FISHERY RESEARCH

PROJECT 4: HATCHERY TROUT EVALUATIONS

GRANT # F-73-R-34

Report Period July 1, 2011 to June 30, 2012

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IDFG Report Number 12-11
July 2012

ANNUAL PERFORMANCE REPORT

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Project 4: Hatchery Trout Evaluations

Subproject #1: Use of Tiger Muskellunge to Remove Brook Trout from High Mountain Lakes

Subproject #2: Sterile Trout Investigations: Relative Performance and Recommended Stocking Density for Triploid Westslope Cutthroat Trout in Idaho Alpine Lakes

Subproject #3: Improving Returns of Hatchery Catchable Rainbow Trout: Statewide Exploitation Rates and Evaluating Rearing Density

Subproject #4: Hatchery Catchable Rainbow Trout Performance Between Hatcheries At CJ Strike Reservoir

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IDFG Report Number 12-11
July 2012

TABLE OF CONTENTS

Page

Table of Contents, continued.

Page

LIST OF TABLES

Page

List of Tables, continued.

Page

LIST OF FIGURES

Page

List of Figures, continued.

Page

ANNUAL PERFORMANCE REPORT
SUBPROJECT #1: USE OF TIGER MUSKELLUNGE TO REMOVE BROOK TROUT FROM HIGH MOUNTAIN LAKES

State of: Idaho

Grant No.: F-73-R-34 Fishery Research

Project No.: 4

Title: Hatchery Trout Evaluations

Subproject #1: Use of Tiger Muskellunge to Remove Brook Trout from High Mountain Lakes

Contract Period: July 1, 2011 to June 30, 2012

ABSTRACT

Nonnative brook trout *Salvelinus fontinalis* populations in high mountain lakes threaten the persistence of native fish and often offer limited fishing opportunity because of stunted growth. Elimination of brook trout populations by stocking tiger muskellunge *Esox lucius x masquinongy* may be an efficient means for eliminating some populations, especially in low complexity habitats. Elimination of brook trout populations could contribute to conservation efforts by allowing lakes to be restocked with western salmonids. In 2007, nine alpine lakes containing stunted brook trout populations were planted with tiger muskellunge (40 fish/ha) with an average length of 317 mm. Four additional lakes were not stocked to function as controls. Lakes were surveyed yearly in summer from 2008-2011 to compare changes in brook trout size and abundance relative to 2005/2006 data. Relative abundance of brook trout varied widely among the nine study lakes but declined substantially in most lakes, while average length and weight increased noticeably following stocking with tiger muskellunge. Mean catch rates of brook trout declined from 22.8 per net-night before planting tiger muskellunge, to 2.6 per net-night in 2011, with no brook trout having been caught in two lakes. Prior to tiger muskellunge, mean brook trout length and weight was 212 ± 3 mm (n = 519) and 88 ± 5 g, respectively. Four years after stocking tiger muskellunge, mean brook trout length was 256 ± 10 mm (n = 138) and 188 ± 42 g in 2011. Catch rates of brook trout declined slightly in control lakes, but size distributions remained largely unchanged. The initial attempt to use habitat characteristics to classify lakes according to the likelihood of eradicating brook trout was generally not an accurate predictor of results, suggesting these characteristics were not the primary factors driving successful tiger muskellunge predation of brook trout. If only using tiger muskellunge, brook trout may overcome eradication efforts by recolonizing lakes from refuge habitats and by density-dependent recruitment success. I recommend combining tiger muskellunge introductions with other suppression methods in lake tributaries or outlets to increase the chances of eliminating brook trout.

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INTRODUCTION

During the early 20th century, brook trout *Salvelinus fontinalis* were introduced to high mountain lakes throughout the western United States and Canada, including Idaho. Most introduction efforts ceased by the 1950s, but by this time, brook trout had established self-sustaining populations in many lakes. Although some of these populations have sustained recreationally important fisheries (Donald et al. 1980), the vast majority do not offer quality fishing opportunities. More importantly, some of these populations threaten the persistence of native fish and amphibian populations.

According to Bahls (1992), over 95% of the deep, high mountain lakes in western North America were fishless prior to human introduction of salmonids. Therefore, establishment of salmonids, including brook trout, in high mountain lakes did not likely reduce numbers of native fish substantially within these habitats; however, these introductions have been linked to declines in other native biota such as amphibians (Pilliod 2001; Murphy 2002) and downstream fish populations. High elevation streams contain some of the strongest remaining cutthroat trout *Oncorhynchus clarkii* and bull trout *Salvelinus confluentus* populations. Headwater lakes within these drainages often contain nonnative trout and may act as source populations for colonization of nonnative fish into downstream habitats (Adams et al. 2001). These authors found that brook trout were capable of invading habitats by their ability to disperse downstream through 80% slopes and over 18 m waterfalls. Brook trout have the ability to outcompete cutthroat trout (De Staso and Rahel 1994) and may eventually eliminate some cutthroat trout populations (Kruse et al. 2000). Additionally, brook trout may hybridize with or displace bull trout, thereby reducing or eliminating some populations (Kitano et al. 1994; Kanda et al. 2002).

Within high mountain lakes, brook trout are capable of spawning in inlet and outlet tributaries, as well as lake margins (Fraser 1989). Due to a combination of abundant spawning habitats, early age at maturity, and few predators, brook trout populations often reach very high densities (Donald and Alger 1989). Since most high mountain lakes are low in productivity, high-density brook trout populations are often prone to stunting (Donald and Alger 1989; Hall 1991; Parker et al. 2001), at which point they become of marginal interest to anglers (Rabe 1970; Donald et al. 1980; Donald and Alger 1989). In this case, fisheries managers may be interested in shifting the size structure of brook trout populations in high mountain lakes to provide higher proportions of quality fish (i.e. those ≥254 mm). In high mountain lakes where complete removal of brook trout is unlikely, investigating techniques to improve the size structure of brook trout populations may be a practical secondary objective.

Biologists have employed several techniques to reduce or eliminate brook trout and other nonnative trout populations from high mountain lakes. Such techniques have included high-intensity gill netting, rotenone application, electrofishing, and introducing piscivorous salmonids. During a brook trout removal effort from a 1.6 ha high mountain lake in the Sierra Nevada mountains in California, three to six gill nets were set per night during the ice-free period for a total effort of 108 net days (Knapp and Matthews 1998). This effort effectively removed the entire population (97 fish) at an estimated cost of $5,600. However, the authors speculated that this technique would not be effective in lakes exceeding 3 ha. With a similar effort, Parker et al. (2001) were able to remove an entire brook trout population (261 fish) from a 2.1 ha lake in Banff National Park, Alberta, Canada. The majority of fish were removed within the first week of netting (54%). Furthermore, within the first year of netting, they suspected that the entire adult population was removed by the time nets were retrieved after ice-off, and only a few juvenile fish were caught thereafter. Walters and Vincent (1973) used rotenone to eliminate brook trout from 1.1 ha Emmaline Lake, Colorado. However, biologists rarely use this method in high lakes due to cost and difficulty of application and subsequent detoxification of outflow, and the negative perception associated with applying chemicals in remote, relatively pristine areas or designated wilderness.

Using piscivorous fish is an attractive alternative for managing brook trout populations in that little effort is needed besides an initial stocking effort and subsequent monitoring. However, results for this technique have been inconsistent. The state of Colorado occasionally stocked lake trout *Salvelinus namaycush* and brown trout *Salmo trutta* in high mountain lakes to control brook trout populations (Nelson 1988). From 1960-1964, experimental plants of lake trout were made in five lakes, and lake trout established self-sustaining populations in all five lakes. By the early 1980s, no response in brook trout populations was noted in two lakes, numbers of brook trout were decreased in two other lakes, and they were eliminated, or nearly so, from one lake. Nelson (1988) also noted that brook trout lakes that contained brown trout had lower densities of brook trout, with more brook trout over 250 mm.

Similar attempts have been made in Idaho using Kamloops rainbow trout *O. mykiss*, bull trout, and brown trout. In 1993, Idaho Department of Fish and Game (IDFG) personnel stocked 702 Kamloops rainbow trout in Carlson Lake in an effort to improve the size structure of stunted brook trout (Brimmer et al. 2002). Unfortunately, this attempt was unsuccessful, as the brook trout size structure in the lake was unchanged. Kamloops rainbow trout were stocked at an average weight of 133 g (3.7 per lb) and an approximate length of 200 mm (8”). These fish were likely too small at stocking to exert significant predation pressure, and due to high densities of brook trout, were likely not able to grow large enough to do so. Similar efforts were made in several lakes within Region 4 and the McCall subregion, but to date, none of these efforts have been successful in eliminating or even reducing brook trout densities from their respective lakes (P. Janssen and F. Partridge, IDFG, personal communication).

Tiger muskellunge *Esox lucius X masquinongy* are a cross between a male northern pike *E. lucius* and a female muskellunge *E. masquinongy*. Tiger muskellunge have been stocked in lakes and reservoirs throughout the northern United States to provide trophy angling opportunities (Storck and Newman 1992) and to control prey, rough, and pan-fish populations (Wahl and Stein 1993). Tiger muskellunge are preferred over their parental species due to their superior growth rates, ease of hatchery rearing, intermediate angling vulnerability (Weithman and Anderson 1977; Brecka et al. 1995), and because they are functionally sterile (Crossman and Buss 1965). Sterility allows biologists to stock tiger muskellunge with no threat of creating self-sustaining populations. Tiger muskellunge are highly effective predators on a variety of fish but prefer soft-rayed fusiform prey (Tomcko et al. 1984). When in high densities, muskellunge have been shown to limit densities of prey species such as white suckers *Catastomus commersonii* and black crappie *Pomoxis nigromaculatus* (Siler and Beyerle 1986), showing promise as a means to manage unwanted brook trout populations.

During 1998 and 1999, IDFG personnel began a management case study to determine if tiger muskellunge could eliminate brook trout from Ice Lake and Rainbow Lake, two high mountain lakes in the Clearwater region. Tiger muskellunge were stocked into Ice Lake at a density of 41 fish/ha (E. Schriever and P. Murphy, IDFG, personal communication). To suppress brook trout further, IDFG personnel removed fish from inlet and outlet habitats with backpack electrofishing gear. From 1998 to 2001, catch in a single gill net declined from 17 fish to zero fish per net-night. Although some fry were seen in the inlet and outlet, the brook trout population in Ice Lake had been substantially reduced and possibly eliminated with one tiger muskellunge stocking. In Rainbow Lake, tiger muskellunge were stocked during 1999 and 2000 at densities of 6.1 and 33.6 fish/ha, respectively. An initial survey during 1998 indicated that brook trout densities were high (85 fish per net-night). By 2001, two years after the initial introduction of tiger muskellunge, brook trout catch decreased to 10 fish per net-night. The authors speculated that brook trout would not likely be eliminated from Rainbow Lake with tiger muskellunge predation and backpack electrofishing, due to the size of the inlet and outlet. They anticipated instead that reduced densities would improve the size structure of the remaining brook trout, thereby improving fishery quality (E. Schriever and P. Murphy, IDFG, personal communication).

Tiger muskellunge have also been used by IDFG personnel in Region 7 to improve the size structure of brook trout in Carlson Lake. Carlson Lake once produced trophy size brook trout but recently only contained small stunted fish (Brimmer et al. 2002). Prior to introduction of tiger muskellunge, a population estimate indicated that the lake contained 9,900 brook trout. During 2002, forty-one tiger muskellunge were introduced. By 2003, the brook trout population had decreased by an estimated 8.5% (Esselman et al. 2004). No additional population assessments have been attempted due to high mortality of tiger muskellunge in gill nets but will be attempted in future years.

Although encouraging, the results of the two IDFG management efforts above do not provide the scope necessary to reach firm conclusions regarding the utility of tiger muskellunge for eliminating undesirable brook trout populations. In this progress report, I describe initial efforts to investigate the effectiveness of introducing tiger muskellunge to reduce or eliminate brook trout populations in alpine lakes in Idaho. I compare changes in brook trout populations and relative density following tiger muskellunge introduction.

RESEARCH GOAL

1. To eliminate or improve the size structure of brook trout populations from high mountain lakes, thereby reducing threats to native species and allowing restocking of lakes with sterile western salmonids to improve recreational angling opportunities.

OBJECTIVES

1. To determine if tiger muskellunge stocked at densities of 40 fish per hectare into high mountain lakes with stunted brook trout populations can cause recruitment failure and eventual elimination of populations within five years.

2. To determine lake and associated inlet or outlet characteristics that influence success/failure of brook trout eradication efforts with tiger muskellunge.

METHODS

During 2005, IDFG regional fisheries personnel and U.S. Forest Service personnel provided high mountain lake information that facilitated study site selection. Lakes that were known to have brook trout populations and were thought to have limited inlet and outlet spawning habitats were preferentially selected for this study. Steep drainages were preferred, as they most likely possessed barriers that would prevent recolonization by any downstream brook trout populations. Nine lakes throughout central Idaho received tiger muskellunge for this evaluation (Figure 1). Additionally, brook trout densities were monitored at four additional control lakes that had established brook trout populations and were in close proximity to the treatment lakes, but did not receive tiger muskellunge.

Lake Sampling

Study lakes were sampled during 2005 or 2006 to determine relative density, age, and size structure of brook trout populations as well as habitat characteristics. All lakes were surveyed with floating gill nets and angling from August 4 to September 29, 2005, except for Grass Mountain #1, Grass Mountain #2, and Corral Lake, which were surveyed in July 2006. The experimental gill nets used had 19, 25, 30, 33, 38, and 48 mm bar mesh panels and were 46 m long by 1.5 m deep. Typically, four gill nets were set in the early afternoon and pulled the following morning. While nets fished, the two- or three-person crew used spin- and fly-fishing gear to collect additional samples. Captured fish were identified to species, measured to the nearest millimeter (total length), and weighed to the nearest gram. Catch-per-unit-effort (CPUE) of brook trout was calculated by lake as the total brook trout caught per net-night. Angling CPUE was calculated as the total number fish caught per hour angling. Gill net CPUE was used as an estimate of relative abundance before and after stocking tiger muskellunge. See Kozfkay and Koenig (2006) for complete descriptions of age structure, size distributions, and mortality estimates.

Tiger muskellunge were reared at Hagerman State Fish Hatchery. Some authors have indicated that tiger muskellunge reared only on pellet diets are less effective predators on live fish and do not survive well after stocking (Gillen et al. 1981). Tiger muskellunge were therefore converted to live brook trout two weeks prior to stocking to make them more effective predators in the wild and increase their survival after stocking. Tiger muskellunge were stocked on June 12, 2007 into the study lakes. At the time of stocking, the mean length of the tiger muskellunge was 317 mm but ranged from 160 to 400 mm. Tiger muskellunge were planted by helicopter using an adjustable-volume fire bucket set at 946 liters (250 gallons). Tiger muskellunge were counted by hand before each flight, and densities in the fire bucket did not exceed two fish/gallon. Stocking density of tiger muskellunge was held constant across lakes at 40 fish/ha for 2,929 total fish planted (Table 1).

Study lakes were resampled first in 2008, approximately 13 months after tiger muskellunge were planted, and again yearly from 2009 to 2011. Fish were sampled using two floating gill nets (set overnight) and processed according to the methods above. However, only two nets were fished at each lake in an effort to reduce bycatch of tiger muskellunge. Additional samples of brook trout and tiger muskellunge were collected with hook and line techniques using a variety of flies and lures.

Lake habitat and amphibian surveys were conducted at each of the nine lakes at the time fish were sampled in 2008 and 2009. A series of five transects were placed at equal distances perpendicular to the long axis of the lake with the aid of a laser rangefinder. Lake width was measured at each transect using a laser range finder. Depth was measured with a handheld sonar unit at five equidistant points along each transect. Specific conductivity, pH, and surface temperature were measured at the middle of each transect using Hanna handheld conductivity and temperature/pH meters (Model #HI 98308, DiST 4 and #HI 98127). Lake location and elevation were recorded with the use of a handheld GPS unit. Lake area was calculated with geographic information systems (ArcGIS 9.1). In addition, amphibian surveys were conducted visually by slowly walking the entire perimeter of each lake along the water shore interface and looking near and under woody debris and recording the count, life stage, and species encountered. Basic stream habitat data were collected in inlet and outlets of study reservoirs in an effort to collect information that might help explain eradication success. Measurements were performed over the first 200 m of stream above (inlets) and below (outlets) each lake. Bankfull width was collected every 25 m and the area of suitable trout spawning habitat was estimated using a meter stick. Elevation was measured at the lake level and at the end of each stream reach with a handheld GPS unit. Stream gradient was calculated by dividing the difference in elevation from the start and end of the reach divided by the reach length.

Removal potential (the likelihood that brook trout would be successfully eradicated) at each lake was categorized with a qualitative value based on the following criteria:

- Very High: lakes with no inlet and/or outlet spawning habitat; low habitat complexity within the lake.

- High: lakes contain only limited inlet and/or outlet spawning habitat; lake outlets possess migration barriers.

- Moderate: lakes contain some accessible inlet and/or outlet spawning habitat.

- Low: lakes contain abundant inlet and/or outlet spawning habitat; low gradient outlets with spawning habitat present, connections to lentic habitats with established brook trout present.

Management Actions

In fall 2010, Region 3 McCall fisheries staff determined conditions in Grass Mountain #1 and #2 were sufficient to justify additional management actions. Brook trout densities were significantly reduced and tiger muskies were in very low numbers in 2009, and none were found in 2010 (Table 4). However, brook trout were still present in the stream connecting the Grass Mountain lakes, and were unlikely to be impacted by tiger muskellunge. Brook trout were also present below the lakes in the outlet of Grass Mountain #2. Brook trout in these locations were likely to persist without further action and represented a source population that could recolonize each lake and reverse previous efforts to reduce brook trout densities. Nampa Research staff assisted Region 3 McCall with a chemical treatment using rotenone applied to the connecting stream of the Grass Mountain #1 and #2 lakes and the outlet of the lower lake. Details describing the treatment can be found in Appendices A and B.

Stream discharge was estimated on the day of treatment using a fluorescein dye (to estimate mean velocity) and mean width and depth measurements. The outlet of the upper lake (0.16 cfs) was treated with a drip can for 2 hours at 2.0 ppm (70 ml of rotenone). The outlet of the upper lake constituted approximately 300 m of stream before entering the lower lake. No deactivation station was used, as the lake would sufficiently dilute the chemical. A backpack sprayer was used to treat standing pools in the lower segment, just above the lower lake where stream velocities were too low for effective treatment with the drip station. The outlet of the lower lake (0.17 cfs) was treated at 1.5 ppm for 2 hours with a total of 60 ml rotenone. The target treatment reach was approximately 305 m of stream before reaching a natural fish barrier. Below the fish barrier, a potassium permanganate deactivation drip station was operated. The drip station administered a 4.5 ppm potassium permanganate solution for 3 hours.

RESULTS

Lake Sampling

Relative abundance of brook trout varied widely among the nine study lakes, but most lakes saw substantial declines in CPUE and increased average size of brook trout in the years following introduction of tiger muskellunge. In 2008, sampling of the nine high mountain lakes stocked with tiger muskellunge yielded 132 brook trout and 49 tiger muskellunge, which were the only two species collected. The majority of the brook trout sampled were caught at Merriam Lake (*n* = 70), while catch at all other locations ranged from one to 16 total brook trout. Mean CPUE ranged from one to 17.5 brook trout per net-night, with an average of 5.1 per net-night overall. Catch-per-unit-effort at several lakes (Black, Corral, and Grass Mountain #2) was equal or less than one trout per net-night, indicating very low densities only one year after tiger muskellunge were introduced.

In 2009, sampling the nine treatment lakes yielded 138 brook trout and 30 tiger muskellunge. Merriam Lake again had the largest number of brook trout sampled (*n* = 63), while no brook trout were captured at Black, Corral, and Granite Twin lakes (Table 2). In general, CPUE of brook trout continued to decline in 2009 with some exceptions. Mean catch rates of brook trout were 4.3 per net-night, with 301 hours of netting to capture 78 total brook trout. No brook trout were captured in three of the nine lakes, including Black, Corral, and Granite Twin lakes (Table 2). Granite Twin Lake showed a marked decline from 5.5 to zero brook trout from 2008 to 2009, suggesting continued predation by tiger muskellunge, despite no additional stocking. Even though the average gill net catch rate continued to decrease, CPUE actually increased in three other lakes since 2008 (Table 2).

In 2010, sampling yielded 84 brook trout and only 12 tiger muskellunge with a mean catch rate of 3.9 brook trout per net-night. CPUE remained consistent at five lakes but increased at Granite Twin and Shirts lakes, probably from young brook trout present there in 2009 but too small to recruit to the gill nets until this year. CPUE continued to decline at Grass Mountain #1 and #2 lakes. As in years past, Merriam Lake produced the largest number of brook trout (*n* = 38), while no brook trout were collected at Black and Corral lakes. Overall, these data show much lower trout catch rates compared to pretreatment surveys, which averaged 22.8 brook trout per net-night (Table 2).

In 2011, sampling yielded 76 brook trout and 17 tiger muskellunge. Mean catch rates for brook trout were 2.6 per night with 314.7 hours of gill netting (Table 2). CPUE ranged from zero to 12.5 trout per net-night. Brook trout catch rates in treatment locations remained low in 2011 and were similar to those in 2010 in most locations, except Spruce Gulch, which showed a noticeable decline from 2008-2010 results. As in previous years, Merriam Lake again produced the largest number of brook trout, accounting for the majority of brook trout sampled from treatment lakes (Table 2). No brook trout were sampled from Black and Corral lakes for the third year in a row, and only one brook trout was sampled from Granite Twin Lakes. Overall, brook trout appeared to be persisting in most of the lakes, but at very low densities that remained consistent over the last three years of sampling (Figure 5).

After tiger muskellunge were introduced, angling catch rates of brook trout in 2008 were low overall but heavily reduced in the two lakes where angling data were comparable (Table 2). In 2008, 63.5 total hours of angling were expended which produced 41 brook trout. However, Merriam Lake accounted for 35 of these trout alone, and angling success was poor at most lakes. Without Merriam Lake, the mean angling CPUE for brook trout decreased from 0.55

trout/hr to 0.15 trout/hr. Before introducing tiger muskellunge, mean catch rates of brook trout were 1.5 trout/hr, based on Corral Lake and Shirts Lake. In 2009, mean angling catch rates increased slightly to 0.60 trout/hr, mainly as a result of increased catches from Grass Mountain #1 and Upper Hazard lakes. As with the gill net surveys, no brook trout were caught angling from three lakes, including Black, Corral, and Granite Twin lakes. Angling effort was lower in 2010, but catch rates remained comparable to previous years. As in 2009, no brook trout were caught by angling in Black, Corral, and Granite Twin lakes, and additionally none in Grass Mountain #1 or Upper Hazard lakes (Table 2). In 2011, 20.80 total hours of angling effort yielded 29 brook trout. Similar to gill nets, Merriam Lake accounted for most of the brook trout sampled (93%). Catch rates were low in all lakes, with Grass Mountain #2 and Upper Hazard each producing only one brook trout, while no fish were caught in Black, Granite Twin, Shirts, and Spruce Gulch lakes. The mean angling CPUE for 2011 was 0.45 trout/hr, but only 0.21 trout/hr when not including Merriam Lake.

The overall size distribution of brook trout noticeably shifted after tiger muskellunge were stocked (Figure 2). Despite variation in size across lakes, the mean size of brook trout increased slightly compared to 2005/2006 (pre-tiger muskellunge) within one year, based on 95% confidence intervals (Table 3). In 2008, the overall mean brook trout length and weight was 246 ± 6 mm (n = 132) and 161 ± 11 g, compared to 212 ± 3 mm (n = 519) and 88 ± 5 g before tiger muskellunge were introduced (Table 3). In 2009, mean brook trout size again increased in four out of five lakes where they were caught (no brook trout were caught in three of the study lakes). Brook trout averaged 264 ± 7 mm (n = 138) in length, with a mean weight of 181 ± 15 g (n = 138). Only Upper Hazard showed a small decline in mean length, although not significant based on 95% confidence intervals (Table 3). Average size decreased slightly in 2010, most likely from small fish caught at Granite Twin Lakes and Shirts Lake. Brook trout averaged 237 ± 7 mm (n = 84) in length, with a mean weight of 187 ± 16 g (n = 69). In 2011, the average length was 256 ± 10 mm (n = 76), with a mean weight of 188 ± 42 g (n = 42), showing a slight increase over previous years.

While small sample sizes at some lakes likely precluded meaningful comparisons of mean length (Black, Corral, Grass Mountain #2, and Shirts), the distribution of brook trout sizes indicates an increase in the proportion of larger sized fish, increasing average size and trophy potential at most lakes (Table 2, Figure 3). In the pretreatment surveys, about 40% of the brook trout sampled were ≤200 mm, compared to only 5% in 2008 and 2009. The percent of brook trout ≤200 mm increased to 24% in 2010, mainly from fish found in Shirts, Granite Twin, and Upper Hazard lakes, but then decreased in 2011 to 11%. Prior to tiger muskellunge, 18% of brook trout were ≥254 mm, and of those, only 4% were ≥279 mm. Sampling in 2008-2011 showed that on average, 40-63% of brook trout equaled or exceeded 254 mm, with 17-30% equal or greater than 279 mm. These data indicate a marked increase in the proportion of larger brook trout in the sample, corresponding with lower overall abundance.

Tiger muskellunge were more common soon after stocking (as expected), but only remain in low densities in some lakes. In 2008, tiger muskellunge were documented in all lakes except Shirts Lake, while in 2011 they were only confirmed in five lakes. Currently, Black Lake appears to have the largest number of tiger muskellunge encountered (Table 4), but numbers are too low to compare across lakes. The mean length of tiger muskellunge increased from 460 mm in 2008 to 626 mm in 2011 (Table 4).

In contrast to lakes that received plants of tiger muskellunge, the four control lakes saw little change in brook trout populations. Mean length and weight of brook trout was not markedly different between years (Table 5), and catch rates (both angling and gill nets) of brook trout decreased only slightly from 2009 (Table 6).

Potential study lakes included a wide variety of physical habitat characteristics and inlet and outlet morphologies (Table 1). However, there was no consistent pattern of success in relation to perceived potential for elimination at the time the study was initiated. Spruce Gulch and Corral lakes were considered to have “very high” probability for elimination. These lakes had little or no inlet/outlet spawning habitat, limited tributary habitat with barriers nearby, and low complexity lake habitat. At this time, brook trout are heavily reduced in Corral Lake (if not absent), but are still present in Spruce Gulch Lake. The potential for elimination at Granite Twin, Merriam, and Shirts lakes was thought to be “high.” These lakes had only limited spawning habitat in inlet tributaries and possessed migration barriers in outlet tributaries. While brook trout were reduced in Granite Twin and Shirts lakes, Merriam Lake has shown almost no change and CPUE remains consistent. The brook trout population in Black Lake, Upper Hazard, Grass Mountain #1, and Grass Mountain #2 lakes were considered to have “moderate” elimination potential because of easily accessible spawning habitat and tributary refuge habitat where brook trout might escape predation from tiger muskellunge. Brook trout were heavily reduced in Black Lake, yet were still present in Upper Hazard, Grass Mountain #1, and Grass Mountain #2 lakes.

Management Actions

No live fish were seen in the outlet of the upper Grass Mountain Lake after the chemical treatment was completed in 2010. One live brook trout was found in the lower portion of the treatment reach for the lower lake outlet. There was a small spring seep, which was missed during the primary treatment. This was subsequently treated with an additional 5 ml of rotenone. No dead fish were found below the deactivation station at the end of the treatment. Brook trout were the only species observed during the treatment.

Following treatment, both lakes were stocked by aircraft with trout fry in fall 2010 from the McCall Hatchery. The lower Grass Mountain Lake received 1,500 triploid rainbow trout fry and 700 westslope cutthroat trout fry. The upper Grass Mountain Lake was stocked with 2,200 westslope cutthroat fry. I did not find any evidence of this stocking group in 2011, but fish were likely too small to be recruited to gill nets. Further sampling in 2012 might indicate whether stocking was successful.

DISCUSSION

Prior to introducing tiger muskellunge, most lakes in this study generally contained small brook trout. On average, only a small proportion (18%) of the trout sampled were over 254 mm (ten in). Brook trout populations were characterized by an abundance of younger year classes and slow growth rates, especially after age-4 (Kozfkay and Koenig 2006). Thus, these populations were likely of limited interest to anglers and presented an opportunity for improvement. Removal of these stunted brook trout populations could help conserve native species and may improve recreational fishing opportunities if the lakes are restocked with native salmonids.

Most lakes planted with tiger muskellunge showed substantial declines in CPUE and increased average size of brook trout quickly following stocking with tiger muskellunge. Conversely, control lakes that did not receive tiger muskellunge showed little or no change in relative abundance or average size of brook trout. Even though sampling effort was lower in post-treatment surveys compared to pretreatment surveys (in an effort to avoid sacrificing tiger muskellunge), results suggest that brook trout populations were severely reduced following tiger muskellunge stocking in 2007. Tiger muskellunge were highly effective predators on brook trout in most study locations. The effectiveness of the tiger muskellunge was probably improved by their large average size at the time of stocking (>300 mm) and previous experience with live brook trout (in the hatchery). In general, esocids survive better and have higher foraging success when reared on a diet of live fish, and are stocked at larger sizes (>250 mm) in the spring, with high densities of suitable prey (Storck and Newman 1992; Szendrey and Wahl 1996; Larscheid et al. 1999; Wahl 1999). This corresponds well with the design of this study and the conditions found in these lakes.

While brook trout catch rates declined, average length generally increased following tiger muskellunge stocking. Mean brook trout lengths likely increased because of lower density (i.e. reduced competition), or because the largest individuals escaped predation through avoidance or exceeding the gape limitation of the tiger muskellunge. Anderson (1973) suggested that large piscivores could improve the size structure of prey populations by reducing prey densities and triggering compensatory increases in growth. Similarly, Donald and Alger (1989) reported increases in mean weight for all age classes of brook trout in a subalpine lake when subjected to only 20% exploitation. Reductions in brook trout were undoubtedly facilitated by the stocking density of 40 tiger muskellunge per hectare, well beyond the 25 fish/ha considered “high” by Storck and Newman (1992).

Despite the increase in mean brook trout length in most lakes, mean length actually declined in 2010 in Granite Twin, Shirts, and Upper Hazard lakes. Planting tiger muskellunge in Upper Hazard Lake did not seem to have a significant impact, and tiger musky appeared to be in very low densities since 2008, suggesting little impact to brook trout. The decrease in mean size in Granite Twin and Shirts lakes is likely the result of a young year class of brook trout that were present in 2009, but too small to recruit to the gill nets or angling. No brook trout were sampled in Granite Twin Lake in 2009, and only two were caught in Shirts Lake in 2009, despite fry being present in both lakes at that time. These lakes appear to have a new year class of brook trout entering the population. In 2011, catch rates of brook trout declined as mean size increased, suggesting continued predation and limited recruitment. As tiger muskellunge densities decline, brook trout might experience less predation pressure. Consistent low catch rates from 2010 and 2011 surveys suggest that brook trout have yet to rebound in most lakes where tiger muskellunge are still present. Further sampling in years to come may be needed to monitor whether brook trout can reestablish themselves or if existing tiger muskellunge will continue to limit their success.

The initial attempt to classify lakes by the likelihood of eradicating brook trout was generally not an accurate predictor of results. This suggests I have an incomplete understanding of the primary factors driving successful brook trout eradication by tiger muskellunge, at least two years after stocking. For example, Merriam and Shirts lakes were thought to have “high” probability of eradication, when in fact these lakes showed the least success of all. Black Lake was considered to have only “moderate” probability of success, but results suggest much greater impact to brook trout than first anticipated. Only at Corral Lake did results mirror those anticipated by classifying probability of eradication as “very high.”

Merriam Lake showed almost no effect from stocking tiger muskellunge. Unlike any other lakes in this study, Merriam Lake actually saw a marked increase in CPUE for both gill nets and angling in 2008, followed by similar catch rates in 2009 and 2010. Merriam Lake sits at the highest elevation of the study lakes and had the lowest average temperature, with only one tiger muskellunge having been observed in 2008. Conditions here may have been unfavorable for tiger muskellunge, and predation pressure on brook trout may have been light. Regardless of poor tiger muskellunge survival in Merriam Lake, mean brook trout length still increased and smaller size classes were heavily reduced (Figure 2). Removal of brook trout in Merriam Lake is unlikely without future action.

Brook trout catch rates in Spruce Gulch declined by about half of pre-tiger muskellunge rates in 2008, but remained similar in 2009 and 2010, followed by another reduction in 2011. Tiger muskellunge in Spruce Gulch were the smallest captured in 2008, but the number observed over time suggests moderate survival compared to other lakes. Catch of large brook trout was consistent until 2011, when only two were captured. At this time, it appears that both brook trout and tiger muskellunge continue to persist at low densities, and it is unknown whether brook trout will be eliminated from Spruce Gulch without additional management actions.

Brook trout declined in some lakes more quickly than in others, and declines continued through 2011 in most lakes. In 2008, Corral Lake showed the largest reduction in CPUE of brook trout of all the lakes planted with tiger muskellunge, and no brook trout have been captured during 2009-2011 surveys. The lake habitat appears ideal for lie-in-wait predators like tiger muskellunge. Corral Lake is shallow, with abundant submerged woody debris and emergent aquatic vegetation. It is a small lake with the lowest elevation of those planted and summer water temperatures that may be suited for tiger muskellunge growth. Faster growing tiger muskellunge would be able to eat progressively larger prey, thereby reducing the fraction of the brook trout population that would otherwise exceed the gape limitation. Granite Twin Lake also showed rapid declines in brook trout, with none having been collected in 2009. However, more recent data suggests a very low density brook trout population persists. Similarly, Black Lake showed rapid declines in brook trout, with none having been caught during 2009-2011. Although no brook trout were sampled, they are likely still present in the outlet of Black Lake. Continued presence of tiger muskellunge may be limiting their recruitment success.

Upper Hazard Lake showed only a moderate reduction in brook trout catch rates and a modest increase in mean brook trout length in both survey years. Even with abundant complex shoreline habitat (in terms of boulders and woody debris), tiger muskellunge only had a minor impact to brook trout. This is one of the larger lakes in the study (15.8 ha), with an average depth over 7 m and a maximum recorded depth of 21.4 m, suggesting a large amount of pelagic habitat. Tipping (2001) found tiger muskellunge preferred shallow water macrophytes (3-5 m deep) in summer and fall. He speculated that this habitat preference likely reduced their opportunity to prey on salmonids, which are generally pelagic. This tendency for salmonids to occupy pelagic zones while tiger muskellunge remain mainly littoral might help explain the lower success of eradication efforts in larger lakes like Upper Hazard, despite abundant littoral cover for concealment. This pattern might also apply to Merriam Lake, which despite its smaller surface area, has higher average and maximum depths, corresponding to its steep shorelines and limited littoral habitat.

Despite heavy predation by tiger muskellunge, complete eradication might have only been achieved in Corral Lake and Black Lake at this time, as at least some brook trout were found in all other lakes. Although no brook trout were sampled in 2009-2011, brook trout may still be present at very low levels in Corral Lake and Black Lake. No brook trout were sampled at Black Lake in 2009 or 2010, but one was seen in the outlet in 2010, suggesting a very low-density population. At this point in the study, these results are similar to those reported from previous IDFG studies to manage brook trout in Lower Rainbow Lake and Ice Lake in the Clearwater River drainage (Schriever and Murphy, *In Press*). These lakes were stocked with tiger muskellunge in 1999 and affected brook trout with mixed results. Lower Rainbow Lake (4.5 ha) was initially stocked with a low density of tiger muskellunge, then restocked again with a higher density (40.7 fish/ha) a year later. Brook trout densities decreased while mean length increased following treatment, but eradication was never achieved. Failure to remove brook trout was likely a result of lower tiger muskellunge stocking density, abundant complex lake habitat, and extensive inlet and outlet habitat that reduced the effectiveness of tiger muskellunge to consume brook trout. Brook trout were successfully removed from Ice Lake, which is a very small lake (0.54 ha) and was stocked with a high density of tiger muskellunge (40.7 fish/ha surface area). Stocked in 1999, tiger muskellunge were observed until 2001, but no brook trout were observed in 2002. Small lake size, minimal inlet/outlet habitat, and low complexity lake habitat likely helped to remove brook trout. Within both mountain lakes, tiger muskellunge introductions were coupled with electrofishing removal of brook trout from lake inlets and outlets. Together, these significantly changed the composition of the brook trout population and decreased overall brook trout abundance in these two lakes (Schriever and Murphy, *In Press*).

More recently, Rhodes et al. (2007) reported similar findings in four additional lakes in the Clearwater drainage treated with tiger muskellunge in 2006. Fly, Heather, Platinum and Running lakes range in size from 1.0 ha to 8.4 ha and were stocked with tiger muskellunge at similar densities (40 fish/ha). Their results indicated similar shifts in mean brook trout size, with an overall average increase of 76 mm in length, while catch-per-unit-effort also declined in three of the four lakes simultaneously. Survey results from 2008 showed mean brook trout length again increased, but only in two of the four lakes (Fly and Running lakes), while it decreased in Platinum Lake and remained unchanged in Heather Lake (Rhodes and Dupont 2009). CPUE also decreased in all lakes except Platinum, suggesting that tiger muskellunge continued to reduce brook trout numbers two years after planting. As with previous studies, full eradication was not achieved using tiger muskellunge alone. The current study differs in that no electrofishing removal was conducted to improve eradication efforts at any lakes. However, a chemical treatment was applied to the inlet and outlet complex of Grass Mountain #1 and #2 lakes to aid in reducing brook trout recruitment from nearby refugia. Another important difference with the current study is that tiger muskellunge were only stocked on one occasion across a larger number of lakes. The lakes used in this study were of larger sizes with deeper mean depths, on average, with several lakes over 10 ha in surface area.

At this point in the study, one can only discuss the short-term success of tiger muskellunge to reduce brook trout in mountain lakes. Short-term success is likely dependent on lake morphology and size (shallow, small lakes), while long-term success may likely be a function of brook trout recruitment through reproduction or immigration from inlet/outlet refugia and spawning. The population dynamics and species interactions between tiger muskellunge and brook trout in alpine lakes are poorly understood. Long-term success of eradicating brook trout may hinge on whether tiger muskellunge can live long enough to continue limiting brook trout. If tiger muskellunge exhaust their food resources quickly, they may starve and die off before completely removing brook trout. As with Schriever and Murphy (*In Press*), I also noted that brook trout were present in inlet and outlet streams, away from typical tiger muskellunge habitat. Without further effort to remove brook trout that persist in refuge habitats such as inlet or outlet streams, lakes could be recolonized shortly after tiger muskellunge disappear (Schriever and Murphy, *In Press*). Completely eradicating brook trout using tiger muskellunge may require several stockings to maintain enough predation to collapse a brook trout population. Additionally, brook trout that escape predation may represent the largest most fecund individuals that have the highest chance to repopulate a mountain lake. In the absence of predatory tiger muskellunge, brook trout may rebound quickly, so multiple suppression methods should be combined for the best chance of success. Evidence from 2010 supports this, based on the fact that a new year class of brook trout were captured at Granite Twin and Shirts lakes, from fry that were present in 2009, despite no adults having been captured. However, 2011 data suggests that remaining tiger muskellunge have already begun to reduce this year class, and no brook trout fry were observed in these lakes in 2011.

While complete eradication is unlikely, introducing tiger muskellunge appears to be an effective means to reduce brook trout densities in alpine lakes. After an initial stocking effort, only cursory sampling efforts are needed to document population responses in small, shallow lakes. Tiger muskellunge can live for several years after stocking, thereby removing brook trout for extended periods. In larger, more complex lakes, additional effort may be needed to eliminate brook trout not accessible to tiger muskellunge. Such fish might include those inhabiting outlet and inlet tributaries or near seep springs, unless they are forced to move to the main lake during winter. Both electrofishing and chemical treatment could prove useful in such scenarios.

This study is currently at an important stage, where decisions about using other treatment options should be made. If left untreated, brook trout populations in these lakes are likely to rebound quickly from the few large remaining adults or young brook trout already spawned. In cooperation with Region 3M staff, the inlet/outlets of Grass Mountain #1 and #2 were chemically treated in 2010 and lakes restocked with cutthroat and rainbow trout in an effort to reduce recruitment in the brook trout population and to shift the fishery towards different species less prone to stunting. Current conditions in some lakes (such as Corral Lake) suggest other treatments could be highly successful for eradicating brook trout completely, while conditions in other lakes suggest further efforts are likely futile or too difficult (such as Merriam Lake). Table 7 lists some of the key attributes of each lake that may help guide future treatment options, and whether further treatments should be considered. Smaller lakes with simple inlet and outlet habitat and few numbers of juvenile fish should be a priority, since they offer great benefit at little effort. Larger lakes with little change in brook trout populations and complex habitats would not be worth the effort necessary for successful eradication.

RECOMMENDATIONS

1. Sample all study lakes for one more year in 2012 to evaluate changes in brook trout populations and longevity of tiger muskellunge. Sampling in 2012 will also indicate whether rainbow and cutthroat fry stocking in 2010 was successful.

ACKNOWLEDGEMENTS

I would like to acknowledge the hard work and dedication of Peter Gardner, Chris Sullivan, John Cassinelli, and Lars Alsager during the surveying of these lakes. I would also like to thank Dale Allen, Paul Jansen, Brian Flatter, Tom Curet, Bob Esselman, and Bart Gamett for providing information and assistance that facilitated study site selection. Ed Schriever and Joe Dupont provided guidance in developing this study, which is essentially a broader-scale extension of work they have done in the Clearwater Region. Joe Chapman and the staff at Hagerman Hatchery raised and transported the tiger muskellunge and were critical to the success of this project.

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Table 1. Physical description of study waters planted with tiger muskellunge in 2007.

Lake name	Number planted	Area (ha)	Elevation (m)	Mean depth (m)	Max depth (m)	Mean spec. cond. (µS/cm)	Mean temp (C)	Mean pH
Black Lake	420	10.5	2199	19.7	37.8	31	16.1	7.72
Corral Lake	104	2.6	2085	4	24	-	15.9	7
Granite Twin	656	16.1	2183	7.4	20.4	6.4	13.2	7.72
Grass Mtn 1	206	5.1	2263	2.9	6.1	4.8	15.1	6.78
Grass Mtn 2	225	5.1	2238	2.6	3.7	5	14	6.52
Merriam Lake	107	2.6	2926	7.5	34	20.8	10	8.52
Shirts Lake	140	3.5	2254	7.7	3	15.6	13.1	8.3
Spruce Gulch	439	10.9	2698	4.9	13	8.8	15.9	6.84
Upper Hazard	632	15.8	2264	7.6	21.4	3	13.8	8.24

Lake name	IDFG catalog	Region	Distance from road (km)	Part of chain?	Inlet spawning habitat?	Outlet spawning habitat?	Outlet barrier w/in 1 km?	Elimination potential	Apparent success
Black Lake	07-00-00-0143	3M	0	No	Yes	Yes	Yes	Moderate	Yes
Corral Lake	07-00-00-0177	3M	0.9	No	No	No	Yes	Very High	Yes
Granite Twin	07-00-00-0193	3M	1.9	No	No	Yes	Yes	High	Yes
Grass Mtn 1	07-00-00-0180	3M	3	Yes	No	No	No	Moderate	No
Grass Mtn 2	07-00-00-0183	3M	3	Yes	Yes	No	No	Moderate	No
Merriam Lake	07-00-00-1308	7	3.1	No	Yes	Yes	Yes	High	No
Shirts Lake	09-00-00-0271	3M	1.9	No	No	Yes	Yes	High	No
Spruce Gulch	07-00-00-1316	7	10.6	No	No	No	Yes	Very High	No
Upper Hazard	07-00-00-0170	3M	3.1	Yes	Yes	Yes	Yes	Moderate	No

Table 2. Mean catch-per-unit-effort by gill nets (fish per net-night) and angling (trout/hr) sampled from nine mountain lakes before and after tiger muskellunge were introduced in 2007. The total trout caught by each method (n) is shown by lake. Dashed lines indicate where angling was not conducted.

	2005-06			2008			2009			2010			2011		
Lake Name	CPUE	Hours	n	CPUE	Hours	n	CPUE	Hours	n	CPUE	Hours	n	CPUE	Hours	n
Gill Nets															
Black Lake	13.5	55.5	54	1.0	23.5	2	0	58	0	0.0	29.3	0	0	26.8	0
Corral Lake	60.0	10.0	60	1.0	31.4	2	0	29	0	0.0	38.7	0	0	33.8	0
Granite Twin	20.0	55.5	80	5.5	31.9	11	0	27	0	2.5	34.4	5	0.5	39.0	1
Grass Mtn 1	28.0	16.5	28	6.0	32.8	12	6.5	33	13	3.0	35.1	6	3	36.8	6
Grass Mtn 2	35.0	17.0	35	0.5	30.9	1	4.5	40	9	1.0	35.0	2	1	26.2	2
Merriam Lake	9.3	73.3	37	17.5	24.2	35	16.0	31	32	14.5	29.3	29	12.5	36.9	25
Shirts Lake	14.3	48.0	57	2.0	25.8	4	0.5	23	1	3.5	25.4	7	2	35.7	4
Spruce Gulch	15.8	65.5	63	8.0	22.4	16	6.5	26	13	6.0	24.8	12	1	36.0	2
Upper Hazard	9.0	81.3	36	4.0	28.3	8	5.0	35	10	4.5	37.5	9	3.5	43.7	7
Total	22.8	422.5	450	5.1	251.0	91	4.3	301	78	3.9	290.5	70	2.61	314.7	47
Angling															
Black Lake	-	0	0	0.05	22	1	0	17.5	0	0.0	1.8	0	0	2.0	0
Corral Lake	2.0	2	4	0	5	0	0	4.4	0	0.0	2.0	0	-	0	0
Granite Twin	-	0	0	0.80	5	4	0	8.5	0	0.0	11.0	0	0	2.0	0
Grass Mtn 1	-	0	0	0	2	0	1.1	7	8	-	0.0	-	-	0	-
Grass Mtn 2	-	0	0	-	0	-	0.2	5.5	1	0.0	1.8	0	0.5	2.0	1.0
Merriam Lake	-	0	0	3.33	10.5	35	2.6	12	31	2.1	4.3	9	2.9	9.3	27.0
Shirts Lake	4.3	15	65	0	6	0	0.2	5	1	0.8	1.3	1	0	2.0	0
Spruce Gulch	-	0	0	0	8	0	0.3	4	1	3.1	1.3	4	0	2.0	0
Upper Hazard	-	0	0	0.20	5	1	1.1	16	17	0.0	1.8	0	0.7	1.5	1.0
Total	6.3	17	69	0.55	63.5	41	0.6	79.9	59	0.6	25.1	14	0.5	20.8	29.0

Table 3. Mean length (mm) and weight (g) of brook trout (with 95% confidence intervals) sampled from nine mountain lakes by survey year tiger muskellunge were introduced into the listed lakes in 2007.

Lake name	Mean length (mm)	n	Mean weight (g)	n	Mean condition	Longest five
			2005-2006			
Black Lake	203 (± 7)	54	80 (± 7)	54	0.93	244
Corral Lake	206 (± 12)	64	94 (± 12)	64	1.09	262
Granite Twin	232 (± 12)	80	124 (± 12)	80	0.90	291
Grass Mtn 1	209 (± 19)	28	104 (± 24)	28	0.99	278
Grass Mtn 2	251 (± 10)	35	161 (± 18)	35	0.98	286
Merriam Lake	205 (± 14)	37	91 (± 18)	37	0.94	265
Shirts Lake	196 (± 5)	122	31 (± 7)	122	1.04	231
Spruce Gulch	207 (± 9)	63	92 (± 11)	63	0.98	260
Upper Hazard	227 (± 14)	36	113 (± 18)	36	0.90	292
Total	212 (± 3)	519	88 (± 5)	519	0.97	268
			2008			
Black Lake	241 (± 87)	3	115 (± 118)	3	0.80	241*
Corral Lake	263 (± 400)	2	170 (± 762)	2	0.89	263*
Granite Twin	265 (± 13)	15	194 (± 25)	15	1.03	290
Grass Mtn 1	283 (± 15)	12	263 (± 34)	12	1.16	303
Grass Mtn 2	287	1	210	1	0.89	287*
Merriam Lake	232 (± 7)	70	124 (± 9)	66	1.04	288
Shirts Lake	225 (± 60)	4	128 (± 100)	4	1.08	225*
Spruce Gulch	264 (± 11)	16	223 (± 29)	16	1.19	283
Upper Hazard	246 (± 29)	9	1567 (± 41)	9	1.01	268
Total	*246 (± 6)*	*132*	*161 (± 11)*	*128*	*1.06*	*272*
			2009			
Black Lake	-	0	-	0	-	-
Corral Lake	-	0	-	0	-	-
Granite Twin	-	0	-	0	-	-
Grass Mtn 1	299 (± 8)	21	243 (± 22)	21	0.90	324
Grass Mtn 2	286 (± 46)	10	244 (± 64)	10	0.95	317
Merriam Lake	251 (± 4)	63	138 (± 8)	63	0.88	280
Shirts Lake	273 (± 121)	2	188 (± 158)	2	0.93	273*
Spruce Gulch	309 (± 12)	14	337 (± 51)	14	1.12	326
Upper Hazard	235 (± 23)	28	130 (± 27)	28	0.88	296
Total	*264 (± 7)*	*138*	*181 (± 15)*	*138*	*0.91*	*334*

* Five or less brook trout captured.

Table 3. Continued.

Lake name	Mean length (mm)	n	Mean weight (g)	n	Mean condition	Longest five
			2010			
Black Lake	-	0	-	0	-	-
Corral Lake	-	0	-	0	-	-
Granite Twin	148 (± 32)	5	34 (± 18)	5	0.97	148
Grass Mtn 1	275 (± 93)	6	230 (± 123)	6	0.96	311
Grass Mtn 2	338 (± 32)	2	430	2	1.12	-
Merriam Lake	253(± 5)	38	163 (± 11)	29	1.00	276
Shirts Lake	166 (± 12)	8	41 (± 5)	6	0.92	174
Spruce Gulch	315 (± 20)	16	352 (± 82)	12	1.20	355
Upper Hazard	162(± 33)	9	56 (± 29)	9	1.15	196
Total	*237 (± 7)*	*84*	*187 (± 16)*	*69*	*1.05*	*243*
			2011			
Black Lake	-	0	-	0	-	-
Corral Lake	-	0	-	0	-	-
Granite Twin	236	1	110	1	0.84	236*
Grass Mnt 1	282 (±58)	6	266 (± 109)	6	1.19	303
Grass Mnt 2	273 (±271)	3	210 (± 2224)	2	1.03	273*
Merriam Lake	260 (± 8)	52	172 (± 23)	25	0.98	290
Shirts Lake	233 (± 151)	4	590	1	4.66	233*
Spruce Gulch	320 (± 191)	2	385 (± 826)	2	1.17	320*
Upper Hazard	204 (± 19)	8	67 (± 16)	7	0.78	217
Total	*256 (± 10)*	*76*	*188 (± 42)*	*44*	*1.52*	*340*

* Five or less brook trout captured.

Table 4. Mean length (mm) of tiger muskellunge (with 95% confidence intervals where possible) sampled from nine mountain lakes by survey year and method. Tiger muskellunge were introduced into the listed lakes in 2007. Dashed lines indicate missing values.

Lake name	Mean length (mm)	n	Gill net	Angling	Visual
		2008			
Black Lake	478 (±31)	26	1	25	0
Corral Lake	572 (±103)	6	0	6	0
Granite Twin	375	1	1	0	0
Grass Mtn 1	526 (±114)	2	2	0	0
Grass Mtn 2	605	1	1	0	0
Merriam Lake	-	0	0	0	1
Shirts Lake	-	0	0	0	0
Spruce Gulch	344 (±51)	12	1	11	0
Upper Hazard	495	1	1	0	0
Mean	460 (±31)	49	7	42	1
		2009			
Corral Lake	494 (±136)	10	0	4	6
Granite Twin	580 (±108)	6	0	2	4
Grass Mtn 1	431	1	0	0	1
Grass Mtn 2	-	0	0	0	0
Merriam Lake	-	0	0	0	0
Shirts Lake	643	8	1	0	7
Spruce Gulch	370	5	1	0	4
Upper Hazard	-	1	1	0	0
Mean	535 (±41)	41	5	13	23

Table 4. Continued.

Lake name	Mean length (mm)	n	Gill net	Angling	Visual
		2010			
Black Lake	635	2	0	0	2
Corral Lake	-	0	0	0	0
Granite Twin	713 (±60)	6	0	2	4
Grass Mtn 1	-	0	0	-	0
Grass Mtn 2	-	0	0	0	0
Merriam Lake	-	0	0	0	0
Shirts Lake	710	2	0	0	2
Spruce Gulch	545	2	1	1	0
Upper Hazard	-	0	0	0	0
Mean	672 (±73)	12	1	3	8
		2011			
Black Lake	599 (±76)	7	0	3	4
Corral Lake	711	2	1	-	1
Granite Twin	-	0	0	0	0
Grass Mnt 1	-	0	0	-	0
Grass Mnt 2	570	1	1	0	0
Merriam Lake	-	0	0	0	0
Shirts Lake	648 (±50)	5	0	3	2
Spruce Gulch	609	2	0	0	2
Upper Hazard	-	0	0	0	0
Mean	626 (±74)	17	2	6	9

Table 5. Mean length (mm) and weight (g) (with 95% confidence intervals), condition, and trophy potential (assessed by the mean of the five longest fish) of brook trout sampled from four control mountain lakes. These lakes were in the same drainage as most of the treated lakes.

Lake name	Mean length (mm)	n	Mean weight (g)	n	Mean condition	Longest five
			2005			
Hard Creek Lake	226 (± 19)	44	140 (± 38)	44	0.98	340
			2006			
Black Lake #2	192 (± 29)	25	100 (± 33)	25	1.01	270
Hard Creek Lake	217 (± 18)	31	110 (± 24)	31	0.96	287
Lloyds Lake	220 (± 15)	30	120 (± 23)	30	1.04	281
Rainbow Lake	185 (± 18)	30	66 (± 17)	30	0.97	260
Total	210 (± 56)	160	111 (± 88	160	0.99	287
			2009			
Black Lake #2	236 (± 16)	31	131 (± 19)	31	0.95	294
Hard Creek Lake	233 (± 11)	72	130 (± 20)	46	0.93	315
Lloyds Lake	233 (± 13)	45	140 (± 21)	45	1.00	296
Rainbow Lake	213 (± 14)	22	78 (± 14)	22	0.78	253
Total	231 (± 44)	170	125 (± 65)	144	0.93	290
			2010			
Black Lake #2	198 (± 19)	31	94 (± 20)	31	1.05	253
Hard Creek Lake	229 (± 24)	23	117 (± 26)	13	0.54	283
Lloyds Lake	208 (± 20)	17	79 (± 28)	10	0.62	246
Rainbow Lake	194 (± 14)	33	80 (± 13)	33	1.10	234
Total	203 (± 9)	104	91 (± 10)	87	0.88	254
			2011			
Black Lake #2	219 (± 14)	33	116 (± 20)	33	1.11	281
Hard Creek Lake	227 (± 21)	21	111 (± 31)	12	0.95	283
Lloyds Lake	220 (±16)	21	115 (± 33)	17	1.09	269
Rainbow Lake	199 (± 9)	54	81 (± 9)	54	1.03	243
Total	212 (± 7)	129	99 (± 9)	116	1.05	281

Table 6. Mean catch-per-unit-effort by gill nets (fish per net-night) and angling (fish per hour) sampled from four control mountain lakes by sample year. These lakes were in the same drainage as most of the treated lakes. Dashed lines indicate where angling was not conducted.

Lake name	CPUE Gill nets	Net-nights	n	CPUE angling	n	Angling hours
			2005			
Hard Creek Lake	22	2	44	-	-	0
			2006			
Black Lake #2	11	1	11	7.0	14	2
Hard Creek Lake	31	1	31	-	-	-
Lloyds Lake	30	1	30	-	-	-
Rainbow Lake	30	1	30	-	-	-
Total	22.5	4	90	7.0	14	2
			2009			
Black Lake #2	9.0	2	18	6.5	13	2
Hard Creek Lake	23.0	2	46	5.1	26	5.05
Lloyds Lake	21.5	2	43	1.3	6	4.5
Rainbow Lake	7.5	2	15	1.9	7	3.75
Total	15.25	8	122	3.4	52	15.3
			2010			
Black Lake #2	15.0	2	30	-	-	-
Hard Creek Lake	7.0	2	14	3.2	9	2.8
Lloyds Lake	6.5	2	13	2.0	4	2.0
Rainbow Lake	16.5	2	33	-	0	1.0
Total	11.3	8	90	2.5	13	5.8
			2011			
Black Lake #2	16.5	2	33	-	-	-
Hard Creek Lake	10.5	2	21	4	8	2
Lloyds Lake	8.5	2	17	4	4	1
Rainbow Lake	26.5	2	53	-	-	-
Total	15.5	8	124	4	12	3

Table 7. Summary details to help consider future management options for continued suppression of brook trout (BKT) and the future direction for mountain lakes stocked with tiger muskellunge (TM).

Lake	Area (ha)	Part of Chain?	Refugia	Barrier w/in 1km?	Initial BKT Num	Final BKT Num	TM Remaining	YOY Present 2011	Changed BKT Size	Treatment Potential	Potential Treatment	Treatment Priority
Black Lake	10.5	No	Inlet/Outlet/ Shoreline	Yes	54	0	7	None observed	-	inlet/outlet good targets very deep, large lake	Yes	3
Corral Lake	2.6	No	Inlet	Yes	60	0	2	None observed	-	easy inlet/outlet treatments maybe whole lake?	Yes	1
Granite Twin Lakes	16.1	No	Inlet	Yes	80	0	0	None observed	+ 4 mm	easy inlet treatment	Maybe	2
Grass Mt Lake #1	5.1	Yes	Outlet	No	28	6	0	Fry along shore	+ 76 mm	easy outlet treatment but can TM kill all adult BKT?	Treated in 2010	-
Grass Mt Lake #2	5.1	Yes	Inlet/Outlet	No	35	3	1	Fry along shore	+ 22 mm	easy inlet treatment easy outlet treatment but can TM kill all adult BKT?	Treated in 2010	-
Merriam Lake	2.6	No	Inlet/Outlet	Yes	37	52	0	Juveniles in inlet	+ 55 mm	too many adult BKT no TM left	No	-
Shirts Lake	3.5	No	Inlet/Outlet/ Shoreline	Yes	57	4	5	None observed	+ 37 mm	easy outlet treatment lots of small inlets few adult BKT, some TM left	Yes	4
Spruce Gulch Lake	10.9	No	Shoreline	Yes	63	2	2	None observed	+ 113 mm	too many adult BKT	No	-
Upper Hazard Lake	15.8	Yes	Inlet/Outlet/ Shoreline	Yes	36	8	0	Juveniles in outlet	- 27 mm	too many adult BKT	No	-

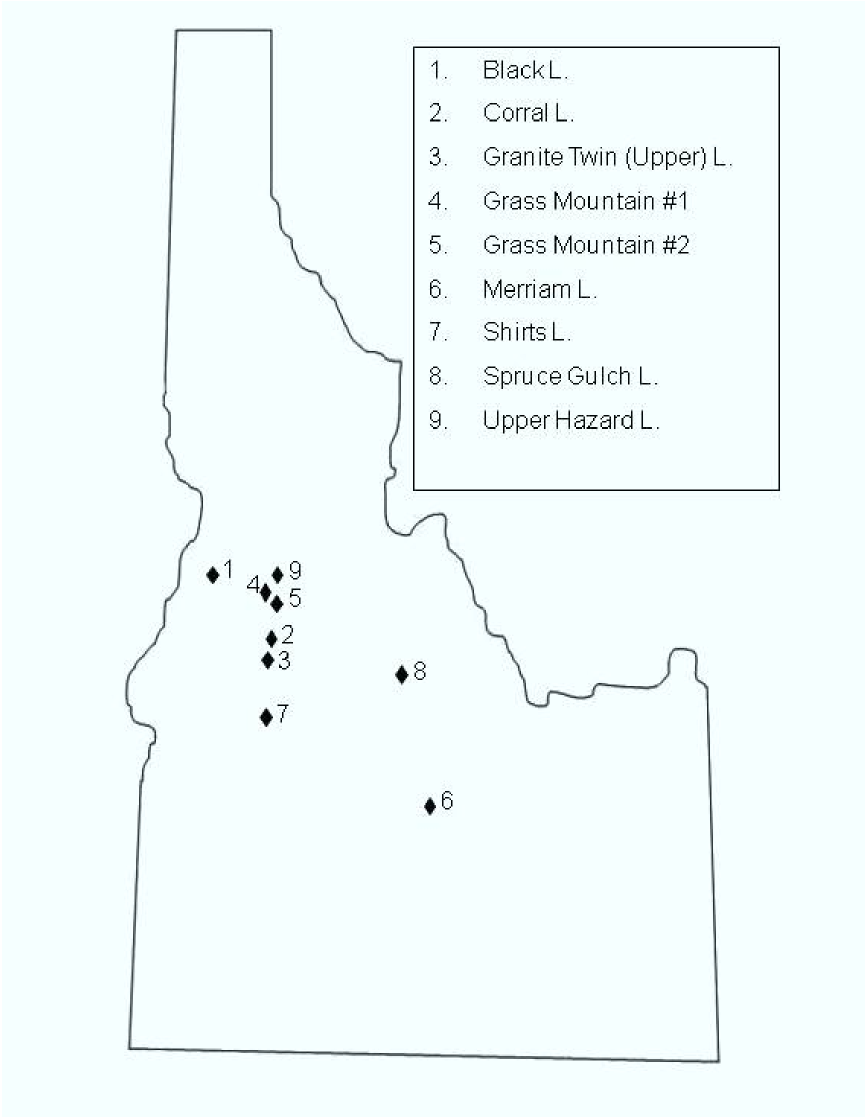


Figure 1. Locations of nine high mountain lakes in Idaho that were chosen for inclusion in a study designed to eliminate brook trout populations by stocking tiger muskellunge. Lakes were initially surveyed in 2005 or 2006 and planted with tiger muskellunge in 2007. Sampling was again conducted in 2008 to investigate subsequent changes to brook trout populations.

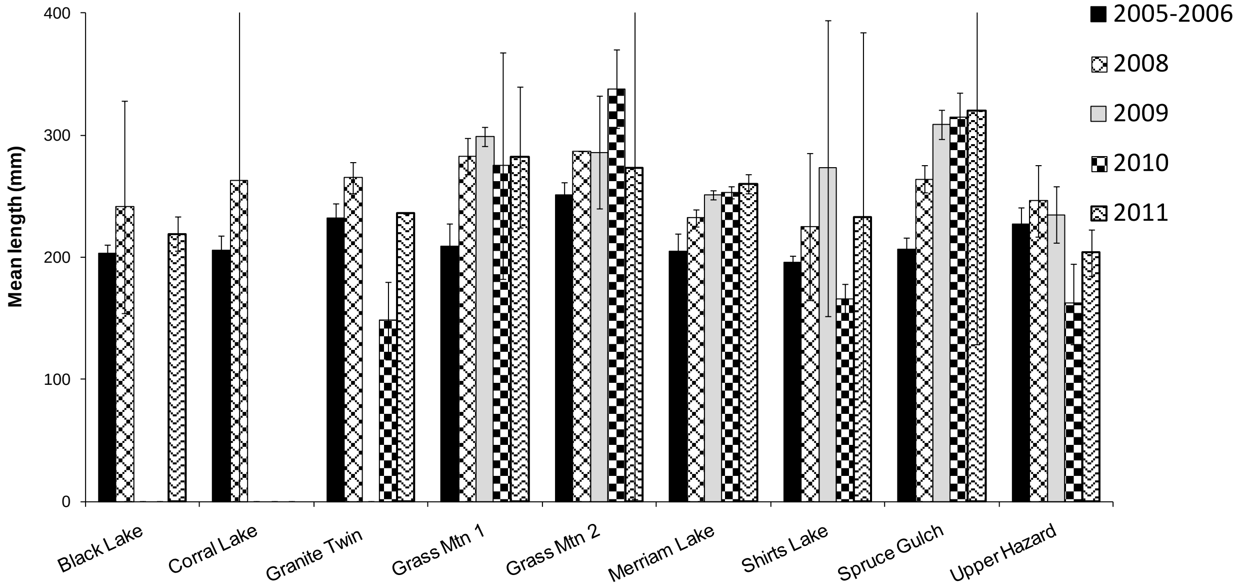


Figure 2. Mean total length of brook trout before (2005-06) and after tiger muskellunge were introduced in 2007. Error bars indicated 95% confidence intervals around the mean, where sample sizes allowed. Wide confidence intervals at Corral Lake are a result of low sample size (*n* = 2). Missing bars indicate no brook trout were captured.

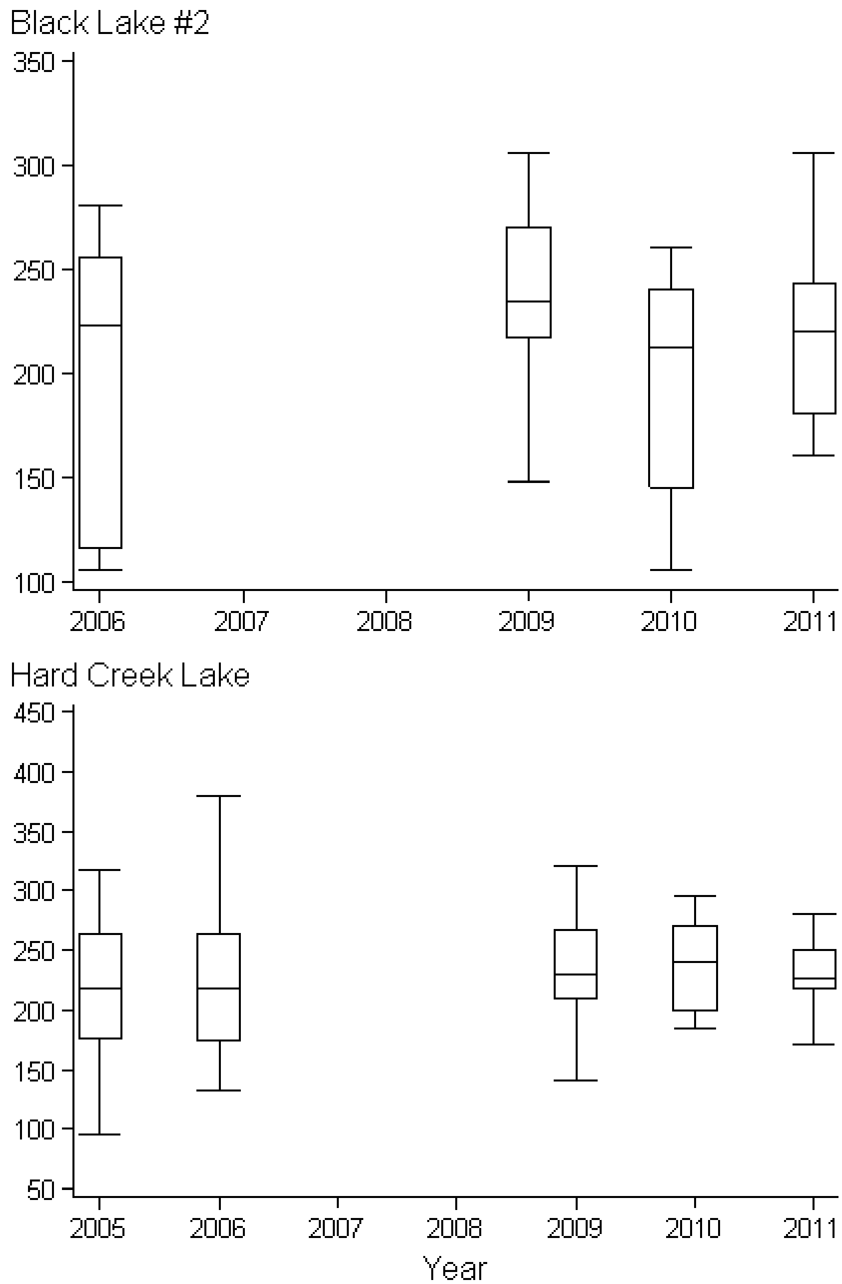
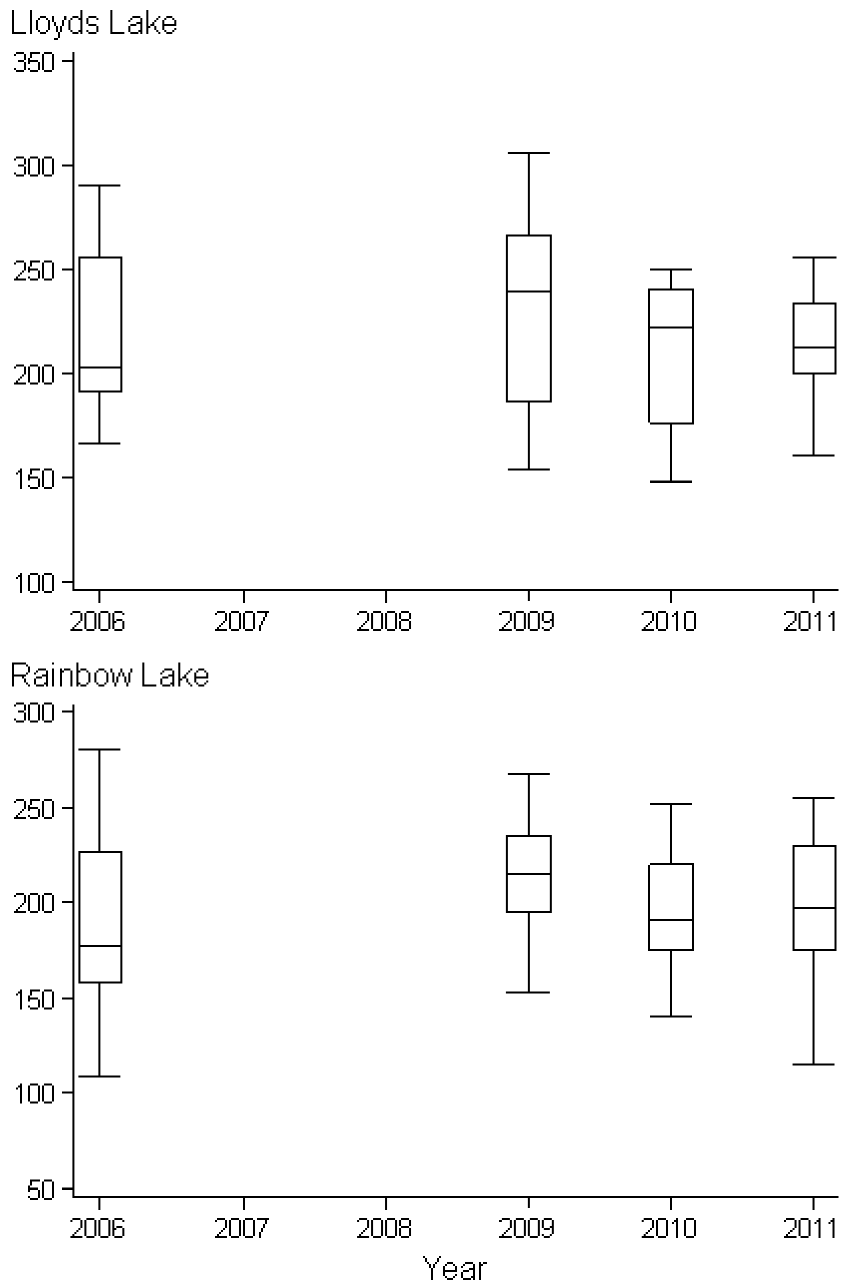


Figure 3. Box plot of brook trout total length (mm) by year for four control lakes that did not receive plants of tiger muskellunge. Error bars indicate 1.5 times the interquartile range.



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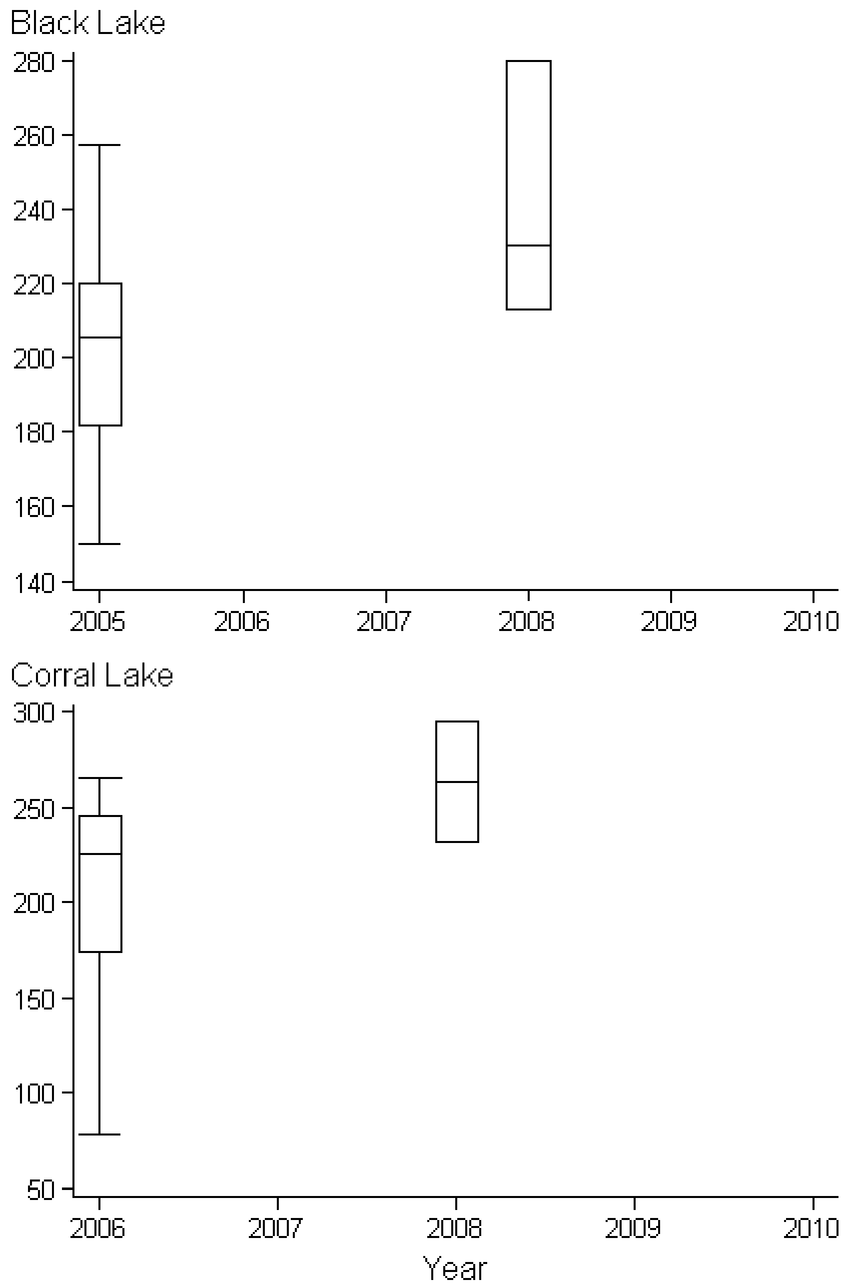
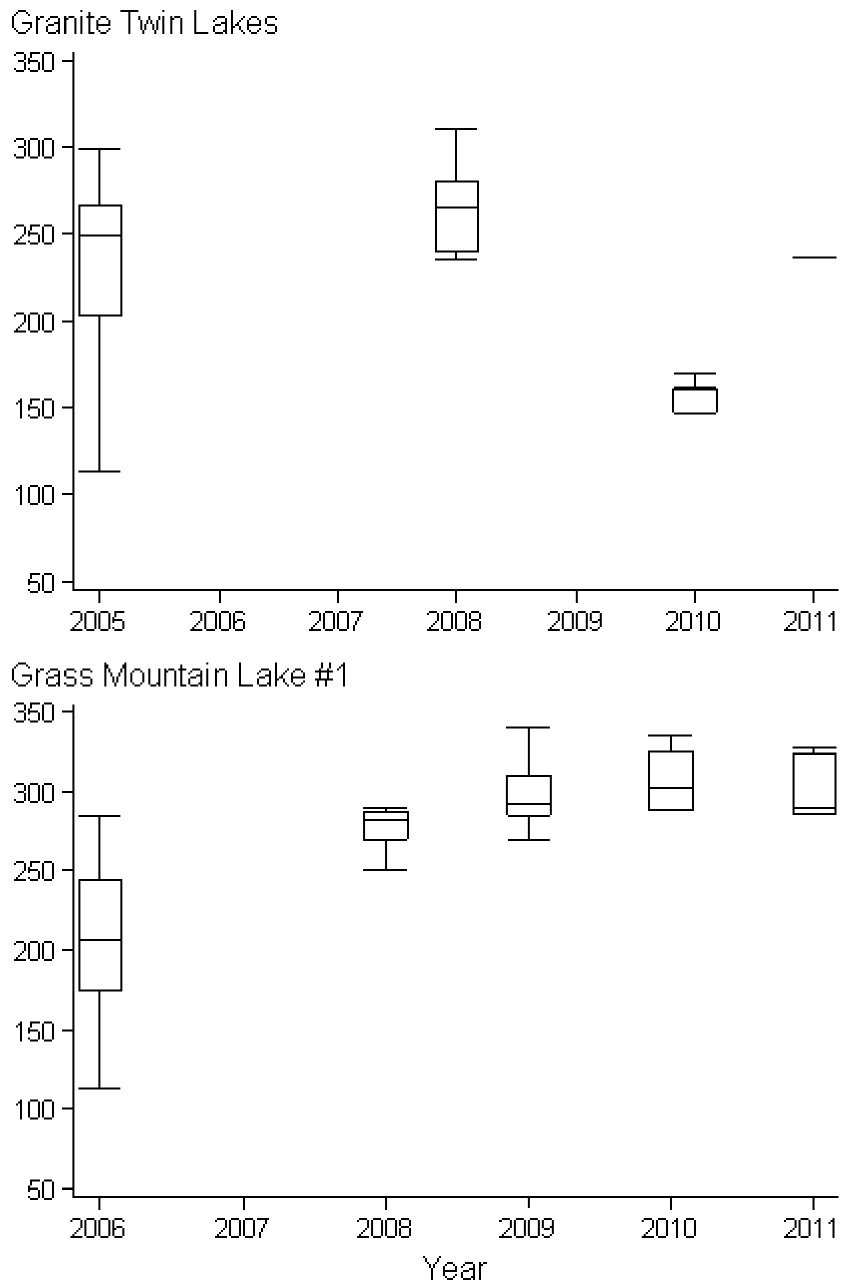


Figure 4. Box plot of brook trout total length (mm) by year for nine “treatment” lakes. Tiger muskellunge were stocked in 2007 and lakes were again surveyed beginning in 2008. Error bars indicate 1.5 times the interquartile range.



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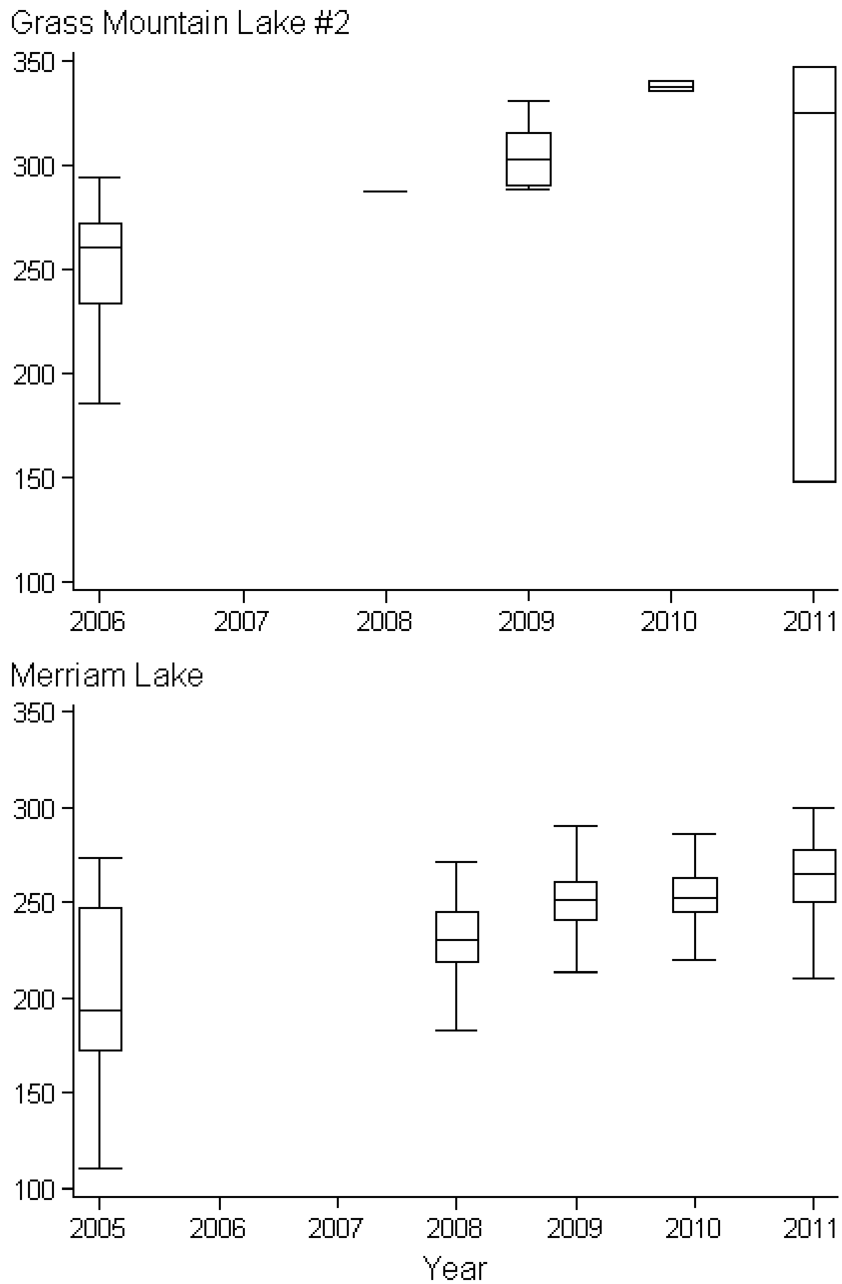

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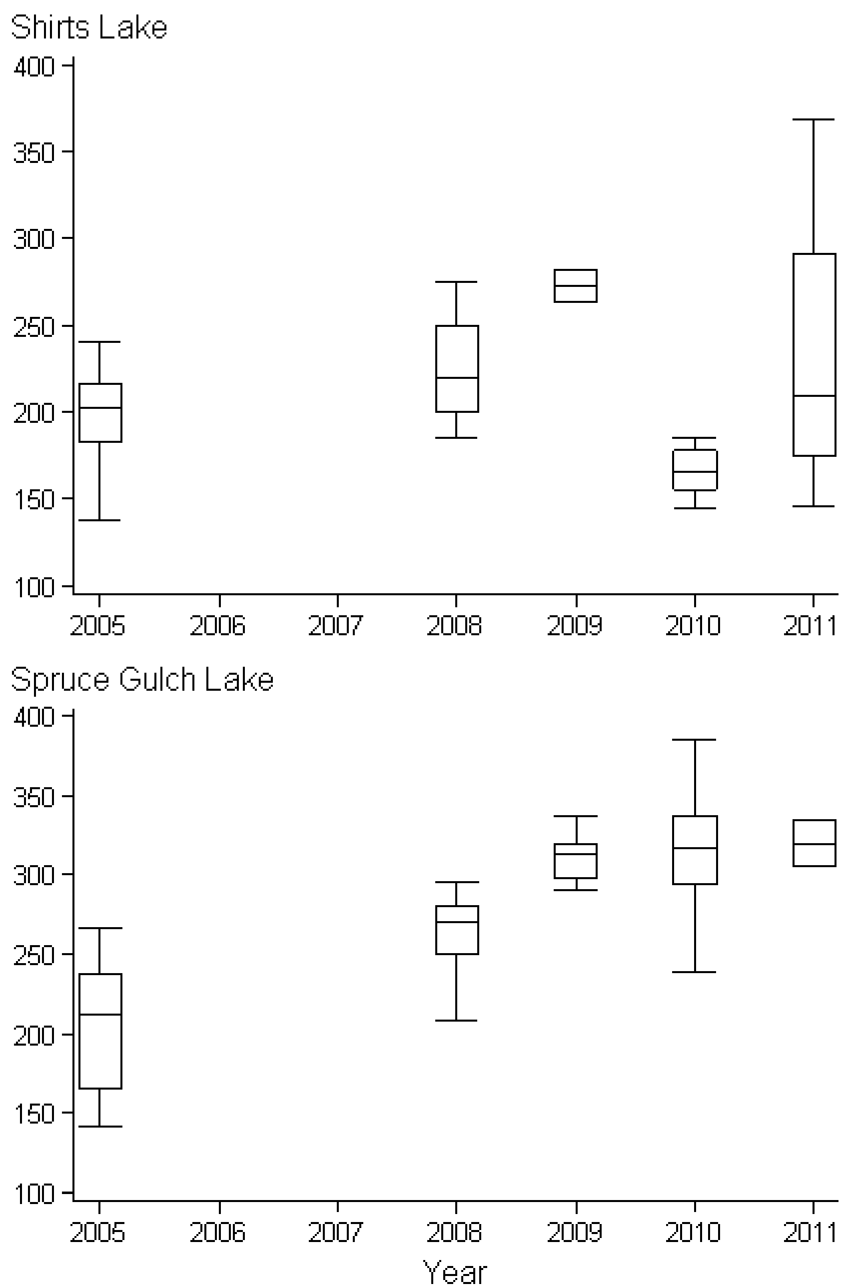

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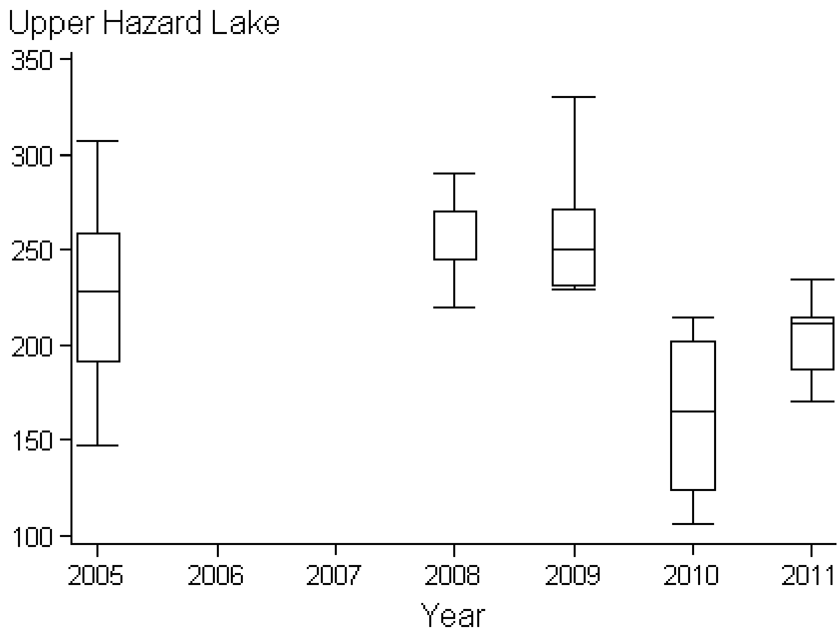

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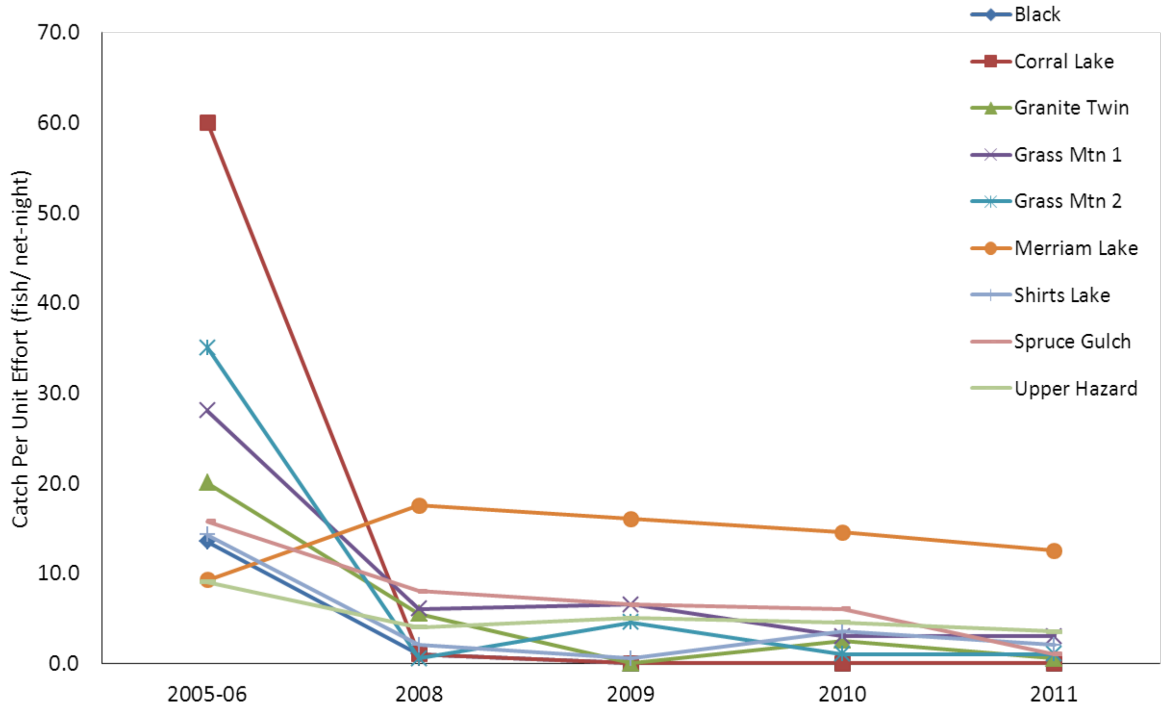

Figure 5. Gill net catch-per-unit-effort (CPUE) in fish per net-night of brook trout from nine treatment lakes stocked. Lakes were initially surveyed in 2005/06 and stocked with tiger muskellunge in 2007. Post-treatment sampling began in 2008.

ANNUAL PERFORMANCE REPORT
SUBPROJECT #2: STERILE TROUT INVESTIGATIONS: RELATIVE PERFORMANCE AND RECOMMENDED STOCKING DENSITY FOR TRIPLOID WESTSLOPE CUTTHROAT TROUT IN IDAHO ALPINE LAKES

State of: Idaho | Grant No.: F-73-R-34 Fishery Research

Project No.: 4 | Title: Hatchery Trout Evaluations

Subproject #2: Production of Sterile Trout

Contract Period: July 1, 2011 to June 30, 2012

ABSTRACT

Fishing alpine lakes is highly rewarding and is an important component of Idaho's recreational economy. Westslope cutthroat trout (WCT) *Oncorhynchus clarkii lewisi* are stocked in about 677 Idaho alpine lakes, and compose approximately 57% (by number) of the fish requested for alpine lake stocking. Stocked westslope cutthroat trout are mixed-sex diploid (2N) fish capable of naturally reproducing and interbreeding with wild native cutthroat stocks. The Idaho Department of Fish and Game (IDFG) in 2001 established a policy to stock only triploid rainbow trout *Oncorhynchus mykiss* in stocked fisheries where diploid hatchery fish might pose a genetic risk to native trout populations. Since there are no triploid (3N) sterile cutthroat trout stocks currently available, all-female triploid rainbow trout have become the default choice where sterile trout are desired, decreasing the total westslope cutthroat trout stocked historically. Lower survival after stocking for triploid salmonids is common, and little information currently exists to inform stocking strategies for triploid trout in alpine lakes. Fishery managers should anticipate lower survival rates for triploid trout, so stocking density guidelines are needed specifically for triploid WCT. This study aims to develop a quantitative model to predict fishery performance for triploid WCT using stocking density and lake habitat characteristics. In 2011, IDFG staff stocked 16 lakes with diploid WCT and 15 lakes with triploid WCT across a range of densities. Additional lakes will be stocked in 2013 to further increase sample size. After sampling lakes in 2014 (lakes stocked in 2011) and 2016 (lakes stocked in 2013), stocking density models for 2N and 3N WCT will be compared to examine any significant differences, which could be useful to inform future stocking guidelines. Refining stocking strategies to improve mountain lake fisheries while minimizing impacts to native salmonids remains important – especially as interest in moving towards triploid cutthroat trout increases.

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INTRODUCTION

Fishing opportunities in alpine lakes are highly rewarding, offering solitude, dramatic scenery, and a backcountry experience seldom found in other fisheries. Not surprisingly, anglers visiting alpine lakes typically express high levels of satisfaction with their fishing experience (WGF 2002; IDFG 2007). High mountain lakes are an important component of Idaho's recreation economy, drawing an estimated 40,000 anglers each year (IDFG 2007). According to 2003 economic survey data, recreational fishing at Idaho's mountain lakes generated over 59,000 trips with over $10M in associated statewide retail sales (IDFG unpublished data). While economic benefits of fishing alpine lakes are considerable, the costs associated to stock these lakes annually is relatively low. In 2008, the McCall Fish Hatchery stocked 170,070 fry in 215 mountain lakes with an average flight cost of $67.91 per lake, with about $42 total in feed (Frew 2008). Currently, the IDFG high mountain lakes Default Request List indicates about 600,000 fry are stocked into 677 mountain lakes on a rotating basis, with most lakes (82%) receiving fish every three years.

The IDFG Fisheries Management Plan dictates that alpine lakes will be managed "to reduce or eliminate impacts to native species in and downstream from alpine lakes" (IDFG 2007). Trout introduced to high mountain lakes have been identified as posing a risk to native salmonids in downstream habitats by establishing source populations in headwater locations (Adams et al. 2001). Triploid salmonids, created by heat or pressure shock, are functionally sterile and may be a useful tool for managing alpine lake fisheries. Sterility can help avoid genetic introgression with native wild stocks and may provide a fishery benefit such as increased growth (Thorgaard 1986; Boulanger 1991; Teuscher et al. 2003) or longevity (Parkinson and Tsumura 1988; Johnston et al. 1993; Warrillow et al. 1997). Because of these attributes, IDFG in 2001 established a policy to stock only triploid rainbow trout *Oncorhynchus mykiss* in stocked fisheries where diploid hatchery fish might pose a genetic risk to native trout populations (IDFG 2007). However, no such policy currently exists for stocking westslope cutthroat trout *Oncorhynchus clarkii lewisi*.

Currently, westslope cutthroat trout (WCT) compose approximately 57% (by total number) of the requested trout stocked in high mountain lakes (Frew 2008), followed secondly by all-female triploid (Troutlodge Inc.) rainbow trout (23%). Westslope cutthroat trout stocked throughout Idaho originate from the IDFG broodstock facility at Cabinet Gorge Fish Hatchery, initially derived from the King's Lake stock in British Columbia. At this time, WCT stocked into alpine lakes are mixed-sex diploid trout capable of naturally reproducing and interbreeding with wild native cutthroat trout stocks. Until recently, cutthroat trout stocking comprised a much larger proportion of high lakes stocking, but concerns over risks to native species have increased requests for triploid trout. Since there are no triploid cutthroat trout stocks currently available, all-female triploid rainbow trout have become the default choice where sterile trout are desired. It appears that the IDFG Cabinet Gorge WCT broodstock has some level of introgression with rainbow trout. Additionally, fishery managers concerned with conserving native WCT are interested in preventing hatchery cutthroat trout stocked into mountain lakes from breeding with wild native cutthroat trout in downstream habitats.

Lower survival after stocking for triploid salmonids (compared to their diploid counterparts) has been found in all-female rainbow trout fry (Brock et al. 1994), fingerling rainbow trout (Simon et al. 1993), and fingerling coho salmon *Oncorhynchus kisutch* (Rutz and Baer 1996). Previous IDFG research on using mixed-sex rainbow trout (Hayspur strain) in high mountain lakes found significantly lower survival to age-3 and age-4 for triploids relative to diploids in the same lakes (Koenig et al. 2011). Overall, the return of 3N trout in alpine lakes in

Idaho was low compared to 2N trout, with diploids accounting for 0.68 of the total marked fish caught. Generally, about 1.5 to 2 times as many diploid returns as triploid returns can be expected for mixed-sex rainbow trout, based on several years of stocking and surveys. Despite potential lower survival compared to diploids, triploid trout remain a useful alternative to reduce genetic impacts to wild trout when stocking sport fish, assuming the poorer survival can be mitigated.

Currently, no information exists to inform stocking rates of triploid trout in alpine lakes. Historically, for diploid trout, “trial and error” was the most common strategy for establishing stocking rates in alpine lakes throughout western states, with Idaho having relatively little data for estimating appropriate stocking rates (Bahls 1992). A more recent survey of high lake fisheries managers across several western states indicated that quantitative models and stocking decisions based on regular surveys are still rare (Meyer and Schill 2007). They found most of the changes in mountain lake stocking practices have focused around incorporating mainly native species, reducing stocking where natural recruitment occurs, and reducing impacts to native amphibians. Despite these shortcomings, stocking strategies are remarkably similar between states. Most lakes, including those in Idaho, are mainly stocked with either rainbow trout or a subspecies of cutthroat trout, generally on a rotation of every 2-4 years. The IDFG high mountain lakes Default Request List indicates about 600,000 fry are stocked into 677 mountain lakes on a rotating basis. Most stocked lakes receive fish every three years (82%) with some every two years (16%) or annually (3%). Fish are typically stocked by aircraft at 25-50 mm total length (TL) in mid- or late summer, typically at densities of 50-200 fish/acre (Meyer and Schill 2007). Survey data describing fish populations and angling pressure in alpine lakes is difficult to come by on a frequent enough basis to accurately adjust stocking rates across hundreds of lakes. As a result, most stocking practices are based on limited data and may not be optimal for each lake or species. In this respect, a quantitative model for triploid WCT using stocking density to predict fishery performance will be valuable for managing alpine lakes.

Several previous studies have examined factors that affect growth of trout in mountain lakes, mainly using multiple regression techniques. Commonly studied variables consist of habitat and water-quality metrics such as elevation, lake area, volume, mean depth, shoreline development, Secchi depth, total dissolved solids, water temperature, prey density, and stocking density. Donald et al. (1980) reported that 54% of lake-to-lake variation in brook trout growth was attributable to amphipod density and that growth was positively correlated with summer water temperature and specific conductance. In a similar study, Donald and Anderson (1982) found the lake-to-lake variation in weight of rainbow trout was attributable to total dissolved solids (42%), stocking density (30%), and mean depth (3%). Fredericks et al. (2002) used similar methods to optimize stocking in 14 northern Idaho high lakes. They used several physical lake characteristics, stocking density, and metrics of accessibility to predict growth and densities of westslope cutthroat trout. Stocking density and elevation were the only significant factors related to age-at-length, with an adjusted r^2 of 0.54 when used together. Bailey and Hubert (2003) investigated how manageable factors (harvest rate, access, stocking rates) affected density, biomass, growth, and population structure of cutthroat trout in alpine lakes. They concluded that angler access (as an index of fishing pressure) was the primary factor affecting stock structure, while stocking rates affected densities. While these studies provide models for stocking trout in mountain lakes, they do not include any guidelines specific to triploid cutthroat trout, which could be considerably different than for diploid fish.

Refining stocking strategies to improve mountain lake fisheries while minimizing impacts to native salmonids remains important – especially as interest in utilizing triploid cutthroat trout increases. Fishery managers should anticipate lower survival rates for triploid trout, so stocking density guidelines for alpine lakes are needed specifically for triploid WCT. These guidelines could help ensure satisfactory fisheries while retaining the conservation benefits of triploid WCT. The goal of this study is to develop guidelines to optimize stocking of triploid WCT in alpine lakes, and to compare those guidelines with those for normal diploid WCT. While no results are currently available, this report describes the study design, study locations, methodology, and functions as an update on the progress of this evaluation so far.

<u>Fin Clip Comparison</u>

Fin clips have several advantages that make them popular for marking salmonids for a wide variety of studies. Adipose and ventral clips are a cost-effective batch mark that are easily applied with good long-term mark retention. Fin clips can be used to mark very small fish and are externally visible without special equipment, even after fish have grown to adult sizes. Unlike coded wire and chemical marks, fin clips do not require a lethal sample. Despite these advantages, differences in survival may exist between different types of fin clips, limiting their utility to assess survival of marked groups.

Mortality of salmonids marked with ventral fin clips can be highly variable and is generally higher compared to adipose-clipped salmonids of the same group (Nicola and Cordone 1973; Mears and Hatch 1976; Jacobs 1990; PSC 1995; PSC 1997). Nicola and Cordone (1973) studied rainbow trout in one California alpine lake. They found that rainbow trout with ventral clips were recovered at 81% of the rate as adipose-clipped trout from two separate release groups over several years. Although fewer ventral-clipped rainbow trout were recovered, differences in returns between adipose-clipped trout and ventral-clipped trout were only significantly different in one of the two release groups. Mears and Hatch (1976) found that overwinter survival of ventral-clipped Eastern brook trout in a shallow, reclaimed pond survived at only 43% of adipose-clipped brook trout. Similarly, Vincent-Lang (1993) found that returns of coho salmon *Oncorhynchus kisutch* to Bear Lake, Alaska, were much lower for ventral-clipped salmon than for adipose-clipped salmon over four different brood years. Coho salmon with left and right ventral fin clips returned at 55% and 61% of the rate of adipose-clipped salmon, respectively. Few studies exist that directly compare survival of adipose and ventral fin clipped salmonids stocked in the same lakes. The Nicola and Cordone (1973) study is informative, but is limited by only having used one lake for evaluation.

Adipose and ventral fin clips have been used previously for alpine lake evaluations to distinguish treatment groups (Koenig et al. 2011), but differences in fin clips between groups could have affected the results. The magnitude of the fin clip effect in Koenig et al. (2011) in explaining differences in survival of diploid and triploid marked groups is unknown. As a part of the larger westslope cutthroat evaluation in alpine lakes, we will also compare relative survival of adipose and ventral-clipped rainbow trout fry stocked in a smaller subset of lakes.

OBJECTIVES

1. Examine relationships between catch per unit effort (CPUE) and biomass per unit effort (BPUE) and length-at-age of WCT to fry stocking density (and other environmental variables) and develop stocking recommendations specific to 3N and 2N WCT in alpine lakes.

2. Compare relative survival of rainbow trout marked with adipose and ventral fin clips stocked in alpine lakes.

METHODS

Study Sites

Lakes to be included in this evaluation will consist of a subset of alpine lakes currently stocked with westslope cutthroat trout by IDFG. Lakes will be stocked in two groups, one in 2011 and a second in 2013. For each year of stocking, lakes will be selected from those normally scheduled to receive trout plants based on the default request lists. Two groups of 16 lakes will be stocked in 2011 with either marked 2N or marked 3N WCT for a total of 32 lakes in the first year of stocking (Table 8). Diploid and triploid cutthroat trout will not be stocked in sympatry to avoid the confounding factor of 2N/3N competition and the need for additional marks. Additional lakes will be added in 2013 to increase the sample size of the experiment to include more locations. Marked 2N and 3N WCT study fish will be used to meet stocking requests while also providing valuable research data and minimizing extra costs of rearing and stocking. Lakes will be chosen throughout central Idaho to encompass a wide geographical range. Candidate lakes occurring in clusters will be prioritized to maximize the number of study sites while minimizing travel time between sites to increase sampling efficiency. Marking cost and flight time will also be considered when choosing study sites, since resources are limited and long flights and large stocking groups may be cost-prohibitive.

Egg Collection / Rearing / Stocking

Sterile WCT were collected at Cabinet Gorge hatchery on May 16, 2011 using standard spawning techniques followed by pressure treatment to induce triploidy. Approximately 120 female cutthroat trout were used to collect enough eggs (about 100,000 3N eggs), assuming roughly 50% survival to the eyed egg stage. Eggs were pressure treated at 300 Celsius-minutes after fertilization (CMAF) at pressure 9,500 psi for 5 minutes duration. Each pressure-treated batch contained eggs from 20-30 females. After eye-up, eggs were transferred to the McCall Hatchery for rearing. A subsample (n = 100) of WCT were retained for blood analysis (via flow cytometry) to confirm ploidy level before stocking. Normal 2N WCT were obtained in the same fashion, with the exception of the pressure treatment process. These fish were reared in a separate raceway from the 3N group. At the time of stocking, 100 fish from both test groups were sampled to describe the mean total length (mm) and weight (g) prior to stocking. This process will be repeated again in 2013 to produce a second lot of 3N WCT for expanding the number of study sites.

Diploid and triploid test groups were marked with adipose fin clips at McCall Hatchery shortly before stocking. Adipose fin clips were used to denote inclusion in this study and to separate test fish from other trout previously stocked or naturally produced in study lakes. Diploid and triploid marked fish were not stocked in the same lakes together, so one mark was sufficient to identify test fish. An Individual Fish Counter (Northwest Marine Technology) with four counting stations was used for accurately counting fish during marking. Fish were stocked by aircraft or backpack by McCall Hatchery staff from September 29 to October 1, 2011. The number of marked fish stocked in each lake was intended to meet the default request for that location, resulting in a range of stocking densities depending on lake size and number of fish stocked (Table 8).

Sampling

Sampling assistance will be required from Regional fisheries staff to sample all lakes in the study each year. Nampa Research staff will sample up to 20 lakes, but will need additional assistance to collect enough data. Nampa Research staff will develop a standardized sampling protocol and coordinate sampling among Regional fisheries staff. Lakes will likely be sampled three and four years after stocking (years 2014 and 2015) to evaluate the contribution of marked fish at each lake. Lakes will be sampled using a combination of angling and gill nets. Floating experimental gillnets consisting of nylon mesh panels of 19, 25, 30, 33, 38, and 48 mm bar mesh (46 m long and 1.5 m deep) will be set overnight to collect fish at each lake. Fly and spinning tackle with be used to collect additional samples and to collect data on angling catch rates. Data collected from captured fish will include species, total length (mm), weight (g), any fin clips, sagittal otolith samples, and scale samples.

Lake surveys will include collecting habitat and water quality data that could explain variation in fish population structure, growth, or density. These parameters should include Secchi depth, water temperature, conductivity, pH, mean depth, and maximum depth. Lake elevation will be determined using topographic maps or GPS. Lake area will be measured using aerial photos and Arc GIS software. As a surrogate for fishing pressure and harvest, an index of access difficulty will be calculated using methods described by Bailey and Hubert (2003), including metrics such as road distance, trail distance, off-trail distance, and elevation gain.

Data Analysis

Fishing quality and standing cutthroat trout stocks will be described with a variety of variables describing fish size structure and catch rates. These may include catch per unit effort (CPUE), biomass per unit effort (BPUE), incremental growth rates, and proportional stocking density (PSD). Mean catch rate (CPUE) at each lake will be calculated as the average catch rate (fish/hour) across the total number of nets or anglers. PSD (using 200 mm as stock length and 350 mm as quality length) and mean total length will characterize stock structure in each lake. Back-calculated length-at-age of marked fish will be estimated using whole otoliths and Fish BC software. Growth rates across lakes (and ploidy level, if data allows) could be compared using incremental growth. Bailey and Hubert (2003) compared growth rates using back-calculated lengths to estimate mean incremental growth during the first full year (age 2-3) that stocked fish spent in each lake.

Relationships between physical lake features, access difficulty, and characteristics of 3N cutthroat trout stocks will be identified using a combination of graphic (scatter plots) and numerical techniques including Pearson correlation, linear-regression, and multiple-regression. Separate regression models will be developed for both 3N and 2N WCT. Stocking density models for 2N and 3N cutthroat trout will be compared to examine any significant differences that might exist which could be useful to inform future stocking guidelines.

Fin Clip Comparison

A separate selection of lakes was used for the fin clip evaluation. These lakes were chosen from a subset of alpine lakes normally scheduled to be stocked with triploid rainbow trout by IDFG in 2011. All-female triploid rainbow trout were obtained from Troutlodge, Inc. and reared at McCall Hatchery. Shortly before stocking, rainbow trout were marked by hand with either adipose or right ventral fin clips. Trout were taken from within the same rearing unit to avoid differences in rearing conditions or size. Equal numbers of adipose and ventral-clipped trout were stocked together in each of 10 lakes by aircraft in September 2011. The number of marked fish stocked in each lake was intended to meet the default request for that location. Lakes will be sampled with floating gill nets in 2014 as described above. The proportion of adipose and ventral-clipped rainbow trout captured will be used to assess differences in relative survival between fin clips.

RESULTS AND DISCUSSION

During the week of September 23, 2011, 14,132 3N and 13,625 2N WCT were marked with adipose fin clips at McCall Hatchery. Sixteen lakes were stocked with 2N WCT and 15 with 3N WCT from September 29 to October 1, 2011 (Table 8). Only 15 lakes were stocked with 3N WCT because of a mistake during the stocking process. At the time of stocking, marked 2N and 3N WCT groups were of similar length and weight. The mean length and weight for the 2N group (± 95% confidence intervals) was 44.2 ± 1 mm and 0.87 ± 0.1 g (539 fish/lb), respectively. The mean length and weight for the 3N group was 42.8 ± 1 mm and 0.85 ± 0.1 g (558 fish/lb), respectively. Thus, the 2N and 3N groups were very similar in mean length and weight at the time of stocking. Flow cytometry analysis of the 3N WCT group indicated 100% triploid induction (n = 99).

Test fish stocked in this evaluation were smaller compared to those used for previous evaluations in high mountain lakes. Previous studies using rainbow trout fry used experimental groups with mean lengths ranging from 62 mm to 67 mm (Koenig et al. 2011). Those rainbow trout were also stocked earlier starting in mid-August, which is more similar to typical timing for alpine lake stocking, but still much larger size than normal. Raising test groups of WCT to large enough sizes for marking was problematic and resulted in stocking lakes later than normal. WCT eggs are not available as early as rainbow trout from Troutlodge, Inc. or Hayspur Hatchery. Once hatched, WCT are more difficult to culture and do not grow as quickly in the hatchery as domesticated rainbow trout. Later egg availability and slower growth rate delayed fish marking until mid-September before fish were large enough to adipose-clip. This meant stocking did not occur until around October 1, almost a month later than normal stocking would occur. While these test groups may have less time to forage in alpine lakes before the onset of winter, they were much larger (539-558 fish/lb) than normally produced westslope cutthroat stocked earlier in the summer (800–1,200 fish/lb; Jamie Mitchell, IDFG, personal communication). Additionally, the small average size of the test groups made adipose clipping challenging and time consuming.

Fin Clip Comparison

For the fin clip comparison, rainbow trout were marked at McCall Hatchery on September 22, 2011 and stocked from September 29-30, 2011 by aircraft. Ten lakes were stocked with equal numbers (324 each) of adipose and ventral-clipped rainbow trout (Table 9). At marking, the mean length (with 95% confidence intervals) of adipose and ventral-clipped groups was 50.2 ± 1 mm and 51.2 ± 1 mm, respectively. The mean weight (with 95% confidence intervals) of adipose and ventral-clipped groups was 1.30 ± 0.07 g and 1.33 ± 0.07 g, respectively.

RECOMMENDATIONS

1. Spawn and rear a second lot of 100,000 3N westslope cutthroat trout eggs in May 2013 for stocking in fall 2013.

2. Coordinate with Regional Fish Managers to develop a second list of study site lakes for 2013 2N/3N WCT stocking.

ACKNOWLEDGEMENTS

John Rankin and Jamie Mitchell of Cabinet Gorge and McCall hatcheries, respectively, did an excellent job helping with spawning and pressure shocking westslope cutthroat trout. They were instrumental in rearing each test group and were very helpful when it came time to collect blood samples and fin-clip test groups.

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Table 8. Study lakes stocked in 2011 with adipose-clipped diploid (2N) and triploid (3N) westslope cutthroat trout (C2) for developing ploidy-specific stocking density guidelines.

Study	Lake name	Catalog #	Stocking date	Region	Location (lat./long. NAD87)	Species	Mark	Number stocked	Area (ha)	Elevation (m)	Stocking density (fish/ha)
2N WCT	Black L	07-0143	9/29/2011	3M	45.18879 N, 116.59950 W	C2	Ad clip	2500	11.75	1338	213
2N WCT	Burnt Knob L (Upper)	06-0589	10/1/2011	2	45.70436 N, 114.98733 W	C2	Ad clip	500	1.00	2237	501
2N WCT	Creek L	07-0422	9/30/2011	3M	45.32767 N, 115.97402 W	C2	Ad clip	500	2.52	2259	198
2N WCT	Hidden L	07-0179	9/27/2011	3M	45.14851 N, 116.15208 W	C2	Ad clip	1000	4.40	2280	227
2N WCT	Hurst L	07-0261	10/1/2011	2	45.51462 N, 115.73680 W	C2	Ad clip	500	1.38	2265	362
2N WCT	Kelly L #03 (Kelly #4)	07-0274	10/1/2011	2	45.64323 N, 115.67846 W	C2	Ad clip	500	2.68	2264	187
2N WCT	Kimberly L #02	07-0244	9/29/2011	3M	45.40261 N, 115.86811 W	C2	Ad clip	750	1.27	2168	592
2N WCT	Mirror L	06-0640	10/1/2011	2	45.61990 N, 115.70402 W	C2	Ad clip	500	2.25	2232	223
2N WCT	N F Twenty Mile L #02 (East)	09-0396	9/29/2011	3M	45.12333 N, 115.91750 W	C2	Ad clip	1000	6.40	2305	156
2N WCT	Pete Creek L #03	07-0416	9/29/2011	3M	45.26406 N, 115.97513 W	C2	Ad clip	500	0.81	2405	614
2N WCT	Saddle Creek L	07-0304	10/1/2011	2	45.62492 N, 115.02844 W	C2	Ad clip	500	4.85	2250	103
2N WCT	Six Basin L #02	05-0136	9/30/2011	3M	45.19739N, 116.59432 W	C2	Ad clip	1000	7.55	2266	132
2N WCT	Trilby L #01 (Lower)	07-0307	10/1/2011	2	45.65464 N, 114.99317 W	C2	Ad clip	500	5.47	2504	91
2N WCT	Tule L	07-0519	10/3/2011	3M	44.62962 N, 115.68400 W	C2	Ad clip	500	3.62	2253	138
2N WCT	Union L	07-0248	10/1/2011	3M	45.35629 N, 115.80985 W	C2	Ad clip	1000	3.09	2102	324
2N WCT	Upper California L	07-0253	10/1/2011	3M	45.33833 N, 115.84861W	C2	Ad clip	500	0.52	2039	970
3N WCT	Bear L	07-0245	9/29/2011	3M	45.43573 N, 115.84430 W	3N C2	Ad clip	1000	1.38	1678	723
3N WCT	Burnt Knob L (Lower)	06-0586	10/1/2011	2	45.70714 N, 114.98317 W	3N C2	Ad clip	500	1.30	2255	384
3N WCT	Cooks L	07-0278	10/1/2011	3M	45.34185 N, 115.74513 W	3N C2	Ad clip	1000	2.03	2369	492
3N WCT	Crescent L	07-0259	10/1/2011	2	45.59157 N, 115.65791 W	3N C2	Ad clip	500	2.25	2237	222
3N WCT	Lake Creek L #02 (South, Up)	07-0283	10/1/2011	2	45.60480 N, 115.06094 W	3N C2	Ad clip	1000	7.54	2444	133
3N WCT	Middle California L	07-0250	10/1/2011	3M	45.33240 N, 115.84485 W	3N C2	Ad clip	1000	0.56	1775	1792
3N WCT	Mirror L	07-0114	10/1/2011	2	45.33655 N, 116.52570 W	3N C2	Ad clip	500	4.65	2405	108
3N WCT	N F Twenty Mile L #01 (North)	09-0395	10/1/2011	3M	45.12528 N, 115.92556 W	3N C2	Ad clip	1000	6.81	2364	147
3N WCT	Pete Creek L #02	07-0418	9/29/2011	3M	45.28879 N, 115.98291 W	3N C2	Ad clip	500	1.92	2276	260
3N WCT	Satan L	07-0140	9/29/2011	3M	45.20100 N, 116.55432 W	3N C2	Ad clip	1500	2.19	2314	684
3N WCT	Six Basin L #01	05-0135	9/30/2011	3M	45.19627 N, 116.60098 W	3N C2	Ad clip	500	2.20	2230	227
3N WCT	Spread Point L (Goodman)	07-0305	10/1/2011	2	45.64408 N, 115.00983 W	3N C2	Ad clip	1000	9.75	2181	103
3N WCT	Trilby L #03 (Upper)	07-0309	10/1/2011	2	45.65603 N, 115.00344 W	3N C2	Ad clip	500	6.48	2115	77
3N WCT	Twin L #02	07-0148	9/30/2011	3M	45.15405 N, 116.52043 W	3N C2	Ad clip	500	2.14	2253	234
3N WCT	Wiseboy L (Lower)	06-0635	10/1/2011	2	45.62897 N, 115.70059 W	3N C2	Ad clip	500	7.92	2115	63

Table 9. Study lakes stocked in 2011 with adipose (AD) and ventral-clipped (RV) triploid Troutlodge rainbow trout (TT) to compare relative survival between fin clips.

Study	Lake name	Catalog #	Stocking date	Region	Location (lat./long. NAD87)	Species	Mark	Number stocked	Area (ha)	Elevation (m)	Stocking density (fish/ha)
Fin Clip	Basin L (Sheep Creek L #02)	05-0102	9/30/2011	2	45.34489 N, 116.55589 W	TT	AD/RV	250 ea	2.79	2251	179
Fin Clip	Bernard L #01	05-0112	9/30/2011	2	45.36652 N, 116.57330 W	TT	AD/RV	250 ea	1.29	2227	387
Fin Clip	Bernard L #02	05-0114	9/30/2011	2	45.36519 N, 116.57518 W	TT	AD/RV	250 ea	1.92	2226	261
Fin Clip	Emerald L	05-0132	9/29/2011	3M	45.21230 N, 116.57033 W	TT	AD/RV	500 ea	10.35	2074	97
Fin Clip	Gem L (Sheep Creek L #03)	05-0107	9/30/2011	2	45.33643 N, 116.55398 W	TT	AD/RV	250 ea	6.12	2383	82
Fin Clip	Horse Pasture L	05-0141	9/29/2011	3M	45.17853 N, 116.57117 W	TT	AD/RV	250 ea	3.63	2183	138
Fin Clip	Six Basin L #03	05-0137	9/30/2011	3M	45.19470 N, 116.59874 W	TT	AD/RV	250 ea	0.77	2255	653
Fin Clip	Six Basin L #04	05-0138	9/30/2011	3M	45.19500 N, 116.59500 W	TT	AD/RV	250 ea	0.82	2253	606
Fin Clip	Triangle L	05-0119	9/30/2011	2	45.32076 N, 116.56354 W	TT	AD/RV	250 ea	3.30	2301	151
Fin Clip	Upper Emerald L	05-0133	9/30/2011	3M	45.19917 N, 116.57997 W	TT	AD/RV	250 ea	0.16	2432	3089

ANNUAL PERFORMANCE REPORT
SUBPROJECT #3: IMPROVING RETURNS OF HATCHERY CATCHABLE RAINBOW TROUT: STATEWIDE EXPLOITATION RATES AND EVALUATING REARING DENSITY

State of:	Idaho	Grant No.:	F-73-R-34 Fishery Research
Project No.:	4	Title:	Hatchery Trout Evaluations
Subproject #1:	Improving Returns of Hatchery Catchable Rainbow Trout		
Contract Period:	July 1, 2011 to June 30, 2012		

ABSTRACT

Idaho Department of Fish and Game (IDFG) hatcheries are integral to managing coldwater sportfishing opportunities in Idaho. Despite the costs associated with stocking catchable trout, a comprehensive evaluation of hatchery catchable exploitation rates (i.e. return-to-creel) in Idaho's predominant put-and-take fisheries has been lacking. Optimizing rearing density is one technique that may help enhance recruitment of hatchery-reared fish into stocked fisheries. This project is intended to (1) evaluate exploitation rates of the most-stocked water bodies, and (2) research hatchery rearing techniques to increase return-to-creel of catchable rainbow trout. In 2011, Nampa Research staff released 33,359 nonreward Floy®-tagged hatchery rainbow trout across 49 water bodies statewide. The statewide average total length (± 95% C.I.) of catchable rainbow trout tagged during 2011 was 257 ± 0.3 mm, (10.1 in). Statewide, average exploitation and "total use" (± 90% C.I.) for hatchery catchable rainbow trout across the waters I evaluated was 19.8% (± 2.2%) and 29.5% (± 3.0%). On average, exploitation and "total use" for 16 urban ponds was 36.3% (± 6.0%) and 50.1% (± 7.0%), respectively. Mean "total use" (harvest and released) of rainbow trout was significantly different across rearing densities. The low density (DI = 0.15) treatment had the highest "total use" (22.9%) on average, and was significantly different from medium- and high-density groups. Mean "total use" of rainbow trout was also significantly different across hatcheries. Hagerman and American Falls hatcheries had similar average "total use" of catchable rainbow trout (21.3% and 21.5%) and were significantly different from Nampa Hatchery (17.5%). When looking at the relative differences between treatments, the "total use" of low-density treatment fish was 24.5% higher than high-density fish, on average. At this time, the higher return-to-creel of fish raised at low densities will likely not be sufficient to offset the reduced number of fish raised and stocked. Further analysis will be required as tag returns begin to accumulate and more information is gathered about exploitation and total use. Analysis should examine the role of flow index, size-at-stocking, and fish health on exploitation and total use of catchable rainbow trout. The current level of analysis is preliminary, with more rigorous analysis anticipated as final data is compiled.

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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 ten hatcheries that raise up to 18 varieties of salmonids for inland coldwater fisheries. In 2008, resident hatcheries stocked over 16.5 million fish in over 500 water bodies (Frew 2008), including about 2.4 million "catchable-sized" rainbow trout. Producing catchable rainbow trout (typically stocked at 203 mm–305 mm in length) accounts for over 50% of the annual resident hatchery budget and about 84% of the total weight of fish stocked annually (Table 10). Hagerman, Nampa, and American Falls hatcheries provide the majority of IDFG catchable trout, with Hagerman providing almost half (Table 10). The default catchables request list is the standard stocking schedule for all waters statewide. According to this list, catchable rainbow trout *Oncorhynchus mykiss* are planted in about 293 water bodies throughout Idaho (T. Frew, IDFG, personal communication). Catchable rainbow trout raised by IDFG are typically one of six strains, with the majority being Troutlodge Inc. triploid Kamloops (TT), Hayspur triploid (T9), or Hayspur Kamloops triploid (KT) (Table 11). Despite the large number of waters stocked with catchable rainbow trout, a small number of water bodies account for large proportions of the total catchable rainbow trout stocked. For example, five water bodies (Cascade, American Falls, Blackfoot, Chesterfield reservoirs, and the Boise River) account for 21% (456,000 fish) of the total annual catchable production. Fifty percent of the catchable rainbow trout are stocked into about 30 locations, while 60% are stocked into 48 locations (Table 11).

A large component of hatchery trout "quality" should be contribution to angler return-to-creel (either catch or harvest). More information on return-to-creel rates of catchable rainbow trout is currently needed. Exploitation rates of Idaho's most prominent stocked fisheries could identify locations where catch objectives are met, or where stocking is not providing the intended benefit. This information could identify underperforming fisheries or poor fish performance. 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 will be critical to guide the decision-making process and implement changes in allocating catchable rainbow trout production.

Current hatchery production capacity and funding are not increasing, while demand for hatchery catchable trout remains steady or is increasing. Despite the costs associated with stocking catchable trout, a comprehensive evaluation of hatchery catchable exploitation rates (i.e. return-to-creel) in Idaho's predominant put-and-take fisheries is lacking. Previous studies focused mainly on certain regions and included a limited number of waters (Mauser 1994; Mauser 1995; Dillon and Alexander 1997; Megargle and Teuscher 2001). Total hatchery production is an insufficient yardstick to determine whether hatcheries are successful. Instead, hatchery success should be measured in terms of contribution to harvest (Blankenship and Daniels 2004).

Recent IDFG studies have begun to evaluate exploitation on a statewide basis using angler-caught tagged fish (Meyer et al. 2010). These evaluations were mainly intended to derive angler tag response rates so that managers could estimate angler harvest in fisheries across Idaho. As part of that work, they also estimated exploitation rates for hatchery catchable rainbow trout in four of the top-10 waters stocked, but only six of the top-20 waters (Table 12). While this represents progress, only one water body (Cascade Reservoir) has been evaluated over several years, so little is known about variation in return-to-creel rates between years in our major stocked fisheries. Given the current economic climate for IDFG hatchery funding, efforts must be made to ensure that hatchery programs remain efficient while producing a quality product for Idaho anglers.

In addition to the primary goal of determining exploitation rates for major catchable trout fisheries, evaluating methods to increase returns is also important. Rearing conditions and culture techniques vary across hatcheries and can affect poststocking survival and return-to-creel. Differences in rearing conditions such as raceway density (Elrod et al. 1989) or feed type (Barnes et al. 2009) can affect the quality and return-to-creel of hatchery fish. The effect of rearing density on poststocking survival of hatchery salmonids has been widely studied for Chinook salmon *Oncorhynchus tshawytscha* (Martin and Wertheimer 1989), coho salmon *Oncorhynchus kisutch* (Fagerlund et al. 1981; Schreck et al. 1985; Banks 1992), and steelhead trout (Tipping et al. 2004). Results are often inconsistent and difficult to interpret and may differ between species, brood years, and hatcheries (reviewed in Ewing and Ewing 1995). While rearing density effects on poststocking survival have been studied for anadromous Pacific salmonids, few studies are available for inland trout species. Previous studies have mainly focused on in-hatchery performance of cutthroat trout *Oncorhynchus clarkii* (Kindschi and Koby 1994; Wagner et al. 1997), lake trout *Salvelinus namaycush* (Soderberg and Krise 1986), and rainbow trout (Kindschi et al. 1991; Wagner et al. 1996; Procarione et al. 1999). These studies generally concluded that rearing fish at high densities often results in lower survival, decreased growth, decreased food conversion rates, and reduced health.

Managing basic resources such as rearing space, water flows, and stocking densities are highly important to hatchery operations (Banks and LaMotte 2002). Optimizing rearing density is one technique that may help enhance recruitment of hatchery-reared fish into stocked fisheries (Elrod et al. 1989). Lower rearing densities may increase the yield of stocked fish, or provide an economic benefit to hatcheries if losses from disease outbreaks are reduced. Rearing fish at lower densities means that fewer total fish will be produced. If a net gain is to be realized – either increased harvest or equal harvest with lower stocking – return rates from low-density groups must be high enough to compensate for the reduced numbers of trout stocked (Martin and Wertheimer 1989). As operating costs continue to increase, rearing fish more efficiently will become more important. Encouraging innovation and experimentation in hatcheries will help these facilities respond to new goals and culture techniques (Blankenship and Daniels 2004). Evaluating how rearing techniques affect return-to-creel could develop strategies to raise fish more effectively

Previous research has indicated that tag returns can be highly variable across a small number of reservoirs and streams, but recent data for Idaho's major catchable fisheries is limited. Tag returns can be variable both across locations and within a location across years. Teuscher et al. (1998) reported tag return rates (unadjusted for tag response rates) for catchable rainbow trout in 18 Idaho streams ranged from 7.5-42.5%, averaging 17.1%. Megargle and Teuscher (2001) estimated unadjusted return rates of catchable rainbow trout in 16 Idaho waters between Hagerman, Nampa, and American Falls hatcheries in 1999 and 2000. Return rates were highly variable among locations, (15-73%), and showed significant year-to-year variation in return rates within stocking locations and hatcheries. In a more recent example, the total tags returned from catchable plants in Cascade Reservoir (Table 3) ranged from 0-18 in two different years, but few locations exist with several years of tag returns for hatchery trout (Meyer et al. 2010). Several years of data may be needed to encompass random yearly variation in exploitation rates of the most-stocked fisheries.

OBJECTIVES

1. Determine the average return-to-creel (exploitation) and catch rates of catchable rainbow trout in *at least* the top 50% of waters stocked (as determined by the total trout stocked).

2. Describe the variation in exploitation and catch rates across several years within these water bodies.

3. Evaluate return-to-creel and catch rates of rainbow trout raised at different densities at major IDFG production facilities.

4. Compare return-to-creel and catch rates of rainbow trout raised at different densities to assess whether current raceway densities are optimizing return-to-creel rates.

METHODS

Statewide Exploitation

Study sites were selected based on data in the 2010 default catchables request list. Waters were ranked according to total number of catchable rainbow trout planted annually and chosen to evaluate locations that comprise 50% of the total catchable rainbow trout stocked annually (Table 11). Many study sites were utilized to evaluate exploitation rates, as well as rearing density treatments and comparisons between hatcheries. Additional waters were added as resources allowed to evaluate up to the 60% stocking level. This included the most-stocked waters that comprise 60% of the total catchable rainbow trout stocked annually. Additional waters were added to increase sample sizes for rearing density comparisons.

When taken individually, urban ponds do not receive enough fish to be considered in the “Top-50%,” but account for the most catchable rainbow trout stocked annually when combined (Table 11). Therefore, a statewide assessment of return-to-creel across urban ponds was deemed desirable. Regional Fishery Managers from each Region supplied a list of small ponds with general harvest regulations managed as short-term put-and-take fisheries, often located in or near populated areas. This list was stratified into low/medium/high use groups based on perceived harvest, and tags were distributed to include a subsample of ponds in most regions on a 3-year rotation (Table 12).

Rearing Density Study

Rainbow trout used in rearing density experiments originated as eggs purchased from Troutlodge Inc., an all-female triploid rainbow trout stock commonly used in IDFG facilities. Density trials were conducted at the three major facilities that produce catchable trout: Hagerman, Nampa, and American Falls hatcheries. Most IDFG facilities set a target maximum density index (DI) value of 0.3 lbs/ft^3/inch of fish, based on past experience and the recommendations of Piper et al. (1982). Rearing density treatments were low, medium, and high, corresponding to 50%, 75%, and 100% of the target maximum density index value, respectively. Therefore, the rearing density index values for the low, medium, and high treatments were 0.15, 0.23, and 0.3, respectively. Because of space limitations in 2011, there were only two treatment groups (low and high), at Hagerman Hatchery. All three treatment groups were administered at Nampa and American Falls hatcheries. Rearing density groups were not to exceed the specified maximum treatment density index for each treatment during the rearing period. As fish grew and densities increased, fish were extended into lower raceway sections to avoid exceeding the specified maximum values. Treatment densities were assigned to individual egg lots and carried through one entire raceway, so that only a single treatment was raised in each raceway. The approximate number of fish for each treatment raceway was first established using egg counts. Treatment lots were then inventoried at the fry stage using pound-counts when transferred from hatching containers to outside raceways and when moved between raceways.

Rearing density treatment groups were raised using culture techniques standard to each facility. Raceway densities and fish sizes were monitored closely to minimize size differences between treatment groups and hatcheries. Feeding rates were adjusted using monthly pound counts and feed projections to adjust growth to target size of 3 fish/lb at 10 in at stocking. Feed projections at each hatchery were done using the Hatchery Constant (HC) method (Piper et al. 1982) with $\Delta L = 0.025 – 0.033$ to target 1” growth per month. Projections were adjusted to reflect changes in loading rates from mortalities and stocking events. All facilities fed treatment groups the floating commercial trout diet Rangen Inc. EXTR 450. Feed size was adjusted for fish length based on feed guidelines provided by Rangen Inc.

American Falls Hatchery

Rainbow trout were reared on 12.8°C spring water in single-pass fashion. Fry were started using indoor concrete vats (17.5’ x 4’ x 2.5’) and fed using a combination of hand-feeding and belt-feeders. After reaching approximately 200 fish/lb, fish were inventoried using pound counts and moved to outdoor concrete raceways (8’ x 200’ x 2 sections). Fish were reared in these raceways and hand-fed for the remainder of the rearing period.

Hagerman Hatchery

Density treatment groups were reared on the Tucker Spring water source (15°C). Fry were started in indoor concrete vats (14’ x 2.7’ x 2’). After reaching 1.80 in, fish were inventoried using pound counts and moved to small outdoor concrete raceways (100’ x 3.6’ x 1.8’). After reaching 3 in, fish were again inventoried and moved to large concrete raceways (8’ x 100’ x 2 sections). Upon reaching 8 in, fish were again inventoried and moved to large concrete raceways (12’ x 100’ x 2 sections), where they were raised for the remainder of the rearing period. Fish were fed by hand until reaching 4 inches in the large raceways, at which time they were fed mechanically with a tractor.

Nampa Hatchery

Nampa Hatchery raised fish on single-pass water from a spring source at 15°C. Density treatment groups were hatched into small concrete outdoor raceways (5’ x 25’’ x 2 sections) and fed using a combination of hand-feeding and belt feeders on a 12-hour timer. After reaching 50-75 fish/lb, fish were inventoried using pound counts and moved to large outdoor concrete raceways (12’ x 100’ x 2 sections) and hand-fed for the remainder of the rearing period.

<u>Tagging</u>

The majority of catchable rainbow trout raised in IDFG facilities are all-female rainbow trout that originate as eggs purchased from Troutlodge, Inc. The Hayspur Hatchery broodstock facility also supplies a significant portion of triploid catchable trout eggs (T9), though not as many as the TT group (Table 11). This resulted in a mix of TT and T9 evaluations, depending on which lots were normally scheduled to stock the evaluated waters (Table 11). Trout were collected at each participating hatchery by first crowding within raceways, then collecting with dip nets to be tagged. Crowding fish ensured a random sample of fish from the entire raceway and reduced size-selected bias. Trout were individually measured for total length (mm) and tagged using 70 mm (51 mm of tubing) fluorescent orange Floy® FD-68BC T-bar anchor tags treated with algaecide. All fish greater than 160 mm in a sample were tagged to reduce bias. Trout were returned to submerged enclosures or empty raceway sections and allowed to recover overnight. Mortalities and shed tags were collected and recorded before loading fish for transport. Tagged trout were then loaded by dip net onto stocking trucks and transported to stocking locations. After stocking, truck tanks were checked for shed tags. Site-specific exploitation rates were determined using the facility and stock of fish normally used to stock that water body whenever possible. In these locations (no density trial fish), fish were marked from the normal production lots and raceways intended for those locations. Tagged fish were loaded along with the total stocking load, allowed to mix, and were stocked as normal. Fish from the rearing density trial were tagged from the respective experimental raceways, and then combined and loaded with the normal lot of fish scheduled for that stocking event. For additional comparisons, some hatcheries stocked density trial fish in locations they normally do not stock. In these cases, tagged fish were transported alone without additional production fish. All anchor tags were labeled with "IDFG" and the tag reporting phone number (IDFG 1-866-258-0338) on one side, and the tag number on the reverse side. Anglers could report tags using the IDFG "Tag-You're-It" phone system and website (accessible at https://fishandgame.idaho.gov/feedback/fish/forms/reportTaggedFishAngler.cfm), as well as at regional IDFG offices and by mail.

Reward tags were used to monitor declines in tag reporting rate that can occur over time if anglers lose interest or become "swamped" by too many tags (Henny and Burnham 1976). Additionally, few tags had been previously used in urban ponds, so whether the average reporting rate differed from other waters was unknown. A subset of waters was chosen to receive reward tags in addition to standard nonreward tags. In locations that received reward tags, rewards were distributed at a constant rate of 10% of the total tags planted. Reward tags were identical to nonreward tags in size, shape and color, but contained additional text ("Reward") and the amount ($50). Tags of $50 were used because they have shown sufficiently high reporting rates (89.2%) for catchable rainbow without the added cost of $100 or $200 tags (Meyer et al. 2010).

Most stocked waters receive several plants over the course of the fishing season. Tags were distributed over the fishing season to characterize average return rates more accurately than a single release event. Most lakes and reservoirs were stocked with a large plant of trout in spring, followed by a second smaller plant in fall. We distributed tags during spring and fall stocking events to capture both events. Other locations were stocked more frequently (urban ponds, some streams). For these waters, I randomly chose one month within each quarter and distributed tags evenly across those months. Typically, 400 tags (plus any reward tags at 10% rate when used) were stocked to estimate exploitation rates. In smaller waters, I reduced the number of tags in a given plant to no more than 10% of the total fish stocked to avoid "swamping" anglers with tags. I used the same tagging protocol for the rearing density trial groups. We tagged 200 fish from each treatment group per stocking event. In some cases (Nampa Hatchery), we had the opportunity to tag additional groups of normal production fish (n = 200) rainbow trout for added comparisons.

Data Analysis

Angler tag return rate (λ) was estimated using the relative reporting rate of nonreward tags relative to that of high-reward tags (Pollock et al. 2001). The associated variance was calculated according to Henny and Burnham (1976) and used to generate 90% confidence intervals. Statewide average reporting rate for rainbow trout found in Meyer et al. (2010) was calculated using $50 reward tags,

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

where R_t and R_r are the number of standard tags released and reported, respectively, and N_t and N_r are the number of $50 reward tags released and reported, respectively. I was concerned that the tag reporting rate might differ for heavily fished urban ponds, so I calculated tag reporting rates separately for urban ponds and all other waters. Eestimates for λ were adjusted to account for the fact that about 89.2% of $50 tags are actually reported, according to Meyer et al. (2010). Only non-reward tags from water bodies that included a subset of reward tags released were used to calculate reporting rates.

I calculated exploitation (total harvest) within one year (up to February 14, 2011 for this report) after stocking according to the methods of Meyer et al. (2010). The annual unadjusted exploitation rate (*u*) was calculated as the number of nonreward tagged fish reported as harvested within one year of tagging, divided by the number of nonreward tags released. Unadjusted exploitation and "total use" were adjusted (*u'*) by incorporating the average angler tag reporting rate (λ = 49.2%, corrected for 89.2% reporting for $50 tags), first year tag loss (Tag_l = 8.2%), and tagging mortality (Tag_m = 0.8%) for rainbow trout based on extensive Floy®-tagging from 2006 to 2009 presented in Meyer et al. (2010). Estimates were calculated for each individual stocking event.

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

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) which was used to derive 90% confidence intervals. A more complete description of these methods and the associated formulas is presented in Meyer et al. (2010).

Because some anglers release fish voluntarily, exploitation estimates may not necessarily characterize the utilization of fish by anglers (Quinn 1996). To account for catch-and-release in addition to harvest, I also calculated "total use." For "total use," I changed *u'* to include the total fish caught for each release group, including those reported as both harvested and released. Calculations were otherwise performed as described above.

I compared tag returns across rearing densities with ANOVA and Tukey's multiple comparisons using Proc GLM with α = 0.1 (SAS 9.1). The model included angler "total use" as the dependent variable, with water body, hatchery of origin, and rearing density as factors. Angler "total use" (percent data with binomial distribution, ranging from 0-100%) was arcsine transformed to approximate a normal distribution prior to ANOVA analysis (Zar 1999). Sample size for comparisons was based on individual water bodies as the unit of observation. Initial analysis indicated second- and third-order interaction terms were not significant, so I limited our analysis to include only first-order interaction terms (water*hatchery).

RESULTS

Statewide Exploitation

In 2011, Nampa Research staff released 33,359 nonreward tagged hatchery rainbow trout across 49 water bodies statewide with 202 individual tag groups (Table 14). By March 1, 2012, anglers returned 4,023 of these tags. Exploitation and "total use" varied widely (0-96.8%) across water bodies. Table 14 provides detailed results by Region for each water body in this study by stocking event. On average, statewide exploitation and "total use" (± 90% C.I.) for hatchery catchable rainbow trout across the waters I evaluated was 19.8% (± 2.2%) and 29.5% (± 3.0%), respectively, for all tags released in 2011 as of this report.

During 2011, tagged rainbow trout were released into 16 urban ponds over 46 tagging events (which included Wilson Springs ponds). On average, exploitation and "total use" for these urban ponds in 2011 for hatchery catchable rainbow trout was 36.3% (± 6.0%) and 50.1% (± 7.0%), respectively. However, estimated harvest for individual tag groups varied widely across ponds, ranging from 0% to 96.8% (Table 14). Catchables in urban ponds were caught quickly after stocking, with the mean and median days at large being 17 and 8 days, respectively (Figure 6).

The statewide average total length (± 95% C.I.) of catchable rainbow trout tagged during 2011 was 257 ± 0.3 mm (10.1 in) when considered across all waters and hatcheries. However, total length varied among hatcheries (Figure 7), and was likely influenced by tagging date (later tagged fish being larger), and the rearing hatchery of origin. Total length of tagged catchable trout was less variable across Regions, with Region 1 having slightly shorter fish, and Region 6 having slightly longer fish (Figure 8).

Rearing Density Trial

Rearing density index values fluctuated over time during the rearing period as fish grew and as rearing space was adjusted. Raceway volume was adjusted over time to prevent treatment groups from exceeding treatment densities. On average, treatment densities were below the specified maximum density values of 0.3, 0.23, and 0.15 lbs/ft^3/inch of fish for the high/medium/low-density treatments (Table 15). Densities at American Falls and Hagerman hatcheries were consistently below specified treatment values (Figure 9, Figure 10), while density index values at Nampa Hatchery were the closest to the specified treatments (Figure 11). Rainbow trout included in the density rearing experiment ranged in size from 242 mm to 258 mm at the time of stocking, with slight differences in average length between density treatment groups. At all three hatcheries, low-density fish were slightly longer than both medium and high-density fish (Table 15), with the difference being most pronounced at Nampa Hatchery (15 mm). However, when combined across treatments, overall mean length at stocking was similar across American Falls, Hagerman, and Nampa hatcheries (Table 15).

Mean "total use" of rainbow trout was significantly different across rearing densities ($P < 0.0001$, $F = 9.75$, $df = 3$). The low density (DI = 0.15) treatment had the highest "total use" (22.9%) on average, and was significantly different from medium- and high-density groups. Mean "total use" for the other rearing densities ranged from 17.3%-19.3%, but were not statistically distinguishable (Table 16). Water body was a significant factor (*P* <0.0001, *F* = 56.55, *df* = 22) in the model, indicating much of the variation in "total use" was due to inherent differences among waters (Table 16). Mean "total use" of rainbow trout was also significantly different across hatcheries (*P* <0.0001, *F* = 18.38, *df* = 2). Hagerman and American Falls hatcheries had similar average "total use" of catchable rainbow trout (21.3% and 21.5%), and were significantly different from Nampa Hatchery (17.5%). However, the model included a significant interaction of water*hatchery, indicating that differences between hatcheries was not consistent across water bodies (Table 16).

Tag Reporting Rate

We released $50 reward tags across 26 waters, with seven of these waters considered as urban ponds. As of March 1, 2011, the statewide overall average adjusted tag reporting rate for catchable hatchery rainbow trout using nonreward tags was 48.9%. When urban ponds were removed, this statewide average adjusted reporting rate decreased slightly to 49.1%, while the adjusted reporting rate at urban ponds was 46.6%. These results suggest that the tag reporting rate is slightly lower for urban ponds, but probably does not differ significantly.

DISCUSSION

Statewide Exploitation

Our estimate of overall statewide exploitation of hatchery catchable trout (19.8%) is slightly higher than that previously reported by Meyer et al. (2010) of 15.5%. This is probably reasonable, given that their estimate was based on 18 waters over 4 years and mainly included larger reservoirs, which generally show lower exploitation rates (Meyer et al. 2010). Our more recent estimate includes several urban ponds, which probably increased the average exploitation rate statewide (Table 14).

Estimated harvest for urban ponds varied widely across different ponds. No tags were returned from several ponds in south-central Idaho (Freedom Park, Rupert Gravel, Connor ponds), likely due to predation by American White Pelicans *Pelecanus erythrorhynchos*; in contrast, other locations had harvest as high as 96.8% for some release groups (e.g., Wilson Ponds).

On average, IDFG hatcheries met the goal of producing catchable rainbow trout at the requested 10-inch length. However, while the average length of catchable trout was achieved, significant variation in length occurred within and between hatcheries. Length-at-stocking is influenced by tagging date, rearing hatchery, and the rearing period, all of which can affect size throughout the stocking season. Catchable rainbow trout from McCall, Sandpoint, Mullan, Sawtooth, and Clearwater hatcheries originate from Nampa Hatchery. Therefore, mean length at these facilities depends largely on the size distribution at Nampa Hatchery at the time fish are transferred for redistribution. Little growth is expected after fish reach redistribution facilities. Regional average length of catchable trout should be directly related to the stocking and rearing hatchery. In the case of Region 1, these fish were stocked from Mullan and Sandpoint hatcheries, redistributed originally from Nampa Hatchery in spring 2011 for stocking throughout the summer. The minimum length presented in Figure 7 and Figure 8 is slightly biased high, because we did not tag fish less than 160 mm, though fish below 160 mm were rare. Variation in hatchery catchable rainbow trout length using current rearing techniques should be expected. Within any production lot, there is a genetic basis for slow growth in some fish (Westers 2001).

Additionally, culture techniques to reduce size variation (such as hand-feeding, demand feeders, or grading) are not commonly employed in large IDFG facilities. Benefits from minimizing size variation in IDFG hatcheries have not been thoroughly evaluated.

Rearing Density

"Total use" of catchable rainbow trout appeared to be slightly higher for fish reared at lower densities, but the effect seemed most pronounced at Hagerman Hatchery (Figure 12). Hagerman and American Falls hatcheries have similar average "total use" of catchable rainbow trout (21.3% and 21.5%) and were significantly different from Nampa Hatchery (17.5%). However, we must be careful when interpreting these results, as the model included a significant interaction of water*hatchery, indicating that differences between hatcheries were not consistent across water bodies (Table 16). Therefore, we cannot make general conclusions about the relative performance between hatcheries without considering the waters in which fish were stocked. Effects of rearing density probably interact with other factors such as water flow, disease loading, and water quality. These factors vary among hatcheries and complicate the relationship of rearing density to angler return rates, where certain relationships may only be applicable at individual facilities.

Results indicate that fish raised at lower density do return to anglers at higher rates. When looking at the relative differences between treatments, the "total use" of low-density treatment fish was 24.5% higher than high-density fish, on average (Table 16). Total use for normal production was lower than the low-density treatment (Figure 12) and similar to medium/high treatment groups, but differences were not statistically different in our analysis at this time (Table 16). This was most likely a result of the limited sample size (n = 6) and high variation in returns across waters. Results from the normal production group were most similar to the high-density group, which make sense given the fact that they experienced similar (or greater) rearing density conditions during rearing. Increased percent survival associated with lower rearing density is well documented among studies of salmon returns (Martin and Wertheimer 1989; Banks 1992; Ewing and Ewing 1995; Banks and LaMotte 2002). However, as Martin and Wertheimer (1989) cautioned, "the adult return rate must be great enough to compensate for the reduced number of smolts produced." In our study, the increase in total use is not proportional to the decline in numbers of fish raised. A 50% decline in the number of fish raised would need to produce a 100% increase in total use to offset the fact that half as many fish were raised. More detailed cost data is needed to evaluate the cost-per-fish returned to anglers from rearing fewer fish. Whether improved return to anglers of lower density fish can overcome the relatively fixed costs of hatchery operations remains questionable. Further analysis will be required as tag returns begin to accumulate and more information is gathered about exploitation and total use. Analysis should examine the role of flow index, size-at-stocking, and fish health on exploitation and total use of catchable rainbow trout. The current level of analysis is only at the preliminary stage, and more rigorous analysis is anticipated as more data is compiled.

The effects of hatchery rearing density on salmonids are well documented in the literature. Increased rearing density is associated with detrimental effects such as decreased growth, weight, food conversion efficiency, and survival has been shown to occur during hatchery rearing for coho salmon (Fagerlund et al. 1981), Snake River cutthroat trout *Oncorhynchus clarkii bouvierii* (Kindschi et al. 1994), Bonneville cutthroat trout *Oncorhynchus clarkii utah,* and rainbow trout (Procarione et al. 1999). Fagerlund et al. (1981) reported that juvenile coho salmon raised at higher densities showed significant decreases in weight, length, condition factor, food conversion efficiency, as well as higher mortality. Kindschi and Koby

(1994) found similar results, with high densities (0.48–2.30 $lb/ft^3/in$) adversely affecting weight gain, feed conversion, survival, and fish health in Snake River cutthroat trout reared over 18 weeks. The authors speculated that low-density treatment did not achieve projected growth rates because of stressful social interactions associated with low rearing density. Procarione et al. (1999) showed rainbow trout reared at high densities (over 4 weeks) had lower growth and food conversion rates, but that high density itself was probably not a chronic stressor. Soderberg and Krise (1986) studied growth and survival of lake trout raised in circular tanks at four densities: 0.25, 0.50, 1.0, 2.0 $lb/ft^3/in$. They found mortality was higher at the highest density, but found no differences in growth over the 97-day experiment. Most published studies have focused on the in-hatchery impacts to fish health and growth, generally over time frames much shorter than the 10-12 months needed to produce a catchable-sized rainbow trout, with little study on how rearing conditions affect poststocking survival.

Some studies have examined how rearing density may affect poststocking survival of salmonids, with most studies focusing on anadromous salmon species and little on rainbow trout. Elrod et al (1989) found poststocking survival of fingerling lake trout was only 76% of those raised under low densities. Ewing and Ewing (1995) reported that increased hatchery rearing density produced lower percent survival to adulthood for Chinook salmon in 14 of 15 brood years, but not in coho salmon. The authors speculated that longer rearing time at higher density could impose higher stress on hatchery fish. Generally, rearing density was negatively correlated with the percent survival of salmon smolts and subsequent adult returns. However, in most studies, the higher number of smolts produced offset the effects of greater density, providing more returned adults (Martin and Wertheimer 1989; Banks 1992; Banks and LaMotte 2002). Contrary to most salmon studies, Tipping et al. (2004) found no difference in adult survival of steelhead raised under reduced raceway loading and density. These authors recommended raising more fish (same raceways, higher densities) to increase adult steelhead return rates.

After stocking was completed, American Falls Hatchery staff suggested that raceway inventories had been inaccurate, and that the calculated density index values were incorrect. Fewer fish than projected remained at the end of the rearing period, suggesting actual rearing densities were lower than calculated. This was presumably a result of errors made during the inventory process when moving fish from the early rearing vats to the outside raceways. American Falls staff used stocking records of total pounds of fish stocked to back-calculate actual rearing densities in the treatment raceways. The average low and medium density index values did not differ between the back-calculated and projected values. However, back-calculations from stocking records indicated the average density index for the high-density group was 0.19 instead of 0.16 as projected during rearing. This suggests that the high-density group was actually raised at higher density than previously thought, making it much closer in fact to the prescribed separations and maximum treatment values intended. This observation also corroborates the observed mortality and oxygen stress in the high-density rearing group.

American Falls Hatchery experienced some low dissolved oxygen, presumably stressing fish and causing some mortality in the high-density groups. In mid-March 2011, Tim Klucken (Hatchery Manager) reported oxygen levels in the lower high-density treatment raceway (#13) had reached 5.6 ppm. Fish were “gilling” on the bottom and riding high in the water column, presumably under stress from low oxygen. He had earlier anticipated a problem might arise when he reported his concern about the flow index values exceeding 1.4 lbs/GPM/inch, above the normal recommended levels of 1.25 lbs/GPM/inch. Records indicate fish were above the recommended flow index values for several weeks near the end of the rearing cycle (Figure 9) because of limited water flows. At the time, more raceways were filled to meet production demands, spreading out available water across more raceways and reducing flows in individual raceways. This may have caused added stress on this experimental group, which could have affected poststocking performance. American Falls Hatchery was the only hatchery where treatment groups exceeded recommended flow index values (Figure 9, 10, 11). Flows may be more critical than rearing densities at this station, and dissolved oxygen may be the limiting factor as loading increases.

As expected, rearing densities fluctuated greatly over the rearing period, as well as between hatcheries. At American Falls Hatchery, separation of the density treatments did not achieve the specified goal of 50%/75%/100% of the maximum treatment value. Average density index for the high-density group was on average only 0.16 (Table 15). The low and medium-density treatments were at 63% and 81% of the maximum, respectively, showing slightly above the desired treatment values. Overall, fish were reared at much lower densities at American Falls compared to Nampa and Hagerman hatcheries, mainly because water flow became limiting before treatment densities could be achieved. On average, density index values at Hagerman Hatchery were below the specified maximum treatment levels, but maintained excellent separation between treatments. The low-density was 50% of the high-density group, so I am confident that a real difference in treatments was applied between groups. Nampa Hatchery staff did well in keeping treatment densities at or below specified maximums (Figure 11). Nampa Hatchery achieved average density index values closest to the specified treatment levels, and maintained good separation between high, medium, and low treatments. The low and medium-density treatments were 52% and 80% of the maximum average density (Table 15), getting close to the desired 50% and 75% levels. Additionally, we tagged some groups of normal production at Nampa Hatchery. On average, Nampa Hatchery normal production fish had density index values higher than the high-density treatment groups (0.3) during some portion of the rearing period (Figure 11). However, this trend was not consistent as illustrated by the consistent higher densities of Raceway C6 but not Raceway C3 (Figure 11). The highest densities usually occur most often in April through June, when fish have reached their largest size and stocking has not begun in earnest.

Tag Reporting Rate

At this time, the tag reporting rate does not appear to be changing from that reported previously by Meyer et al. (2010). They found the nonreward average reporting rate for hatchery trout was 49.2%, which is almost identical to our findings (48.9%). I saw the average reporting rate actually decrease slightly when looking at urban ponds, but that was based on a limited sample of only seven waters where reward tags were used. Further reward tagging in urban ponds in 2012 should increase this sample size, which should provide more definitive evidence of whether the nonreward tag reporting rate differs significantly from the statewide average. If so, exploitation and “total use” estimates could be calculated separately for urban ponds to provide more accurate estimates in those waters. Additional reward tagging in 2012 across a greater range of waters will improve the resolution of tag reporting data statewide. If enough reward tags are returned, it may be possible to examine whether reporting rates differ across geographic regions of the state. Anecdotal observations by IDFG staff have suggested the statewide average reporting rate may be significantly different from local reporting rates, which could result in inaccurate estimates of exploitation.

RECOMMENDATIONS

1. Continue collecting and compiling tag returns until November 2012 to complete one year at large for the 2011 tag groups, at which point more complete data analysis can begin.

2. Perform a comprehensive data analysis of tag returns to examine the effect of size-at-stocking and flow index during rearing.

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Table 10. Idaho Department of Fish and Game annual resident fish hatchery production summary for 2008, taken from Frew (2008).

Production Hatchery	Put-and-Take Number	Pounds	Put-Grow-and-Take Number	Pounds	Average Fish per pound	Feed Pounds	Feed Costs	Average Length	Total cost	Cost 1,000 fish	Cost/ Pound
American Falls	271,810	74,236	11,785	2,577	3.69	70,424	$35,378	8.43	$230,031	$700.00	$3.15
Ashton	171,573	28,285	245,095	8,979	11.18	33,921	$21,607	5.83	$189,198	$454.00	$5.08
Cabinet Gorge	0	0	7,359,498	30,774	239.15	28,671	$27,479	2.1	$294,159	$39.97	$10.70
Grace	79,303	32,164	1,582,325	19,311	31.2	61,514	$32,856	4.1	$224,609	$122.00	$3.19
Hagerman	1,105,162	447,090	1,528,276	44,108	5.36	672,374	$348,850	7.45	$649,800	$134.87	$1.32
Mackay	89,313	42,877	2,630,134	41,573	32.2	71,126	$41,077	4.0	$284,612	$107.89	$3.67
McCall[1]	0	0	192,980	940	205.3	29	$43	2.3	$14,940	$77.42	$329.22
Nampa	739,450	227,052	394,636	9,064	4.8	223,537	$111,223	7.78	$437,862	$386.12	$1.85
Sandpoint	0	0	119,009	88	1,352	22	$0	1.0	$10,367	$140.00	$117.81
Sawtooth	0	0	75,875	18.7	4,000	0	0	1.0	$5,624	$N/A	$N/A
TOTAL	2,465,611	851,704	14,139,613	157,432		1,161,618	$618,513		$2,341,202	$141.90	$2.16

[1] Flight costs only

Note: Total cost for each hatchery is that hatchery's total budget minus capital outlay expenditures

Redistribution of catchables

Hatchery											
Clearwater	92,060	29,696	0	0	3.7	3,000	$3,030	9.0	$25,591	$277.98	$0.86
McCall[2]	104,316	28,977	0	0	3.6	1,852	$2,025	9.0	$9,451	$N/A	$N/A
Mullan	35,004	10,001	0	0	3.5	0	0	9.0	$38,723	$1,106.24	$3.87
Sandpoint	112,513	33,145	0	0	3.4	850	0	9.0	$52,174	$460.00	$1.57
Sawtooth	46,129	13,647	0	0	3.4	308	126	9.0	$13,275	$278.21	$0.76
Hayspur[3]	35,757	12,929	0	0	2.77	0	0	9.5	$9,948	$278.21	$0.76

[2] Distribution mileage costs only
[3] Distribution costs were not broken out of the overall hatchery budget.

Table 11. The “Top-60%” waters (the most-stocked waters that comprise 60% of the total catchable rainbow trout stocked annually) according to the Default Catchables Request list (DCR) as of March 2010. Study type denotes which water bodies are included in comparing return-to-creel (expl only), rearing density (expl+dens), or hatchery effects (expl+dens+hatch). Study Type is not listed for waters skipped in 2011.

Study type	Rank	Species / Water	Hayspur Kamloops triploid	Rainbow unspecified	Hayspur rainbow	Steelhead	Triploid unspecified	Hayspur triploid	Troutlodge triploid	Grand Total	PCT of Total	Cumm-ulative %	Num Stockings	Hatchery Name
		Total	**154,900**	**41,400**	**40,700**	**75,000**	**25,000**	**844,270**	**1,019,500**	**2,200,770**	**100%**			
Expl only	1	Urban Ponds	7,000					96,300	114,450	190,750	8.7%	8.7%	Many	MULTIPLE
Expl only	2	Cascade Res				75,000			75,000	150,000	6.8%	15.5%	1	HAGERMAN
Expl only	3	Blackfoot Res							130,000	130,000	5.9%	21.4%	1	AMERICAN FALLS
Expl+Dens	4	American Falls Res							66,000	66,000	3.0%	24.4%	2	AMERICAN FALLS
Expl only	5	Boise River							56,000	56,000	2.5%	26.9%	24	NAMPA
Expl+Dens+Hatch	6	Chesterfield Res							54,000	54,000	2.5%	29.4%	2	HAGERMAN
Expl only	7	Dworshak Res					25,000	25,000		50,000	2.3%	31.7%	2	NAMPA
Expl+Dens+Hatch	8	Island Park Res			40,700					40,700	1.8%	33.5%	4	HAGERMAN
Expl+Dens+Hatch	9	Salmon Falls Creek Res						40,000		40,000	1.8%	35.3%	3	HAGERMAN
Expl+Dens+Hatch	9	Winchester Res						40,000		40,000	1.8%	37.1%	4	HAGERMAN
	11	Ashton Res						34,400		34,400	1.6%	38.7%	5	ASHTON
Expl+Dens	12	Mann L						34,000		34,000	1.5%	40.3%	4	HAGERMAN
Expl+Dens	13	Spring Valley Res						32,500		32,500	1.5%	41.7%	4	HAGERMAN
Expl only	14	Salmon River							31,200	31,200	1.4%	43.1%	4	SAWTOOTH
Expl+Dens+Hatch	15	Horsethief Res							30,000	30,000	1.4%	44.5%	3	HAGERMAN
Expl only	16	Deer Creek Res						27,500		27,500	1.2%	45.8%	5	CLEARWATER
	17	Litte Payette Lake							25,000	25,000	1.1%	46.9%	2	NAMPA
Expl only	18	Wilson Spring Ponds							24,000	24,000	1.1%	48.0%	12	NAMPA
Expl only	19	Elk Creek Res						22,500		22,500	1.0%	49.0%	4	CLEARWATER
Expl+Dens	19	Moose Creek Res						22,500		22,500	1.0%	50.0%	4	HAGERMAN
	21	Bear River							21,850	21,850	1.0%	51.0%	14	GRACE
Expl+Dens	22	Mackay Res		21,000						21,000	1.0%	52.0%	3	MACKAY
Expl only	23	Fernan Lake	20,000							20,000	0.9%	52.9%	5	SANDPOINT
Expl+Dens	23	Lake Walcott						20,000		20,000	0.9%	53.8%	1	HAGERMAN
Expl only	25	Hauser Lake	19,000							19,000	0.9%	54.7%	6	SANDPOINT
Expl+Dens	26	Deep Creek Res							18,300	18,300	0.8%	55.5%	2	HAGERMAN
	27	Riley Creek						16,275		16,275	0.7%	56.2%	8	HAGERMAN
	28	Frank Oster #1						15,875		15,875	0.7%	57.0%	8	HAGERMAN
Expl+Dens+Hatch	29	Anderson Ranch Res						15,000		15,000	0.7%	57.6%	1	HAGERMAN
Expl+Dens	29	Lost Valley Res							15,000	15,000	0.7%	58.3%	1	HAGERMAN
	29	Oakley Res						15,000		15,000	0.7%	59.0%	1	HAGERMAN
Expl+Dens	29	Roseworth Res						15,000		15,000	0.7%	59.7%	1	HAGERMAN
Expl+Dens	33	Stanley Lake						14,000		14,000	0.6%	60.3%	3	NAMPA
Expl+Dens	33	Warm Lake							14,000	14,000	0.6%	60.9%	2	NAMPA
	35	SF Boise River						13,500		13,500	0.6%	61.6%	4	NAMPA
	36	Henry's Fork						12,950		12,950	0.6%	62.2%	4	ASHTON
	37	Birch Creek		12,200						12,200	0.6%	62.7%	4	MACKAY
Expl+Dens	38	Mann Creek Res							12,000	12,000	0.5%	63.3%	3	NAMPA
	38	Montpelier Res							12,000	12,000	0.5%	63.8%	2	GRACE
Expl+Dens	38	Sagehen Res							12,000	12,000	0.5%	64.3%	3	NAMPA
	38	Snake River Gem State						12,000		12,000	0.5%	64.9%	4	AMERICAN FALLS
Expl+Dens	42	Little Wood Res						11,500		11,500	0.5%	65.4%	2	NAMPA
	43	Rock Creek						11,200		11,200	0.5%	65.9%	3	HAGERMAN
Expl+Dens	44	Devils Creek Res							10,800	10,800	0.5%	66.4%	3	HAGERMAN
	45	Gavers Lagoon						10,000		10,000	0.5%	66.9%	5	HAYSPUR
	45	Kelso Lake	10,000							10,000	0.5%	67.3%	3	SANDPOINT
	45	Lucky Peak							10,000	10,000	0.5%	67.8%	1	HAGERMAN
Expl+Dens+Hatch	45	Magic Res						10,000		10,000	0.5%	68.2%	1	HAGERMAN
	45	Mormon Res						10,000		10,000	0.5%	68.7%	1	HAGERMAN

Table 12. List of waters by Region and stratified by perceived harvest (low/medium/high) used to evaluate return-to-creel of hatchery catchable rainbow trout in “urban ponds” statewide. Locations to receive tags were chosen to encompass most regions and assigned on a 3-year rotation with reward tags in each stratum. Tag numbers outlined with boxes indicate receiving reward tags.

Region	Water	Stocked	Tags 2011	Tags 2012	Tags 2013
		Low			
03B	Caldwell P #2	2,400		250	
03B	Caldwell P #3	2,000			
03B	Duff Lane Pond	1,000			250
03B	Eagle Island Park Pond	4,500	250		
03B	Quinn Pond	4,500			
03B	Veterans Pond	4,000			
4	Connor Pond	1,000	250		
4	Emerald Lake	6,000			
6	Rigby Lake	5,000			250

Region	Water	Stocked	Tags 2011	Tags 2012	Tags 2013
		Medium			
1	Crystal Lake	3,000	250		
03B	Caldwell City P	5,000	250		
03B	Ed's Pond	1,750		250	
03B	Horseshoe Bend Mill P	6,000		250	
03B	Merrill Park P	5,000			
03B	Payette Greenbelt P	3,500			250
03B	Sego Prairie P	1,750			
03M	Browns P	4,450			
03M	Council Park P	2,000			250
4	Camas P #02	3,000		250	
4	Dierkes lake	7,000	200		
4	Dollar Lake	600			
4	Featherville Dredge P	6,000	150		
4	Penny Lake	2,900			
4	Rupert Gravel Pond	2,000	250		
6	Rexburg City P	3,600			
6	Roberts Gravel P	5,400		250	
7	Kids Creek P	2,400	250		

Region	Water	Stocked	Tags 2011	Tags 2012	Tags 2013
		High			
1	Post Falls Park P	4,000		250	
2	Hordemann P	850	175		250
2	Robinson P	7,750	275		
2	Snake River Levee P	8,550	200		
03B	Marsing Hwy P	6,000			
03B	McDevitt P	7,500	275		
03B	Park Center	8,000		275	
03B	Riverside	7,200			275
03B	Sawyers P	7,500		275	
03B	Settlers Park P	2,400			
03B	Ten Mile P	5,250			275
03B	Weiser Community P	4,200			
03M	Fischer P	5,000			250
03M	Rowlands P	6,000	250		
4	Filer P	7,600		250	
4	Freedom Park P (Burley)	1,500	150		
4	Heagle Park P	500			250
4	Lake Creek L	2,100		250	
6	Ryder Park P	5,000		250	
6	Trail Creek P	3,600	250		
7	Blue Mountain Meadow P	1,500			
7	Hyde P	800		250	

Table 13. Estimates of tag reporting rate and annual exploitation based on returns of nonreward and high dollar ($100 and $200) tags for hatchery catchable rainbow trout (taken from Meyer et al. 2010). Rank was assigned based on the total trout requested on the Default Catchables Request list. Numbers and tag reporting rates were divided between tags returned within one year of release and all tags returned, but exploitation estimates all apply to one year from the tagging date. Also shown are exploitation estimates where site-specific reporting rates were unavailable, and where mean reporting rates for a species were used instead. Gray boxes indicate the recommended exploitation estimate for each site.

						Nonreward tags				High reward					Annual exploitation		
						Returned				Returned			Tag reporting rate		Using site-specific reporting rate		Using mean reporting rate
Rank	Year	Water body	Species	Region	Origin	Within 1 year	Total	Harvested	Released	Within 1 year	Total	Released	Within 1 year	Total	Within 1 year	Total	
1	2006	Cascade Res.	Rainbow trout	3M	Hatchery	15	18	15	378	2	3	40	0.794	0.635	5.6	7.0	9.1
1	2006	Cascade Res.	Steelhead trout	3M	Hatchery	5	9	3	377	1	1	40	0.531	0.955	1.7	0.9	1.8
1	2008	Cascade Res.	Rainbow trout	3M	Hatchery	0	0	0	304			0					0.0
1	2008	Cascade Res.	Steelhead trout	3M	Hatchery	0	0	0	304	0	0	32			0.0	0.0	0.0
4	2007	Boise R.	Rainbow trout	3N	Hatchery	82	89	45	380	17	18	39	0.495	0.507	26.8	26.2	
5	2006	Chesterfield Res.	Rainbow trout	5	Hatchery	16	21	10	231	1	5	25	1.732	0.455	2.8	10.7	9.9
5	2006	Chesterfield Res.	Rainbow trout (holdovers)	5	Hatchery	9	17	7	147	3	7	15	0.306	0.248	17.6	21.7	9.1
11	2006	Mann Lake	Rainbow trout	2	Hatchery	49	57	35	343	7	9	40	0.816	0.739	14.0	15.5	
13	2009	Lower Salmon R.	Rainbow trout	2	Hatchery	0	0	0	16			0					0.0
6	2009	Dworshak Res.	Rainbow trout	2	Hatchery	3	4	3	325			0					2.1
23	2006	Lake Walcott	Rainbow trout	4	Hatchery	48	85	44	699	16	22	95	0.408	0.525	17.3	13.5	
30	2008	Anderson Ranch Res.	Rainbow trout	4	Hatchery	23	26	20	606	5	6	63	0.478	0.450	7.7	8.2	
39	2007	Mann Creek Res.	Rainbow trout	3N	Hatchery	68	76	66	380	12	15	40	0.596	0.533	32.7	36.6	
43	2007	Little Wood Res.	Rainbow x cutthroat	4	Hatchery	5	6	5	378	2	3	40	0.265	0.212	5.6	7.0	3.0
46	2006	Lucky Peak Res.	Rainbow trout	3N	Hatchery	33	42	30	381	4	4	40	0.866	1.102	10.2	8.0	18.0
46	2009	Round Lake	Rainbow trout	1	Hatchery	34	36	30	198			0					34.6
46	2009	Kelso Lake	Rainbow trout	1	Hatchery	72	73	68	197			0					78.9
57	2007	Glendale Res.	Rainbow x cutthroat	5	Hatchery	76	86	64	379	21	22	39	0.372	0.402	50.9	47.1	
119	2007	North Fork Payette R.	Rainbow trout	3M	Hatchery	43	53	31	670	9	14	72	0.513	0.407	10.1	12.8	
226	2009	Red R.	Rainbow trout	2	Hatchery	4	5	4	100			0					9.1
244	2009	Palouse R.	Rainbow trout	2	Hatchery	2	2	2	100			0					4.6

Table 14. Total nonreward tags released by water body, hatchery, treatment, and date. Exploitation (harvest) and "total use" (harvested plus released fish) are shown as of February 14, 2012 with associated 90% confidence intervals (C.I.).

							Disposition			Adjusted exploitation		Adjusted total use	
Region	Water Body	Hatchery	Release Location	Tagging Date	Treatment	Tags Released	Harvested	Harvested b/c tagged	Released	Estimate	90% C.I.	Estimate	90% C.I.
1	Crystal Lake	Sandpoint	Crystal Lake	5/3/2011	Production	117	4	1		6.3%	6.3%	7.9%	7.1%
				5/18/2011		117	1			1.6%	3.1%	1.6%	3.1%
	Fernan Lake	Mullan	Fernan Lake	6/2/2011	Production	197	3		3	2.8%	3.3%	5.6%	4.6%
				6/15/2011		198	7		1	6.5%	5.0%	7.5%	5.4%
	Hauser Lake	Sandpoint	Hauser Lake	5/18/2011	Production	193	6		1	5.8%	4.7%	6.7%	5.1%
				5/3/2011		192	7		1	6.7%	5.2%	7.7%	5.5%
2	Deer Creek Res.	Clearwater	Deer Creek	5/10/2011	Production	397	21			9.8%	4.6%	9.8%	4.6%
				10/19/2011		400				0.0%		0.0%	
	Dworshak Res.	Nampa	Dworshak	6/13/2011	Production	400	10		2	4.6%	3.0%	5.6%	3.3%
	Elk Creek Res.	Clearwater	Elk Creek	6/14/2011	Production	400	95	9	17	44.0%	12.0%	56.0%	14.3%
				10/26/2011		397	19		15	8.9%	4.3%	15.9%	6.1%
	Hordeman P.	Clearwater	Hordeman P.	4/26/2011	Production	74	24		1	60.0%	23.5%	62.5%	23.9%
				5/17/2011		100	4			7.4%	7.4%	7.4%	7.4%
	Mann Lake	Hagerman	Mann Lake	4/7/2011	Production	400	49	10	23	22.7%	7.6%	37.9%	10.8%
				5/10/2011	High density	200	19	2	15	17.6%	8.4%	33.3%	12.1%
				5/10/2011	Low density	199	29	4	10	27.0%	10.7%	40.0%	13.5%
				10/12/2011	Clearsprings 2N	100			1	0.0%		1.9%	3.7%
				10/12/2011	Hayspur 3N	99				0.0%		0.0%	
	Moose Creek Res.	Hagerman	Moose Creek	4/25/2011	High density	200	32	4	5	29.6%	11.3%	37.9%	13.1%
				4/25/2011	Low density	198	43	4	4	40.2%	13.6%	47.7%	15.0%
				10/12/2011	Production	397	26	4	5	12.1%	5.2%	16.3%	6.2%
	Robinson P.	Clearwater	Robinson P.	4/21/2011	Production	150	44	1	2	54.3%	17.6%	58.0%	18.3%
				9/27/2011		125	11	1	9	16.3%	9.9%	31.1%	13.8%
	Spring Valley Res.	Hagerman	Spring Valley	5/10/2011	Production	400	81	12	19	37.5%	10.7%	51.8%	13.5%
				10/12/2011	High density	200	37	1		34.2%	12.3%	35.2%	12.5%
				10/12/2011	Low density	200	47	1	4	43.5%	14.2%	48.1%	15.1%
	Snake River Levee P.	Clearwater	Parking lot	3/17/2011	Production	100	24		5	44.4%	18.2%	53.7%	20.0%
				4/11/2011		99	20	6	5	37.4%	16.7%	58.0%	20.9%
	Winchester Lake	AmFalls	Winchester Lake	4/26/2011	High density	200	44	7	8	40.7%	13.6%	54.6%	16.3%
				4/26/2011	Low density	200	55	6	6	50.9%	15.6%	62.0%	17.7%
				4/26/2011	Med density	200	44	8	8	40.7%	13.6%	55.5%	16.5%
		Hagerman		4/25/2011	High density	200	34	2	6	31.5%	11.7%	38.9%	13.3%
				4/25/2011	Low density	200	37	8	10	34.2%	12.3%	50.9%	15.6%
				10/12/2011	Production	396	19	2	6	8.9%	4.3%	12.6%	5.3%
		Nampa		4/26/2011	High density	200	34	4	6	31.5%	11.7%	40.7%	13.6%
				4/26/2011	Low density	200	35	7	2	32.4%	11.9%	40.7%	13.6%
				4/26/2011	Med density	195	19	9	2	18.0%	8.6%	28.5%	11.2%
3B	Boise River	Nampa	Americana	7/26/2011	Production	40	5		7	23.1%	19.8%	55.5%	29.0%
			Barber Park			40	5	3	7	23.1%	19.8%	69.4%	31.5%
			Boise State			40	11	2	4	50.9%	28.0%	78.7%	33.0%
			Eagle North			20	3	2	3	27.8%	29.9%	74.0%	43.0%
			Eagle South			20	2		1	18.5%	24.9%	27.8%	29.9%
			Glenwood			40	5	1	5	23.1%	19.8%	50.9%	28.0%
			Linder North			20	4	1	1	37.0%	33.7%	55.5%	39.3%
			Linder South			20	2	2	2	18.5%	24.9%	55.5%	39.3%
			Park Center			40	1	2	8	4.6%	9.1%	50.9%	28.0%
			Star			40	7	1	2	32.4%	23.0%	46.3%	26.9%
			Americana	10/18/2011	Production	40	15		7	69.4%	31.5%	101.8%	35.7%
			Barber Park			40	1		4	4.6%	9.1%	23.1%	19.8%
			Boise State			20	2		2	18.5%	24.9%	37.0%	33.7%
			Eagle North			20	2		2	18.5%	24.9%	37.0%	33.7%
			Eagle South			20	1		4	9.3%	18.0%	46.3%	36.8%
			Glenwood			20	3	4	2	27.8%	29.9%	83.3%	44.3%
			Linder North			40	1	2	11	4.6%	9.1%	64.8%	30.7%
			Linder South			40	3	2	2	13.9%	15.6%	32.4%	23.0%
			Park Center			40	12	2	7	55.5%	29.0%	97.2%	35.2%
			Star			40	10		7	46.3%	26.9%	78.7%	33.0%

Table 14. Continued.

Region	Water Body	Hatchery	Release Location	Tagging Date	Treatment	Tags Released	Disposition			Adjusted exploitation		Adjusted total use	
							Harvested	Harvested b/c tagged	Released	Estimate	90% C.I.	Estimate	90% C.I.
	Caldwell Rotary P.	Nampa	Caldwell Rotary P.	4/6/2011	Production	125	40	1	10	59.2%	19.6%	75.5%	22.4%
				10/18/2011		125	26	3	6	38.5%	15.5%	51.8%	18.2%
	Eagle Is. Park P.	Nampa	Eagle Island Park P.	4/6/2011	Production	125	21	2	3	31.1%	13.8%	38.5%	15.5%
				10/19/2011		125	24	2	9	35.5%	14.9%	51.8%	18.2%
	Manns Creek Res.	Nampa	Manns Creek	4/20/2011	High density	197	4	2		3.8%	3.8%	5.6%	4.6%
				4/20/2011	Low density	199	10	1		9.3%	6.0%	10.2%	6.3%
				4/20/2011	Med density	198	3			2.8%	3.2%	2.8%	3.2%
				4/20/2011	Production	199	2	1	2	1.9%	2.6%	4.7%	4.2%
	McDevitt P.	Nampa	McDevitt P.	4/6/2011	Production	150	30	6	15	37.0%	14.2%	62.9%	19.2%
				10/19/2011		125	17		5	25.2%	12.4%	32.6%	14.2%
	Mountain Home	Hagerman	Mountain Home	10/12/2011	Clearsprings 2N	100	1	1	1	1.9%	3.7%	5.6%	6.4%
				10/12/2011	Hayspur 3N	100	4			7.4%	7.4%	7.4%	7.4%
	Sage Hen Res.	Nampa	Sage Hen	6/7/2011	High density	200	27	4	5	25.0%	10.3%	33.3%	12.1%
				6/7/2011	Low density	200	38	3	12	35.2%	12.5%	49.0%	15.3%
				6/7/2011	Med density	200	26	4	14	24.1%	10.0%	40.7%	13.6%
3B				6/7/2011	Production	200	26	4	11	24.1%	10.0%	37.9%	13.1%
	Wilson Springs P.	Nampa	Wilson Springs P.	2/3/2011	Production	50	24	1	2	88.8%	31.7%	100.0%	33.1%
				2/10/2011	Production	50	22		3	81.4%	30.7%	92.5%	32.2%
				2/17/2011	Production	50	18	2	4	66.6%	28.4%	88.8%	31.7%
				2/24/2011	Production	50	26	2	3	96.2%	32.6%	114.8%	34.5%
				4/6/2011	Production	50	11		4	40.7%	23.1%	55.5%	26.4%
				4/14/2011	Production	50	22	1	6	81.4%	30.7%	107.4%	33.8%
				4/22/2011	Production	50	13			48.1%	24.8%	48.1%	24.8%
				4/28/2011	Production	50	15		1	55.5%	26.4%	59.2%	27.1%
				7/7/2011	High density	50	14	6	3	51.8%	25.6%	85.1%	31.3%
				7/14/2011	Production	49	5	3	9	18.9%	16.3%	64.2%	28.2%
				8/4/2011	Production	50	9	1	2	33.3%	21.1%	44.4%	24.0%
				8/10/2011	Production	50	10	1	6	37.0%	22.1%	62.9%	27.8%
				10/7/2011	Production	50	7	1		25.9%	18.8%	29.6%	20.0%
				10/15/2011	Production	50	11		5	40.7%	23.1%	59.2%	27.1%
				10/19/2011	Production	50	4	1	4	14.8%	14.4%	33.3%	21.1%
				10/27/2011	Production	50	8	2	6	29.6%	20.0%	59.2%	27.1%
	Cascade Res	Hagerman	City Boat Ramp	10/31/2011	Clearsprings 2N	200				0.0%		0.0%	
					Hayspur 3N	200	1		1	0.9%	1.8%	1.9%	2.6%
	Horsethief Res.	AmFalls	Horsethief Res.	5/17/2011	High density	200	38	4	10	35.2%	12.5%	48.1%	15.1%
		AmFalls		5/17/2011	Low density	200	34	7	5	31.5%	11.7%	42.6%	14.0%
		AmFalls		5/17/2011	Med density	200	38	6	12	35.2%	12.5%	51.8%	15.8%
		Hagerman		5/17/2011	High density	200	23	2	5	21.3%	9.4%	27.8%	10.9%
		Hagerman		5/17/2011	Low density	199	38	2	7	35.3%	12.6%	43.7%	14.3%
		Hagerman		9/16/2011	Production	400	29	4	3	13.4%	5.5%	16.7%	6.3%
		Nampa		5/18/2011	High density	200	22	4	5	20.4%	9.1%	28.7%	11.1%
3M		Nampa		5/18/2011	Low density	200	31	5	1	28.7%	11.1%	34.2%	12.3%
		Nampa		5/18/2011	Med density	200	34	3	4	31.5%	11.7%	37.9%	13.1%
	Lost Valley Res.	Hagerman	Lost Valley	6/6/2011	High density	199	17	5	3	15.8%	8.0%	23.3%	9.9%
				6/6/2011	Low density	200	44	1	1	40.7%	13.6%	42.6%	14.0%
	Rowlands P.	McCall	Boat Ramp	7/8/2011	Production	122	38	9	2	57.7%	19.4%	74.3%	22.4%
				5/20/2011		125	15	5	7	22.2%	11.6%	40.0%	15.8%
	Warm Lake	Nampa	Warm Lake	6/28/2011	High density	200	32	5	4	29.6%	11.3%	37.9%	13.1%
				6/28/2011	Low density	200	42	2	5	38.9%	13.3%	45.3%	14.6%
				6/28/2011	Med density	200	42	5	5	38.9%	13.3%	48.1%	15.1%
				6/28/2011	Production	200	19	5	4	17.6%	8.4%	25.9%	10.5%
	Anderson Ranch	AmFalls	Curlew Boat Ramp		High density	200	10	3	2	9.3%	6.0%	13.9%	7.4%
		AmFalls		5/6/2011	Low density	200	13	1	4	12.0%	6.9%	16.7%	8.2%
		AmFalls			Med density	200	9	2	7	8.3%	5.6%	16.7%	8.2%
4		Hagerman		5/4/2011	High density	198	8	3	1	7.5%	5.4%	11.2%	6.6%
		Hagerman			Low density	200	10	2	1	9.3%	6.0%	12.0%	6.9%
		Nampa			High density	200	4		1	3.7%	3.7%	4.6%	4.2%
		Nampa		5/4/2011	Low density	200	8		5	7.4%	5.3%	12.0%	6.9%
		Nampa			Med density	200	7		1	6.5%	5.0%	7.4%	5.3%

Table 14. Continued.

Region	Water Body	Hatchery	Release Location	Tagging Date	Treatment	Tags Released	Disposition			Adjusted exploitation		Adjusted total use	
							Harvested	Harvested b/c tagged	Released	Estimate	90% C.I.	Estimate	90% C.I.
	Connor P.	Hagerman	Connor P.	4/19/2011	Production	149				0.0%		0.0%	
	Dierke's Lake	Hagerman	Dierke's Lake	10/11/2011	Clearsprings 2N	95	2	1	8	3.9%	5.5%	21.4%	12.8%
				10/11/2011	Hayspur 3N	99	2	2	8	3.7%	5.2%	22.4%	12.9%
	Featherville Dredge P.	Hagerman	Featherville Dredge P.	6/13/2011	Production	149	25	6	3	31.1%	12.9%	42.2%	15.3%
	Freedom Park P.	Hagerman	Freedom Park P.	4/20/2011	Production	75				0.0%		0.0%	
	Lake Walcott	Hagerman	Gifford Springs	4/12/2011	High density	200				0.0%		0.0%	
				4/12/2011	Low density	200	6		1	5.6%	4.6%	6.5%	5.0%
	Little Camas	Hagerman	Little Camas	4/11/2011	Production	397	40	2	3	18.6%	6.7%	21.0%	7.3%
				6/21/2011	High density	200	6	2	3	5.6%	4.6%	10.2%	6.3%
				6/21/2011	Low density	199	7		1	6.5%	5.0%	7.4%	5.3%
	Little Wood Res.	Nampa	Little Wood	6/21/2011	Med density	200	5	2	2	4.6%	4.2%	8.3%	5.6%
				6/21/2011	Production	199	4		1	3.7%	3.7%	4.7%	4.2%
		AmFalls		4/27/2011	High density	200				0.0%		0.0%	
		AmFalls	West Magic	4/27/2011	Low density	200	4		1	3.7%	3.7%	4.6%	4.2%
		AmFalls		4/27/2011	Med density	200	1			0.9%	1.8%	0.9%	1.8%
		Hagerman		4/27/2011	High density	200	6			5.6%	4.6%	5.6%	4.6%
4	Magic Res	Hagerman	Myrtle Point	4/27/2011	Low density	200	2	1		1.9%	2.6%	2.8%	3.2%
		Hagerman		11/2/2011	Clearsprings 2N	199	4	2	2	3.7%	3.7%	7.4%	5.3%
		Hagerman		11/2/2011	Hayspur 3N	200	5	1	3	4.6%	4.2%	8.3%	5.6%
		Nampa		4/26/2011	High density	200	1		1	0.9%	1.8%	1.9%	2.6%
		Nampa	West Magic	4/26/2011	Low density	200	4		1	3.7%	3.7%	4.6%	4.2%
		Nampa		4/26/2011	Med density	195				0.0%		0.0%	
	Rupert Gravel P.	Hagerman	Rupert Gravel P.	4/19/2011	Production	150				0.0%		0.0%	
		AmFalls		4/19/2011	High density	200	1			0.9%	1.8%	0.9%	1.8%
		AmFalls		4/19/2011	Low density	200	6	1	4	5.6%	4.6%	10.2%	6.3%
		AmFalls		4/19/2011	Med density	200	6		2	5.6%	4.6%	7.4%	5.3%
		Hagerman		4/19/2011	High density	200	4		2	3.7%	3.7%	5.6%	4.6%
	Salmon Falls Creek	Hagerman	Grays Landing	4/19/2011	Low density	200	9	2	4	8.3%	5.6%	13.9%	7.4%
		Hagerman		9/8/2011	Production	400	6	1		2.8%	2.3%	3.2%	2.5%
		Nampa		4/20/2011	High density	200			3	0.0%		2.8%	3.2%
		Nampa		4/20/2011	Low density	199	3	1	1	2.8%	3.2%	4.7%	4.2%
		Nampa		4/20/2011	Med density	198	3	1		2.8%	3.2%	3.7%	3.8%
	Roseworth Res.	Hagerman	Roseworth	4/6/2011	High density	200	4	1		3.7%	3.7%	4.6%	4.2%
		Hagerman		4/6/2011	Low density	200	8		2	7.4%	5.3%	9.3%	6.0%
					High density	200	6			5.6%	4.6%	5.6%	4.6%
	American Falls	AmFalls	Sportsmans Park	4/11/2011	Low density	200	1			0.9%	1.8%	0.9%	1.8%
					Med density	200	3			2.8%	3.2%	2.8%	3.2%
				10/18/2011	Production	399	2		1	0.9%	1.3%	1.4%	1.6%
	Blackfoot Res.	Hagerman	Blackfoot	9/27/2011	Production	399		1	4	0.0%		2.3%	2.1%
		AmFalls			High density	275	3			2.0%	2.3%	2.0%	2.3%
		AmFalls		5/17/2011	Low density	200			2	0.0%		1.9%	2.6%
		AmFalls			Med density	200	2	1		1.9%	2.6%	2.8%	3.2%
		Hagerman		5/17/2011	High density	200				0.0%		0.0%	
5	Chesterfield Res.	Hagerman	Chesterfield		Low density	200	5		2	4.6%	4.2%	6.5%	5.0%
		Hagerman		10/14/2011	Production	400	4	1	9	1.9%	1.9%	6.5%	3.6%
		Nampa			High density	200	1		1	0.9%	1.8%	1.9%	2.6%
		Nampa		5/17/2011	Low density	200				0.0%		0.0%	
		Nampa			Med density	200			1	0.0%		0.9%	1.8%
	Deep Creek Res.	Hagerman	Main Boat Ramp	5/10/2011	High density	200	7	2	6	6.5%	5.0%	13.9%	7.4%
				5/10/2011	Low density	200	17	1	11	15.7%	7.9%	26.8%	10.7%
	Devils Creek Res.	Hagerman	Devils Creek	5/10/2011	High density	200	16	4	2	14.8%	7.7%	20.4%	9.1%
				5/10/2011	Low density	200	28	4	8	25.9%	10.5%	37.0%	12.9%

Table 14. Continued.

Region	Water Body	Hatchery	Release Location	Tagging Date	Treatment	Tags Released	Disposition: Harvested	Disposition: Harvested b/c tagged	Disposition: Released	Adjusted exploitation: Estimate	Adjusted exploitation: 90% C.I.	Adjusted total use: Estimate	Adjusted total use: 90% C.I.
		AmFalls		5/17/2011	High density	200	25	5	3	23.1%	9.8%	30.5%	11.5%
		AmFalls		5/17/2011	Low density	200	25	3	5	23.1%	9.8%	30.5%	11.5%
	Mackay Res.	AmFalls	Boat Ramp	5/17/2011	Med density	200	33	9	8	30.5%	11.5%	46.3%	14.7%
		Mackay		6/3/2011	Production	200	20	7	13	18.5%	8.7%	37.0%	12.9%
		Mackay		6/21/2011	Production	199	25	7	1	23.3%	9.9%	30.7%	11.6%
		AmFalls		6/13/2011	High density	200	21	2		19.4%	8.9%	21.3%	9.4%
		AmFalls		6/13/2011	Low density	200	24	3	2	22.2%	9.6%	26.8%	10.7%
		AmFalls		6/13/2011	Med density	200	20	3	1	18.5%	8.7%	22.2%	9.6%
		Hagerman		9/21/2011	High density	199	11	2	1	10.2%	6.3%	13.0%	7.2%
	Island Park Res.	Hagerman	Buttermilk/McCrea	9/21/2011	Low density	198	14	2		13.1%	7.2%	15.0%	7.7%
6		Hagerman		6/13/2011	High density	199	1		1	0.9%	1.9%	1.9%	2.6%
		Hagerman		6/13/2011	Low density	200	5	3	1	4.6%	4.2%	8.3%	5.6%
		Nampa		6/14/2011	High density	200	3			2.8%	3.2%	2.8%	3.2%
		Nampa		6/14/2011	Low density	199	3			2.8%	3.2%	2.8%	3.2%
		Nampa		6/14/2011	Med density	200	1	2		0.9%	1.8%	2.8%	3.2%
				6/22/2011		50	15	3	4	55.5%	26.4%	81.4%	30.7%
				7/12/2011		50	7	5	1	25.9%	18.8%	48.1%	24.8%
	Trail Creek P.	Ashton	Trail Creek P.	7/25/2011	Production	45	14	1	1	57.6%	28.0%	65.8%	29.5%
				8/8/2011		55	9	7		30.3%	19.3%	53.8%	25.1%
				9/7/2011		50	8		2	29.6%	20.0%	37.0%	22.1%
				9/27/2011		50	13	1		48.1%	24.8%	51.8%	25.6%
	Kids Creek P.	Mackay	Parking lot	4/20/2011	Production	50	7	1	4	25.9%	18.8%	44.4%	24.0%
				8/24/2011		49	3		3	11.3%	12.8%	22.7%	17.8%
			Section 5	6/22/2011		56	1	1	3	3.3%	6.5%	16.5%	14.4%
			Section 6	6/23/2011		172	17	8	11	18.3%	9.2%	38.7%	13.9%
			Section 7	6/23/2011		56	4		3	13.2%	12.9%	23.1%	16.9%
	Salmon River	Sawtooth	Section 8	6/23/2011	Production	116	13	1	5	20.7%	11.6%	30.3%	14.1%
7			Section 6	9/19/2011		38			1	0.0%		4.9%	9.6%
			Section 7	9/20/2011		38	1		1	4.9%	9.6%	9.7%	13.4%
			Section 8	9/20/2011		24				0.0%		0.0%	
				6/21/2011	High density	200	12	5	5	11.1%	6.6%	20.4%	9.1%
	Stanley Lake	Nampa	Stanley Lake	6/21/2011	Low density	200	20	3	7	18.5%	8.7%	27.8%	10.9%
				6/21/2011	Med density	200	12	2	5	11.1%	6.6%	17.6%	8.4%
				6/21/2011	Production	200	10	5	4	9.3%	6.0%	17.6%	8.4%

Table 15. Mean density index (DI, lbs fish/ft^3/inch), flow index (FI, lbs/GPM/inch) across the entire rearing period by hatchery and treatment for tagged catchable rainbow trout. Length is the mean total length (mm) at the time of stocking (with 95% confidence intervals) for fish tagged from February to June. Nampa Hatchery was the only hatchery where normal production fish were released in conjunction with density treatment groups.

	American Falls			Hagerman			Nampa			Overall mean
	DI	FI	Length (mm)	DI	FI	Length (mm)	DI	FI	Length (mm)	length (mm)
Low	0.10	0.32	257 (± 1)	0.10	0.50	266 (± 1)	0.13	0.29	257 (± 1)	247 (± 1)
Medium	0.13	0.49	255 (± 1)	-	-	-	0.20	0.50	251 (± 1)	258 (± 1)
High	0.16*	0.67	253 (± 1)	0.21	0.79	266 (± 1)	0.25	0.59	242 (± 1)	253 (± 1)
Normal Production	-	-	-	-	-	-	0.30	-	251 (± 2)	257 (± 1)
Overall avg.			254 (± 1)			253 (± 1)			252 (± 1)	253 (± 1)

*Back-calculated density index values from stocking records suggest this value was actually 0.19.

Table 16. ANOVA results for “total use” of hatchery trout (harvested or released) by four rearing densities (low/medium/high/normal production) across three IDFG hatcheries. Comparisons were made using Tukey’s multiple comparisons. Groups with the same Tukey letter group are not statistically different at α = 0.1. These results do not include normal production groups outside the density treatment experiment.

ANOVA results			
Source	DF	F value	P value
Model	39	34.93	< 0.0001
Water body	22	56.55	< 0.0001
Hatchery	2	22.3	< 0.0001
Water body * Hatchery	12	3.31	0.0010
Rearing Density	3	11.23	< 0.0001
Multiple comparisons			
	Mean total use	N	Tukey group
	Rearing Density		
Low	22.9%	37	A
Normal	18.6%	6	B, A
Medium	19.3%	21	B
High	17.3%	37	B
	Hatchery		
Hagerman	21.3%	33	A
AmFalls	21.5%	27	A
Nampa	17.5%	41	B

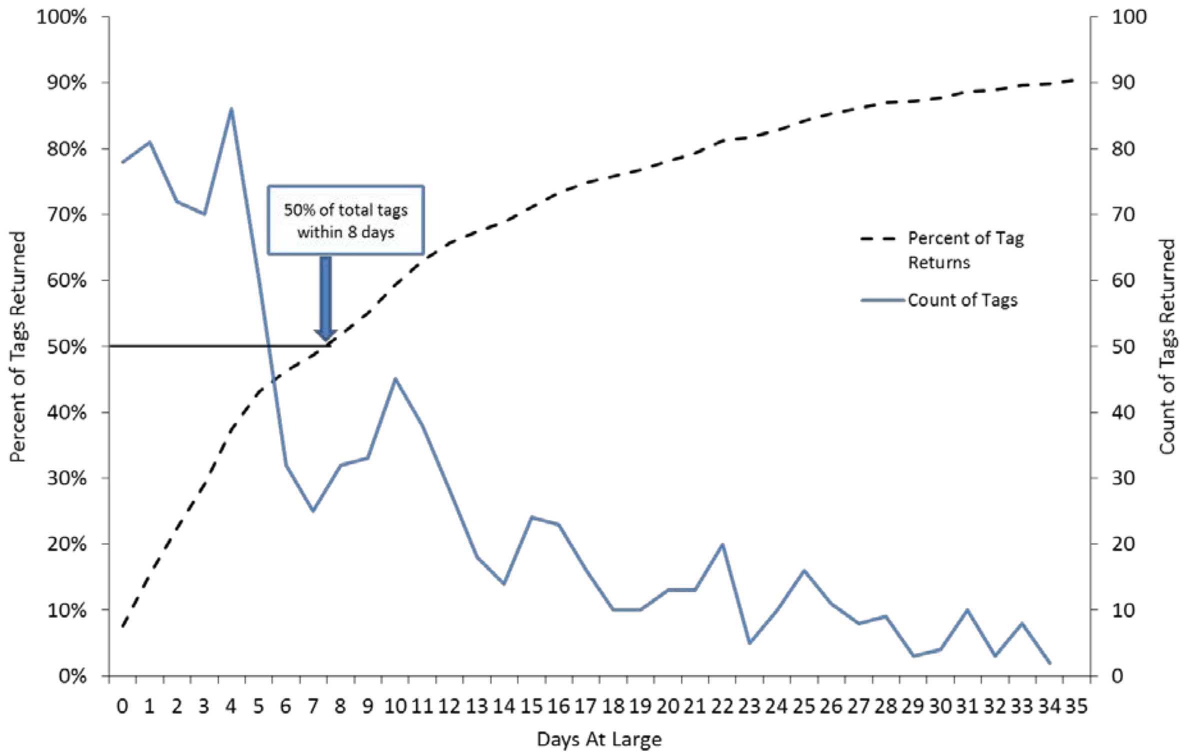

Figure 6. Count and cumulative percent of total tags returned by days after stocking (Days At Large) for hatchery catchable rainbow trout in 16 “urban ponds” combined across Idaho in 2011 within 35 days of stocking.

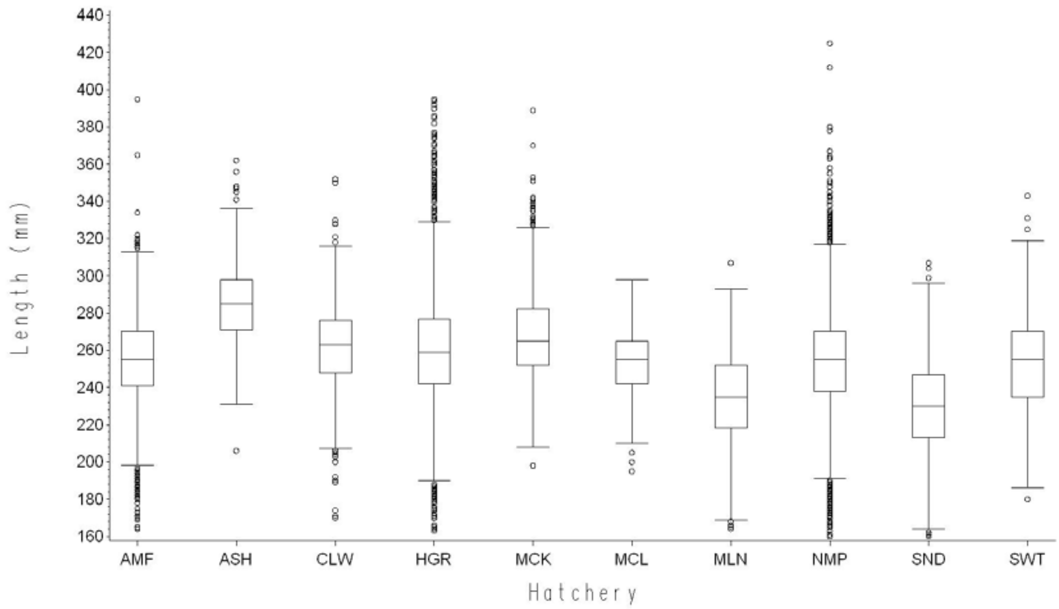

Figure 7. Box plot of total length (mm) for all catchable rainbow trout tagged during 2011 at American Falls (AMF), Ashton (ASH), Clearwater (CLW), Hagerman (HGR), Mackay (MCK), McCall (MCL), Mullan (MLN), Nampa (NMP), Sandpoint (SND), and Sawtooth (SWT) hatcheries. Boxes constitute the interquartile range with whiskers extending 1.5 times the interquartile range. Open circles indicate outliers.

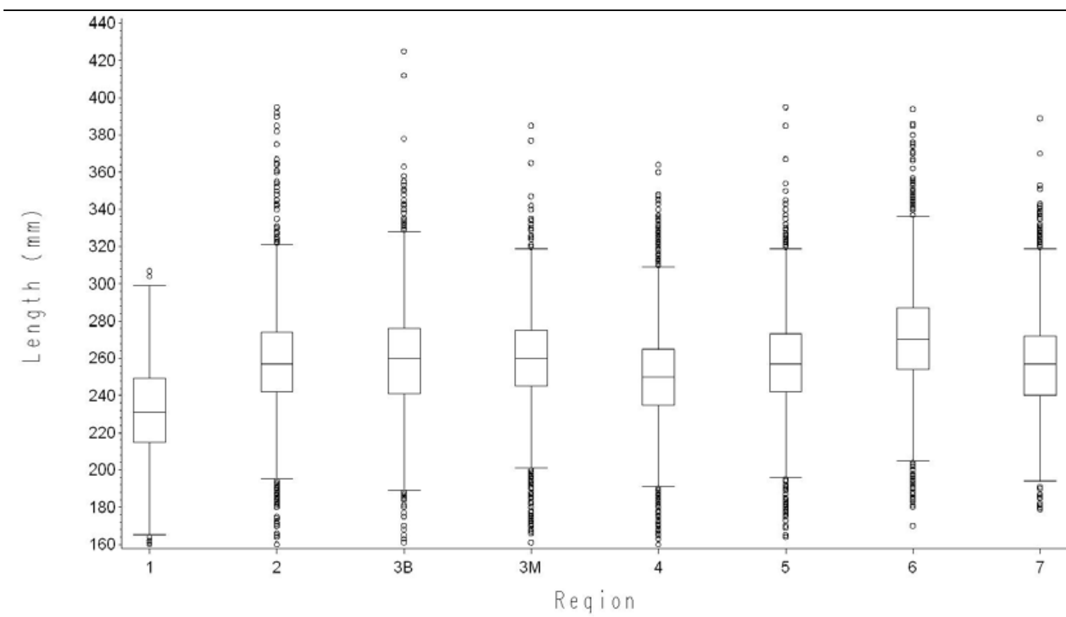

Figure 8. Box plot of total length (mm) for all tagged catchable rainbow trout by Region in which they were stocked during 2011. Boxes constitute the interquartile range with whiskers extending 1.5 times the interquartile range. Open circles indicate outliers.

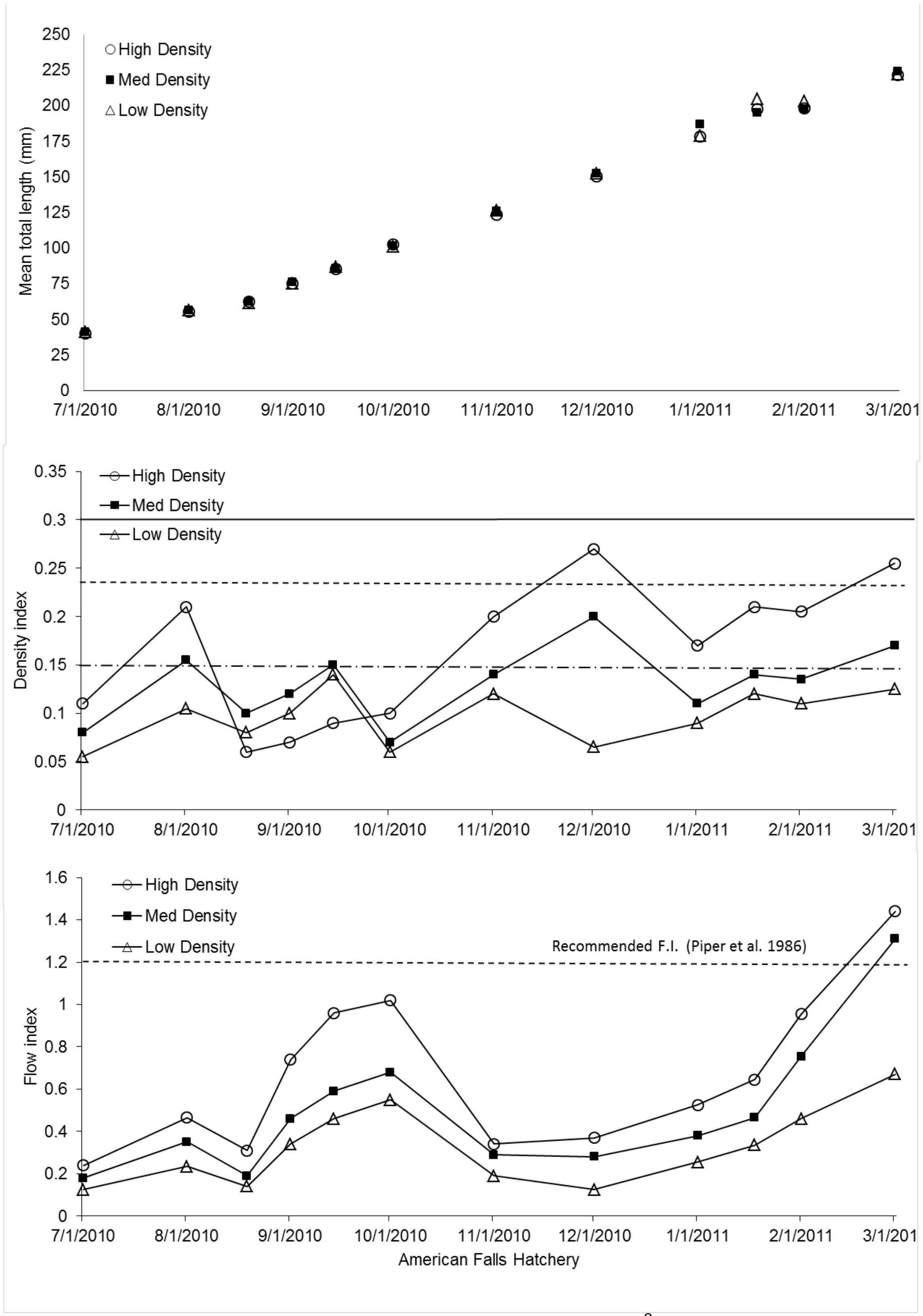

Figure 9. Mean total length (mm), density index (lbs/ft^3/inch), and flow index (lbs/inch x gal/min) by treatment (high/med/low density) during the rearing period for American Falls Hatchery.

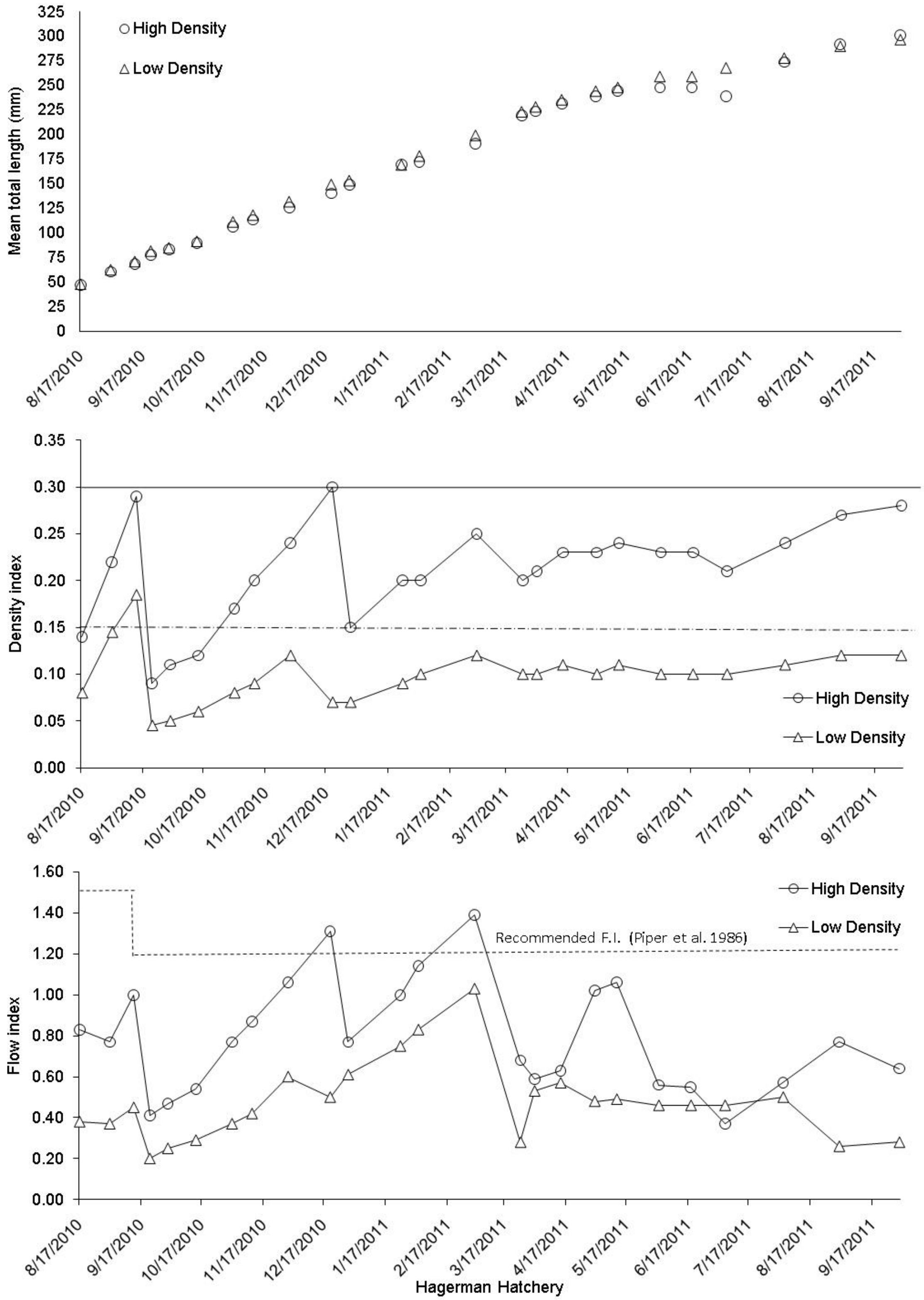

Figure 10. Mean total length (mm), density index (lbs/ft^3/inch), and flow index (lbs/inch x gal/min) by treatment (high/med/low density) during the rearing period for Hagerman Hatchery.

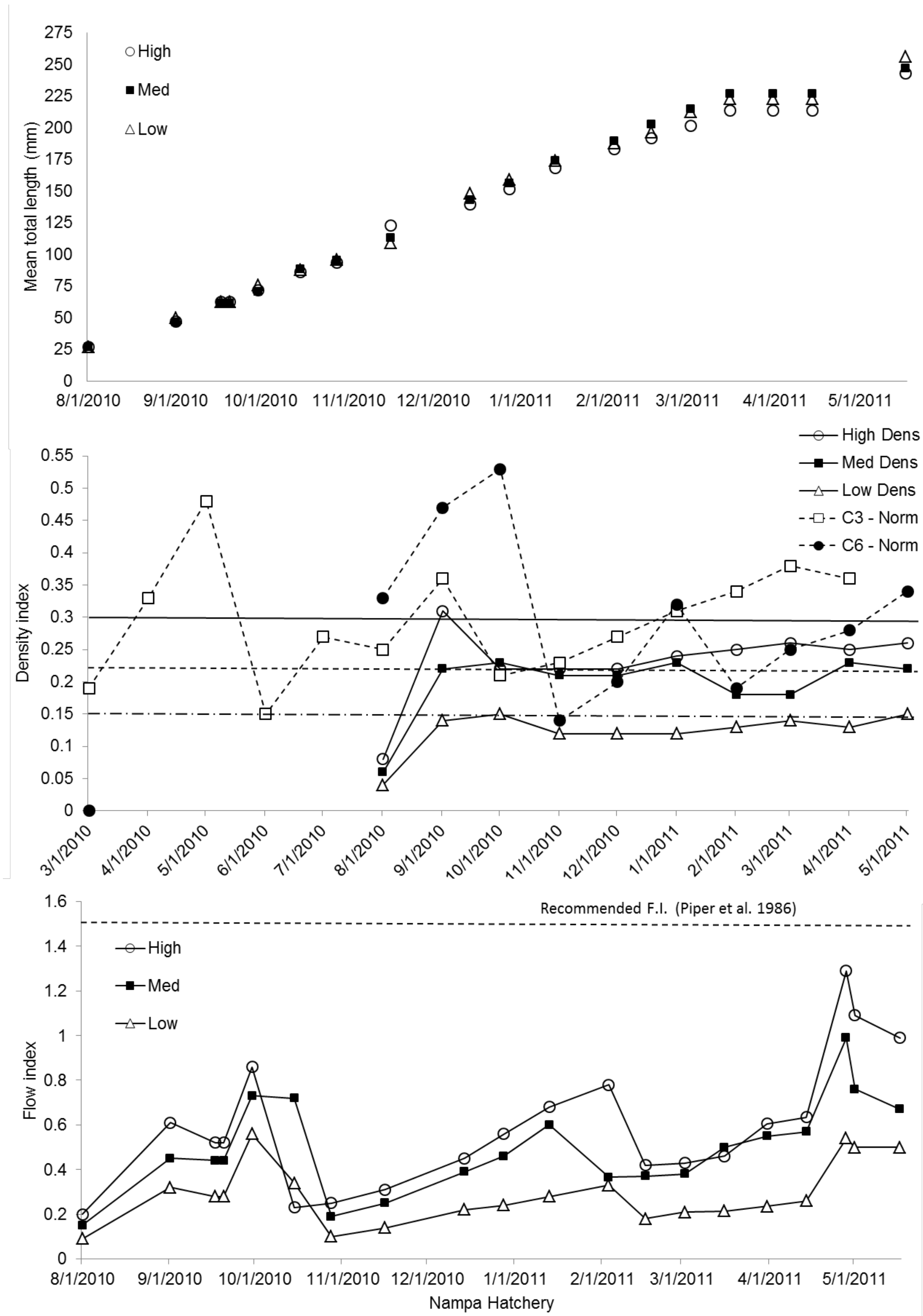

Figure 11. Mean total length (mm), density index (lbs/ft^3/inch), and flow index (lbs/inch x gal/min) by treatment (high/med/low density) and two normal production lots (C3 and C6) during the rearing period for Nampa Hatchery.

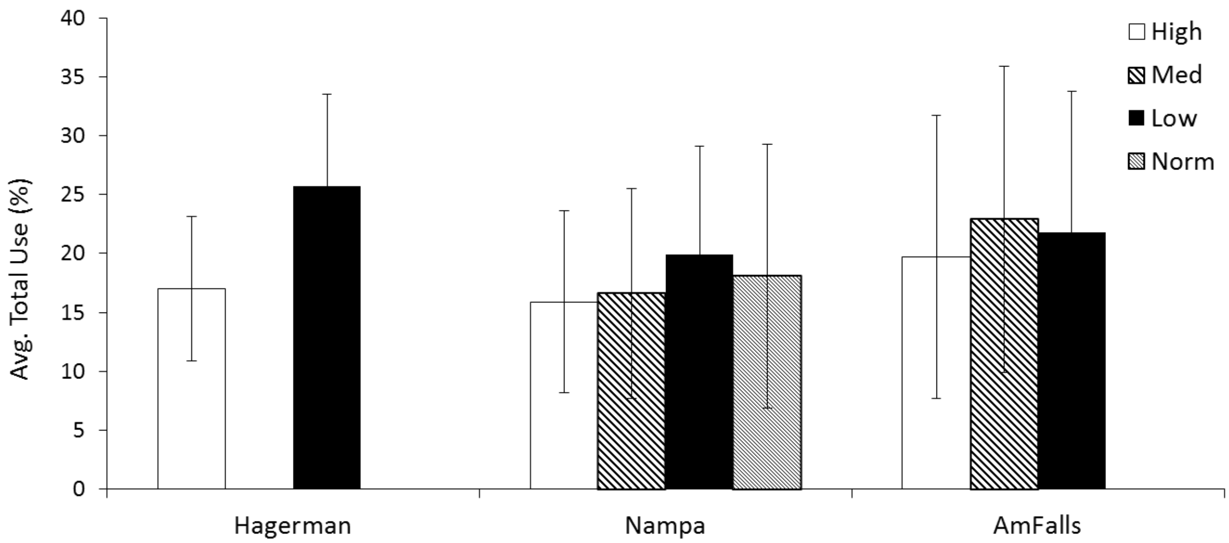

Figure 12. Mean "total use" (combined harvested and released) of hatchery catchable rainbow trout by rearing density treatment level across all waters. Low, medium, and high rearing density treatments were assigned as density index values of 0.15, 0.23, and 0.3 ($lbs/ft^3/in$), respectively. Standard production lots are indicated as normal density and usually exceeded 0.3 DI values at some point during rearing. Error bars indicate 90% confidence intervals around the mean.

ANNUAL PERFORMANCE REPORT
SUBPROJECT #4: HATCHERY CATCHABLE RAINBOW TROUT PERFORMANCE BETWEEN HATCHERIES AT CJ STRIKE RESERVOIR

State of: Idaho

Grant No.: F-73-R-34 Fishery Research

Project No.: 4

Title: Hatchery Trout Evaluations

Subproject #1: Improving Returns of Hatchery Catchable Rainbow Trout

Contract Period: July 1, 2011 to June 30, 2012

ABSTRACT

Producing "catchable" rainbow trout *Oncorhynchus mykiss* (typically stocked at 203 mm–305 mm in length) accounts for over 50% of the annual Idaho Fish and Game (IDFG) resident hatchery budget and about 84% of the total weight of resident fish stocked annually. Rearing conditions and culture techniques vary across hatcheries and may affect the survival and subsequent return of hatchery fish to anglers. Rangen Inc., a private hatchery near Hagerman, Idaho, raises rainbow trout for CJ Strike Reservoir under contract to Idaho Power, which requires very specific metrics of quality to ensure good survival and return-to-creel. IDFG is interested in understanding if this extra effort to produce high quality fish has measurable benefit to anglers. Comparing returns of similar trout from different hatcheries could indicate if different hatcheries show any survival advantage and improve techniques to increase returns of hatchery trout. In October 2010, we stocked equal numbers of all-female triploid rainbow trout from five IDFG facilities and Rangen Inc. into CJ Strike Reservoir. Return-to-creel was monitored using T-bar anchor tags for one year following release. Exploitation (harvest and "total use") were corrected for tagging mortality, tag loss, and tag return rate (non-compliance). Mean total length at stocking varied across hatcheries, with Hagerman Riley Creek being the largest (322 ± 6 mm), and Nampa Hatchery being smallest (248 ± 5 mm). Adjusted exploitation rate (harvest) varied across hatchery groups, and ranged from 3.7 ± 3% (Nampa Hatchery) to 42 ± 12% (Hagerman Riley Creek), with an overall average adjusted exploitation of 20 ± 5% for CJ Strike Reservoir as a whole. Hagerman Riley Creek cost the most to stock, while the Nampa Hatchery group was the least expensive. Mackay Hatchery had the lowest cost per fish returned to anglers ($1.70), while Nampa Hatchery was the most expensive ($4.69). Total exploitation was significantly correlated to mean length at stocking (adjusted R^2_a = 0.79, P = 0.0045). When the Rangen Inc. group was removed, the adjusted R^2 improved (R^2_a = 0.95, P = 0.0014). Results suggest returns can vary greatly between hatcheries and that larger fish generally provide greater returns. Additionally, rainbow trout raised by Rangen Inc. returned at a higher rate than was predicted by average size at release for IDFG hatchery trout.

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INTRODUCTION

Idaho Department of Fish and Game (IDFG) fish hatcheries are an integral part of managing coldwater sportfishing opportunities in Idaho. The resident hatchery program operates ten facilities with an annual budget of about $2.3 million. Producing “catchable” rainbow trout (typically stocked at 203 mm–305 mm in length) accounts for over 50% of the annual resident hatchery budget and about 84% of the total weight of resident fish stocked annually (Frew 2008). Demand for hatchery products continues to grow while costs to raise fish are increasing. At the same time, budgets to operate IDFG hatcheries are not expanding and may possibly be decreasing. Given the current economic climate involving IDFG hatchery funding, efforts must be made to ensure that hatchery programs remain efficient while producing a quality product for Idaho anglers.

Rearing conditions and culture techniques vary across hatcheries and may affect the survival and subsequent return of hatchery fish to anglers. Differences in rearing conditions such as raceway density (Elrod et al. 1989) or feed type can affect the quality and return-to-creel of hatchery fish. Fish quality and size can vary between facilities and may have an effect on return rates of hatchery fish. Previous IDFG evaluations have shown larger trout generally return at higher rates in streams (Mauser 1994), and that returns among hatcheries can be highly variable even within the same water body (Megargle 2000; Megargle and Teuscher 2001). Idaho Power (IPC) is responsible for stocking catchable-sized rainbow trout in CJ Strike Reservoir for recreational angling. Rangen Inc., a private hatchery near Hagerman, Idaho, raises rainbow trout for this program under contract. Idaho Power requires these rainbow trout meet very specific metrics of quality with hopes to ensure good survival and return-to-creel after stocking. Rangen Inc. must meet specified criteria for rearing density (<0.3), flow index (<0.8), weight (2-2.5 fish/lb), size variation (90% between 216 mm and 279 mm), and fin quality (≥85% of natural) prior to stocking. IDFG was interested in understanding if this extra effort to produce high quality fish had a measurable benefit to anglers. IDFG stocks rainbow trout with a management goal of achieving 40% return-to-creel (IDFG 2007) and is interested in improving resident hatchery products. Comparing returns of similar trout from different hatcheries could indicate if fish from different hatcheries show any survival advantage. This information could direct further research into modifying specific rearing conditions or techniques to improve the return of hatchery trout.

When using hatcheries for recreational fisheries, total hatchery production is an insufficient yardstick to determine whether hatcheries are successful. Instead, success should be measured in terms of contribution to harvest (Blankenship and Daniels 2004). Despite the high costs of operating hatcheries and stocking trout for sportfishing, the contribution to the creel of hatchery trout is rarely evaluated. Evaluating hatchery catchable returns could determine the effectiveness of Resident Hatchery products and whether hatchery stocking is meeting fishery management objectives. The goal of this study was to compare exploitation rates of stocked trout across different IDFG hatcheries and the Rangen Inc. facility.

OBJECTIVES

1. Compare return-to-creel of hatchery catchable rainbow trout stocked into CJ Strike Reservoir across several IDFG hatcheries and the Rangen Inc. hatchery.

METHODS

All rainbow trout used for this evaluation were raised from commercially available Troutlodge all-female triploid eggs. Fish marked for this evaluation from IDFG hatcheries were taken from standard production lots raised under normal production conditions with standard operating protocols for annual fall trout stocking. Average rearing density index and flow index values based on records for IDFG hatcheries are presented in Table 17. Fish raised by Rangen Inc. were reared privately at their Hagerman facility under the guidelines specified by Idaho Power intended to ensure trout of high quality with good survival and return-to-creel after stocking (S. Brink, Idaho Power Company, personal communication). These include the following criteria:

- maintaining a rearing density index less than 0.3 lbs/ft^3/in
- flow index less than 0.8 lbs/GPM/inch
- average fish weight between 2-2.5 fish/lb
- length variation where 90% of fish are between 216 mm – 279 mm
- fin quality ≥85% of natural on average prior to stocking

Trout were collected at each participating hatchery by first crowding within raceways, then with dip nets to be tagged. Crowding fish ensured a random sample of fish from the entire raceway and reduced size-selected bias. The first 100 trout tagged were measured (total length, mm) and weighed (wet, g) to characterize the size of each release group. Trout were then tagged using 70 mm (51 mm of tubing) fluorescent orange T-bar anchor tags treated with algaecide. After tagging, trout were returned to submerged enclosures and allowed to recover overnight. Mortalities and shed tags were collected and recorded before loading fish for transport. Approximately 400 trout were tagged at each hatchery. The number of fish tagged at each hatchery differed slightly because of tag malfunctions (Table 18). Tags were labeled with the agency and tag reporting phone number (IDFG 1-866-258-0338) on one side, with the tag number on the reverse side. Tags were reported through the IDFG “Tag-You’re-It” phone system and website, as well as at regional IDFG offices and by mail.

The stocking date was coordinated between hatcheries based on the regularly scheduled plant for the Idaho Power Rangen Inc. group. Tagging and stocking were coordinated so that all trout were marked in identical fashion and stocked within the same 48-hour period. Trout were marked on October 18 and 19, 2010, held overnight in the hatchery to recover, and then stocked the following day. All marked fish were transported via tanker truck and released at the Cottonwood Access boat ramp at the southeastern side of CJ Strike Reservoir.

Total exploitation (total harvest) and use (total fish harvested or released) for the year after stocking were calculated according to the methods of Meyer et al. (2010). Unadjusted exploitation (harvest) and “total use” (harvest plus released) were adjusted by incorporating the angler tag reporting rate (49.2%), first year tag loss (8.2%), and tagging mortality (0.8%) for rainbow trout based on extensive T-bar anchor tag data from 2006 to 2009 (Meyer et al. 2010).

Stocking costs were estimated based on hatchery records for cost per fish produced (T. Frew, IDFG, personal communication). I calculated the total pounds stocked using the average weight of fish (fish/lb) and the total number stocked. Total stocking cost and cost per pound stocked were calculated by the cost per fish stocked, average fish weight, and total pounds stocked. Cost per fish returned was calculated using the adjusted “total use” rate and the stocking cost per fish. Cost per pound of fish returned was based on the average fish weights at the time of stocking and the adjusted "total use" rate.

I used ordinary least squares regression to examine correlation between mean length and conditions at stocking and total adjusted use across hatchery release groups. Correlations were considered statistically significant with $\alpha = 0.05$.

RESULTS

Mean total length at stocking varied across hatcheries, with Hagerman Riley Creek being the largest (322 ± 6 mm), Nampa Hatchery being smallest (248 ± 5 mm), and the Hagerman Tucker Springs group showing the largest variation (Figure 18). The Hagerman Riley Creek group was also the heaviest on average (381 ± 23 g, 1.2 fish/lb), but the Hagerman Tucker Springs group had the highest condition factor (K) at 1.26 ± 0.06 (Table 18).

Within one year of release, 330 tags were reported. The majority of trout caught were reported as having been harvested (90%), suggesting CJ Strike Reservoir is a harvest-oriented rainbow trout fishery. The majority of tags (89%) were reported having been caught in the reservoir, while 11% were caught in the Snake River below CJ Strike Dam. Adjusted total exploitation rate (harvest) varied across hatchery groups and ranged from 3.7 ± 3% (Nampa Hatchery) to a high of 42 ± 12% (Hagerman Riley Creek), with an overall average adjusted exploitation of 20 ± 5% (Table 18). Adjusted "total use" (harvested and released fish) was slightly higher, with an overall average of 21.9 ± 5%. Exploitation and total use for the IPC Rangen Inc. group was 28.7 ± 9% and 30.1 ± 9%, respectively. The mean length of time at large before a trout either was harvested or released was 126 days, with 50% of the total harvest occurring by approximately February 12, 2011, or 115 days after stocking (Figure 14).

The cost for stocking each group was highest for the Hagerman Riley Creek group ($262.14) and least expensive for the Nampa Hatchery group ($86.90). When exploitation and "total use" were included into cost, Mackay Hatchery had the lowest cost per fish used ($0.90), while Nampa Hatchery was the most expensive ($4.69). Stocking costs were not available for the Rangen Inc. group.

Total adjusted exploitation was significantly correlated to mean length at stocking (adjusted $r^2_a = 0.79$, $P = 0.0045$). Based on a scatter plot of the data (Figure 15), a more refined relationship existed specifically for IDFG hatcheries. When the IPC Rangen Inc. group was removed, the adjusted r^2 improved ($r^2_a = 0.95$, $P = 0.0014$). Based on the scatter plot and these data, results suggest that rainbow trout raised by Rangen Inc. returned at a higher rate than predicted by average size at release for IDFG hatchery trout.

DISCUSSION

Mean harvest and "total use" (20% and 21.9%, respectively) of hatchery rainbow trout at CJ Strike were similar to those reported by Meyer et al. (2010) for several large Idaho reservoirs. They reported "total use" of hatchery catchable rainbow trout at Anderson Ranch, Chesterfield, Walcott, and Lucky Peak reservoirs was 15%, 21%, 28%, and 25%, respectively. While most returns at CJ Strike still fall short of the 40% target specified by IDFG for put-and-take waters (IDFG 2007), they are similar to other trout fisheries in large reservoirs.

The Hagerman Riley Creek group had the highest harvest and "total use" rates, returning about 47% higher than the next best group. The next best groups were from Rangen Inc. and Mackay hatcheries, showing very similar results around 30% "total use." The Nampa Hatchery group showed the lowest returns, with only 10 total tags having been reported (4.7%). I found a significant positive correlation of return-to-creel and mean size-at-stocking (Figure 15), indicating larger rainbow trout returned at higher rates. The Hagerman Riley Creek lot was the largest (322 mm) of the groups stocked, and performed very well. These trout were raised to meet specific fall stocking requests for Blackfoot Reservoir, and were not typical of catchable trout raised in IDFG hatcheries. The Mackay Hatchery group was the second largest of all groups, but also showed the least variation in length at stocking (Figure 13). Lower size variation could mean fewer small fish in the lot, and perhaps this contributed to higher return rates. On average, rainbow trout from Nampa and American Falls hatcheries were at large almost 30 days longer than other hatcheries before being caught. Given the relationship of size to return, this may be related to the fact that they were the two smallest groups on average. Perhaps there is a certain acceptable size at which hatchery trout recruit to the fishery, and these groups needed time to grow into that size range.

Several previous studies found size at stocking was often correlated with return-to-creel. Mauser (1994) found tag returns from trout stocked at 300 mm were 1.2 times higher than those stocked at 240 mm across several streams in the Wood River drainage. Baird et al. (2006) reported similar findings in a large Adirondack river, where large (>300 mm) catchable rainbow trout contributed more to the total catch than small (<260 mm) rainbow trout. The authors speculated the smaller fish had lower initial health and were affected by stocking and tagging-related stress. Teuscher (1999) investigated size-at-stocking and return-to-creel across 19 Idaho streams. He concluded that large catchable rainbow trout (285 mm) did not return significantly higher than small-sized (236 mm) catchable rainbow trout when combined across all streams. However, when he compared returns of trout from the same raceway, there was a significant positive correlation between size and return-to-creel, implying that catch rates were related to behavioral differences inherent to larger fish within the same rearing group. One important difference in this study from that of Teuscher (1999) is that I saw a correlation of returns to size at stocking across several hatcheries, not just from fish within the same raceway. This suggests that size itself imparts some survival advantage independent of behavior, or that larger rainbow trout are inherently more catchable.

While return-to-creel was highly correlated with size-at-stocking, the Rangen Inc. group did not fit the relationship as well as IDFG facilities. When the Rangen Inc. group was removed from the dataset, correlation increased from $r^2 = 0.79$ to $r^2 = 0.95$ (Figure 13). Rangen Inc. fish lie above the trend line fit to the data. While this comparison is based on one data point, the data indicate that Rangen Inc. rainbow trout returned to anglers at a higher rate than would be otherwise predicted based on size alone. These data suggest factors other than size may also affect return-to-creel of hatchery rainbow trout. The fact that the Rangen Inc. fish do not lie on the same line as IDFG groups suggests there may be some difference in rearing practices between hatcheries that could result in different return-to-creel.

Costs to stock each group varied widely across hatcheries, but Mackay Hatchery appeared to be the most cost-effective. This group was only slightly more expensive than fish stocked from American Falls, Grace, and Nampa, but showed the lowest cost per fish in the creel. The stocking cost for each group was highest for the Hagerman Riley Creek fish, probably because of the added feed costs required to rear them to large size. While these fish were the most expensive to stock, they were similarly cost-effective to Grace and American Falls hatcheries when return-to-angler cost was considered. This group was even more cost-effective if comparing cost of weight of fish returned to anglers (Table 18). High initial stocking costs for large fish could be justified if returns are high enough. Mauser (1994) found that larger trout returned to anglers at higher rates (in streams). However, he cautioned against stocking fewer, larger trout, because returns would not be sufficiently high enough to maintain catch rates such as those from stocking larger numbers of smaller trout. Larger fish must return at much higher rates to offset higher rearing costs, which may not always occur. Mauser (1994) also concluded that most stream anglers preferred catching one large trout (300 mm) over two small (240 mm) trout, suggesting stocking fewer, larger fish could be cost-effective for increasing angler satisfaction, but not necessarily by increasing harvest rates. Managing for medium-sized fish with good performance could be the best strategy to balance rearing cost, return rates, and angler satisfaction. In this study, fish from Mackay Hatchery appeared to be the closest to achieving this. Idaho Power did not provide any cost information, so cost comparisons to Rangen Inc. fish were not possible.

Rearing conditions (in terms of density and flow) varied slightly across IDFG facilities. Flow index at Nampa Hatchery was the only exception, being higher than most facilities and the Rangen Inc. criteria. Average rearing density index was lower across most IDFG facilities than that of Rangen Inc., with the exception of Nampa Hatchery, which was similar. Rangen Inc. fish had the highest average density index, but the lowest flow index values, indicating greater water turnover despite crowded conditions. Good returns of these fish suggest raceway flows may be an important factor affecting poststocking returns. Rainbow trout from Mackay Hatchery (reared at low density because of dissolved oxygen limitations) performed well, but rainbow trout from American Falls Hatchery reared at similar density and lower flow index did not perform as well. Nampa Hatchery had the highest rearing density and flow index values, along with the lowest return-to-creel. While these may be correlated, I do not have sufficient information to conclude how they are related. If return-to-creel is related to rearing conditions, the effects may be variable and hard to quantify without more data. Higher return-to-creel of the Rangen group suggests that factors other than density, flow, strain, and diet can affect poststocking performance.

This study has some significant limitations that need to be considered when interpreting the results. Returns from hatchery catchable rainbow trout at a particular water body can vary between years, even from the same hatchery (Megargle and Teuscher 2001; Meyer et al. 2010). This study only represents one stocking event in a single year, at a single reservoir. Future research is needed to understand the mechanisms affecting survival of hatchery trout between facilities. While broad conclusions are not possible from this study, it does suggest differences in the hatchery environment and size-at-stocking can play a role in poststocking returns of catchable rainbow trout. Further research is needed to identify which aspects of the rearing environment most significantly affect return-to-creel.

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Table 17. Average density index (DI, lbs fish/ft^3/inch), flow index (FI, lbs/GPM/inch), and average water temperature (°C) for IDFG and Rangen Inc. facilities during the rearing period for catchable-sized rainbow trout planted in CJ Strike Reservoir in October 2010. Values are based on hatchery records for 2010.

Hatchery	Mean D.I. (lbs/ft^3/in)	Mean F.I. (lbs/gpm/in)	Mean temperature (C)
American Falls	0.13	0.42	12.8
Grace	0.18	0.65	11.7
Hagerman	0.18	0.83	15
Mackay	0.13	0.62	12.2
Nampa	0.23	1.07	15
Rangen Inc.	0.24	0.46	15

Table 18. Size-at-stocking and associated return-to-creel information by hatchery for catchable rainbow trout stocked in CJ Strike Reservoir in October 2010. Length, weight, and condition are shown with 95% confidence intervals. Adjusted exploitation and adjusted use are shown with 90% confidence intervals.

Hatchery	Tags released	Length (mm) at release	Weight (g) at release	Condition (K)	Fish/lb	Tags harvested	Tags released	Adjusted exploitation	Adjusted total use	Mean days to use
American Falls	402	253 ± 4	180 ± 8	1.09 ± 0.01	2.5	29	2	13.4 ± 5%	14.3 ± 6%	151
Grace	399	262 ± 5	192 ± 8	1.08 ± 0.08	2.4	35	5	16.2 ± 6%	18.6 ± 7%	124
Mackay	399	284 ± 5	233 ± 9	1.03 ± 0.06	1.9	54	9	25.1 ± 8%	29.2 ± 9%	124
Nampa	395	248 ± 5	165 ± 10	1.06 ± 0.04	2.7	8	2	3.7 ± 3%	4.7 ± 3%	153
Hagerman Riley Cr.	399	322 ± 6	381 ± 23	1.12 ± 0.02	1.2	91	5	42.2 ± 12%	44.5 ± 12%	123
Hagerman Tucker Sp.	396	260 ± 9	226 ± 19	1.26 ± 0.06	2.0	19	6	8.9 ± 4%	11.7 ± 5%	129
Rangens IPC	400	264 ± 5	223 ± 13	1.18 ± 0.02	2.03	62	3	28.7 ± 9%	30.1 ± 9%	119
Total	*2790*					*298*	*32*	*20 ± 5%*	*21.9 ± 5%*	*126*

Hatchery	Fish returned	Pounds stocked	Pounds returned	Cost per fish stocked	Total stocking cost	Cost per lb stocked*	Cost per fish returned	Cost per lb. returned**
American Falls	57	161	23	$0.23	$92.46	$0.58	$1.61	$4.03
Grace	74	166	31	$0.25	$98.15	$0.59	$1.33	$3.18
Mackay	117	210	61	$0.26	$104.54	$0.50	$0.90	$1.70
Nampa	19	146	7	$0.22	$86.90	$0.59	$4.69	$12.68
Hagerman Riley Cr.	178	333	148	$0.66	$262.14	$0.79	$1.48	$1.77
Hagerman Tucker Sp.	46	198	23	$0.37	$147.71	$0.75	$3.19	$6.38
Rangens IPC	120	197	59	N/A	N/A	N/A	N/A	N/A

* Cost per fish according to the Default Catchables Request List and don't include transportation (T. Frew, personal communication).

** Based on weight of fish at the time of stocking

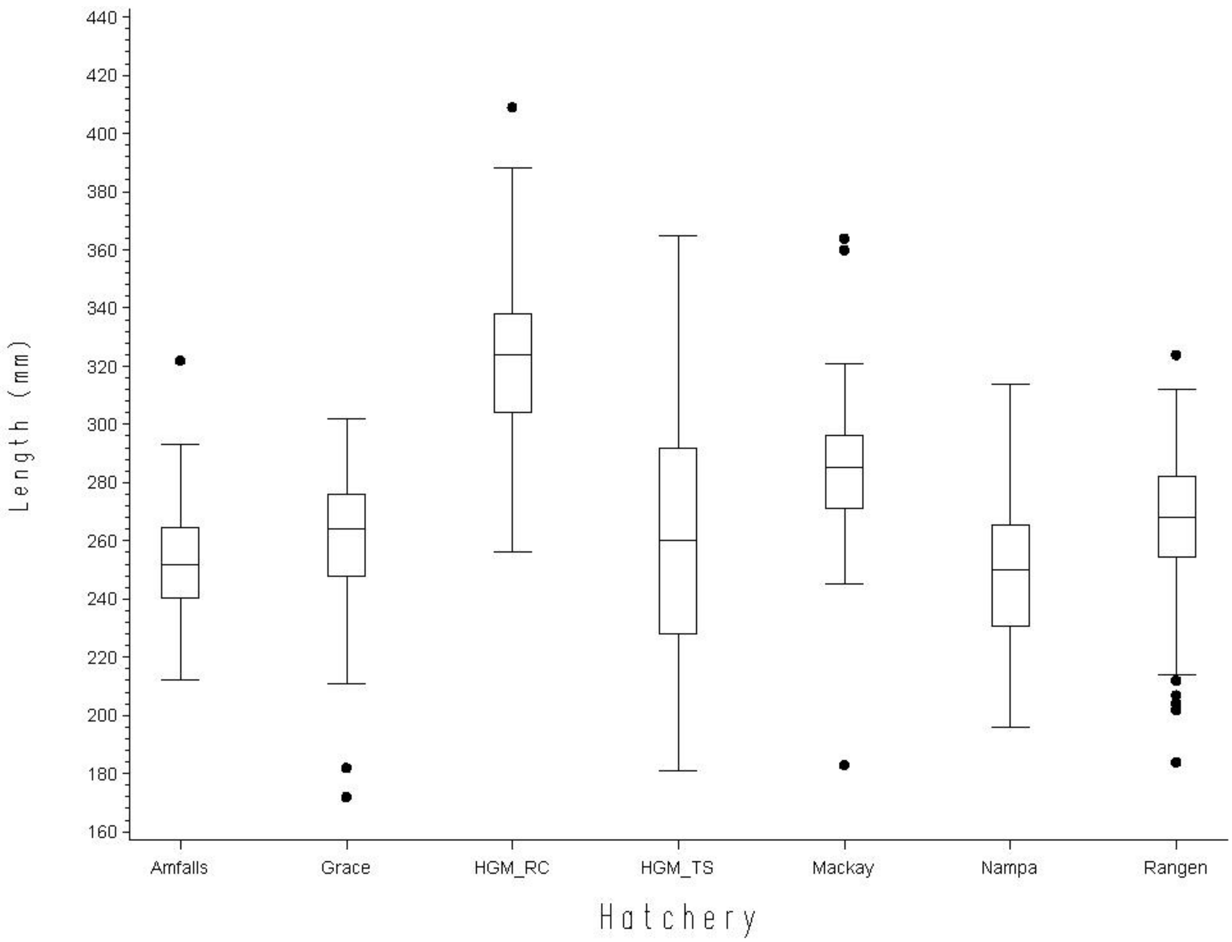

Figure 13. Box plot of total length (mm) by hatchery at the time of tagging for CJ Strike Reservoir in October 2010. The centerline of the boxes indicates the median value, while top and bottom are the 25th and 75th percentiles. Whiskers indicate 1.5 times the interquartile range, with outliers shown beyond that. Abbreviations HGM_RC and HGM_TS refer to Hagerman Riley Creek and Hagerman Tucker Springs sources, respectively.

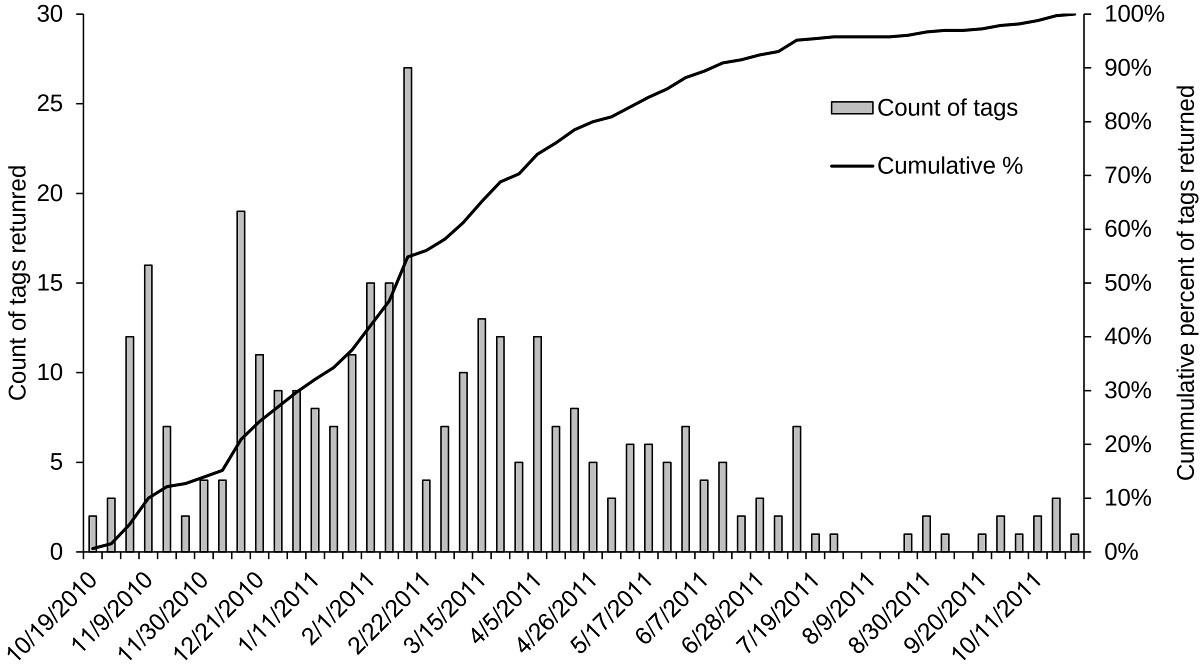

Figure 14. Total count and cumulative percent of returned rainbow trout tags over time within one year of release at CJ Strike Reservoir.

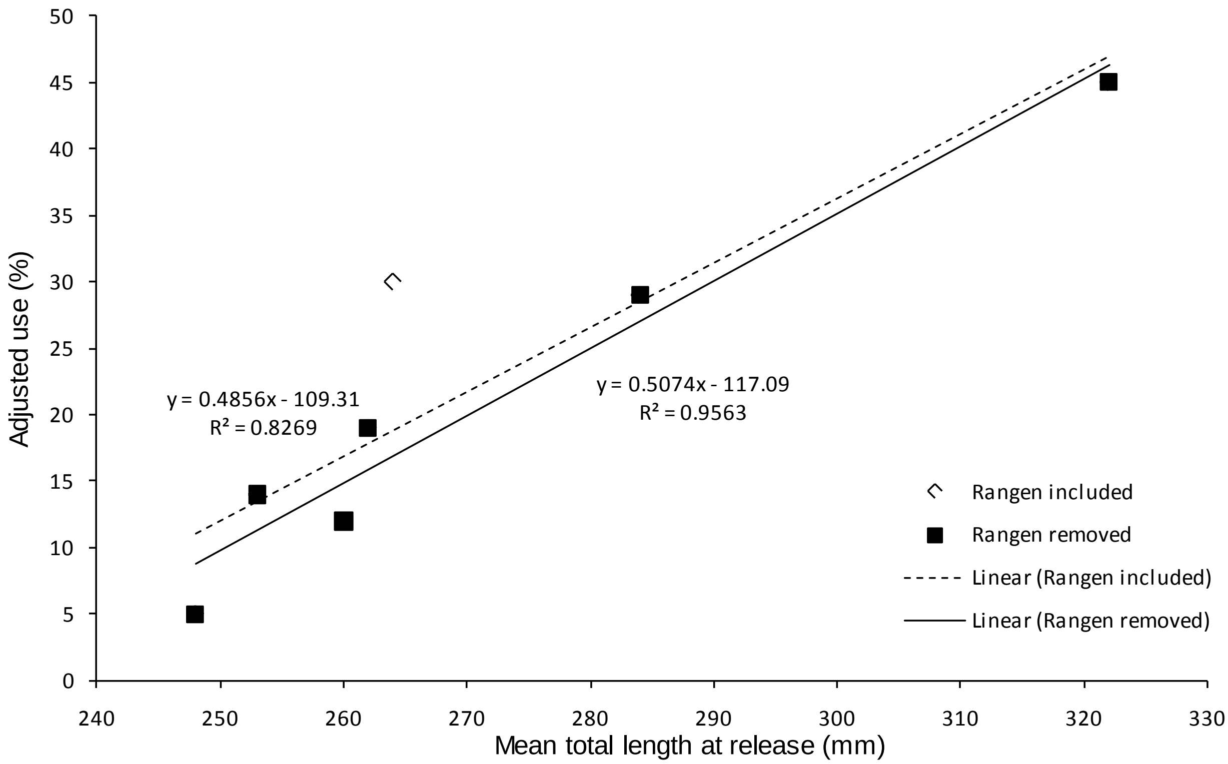

Figure 15. Scatter plot of total adjusted use (harvested and released fish) against size-at-stocking for hatchery catchable rainbow trout at CJ Strike Reservoir. The open diamond represents Rangen Inc. IPC stocking group, with separate trend lines including and excluding the Rangen Inc. IPC stocking group.

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