four above the river on the hillsides.

Dispersal of radio-tagged catchables corroborated Floy®-tagged catchable data. Median values for maximum known downstream and upstream dispersal distances ranged from -2.8 to 1.2 km from the stocking point (Table 6). Dispersal of radio-tagged catchables in both directions was greater in June than in July or August (Figure 7), but overall median values of dispersal were similar (Table 6). The last point of contact for most (96%) radio-tagged catchables was downstream of the stocking point (Table 6).

Survival of radio-tagged catchables was lower than expected. Median days of survival was 11.5 d for catchables released in June, 6.0 d for July, and 12.0 d for August, excluding data from catchables for which radio contact was lost ($n = 3$; Figure 8). Rates of loss of radio-tagged catchables were barely statistically significantly higher than that of Floy®-tagged catchables tagged and released at the same times and place ($t = 2.012$, $P = 0.047$, d.f. = 47; Figure 9).

DISCUSSION

Observations of Floy® and radio-tagged catchables within 3 km of the stocking point during this study occurred 95% of the time. Similar results were reported for catchables in the upper Salmon River during the early 1960s, where more than 90% of the reported recaptures were within 3.2 km of the release site (Bjornn and Mallet 1964). While the majority of catchables appear to remain within a few km of the stocking point, some individuals may move downstream large distances: 15.6 km maximum observed in this study, 27.4 km for catchables stocked in the upper Salmon River (Bjornn and Mallet 1964), and 158 km for catchables planted in the Portneuf River (Heimer et al. 1985). Reported movements of catchables outside of Idaho are slightly less than what I observed. In a Pennsylvania stream, movements of catchable rainbow trout were downstream ranging from 0.2 to 1.3 km (Trembley 1945). Similarly, movements of catchable rainbow trout were minimal in a Virginia stream, with 75% of reported catches within 1 km of stocking locations, and a median of 60 m of downstream movement (Helfrich and Kendall 1982). In a more recent telemetry study, radio-tagged rainbow trout catchables in a Tennessee tailrace fishery moved quickly downstream after stocking, but only up to 1.5 km, with median distances of 208 and 536 m for fish stocked in July and September, respectively (Bettinger and Bettoli 2002).

Thirty days after stocking during this study, 46% of the Floy®-tagged fish were not counted, and 74% of the radio-tagged fish changed to inactive codes. While the discrepancy seems obvious, statistical comparison of the rates of loss indicated the difference was not large.

The comparison of slopes yielded marginally significant statistical results. However, this may not translate to biological significance. Higher mortality rates of radio-tagged catchables than Floy®-tagged catchables may have resulted from handling stress associated with tagging. The invasive nature of surgical implantation of tags may have caused some differences in mortality since the difference between Floy®-tagged and radio-tagged catchables was uniform throughout the study. Two catchables died within 2 hr of the procedure and were replaced during the August tagging event, and another catchable died at the time of release. Regardless of the cause of this potentially differential mortality, abundance of both groups steadily decreased, indicating high mortality rates and persistence times of less than three months.

I could not quantify mortality precisely. Mortality of radio-tagged catchables was verified for nine (19%) of the 47 presumed mortalities. However, I observed one catchable that survived despite expelling its radio tag through the body wall, leaving the original incision sutures intact. Radio tag expulsion has been documented to occur at rates exceeding 50% (Chisholm and Hubert 1985). However, Chisholm and Hubert (1985) concluded that trout in their study passed internal antenna through the intestinal tract. Transmitters with an external antenna, such as those used in the current study, would be extremely difficult to pass through the intestine, and I do not believe tag expulsion occurred frequently. Nevertheless, I could not determine the fate of 21 (45%) catchables whose radio tag I found in the river without a dead fish associated with the tag. I found 13 radio tags out of the river without a catchable carcass. It seems logical that catchables whose radio tags were found on the bank or hillsides were mortalities, leaving 25 (53%) tags for which I could not determine their fate. The most likely explanation would be mortality and decomposition to the point that fish flesh was gone at the time of tag recovery. The low frequency of tag retrieval trips and the relatively quick rate of observed decomposition make catchable mortality more likely than tag expulsion. Complete decomposition of rainbow trout flesh apparently requires 4 to 10 months (Parmenter and Lamarra 1991; Minshall et al. 1991). However, partial decomposition would be sufficient to allow radio transmitters to be separated from fish carcasses.

Survival of Floy®- and radio-tagged catchables was typical of those reported in similar studies. Average survival of radio-tagged catchables in the present study was just over 14 d, while persistence of Floy®-tagged catchables was less than three months. Teuscher et al. (2003) observed 40-90% higher overall survival of triploid catchables over diploid catchables in two reservoirs. Thus, the effect of triploidy on survival of catchables in streams was of particular interest. However, triploid catchables used during this study survived at rates similar to published studies using diploid catchables. Stream catchables do not appear to contribute to angler catch rates in multiple years. In a Pennsylvania study, catchables failed to contribute past one year (Trembley 1945). Overwinter survival rates for catchable cutthroat trout stocked into an Alberta stream was <3%, while wild cutthroat trout experienced 46% survival (Miller 1952). In a tailrace fishery downstream of Hoover Dam, no marked catchables were observed four weeks post release, despite more than 5,600 catchables being marked (Walters et al. 1997). In a Tennessee tailrace fishery, radio-tagged catchables had median persistence times of only 7 to 20 d (Bettinger and Bettoli 2002).

I lost contact with four radio-tagged catchables before their transmitters changed to an inactive code. Contact may have been lost via transmitter malfunction, avian predation, or illegal harvest. Tag malfunction or avian predation (by birds carrying prey long distances away from the road) was not verified. However, illegal harvest was. All Floy® tags used during this study had reporting information printed on them, and thus some reports were received. Signs were not installed at the study site, because attracting anglers was intentionally avoided. Thus, all reports were voluntary. Ten fish were reported as caught, with one reported as harvested. All catchables were smaller than the 356 mm (14”) minimum regulation for this section of stream, and it is unlikely that fish grew the deficit in the short time frame available.

Dispersal of stocked catchables was primarily in the downstream direction in both the present study and previous studies (Helfrich and Kendall 1982; Heimer et al. 1985). However, dispersal direction did appear to vary over the study period, with relatively wider dispersal in early summer in both directions, little dispersal in midsummer, and slightly wider dispersal in early fall that was limited to the downstream direction. Such movement patterns are not surprising given the typical life history strategy of stream-dwelling rainbow trout. Wild rainbow trout in a 6^{th} order stream would be expected to undertake some sort of upstream migration in spring for spawning, followed by limited movement during summer growth periods, followed by downstream movement in the fall in search of overwinter habitat. Although the sterile catchables used in this study displayed roughly the same movement patterns, their movements were limited to short distances, with median dispersal distances of only about 2 km.

Electrofishing in the study reaches may have affected dispersal and survival rates based on snorkel surveys. Catchables released in August were stocked 10 d before electrofishing surveys were initiated within the same reach for routine monitoring of the river population. Relatively few Floy®-tagged catchables released in August were counted during snorkel surveys after the electrofishing surveys. Counts of Floy®-tagged catchables released in August during snorkel surveys were lower than a simple linear regression trend line for the dataset during the two weeks that electrofishing surveys were conducted. Furthermore, during electrofishing surveys, fewer catchables were counted during the recapture run than the marking run. Roughly half of the total number of catchables counted during the electrofishing survey marking run were counted during the recapture run, though numbers of wild trout counts increased.

RECOMMENDATIONS

1. Directly assess radio-tag surgery effects on catchable survival in a natural stream environment.

2. Stocking practices should limit stocking events to no more than 3 weeks prior to anticipated need in the fishery.

3. Catchables should be stocked within 1 km of areas frequented by anglers to maximize catch rates.

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Table 6. Maximum downstream and upstream observed dispersal distances from the stocking point and final locations for radio-tagged catchables in the Middle Fork Boise River in 2006.

	Dispersal from stocking point (km)		
Radio Tag	Downstream	Upstream	Last
	June Release		
11A	-1.1	2.5	-1.1
18A	-4.6	11.2	-2.9
20A	-15.6	2.5	-15.6
21A	-12.4	-2.1	-12.4
22A	-2.1	2.5	2.5
23A	-16.5	-2.8	-16.5
24A	-0.4	0.0	-0.4
25A	-0.2	2.5	-0.2
26A	-2.3	-0.2	-2.3
27A	-6.7	-0.3	-6.7
28A	-3.4	-1.0	-3.4
29A	-9.7	-0.4	-9.7
30A	-0.6	2.6	-0.4
31A	-1.5	2.5	-1.5
Median	**-2.8**	**1.2**	**-2.6**
	July Release		
10A	-2.1	-2.1	-2.1
11B	-1.7	-0.9	-1.7
12A	0.0	0.5	0.5
13A	-3.2	-2.1	-3.2
14A	-2.0	-0.2	-2.0
15A	-3.2	-0.3	-3.2
16A	-0.9	-0.3	-0.9
17A	-1.0	-1.0	-1.0
19A	-0.7	-0.6	-0.7
21B	-5.1	-2.1	-5.1
23B	-3.6	-0.6	-3.6
24B	0.0	0.0	0.0
25B	-11.4	-1.5	-11.4
28B	-2.2	0.0	-2.2
29B	-1.2	-0.7	-1.2
30B	-1.5	-0.2	-1.5
31B	-4.6	-0.4	-4.6
Median	**-2.0**	**-0.6**	**-2.0**
	August Release		
11C	-3.2	-0.5	-3.2
13B	-0.4	0.1	-0.4
16B	-0.5	0.1	-0.5
17B	0.0	0.0	0.0
19B	-3.0	0.0	-3.0
21C	-0.5	0.6	0.0
23C	-0.6	-0.6	-0.6
25C	-2.0	-1.4	-2.0
26B	-3.4	-1.5	-3.4
27B	-1.9	-1.0	-1.9
28C	-2.8	0.1	-2.8
29C	-1.2	0.3	-1.2
30C	-2.7	-2.7	-2.7
31C	-1.0	-0.2	-1.0
32A	-2.2	-0.5	-2.2
33A	-1.3	-1.3	-1.3
34A	-2.2	-1.7	-2.2
35A	-1.4	-1.4	-1.4
36A	-0.5	-0.5	-0.5
37A	-10.4	-0.4	-10.4
38A	-10.4	-5.9	-10.4
39A	-2.3	0.1	-2.3
Median	**-1.9**	**-0.5**	**-1.9**

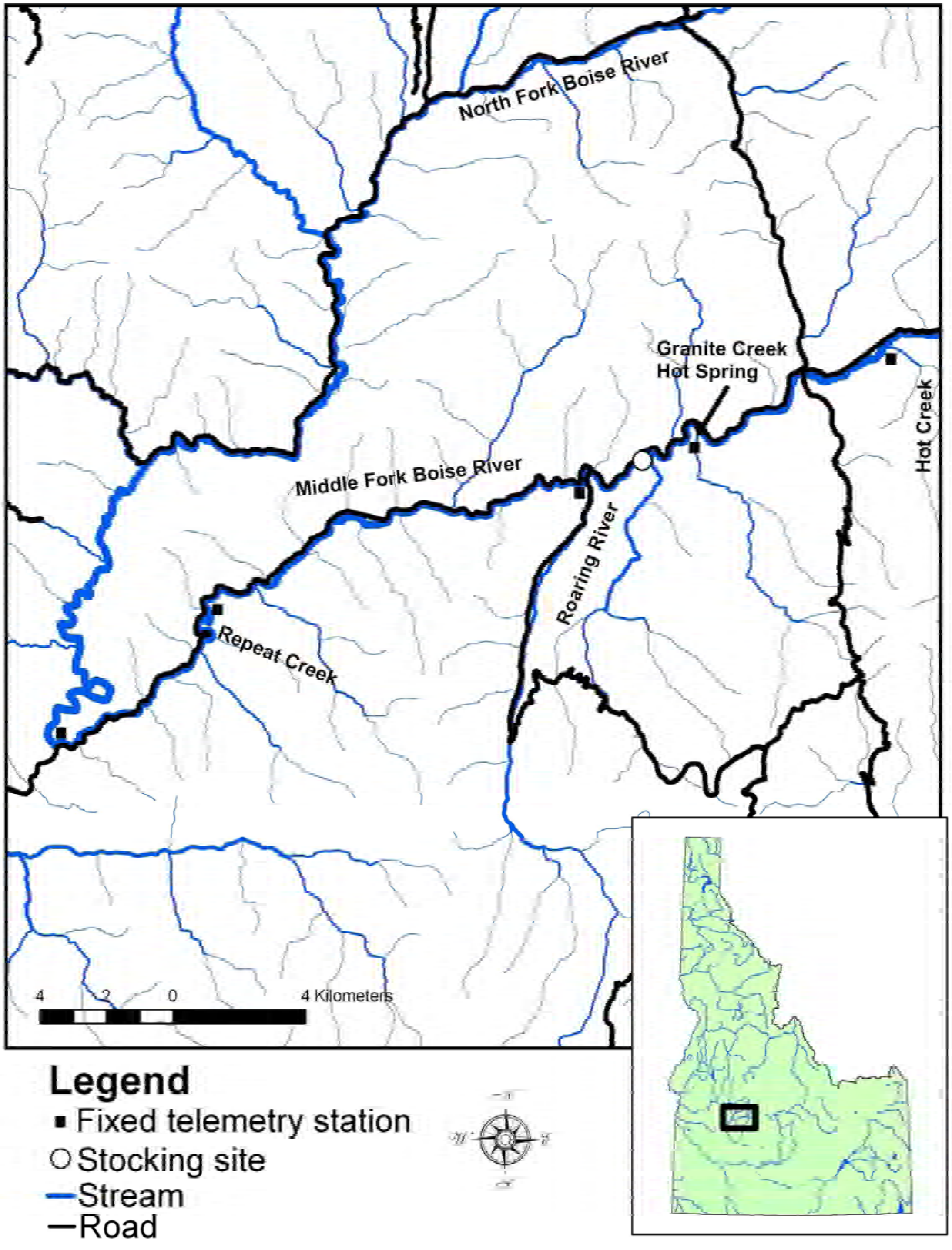

Figure 5. Map of Middle Fork Boise River study area including location of 2006 telemetry stations and the stocking site.

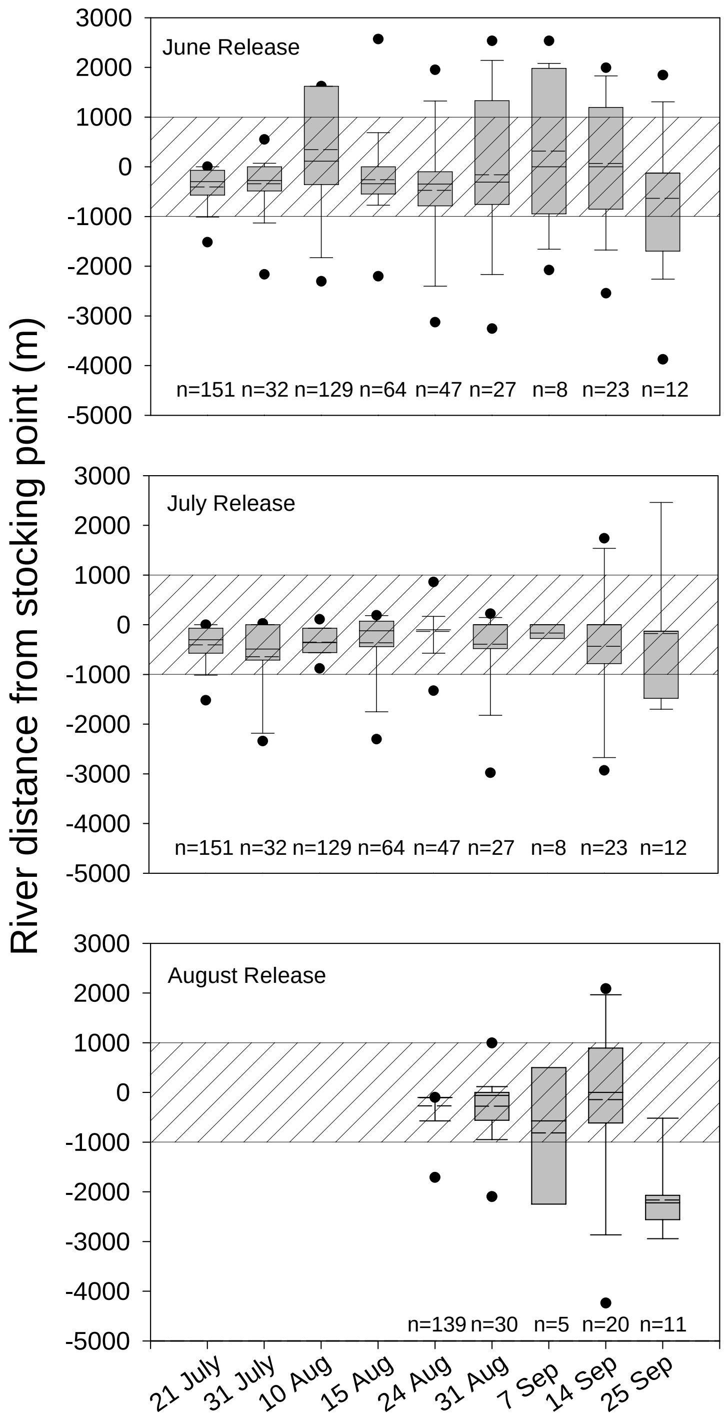

Figure 6. Boxplots depicting dispersal distances of three groups of Floy®-tagged catchables released at the same spot in June, July, and August 2006 in the Middle Fork Boise River. Boxes represent 50% of the counts during snorkel surveys, and the outliers (dots) shown are the 5th and 95th percentiles. Solid lines in the boxes are median values, and dashed lines are mean values. The hashed area of the figure is the 2 rkm surrounding the stocking site.

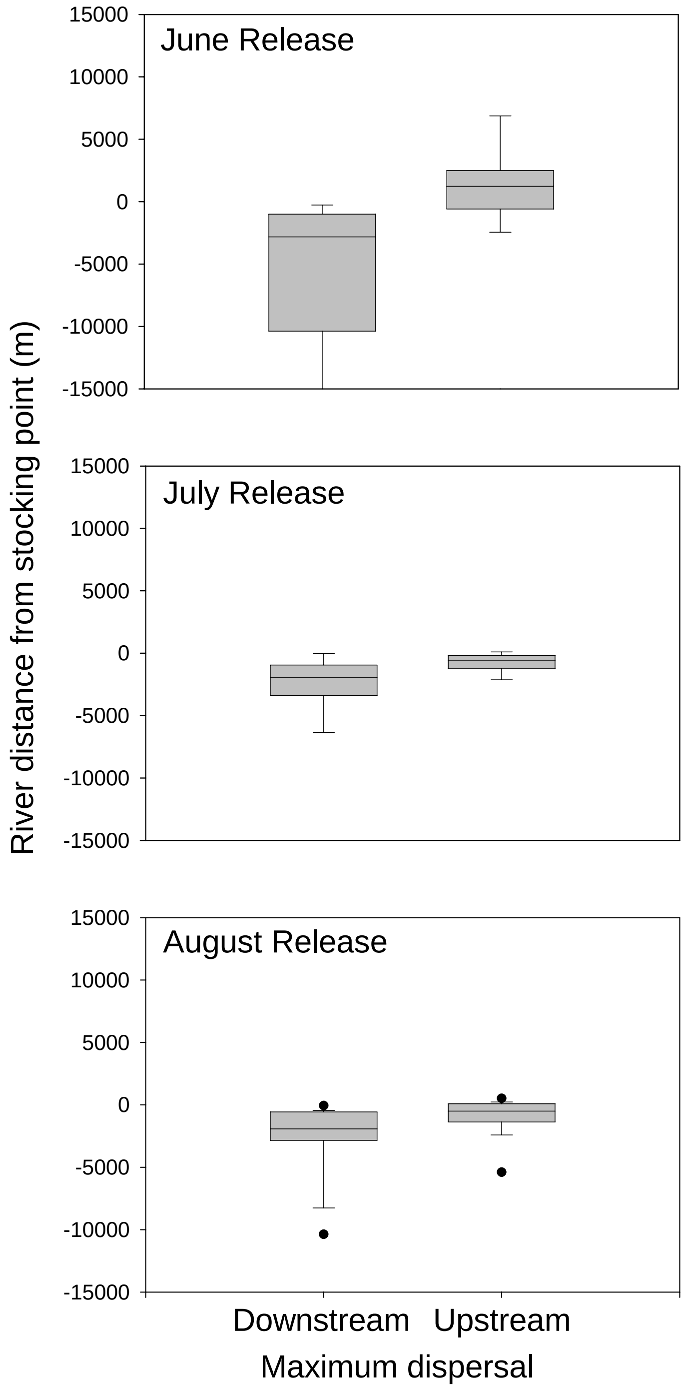

Figure 7. Boxplots depicting range of maximum upstream and downstream dispersal distances of three groups of radio-tagged catchables released at the same spot once during the months of June, July, and August in the Middle Fork Boise River in 2006. Boxes represent 50% of the counts during snorkel surveys, and the outliers shown are the 5th and 95th percentiles. Solid lines in the boxes are median values, and dashed lines are mean values.

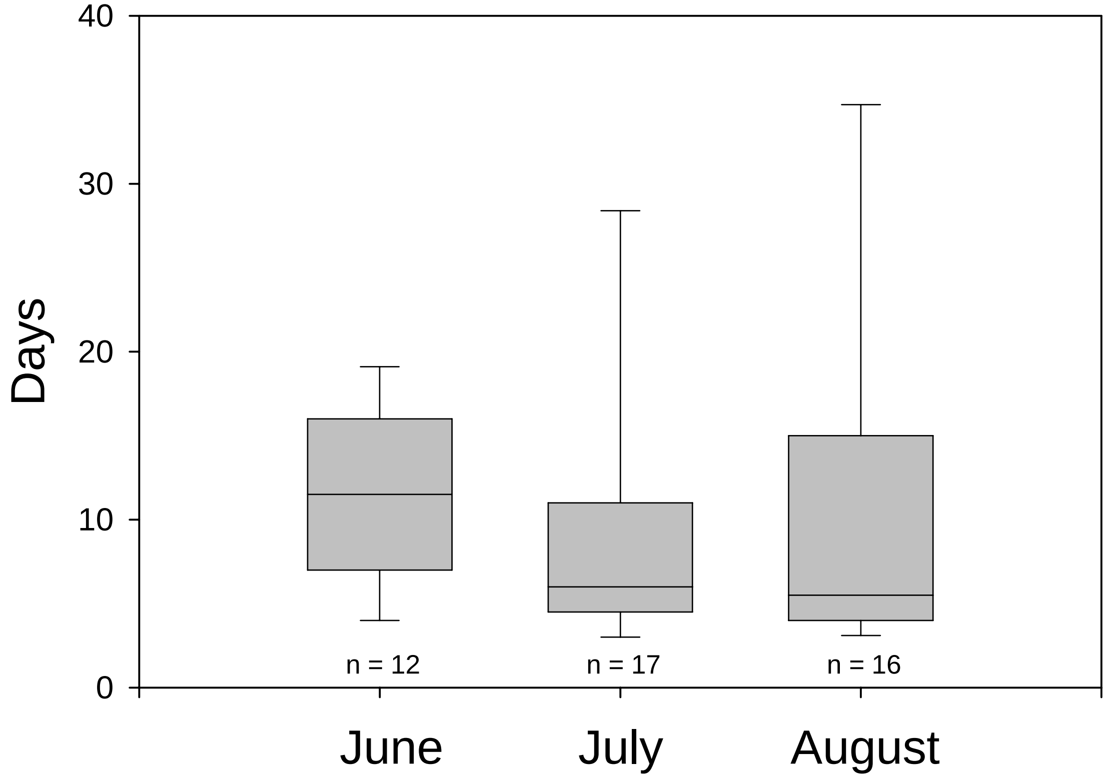

Figure 8. Boxplots showing variability in days of survival for radio-tagged catchables released into the Middle Fork Boise River in June, July, and August in 2006. Data included for catchables with complete telemetry records (includes stationary records) only.

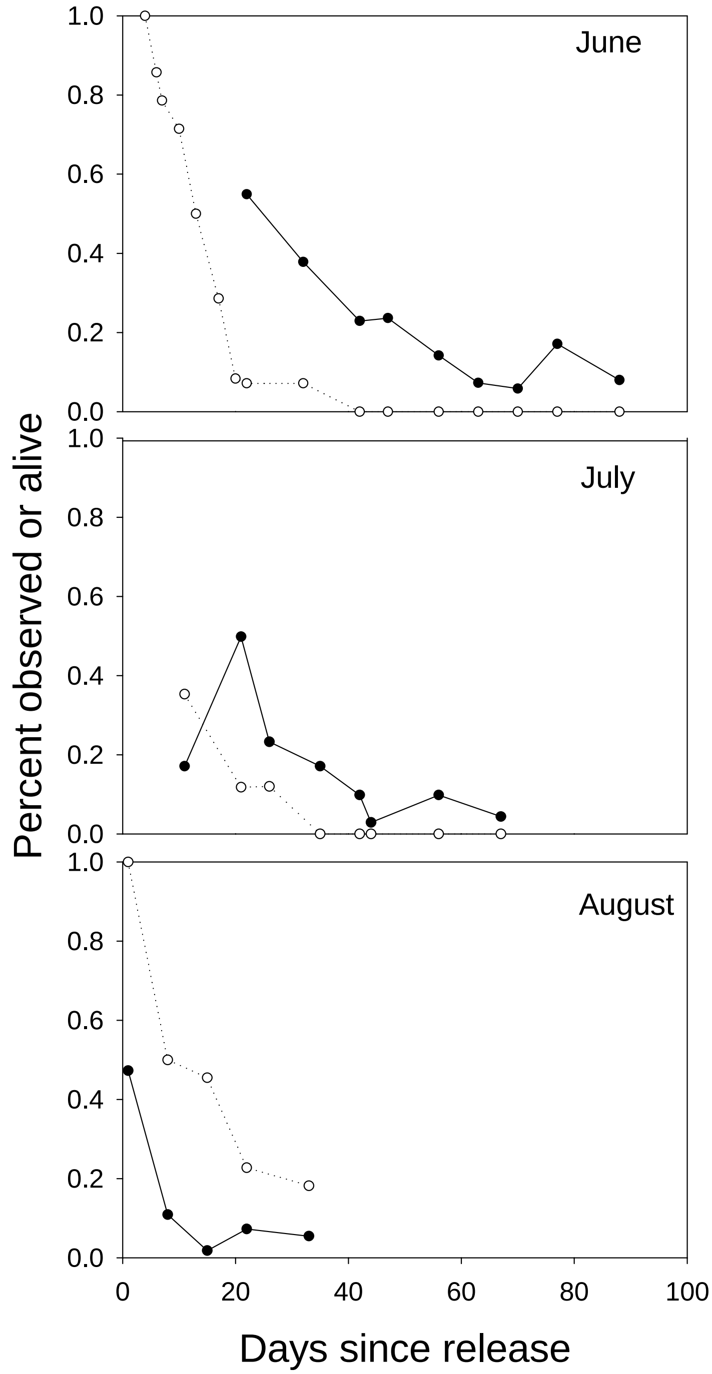

Figure 9. Comparison of Floy®-tagged catchable observation rates versus radio-tagged catchable survival relative to days after release in the Middle Fork Boise River in 2006. Solid circles represent Floy®-tagged catchables while open circles represent radio-tagged catchables.

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