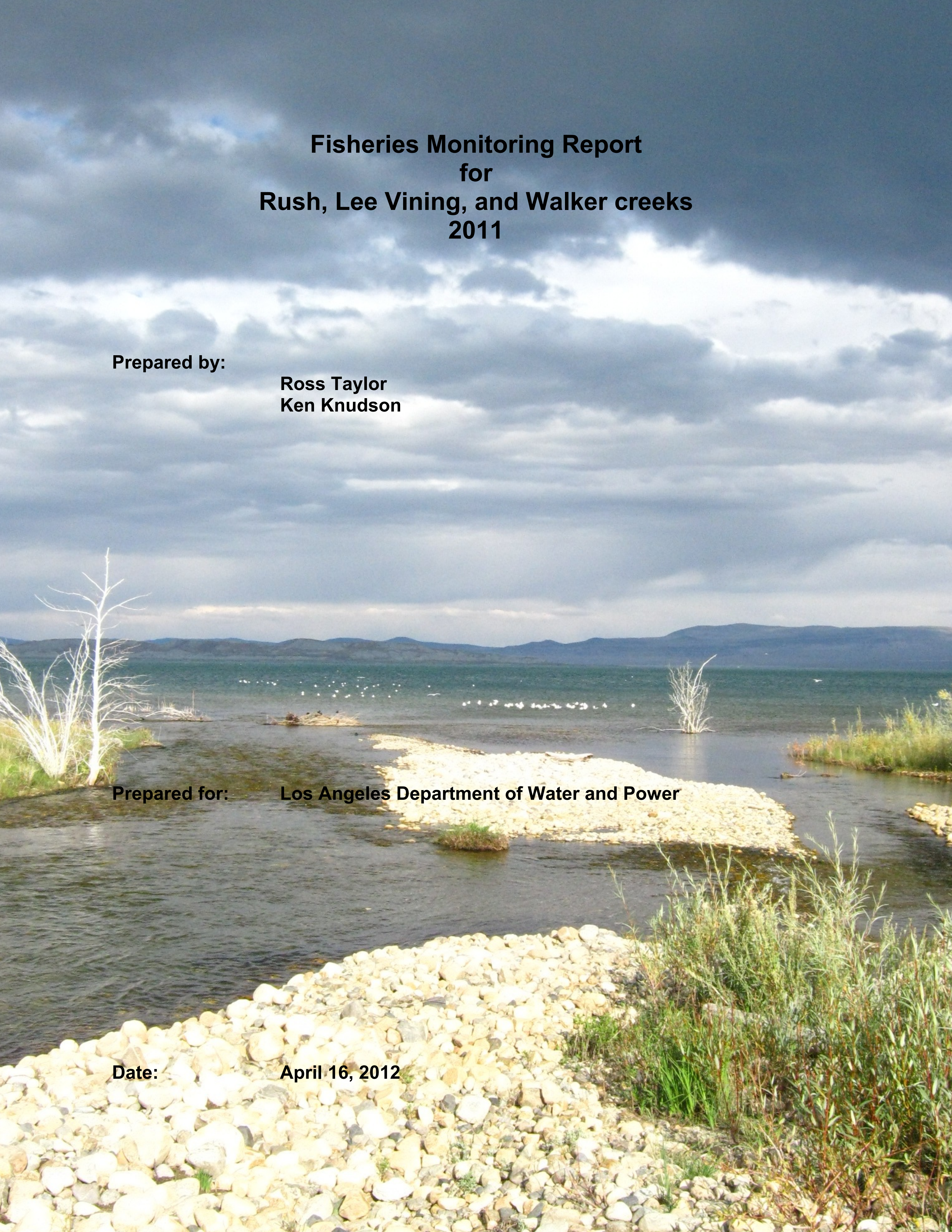
Section 3

Fisheries Monitoring Report for
Rush, Lee Vining, Parker, and Walker Creeks
2011-12



Fisheries Monitoring Report
for
Rush, Lee Vining, and Walker creeks
2011

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Table of Contents

Table of Contents 2
List of Tables 4
List of Figures 6
Executive Summary 8
  Density Estimates of Age-1 and older Brown Trout 8
  Density Estimates of Age-0 Brown Trout 9
  Density Estimates of Age-1 and older Rainbow Trout 9
  Density Estimates of Age-0 Rainbow Trout 9
  Standing Crop Estimates of Brown Trout 10
  Condition Factor of Brown Trout between 150 mm and 250 mm in Length 10
  Relative Stock Densities (RSD's) 11
  Termination Criteria 11
Introduction 12
Study Area 13
Methods 16
  Length-Weight Relationships 19
  Fin Clips, PIT Tags and Growth Estimates 19
  Relative Stock Density (RSD) Calculations 19
  Termination Criteria Calculations and Analyses 20
    Rush Creek TC for Upper, Bottomlands and County Road Sections 21
    Lee Vining Creek TC 21
    Rush Creek TC for the MGORD Section 22
    How to use the Quantifiable Termination Criteria 23
Results 24
  Channel Lengths and Widths 24
  Fish Population Abundance 24
    Rush Creek – County Road Section 24
    Rush Creek – Bottomlands Section 25
    Rush Creek – Upper Section 25
    Rush Creek – MGORD Section 25
    Lee Vining Creek – Main Channel Section 31
    Lee Vining Creek – Side Channel Section 31
    Walker Creek 31
  Catch of Rainbow Trout in Rush and Lee Vining Creeks 35
  Relative Condition of Brown Trout 38
  PIT Tag Recaptures and Measured Growth Rates 43
    Growth of Age-0 Trout between 2010 and 2011 43
    Growth of Age-2 and Age-3 Trout between 2010-2011 47
    Shed Rate of PIT Tags between 2009 and 2011 49
    Population Estimates and Densities, by age-class, during September 2011 52
  Estimated Trout Density Comparisons 57
  Estimated Trout Densities Expressed in Numbers per Unit Length 64
  Estimated Trout Standing Crop Comparisons 66
  Relative Stock Density (RSD) Results for Rush and Lee Vining Creeks 70
  Termination Criteria Results 73

Discussion 75
Brown Trout Responses to Winter Baseflows 75
Trout Growth between 2010 and 2011 79
Termination Criteria Discussion 81
Methods Evaluation 85
References Cited 88
Appendix A: Aerial Photographs of Long-term Monitoring Sections 91
Appendix B: Lee Vining Creek – Termination Criteria Calculation Memo 98
Appendix C: PIT Tag Recaptures from 2011 Sampling Season 102
Appendix D: Proofed Data Summaries for Sampling Years 2007 - 2010 111

List of Tables

Table 1. Total length (m), average wetted width (m), and total surface area (m^2) of sample sections in Rush, Lee Vining, and Walker creeks sampled between September 10 -21, 2011. Values for 2010 provided for comparisons. 24
Table 2. Rush Creek and Lee Vining Creek mark-recapture estimates for 2011 showing total number of fish marked (M), total number captured on the recapture run (C), total number recaptured on the recapture run (R), and total estimated number and its associated standard error (S.E.) by stream, section, date, species and size class. Mortalities (Morts) were those fish that were captured during the mark run, but died prior to the recapture run. Mortalities were not included in mark-recapture estimates and should be added to estimates for accurate total estimates. NP = estimate not possible. 30
Table 3. Depletion estimates made in the Lower side channel section of Lee Vining Creek and Walker Creek during September 2011 showing number of fish captured in each pass, estimated number, probability of capture (P.C.) by species and length group. 34
Table 4. Numbers of age-0 rainbow trout caught in Lee Vining Creek main channel section, 2000-2011. 36
Table 5. Numbers of age-1 and older rainbow trout caught in Lee Vining Creek main channel section, 2000-2011. 36
Table 6. Numbers of age-0 rainbow trout caught in Lee Vining Creek side channel section, 2000-2011. 37
Table 7. Numbers of age-1 and older rainbow trout caught in Lee Vining Creek side channel section, 2000-2011. 37
Table 8. Regression statistics for $\log_{10}$ transformed length (L) to weight (WT) for brown trout 100 mm and longer captured in Rush Creek by sample section and year. The 2011 regression equations are in **bold** type. 39
Table 8 (continued). 40
Table 9. Total numbers of trout implanted with PIT tags during the 2009 sampling season, by stream, sample section, age-class and species. 44
Table 10. Total numbers of trout implanted with PIT tags during the 2010 sampling season, by stream, sample section, age-class and species. 45
Table 11. Fish recaptured in 2011 with PIT tags implanted during the 2010 sampling season, by stream reach. 45
Table 12. Growth of 102 age-1 brown trout recaptured in 2011 that were implanted with PIT tags as age-0 fish during the 2010 sampling season, by stream reach. 46
Table 13. Comparison of annual growth rates of brown trout between age-0 and age-1 as determined by adipose fin clips and PIT tag recaptures, by stream reach. 46
Table 14. Growth of twenty-one age-2 fish recaptured in 2011 that had also been recaptured as age-1 fish during the 2010 sampling season, at three Rush Creek sections and the Walker Creek section. 50
Table 15. Growth of fourteen age-3 fish recaptured in 2011 that had also been recaptured as age-2 fish during the 2010 sampling season, at two Rush Creek sections and sections on Walker and Lee Vining creeks. 50

Table 16. Growth of 27 age-2 fish recaptured in 2011 that were implanted with PIT tags as age-1 fish during the 2010 sampling season, for the MGORD section of Rush Creek. 51
Table 17. Population estimates, densities and PIT tag return rates, by age class, for brown trout populations at three electrofishing sections on Rush Creek and sections on Walker and Lee Vining creeks, September 2011. 54
Table 18. Total numbers of trout implanted with PIT tags during the 2011 sampling season, by stream, sample section, age-class and species. 55
Table 19. Average length (mm), minimum length, maximum length, average weight (g), and number (901 total fish) of age-0 trout implanted with PIT tags during the 2011 sampling season, by stream, sample section, and species. 56
Table 20. Total number of brown trout per kilometer of stream channel for Rush Creek sample sections, 2000 - 2011. The value within (#) denotes the number of age-1 and older trout per kilometer. 65
Table 21. Total number of brown and rainbow trout per kilometer of stream channel for Lee Vining Creek sample sections, 2000 – 2011. The value within (#) denotes the number of age-1 and older trout per kilometer. 65
Table 22. Comparison of 2010-2011 brown trout standing crop (kg/ha) estimates in Rush Creek study sections. 67
Table 23. Comparison of 2010-2011 total (brown and rainbow trout) standing crop (kg/ha) estimates in Lee Vining Creek study sections. 67
Table 24. RSD values for brown trout in Rush Creek study sections, for 2000-2011. . 71
Table 24 (continued). 72
Table 25. RSD values for brown and rainbow trout in the Lee Vining Creek main channel study section, for 2000-2011 72
Table 26. Termination criteria analyses for the County Road section of Rush Creek. Bold values indicate that an estimated value met the termination criterion. 73
Table 27. Termination criteria analyses for the Upper section of Rush Creek. Bold values indicate that an estimated value met the termination criterion. 73
Table 28. Termination criteria analyses for the MGORD section of Rush Creek. Bold values indicate that an estimated value met the termination criterion. 74
Table 29. Termination criteria analyses for Lee Vining Creek's main channel section. Bold values indicate that an estimated value met the termination criterion. Values within parentheses are additive values of main and side channel sections. 74
Table 30. Total catch, population estimates, and densities for brown trout >255 mm (>10 inches) in length at the Bottomlands and County Road sections of Rush Creek during September 2000–2011. Catch numbers were used for density estimate calculations whenever there were less than four recaptures. 78
Table 31. Growth (g) comparisons of Rush Creek age-0 to age-1 brown trout in years 2006-2007, 2008-2009, 2009-2010, and 2010-2011 with adipose fin clips administered during the 2006 and 2008 sampling seasons and PIT tags impanted in the 2009 and 2010 season, respectively. 79

List of Figures

Figure 1. Map of Mono Basin study area with 2011 fish sampling sites displayed (created by McBain and Trush 2009). 13
Figure 2. Daily stream flows (c.f.s.) in Rush Creek at three locations between April and September 2011. Data were provided by LADWP. 14
Figure 3. Daily stream flows (c.f.s.) in Lee Vining at the LADWP diversion between April and and October 2011. Data were provided by LADWP. 15
Figure 4. Anode operators and netters sampling Rush Creek's Upper section, 2009. 18
Figure 5. Electro-fishing barge with generator and cooler on Upper Rush Creek, 2009. 18
Figure 6. Length-frequency histograms of brown trout captured in the County Road (top) and Bottomlands (bottom) sections of Rush Creek between September 9th and 19th, 2011. Note different scales on both x-axes and y-axes. 26
Figure 7. Length-frequency histograms of brown trout captured in the Upper (top) and MGORD (bottom) sections of Rush Creek between September 9th and 19th, 2011. Note different scales on both x-axes and y-axes. 27
Figure 8. Length-frequency histograms of rainbow trout captured in the County Road (top) and Bottomlands (bottom) sections of Rush Creek between September 9th and 19th, 2011. 28
Figure 9. Length-frequency histogram of rainbow trout captured in the Upper section of Rush Creek between September 9th and 19th, 2011. Note different scales on both x-axes and y-axes. 29
Figure 10. Length-frequency histograms of brown trout captured in the Main channel (top) and Side channel (bottom) sections of Lee Vining Creek between September 9th and 19th, 2011. Note different scales on the y-axes. 32
Figure 11. Length-frequency histograms of rainbow trout captured in the Main channel section of Lee Vining Creek between September 9th and 19th, 2011. 33
Figure 12. Length-frequency histogram of brown trout captured in Walker Creek on September 14, 2011. 33
Figure 13. Condition factors for brown trout 150 to 250 mm long in sample sections of Rush, Lee Vining, and Walker creeks from 1999 to 2011. Note the x-scale starts at 0.8 and red vertical line indicates condition factor of 1.0. 41
Figure 14. Comparison of condition factors for rainbow trout and brown trout 150 to 250 mm long in main channel sample section of Lee Vining Creek from 2000 to 2011. Note the x-scale starts at 0.8. Note: main channel was not sampled in 2006 due to high flows. 42
Figure 15. Estimated number of age-1 and older brown trout per hectare in sections of Rush and Walker creeks from 2000 to 2011. 58
Figure 16. Estimated number of age-1 and older brown trout per hectare in sections of Lee Vining Creek from 1999 to 2011. 59
Figure 17. Estimated number of age-1 and older rainbow trout per hectare in sections of Lee Vining Creek from 1999 to 2011. 60
Figure 18. Estimated number of age-0 brown trout per hectare in sections of Rush Creek (bottom) and Walker creeks (top) from 2000 to 2011. 61
Figure 19. Estimated number of age-0 brown trout per hectare in sections of Lee Vining Creek from 1999 to 2011. 62

Figure 20. Estimated number of age-0 rainbow trout per hectare in sections of Lee Vining Creek from 1999 to 2011 63
Figure 21. Estimated total standing crop (kilograms per hectare) of brown trout in all sample sections within Rush Creek, 1999-2011. Section and year are shown on the y-axis. Note: red denotes estimated standing crop of rainbow trout in Upper Rush section for 2011. 68
Figure 22. Estimated total standing crop (kilograms per hectare) of brown trout and rainbow trout in all sample sections within the Lee Vining Creek drainage, 1999-2011. Section and year are shown on the y-axis 69

Executive Summary

This report presents results of the fifteenth year of fish population monitoring for Rush, Lee Vining, and Walker creeks pursuant to State Water Resources Control Board (SWRCB) Decision #1631 and the thirteenth year following SWRCB Orders #98-05 and #98-07.

The 2011 electro-fishing sampling occurred between September 9th and 19th. Mark-recapture electro-fishing techniques were utilized to estimate trout populations in three sections of Rush Creek and one section of Lee Vining Creek. The lengths of the 2011 sampling sections were the same as those modified in 2009 and sampled in 2010. Fish population estimates for the Lower Lee Vining Creek side channel and Walker Creek were made using electro-fishing depletion methods. In 2011, the MGORD section of Rush Creek was sampled for the purpose of generating relative stock density (RSD) values and condition factors, recapturing previously PIT tagged fish, and implanting PIT tags in untagged fish. The MGORD section is sampled for a population estimate in even-years only.

Density Estimates of Age-1 and older Brown Trout

In 2011, the estimated densities (number per hectare) of age-1 and older brown trout in the County Road section of Rush Creek was 1,215.8 fish/ha, an 18% decrease from the 2010 estimate. In 2011, the Bottomlands section of Rush Creek had an estimated density of 1,155.5 age-1 and older brown trout/ha, a 6% drop from the 2010 estimate. The Upper section of Rush Creek had an estimated density of 2,201 age-1 and older brown trout/ha in 2011, a 107% increase from the 2010 estimate. The 2011 density estimate of age-1 and older brown trout/ha in Upper Rush was the highest recorded for this section over a 12-year period. In Walker Creek the 2011 density estimate of 1,505 age-1 and older brown trout/ha was 25% less than the 2010 estimate. Walker Creek's density estimate of age-1 and older brown trout has decreased by 46% over a two-year period since the record high value was set in 2009.

In 2011, the side channel section of Lee Vining Creek produced an estimated density of 355 age-1 and older brown trout/ha, the first time since 2002 that the density estimate has exceeded 300 fish/ha. The 2011 density estimate was a 209% increase from the 2010 estimate. Between 2010 and 2011, the estimated density of age-1 and older brown trout in the main channel of Lee Vining Creek decreased by 3% from 432 fish/ha to 421.2 fish/ha. The 2011 density estimate of age-1 and older brown trout in the main channel section was the second lowest estimate for this section in 12 years of sampling.

Density Estimates of Age-0 Brown Trout

Between 2010 and 2011, estimated densities of age-0 brown trout increased in the Upper Rush Creek section and decreased in the Bottomlands and County Road sections. The Upper section's 2011 density estimate of 10,629.1 age-0 brown trout/ha was an 83% increase from the 2010 estimate. The Rush Creek Bottomlands section had an estimated density of 2,217.7 age-0 brown trout/ha in 2011, a 32% decrease from the 2010 estimate. The County Road section had an estimated density of 2,160.2 age-0 brown trout/ha in 2011, a 22% decrease from the 2010 estimate. In Walker Creek the density estimate of age-0 brown trout decreased by 65% in 2011 (845.4fish/ha) from 2010 (2,391.8 fish/ha).

In 2011, the age-0 brown trout density estimate in the main channel section of Lee Vining Creek of 755.5 fish/ha was a 132% increase from the 2010 density estimate. The 2011 density estimate of age-0 brown trout within the Lee Vining Creek side channel of 276.1 fish/ha, was a slight increase from the 2010 estimate of 256.4 fish/ha. The Lee Vining Creek side channel has supported very low densities of age-0 brown trout since the 2005 sampling season.

Density Estimates of Age-1 and older Rainbow Trout

Because rainbow trout have consistently comprised a minor component of Rush Creek's trout population a decision was made in 2008 to cease attempting to generate population, density and biomass estimates of rainbow trout. However in 2011, a total of 263 rainbow trout (218 age-0 fish) were captured in Rush Creek and comprised 7.8% of all captured trout. Since annual sampling started in 1999, this was the greatest proportion of rainbow trout captured in Rush Creek and we suspect that the extensive spilling of water from Grant Lake Reservoir was the primary cause of this influx of rainbow trout.

In 2011, no age-1 and older rainbow trout were captured in the Lee Vining Creek side channel. For the Lee Vining Creek main channel section, the estimated densities of age-1 and older rainbow trout dropped by 42% between 2010 and 2011. For the years 1999-2001, 2003-2005, 2007 and 2011 insufficient numbers of age-1 and older rainbow trout were captured to generate population estimates, thus these density estimates were derived from catch data. In 2006 the flow was too high to safely electro-fish the main channel.

Density Estimates of Age-0 Rainbow Trout

In 2011, a single age-0 rainbow trout was captured in the main channel section and no age-0 rainbow trout were captured in the side channel section of Lee Vining Creek. The single age-0 rainbow trout captured in the main channel section generated a density estimate of 7 fish/ha. The 2011 sampling season was the third straight year in which no age-0 rainbow trout were captured in the side channel section of Lee Vining Creek.

Standing Crop Estimates of Brown Trout

In Rush Creek, brown trout standing crop estimates decreased from 2010 to 2011 in the County Road and Bottomlands sample sections; these sections also experienced decreases from 2009 to 2010. In the County Road section, the 2011 estimated standing crop of 83.6 kg/ha was a 39% decrease from the 2010 estimate. In the Bottomlands section, the 2011 estimated standing crop of 90.5 kg/ha was a 22% decrease from the 2010 estimate. In the Upper Rush section, the 2011 estimated standing crop of 224.5 kg/ha was a 46% increase from the 2010 estimate, and exceeded 200 kg/ha for the first time since 2000.

Between 2010 and 2011, Walker Creek experienced a slight increase of 2% in estimated standing crop. The 2011 estimated standing crop of brown trout in Walker Creek was 130.2 kg/ha.

In Lee Vining Creek total standing crops (brown and rainbow trout combined) increased by 53% between 2010 and 2011 in the side channel section, and increased by 6% in the main channel section. The main channel section's 2011 total standing crop estimate of 70.5 kg/ha was the second-lowest estimate for this section for the 12-year monitoring period.

Condition Factor of Brown Trout between 150 mm and 250 mm in Length

Mean condition factors for brown trout 150 to 250 mm were <1.00 for the County Road and Bottomlands sections in Rush Creek indicating that brown trout condition was below average in these sections during 2011. The Upper Rush Creek section had a condition factor of 1.00 in 2011, a slight increase from the 0.98 value recorded in 2010. In the MGORD section of Rush Creek, the 2011 average condition factor of brown trout 150 to 250 mm was 0.98, down slightly from 0.99 in 2010.

The mean condition factor for 150 to 250 mm brown trout in Lee Vining Creek during 2011 was over 1.00 in both the main and side channel sections, indicating that brown trout condition was good. In the main channel section, the mean condition factor of 1.08 in 2011 was a slight increase from the 2010 value of 1.07. In the side channel section, the mean condition factor of 1.05 in 2011 was a slight increase from the 2010 value of 1.04. For the past 11 sample seasons in which data were available for Lee Vining Creek, rainbow trout had higher condition factors than brown trout in 10 of the seasons. Sample season 2004 was the only year in which brown trout had a slightly higher condition factor than rainbow trout, 1.06 versus 1.05.

Relative Stock Densities (RSD's)

RSD-225 values for brown trout in the three annually-sampled sections of Rush Creek decreased between 2010 and 2011 after experiencing substantial increases between 2009 and 2010. In 2011, brown trout with lengths >300 mm were captured in all three Rush Creek sections. RSD-300 values remained low in the Upper Rush Creek section, with a decrease from 3 to 1 between 2010 and 2011, and one brown trout greater than 375 mm in length was sampled. In 2011, the Rush Creek County Road section had an RSD-300 value of 1, the second straight season this section has recorded a RSD-300 value. The Bottomlands section had an RSD-300 value of 1 in 2011, with three fish greater than 300 mm in length captured.

The RSD-225 and RSD-300 values in the MGORD section of Rush Creek increased between 2010 and 2011. The RSD-375 value for 2011 was 4, a slight decrease from the value of 5 for the 2010 sampling season. The eight brown trout >375 mm captured in 2011 was, by far, the lowest number of larger fish ever caught in the MGORD section.

In the Lee Vining Creek main channel sample section, the 2011 RSD-225 value was 48 for all trout (brown and rainbow trout combined), a decrease of 13% from the 2010 RSD-225 value of 55. In 2011, the Lee Vining Creek main channel section had a RSD-300 value of 10, the highest RSD-300 value ever recorded for Lee Vining Creek. In 2011, a total of six fish >300 mm in length (three brown trout and three rainbow trout) were captured in Lee Vining Creek, including a 400 mm wild rainbow trout.

Termination Criteria

In Rush Creek, none of the annually sampled sections met the target of meeting four out of five termination criteria for the most-recent three-year average which encompassed 2009-2011. The County Road section met only one of the five termination criteria (density) and the Upper Rush section met two of the five termination criteria (density and condition factor).

The MGORD section of Rush Creek met only one of three RSD termination criteria (RSD-225 = 74) for the three-year average of sampling years 2009-2011.

In Lee Vining Creek, the main channel section failed to achieve the target of meeting three out of four termination criteria. The main channel section met two of the four termination criteria (condition factor and RSD-225) for the three-year average of sampling years 2009-2011.

Introduction

This report presents results of the fifteenth year of fish population monitoring for Rush, Lee Vining, Parker and Walker creeks pursuant to State Water Resources Control Board (SWRCB) Decision #1631 and the thirteenth year following SWRCB Orders #98-05 and #98-07. Pilot studies were conducted in 1997 and 1998 to determine appropriate methods for generating statistically valid population estimates with 1999 being the first year estimates were generated for all study sections. Sampling year 2000 was the first season where a barge electroshocker was utilized on Rush Creek. As required, fish population monitoring will continue until the streams have met termination criteria included in the Settlement Agreement or upon approval of the SWRCB following public notice and opportunity for public comment. These termination criteria describe the presumed pre-project conditions for fish population structure:

1. Rush Creek fairly consistently produced brown trout weighing ¾ to two pounds. Trout averaging 13 to 14 inches were also regularly observed.

2. Lee Vining Creek sustained catchable brown trout averaging eight to 10 inches in length. Some trout reached 13 to 15 inches.

In addition to these criteria, Order 98-07 states the monitoring team will develop and implement a means for counting or evaluating the number, weights, lengths and ages of fish present in various reaches of Rush Creek, Lee Vining Creek, Parker Creek and Walker Creek. No specific termination criteria were set forth for Parker and Walker creeks, tributaries to Rush Creek.

The Settlement Agreement states that the monitoring team will consider young-of-year (age-0) production, survival rates between age classes, growth rates, total fish per mile and any other quantified forms as possible termination criteria, although the Settlement Agreement does not compel the choice of any one form. In 2007, a new suite of termination criteria were proposed by the Fisheries Stream Scientist in an attempt to make the calculation and interpretation of the fisheries termination criteria more quantifiable (Hunter 2007). The proposed metrics were well received by the interested parties; however, the proposed values assigned to signify “recovery” of the fishery were contentious. Along with population estimates; the annual fishery monitoring report includes the metrics of biomass, density, condition factor and relative stock density (RSD) because these are generally accepted by fishery professionals as repeatable and quantifiable measurements of stream-dwelling trout populations.

This report provides fish population data mandated by the Orders and the Settlement Agreement. Fish length data are reported as total length in millimeters (mm) in this report. For those not used to working in the metric system, an easy numerical reference point is 200 mm which is approximately eight inches. An eight-inch trout is often referred to as the minimum size of a “catchable” trout. In this report, all streamflow or water quantity values are reported in cubic feet per second (c.f.s.) or acre-feet (af) since these are the units used in the Orders and the Settlement Agreement.

Study Area

In 2011, the annual sampling sections were similar to the sections sampled in 2009 and 2010 (Figure 1). In Rush Creek the MGORD, Upper, Bottomlands, County Road, and Walker Creek sections were the same as those sampled in 2010. In Lee Vining Creek the main channel and side channel sections sampled in 2011 were the same as sampled in 2009 and 2010. Aerial photographs of the currently-sampled long-term monitoring sections are provided in Appendix A.

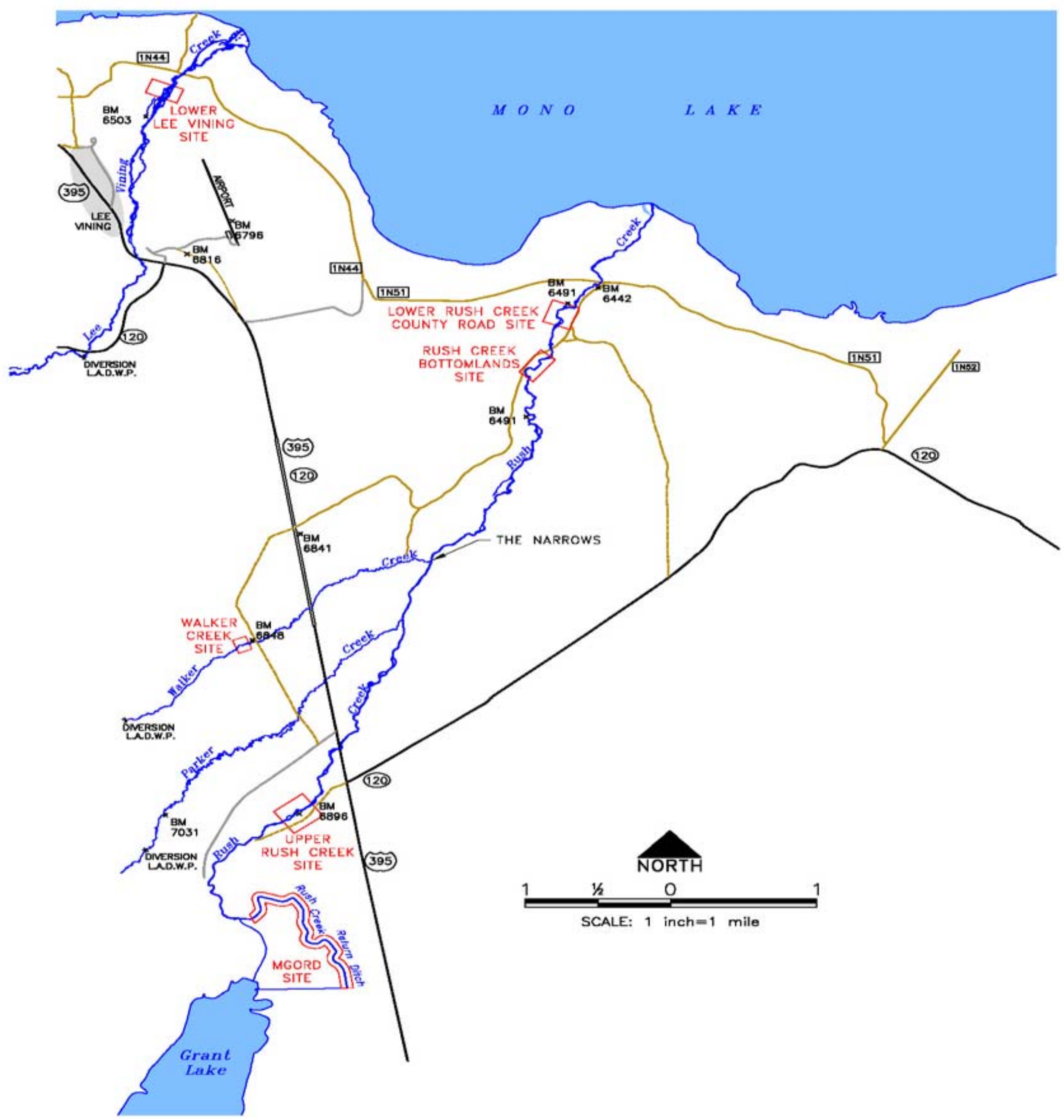


Figure 1. Map of Mono Basin study area with 2011 fish sampling sites displayed (created by McBain and Trush 2009).

For the 2011 runoff year (from April 1, 2011 to March 31, 2012) the April 1st forecast was 147.8% (180,500 acre-feet). Runoff for the April-September period was forecasted to be 149% of average (154,800 acre-feet). Thus, the 2011 runoff year was officially a "Wet" runoff year.

The ascension of snowmelt-driven peak flows started in late June and peak flows occurred throughout the month of July (Figure 2). Grant Lake Reservoir (GLR) also spilled for from April 1st to August 16th. Flows in Rush Creek downstream of the Narrows were also augmented by the snowmelt peaks of Parker and Walker creeks (Figure 1). The peak flow below the Narrows was approximately 561 c.f.s. on July 8, 2010 (Figure 2). Stream flows below the Narrows exceeded 500 c.f.s. for seven days (July 5th – 11th) and exceeded 300 c.f.s. for 32 days between June 22nd and August 5th (Figure 2).

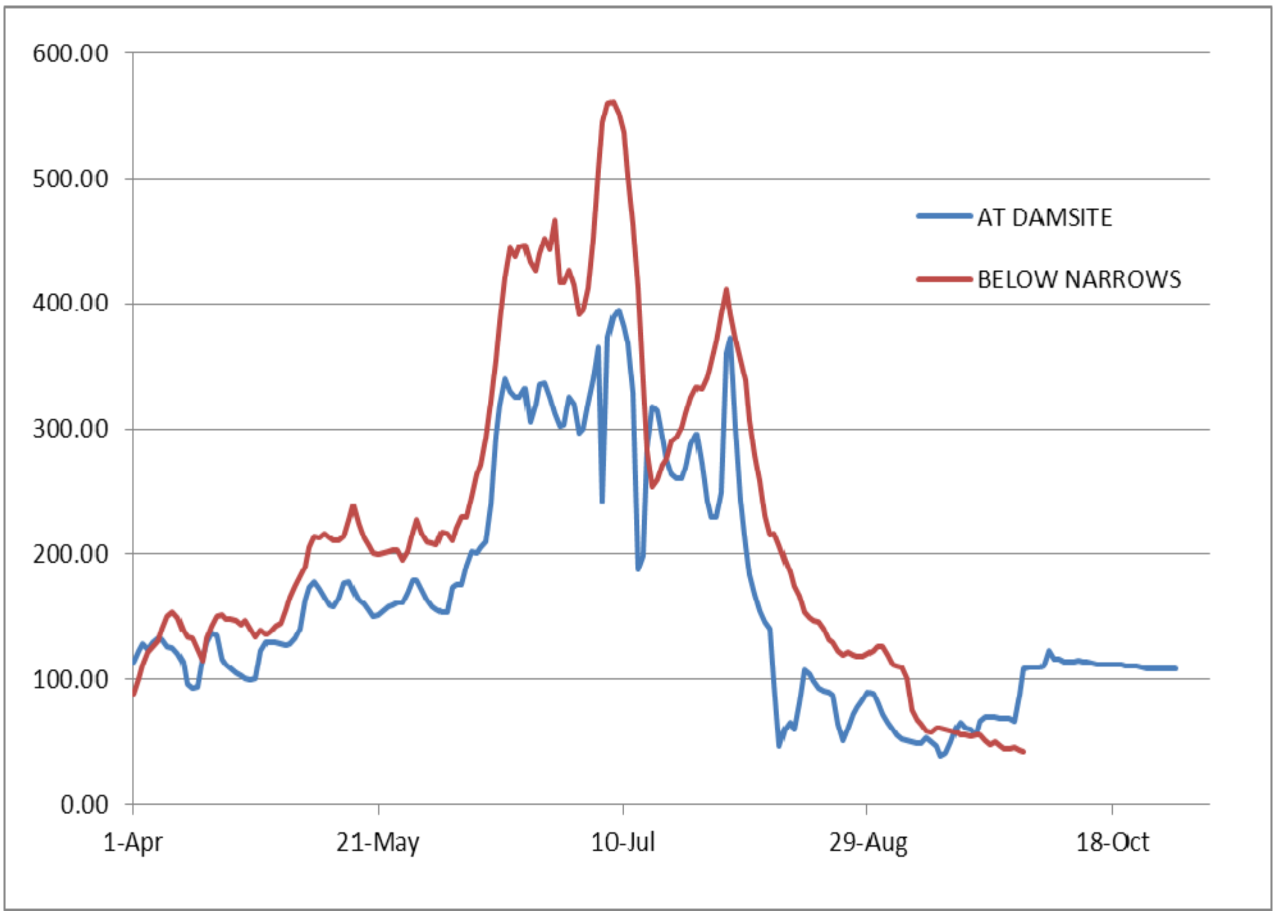


Figure 2. Daily stream flows (c.f.s.) in Rush Creek at three locations between April and September 2011. Data were provided by LADWP.

The peak flow in Lee Vining Creek below the LADWP diversion (LVC Below) in 2011 was approximately 532 c.f.s. and occurred on June 24th (Figure 3). A secondary peak of approximately 528 c.f.s. occurred on July 5th (Figure 3). During the peak runoff period, flows in Lee Vining Creek below the LADWP diversion exceeded 300 c.f.s. for 30 days, between June 14th and July 13th (Figure 3). As during most years, Lee Vining Creek experienced several distinct peaks in run-off due to snowmelt occurring at distinct breaks in elevation and/or the effects of cooling and warming air temperatures. The differences in flows between “LVC Above” and “LVC Below” were primarily due to LADWP implementing the diversion rate strategy recommended by the Stream Scientists in the Synthesis Report, in which a portion of the flows may be diverted to Grant Lake Reservoir when flows at LVC Above are less than 250 c.f.s. (Figure 3). The larger difference between LVC Above and LVC Below flows in late August through September was because flows were reduced by LADWP to allow for safer and more effective sampling conditions for the annual fisheries sampling (Figure 3).

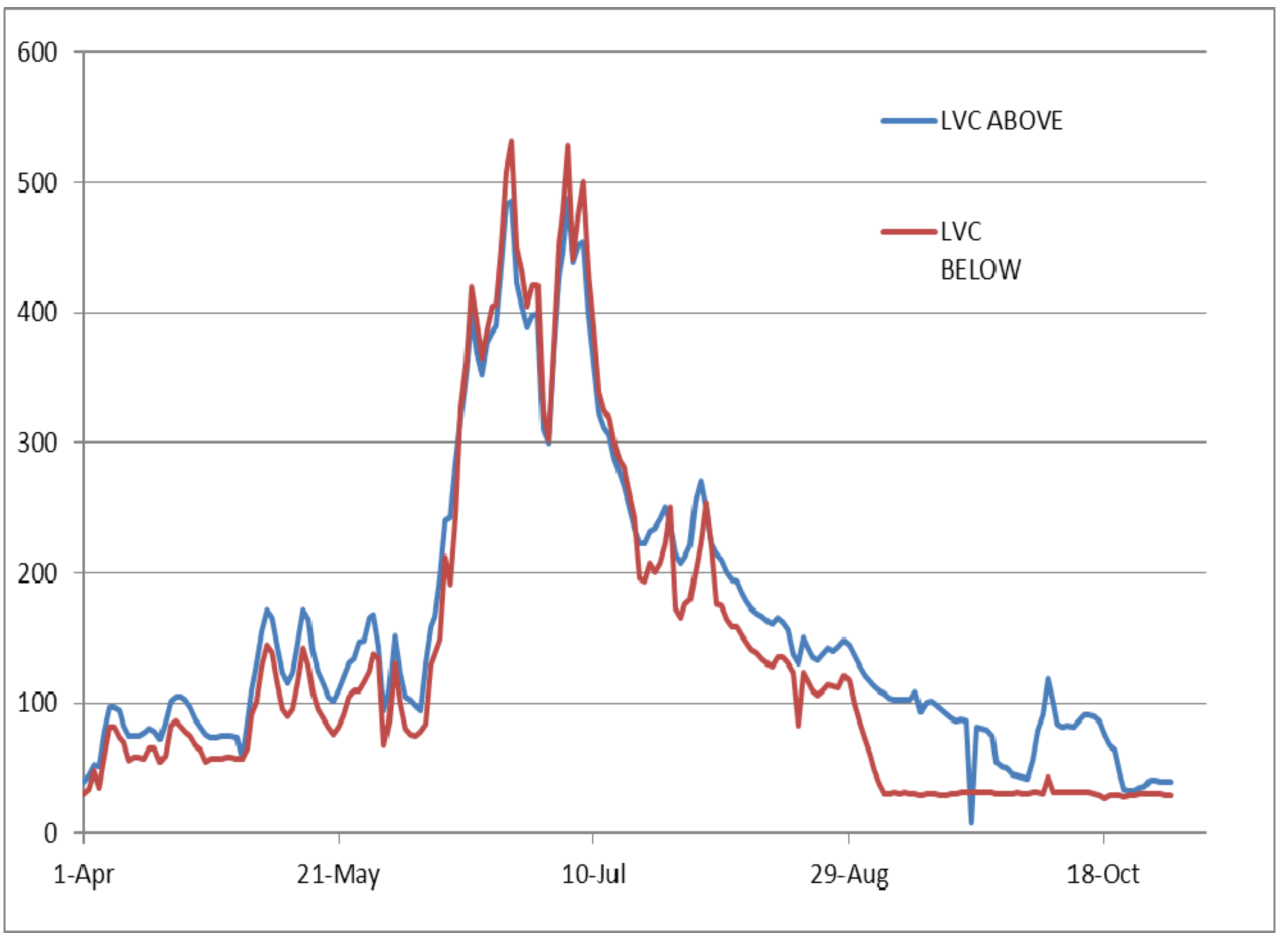


Figure 3. Daily stream flows (c.f.s.) in Lee Vining at the LADWP diversion between April and and October 2011. Data were provided by LADWP.

Methods

Field sampling for generating fish population estimates occurred during the late summer between September 9th and 19th, 2011. Mark-recapture estimates were made in three sections of Rush Creek – Upper, Bottomlands and County Road and in the main channel section of Lee Vining Creek.

For all mark-recapture sampling efforts in Rush Creek, fish were captured using a Smith-Root® 2.5 GPP electro-fishing system that consisted of a Honda® generator powering a variable voltage pulsator (VVP) that had a rated maximum output of 2,500 watts. This unit was contained in a six-foot long plastic barge that was walked down the Rush Creek channel. A sampling run consisted of a single downstream pass starting at the upper block fence and terminating at the lower block fence. During mark-recapture electro-fishing an insulated cooler with several battery-powered aerators was also carried in the barge to transport captured fish. A pair of two-person teams consisting of an anode operator and a dip netter fished each half of the channel as the barge moved in a downstream direction (Figure 4). The fifth crewmember maneuvered the barge downstream, monitored the condition of the captured fish in the fish cooler, and acted as the crew's safety officer (Figure 5). All netted fish were placed in the insulated cooler shortly after capture. In all sections of Rush Creek, frequent stops were made to process fish as the cooler became full.

A drift boat was utilized to capture fish in the MGORD and required a five-person crew to operate. The electro-fishing barge was tied-off to the starboard side of the drift boat and two persons walked the drift boat downstream with the boat perpendicular to the channel with the port side facing downstream. An anode was thrown back and forth across the width of the MGORD by a crewmember in the drift boat. Another crewmember netted stunned fish from the drift boat and placed them in the insulated cooler. A third person sat in the stern of the drift boat, monitored the electro-fishing equipment and was responsible for the safety of other crewmembers. Usually no more than several hundred meters of the MGORD could be sampled before the cooler was full of fish. At these sub-stops, all captured fish were transferred to net-pens. A separate team of three people was required to process captured fish and record data.

Mark-recapture sampling on the Lower Lee Vining Creek main-channel section was accomplished with two Smith-Root® backpack electro-fishers (models SR-24 and SR-20B). A sampling run consisted of two passes through the study section, first an upstream pass from the lower block fence to the upper block fence, immediately followed by a downstream pass back to the lower block fence. This technique also required five persons: two electro-fisher operators, two dip netters, and a bucket carrier to transfer captured fish to net pens.

Depletion estimates were made in the Walker Creek sample section and in the side-channel associated with the Lower Lee Vining Creek section (aka B-1 channel). For all depletion estimates the Smith-Root® backpack electro-fishers were used to capture fish. A single electro-fisher was used to sample the Lee Vining Creek side-channel and

Walker Creek. One dip-netter accompanied the electro-fisher and netted fish stunned by that electro-fisher. Another crew member served as a backup dip-netter and carried a five-gallon live bucket equipped with an aerator in which captured fish were placed immediately after capture.

To meet the assumption of a closed population for mark-recapture sampling purposes, all sample sections were blocked at both ends (upper and lower boundaries) prior to sampling. The sections were blocked by 12 mm mesh hardware cloth fences that were installed at the upper and lower boundaries. These hardware cloth fences were installed by driving metal t-posts at approximately two-meter intervals through the bottom portion of the hardware cloth approximately 15 cm from its bottom edge. Rocks were hand-placed along the bottom edge of the hardware cloth to prevent fish from passing underneath the block fence. Rope was then strung across the top of each t-post and anchored to either t-posts or trees on each stream bank. The wire fence was held vertically by wiring the top of the hardware cloth to this rope with baling wire. These fences were installed prior to the marking run and maintained in place until after the recapture effort was completed. Fences were cleaned and checked at least twice daily to ensure they remained in place and for enumerating any dead fish caught on the fences between the mark and recapture sampling period (duration of seven days).

For the two sections (Lower Lee Vining Creek side-channel and Walker Creek) where depletion estimates were made, the upper and lower boundaries were temporarily blocked with 12 mm mesh nylon seine nets. These nets were in place only for the duration of the multiple passes required to generate estimates, usually no more than several hours.

All captured fish were anesthetized, measured to the nearest mm (total length) and most were weighed to the nearest gram on a digital scale. Data were entered onto data sheets (hard copies) in the field and later entered into spreadsheet databases. All entered data were proofed against the hard copies for accuracy.

All fish captured in study sections where mark-recapture estimates were made were fin-clipped during the marking electro-fishing run for later identification during the recapture electro-fishing run. The lower caudal fin was clipped to mark fish in the County Road and Upper sections of Rush Creek and in Lee Vining Creek. The anal fin was clipped to mark fish in the Bottomlands section of Rush Creek. Fin clips were made by using a scissors to make a straight vertical cut from the top, or bottom, of the fin approximately 1-3 mm deep at a location about 1-3 mm from the fin's posterior edge.

For calculating biomass and density estimates, channel lengths and widths were re-measured. Wetted widths were measured with a tape along the entire length of each study reach at approximately 10-meter intervals. The annual re-measurement also provided insight into potential changes in channel geometry within the study reaches.

Population and biomass estimates were made for all mark-recapture and depletion estimates using Excel spreadsheets and/or Microfish software program with the appropriate equations. All mark-recapture estimates employed the modified Peterson estimator's equations embedded within Excel spreadsheets (Chapman 1951, as cited in Ricker 1975).

Figure 4. Anode operators and netters sampling Rush Creek's Upper section, 2009.

Figure 5. Electro-fishing barge with generator and cooler on Upper Rush Creek, 2009.

Length-Weight Relationships

Length-weight regressions (Cone 1989) were calculated for brown trout in each section of Rush Creek by year to assess differences in length-weight relationships between sections and years. Log_{10} transformations were made on both length and weight prior to running regressions. Only brown trout 100 mm and longer were analyzed. Fulton-type relative condition factors were also computed in MicroFish (fisheries software) according to methods initially developed by LeCren (1951) and expanded by Swingle (1965) and Swingle and Shell (1971) for all brown trout 150 to 250 mm.

Due to the difficulty of accurately sexing most brown trout captured during our annual sampling, no attempt was made to determine separate condition factors for male and female fish. Our sampling occurs at the same time every year (early to mid-September), thus any changes in condition factor would not be due to seasonal differences. However, factors such as runoff year-type, water temperature and climatic conditions affect the length and quality of each year's potential growth season leading up to the September sampling period.

Fin Clips, PIT Tags and Growth Estimates

Starting in 2009, PIT tags were implanted in all age-0 brown trout (>80 mm) captured during the recapture run to estimate future growth. All PIT-tagged fish were also given permanent adipose fin clips so that during future sampling events all adipose fin-clipped fish could be scanned with a tag reader. In 2010 and 2011, PIT tags were also implanted in any recaptured trout that had an adipose fin clip, but did not have a PIT tag when scanned by the tag reader (fish had "shed" its previous tag). Finally, PIT tags were implanted in nearly all of the trout captured during the single electrofishing pass conducted in the MGORD section of Rush Creek.

During the 2011 sampling, all captured fish were carefully examined for previously clipped adipose fins (adipose fin-clip recaptures). Those fish that were missing their adipose fin were scanned with a PIT tag reader. For fish that had retained their PIT tag, the tag number and current length and weight were recorded. In many cases, partially regenerated adipose fins were re-clipped to make future identification easier.

Relative Stock Density (RSD) Calculations

Relative stock density (RSD) was introduced as a new parameter in 2006 as a quantitative termination criterion. RSD's are numerical descriptors of length-frequency data. Given representative samples of a population RSD's are easily calculated and can provide insight or predictive ability about population dynamics. Please refer to the 2006 Mono Basin Fisheries Report for a more detailed literature review regarding RSD concepts and relevance as a quantifiable form of termination criteria (Hunter et al.2007).

RSD values are simply reported as the proportions (percentage x 100) of the total number of brown trout ≥150 mm (~6") in length that are also ≥225 mm or ~9" (RSD-225), ≥300 mm or ~12" (RSD-300) and ≥375 mm or ~15" (RSD-375). These three RSD values are calculated by the following equations:

RSD-225 = [(# of brown trout ≥225 mm) ÷ (# of brown trout ≥150 mm)] x 100
RSD-300 = [(# of brown trout ≥300 mm) ÷ (# of brown trout ≥150 mm)] x 100
RSD-375 = [(# of brown trout ≥375 mm) ÷ (# of brown trout ≥150 mm)] x 100

Termination Criteria Calculations and Analyses

In Decision-1631, the agreed upon termination criteria for Lee Vining Creek was to sustain a fishery for naturally-produced brown trout that averaged eight to 10 inches in length (200 to 250 mm) with some fish reaching 13 to 15 inches (325 to 375 mm). The agreed upon termination criteria for Rush Creek states that Rush Creek fairly consistently produced brown trout weighing from 0.75 to two pounds. Trout averaging 13 to 14 inches (325 to 350 mm) were also allegedly observed on a regular basis prior to the 1941 diversion of this stream.

The termination criteria provided in this report are based on the suite of termination criteria proposed by the Fisheries Stream Scientist in an attempt to make the calculation and interpretation of the fisheries termination criteria a more quantifiable exercise (Hunter 2007). The rationale for replacing the original termination criteria was to evaluate brown trout populations with metrics derived from quantifiable methodologies that are generally accepted as standards by fisheries professionals. As stated in previous annual reports no data were available that provided a scientifically quantitative picture of trout populations that these streams supported on a self-sustaining basis prior to 1941 (Hunter et al. 2000-2009 and Taylor et al. 2010-2011).

Four repeatable and quantifiable metrics are now employed as termination criteria to evaluate the brown trout populations in the Upper, Bottomlands, and County sections of Rush Creek – biomass, density, condition and relative stock density (RSD) of catchable trout (≥225 mm or ≥9") in the populations. The same four criteria are applied to all trout (brown and rainbow combined) in the Lee Vining Creek sample section. A fifth metric of RSD-300 for brown trout (percentage of brown trout ≥300 mm or ≥12") is also applied to only Rush Creek sample sections. The values for these fisheries metrics, as discussed below, represent realistic recovery goals for the streams.

Finally, three termination criteria RSD metrics are now applied to the MGORD portion of Rush Creek – the RSD of brown trout ≥225 mm (RSD-225), ≥300 mm (RSD-300) and ≥375 mm (RSD-375).

Rush Creek TC for Upper, Bottomlands and County Road Sections

Termination Criterion #1 – Biomass: Total brown trout standing crop estimates based on kilograms per hectare of biomass. Total standing crop estimates will also be calculated to reflect contribution by two age-classes (age-0 and ≥age-1). The termination criterion for biomass estimate is **≥ 175 kg/ha**. Trends in brown trout standing crop data are assessed with three-year moving averages by computing the average of the three most-current years of data. That average should meet the termination criteria of at least **175 kg/ha**.

Termination Criterion #2 – Density: Total number of brown trout per unit length (km) of stream channel. The termination criterion for total number of trout per kilometer is **≥3,000 trout/km**. Trends in total number of trout per kilometer are assessed with three-year moving averages by computing the average of the three most-current years of data. That average should meet the termination criteria of at least **3,000 trout/km**.

Termination Criterion #3 – Condition: Condition factor of brown trout ≥age-1+ is computed and should not drop below **1.00**. Values below 1.00 should be of concern to managers. When standing crop values drop, fishery would be considered in “good condition” if condition factors remain stable or increase. It is possible that higher densities (# of fish/ha) will result in lower condition factors for individual groups of trout due to density dependent competition. Trends in condition factor are assessed with three-year moving averages by computing the average of three most-current years of data. That average should meet the termination criteria of condition factor **≥1.00**.

Termination Criterion #4 – RSD-225: RSD-225 values of brown trout are computed for all sections of Rush Creek and should not drop below **35**. Trends in RSD-225 are assessed with three-year moving averages by computing the average of the three most-current years of data. That average should meet the termination criteria RSD-225 value of at least **35**.

Termination Criterion #5 – RSD-300: RSD-300 values of brown trout are computed for all sections of Rush Creek and should not drop below **5**. Trends in RSD-300 are assessed with three-year moving averages by computing the average of the three most-current years of data. That average should meet the termination criteria RSD-300 value of at least **5**.

Lee Vining Creek TC

During the drafting of this report, the effects of the varying amounts of streamflow split between Lee Vining Creek’s main channel and side channel sections on TC calculations was more closely examined. Starting with the 2011 annual data set we propose using an additive approach to determine the TC values of biomass, density, and condition factor in Lee Vining Creek. This approach allows a determination of the total biomass and density of of the main and side channels combined, but also accounts for varying surface area and section lengths as influenced by streamflow amounts in either channel. Please refer to Appendix B for a detailed explanation of the proposed additive approach.

Termination Criterion #1 – Biomass: Total trout (brown and wild rainbow combined) standing crop estimates based on kilograms per hectare of biomass. Total standing crop estimates will also be calculated to reflect contribution by two age-classes (age-0 and ≥age-1). Total standing crops will be evaluated for the main channel alone and for the main and side channels combined. The termination criterion for biomass estimate is **≥ 150 kg/ha**. Trends in total trout standing crop data are assessed with three-year moving averages by computing the average of the three most-current years of data. That average should meet the termination criteria of at least **150 kg/ha**.

Termination Criterion #2 – Density: Total number of trout per unit length (km) of stream channel. Densities will be evaluated for the main channel alone and for the main and side channels combined. The termination criterion for total number of trout per kilometer is **≥1,400 trout/km**. Trends in total number of trout per kilometer are assessed with three-year moving averages by computing the average of the three most-current years of data. That average should meet the termination criteria of at least **1,400 trout/km**.

Termination Criterion #3 – Condition: Condition factor of trout ≥age-1+ is computed and should not drop below **1.00**. Trends in condition factor are assessed with three-year moving averages by computing the average of three most-current years of data. That average should meet the termination criteria of condition factor **≥1.00**.

Termination Criterion #4 – RSD-225: RSD-225 values of all trout (brown and wild rainbow) are computed for both Lee Vining Creek study sections and should not drop below **30**. Trends in RSD-225 are assessed with three-year moving averages by computing the average of the three most-current years of data. That average should meet the termination criteria RSD-225 value of at least **30**.

Rush Creek TC for the MGORD Section

For the Rush Creek MGORD study section three termination criteria metrics of RSD are utilized – the RSD of brown trout ≥225 mm (≥9”), ≥300 mm (≥12”) and ≥375 mm (≥15”).

RSD-225 value in the MGORD is computed and should not drop below **60**.
RSD-300 value in the MGORD is computed and should not drop below **30**.
RSD-375 value in the MGORD is computed and should not drop below **5**.

Trends in RSD-225, RSD-300 and RSD-375 were assessed with three-year moving averages by computing the average of the three most-current years of data. The averages should meet the termination criteria of **60**, **30** and **5**, respectively.

The rationale for assessing these “large trout” metrics specifically for the MGORD is that this human-constructed section below Grant Lake Reservoir has unique spring creek-like characteristics that support the growth of large brown trout similar to the pre-1941 productivity of the human-influenced springs below the Rush Creek Narrows. Two years of movement study data demonstrated that approximately 40 to 50% of the large (>300 mm) radio-tagged brown trout migrated between the MGORD and downstream reaches of Rush Creek, especially during autumn and winter (Taylor et al. 2009b). To most accurately evaluate the status of large brown trout in the Rush Creek system immediately downstream of Grant Lake Reservoir, data for computing RSD values of MGORD brown trout should be collected in September, prior to the onset of the fall spawning season when migrations occur.

How to use the Quantifiable Termination Criteria

1. With the most-current data set, calculate the biomass, density, condition factor and RSD-225 values for each section of Rush Creek and Lee Vining Creek. Calculate the RSD-300 values for Rush Creek sections only. Calculate the RSD-375 value for the MGORD section of Rush Creek.

2. For the current year and the two previous years, calculate the three-year running averages of biomass, density, condition factor and RSD-225 for each section of Rush Creek and Lee Vining Creek. Calculate the three-year running averages of RSD-300 for Rush Creek sections only. *Five years of data are necessary to compute a complete set of three, three-year running averages.*

3. For the Upper, Bottomlands and County Road sections of Rush Creek, a section would be considered “recovered” if it met four of the five termination criteria for three consecutive years that the three-year running averages were calculated. The rationale is that in years of high young-of-year (age-0) recruitment, densities will be high with fairly low biomass estimates. Conversely, in years of low age-0 recruitment densities will probably drop, but biomass of older trout should increase. Years of high densities may also exhibit lower condition factors due to density-dependent competition for available food and/or habitat. In Rush Creek, lower condition factors may also be influenced the summer water temperature regime.

4. For Lee Vining Creek, the sample section would be considered “recovered” if it met three of the four termination criteria for three consecutive years that the three-year running averages were calculated.

Results

Channel Lengths and Widths

Slight differences in channel widths between sample years may be attributable to the varying locations where each width measurement was taken to generate a sample reach's average width, as well as slight differences in the September streamflow between 2010 and 2011 (Table 1). Larger differences may also be attributable to actual channel changes caused by the high peak flows (Table 1). Previous channel measurements are presented to illustrate the differences in some sections' channel widths (Table 1).

Table 1. Total length (m), average wetted width (m), and total surface area (m^2) of sample sections in Rush, Lee Vining, and Walker creeks sampled between September 10 -21, 2011. Values for 2010 provided for comparisons.

Section	Length (m) 2010	Width (m) 2010	Area (m^2) 2010	Length (m) 2011	Width (m) 2011	Area (m^2) 2011
Rush – Co. Road	329	8.2	2,697.8	329	8.4	2,763.6
Rush - Bottomlands	437	7.8	3,408.6	437	8.1	3,539.7
Rush – Upper	430	8.3	3,569.0	430	8.4	3,612.0
Rush - MGORD	2,230	12.0	26,760.0	N/S	N/S	N/S
Lee Vining – Main	255	5.9	1,504.5	255	5.4	1,3,77.0
Lee Vining - Side	195	2.6	507.0	195	2.6	507.0
Walker Creek	194	2.5	485.0	194	2.5	485.0

*N/S = not sampled for population estimate in 2011

Fish Population Abundance

Rush Creek – County Road Section

In 2011 approximately 56% of the 599 brown trout captured in the County Road section of Rush Creek were young-of-the-year (age-0) fish between 61 and 124 mm in length; and the longest brown trout captured was 314 mm (Figure 6). This section supported an estimated 593 age-0 and 331 age-1 and older brown trout (Table 2); about 80% of the latter were brown trout ranging from 125-199 mm, which (based on the recapture of PIT tagged cohorts in 2010 and 2011) were primarily age-1 fish. Estimates of brown trout were about as precise as the previous year with standard errors ranging from 5.5% to 8% of the estimates.

Eighteen rainbow trout were sampled in 2011 and 17 of these were age-0 fish (Figure 8). No population estimates were generated for rainbow trout due to insufficient numbers of recaptures.

Rush Creek – Bottomlands Section

In 2011 approximately 53% of the 646 brown trout captured in the Bottomlands section of Rush Creek were young-of-the-year (age-0) fish between 61 and 117 mm and the longest brown trout captured was 349 mm (Figure 6). This section supported an estimated 775 age-0 and 406 age-1 and older brown trout (Table 2). Estimates of brown trout were less precise than the previous year with standard errors ranging from 6% to 11% of the estimates.

Twenty-one rainbow trout were sampled in 2011 and 20 of these were age-0 fish (Figure 8). No population estimates were generated for rainbow trout due to insufficient numbers of recaptures.

Rush Creek – Upper Section

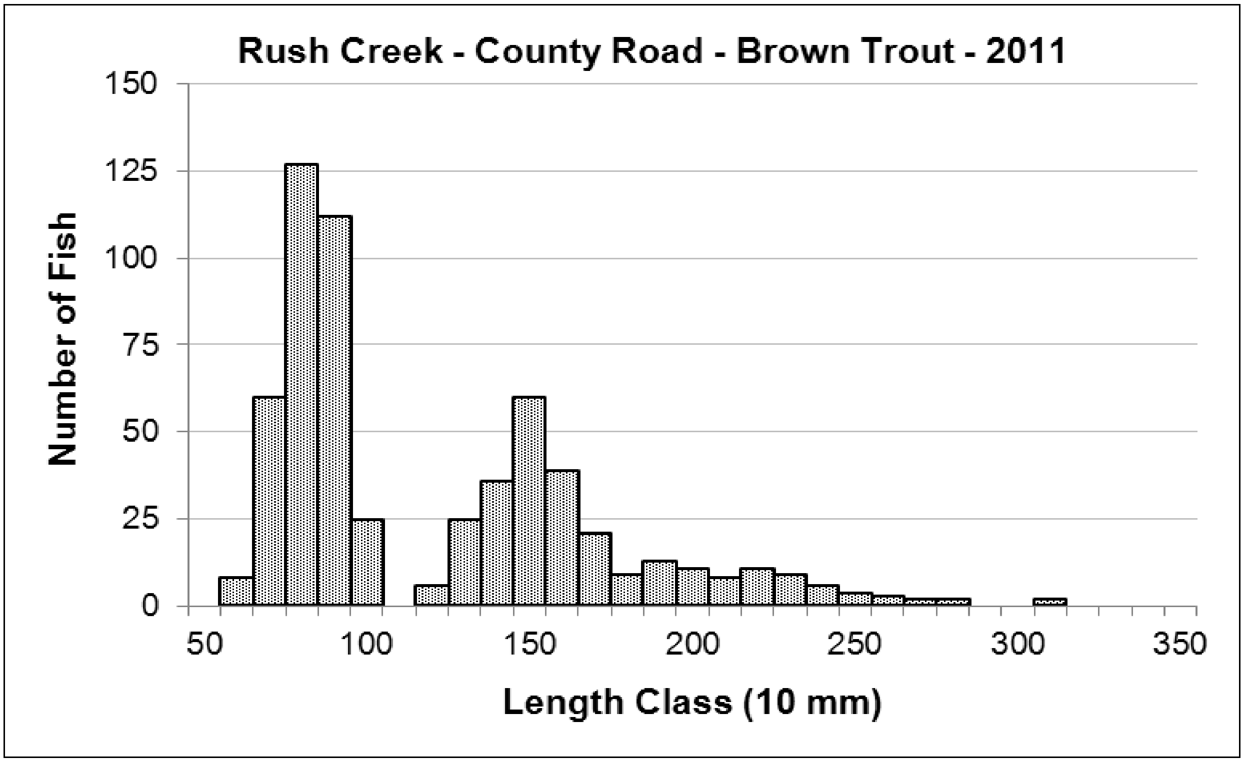
In 2011 approximately 67% of the 1,618 brown trout captured in the Upper section of Rush Creek were young-of-the-year (age-0) fish between 49 and 105 mm and the longest brown trout captured was 458 mm (Figure 7). Seven brown trout greater than 300 mm were sampled in 2011, including three fish greater than 350 mm. This section supported an estimated 3,794 age-0 and 756 age-1 and older brown trout (Table 2). Estimates of brown trout were more precise than the previous year with standard errors ranging from 7% to 10% of the estimates.

Two hundred and six rainbow trout (178 age-0 fish) were sampled in 2011 that ranged in length from 49 to 346 mm (Figure 9). Unlike most years, in 2011 sufficient numbers of rainbow trout were captured to generate estimates. This section supported an estimated 338 age-0 and 36 age-1 and older rainbow trout (Table 2). These estimates of rainbow trout had standard errors ranging from 4% to 15% of the estimates.

Rush Creek – MGORD Section

In 2011 no population estimate was generated for the MGORD section of Rush Creek. Only one age-0 brown trout was captured during the single electrofishing pass made on the MGORD section of Rush Creek. A total of 226 brown trout were captured in the MGORD, eight of these brown trout were at least 375 mm in length and five of these fish exceeded 400 mm in length (Figure 7).

Eighteen rainbow trout were captured in the MGORD in 2011 (Figure 9). These rainbow trout ranged from 84 mm to 308 mm in length and three were age-0 fish.



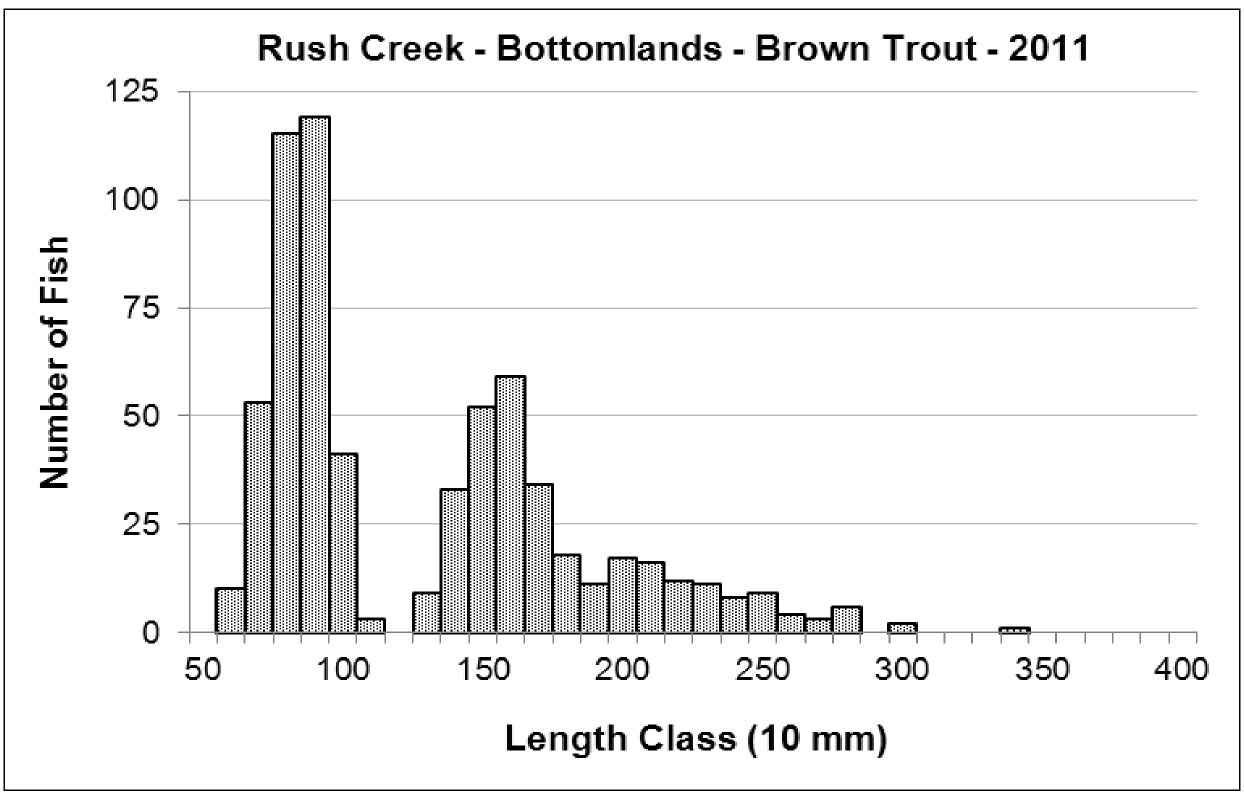
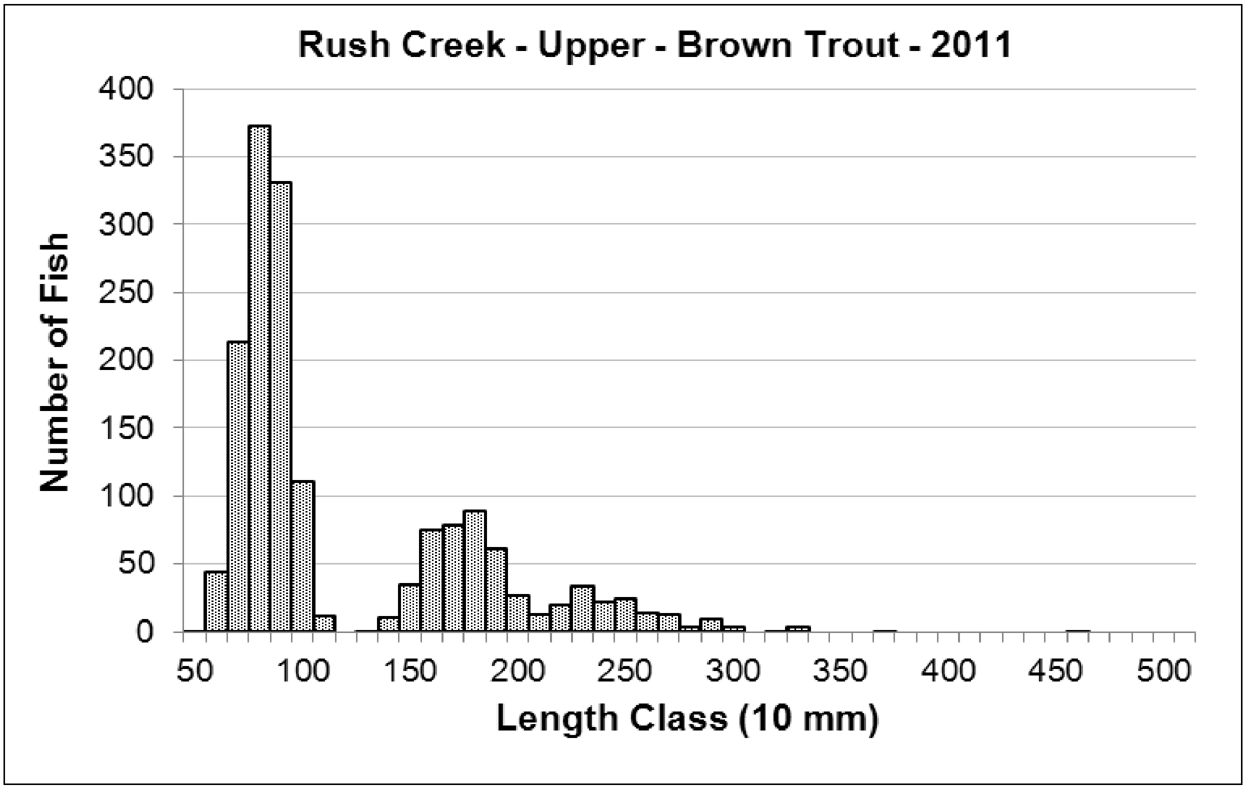


Figure 6. Length-frequency histograms of brown trout captured in the County Road (top) and Bottomlands (bottom) sections of Rush Creek between September 9th and 19th, 2011. Note different scales on both x-axes and y-axes.



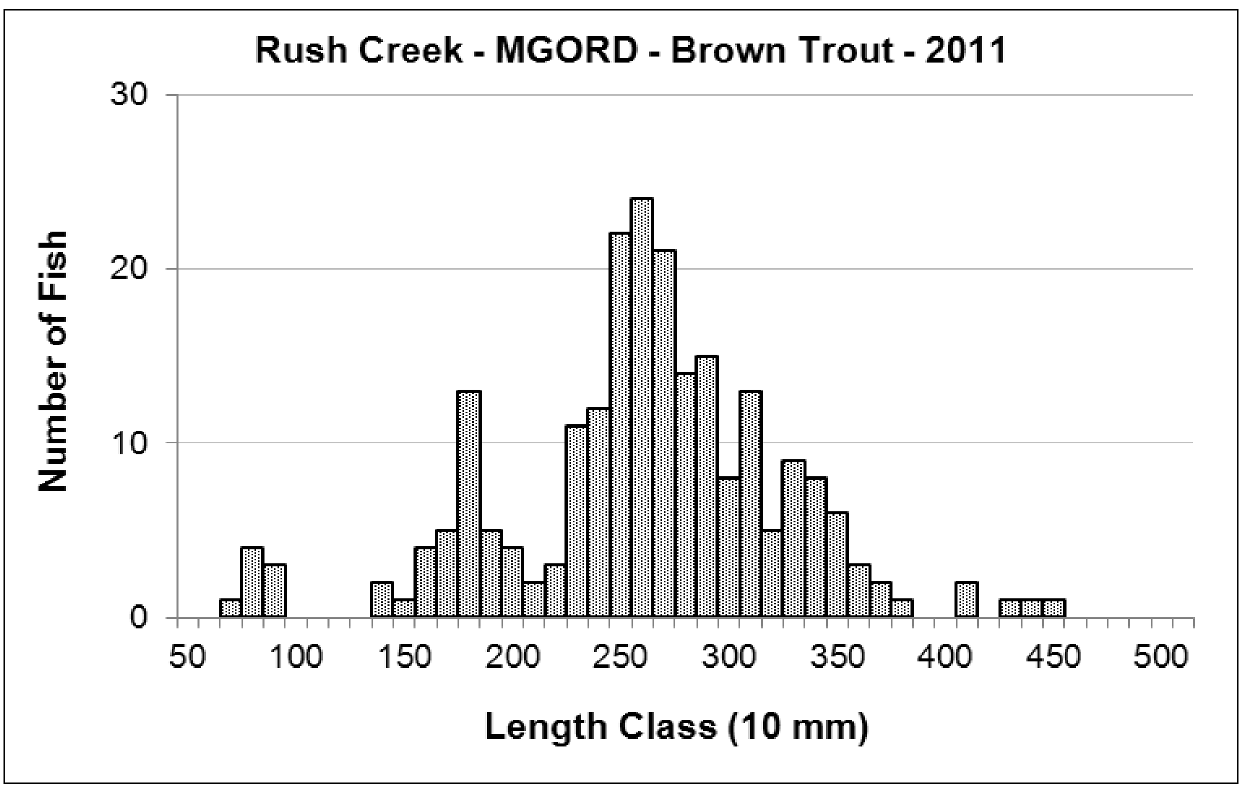
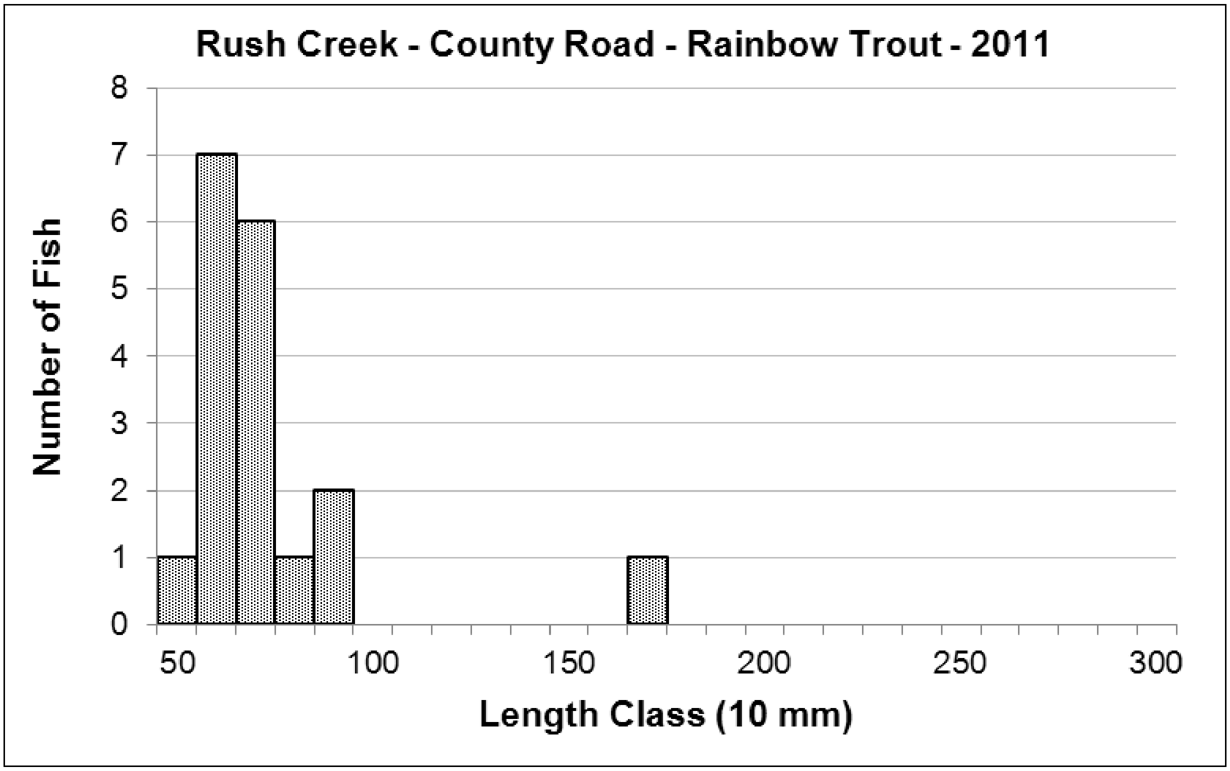


Figure 7. Length-frequency histograms of brown trout captured in the Upper (top) and MGORD (bottom) sections of Rush Creek between September 9th and 19th, 2011. Note different scales on both x-axes and y-axes.



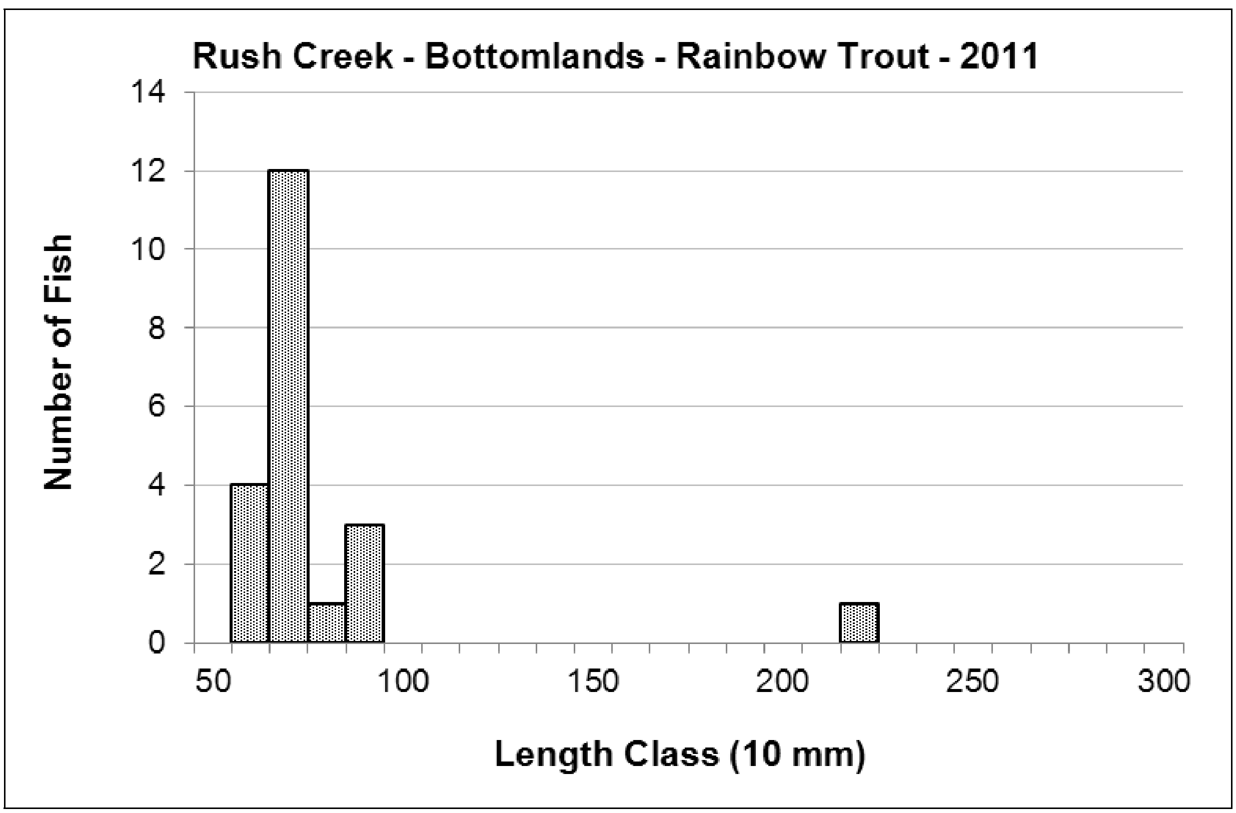
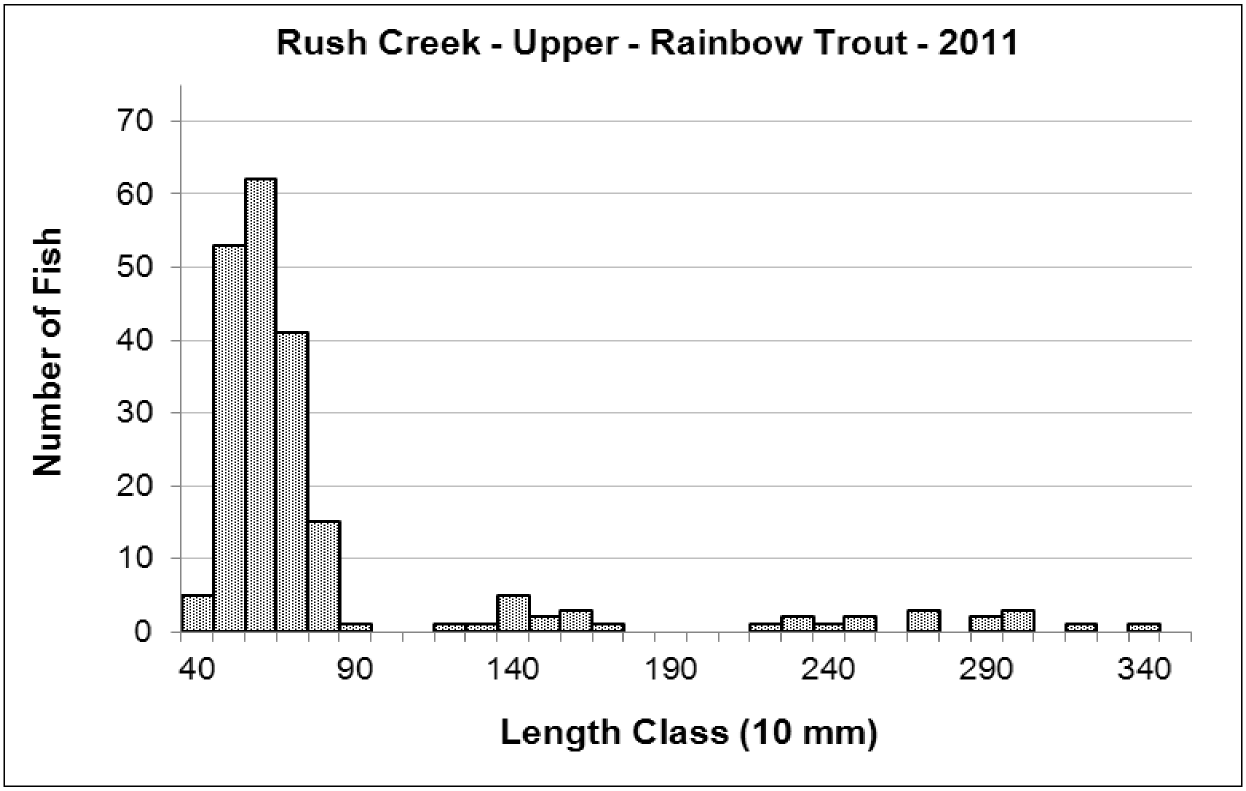


Figure 8. Length-frequency histograms of rainbow trout captured in the County Road (top) and Bottomlands (bottom) sections of Rush Creek between September 9th and 19th, 2011.



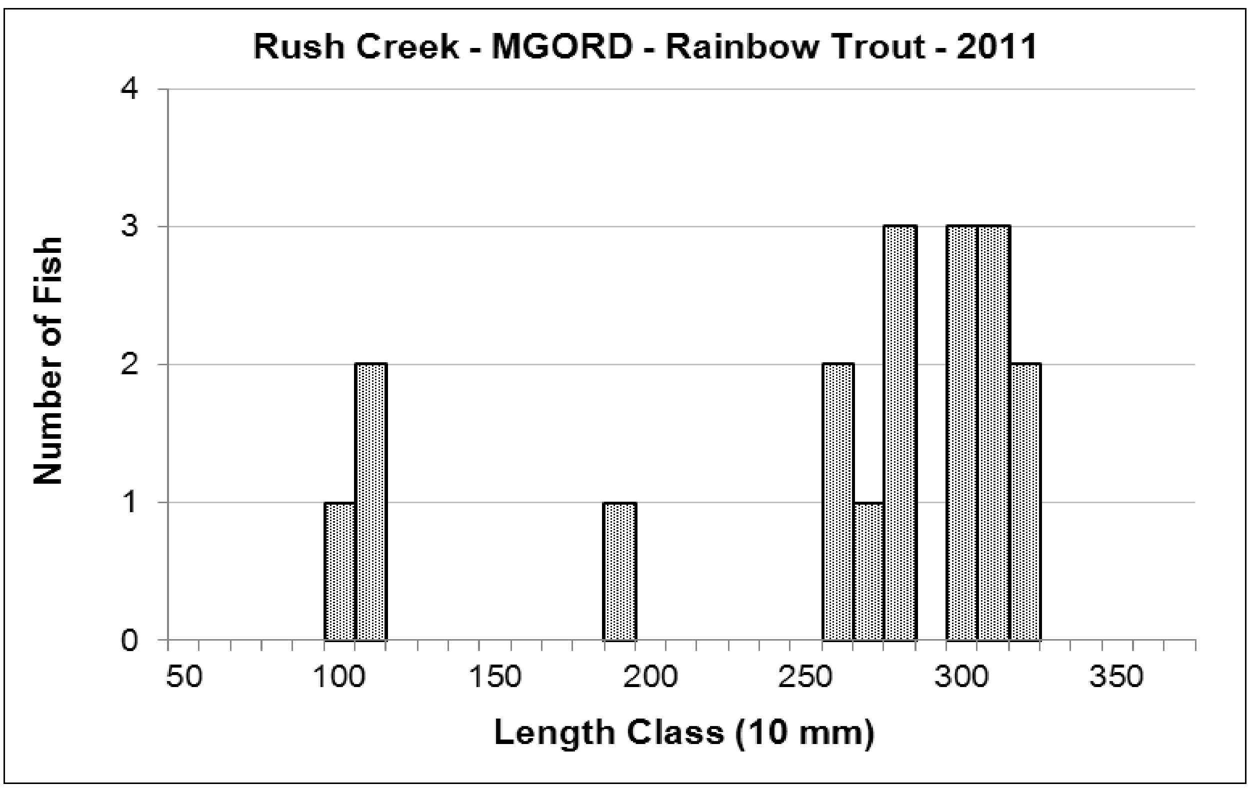


Figure 9. Length-frequency histogram of rainbow trout captured in the Upper section of Rush Creek between September 9th and 19th, 2011. Note different scales on both x-axes and y-axes.

Table 2. Rush Creek and Lee Vining Creek mark-recapture estimates for 2011 showing total number of fish marked (M), total number captured on the recapture run (C), total number recaptured on the recapture run (R), and total estimated number and its associated standard error (S.E.) by stream, section, date, species and size class. Mortalities (Morts) were those fish that were captured during the mark run, but died prior to the recapture run. Mortalities were not included in mark-recapture estimates and should be added to estimates for accurate total estimates. NP = estimate not possible.

Stream / Section / Date / **Species**	Size Class (mm)	M	C	R	Morts	**Estimate**	S.E.
		Mark - recapture estimate parameter values					
Rush Creek							
County Road							
9/11+18/11							
Brown Trout							
	0 - 124 mm	192	202	65	4	**593**	48.3
	125 - 199 mm	155	117	69	5	**262**	14.8
	>200 mm	44	38	24	0	**69**	5.5
Bottomlands							
9/10+17/11							
Brown Trout							
	0 - 124 mm	191	185	45	10	**775**	85.7
	125 - 199 mm	140	136	63	3	**301**	20.2
	>200 mm	75	49	35	0	**105**	6.7
Upper Rush							
09/09+16/11							
Brown Trout							
	0 - 124 mm	415	674	73	68	**3,794**	374.9
	125 - 199 mm	175	245	78	32	**547**	37.5
	>200 mm	105	96	48	7	**209**	15.3
Upper Rush							
09/09+16/11							
Rainbow Trout							
	0 - 124 mm	46	129	17	20	**338**	56.8
	125 - 199 mm	5	8	3	2	**13**[a]	2.6
	>200 mm	10	10	4	0	**23**[a]	5.4
Lee Vining Creek							
Main Channel							
9/12+19/11							
Brown Trout							
	0 - 124 mm	39	34	14	12	**92**	13.9
	125 - 199 mm	18	19	12	0	**28**	2.6
	>200 mm	25	24	20	0	**30**	1.2
Rainbow Trout							
	0 - 124 mm	1	0	0	0	**0**	0
	>125 mm	5	8	5	0	**8**[a]	0

[a/] These estimates have fewer than 7 recaptures.

Lee Vining Creek – Main Channel Section

In 2011 approximately 57% of the 125 brown trout captured in the main channel section of Lee Vining Creek were young-of-the-year (age-0) fish between 56 and 88 mm and the longest brown trout captured was 310 mm in length (Figure 10). There were three brown trout ≥300 mm captured in the main channel section in 2011. This section supported an estimated 92 age-0 and 58 age-1 and older brown trout (Table 2).

Only nine rainbow trout were captured in 2011 and one of these was an age-0 fish (Figure 11). This section supported an estimated eight age-1 and older rainbow trout; however this estimate was generated with less than seven recaptures (Table 2).

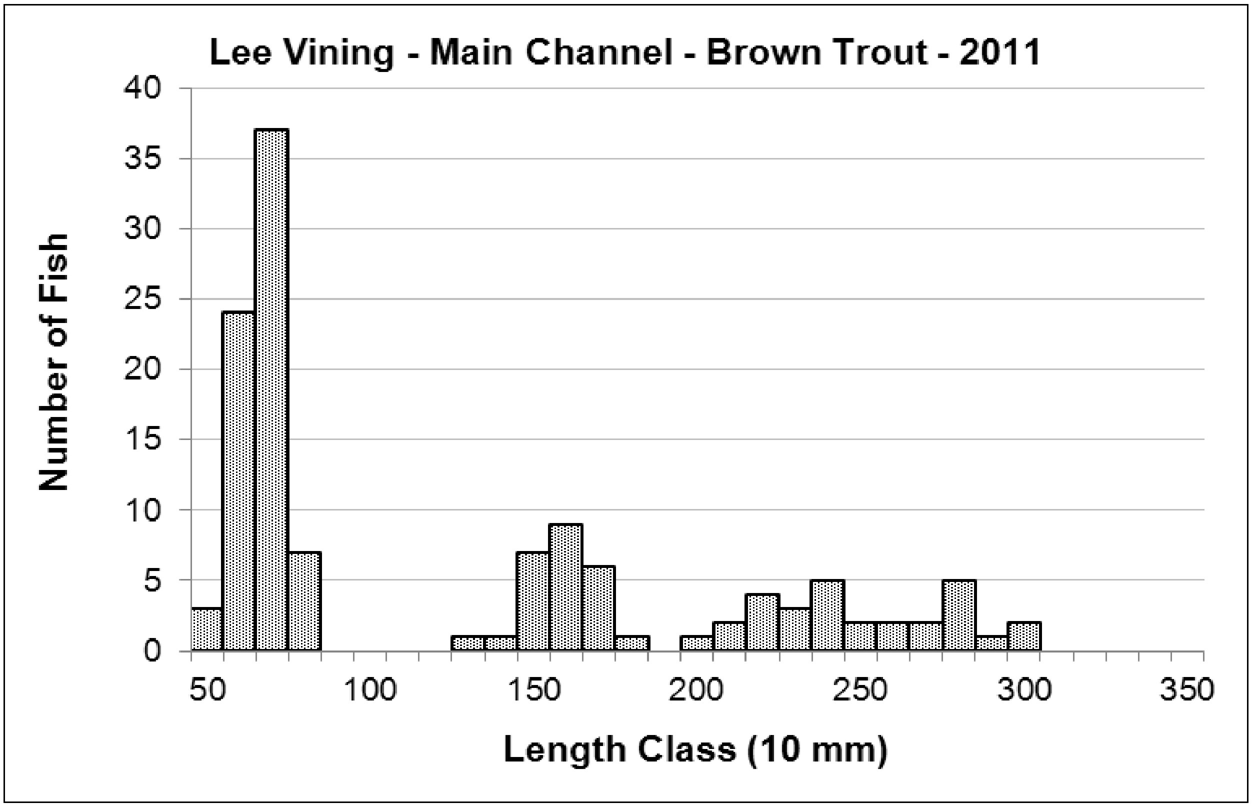
Lee Vining Creek – Side Channel Section

In 2011 a total of 30 brown trout were captured in the side channel section of Lee Vining Creek; 12 fish were age-0 and 18 fish were age-1 and older (Figure 10).The longest brown trout captured was 265 mm (Figure 10). Twenty-six fish were captured on the first of two electro-fishing depletion passes made. This section supported an estimated 14 age-0 brown trout and 18 age-1 and older brown trout (Table 3).

In 2011 no rainbow trout were captured in the Lee Vining Creek side channel. This was the third straight sample year that no age-0 rainbow trout were captured in the Lee Vining Creek side channel.

Walker Creek

In 2011, 114 brown trout were captured in four electro-fishing passes and 41 of these brown trout were age-0 fish between 85 and 114 mm in length (Figure 12). For the past seven years, age-0 brown trout numbers have fluctuated widely in Walker Creek with very high numbers (>300) captured in 2007 and 2008, 203 captured in 2004, 113 captured in 2009, 80 captured in 2006, and four captured in 2005. In 2011, Walker Creek supported an estimated 41 age-0 and 73 age-1 and older brown trout (Table 3).



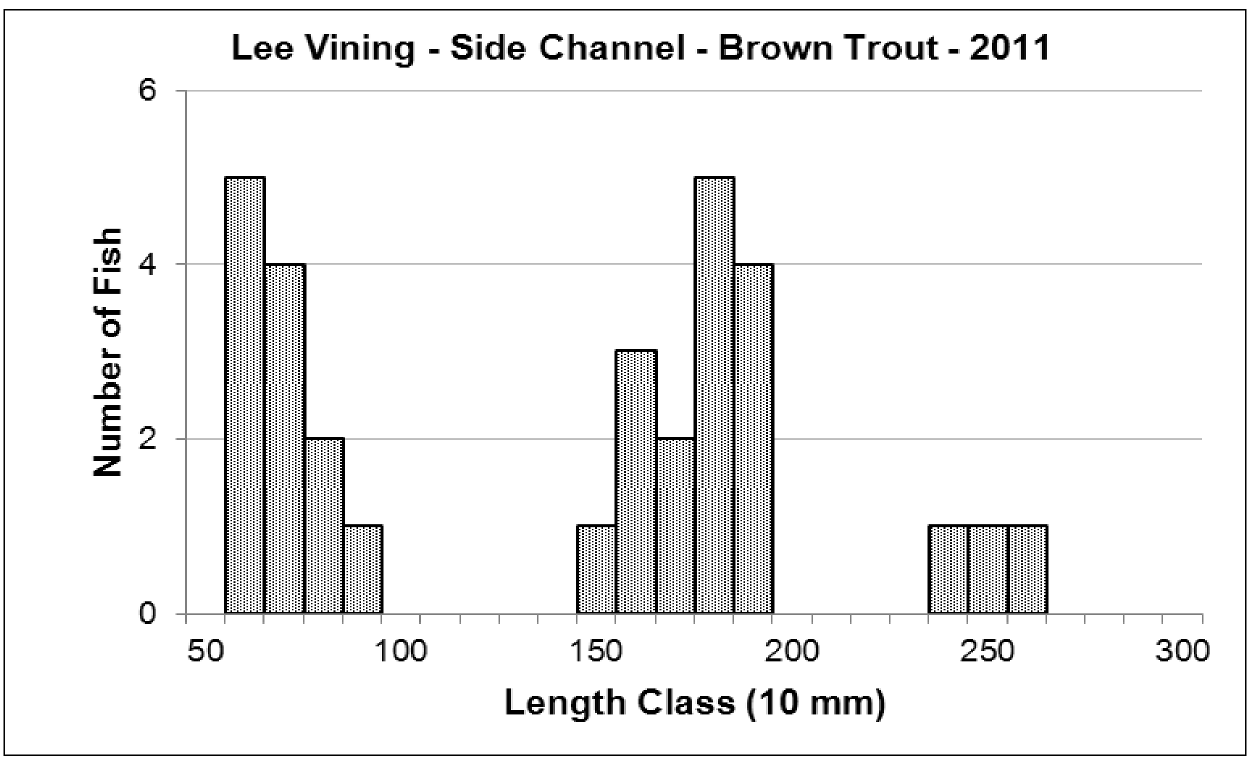


Figure 10. Length-frequency histograms of brown trout captured in the Main channel (top) and Side channel (bottom) sections of Lee Vining Creek between September 9th and 19th, 2011. Note different scales on the y-axes.

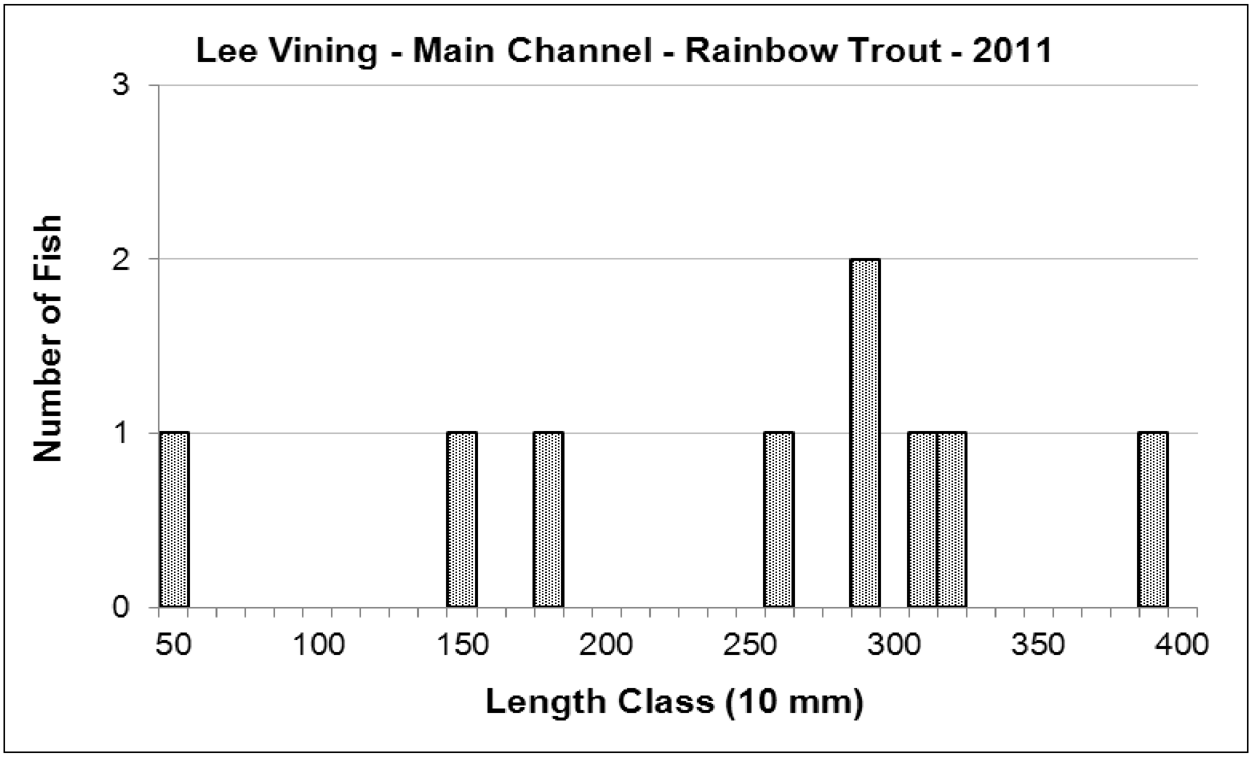


Figure 11. Length-frequency histograms of rainbow trout captured in the Main channel section of Lee Vining Creek between September 9th and 19th, 2011.

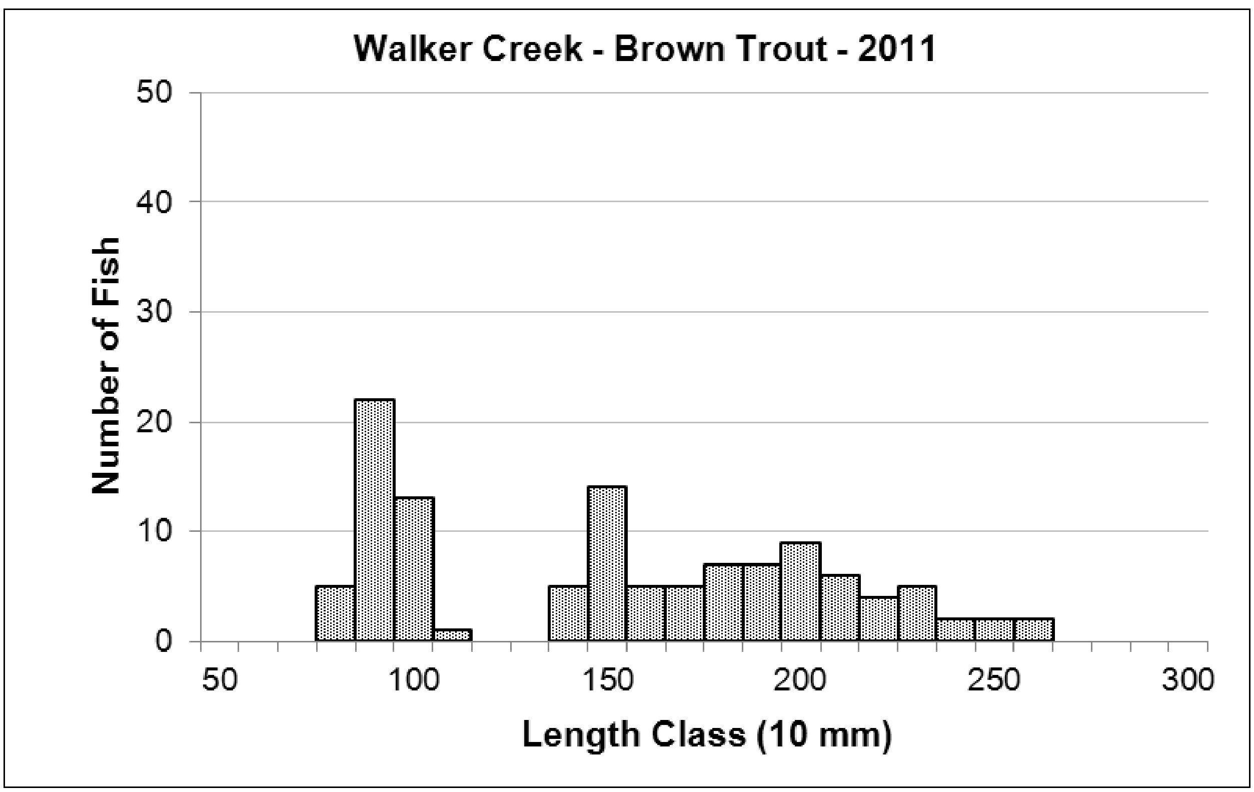


Figure 12. Length-frequency histogram of brown trout captured in Walker Creek on September 14, 2011.

Table 3. Depletion estimates made in the Lower side channel section of Lee Vining Creek and Walker Creek during September 2011 showing number of fish captured in each pass, estimated number, probability of capture (P.C.) by species and length group.

Stream - Section Date / **Species**	Size Class (mm)	Removals	Removal Pattern	**Estimate**	P.C.
Lee Vining Creek - Lower - B1 Channel - 9/12/2011					
Brown Trout					
	0 - 124 mm	2	9 3	**14**	0.67
	125 - 199 mm	2	13 0	**13**	1.00
	200 + mm	2	4 1	**5**	0.75
Rainbow Trout					
	0 - 124 mm	2	0 0	**0**	0.0
	125 - 199 mm	2	0 0	**0**	0.0
	200 + mm	2	0 0	**0**	0.0
Walker Creek - above old Hwy 395 - 9/14/2011					
Brown Trout					
	0 - 124 mm	4	30/7/3/1	**41**	0.72
	125 - 199 mm	4	30/8/2/3	**43**	0.67
	200 + mm	4	25/4/0/1	**30**	0.81

Catch of Rainbow Trout in Rush and Lee Vining Creeks

For the past thirteen years of annual sampling, rainbow trout have been a minor component of the Rush Creek fishery, typically accounting for less than five percent of the total catch of trout. In most years we were unable to generate mark-recapture estimates due to a lack of recaptures. In 2011, 3,352 trout were captured in Rush Creek and 263 of these were rainbow trout (or 7.8% of the catch). To date, this is the highest proportion of rainbow trout ever sampled in Rush Creek. Most of these rainbow trout were captured in the Upper Rush section (206 fish) and we suspect that the extensive spill from Grant Lake Reservior introduced many of these fish to the Rush Creek channel downstream of the dam. We also suspect that some of these fish were able to successfully spawn in smaller side channels that remained watered during 2011's extended runoff since a majority of the rainbow trout captured were age-0 fish. However, starting with the 2008 annual report we proposed that the catch of rainbow trout in Rush Creek would simply be reported, primary because the Rush Creek termination criteria in the Orders was focused on brown trout. Thus, no effort was made to extrapolate rainbow trout catch numbers into density estimates or utilized in the computation of total biomass estimates for Termination Criteria evaluation purposes.

Rainbow trout numbers in Lee Vining Creek have been variable over the past twelve years, with enough fish sampled to generate estimates of age-0 fish or age-1 and older fish in some years (Tables 4 - 7). In the main channel section, sufficient numbers of age-0 rainbow trout were sampled to generate population estimates in four out of 12 years (Table 4). In the main channel section, sufficient numbers of age-1 and older rainbow trout were sampled to generate population estimates in five out of 12 years (Table 5). Using depletion electrofishing, sufficient numbers of age-0 rainbow trout were captured in the Lee Vining Creek side channel section to generate population estimates in 10 of 12 years (Table 6). In the side channel, population estimates of age-1 and older rainbow were generated in six of 12 years (Table 7).

Because rainbow trout constitute a significant component of the Lee Vining Creek trout fishery, an effort has been made to utilize whatever data were available in all years to generate density and biomass values. In years when sufficient numbers of rainbow trout were sampled to generate population estimates, these statistically valid estimates were used to compute density and biomass estimates. In years when insufficient numbers of rainbow trout were sampled to generate population estimates, catch numbers were used to compute density and biomass values. Although catch numbers are not statistically valid, density estimates generated by catch numbers are consistently lower than mark-recapture estimates in seasons when comparisons can be made (Tables 4 and 5).

Table 4. Numbers of age-0 rainbow trout caught in Lee Vining Creek main channel section, 2000-2011.

Sample Year	Area of Sample Section (Ha)	Number of Fish on Marking Run	Number of Fish on Capture Run	Number of Recap Fish	Pop Estimate	Estimated Number of Fish per Hectare	Number of Fish Caught (Catch)	Catch per Hectare
2011	0.1377	1	0	0	NP	NP	1	7
2010	0.1505	0	0	0	0	0	0	0
2009	0.1505	4	4	0	NP	NP	8	53
2008	0.1377	17	31	9	57	414	39	283
2007	0.0884	42	56	22	106	1,199	76	860
2006	NS*	--	--	--	--	--	--	--
2005	0.0744	0	0	0	0	0	0	0
2004	0.0744	1	0	0	NP	NP	1	13
2003	0.0744	0	0	0	0	0	0	0
2002	0.0744	0	1	0	NP	NP	1	13
2001	0.0898	3	5	1	NP	NP	7	78
2000	0.0898	0	1	0	NP	NP	1	22

*NS stands for not sampled due to high flows

Table 5. Numbers of age-1 and older rainbow trout caught in Lee Vining Creek main channel section, 2000-2011.

Sample Year	Area of Sample Section (Ha)	Number of Fish on Marking Run	Number of Fish on Capture Run	Number of Recap Fish	Pop Estimate	Estimated Number of Fish per Hectare	Number of Fish Caught (Catch)	Catch per Hectare
2011	0.1377	5	8	5	8	56	8	56
2010	0.1505	12	9	7	15	100	14	93
2009	0.1505	39	32	12	98	651	59	392
2008	0.1377	71	64	37	129	936	98	712
2007	0.0884	3	5	1	NP	NP	7	79
2006	NS*	--	--	--	--	--	--	--
2005	0.0744	3	3	0	NP	NP	6	81
2004	0.0744	2	2	2	NP	NP	2	27
2003	0.0744	5	6	5	NP	NP	6	81
2002	0.0744	10	10	7	14	188	13	175
2001	0.0898	9	8	4	NP	NP	13	145
2000	0.0898	1	3	0	NP	NP	4	45

*NS stands for not sampled due to high flows

Table 6. Numbers of age-0 rainbow trout caught in Lee Vining Creek side channel section, 2000-2011.

Sample Year	Area of Sample Section (Ha)	Number of Fish Caught on Pass #1	Number of Fish Caught on Pass #2	Number of Fish Caught on Pass #3	Pop Estimate	Estimated Number of Fish per Hectare	Number of Fish Caught (Catch)	Catch per Hectare
2011	0.0507	0	0	--	0	0	0	0
2010	0.0507	0	0	--	0	0	0	0
2009	0.0488	0	0	--	0	0	0	0
2008	0.0488	5	2	--	7	143	7	143
2007	0.0488	4	0	--	NP	NP	4	82
2006	0.0761	46	26	--	100	1,314	72	946
2005	0.0936	0	0	--	0	0	0	0
2004	0.0936	82	30	--	127	1,357	112	1,197
2003	0.0936	0	0	--	0	0	0	0
2002	0.0936	28	17	--	64	684	45	481
2001	0.1310	69	23	--	102	779	92	702
2000	0.0945	32	15	--	57	603	47	497

Table 7. Numbers of age-1 and older rainbow trout caught in Lee Vining Creek side channel section, 2000-2011.

Sample Year	Area of Sample Section (Ha)	Number of Fish Caught on Pass #1	Number of Fish Caught on Pass #2	Number of Fish Caught on Pass #3	Pop Estimate	Estimated Number of Fish per Hectare	Number of Fish Caught (Catch)	Catch per Hectare
2011	0.0507	0	0	--	0	0	0	0
2010	0.0507	1	0	--	1	20	1	20
2009	0.0488	15	0	--	15	307	15	307
2008	0.0488	3	1	--	4	82	4	82
2007	0.0488	6	0	--	NP	NP	6	123
2006	0.0761	5	0	--	NP	NP	5	66
2005	0.0936	7	2	--	9	96	9	96
2004	0.0936	5	0	--	NP	NP	5	53
2003	0.0936	13	0	--	NP	NP	13	139
2002	0.0936	29	4	--	33	353	33	353
2001	0.1310	38	3	--	41	313	41	313
2000	0.0945	9	0	--	NP	NP	9	95

Relative Condition of Brown Trout

Log_{10} transformed length-weight regressions for captured brown trout ≥100 mm had r^2-values over 0.98 for all sample events, indicating that weight was strongly correlated to length (Table 8). The length-weight relationships observed during 2011 indicated condition of brown trout 100 mm and longer in the County Road and Bottomlands sections of Rush Creek continued to decline from the improved conditions that occurred in 2009 after condition factors in 2007 and 2008 were less than 1.00 (Table 8 and Figure 13). Brown trout in Lee Vining Creek appeared to be in good condition in 2011 (>1.00) and in the main channel section, the 2011 condition improved from the previous year (Figure 13).

A fish condition factor of 1.00 is considered average (Reimers 1963; Blackwell et al. 2000) and mean condition factors for brown trout 150 to 250 mm were <1.00 for the County Road and Bottomlands sections in Rush Creek indicating that brown trout condition was below average in these sections during 2011 (Figure 13). The Upper Rush Creek section had a condition factor of 1.00 in 2011, a slight increase from the 0.98 value recorded in 2010 (Figure 13). Between 2000 and 2006, condition factors of brown trout were ≥1.00 in the Upper Rush section and in the five seasons between 2007 and 2011 only two seasons had values ≥1.00 (2009 and 2011) (Figure 13). The 2011 season was the fourth year that the Bottomlands section of Rush Creek was sampled and the condition factor was 0.94, down from 0.98 computed for the 2010 season (Figure 13).

In the MGORD section of Rush Creek, the 2011 average condition factor of brown trout 150 to 250 mm was 0.98, down slightly from 0.99 in 2010 (Figure 13). When the MGORD condition factor data were examined more closely, a wide range in condition factors was evident, as well as varying condition by size class of brown trout. For the past six sample seasons, the condition factor of brown trout between 150 and 299 mm has been consistently higher than the condition factor of brown trout ≥300 mm.

The mean condition factor for 150 to 250 mm brown trout in Lee Vining Creek during 2011 was over 1.00 in both the main and side channel sections, indicating that brown trout condition was good. In the main channel section, the mean condition factor of 1.08 in 2011 was a slight increase from the 2010 value of 1.07 (Figure 13). In the side channel section, the mean condition factor of 1.05 in 2011 was a slight increase from the 2010 value of 1.04 (Figure 13).

Over the past 12 years when handling fish in Lee Vining Creek we have visually noted that most of the rainbow trout appeared “chunkier” than the brown trout, thus probably having higher condition factor values. For this annual report, conditions factors for rainbow trout between 150 and 250 mm were calculated for Lee Vining Creek (Figure 14). For the 11 sample seasons in which data were available, rainbow trout had higher condition factors than brown trout in 10 of the seasons (Figure 14). Sample season 2004 was the only year in which brown trout had a slightly higher condition factor than rainbow trout, 1.06 versus 1.05 (Figure 14).

Table 8. Regression statistics for $\log_{10}$ transformed length (L) to weight (WT) for brown trout 100 mm and longer captured in Rush Creek by sample section and year. The 2011 regression equations are in **bold** type.

Section	Year	N	Equation	r^2	P
County Road	2000	412	$\log_{10}(WT) = 2.94*\log_{10}(L) - 4.83$	0.99	< 0.01
	2001	552	$\log_{10}(WT) = 2.91*\log_{10}(L) - 4.81$	0.98	< 0.01
	2002	476	$\log_{10}(WT) = 2.95*\log_{10}(L) - 4.88$	0.99	< 0.01
	2003	933	$\log_{10}(WT) = 3.00*\log_{10}(L) - 5.01$	0.99	<0.01
	2004	655	$\log_{10}(WT) = 2.97*\log_{10}(L) - 4.94$	0.99	<0.01
	2005	257	$\log_{10}(WT) = 2.97*\log_{10}(L) - 4.90$	0.98	<0.01
	2006	373	$\log_{10}(WT) = 3.00*\log_{10}(L) - 5.00$	0.99	<0.01
	2007	912	$\log_{10}(WT) = 2.789*\log_{10}(L) - 4.565$	0.98	<0.01
	2008	398	$\log_{10}(WT) = 2.794*\log_{10}(L) - 4.585$	0.99	<0.01
	2009	456	$\log_{10}(WT) = 2.994*\log_{10}(L) - 4.898$	0.99	<0.01
	2010	375	$\log_{10}(WT) = 3.014*\log_{10}(L) - 5.044$	0.99	<0.01
	2011	**298**	$\mathbf{\log_{10}(WT) = 2.950*\log_{10}(L) - 4.9137}$	**0.99**	**<0.01**
Bottomlands	2008	611	$\log_{10}(WT) = 2.773*\log_{10}(L) - 4.524$	0.99	<0.01
	2009	511	$\log_{10}(WT) = 2.920*\log_{10}(L) - 4.821$	0.99	<0.01
	2010	425	$\log_{10}(WT) = 2.999*\log_{10}(L) - 5.005$	0.99	<0.01
	2011	**361**	$\mathbf{\log_{10}(WT) = 2.926*\log_{10}(L) - 4.858}$	**0.99**	**<0.01**
Upper	1999	317	$\log_{10}(WT) = 2.93*\log_{10}(L) - 4.84$	0.98	< 0.01
	2000	309	$\log_{10}(WT) = 3.00*\log_{10}(L) - 4.96$	0.98	< 0.01
	2001	335	$\log_{10}(WT) = 2.99*\log_{10}(L) - 4.96$	0.99	< 0.01
	2002	373	$\log_{10}(WT) = 2.94*\log_{10}(L) - 4.86$	0.99	< 0.01
	2003	569	$\log_{10}(WT) = 2.96*\log_{10}(L) - 4.89$	0.99	<0.01
	2004	400	$\log_{10}(WT) = 2.97*\log_{10}(L) - 4.94$	0.99	<0.01
	2005	261	$\log_{10}(WT) = 3.02*\log_{10}(L) - 5.02$	0.99	<0.01
	2006	485	$\log_{10}(WT) = 2.99*\log_{10}(L) - 4.98$	0.99	<0.01
	2007	436	$\log_{10}(WT) = 2.867*\log_{10}(L) - 4.715$	0.99	<0.01
	2008	594	$\log_{10}(WT) = 2.967*\log_{10}(L) - 4.937$	0.99	<0.01
	2009	612	$\log_{10}(WT) = 2.941*\log_{10}(L) - 4.855$	0.99	<0.01
	2010	420	$\log_{10}(WT) = 2.995*\log_{10}(L) - 4.994$	0.99	<0.01
	2011	**547**	$\mathbf{\log_{10}(WT) = 3.006*\log_{10}(L) - 5.014}$	**0.99**	**<0.01**

Table 8 (continued).

Section	Year	N	Equation	R^2	P
MGORD	2000	82	$Log_{10}(WT) = 2.909*Log_{10}(L) – 4.733$	0.98	<0.01
	2001	769	$Log_{10}(WT) = 2.873*Log_{10}(L) – 4.719$	0.99	<0.01
	2004	449	$Log_{10}(WT) = 2.984*Log_{10}(L) – 4.973$	0.99	<0.01
	2006	593	$Log_{10}(WT) = 2.956*Log_{10}(L) – 4.872$	0.98	<0.01
	2007	643	$Log_{10}(WT) = 2.914*Log_{10}(L) – 4.825$	0.98	<0.01
	2008	862	$Log_{10}(WT) = 2.827*Log_{10}(L) – 4.602$	0.98	<0.01
	2009	689	$Log_{10}(WT) = 2.974*Log_{10}(L) – 4.933$	0.99	<0.01
	2010	694	$Log_{10}(WT) = 2.892*Log_{10}(L) – 4.756$	0.98	<0.01
	2011	**218**	**$Log_{10}(WT) = 2.917*Log_{10}(L) – 4.823$**	**0.98**	**<0.01**

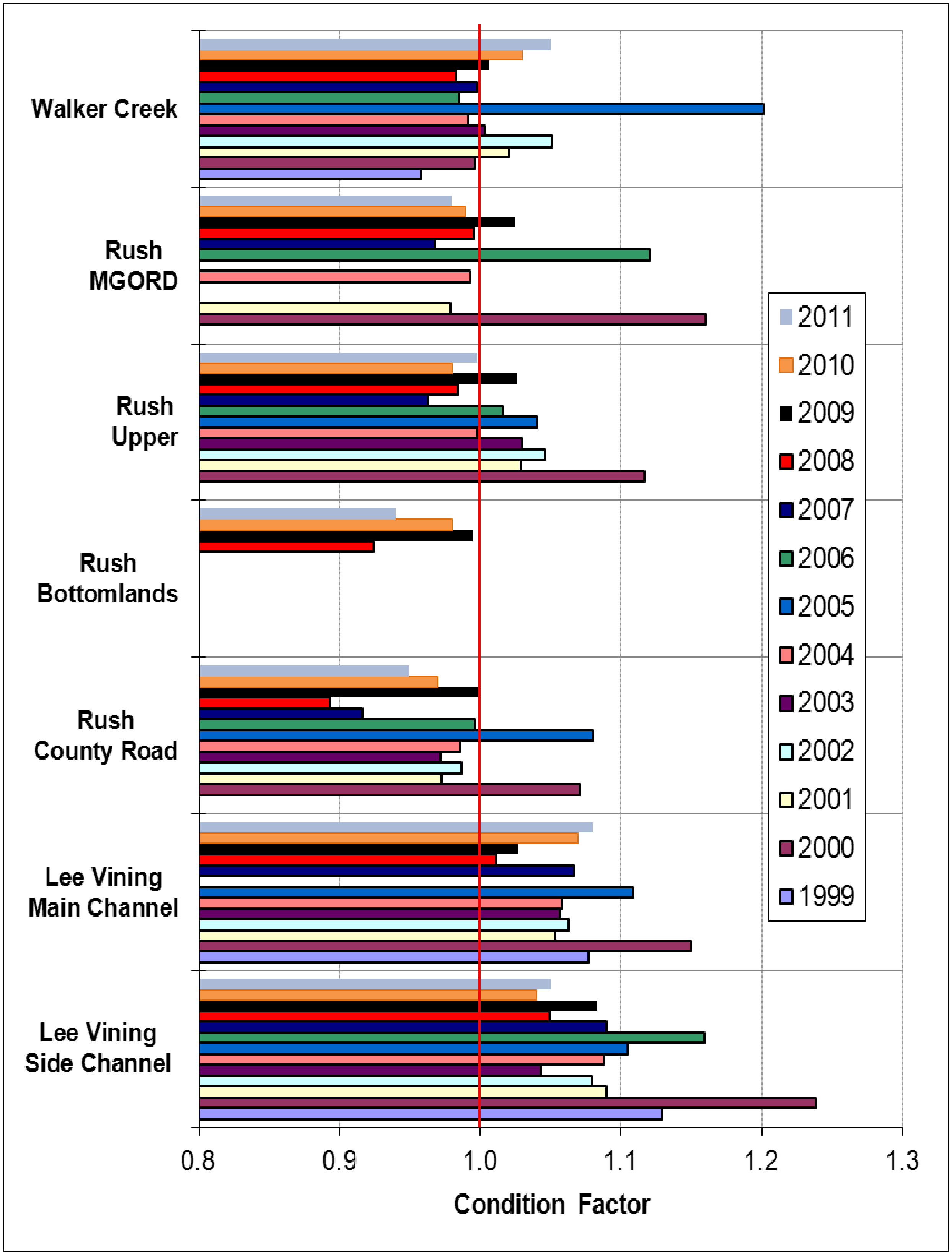


Figure 13. Condition factors for brown trout 150 to 250 mm long in sample sections of Rush, Lee Vining, and Walker creeks from 1999 to 2011. Note the x-scale starts at 0.8 and red vertical line indicates condition factor of 1.0.

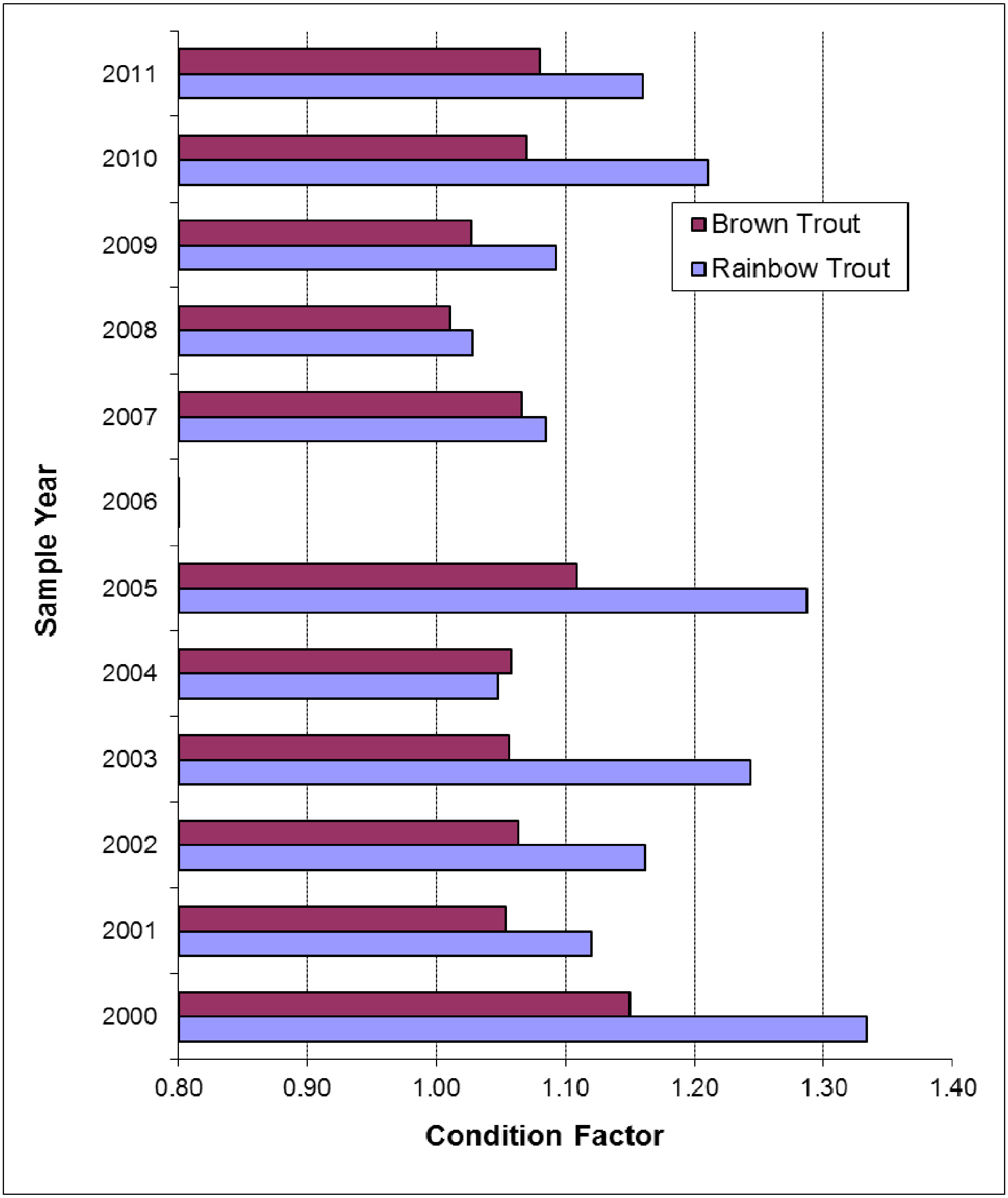


Figure 14. Comparison of condition factors for rainbow trout and brown trout 150 to 250 mm long in main channel sample section of Lee Vining Creek from 2000 to 2011. Note the x-scale starts at 0.8. Note: main channel was not sampled in 2006 due to high flows.

PIT Tag Recaptures and Measured Growth Rates

During the 2009 sampling season, a total of 1,596 trout received adipose fin clips and PIT tags, 1,572 were brown trout and 24 were rainbow trout (Table 9). In Rush Creek, 597 age-0 trout were clipped and tagged, in Walker Creek 114 age-0 fish were clipped and tagged, and in Lee Vining Creek 19 age-0 fish were clipped and tagged (Table 9).

During the 2010 sampling season, a total of 1,274 trout received adipose fin clips and PIT tags, 1,257 were brown trout and 17 were rainbow trout (Table 10). In Rush Creek, 741 age-0 trout were clipped and tagged, in Walker Creek 81 age-0 fish were clipped and tagged, and in Lee Vining Creek 38 age-0 fish were clipped and tagged (Table 10).

Thus, over the two sampling seasons of 2009 and 2010, a total of 2,870 PIT tags were implanted, including 1,590 age-0 fish.

Growth of Age-0 Trout between 2010 and 2011

In 2011, 221 fish with adipose fin-clips were recaptured that had PIT tags when scanned with a tag reader, for a recapture rate of 7.7% over a two year period (Table 11). Specific growth data for each of these 221 fish is located in Appendix C. Of these 221 recaptured fish, 102 were tagged as age-0 fish in 2010 and the recapture rate for this corhort of fish was 11.9% (Table 11). In the County Road and Bottomlands sections of Rush Creek the average growth rates of age-0 to age-1 fish for the one year between 2010 and 2011 were lower than growth rates of age-0 fish to age-1 fish for the one year between 2009 and 2010, which in turn, where lower than the growth rates of age-0 to age-1 fish between 2008 and 2009 (Tables 12 and 13). Growth rates between 2008 and 2009 were available because in 2008 all sampled age-0 fish received adipose fin clips. For the County Road section of Rush Creek the average growth for age-0 brown trout between 2010 and 2011 was 68 mm in length and 33 g in weight (Table 12) versus 73 mm and 36 g between 2009 and 2010. For the Bottomlands section of Rush Creek the average growth for age-0 brown trout between 2010 and 2011 was 71 mm and 36 g (Table 12) versus 77 mm and 40 g between 2009 and 2010.

Unlike the County Road and Bottomlands sections' decreased growth rates, for Upper Rush and Walker Creek the average growth rates of age-0 to age-1 fish for the one year between 2010 and 2011 were slightly greater than growth rates of age-0 fish to age-1 fish for the one year between 2009 and 2010 (Table 12). For Upper Rush Creek, the average growth for age-0 brown trout between 2010 and 2011 was 83 mm and 48 g (Table 12) versus 80 mm and 48 g between 2009 and 2010. In Walker Creek, the average growth of age-0 to age-1 brown trout between 2010 and 2011 was 71 mm and 34 g (Table 12) versus 51 mm and 20 g between 2009 and 2010. For Upper Rush Creek, the greatest annual growth rates for age-0 to age-1 brown trout occurred between 2008 and 2009 (Table 13). As previously stated, growth rates between 2008 and 2009 were available because in 2008 all sampled age-0 fish received adipose fin clips.

In the MGORD section of Rush Creek, a single age-1 brown trout was recaptured in 2011 that was PIT tagged as age-0 fish in 2010 (Table 10). This brown trout was tagged as an age-0 fish in the Upper Rush sample section and migrated upstream to the MGORD sometime between September of 2010 and September of 2011 (Table 12). This single fish grew 85 mm and 25 g between 2010 and 2011, significantly less than the growth of seven PIT tagged fish captured as age-1 in 2010 that had an average growth of 107 mm in length and an average weight gain of 85 g (Table 13). Five of these seven fish were tagged as age-0 fish in the Upper Rush section in 2009 and were recaptured in 2010 as age-1 fish in the MGORD.

In the Lee Vining Creek main channel section, six age-1 brown trout were recaptured in 2011 that were PIT tagged at age-0 in 2010 (Table 12). For these six brown trout, the average growth between 2010 and 2011 was 72 mm and 37 g (Table 12). In the Lee Vining Creek side channel section, three age-1 brown trout were recaptured in 2011 that were PIT tagged at age-0 in 2010 (Table 12). For these three fish, the average growth between 2010 and 2011 was 88 mm and 54 g – 16 mm and 17 g greater than the growth rates exhibited in the main channel section (Table 12). No movement of PIT tagged fish between the Lee Vining Creek main and side channels was documented by tag recaptures in 2011.

Table 9. Total numbers of trout implanted with PIT tags during the 2009 sampling season, by stream, sample section, age-class and species.

Stream	Sample Section	Number of Age-0 Brown Trout	Number of Age-1 Brown Trout	Number of Age-0 Rainbow Trout	Number of Age-1 Rainbow Trout	Reach Totals
Lee Vining Creek	Main Channel	10	45	4	3	62 fish
Lee Vining Creek	Side Channel	5	0	0	1	6 fish
Rush Creek	County Road	108	29	0	0	137 fish
Rush Creek	Bottom-lands	164	68	0	0	232 fish
Rush Creek	Upper	256	26	15	1	298 fish
Rush Creek	MGORD	54	642*	0	0	696 fish
Walker Creek	Above old 395	114	51	0	0	165 fish
Species and Age-class Totals:		**711**	**861**	**19**	**5**	**Grand Total: 1,596 fish**

*Many of these MGORD fish were >age-1.

Table 10. Total numbers of trout implanted with PIT tags during the 2010 sampling season, by stream, sample section, age-class and species.

Stream	Sample Section	Number of Age-0 Brown Trout (<125 mm)	Number of Age-1 and older Brown Trout	Number of Age-0 Rainbow Trout (<125 mm)	Number of Age-1 and older Rainbow Trout	Reach Totals
Lee Vining Creek	Main Channel	24	8	0	1	33 fish
Lee Vining Creek	Side Channel	13	0	0	0	13 fish
Rush Creek	County Road	210	7	0	0	217 fish
Rush Creek	Bottom-lands	284	3	0	0	287 fish
Rush Creek	Upper	242	11	4	0	257 fish
Rush Creek	MGORD	1	359*	0	12	372 fish
Walker Creek	Above old 395	81	14	0	0	95 fish
Species and Age-class Totals:		**855**	**402**	**4**	**13**	**Grand Total: 1,274 fish**

*Many of these MGORD fish were >age-1.

Table 11. Fish recaptured in 2011 with PIT tags implanted during the 2010 sampling season, by stream reach.

Stream	Sample Section	Number of Age-1 Brown Trout	Number of Age-2+ Brown Trout	Number of Age-1 Rainbow Trout	Number of Age-2+ Rainbow Trout	Reach Totals
Lee Vining Creek	Main Channel	6	6	0	0	12 fish
Lee Vining Creek	Side Channel	3	1	0	0	4 fish
Rush Creek	County Road	28	11	0	0	39 fish
Rush Creek	Bottom-lands	28	12	0	0	40 fish
Rush Creek	Upper	29	12*	0	0	41 fish
Rush Creek	MGORD	1	66**	0	0	67 fish
Walker Creek	Above old 395	7	11***	0	0	18 fish
Species and Age-class Totals:		**102**	**119**	**0**	**0**	**Grand Total: 221 fish**

*Three of these fish were >age-2.
**Most of these fish were >age-2.
***Five of these fish were >age-2.

Table 12. Growth of 102 age-1 brown trout recaptured in 2011 that were implanted with PIT tags as age-0 fish during the 2010 sampling season, by stream reach.

Collection Location	Number of Fish Recap.	Growth Ave. Length (mm)	Min. Growth Length (mm)	Max. Growth Length (mm)	Growth Ave. Weight (g)	Min. Growth Weight (g)	Max. Growth Weight (g)
Lee Vining Ck - Main	6	72	58	3	37	24	51
Lee Vining Ck - Side	3	88	73	97	54	35	64
Rush - Co. Road	29	68	56	88	33	20	48
Rush - Bottomlands	28	71	48	109	36	21	69
Rush - Upper	29	83	55	112	48	24	79
Rush – MGORD	1*	63	--	--	25	--	--
Walker Creek	7	71	62	92	34	22	48

* This fish was tagged in the Upper Rush sampling section.

Table 13. Comparison of annual growth rates of brown trout between age-0 and age-1 as determined by adipose fin clips and PIT tag recaptures, by stream reach.

Collection Location	2008-2009 Growth Ave. Length (mm)	2009-2010 Growth Ave. Length (mm)	2010-2011 Growth Ave. Length (mm)	2008-2009 Growth Ave. Weight (g)	2009-2010 Growth Ave. Weight (g)	2010-2011 Growth Ave. Weight (g)
Lee Vining Ck - Main	N/A	80	72	N/A	42	37
Lee Vining Ck - Side	N/A	N/A	88	N/A	N/A	54
Rush - Co. Road	78	73	68	41	36	33
Rush - Bottomlands	84	77	71	43	40	36
Rush - Upper	89	80	83	51	48	48
Rush – MGORD	N/A	107	63	N/A	85	25
Walker Creek	68	51	71	27	20	34

Growth of Age-2 and Age-3 Trout between 2010-2011

During 2011, twenty one age-2, PIT-tagged brown trout that had also been captured as age-1 fish in 2010 were captured at four sections in the study area (Table 14), along with fourteen age-3 fish that had also been captured as age-2 fish in 2010 (Table 15). These 35 fish provided the basis for the growth rate information found in these tables as well as the information for determination of probable length-at-age. Additionally during 2011, there were eleven other age-2 or age-3, PIT-tagged fish that had been captured in 2009, but not in 2010. These fish were not included in the 2010-2011 growth calculations, but were included when determining the length-at-age ranges of age-2 and age-3 fish at the sections during 2011.

In the County Road section of Rush Creek, five PIT tagged brown trout were captured in 2011 out of 20 tagged fish that had also been captured as age-1 fish in 2010, for a recapture rate of 25%. These age-2 fish grew an average of 37 mm/yr in length (range = 21 to 43 mm/yr) and gained an average of 46 g/yr (range = 36 to 65 g) (Table 14). Also in 2011, two age-3 brown trout were captured out of nine tagged fish that had also been captured as age-2 fish in 2010, for a recapture rate of 22%. These two fish grew an average of 24 mm/yr in length (range = 22 to 26 mm/yr) and gained an average of 44 g/yr (range = 38 to 49 g/yr) (Table 15). Four other age-2 PIT tagged brown trout were captured in the County Road section that had not been captured as age-1 fish in 2010. Between 2009 and 2011, these four fish grew an average of 112 mm/2yrs (range = 104 to 116 mm/2yrs) and gained an average of 76 g/2yrs (range = 59-89 g/2yrs).

In the Bottomlands section of Rush Creek, six PIT tagged brown trout were captured in 2011 out of 36 tagged fish that had also been captured as age-1 fish in 2010, for a recapture rate of 17%. These age-2 fish grew an average of 35 mm in length (range = 23 to 54 mm) and gained an average of 32 g (range = 22 to 43 g) (Table 14). Also in 2011, four age-3 brown trout were captured out of nine tagged fish that also had been captured as age-2 fish in 2010, for a recapture rate of 44%. These four fish grew an average of 13 mm in length (range = 7 to 19 mm) and gained an average of only 14 g (range = 5 to 21 g) (Table 15). Two other age-2 PIT tagged brown trout were captured in the Bottomlands section that had not been captured as age-1 fish in 2010. Between 2009 and 2011, these fish grew an average of 117 mm/2yrs (range = 110-124 mm/2yrs) and gained an average of 98 g/2yrs (range = 94-102 g/2yrs).

In the Upper Rush Creek section, seven PIT tagged brown trout were captured in 2011 out of 24 tagged fish that had also been captured as age-1 fish in 2010, for a recapture rate of 29%. These age-2 fish grew an average of 54 mm/yr in length (range = 42 to 61 mm/yr) and gained an average of 73 g/yr (range = 55 to 102 g/yr) (Table 14). During 2010 only three age-2 PIT tagged brown trout had been captured in the Upper Rush section, and none of these fish were captured again as age-3 fish in 2011. However, one age-4 fish that had also been captured as an age-3 fish in 2010 grew 14 mm/yr in length and gained 44 g/yr between 2010 and 2011. Two other age-2 PIT tagged brown trout were captured in the Upper Rush section that had not been captured as age-1 fish in 2010. Between 2009 and 2011, these fish grew an average of 150 mm/2yrs (range =

129-171 mm/2yrs) and gained an average of 144 g/2yrs (range = 104-183 g/2yrs). Two PIT tagged fish were captured in 2011 of which we were unsure about their age at the time of tagging in 2010. These fish were therefore not included in any growth calculations or age determinations.

On Walker Creek, three PIT tagged brown trout were captured in 2011 out of nine tagged fish that had also been captured as age-1 fish in 2010, for a recapture rate of 33%. These age-2 fish grew an average of 60 mm/yr (range = 52-66 mm/yr) and gained an average of 56 g/yr (range = 52-62 g/yr). Also in 2011, four age-3 brown trout were captured out of 16 that had also been captured as age-2 fish in 2010, for a recapture rate of 25%. These four fish grew an average of 28 mm/yr (range = 22-34 mm/yr) and gained an average of 44 g/yr (range = 39-48 g/yr). Three PIT tagged fish were captured in 2011 of which we were unsure about their age at the time of tagging in 2010 (these fish had shed tags originally implanted in 2009 and were re-tagged in 2010). These fish, which were either age-2 or age-3, were therefore not included in any growth calculations or age determinations.

On Lee Vining Creek, four age-3, PIT-tagged brown trout were captured in 2011 out of nine tagged fish that had also been captured as age-2 fish in 2010, for a recapture rate of 57%. These fish grew an average of 41 mm/yr in length (range = 22-53 mm/yr), and gained an average of 100 g/yr (range = 61-131 g/yr).Two other age-3 fish were captured in 2011 that had not been captured as age-2 fish in 2010. These two fish grew an average of 112 mm/2yr (range = 102-122 mm/2yrs) and gained an average of 206 g/2yrs (range = 148-263 g/2yrs). One of these fish was 310 mm in length, which was the largest individual captured in this section in 2011.

In the MGORD, 27 of the PIT tagged brown trout captured in 2011 were between 181-240 mm, and at the time of tagging in 2010 were probably age-1 fish. This assumption was based on the length range of known, PIT tagged, age-1 fish caught in the MGORD (208-231 mm), as well as the 10 mm break in lengths between 240-250 mm of the fish tagged in 2010 that were captured in 2011. Between 2010 and 2011, these 27 age-2 fish grew an average of 59 mm/yr in length (range = 25 to 107 mm/yr) and gained an average of 87 g/yr (range = 25 to 142g/yr) (Table 16). In comparison, the average growth of MGORD brown trout from age-1 to age-2 between 2009 and 2010 was 50 mm/yr and 79 g/yr. Both of these annual growth rates for the MGORD are similar to the growth rates for age-2 brown trout at the Upper Rush section from 2010-2011 (54 mm/yr and 73 g/yr) (Table 14).

In last year's annual fisheries report we discussed that as the size class of MGORD recaptured fish increased, their growth rates between 2009 and 2010 decreased (Taylor et al. 2011). This decrease in growth of larger fish was most apparent in brown trout that were >300 mm in length at the time of tagging. The average growth of the 21 PIT tagged fish recaptured in 2010 that were >300 mm in length when tagged in 2009 was 15 mm/yr in length (range = -20 to 80 mm/yr) and a mere 2 g/yr in weight (range = -251 to 347 g/yr). Eleven of these 21 fish (52%) lost weight between 2009 and 2010. In 2011, 17 brown trout were recaptured that were >300 mm when tagged in 2010. Their average growth rates between 2010 and 2011 were 18 mm/yr in length (range = -8 to 52 mm/yr) and 78 g/yr in weight (range = -52 to 291 g/yr). Only two of these 17 fish

(12%) lost weight between 2010 and 2011, a large difference when compared to the 52% of fish >300 mm that lost weight between 2009 and 2010.

Apparent one-year survivals of fish between age-0 and age-1 (2010 to 2011) were based on the number originally PIT tagged with an assumption that any fish that left the sampling area died ("apparent mortality") unless fish were recaptured in another sample section. Any PIT tagged fish recaptured in a different section were counted in the apparent survival calculation for the section where they were originally tagged. After two seasons of recapturing PIT tagged fish, we have only documented movement inbetween sections seven times out of a total of 436 recaptures, thus inter-section movement appears to occur infrequently. Six of the seven documented inter-section movements involved age-0 Upper Rush brown trout moving upstream into the MGORD. The apparent 2010-2011 survivals were very similar among the Rush Creek sections and the section on Walker Creek: approximately 13% for the County Road section, 10% for the Bottomlands section, 12% for the Upper section of Rush Creek, and 9% for Walker Creek. In Lee Vining Creek, the apparent one-year survival of PIT tagged fish between age-0 and age-1 (September 2010 and 2011) was approximately 37.5%.

For all sample reaches the growth range of fish varied widely, even for similar age and size (at time of tagging) fish within sample sections. Tables with individual growth data for the 221 PIT tagged fish recaptured in 2011 are provided in Appendix C.

Shed Rate of PIT Tags between 2009 and 2011

In 2011, a total of eight trout with adipose fins were captured that lacked PIT tags when scanned with a tag reader. In 2010, a total of 45 trout were captured that lacked PIT tags when scanned with a tag reader. Some of these fish had visible scars on their bellies from where tags had been implanted in 2009 or 2010. The calculated shed rate of PIT tags between 2009 and 2011 was 1.8% (53÷2,870). This rate was lower than rates reported by other PIT tagging studies (Ombredane et al. 1998; Bateman and Gresswell 2006).

Table 14. Growth of twenty-one age-2 fish recaptured in 2011 that had also been recaptured as age-1 fish during the 2010 sampling season, at three Rush Creek sections and the Walker Creek section.

Collection Location	PIT Tag Number	2010 Length (mm)	2011 Length (mm)	2010 Weight (g)	2011 Weight (g)	Growth in Length (mm)	Growth in Weight (g)
Rush Creek County Road	0936299	160	197	39	75	37	36
	0110997	168	209	44	80	41	36
	0109973	170	213	44	96	43	52
	0910924	195	221	71	113	26	42
	0938535	208	244	84	149	36	65
Average Growth in the County Road Section Between 2010 and 2011						**37**	**46**
Rush Creek Bottomlands	0123570	155	209	35	78	54	43
	0937007	161	186	44	66	25	22
	0111924	174	213	49	83	39	34
	0924797	183	215	69	104	32	35
	0121350	168	205	42	73	37	31
	0112154	186	209	64	88	23	24
Average Growth in the Bottomlands Section Between 2010 and 2011						**35**	**32**
Upper Rush Creek	0935502	165	221	44	110	56	66
	0936745	161	222	43	112	61	69
	0117810	188	238	61	127	50	66
	0935610	190	234	69	135	44	66
	0109142	180	245	55	157	65	102
	0932673	177	219	55	106	42	55
	0910463	195	256	76	165	61	89
Average Growth in the Upper Section Between 2010 and 2011						**54**	**73**
Walker Creek	0107405	144	196	31	83	52	52
	0934081	126	189	19	81	63	62
	0905768	138	204	28	82	66	54
Average Growth in Walker Creek Between 2010 and 2011						**60**	**56**

Table 15. Growth of fourteen age-3 fish recaptured in 2011 that had also been recaptured as age-2 fish during the 2010 sampling season, at two Rush Creek sections and sections on Walker and Lee Vining creeks..

Collection Location	PIT Tag Number	2010 Length (mm)	2011 Length (mm)	2010 Weight (g)	2011 Weight (g)	Growth in Length (mm/yr	Growth in Weight (g/yr)
Co.Road	0106769	208	230	79	117	22	38
	0906504	229	255	113	162	26	49
Average Growth in the County Road Section Between 2010 and 2011						**24**	**44**
Bottomlands	0103525	210	219	95	100	9	5
	0921335	212	229	106	117	17	11

	0924548	238	257	120	141	19	21
	0904696	234	241	123	143	7	20
Average Growth in the Bottomlands Section Between 2010 and 2011						**13**	**14**
Walker Creek	0914927	169	202	48	98	33	48
	0105197	174	208	52	93	34	41
	0936228	193	217	74	121	24	47
	0904753	196	218	82	121	22	39
	Average Growth Between 2010 and 2011					**28**	**44**
Lee Vining Creek	0096917	235	281	145	261	46	116
	0927890	249	271	172	239	22	67
	0914307	227	271	126	213	44	87
	0911274	228	281	123	254	53	131
	Average Growth Between 2010 and 2011					**41**	**100**

Table 16. Growth of 27 age-2 fish recaptured in 2011 that were implanted with PIT tags as age-1 fish during the 2010 sampling season, for the MGORD section of Rush Creek.

Collection Location	PIT Tag Number	2010 Length (mm)	2011 Length (mm)	2010 Weight (g)	2011 Weight (g)	Growth in Length (mm)	Growth in Weight (g)
Rush Creek MGORD	3448280	181	254	52	135	73	83
	3622485	186	233	67	105	47	38
	1888784	187	250	65	139	63	74
	1898184	189	266	65	157	77	92
	1875639	190	251	70	157	61	87
	1890827	200	250	79	140	50	61
	3558100	203	246	84	168	43	84
	3623039	207	270	83	166	63	83
	3468069	208	264	76	163	56	87
	3644730	208	262	90	179	54	89
	3380781	210	278	94	202	68	108
	3470544	210	272	104	191	62	87
	3458934	212	266	88	166	54	78
	1888674	213	276	86	173	63	87
	1900738	215	266	90	175	51	85
	1900578	219	257	92	163	38	71
	3458530	219	300	104	246	81	142
	1889565	223	292	99	234	69	135
	1903275	224	281	109	199	57	90
	1889002	226	272	110	177	46	67
	3450995	231	274	116	185	43	69
	3579285	232	298	107	241	66	134
	3373191	233	340	322	378	107	56
	1915826	238	280	117	203	42	86
	3365010	239	305	126	244	66	118
	3460436	239	312	126	263	73	137
	1900411	240	265	125	156	25	31
Average Growth in the MGORD Section Between 2010 and 2011						**59**	**87**

Population Estimates and Densities, by age-class, during September 2011

During 2011, for the first time, three age-classes of PIT-tagged brown trout were recaptured within our study areas. Along with providing age-specific growth information, these fish also helped define the length breaks between age-classes at each study section. This known length-at-age data, along with the length-frequency histograms for each section, were used to develop the "most probable" length ranges for each age-class at each section (Table 17). As discussed earlier, growth rates of individual fish of the same age at the same section can vary considerably, with some "outliers" growing much faster or slower than most of their cohorts. Knowing the exact length distribution each cohort is therefore impossible, unless every fish in the section were tagged and recaptured. However, the probable length ranges shown in Table 17 for each cohort and section are the best ever calculated for streams in the study area (or any other stream in the Eastern Sierras) because of the number and distribution of recaptured PIT-tagged brown trout at each study section (Appendix C, Final Table). This appendix also shows the Mark, Capture and Recapture numbers that were used to develop the cohort population estimates shown on Table 17, as well as the lengths and total surface areas of the sections in 2011.

The length ranges of age-classes at the County Road and Bottomlands sections were very similar in 2011, as were the densities (numbers/ha and numbers/ km) of each cohort. Also, based on recaptured PIT tagged fish, the lengths of the largest age-1, age-2 and age-3 brown trout were almost exactly the same at the two sections; the largest recaptured age-3 fish were about 10 inches in length at both sections (255 mm at County Road and 257 mm at Bottomlands). The striking similarities between these nearby sections, not only in the length ranges of the cohorts, but also in the densities of their brown trout populations (Table 17), suggests that the County Road section could be eliminated in the near future without compromising the monitoring objectives for Rush Creek downstream of the Narrows. However, both sections should be monitored in 2012 to gather one more year of PIT tag recapture data, which will hopefully yield growth and size information for age-4 brown trout in lower Rush Creek (downstream of the Narrows).

Age-2 fish at the Upper Rush section were similar in length, or larger than, age-3 fish at the two lower sections. The largest age-2 fish recaptured with a PIT tag at Upper Rush was 270 mm in length, compared to 255 and 257 mm for the largest age-3 fish recaptured with PIT tags at the lower sections (Table 17). This length-at-age difference is primarily a result of mean growth rates for age-2 brown trout being roughly twice as high at the Upper Rush section compared to both the Bottomlands and County Road sections (Table 14). At the same time, densities of age-3 and older brown trout at Upper Rush (76 fish/ha) were around one-half the densities at County Road (126 fish/ha) and the Bottomlands (145 fish/ha) (Table 17). These density differences for older (age-3+) brown trout are likely related to more preferred brown trout habitat (per unit area) being present in the lower sections compared to the higher-gradient Upper section as determined by the instream flow study (Taylor et al. 2009a). No age-3 PIT-tagged fish were recaptured within the Upper Rush section in 2011, which prevented the determination of a length range for this age-class at this section.

No age-2 fish with PIT tags were recaptured on Lee Vining Creek during 2011. However, the recapture rate of age-3 PIT-tagged brown trout was high (57%) (Table 17), and the breakpoint between age-1 and age-2 fish on the length-frequency histogram was clear (Figure 10), resulting in a most probable length range of 209-262 mm for age-2 fish at this section, which was very similar to the length range for age-2 brown trout at the Upper Rush section (214-270 mm). The length range for age-3 brown trout recaptured with PIT tags was 266-310 mm. Growth rates for age-3 fish at this section were over twice as high as the growth rates for age-3 fish at the County Road, Bottomlands and Walker Creek sections (Table 15), resulting in some fish reaching 310 mm (over 12 inches) and 329 g (almost ¾ pound) in only three years. However, the density of age-3 fish at this section is relatively low (77 fish/ha), which is similar to the density found at Upper Rush Creek (76/ha). As well, no age-4 (>310 mm) were captured on Lee Vining Creek in 2011, suggesting that few, if any, brown trout reach age-4 on this stream. This lack of age-4 fish in Lee Vining Creek was consistent with earlier scale-analysis efforts (Hunter et al. 2005 and 2006).

On Walker creek, adequate percentages of PIT tag recaptures from three age classes, in combination with the length-frequency histogram, helped determine the probable length ranges for age-1, age-2 and age-3 fish with a fair extent of certainty. Older brown trout in this section were relatively small, with age-3 fish ranging from 204-219 mm, which is considerably shorter than the length ranges for age-3 fish at the sections on Rush and Lee Vining creeks (Table 17). As well, the largest brown trout captured on Walker Creek (probably age-5 or older) was only 262 mm long, which is shorter than the largest age-2 fish on that was recaptured on Upper Rush in 2011. Walker Creek is the smallest stream in the study area both in terms of annual discharge rate and width, and therefore does not have pool habitats that are as large and deep as those found on Rush Creek, which accounts for the smaller maximum sizes for older fish on this stream. Growth in Walker Creek may also be influenced by cooler water temperatures that results in shorter periods where water temperatures are ideal for brown trout growth.

Table 17. Population estimates, densities and PIT tag return rates, by age class, for brown trout populations at three electrofishing sections on Rush Creek and sections on Walker and Lee Vining creeks, September 2011.

Section	Cohort	Length Range (mm)	Total Population Estimate	Number per Hectare	Number per Kilometer	% of total Pop. Est.	PIT Tag Returns Numbers	PIT Tag Returns Percent
Rush Creek – County Road	Age-0	61-105	597	2,160	1,815	63.8%		
	Age-1	124-194	259	937	787	27.7%	28/211	13%
	Age-2	195-229	45	163	137	4.8%	9/20	46%
	Age-3	230-255	23	83	70	2.5%	2/9	22%
	Age-4+	256-314	12	43	36	1.3%		
	TOTALS		936	3,386	2,845	100.0%		
Rush Creek – Bottom-lands	Age-0	61-117	785	2,218	1,796	65.0%		
	Age-1	133-196	317	895	725	26.2%	28/284	10%
	Age-2	197-228	51	144	117	4.2%	9/36	25%
	Age-3	229-257	32	90	73	2.6%	4/9	44%
	Age-4+	258-354	23	65	53	1.9%		
	TOTALS		1,208	3,412	2,764	99.9%		
Rush Creek – Upper Section	Age-0	50-105	3,862	10,821	8,981	83.0%		
	Age-1	128-213	579	1,622	1,347	12.4%	29/246	12%
	Age-2	214-270	183	513	426	3.9%	9/23	39%
	Age-3+	271-458	27	76	63	0.6%	0/3	0%
	TOTALS		4,651	13,032	10,817	99.9%		
Lee Vining Creek – Main Channel Section	Age-0	56-88	104	728	408	64.9%		
	Age-1	133-188	28	190	110	16.9%	6/24	25%
	Age-2	209-262	18	126	71	11.2%	0/1	0%
	Age-3	266-310	11	77	43	6.9%	4/7	57%
	Age-4+	>310	0	0	0	0.0%		
	TOTALS		161	1,121	632	99.9%		
Walker Creek	Age-0	85-114	41	845	211	36.0%		
	Age-1	143-183	32	660	165	28.0%	7/81	9%
	Age-2	186-202	14	289	72	12.3%	3/9	33%
	Age-3	206-219	11	227	57	9.7%	4/16	25%
	Age-4+	220-264	16	330	82	14.0%		
	TOTALS		114	2,351	587	100.0%		

2011 PIT Tagging of Trout in Rush and Lee Vining Creeks

In 2011, a total of 1,065 PIT tags were implanted in Rush, Walker and Lee Vining creeks; of these only 26 tags were implanted in rainbow trout (Table 18). Eight of the 1,065 PIT tags were implanted in fish that had previously clipped adipose fins, but no tag number was read when the fish were scanned with a tag reader. A total of 901 age-0 fish had PIT tags implanted in 2011; of these 23 were rainbow trout (Table 19). Due to the high numbers of small age-0 brown trout encountered in Rush Creek during the 2011 sampling season, we implanted PIT tags in fish as small as 70 mm (Table 19). In Lee Vining Creek, we implanted PIT tags in all age-0 trout due to the low abundance of this cohort (Table 19).

Table 18. Total numbers of trout implanted with PIT tags during the 2011 sampling season, by stream, sample section, age-class and species.

Stream	Sample Section	Number of Age-0 Brown Trout (<125 mm)	Number of Age-1 and older Brown Trout	Number of Age-0 Rainbow Trout (<125 mm)	Number of Age-1 and older Rainbow Trout	Reach Totals
Lee Vining Creek	Main Channel	24	0	0	0	24 fish
Lee Vining Creek	Side Channel	11	14	0	0	25 fish
Rush Creek	County Road	196	1	6	0	203 fish
Rush Creek	Bottom-lands	178	1	11	0	190 fish
Rush Creek	Upper	393	3	30	0	426 fish
Rush Creek	MGORD	8	142*	3	3	156 fish
Walker Creek	Above old 395	41	0	0	0	41 fish
Species and Age-class Totals:		**851**	**161**	**50**	**3**	**Grand Total: 1,065 fish**

*Many of these MGORD fish were >age-1.

Table 19. Average length (mm), minimum length, maximum length, average weight (g), and number (901 total fish) of age-0 trout implanted with PIT tags during the 2011 sampling season, by stream, sample section, and species.

Stream	Sample Section	Species	Number of Fish Tagged	Mean Length (mm)	Mean Weight (g)	Minimum Length (mm)	Maximum Length (mm)
Lee Vining Creek	Main Channel	Brown Trout	24	75	5	70	88
Lee Vining Creek	Side Channel	Brown Trout	11	76	4	68	91
Rush Creek	County Road	Brown Trout	196	91	7	71	124
Rush Creek	County Road	Rainbow Trout	6	79	5	73	94
Rush Creek	Bottom-lands	Brown Trout	178	92	8	71	117
Rush Creek	Bottom-lands	Rainbow Trout	11	81	5	72	97
Rush Creek	Upper	Rainbow Trout	30	80	6	70	125
Rush Creek	Upper	Brown Trout	393	85	6	70	105
Rush Creek	MGORD	Brown Trout	8	89	7	80	94
Rush Creek	MGORD	Rainbow Trout	3	90	7	84	94
Walker Creek	Above old 395	Brown Trout	41	98	9	85	114

Estimated Trout Density Comparisons

In 2011, the estimated densities (number per hectare) of age-1 and older brown trout in the County Road section of Rush Creek was 1,215.8 fish/ha (Figure 15). The 2011 estimate was an 18% decrease from the estimate of 1,490.1 fish/ha in 2010. The 2011 density estimate was also the second straight decrease after the record high of 2,177 fish/ha in 2009 (Figure 15).

Between 2010 and 2011, the Bottomlands section of Rush Creek experienced another decrease in the estimated densities of age-1 and older brown trout. Since the start of sampling the Bottomlands section in 2008, density estimates of age-1 and older brown trout have decreased each year (Figure 15). In 2011, the Bottomlands section of Rush Creek had an estimated density of 1,155.5 age-1 and older brown trout/ha, a 6% drop from the 2010 estimate (Figure 15).

The Upper section of Rush Creek had an estimated density of 2,201 age-1 and older brown trout/ha in 2011, a 107% increase from the 2010 estimate of 1,062 fish/ha (Figure 15). The 2011 density value at the Upper section reversed a recent trend, where the numbers of age-1 and older brown trout per hectare had gradually declined from 2007 through 2010 (Figure 15). The 2011 density estimate of 2,201 age-1 and older brown trout/ha was the highest recorded for this section over a 12-year period (Figure 15).

In Walker Creek the 2011 density estimate of 1,505 age-1 and older brown trout/ha was 25% less than the 2010 estimate (Figure 15). The density of age-1 and older brown trout has decreased by 46% over a two-year period since the record high value was set in 2009 (Figure 15).

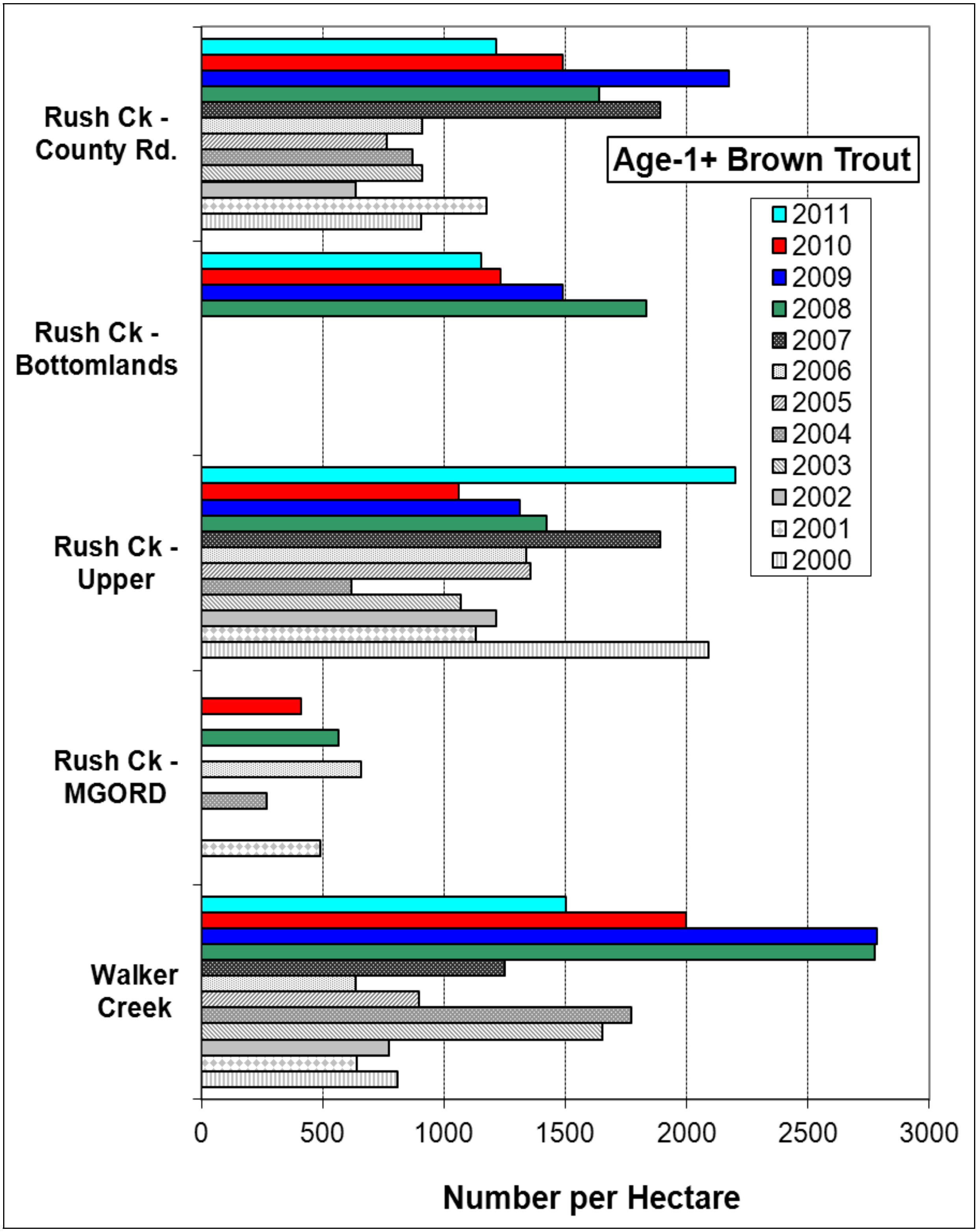


Figure 15. Estimated number of age-1 and older brown trout per hectare in sections of Rush and Walker creeks from 2000 to 2011.

In 2011, the side channel section of Lee Vining Creek produced an estimated density of 355 age-1 and older brown trout/ha, the first time since 2002 that the density estimate has exceeded 300 fish/ha (Figure 16). The 2011 density estimate was a 209% increase from the 2010 estimate of 118 age-1 and older brown trout/ha (Figure 16).

Between 2010 and 2011, the estimated density of age-1 and older brown trout in the main channel of Lee Vining Creek decreased by 3% from 432 fish/ha to 421.2 fish/ha (Figure 16). The 2011 density estimate of age-1 and older brown trout in the main channel section was the second-lowest estimate for this section in 12 years of sampling (Figure 16).

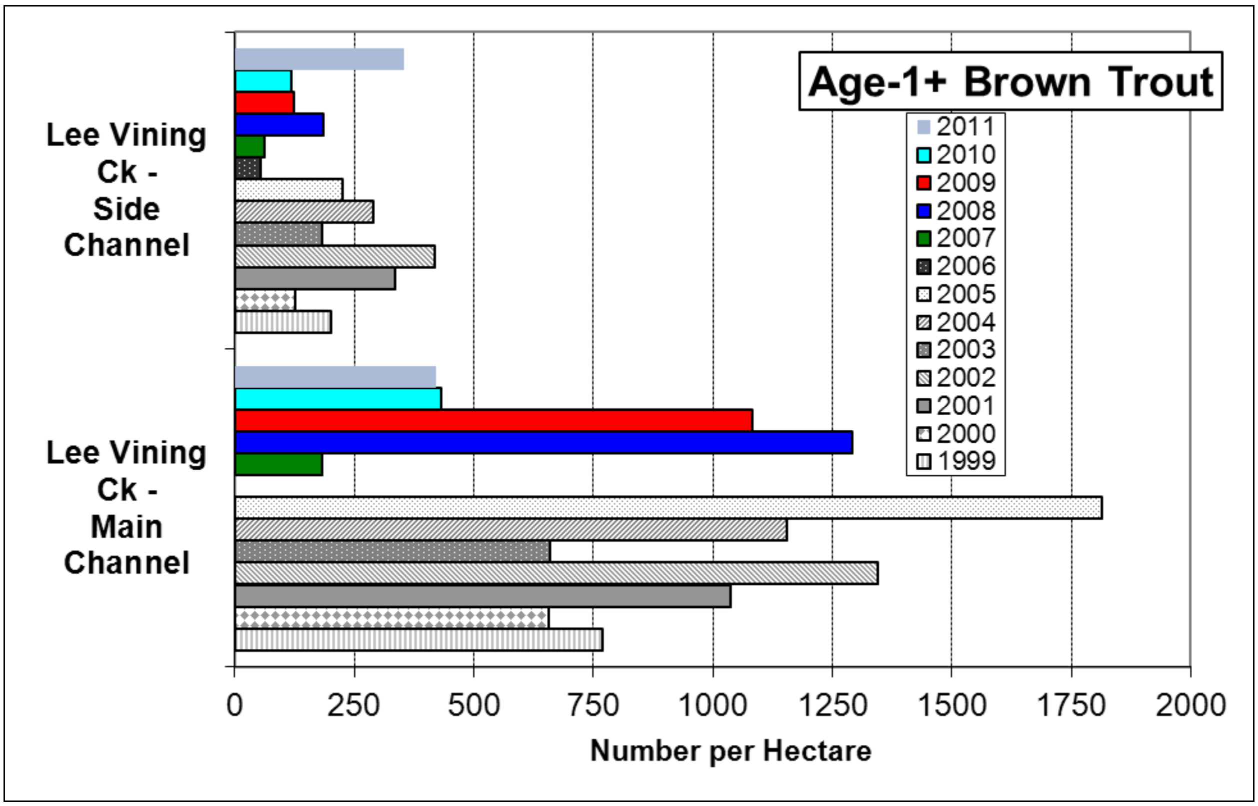


Figure 16. Estimated number of age-1 and older brown trout per hectare in sections of Lee Vining Creek from 1999 to 2011.

In 2011, no age-1 and older rainbow trout were captured in the Lee Vining Creek side channel. For the Lee Vining Creek main channel section, the estimated densities of age-1 and older rainbow trout dropped by 42% between 2010 and 2011 (Figure 17). For the years 1999-2001, 2003-2005, 2007 and 2011 insufficient numbers of age-1 and older rainbow trout were captured to generate population estimates, thus these density estimates were derived from catch data. In 2006 the flow was too high to safely electro-fish the main channel.

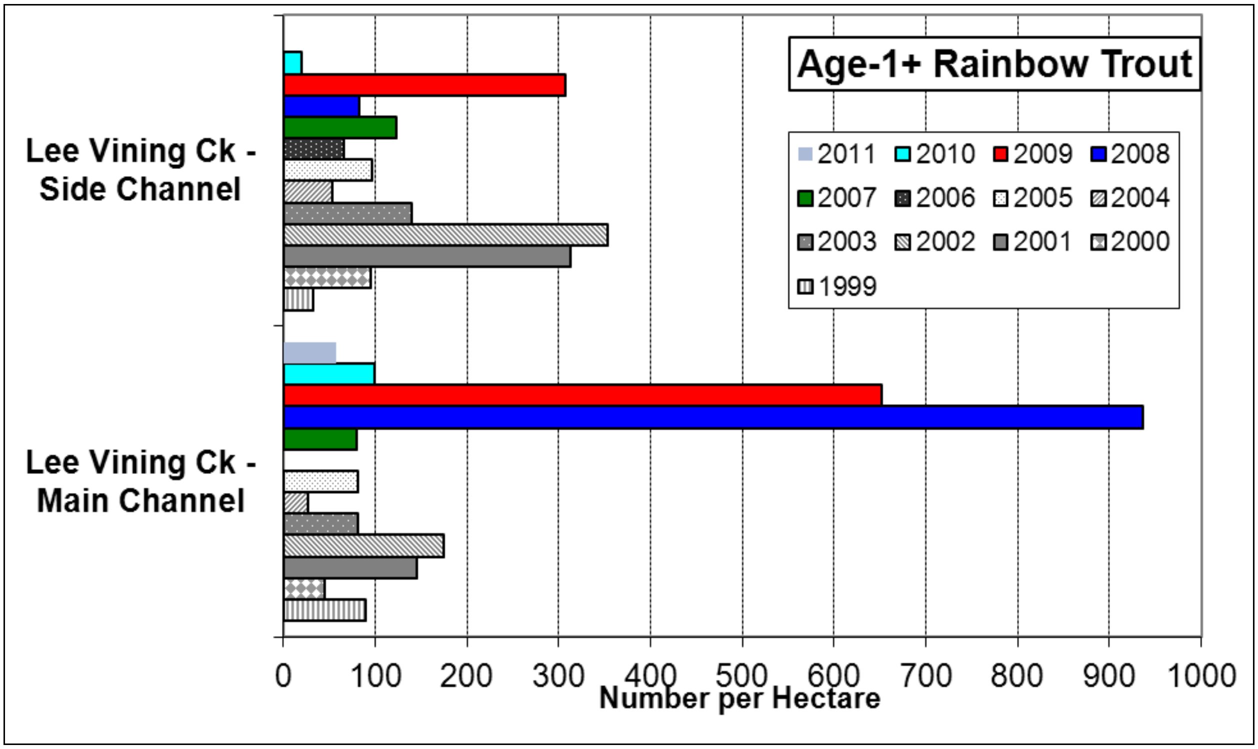


Figure 17. Estimated number of age-1 and older rainbow trout per hectare in sections of Lee Vining Creek from 1999 to 2011.

Between 2010 and 2011, estimated densities of age-0 brown trout increased in the Upper Rush Creek section and decreased in the Bottomlands and County Road sections (Figure 18). The Upper section's 2011 density estimate of 10,629.1 age-0 brown trout/ha was an 83% increase from the 2010 estimate of 5,836.4 age-0 brown trout/ha (Figure 18). The Upper section's 2011 density estimate of 10,629.1 age-0 brown trout/ha was the highest value for this section since the 2000 sampling season. The Rush Creek Bottomlands section had an estimated density of 2,217.7 age-0 brown trout/ha in 2011, which was a 32% decrease from the 2010 estimate of 3,130.3 age-0 brown trout/ha (Figure 18). The County Road section had an estimated density of 2,160.2 age-0 brown trout/ha in 2011, which was a 22% decrease from the 2010 estimate of 2,776.3 age-0 brown trout/ha (Figure 18).

In Walker Creek the density estimate of age-0 of brown trout decreased by 65% in 2011 (845.4fish/ha) from 2010 (2,391.8 fish/ha); this was the fourth consecutive decrease in age-0 brown trout densities since the estimate of 9,899.8 fish/ha in 2007 (Figure 18).

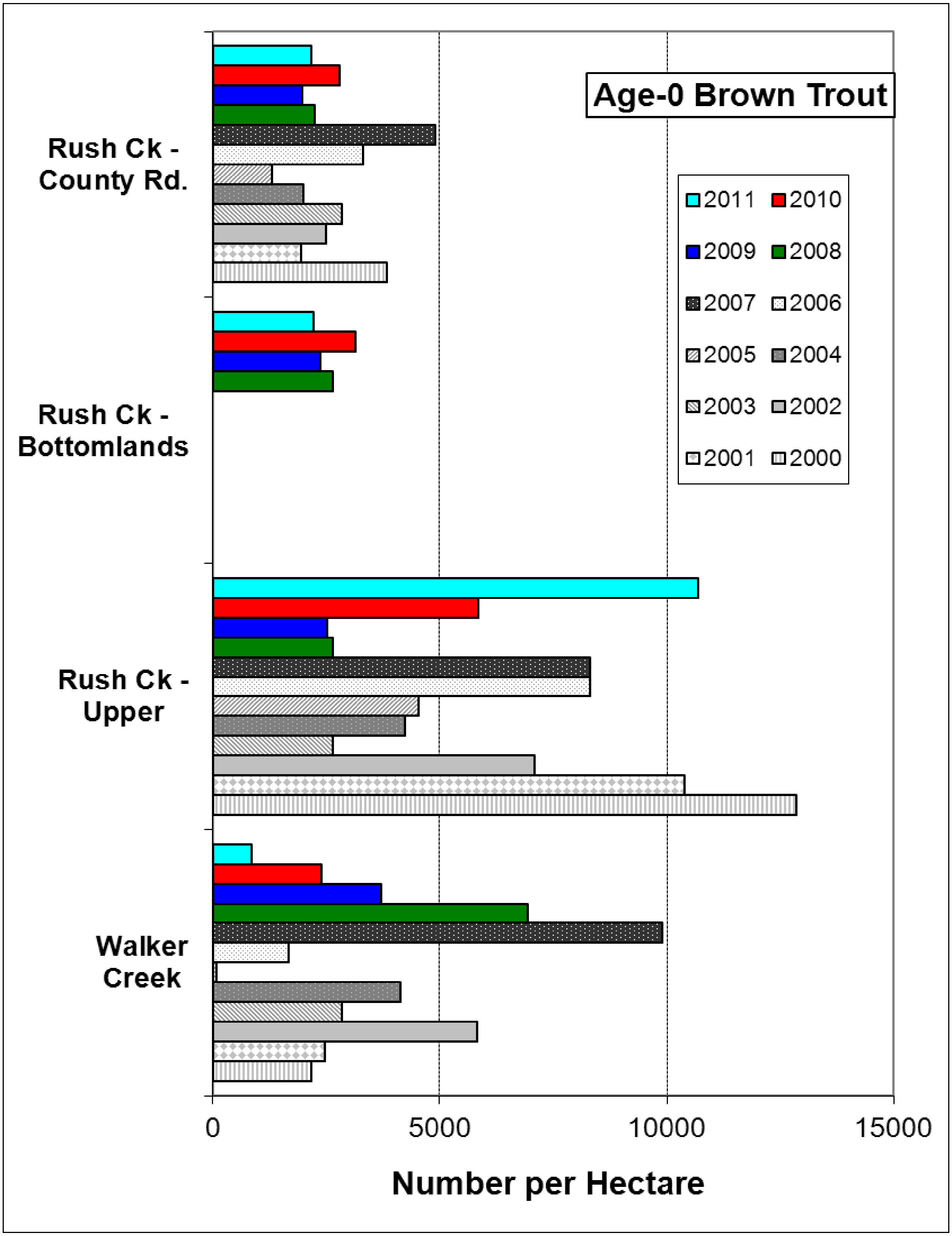


Figure 18. Estimated number of age-0 brown trout per hectare in sections of Rush Creek (bottom) and Walker creeks (top) from 2000 to 2011.

In 2011, the age-0 brown trout density estimate in the main channel section of Lee Vining Creek of 755.5 fish/ha was a 132% increase from the 2010 density estimate of 325.7 fish/ha (Figure 19). The 2011 density estimate of age-0 brown trout within the Lee Vining Creek side channel was 276.1 fish/ha, a slight increase from the 2010 estimate 256.4 fish/ha (Figure 19). The Lee Vining Creek side channel has supported very low densities of age-0 brown trout since the 2005 sampling season (Figure 19).

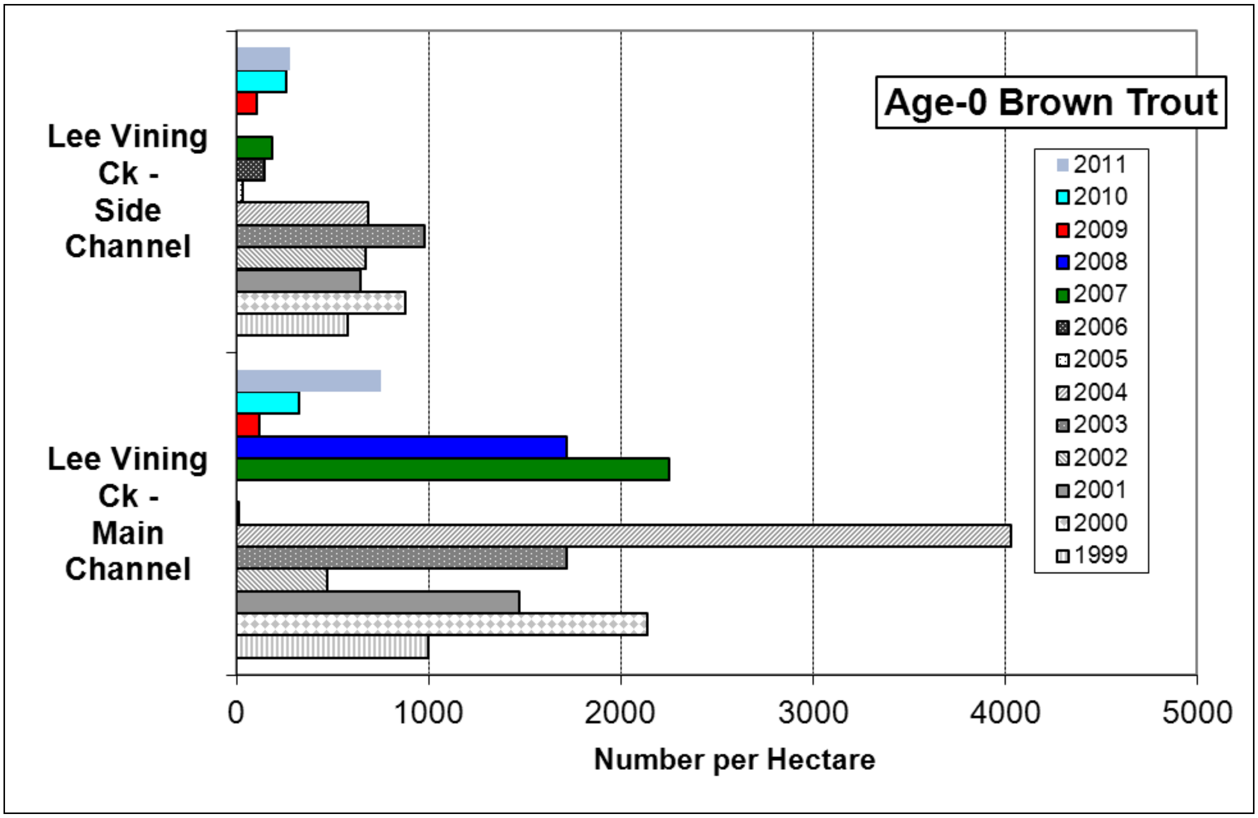


Figure 19. Estimated number of age-0 brown trout per hectare in sections of Lee Vining Creek from 1999 to 2011.

In 2011, a single age-0 rainbow trout was captured in the main channel section and no age-0 rainbow trout were captured in the side channel section of Lee Vining Creek (Figure 20). The single age-0 rainbow trout captured in the main channel section generated a density estimate of 7 fish/ha (Figure 20). The 2011 sampling season was the third straight year in which no age-0 rainbow trout were captured in the side channel section of Lee Vining Creek (Figure 20).

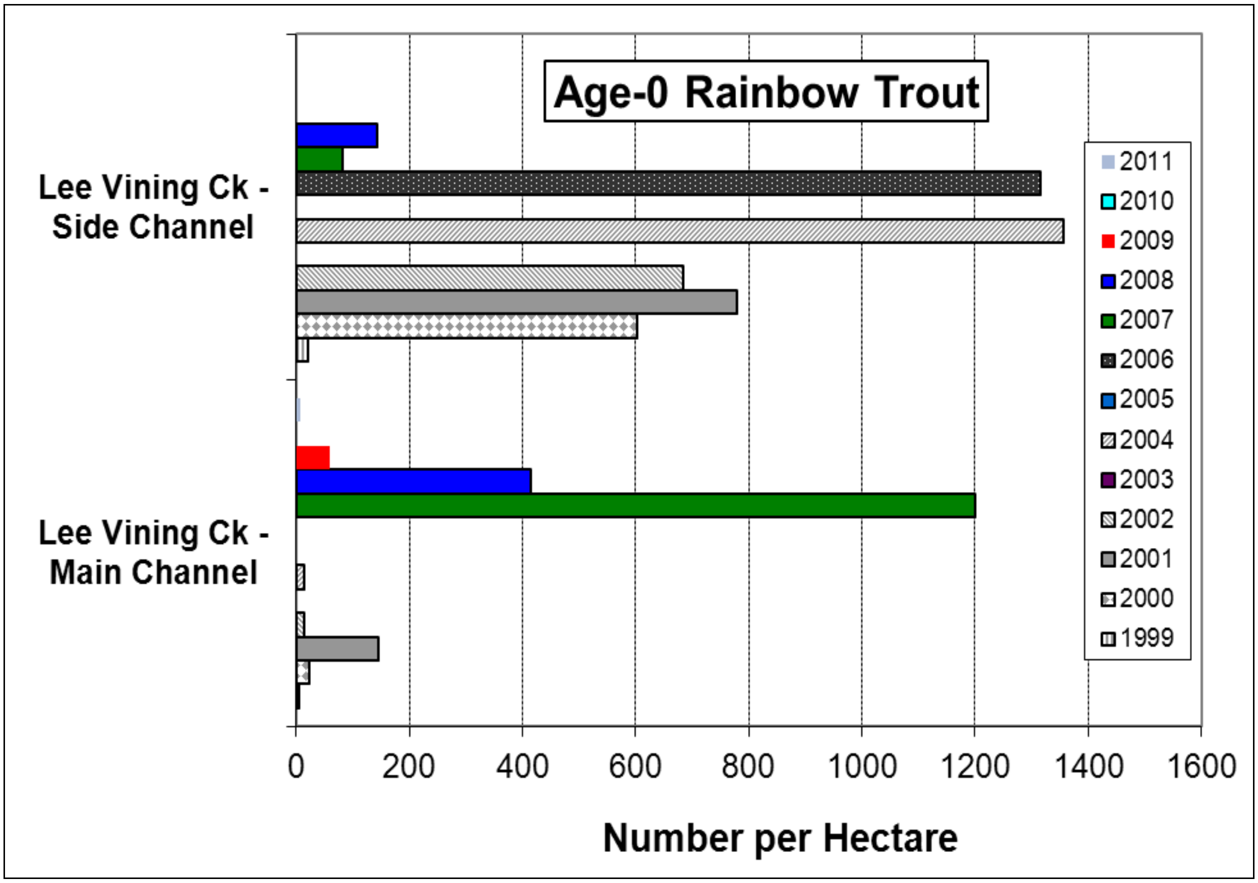


Figure 20. Estimated number of age-0 rainbow trout per hectare in sections of Lee Vining Creek from 1999 to 2011.

Estimated Trout Densities Expressed in Numbers per Unit Length

For termination criteria purposes, trout density estimates were also calculated by number of fish per kilometer of stream channel. In the Rush Creek sections the numbers of fish per kilometer were estimated for brown trout only (Table 20). In the Lee Vining Creek sections the numbers of fish per kilometer were estimated for brown and rainbow trout combined (Table 21). Lee Vining Creek trout densities per unit length were calculated separately for the main and side channel sections as well as combined using the additive approach decribed in Appendix B (Table 21).

In Rush Creek from 2010 to 2011, the County Road section experienced a 19% decrease in total numbers of brown trout per km, including a 16% decrease in the numbers of age-1 and older brown trout per km (Table 20). The Bottomlands section of Rush Creek experienced a 20% decrease in total numbers of brown trout per km, including a 3% drop in the numbers of age-1 and older brown trout per km (Table 20). For termination criteria evaluation, the 2011 trout/km density estimates for the County Road and Bottomlands sections fell below the 3,000 fish/km threshold.

The Upper Rush Creek section experienced an 89% increase in total numbers of brown trout per km, including a 110% increase in the numbers of age-1 and older brown trout per km (Table 20). For the Upper section, the numbers of age-1 and older brown trout per km estimated in 2011 was the highest estimate generated for the past 12 years of fisheries monitoring (Table 20).

In Lee Vining Creek from 2010 to 2011, the main channel section experienced a 76% increase in the total numbers of trout per km; however the numbers of age-1 and older trout per km decreased by 18% (Table 21). In 2011, the estimate of 258 age-1 and older trout per km in the main channel section was the second lowest estimate ever generated for this section (Table 21). From 2010 to 2011, the side channel section experienced a 36% increase in the total numbers of trout per km and the numbers of age-1 and older trout per km increased by 15% (Table 21). Compared to pre-2006 estimates, the 2011 estimate of 92 age-1 and older trout per km in the Lee Vining Creek side channel was quite small.

Table 20. Total number of brown trout per kilometer of stream channel for Rush Creek sample sections, 2000 - 2011. The value within (#) denotes the number of age-1 and older trout per kilometer.

Collection Location	2000 Total Number of Brown Trout per Km	2001 Total Number of Brown Trout per Km	2002 Total Number of Brown Trout per Km	2003 Total Number of Brown Trout per Km	2004 Total Number of Brown Trout per Km	2005 Total Number of Brown Trout per Km	2006 Total Number of Brown Trout per Km	2007 Total Number of Brown Trout per Km	2008 Total Number of Brown Trout per Km	2009 Total Number of Brown Trout per Km	2010 Total Number of Brown Trout per Km	2011 Total Number of Brown Trout per Km
Rush Ck- County Road	3,832 (725)	2,530 (942)	2,618 (536)	3,136 (764)	2,095 (641)	1,737 (641)	3,242 (702)	5,018 (1,400)	3,186 (1,346)	3,064 (1,611)	3,499 (1,222)	2,836 (1,021)
Rush Ck – Bottom-land	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3,579 (1,467)	2,962 (1,147)	3,405 (963)	2,732 (936)
Rush Ck- Upper	11,054 (1,547)	8,535 (837)	6,137 (900)	2,740 (791)	3,881 (495)	5,032 (1,167)	7,905 (1,100)	8,672 (1,609)	3,607 (1,267)	3,444 (1,186)	5,725 (881)	10,830 (1,849)

Table 21. Total number of brown and rainbow trout per kilometer of stream channel for Lee Vining Creek sample sections, 2000 – 2011. The value within (#) denotes the number of age-1 and older trout per kilometer.

Collection Location	2000 Total Number of Brown and Rainbow Trout per Km	2001 Total Number of Brown and Rainbow Trout per Km	2002 Total Number of Brown and Rainbow Trout per Km	2003 Total Number of Brown and Rainbow Trout per Km	2004 Total Number of Brown and Rainbow Trout per Km	2005 Total Number of Brown and Rainbow Trout per Km	2006 Total Number of Brown and Rainbow Trout per Km	2007 Total Number of Brown and Rainbow Trout per Km	2008 Total Number of Brown and Rainbow Trout per Km	2009 Total Number of Brown and Rainbow Trout per Km	2010 Total Number of Brown and Rainbow Trout	2011 Total Number of Brown and Rainbow Trout
Lee Vining - Main Channel	674 (337)	1,333 (567)	883 (729)	1,181 (355)	936 (568)	917 (910)	Not Sampled – too high of flow	2,116 (148)	2,357 (1,204)	1,129 (1,023)	506 (314)	893 (258)
Lee Vining - Side Channel	853 (112)	623 (287)	731 (369)	626 (154)	1,144 (165)	169 (154)	618 (48)	113 (46)	103 (67)	134 (108)	103 (36)	164 (92)
LV Main + Side Additive	764 (225)	978 (427)	807 (549)	904 (255)	1,040 (367)	543 (532)	Not combined in 2006	1,000 (91)	1,380 (711)	698 (627)	331 (193)	451 (187)

Estimated Trout Standing Crop Comparisons

In Rush Creek, brown trout standing crop estimates decreased from 2010 to 2011 in the County Road and Bottomlands sample sections, these sections also experienced decreases from 2009 to 2010 (Table 22 and Figure 21). In the County Road section, the 2011 estimated standing crop of 83.6 kg/ha was a 39% decrease from the 2010 estimate (Table 22 and Figure 21). In the Bottomlands section, the 2011 estimated standing crop of 90.5 kg/ha was a 22% decrease from the 2010 estimate (Table 22). In the Upper Rush section, the 2011 estimated standing crop of 224.5 kg/ha was a 46% increase from the 2010 estimate, and exceeded 200 kg/ha for the first time since 2000 (Table 22). Between 2010 and 2011, Walker Creek experienced a slight increase of 2% in estimated standing crop (Table 22 and Figure 21). In Lee Vining Creek total standing crops (brown and rainbow trout combined) increased by 39% between 2010 and 2011 in the side channel section, and increased by 6% in the main channel section (Table 23 and Figure 22).

Total standing crops have been estimated since 1999 to determine potential trends (Figures 21 and 22). Total standing crop takes into account the total biomass of fish per unit area, not necessarily the age-class structure of the trout populations. In Rush Creek, where brown trout have dominated the fish community, the County Road section's estimated total standing crop remained fairly constant from 2000 through 2005; followed by two straight seasons of increased production in 2006 and 2007; a nearly 30% decrease in 2008 (although this value was still higher than any estimated from 2000 through 2005); a nearly 70% increase in 2009; a slight decrease in 2010; and finally a large (39%) drop in 2011 (Figure 21). In the Rush Creek Upper section after the peak standing crop estimate in 2000; estimates declined for four straight years (2001 - 2004); followed by three consecutive seasons with estimates greater than 150 kg/ha; a 34% decrease in 2008 to 107.2 kg/ha; followed by two straight years of increases in 2009 and 2010; and finally a large (46%) increase in 2011 to 224.5 kg/ha (the highest value ever recorded for this section) (Figure 21). In addition to the record-high brown trout standing crop estimate, in 2011 the Upper Rush section also produced an estimated 18.5 kg/ha of rainbow trout (Figure 21). The relatively new Rush Creek Bottomlands section has experienced a 33% decrease in estimated standing crop between 2009 and 2011 after an increase between the first and second years of sampling (Figure 21). For the Bottomlands section, the 2011 total standing crop estimate was the lowest value recorded for the four years this section has been sampled (Figure 21).

In the MGORD section of Rush Creek, no standing crop estimate was generated for sample year 2011 (Figure 21). Standing crop estimates in the MGORD have generally been lower than estimates from other sections of Rush Creek, probably because substantial sections of the MGORD lack suitable cover habitat (i.e. elodea beds and willows along the stream banks) for brown trout, which significantly contribute to the overall surface area calculation for this section.

In Walker Creek, the 2011 total brown trout standing crop estimate was a slight increase (2%) from the previous year, and was substainily lower than the estimates for sample years 2007-2009 (Figure 21).

The Lee Vining Creek main channel section's total (brown and rainbow trout combined) standing crop estimate decreased by 25% between 2008 and 2009; then decreased by another 37% between 2009 and 2010; and then increased by 6% between 2010 and 2011 (Figure 22). The main channel's 2011 total standing crop estimate included a relatively small contribution of rainbow trout biomass (24% of the 2011 estimate compared to 44% in 2008 and 2009) (Figure 22). The Lee Vining Creek side channel section's total standing crop estimate in 2011 of 30.9 kg/ha was a 39% increase from the 2010 estimate of 22.3 kg/ha (Figure 22 and Table 23). The 2011 Lee Vining Creek side channel standing crop estimate was comprised solely of brown trout, the first time in the past 12 years that rainbow trout were completely absent from this estimate (Figure 22).

Table 22. Comparison of 2010-2011 brown trout standing crop (kg/ha) estimates in Rush Creek study sections.

Collection Location	2010 Total Standing Crop (kg/ha)	2011 Total Standing Crop (kg/ha)	Percent Change Between 2009 and 2010
Rush Creek - County Road	137.1	83.6	- 39%
Rush Creek - Bottomlands	115.1	90.5	- 22%
Rush Creek – Upper	153.4	224.5	+ 46%
Walker Creek	128.2	130.2	+2%

Table 23. Comparison of 2010-2011 total (brown and rainbow trout) standing crop (kg/ha) estimates in Lee Vining Creek study sections.

Collection Location	2010 Total Standing Crop (kg/ha)	2011 Total Standing Crop (kg/ha)	Percent Change Between 2009 and 2010
Lee Vining Creek - Main Channel	66.3	70.5	+6%
Lee Vining Creek - Side Channel	22.3	30.9	+39%

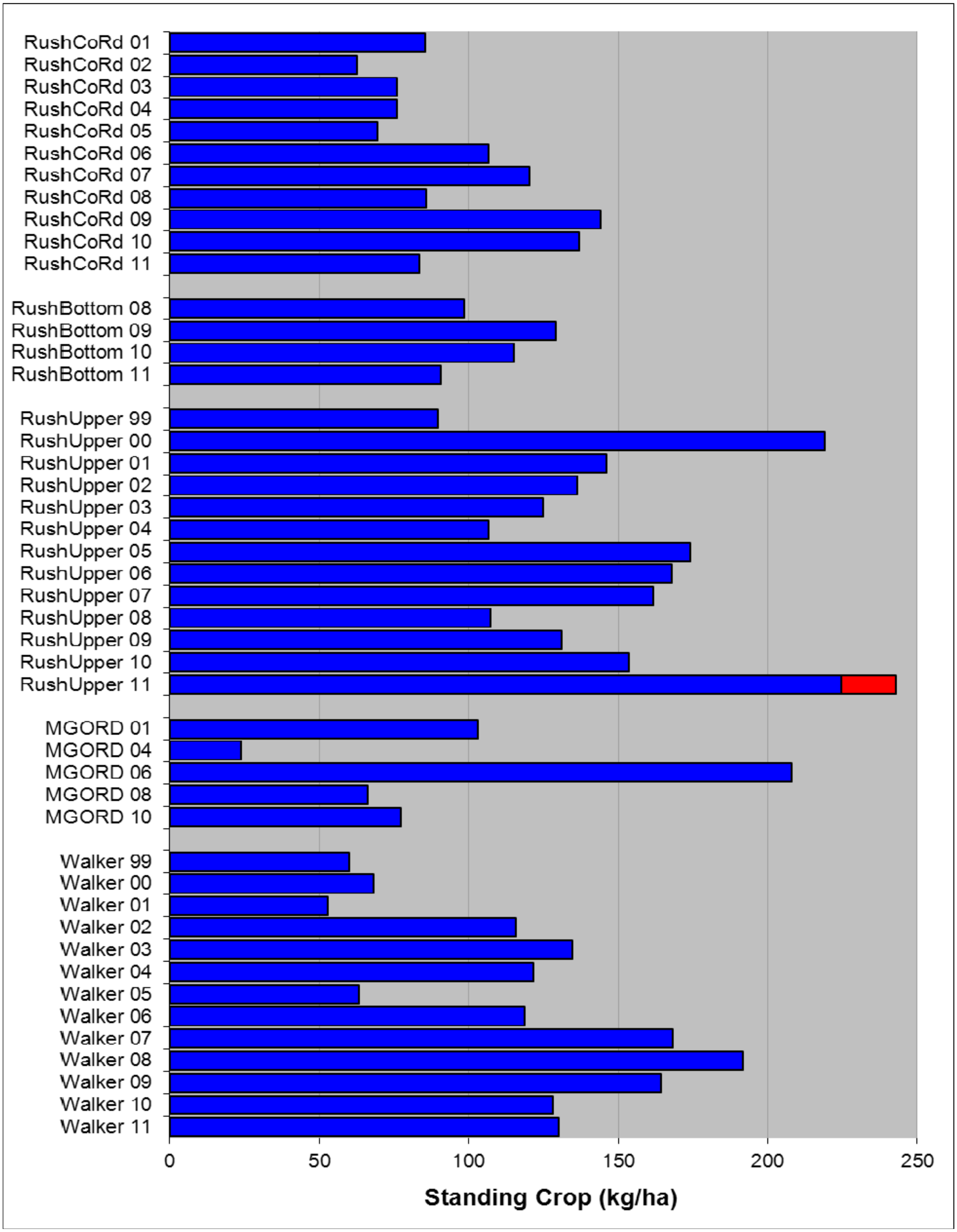


Figure 21. Estimated total standing crop (kilograms per hectare) of brown trout in all sample sections within Rush Creek, 1999-2011. Section and year are shown on the y-axis. Note: red denotes estimated standing crop of rainbow trout in Upper Rush section for 2011.

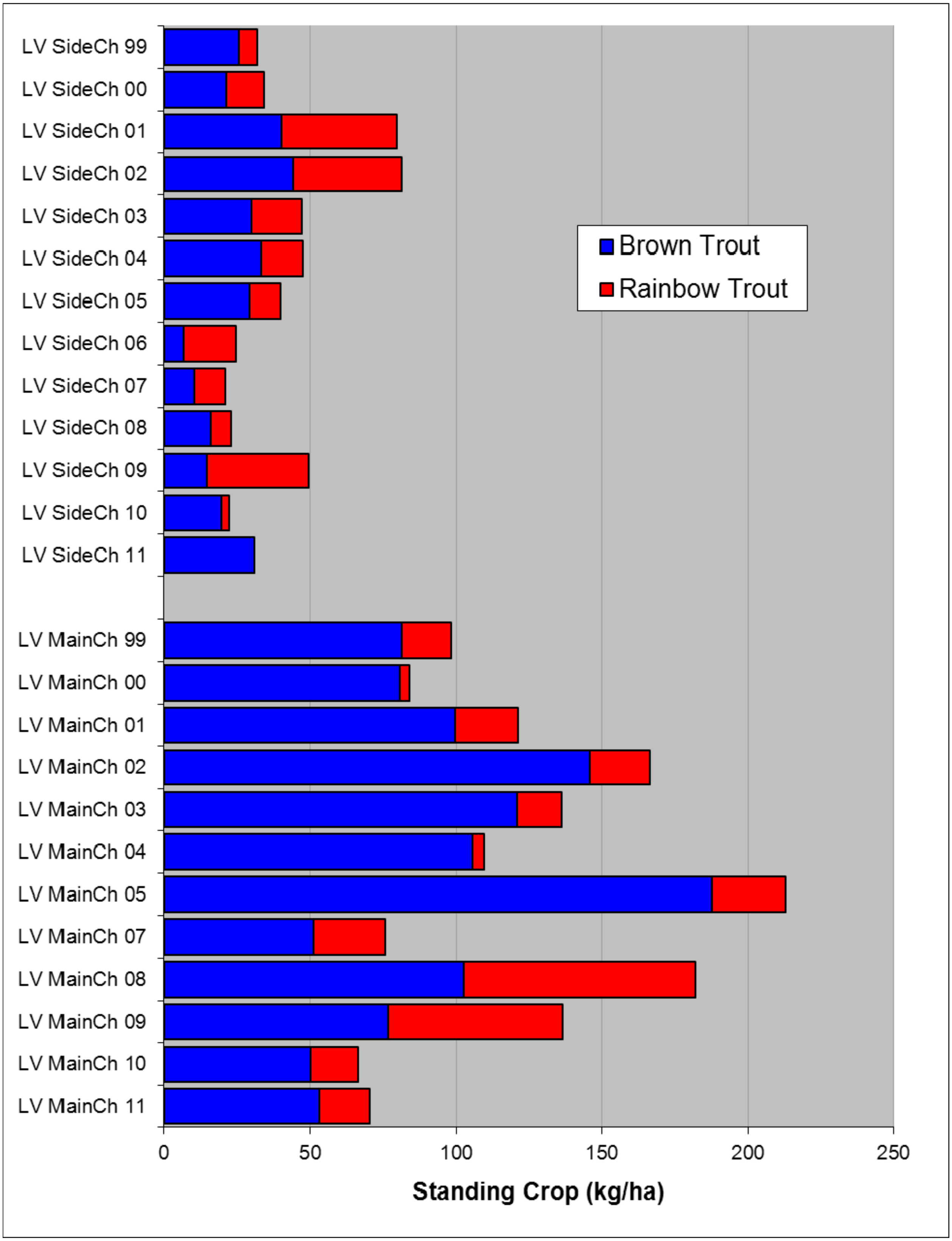


Figure 22. Estimated total standing crop (kilograms per hectare) of brown trout and rainbow trout in all sample sections within the Lee Vining Creek drainage, 1999-2011. Section and year are shown on the y-axis.

Relative Stock Density (RSD) Results for Rush and Lee Vining Creeks

RSD-225 values for brown trout in the three annually-sampled sections of Rush Creek decreased between 2010 and 2011 after experiencing substantial increases between 2009 and 2010 (Table 24). In the County Road and Bottomlands sections these decreases can be attributed to lower numbers of brown trout in the 225-299 mm range, which decreased the proportion of fish >225 mm at these sections. In the Upper section, the numbers of fish in the 225-299 mm range increased slightly, but the proportion of fish in the 150-224 mm range experienced a larger increase, thus the RSD-225 value decreased. In 2011, brown trout with lengths >300 mm were captured in all three Rush Creek sections (Table 24).

RSD-300 values remained low in the Upper Rush Creek section, with a decrease from 3 to 1 between 2010 and 2011, and one brown trout greater than 375 mm in length was sampled (Table 24). In 2011, the Rush Creek County Road section had an RSD-300 value of 1, the second straight season this section has recorded a RSD-300 value (Table 24). The Bottomlands section had an RSD-300 value of 1 in 2011, with three fish greater than 300 mm in length captured (Table 24).

The RSD-225 and RSD-300, values in the MGORD section of Rush Creek increased between 2010 and 2011, due primarily to the large decrease in numbers of fish between 150-224 mm in length (Table 24). The RSD-375 value for 2011 was 4, a slight decrease from the value of 5 for the 2010 sampling season (Table 24). The eight brown trout >375 mm captured in 2011 was, by far, the lowest number of larger fish ever caught in the MGORD section (Table 24). Also, in 2011 the total number of brown trout >150 mm captured in the MGORD was the lowest number of fish ever caught in this section (Table 24).

In the Lee Vining Creek main channel sample section, the 2011 RSD-225 value was 48 for all trout (brown and rainbow trout combined), a decrease of 13% from the 2010 RSD-225 value of 55 (Table 25). In 2011, the Lee Vining Creek main channel section had a RSD-300 value of 10, the highest RSD-300 value ever recorded for Lee Vining Creek (Table 25). In 2011, a total of six fish >300 mm in length (three brown trout and three rainbow trout) were captured in Lee Vining Creek, including a 400 mm wild rainbow trout.

Table 24. RSD values for brown trout in Rush Creek study sections, for 2000-2011.

Sampling Location	Sample Year	Number of Fish ≥150 mm	Number of Fish ≥150-224 mm	Number of Fish 225-299 mm	Number of Fish 300-374 mm	Number of Fish ≥375 mm	RSD-225	RSD-300	RSD-375
Rush Ck – Co Rd	2011	205	170	33	2	0	17	1	
Rush Ck – Co Rd	2010	302	228	71	2	1	25	1	
Rush Ck – Co Rd	2009	356	331	25	0	0	7	0	
Rush Ck – Co Rd	2008*	97	88	9	0	0	9	0	
Rush Ck – Co Rd	2007	591	518	73	0	0	12	0	
Rush Ck – Co Rd	2006	265	187	78	0	0	29	0	
Rush Ck – Co Rd	2005	209	162	47	0	0	22	0	
Rush Ck – Co Rd	2004	409	355	54	0	0	13	0	
Rush Ck – Co Rd	2003	449	384	64	1	0	14	0	
Rush Ck – Co Rd	2002	303	262	40	1	0	14	0	
Rush Ck – Co Rd	2001	418	378	37	3	0	10	1	
Rush Ck – Co Rd	2000	320	277	43	0	0	13	0	
Rush Ck - Bottomlands	2011	267	218	46	3	0	18	1	
Rush Ck - Bottomlands	2010	307	225	81	1	0	27	0	
Rush Ck - Bottomlands	2009	379	321	56	1	1	15	1	
Rush Ck - Bottomlands	2008	160	141	19	0	0	12	0	
Rush Ck – Upper	2011	498	381	110	6	1	23	1	
Rush Ck – Upper	2010	308	202	97	7	2	34	3	1
Rush Ck – Upper	2009	372	322	43	5	2	13	2	1
Rush Ck – Upper	2008	227	189	31	6	1	17	3	
Rush Ck – Upper	2007	282	210	61	9	2	26	4	1
Rush Ck – Upper	2006	233	154	69	10	0	34	4	
Rush Ck – Upper	2005	202	139	56	5	2	31	3	
Rush Ck – Upper	2004	179	112	64	2	1	37	2	
Rush Ck – Upper	2003	264	216	45	2	1	18	1	
Rush Ck – Upper	2002	220	181	35	1	2	18	2	1
Rush Ck – Upper	2001	223	190	27	6	0	15	3	
Rush Ck – Upper	2000	182	158	22	2	0	13	1	

*The relatively low number of fish captured ≥150 mm in 2008 is due to the shortening of the County Road section.

Table 24 (continued).

Sampling Location	Sample Year	Number of Fish ≥150 mm	Number of Fish ≥150-224 mm	Number of Fish 225-299 mm	Number of Fish 300-374 mm	Number of Fish ≥375 mm	RSD-225	RSD-300	RSD-375
Rush Ck - MGORD	2011	216	36	117	55	8	83	29	4
Rush Ck - MGORD	2010	694	252	292	115	35	64	22	5
Rush Ck - MGORD	2009	643	156	338	123	26	76	23	4
Rush Ck - MGORD	2008	856	415	301	118	22	52	16	3
Rush Ck - MGORD	2007	621	144	191	259	27	77	46	4
Rush Ck - MGORD	2006	567	60	200	280	27	89	54	5
Rush Ck - MGORD	2004	424	130	197	64	33	69	23	8
Rush Ck - MGORD	2001	774	330	217	119	108	57	29	14

Table 25. RSD values for brown and rainbow trout in the Lee Vining Creek main channel study section, for 2000-2011.

Sampling Location	Sample Year	Number of Fish ≥150 mm	Number of Fish ≥150-224 mm	Number of Fish 225-299 mm	Number of Fish 300-374 mm	Number of Fish ≥375 mm	RSD-225	RSD-300
Lee Vining Creek	2011	60	31	23	5	1	48	10
Lee Vining Creek	2010	62	28	32	2	0	55	3
Lee Vining Creek	2009	137	106	30	1	0	23	1
Lee Vining Creek	2008	149	138	11	0	0	7	0
Lee Vining Creek	2007	29	24	5	0	0	17	0
Lee Vining Creek	2006	NS	NS	NS	NS	NS	-	-
Lee Vining Creek	2005	60	37	20	2	1	38	5
Lee Vining Creek	2004	70	60	8	2	0	14	3
Lee Vining Creek	2003	52	27	23	2	0	48	4
Lee Vining Creek	2002	100	74	23	3	0	26	3
Lee Vining Creek	2001	90	71	16	3	0	21	3
Lee Vining Creek	2000	51	32	18	1	0	37	2

NS = not sampled due to high flow.

Termination Criteria Results

Prior to calculating the termination criteria values for the 2011 report, the annual data sets from 2007–2010 were proofed, the Access data bases against original hard copies. Summaries of these four annual data sets are located in Appendix D. The following four tables summarize the termination criteria analyses of three-year running averages for the Rush Creek and Lee Vining Creek sample sections (Tables 26-29). In Rush Creek, none of the annually sampled sections met the target of meeting four out of five termination criteria for the most-recent three-year average which encompassed 2009-2011 (Tables 26 and 27). The County Road section met only one of the five termination criteria (density) and the Upper Rush section met two of the five termination criteria (density and condition factor) (Tables 26 and 27).

Table 26. Termination criteria analyses for the County Road section of Rush Creek. Bold values indicate that an estimated value met the termination criterion.

Termination Criteria	2009 – 2011 Average	2008 – 2010 Average	2007 – 2009 Average
Biomass (≥175 kg/ha)	121.5	122.2	116.8
Density (≥3,000 fish/km	**3,132.6**	**3,249.3**	**3,753.7**
Condition Factor (≥1.00)	0.97	0.95	0.94
RSD-225 (≥35)	16	14	9
RSD-300 (≥5)	1	0	0
Conclusion	**Met one of five TC**	**Met one of five TC**	**Met one of five TC**

Table 27. Termination criteria analyses for the Upper section of Rush Creek. Bold values indicate that an estimated value met the termination criterion.

Termination Criteria	2009 – 2011 Average	2008 – 2010 Average	2007 – 2009 Average
Biomass (≥175 kg/ha)	169.6	130.6	133.7
Density (≥3,000 fish/km	**6,663.7**	**4,259.0**	**5,249.7**
Condition Factor (≥1.00)	**1.00**	**1.00**	0.99
RSD-225 (≥35)	24	21	19
RSD-300 (≥5)	3	3	3
Conclusion	**Met two of five TC**	**Met two of five TC**	**Met one of five TC**

The MGORD section of Rush Creek met only one of three RSD termination criteria (RSD-225) for the average of years 2009-2011 (Table 28). The RSD-375 average for 2009-2011failed to meet termination criteria due to two consecutive years (2009 and 2011) where low (less than 5) values were recorded (Table 28).

Table 28. Termination criteria analyses for the MGORD section of Rush Creek. Bold values indicate that an estimated value met the termination criterion.

Termination Criteria	2009 - 2011 Average	2008 - 2010 Average	2007 - 2009 Average
RSD-225 (≥60)	**74**	**64**	**68**
RSD-300 (≥30)	25	20	28
RSD-375 (≥5)	4	4	4
Conclusion	**Met TC one of three RSD values**	**Met TC one of three RSD values**	**Met TC one of three RSD values**

In Lee Vining Creek, the main channel section failed to achieve the target of meeting three out of four termination criteria (Table 29). For the 2009-2011 period, the main channel section met two of the four termination criteria (condition factor and RSD-225) (Table 29). For the 2011 annual report we have also provided separate condition factors for brown trout and rainbow trout (Table 29). Finally, for the 2011 report we re-calculated termination criteria values of biomass and density using the additive approach described in Appendix B. These additive values are reported within the parentheses in Table 29.

Table 29. Termination criteria analyses for Lee Vining Creek's main channel section. Bold values indicate that an estimated value met the termination criterion. Values within parentheses are additive values of main and side channel sections.

Termination Criteria	2009 - 2011 Average	2008 - 2010 Average	2007 - 2009 Average
Biomass (≥150 kg/ha)	93.6 (76.7)	134.6 (103.6)	131.1 (103.9)
Density (≥1,400 fish/km	462.3 (493.3)	734.7 (803.0)	1,003.0 (1,026.0)
Condition Factor (≥1.00)	Browns = **1.06** Rainbows = **1.15**	Browns = **1.04** Rainbows = **1.11**	Browns = **1.04** Rainbows = **1.07**
RSD-225 (≥30)	**42**	28	16
Conclusion	**Met two of four TC**	**Met one of four TC**	**Met one of four TC**

Discussion

The 2011 sampling year was the thirteenth consecutive year in which fish population data were collected in Rush and Lee Vining creeks with the methods refined from the two years of pilot studies (1997 and 1998). The year 2011 was also marked by a wet runoff year in which peak flows that exceeded 500 c.f.s. exerted significant influence on the creeks' channels and floodplains. During 2011, a Facilitated Process was initiated to address feasibility issues raised by LADWP in regards to delivering the streamflows recommended in the Synthesis Report by the Stream Scientists (M&T and RTA 2010). The recommended flow changes for improving the growth and survival of trout included: (1) lowering winter baseflows in both Rush and Lee Vining creeks to increase preferred trout holding habitat and to increase storage in GLR, (2) maintaining higher storage levels in GLR to improve summer thermal conditions in Rush Creek, and (3) modifying the receding limb of Rush Creek's hydrograph to improve summer thermal conditions. Additional recommendations generated from McBain and Trush's studies addressed geomorphic and riparian ecosystem functions (M&T and RTA 2010).

Due to extremely low GLR storage levels (winter 2008-2009) and two SWRCB flow variances (winters 2009-2010 and 2010-2011), winter baseflows in Rush and Lee Vining creeks have been within the ranges recommended by the Stream Scientists for two consecutive winters in Lee Vining Creek and for three consecutive winters in Rush Creek. Both creeks also experienced two consecutive runoff years in which peak flows were ≥500 c.f.s. Finally, the 2011 field season was the second year of recapturing PIT tagged fish for specific growth data and the third season of implanting PIT tags in fish on Rush, Walker and Lee Vining creeks.

The Discussion section of this annual report focuses on the response of the Rush Creek trout population to the adjusted winter baseflows, effects of wet runoff year peak flows, a discussion of growth information from recaptures of PIT tagged fish, a termination criteria review, and a methods evaluation. Future fisheries monitoring should focus at evaluating responses of the fish populations to flow regimes recommended in the Synthesis Report or whatever flow regimes are prescribed in an amended license issued by the SWRCB.

In addition to the annual fisheries monitoring sampling conducted in September of 2011, the fisheries monitoring team also completed a pool/habitat survey on Rush and Lee Vining creeks, and completed the second season of collecting data for the primary productivity study. Separate reports for these studies will be completed by June of 2012.

Brown Trout Responses to Winter Baseflows

In the 2009 annual report we speculated that the low flows released into Rush Creek from October 2008 through the spring of 2009 may have caused a reduction in the numbers of age-0 brown trout as documented in September of 2009 (Taylor et al. 2010). For example, the 2009 estimated density of age-0 brown trout in the Upper section of Rush Creek was the lowest observed for the 12 years of the recent sampling record. In the 2009 report we suggested that an examination of the 2010 data could determine if the 2009 low age-0 recruitment translated into much lower densities of age-1 brown trout compared to previous years. In 2010, the densities of age-1 brown trout were reduced by 17% to 32% in the three annually sampled sections, so it does appear that the reduced numbers of age-0 fish in 2009 translated into lower densities of age-1 fish in 2010. It also appears that the reduced numbers of age-1 fish in 2010 translated into fewer age-2 in 2011, at least in the County Road and Bottomlands sections. The population estimates of fish >200 mm dropped from 149 fish to 69 fish in the County Road section and from 128 fish to 105 fish in the Bottomlands section.

However, reduced baseflows also occurred during the winter of 2009-2010 and the estimated densities of age-0 brown trout increased in 2010 from the 2009 values. The increases were quite large too, ranging from 33% in the Bottomlands section to 132% in the Upper section. The reduced baseflows during the winter of 2010-2011 were followed by decreases in densities age-0 brown trout in the County Road and Bottomlands sections of 22% and 32%, yet estimated densities of age-0 brown trout in the Upper section increased by 86%. Thus, from these three years of age-0 brown trout density data, it is still inconclusive what effect, if any that lower winter baseflows may have on recruitment of age-0 fish.

The primary objective of the winter baseflow recommendation was to increase the amount of holding habitat for over-wintering brown trout, which would ultimately increase the survival of older, and thus larger, fish in lower Rush Creek (downstream of the Narrows). To test the response of the fishery, we examined the annual densities of brown trout >255 mm (>10 inches), the minimum length of age-4 fish at the County Road and Bottomlands sections in 2011as determined by PIT tag return data and length-frequency histograms, to see if there were any trends in the densities of these older and larger fish in lower Rush Creek from September 2000-2011.

At the Bottomlands section, which was first sampled in 2008, there was a definite increase in the densities of older and larger brown trout following implementation of lowered winter baseflows. In 2008, no brown trout >255 mm in length were captured in this section. In 2009, the first year after lowered winter baseflows were implemented, the estimated densities of brown trout >255 mm in length increased to 39 fish/ha and 30 fish/km, and then nearly doubled to 73 fish/ha and 57 fish/km in 2010, before dropping slightly in 2011 (Table 30).

The County Road section has been annually sampled since 2000, and thus provided a more long-term record to evaluate the benefits of lowered winter baseflows. The length and area of this section has changed from year to year, but conversion of the fish population estimates to per-unit-area and per-unit-length density estimates allowed for accurate comparisons among the 12 years. As at the Bottomlands section, the highest densities of brown trout >255 mm in length at the County Road section were in 2010, when 93 fish/ha and 76 fish/km were estimated (Table 30). These density values were two to three times higher than during 2006 (37 fish/ha and 28 fish/km), which were the highest density estimates for brown trout >255 mm at this section during the nine year period from 2000-2008.

To further quantify the benefits of lowered winter baseflows, mean density estimates for brown trout >255 mm in lower Rush Creek during three time periods were summarized at the bottom of Table 30. The lowest mean density values were for the period from 2000-2005, when only 16 fish/ha and 12 fish/km were estimated. Following the high runoff years in 2005 and 2006, more large pool habitat was present in lower Rush Creek (Knudson et al. 2009). This increase in habitat probably accounts for the somewhat higher mean densities of larger brown trout at this section from 2006-2008 (24 fish/ha and 19 fish/km). The highest mean densities were present from 2009-2011, when 48 fish/ha and 39 fish/km were estimated at the County Road section and 59 fish/ha and 47 fish/km at the Bottomlands (Table 30). A final measure of the benefits of lowered winter baseflows, perhaps more from an angler's perspective, can be seen on the last column of Table 30, which shows the approximate number of >255 mm (>10 inch) brown trout per 100 m (a reasonable length of stream to fish in an hour or so). During 2010-2011 there were roughly four to eight of these larger brown trout to (at least potentially) catch per 100 m, compared to only one or two brown trout >255 mm per 100 m during most of the years from 2000-2009.

The lower winter baseflows recommended in the Synthesis Report, which were implemented from 2009-2011, appeared to substantially increase the density of older and larger brown trout in lower Rush Creek. Unfortunately, during the winter of 2011-2012 LADWP decided to return to the higher winter baseflow rates that had been earlier prescribed in Order 98-05 (which were essentially the winter flows that were present from 2000-2008). This return to the 98-05 prescribed winter flow levels may confound interpretations of the benefits of lower winter baseflows into the future, and may result in lower densities of larger brown trout at the Bottomlands and County Road sections, at least during 2012.

In Lee Vining Creek, the over-riding factor constraining the consistent production of older and larger trout still appears to be the scarcity of pools or runs that provide suitable, low-velocity holding habitat. The pool surveys and habitat typing documented the low abundance of pools within the lowermost 10,000 ft of Lee Vining Creek (Knudson et al. 2009). Pool/habitat data collected in September 2011 found that pool habitat has decreased in Lee Vining Creek since the 2009 survey. For example, the largest Class 5 pool above the County Road ford that was measured in 2009 was filled with bedload and reduced to a riffle after the high, sustained runoff of 2011. We will discuss in further detail Lee Vining Creek's trout habitat in the 2011 pool/habitat report due May 2012. Low recruitment of age-0 trout during average and wetter runoff year types also affects the numbers of fish available for survival to older age classes. In past annual reports we have mentioned this as a probable cause of the sporadic up-and-down nature of age-0 recruitment in Lee Vining Creek and the carry-over to densities of age-1 and age-2 fish (Hunter et al. 2000-2008). In Appendix D of the Synthesis Report we analyzed Lee Vining Creek water temperature data and determined that the emergence of brown trout frequently occurred during, or just after, the peak snowmelt period (M&T and RTA 2010). Thus, in average and wetter year types, age-0 brown trout are either still residing as alevins in the streambed substrate or are weak-swimming, newly emerged fry when peak flows moblize the channel bed. The typically sharp rising and falling limbs of Lee Vining Creek's hydrograph probably create unfavorable conditions for newly emerged fry to maintain positions along channel margins.

Table 30. Total catch, population estimates, and densities for brown trout >255 mm (>10 inches) in length at the Bottomlands and County Road sections of Rush Creek during September 2000–2011. Catch numbers were used for density estimate calculations whenever there were less than four recaptures.

Sample Section	Year of Sampling	Section Area (ha)	Section Length (km)	Fish >255 mm on Mark Run (M)	Fish >255 mm on Recap Run (C)	Clipped Fish >255 mm on Recap Run (R)	Total Catch of Fish ≥255 mm	Population Estimate	Number per Hectare	Number per Kilometer	Approx. Number per 100 Meters
Rush Creek Bottom-lands	2011	0.3540	437	19	12	10	21	23	65	53	5
	2010	0.3409	437	20	14	11	23	25	73	57	6
	2009	0.3365	437	11	6	5	12	13	39	30	3
	2008	0.3496	437	0	0	0	0	0	0	0	0
Rush Creek County Road	2011	0.2764	329	9	7	5	11	12	43	36	4
	2010	0.2698	329	20	16	13	23	25	93	76	8
	2009	0.2435	329	2	2	2	2	N/P	8	6	1
	2008	0.1943	237	2	2	1	3	N/P	15	13	1
	2007	0.6016	813	7	9	5	11	12	20	15	2
	2006	0.6260	813	13	12	2	23	N/P	37	28	3
	2005	0.6829	813	7	1	1	7	N/P	10	9	1
	2004	0.5935	813	9	9	5	13	16	27	20	2
	2003	0.6829	813	9	8	6	11	12	18	15	2
	2002	0.6504	813	6	7	4	9	10	15	12	1
	2001	0.4878	813	9	6	6	9	10	21	12	1
	2000	0.4878	813	3	3	3	3	N/P	6	4	<1
					2000-2005 Mean Values at Co. Road				16	12	1
					2006-2008 Mean Values at Co. Road				24	19	2
					2009-2011 Mean Values at Co. Road				48	39	4
					2009-2011 Mean Values at Bottomlands				59	47	5

For the past two years, peak flows in Lee Vining Creek have exceeded 500 c.f.s. and recruitment of age-0 brown has been low when compared to the 13 years of annual data. The recruitment of age-0 rainbow trout has also been very low for the past two years. No age-0 rainbow trout have been sampled in the Lee Vining Creek side channel for three straight years and numbers of age-0 rainbow trout in the main channel section have been too low for generating population estimates for three straight years as well. As of mid-April 2012, it appears that Lee Vining Creek will most likely experience lower peaks flows during RY2012, and we should expect an improvement in the recruitment of age-0 rainbow trout. However, the past several years of low rainbow trout recruitment may ultimately affect the numbers of age-0 fish produced in 2012 due to low numbers of spawning aged fish.

Trout Growth between 2010 and 2011

In 2011, 86 age-1 fish with adipose fin-clips were recaptured in the three annually sampled sections of Rush Creek that had PIT tags when scanned with a tag reader (Table 12). In the County Road and Bottomlands sections the average growth rates of age-0 to age-1 fish for the one year between 2010 and 2011 were slightly (3 to 4 g) lower than growth rates of age-0 to age-1 fish for the one year between 2009 and 2010 (Table 31). In the Upper Rush section, the average growth of age-0 to age-1 fish between 2010 and 2011 was the same as the growth between 2009 and 2010 (Table 31). However, the 2010-2011 growth rates were still higher than the age-0 to age-1 growth rates documented during the dry RY2007 (Table 31). Across all four years where we have data, growth rates of brown trout in Rush Creek between age-0 and age-1 have consistently increased from the County Road to the Bottomlands to the Upper Rush sampling sections (Table 31). The 2011 PIT tag returns also confirmed that higher growth rates in Upper Rush also occurred between age-1 and age-2. In the Upper Rush section, brown trout averaged 73g/yr of growth between age-1 and age-2, compared to an average of 32g/yr in the Bottomlands section and an average of 46g/yr in the County Road section (Table 14).We speculate this gradient in growth may be attributed to one or more of the following reasons: 1) the Upper Rush section is closer to the Grant Lake Reservoir outfall, which is a source of organic and nutrient enrichment, 2) more favorable thermal and dissolved oxygen regimes for growth occur higher in the stream system, 3) slight differences in emergence timing with fish emerging earlier higher in the stream system, or 4) differences in parental genetics as in some age-0 fish in Upper Rush may be progeny of larger brown trout from the MGORD.

Table 31. Growth (g) comparisons of Rush Creek age-0 to age-1 brown trout in years 2006-2007, 2008-2009, 2009-2010, and 2010-2011 with adipose fin clips administered during the 2006 and 2008 sampling seasons and PIT tags implanted in the 2009 and 2010 season, respectively.

	Co. Rd. Rush Creek	Bottomlands Rush Creek	Upper Rush Creek
2006-2007 Growth (g)	25	N/A	32
2008-2009 Growth (g)	41	43	51
2009-2010 Growth (g)	36	40	48
2010-2011 Growth (g)	33	36	48

The PIT tag return data continues to provide additional insights about brown trout growth in Rush Creek. One interesting aspect is that as fish survive past age-2, their growth rates appear to decrease. This aspect of brown trout biology has been noted by other researchers and in one study was attributed to onset of sexual maturity and a different physiological allocation of protein intake (Vøllestad et al. 2002). This difference in the growth rates of older brown trout was more apparent in the late summer prior to the upcoming spawning season (Vøllestad et al. 2002). The probable length-at-age data for Rush Creek brown trout presented in Table 17, in conjunction with the declining growth rates as fish age has implications when considering the termination criteria regarding the availability of older and larger fish. Given that an age-3 brown trout in Rush Creek downstream of the Narrows is between 230–255 mm in length (Table 17), these fish probably need to survive to at least age-5 to exceed 300 mm in length and contribute towards the calculation of an RSD-300 value. Hopefully in 2012, we will recapture some age-4 PIT tagged fish to better determine growth rates between age-3 and age-4 and be better able to assess the likelihood of lower Rush Creek's brown trout population attaining an age-class structure where at least 5% of the catchable fish are >300 mm in length.

The PIT tag data collected to date continues to show that brown trout growth in the MGORD is excellent for younger fish, but tapers off as fish exceed 300 mm in length. As previously reported, many (52%) of the fish captured in 2010 that were >300 mm in length when PIT tagged, lost weight between 2009 and 2010 (Taylor et al 2011). Between 2010 and 2011, the growth of fish >300 mm improved and only 12% (two of 17 fish) of the fish captured in 2011 exhibited weight loss. We suspect that the widespread presence of deep, slow-water habitat and overhead cover that is present within the MGORD during most of the year allow brown trout to live longer than in other sections of Rush Creek, and that some MGORD fish experience the effects of senescence (biological aging that occurs after an organism reaches maturity). However, the 2011 sampling in the MGORD showed that weight loss in larger fish is not necessarily a one-way phenomenon. For example, a 338 mm/357 g brown trout PIT tagged in 2009 (tag #7025228) grew 2 mm and lost 44 g between 2009 and 2010. This same fish was captured again in 2011 and had grown 21 mm and gained 67 g between 2010 and 2011. Its 2011 weight of 380 g was 23 g more than its 2009 weight.

Finally, in 2011 we recaptured another age-1 brown trout in the MGORD that was PIT tagged the previous year as an age-0 fish in the Upper Rush section. In 2010, five age-1 recaptures in the MGORD were tagged as age-0 fish in Upper Rush. These documented movements of juvenile fish from Upper Rush to the MGORD continue to strengthen the connection that the MGORD population of brown trout have with the natural channel downstream. During the movement study approximately 50% of the radio tagged fish moved out of the MGORD for spawning purposes for two consecutive spawning seasons (Taylor et al. 2009b). However, as with most radio telemetry studies, it was difficult to have confidence in extrapolating the migration behaviors of a few tagged MGORD fish to the rest of the population. We had speculated that a relatively large number of brown trout may leave the MGORD during the fall-early winter for spawning, but had no means to assess this degree of movement. Over the past three seasons we have implanted PIT tags in more than 1,200 MGORD fish and will most likely tag another 200-300 fish in September of 2012. We recommend that LADWP consider monitoring the fall-early winter movement of brown trout out of the MGORD with an array of PIT tag hoop antennas and tag readers set up at the lower end of the MGORD. A temporary array of hoop antennas in conjunction with weir panels to funnel the fish through the hoops could be installed and operated (for three to four months) for a relatively low cost and provide detailed information about spawning movements of a much larger segment of the MGORD trout population than the radio telemetry study did. A more in-depth evaluation of the movement patterns of MGORD fish may provide LADWP better information in selecting potential alternatives for altering GLR's outlet to allow reliable delivery of the Stream Scientists' peak flow recommendations in wetter year types. One GLR outlet reconfiguration alternative presented by LADWP during the Facilitated Process involves terminating the release of streamflow down the MGORD.

Termination Criteria Discussion

The stream and fisheries monitoring programs were originally described in Order 98-05 as the means for the Stream Scientists to evaluate the prescribed SRF flows. Section 1a.2e of Order 98-05 also stated the Stream Scientists "shall make a recommendation to the SWRCB regarding any recommended actions to preserve and protect the streams". The evaluation of the SRF flows was to occur after an eight to ten year period. Order 98-05 (section 1b.4a) also described when the stream monitoring programs may be "terminated". This termination point would identify when the streams and trout fisheries had reached recovery, thus signaling the end of the monitoring programs. The SWRCB would make this determination based on consideration of "whether fish are in good condition" and this would include "self-sustaining populations of brown trout and other trout similar to those that existed prior to diversion of water by the Licensee and which can be harvested in moderate numbers".

The termination criteria (TC) were further described and defined in Order 98-07, which also provided the Stream Scientists the latitude to select the metrics to measure TC using repeatable and quantifiable methods. Chris Hunter made such an effort in 2007 to define the metrics and values that would signal "recovery" (Hunter 2007). His primary rationale behind this effort was that was little or no quantifiable data that characterized the pre-1941 fisheries in Rush and Lee Vining creeks (Hunter 2007). When Hunter presented his TC document to the SWRCB, LADWP and the interested parties there appeared to be acceptance of the metrics; however the values presented to signify recovery were contentious. There was never any formal acceptance or rejection of Hunter's proposed TC metrics or values by the SWRCB, but starting with the 2008 annual report the fisheries monitoring team has used these metrics and values in their TC analyses.

In the Synthesis Report, the Stream Scientists suggested "that the TC specified in Order 98-07 have served their purpose in guiding a quantitative assessment of stream ecosystem recovery over the past 12 years, but have limited utility in the next phase of instream flow implementation and monitoring". We still support this statement and recommend that future monitoring is tailored to assess instream flows that are eventually prescribed by the SWRCB in an amended license to LADWP. The metrics of

biomass, condition factor and age-class structure of the trout populations should still be considered as valid criteria to assess the fisheries' responses to future flow regimes.
In reviewing the past 13 years of annual fisheries data, the TC analyses, and the additional studies that were conducted; the emerging status of Rush and Lee Vining creek's fisheries includes the following:

Rush Creek:

1. Brown trout are the dominant species in Rush Creek, comprising more than 95% of the fish sampled over the past 13 years.
2. Ample annual recruitment of age-0 fish occurs. Adequate numbers of age-0 fish are produced on a consistent basis.
3. Elevated summer water temperatures affect the growth and condition factors of brown trout during drier year-types. Managing GLR to maintain adequate storage levels (at or above 20,000 acre-feet) during the summer is the best tool LADWP has to moderate elevated water temperatures in Rush Creek. Parker and Walker creeks also provide cooler inflow to lower Rush Creek.
4. Larger brown trout (>300 mm) are uncommon in Rush Creek, except for the MGORD. Testing of the Stream Scientist's recommended lower winter base flows coincided with measureable density increases of larger trout (>255 mm) in Rush Creek downstream of the Narrows.
5. The lower Rush Creek channel currently contains better brown trout habitat than it did prior to the start of the monitoring program. Large, channel-forming flows in wetter year-types are important to the system. The complexity of habitat within pools will continue to improve as the riparian vegetation matures and LWD is recruited to the channel; however this final enhancement of trout habitat is many years away from happening.
6. The TC metric of biomass (≥175 kg/ha) has not been met for any of the three-year averages, but the Upper Rush section has come close to or exceeded 175 kg/ha in three individual years (2000, 2005, and 2011). The most recent (2009-2011) three-year average of 169.6 kg/ha is the closest to reaching the biomass recovery value. The County Road and Bottomlands sections have failed to exceed 150 kg/ha in any individual sampling year.
7. The TC metric of density (3,000 fish/km) is being met consistently in all Rush Creek sections, due primarily to the large numbers of age-0 fish.
8. The TC metric of condition factor ≥1.00 has been met in some years, but all three-year averages have been right at 1.00. Individually, very few Rush Creek fish have condition factors >1.10. Lower condition factors are most likely influenced by summer water temperatures and possibly by high densities of age-0 fish.
9. The TC metrics of RSD-225 and RSD-300 have not been met in either the County Road or Upper Rush sections, but the Upper Rush section has scored three-year average values of 3 to 4 in the RSD-300 metric consistently. Length-at-age information presented in this report suggests that in lower Rush Creek (downstream of the Narrows) brown trout may have to survive to at least age-5 to exceed 300 mm in length. In Upper Rush, brown trout may exceed 300 mm by age-3 or age-4 due to higher growth rates.

10. Pre-1941 trout production in lower Rush Creek was most likely driven by the Vestal's spring flow and nutrient loading that were on varying levels influenced by in-basin irrigation and intensive livestock grazing. The pre-1941 excavated duck ponds near the Mono Lake delta that were filled and maintained by diverted Rush Creek flow also provided suitable habitat for larger trout. Restoring these conditions is, for the most part, infeasible and inconsistent with the goal of restoring a healthy, self-sustaining stream ecosystem.
11. The MGORD is the section of Rush Creek that consistently produces larger brown trout (>300 mm). Ages determined from otoliths collected from a limited number of sacrificed fish confirmed that MGORD fish can survive to much older ages than fish from other Rush Creek sections. The radio telemetry study and PIT tag returns documented that some fish residing in the MGORD seasonally use downstream sections of Rush Creek for spawning and over-wintering, and that some of their progeny likely migrate up into the MGORD.
12. Water chemistry measurements have shown that Rush Creek is a relatively sterile system, with very low alkalinity concentrations that have declined over the past 20 years. When compared to other streams with similar water chemistry, Rush Creek appears to be quite efficient in the annual production of fish biomass, especially in the Upper section.

<u>Lee Vining Creek:</u>

1. On an annual basis, rainbow trout have comprised approximately 10 to 40% of the fish sampled in Lee Vining Creek. Rainbow trout numbers appear to fluctuate with water-year type and are more abundant in drier year types.
2. Annual recruitment of age-0 brown trout and rainbow trout is sporadic. Lower age-0 recruitment appears to coincide with wetter runoff years and rainbow trout recruitment is more inconsistent than brown trout age-0 recruitment. Inconsistent recruitment of age-0 fish appears to carry over to lower densities of age-1 and older fish in subsequent years.
3. Summer water temperatures are suitable for good trout growth andcondition factors during all water-year types in Lee Vining Creek.
4. Pool and run habitat in Lee Vining Creek is much less abundant than in Rush Creek below the Narrows and was even further degraded by 2011's large peak flows. Lee Vining Creek is steeper than Rush Creek, and has a coarser stream bottom dominated by boulders and large cobble which is less conducive for supporting the same frequency and quality of pool habitat as found in lower Rush Creek. Pocket water habitats are more common in Lee Vining Creek, which provide good foraging habitat, but lack the cover and low-velocity elements of preferred winter holding habitat.
5. The TC metric of biomass (≥150 kg/ha) was met for one of the three-year averages (2005/2007/2008), and the main channel section has exceeded 150 kg/ha in three individual years (2000, 2005, and 2008).
6. The TC metric of density (1,400 fish/km) has not been met for any of the three-year averages, but has been exceeded in the main channel section twice in individual years (2007 and 2008).

7. The TC metric of condition factor has been consistently met in Lee Vining Creek. Both brown trout and rainbow trout have condition factors >1.00. Both species growth quickly in Lee Vining Creek, but few fish survive to age-3 or older.
8. The TC metric of RSD-225 (≥30) for a three-year average was met for the first time after the 2011 season (2009-2011 average), and has been met for five individual years (2000, 2003, 2005, 2010, and 2011).
9. Although a TC metric of RSD-300 was not proposed for Lee Vining Creek, this system has consistently produced a RSD-300 value, including a value of 10 in 2011 (Table 25).

In review, the termination criteria in the Settlement Agreement that generally described the presumed pre-project conditions for fish population structure was:

1. Rush Creek fairly consistently produced brown trout weighing ¾ to two pounds. Trout averaging 13 to 14 inches were also regularly observed.

2. Lee Vining Creek sustained catchable brown trout averaging eight to 10 inches in length. Some trout reached 13 to 15 inches.

When the results of the fisheries monitoring data collected over the past 13 years are compared to these descriptive, yet generalized criteria, one could presume that the trout populations (brown and rainbow combined) in Lee Vining Creek are closer to “recovery” than in Rush Creek. Lee Vining Creek’s size structure is consistent with the above criteria when rainbow trout are included, plus the consistent condition factors >1.00 meets the “fishery in good condition” statement in Order 98-05. The inconsistent recruitment of age-0 fish in Lee Vining Creek is a liability, as is the very low numbers of brown trout surviving beyond age-3. In Rush Creek, only the MGORD section comes close to meeting the size criteria listed above. However, the increased numbers of brown trout >255 mm (10 inches) in lower Rush Creek that coincided with the testing of lowered winter baseflows were encouraging. The continuation of these lower winter baseflows should be a priority during implementation of any future management plans or prescribed flow regimes for both Rush and Lee Vining creeks. The frequently less than average condition factors of Rush Creek trout are also a liability towards achieving a “fishery in good condition”, but management of GLR levels and summer flow regimes as recommended in the Synthesis Report will hopefully lead to improved condition factors.

Finally, Order 98-05 also describes that when “recovered” the fisheries on both creeks should be able to sustain “harvests in moderate numbers”. First of all, “moderate numbers” is vague – is this a daily angler bag limit or a quota of how many fish may be taken in a single fishing season? Under what level of fishing pressure can either creek sustain a “moderate harvest” and still maintain the size class structures described in the Orders? Lee Vining Creek has had a two-fish daily limit for almost 10 years and when this rule change was made it was not supported by the fisheries Stream Scientist. Luckily, fishing pressure has been very low on lower Lee Vining Creek, probably due to the lack of stocking and the no-bait restrictions. In Lee Vining Creek, given that relatively few trout survive to age-3+ and the sporadic recruitment of age-0 fish, harvesting of spawning aged fish would not be sustainable if fishing pressure was increased or encouraged. Recently on Rush Creek below GLR there has been local effort to open up this reach to bait fishing and a daily bag limit. Again, the fishery Stream Scientist does not support this effort and feels that increased fishing pressure along with "moderate harvest" limits would confound monitoring efforts tailored to evaluate the fishery's response to flows prescribed to produce older and larger fish. We encourage that LADWP and the interested parties continue to support the current CDFG regulations on Rush Creek downstream of GLR so that it may be enjoyed as a catch-and-release wild trout fishery.

Methods Evaluation

Electro-fishing to conduct mark-recapture estimates in larger streams and depletion estimates in smaller streams and side channels have consistently provided relatively reliable estimates. Having a field technician or biologists from LADWP's Bishop Office dedicated to maintaining block fences has reduced the frequency of block fence failures in recent years (2003-2011) compared to earlier years. Maintaining block fences ensures that the assumption of population closure is met, thus estimates are more reliable. During the 2011 field season there were no complete block fence failures.

In 2011, major changes to the stream channel were observed within the annual sample sections on Rush and Lee Vining creeks, due to the large (>500 c.f.s.) discharges that both creeks experienced during the wet-year runoff. In Rush Creek sample sections, most channel changes were evident in the Bottomlands and County Road sections where we observed the following: filling-in of some pools along with the creation or expansion of other pools, movement of woody debris accumulations, bank scour, and changes in flow contributions at channel splits. In Lee Vining Creek similar types of channel changes were observed, except that many pools were filled and few new ones were created. Because of the large runoff events in Rush and Lee Vining creeks, the fisheries team also completed pool/habitat surveys in September of 2011. Results from these surveys will be reported in a separate document. These channel changes were expected because of the magnitudes of two consecutive wet runoff year flow regimes, changing Mono Lake levels, and continuing maturation of riparian vegetation.

We have consistently sampled within the three main reaches in Rush Creek (MGORD, Upper Rush, and County Road) and have time-series fish abundance and condition data for the past 13 years that represent fish population responses to varying climatic conditions, water-year types, and flow management regimes. The upstream and downstream boundaries of all sample sections have been permanently marked. Because continued channel evolution within Rush and Lee Vining creeks is anticipated, we recommend that channel lengths and widths are re-measured annually.

Modifying the sections sampled could represent a loss of time-series data unless efforts are made to index relative changes between individual sample sections. In past annual reports we found that the length-weight regression lines for the Bottomlands and County Road sections were nearly identical (Taylor et al. 2010), indicating that brown trout in these two sections were responding in a similar fashion to their environment. Mean growth rates and age structures of the brown trout populations at these two sections are also very similar. These similarities suggest that replacing the County Road section with the Bottomlands section should not result in any loss of time-series information related individual fish condition factor analyses. In the 2010 annual report we recommend that the County Road section was sampled annually until sufficient data (five annual sampling events) were collected in the Bottomlands section to compute a series of three, three-year running averages (Taylor et al. 2011). Thus, LADWP may consider dropping the County Road section from the annual fisheries monitoring program in September of 2013. We strongly recommend that the County Road section is sampled one more season (September 2012) so that specific growth information can be collected one more time from the large numbers of PIT tagged fish currently residing in that section. Starting in 2013, the Bottomlands section would be the annually sampled section downstream of the Narrows and the Upper section would be the annually sampled section upstream of the Narrows. We still recommend that the MGORD section is sampled in even years for mark-recapture population estimates and in odd years for RSD calculations.

Because rainbow trout have comprised such a minor portion (<2%) of the Rush Creek trout population during the last 13 years of annual sampling, we recommend reporting only numbers of rainbow trout sampled and not attempting to make estimates of density or biomass. We suspect that the increased numbers of rainbow trout present in Rush Creek in 2011 (nearly 8% of the trout captured) was related to the extended spill from GLR and that rainbow trout will soon return to comprising 2% or less of the trout population. In Lee Vining Creek, during years when sufficient numbers of fish are captured to generate reliable population estimates, these estimates will be used to compute density and biomass estimates. However; in years when relatively few fish are captured, catch numbers will be used to generate density and standing crop estimates.

During the past 13 years we experimented in our selection of length class break points to provide the most precise estimates using mark-recapture estimators. While selection of different length class break points across years allows for slightly more precise estimates, we have found that standardizing length class break points provides for better data consistency at a very modest loss of precision. Another issue in selection of length class break points was our desires to have the lowest length class encompass all age-0 fish during any given year. However, we have found that brown trout from 120 to 130 mm could be either age-0 or age-1 depending upon the growth conditions during any given year. Consequently, in earlier annual reports, a variety of length categories were used, which lead to difficulties in comparing age-0 and age-1 and older density and biomass estimates across all sample years (Hunter et al. 2000, 2001, 2002, 2003). For the 2008 annual report, we re-adjusted earlier data sets and standardized estimates into three size class categories: <125mm, 125-199 mm, and ≥200 mm. We recommend that all future monitoring use these size categories to generate population estimates and associated population metrics. Although we may misclassify a few large age-0 fish or a few small age-1 fish, we feel that consistency in managing the long-term data sets is more important.

Since 2009 the use of PIT tags has allowed us to track the survival, growth, and movement of individual age-0 brown trout. We now will be able to more accurately determine the size ranges of age-1, age-2, and age-3 (and eventually age-4 and age-5) fish in subsequent years. The continued use of PIT tags will be an important component of future long-term monitoring of Rush and Lee Vining creeks' trout populations when evaluating the effectiveness of flow recommendations made by the Stream Scientists in the Synthesis Report or whatever flow regimes are prescribed in an amended license issued by the SWRCB.

Because RY2011 was a Wet year, streamflows were quite high throughout the summer. The fisheries Stream Scientist and LADWP staff communicated in early August so that flows in Lee Vining Creek could be lowered by mid-September to allow for safe wading conditions. We followed the recommendation made in previous annual reports that maximum flow criteria be set for both creeks in early September to ensure that electro-fishing sampling can be conducted safely and efficiently. We continue to recommend that flows in Rush and Lee Vining creeks not exceed 40 c.f.s. (± 5 c.f.s.) during the annual sampling period (a two week-period of September starting soon after the Labor Day holiday).

Over the past five seasons, the biological staff from LADWP's Bishop Office has increased their role in participating with the annual fisheries population sampling. They have also provided assistance with the instream flow studies, pool surveys, temperature monitoring, winter icing monitoring, and water quality sampling. This gradual increase in the participation of the Bishop Office staff in conducting the annual fisheries monitoring was also described in the Synthesis Report and ushers in a diminished role of the consulting Stream Scientists when future monitoring is conducted to assess the revised streamflows recommended in the Synthesis Report or whatever flow regimes are prescribed in an amended license issued by the SWRCB.

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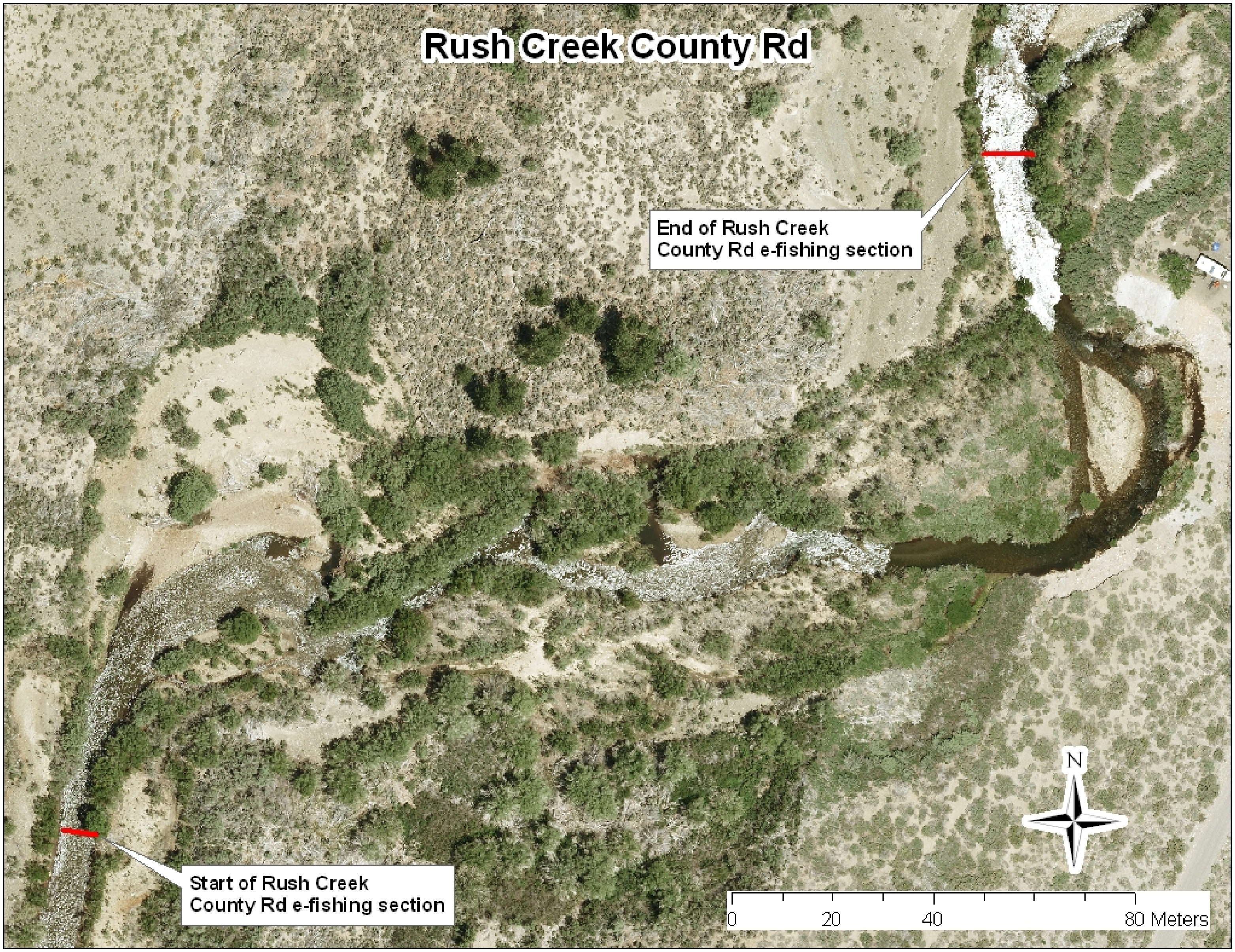
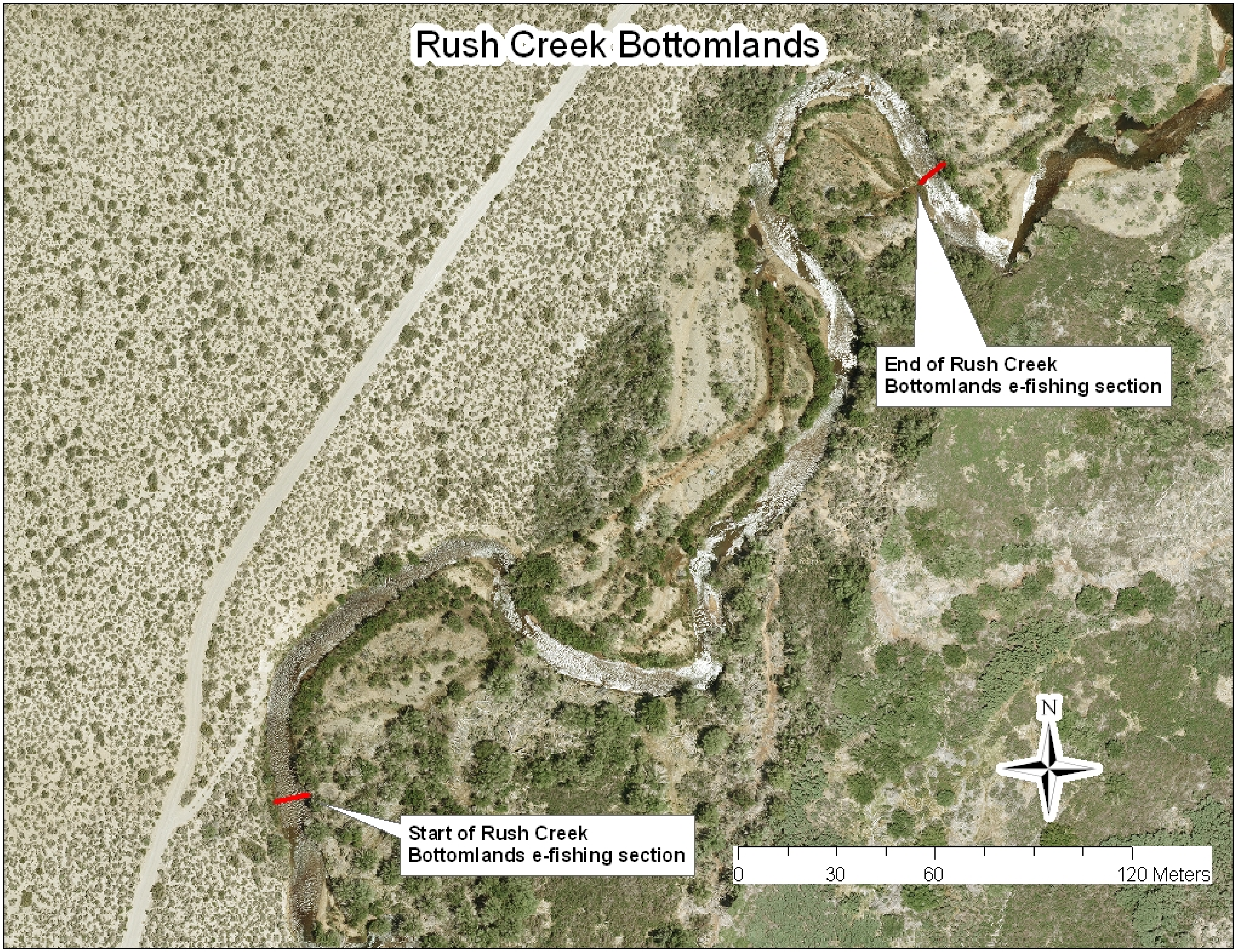
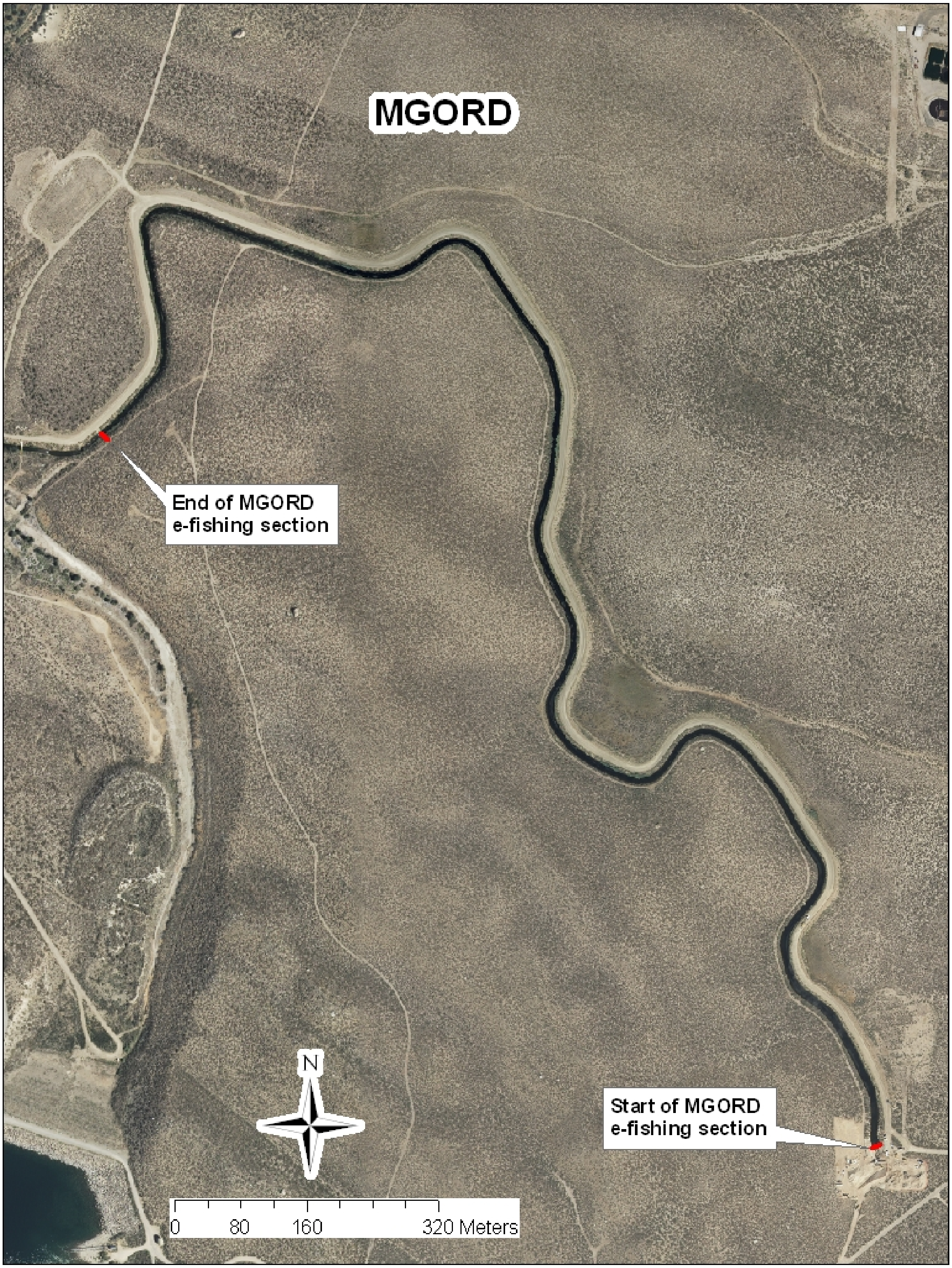
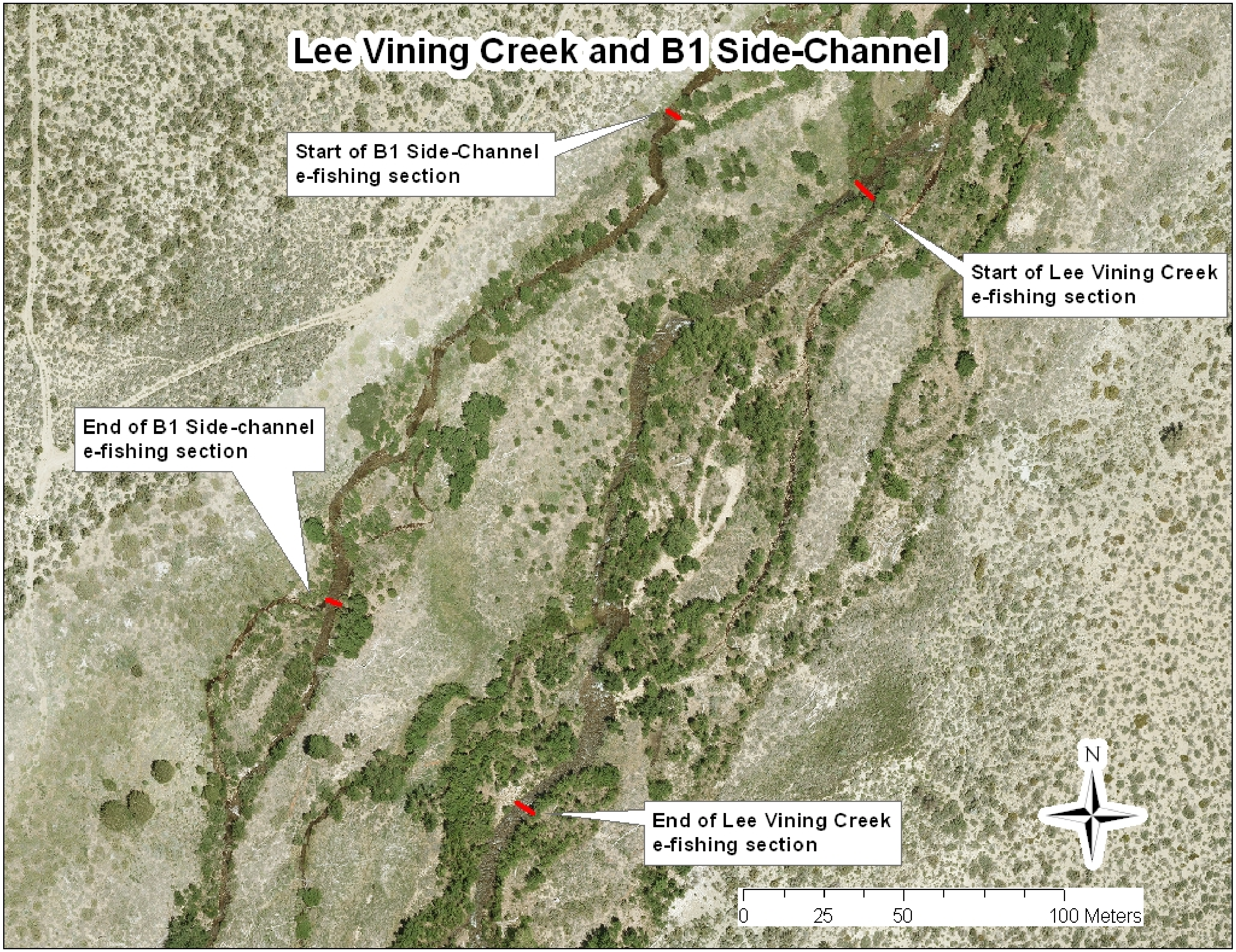
Appendix A: Aerial Photographs of Long-term Monitoring Sections


Rush Creek County Rd
End of Rush Creek
County Rd e-fishing section
Start of Rush Creek
County Rd e-fishing section
N
0
20
40
80 Meters


Rush Creek Bottomlands
End of Rush Creek Bottomlands e-fishing section
Start of Rush Creek Bottomlands e-fishing section
N
0
30
60
120 Meters


Upper Rush above old 395
End of Upper Rush Creek e-fishing section
Start of Upper Rush Creek e-fishing section
N
0
30
60
120 Meters


MGORD
End of MGORD e-fishing section
Start of MGORD e-fishing section
N
0
80
160
320 Meters


Lee Vining Creek and B1 Side-Channel
Start of B1 Side-Channel e-fishing section
Start of Lee Vining Creek e-fishing section
End of B1 Side-channel e-fishing section
End of Lee Vining Creek e-fishing section
N
0
25
50
100 Meters


Walker Creek above old 395
Start of Walker Creek e-fishing section
End of Walker Creek e-fishing section
0
12.5
25
50 Meters
N

Appendix B: Lee Vining Creek – Termination Criteria Calculation Memo

Lee Vining Creek – Main and Side Channel Estimates – Analysis for Termination Criteria (TC) Purposes

Recent discussions with LADWP's fisheries biologist Jason Morgan about the Lee Vining Creek TC calculations in the annual fisheries monitoring reports initiated a re-examination of the TC recommendations made in 2007 by Chris Hunter, who was at that time the Water Board appointed fisheries stream scientist.

In the TC recommendation document (Hunter 2007), the fisheries stream scientist with the assistance of his sub-consultants proposed new metrics and values for determining when the streams (Rush and Lee Vining) had reached recovery. The Lee Vining Creek monitoring reach posed a challenge because sampling occurred in both main channel and side channel reaches. The TC document recommended a standing crop metric of kilograms per hectare (an area-based estimate) and a density metric of number of fish per kilometer (a linear-based estimate). In dealing with the main and side channels, the TC document recommended simply combining the standing crop estimates of the two channels to determine the total kg/ha as produced by certain flow release from LADWP's facilities. The TC recommendation for handling the density estimates of fish/km was to average the main and side channel estimates.

Although the TC document was completed in 2007, work and discussion on the subject started in 2005 and much of the data used in developing the TC recommendations were from the 1999-2004 data sets. Prior to 2006, the lower Lee Vining Creek main and side channel sections were nearly equal in length and wetted area. This changed after the high flows of 2005 and 2006 when changes to channel morphology resulted in most of the flow going down the main channel section, which in turn reduced the mean width of the side channel section from 4.8 m (in 2004) to 2.6 m (in 2010), and increased the mean width of the main channel from 4.8 m to 5.9 m during the same time period. Also, when the upper Lee Vining Creek section was dropped in 2008, the length of the lower main channel section was increased from 155 m to 255 m, which exacerbated the difference in length between the sections. Thus, since 2007 the lengths, widths and total areas (in hectares) of both sections have become increasingly divergent, thus negating the rationale described in Hunter (2007) for determining TC values in Lee Vining Creek. Because of the dynamic nature of Lee Vining Creek's stream channel, a valid method to calculate TC values for the main and side channels must be able to account for any future changes in flow contribution and surface area. Two possible options are: (1) employing a weighted average to account for any future changes in channel lengths, widths and areas; or (2) utilizing an additive approach where channel lengths and areas are totaled along with the fish estimates to generate TC metrics that more equitably account for the varying contributions from the main and side channel sections.

In this memo we demonstrate the logic of utilizing the additive approach. The following hypothetical fish data were used along with the actual 2011 section lengths, widths, and surface areas to propose a valid method for calculating TC for Lee Vining Creek. The following calculations compare the TC values obtained by using the additive approach to the values generated by the previously proposed methods that are now less accurate because of the changes to channel lengths, widths and surface areas that have occurred in recent years. These calculations clearly show that utilization of the additive approach will prevent the over and/or under estimates that are now inherent if the old methods for calculating TC values for Lee Vining Creek were to be continued.

<u>Data for Main Channel Section:</u>

Hypothetical age-0 estimate = 100 fish with average weight of 5g for a total weight = 500g

Hypothetical age-1+ estimate = 50 fish with average weight of 150g for a total weight = 7,500g

Actual 2011 Channel dimensions: length = 255m, average width = 5.4m, area = 1,377m^2 or 0.1377ha.

<u>Data for Side Channel Section:</u>

Hypothetical age-0 estimate = 20 fish with average weight of 4.5g for a total weight = 908g

Hypothetical age-1+ estimate = 25 fish with average weight of 160g for a total weight = 4,000g

Actual 2011 Channel dimensions: length = 195m, average width = 2.6m, area = 507m^2 or 0.0507ha.

<u>1. Density Estimates – numbers of fish per hectare</u>

<u>Main Channel:</u>
Age-0 estimate: 100 fish/.1377 ha = 726 fish/ha
Age-1 estimate: 50 fish/.1377 ha = 363 fish/ha

<u>Side Channel:</u>
Age-0 estimate: 20 fish/.0507 ha = 395 fish/ha
Age-1 estimate: 25 fish/.0507 ha = 493 fish/ha

<u>Main and Side Channel – proposed additive approach:</u>
Age-0 estimate: 120 fish/.1884 ha = **637 fish/ha**
Age-1 estimate: 75 fish/.1884 ha = **398 fish/ha**

<u>Straight Average:</u>
Age-0 estimate = 726 fish/ha + 395 fish/ha ÷ 2 = 561 fish/ha…….under estimates.
Age-1 estimate = 363 fish/ha + 493 fish/ha ÷ 2 = 428 fish/ha……….over estimates.

<u>Combine Separately Generated Estimates</u>
Age-0 estimate = 726 fish/ha + 395 fish/ha = 1,121 fish/ha…….over estimates.
Age-1 estimate = 363 fish/ha + 493 fish/ha = 856 fish/ha……….over estimates.

2. Density Estimates – numbers of fish per kilometer

Main Channel:
Age-0 estimate: 100 fish/.255 km = 392 fish/km
Age-1 estimate: 50 fish/.255 km = 196 fish/km

Side Channel:
Age-0 estimate: 20 fish/.195 km = 103 fish/km
Age-1 estimate: 25 fish/.195 km = 128 fish/km

Main and Side Channel – proposed additive approach:
Age-0 estimate: 120 fish/.450 km = **267 fish/km**
Age-1 estimate: 75 fish/.450 km = **167 fish/km**

Straight Average:
Age-0 estimate = 392 fish/km + 103 fish/km ÷ 2 = 248 fish/km…….under estimates.
Age-1 estimate = 196 fish/km + 128 fish/km ÷ 2 = 162 fish/km……….under estimates.

Combine Separately Generated Estimates
Age-0 estimate = 392 fish/km + 103 fish/km = 495 fish/km…….over estimates.
Age-1 estimate = 196 fish/km + 128 fish/km = 324 fish/ha……….over estimates.

3. Standing Crop Estimates – kilograms of fish per hectare

Main Channel:
8.0 kg of fish/.1377 ha = 58.10 kg/ha

Side Channel:
4.908 kg of fish/.0507 ha = 96.80 kg/ha

Main and Side Channel – proposed additive approach:
12.908 kg of fish/.1884 ha = **68.51 kg/ha**

Straight Average:
(58.10 kg/ha + 96.80 kg/ha) ÷ 2 = 77.45 kg/ha…………….over estimates

Combine Separately Generated Estimates
58.10 kg/ha + 96.80 kg/ha = 154.90 kg/ha………………over estimates

Appendix C: PIT Tag Recaptures from 2011 Sampling Season

RUSH CREEK - CO RD SECTION - GROWTH OF PIT TAGGED FISH BETWEEN 2010 AND 2011

Tag Number	2010 Length (mm)	2010 Weight (g)	2011 Length (mm)	2011 Weight (g)	Growth in Length (mm)	Growth in Weight (g)	2011 Condition Factor
3446738	82	6	140	26	58	20	0.95
1887589	89	7	145	30	56	23	0.98
3476298	91	7	153	33	62	26	0.92
3443810	95	6	154	33	59	27	0.90
1901983	90	7	155	34	65	27	0.91
1923735	99	8	156	36	57	28	0.95
1911475	95	8	156	36	61	28	0.95
3589363	83	5	148	33	65	28	1.02
3476088	99	10	156	39	57	29	1.03
3469837	96	8	158	37	62	29	0.94
3585957	85	5	155	34	70	29	0.91
1902812	91	9	157	40	66	31	1.03
3589071	90	7	159	40	69	33	1.00
3446715	91	8	161	41	70	33	0.98
3632875	89	7	162	40	73	33	0.94
3589005	94	8	162	42	68	34	0.99
1878824	86	6	164	40	78	34	0.91
3448961	101	9	166	44	65	35	0.96
3472792	100	11	168	46	68	35	0.97
1901863	96	8	168	45	72	37	0.95
3542660	97	8	167	46	70	38	0.99
1890892	96	9	174	48	78	39	0.91
3582685	107	12	177	52	70	40	0.94
1900605	108	13	179	53	71	40	0.92
1909023	112	13	183	55	71	42	0.90
3619089	101	10	181	54	80	44	0.91
3444605	106	11	194	57	88	46	0.78
1900918	97	9	179	57	82	48	0.99
					68	**33**	**0.95**

RUSH CREEK - CO RD SECTION - GROWTH OF PIT TAGGED FISH BETWEEN 2009 AND 2011

Tag Number	2009 Length (mm)	2009 Weight (g)	2011 Length (mm)	2011 Weight (g)	2009-2011 Growth in Length (mm)	2009-2011 Growth in Weight (g)	Comments
0936692	82	5	190	64	108	59	
0924450	93	9	207	78	114	69	
0935501	97	10	208	97	111	87	
0932593	99	9	215	98	116	89	Tagged in MGORD-Sect A
					112	**76**	

Tag Number	2009 Length (mm)	2009 Weight (g)	2010 Length (mm)	2010 Weight (g)	2009-2010 Growth in Length (mm)	2009-2010 Growth in Weight (g)	2011 Length (mm)	2011 Weight (g)	2010-2011 Growth in Length (mm)	2010-2011 Growth in Weight (g)	2011 Condition Factor
0936299	93	9	160	39	67	30	197	75	37	36	0.98
0110997	101	10	168	44	67	34	209	80	41	36	0.88
0109973	102	12	170	44	68	32	213	96	43	52	0.99
0910924	102	10	195	71	93	61	221	113	26	42	1.05
0938535	103	11	208	84	105	73	244	149	36	65	1.03
					80	**46**			**37**	**46**	**0.98**
0106769	134	22	208	79	74	57	230	117	22	38	
0906504	168	51	229	113	61	62	255	162	26	49	
					68	**60**			**24**	**44**	

Age-0 to Age-1 Growth in Length: Range = 56-88 mm, Average = 68 mm (2009-2010 Average = 73 mm)

Age-0 to Age-1 Growth in Weight: Range = 20-73 g, Average = 33 g (2009-2010 Average = 36 g)

Age-0 to Age-2 Growth in Length: Range = 108-116 mm, Average = 112 mm

Age-0 to Age-2 Growth in Weight: Range = 59-89 g, Average = 76 g

Age-1 to Age-2 Growth in Length: Range = 26-43 mm, Average = 37 mm

Age-1 to Age-2 Growth in Weight: Range = 36-65 g, Average = 46 g

Age-2 to Age-3 Growth in Length: Range = 22-26 mm, Average = 24 mm

Age-2 to Age-3 Growth in Weight: Range = 38-49 g, Average = 44 g

Recapture Rate of Tagged Age-0 Fish: 211 tagged in 2010 and 28 recaptured in 2011 = **13.3%** (Recap rate in 2010 was **20.7%)**

RUSH CREEK - BOTTOMLANDS SECTION - GROWTH OF PIT TAGGED FISH BETWEEN 2010 AND 2011

Tag Number	2010 Length (mm)	2010 Weight (g)	2011 Length (mm)	2011 Weight (g)	Growth in Length (mm)	Growth in Weight (g)	2011 Condition Factor	Comments
3616072	93	8	141	29	48	21	1.04	
3619450	84	6	138	27	54	21	1.03	
3641917	81	6	146	29	65	23	0.93	
3572514	82	5	147	28	65	23	0.88	
3586150	84	6	150	29	66	23	0.86	
3621167	106	11	158	35	52	24	0.89	
3569735	86	6	147	31	61	25	0.98	
3569606	92	7	149	33	57	26	1.00	
3578653	86	6	151	33	65	27	0.96	
3622964	87	8	154	36	67	28	0.99	
3575475	94	7	171	39	77	32	0.78	
3589583	95	8	163	41	68	33	0.95	
3532735	91	6	161	40	70	34	0.96	
3552878	108	11	170	48	62	37	0.98	
3582326	97	10	169	47	72	37	0.97	
3616634	81	5	165	42	84	37	0.94	Tagged in CoRd
3592570	94	8	169	47	75	39	0.97	
3615106	100	10	164	50	64	40	1.13	
3612849	108	11	176	51	68	40	0.94	
3585509	106	11	176	51	70	40	0.94	
3601610	97	10	176	51	79	41	0.94	
3645965	95	10	178	51	83	41	0.90	
3631082	97	8	175	50	78	42	0.93	
3569596	93	8	180	52	87	44	0.89	
3646339	107	11	181	58	74	47	0.98	
3582961	117	16	194	65	77	49	0.89	
3633510	112	14	196	65	84	51	0.86	
3569647	98	9	207	78	109	69	0.88	
					71	**36**	**0.94**	

RUSH CREEK - BOTTOMLANDS SECTION - GROWTH OF PIT TAGGED FISH BETWEEN 2009 AND 2011

Tag Number	2009 Length (mm)	2009 Weight (g)	2011 Length (mm)	2011 Weight (g)	Growth in Length (mm)	Growth in Weight (g)	Comments
0933121	110	14	234	116	124	102	
0129291	111	16	221	110	110	94	
					117	**98**	

Tag Number	2009 Length (mm)	2009 Weight (g)	2010 Length (mm)	2010 Weight (g)	2009-2010 Growth in Length (mm)	2009-2010 Growth in Weight (g)	2011 Length (mm)	2011 Weight (g)	2010-2011 Growth in Length (mm)	2010-2011 Growth in Weight (g)	2011 Condition Factor
0123570	82	6	155	35	73	29	209	78	54	43	0.85
0937007	88	7	161	44	73	37	186	66	25	22	1.03
0111924	91	7	174	49	83	42	213	83	39	34	0.86
0924797	97	11	183	69	86	58	215	104	32	35	1.05
0121350	98	10	168	42	70	32	205	73	37	31	0.85
0112154	102	11	186	64	84	53	209	88	23	24	0.96
					78	**42**			**35**	**32**	**0.93**
0103525	163	42	210	95	47	53	219	100	9	5	0.95
0921335	171	56	212	106	41	50	229	117	17	11	0.97
0924548	176	53	238	120	62	67	257	141	19	21	0.83
0904696	186	65	234	123	48	58	241	143	7	20	1.02
					50	**57**			**13**	**14**	**0.94**

Age-0 to Age-1 Growth in Length: Range = 48-109 mm, Average = 71 mm (2009-2010 Average = 77 mm)

Age-0 to Age-1 Growth in Weight: Range = 21-69 g, Average = 36 g (2009-2010 Average = 40 g)

Age-0 to Age-2 Growth in Length: Range = 110-124mm, Average = 117 mm

Age-0 to Age-2 Growth in Weight: Range = 94-102 g, Average = 98 g

Age-1 to Age-2 Growth in Length: Range = 23-54 mm, Average = 35 mm

Age-1 to Age-2 Growth in Weight: Range = 22-43 g, Average = 32 g

Age-2 to Age-3 Growth in Length: Range = 7-19 mm, Average = 13 mm

Age-2 to Age-3 Growth in Weight: Range = 5-21 g, Average = 14 g

Recapture Rate of Tagged Age-0 Fish: 285 tagged in 2010 and 45 recaptured in 2011 = **9.8%** (2010 Recap rate = **19.4%**)

RUSH CREEK - UPPER SECTION - GROWTH OF PIT TAGGED FISH BETWEEN 2010 AND 2011

Tag Number	2010 Length (mm)	2010 Weight (g)	2011 Length (mm)	2011 Weight (g)	Growth in Length (mm)	Growth in Weight (g)	2011 Condition Factor
3585942	99	10	154	34	55	24	0.93
3602882	92	8	153	36	61	28	1.01
0112648	86	7	158	38	72	31	0.96
0914925	90	7	162	42	72	35	0.99
0935580	92	8	168	46	76	38	0.97
0913208	87	7	173	46	86	39	0.89
0120728	93	8	167	48	74	40	1.03
0943166	101	10	175	50	74	40	0.93
3628901	98	10	177	50	79	40	0.90
0935415	97	9	176	51	79	42	0.94
0944106	101	10	177	54	76	44	0.97
3599374	93	8	173	52	80	44	1.00
3641398	101	11	178	56	77	45	0.99
3645082	100	10	178	55	78	45	0.98
3632407	87	7	172	52	85	45	1.02
0114900	100	9	182	56	82	47	0.93
3614869	93	8	178	57	85	49	1.01
3569572	99	9	178	59	79	50	1.05
0944247	118	18	196	69	78	51	0.92
3612287	96	8	184	61	88	53	0.98
3592497	101	10	192	63	91	53	0.89
3617856	96	9	189	62	93	53	0.92
0098344	97	9	185	66	88	57	1.04
3598743	93	8	188	68	95	60	1.02
0928722	104	10	195	74	91	64	1.00
3551476	81	5	190	69	109	64	1.01
0938584	95	10	194	75	99	65	1.03
3579597	107	12	203	83	96	71	0.99
3617115	101	10	213	89	112	79	0.92
					83	**48**	**0.97**
							Comments
0905890	214	106	238	142	24	36	Age-1 in 2010?
0941173	234	115	268	181	34	66	Age-2 in 2010?

RUSH CREEK - UPPER SECTION - GROWTH OF PIT TAGGED FISH BETWEEN 2019 AND 2011

Tag Number	2009 Length (mm)	2009 Weight (g)	2011 Length (mm)	2011 Weight (g)	Growth in Length (mm)	Growth in Weight (g)	Comments
0943825	96	8	225	112	129	104	
0911825	99	10	270	193	171	183	
					150	**144**	

Tag Number	2009 Length (mm)	2009 Weight (g)	2010 Length (mm)	2010 Weight (g)	2009-2010 Growth in Length (mm)	2009-2010 Growth in Weight (g)	2011 Length (mm)	2011 Weight (g)	2010-2011 Growth in Length (mm)	2010-2011 Growth in Weight (g)	2011 Condition Factor
0935502	90	8	165	44	75	36	221	110	56	66	1.02
0936745	92	8	161	43	69	35	222	112	61	69	1.02
0117810	100	10	188	61	88	51	238	127	50	66	0.92
0935610	102	12	190	69	88	57	234	135	44	66	1.05
0109142	103	12	180	55	77	43	245	157	65	102	1.07
0932673	109	14	177	55	68	41	219	106	42	51	1.01
0910463	110	15	195	76	85	61	256	165	61	89	0.98
					79	**46**			**54**	**73**	**1.01**
0922419	284	220	307	277	23	57	321	321	14	44	Age-3 in 2009?
3377698			325	352	325	352	No record of tag #				

Age-0 to Age-1 Growth in Length: Range = 55-112 mm , Average = 83 mm (2009-2010 Average = 80 mm)

Age-0 to Age-1 Growth in Weight: Range = 24-79 g, Average = 48 g (2009-2010 Average = 48 g)

Age-0 to Age-2 Growth in Length: Range = 129-171 mm, Average = 150 mm

Age-0 to Age-2 Growth in Weight: Range = 104-183 g, Average = 144 g

Age-1 to Age-2 Growth in Length: Range = 42-65 mm, Average = 54 mm

Age-1 to Age-2 Growth in Weight: Range = 51-102 g, Average = 73 g

Recapture Rate of Tagged Age-0 Fish: 246 tagged in 2010 and 29 recaptured in 2011 = **11.8%** (2010 recap rate = 9%)

RUSH CREEK - MGORD SECTION - GROWTH OF PIT TAGGED FISH BETWEEN 2010 AND 2011

Tag Number	2010 Length (mm)	2010 Weight (g)	2011 Length (mm)	2011 Weight (g)	Growth in Length (mm)	Growth in Weight (g)	Comments
0922879	83	6	146	31	63	25	From Up Rush
3448280	181	52	254	135	73	83	
3622485	186	67	233	105	47	38	
1888784	187	65	250	139	63	74	
1898184	189	65	266	157	77	92	
1875639	190	70	251	157	61	87	
1890827	200	79	250	140	50	61	
3558100	203	84	246	168	43	84	
3623039	207	83	270	166	63	83	
3468069	208	76	264	163	56	87	
3644730	208	90	262	179	54	89	
3380781	210	94	278	202	68	108	
3470544	210	104	272	191	62	87	
3458934	212	88	266	166	54	78	
1888674	213	86	276	173	63	87	
1900738	215	90	266	175	51	85	
1900578	219	92	257	163	38	71	
3458530	219	104	300	246	81	142	
1889565	223	99	292	234	69	135	
1903275	224	109	281	199	57	90	
1889002	226	110	272	177	46	67	
3450995	231	116	274	185	43	69	
3579285	232	107	298	241	66	134	
3373191	233	322	340	378	107	56	
1915826	238	117	280	203	42	86	
3365010	239	126	305	244	66	118	
3460436	239	126	312	263	73	137	
1900411	240	125	265	156	25	31	
					59	**87**	
1891828	250	142	315	370	65	228	
3623111	254	140	281	173	27	33	
3475668	257	170	303	275	46	105	
1895944	262	170	288	234	26	64	
3398099	264	171	298	254	34	83	
3455513	266	193	302	271	36	78	
0940687	271	185	305	289	34	104	
3464872	284	198	311	266	27	68	
3621073	285	193	321	289	36	96	
3473565	286	224	289	213	3	-11	
1873781	288	245	298	240	10	-5	
3625078	288	203	300	242	12	39	
3636489	299	260	322	304	23	44	
3451063	301	272	347	432	46	160	
3467655	304	279	328	350	24	71	
3600852	307	298	310	310	3	12	
3369646	330	329	362	437	32	108	
0928543	340	363	345	385	5	22	
1895370	343	363	337	311	-6	-52	
3449297	351	377	376	455	25	78	
3572971	380	300	375	331	-5	31	
3454442	384	575	436	823	52	248	
3454166	407	609	415	697	8	88	
1880110	414	697	450	988	36	291	
					45	**86**	

RUSH CREEK - MGORD SECTION - GROWTH OF PIT TAGGED FISH BETWEEN 2009 AND 2011							
Tag Number	2009 Length (mm)	2009 Weight (g)	2011 Length (mm)	2011 Weight (g)	Growth in Length (mm)	Growth in Weight (g)	Comments
0121766	107	13	249	167	142	154	
0112881	112	15	277	211	165	196	
0098051	208	98	314	304	106	206	
0909487	208	88	312	280	104	192	
0920208	222	104	280	190	58	86	
7028428	236	151	315	270	79	119	
7024257	265	212	332	355	67	143	
7020820	267	203	315	307	48	104	
7032348	287	268	334	383	47	115	
7017115	293	258	344	361	51	103	
7024541	317	319	348	392	31	73	
7022674	358	483	385	511	27	28	
					56	**106**	

Tag Number	2009 Length (mm)	2009 Weight (g)	2010 Length (mm)	2010 Weight (g)	2009 to 2010 Growth in Length (mm)	2009 to 2010 Growth in Weight (g)	2011 Length (mm)	2011 Weight (g)	2010 to 2011 Growth in Length (mm)	2010 to 2011 Growth in Weight (g)
0943520	107	13	203	71	96	58	263	167	60	96
0936552	201	77	243	131	42	54	334	345	91	214
0904177	223	109	278	218	55	109	332	349	54	131
0922135	227	141	244	141	17	0	252	162	8	21
7017896	262	198	288	261	26	63	320	348	32	87
7033593	283	229	302	254	19	25	314	267	12	13
7025643	296	252	334	352	38	100	363	400	29	48
7022992	326	355	340	373	14	18	345	368	5	-5
7025228	338	357	340	313	2	-44	361	380	21	67
7021391	358	463	388	540	30	77	414	601	26	61
7019380	462	1056	464	805	2	-251	456	891	-8	86

Age-1 to Age-2 Growth in Length: Range = 25-107 mm , Average = 59 mm

Age-1 to Age-2 Growth in Weight: Range = 31-142 g, Average = 87 g

WALKER CREEK - GROWTH OF PIT TAGGED FISH BETWEEN 2010 AND 2011

Tag Number	2010 Length (mm)	2010 Weight (g)	2011 Length (mm)	2011 Weight (g)	Growth in Length (mm)	Growth in Weight (g)
0122109	82	6	147	28	65	22
0935879	82	6	152	34	70	28
0943145	84	6	176	54	92	48
0936121	88	8	165	40	77	32
0943810	88	6	154	39	66	33
0120400	90	7	152	38	62	31
0911377	119	16	183	58	64	42
					71	**34**
0929212	173	55	206	101	33	46
0109599	183	64	208	99	25	35
0111671	229	110	235	125	6	15

Tag Number	2009 Length (mm)	2009 Weight (g)	2011 Length (mm)	2011 Weight (g)	2009-2011 Growth in Length (mm)	2009-2011 Growth in Weight (g)
0905634	243	133	251	162	8	29

Tag Number	2009 Length (mm)	2009 Weight (g)	2010 Length (mm)	2010 Weight (g)	2009-2010 Growth in Length (mm)	2009-2010 Growth in Weight (g)	2011 Length (mm)	2011 Weight (g)	2010-2011 Growth in Length (mm)	2010-2011 Growth in Weight (g)
107405	85	6	144	31	59	25	196	83	52	52
934081	90	9	126	19	36	10	189	81	63	62
905768	95	9	138	28	43	19	204	82	66	54
									60	**56**
914927	139	29	169	48	30	19	202	96	33	48
105197	144	30	174	52	30	22	208	93	34	41
936228	156	38	193	74	37	36	217	121	24	47
904753	163	43	196	82	33	39	218	121	22	39
									28	**44**

Age-0 to Age-1 Growth in Length: Range = 62-92 mm , Average = 71 mm (2009-2010 Average = 51 mm)

Age-0 to Age-1 Growth in Weight: Range = 22-48 g, Average = 34 g (2009-2010 Average = 20 g)

Age-1 to Age-2 Growth in Length: Range = 52-66 mm , Average = 60 mm

Age-1 to Age-2 Growth in Weight: Range = 52-62 g, Average = 56 g

Age-2 to Age-3 Growth in Length: Range = 22-34 mm , Average = 28 mm

Age-2 to Age-3 Growth in Weight: Range = 39-48 g, Average = 44 g

Recapture Rate of Age-0 Tagged Fish: 81 tagged in 2010 and 7 recaptured in 2011 = 8.6%

LEE VINING CREEK - GROWTH OF PIT TAGGED FISH BETWEEN 2010 AND 2011

Tag Number	2010 Length (mm)	2010 Weight (g)	2011 Length (mm)	2011 Weight (g)	Growth in Length (mm)	Growth in Weight (g)	Comments
0116643	82	5	155	40	73	35	tagged and recap in side-channel
0117063	93	9	190	72	97	63	tagged and recap in side-channel
0942143	93	9	186	73	93	64	tagged and recap in side-channel
					88	**54**	
3445971	84	4	142	28	58	24	Main channel
0924979	84	5	155	38	71	33	Main channel
0119422	85	6	163	45	78	39	Main channel
3444826	87	7	151	36	64	29	Main channel
0913586	91	9	174	60	83	51	Main channel
3473421	94	9	171	57	77	48	Main channel
					72	**37**	

LEE VINING CREEK - GROWTH OF PIT TAGGED FISH BETWEEN 2009 AND 2011

Tag Number	2009 Length (mm)	2009 Weight (g)	2011 Length (mm)	2011 Weight (g)	Growth in Length (mm)	Growth in Weight (g)	Comments
0937101	105	12	257	177	152	165	tagged and recap in side-channel
0924669	164	47	266	195	102	148	Main channel
0119030	188	66	310	329	122	263	Main channel
					112	**206**	

Tag Number	2009 Length (mm)	2009 Weight (g)	2010 Length (mm)	2010 Weight (g)	2009-2010 Growth in Length (mm)	2009-2010 Growth in Weight (g)	2011 Length (mm)	2011 Weight (g)	2010-2011 Growth in Length (mm)	2010-2011 Growth in Weight (g)
0096917	168	52	235	145	67	93	281	261	46	116
0927890	182	57	249	172	67	115	271	239	22	67
0914307	N/A	N/A	227	126	N/A	N/A	271	213	44	87
0911274	N/A	N/A	228	123	N/A	N/A	281	254	53	131
NOTE: the two fish above were tagged in 2009, but had shed their tags when captured in 2010, both were re-tagged in 2010.									**41**	**100**

Side Channel: Age-0 to Age-1 Growth in Length: Range = 73-97 mm , Average = 88 mm

Side Channel: Age-0 to Age-1 Growth in Weight: Range = 35-64 g, Average = 54 g

Main Channel: Age-0 to Age-1 Growth in Length: Range = 58-83 mm , Average = 72 mm

Main Channel: Age-0 to Age-1 Growth in Weight: Range = 24-51 g, Average = 37 g

Age-2 to Age-3 Growth in Length: Range = 22-53 mm, Average = 41 mm

Age-2 to Age-3 Growth in Weight: Range = 67-131 g, Average = 100 g

Age-1 to Age-3 Growth in Length: Range = 102-122 mm, Average = 112 mm

Age-1 to Age-3 Growth in Weight: Range = 148-263 g, Average = 206 g

Recapture Rate of Tagged Age-0 Fish: 24 tagged in 2010 and 9 recaptured in 2011 = 37.5%

Appendix C. Population estimates and densities, by age-class, for brown trout populations at three sections on Rush Creek and sections on Lee Vining and Walker creeks during Sept. 2011. Also shown are the PIT tag return rates for each age-class at each section.

Section Area (ha) Leng. (m)	Cohort	Length Range (mm)	M	C	R	Pop. Est.	Morts	Total Est.	Number per ha	Number per km	% of Tot. Pop.	PIT Tag Return Information Number	Percent	Ln range (mm)	Outlier(s)
Rush Cr.	age-0	61-105	192	202	65	593	4	597	2160	1815	63.8%				
Co. Road	age-1	124-194	150	114	67	254	5	259	937	787	27.7%	28/211	13%	140-194	
0.2764 ha	age-2	195-229	27	25	11	45	0	45	163	137	4.8%	9/20	46%	197-221	244
329 m	age-3	230-255	13	11	6	23	0	23	83	70	2.5%	2/9	22%	230-255	
	age-4+	256-314	9	7	5	12	0	12	43	36					
	Totals							936	3386	2845	100.1%				
Rush Cr.	age-0	61-117	191	185	45	775	10	785	2218	1796	65.0%				
B'Lands	age-1	133-196	142	133	60	314	3	317	895	725	26.2%	28/284	10%	138-196	207
0.3540 ha	age-2	197-228	39	30	23	51	0	51	144	117	4.2%	9/36	25%	205-221	186 & 234
437 m	age-3	229-257	18	11	6	32	0	32	90	73	2.6%	4/9	44%	229-257	219
	age-4+	258-354	19	11	9	23	0	23	65	53	1.9%				
	Totals							1208	3412	2764	99.9%				
Rush Cr.	age-0	50-105	415	674	73	3794	68	3862	10821	8981	83.0%				
upper	age-1	128-213	186	257	87	547	32	579	1622	1347	12.4%	29/246	12%	153-213	
0.3569 ha	age-2	214-270	77	70	30	178	5	183	513	426	3.9%	9/23	39%	219-270	
430 m	age-3+*	271-458	17	14	9	26	1	27	76	63	0.6%	0/3	0%		
	Totals							4651	13032	10817	99.9%				
L. Vining	age-0	56-88	39	34	14	92	12	104	728	408	64.9%				
Cr.(main)	age-1	133-188	18	19	12	28	0	28	190	110	16.9%	6/24	25%	142-174	
0.1428 ha	age-2	209-262	15	16	13	18	0	18	126	71	11.2%	0/1	0%		
255 m	age-3	266-310	10	8	7	11	0	11	77	43	6.9%	4/7	57%	266-310	
	age-4+**	>310	0	0	0	0	0	0	0	0	0.0%				
	Totals							161	1121	632	99.9%				
			Pass-1	Pass-2	Pass-3	Pass-4									
Walker															
Creek	age-0	85-114	30	7	3	1		41	845	211	36.0%				
0.0485 ha	age-1	143-183	23	6	2	1		32	660	165	28.0%	7/81	9%	147-183	
194 m	age-2	186-202	6	5	0	2		14	289	72	12.3%	3/9	33%	189-204	
	age-3	206-219	10	1	0	0		11	227	57	9.7%	4/16	25%	202-218	
	age-4+	220-264	15	0	0	1		16	330	82	14.0%				
	Totals							114	2351	587	100.0%				

*no age-3 fish with PIT tags were recaptured at the Upper Rush section
**the largest brown trout captured on LV was a PIT-tagged 3 year-old that was 310 mm long

Appendix D: Proofed Data Summaries for Sampling Years 2007 - 2010

Data Summaries for Mono Fisheries Sampling – **September 2007**

Table 1. Reach lengths, widths, and areas for 2007.

Reach	Length (m)	Width (m)	Area (m^2)	Area (hectares)
Rush Co Rd	813	7.4	6,016.0	0.6016
Rush Upper	430	8.5	3,655.0	0.3655
LV Main	155	5.7	883.5	0.08835
LV Side	195	2.5	487.5	0.04875
Walker	228	2.1	478.8	0.04788

Table 2. Brown trout population estimates for calculating density and standing crop estimates. For mark-recap estimates, the total estimate includes mortalities from the marking run.

Reach	BNT <125mm	BNT 125-199mm	BNT ≥200mm
Rush Co Rd	2,941	896	242
Rush Upper	3,037	537	155
LV Main	199	10*	6*
LV Side	9	0	3
Walker	474	36	24

*estimate made with less than 7 recaps

Table 3. Rainbow trout population estimates for calculating density and standing crop estimates. For mark-recap estimates, the total estimate includes mortalities from the marking run.

Reach	RBT <125mm	RBT 125-199mm	RBT ≥200mm
LV Main	106	1*	6*
LV Side	4	4	2

*catch data

Table 4. Brown trout average weights (g) for calculating standing crop estimates.

Reach	BNT <125mm	BNT 125-199mm	BNT ≥200mm
Rush Co Rd	5.5	37.2	94.6
Rush Upper	5.1	36.6	154.4
LV Main	14.2	65.9	172.5
LV Side	13.1	0	127.0
Walker	5.0	55.4	153.5

Table 5. Rainbow trout average weights (g) for calculating standing crop estimates.

Reach	RBT <125mm	RBT 125-199mm	RBT ≥200mm
LV Main	12.1	47.0	139.8
LV Side	15.0	61.5	111.5

Table 6. Brown trout density estimates (fish/ha and fish/km) for age-0 (<125mm) and age-1 and older fish (≥125mm).

Sampling Reach	**BNT Age-0**	**BNT ≥Age-1**	**BNT Age-0**	**BNT ≥Age-1+**
	Number of fish per hectare		Number of fish per km	
Rush Co Rd	4,888.63	1,891.62	3,618	1,400
Rush Upper	8,309.17	1,893.30	7,063	1,609
LV Main	2,252.41	181.10	1,284	103
LV Side	184.62	61.54	46	15
Walker	9,899.75	1,253.13	2,079	263
Reach	**RBT Age-0**	**RBT ≥Age-1**	**RBT Age-0**	**RBT ≥Age-1**
LV Main	1,199.77	79.23	684	45
LV Side	82.05	123.08	21	31

Table 7. Brown trout standing crop estimates (kg/ha), for age-0, age-1 and older, and total.

Reach	**BNT Age-0**	**BNT ≥Age-1**	**BNT Total**
Rush Co Rd	26.89	55.40 + 38.05	120.34
Rush Upper	42.38	53.77 + 65.48	161.63
LV Main	31.98	7.46 + 11.71	51.15
LV Side	2.42	0.00 + 7.82	10.24
Walker	49.50	41.65 + 76.94	168.09

Table 8. Rainbow trout standing crop estimates (kg/ha), for age-0, age-1 and older, and total.

Reach	**RBT Age-0**	**RBT ≥Age-1**	**RBT Total**
LV Main	14.52	0.53 + 9.49	24.54
LV Side	1.23	5.05 + 4.57	10.85

Lee Vining Creek – **2007** Main and Side Channel additive estimates for TC Determinations

Note: these calculations include both brown and rainbow trout

Density: fish per hectare

Age-0 fish: 318 fish/.1371 ha = 2,319.47 fish/ha

Age-1 and older: 32 fish/.1371 ha = 233.41 fish/ha

Density: fish per kilometer

Age-0 fish: 318 fish/0.35 km = 909 fish/km

Age-1 and older: 32 fish/0.35 km = 91 fish/km

Standing Crop: kilograms per hectare (BNT main + BNT side + RBT main + RBT side)

Fish <125mm: (2.8258 kg + 0.1179 kg + 1.2826 kg + 0.06 kg)/.1371 ha = 31.26 kg/ha

Fish 125-199mm: (0.659 kg + 0.00 kg + 0.047 kg + 0.246 kg)/.1371 ha = 6.94 kg/ha

Fish ≥200mm: (1.035 kg + 0.381 kg + 0.8388 kg + 0.232)/.1371 ha = 18.07 kg/ha

TOTAL: 56.27 kg/ha

Data Summaries for Mono Fisheries Sampling – **September 2008**

Table 1. Reach lengths, widths, and areas for 2008.

Reach	Length (m)	Width (m)	Area (m^2)	Area (hectares)
Rush Co Rd	237	8.2	1,943.4	0.19434
Rush B'lands	437	8.0	3,496.0	0.3496
Rush Upper	430	8.9	3,827.0	0.3827
Rush MGORD	2,230	12.0	26,760.0	2.6760
LV Main	255	5.4	1,377.0	0.1377
LV Side	195	2.5	487.5	0.04875
Walker	228	2.1	478.8	0.04788

Table 2. Brown trout population estimates for calculating density and standing crop estimates. For mark-recap estimates, the total estimate includes mortalities from the marking run.

Reach	BNT <125mm	BNT 125-199mm	BNT ≥200mm
Rush Co Rd	436	284	35
Rush B'lands	923	558	83
Rush Upper	1,006	434	111
Rush MGORD	15*	857	658
LV Main	237	144	34
LV Side	0	4	5
Walker	332	104	29

*catch data

Table 3. Rainbow trout population estimates for calculating density and standing crop estimates. For mark-recap estimates, the total estimate includes mortalities from the marking run.

Reach	RBT <125mm	RBT 125-199mm	RBT ≥200mm
LV Main	57	84	45
LV Side	7	4	0

Table 4. Brown trout average weights (g) for calculating standing crop estimates.

Reach	BNT <125mm	BNT 125-199mm	BNT ≥200mm
Rush Co Rd	7.7	34.9	96.9
Rush B'lands	7.1	35.6	95.9
Rush Upper	7.8	40.4	140.9
Rush MGORD	8.8	60.9	189.3
LV Main	8.0	58.6	111.7
LV Side	0.0	75.8	95.4
Walker	4.9	38.0	124.3

Table 5. Rainbow trout average weights (g) for calculating standing crop estimates.

Reach	RBT <125mm	RBT 125-199mm	RBT ≥200mm
LV Main	6.3	60.0	122.8
LV Side	7.7	72.5	0.0

Table 6. Brown trout density estimates (fish/ha and fish/km) for age-0 (<125mm) and age-1 and older fish (≥125mm).

Sampling Reach	BNT Age-0	BNT ≥Age-1	BNT Age-0	BNT ≥Age-1+
	Number of fish per hectare		Number of fish per km	
Rush Co Rd	2,243.49	1,641.45	1,840	1,346
Rush B'lands	2,640.16	1,833.52	2,112	1,467
Rush Upper	2,628.69	1,424.09	2,340	1,267
Rush MGORD	5.61	566.14	7	679
LV Main	1,721.13	1,292.67	929	698
LV Side	0.00	184.62	0	46
Walker	6,934.00	2,777.78	1,456	583
Reach	**RBT Age-0**	**RBT ≥Age-1**	**RBT Age-0**	**RBT ≥Age-1**
LV Main	413.94	936.82	224	506
LV Side	143.59	82.05	36	21

Table 7. Brown trout standing crop estimates (kg/ha), for age-0, age-1 and older, and total.

Reach	BNT Age-0	BNT ≥Age-1	BNT Total
Rush Co Rd	17.27	51.00 + 17.45	85.72
Rush B'lands	18.75	56.82 + 22.77	98.34
Rush Upper	20.50	45.82 + 40.87	107.19
Rush MGORD	0.05	19.50 + 46.55	66.10
LV Main	13.77	61.28 + 27.58	102.63
LV Side	0.00	6.22 + 9.78	16.00
Walker	33.98	82.54 + 75.29	191.81

Table 8. Rainbow trout standing crop estimates (kg/ha), for age-0, age-1 and older, and total.

Reach	RBT Age-0	RBT ≥Age-1	RBT Total
LV Main	2.61	36.60 + 40.13	79.34
LV Side	1.11	5.95	7.06

Lee Vining Creek – **2008** Main and Side Channel additive estimates for TC Determinations

Note: these calculations include both brown and rainbow trout

Density: fish per hectare

Age-0 fish: 301 fish/.18645 ha = 1,614.37 fish/ha.

Age-1 and older: 320 fish/.18645 ha = 1,716.28 fish/ha

Density: fish per kilometer

Age-0 fish: 301 fish/0.45 km = 669 fish/km

Age-1 and older: 320 fish/0.45 km = 711 fish/km

Standing Crop: kilograms per hectare (BNT main + BNT side + RBT main + RBT side)

Fish <125mm: (1.896 kg + 0.00 kg + 0.3591 kg + 0.0539 kg)/.18645 ha = 12.38 kg/ha

Fish 125-199mm: (8.4384 kg + 0.3032 kg + 5.04 kg + 0.29 kg)/.18645 ha = 75.47 kg/ha

Fish ≥200mm: (3.7978 kg + 0.477 kg + 5.526 kg + 0.00)/.18645 ha = 52.57 kg/ha

TOTAL: 140.42 kg/ha

Data Summaries for Mono Fisheries Sampling – **September 2009**

Table 1. Reach lengths, widths, and areas for 2009.

Reach	Length (m)	Width (m)	Area (m^2)	Area (hectares)
Rush Co Rd	329	7.4	2,434.6	0.24346
Rush B'lands	437	7.7	3,364.9	0.33649
Rush Upper	430	9.0	3,870.0	0.3870
LV Main	255	5.9	1,504.5	0.15045
LV Side	195	2.5	487.5	0.04875
Walker	228	2.3	524.4	0.05244

Table 2. Brown trout population estimates for calculating density and standing crop estimates. For mark-recap estimates, the total estimate includes mortalities from the marking run.

Reach	BNT <125mm	BNT 125-199mm	BNT ≥200mm
Rush Co Rd	478	408	122
Rush B'lands	793	342	159
Rush Upper	970	371	137
LV Main	18*	131	32
LV Side	5	4	2
Walker	195	122	24

*estimate made with 2 recaps

Table 3. Rainbow trout population estimates (or catch data = shaded values) for calculating density and standing crop estimates. For mark-recap estimates, the total estimate includes mortalities from the marking run.

Reach	RBT <125mm	RBT 125-199mm	RBT ≥200mm
LV Main	9	60	38
LV Side	0	7	8

Table 4. Brown trout average weights (g) for calculating standing crop estimates.

Reach	BNT <125mm	BNT 125-199mm	BNT ≥200mm
Rush Co Rd	7.6	46.1	103.3
Rush B'lands	8.9	51.6	117.9
Rush Upper	10.8	56.9	139.2
LV Main	7.5	53.3	138.0
LV Side	10.8	67.3	195.5
Walker	6.4	37.4	116.7

Table 5. Rainbow trout average weights (g) for calculating standing crop estimates.

Reach	RBT <125mm	RBT 125-199mm	RBT ≥200mm
LV Main	4.6	61.4	138.3
LV Side	0	69.4	151.5

Table 6. Brown trout density estimates (fish/ha and fish/km) for age-0 (<125mm) and age-1 and older fish (≥125mm).

Sampling Reach	BNT Age-0	BNT ≥Age-1	BNT Age-0	BNT ≥Age-1+
	Number of fish per hectare		Number of fish per km	
Rush Co Rd	1,963.36	2,176.95	1,453	1,611
Rush B'lands	2,356.68	1,488.90	1,815	1,147
Rush Upper	2,506.46	1,312.66	2,256	1,181
LV Main	119.64	1,083.42	71	639
LV Side	102.56	123.08	26	31
Walker	3,718.54	2,784.13	855	640
Reach	**RBT Age-0**	**RBT ≥Age-1**	**RBT Age-0**	**RBT ≥Age-1**
LV Main	59.82	651.38	35	384
LV Side	0	307.69	0	77

Table 7. Brown trout standing crop estimates (kg/ha), for age-0, age-1 and older, and total.

Reach	BNT Age-0	BNT ≥Age-1	BNT Total
Rush Co Rd	14.92	77.26 + 51.76	143.94
Rush B'lands	20.97	52.44 + 55.71	129.12
Rush Upper	27.07	54.55 + 49.28	130.90
LV Main	0.90	46.41 + 29.35	76.66
LV Side	1.11	5.52 + 8.02	14.65
Walker	23.80	87.01 + 53.41	164.22

Table 8. Rainbow trout standing crop estimates (kg/ha), for age-0, age-1 and older, and total.

Reach	RBT Age-0	RBT ≥Age-1	RBT Total
LV Main	0.28	24.49 + 34.93	59.70
LV Side	0.00	9.97 + 24.86	34.83

Lee Vining Creek – **2009** Main and Side Channel additive estimates for TC Determinations

Note: these calculations include both brown and rainbow trout

Density: fish per hectare

Age-0 fish: 32 fish/.1992 ha = 160.64 fish/ha.

Age-1 and older: 282 fish/.1992 ha = 1,415.66 fish/ha

Density: fish per kilometer

Age-0 fish: 32 fish/0.45 km = 71 fish/km

Age-1 and older: 282 fish/0.45 km = 627 fish/km

Standing Crop: kilograms per hectare (BNT main + BNT side + RBT main + RBT side)

Fish <125mm: (0.135 kg + 0.054 kg + 0.0414 kg + 0.0 kg)/.1992 ha = 1.16 kg/ha

Fish 125-199mm: (6.9823 kg + 0.2692 kg + 3.684 kg + 0.4858 kg)/.1992 ha = 57.34 kg/ha

Fish ≥200mm: (4.416 kg + 0.391 kg + 5.2554 kg + 1.212)/.1992 ha = 56.60 kg/ha

TOTAL: 115.10 kg/ha

Data Summaries for Mono Fisheries Sampling – **September 2010**

Table 1. Reach lengths, widths, and areas for 2010.

Reach	Length (m)	Width (m)	Area (m^2)	Area (hectares)
Rush Co Rd	329	8.2	2,697.8	0.26978
Rush B'lands	437	7.8	3,408.6	0.34086
Rush Upper	430	8.3	3,569.0	0.3569
Rush MGORD	2,230	12.0	26,760.0	2.6760
LV Main	255	5.9	1,504.5	0.15045
LV Side	195	2.6	507.0	0.0507
Walker	194	2.5	485.0	0.0485

Table 2. Brown trout population estimates for calculating density and standing crop estimates. For mark-recap estimates, the total estimate includes mortalities from the marking run.

Reach	BNT <125mm	BNT 125-199mm	BNT ≥200mm
Rush Co Rd	749	253	149
Rush B'lands	1,067	292	129
Rush Upper	2,083	196	183
Rush MGORD	5	186	916
LV Main	49	26*	39
LV Side	13	2	4
Walker	116	79	18

*estimate made with 3 recaps

Table 3. Rainbow trout population estimates (or catch data = shaded values) for calculating density and standing crop estimates. For mark-recap estimates, the total estimate includes mortalities from the marking run.

Reach	RBT <125mm	RBT 125-199mm	RBT ≥200mm
LV Main	0	8*	7*
LV Side	0	0	1

*estimate made with 3 recaps

Table 4. Brown trout average weights (g) for calculating standing crop estimates.

Reach	BNT <125mm	BNT 125-199mm	BNT ≥200mm
Rush Co Rd	7.1	46.7	133.2
Rush B'lands	7.4	46.7	137.1
Rush Upper	7.8	55.6	150.9
Rush MGORD	6.3	67.0	212.3
LV Main	6.5	54.1	149.3
LV Side	7.5	66.5	190.5
Walker	7.2	43.7	107.2

Table 5. Rainbow trout average weights (g) for calculating standing crop estimates.

Reach	RBT <125mm	RBT 125-199mm	RBT ≥200mm
LV Main	0	68.0	269.1
LV Side	0	0	136.0

Table 6. Brown trout density estimates (fish/ha and fish/km) for age-0 (<125mm) and age-1 and older fish (≥125mm).

Sampling Reach	BNT Age-0	BNT ≥Age-1	BNT Age-0	BNT ≥Age-1+
	Number of fish per hectare		Number of fish per km	
Rush Co Rd	2,776.34	1,490.10	2,277	1,222
Rush B'lands	3,130.32	1,235.11	2,442	963
Rush Upper	5,836.37	1,061.92	4,844	881
Rush MGORD	1.87	411.81	11	494
LV Main	325.69	432.04	192	255
LV Side	256.41	118.34	67	31
Walker	2,391.75	2,000.00	598	500
Reach	**RBT Age-0**	**RBT ≥Age-1**	**RBT Age-0**	**RBT ≥Age-1**
LV Main	0	99.70	0	59
LV Side	0	19.72	0	5

Table 7. Brown trout standing crop estimates (kg/ha), for age-0, age-1 and older, and total.

Reach	BNT Age-0	BNT ≥Age-1	BNT Total
Rush Co Rd	19.71	43.80 + 73.57	137.08
Rush B'lands	23.16	40.01 + 51.89	115.06
Rush Upper	45.52	30.53 + 77.37	153.42
Rush MGORD	0.01	4.66 + 72.67	77.34
LV Main	2.12	9.35 + 38.70	50.17
LV Side	1.92	2.62 + 15.03	19.57
Walker	17.22	71.18 + 39.79	128.19

Table 8. Rainbow trout standing crop estimates (kg/ha), for age-0, age-1 and older, and total.

Reach	RBT Age-0	RBT ≥Age-1	RBT Total
LV Main	0	3.62 + 12.52	16.14
LV Side	0	0.0 + 2.68	2.68

Lee Vining Creek – **2010** Main and Side Channel additive estimates for TC Determinations

Note: these calculations include both brown and rainbow trout

Density: fish per hectare

Age-0 fish: 62 fish/.20115 ha = 308.23 fish/ha

Age-1 and older: 87 fish/.20115 ha = 432.51 fish/ha

Density: fish per kilometer

Age-0 fish: 62 fish/0.45 km = 138 fish/km

Age-1 and older: 87 fish/0.45 km = 193 fish/km

Standing Crop: kilograms per hectare (BNT main + BNT side + RBT main + RBT side)

Fish <125mm: (0.3185 kg + 0.0975 kg + 0.0 kg + 0.0 kg)/.20115 ha = 2.07 kg/ha

Fish 125-199mm: (1.4066 kg + 0.133 kg + 0.544 kg + 0.0 kg)/.20115 ha = 10.36 kg/ha

Fish ≥200mm: (5.8227 kg + 0.762 kg + 1.8837 kg + 0.136)/.20115 ha = 42.78 kg/ha

TOTAL: 55.21 kg/ha

Pool and Habitat Studies on Rush and Lee Vining Creeks
1991 - 2011
Prepared for
Los Angeles Department of Water and Power

By
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INTRODUCTION

In nearly every stream system that supports brown trout; high-quality pools (the largest and deepest pools with the highest amount of hiding cover) tend to be the domain of the biggest trout (Canjuk and Power 1986; Heggenes et al. 1993; Heggenes 2002; Meyers et al. 1992). Habitat surveys conducted on Rush Creek downstream of Grant Lake Reservoir (GLR) during 1984, 1987 and 1991 found that pool habitats, and particularly large, deep pools, were rare to uncommon throughout most of this stream segment (Trihey and Associates 1994). To determine how the distribution and abundance of high-quality pool habitats were evolving over time along this approximately 8.7 mile segment of lower Rush Creek, three additional pool/habitat surveys were conducted from 2002 to 2011. During the initial survey, conducted between June 2002 and September 2003, the distribution and abundance of high-quality pools were determined. During the 2008 and 2011 surveys, not only were the size and location of high-quality pools measured, but also the lengths of other habitat types, including high and low gradient riffles, run/glides and smaller pool habitats. Measuring the lengths and depths of all habitat types along this reach of Rush Creek during the 2008 and 2011 surveys allowed us to more directly compare our results to a "pre-restoration" habitat inventory that was conducted along this reach in 1991 (Trihey and Associates 1994).

Two habitat typing surveys were conducted on 1.9 miles of lower Lee Vining Creek from the Town of Lee Vining to Mono Lake. The first survey, conducted from September 2008 through April 2009, provided an initial determination of the distribution and abundance of high-quality pools and other habitat types; these data were used to select sub-reaches for the 2009 Instream Flow Study (IFS) on lower Lee Vining Creek (Taylor et al. 2009). The September 2011 survey was conducted to determine what changes, if any, occurred to the already low numbers of high-quality pools on Lee Vining Creek between 2008/09 and 2011.

The stream discharge rates that were present during the days when habitat surveys were conducted on Rush and Lee Vining creeks are shown on Table 1. The stream flows for the MGORD to the Narrows section were from the LADWP gauge at the MGORD. The flows for the reaches downstream of the Narrows were estimated by totaling the MGORD, Parker and Walker LADWP gauging station flows. The stream flows for Lee Vining Creek were taken from the LADWP gauge at the diversion.

The initial Rush Creek survey was started in June 2002 and finished in September 2003. During that time period it is unlikely that there were any major changes in either sizes or depths of pools in Rush Creek because the 2003 runoff was below average. Maximum stream discharge rates in the MGORD during Runoff Year 2003 were low, ranging from 193 to 203 cfs from June 3rd to June 8th. Given the low discharge rate and brief duration of this peak runoff flow, it is unlikely that any noticeable bedload or channel movement occurred on Rush Creek between June 2002 and September 2003. However, the above average runoff flows of 2005, and especially 2006, caused noticeable channel scouring and bedload movement, which appeared to increase the amount of high-quality or "big pool" habitat on Rush Creek, particularly in the bottomlands (downstream of the Narrows).

Table 1. Stream Flows and dates of the Pool/Habitat Surveys on Rush and Lee Vining Creeks.

Rush Creek Sections	2002-2003 Survey Dates	2002-2003 Survey Flows (cfs)	2008-2009 Survey Dates	2008-2009 Survey Flows (cfs)	2011 Survey Dates	2011 Survey Flows (cfs)
Upstream of the Narrows	June 25, 2002	50	July 18, 2008	42	September 21, 2011	39
Narrows to 10-Channel Exit	June 26, 2002	92	July 19-20, 2008	70	September 22, 2011	51
10-Channel to County Road Ford	September 13, 2002	54	July 20-21, 2008	73	September 22-23, 2011	9/23 = 48
County Road Ford to Mono Lake	September 6, 2003	59	September 12-13, 2008	43	September 23-24, 2011	9/24 = 50
Lee Vining Creek Sections			**2008-2009 Survey Dates**	**2008-2009 Survey Flows (cfs)**	**2011 Survey Dates**	**2011 Survey Flows (cfs)**
Upper Half of approx. 10,000 foot reach			Sept. 9th and 13th 2008	21	September 25th	23
Lower Half of approx. 10,000 foot reach			April 26-27, 2009	45	September 25th	23

It was the advent of these channel-changing flows, which peaked at nearly 600 cfs for close to a month downstream of the Narrows during 2006, that spurred the 2008 pool and habitat typing survey on Rush Creek. Quantification of the length and periodicity of all habitat units during 2008 on Rush Creek and during 2009 on Lee Vining Creek also aided in the selection of the stream study reaches that were ultimately used during the IFS on both of these streams (Taylor et al. 2009). The September 2011 habitat typing surveys were conducted in response to another relatively high runoff year. Stream flows below the Narrows exceeded 500 cfs for seven days and exceeded 400 cfs for over three weeks, with a peak discharge of 561 cfs on July 8, 2011.

The habitat of the MGORD, which is a 1.4 mile canal that transports water from GLR to the historic Rush Creek channel, was not included in any of the habitat surveys This artificial channel is essentially one long, interconnected series of relatively deep, low-gradient glide/run or pool habitat. Water velocity measurements, taken 0.5 ft above the stream bottom across random transects in the MGORD were typically 0.7 fps or less, which is the slow-water habitat that is preferred by brown trout in Rush Creek's natural channel (Taylor et al. 2009). Most overhead cover is provided by submerged vegetation (primarily elodea mats), which varies in density during different seasons; and, to a lesser extent, by large in-stream boulders and some mature willow clusters. LADWP's current practice of not cutting back the riparian vegetation along the inside (left) bank of the canal should lead to increased densities of mature willows, and the vital fish habitat that they provide for large fish. Continuation of this and other habitat enhancement efforts is important, because the MGORD supports by far the highest densities of large (>300 mm) brown trout in Rush Creek downstream of GLR. The lower 1,200 feet of the MGORD contains a series of grade-control weirs that step the canal down to its confluence with Rush Creek's natural channel. This somewhat higher gradient portion of the MGORD contains ample amounts of suitable sized spawning substrate, which is heavily utilized by spawning fish in the late autumn.

METHODS

Pools were rated in the field using criteria developed by Platts et al. (1983) for use on trout streams that range from 20 to 60 feet (6 to 18 meters) in width. To account for variations in pool depths that occur with changing stream discharge rates (and resulting stream stage heights), riffle crest depths were also measured at the tail-out of each pool (Lisle 1988). These measurements allowed us to calculate residual pool depths; where:

Residual Pool Depth = Maximum Pool Depth – Riffle Crest Depth

Using residual depths removes differences in maximum depths attributable to stage height differences. Residual depths also predict the maximum depths of pools that would be present during a worst-case (zero discharge) situation. We used the more stringent residual depth measurements (instead of maximum depth as suggested by Platts et al. 1983) when rating pools on Rush Creek. During the initial survey only the largest or highest quality pools (those rated Class-4 or Class-5) were recorded, using the following criteria:

The pool's maximum width had to be at least 90% of the mean channel width, and its residual depth had to be at least 2.0 feet; then:

(1) The pool was rated as Class-5 if (a) it had a residual depth >3.0 feet with some (>25%) hiding cover, or if (b) it had a residual depth of 2.0 to 2.9 feet with abundant (>75%) cover;
(2) The pool was rated as Class-4 if (a) it had a residual depth >3.0 feet with sparse (<25%) cover, or if (b) it had a residual depth of 2.0 to 2.9 feet with intermediate (50-74%) cover.

Within the Class-5 pools, the percent-relative abundance (PRA) of seven stream bottom substrate-types, ranging from silt to bedrock; and seven stream bank vegetation-types, ranging from none (or exposed) to moist-site shrubs (like willows or dogwood), were recorded. Also recorded was the percentage of a pool's surface area that was covered by eight cover types: overhanging vegetation, submerged vegetation, large woody accumulations, small woody accumulations, boulders, root wads, undercut banks and bubble curtains were estimated. The total of these percentages provided a Total Habitat PRA score for each Class-5 pool.

During the habitat typing surveys in 2008/09 and 2011, the lengths and residual depths of Class-2 and Class-3 pools were also measured. The maximum widths of these pools were generally <50% of the stream's mean width. The residual depths of these smaller pools were also typically <2.0 feet, although some larger pools with residual depths of 2.0 to 2.9 feet – but with sparse (<25%) cover – were also rated as Class-2 or Class-3. The 2008/09 and 2011 surveys also recorded the lengths of all high gradient riffles, low gradient riffles and glide/run habitat units:

High Gradient Riffle (HGR) units were typically found within moderate to high gradient stream sections, which resulted in most (>50%) of the unit's surface area being covered with surface agitation (or "bubble curtains").

Low Gradient Riffle (LGR) units were usually within low gradient stream sections, which resulted in only some (<25%) of the unit's surface area being covered by surface agitation.

Glide/Run habitat units were mostly within low to moderate gradient stream sections. These units were characterized by relatively uniform and/or "u-shaped" channel cross sections with no pronounced scour pockets or areas of surface agitation.

We did not break out, or measure, the lowest quality (Class-1) pools during any of the surveys on Rush Creek. These small, mostly "pocket pools" were primarily within riffles (either high- or low-gradient), and thus were included as part of these riffle units. On Lee Vining Creek, the number of pocket pools within each riffle unit was enumerated during the 2009 survey because, collectively, these small units comprised the majority of pool habitat in this high-gradient stream. Changes in pocket pool areas within Lee Vining Creek were then evaluated in response to changing stream flows as part of the IFS on this stream (Taylor et al. 2009).

The lengths of all habitat units were measured to the nearest foot with a hip-chain. Because of the ever-changing location of Mono Lake's shoreline, and thus the mouths of the streams, we started both surveys at the upper end of the study areas and proceed in a downstream direction. The latitude and longitude of each pool was also taken with a hand-held GPS unit. The accuracy of these measurements ranged from ±15 to 45 feet, depending upon the number of satellites that were present.

To further examine the historical development of high-quality pools in Rush Creek downstream of the Narrows, we compared pool measurements from our surveys to the locations, lengths and residual depths of pools that were measured during a 1991 pool and habitat study on Rush Creek downstream of GLR (Trihey and Associates 1994). The 1991 study did not utilize a pool quality rating system like Platts et al. (1983), so we employed residual depth measurements as a surrogate for a pool quality rating system, which allowed us to compare our more recent data to that collected 20 years earlier. We compared, by stream reach, the number of pools that had residual depths ranging from 2.0 – 2.9 ft (potential Class-4 pools), and those with residual depths >3.0 ft (potential Class-5 pools) during 1991, 2002/03, 2008/09 and 2011. This surrogate system does not incorporate cover, another key component of high-quality pools, but does help chronicle the natural development of more, deeper pool habitat on lower Rush Creek.

The portion of Rush Creek that was evaluated - from the bottom end of the MGORD downstream to the Mono Lake Delta - was divided into seven separate reaches, with the 10-Channel split-out as an eighth reach (Table 2). Reaches #1 - #3 were located upstream of the Narrows and Reaches #4 - #7 were located downstream of the Narrows (Table 2). The upper end of the 10-Channel started at the top of Reach #5 and re-entered the main channel approximately 1/3 of the distance down Reach #5. Reach #1 was not evaluated during 2011, so the totals for Reaches #2 - #7 are shown for the three survey-years on the second to last row of Table 2. During the 1991 survey (Trihey and Associates 1994), lower Rush Creek was divided into five study segments: Segment 1 was the MGORD, Segment 2 was the Gorge (our Reach 1), Segment 3 was from the bottom of the Gorge to the Narrows (our Reaches 2 and 3), Segment 4 was from the Narrows to the County Road Ford (our Reaches 4 and 5) and Segment 5 was from the Ford to Mono lake (our Reaches 6 and 7).

RESULTS

Rush Creek

Based on our hip-chain measurements, the total length of Rush Creek from the top of Reach #2 to Mono Lake was relatively unchanged (<3%) from 2002 (39,328 ft), through 2008 (39,715 ft) and 2011 (40,448 ft), although the lengths of some individual stream reaches either increased or decreased somewhat more than 3% between certain years (Table 2). Some of these length differences between the years were likely real, while others were probably measurement error, because there is about a 1-2% level of error associated with hip-chain measurements, especially when trying to carefully follow the channel thalweg through dense riparian vegetation, swift water, unstable/slippery stream bottom substrates or deep pools. Strong cross winds can also affect the accuracy of hip-chain measurements. Therefore, our hip-chain measurements may or may not coincide with the channel length measurements that are periodically recomputed from the most recent aerial photographs as part of other management activities in the Mono Lake Basin, although computing channel lengths from photographs also has accuracy limitations. Nonetheless, we feel that our hip-chain measurements provided the level of precision that was needed to accomplish our study.

High-Quality Pool Surveys

The total numbers and the percent-relative-abundance (PRA) of high-quality pools were substantially lower at the Reaches upstream (#1-#3) versus downstream (#4-#7) of the Narrows during 2002, and especially during 2008 and 2011 (Table 2 and Figures 1 and 2). Furthermore, the already low numbers and PRA of high-quality pools upstream of the Narrows steadily decreased from 2002-2011. For example, at Reach #3, the PRA of these pools decreased from an already low 1.8% of the total reach length in 2002 to 0.0% in 2011 (Table 2).

In response to the high runoff events of 2005 and 2006, the PRA and total numbers of high-quality pools increased within all the Reaches downstream of the Narrows between the 2002/03 and 2008 surveys. In the Reaches from the County Road Ford to Mono Lake (#6 and #7) and in the 10-Channel (#8), the PRA and total numbers of high-quality pools were two to five times higher in 2008 versus 2002/03. The largest increase between these years was at Reach #7, from the County Road Culvert to Mono Lake. Here, the PRA of high-quality pools increased from being only 3.4% of the total reach length in 2003, to 16.8% of the total reach length in 2008 (Figure 1); while the total number of these pools increased from three to 10 (Figure 2); and the total length of these pools increased from 154 feet to 883 feet (Table 2).

The PRA and total numbers of high-quality pools didn't increase as noticeably between the 2002/03 and 2008 surveys at Reaches #4 and #5. However, these Reaches already had relatively high numbers of high-quality pools in 2002 (Figure 2). Reach #5 - from the exit of the 10-Channel to the County Road Ford – had the highest PRA of high-quality pools along the mainstem of Rush Creek during both 2002/03 (15.3%) and 2008 (21.4%). Only the 10-Channel had a higher PRA of high-quality pools (34.1%) during 2008 (Figure 1). Overall, the PRA of high-quality pools on Rush Creek from Reach #2 through #7 nearly doubled between 2002/03 (5.8%) compared to 2008 (9.9%), with all of the increase occurring in the Reaches downstream of the Narrows (Table 2).

The 2011 high runoff event did not affect all of the Reaches downstream of the Narrows in the same manner. The PRA and total numbers of high-quality pools continued to steadily increase at the Reaches downstream of the County Road Ford (#6 and #7). In fact, the PRA of high-quality pools at Reach #7 (24.1%) was the highest in the study area during 2011 (Figure 1). The numbers and PRA of high-quality pools were almost exactly the same in 2008 and 2011 at Reach #5, which suggests that the channel deposition and scouring actions of the 2011 flood were roughly equal in throughout this Reach. Substantial sediment and bedload deposition occurred along Reach #4 between 2008 and 2011, filling many of the pools that were present in 2008, and causing numerous channel changes. These changes in channel morphology resulted in the PRA and total numbers of high-quality pools being reduced to less than one-half of their 2008 values at this Reach (Table 2). Similar reductions in high-quality pool numbers and abundance also occurred in the 10-Channel (Reach 8) between the 2008 and 2011 surveys, probably because of substrate mobilization, followed by deposition, during the 2011 runoff season.

Table 2. Length, percent relative abundance (PRA) and numbers of Class 4, Class 5 and total number of high-quality pools at eight stream reaches on Rush Creek during the initial (2002-03) survey and follow-up (2008 and 2011) surveys.

Reach Number and Name		Year Surveyed	Total Length (ft)	Class 4 Pools		Class 5 Pools		Class 4 and 5 Totals		
				Number	Length	Number	Length	Number	Length	PRA
#1	Gorge	**2002**	4,628	5	184	4	185	9	369	7.9%
		2008	4,628	1	36	4	183	5	219	4.7%
		2011	**Reach #1 not surveyed in 2011**							
#2	Gorge to Hwy 395	**2002**	6,682	2	118	2	163	4	281	4.2%
		2008	6,729	3	157	0	0	3	157	2.3%
		2011	7,056	3	178	0	0	3	178	2.5%
#3	Hwy 395 to Narrows	**2002**	9,540	3	148	0	0	3	148	1.6%
		2008	9,155	1	77	0	0	1	77	0.8%
		2011	9,461	0	0	0	0	0	0	0.0%
#4	Narrows to 10-Ch Exit	**2002**	8,010	6	228	7	401	13	629	7.9%
		2008	8,150	9	505	9	700	18	1,205	14.8%
		2011	7,732	5	358	3	139	8	497	6.4%
#5	10-Ch Exit to Co. Rd. Ford	**2002**	6,345	10	493	6	477	16	970	15.3%
		2008	6,262	6	482	12	882	18	1,364	21.8%
		2011	6,857	8	845	9	653	17	1,498	21.8%
#6	Co. Rd. Ford to Culvert	**2002**	4,122	1	51	1	62	2	113	2.7%
		2008	4,430	2	115	4	208	6	323	7.3%
		2011	4,551	6	405	4	198	10	603	13.2%
#7	Culvert to Mono Lake	**2002**	4,629	1	58	2	96	3	154	3.4%
		2008	4,989	0	0	10	883	10	883	16.7%
		2011	4,791	5	406	8	747	13	1,153	24.1%
#2 - #7	Gorge to Mono Lake	**2002**	39,328	23	1,096	18	1,199	41	2,295	5.8%
		2008	39,715	21	1,336	35	2,623	56	3,959	9.9%
		2011	40,448	27	2,192	24	1,737	51	3,929	9.7%
#8	10-Channel Split	**2002**	1,994	2	184	1	45	3	229	11.5%
		2008	1,525	3	256	3	262	6	518	34.1%
		2011	1,716	2	132	1	236	3	368	21.4%

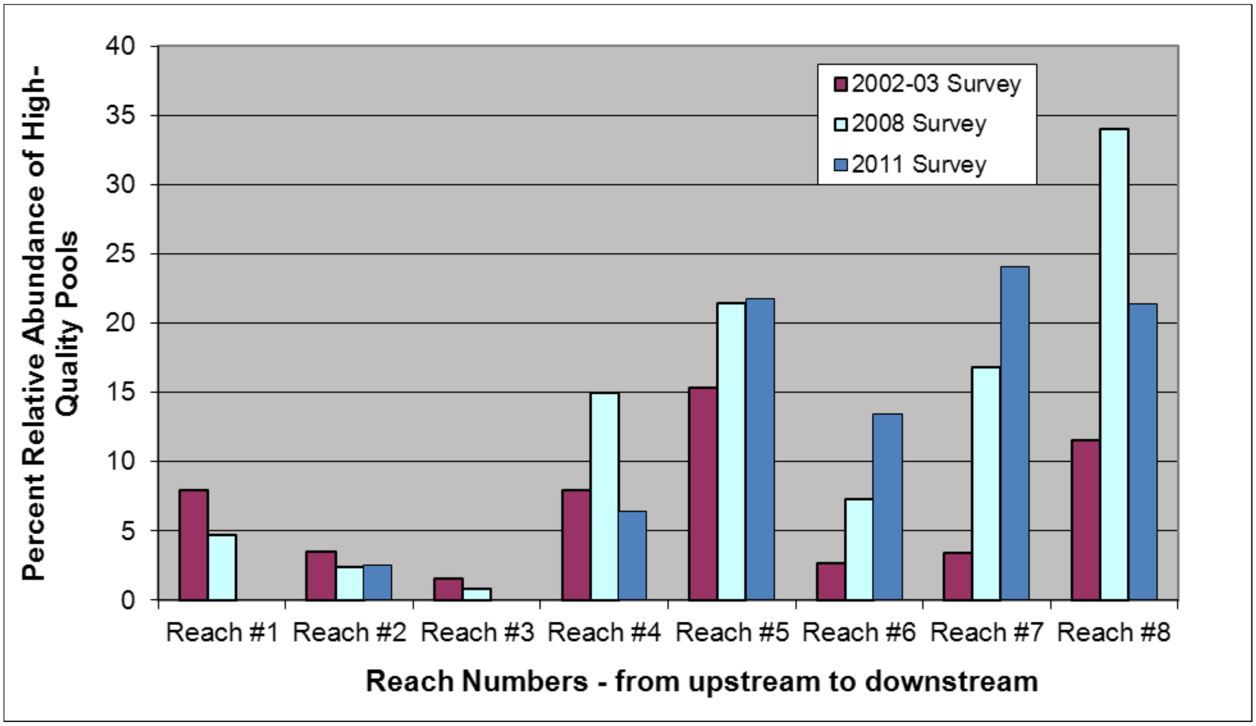

Figure 1. Percent Relative Abundance (PRA) of High Quality (Class-4 and Class-5 Pools) within eight stream reaches on Rush Creek during the initial (2002/03) and follow-up (2008 and 2011) pool surveys. Note: Reach #1 not surveyed in 2011.

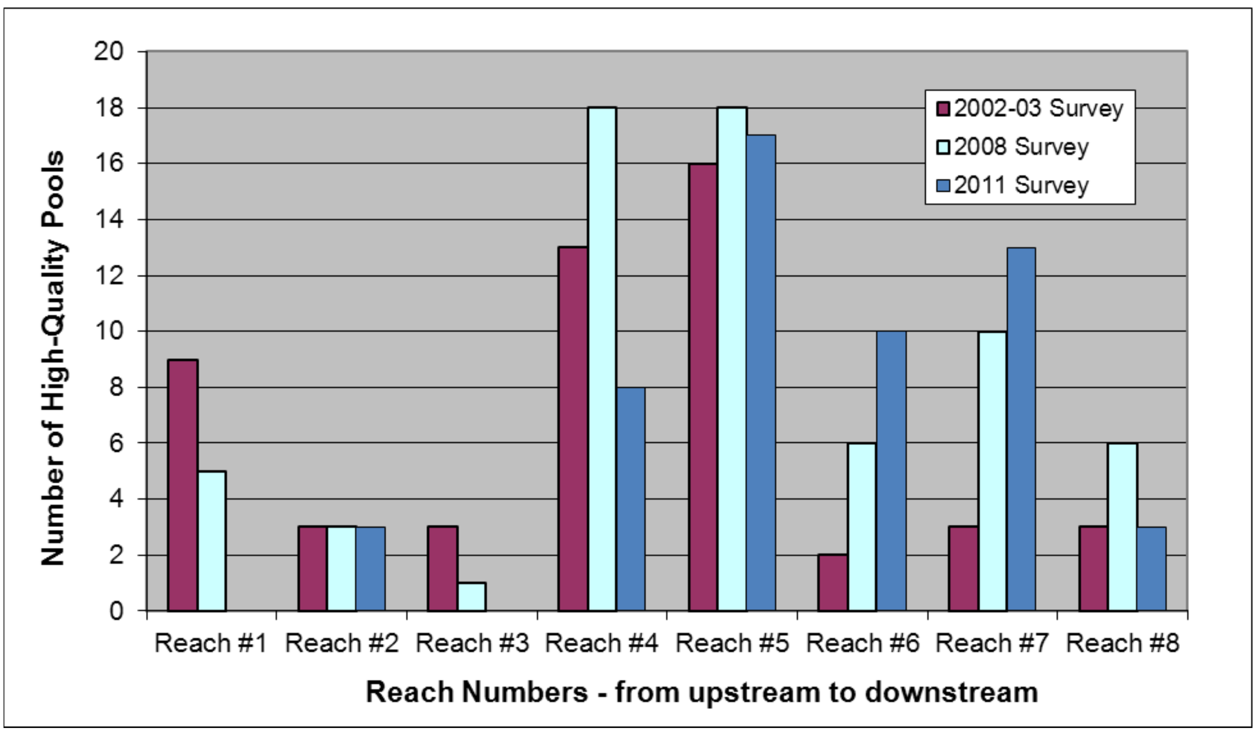

Figure 2. Total Numbers of High Quality (Class-4 and Class-5 Pools) within eight stream reaches on Rush Creek during the initial (2002/03) and follow-up (2008 and 2011) pool surveys. Note: Reach #1 not surveyed in 2011.

At the survey Reaches upstream of the Narrows (#1 through #3), the total number of pools with residual depths ranging from 2.0 ft to 2.9 ft (potential Class 4 pools) and those with residual depths >3.0 (potential Class 5 pools) remained largely unchanged, or decreased slightly, compared to the numbers that were present during the 1991 "pre-restoration" habitat inventory (Figures 3 and 4). Downstream of the Narrows, numbers of with residual depths ranging from 2.0-2.9 ft increased steadily, and almost exponentially, at Reaches #6 and #7 from 1991 through 2011; at Reaches #4 and #5 numbers of these pools also sharply increased from 1991-2008 and then slightly decreased between 2008 and 2011 (Figure 3).

Total numbers of pools with residual depths >3.0 ft substantially increased at all of the Reaches downstream of the Narrows from 1991 through 2008, and then remained the same or decreased somewhat between 2008 and 2011 at Reaches #5 - #7 (Figure 4). The largest decrease in the number of pools with residual depths >3.0 ft between the 2008 and 2011 surveys occurred at Reach 4, which also had the largest decrease in the number and PRA of high-quality pools in the study area between 2008 and 2011 (Figures 1 and 2).

At all Reaches downstream of the Narrows, the PRA of pool habitats with residual depths >2.0 (potential Class 4 or 5 pools) were much higher during 2008 and 2011 compared to the 1991 survey (Figure 5). The largest increases in deeper pool habitats over this 20-year period were at Reaches #6 and #7. For example, at Reach #7 the PRA of pools with residual depths >2.0 ft increased from being just 1.3% of the total Reach during 1991 to 29.8% of the Reach's length in 2011- an increase of over 20-fold (Figure 5); furthermore, half of these relatively new pools had residual depths >3.0 ft (Figures 3 and 4). Reach 5 consistently had the highest PRA of pools with residual depths >2.0 during each of the survey years from 1991-2008 (Figure 5); during 2011, the PRA of these deeper pool habitats was still high (28.8%) at Reach 5, but slightly lower than was present at this Reach in 2008 (30.3%), and at Reach #7 during 2011 (29.8%). As with the other evaluations of pool habitat quality discussed earlier, the PRA of deeper pool habitat at the Reaches upstream of the Narrows remained the same, or decreased from the already low values found during 1991 (Figure 5).

<u>Habitat-Typing Surveys</u>

<u>Comparisons between the 2008 and 2011 Surveys</u>

During both 2008 and 2011, HGR habitat units dominated the reaches upstream of the Narrows, with the PRA of this habitat type accounting for over three-quarters of the total lengths (Table 3) and PRA (Table 4) of Reaches #2 and #3. There were slight increases in the PRA of LGR habitat units at both of these reaches between 2008 (1.8-2.3%) and 2011 (7.4-7.6%). At Reach 2, the PRA of high-quality pools remained low and largely unchanged between 2008 and 2011, but the length of smaller (Class 2/3) pool habitat increased (Table 3), causing the PRA of total pool habitat to almost double between the years. At Reach #3, the already miniscule amount of pool habitat that was present in 2008 decreased to even lower levels in 2011, while the length and PRA of LGR and run/glide habitat units increased slightly between the years (Tables 3 and 4).

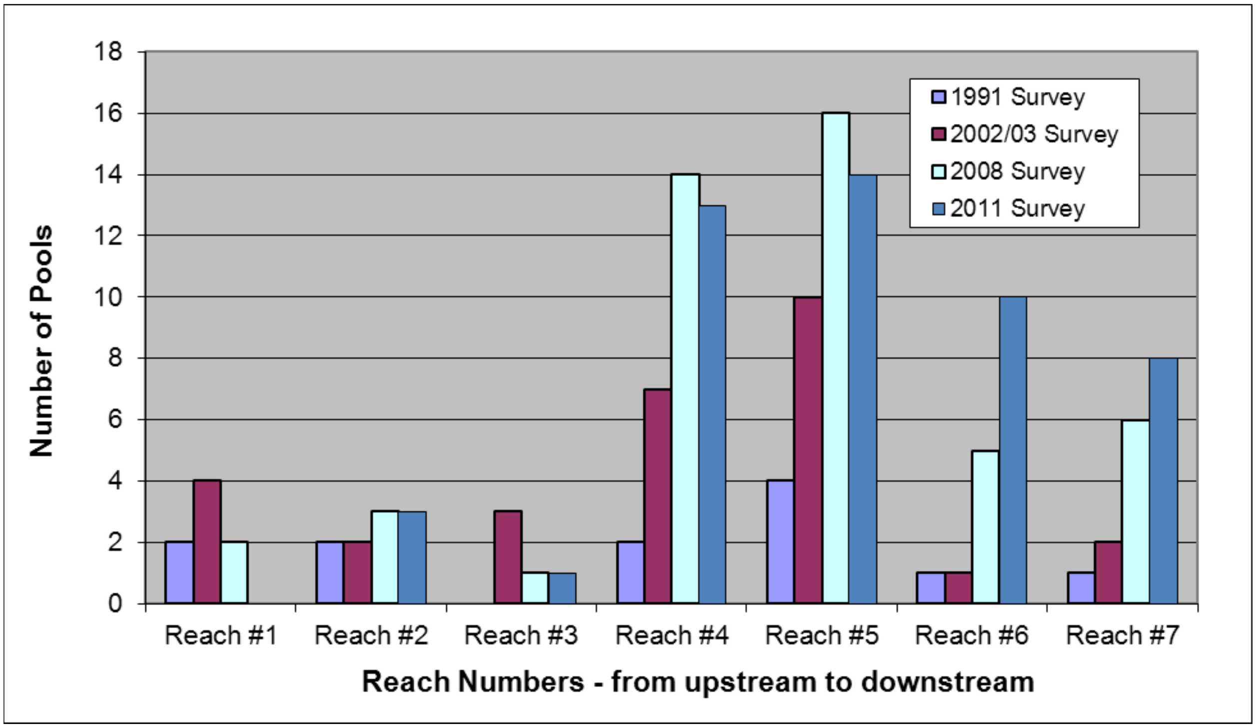

Figure 3. Total Numbers of Pools with Residual Depths ranging from 2.0-2.9 ft within seven stream reaches on Rush Creek during the 1991 Trihey habitat typing survey, the initial (2002/03), and follow-up (2008 and 2011) pool surveys. Note: Reach #1 not surveyed in 2011.

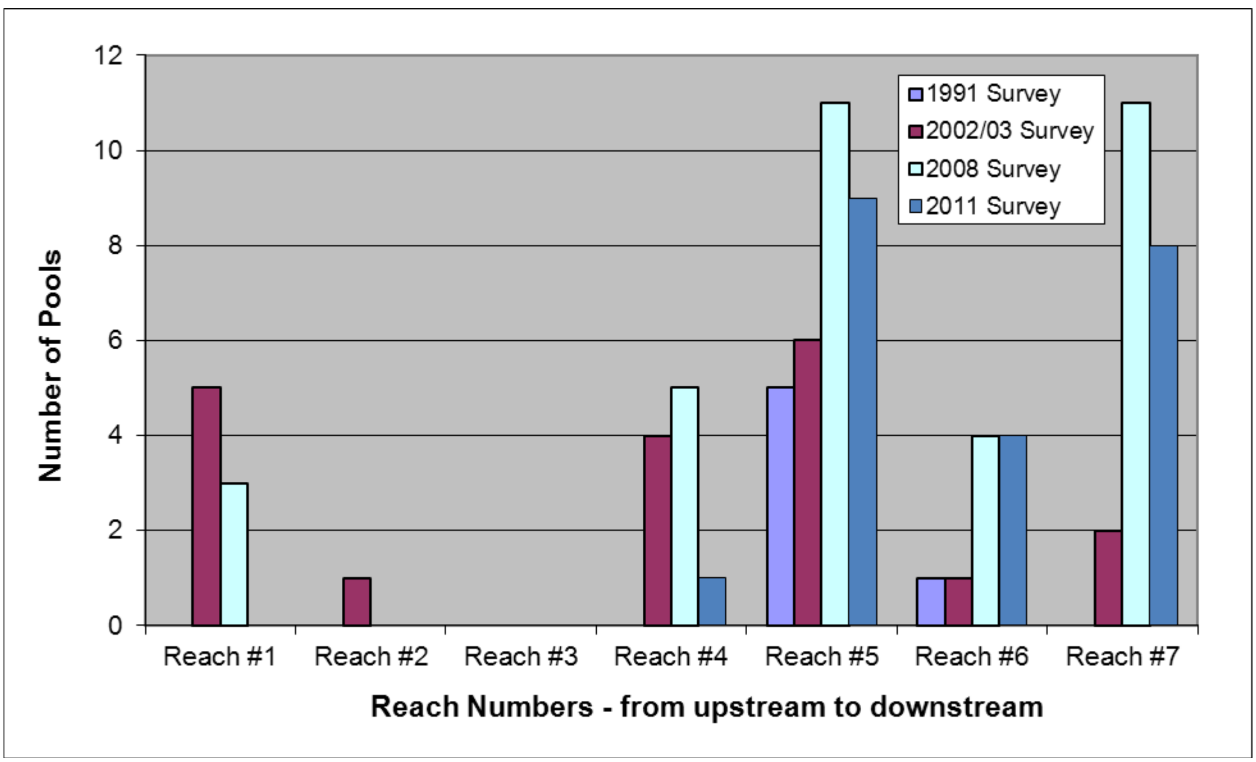

Figure 4. Total Numbers of Pools with Residual Depths Greater than 3.0 ft within seven stream reaches on Rush Creek during the 1991 Trihey habitat typing survey, the initial (2002/03), and follow-up (2008 and 2011) pool surveys. Note: Reach #1 not surveyed in 2011.

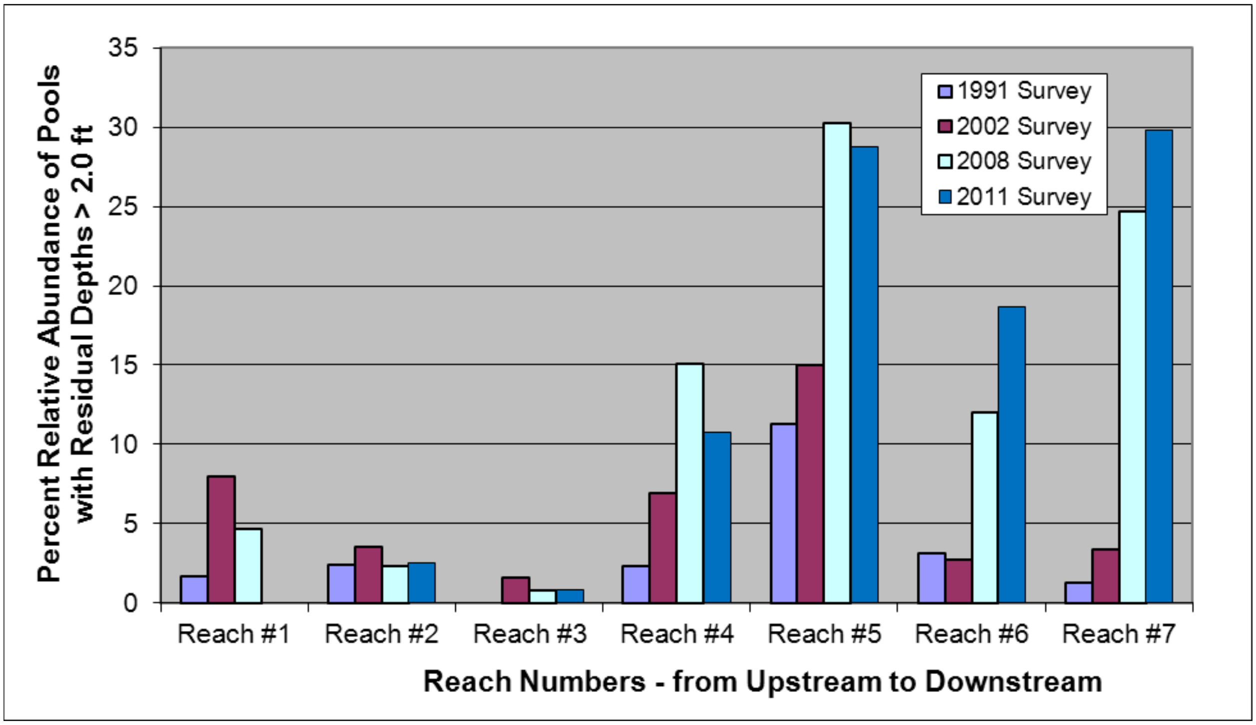

Figure 5. PRA of Pools with Residual Depths >2.0 ft at seven reaches on Rush Creek during the 1991 Trihey habitat typing survey, the initial (2002/03), and follow-up (2008 and 2011) pool surveys. Note: Reach #1 not surveyed in 2011.

At Reach #4, just downstream of the Narrows, the PRA of HGR habitat decreased from 61.5% in 2008 to 38.2% in 2011, while LGR habitat in turn increased in an almost equal manner from 7.8% to 33.9% (Table 4 and Figures 6 and 7). The PRA of total pool habitat remained almost constant at this reach between 2008 (19.8%) and 2011 (19.7%), but the PRA of Class 2/3 pools increased from 5.0 to 13.3%, while Class 4/5 pools decreased from 14.8 to 6.4% (Table 4); run/glide habitat was uncommon at this reach during both 2008 (11.0%) and 2011 (8.2%). At Reach #5, the PRA of high-quality (Class 4/5) pools was exactly the same during both surveys (21.8%), but the PRA of smaller, Class 2/3 pools increased from 9.6% in 2008 to 21.0% in 2011, which increased total pool habitat to a very high level of 42.8% at this reach during 2011 (Table 4 and Figure 7). The increase in smaller pool habitat in Reach #5 was accompanied by a loss in run/glide habitat between 2008 (21.2%) and 2011 (8.4%). The PRA of HGR habitat decreased from39.2% in 2008 to 23.3% in 2011, while LGR habitat increased from 8.2% to 25.5%.

The PRA of Class 2/3 pools at Reach #6 remained fairly constant between 2008 and 2011, but the PRA of high-quality pools increased from 7.3% in 2008 to 13.2% in 2011, as did total pool habitat (from 21.4% to 27.8%). Run/glide habitat remained relatively constant at this reach between the years (20.2-23.3%), but HGR habitat decreased by 12.2% and LGR habitat increased by 10.0% (Table 4 and Figures 6 and 7). The percentage of high-quality pools at Reach #7 also increased from 2008 (16.7%) to 2011 (24.1%); while the PRA of smaller pools decreased slightly, resulting in a somewhat higher total pool PRA in 2011 (31.6%) compared to 2008 (25.8%). HGR habitat decreased from 36.0% in 2008 to 15.6% in 2011, while HGR habitat increased from 22.1% to 34.1% and run/glide habitat was relatively unchanged (16.1% and 18.6%).

In the 10-Channel (Reach #8), the PRA of HGR habitat decreased from 28.4% in 2008 to 8.2% in 2011, while the PRA of LGR habitat increased from 5.8% to 25.8% between the surveys (Table 4). The PRA of high-quality pool habitat decreased from 34.1% in 2008 to 21.4% in 2011, while the PRA of smaller, Class 2/3 pools increased from 5.6% to16.7%, which resulted in the PRA for total pool habitat remaining largely the same in 2008 (39.6%) and 2011 (38.1%). The PRA of run/glide habitat was also very similar during both 2008 (26.2%) and 2011 (27.9%).

Comparisons amongst the 1991, 2008 and 2011 Surveys

Substantial changes occurred to the composition of habitat-types on Rush Creek between 1991 and 2008/11. Before describing these changes, a word of caution is needed about comparing the 1991 results to our results. The 1991 surveys broke-out more habitat types that we did, and included a habitat type (fast run) that is no longer recognized in more current methodologies (CDFG 2002). Because our surveys were focused on pools, we tended to lump high-gradient riffles, pocket water and fast runs all as high-gradient riffles. While changes most likely occurred in the composition of riffles and runs between 1991 and 2008/2011, the large shifts documented can at least partially be attributed to the different classification systems utilized. We believe the important comparisons between 1991 and 2008/11 are the shifts in pool frequency and quality.

During 1991, “almost 90% of Segment 1 consisted of relatively shallow, fast flowing water” (Trihey and Associates 1994). Habitat in this segment upstream of the Narrows during 1991 was primarily a combination of HGR and LGR habitat, with some run/glide habitat also being present (Table 5 and Figure 8). During the 2008 and 2011 surveys, most of this segment still consisted of relatively shallow, fast flowing water, but was almost totally dominated by HGR habitat. The PRA of pool habitat in Segment 1 slightly increased from 1.9% in 1991 to 4.4% in 2011.

At Segment 2, run/glides comprised roughly one-half (51.9%) of the habitat present in 1991, with the rest almost evenly split among HGR, LGR and pool habitat. Trihey and Associates (1994) further stated that “spawning habitat [in this segment] suffered from chemical cementing of the substrate and the presence of angular shaped gravels”. During 2008, HGR habitat was dominant (51.8%), with run/glide habitat comprising only 15.4% of the segment (Table 5). The PRA of LGR habitat in this segment increased from only 8.0% in 2008 to 29.9% in 2011, while the PRA of HGR habitat decreased from 51.8% to 31.2%. The PRA of pool habitat in Segment 2 was the highest among the three segments during each of the survey years, and steadily increased from 13.1% in 1991, to 24.8% in 2008 and 30.6% in 2011 (Table 5 and Figure 8).

During 1991, Segment 3 was dominated by run/glide habitat (PRA of 73.9%). Again quoting the Trihey and Associates (1994) report: “the stream channel [in this section] lacks complexity and the run habitat tends to be shallow and void of cover”; furthermore, spawning habitat was impacted by “the presence of pumice and fine sediments”. By 2008, HGRs were the most common habitat-type in this segment (43.8%), followed by pools (23.7%), run/glides (19.5%) and LGR habitat (13.0%). During 2011 pools, which comprised only 7.9% of the length of Segment 3 in 1991, were the dominant habitat-type (PRA =29.7%), followed by HGR habitat (27.1%), LGR habitat (23.7%) and run/glides (19.4%) (Table 5 and Figure 8).

Appendix A contains a spreadsheet of the 2011 Rush Creek habitat typing data.

Table 3. Lengths, in feet, of habitat units at six mainstem stream reaches on Rush Creek (#2 - #7) and in the 10-Channel (#8) during September of 2008 and 2011.

Habitat Type	Survey Year	Reach #2	Reach #3	Reach #4	Reach #5	Reach #6	Reach #7	Reaches #2 -#7	Reach #8
HGR	**2008**	5,632	8,572	5,009	2,455	2,327	1,797	25,792	433
	2011	5,407	8,335	2,952	1,598	1,786	749	20,827	141
LGR	**2008**	122	213	636	513	125	1,101	2,710	88
	2011	537	698	2,621	1,746	582	1,636	7,820	443
Glide-Run	**2008**	663	126	893	1,328	1,032	805	4,847	400
	2011	506	308	634	577	919	891	3,835	478
Class 2/3 Pool	**2008**	155	167	407	602	623	453	2,407	86
	2011	428	120	1,028	1,438	661	362	4,037	286
Class 4/5 Pool	**2008**	157	77	1,205	1,364	323	833	3,959	518
	2011	178	0	497	1,498	603	1,153	3,929	368
Total All Pools	**2008**	312	244	1,612	1,966	946	1,286	6,366	604
	2011	606	120	1,525	2,936	1,264	1,515	7,966	654
Total Reach Length	**2008**	6,729	9,155	8,150	6,262	4,430	4,989	39,715	1,525
	2011	7,056	9,461	7,732	6,857	4,551	4,791	40,448	1,716

Table 4. Percent relative abundance of habitat units at six mainstem stream reaches on Rush Creek (#2 - #7) and in the 10-Channel (#8) during September of 2008 and 2011.

Habitat Type	Survey Year	Reach #2	Reach #3	Reach #4	Reach #5	Reach #6	Reach #7	Reaches #2 -#7	Reach #8
HGR	**2008**	83.7%	93.4%	61.5%	39.2%	52.5%	36.0%	64.9%	28.4%
	2011	76.6%	88.1%	38.2%	23.3%	40.3%	15.6%	51.5%	8.2%
LGR	**2008**	1.8%	2.3%	7.8%	8.2%	2.8%	22.1%	6.8%	5.8%
	2011	7.6%	7.4%	33.9%	25.5%	12.8%	34.1%	19.3%	25.8%
Glide-Run	**2008**	9.9%	1.3%	11.0%	21.2%	23.3%	16.1%	12.2%	26.2%
	2011	7.2%	3.3%	8.2%	8.4%	20.2%	18.6%	9.5%	27.9%
Class 2/3 Pool	**2008**	2.3%	1.8%	5.0%	9.6%	14.1%	9.1%	6.1%	5.6%
	2011	6.1%	1.3%	13.3%	21.0%	14.5%	7.6%	10.0%	16.7%
Class 4/5 Pool	**2008**	2.3%	0.8%	14.8%	21.8%	7.3%	16.7%	10.0%	34.1%
	2011	2.5%	0.0%	6.4%	21.8%	13.2%	24.1%	9.7%	21.4%
Total All Pools	**2008**	4.6%	2.6%	19.8%	31.4%	21.4%	25.8%	16.0%	39.6%
	2011	8.6%	1.3%	19.7%	42.8%	27.8%	31.6%	19.7%	38.1%

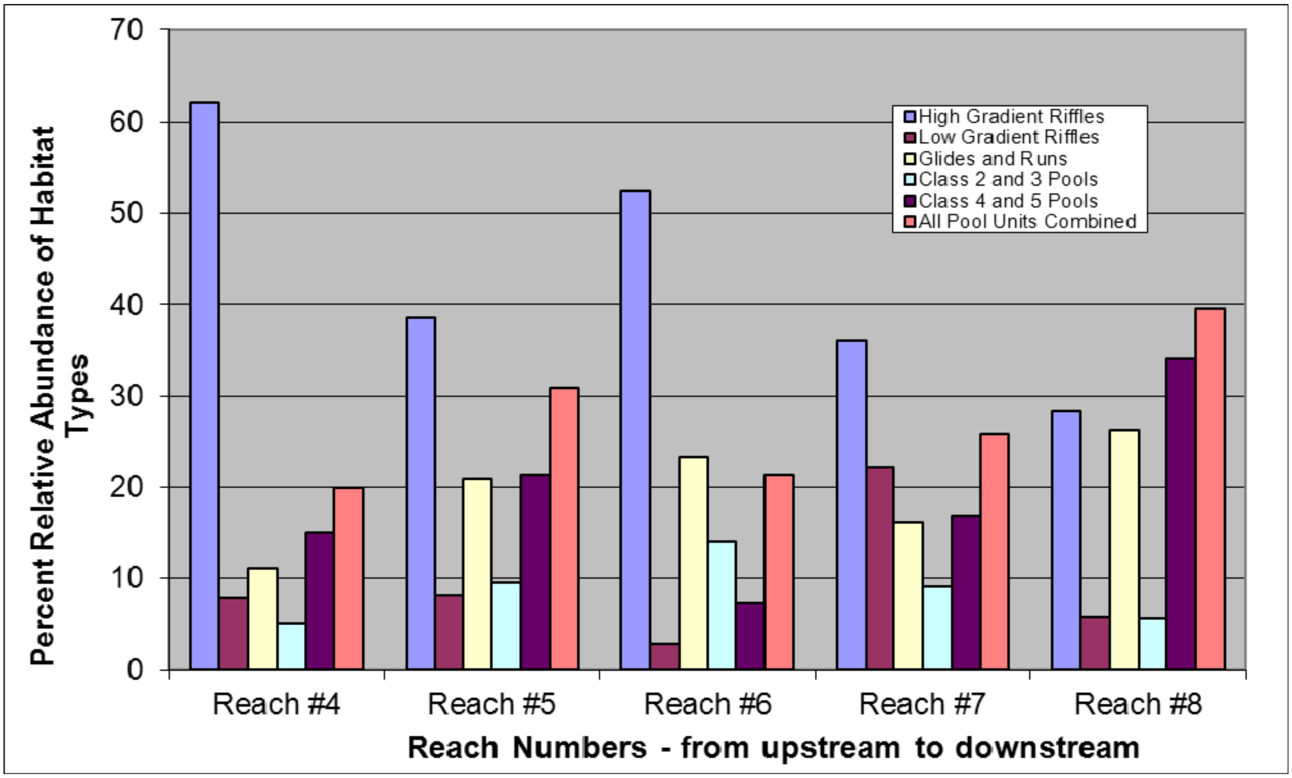

Figure 6. PRA of High Gradient Riffles (HGR), Low Gradient Riffles (LGR), Glide/Runs, Class 2 and 3 Pools, and Class 4 and 5 ("High Quality") Pools at five reaches on Rush Creek during 2008.

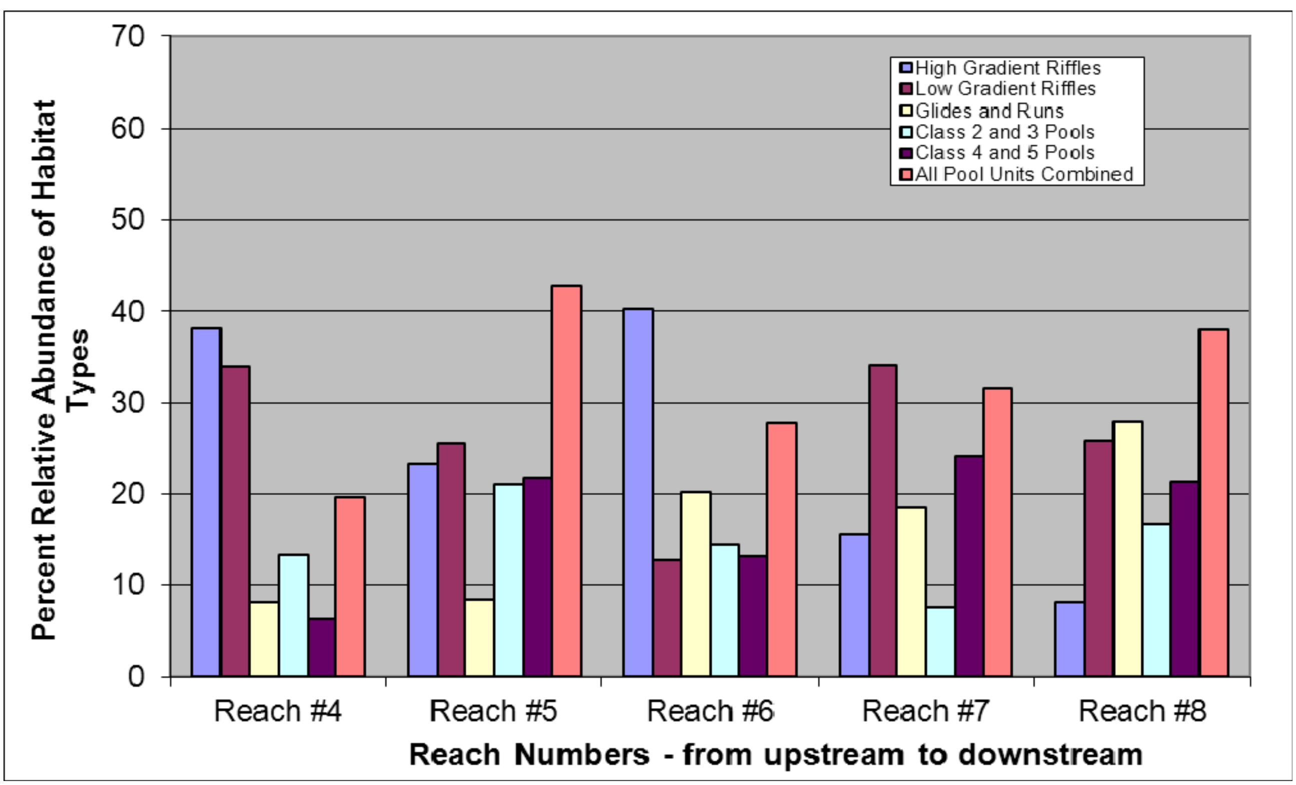

Figure 7. PRA of High Gradient Riffles (HGR), Low Gradient Riffles (LGR), Glide/Runs, Class 2 and 3 Pools, and Class 4 and 5 ("High Quality") Pools at five reaches on Rush Creek during 2011.

Table 5. Lengths (feet) and percent relative abundance (PRA) of basic habitat types during 1991, 2008, and 2011 surveys at three Rush Creek segments: #1 bottom of Gorge to Narrows, #2 Narrows to CoRd Ford, and #3 CoRd Ford to Mono Lake.

Segment Number	Habitat Type	1991 Survey		2008 Survey		2011 Survey	
		Length (ft)	PRA	Length (ft)	PRA	Length (ft)	PRA
#1 – Bottom of Gorge to Narrows	HGR	6,737	40.6%	14,204	89.4%	13,742	83.2%
	LGR	5,791	34.9%	335	2.1%	1,235	7.5%
	Run	2,905	17.5%	789	5.0%	814	4.9%
	Pool	317	1.9%	556	3.5%	726	4.4%
	Other	850	5.1%	0	0	0	0
	Total	16,600		15,884		16,517	
#2 – Narrows to Co Rd Ford	HGR	2,324	16.6%	7,464	51.8%	4,550	31.2%
	LGR	1,988	14.2%	1,149	8.0%	4,367	29.9%
	Run	7,266	51.9%	2,221	15.4%	1,211	8.3%
	Pool	1,834	13.1%	3,578	24.8%	4,461	30.6%
	Other	588	4.2%	0	0	0	0
	Total	14,000		14,421		14,589	
#3 – Co Rd Ford to Mono Lake	HGR	1,541	16.6%	4,124	43.8%	2,535	27.1%
	LGR	74	0.8%	1,226	13.0%	2,218	23.7%
	Run	6,868	73.9%	1,837	19.5%	1,810	19.4%
	Pool	733	7.9%	2,232	23.7%	2,779	29.7%
	Other	84	0.9%	0	0	0	0
	Total	9,300		9,419		9,342	

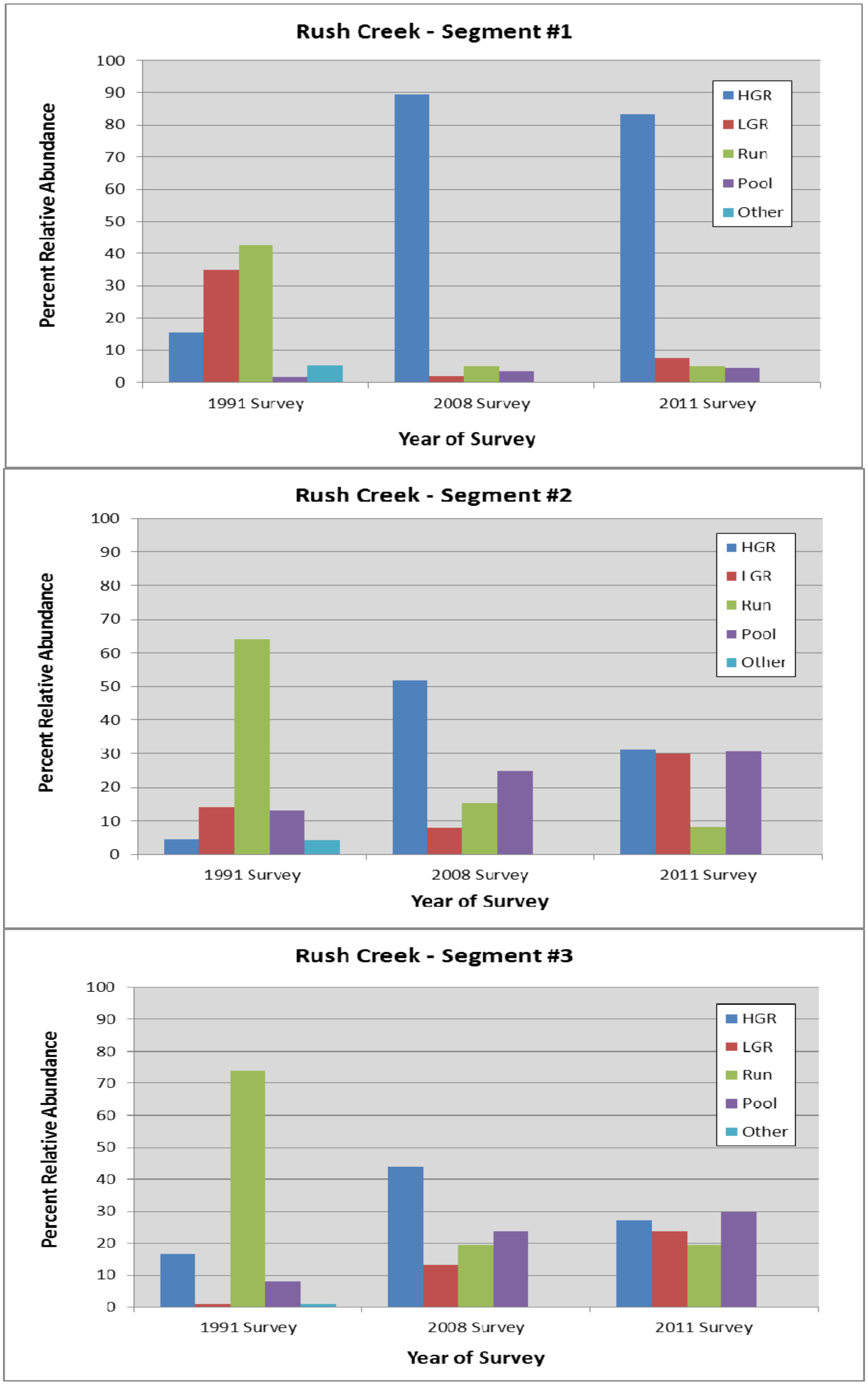

Figure 8. Percent relative abundance of four basic habitat types during 1991, 2008, and 2011surveys at three Rush Creek segments: #1 bottom of Gorge to Narrows, #2 Narrows to CoRd Ford, and #3 CoRd Ford to Mono Lake.

Lee Vining Creek

At the two stream reaches on Lee Vining Creek upstream of the County Road Ford, there was little change in the PRA of habitat- types between 2008 and 2011 (Table 6). Reach 1 was dominated by HGR habitat during both 2008 (PRA =95.2%) and 2011 (96.2%) (Table 6); there were no Class 2 or larger pools in this reach, but small pocket pools where common. Reach 2 was also dominated by HGRs, with some glide/run habitat (17%) and lesser amounts of Class 2/3 pools (7%) and high quality pools (2%). Downstream of the County Road Ford (Reach 3), the PRA of HGR habitat decreased from 66.6% of the stream's length in 2008 to 49.9% in 2011, while the PRA of LGR habitat increased from 0.0% to 8.4% and glide/run habitat increased from 11.0% to 24.2%. The PRA of Class 2/3 pools remained about the same between the years (13.5 and13.8%), but there was a sharp reduction in the already low PRA of high-quality pools in this reach between 2008 (8.6%) and 2011 (3.9%) and throughout Lee Vining Creek; i.e. 3.4% in 2008 compared to only 1.9% in 2011 (Table 6).

Appendix B contains a spreadsheet of the 2011 Lee Vining Creek habitat typing data set.

Table 6. Percent relative abundance (PRA) of habitat types at three reaches on Lee Vining Creek during 2008 and 2011.

Habitat Type	**Survey Year**	**Reach #1 -** Behind Town to Top of A-Channel	**Reach #2 -** Top of A-Channel to Co. Rd. Ford	**Reach #3 –** Co. Rd. Ford to Mono Lake	**Reach Totals**
HGR	2008	95.2%	74.9%	66.6%	76.8%
	2011	96.2%	72.4%	49.9%	70.3%
LGR	2008	0.0%	0.0%	0.0%	0.0%
	2011	0.0%	2.6%	8.4%	3.9%
Glide/Run	2008	4.8%	16.5%	11.0%	12.3%
	2011	1.5%	17.0%	24.2%	16.0%
Class 2-3 Pools	2008	0.0%	7.0%	13.8%	7.6%
	2011	2.3%	6.5%	13.5%	7.8%
Class 4-5 Pools	2008	0.0%	1.6%	8.6%	3.4%
	2011	0.0%	1.5%	3.9%	1.9%
Total all Pools	2008	0.0%	8.6%	22.4%	11.0%
	2011	2.3%	8.0%	17.4%	9.8%

DISCUSSION

The Narrows, an approximately 200 foot-long gorge through a granitic dike, separates lower Rush Creek's stream channel into two roughly equal halves that responded differently to the high water events of 2006 and 2011. In the relatively high gradient half of Rush Creek from the bottom of the MGORD to the Narrows, the already low abundance of high-quality pool habitat remained unchanged or declined between 2002 and 2011. In contrast, most of the lower-gradient stream reaches downstream of the Narrows experienced steady, and often substantial, increases in the abundance of high-quality pool habitat. The 1991 study was called a "pre-restoration" survey. Twenty years later, our work can probably be best labeled as a "progress report". Habitat conditions have generally improved on lower Rush Creek, but are not by any means completely restored. Pool habitats should continue to gain complexity as the riparian vegetation matures and starts to recruit LWD to the stream channel. Changes that have occurred to the abundance of high-quality pools from 1991-2011 at eight stream reaches on lower Rush Creek are summarized below.

<u>Rush Creek - Upstream of the Narrows</u>

In the Gorge (Reach #1), very large boulders and large trunks of fallen Jeffry Pine have created a handful of very stable high-quality pools within an otherwise high-gradient reach dominated by cascades, riffles and pocket pools. We did not resurvey this reach during 2011, because we noted little change in the location and size of high-quality pool habitat in this reach between 2002 and 2008, and – from an even more long-term perspective - because of the persistence of overall channel morphology in Reach 1 between 1941 and 1991 (Stine 1992). Given that the stream bottom and banks of this reach are comprised of very large materials, the few large pools that are present will likely persist well into the future, but opportunities for the development of additional high-quality pools will remain limited.

From the bottom of the Gorge to Highway 395 (Reach #2), the already low abundance of high-quality pools declined somewhat, especially between 2002 and 2011, partially because of the loss in lengths and residual depths of three artificial "Trihey" pools that were constructed within this reach during the mid-1990's (Table 6). These pools were excavated with mechanized heavy equipment and large root wads were lowered from helicopters into the stream channel. Residual depths and pool quality ratings have remained stable at the upper pool, but have declined steadily at the other two; the loss in length, residual depth and pool quality was most evident at the lowermost pool. This loss of artificial pool habitat was partially offset by the development of several natural pools in this reach between 2002 and 2011. The potential for future development of high-quality pools in Reach 2 is limited, primarily because of relatively high stream gradients and large bottom substrate sizes. However, the continued maturation and size of riparian vegetation root structures along the stream banks will likely lead to eventual increases in the residual depths, and thus potential pool quality, at some of the smaller (Class 2/3) pools that were measured during the 2011 survey.

At Reach #3, from Highway 395 downstream to the Narrows, the PRA of high-quality pools declined from a mere 1.6% of the stream reach to 0.0% in 2011. Over the course of several decades, gravel mining operations have extensively altered the stream channel and have removed much of the spawning-sized gravel from the floodplain. During all of the surveys from 1991-2011, habitat complexity- especially pool habitat- was lacking; i.e. this reach was dominated by high gradient riffles both in 2008 (93.4%) and 2011 (88.1%). The stream channel and banks of this Reach 3 are comprised primarily of cobble and small boulders, and the recovery of riparian vegetation has been slower than at any other reach on Rush Creek. It is unlikely that any new high-quality pools will be formed in this reach for at least several decades, if not longer.

Table 6. Lengths, depths, and pool quality classifications for three artificial "Trihey" pools in the Upper Rush Creek electrofishing section during 2002, 2008, and 2011.

Trihey Pool Location	Survey Year	Total Length (ft)	Max. Depth (ft)	Residual Depth (ft)	Pool Quality Rating	Lat. N37	Long. W119
#1 – Upper-most	2002	72	2.9	2.3	4	.88311	.09623
	2008	52	3.7	2.3	4		
	2011	67	3.5	2.3	4		
#2 - Middle	2002	52	3.6	2.9	4	.88361	.0951
	2008	60	3.1	1.9	3		
	2011	42	3.3	1.8	3		
#3- Lower-most	2002	111	3.9	3.2	5	.88457	.09433
	2008	45	3.7	2.6	4		
	2011	58	3.1	1.9	3		

Rush Creek - Downstream of the Narrows

During our surveys from 2002 to 2011, the PRA of high-quality pool at Reach #4 (from the Narrows to the exit of the 10-Channel) increased from 7.9% in 2002 to a high of 14.8% in 2008, and then decreased to a low of 6.4% in 2011 (Figure 1). Many of the new or enlarged pools that were present after the 2006 high water event where either partially filled (i.e. reduced to Class 2/3 pools), or were totally abandoned, in response to the channel erosion and deposition caused by the 2011 peak flows. Reach #4 was consistently the most visibly unstable reach that we surveyed on Rush Creek, with numerous channel changes and small head-cuts occurring at various locations during all three of our surveys. The instability of this reach was also noted by Trihey and Associates during the 1991survey; quoting the authors: "Throughout [this reach] the stream is re-establishing a floodplain with an incised channel through active bank erosion". Until the stream channel incision that occurred in response to the lowering of Mono Lake's water levels between 1941 and 1991 (Stine 1992) eventually reaches the granitic dike at the Narrows, the abundance of high-quality pool habitat in Reach #4 will likely continue to fluctuate as it did from 2002 to 2011 during future high water events.

Reach #5, from the exit of the 10-Channel to the County Road Ford consistently contained a relatively high abundance of pools throughout the twenty-year period from 1991 to 2011. During 1991, the PRA of total pool habitat in this reach was over three times higher than was found at any of the other stream reaches (Trihey and Associates 1994). The PRA of high-quality pool habitat increased from 15.3% in 2002 to 21.4% in 2008 as a result of the 2006 peak flows. The abundance of high-quality pools and remained about the same (21.8%) during 2011, which suggests that the scouring and deposition caused by the 2011 peak flows were roughly equal within the larger pools in this reach. The PRA of total pool habitat at Reach #5 in 2011 was 42.8%, which was by far the highest density found anywhere on Rush Creek during either 2008 or 2011. The stream channel in this reach was relatively stable from 2002 to 2011. High-quality pool habitat should continue to remain abundant in this reach, at least for the foreseeable future.

From the County Road Ford to the County Road Culvert (Reach #6), numerous channel changes, resulting from a combination of small head-cuts, stream bank scouring and bedload deposition, occurred between 2002 and 2011. Despite this channel instability, the PRA of high-quality pools increased from only 2.7% in 2002, to 7.3% in 2008 and 13.4% in 2011. The continued presence of channel head-cutting in this reach during 2011, although less evident than in Reach #4, will likely cause fluctuations in the abundance of high-quality pool habitat to continue in this reach for an indefinite period.

During 1991, the stream reach between the County Road Culvert and Mono Lake was dominated by shallow run/glide habitat, deep pools were rare and stream bottom substrates were primarily composed of fine sediments (Trihey et al. 1994). During 2002, the PRA of high-quality pools was still very low (3.4%). Following the 2006 high runoff flows, the PRA of these large pools increased to 16.8%, and then increased again to 24.1% of the stream reach after the 2011 peak flows. The latter value was the highest recorded for any stream reach on Rush Creek from 2002 to 2011. The stream channel in Reach #7 was somewhat more stable than was found upstream of the County Road Culvert, with no obvious head-cuts being present in 2011. Many of the newly-formed high-quality pools in this reach are likely to persist for some time, but about 50% of these pools will eventually be inundated by Mono Lake's rising surface elevation.

The 10-Channel (Reach #8) was a small, sediment-filled side channel during 1991 and 2002, capturing less than a quarter of Rush Creek's flow. Channel changes caused by 2006 peak flows directed much more of Rush Creek's flow into the 10-Channel, which intensified channel scouring in this reach and caused the PRA of high-quality pool habitat to increase from 11.5 % in 2002 to 34.1% in 2008. More deposition than scouring occurred in this reach during the 2011 peak flows, causing the PRA of high-quality pools to decrease to 21.4%. The best pool habitat during 2008 and 2011 was near the bottom of the reach, where the stream has been dammed by woody debris interwoven within willows and other living and dead shrubs. If or when this unstable dam breaks, the PRA of high-quality pool habitat will drop substantially in this reach. The resulting drop in channel elevation will likely lead to a larger portion of the stream's flow being captured by the 10-Channel, leading to further dewatering of the upper portion of Reach #5.

Lee Vining Creek

Lee Vining Creek's stream channel was highly unstable throughout the study area, but particularly in Reaches 2 and 3, where many new channels were formed and others abandoned by the erosive actions of the 2011 peak flows. For example, the only large Class 5 pool that was present in Reach 2 during 2008 was completely filled with cobble and gravel and was reduced to a shallow riffle during the 2011 peak flows; at the same time, two new Class 4 pools were formed in this reach between 2008 and 2011. In Reach 3, the majority of high-quality pools that we measured in 2008 were either shorter, shallower or had less cover than during 2011, which resulted in a decrease in the PRA of high-quality pool habitat in this reach from 3.4% in 2008 to only 1.9% in 2011.

Lee Vining Creek upstream of the County Road Ford is high gradient with boulders and cobble comprising most of the stream channel and banks. Downstream of the County ford, the stream channel is lower gradient, but is still trying to reestablish a channel through a sparsely vegetated riparian area. Given the unsuitable conditions for pool development in Reaches 1 and 2 and the highly unstable channel in Reach 3, the abundance of high-quality pools on Lee Vining Creek will continue to fluctuate, but remain very low, until the stream's riparian community significantly matures to include large cottonwood and Jeffery Pines, which will likely take at least several decades. Even then, we doubt that the occurrence of high-quality pools in Lee Vining Creek will approach the numbers already present in Rush Creek.

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Rush Creek September 2011 Habitat Typing and Pool Survey

Habitat Type	Start Distance (ft)	Unit Length (ft)	Max Depth (ft)	Residual Depth (ft)	LAT. N37.	LONG. W119	GPS Accuracy +/- ft	COMMENTS
PO-1	0	41	3.3	1.6	.879	.1036	12	CL-2- PO-8 (CL-3) in '08
HGR-1	41	206						
PO-2	247	42	3.3	1.7	.87925	.10303	14	CL 2/3- new since '08
HGR-2	289	257						
LGR-1	546	66						
HGR-3	612	743						
PO-3	1355	97	3	1.6	.88126	.10062	8.5	CL-2-PO-9 (CL-3) in '08
HGR-4	1452	52						
PO-4	1504	43	3.2	1.8	.88134	.10024	10	CL-3-new since '08
HGR-5	1547	51						
LGR-2	1598	105						
HGR-6	1703	104						
PO-5	1807	40	2.7	1.5	.88158	.09924	15	CL-2- new since '08
HGR-7	1847	101						
PO-6	1948	61	2.6	1.2	.88164	.09872	13	CL-2 - P4-2 in '08 (3.4'max.dep)
HGR-8	2009	143						
Top UPRU	2061							
GL-1	2152	73	2.6					
HGR-9	2225	44						
GL-2	2269	40	2.5					
HGR-10	2309	239						
P4-1	2548	67	3.5	2.3	.88254	.09707	13	P4-3 in '08 (upper Trihey pool)
chan exit	2615							
HGR-11	2615	181						
GL-3	2796	80	2.6					
chan rtn	2796							
HGR-12	2876	173						
PO-7	3049	46	3.3	1.8	.88311	.09623	14	CL-3 -PO-11 (CL-3) in '08
HGR-13	3095	212						
LGR-3	3307	121						
PO-8	3428	58	3.1	1.9	.88361	.0951	14	CL-3 - P4-4 in '08 (3.7' max dep)
HGR-14	3486	414						
Bot UPRU	3531							
chan exit	3541							
P4-2	3900	47	3.7	2.9	.88457	.09433	13	PO-12 CL-3) in '08
HGR-15	3947	30						
GL-4	3977	59	2.3					
HGR-16	4036	409						
LGR-4	4445	137						
HGR-17	4582	443						
chan rtn	4857							
GL-5	5025	137	2.8					
HGR-18	5162	157						
chan rtn	5162							
LGR-5	5319	59						
HGR-19	5378	136						

Habitat Type	Start Distance (ft)	Unit Length (ft)	Max Depth (ft)	Residual Depth (ft)	LAT. N37.	LONG. W119	GPS Accuracy +/- ft	COMMENTS
P4-3	5514	64	3.3	2.6	.88822	.09266	15	art. Pool for stream gauging
HGR-20	5578	562						
br. xing	5583							old HWY 395 bridge
LGR-6	6140	59						
HGR-21	6199	133						
GL-6	6332	117	2.2					
HGR-22	6449	883						
br. xing	6728							top of new HWY 395 bridge
br. Xing	7056							bot. of new HWY 395 bridge
GL-7	7332	45	2.7					
HGR-23	7377	268						
GL-8	7645	31	2.1					
HGR-24	7676	116						
PO-9	7792	48	2.6	1.6	.89318	.08878		CL-2 little cover
HGR-25	7840	1764						
chan exit	9322							
LGR-7	9604	84						
HGR-26	9688	269						
GL-9	9957	58	2.4					
HGR-27	10015	299						
chan exit	10015							
LGR-8	10314	89						
HGR-28	10403	814						
chan exit	10592							
chan rtn	11080							
LGR-9	11217	152						
chan exit	11369							
HGR-29	11369	536						
chan exit	11736							
chan rtn	11817							
GL-10	11905	52	2.1					
HGR-30	11957	300						
LGR-10	12257	73						
HGR-31	12330	562						
LGR-11	12892	53						
HGR-32	12945	462						
PO-10	13407	72	3.3	2.2	.90609	.08286	8	CL-2 no cover (gr. Plant pool)
HGR-33	13479	1041						
Parker Cr	13595							
LGR-12	14520	99						
HGR-34	14619	596						
GL-11	15215	82						
HGR-35	15297	445						
LGR-13	15742	83						
HGR-36	15825	257						
LGR-14	16082	65						
HGR-37	16147	175						
GL-12	16322	40						
HGR-38	16362	212						

Habitat Type	Start Distance (ft)	Unit Length (ft)	Max Depth (ft)	Residual Depth (ft)	LAT. N37.	LONG. W119	GPS Accuracy +/- ft	COMMENTS
Walker Cr	16517							
PO-11	16574	25	4	1.7	.91371	.0791	30	CL-2/3 - PO-17 (CL-2/3) in '08
HGR-39	16599	86						
PO-12	16685	20	4.1	2.1	.91394	.07902	33	CL-3 - P4-6 (2.8' res dep) in '08
HGR-40	16705	23						
PO-13	16728	19	3	2	.91411	.07904	35	CL-3 - new since '08
PO-14	16747	24	3.2	1.3	.91411	.07904	35	CL-2 - new since '08
HGR-41	16771	67						
PO-15	16838	32	3.3	1.6	.91428	.07878	16	CL-2/3 - P4-7 in '08?
HGR-42	16870	23						
chan exit	16887							
PO-16	16893	27	3	1	.91449	.07873	21	CL-2 - PO-18 (CL-2/3) in '08
HGR-43	16920	52						
chan rtn	16963							
PO-17	16972	32	3.2	1.2	.91454	.07845	17	CL-2 - PO-19 (CL-3) in '08
LGR-15	17004	93						
HGR-44	17097	80						
LGR-16	17177	108						
HGR-45	17285	290						
LGR-17	17575	160						
HGR-46	17735	149						
chan exit	17735							
LGR-18	17884	147						
HGR-47	18031	109						
LGR-19	18140	154						
HGR-48	18294	193						
chan exit	18360							
PO-18	18487	40	3.8	2.1	.91686	.07445	13	CL-3. P5-5 or P4-8 in 2008?
HGR-49	18527	65						
chan rtn	18550							
GL-13	18592	64	2.5					
HGR-50	18656	93						
PO-19	18749	62	3.2	1.7	.91669	.07358	32	CL-2
LGR-20	18811	59						
PO-20	18870	65	3.2	1.9	.91695	.07351	17	CL-2/3
chan exit	18909							
HGR-51	18935	97						
chan rtn	19032							
PO-21	19032	81	3.1	1.9	.91718	.07301	16	CL-3 abundant cover
HGR-52	19113	73						
PO-22	19186	95	3.3	2.3	.91747	.07285	23	CL-3
HGR-53	19281	132						
chan exit	19329							
P4-4	19413	55	3.5	2.3	.91801	.07262	21	P5-8 in '08?
chan rtn	19413							
HGR-54	19468	66						
LGR-21	19534	87						
HGR-55	19621	105						
LGR-22	19726	92						

Habitat Type	Start Distance (ft)	Unit Length (ft)	Max Depth (ft)	Residual Depth (ft)	LAT. N37.	LONG. W119	GPS Accuracy +/- ft	COMMENTS
HGR-56	19818	44						
PO-23	19862	30	2.7	1.3	.91922	.07227	16	CL-2
HGR-57	19892	44						
Gl-14	19936	59	2.7					
HGR-58	19995	82						
P4-5	20077	69	4.1	2.9	.91977	.07203	12	
HGR-59	20146	29						
PO-24	20175	47	2.5	1.2	.91988	.07181	15	CL-2
HGR-60	20222	66						
LGR-23	20288	44						
GL-15	20332	147	2.7					
HGR-61	20479	156						
P4-6	20635	45	3.8	2.7	.92094	.07094	12	
HGR-62	20680	87						
PO-25	20767	52	2.6	1.4	.92128	.07102	14	CL-2/3
HGR-63	20819	80						
P5-1	20899	78	4.2	2.9	.92152	.07069	12	P5-10 in '08?
HGR-64	20977	64						
LGR-24	21041	97						
chan exit	21097							"4Bii" chan
HGR-65	21138	113						
GL-16	21251	90	2.6					
PO-26	21341	45	3.2	1.5	.92189	.06932	15	CL-2/3
HGR-66	21386	183						
chan exit	21386							
chan rtn	21419							
GL-17	21569	51	2.6					
PO-27	21620	69	3.7	2.3	.92258	.06921	16	CL-3
HGR-67	21689	32						
PO-28	21721	31	3.2	2.1	.92284	.0692	15	CL-3
LGR-25	21752	94						
GL-18	21846	74	2.5					
HGR-68	21920	37						
P5-2	21957	25	4.5	3	.09233	.06873	13	
LGR-26	21982	30						
PO-29	22012	44	3.6	2.4	.92345	.06885	15	CL-3
LGR-27	22056	172						
PO-30	22228	46	2.7	1.2	.92399	.06889	14	CL-2
LGR-28	22274	31						
PO-31	22305	63	3.1	2.1	.92437	.06867	14	CL-3
LGR-29	22386	371						
chan exit	22483							"8" chan (dry)
PO-32	22739	24	2.1	1.1	.92527	.06767	22	CL-2
GL-19	22763	81	2					
LGR-30	22844	497						
chan exit	23213							
chan rtn	23341							
GL-20	23341	24	1.8					
LGR-31	23365	30						

Habitat Type	Start Distance (ft)	Unit Length (ft)	Max Depth (ft)	Residual Depth (ft)	LAT. N37.	LONG. W119	GPS Accuracy +/- ft	COMMENTS
HGR-69	23395	117						Start major channel braiding
PO-33	23512	55	2.9	1.8	.92708	.06618	16	CL-2/3
LGR-32	23567	162						
HGR-70	23729	58						
LGR-33	23787	88						
GL-21	23875	44	2.5					
P5-3	23919	36	5.5	4.1	.92815	.0661	15	part of P5-13 in '08
P4-7	23955	37	4.1	2.9	.928	.066	12	part of P5-13 in '08
LGR-34	23992	51						
P4-8	24043	152	4.1	2.6	.92811	.06561	16	PO-28 (CL-2/3) in '08
LGR-35	24195	54						
chan exit	24249							Top of 10-channel
GL-22	24249	51	2.8					
HGR-71	24300	119						
LGR-36	24419	98						End of major channel braiding
HGR-72	24517	85						
GL-23	24602	29	2.2					
HGR-73	24631	37						
GL-24	24668	54	1.8					
HGR-74	24722	57						
top LORU	24779							Top of old efish section
LGR-37	24779	107						
PO-34	24866	41	2.5	1.7	.93007	.06589	16	CL-2 - PO-29 (CL-3) in '08
GL-25	24927	86	1.9					
HGR-75	25013	109						
PO-35	25122	68	2.7	1.2	.93031	.06667	14	CL-2
P5-4	25190	50	4.9	4.3	.93047	.0667	14	new CL-5 (GL-23 in '08)
HGR-76	25240	79						
P5-5	25319	65	4.2	3.4	.93084	.0666	16	P5-14 in '08
HGR-77	25384	24						
P4-9	25408	51	3	2.4	.93073	.06637	9	P4-15 in '08
LGR-38	25459	76						
PO-36	25535	47	2.5	1.5	.93082	.06593	14	CL-2
LGR-39	25582	89						
PO-37	25671	52	2.7	1.5	.93113	.0658	12	CL-2
HGR-78	25723	97						
PO-38	25820	94	2.6	1.7	.9313	.06641	17	CL-2
HGR-79	25914	62						
P4-10	25976	79	3.7	2.8	.9314	.06671	12	P5-15 in '08 (and '02)
HGR-80	26055	74						
bot LORU	26086							Bot. of old efish section
GL-26	26129	64	1.7					
P4-11	26193	138	3.2	2.5	.93197	.06642	15	new CL-4 (GL-27 & PO-31 in '08)
LGR-40	26331	233						
chan rtn	26381 - 26478							multiple "10" chan returns
GL-27	26564	59	1.7					
LGR-41	26623	58						
HGR-81	26681	48						
GL-28	26729	34	2.4					

APPENDIX A: RUSH CREEK - SEPTEMBER 2011 HABITAT TYPING AND POOL SURVEY DATA

Habitat Type	Start Distance (ft)	Unit Length (ft)	Max Depth (ft)	Residual Depth (ft)	LAT. N37.	LONG. W119	GPS Accuracy +/- ft	COMMENTS
PO-39	26763	91	2.7	1.4				CL-2
chan rtn	26854				.9332	.06586		final, largest "10" chan return
LGR-42	26854	48						
P5-6	26902	77	4.2	3.2	.9334	.06567	15	P5-16 in '08
HGR-82	26979	17						
PO-40	26996	70	3.2	1.8	.93352	.06592	17	CL-2
LGR-43	27066	32						
PO-41	27098	108	3.2	1.9	.9338	.06628	16	CL-2
str ga sta	27152							MC&Trush staff gauge
LGR-44	27206	146						
P4-12	27352	90	4.2	2.9	.93428	.06677		PO-33 (CL-3+) in '08
HGR-83	27442	114						
PO-42	27556	55	3	1.4	.93476	.06683		CL-2 - part of P5-17 in '08
P4-13	27611	189	4.7	3.1	.93502	.06678	8	<25% cover - P5-17 in '08
HGR-84	27800	47						
LGR-45	27847	67						
GL-29	27914	131	2.2					
P5-7	28045	62	>6	>4	.93591	.06635	17	P5-18 in '08
HGR-85	28107	31						
P5-8	28138	54	4.5	2.8	.93606	.06657	13	P5-19 in '08
PO-43	28192	88	3.4	2	.93608	.06685	20	CL-2/3 - PO-34 (CL-2/3) in '08
HGR-86	28280	59						
LGR-46	28339	229						
topB'land	28431							Top of Bottomlands efish sec
GL-30	28568	49	2.2					
HGR-87	28617	67						
LGR-47	28684	54						
PO-44	28738	67	3.2	2	.9371	.06618	13	CL-3 - part of P4-19 in '08
PO-45	28805	130	4.1	2.8	.937	.06614	12	CL-3 - part of P4-19 in '08
LGR-48	28935	83						
HGR-88	29018	46						
P4-14	29064	86	3.4	2.2	.93673	.06547	16	P5-20 in '08
HGR-89	29150	31						
P4-15	29181	130	3.5	2.3	.93706	.06544	14	P5-21 in '08
LGR-49	29311	92						
P5-9	29403	68	4.3	3	.93743	.06501	20	P5-22 in '08
LGR-50	29471	44						
PO-46	29515	90	3.6	2.3	.93784	.06499	15	CL-3 - P4-20 in '08
HGR-90	29605							
PO-47	29660	121	2.8	1.5	.93827	.06519	18	CL-2 - PO-35 (CL-3+) in '08
HGR-91	29781	36						
PO-48	29817	83	3.3	1.9	.93837	.06484	16	CL-3 - PO-36 (CL-3) in '08
botB'land	29900							Bot. of Bottomlands efish sec
HGR-92	29900	70						
PO-49	29970	43	3.5	2.1	.93809	.06459	12	CL-3 - PO-37 (CL-2) in '08
HGR-93	30013	31						
P5-10	30044	164	>5.5	>4.3	.93791	.06431	15	P5-23 in '08
HGR-94	30208	69						
GL-31	30277	20	2.6					

Habitat Type	Start Distance (ft)	Unit Length (ft)	Max Depth (ft)	Residual Depth (ft)	LAT. N37.	LONG. W119	GPS Accuracy +/- ft	COMMENTS
PO-50	30297	56	3.1	2	.93826	.06393	15	CL-3
HGR-95	30353	100						
LGR-51	30453	36						
PO-51	30489	54	3.2	1.4	.93844	.06338	12	CL-2 - PO-38 (CL-3+) in '08
HGR-96	30543	34						
P4-16	30577	82	4	2.9	.93856	.06352	8	P5-24 in '08
LGR-52	30659	226						
PO-52	30885	80	3.4	1.9	.93919	.06313	13	CL-2 - new since '08
LGR-53	30965	28						
P5-11	30993	58	4.8	3.5	.9394	.06296	14	P5-25 in '08
P5-12	31051	55	4.1	3.1	.93951	.06306	15	new since '08
str xing	31106							CORD ford
HGR-97	31106	23						
PO-53	31129	82	3.8	2.6	.93967	.06332	9	CL-3 - PO-40 (CL-3) in '08
HGR-98	31211	56						
PO-54	31267	39	3.5	2	.93991	.06347	15	CL-2 - new since '08
GL-32	31306	150	2.8					
HGR-99	31456	39						
PO-55	31495	35	2.7	1.4	.94051	.06377	15	CL-2 - new since '08
LGR-54	31530	32						
P4-17	31562	37	4.5	2.2	.94066	.06367	14	P5-26 in '08
HGR-100	31599	55						
P4-18	31654	132	3.4	2	.94075	.06341	16	PO-41 CL-3+) in '08
HGR-101	31786	167						
GL-33	31953	136	2.7					
HGR-102	32089	217						
PO-56	32306	96	3.1	1.7	.94236	.06286	12	CL-2 - PO-42 (CL-2/3) in '08
LGR-55	32402	47						
P5-13	32449	41	4.2	3	.94268	.06274	13	P5-27 in '08
P5-14	32490	48	4.6	3.3	.94274	.06281	13	new since '08
HGR-103	32538	39						
PO-57	32577	62	2.5	1.1	.94296	.0629	16	CL-2 - PO-43 (CL-2/3) in '08
HGR-104	32639	80						
LGR-56	32719	194						
top CORD	32913							Top of CoRd efishing section
GL-34	32913	159						
chan exit	33072							
HGR-105	33072	99						
chan rtn	33171							
P4-19	33171	53	3.6	2.2	.94427	.06212	15	P5-28 in '08
HGR-106	33224	47						
GL-35	33271	121	3.5					
HGR-107	33392	23						
P5-15	33415	51	4.2	3	.94432	.06163	16	P5-29 in '08
GL-36	33466	80	2.3					
LGR-57	33546	61						
HGR-108	33607	77						
LGR-58	33684	60						
GL-37	33744	76	2.6					

Habitat Type	Start Distance (ft)	Unit Length (ft)	Max Depth (ft)	Residual Depth (ft)	LAT. N37.	LONG. W119	GPS Accuracy +/- ft	COMMENTS
chan exit	33793							
LGR-59	33820	32						
PO-58	33852	65	3.9	2.7	.94452	.06017	15	CL-2 (poor cover) new since '08
HGR-109	33917	29						
chan rtn	33946							
PO-59	33946	93	3	1.4	.94476	.06049	11	CL-2 - PO-45 (CL-2/3) in '08
LGR-60	34039	76						
bot CORD	34104							Bot. of CoRd efishing section
HGR-110	34115	82						
chan exit	34115							
P4-20	34197	26	3.8	2.5	.94535	.06042	16	
GL-38	34223	49	1.9					
P4-21	34272	100	3.5	2.3	.94545	.06003	14	PO-47 (CL-2) in '08
chan rtn	34294							
HGR-111	34372	180						
chan exit	34372							
chan rtn	34500							
GL-39	34552	60	1.8					
LGR-61	34612	25						
P4-22	34637	57	4.7	2.9	.94626	.05953	12	PO-48 (CL-2) in '08
HGR-112	34694	18						
PO-60	34712	43	3.7	1.9	.94616	.05931	13	CL-3 - P4-22 in '08
LGR-62	34755	21						
PO-61	34776	53	4.1	2.4	.94634	.05923	8	CL-3
LGR-63	34829	34						
GL-40	34863	51	2.8					
HGR-113	34914	199						
GL-41	35113	37	2.8					
P5-16	35150	58	5.2	3.6	.94688	.05812	12	new since '08
HGR-114	35208	62						
PO-62	35270	50	3.2	1.4	.94717	.05801	14	CL-2
HGR-115	35320	83						
PO-63	35403	43	3.5	1.7	.9471	.05755	13	CL-2
HGR-116	35446	211						
culv.top	35600							Top of the County Rd. culvert
culv. Bot	35657							Bot. of the County Rd. culvert
P4-23	35657	47	4.2	2.8	.94767	.05709	9	P5-30 in '08
HGR-117	35704	118						
GL-42	35822	60	2.4					
PO-64	35882	91	3.4	2.1	.94823	.05743	10	CL-3
GL-43	35973	67	2.8					
HGR-118	36040	100						
LGR-64	36140	54						
GL-44	36194	207	3					
chan exit	36333							
HGR-119	36401	63						
P5-17	36464	34	4.7	2.7	.94945	.05812	14	part of P5-31 in '08
P4-24	36498	117	4.3	2.8	.94933	.05798	7	part of P5-31 in '08
chan rtn	36570							

Habitat Type	Start Distance (ft)	Unit Length (ft)	Max Depth (ft)	Residual Depth (ft)	LAT. N37.	LONG. W119	GPS Accuracy +/- ft	COMMENTS
LGR-65	36615	65						
HGR-120	36680	180						
GL-45	36860	70	2.7					PO-52(2/3)
LGR-66	36930	39						
P5-18	36969	95	5.2	3.7	.95014	.05704	11	PO-52 (CL-3) in '08
HGR-121	37064	51						
P5-19	37115	22	4.4	2.2	.95035	.05674	10	P5-32 in '08
LGR-67	37137	19						
P4-25	37156	77	4.4	3	.95029	.05654	11	part of P5-32 in '08
LGR-68	37233	153						
GL-46	37386	128	2.2					
LGR-69	37514	63						
PO-65	37577	89	2.3	1	.95076	.05527	14	CL-2 - PO-53 (CL-3) in '08
GL-47	37666	154	3.4					
LGR-70	37820	90						
HGR-122	37910	52						
GL-48	37962	70	2.3					
LGR-71	38032	265						
HGR-123	38297	67						
P4-26	38364	82	4.2	2.7	.95172	.0537	12	P5-34 in '08 (5.1' max dep)
HGR-124	38446	19						
P5-20	38465	127	6.2	4.7	.95191	.05347	8	P5-35 in '08 (5.2' max dep)
LGR-72	38592	201						
P4-27	38793	83	5.2	3.8	.95243	.05277	14	PO-55 (CL-3) in '08 - 4.5' max
LGR-73	38876	85						
HGR-125	38961	99						
P5-21	39060	70	5.3	3.9	.95286	.05206	12	P5-36 in '08 (5.0' max dep)
GL-49	39130	52	2.5					
PO-66	39182	98	3.9	2.6	.95326	.05219	7	CL-3 new since '08
LGR-74	39280	182						
PO-67	39462	84	3.3	2	.95392	.05228	14	CL-3 - PO-56 (CL-3) in '08
LGR-75	39546	24						
P5-22	39570	120	>6.0	>5.0	.95425	.05236	12	P5-37 in '08 (4.7' max D)
LGR-76	39690	62						
P5-23	39752	142	5.5	4	.9546	.05211	12	P5-38 in '08 (4.6' max D)
GL-50	39894	83	2.1					
P5-24	39977	137	5.7	4.7				P5-39 in '08 (4.2 max D)
LGR-77	40114	334						
chan split	40448							Mono Lake delta starts

Lee Vining Creek - Habitat Typing and Pool Survey - September 25, 2011

Habitat Type	Start Distance (ft)	Unit Length (ft)	Max Depth (ft)	Residual Depth (ft)	LAT. N37	LONG. W119	GPS Accuracy +/- ft	Comments
HGR-1	0	201			.95826	.11594		gps for survey start
PO-1	201	23	3	2	.95872	.11618	18	CL-3 (good cover)
HGR-2	224	916						
chan exit	300							
chan rtn	409							
chan exit	700							
chan rtn	809							
chan rtn	842							
chan rtn	918							
PO-2	1140	23	2.5	1.1	.96111	.11609	18	CL-2 (little cover)
HGR-3	1163	658						
chan exit	1330							
chan rtn	1459							
GL-1	1821	31	2.2					
HGR-4	1852	368						
chan exit	2025							"A" chan- no flow
GL-2	2220	52	2					
PO-3	2272	34	2.9	1.5	.96405	.11525	11	CL-2
HGR-5	2306	759						
chan rtn	2615							
GL-3	3065	38	2.4					
HGR-6	3103	105						
GL-4	3208	58	2.5					
chan rtn	3229							
HGR-7	3266	156						
P4-1	3422	22	3.2	2	.96697	.11449	16	new -by old cw pool
HGR-8	3444	61						
PO-4	3511	33	2.3	1.1	.96712	.11428	15	CL-2
HGR-9	3544	36						
GL-5	3580	93	2.4					
chan exit	3673							
HGR-10	3673	51						
GL-6	3724	47						
PO-5	3771	27	3.3	2.5	.96764	.11378	17	CL-3 (good cover)
chan rtn	3798							
HGR-11	3798	87						
GL-7	3885	66	2.2					
HGR-12	3951	47						
GL-8	3998	43	2.4					
chan rtn	4006							"A" chan- no flow
HGR-13	4041	290						
old pool	4095				.96836	.11332	15	P5-1 in '08, now HGR
chan exits	4112							mult chan exits
chan rtns	4265							mult. Chan rtns
PO-6	4331	49	2.5	1.2	.96895	.11312	15	CL-2
LGR-1	4380	36						

Habitat Type	Start Distance (ft)	Unit Length (ft)	Max Depth (ft)	Residual Depth (ft)	LAT. N37	LONG. W119	GPS Accuracy +/- ft	Comments
GL-9	4416	32	2.2					
chan exit	4416							
HGR-14	4448	30						
chan rtn	4478							
PO-7	4478	50	2.6	1.4	.96928	.1128	17	CL-2
HGR-15	4528	17						
PO-8	4545	24	3	1.6	.9693	.11285	21	CL-2
HGR-16	4569	279						
GL-10	4848	37	2.4					
HGR-17	4885	135						
sec. top	4991							Top of efishing section
LGR-2	5020	83						
HGR-18	5103	37						
GL-11	5140	60	2.4					
HGR-19	5200	121						
GL-12	5321	27	2.2					
HGR-20	5348	69						
GL-13	5417	39	2.4					
HGR-21	5456	132						
GL-14	5588	34	1.9					
HGR-22	5622	97						
GL-15	5719	26	2.2					
HGR-23	5745	53						
PO-9	5798	53	2.4	1.1	.97217	.11076	18	CL-2
sec. bot.	5839							Bottom of efishing section
HGR-25	5851	37						
GL-16	5888	62	1.8					
chan rtn	5888							
HGR-25	5950	179						
chan exit	5950							
chan rtn	6031							
GL-17	6129	32	1.9					
HGR-26	6161	70						
GL-18	6231	33	1.6					
HGR-27	6264	27						
PO-10	6291	27	2.4	1.4	.97321	.1099	17	CL-3 (ex. Cover)
HGR-28	6318	235						
P4-2	6553	47	3.5	2	.97357	.10937	9	
road xing	6600							Co. Rd. ford
HGR-29	6600	106						
GL-19	6706	87	2.2					
HGR-30	6793	215						
PO-11	7008	38	2.6	1.3	.97401	.10815	15	CL-2 (IFS #2?)
HGR-31	7046	73						
GL-20	7119	55	1.8					
PO-12	7174	53	2.8	1.6	.97435	.10767	12	CL-2/3 (IFS #3?)
HGR-32	7227	73						
GL-21	7300	36	2.1					

Habitat Type	Start Distance (ft)	Unit Length (ft)	Max Depth (ft)	Residual Depth (ft)	LAT. N37	LONG. W119	GPS Accuracy +/- ft	Comments
HGR-33	7336	65						
GL-22	7401	105	2					
HGR-34	7506	50						
PO-13	7556	44	2.4	1.3	.97464	.10674	16	CL-2 (old culvert pool IFS)
HGR-35	7600	102						
PO-14	7702	21	2.7	1.3	.97494	.10664	8	CL-2
GL-23	7723	41	1.9					
chan rtn	7764							last rtn fr. above Ford xing
P5-1	7764	53	4.3	3.3	.97512	.10648	14	IFS #9?
HGR-36	7817	63						
GL-24	7880	104	1.9					
HGR-37	7984	38						
GL-25	8022	58	2.1					
HGR-38	8080	222						
PO-15	8302	33	2.6	1.2	.97596	.10546	14	CL-2
GL-26	8335	47	2.3					
HGR-39	8382	115						
PO-16	8497	44	2.6	1.6	.97631	.10507	16	CL-3 (abundant cover)
HGR-40	8541	67						
GL-27	8608	108	2.2					
HGR-41	8716	27						
PO-17	8743	43	2.8	1.8	.97667	.10447	16	CL-2 (poor cover)
HGR-42	8786	52						
PO-18	8838	43	2.9	1.6	.97658	.10423	17	CL-2
LGR-3	8881	163						
P4-3	9044	69	3.4	2.4	.97685	.10362	17	
HGR-43	9113	24						
PO-19	9137	20	2.5	1.3	.97703	.10356	18	CL-2
HGR-44	9157	18						
GL-28	9175	46	2.2					
HGR-45	9221	45						
PO-20	9266	73	2.7	2	.97717	.10307	18	CL-3 IFS #13 <25% cv.
HGR-46	9339	65						
P4-4	9404	50	4	3	.97703	.10269	17	poor (<25%) cover
HGR-47	9454	45						
GL-29	9499	49	2.2					
LGR-4	9548	95						
Delta	9643							Start Mono Lake delta

PRIMARY PRODUCTIVITY/STREAM PRODUCTIVITY -1/17/12 UPDATE
By Ken Knudson and Ross Taylor

INTRODUCTION

Water samples collected by the California Department Fish and Game (CDFG) from 1984-1991 indicated that Rush Creek was a soft-water stream with low concentrations of dissolved solids. The purpose of this investigation was to collect updated water samples for the analyses of inorganic micronutrients to determine the fertility level of Rush, Lee Vining and Walker creeks. Primary Production, which is expressed as the rate at which these micronutrients are converted to living organic matter like benthic algae (periphyton) was also grossly estimated at three locations on Rush Creek, two locations on Lee Vining Creek, and two locations on the Owens River.

The final objective of the study was to compare the standing crops (biomass) and/or the annual production levels of the brown trout populations in the study area to the biomass or production rates of brown trout populations in other streams found to have similar fertility and/or primary production rates. This latter task will help establish whether or not the biomass and annual production of fish flesh in the Mono Basin streams is within a range of expected or predicted values, given the stream's fertility and primary production levels.

METHODS

Water samples were collected during September 2010, February 2011 and September 2011 at three stations on Rush Creek (the MGORD, the Upper Rush electrofishing section and the County Road ford) and two on Lee Vining (Highway 395 and the County Road ford).Stations on the Owens River above and below the confluence of Hot Creek during September 2010 and February 2011. Water samples were also collected within the Walker Creek electrofishing section during September 2011. Analyses were conducted for the following parameters (laboratory detection limits for each parameter are in parenthesis):

Alkalinity, Total as CaCO3 (4.0 mg/l)
Conductivity (1.0 umhos/cm)
Hardness as CaCO3 (1.0 mg/l)
Nitrogen, Kjeldahl, Total as N (0.5 mg/l)
Nitrogen, Nitrate+Nitrite as N (0.05 mg/l)
Nitrogen, Ammonia as N (0.1 mg/l)
Phosphorus, Orthophosphate as P (0.01 mg/l)
Phosphorus, Total as P (0.01 mg/l)

Utilizing periphytometers (floating microscope slide trays), the growth rates of periphyton (attached benthic algae) were evaluated concurrent with the two September water quality sampling episodes at the five stations on Rush and Lee Vining creeks. After being placed in the streams for 12-18 days, the ash-free dry weight (biomass) and chlorophyll-a concentrations of the organic matter that had attached to the slides were determined. The rate of this accumulation provided gross estimates of the two stream's primary productivity rates.

Water quality data for streams outside of the Mono Basin are currently being gathered from online sources (the USGS's National Water Quality Information System and the EPA's STORET websites), CDFG reports and the published literature. Emphasis is being placed on the latter, particularly published papers that discuss brown trout biomass/annual production rates in relation to fertility/primary productivity rates.

PRELIMIARY FINDINGS

Instream concentrations of nitrogen and phosphorus micronutrients were extremely low in the Mono Basin streams during all of the sampling episodes. Of the 50 individual laboratory analyses that were conducted for these micronutrients on samples collected from Rush and Walker creeks, all were below the laboratory detection limits listed above. On Lee Vining Creek, only two of the thirty individual analyses for these micronutrients were high enough to be detectable, a 0.9 mg/l value for total Kjeldahl nitrogen (TKN) at the lower station in September 2011 and a 0.05 mg/l value for nitrate+nitrite at the upper station in February 2011. These results demonstrate that streams in the Mono basin are low in fertility when compared to other nearby streams that are influenced by non-point nutrient sources. For example, at our Owens River stations, total phosphorus (TP) concentrations ranged from 0.10- 0.12 mg/l and orthophosphorus (OP) concentrations ranged from 0.02- 0.10 mg/l. Another local stream that is influenced by nonpoint runoff from livestock operations is the East Walker near Bridgeport, where analyses for TKN and TP concentrations were always above detection limits during twelve monthly sampling episodes from April 2000 through April 2001 (USGS website). TKN concentrations at this station ranged from 0.5-1.3 mg/l and TP concentrations ranged from 0.02-0.15 mg/l during this time period.

Water samples collected during our study also confirmed that the Mono basin streams are very soft-water systems. Total hardness values were extremely low, ranging from 4-6 mg/l. Total alkalinity concentrations were only slightly higher, ranging from 11-18 mg/l. Total alkalinity values for Rush Creek from 1984-1991 ranged from 21-34 mg/l, suggesting that Rush Creek's water has become even softer over the past two decades. Total alkalinity concentrations on the East Walker ranged from 50-98 mg/l, and from 82-123 mg/l at stations on the upper Owens River, which is also influenced by numerous spring creek flows. Hardness values on the East Walker ranged from 41-73 mg/l; these concentrations are roughly ten times higher than found on streams in the Mono Basin.

Thus far in our research of the published literature, we have found very few papers that have attempted to correlate concentrations of nitrogen and phosphorus micronutrients, let alone primary production rates, with brown trout biomass or the annual production rates of brown trout. Most studies that utilize these parameters or measurements have been conducted without concurrent fisheries evaluations and in hard-water streams with relatively high background levels of micronutrients, and often in response to real or potential water quality degradation.

The water quality parameters that have most often been collected in conjunction with evaluations of brown trout biomass/annual production rates are specific conductivity (which provides an estimate of total dissolved solid concentrations) and total alkalinity (as $CaCO_3$). The latter is a direct measure of the fertility of a stream because the carbonate molecule is the primary source of carbon for periphyton and other plant life in streams.

We are presently reviewing several published papers that have collected total alkalinity in conjunction brown trout biomass and/or annual productivity evaluations. Two of these publications include compilations of studies conducted in Europe (Almodovar et al. 2006) and the United States (Kwak and Waters 1997) that have demonstrated strong, positive correlations between annual production rates of brown trout and instream concentrations of total alkalinity. Correlations between total alkalinity and trout biomass were also somewhat apparent during these compilations, but were not as strong as the alkalinity-annual production linear relationships.

Our early (and very preliminary) findings suggest that biomass values (in kilograms/hectare) for the Mono Basin streams are within the range of, or higher than, the values found in reports and publications for other soft-water streams with total alkalinities <25 mg/l. In fact, biomass values on the Mono Basin streams are as high as reported for some streams with total alkalinity concentrations ranging from 72-108 mg/l.

While the above biomass to alkalinity relationships are informative, the more definitive linear relationships between alkalinity and annual brown trout production that have been developed in the studies mentioned above is of much more predictive value. Starting in 2009, PIT tags have been annually implanted into age-0 brown trout in the study area. After the 2011 field season, for the first time, we will be able to accurately compute the annual growth rates, and thus annual production rates, of both age-1 and age-2+ brown trout in our study sections, which will allow us to more accurately determine whether brown trout production rates on our streams are within the range of values reported for other soft-water streams with low alkalinity concentrations world-wide.

LITERATURE CITED

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