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John Cassinelli
Senior Fisheries Research Biologist

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Project 4: Hatchery Trout Evaluations

Subproject #1: Improving Returns of Hatchery Catchable Rainbow Trout Including Four Year Evaluations of Statewide Exploitation Rates, Hatchery Size Grading, and Magnum versus Standard Catchable Releases

Subproject #2: Relative Performance of Triploid Kokanee Salmon in Idaho Lakes and Reservoirs

By

John Cassinelli

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

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ABSTRACT

Idaho Department of Fish and Game (IDFG) hatcheries are integral to managing coldwater sportfishing opportunities in Idaho. A comprehensive evaluation of hatchery catchable trout exploitation rates in Idaho's put-and-take fisheries was identified as a need and initiated in 2011. This project is intended to (1) evaluate catch and harvest rates of the most-stocked waters statewide, and (2) conduct research focusing on hatchery rearing techniques to increase return-to-creel of catchable Rainbow Trout *Oncorhynchus mykiss*. Since 2011, IDFG has released roughly 30,000 T-bar anchor tagged catchables annually to evaluate returns of stocked catchables to anglers. Research specific to hatchery rearing techniques currently includes studies of size grading, and magnum (305 to 320 mm, average) vs. standard (254 mm average) catchables. This report serves as an update for 2014 tagging, and this year provides a summary of factors influencing statewide exploitation for stocking years 2011–2014. Average harvest and total catch for catchable Rainbow Trout across all evaluated waters was 19.5% (± 2.8%) and 24.6% (± 3.5%), respectively, for all tags released in 2014 and reported within 365 days of release. Magnum catchables were released alongside standard catchables at 30 Idaho lakes and reservoirs. Magnums continued to show a nearly two-fold increase in return-to-creel over standard catchables. For standard catchables stocked from 2011–2014, first-year angler return rates across all four study years averaged 23% and ranged from 0% to 76% for individual stocking events; the variation in angler returns was best explained by fish length, rearing hatchery, and size and elevation of the water stocked. Average days-at-large for angled fish in individual waters varied from a low of 10 d to a high of 297 d, and this variation was best explained by water size, stocking season, and the rearing hatchery. We found the highest angler returns for larger catchables stocked into smaller waters at lower elevations. However, these smaller waters also had shorter catchable fisheries, requiring more frequent stocking to prolong the fisheries through the entire angling season. When considering these findings, managers must also consider the balance between angler catch, effort, and satisfaction as they work towards maximizing the benefit to anglers from put-and-take fisheries.

Author:

John Cassinelli
Senior Fisheries Research Biologist

INTRODUCTION

Idaho Department of Fish and Game (IDFG) hatcheries are integral to managing coldwater sportfishing opportunities in Idaho. IDFG's "resident" (non-anadromous) hatchery program consists of 10 hatcheries that raise up to 18 strains of salmonids for inland coldwater fisheries. In 2015, Idaho resident hatcheries stocked over 17 million fish, including about 1.5 million catchable-sized (200–350 mm total length; herein, catchables) Rainbow Trout *Oncorhynchus mykiss*. Producing catchables accounts for over 50% of the annual resident hatchery budget. Hagerman, Nampa, and American Falls fish hatcheries produce the majority of IDFG catchables. According to the default catchables stocking request list, Rainbow Trout are planted in approximately 290 waters throughout Idaho. Catchables have become an important component of many fisheries management programs in coldwater habitats because they provide instantaneous fisheries once they are stocked. This is especially important in altered habitats such as impounded reservoirs, which typically do not support wild trout populations, and often do not provide adequate conditions over a sufficient time period for put-and-grow fisheries to develop (Trushenski et al. 2010).

Current hatchery production capacity and funding are not increasing, while demand for hatchery catchable trout remains steady or is increasing. Considering the costs associated with stocking catchable trout, a comprehensive evaluation of angler catch of hatchery catchables in Idaho's predominant put-and-take fisheries was needed. Recent IDFG studies have been evaluating return-to-creel on a statewide basis using angler-caught tagged fish (Meyer et al. 2012, Cassinelli and Koenig 2013, Cassinelli 2014, Cassinelli 2015). These studies have evaluated return-to-creel of catchable trout across numerous waters throughout Idaho, reared under a variety of conditions. However, given the current economic climate for IDFG hatchery funding and the continued increase in fish feed costs, continued efforts to ensure that hatchery programs remain efficient while producing a quality product for Idaho anglers are of high priority and require continued research.

One of the key metrics defining a "quality" hatchery trout should be the contribution to angler return-to-creel (either catch or harvest). Numerous factors have been shown to influence post-stocking performance of catchables, including (but not limited to) the temperature, size, species composition, elevation, and water quality of the water being stocked, as well as hauling distance from the hatchery, fish size-at-stocking, stocking season, hatchery feed used, and stocking density (e.g., Wiley et al. 1993; Yule et al. 2000; Barnes et al. 2009; Koenig and Meyer 2011; Ashe et al. 2014). While not all of these factors can be controlled by hatchery staff or fisheries managers to boost angler return-to-creel rates, it is nevertheless valuable to understand the effects such factors have on post-release performance of catchables, regardless of the level of control that can be exerted on them.

In addition to understanding the factors that influence catchable return-to-creel, it is also important for managers to better understand what factors might influence the longevity of catchable fisheries. If a desirable percentage of the stocked trout are caught by anglers but all of the catch occurs in a short period of time post-stocking, receiving waters might need to be stocked more than once during the angling season to maintain return rates acceptable to anglers. Decisions about effective allocation of catchable trout could subsequently improve the efficiency of the resident hatchery system and directly benefit anglers by increasing return-to-creel of catchable trout. This type of monitoring and evaluation program is critical in the decision-making process of allocating catchable Rainbow Trout production.

The current target length for a catchable trout released from an IDFG hatchery is variable, from 254 to 305 mm, depending on the receiving water. Previous studies have shown a strong correlation between increased size-at-release and increased return-to-creel for hatchery trout (Mullan 1956; Wiley et al. 1993; Yule et al. 2000; Cassinelli 2015). While larger trout may return to the creel at a higher rate, rearing fish to a larger size comes with significant increases in rearing costs. Therefore, it is important to find a balance between size-at-release, rearing costs, and return-to-creel. Rearing tools such as size grading can be used as a means to select for larger fish from a given rearing container at the time of release. By selecting the larger fish for release, smaller fish can be retained and given additional rearing time to increase their size. Size grading was shown to be an effective tool to decrease variance and increase overall size of hatchery Yellow Perch *Perca flavescens* (Wallat et al. 2005) and increase growth in hatchery Atlantic Salmon *Salmo salar* (Gunnes 1976). However, grading was shown to have no growth benefit in Arctic Charr *Salvelinus alpinus* (Wallace and Kolbeinshavn 1988) and was not recommended as a standard rearing procedure to increase weight gain in rearing Brook Trout *Salvelinus fontinalis*, Brown Trout *Salmo trutta*, and Rainbow Trout (Pyle 1966). These mixed results show that while size grading may have the potential to increase the average size at stocking and lower size variation, grading effects on post-stocking performance need further evaluation as they pertain to hatchery catchables.

Study Questions

This project consists of two major components: (1) an evaluation of statewide catch and harvest rates of the most-stocked waters in Idaho, and (2) investigations on the effects of hatchery rearing techniques on total catch of stocked catchable trout in Idaho. The following outlines the goals and objectives of these major components.

Catch and Harvest Rate: Allocate hatchery resources to maximize benefits to anglers from catchable hatchery Rainbow Trout stocked in Idaho waters.

Objectives:

- Determine the average catch and harvest rates of catchable Rainbow Trout in *at least* the top 50% of waters stocked (as determined by the total trout stocked) for release year 2014.

- Determine what factors were most influential on the return-to-creel of catchables stocked into lentic waters throughout the state of Idaho, across multiple stocking events, for stocking years 2011-2014.

    - Determine what factors influence the longevity of the fishery subsequent to each stocking for the same time period.

Hatchery Rearing Techniques: Increase hatchery production efficiency by modifying rearing practices to maximize catch and harvest rates.

Objectives:

- Evaluate total catch rates of Rainbow Trout that are graded vs. non-graded during rearing.

- Evaluate total catch benefit from releasing magnum-sized catchables (average 325 mm and 305 mm) vs. standard-sized catchables (average 250 mm).

METHODS

Catchables were raised from 2011 to 2014 from eggs either purchased from Troutlodge, Inc. (all-female triploids) or fertilized internally from IDFG's Hayspur strain (mixed-sex triploids). These two sources annually provide nearly all of the eggs used in the IDFG resident hatchery program.

Stocking Year 2014 Statewide Exploitation

The most recent stocking year with enough time-at-large to be fully evaluated for this report was 2014. Stocking year 2014 angler return data was incorporated in the four-year statewide return evaluation while angler-specific return data for 2014 was included in this report independently. Previous stocking year-specific (2011, 2012, and 2013) angler return info can be found in previous year's reports (Cassinelli and Koenig 2013, Cassinelli 2014, Cassinelli 2015).

Four-year Statewide Return Evaluation

Fish were reared at eight different hatcheries for this study, but the vast majority of fish (roughly 90%) were reared at the three largest IDFG resident trout facilities (i.e., Hagerman, Nampa, and American Falls fish hatcheries). Fish were reared to catchable size (with a target of 254 mm [total length] at time of stocking) in outdoor concrete raceways on 13-15°C single-use spring water. Rearing conditions such as feeding, inventorying, and raceway density, differed little between hatchery facilities. For this evaluation, only standard 254 mm average length catchables not part of any rearing experiment were used.

For release years 2011-2014, study waters were selected based on data in the yearly IDFG Default Catchables Request Lists. Waters were ranked according to total number of catchable Rainbow Trout stocked annually and chosen to evaluate locations that comprise at least 50% of the total catchables stocked annually. As resources allowed, additional waters were added to evaluate to the level of 60% of waters stocked and to increase sample sizes for rearing density and size grading comparisons. Exploitation was evaluated as both "total caught" (any fish kept or released) and "harvested" (only fish that were kept) (Appendix A.), but only total catch was used in our analyses.

A number of water-specific and stocking-specific characteristics that might influence angler return rates or days-at-large of stocked catchables were measured (Table 1). Continuous independent variables included the elevation (m) and surface area (km^2) of the water being stocked; mean total length (mm) of fish for each stocking event; hauling distance (km) from hatchery to stocking location; cumulative three month pre- and post-stocking precipitation (cm); average three month pre- and post-stocking air temperature (°C); human population size within 50 km of the stocked water; and the stocking density (fish/km^2). Categorical independent variables included the rearing hatchery and season of stocking. Hatcheries other than American Falls, Hagerman, and Nampa were aggregated together into a group called "other" due to these remaining hatcheries having too few releases to be analyzed independently. Seasons were classified as spring (March–May), summer (June–August), and fall (September–November). No tagged fish were stocked in the winter months.

The elevation and surface area of each water, along with hauling distance from stocking hatchery, were measured using ArcGIS software. Estimates of human population within 50km of

stocking locations were also generated using ArcGIS, by creating 50km buffers around each water body and then using data from the most recent (i.e., 2010) U.S. census to determine the population within the buffer. Pre- and post-stocking cumulative precipitation and pre- and post-stocking average air temperature estimates were generated using data from the National Weather Service Cooperative Observer Stations downloaded from the Western Regional Climate Center website (www.wrcc.dri.edu). Data were pulled from a single observation site nearest to the stocking location.

Magnum Rearing

Based on preliminary results from returns of magnum trout stocked from American Falls Fish Hatchery in release year 2013, the magnum catchable program was expanded in 2014 by both repeating a spring and fall magnum/standard comparison at American Falls, and by adding a magnums/standard comparison at Nampa Fish Hatchery. Similar to 2013, American Falls Fish Hatchery reared both magnum and standard catchables to be stocked side-by-side in 10 lakes and reservoirs in June of 2014. This was repeated in 10 additional waters in October of 2014. For all 20 stockings, 200 tagged magnums and 200 tagged standard catchables were simultaneously released. At Nampa Fish Hatchery, the magnum comparison was incorporated into the ongoing grading study. Magnum groups were graded (as outlined below) and both graded and non-graded magnums were released alongside standard non-graded catchables in 10 different lakes and reservoirs.

Size Grading

The prerelease size grading evaluation started at American Falls, Hagerman, and Nampa fish hatcheries in 2013 and has been ongoing. The study was designed as a paired study at each facility in that all tagged, graded fish that were stocked had a group of traditionally-reared, non-graded, tagged catchables stocked into the same water body at the same time. Graded treatment raceways and non-graded control raceways were reared on similar water sources at similar flow and densities. Grading was conducted by crowding fish in raceways with grade racks (passive approach). Each facility graded a group of fish prior to release in the spring/early summer (April–June) and in the late summer/fall (July/August–September/October). Each graded group had an initial grading event where fish that were 254 mm or greater were targeted to be graded off and stocked. Remaining fish were reared for a four-week period followed by a second grading event, and graded fish were again stocked. Remaining fish were reared an additional four weeks and subsequently stocked. At each grading event and at final stocking, up to four stocking locations (per hatchery) received graded and non-graded tagged fish that represented up to 10% of the total release at each stocking location during that time interval.

Starting with the 2014 stocking year, 305 mm average sized “magnum” catchables from Nampa Fish Hatchery were stocked at a production level into numerous lakes and reservoirs in southwest Idaho. These fish were incorporated into the grading evaluation and both graded and non-graded magnums were stocked into each study water, along with a group of traditional 254 mm catchables, so that all three groups could be compared. Each hatchery’s rearing and grading strategy for 2014 release groups is outlined below.

American Falls Fish Hatchery

At American Falls, there was one treatment (graded) and one control (non-graded) raceway during both the spring/early summer and late summer/fall periods. The spring/late

summer treatment group received their first grade/stocking in early April, their second grade/stocking in early May, and the remaining fish were stocked in early June. The late summer/fall group received their first grade/stocking in August, their second grade/stocking in September, and the remaining fish were stocked in October. Fish were graded using passive grading crowder racks crowded from the upper and lower end of the treatment raceways.

Hagerman Fish Hatchery

At Hagerman, there were two treatment and one control raceway in the spring/early summer, and one treatment and one control raceway in the late summer/fall. One spring/early summer treatment group was a regular prerelease graded group and the other was both early (fry in vats) and prerelease graded. Groups were graded and stocked in April, their second grade/stocking was in early May, and the remaining fish were stocked in early June. The late summer/fall group received their first grade/stocking in August, their second grade/stocking in September, and the remaining fish were stocked in October. Passive racks crowded from the top and bottom of the raceway was the grading method used.

Nampa Fish Hatchery

At Nampa, there was one treatment and two control raceways in the spring/early summer and one treatment and one control raceway in the late summer/fall. The spring treatment group consisted of 305 mm average sized magnums that were graded prior to release. This group received their first grade/stocking in April, their second grade/stocking in May, and the remaining fish were stocked in June. One control group was non-graded magnums and the other was non-graded standard 254 mm catchables. The late summer/fall group received their first grade/stocking in July, their second grade/stocking in August, and the remaining fish were stocked in September and consisted of 254 mm graded and control raceways, as no magnums were released in the late summer/fall. Passive racks crowded from the top and bottom of the raceway was the grading method used.

Tagging and Stocking

Catchables were tagged prior to stocking with 70 mm fluorescent orange T-bar anchor tags. Fish were collected for tagging by crowding them within raceways and capturing them with dip nets. This ensured a representative sample was collected from the entire raceway. Fish were sedated, measured to the nearest mm, and tagged just under the dorsal fin following the methods of Guy et al. (1996). After tagging, trout were returned to an empty section of raceway, or to a holding pen in the raceway, for at least 12 hours. Within 48 hours of tagging, tagged fish were loaded by dip net onto stocking trucks with the normal lot of untagged fish and transported to stocking locations. Mortalities and shed tags were rare (<1%), and were collected and recorded prior to loading fish for transport. Some waters were stocked with tagged fish only one time in a calendar year while others were stocked multiple times depending on the popularity and general use of the water. Stocking events occurred from March through November annually.

The return-to-creel and days-at-large data collected was based on the anchor tags reported by anglers. Anglers could report tags using the IDFG (Tag! You're It!) phone system or website (set up specifically for this program), as well as at regional IDFG offices or by mail. To facilitate angler reporting of tagged fish, anchor tags were labeled with "IDFG" and a tag reporting phone number on one side, with a unique tag number on the reverse side. Each year, a subset of study waters received $50 reward tags in addition to standard non-reward tags. In

locations that received reward tags, rewards were distributed at a constant rate of 10% of the total tags stocked. Reward tags were identical to non-reward tags in size, shape, and color, but contained additional text ("Reward") and the reward amount ("$50"). For a more detailed description of the angler tag reporting system used, see Meyer et al. (2012) and Meyer and Schill (2014).

Data Analysis

To estimate the angler tag reporting rate (λ) of non-reward tags, I used the high-reward method (Pollock et al. 2001) and equation:

$$\lambda = \frac{Rr / Rt}{Nr / Nt}$$

where *Rt* and *Rr* are the number of non-reward tags stocked and reported, respectively, and *Nt* and *Nr* are the number of reward tags stocked and reported, respectively. This equation was calibrated to account for the fact that an estimated 88% of $50 tags are actually reported (Meyer et al. 2012). The year-specific tag reporting rate, calculated by pooling tags from all waters that received reward tags within a given stocking year, was used to correct angler return rates at all waters for that stocking year. Additionally, all tags across all waters that received reward tags across all years were pooled to calculate an aggregate tag reporting rate. Year-specific catch and harvest estimates were then calculated using both the appropriate year-specific reporting rate and the aggregate reporting rate to see if variation in any year-specific reporting rate might be biasing that year's catch and harvest calculations.

In each study year, a portion of the trout was double tagged to calculate tag loss rates. Double-tagged fish received two tags implanted next to each other on the same side of the fish. All anglers returning tags were asked if the fish they caught was tagged with one or two tags. Any double-tagged fish that lost a tag were used to calculate tag shedding rates following the methods of Meyer and Schill (2014).

Harvest was calculated within the first year (365 days) and the second year (366 to 730 days) after stocking, following the methods of Meyer et al. (2012). The annual unadjusted harvest rate (*u*) was calculated as the number of non-reward tagged fish reported as harvested within one year of tagging, divided by the number of non-reward tags released. Unadjusted harvest and total catch were adjusted (*u'*) by incorporating the average angler tag reporting rate (*λ)*, first year tag loss (Tag_l), and tagging mortality (Tag_m) for Rainbow Trout tagged as part of this study. Estimates were calculated for each individual stocking event using the formula:

$$u' = \frac{u}{\lambda(1 - Tag_l)(1 - Tag_m)}$$

Variance for the denominator in the above equation was estimated using the approximate formula for the variance of a product in Yates (1953). Variance for *u'* was calculated using the approximate formula for the variance of a ratio (Yates 1953) and was used to derive 90% CIs. A more complete description of these methods and the associated formulas is described in Meyer et al. (2012).

Because some anglers release fish voluntarily, harvest estimates may not necessarily characterize the utilization of fish by anglers (Quinn 1996). To account for catch-and-release in

addition to harvest, “total catch” was also calculated. For this, u' was changed to include the total number of fish caught for each release group, including those harvested and released. Calculations were otherwise performed as described above.

I compared tag returns across waters using general linear models. Each stocking event was considered the unit of observation for our analyses. For the four-year statewide evaluation, two separate models were developed to quantify adjusted total angler return rates and average days-at-large (post-stocking) of all fish caught for each stocking event. Selection of variables to include in the general linear models followed the methods outlined in detail by Hosmer et al. (2013); these authors termed their method purposeful selection of variables. In short, I included all plausible variables in the full models, and assessed the importance of each variable using the P-value of its F-statistic. Variables were continually removed (in order of least significant P-values) until all remaining variables in the reduced models were statistically significant. Then, plausible first-order interactions between the remaining variables were tested and included if statistically significant. Finally, each previously removed variable was added back into the reduced models singularly to verify insignificance, resulting in the final models. For categorical variables that were statistically significant, Duncan’s Multiple Range Test was used to determine which levels differed. Residuals of the final models were evaluated diagnostically to assess normality and heteroscedasticity. Analyses were conducted using the SAS statistical software package (SAS Institute Inc. 2010) with an α value of 0.05.

RESULTS

Stocking Year 2014 Statewide Exploitation

In 2014, 32,773 non-reward tagged hatchery catchables were released across 49 waters statewide (Table 2) and included 175 individual tag groups (Table 3). By January 1, 2015, anglers returned 2,964 of these tags (within 365 days of each individual stocking). Harvest and total catch varied widely (0-87.1%) across all waters (Table 3). For all tags released in 2014 and reported within 365 days of release, average statewide harvest and total catch (± 90% C.I.) for hatchery catchables across the waters evaluated were 20.1% (± 2.9%) and 25.7% (± 3.7%), respectively. The mean and median days-at-large for all fish stocked were 84 and 42 days, respectively. The average total length of standard catchable Rainbow Trout tagged during 2014 was 256 mm from all hatcheries.

Four-year Statewide Return Evaluation

Across the four years of our study, 50,745 catchables were tagged and stocked into 54 different waters over 226 individual stocking events. Anglers reported a total of 5,092 of these tags. First-year angler return rates across all four study years averaged 23.0% and ranged from 0.0% to 76.4% for individual stocking events. The number of days-at-large prior to harvest were similar across all four years of the study. Of the fish that were eventually caught and reported, it took anglers an average of 22 days to return 25% of the fish, 51 days to return 50%, and 122 days to return 75%. Average days-at-large for fish caught at different waters varied from a low of 10 days to a high of 297 days.

The best general linear model for explaining the variation in angler returns included fish length ($F = 11.02$, $P = 0.001$), the size of the water stocked ($F = 27.07$, $P < 0.001$), the elevation of the water stocked ($F = 6.58$, $P = 0.011$), and the rearing hatchery ($F = 3.10$, $P = 0.028$). This model explained 23% of the variation in angler returns. Return-to-creel increased in smaller

waters that were at lower elevations and were stocked with larger fish (Figure 1). Return-to-creel was highest for fish stocked from those hatcheries classified as “other” (30.6%), followed by returns from Nampa Fish Hatchery (24.6%), American Falls Fish Hatchery (21.6%), and Hagerman Fish Hatchery (20.8%). Duncan’s Multiple Range Test showed that angler return rates from “other” hatcheries differed from Hagerman and American Falls fish hatcheries; no other differences were significant.

The best general linear model for explaining variation in days-at-large for fish eventually caught by anglers included the size of the water stocked ($F = 30.59$, $P < 0.001$), the season of stocking ($F = 20.79$, $P < 0.001$), and the rearing hatchery ($F = 4.45$, $P = 0.005$). This model explained 39% of the variation in days-at-large. Fish stocked in larger waters took longer to catch (Figure 2), as did fish stocked in the fall (146 days) compared to those stocked in the summer (82 days) and spring (77 days). Fish reared at Nampa Fish Hatchery were at-large for a significantly shorter period (70 days) than fish from the American Falls (117 days), Hagerman (98 days), and “other” hatcheries (99 days).

Magnum Rearing

For American Falls Fish Hatchery, magnums averaged 320 mm and standards averaged 257 mm at stocking. For the first year at-large, magnums stocked in June had an average catch rate of 55.0% (± 13.1%) while their standard counterparts had a catch rate of 29.1% (± 8.9%). For the October stockings, magnums were caught at a rate of 28.7% (± 8.7%) while standards were caught at 9.3% (± 4.3%) (Figure 3).

For Nampa Fish Hatchery, graded magnums averaged 315 mm at release, non-graded magnums were 312 mm, and standard catchables were 267 mm. Graded magnums were caught at 43.5% (± 6.7%), non-graded magnums at 44.2% (± 6.8%), and non-graded standards at 27.1% (± 4.4%) (Figure 3).

Size Grading

Similar to 2013, results of the 2014 size-graded releases were mixed. Our method of grade/release, rear, grade/release, rear, release, resulted in larger fish being released from grade groups early in the process but the controls typically caught or surpassed the treatment group in average size by the final release, resulting in similar net returns for the two groups (Table 4). The mean catch rate for all releases that were graded was 17.4% (± 2.6%) while the mean return rates for all control releases was 17.0% (± 2.6%).

Tag Reporting Rate

Fifty dollar reward tags were released across 16 waters in 2014. The statewide overall average tag reporting rate for catchable hatchery Rainbow Trout in 2014 was 40.0% while estimated first year tag loss was 6.0%. Tag loss across all study years is outlined in Table 5. The current aggregate tag reporting rate, across all years of the study is 44.6%. There was little difference in catch estimates using the aggregate reporting rate across all years compared to using year-specific tag reporting rates (Figure 4).

DISCUSSION

Stocking Year 2014 Statewide Exploitation

Our estimates of overall statewide harvest (20.1%) and total catch (25.7%) of hatchery catchable trout released in 2014 remain similar to the statewide estimates for fish released in 2011 through 2013 (Cassinelli 2014 and Cassinelli 2015) (Table 6). Similarly, the mean and median days-at-large for 2014-stocked fish remain similar to those observed in previous years. The 2014 tagging groups were the final year-class that were stocked as part of the statewide exploitation evaluation and the results of that four-year study are included in this report.

Four-year Statewide Return Evaluation

The results of our study suggest that several water- and stocking-specific conditions affect angler return rates and fishery longevity for catchables stocked in lentic systems in Idaho, some of which are under the direct purview of fisheries managers. For example, stocking larger catchables had the predictable effect of generating higher return rates, as has been previously observed in both lotic (Cresswell 1981; Wiley et al. 1993) and lentic systems (Butler and Borgeson 1965; Wiley et al. 1993; Yule et al. 2000). Wiley et al. (1993) speculated that larger hatchery trout were better able to deal with environmental changes such as reservoir drawdown and might not be as affected by limited food or the presence of predators. If increased fish size results in increased angler returns, simply increasing the size-at-stocking should theoretically increase statewide return-to-creel rates. However, the cost of growing hatchery trout to a larger size increases exponentially, especially at catchable size (Southwick and Loftus 2003). Given a fixed budget and finite amount of rearing space, rearing larger fish would require decreasing the total number of catchables produced and may result in fewer total fish caught by anglers unless the reduced production was more than offset by increased catchability of the larger fish. A better understanding of how to maximize the tradeoff between size-at-stocking, numbers of fish produced (and subsequently stocked), and angler return-to-creel is necessary before any specific management recommendations can be made with regard to size-at-release of hatchery catchables.

Fisheries managers also have direct control over when to stock catchables. While our results did not show any significant differences in angler return rates across stocking seasons, they do suggest that catchables stocked in the fall were at large significantly longer (by about 50%) than those stocked in the spring and summer. Fish stocked in the spring and early summer are likely caught more quickly since they are stocked when angling effort is high and fishing conditions are ideal. Conversely, fishing pressure is delayed for catchables stocked in the fall (when many anglers become hunters) and does not likely increase until later in the year during ice fisheries, which can be an effective means of catching hatchery trout (Havey and Locke 1980). Safe ice conditions often do not materialize until several months after fall stocking, whereas spring and summer stockings are timed for immediate angling pressure. Finally, a higher portion of catchables stocked in the fall survive through the winter and are caught by anglers when angling pressure increases the following spring. While overall angler return rates were not different for fish stocked in the fall, prolonged catch of these fish in winter fisheries and into the following spring makes fall stockings a valuable management tool.

Besides the effect of fish size on angler returns, our most important finding was that in larger waters, a smaller percentage of the stocked fish were caught by anglers, and days-at-large increased with water size. This finding concurs with research on Maine lakes, where water size was the most influential factor affecting angler returns and was negatively correlated with

angler catch of hatchery Brook Trout (Ashe et al. 2014). However, as mentioned earlier, water size and stocking density were highly correlated in our study (r = -0.86), thus I cannot be certain whether reduced angler return rates were associated with larger waters or lower stocking density. In small Alberta put-and-take fisheries, stocking either low or high densities of trout produced low angler return rates (Patterson and Sullivan 2013), indicating that density was not an important driver of angler returns in their waters. In Idaho, as in most western states and provinces, angler return rates of stocked trout are generally highest in smaller waters, and this may have little to do with stocking density but rather, is related to the size of the water. Lacustrine fish such as hatchery trout may be exploited by anglers more effectively in small lakes (Ryder et al. 1974), because smaller lakes usually contain proportionally more littoral habitat, which is particularly well suited for catchable trout (Vehanen 1997; Swales 2006), and anglers are more efficient at targeting these areas.

Rearing hatchery influenced both angler return rates and the days-at-large until capture. However, trout from the three largest hatcheries (Nampa, Hagerman, and American Falls) had similar angler return rates. The hatcheries grouped into the “other” category had the highest return rates but consisted of only a small number of stockings from several hatcheries scattered across the state. These facilities were a mix of small rearing hatcheries and redistribution hatcheries. Past research investigating angler returns among IDFG hatcheries has been variable, with some results showing a difference in return rates among hatcheries (Kozfkay and Megargle 2002) and other results showing no difference (Cassinelli et al. 2016). These inconsistent findings suggest that identifying specific hatchery conditions influencing returns would likely require direct manipulation of the hatchery environment in a controlled experiment.

The wide range of lake and reservoir habitats across Idaho allowed us to evaluate angler returns of catchables across a wide range of elevations (477-2,143 m above sea level). Our finding of lower return rates at higher elevations is somewhat counterintuitive, as higher elevation waters are generally thought to have better water quality and cooler temperatures (Miranda and Bettoli 2010), both important characteristics for Rainbow Trout (Swales 2006). However, Hubert and Chamberlain (1996) found that the size and abundance of Rainbow Trout (mostly of hatchery origin) were negatively correlated with increased elevation for lakes and reservoirs ranging from 1,113 to 3,338 m above sea level in Wyoming. Higher elevation waters are typically less productive (Donald et al. 1980; Hubert and Chamberlain 1996) and more remote, resulting in less angler effort. Conversely, lower elevation waters typically are more productive and therefore support higher Rainbow Trout survival and growth (Hubert and Chamberlain 1996; Swales 2006), and such waters are generally more heavily fished. While managers could likely boost returns by simply shifting stocking towards more productive, lower elevation waters, this could negatively impact anglers who enjoy fishing more scenic, remote, higher elevation waters (Harris and Bergersen 1985; Beardmore et al. 2015).

The mean angler return rate observed (23%) across the waters stocked was generally lower than preferred for lentic put-and-take catchable trout fisheries. Additionally, our study identified 14 individual stocking events across 10 waters that resulted in zero returns of hatchery catchables. Of these 10 waters, 3 of them had zero returns for more than one stocking event. Identifying and modifying releases that appear to have little to no benefit to anglers is an important component of this multiyear study, as managers are able to modify or even eliminate such stockings. It should be noted that about 20% of IDFG’s catchable trout are stocked into community fishing ponds. While these waters are not included in this analysis, previous work has shown these waters have much higher angler return rates. For example, in 2014 the overall average angler return rate from 13 Idaho community ponds was 54.0% (Cassinelli 2015). Higher angler return rates from community ponds helps offset lower return rates from larger waters and

allows fisheries managers to stock a diversity of waters which provide anglers with more options and helps distribute angling effort.

Our best models only explained 23% of the variation in angler catch rates and 39% of the variation in days-at-large after stocking. Thus, there are clearly other water- and stocking-specific conditions that influence angler return rates and fishery longevity that were not included in the analyses. As mentioned above, one of the more obvious variables is angler effort, which is positively correlated to angler returns (Butler and Borgeson 1965; Loomis and Fix 1998; Askey et al. 2013; Patterson and Sullivan 2013). While human population size was included in the analysis as a potential surrogate for angler effort, the direct correlation between human population size and angling effort remains unclear. Another likely important factor that was not accounted for was reservoir drawdown, which varies tremendously from year to year depending on irrigation demands and hydropower operations, and has been implicated in the poor survival and low return rates of stocked trout (Wiley et al. 1993; McLellan et al. 2008; Koenig and Meyer 2011). In southern Idaho, the abundance of avian predators – especially American white pelicans *Pelecanus erythorhynchos* and double-crested cormorants *Phalacrocorax auritus* – has greatly increased in recent years, and has been shown to negatively impact angler return rates of catchables (Meyer et al. 2016). Unfortunately, at the scale of this study, monitoring these (and other) important factors was not feasible, and likely contributed to less explanatory models.

These results, and those from previous studies relating post-stocking hatchery trout performance to water- and stocking-specific conditions, emphasize some of the complexities that fisheries managers face in allocating catchables in put-and-take fisheries. If the sole focus was to maximize angler returns, managers could simply stock larger catchables, more often, into smaller, low elevation waters. However, the ultimate priority for fisheries managers is not to maximize yield of catchable angler returns, but rather to maximize angler satisfaction, and these are not necessarily interrelated (Arlinghaus 2006; Patterson and Sullivan 2013). Askey et al. (2013) suggests that an optimal stocking strategy at a regional scale is to maximize total angler effort, because anglers will adjust their effort to target waters with higher catch rates, thus balancing catch and effort across numerous waters over each fishing season. As long as enough fish are stocked into put-and-take fisheries to achieve a threshold level of return rates, angler satisfaction may be sufficient to generate ample angling effort (Loomis and Fix 1998; Patterson and Sullivan 2013). By better understanding how certain factors and conditions impact fishery performance following the stocking of catchable trout, fisheries managers can work to improve the efficiency of stocking programs and better explain the variation in stocking performance to anglers and policymakers alike. Finding the balance between angler effort, catch, and satisfaction will ultimately maximize the value of put-and-take fisheries.

Magnum Rearing

Magnum sized catchable trout were encountered by anglers at a much higher rate than standard sized catchables. For fish released from American Falls Fish Hatchery in the summer of 2014, there was a roughly 88% increase in the returns of magnums over standard sized catchables. American Falls Fish Hatchery magnums released in the fall had a 159% increase in returns over standards. For Nampa Fish Hatchery magnums released across the spring and summer, magnums had a 63% higher overall catch rate than standard catchables. These results confirm the added benefit of rearing catchables to an increased size. Despite having to reduce production by roughly 40% to accommodate the larger sized fish, anglers benefit from catching larger fish and in most waters, see an increase in the overall numbers of fish returned to creel. Magnum stockings will continue to expand in lakes and reservoirs and comparisons will also be made between magnums and standards in flowing waters starting in 2015.

Tag Reporting Rate

Prior to 2012, the overall tag reporting rate did not appear to change much from that reported previously by Meyer et al. (2012), who found that non-reward average reporting rate for hatchery trout was 49.4%. However, 2012 tags were reported at a rate of 37.2% in their first year at large. This represented a 22% decrease in reporting rate from that of 2011 tags. However, in 2013 the tag reporting rate increased to 39.3% and in 2014 to 40.0%, indicating that year-specific tag reporting rates will likely continue to fluctuate based on waters receiving reward tags. It should be noted that tag reporting rates will also fluctuate each year by chance alone, and whether there is a long-term trend in increasing or decreasing reporting rates will likely take years to definitively recognize. Considering the minimal number of reward tags needed each year to calculate tag reporting rate annually, $50 reward tags should be released each year that the Tag-You're-It program is used for broad-scale evaluations of catchable trout return-to-creel.

A concern with such fluctuations is whether variation in tag reporting rates is affecting our overall results and influencing the conclusions being drawn from catch estimates of stocked catchables. Estimating catch based both on an aggregate reporting rate and on year-specific reporting rates (Figure 4) demonstrates that the substantial annual variation in catch observed at some waters is likely real and not an artifact of annual variation in tag reporting rate. I also constructed general linear models for the four-year statewide return evaluation study using both an aggregate and year-specific tag reporting rates, and the results were equivalent, indicating that conclusions drawn regarding factors that influence catch of stocked fish were not affected by tag reporting rates.

As more year-specific tag reporting rate information is generated, using an aggregate tag reporting rate across multiple years may prove more efficient if tag returns do not show a long-term increasing or decreasing trend. This would help minimize year-specific biases in tag returns related to chance variation. The current aggregate tag reporting rate of 44.6% is very similar to the 2014 year-specific tag reporting rate of 40.0% and using either reporting rate results in very similar estimates of catch and harvest. I will continue to monitor variation in year-specific reporting rates and trends in the aggregate overall reporting rate through time to determine if using the aggregate becomes more appropriate than the current method of using year-specific rates.

FUTURE RESEARCH RECOMMENDATIONS

1. Continue collecting and compiling tag returns.

    a. November 2015 completed four years at large for the 2011 tag groups, three years at large for 2012 tags, two years at large for 2013 tags, and one year at large for the 2014 tags.

    b. Consider monitoring angler effort in association with catchable stocking to assess how effort may influence return rates. Rather than full-blown creel surveys, this could be done with car counters and trail cameras as a modified method of approximating relative angler effort across waters.

2. Further evaluate hatchery rearing techniques to assess if decreased size variation and a larger size-at-stocking are feasible rearing objectives resulting in a significant increase in return-to-creel.

    a. Grading a subset of hatchery catchables prior to release in 2014 is currently being evaluated and this evaluation was repeated during the 2015 release.

    b. Magnum releases were expanded to flowing waters in 2015 and will be further evaluated alongside standard catchables.

3. Continue releasing $50 reward tags at low rates each year to assess whether reporting rates by anglers fluctuate through time or trend upward or downward.

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Table 1. Water-specific and stocking-specific characteristics evaluated to test their effects on angler return rates and days-at-large for hatchery-reared catchable Rainbow Trout released in lakes and reservoirs in Idaho from 2011 to 2014.

Variable	Range	Connection to catchable post-release performance	Citations
Elevation of water (m)	447 - 2143	Elevation of impounded reservoirs may influence water quality (temperature, pH, etc.), which can affect post-release catchable performance.	Bryan 1982
Surface area of water (km^2)	0.07 - 223.7	Smaller, shallower lentic waters are often more productive, and often contain fewer species, which can reduce competition and predation.	Ashe et al. 2014
Stocking density (fish stocked/km^2)	12 - 50,000	Should be a direct relationship between the number of fish stocked and encounter rates by anglers, though this is not always supported by empirical study.	Miko et al. 1995; but see Patterson and Sullivan 2013
Mean length (mm) of stocked fish	220 - 298	Larger trout are better able to escape predators, have higher energy reserves, and may be more aggressive in foraging, and thus more vulnerable to angling.	Wiley et al. 1993; Yule et al. 2000; Cassinelli et al. 2016
Hauling distance from hatchery to water (km)	2.4 - 840.1	Lengthy hauling distances can impart physiological stress on hatchery fish prior to release, diminishing their post-release condition and subsequent performance.	McDonald et al. 1993; Barton 2000
Nearby cumulative three month pre- and post-stocking precipitation (cm)	pre (0.6 - 22.2) post (0.4 - 18.0)	Nearby precipitation strongly influences drawdown, which can influence water quality and food availability in impounded reservoirs, which in turn can influence trout survival.	Bryan 1982
Nearby average three month pre- and post-stocking air temperature (°C)	pre (-3.6 - 21.9) post (-5.6 - 22.7)	Air temperature can be a surrogate for water temperature, which in turn can influence water quality and trout survival.	Barwick et al. 2004
Human population size within 50 km of water	105 - 428,042	Affects amount of angler effort on waters, which is inherently related to overall catch and longevity.	Post et al. 2008; Post and Parkinson 2012
Rearing hatchery	–	Fish health often varies between hatcheries, which in turn can affect growth and production. These issues can carry over to post-stocking perfromance.	Iwama et al. 1997
Season of stocking (spring, summer, or fall)	–	Stocking often coincides with peak angling effort, which is typically spring and summer and not fall. But poor summer water quality may hinder survival of stocked fish at that time.	Wiley et al. 1993; Yule et al. 2000

Table 2. Waters that were stocked with tagged catchables in 2014 along with the total number of catchables stocked in those waters for the calendar year. These waters represent roughly the top 50% of waters stocked in 2014.

Water	Total Catchables Stocked in 2014	Total Stockings* in 2014	Total No. Taged Fish Stocked	No. of Stockings With Tagged Fish	IDFG Region
Alexander Reservoir	5,396	1	397	1	5
Alturas Lake	8,703	3	400	2	7
American Falls Reservoir	97,021	3	993	1	5
Arrowrock Reservoir	42,239	2	997	2	3N
Ashton Reservoir	42,171	4	1592	3	6
Big Smokey Creek	4,288	4	200	1	4
Blackfoot Reservoir	4,358	1	994	1	5
Bull Trout Lake	5,710	4	100	1	3N
Cascade Reservoir	61,888	2	1194	1	3M
Chesterfield Reservoir	56,490	4	2295	4	5
Crystal Lake	5,970	14	69	1	4
Deep Creek Reservoir	14,298	3	900	2	5
Devils Creek Reservoir	16,899	3	298	1	5
Foster's Reservoir	8,833	5	398	1	5
Glendale Reservoir	9,970	4	798	2	5
Horsethief Reservoir	35,102	3	1297	2	3M
Island Park Reservoir	28,394	5	1897	5	6
Jensen Grove Pond	5,000	2	399	1	5
Jim Moore Pond	5,400	2	400	2	6
Lake Cleveland	4,866	3	200	1	4
Lake Walcott	39,804	2	1199	2	4
Lamont Res	4,997	1	399	1	5
Little Wood Reservoir	10,753	2	599	1	4
Lost Valley Reservoir	15,052	1	898	1	3M
Lucky Peak Reservoir	35,309	2	886	1	3N
Mackay Reservoir	21,403	4	400	1	6
Magic Reservoir	5,040	1	442	1	4
Mann Creek Reservoir	9,095	3	1230	3	3N
Mann Lake	33,865	4	581	1	2
Moose Creek Reservoir	21,394	5	619	2	2
Oakley Reservoir	10,795	2	994	2	4
Perkins Lake	1,613	2	50	1	7
Sage Hen Reservoir	11,972	3	447	1	3N
Salmon Falls Creek Reservoir	39,909	4	1600	3	4
Snake River (upper) R5	8,875	5	200	1	5
Snake River (upper) R6	4,870	6	120	1	6
Snake River Gem State	11,900	5	400	2	6
Snake River Henry's Fork	13,670	5	500	2	6
Snake River Lower	8,000	2	301	1	4
Soldier's Meadow Reservoir	10,494	2	448	1	2
Spring Valley Reservoir	36,950	5	597	1	2
Springfield Reservoir	1,000	1	100	1	5
Stanley Lake	14,326	4	1193	3	7
Stone Reservoir	8,770	3	190	1	4
Sublett Reservoir	4,750	1	400	1	4
Ten Mile Pond	4,200	14	50	1	3N
Twin Lake Reservoir	11,460	2	398	1	5
Warm Lake	24,057	2	898	1	3M
Winchester Lake	46,755	4	1198	2	2
Totals	934,074	169	33,155	76	

* Stockings within the same week were considered as a single stocking

Table 3. Total nonreward tags released by water body, hatchery, treatment, and date in 2014. Harvest and Catch are through the first year at large and shown as of January 1, 2016 with associated 90% confidence intervals (C.I.).

						Disposition			Harvest		Catch	
Region	Water Body	Hatchery	Tagging Date	Treatment	Tags Released	Harvested	Harvested b/c tagged	Released	Estimate	90% C.I.	Estimate	90% C.I.
2	Mann Lake	Hagerman	12-May-14	Grading Ctrl	187	5	0	1	7.2%	4.4%	8.7%	4.9%
				Grading Tx	199	9	0	0	12.2%	5.7%	12.2%	5.7%
				Grading Tx Early	195	9	0	2	12.5%	5.8%	15.2%	6.4%
	Moose Creek Res	Hagerman	17-Jun-14	Grading Ctrl	75	8	0	1	28.8%	13.7%	32.4%	14.5%
				Grading Tx	75	8	0	1	28.8%	13.7%	32.4%	14.5%
				Grading Tx Early	75	8	1	0	28.8%	13.7%	32.4%	14.5%
			20-Oct-14	Grading Ctrl	198	27	0	1	40.9%	11.0%	42.3%	11.2%
				Grading Tx	196	17	1	0	26.2%	8.6%	27.6%	8.8%
	Soldier Meadow s Res	Hagerman	14-May-14	Grading Ctrl	149	5	0	2	9.1%	5.6%	12.7%	6.6%
				Grading Tx	149	4	0	0	7.3%	5.0%	7.3%	5.0%
				Grading Tx Early	149	5	1	1	9.0%	5.5%	12.6%	6.6%
	Spring Valley Res	Hagerman	17-Jun-14	Grading Ctrl	199	26	0	2	36.7%	10.3%	39.4%	10.7%
				Grading Tx	199	20	0	2	27.2%	8.7%	29.9%	9.2%
				Grading Tx Early	199	17	3	1	23.1%	8.0%	28.5%	8.9%
	Winchester Lake	Hagerman	15-Apr-14	Grading Ctrl	200	13	0	2	17.6%	6.9%	20.3%	7.4%
				Grading Tx	200	21	0	1	28.4%	8.9%	29.7%	9.1%
				Grading Tx Early	199	26	1	0	35.3%	10.1%	36.7%	10.3%
			12-May-14	Grading Ctrl	200	21	1	2	28.4%	8.9%	32.4%	9.6%
				Grading Tx	199	24	1	5	32.6%	9.6%	40.7%	10.9%
				Grading Tx Early	200	30	2	1	40.5%	10.9%	44.6%	11.5%
3B	Arrow rock Res	American Falls	21-Oct-14	Magnum Tx	200	28	2	9	40.5%	10.9%	56.8%	13.3%
		Hagerman	20-Oct-14	Grading Ctrl	397	23	1	2	19.7%	5.5%	22.5%	5.99%
				Grading Tx	400	22	1	2	16.2%	4.9%	18.9%	5.39%
	Bull Tout Lake	Nampa	20-Aug-14	Grading Ctrl	50	1	0	0	10.8%	10.3%	10.8%	10.3%
				Grading Tx	50	0	0	0	16.2%	12.5%	16.2%	12.5%
	Lucky Peak Res	Nampa	17-Apr-14	Standards	290	20	1	4	19.6%	6.2%	25.2%	7.2%
				Magnum Ctrl	296	42	3	5	38.3%	9.2%	45.6%	10.3%
				Magnum Tx	300	43	5	3	38.7%	9.2%	45.9%	10.3%
	Manns Creek Res	Nampa	16-Apr-13	Standards	110	8	1	1	24.6%	10.6%	29.5%	11.7%
				Magnum Ctrl	111	13	1	0	41.4%	13.8%	51.1%	15.4%
				Magnum Tx	114	21	0	4	66.4%	17.5%	75.9%	18.8%
			14-May-13	Standards	149	21	0	1	38.1%	11.8%	39.9%	12.1%
				Magnum Ctrl	150	32	1	3	57.7%	14.7%	64.9%	15.7%
				Magnum Tx	151	34	3	4	60.8%	15.1%	73.4%	16.8%
			24-Sep-14	Grading Ctrl	200	22	0	3	33.8%	9.8%	37.8%	10.5%
				Grading Tx	200	29	0	4	39.2%	10.7%	44.6%	11.5%
	Sage Hen Res	Nampa	14-May-13	Standards	135	14	3	1	34.0%	11.5%	42.0%	12.9%
				Magnum Ctrl	135	30	1	8	60.1%	15.6%	80.1%	18.3%
				Magnum Tx	133	18	1	4	36.6%	12.0%	50.8%	14.3%
	Ten Mile Pond	Nampa	24-Sep-14	Grading Ctrl	25	1	0	0	10.8%	14.5%	10.8%	14.5%
				Grading Tx	25	1	0	0	10.8%	14.5%	10.8%	14.5%
3M	Cascade Res	Nampa	14-May-13	Standards	398	4	2	1	2.7%	1.9%	4.1%	2.3%
				Magnum Ctrl	397	10	0	4	7.5%	3.2%	11.6%	4.1%
				Magnum Tx	399	5	2	3	3.4%	2.1%	6.8%	3.0%
	Horsethief Resrvoir	Nampa	7-May-14	Standards	299	39	1	5	35.2%	8.7%	40.7%	9.5%
				Magnum Ctrl	300	64	2	5	58.6%	12.0%	64.9%	12.9%
				Magnum Tx	299	75	2	7	67.8%	13.3%	75.9%	14.3%
			25-Sep-14	Grading Ctrl	200	12	0	5	18.9%	7.1%	25.7%	8.4%
				Grading Tx	199	17	1	1	25.8%	8.5%	29.9%	9.2%
	Lost Valley Res	Nampa	7-Jun-14	Standards	298	33	1	3	31.7%	8.2%	38.1%	9.1%
				Magnum Ctrl	300	41	0	6	47.7%	10.5%	56.8%	11.8%
				Magnum Tx	300	40	0	6	42.3%	9.7%	48.6%	10.6%
	Warm Lake	Nampa	7-Jun-14	Standards	300	35	2	6	31.5%	8.1%	38.7%	9.2%
				Magnum Ctrl	298	51	3	10	46.2%	10.3%	58.0%	12.0%
				Magnum Tx	300	46	6	7	41.4%	9.6%	53.1%	11.3%

Region	Water Body	Hatchery	Tagging Date	Treatment	Tags Released	Disposition			Harvest		Catch	
						Harvested	Harvested b/c tagged	Released	Estimate	90% C.I.	Estimate	90% C.I.
4	Big Smokey Creek	Hagerman	18-Aug-14	Grading Ctrl	100	2	0	0	5.4%	5.2%	5.4%	5.2%
				Grading Tx	100	1	0	1	2.7%	3.7%	5.4%	5.2%
	Crystal Lake	American Falls	19-Aug-14	Grading Ctrl	34	0	0	0	0.0%		0.0%	
				Grading Tx	35	0	0	1	0.0%		7.7%	10.4%
	Lake Cleveland	Hagerman	18-Aug-14	Grading Ctrl	100	24	1	3	67.6%	18.5%	86.5%	21.0%
				Grading Tx	100	27	1	1	78.4%	20.0%	86.5%	21.0%
	Lake Walcott		15-Sep-14	Grading Ctrl	400	19	0	6	18.9%	5.4%	25.0%	6.4%
				Grading Tx	400	19	0	1	18.2%	5.3%	18.9%	5.4%
		American Falls	22-Oct-14	Magnums	200	7	1	2	14.9%	6.3%	21.6%	7.7%
				Standards	199	5	0	1	10.9%	5.3%	12.2%	5.7%
	Little Wood Reservoir	Nampa	7-Jun-14	Standards	200	5	0	0	6.8%	4.2%	6.8%	4.2%
				Magnum Ctrl	200	7	0	2	9.5%	5.0%	12.2%	5.6%
				Magnum Tx	199	7	0	2	9.5%	5.0%	12.2%	5.7%
	Magic Reservoir	Nampa	16-Apr-14	Standards	149	3	0	0	5.4%	4.3%	5.4%	4.3%
				Magnum Ctrl	149	4	1	0	7.3%	5.0%	9.1%	5.6%
				Magnum Tx	144	7	2	1	13.1%	6.8%	18.8%	8.2%
	Oakley Res	Hagerman	15-Apr-13	Grading Ctrl	200	0	0	0	0.0%		0.0%	
				Grading Tx	200	2	0	0	2.7%	2.6%	2.7%	2.6%
				Grading Tx Early	200	1	1	0	1.4%	1.8%	2.7%	2.6%
		American Falls	18-Jun-13	Magnums	197	34	1	1	50.8%	12.5%	53.5%	12.9%
				Standards	196	19	0	0	26.2%	8.6%	26.2%	8.6%
	Salmon Falls Creek Res	Hagerman	15-Apr-13	Grading Ctrl	250	0	0	0	0.0%		0.0%	
				Grading Tx	250	1	0	1	1.1%	1.5%	2.2%	2.1%
				Grading Tx Early	250	2	0	1	2.2%	2.1%	3.2%	2.6%
			15-May-14	Grading Ctrl	150	1	4	0	1.8%	2.5%	9.0%	5.5%
				Grading Tx	150	1	2	0	1.8%	2.5%	5.4%	4.3%
				Grading Tx Early	150	0	3	1	0.0%		7.2%	4.9%
		American Falls	21-Oct-14	Magnums	180	11	1	2	21.0%	7.9%	25.5%	8.8%
				Standards	180	0	0	0	0.0%		0.0%	
	Snake River Low er	American Falls	18-Jun-14	Grading Ctrl	150	1	0	1	1.8%	2.5%	3.6%	3.5%
				Grading Tx	150	1	0	0	1.8%	2.5%	1.8%	2.5%
	Stone Res	American Falls	14-Apr-14	Grading Ctrl	100	0	0	0	0.0%		0.0%	
				Grading Tx	90	0	0	0	0.0%		0.0%	
	Sublett Res	American Falls	14-May-13	Grading Ctrl	199	28	7	5	38.0%	10.5%	54.3%	12.9%
				Grading Tx	200	20	1	6	27.0%	8.7%	36.5%	10.3%
5	Alexander Res	American Falls	21-Oct-14	Magnums	180	0	0	1	0.0%		1.5%	2.0%
				Standards	177	0	0	0	0.0%		0.0%	
	American Falls Res	American Falls	21-Oct-14	Grading Ctrl	356	0	0	0	2.3%	1.8%	2.3%	1.8%
				Grading Tx	358	4	0	0	3.0%	2.1%	3.0%	2.1%
				Magnums	180	8	1	0	15.0%	6.6%	21.0%	7.9%
	Blackfoot Res	American Falls	23-Oct-14	Grading Ctrl	358	0	0	0	2.3%	1.8%	2.3%	1.8%
				Grading Tx	356	1	0	0	3.8%	2.4%	3.8%	2.4%
				Magnums	180	2	0	1	12.0%	5.9%	13.5%	6.3%
	Chesterfield Res	Hagerman	14-May-14	Grading Ctrl	300	0	0	0	0.0%		0.0%	
				Grading Tx	300	0	0	0	0.0%		0.0%	
				Grading Tx Early	299	0	0	0	0.0%		0.0%	
		American Falls	18-Jun-14	Magnums	200	27	0	4	36.5%	10.3%	41.9%	11.1%
				Standards	200	12	3	4	16.2%	6.6%	25.7%	8.4%
			21-Oct-14	Magnums	178	5	0	7	16.7%	7.0%	33.4%	10.2%
		Hagerman	20-Oct-14	Grading Ctrl	380	12	1	13	13.5%	4.5%	26.3%	6.7%
				Grading Tx	398	4	1	9	4.8%	2.5%	12.2%	4.2%
	Deep Creek Res	American Falls	18-Jun-13	Magnums	200	34	3	9	45.9%	11.7%	62.2%	14.0%
				Standards	200	20	2	16	29.7%	9.1%	54.0%	12.9%
		Hagerman	15-Sep-14	Grading Ctrl	250	36	1	19	41.1%	10.1%	64.9%	13.5%
				Grading Tx	250	27	2	20	32.4%	8.8%	58.4%	12.6%
	Devils Creek Res	Hagerman	17-Jun-14	Grading Ctrl	99	6	0	2	16.4%	9.1%	21.8%	10.5%
				Grading Tx	99	5	1	2	13.6%	8.3%	21.8%	10.5%
				Grading Tx Early	100	8	1	4	21.6%	10.4%	35.1%	13.3%
	Foster's Reservoir	American Falls	18-Jun-14	Magnums	200	35	2	2	47.3%	11.9%	52.7%	12.7%
				Standards	199	4	0	2	5.4%	3.7%	8.1%	4.6%
	Glendale Reservoir	American Falls	18-Jun-14	Magnums	180	50	0	5	76.6%	16.4%	87.1%	17.7%
				Standards	180	25	1	5	39.0%	11.1%	48.0%	12.5%
			22-Oct-14	Magnums	199	28	2	6	43.5%	11.4%	54.3%	12.9%
				Standards	199	13	1	3	17.7%	6.9%	23.1%	8.0%
	Jensen Grove Pond	American Falls	14-Apr-14	Grading Ctrl	200	0	0	0	0.0%		0.0%	
				Grading Tx	199	3	0	0	4.1%	3.2%	4.1%	3.2%
	Lamont Reservoir	American Falls	18-Jun-14	Magnums	200	31	1	2	41.9%	11.1%	45.9%	11.7%
				Standards	200	14	0	2	18.9%	7.1%	21.6%	7.7%
	Snake River (Upper)	American Falls	24-Sep-14	Grading Ctrl	100	7	2	3	18.9%	9.7%	32.4%	12.8%
				Grading Tx	100	3	0	1	8.1%	6.4%	10.8%	7.4%
	Springfield Reservoir	American Falls	21-Oct-14	Grading Ctrl	50	0	0	3	0.0%		16.2%	12.5%
				Grading Tx	50	0	0	3	0.0%		16.2%	12.5%
	Tw in Lakes Res	American Falls	18-Jun-14	Magnums	179	25	0	11	40.8%	11.4%	61.9%	14.5%
				Standards	180	17	0	6	27.0%	9.0%	39.0%	11.1%

Region	Water Body	Hatchery	Tagging Date	Treatment	Tags Released	Disposition			Harvest		Catch	
						Harvested	Harvested b/c tagged	Released	Estimate	90% C.I.	Estimate	90% C.I.
6	Ashton Res	American Falls	13-May-14	Grading Ctrl	298	10	1	1	9.1%	4.0%	10.9%	4.5%
				Grading Tx	298	10	2	5	9.1%	4.0%	15.4%	5.4%
			18-Jun-14	Grading Ctrl	178	4	3	0	6.1%	4.2%	12.1%	6.0%
				Grading Tx	200	7	1	0	8.1%	4.6%	10.8%	5.3%
				Magnums	179	18	4	3	31.7%	9.9%	42.3%	11.6%
			22-Oct-14	Magnums	199	20	0	3	28.5%	8.9%	32.6%	9.6%
				Standards	198	1	1	0	1.4%	1.9%	2.7%	2.6%
	Island Park Res	Hagerman	17-Jun-14	Grading Tx	179	1	0	0	25.7%	8.4%	32.4%	9.6%
				Grading Tx Early	198	3	1	2	5.4%	3.7%	9.5%	5.0%
			18-Aug-14	Grading Ctrl	200	0	0	0	1.5%	2.1%	1.5%	2.1%
				Grading Tx	200	0	0	0	4.1%	3.2%	8.2%	4.6%
			15-Sep-14	Grading Ctrl	150	1	0	0	0.0%		1.4%	1.8%
				Grading Tx	150	0	0	0	2.7%	2.6%	4.1%	3.2%
		American Falls	18-Jun-14	Magnums	200	19	2	3	1.8%	2.5%	1.8%	2.5%
				Standards	200	4	2	1	1.8%	2.5%	1.8%	2.5%
			22-Oct-14	Magnums	200	2	0	1	4.1%	3.2%	5.4%	3.7%
				Standards	200	1	0	0	1.4%	1.8%	1.4%	1.8%
	Jim Moore Pond	American Falls	14-Apr-14	Grading Ctrl	100	0	0	0	0.0%		0.0%	
				Grading Tx	100	1	0	0	2.7%	3.7%	2.7%	3.7%
			13-Sep-14	Grading Ctrl	100	1	0	0	10.8%	7.4%	13.5%	8.2%
				Grading Tx	100	2	0	0	10.8%	7.4%	13.5%	8.2%
	Mackay Res	American Falls	18-Jun-14	Magnums	201	30	1	4	40.3%	10.8%	47.1%	11.8%
				Standards	200	14	1	4	18.9%	7.1%	25.7%	8.4%
	Snake River Gem State	American Falls	18-Jun-14	Grading Ctrl	100	9	1	0	9.0%	8.6%	13.5%	10.5%
				Grading Tx	100	9	1	0	13.5%	10.5%	13.5%	10.5%
		Hagerman	23-Sep-14	Grading Ctrl	100	3	1	0	27.0%	11.7%	29.7%	12.2%
				Grading Tx	100	4	0	0	24.3%	11.1%	27.0%	11.7%
	Snake River Henry's Fork	American Falls	14-May-14	Grading Ctrl	148	6	1	5	10.8%	7.4%	16.2%	9.0%
				Grading Tx	149	11	1	9	13.5%	8.2%	13.5%	8.2%
			19-Aug-14	Grading Ctrl	100	1	0	0	11.0%	6.1%	23.7%	9.2%
				Grading Tx	100	3	1	2	20.0%	8.4%	38.1%	11.8%
	Snake River (Upper)	American Falls	19-Aug-14	Grading Ctrl	60	2	0	0	2.7%	3.7%	2.7%	3.7%
				Grading Tx	60	2	0	0	8.1%	6.4%	16.2%	9.0%
7	Alturas Lake	Nampa	21-Jul-14	Grading Ctrl	100	1	0	0	2.7%	3.7%	2.7%	3.7%
				Grading Tx	100	1	0	0	2.7%	3.7%	2.7%	3.7%
			20-Aug-14	Grading Ctrl	100	0	0	0	5.4%	5.2%	5.4%	5.2%
				Grading Tx	100	1	0	0	8.1%	6.4%	8.1%	6.4%
	Perkins Lake	Nampa	21-Jul-14	Grading Ctrl	25	0	0	0	0.0%		0.0%	
				Grading Tx	25	0	0	0	0.0%		0.0%	
	Stanley Lake	Nampa	6-Jun-14	Standards	88	4	0	1	12.3%	8.3%	18.4%	10.2%
				Magnum Ctrl	90	14	0	5	42.0%	15.2%	57.1%	17.7%
				Magnum Tx	90	2	0	8	6.0%	5.8%	30.0%	12.9%
			21-Jul-14	Grading Ctrl	297	5	1	2	4.5%	2.8%	7.3%	3.6%
				Grading Tx	300	19	1	3	17.1%	5.7%	20.7%	6.3%
			20-Aug-14	Grading Ctrl	150	1	0	0	3.6%	3.5%	3.6%	3.5%
				Grading Tx	148	0	0	0	11.0%	6.1%	14.6%	7.1%

Table 4. Size-at-stocking for graded vs. non-graded controls across the three 2014 stockings for each grading event.

Hatchery	Group	Length (mm)		
		1st Stocking	2nd Stocking	3rd Stocking
Hagerman Late Grade	Treatment	251	246	244
	Controls	229	239	254
Hagerman Early Grade	Treatment	259	259	262
	Controls	229	239	254
American Falls	Treatment	244	246	251
	Controls	231	249	259
Nampa	Mag Treatment	328	310	312
	Mag Control	310	310	312

Table 5. Year-specific angler tag reporting rates.

Stocking Year	Year-Specific Tag Reporting Rate
2011	47.6%
2012	37.2%
2013	39.3%
2014	40.0%
2015	50.9%*
All Years	*44.6%*

* Preliminary reporting rate

Table 6. Total harvest and catch, 0-365 days post-stocking, for stocking years 2011 through 2014.

Stocking Year	Total Harvest 0-364 Days Post Stocking	Total Catch 0-364 Days Post Stocking
2011	18.7% (± 4.0%)	26.0% (± 5.5%)
2012	20.0% (± 3.1%)	25.9% (± 4.0%)
2013	23.4% (± 2.9%)	30.0% (± 3.7%)
2014	20.1% (± 2.9%)	25.7% (± 3.7%)

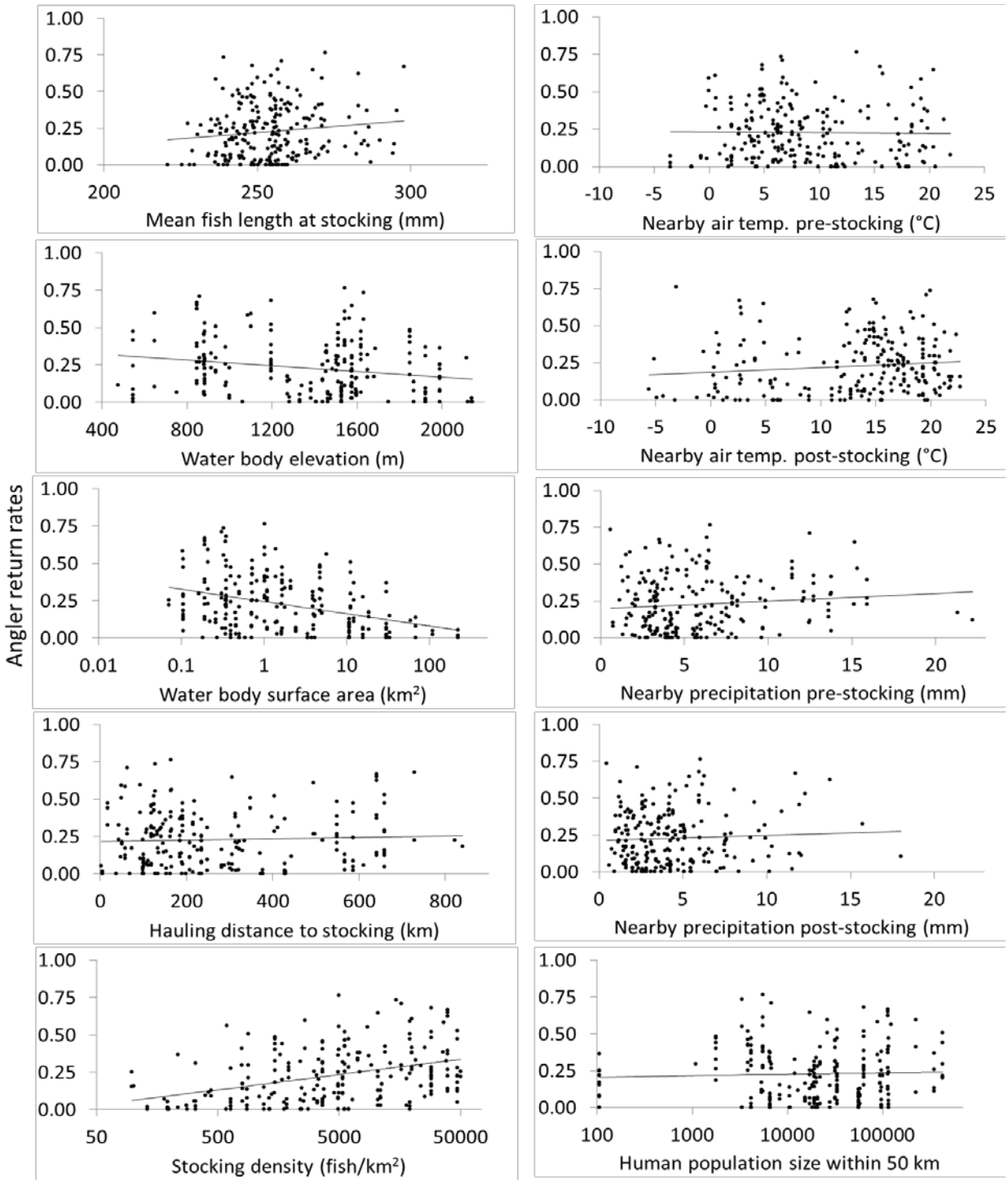

Figure 1. Scatterplots of water-specific and stocking-specific characteristics against angler return rates for Idaho lentic waters stocked with tagged hatchery catchable trout from 2011 to 2014. Stocking density, water surface area, and human population are plotted on logarithmic scales. Lines depict linear regressions fitted to the data; *r* is the correlation coefficient.

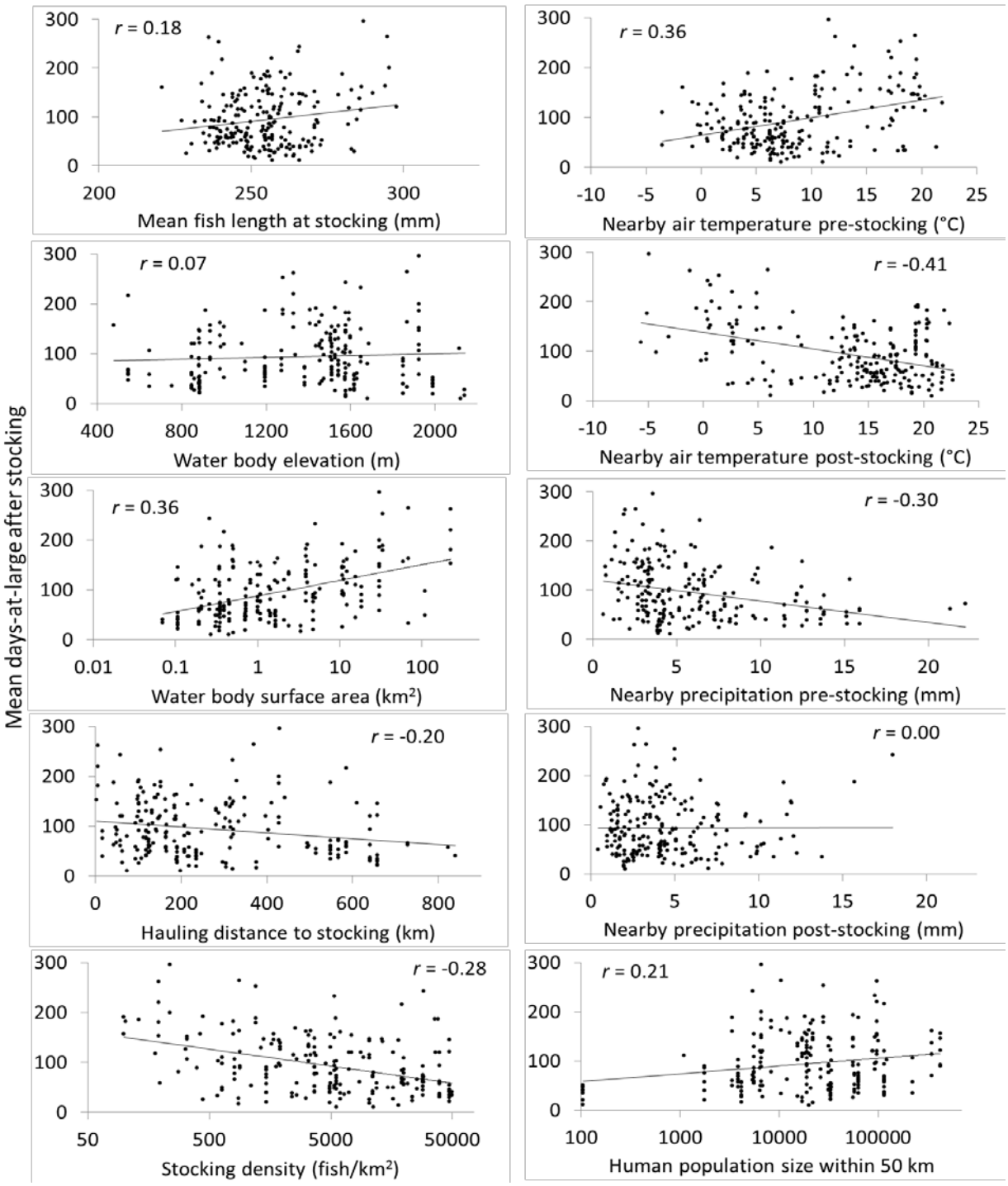

Figure 2. Scatterplots of water-specific and stocking-specific characteristics against mean days-at-large for Idaho lentic waters stocked with tagged hatchery catchable trout from 2011 to 2014. Stocking density, water surface area, and human population are plotted on logarithmic scales. Lines depict linear regressions fitted to the data; *r* is the correlation coefficient.

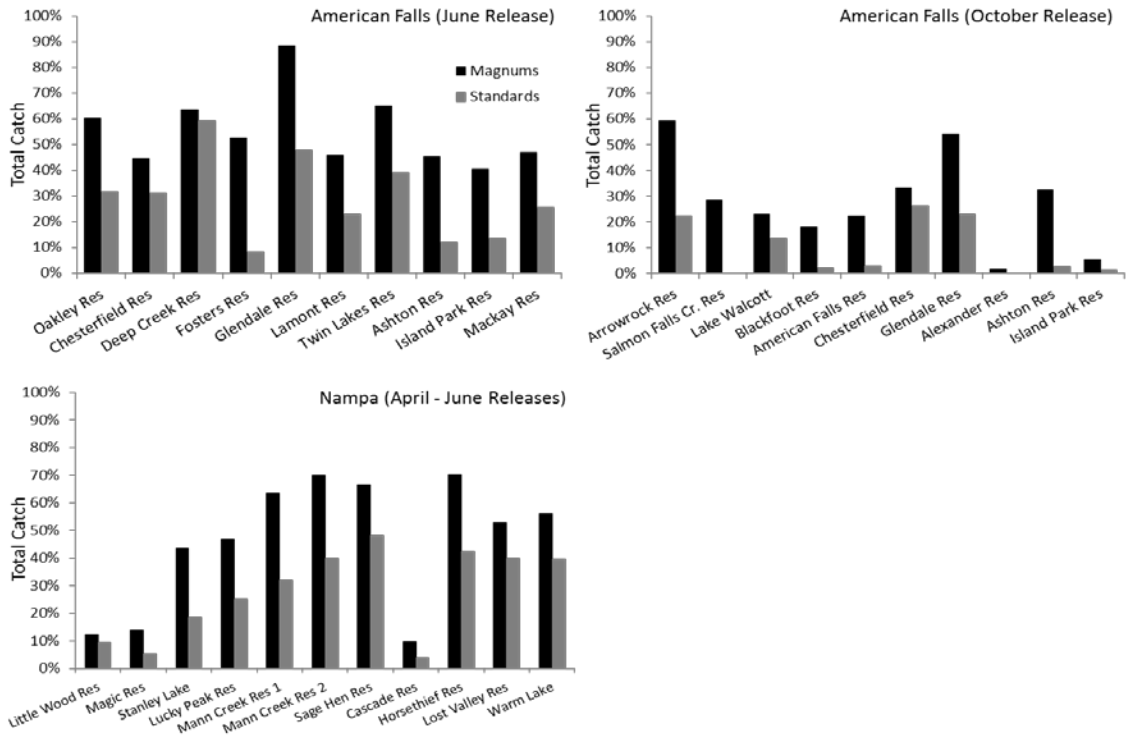

Figure 3. Total catch rate for magnum (Average 13 inch at American Falls Fish Hatchery, 12 inch at Nampa Fish Hatchery) versus standard (10 inch) catchables stocked into various lakes and reservoirs across Idaho. Fish were stocked in 2014.

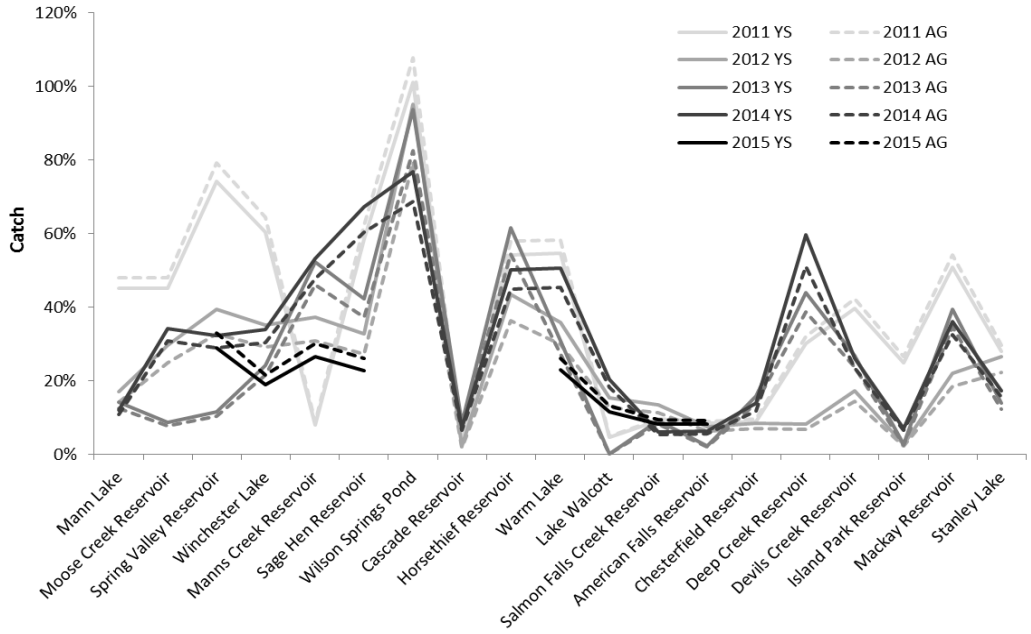

Figure 4. Total year-specific catch rate for waters stocked across all years of the tagging study calculated using year-specific tag reporting rate vs. the aggregate tag reporting rate.

ANNUAL PERFORMANCE REPORT
SUBPROJECT #2: RELATIVE PERFORMANCE OF TRIPLOID KOKANEE SALMON IN IDAHO LAKES AND RESERVOIRS

State of:	Idaho	Grant No.:	F-73-R-38 Fishery Research
Project No.:	4	Title:	Hatchery Trout Evaluations
Subproject #2:	Relative Performance of Triploid Kokanee Salmon in Idaho Lakes and Reservoirs		
Contract Period:	July 1, 2015 to June 30, 2016		

ABSTRACT

Kokanee Salmon *Oncorhynchus nerka* mature early and typically spawn and die at age-3 or age-4. Due to slow growth, short lifespan, and angler preference for larger fish, Kokanee Salmon are often only exploited by anglers for a short period of time during their last year of life. Using triploid salmonids in hatchery-supported freshwater fisheries protects native stocks from potential genetic introgression with hatchery fish, but other benefits may include increased longevity, survival, and growth, all of which could improve Kokanee Salmon fisheries. The objectives of this study were to evaluate whether switching hatchery-supported Kokanee Salmon waters from diploid to triploid stocking would increase survival, longevity, or growth, as measured by increased catch of larger fish in gill net sampling. Four water bodies were selected to be used in our evaluation: two treatments (Mirror Lake and Montpelier Reservoir) and two controls (Lower Twin Lake and Devils Creek Reservoir). In 2015, we completed the fourth season of sampling to describe the existing populations of diploid Kokanee Salmon and to evaluate triploid growth and survival. Lower Twin Lake had the largest Kokanee Salmon, followed by Devil's Creek Reservoir, Montpelier Reservoir, and Mirror Lake. Overall, CPUE increased across sample waters with the exception of Montpelier Reservoir. Length-at-age and age at maturity continued to be highly variable across water bodies. Stocking at the two treatment lakes will continue to consist of only triploid Kokanee Salmon, while control lakes will continue with normal diploid stocking consistent with previous stocking. Sampling will continue annually at least through 2017, when the first group of triploid Kokanee Salmon will have reached age-four, to document any increase in longevity or mean fish size in the population.

Author:

John Cassinelli
Senior Fisheries Research Biologist

INTRODUCTION

Kokanee Salmon *Oncorhynchus nerka* are an important recreational species in reservoirs and lakes across the western United States and Canada (Rieman and Myers 1992). In Idaho, hatchery-reared diploid Kokanee Salmon are stocked to supplement wild populations and to provide put/grow/take fisheries. Kokanee Salmon are often managed to support high yield fisheries or provide a forage base for large piscivores (Wydoski and Bennett 1981). While Kokanee Salmon are important to the harvest-oriented anglers and for providing trophy fisheries, managing for healthy Kokanee Salmon populations is often problematic (Beattie and Clancey 1991). Harvest rates of Kokanee Salmon are heavily influenced by growth rates, population density, and fish size. Since the majority of Kokanee Salmon populations in Idaho are found in oligotrophic lakes or reservoirs, growth rates are relatively low, especially when population densities exceed 50 fish/ha (Rieman and Myers 1992). Additionally, Kokanee Salmon mature early and typically spawn and die at age-3 or age-4 (Johnston et al. 1993). Due to slow growth rates, short life span, and angler's preference for larger fish, Kokanee Salmon are often only exploited for a short period of time during their last year of life.

Using triploid salmonids has become increasingly common in hatchery-supported freshwater fisheries. Since triploids are functionally sterile, one obvious benefit of stocking triploid fish is genetic protection of wild stocks (Rohrer and Thorgaard 1986). However, it is often asserted that sterility may provide a fisheries or aquaculture benefit (Teuscher et al. 2003), such as increased survival (Ihssen et al. 1990) or growth (Habicht et al. 1994; Sheehan et al. 1999). In Kokanee Salmon fisheries, enhanced longevity may provide additional sportfishing opportunity in subsequent years after semelparous diploids would have already perished. Indeed, greater longevity could ultimately result in larger size due to a longer growth period and thus increased yield. However, there are drawbacks to stocking triploids, which may include higher mortality and reduced growth during early life-history stages (Myers and Hershberger 1991). Additionally, survival to eye-up for triploid Kokanee Salmon egg lots may be lower than diploid control groups (Koenig 2011), requiring more eggs to be collected to meet stocking requests.

Post-release performance of sterile Kokanee Salmon relative to non-sterile conspecifics has rarely been evaluated. Parkinson and Tsumura (1988) and Johnston et al. (1993) both found increased longevity but no growth advantage for sterilized fish, and the longevity benefit could not overcome the much poorer survival of younger age classes of triploid fish relative to control (diploid) fish. The overall result of these studies was reduced catch for the triploid groups. More recently, researchers in Canada have been experimenting with triploid Kokanee Salmon in sport fish applications. Initial studies in several lakes stocked only with triploid Kokanee Salmon indicate triploid fish do not produce the same quality fisheries as lakes stocked exclusively with diploid fish (BC Ministry of Forests, Lands and Natural Resource Operations, Mike Ramsay, personal communication). While these studies provide insight into the utility of sterile Kokanee Salmon fisheries, results are questionable because each study was performed in only a few lakes, with no definitive marks to differentiate diploid and triploid fish, making comparisons of catch between groups difficult. In addition, Parkinson and Tsumura (1988) and Johnston et al. (1993) compared treatment and control fish stocked in the same lakes, where competition could have been a factor. Finally, the data from BC Ministry of Forests, Lands and Natural Resource Operations do not include information describing the fishery before switching to triploid only. Our goal was to more definitively evaluate whether switching Kokanee Salmon fisheries from diploid to triploid would result in greater longevity and better size structure (i.e., more larger fish) to the fishery.

OBJECTIVES

1. Describe Kokanee Salmon populations before and after switching to triploid-only stocking relative to control lakes.

2. Increase CPUE of 250 mm (or greater) Kokanee Salmon by at least 25%.

3. Increase the proportion of “quality” sized Kokanee Salmon (PSD; Kokanee Salmon >300 mm) by at least 25% after switching to triploid-only Kokanee Salmon stocking.

METHODS

Study Sites

Since this evaluation focuses on comparing fisheries after converting to triploid-only stocking, study sites were chosen from those currently stocked with Kokanee Salmon. Few locations were suitable for research purposes, as we did not want to risk collapsing any particularly popular sport fisheries, and sites had to be of manageable size for cost and sampling efficiency. Additionally, naturally reproducing populations of Kokanee Salmon may confound results and make interpreting treatment effects difficult, so lakes thought to have negligible natural spawning production were chosen. Based on these selection criteria, two lakes in southeast Idaho and two from northern Idaho were selected for our study. Waters in each region of the state were paired so that one each was a control and a treatment water. Consequently, Mirror Lake and Montpelier Reservoir were chosen as treatment waters, while Lower Twin Lake and Devils Creek Reservoir were chosen as control waters.

Two years (2012 and 2013) of initial sampling was conducted to describe the existing populations (length distributions, age classes, growth rates) of diploid Kokanee Salmon at all four water bodies. After this initial sampling, stocking at the treatment lakes was switched to stocking only triploid Kokanee Salmon, while control lakes continued with normal diploid stocking, consistent with previous years. Since a particular cohort of Kokanee Salmon will not impact the fishery until at least a year after stocking, triploid fish were first stocked in the spring of 2013 in treatment waters.

Collecting Eggs/Spawning

The third triploid treatment and diploid control groups were spawned in September of 2014 during normally scheduled weir operations on the Deadwood River. Kokanee Salmon from normal production were used for the diploid control groups. Triploid production lots were made using pressure-treatment on site. The recipe used was a treatment of 9500 psi at 350 Celsius-minutes after fertilization for five minutes. Since this is an ongoing study, additional treatment and control groups will be spawned in identical fashion through at least 2016.

Hatchery Rearing

Fertilized eggs were flown to Cabinet Gorge Fish Hatchery where they were reared until the eyed egg stage. Diploid and triploid test groups received year-specific otolith thermal marks to distinguish them from naturally produced diploid Kokanee Salmon, and from subsequent year classes to ensure correct age identification. Thermal marks were confirmed prior to stocking.

Stocking lots for Devils Creek and Montpelier reservoirs were transferred to Mackay Fish Hatchery to complete rearing, while Cabinet Gorge Fish Hatchery reared Kokanee Salmon for Mirror and Lower Twin lakes.

Prior to stocking, 100 triploid blood samples and 10 diploid samples were collected to check triploid-induction rates. Blood samples were collected by severing the caudal peduncle of each fish and immersing it in a tube filled with Alsever's solution. Samples were shipped to North Carolina State University for analysis by flow cytometry. At the time of stocking, mean total length (mm) and weight (g) were collected from 100 individual fish in each study group.

Sampling

Kokanee Salmon sampling began in 2012 and will continue annually through at least 2017. Net locations for sampling fish in each water were initially randomly assigned, recorded by GPS, and repeated in proceeding years. The limnetic zone of each water was divided into numbered squares and a random number generator was used to select three squares that serve as the monitoring locations where one net is placed. One net was fished for one night at each of the three locations at each water, for a total annual fishing effort of three net-nights per water.

Kokanee Salmon are sampled each year from mid-June to mid-July, after waters have begun to stratify, around the timing of the new moon phase. Fish are collected using experimental net curtains suspended at the depth of the thermocline. Experimental net curtains measure 55 m long by 6 m deep. Two of the three nets are “small” mesh and composed of panels ranging from 19 to 64 mm bar mesh monofilament, while the third net is “medium” mesh composed of panels ranging from 64 to 152 mm bar mesh monofilament. Panels were randomly positioned on nets during manufacturing.

Data Analysis

Standing Kokanee Salmon stocks before and after switching to triploid-only stocking were described in terms of fish size distribution and catch rates. Mean CPUE at each lake was calculated as the average catch rate (fish/hour) across the total number of nets. Size-at-age and mean total length were used to characterize stock structure in each lake. Sectioned otolith samples were examined to determine fish age, and thermal marks are used to describe the age structure of the populations in each lake.

RESULTS / DISCUSSION

Baseline samples of diploid Kokanee Salmon were collected from all four waters in 2012 and treatment triploid groups were sampled starting in 2013. By 2015, three year classes of treatment fish (age-0, age-1, and age-2) were present in treatment waters. Sampling catch and age structure of sampled fish were similar in 2015 to previous sample years (Table 7). With the exception of Montpelier Reservoir, CPUE increased at all waters in 2015 (Figure 4). Length frequencies and length-at-age were similar to past years; however, age-0 fish were slightly larger at most waters (Figure 5).

Similar to prior years, length at age was highly variable across waters in 2015. For the first time since this study started, Lower Twin Lake had the largest length-at-age while Mirror Lake continued to have the smallest length-at-age. Similar to past years, Devil’s Creek

Reservoir again showed high growth while Montpelier Reservoir showed more moderate growth (Table 4). Additionally, the larger, faster growing fish of Devil's Creek Reservoir and Lower Twin Lake continue to appear to mature and spawn at an earlier age, as no fish over the age of two were sampled, while there were again many age-3 Kokanee Salmon in the slow growing Mirror Lake population. Older Kokanee Salmon age at maturity associated with slower growth rates is well established in the literature (Grover 2005).

Catch-per-unit-effort remained somewhat consistent from 2012 to 2013, but was significantly lower in 2014. However, CPUE rebounded in 2015 with the exception of Montpelier Reservoir, which continued to have the lowest CPUE. Lower Twin Lake had the highest CPUE that we have seen during the study. This was mainly driven by the capture of a large number of age-0 fish.

While CPUE has decreased and length-at-age has increased at Montpelier Reservoir and Mirror Lake since shifting to triploid Kokanee Salmon, similar shifts have also occurred in the two control waters. Future reports will contain more detailed information in regards to this study as the treatment and control groups mature and become more apparent in the overall populations.

ACKNOWLEDGEMENTS

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Table 7. Net-hours, CPUE, and age distribution of diploid (2N) and triploid (3N) Kokanee Salmon in two control and two treatment lakes for sample years 2012, 2013, 2014, and 2015. Gray shaded values represent age classes that are triploid.

Water Body	Sample Year	Treatment	Net-Hours	CPUE	Mean Length-At-Age (mm)			
					Age 0	Age 1	Age 2	Age 3
Montpelier Res.	2012	3N	105.8	1.63	109	203	277	337
	2013		54.5	1.27	112	220	274	NA
	2014		40.0	0.65	105	228	282	314
	2015		44.3	0.54	160	250	315	NA
Mirror Lake	2012	3N	46.5	4.10	100	160	205	246
	2013		45.5	4.37	104	159	205	235
	2014		47.3	1.27	103	185	199	240
	2015		47.1	1.74	133	195	220	236
Devils Creek Res.	2012	2N	49.1	3.60	121	317	459	NA
	2013		47.0	4.68	115	317	467	500
	2014		45.3	1.08	103	277	449	NA
	2015		46.5	1.79	101	285	368	NA
Lower Twin Lake	2012	2N	89.8	3.00	106	293	389	NA
	2013		45.0	1.82	104	289	393	NA
	2014		48.5	0.72	97	263	387	410
	2015		47.9	7.62	137	331	371	NA

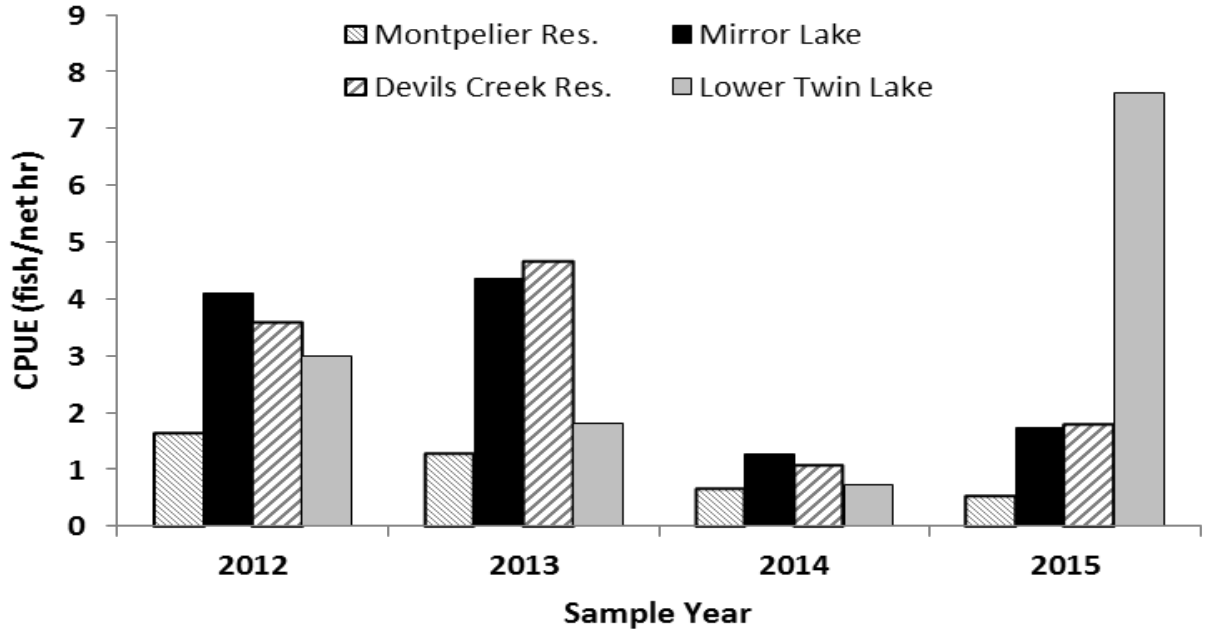

Figure 4. Catch per unit effort for Kokanee Salmon sampling at all four study waters in 2012, 2013, 2014, and 2015.

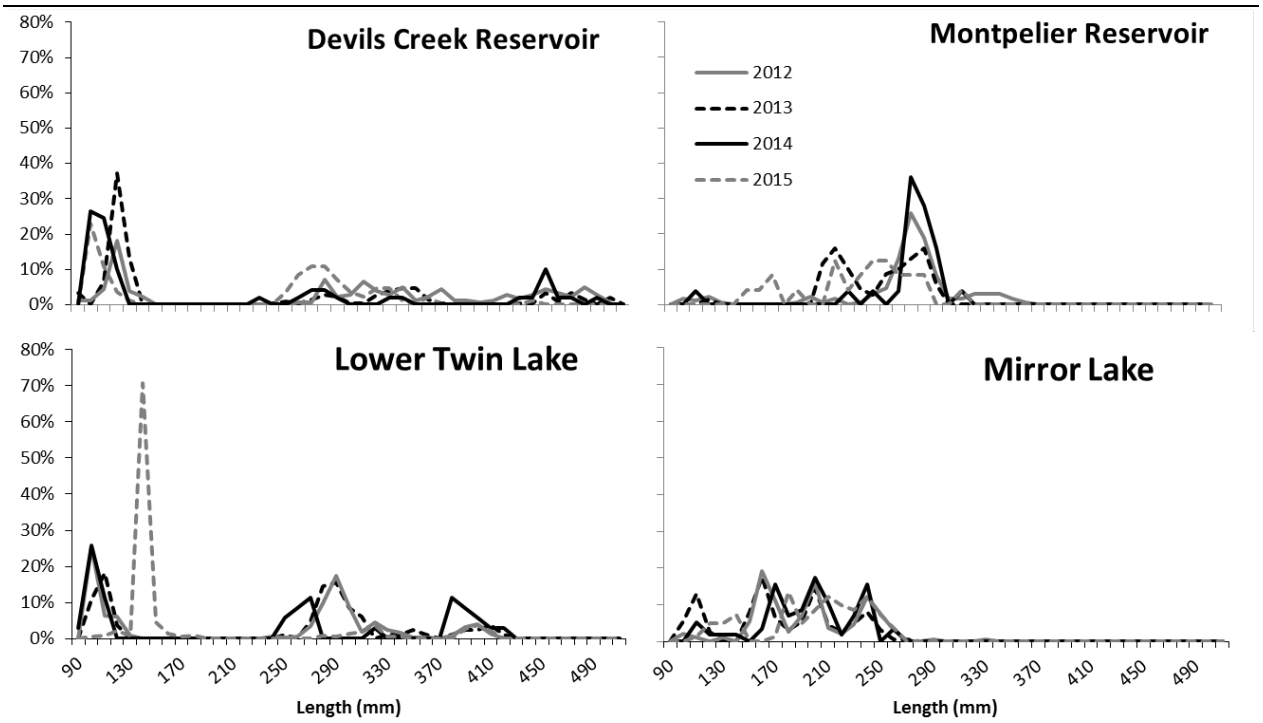

Figure 5. Length distribution (by percent) of Kokanee Salmon across the four different study water bodies. These distributions represent samples taken in the summer of 2012, 2013, 2014, and 2015.

APPENDICES

Appendix A. Harvest and total catch of tagged hatchery catchable Rainbow Trout released in 2011, 2012, and 2013 by water and IDFG region. Harvest and catch estimates for each water represent the average rates for all releases within the first year at large. For treatment- and date-specific return rates by water, see appropriate yearly Hatchery Trout Evaluation Reports.

		2011 Releases		2012 Releases		2013 Releases	
Region	**Water Body**	**Harvest Estimate**	**Catch Estimate**	**Harvest Estimate**	**Catch Estimate**	**Harvest Estimate**	**Catch Estimate**
1	Bull Moose Lake	33.5%	40.5%	-	-	-	-
	Calder Pond	-	-	5.7%	5.7%	-	-
	Clee Creek Pond	-	-	14.1%	22.6%	-	-
	Crystal Lake	5.0%	5.9%	-	-	-	-
	Day Rock Pond	-	-	82.6%	96.8%	-	-
	Fernan Lake	5.8%	8.8%	22.9%	27.2%	-	-
	Freeman Lake	16.2%	17.4%	-	-	53.1%	59.4%
	Gold Creek Pond	-	-	0.0%	0.0%	-	-
	Hauser Lake	7.8%	9.0%	-	-	-	-
	Hayden Lake	24.6%	36.1%	-	-	-	-
	Jewel Lake	64.3%	71.3%	-	-	-	-
	Lucky Friday Pond	-	-	46.0%	48.9%	-	-
	Post Falls Park Pond	-	-	53.3%	72.8%	-	-
	Robinson Lake	31.1%	38.0%	-	-	-	-
	Smith Lake	39.1%	41.4%	-	-	-	-
	Steamboat Pond	-	-	11.3%	11.3%	-	-
	Vondale Lake	-	-	-	-	-	-
2	Campbell's Pond	-	-	-	-	-	-
	Deer Creek Reservoir	11.2%	12.6%	23.4%	25.5%	-	-
	Deyo Reservoir	-	-	-	-	24.3%	33.1%
	Dworshak Reservoir	11.4%	13.1%	-	-	-	-
	Elk Creek Reservoir	35.9%	49.2%	23.3%	31.0%	-	-
	Hordeman Pond	42.0%	43.5%	-	-	12.5%	12.5%
	Lake Waha	-	-	14.1%	16.9%	-	-
	Mann Lake	17.4%	29.3%	16.2%	20.8%	11.0%	15.3%
	Moose Creek Reservoir	36.3%	45.4%	20.6%	26.9%	8.6%	9.4%
	Palouse River Dredge Pond	18.4%	18.4%	-	-	-	-
	Robinson Pond	52.2%	70.1%	-	-	-	-
	Snake River	-	-	-	-	-	-
	Snake River Levee Pond	50.9%	69.5%	-	-	25.0%	25.0%
	Soldier's Meadow Reservoir	-	-	6.5%	6.5%	9.1%	11.2%
	Spring Valley Reservoir	61.0%	69.2%	32.0%	36.3%	10.8%	12.2%
	Winchester Lake	43.5%	57.3%	32.5%	38.1%	20.6%	23.7%

Region	Water Body	2011 Releases		2012 Releases		2013 Releases	
		Harvest Estimate	Catch Estimate	Harvest Estimate	Catch Estimate	Harvest Estimate	Catch Estimate
3B	Arrowrock Reservoir	-	-	28.9%	32.6%	23.6%	27.0%
	Big Trinity Lake	-	-	-	-	0.0%	0.0%
	Boise River	31.7%	69.5%	25.7%	41.8%	33.8%	46.9%
	Bull Trout Lake	-	-	-	-	-	-
	Caldwell Pond #2	-	-	73.1%	78.3%	-	-
	Caldwell Rotary Pond	63.6%	82.9%	-	-	-	-
	CJ Strike Reservoir	-	-	21.9%	24.7%	13.3%	18.0%
	Crane Falls Reservoir	-	-	14.0%	23.8%	3.2%	3.2%
	Crooked River	-	-	-	-	-	-
	Duff Lane Pond	-	-	-	-	25.2%	35.6%
	Eagle Island Park Pond	42.8%	58.4%	-	-	-	-
	Ed's Pond	-	-	75.2%	75.2%	-	-
	Grimes Creek	-	-	-	-	-	-
	Horseshoe Bend Pond	-	-	17.9%	23.3%	-	-
	Indian Creek	-	-	-	-	35.0%	67.5%
	Kleiner Pond	-	-	153.8%	179.4%	25.0%	62.5%
	Lucky Peak Reservoir	-	-	24.7%	35.1%	48.0%	58.3%
	Manns Creek Reservoir	6.0%	7.7%	32.6%	36.4%	71.6%	91.3%
	McDevitt Pond	38.7%	60.4%	-	-	-	-
	Middle Fork Boise River	-	-	-	-	-	-
	Middle Fork Payette River	-	-	-	-	-	-
	Mores Creek	-	-	-	-	-	-
	North Fork Boise River	-	-	-	-	-	-
	Mountain Home Reservoir	22.2%	26.8%	3.5%	3.5%	-	-
	Parkcenter Pond	-	-	22.5%	42.3%	-	-
	Payette River	-	-	-	-	6.3%	6.3%
	Payette Greenbelt Pond	-	-	-	-	29.0%	45.5%
	Riverside Pond	-	-	-	-	59.8%	64.3%
	Sage Hen Reservoir	42.9%	60.4%	29.6%	39.1%	44.7%	50.5%
	Sawyers Pond	-	-	14.7%	23.7%	-	-
	Silver Creek	-	-	-	-	-	-
	Settler's Pond	-	-	-	-	50.0%	125.0%
	Succor Creek Reservoir	-	-	4.2%	4.2%	-	-
	Ten Mile Pond	-	-	-	-	62.8%	66.9%
	Weiser Community Pond	-	-	-	-	-	-
	Wilson Creek	-	-	-	-	-	-
	Wilson Springs Pond	68.2%	91.0%	67.7%	95.9%	58.6%	101.6%
	Quinn's Pond	-	-	-	-	12.5%	12.5%
	Veteran's Pond	-	-	-	-	25.5%	31.9%
3M	Cascade Reservoir	7.5%	8.6%	1.4%	2.2%	9.6%	9.9%
	Council Park Pond	-	-	-	-	41.6%	68.7%
	Fischer Pond	-	-	-	-	15.7%	17.2%
	Gold Fork Creek	-	-	-	-	-	-
	Horsethief Reservoir	44.1%	56.4%	34.5%	40.9%	61.3%	70.5%
	Lost Valley Reservoir	45.1%	51.5%	-	-	42.0%	44.5%
	North Fork Payette River	-	-	-	-	-	-
	Rowlands Pond	50.6%	72.0%	-	-	-	-
	Warm Lake	39.6%	50.4%	26.2%	34.7%	21.5%	27.9%
	Weiser River	-	-	-	-	-	-

Region	Water Body	2011 Releases		2012 Releases		2013 Releases	
		Harvest Estimate	Catch Estimate	Harvest Estimate	Catch Estimate	Harvest Estimate	Catch Estimate
4	Anderson Ranch Reservoir	11.6%	16.5%	17.4%	23.0%	-	-
	Big Smokey Creek	-	-	-	-	-	-
	Big Wood River	-	-	-	-	9.5%	28.2%
	Billingsley Creek	-	-	-	-	1.6%	3.1%
	Blair Trail Reservoir	-	-	-	-	0.0%	0.0%
	Camas Pond #3	-	-	48.4%	54.4%	-	-
	Castle Rock Pond	-	-	-	-	-	-
	Connor Pond	0.0%	0.0%	5.6%	5.6%	-	-
	Crystal Lake	-	-	-	-	10.4%	10.4%
	Dierke's Lake	22.9%	54.9%	-	-	-	-
	Dog Creek Pond	-	-	35.4%	50.2%	-	-
	Featherville Dredge Pond	38.6%	54.1%	-	-	-	-
	Filer / LQ Drain Pond	-	-	54.8%	60.3%	-	-
	Frank Oster Lake #1	-	-	70.5%	87.5%	-	-
	Frank Oster Lake #2	-	-	-	-	-	-
	Frank Oster Lake #3	-	-	-	-	-	-
	Frank Oster Lake #4	-	-	-	-	-	-
	Freedom Park Pond	0.0%	0.0%	-	-	37.6%	43.8%
	Heagle Park Pond	-	-	-	-	18.8%	31.3%
	Lake Cleviland	-	-	-	-	59.2%	62.6%
	Lake Creek Lake	-	-	39.7%	51.0%	-	-
	Lake Walcott	5.1%	5.7%	22.8%	24.2%	0.8%	0.8%
	Little Camas Reservoir	28.1%	33.5%	28.6%	34.2%	-	-
	Little Smokey Creek	-	-	-	-	-	-
	Little Wood Reservoir	18.1%	25.0%	4.2%	5.1%	-	-
	Magic Reservoir	9.2%	12.1%	-	-	9.5%	10.5%
	Oakley Reservoir	-	-	-	-	28.9%	36.5%
	Riley Creek Pond	-	-	69.5%	84.7%	9.5%	9.5%
	Rock Creek	-	-	-	-	-	-
	Roseworth Reservoir	9.4%	11.9%	10.9%	16.2%	40.8%	43.1%
	Rupert Gravel Pond	0.0%	0.0%	-	-	0.0%	0.0%
	Salmon Falls Creek Reservoir	8.8%	12.0%	14.4%	18.5%	11.7%	14.2%
	Snake River (Lower)	-	-	-	-	-	-
	Stone Reservoir	-	-	-	-	6.3%	8.3%
	Sublett Reservoir	-	-	-	-	52.1%	76.4%
	Thorn Creek Reservoir	-	-	12.3%	19.3%	-	-
	Trail Creek	-	-	-	-	18.9%	31.6%
	Warm Springs Creek	-	-	-	-	6.3%	12.6%

Region	Water Body	2011 Releases		2012 Releases		2013 Releases	
		Harvest Estimate	Catch Estimate	Harvest Estimate	Catch Estimate	Harvest Estimate	Catch Estimate
5	Alexander Reservoir	-	-	-	-	-	-
	American Falls Reservoir	12.4%	17.1%	12.3%	14.6%	2.0%	2.4%
	Bear River	-	-	11.0%	28.1%	9.2%	23.4%
	Blackfoot Reservoir	35.8%	43.3%	7.9%	10.9%	-	-
	Chesterfield Reservoir	5.8%	9.0%	3.2%	6.7%	5.7%	11.0%
	Crystal Springs Pond	-	-	-	-	-	-
	Deep Creek Reservoir	18.8%	32.0%	7.1%	8.5%	35.6%	50.3%
	Devils Creek Reservoir	25.3%	35.7%	12.5%	16.0%	19.9%	29.3%
	Edson Fichter Pond	-	-	-	-	48.5%	119.9%
	Foster's Reservoir	-	-	-	-	24.0%	30.2%
	Glendale Reservoir	-	-	-	-	36.6%	48.1%
	Jensen Grove Pond	-	-	-	-	-	-
	Lamont Reservoir	-	-	-	-	-	-
	Montpelier Rearing Pond	-	-	-	-	25.1%	34.4%
	Pleasantview Reservoir	-	-	-	-	32.9%	39.1%
	Portneuf River (Upper)	-	-	-	-	-	-
	Rock Creek East Fork	-	-	-	-	-	-
	Rose Pond	-	-	-	-	18.8%	18.8%
	Snake River (Below American Falls)	-	-	-	-	-	-
	Snake River (General)	-	-	-	-	3.2%	7.3%
	Snake River (Upper) R5	-	-	-	-	-	-
	Springfield Reservoir	-	-	-	-	-	-
	Treasureton Reservoir	-	-	-	-	-	-
	Twin Lakes Reservoir	-	-	-	-	40.0%	49.3%
	Wellness Reservoir	-	-	-	-	-	-
	Weston Reservoir	-	-	-	-	49.3%	54.8%
6	Ashton Reservoir	-	-	-	-	20.0%	29.5%
	Big Lost River	-	-	-	-	9.2%	12.7%
	Birch Creek	-	-	39.6%	52.9%	49.2%	58.6%
	Blue Creek Reservoir	-	-	41.1%	43.9%	-	-
	East Harriman Pond	-	-	46.4%	43.3%	-	-
	Henry's Fork	-	-	14.2%	20.2%	15.8%	15.8%
	Island Park Reservoir	25.0%	30.8%	2.2%	3.4%	2.2%	2.6%
	Jim Moore Pond	-	-	25.4%	36.7%	25.0%	36.8%
	Mackay Reservoir	36.0%	53.1%	18.4%	23.5%	37.6%	53.3%
	Rexburg City Pond	-	-	-	-	28.4%	44.0%
	Rigby Lake	-	-	40.4%	53.9%	45.3%	58.9%
	Ririe Reservoir	-	-	-	-	63.6%	77.7%
	Roberts Gravel Pond	-	-	47.9%	50.8%	-	-
	Ryder Park Pond	89.1%	126.2%	59.4%	69.3%	-	-
	Sand Creek Pond #1	-	-	-	-	30.7%	38.8%
	Snake River (General)	-	-	-	-	8.6%	10.3%
	Snake River (Gem State)	-	-	-	-	-	-
	Snake River (Upper) R6	-	-	34.0%	38.8%	8.7%	10.4%
	Snake River Henry's Fork	-	-	-	-	-	-
	Star Hope Lake	-	-	0.0%	0.0%	-	-
	Stoddard Mill Pond	-	-	32.4%	56.6%	-	-
	Trail Creek Pond	52.9%	71.8%	-	-	35.5%	85.2%
	Warm River	-	-	-	-	42.0%	57.1%

Region	Water Body	2011 Releases		2012 Releases		2013 Releases	
		Harvest Estimate	Catch Estimate	Harvest Estimate	Catch Estimate	Harvest Estimate	Catch Estimate
7	Alturas Lake	-	-	-	-	-	-
	Bayhorse Lake #2	-	-	-	-	-	-
	Blue Mountain Pond	-	-	-	-	-	-
	Cape Horn Lake #1	-	-	-	-	-	-
	Hayden Pond	-	-	-	-	-	-
	Hyde Pond	-	-	16.9%	46.1%	-	-
	Iron Lake	-	-	-	-	-	-
	Iron Lake #2	-	-	-	-	-	-
	Kids Creek Pond	25.5%	47.4%	-	-	19.5%	19.5%
	Little Bayhorse Lake	-	-	-	-	-	-
	Meadow Creek Lake	-	-	-	-	-	-
	Mosquito Flats Reservoir	-	-	-	-	33.6%	36.4%
	Salmon River	10.9%	24.3%	15.3%	19.8%	11.5%	15.2%
	Squaw Creek Pond	-	-	-	-	-	-
	Stanley Lake	15.8%	26.2%	14.1%	26.2%	12.0%	15.1%
	Wallace Lake	-	-	-	-	-	-

Appendix B. Waters that correspond with individual identification numbers for Figure 4.

Region	Water	ID No.
1	FernanLake	1
2	DeerCreekReservoir	2
	DeyoReservoir	3
	DworshakReservoir	4
	ElkCreekReservoir	5
	MannLake	6
	MooseCreekReservoir	7
	SoldierMeadowsReservoir	8
	SpringValleyReservoir	9
	WinchesterLake	10
3M	CascadeReservoir	11
	HorsethiefReservoir	12
	LostValleyReservoir	13
	WarmLake	14
3N	ArrowrockReservoir	15
	BullToutLake	16
	CraneFallsReservoir	17
	LuckyPeakReservoir	18
	MannsCreekReservoir	19
	MountainHomeReservoir	20
	SageHenReservoir	21
4	AndersonRanchReservoir	22
	BlairTrailReservoir	23
	Dierke'sLake	24
	DogCreekReservoir	25
	LakeWalcott	26
	LittleCamasReservoir	27
	LittleWoodReservoir	28
	MagicReservoir	29
	OakleyReservoir	30
	RoseworthReservoir	31
	SalmonFallsCreekReservoir	32
	StoneReservoir	33
	SublettReservoir	34
	ThornCreekReservoir	35
5	AlexanderReservoir	36
	AmericanFallsReservoir	37
	BlackfootReservoir	38
	ChesterfieldReservoir	39
	DeepCreekReservoir	40
	DevilsCreekReservoir	41
	GlendaleReservoir	42
	LamontReservoir	43
	SpringfieldReservoir	44
	TwinLakesReservoir	45
	WestonReservoir	46
6	AshtonReservoir	47
	IslandParkReservoir	48
	MackayReservoir	49
	RirieReservoir	50
7	AlturasLake	51
	MosquitoFlatReservoir	52
	PerkinsLake	53
	StanleyLake	54

Prepared by:

John Cassinelli
Senior Fisheries Research Biologist

Approved by:

IDAHO DEPARTMENT OF FISH AND GAME

_____
Daniel J. Schill
Fisheries Research Manager

_____
James P. Fredericks, Chief
Bureau of Fisheries