Inventory and Survey of the Big Hole River Fisheries Populations including Results of a Fish Tagging Study 2008 - 2014

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Photo credit: Tagged brown trout captured by angler on the Hogback Section of the Big Hole River (Brian Varner photo).

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Abstract:

Fish population statistics for study sections on the Big Hole River are updated and summarized in graphic form for the 2008-2013 period of study. Flow and thermal regimes were much improved from 2008 to 2014 when compared to the prolonged drought experienced from 1999-2007. Dry summers followed in 2012 and 2013 and drought related fishing restrictions were enacted in 2013. General fisheries trends include a decrease in rainbow trout abundance in the Melrose and Jerry Creek sections. Brown trout densities increased through the reporting period across all sections and the most notable increases occurred for larger sized fish particularly in the lower river sections. Recruitment was high in 2013 for age-2 brown trout across the sections sampled. In the Melrose Section this large recruitment class was responsible for the greatest density of brown trout observed since consistent monitoring at the site was initiated in 1980. Rainbow trout density has increased substantially in the Hogback Section and rainbow trout now comprise slightly more than 1/3 the total trout population in the section. An additional population monitoring section was added on the lower Big Hole River beginning at the Pennington Bridge and extending downstream a little over 2 miles (Pennington Section). This section was added to evaluate the current condition of the fishery and collect baseline data to determine the effects on the fishery of potential changes in the drought management plan and habitat improvement projects in the area. Trout densities in the lower river are roughly 1/3 those observed in the nearest section upstream (Hogback) only 15 miles upstream. Two sections were surveyed in the upper Big Hole to monitor the impact of the liberal season and limits on brook trout and to monitor the expansion of brown trout. Mountain whitefish estimates were performed in the Pennington, Melrose and Jerry Creek sections of the Big Hole River to determine current status and population trends of this native species. Mountain whitefish densities exceeded trout densities in the Pennington and Melrose sections, but not in the Jerry Creek Section. It appears the Jerry Creek section is not used for spawning and rearing like the 2 sections monitored in the lower river.

Recent whirling disease samples from of the Big Hole River and many tributaries were collected and analyzed. Results indicate whirling disease is widespread throughout the Big Hole; however, high infection rates that may impact fish populations are only present near Melrose. Other tributaries near Melrose in addition to the formerly identified Camp Creek were also identified as having high whirling disease infection rates.

A tagging study was initiated to evaluate the growth and movement of trout from the fall of 2009 to the spring of 2013. Floy™ tags were inserted into trout captured during normal population monitoring. Growth and movement information was determined using subsequently recaptured fish, either via angler reports or through standard sampling. Growth patterns showed a general increase in growth from upstream to downstream for brown trout across most size classes. For brown trout > 15 inches, growth was substantially greater in the Hogback Section than either the Melrose or Jerry Creek sections. Increasing growth rates in a downstream fashion were much more evident and consistent in rainbow trout. Brown trout growth rates were greater than those of rainbow trout across all size classes of fish. The movement data indicated that a majority of fish were recaptured in relatively the same location as they were tagged (64%) and there was only a very weak relationship between the distance a fish moved and the elapsed time from when it was tagged. The majority of movements observed were in a downstream direction, particularly for rainbow trout. Brown trout were only slightly more likely to travel downstream than upstream but the majority of significant fish movements (those > 10 miles) were in an upstream direction. Brown trout were 3 times as likely to express movements of over 10 miles both upstream and downstream as rainbow trout. Spawning related and other movements were noted between the Big Hole River and the Wise River, North Fork Big Hole River and the Jefferson River. 11.8% of the angler returned tagged fish were harvested, but this likely represents and over-representation of harvest due to tag reporting errors.

ACKNOWLEDGEMENT

The author wishes to express his sincere appreciation of those who assisted during the course of the collection of these data. Scott Lula and Lucas Bateman are to be given most of the credit for the collection of these data. They provided valuable and competent assistance in the field and with data management. Dan Downing, Kirk Perzik, Austin McCullough and other also assisted with field data collection. I would also like to thank the Big Hole River Foundation and the Big Hole Watershed Committee for funding the tagging study. I would also like to thank all those who caught tagged fish in and reported the information. Without these angler and outfitter returns, we would have had little data on fish movements in the river.

INTRODUCTION and STUDY AREA

The Big Hole River is a moderate sized, free flowing stream system that originates in Skinner Meadows near Jackson and flows over 100 miles to its confluence with the Beaverhead River to form the Jefferson River near Twin Bridges, Montana. The popular trout fishery of the river is dominated by brown and rainbow trout with brown trout historically representing the dominant species from approximately the town of Melrose, MT downstream to the mouth. The Big Hole constitutes a high quality and internationally recognized sport fishery and also supports relict populations of relatively rare native aquatic species including westslope cutthroat, Arctic grayling, and western pearlshell mussel. Other native fish species that provide locally popular, but generally under-utilized sport fisheries include the burbot and mountain whitefish. Other species occurring in the river include the native mountain sucker, white sucker and longnose sucker, longnose dace, and Rocky Mountain sculpin and the nonnative redside shiner and common carp. In 2009 the Big Hole River supported an estimated 71,579 angler days of fishing pressure. In 2013 angler pressure was estimated at 83,739 angler days with more than 90% of that pressure exerted within the river reach discussed in this report.

Several population monitoring sections have been established throughout the length of the river to evaluate the effectiveness of fishing regulations. These sections are strategically located to represent specific habitat reaches, angler use and combinations of fish species as they occur longitudinally throughout the drainage. From upstream to downstream these section include: The Jerry Creek Study Section between Jerry Creek and George Grant Fishing Access sites, the Maidenrock Section from 1.5 miles upstream of the FWP Maidenrock Access Site to 150 yard downstream of the Meriwether Ranch bridge, the Melrose Study Section located between Salmon Fly and Brownes Bridge Fishing Access sites and The Hog Back Study Section located between the Glen and Notch Bottom Fishing Access sites. A new study section was established in the lower Big Hole River near Twin Bridges and is called the Pennington Section. This new section is 2.8-miles long beginning at the Pennington Bridge Fishing Access Site and ending at a private take out on private property. The section was extended in 2013 an additional 2.3 miles downstream to encompass a proposed spawning enhancement project on a side slough of the river. Brown trout and rainbow trout data from the Jerry Creek, Maidenrock, Melrose, Hogback and Pennington sections are summarized from 2008 through 2014 in this report. Mountain whitefish population estimates were performed on the Pennington Section in 2009 and 2011, in the Melrose Section in 2012 and in the Jerry Creek Section in 2013.

METHODS

Trout populations in the Big Hole River were sampled through the use of electrofishing techniques based on mark-recapture methodologies described by Vincent (1971). Electrofishing was conducted via boat-mounted, mobile anode techniques which utilize a 3500 watt generator and Leach type rectifying box and a modified fiberglass driftboat. A straight or continuous DC wave current was used at 1,000 to 1,800 watts. Fish captured within the field were drawn to the boat, netted, and deposited into a live car. Individual fish captured were anesthetized, segregated by species, measured for length (0.1 in) and weight (0.01 lbs), marked with a small identifying fin clip, and released. Big Hole River Study Sections required multiple mark and recapture runs because of low and often variable capture efficiency with the recapture pool treated with replacement.

Trout population estimates were computed using log-likelihood methodology (FA+ 2010). Age was assigned to each trout based on fish length and past scale-based age assessments. Spring age-2 brown trout 7-10.9 in were considered age-2, 11-14.9 were age-3, 15.0-17.9 were age-4 and 18+ in were age 5+. Rainbow trout in the fall that were 7-9.9 in were considered age-1, 10-12.9 were age-2, 13.0-15.9 were age-3 and 16+ in were age 4+. All population and biomass estimates as well as population statistics such as relative weight, and mean weight and length were analyzed by inch group. Population estimates were largely calculated for brown trout from March and April samples collected from the study sections while rainbow trout population estimates were calculated from September and October samples. The seasonal segregation of population estimates by species was applied to avoid estimate bias due to spawning movements and migrations (i.e., violations of closed population assumptions). An evaluation of this bias was performed on the Hogback and Melrose Sections of the Big Hole to compare spring and fall estimates for both species to better understand the relationship between estimates.

Measurements of stream discharge and water temperature were obtained from USGS Gage Stations. Water temperature measurements not collected at USGS gaging stations were taken using Onset HOBO U22 Pro V2 temperature loggers set to record temperature at 20 min intervals.

RESULTS and DISCUSSION

Big Hole River Flows and Temperature

The period of 2008 through 2012 was marked by average or above average river flows and summer time temperature. Only in 2010 did the average annual water yield at the Melrose gage drop below 800,000 acre-ft, which is the approximate long-term average for the site (USGS Melrose Gage 1924-2011). Only in August of 2008 did the river drop below the minimum flow to maintain habitat conditions in the Big Hole River of 250 cfs (BHWC 2007). Following the Big Hole River Drought Management Plan, there were no drought related angling restrictions on the lower river during this time period. The greatest flows since 1997 were observed in 2011. In areas where the river is less constrained by natural features (i.e., downstream of Brownes Bridge), significant changes in the river channel were observed. Formerly dry side channels were captured and in some cases became the main channel of the river. Other channels have been abandoned. From 2012-2013 lower than average water conditions were experienced and 2013 was considered a drought year. The 2012 water year was marked by lower than average summer flows and the Stage 1 drought triggers (flows below 250 cfs at the Glen Gage) were enacted in the drought Management Plan in August 2012. Stage 2 closures (200 cfs) were avoided although flows periodically dropped below the 200 cfs level in late August and early September. Drought followed in 2013 with below average snowpack and below average summer precipitation. The average annual water yield in 2013 was similar to the severe drought conditions in the mid 2000's (Table 1). Most of the river was closed to angling or had time of day angling restrictions during the month of August and flows in the lower reaches of the river near Twin Bridges dropped below 50 cfs. Despite low flows and warm water temperatures, no fish kills were reported.

Table 1. Average flow statistics for the Big Hole River at the USGS Melrose Gage for the 1995-2011 period of record.

Year	Annual water yield (acre-ft)	Peak discharge (cfs)	Min July discharge (cfs)	Min Aug discharge (cfs)
1995	954,188	12,000	983	342
1996	1,195,993	12,100	606	320
1997	1,351,646	13,000	1,010	514
1998	934,641	5,020	866	299
1999	768,129	7,500	407	228
2000	406,652	2,480	192	126
2001	408,752	2,530	280	151
2002	521,184	5,300	381	197
2003	635,353	9,520	272	184
2004	410,996	2,250	325	157
2005	482,090	3,430	275	175
2006	657,796	6,500	252	140
2007	569,545	4,150	240	127
2008	824,598	7,660	527	204
2009	904,235	7,980	701	327
2010	761,613	1,0000	736	277
2011	1,208,301	11,700	1,220	381
2012	748,500	5,770	395	201
2013	526,146	3,200	280	180
2014	976,792	8,330	498	399

The Drought Management Plan has been updated annually. Recent changes include the adjustment of flow triggers down 10 cfs to 250, 200 and 150 cfs and the inclusion of a new drought management section on the lower river from Notch Bottom to the mouth that is monitored at the High Road (Hamilton) USGS gage. Also the USGS Maidenrock gage serves as the flow measuring gage for the section from Dickie Bridge to the mouth of Maidenrock Canyon. Moving the measurement to for this section to the Maidenrock Gage has resulted in this section of the river remaining open to angling when other adjacent reaches have closed because of the water inputs from Wise River and other geologic factors that increase water flows and buffer warm water temperatures.

<u>Big Hole River Fish Population Monitoring</u>

<u>Jerry Creek Section</u>

Rainbow trout population estimates were initiated in the Jerry Creek Section in the fall of 1986. Data from this section were used to evaluate the 3 fish limit with a catch and release slot between 13 and 22 inches and artificial lures only regulations placed on the section in 1988. The goal of these regulations was to increase the numbers of fish greater than 13 inches and greater than 16 inches. After 8 years, the slot limit did not have an effect on the numbers of 16 inch and greater rainbow trout in the study section but the numbers of rainbows 13 inches and greater gradually increased through 1993 (Oswald 2000). It was also noted that adult rainbow trout numbers the Melrose Section which had no special regulations, increased during this time period substantially more than the Jerry Creek Section. In 1996 the slot limit was removed from Dickie Bridge to Divide, but the artificial lures only regulation was maintained. Interestingly, this reach of river prior to the adoption of special regulations was known for producing large rainbow and brown trout in excess of 5 pounds (FWP 1989).

Fall rainbow trout estimates were performed on the Jerry Creek Section of the Big Hole River in 2008, 2009, 2010 and 2011. From 2008-2011 rainbow trout density and biomass declined in the Jerry Creek Section, but remained within the range of population fluctuation experienced in the past 25 years (Figure 1). Since the mid 1990's the rainbow trout population appears to cycle with large booms in the population (mostly comprised of periodic spikes in age-1 rainbow recruitment) followed by gradual overall population declines. The biomass of rainbow trout in the section appears to have remained relatively constant through time since the enactment of the special fishing regulations. The higher water conditions experienced from 2008-2011 mimicked those experienced during the late 1990's when there also was a general decline in rainbow trout numbers (Oswald 2000). It is likely that egg and fry mortality are greater for spring spawning rainbow trout during years of high water because incubating eggs and recently hatched fry have to cope with the effects of high flows and stream bed substrate movements.

Despite greater than a 50% reduction in rainbow trout numbers in the Jerry Creek section from 2008-2013, the condition of the fish showed little improvement with exception of 2009 (Figure 2). Relative weight is a measure of a fish's weight relative to its length. Therefore, a higher relative weight means a fish weighs more at a given length. The lower density and biomass of rainbows in the section in theory should yield more available food resources and better growth and when coupled with ideal flow and temperature regimes during the time period. It is unclear why rainbow trout condition has not improved in this section. The lack of increase in condition of rainbow trout may be related to the more recent expansion of the brown trout population in this section of river (see below) such that additional food resources are being consumed by the expanding brown trout population.

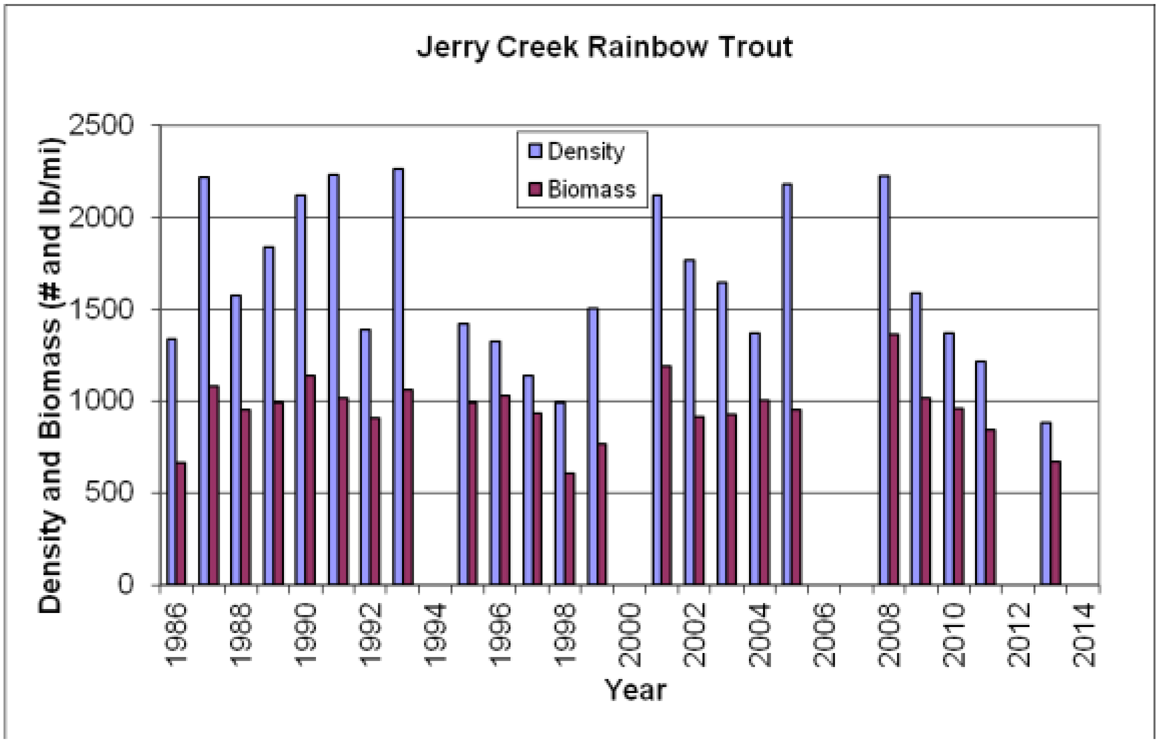

Figure 1. Rainbow trout density and biomass from the Jerry Creek Section of the Big Hole River from 1986 to 2014.

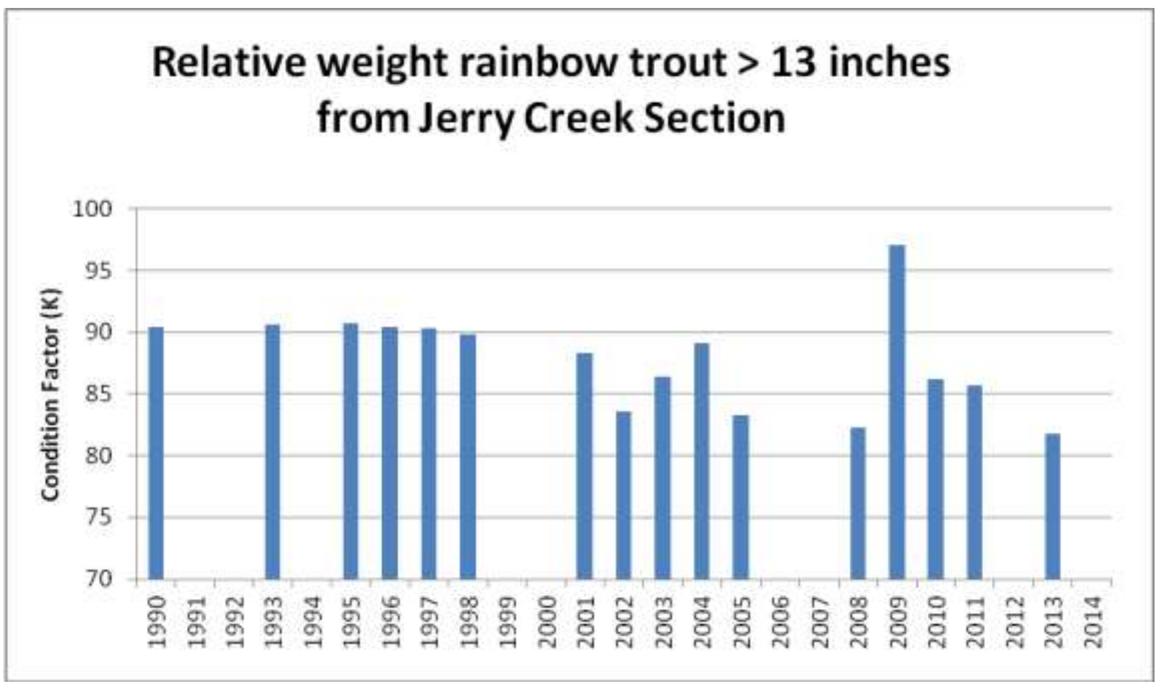

Figure 2. Rainbow trout relative weight from the Jerry Creek Section of the Big Hole River from 1998 to 2011.

The excellent recruitment class of age-1 fish in 2005 and again in 2008 failed to result in subsequent recruitment of older age classes of fish within the Jerry Creek section (Figure 3A). It is possible (as supported by the tagging data) that rainbow trout from areas as far downstream as the Hogback Section migrate to and beyond Jerry Creek to spawn. The progeny of these migratory fish may stay in the Jerry Creek section for only a short period of time then migrate to other areas of the river to grow to adults. Growth rates are greater and overall fish density is less in reaches of the river farther downstream. It is also possible that this migratory strategy produces increased spawning success and has become more prevalent since whirling disease infection rates climbed in the early 1990's near Melrose. Another trend that is clear from the age-1 rainbow trout data is that since the mid 1900's, average age 1 density is much less and much more cyclical than in the 1ate 1980's and early 1990's (Figure 3A). A possible explanation for this decrease in the overall recruitment of age-1 rainbow trout is the increase in brown trout numbers in this section of river since the 1980's (see following section).

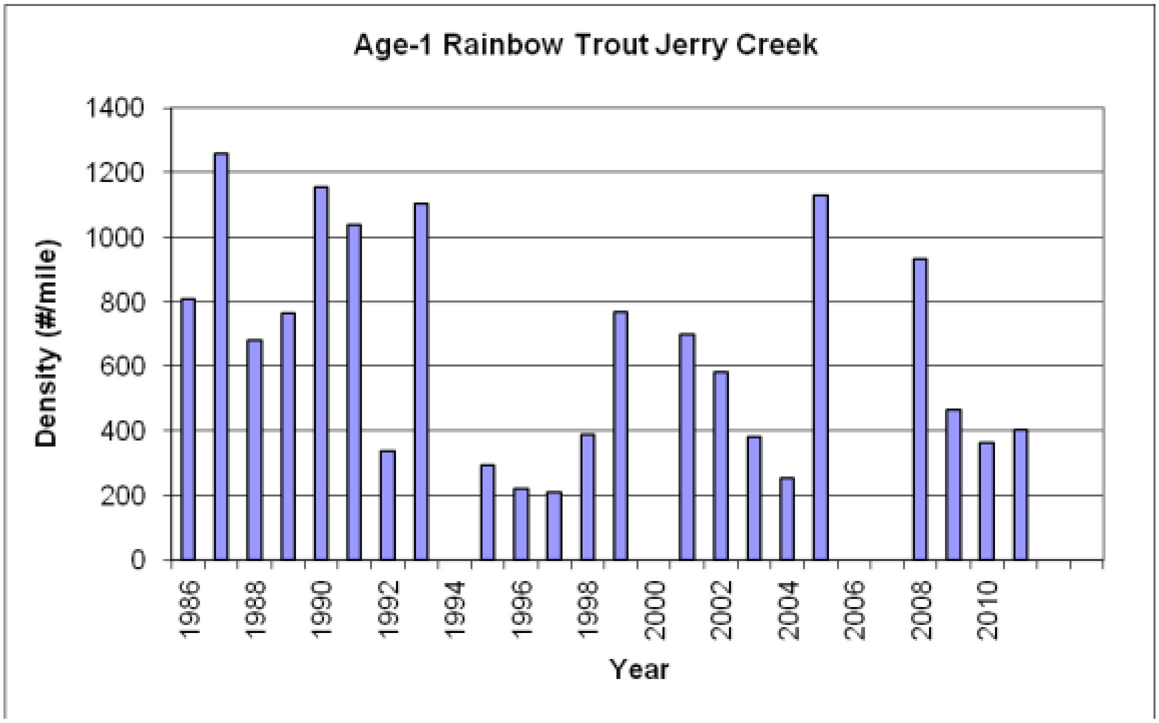

Figure 3A. Age-1 rainbow trout density (number/mile) from the Jerry Creek Section of the Big Hole River from 1986 through 2011.

Anecdotal and limited empirical evidence (Figure 4A) suggests that prior to the mid 1980's there were very few brown trout in the Jerry Creek section of the Big Hole River. Population estimates performed for brown trout between 1986 and 1988 indicate only between 7 and 13% of the total trout population in this reach of river were brown trout (FWP 1989). At that time very few, but large brown trout were present in the river with little evidence of any local natural reproduction. It is unclear why brown trout were not as prevalent through this section of the river when there were populations well established populations farther downstream. A power dam was constructed by the Montana Power Company in the early 1900's across the Big Hole between Divide and Dewey that likely precluded any upstream fish passage and limited upstream brown trout expansion. This dam eventually washed out in the mid to latter part of the century and fish passage was once again present through the canyon. The presence of this fish barrier may have slowed the colonization of the upper river by brown trout. It is also possible that the Butte municipal water dam constructed between 1927 and 1932 at Divide also limited upstream fish passage of brown trout. The stocking records for this section of river indicated that 238,000 brown trout were stocked between 1941 and 1949 but it is unclear if these fish were stocked upstream of these dams. From the 1940's to the early 1980's over 1.2 million rainbow trout were stocked in this same reach of river. It is also possible that prior to the implementation of the special regulations limiting harvest in 1981 and in 1988, angler harvest may have led to the suppression of brown trout numbers. Marked increases in brown trout numbers and size were noted in all study sections of the river upstream of Melrose following the implementation of the special regulations in the 1980's.

Evidence suggests that brown trout numbers have increased substantially in the past 20 years in the Jerry Creek Section (Figure 4A). However, the reliability of the brown trout population estimates performed in this study section in the fall are questionable. A large influx of brown trout occurs in the Jerry Creek section in the fall because of the spawning habitat present in the section which significantly biases population estimates. One of the assumptions of the mark-recapture population estimate is that during the estimate immigration or emigration must be very limited or nonexistent. It is clear that large scale movements of brown trout are occurring during the fall in the Jerry Creek section. Populations estimates performed when large scale moments are occurring will result in over estimates of population size. Further, because movement of brown trout through the section, the recapture efficiencies necessary to produce reliable population estimates were often not obtained, which is why the estimates were not regularly reported. Despite the unreliability of these estimates, the numbers do provide some indication as to the population trend of brown trout in the Jerry Creek section and their increase through time. Although there are large gaps in the data, it is clear that since mid 1980's the brown trout numbers have significantly increased (Figure 4A).

Spring brown trout estimate were performed in the Jerry Creek section of the Big Hole River in 2010 and 2013 (Figure 4A). Because the estimate was done in the spring when large scale movement is limited it should provide a more accurate measurement of the density of brown trout in the Jerry Creek Section. The estimate yielded a total of 1,117 age-2 and older brown trout/mile and a biomass of 1,362 lbs of fish/mile in 2010 and a slightly higher estimate in 2013 (Figure 4A). These estimates were near estimated values from fall sampling in previous years (Figure 4A), but it is likely that these previous estimates are inflated due to the influx of spawning fish. The brown trout population estimated in 2010 and 2013 was nearly 5 times as large as that estimated in 1986 when brown trout population information began to be collected. A marked difference between the rainbow and brown trout populations in the Jerry Creek section is that the brown trout biomass estimate (lbs/mile) exceeds the density estimate (#/mile) suggesting that much of the population is made of larger individuals weighing 1 pound or more. The brown trout in this section of river provide a better opportunity for anglers to catch larger trout (i.e., > 16 inches) than the current rainbow fishery (Figure 5). When combined with the rainbow trout density estimated in 2010, there were over 2,500 trout per mile in the Jerry Creek Section of the Big Hole River. The relatively recent increase in the brown trout population in this section of river may be a causal factor for the lower density and poorer condition of rainbow trout. Another major difference between the populations of the two species is the paucity of juvenile brown trout. Significant brown trout spawning areas are present in the Jerry Creek Section, but length frequency analyses suggest that juvenile brown trout (age-2, 8.0-10.9 inches) are rare (Figure 5). The juvenile brown trout spawned in this section apparently migrate to other areas of the river to rear.

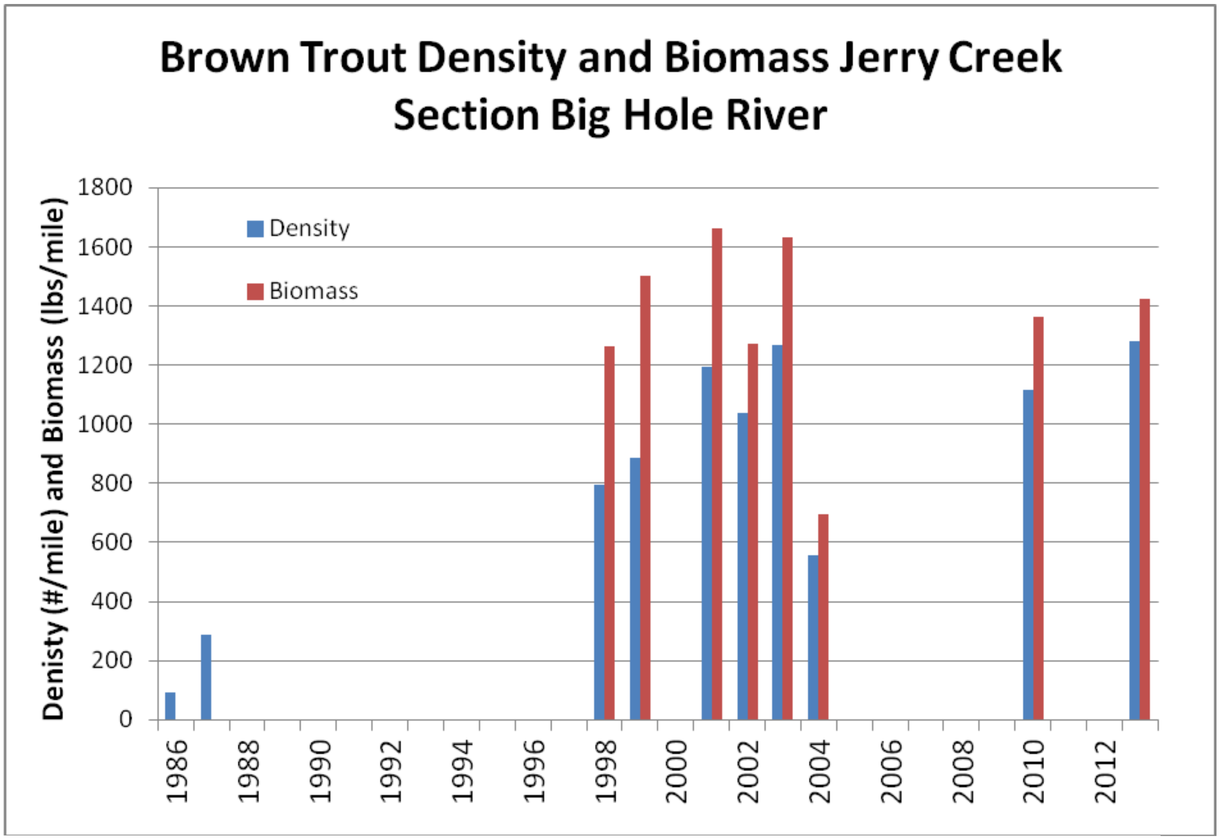

Figure 4A. Age-2 and older brown trout density (number/mile) and biomass (lbs/mile) from the Jerry Creek Section of the Big Hole River from 1986 through 2011. Note: estimates from 1986-2009 were performed in the fall, but the 2010 and 2012 estimates were performed in the spring.

The increase in brown trout numbers in the Jerry Creek Section of the river and in other areas farther upstream has raised concerns about the potential impacts of brown trout on Arctic grayling. Large, but rare brown trout have been known to exist in the river upstream of Jerry Creek, but their distribution was limited. However, more recently, brown trout adults have been captured in electrofishing monitoring in the upper river between Wisdom and Jackson. The expansion of the range of brown trout in this area has primarily occurred within the last 10 years. Within the past 5 years juvenile brown trout have been captured near Jackson suggesting that natural reproduction is occurring in the upper reaches of the river. While densities are currently low, it is possible that the brown trout population could expand in this reach much like what has occurred at Jerry Creek. The large pisciverous brown trout could have impacts on the fishery in this reach of river. To monitor this trend, 2 population monitoring sections were established in the upper river near Wisdom and Jackson.

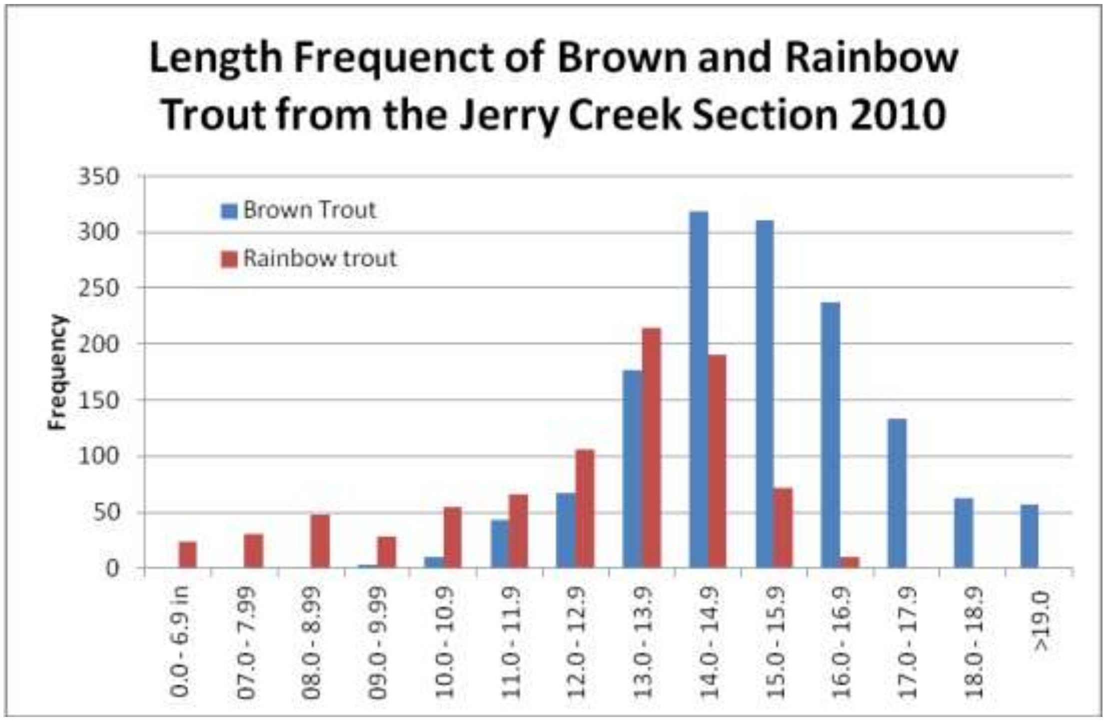

Figure 5. Length frequency plot of brown (blue bars on right) and rainbow (red bars on left) trout from the Jerry Creek Section of the Big Hole River, 2010.

Husted and Wisdom West Section

Two sections were surveyed in the upper Big Hole in the spring of 2013. The goals of these surveys were to evaluate the effect of the liberalized limit and season on brook trout in the upper river and to monitor the recent expansion of brown trout into the upper Big Hole. The sections were selected because they are close to access sites at county roads or state highway crossings that provide good public access to the river. The Wisdom West Section begins at the Highway 43 crossing of the Big Hole River immediately west of Wisdom, MT (45.61845, 113.45682) and ends just downstream of the Wisdom Cemetery (45.67152, 113.45268). The section has been periodically surveyed in the spring from 1987 to 2003. The Husted Section extends from the confluence of Governor Creek and the Big Hole River (45.38448, 113.43428) to near the Miner Creek Road crossing (45.40444, 113.44157). The Husted Section has been monitored in the fall since 2005. This is the first time the section has been sampled in the spring. All fish ≥ 6 inches encountered were captured and included in this analysis. Rocky Mountain sculpin and longnose dace were present in both sections but not captured and enumerated.

In the Wisdom West Section, mountain whitefish were the most abundant species captured followed by brook trout (Table 2). The whitefish and brook trout estimates shown in Table 2 are for fish ≥ 9 inches because too few recaptures were obtained from smaller fish. The brown trout and Arctic grayling estimates were modified Peterson estimates because of the low abundance of these species in the section and low recapture rates. Overall fish densities in this section were low for all species encountered. The most recent population estimate for the Wisdom West Section was performed in 1992 for Arctic grayling and at that time the population was estimated at 63 per mile with a confidence interval of 25.1. This estimate was significantly greater than the estimate computed in 2013. However, it has been well documented that the drought years of the mid 2000's resulted in significant declines in the grayling population in the Big Hole River. Arctic grayling have been periodically sampled from this reach of stream through 2002 but it has not been surveyed since. The data collected in 2013 will serve as a baseline for monitoring the effects of angling regulations on non-native species. Longnose and white suckers were also present in the electrofishing section but were not captured or enumerated.

Table 2. Fisheries survey data (≥9 in) from the Husted and Wisdom West sections of the Big Hole River in 2013 where L is fish length (in) and W is fish weight (lbs). The fish species sampled were: MWF = mountain whitefish, EB = brook trout, LL = brown trout, AG = Arctic grayling, RB = rainbow trout.

Section	Species	# encountered	Pop Est/mi (Std Dev)	Avg L (in) (range)	Avg W (lbs) (range)
Wisdom West	MWF	768	388 (47.1)	12.1 (4.1-18.2)	0.70 (0.06-2.02)
	EB	440	263 (76.3)	10.8 (5.3-18.2)	0.49 (0.06-2.09)
	LL*	70	34 (11.0)	13.2 (7.6-25.0)	0.99 (0.15-7.50)
	AG	19	6 (1.7)	11.1 (5.3-16.3)	0.46 (0.06-1.15)
	RB	12		15.1 (9.0-23.0)	1.46 (0.25-4.45)
Husted	MWF	94	82 (12.7)	13.5 (6.5-18.6)	0.82 (0.04-2.16)
	EB**	302	623 (78.3)	8.5 (4.5-17.9)	0.22 (0.02-1.96)
	LL	110	96 (6.5)	12.7 (5.3-25.9)	0.84 (0.04-7.00)
	AG	0			
	RB	5		16.5 (13.7-20.8)	1.67 (0.82-2.84)

* LL population estimate was for fish ≥7 inches
** EB population estimate was for fish ≥6 inches

Brook trout were the most common species captured in the Husted Section of the Big Hole followed by brown trout. The recent invasion of brown trout is evident from the monitoring done in the fall by the Arctic grayling crew (Figure 6); however the data collected in the spring of 2013 suggests the brown trout density is much lower in the spring than the fall. The data are not directly comparable because a population estimate was performed in the spring and a single pass catch per unit effort was performed in the fall. However, in 2 electrofishing runs only 110 brown trout were captured in the spring and more than 250 were captured in a single pass in the fall of the same year. Conversely nearly 6 times as many brook trout were captured in the spring than the fall, but this large difference is due mostly to the fact that a significant proportion of the brook trout enumerated in the spring of 2013 were between 6 and 10 inches (507) which were not collected in fall sampling. The number of brook trout ≥10 inches was nearly double that observed in the fall. It is possible that brown trout move into the Husted Reach in the fall from other areas of the river to spawn or migrate through the reach to access spawning areas upstream and that brook trout vacate the section (either to access spawning habitat or displaced by brown trout) during that same time frame.

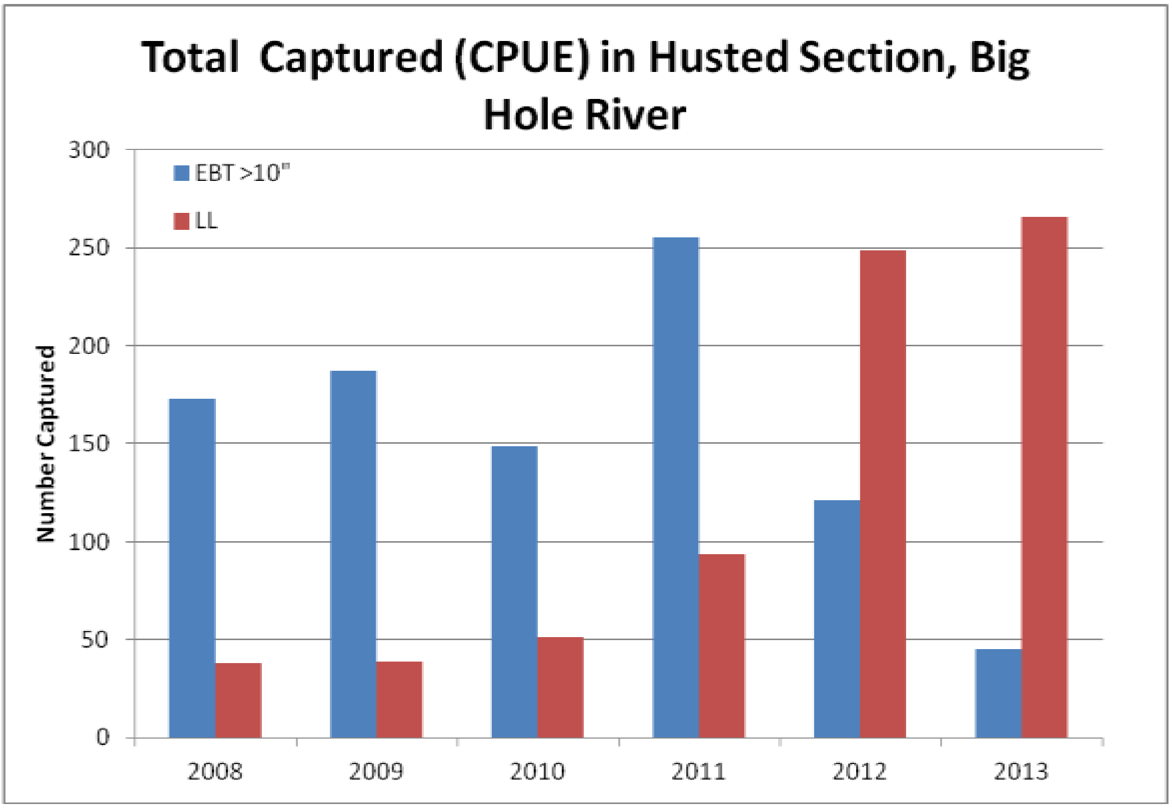

Figure 6. Total number of fish catpure during a single electrofishing pass throught the Husted Section of the Big Hole River in the fall from 2008-2013.

Maidenrock Section

The 3-mile Maidenrock Section of on the Big Hole begins in Maidenrock Canyon at 45.67625, 112.71359 and ends downstream of the Meriwether Ranch bridge at -45.64877, 112.6961. This section was initiated to evaluate the impacts of the special regulations on this section of river established in 1981 (Oswald 1986, 2000) and was sampled both spring and fall. Because of its proximity to the Melrose Section and because the evaluation of the special regulations is complete, the frequency of monitoring the Maidenrock Section has been decreased. The section was monitored in 2012 after 6 years of not being sampled.

The population estimate performed in the Maidenrock Section suggests the population has changed little in the six years since it was last sampled. The total population estimate for brown trout age-2 and older was 1,127/mile. The age-3 and older fish (≥ 13 in) was 721/mile which was above the long-term average of 600/mile. The numbers of age-5 and older fish (≥ 18 in) was 42/mile which was slightly less than the long-term average of 59/mile, but significantly less than peak numbers (over 120/mile) observed in 1986 and 1998 (Oswald 2005). Too few juvenile rainbow trout were recaptured in the Maidenrock Section to obtain a valid population estimate and therefore, the estimate performed in the section was only for fish ≥ 13 in. Rainbow trout ≥ 13 inches in the section were 445/mile with the majority (85%) of those fish being between 12 and 15 inches. The number of rainbow trout/mile greater than 16 inches was 10. The number of larger rainbow trout in the Maidenrock Section has declined dramatically since the mid 1980's. When the special regulations for this section of the river were adopted in 1981 the population of larger fish increased dramatically and more than doubled within 4 years. At that time the river averaged over 40 rainbows ≥16 inches/mile; however, from the early 1990's to the present the average number has been roughly 8/mile. The decline in rainbow trout numbers in the Maidenrock Section have followed a similar pattern to that observed in the Jerry Creek Section (Oswald 2000). It is unclear why the numbers of larger rainbows have declined so dramatically in this section despite special regulations particularly when the Melrose Section located immediately downstream did not follow the same pattern (Oswald 2000). The Melrose Section, located only 3 miles downstream of the Maidenrock Section, was not placed under special regulations in the early 1980's, yet rainbow trout numbers, including those ≥16 inches, increased in the section. Despite the proximity of the Maidenrock and Melrose Sections the habitat characteristics of the two sections differ substantially which is likely why the populations of fish also do not follow the same trends. The combined brown and rainbow trout estimate for the Maidenrock Section was over 1,600 fish/mile. These data suggest the Maidenrock Section is at or slightly above past estimates for combined trout.

Melrose Section

The beginning of the Melrose Section at the bridges over the Big Hole River at Melrose, MT is the dividing line between the area upstream with special angling restrictions initiated in 1981 and the area with no additional restrictions downstream. Upstream of the bridges was artificial lures only with a 3 fish limit and a slot limit on the size of trout that could be harvested. The intent of the slot limit, which was catch and release for all trout between 13 and 22 inches, was to increase the numbers of larger fish in this reach of river. After implementation of these regulations the numbers and size of both rainbow and brown trout increased (Figure 7, FWP 1989). More recently (2007) the slot limit upstream of the bridges has been removed, but the "artificials only" rule remains. Downstream of the bridges the general combined trout limit (5 fish only 1 over 18 inches) and no restrictions on fishing gear have been maintained since 1981. The angling regulation changes immediately upstream of the Melrose Section appeared to have resulted in an increase in trout abundance both upstream and downstream following their implementation (FWP 1989). However, within 10 years, the population of larger fish reached a plateau and even decline somewhat. Oswald (2005) speculated that after time other factors such as habitat availability and quality were limiting the fish population more so than fish harvest because of the corollary relationship between fish populations with and without special harvest regulations. The relationship between habitat quality and availability and the fish population parameters were further explored by Oswald (2009). He found that there were significant (positive?) correlations between fish density and water quantity, but only for the largest size class of fish (age 5+, >18 inches). There were no significant correlations between mean temperatures in August and fish population size in the Big Hole. The data strongly suggest that the annual flow regime is more important in determining potential brown trout standing crop than base summer flow characteristics (Oswald 2009).

Declines in the rainbow trout population in the Melrose Section in the late 1990's that could not be explained by habitat related factors and the frequent encounter of rainbow trout with cranial deformities led to the testing of the river and tributaries in the vicinity of Melrose for whirling disease. High level whirling disease infection rates were discovered and attributed almost exclusively to a drainage ditch/pond in Camp Creek, a tributary to the Big Hole that enters from the east at the town of Melrose (Oswald 2005). The ditch and pond were reclaimed and infection rates were reduced. More recent whirling disease testing will be discussed later in this report.

Brown trout population estimates including those covered in this report are shown in Figure 7. Following prolonged drought in early and mid 2000's, brown trout density and biomass increased in the late 2000's with improved water conditions. Unlike rainbow trout in the Jerry Creek section, brown trout density and biomass exhibited marked increases in response to a strong recruitment cohort of Age II fish in 2007. A significant increase in the age 5+ cohort of fish was noted in 2010 (from 18/mile to 49/mile), likely a result of the strong 2007 age-2 year class. This increase is demonstrated by the increase in biomass also noted in 2010. When biomass and density are equal, it means the average fish weighs 1 lb; therefore the average fish weight in 2010 was greater than 1 lb. However, the sharp increase in standing crop and biomass of brown trout declined back to near average levels the following year likely due to natural mortality of the larger, older age classes. The population estimate in 2012 was the highest recorded density and biomass in the Melrose Section since the inception of the section in 1981. Much of the increased density was attributable to the largest year class of age-2 brown trout on record (Figure 8). This increase corresponds to the high numbers of adult spawning fish observed in 2010 and the good water years that followed which likely led to increased survival of this cohort of fish. The 2012 record population level was eclipsed in 2014 when the population reached an all time high of over 1,800 brown trout per mile. In 2014the population size in the Melrose Section was over double its long-term average size.

Across sections of the Big Hole a semi regular cyclical pattern of boom and bust recruitment occurs when densities of older mature fish decrease then recruitment of juvenile fish increases. The mechanism for this pattern is thought to be predation as older mature fish prey upon juvenile fish and regulate their numbers. This pattern has been observed in other rivers across southwest Montana (Oswald 2006), and has been closely associated with discharge from the dams. The cycles in the Big Hole, unlike the regulated Beaverhead and Ruby rivers, do not appear to be as related to flow regimes (Oswald 2009a, 2009b). However, 2010 and 2012 appear to not follow this pattern because both years were good to excellent years for age-2 brown trout recruitment while there was also a simultaneous large population of adult fish ≥18 inches (Figure 7 and 8). These most recent data suggest that both the number of available spawners and subsequent flow regimes may have more of an impact on age-2 recruitment than predation by adult fish. From 2008-2011 when average flows returned to the to the Big Hole River, brown trout spawning success was much greater 2 of the 3 years (2010 and 2012). These 2 spikes also corresponded to spikes in adult fish 2 years previous (number of adult spawners) and subsequent average or above average flows.

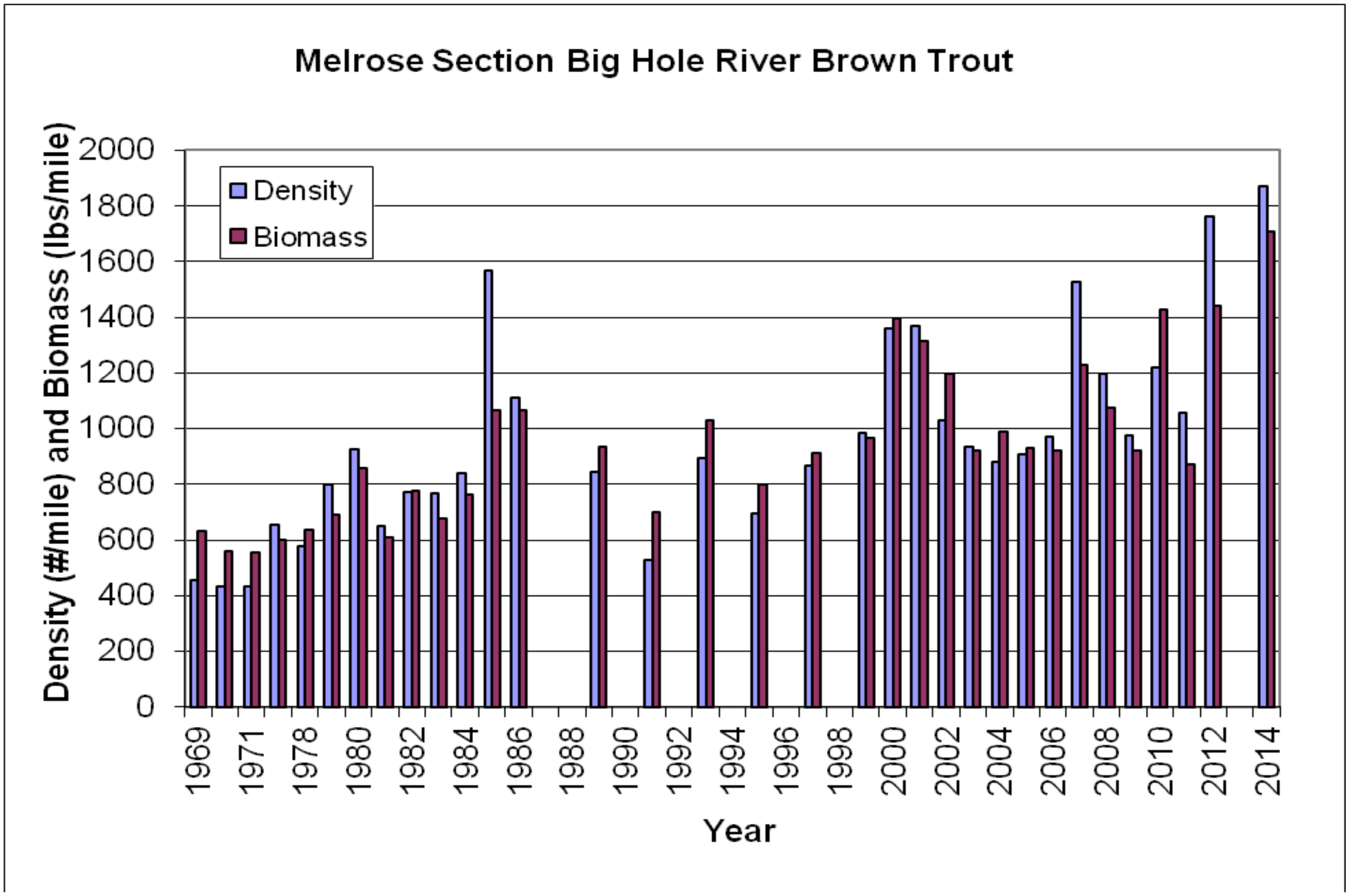

Figure 7. Age-2 and older brown trout density (number/mile) and biomass (lbs/mile) from the Melrose Section of the Big Hole River from 1981 through 2014.

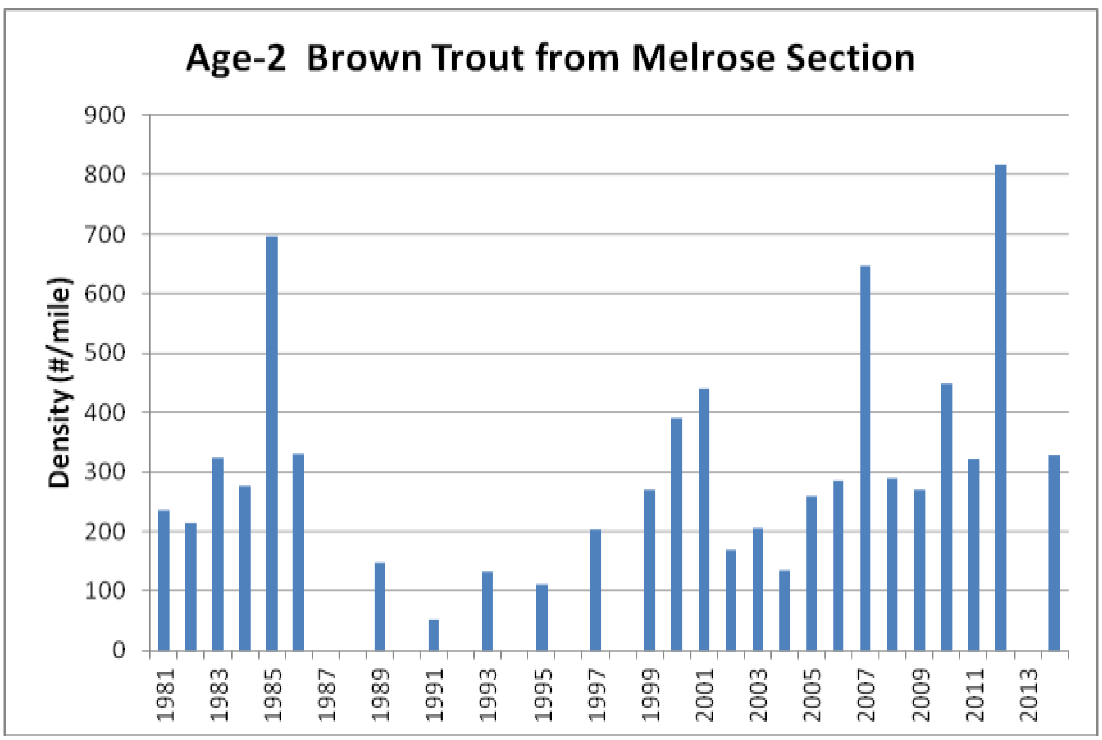

Figure 8. Age-2 brown trout (8-10.9 in) density (number/mile) from the Melrose Section of the Big Hole River from 1981 through 2014.

Since the implementaiotn of the special regulations on the section of the river immediatley upstream of the Melrose Section, brown trout relative weight (Figure 8) has exhibited negative trend. Following the implementaiton of the special regualations upstream of Melrose, brown trout density and biomass increased in the Melrose Section (Figure 7) and plateaued in the late 1980's (Oswald 2000). Some of the lowest realtive weight values observed duirng the history of monitoring at this site were duirng the period covered in this report. The low overall condition of the brown trout during this period corresponds to the highest density values of trout observed since the intiation of the study section. It is highly likely that the high pouplation size is resluting in food limitation for the trout and poor condition.

The rainbow trout population trends in the Melrose Section mimic those in the Jerry Creek Section with declining density and biomass with improved flow conditions from 2008 through 2011 (Figure 10; see also Oswald 2000). Rainbow trout densiteis observed in 2010, 2011 and 2014 were among the lowest observed since population monitoring began in the section in 1981. The expansion of whriling disease into other tribitaries to the Big Hole in the vicinity of Melrose (i.e,. Cherry Creek and Trapper Creek) may be affecting the survial of juvenile rainbow trout in this area. It is unclear if angler harvest is having an impact on rainbow trout abundance in the Melrose Section; however, the prevelance of volunteer catch and release anging on the Big Hole in general would suggest that angling is not likely the cause for reduced ranbow trout abundance. Additional study is warranted to detemine to what extent harvest may be affecting the rainbow population and what management actions, if any, are warranted to increase the rainbow trout density.

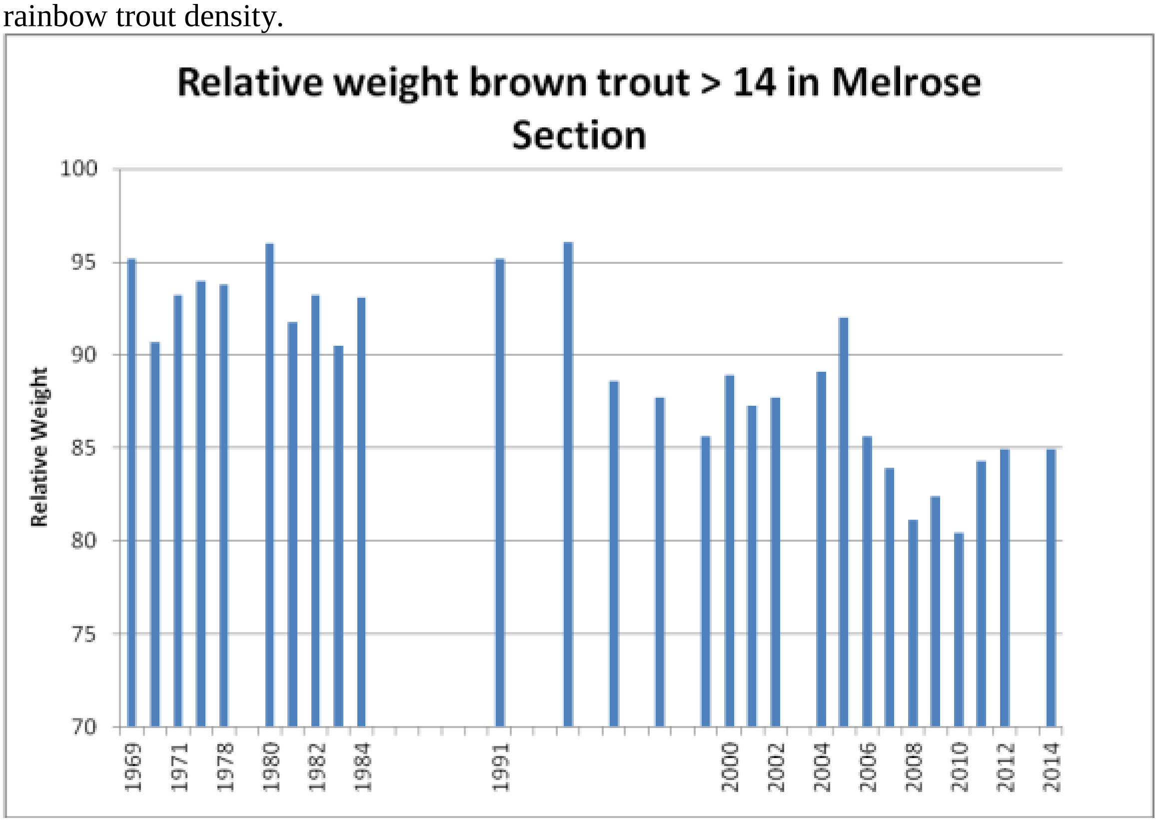

Figure 9. Brown trout relative weight from the Melrose Section 1969-2014.

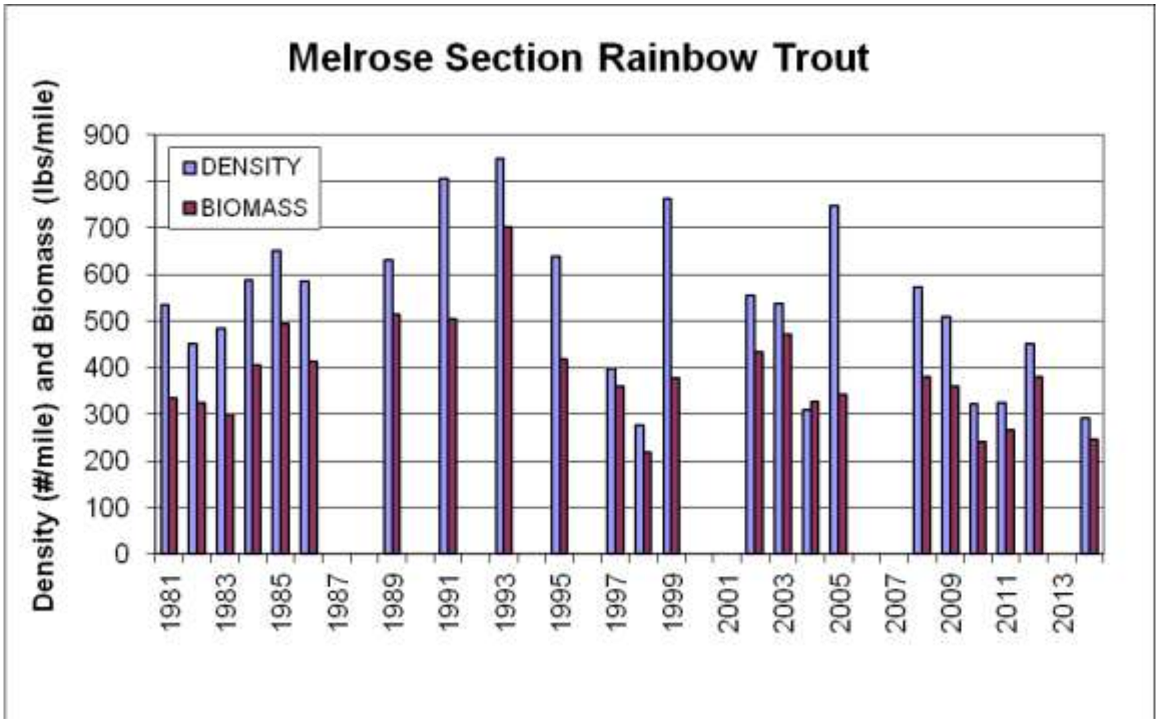

Figure 10. Age-1 and older rainbow trout density (number/mile) from the Melrose Section of the Big Hole River from 1981 through 2014.

Hogback Section

The Hogback Section of the Big Hole River represents the lower reaches of the river where the valley is much less constricted and the river moves back and forth across a wide floodplain. The river habitat consists of a cottonwood and willow forest with a braiding channel. Side channels and islands are common throughout this reach of river and during high water years it is common for the river to change channels. There is little development along the floodplain of the river.

Brown trout populations in the Hog Back Section exhibited an increasing trend from 2008-2011 for density and biomass (Figure 11). The brown trout population in the Hogback Section is more impacted by drought and irrigation withdrawal than the other 2 sections upstream. Densities of age-5+ brown trout (18 inch and larger) in this section have been shown to be positively correlated with total annual discharge, minimum August flow, and with mean August flow (Oswald 2009). The extended drought conditions through much of the early to mid 2000's had significant impacts on the total trout population in the section resulting in a near 50% decrease in the fish population (Figure 11). As drought conditions lessened beginning in 2008 the brown trout population began to increase incrementally until reaching full recovery (over 1,000 fish/mile) in 2012, which was the second highest density recorded.   Age-5 brown trout density was greater in 2012 than in any other year data have been collected in the Hogback Section. Then immediately following a year of drought in 2013 the population was reduced by more than 50% (Figure 13). Because of the strong correlation between brown trout abundance and flow, the importance of ample water regimes and productive habitats at all seasons of the year is a management priority.

There was a stronger than average recruitment of age-2 fish in 2012 (Figure 12). The dip in recruitment of age-2 fish in 2010 may be related to the high density of age-5 fish, which is another pattern noted by Oswald (2009). However, in 2012 the density of age-5 fish was the highest recorded in the section, and the numbers of age-2 was the second greatest value documented. The density of age-2 brown trout declined dramatically in 2014 despite having a very large size class of age-5 fish 2 years prior. These data suggest, as mentioned above for the Melrose Section, that juvenile density may be related to flow and associated habitat availability more so than other factors.

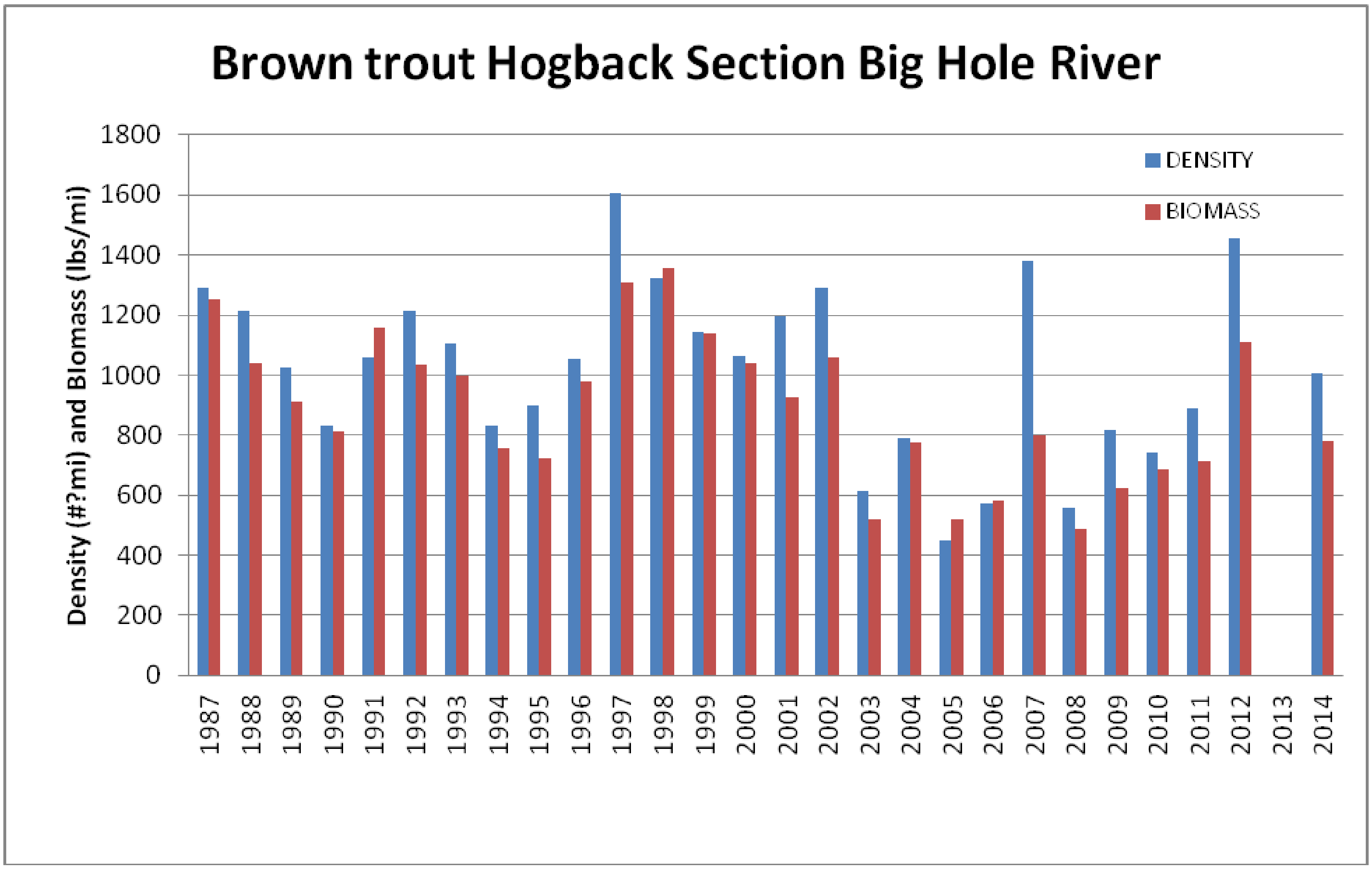

Figure 11. Age-2 and older brown trout density (number/mile) and biomass (lbs/mi) from the Hogback Section of the Big Hole River from 1981 through 2014.

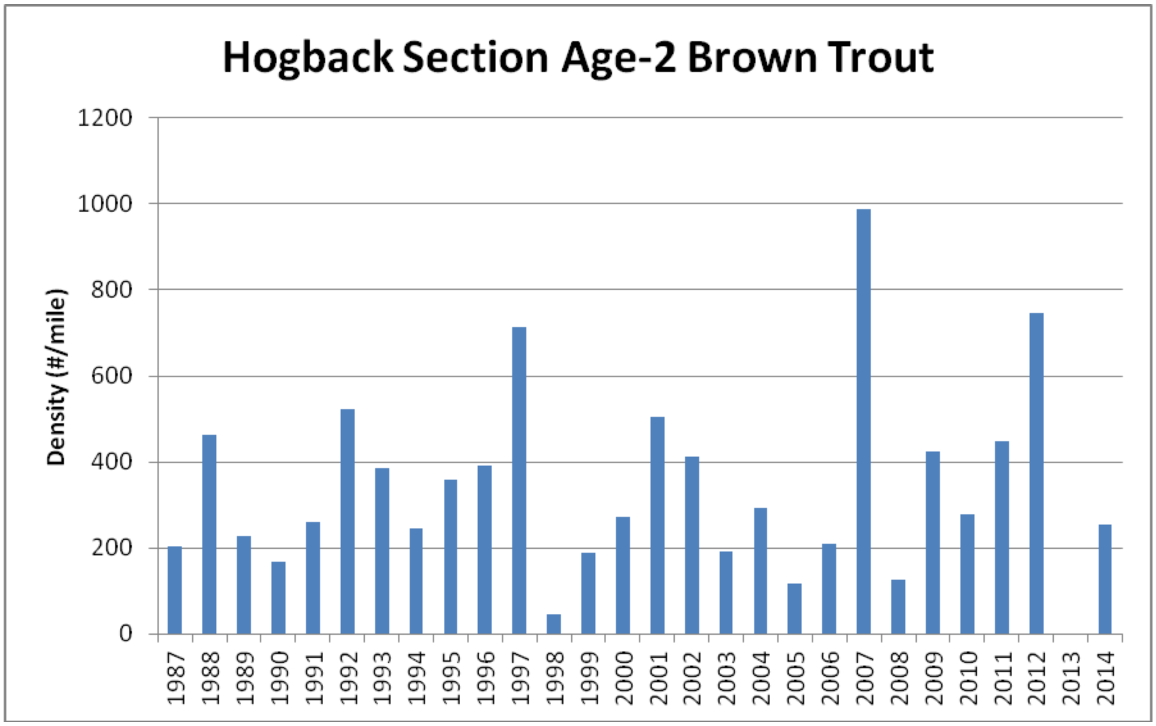

Figure 12. Age-2 brown trout density (number/mile) from the Hogback Section of the Big Hole River from 1987 through 2014.

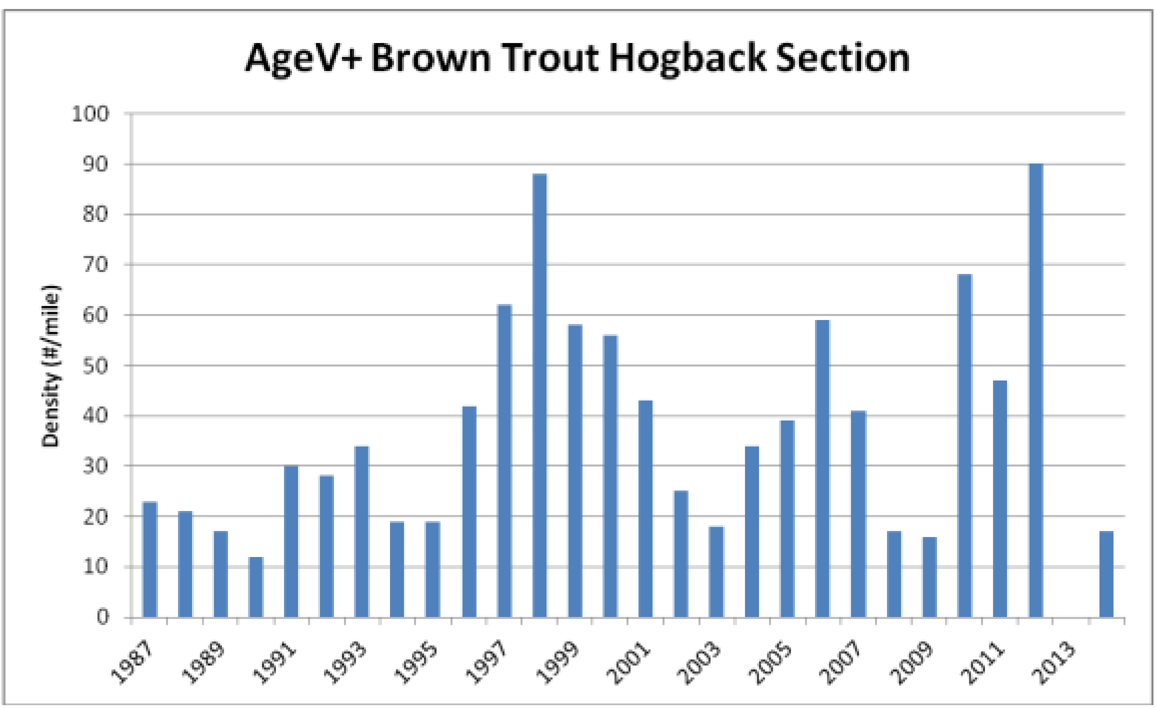

Figure 13. Age-5+ brown trout density (number/mile) from the Hogback Section of the Big Hole River from 1987 through 2014.

The expansion of the rainbow trout population in the Hogback Section of the Big Hole is a relatively recent phenomenon (Figure 14). Likely fueled by the excellent recruitment class of age-1 fish in 2006 and 2007, the rainbow trout population has doubled in the

Hogback Section since 2008. During the early 2000's the brown trout population in the Hogback Section was suppressed (Figure 11), but as flows increased during the past 4 years the brown trout numbers have steadily increased. The rainbow trout in this section have also steadily increased to a peak of 800 rainbows per mile in 2014. The recovery of brown trout and the expansion of the rainbow trout fishery in this section of river has led to the overall density of trout in the Hogback Section to exceed the density of the Melrose Section farther upstream. In addition to increased numbers, the rainbow trout in the Hogback Section are larger with a higher relative weight than rainbows from other sections farther upstream.

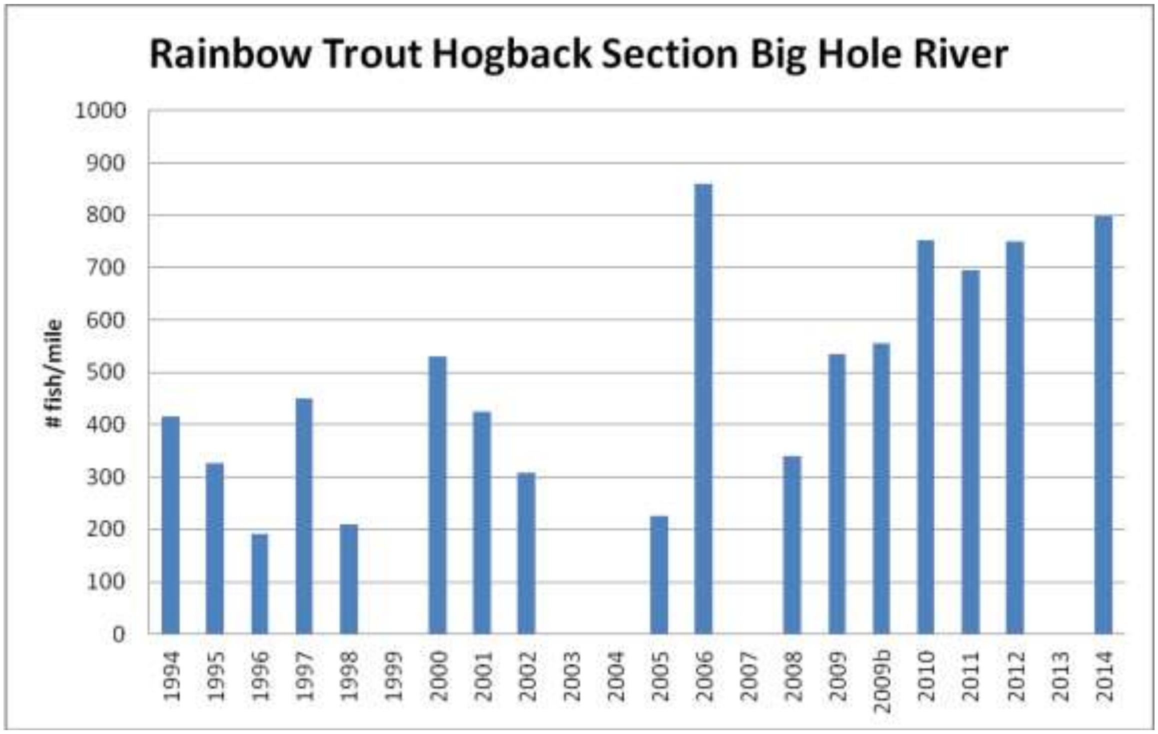

Figure 14. Age-1+ rainbow trout density (number/mile) from the Hogback Section of the Big Hole River from 1994 through 2014.

Pennington Section

To better understand the fishery of the lower Big Hole River (from Notch Bottom to the confluence with the Beaverhead River), a new population monitoring section was initiated in 2009. The Pennington Section begins at the Pennington Fishing Access Site and extends downstream 2.8 miles to a takeout located on private property. Little prior sampling has occurred in this reach of river and therefore little is known about the fishery or its potential. What is known is that this reach of river suffers from chronic dewatering. Multiple irrigation diversions irrigate pasture and hay lands in the area. The floodplain of the Big Hole River in this area is wide and in some cases intercepts the floodplain of the Beaverhead River to the east. This wide and flat area is much more suitable to conveying irrigation water than the steeper valleys upstream resulting in several large diversions from the river. The installation of a USGS real-time flow monitoring gage at the High Bridge (downstream of most irrigation diversions) allows for better tracking of flow in this section of river.

This reach of river is also affected by significant bank stabilization in the form of blanket riprap. These structures limit the river's access to the floodplain and its ability to create new channels. In a river system with a wide floodplain and no ability to access this area during high flows, a simpler, single thread channel with fewer side channels tends to develop. These side channel habitats which would typically provide important spawning and rearing areas are lacking in this reach. This reach of river also lacks any perennially flowing tributary streams. The nearest tributary that flows perennially to the river is Birch Creek more than 20 miles upstream. It is likely that because of the lack of side channel habitats and the lack of tributary streams the fishery in this reach of river has limited spawning and rearing habitat.

Another feature of this reach of river is the large slough/ditch systems that originate in Big Hole and empty into the Beaverhead (e.g., Owsley and Schoolhouse sloughs). These sloughs divert water from the Big Hole that is partly used for irrigation and partly used for the support of the fisheries that have developed in the sloughs. Significant restoration work has been performed in reaches of these systems to improve fisheries habitat. However, it unclear if the fisheries have responded to the habitat improvements and if the Big Hole, Beaverhead and Jefferson rivers benefit from this restoration work.

The Pennington Section of the Big Hole was sampled in 2009, 2011 and again in 2013. Unlike other population monitoring sections, all species of fish encountered were captured and enumerated including mountain whitefish, longnose, white and mountain suckers and Rocky Mountain sculpin in 2009 and 2011. Redside shiners were also present in the section but were not captured. Common carp are also known to be present in this section of river, but none were encountered during sampling. In 2013 the section was expanded downstream an additional 2.3 miles to include a potential spawning habitat enhancement project reach in an adjacent slough channel that originates and discharges back to the river within the section. Brown and rainbow trout were the most common trout species encountered, but a single westslope cutthroat trout was captured in 2011. Brown trout density more than double in the Pennington Section during this study from just over 250 per mile in 2009 to 658 in 2013 (Figure 15). The marked increase from 2011 to 2013 was likely due to the average to above average flows and the successful recruitment of a large age class of 2 year old fish in 2012. Both numbers and size of fish in this section increased during the study period suggesting that food is not a limiting factor at the present population size.

Rainbow trout density and biomass remained relatively static from 2009 through 2011, but declined from 2011 to 2013 (Figure 16). Initially it appeared that the lower sections of the Big Hole (Hogback and Pennington) did not suffer the decline in rainbow abundance during the past higher water years like the sections located farther upstream (Melrose and Jerry Creek), but a similar decline was noted in 2013. Rainbow trout decline in higher water years occurs is several freestone fisheries across Montana, but the mechanism for these declines is poorly understood. It is possible that rainbow trout declines during higher waters years is related to redd scour or displacement of fry during extended periods of high flows. The combined rainbow and brown trout density in the Pennington Section (789/mile in 2013) is significantly less than all other sections in the Big Hole covered in this report, including the Hogback Section located only 15 miles upstream (1,583/mile).

An interesting difference between the fish population in the Pennington Section and other sections is the fast growth rate of juvenile fish. Figure 17 shows brown trout length frequency from the Pennington and Melrose sections. The mode of the age-2 size class of brown trout from the Pennington Section is approximately 11.5 inches and the mode of age-2 fish from the Melrose Section is approximately 9.5 inches indicating substantially faster growth farther downstream. This fast growth rate is likely related to the low density of trout, but it may also be related to warmer water temperatures during years of ample flow. It is likely that this section of river has the capacity to carry significantly more fish per mile than what is currently present. If flow conditions and spawning habitat are improved, it is likely that fishery in this section of river could improve.

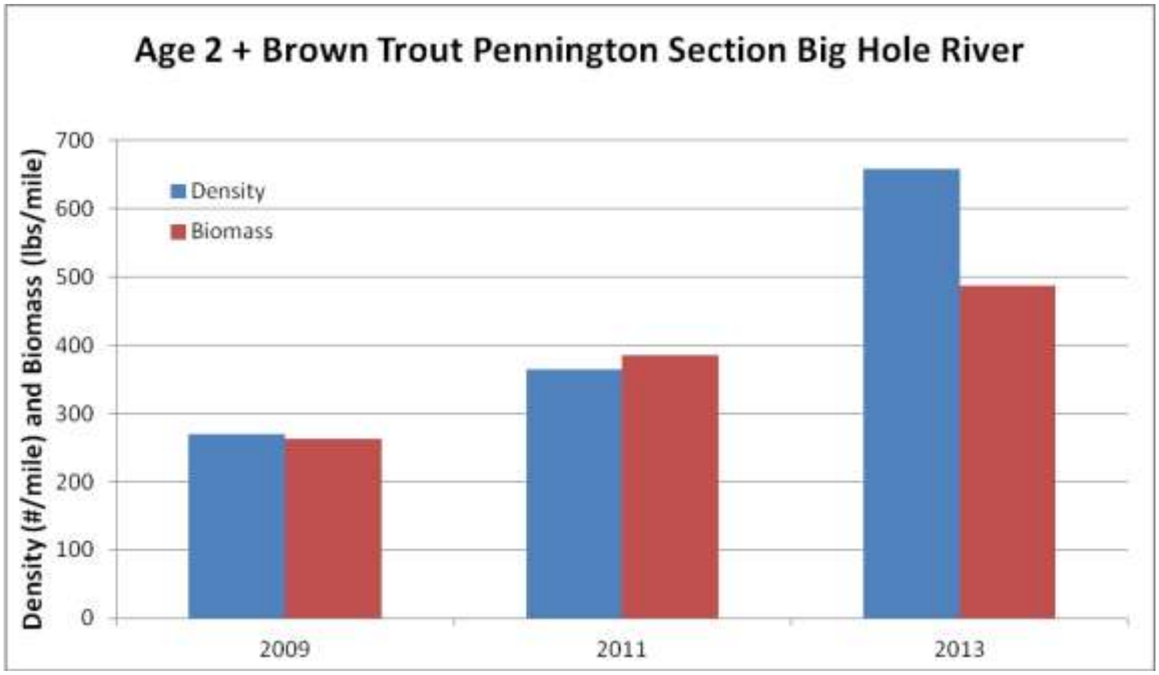

Figure 15. Age-2+ brown trout density (number/mile) and biomass (lbs/mile) from the Pennington Section of the Big Hole River, 2009-2013.

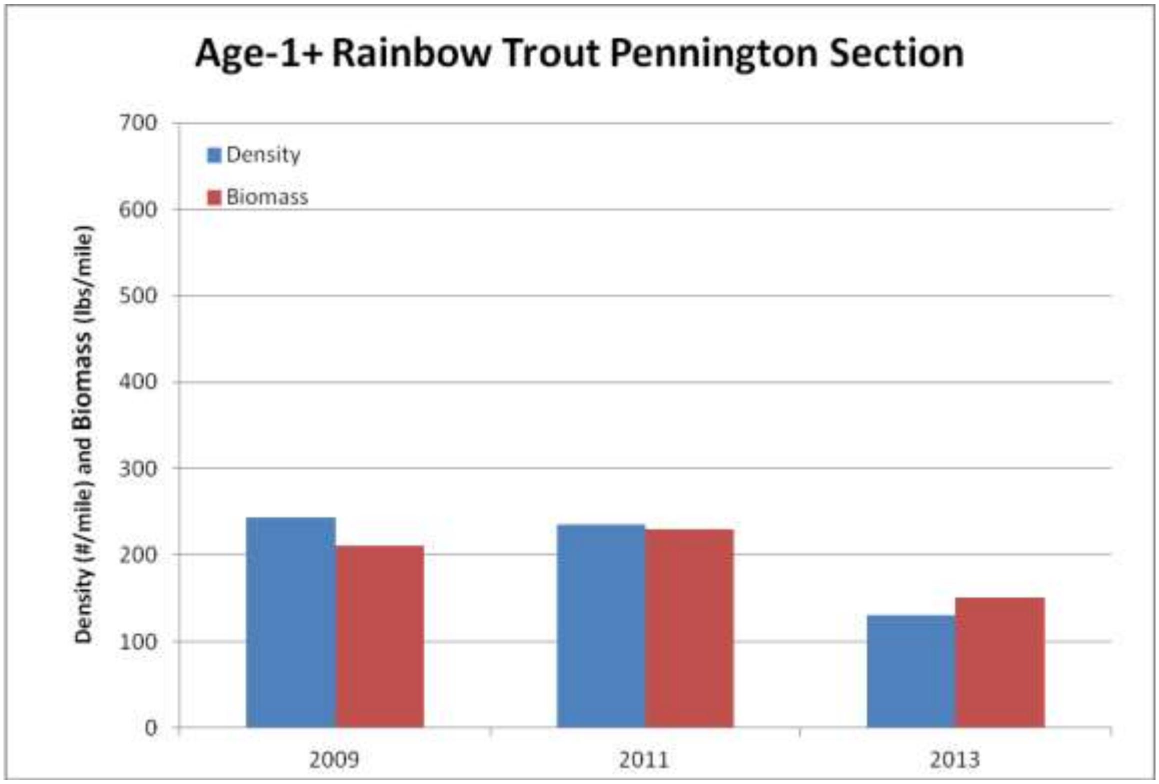

Figure 16. Age-1+ rainbow trout density (number/mile) and biomass (lbs/mile) from the Pennington Section of the Big Hole River, 2009-2013.

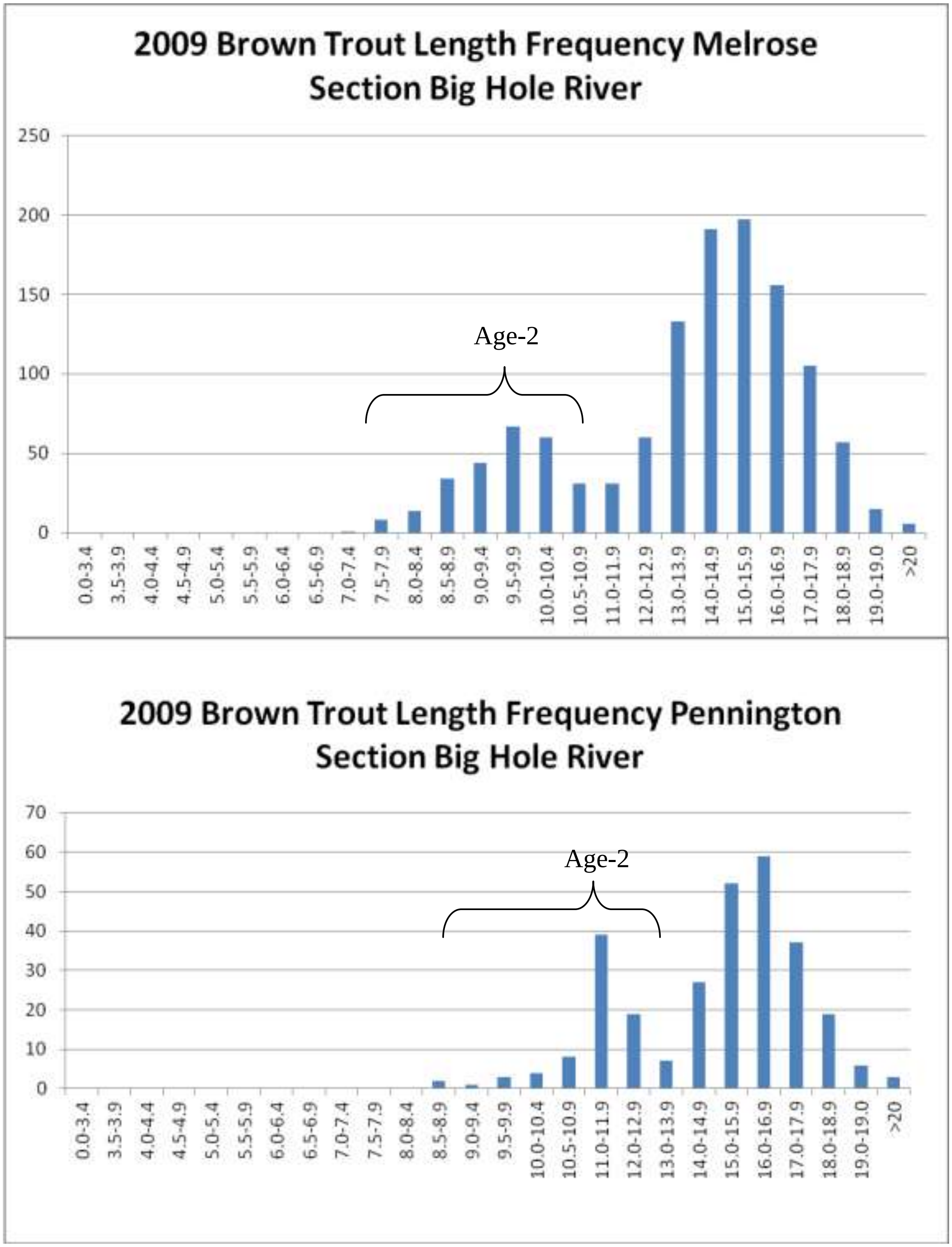

Figure 17. Length frequency of age-2 and older brown trout from the Pennington (top) and Melrose (bottom) sections of the Big Hole River, 2009.

Mountain Whitefish

Mountain whitefish is a game fish with a high harvest limit (20 daily and 40 in possession), but little effort has been expended to understand their population dynamics. One of the reasons for the lack of whitefish data is their reputation for high mortality when captured using electrofishing. A survey of their population had not been attempted in the Big Hole. Anecdotal evidence suggests that whitefish populations are declining regionally across several Montana rivers. While significant declines have not been noted in the Big Hole River more information is needed to better understand the population dynamics of this native species. The first mountain whitefish population estimate performed in the Big Hole River was done in Pennington Section in 2009 and repeated in 2011. A population estimate was performed in the Melrose Section in 2012 and in the Jerry Creek Section in 2013.

The whitefish population in the Pennington Section appears to be thriving. The whitefish density was more than double the density of combined trout (over 1,300 fish/mile in 2009, Figure 18). That number increased substantially in 2011, largely due to a significant increase in age-2 recruitment (note the lack of a significant increase in biomass from 2009 to 2011). All age classes of whitefish are well represented in the Pennington Section (Figure 20) indicative of a healthy and stable population, but the largest cohort observed were age-2 fish (7.0-9.9 inches) suggesting this area is important for spawning and/or rearing. The numbers of age-2 fish observed in the Pennington Section were nearly double those observed in the Melrose Section farther upstream.

The high mortality rates of mountain whitefish observed by others when captured using electrofishing were not noted in sampling in the Big Hole sections. Immediate mortality rates observed were approximately 5%, which is greater than those observed for trout (generally < 1%), with mortality occurring primarily in the smallest size classes. Recapture rates ranged from 17% for 8.0-8.9 inch fish to as high as nearly 40% for fish greater than 14 inches. Recapture rates for trout in the Pennington Section ranged from 14% for 9.0-9.9 inch fish to as high as 26% for larger size classes greater than 14 inches. The numbers of whitefish captured on the 2 marking runs versus the 2 recapture was nearly equal in 2009 (902 marking run, 955 recapture run). The high recapture rates of mountain whitefish on the Pennington Section suggests there is not significant mortality of captured whitefish. The lower mortality rate observed in the Big Hole relative to what others have reported may be attributed to the low conductivity of the Big Hole River (< 200µS), the cold spring temperatures (< 45^{o}F), and potentially the type of electrofishing gear used.

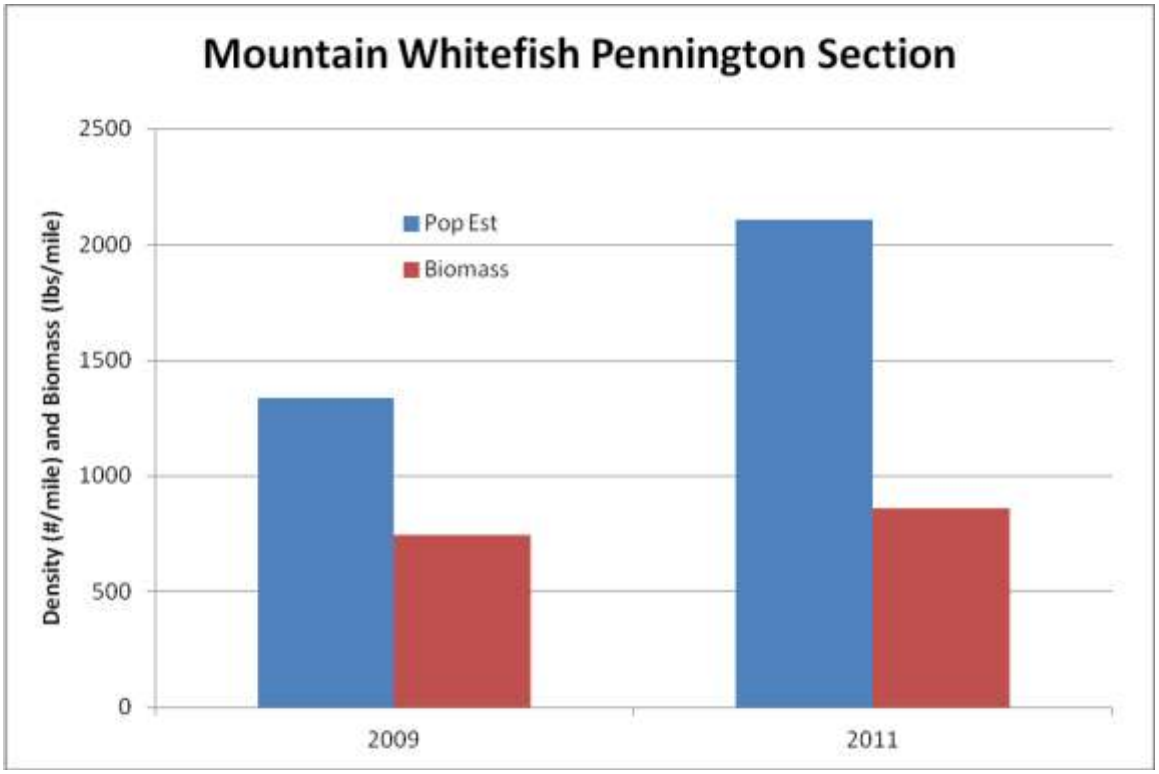

Figure 18. Age-2+ mountain whitefish density (number/mile) and biomass (lbs/mile) from the Pennington Section of the Big Hole River, 2009-2011.

Too few mountain and longnose suckers were captured to produce a population estimate and no estimate was attempted for mottled sculpin. However, an estimate was obtained for white suckers in 2009 (254 fish per mile, Modified Peterson Estimate, FA+, FWP 2008). There is likely some bias in this estimate because suckers are spring spawners and potentially moving into and out of our study section at the time the estimate was performed but this number serves as a baseline for monitoring the sucker population in the future. There does not appear to be an over abundance of any of the sucker species found in Pennington Section.

A mountain whitefish estimate was performed in the Melrose Section in 2012. There is no previous record of a whitefish population estimate being performed in this section. Angler reports of fewer whitefish in the river along with purported regional declines in whitefish abundance prompted the initiation of whitefish monitoring in this section. Whitefish were collected along with trout during the normal population estimate performed in 2012. A total of 2,772 whitefish were captured in the section for a total population estimate of 2,737 whitefish/mile (Figure 19). Whitefish outnumber brown and rainbow trout combined (Figure 19) and when whitefish and trout combined there are nearly 5,000 individual salmonids and 4,000 lbs of fish per mile in the Melrose Section. The mountain whitefish population in the Melrose Section appears to be more heavily weighted toward adult fish (Figure 20) than the Pennington Section yet there is evidence of rearing and reproduction occurring in the section because of the presence of (age-1 and age-2).

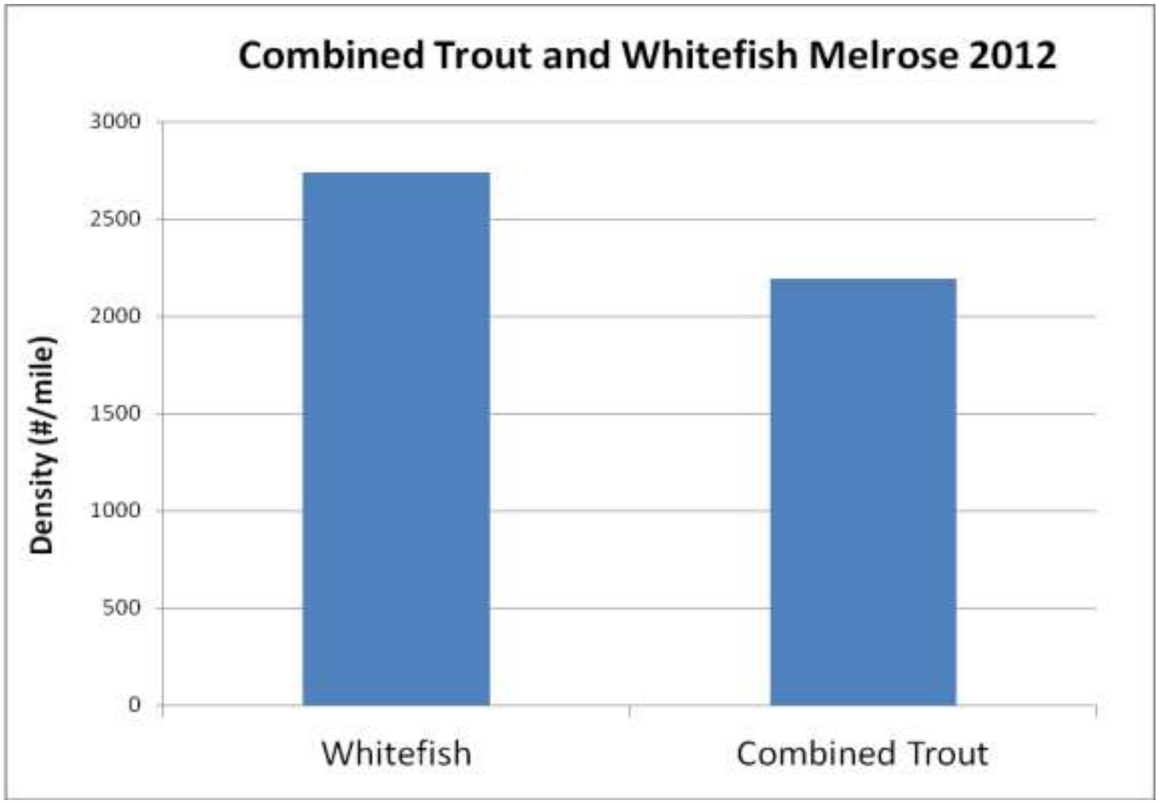

Figure 19. Population estimates for mountain whitefish and combined trout (brown and rainbow trout) from the Melrose Section, Big Hole River 2012.

A mountain whitefish estimate was performed in the Jerry Creek Section in 2013. There is no record of a whitefish population estimate being performed in this section of the river. The whitefish population in the Jerry Creek Section was estimated at 1,180 fish/mile which is less than half the estimates observed in either Melrose or Pennington sections. The population in the Jerry Creek Section appears to be most heavily weighted toward adult (Figure 20). There is little evidence of rearing and reproduction occurring in the section because of the lack of age-2 fish (<10 inches). The mode length of fish in the Jerry Creek section was greater than that of the other 2 sections suggesting there are more larger whitefish found in this section than the other 2. It appears from these limited data that the Jerry Creek Section may be lacking in spawning and/or rearing habitat, but that the adult habitat in the section may be more suitable to larger adult fish. Whitefish are known to migrate long distances to spawn and that juvenile fish drift downstream to warmer waters to rear. The Jerry Creek section was the only section where mountain whitefish did not outnumber brown and rainbow trout combined trout estimate (2,160 in 2013).

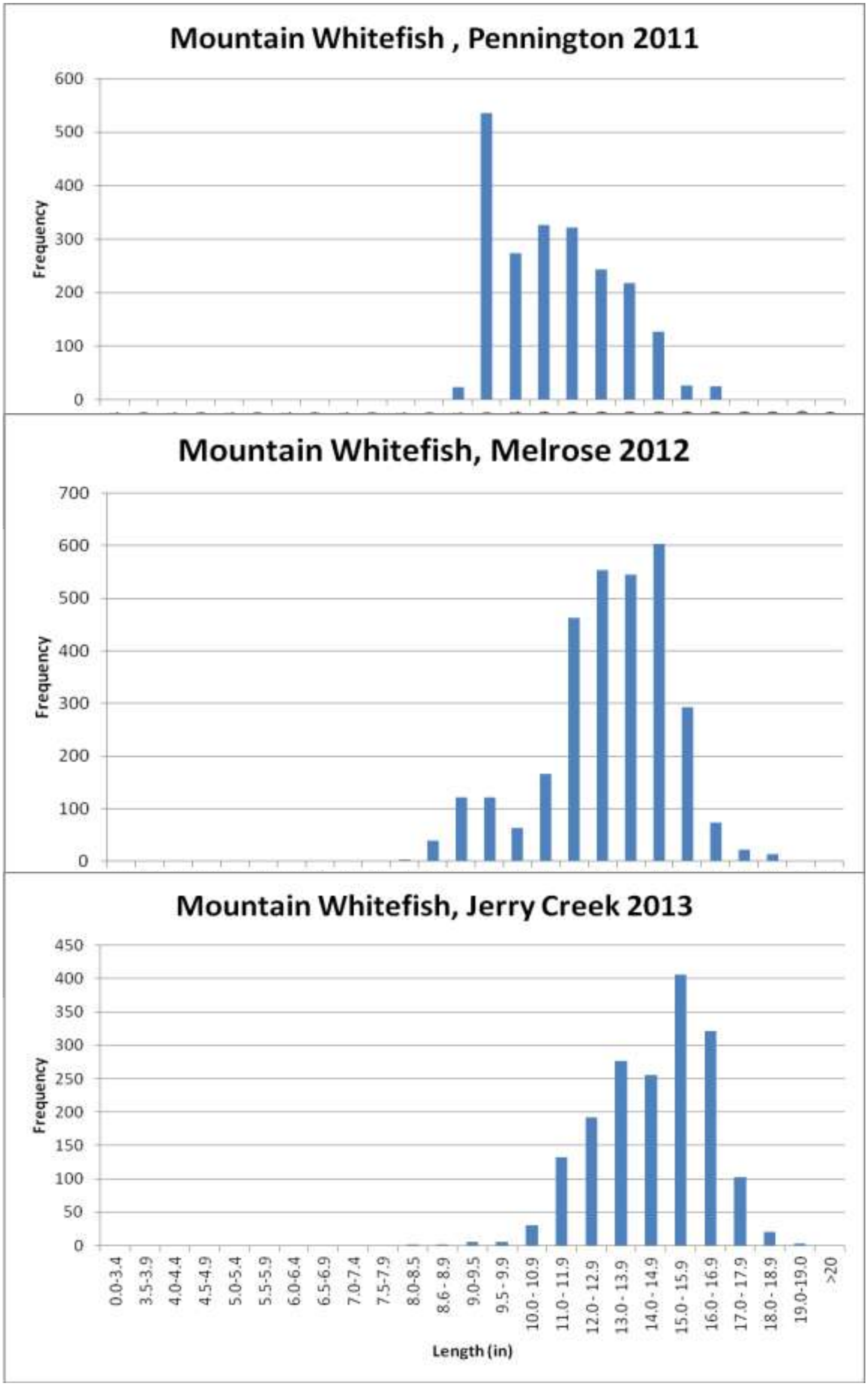

Figure 20. Length frequency of age-2 and older mountain whitefish form the Pennington, Melrose and Jerry Creek Sections.

Evaluation of Seasonal Segregation of Population Estimates

As discussed previously, the timing of trout population estimates have been seasonally segregated on the Big Hole River to avoid estimating populations during known migration times, which violates assumptions of the population models used. Brown trout estimates are performed in the spring and rainbow trout estimates are performed in the fall to avoid spawning related movements of fish. Semiannual electrofishing requires significant effort and results in the disturbance and handling of significantly numbers of fish. We attempted to evaluate the necessity of segregating population estimates in the spring and fall by comparing recapture rates of different size classes from the fall of one year to the average recapture rate of specific size classes of fish from multiple years (we assumed growth was negligible over the winter, so we were capturing the same size fish between spring and fall). If large scale movements of fish are occurring we would expect recapture efficiencies to be significantly lower during the season of spawning related movements for adult sized fish than what should be observed in the non-movement season.

Fall brown trout estimates. An evaluation of the potential to estimate brown trout populations in the fall was attempted in the Jerry Creek Section in 2008. However, mid way through the first recapture run, the effort was abandoned because more brown trout were captured on the first recapture run than the two marking runs combined with very few recaptures. It was obvious that in the Jerry Creek Section large seasonal movements of brown trout are occurring as spawning fish move into that section later in the fall during recapture runs. Fall electrofishing typically begins the 3rd or 4th week in September and concludes by mid October. Although no formal data were collected, anecdotal evidence from the Melrose Section of the Big Hole River would suggest a similar seasonal movement pattern to that which occurs in the Jerry Creek Section. These data suggest that to obtain a valid estimate for brown trout, seasonal segregation of population estimates is necessary. Trout population monitoring in the fall does not occur until mid September through early October because higher river temperatures prior to these dates lead to poor electrofishing efficiency and increased stress on captured fish. It is clear that these later dates, particularly on the recapture runs in October, intersect large-scale brown trout movements to spawning areas and grossly violate the assumptions of the mark-recapture model.

Spring rainbow trout estimates. A comparison of fall versus spring population estimates of rainbow trout were conducted in both the Hogback and Melrose Sections. Spring electrofishing generally begins the 2nd or 3rd week of March and concludes the first week in April. From the evaluation performed in the Hogback Section, recapture rates differed for rainbow trout with lower efficiency occurring for smaller and larger size classes of rainbows with moderate sized fish recapture efficiency being nearly equal between spring and fall (Table 3). It is unclear why there was a discrepancy between spring and fall rainbow trout estimates for smaller sized fish. It is possible that the colder water temperatures present in the spring leads to poorer capture efficiency of smaller fish. The lower recapture rate of larger fish could be related to spawning related movements into and out of the population monitoring section during the spring. While there were discrepancies between spring and fall recapture rates, the differences for the most part were not substantial and within the range annual differences between recapture rates within the fall. Lower capture efficiency lead to an over estimation of the rainbow trout population in this section using spring estimates (Table 3). However, if performed consistently spring rainbow trout estimates would still provide an accurate (although not precise) measure of population trends through time.

There does not to appear to be any consistent or significant bias related to the recapture rates of spawning age fish between spring and fall estimates in the Melrose Section (Table 3). It is likely that because of the early season electrofishing in the spring (beginning in early March and ending generally by April 10), that large-scale rainbow trout movement have not yet commenced. Therefore while there are some biases in spring rainbow trout population estimates these biases do not appear significant enough to justify the seasonal segregation of sampling and the increased effort involved with semiannual electrofishing. However, if a precise measure of rainbow trout density is warranted, fall population estimates appear to produce an estimate with less error than spring estimates.

Table 3. Recapture rates of rainbow trout from the Hogback and Melrose sections used to evaluate the seasonal segregation of population estimates on the Big Hole River.

Hogback			Population Estimates	
Size Class	Fall 2009 Recapture Rate (%)	Average Spring 2005-2011 Recapture Rate (%)	2009	2010
8.0 - 8.9 in	19.0	13.5	118	23
9.0 - 9.9 in	9.5	8.7	82	63
10.0 - 10.9 in	20.0	11.9	16	49
11.0 - 11.9 in	18.8	13.8	32	25
12.0 - 12.9 in	24.4	22.8	62	98
13.0 - 13.9 in	29.0	22.9	45	170
14.0 - 14.9 in	20.0	13.6	42	98
15.0 - 15.9 in	21.9	15.5	43	85
16.0 - 16.9 in	16.7	13.6	32	64
17.0 - 18.9 in	18.2	15.9	26	39
		Total	498	714
Melrose				
Size Class	Fall 2009 Recapture Rate (%)	Average Spring 2010-2011 Recapture Rate (%)		
8.0 - 8.9 in	24.0	0.0	69	4
9.0 - 9.9 in	35.0	9.1	31	20
10.0 - 10.9 in	21.1	40.0	29	15
11.0 - 11.9 in	24.4	24.5	69	29
12.0 - 12.9 in	18.4	18.9	49	48
13.0 - 13.9 in	14.1	21.9	62	52
14.0 - 14.9 in	23.7	15.6	84	74
15.0 - 15.9 in	23.9	20.9	80	119
		Total	473	331

Whirling Disease Monitoring

Whirling disease (WD) testing was initiated in the Big Hole River near Melrose in 2003 following the finding of significant numbers of rainbow trout with cranial deformities and a decline in rainbow trout recruitment that was not evident in other sections of the river

(Oswald 2005). The main river and tributaries in the vicinity of Melrose were tested for WD by placing live, caged juvenile rainbow trout in streams during the spring and fall for 10 days. After exposure, the fish are transported to a laboratory for rearing for approximately several months at which time the fish are sacrificed and examined for the presence of the disease. These initial tests implicated one tributary stream, Camp Creek, and specifically a drainage ditch that had been dammed as the source of WD. The rating scale of infection is 0 to 5 with 5 being the most severe. Fish with low histology ratings generally do not show clinical signs of the disease whereas fish with higher ratings exhibit cranial deformities, whirling behavior, a black tail and mortality. Average histology from cages placed in Camp Creek and the drainage ditch were at or near 5 (on a scale from 0 to 5; McConnell-Baldwin scale). Reclamation efforts were made to the ditch to reduce WD prevalence in this system; however, through 2007 average histology remained at or near 5.

From 2008 to 2011 WD testing has continued to be performed in the Big Hole. Testing efforts have increased to include a more comprehensive survey of tributary streams in and around Melrose in addition to longitudinal testing for the disease from the mouth near Twin Bridges to the headwaters near Jackson. Results of these tests are summarized in Table 3. These most recent tests continue to support prior evidence that the area around Melrose is the focus area for high WD infection. However, unlike prior studies, several other tributary streams such as Cherry and Trapper creeks were also implicated as streams with relatively high rates of WD infections. Infection rates in Camp Creek have declined substantially from average histology ratings of at or near 5 to approximately 2. While all fish tested in Camp Creek had some level of WD infection, it appears that the remediation work done in the drainage ditch leading to Camp Creek has been successful at significantly reducing the infection rate in this stream. However, the infection rate of rainbow trout in the main river remains above historic levels (average 2006-2007 = 3.05, 2009= 3.52). It is likely that the moderate to severe WD infection rates in Trapper and Cherry creeks are offsetting improvements achieved in Camp Creek (Table 3). The closest tributary streams both upstream (Moose and Canyon creeks) and downstream (Rock and Willow creeks) exhibited much lower levels of WD. The recent declines in rainbow trout abundance in the Big Hole River in the vicinity of Melrose may be related to the spread of WD into tributaries in this area. It is interesting that in both Cherry and Trapper Creek that WD infection appears to be limited to areas near the mouths of both streams. It is unclear if the disease is in the early stages of colonization in the streams or if habitat conditions farther upstream are less suitable for the parasite or its secondary invertebrate host. No WD was detected in Jerry Creek.

WD was not detected in most of the Big Hole River longitudinal samples collected in 2008. . The only other location the disease was detected was at Melrose was at Glen, the closest location tested downstream of Melrose. Interestingly, although the testing location at Glen is only 13 miles downstream of Melrose, it demonstrated a very low level of WD infection. Only 2 of 45 fish tested showed evidence of the disease and they had only a grade 1 infection rate. The low infection rate in the lower part of the Big Hole River is likely a large contributor to the expansion of the rainbow trout population in this area. Since these samples were collected, WD has been discovered in disease samples collected from the Big Hole River as far upstream as Jackson.

Table. 3. Whirling disease testing performed from 2008-2011 in the Big Hole River and tributary streams (* 2006-2007 average histology for site was 3.52, ** 2006-2007 average histology for site was 4.96, *** average histology for site 2006-2007 was 4.91).

Stream	Sample Location	Date In	Average Histology	Grade 0	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Total
Big Hole River	Pennington FAS	10/2/2008	0	33	0	0	0	0	0	33
Big Hole River	Glen FAS	10/2/2008	0.04	43	2	0	0	0	0	45
Big Hole River	Salmonfly FAS*	10/2/2008	3.52	1	2	6	13	11	13	46
Big Hole River	Divide FAS	10/2/2008	0	44	0	0	0	0	0	44
Big Hole River	Jerry Creek FAS	10/2/2008	0	31	0	0	0	0	0	31
Big Hole River	Wisdom Bridge	10/2/2008	0	40	0	0	0	0	0	40
Big Hole River	Miner Lake Rd Bridge	10/2/2008	0	42	0	0	0	0	0	42
Camp Creek	RR bridge over creek**	11/3/2010	1.93	3	14	10	9	4	0	40
Camp Creek	Upstream Drainage Ditch***	11/3/2010	2.76	2	5	2	10	9	1	29
Trapper Creek	Peck Bridge near mouth	11/3/2010	3.73	0	3	2	11	11	13	40
Trapper Creek	Glendale	11/3/2010	0	47	0	0	0	0	0	47
Trapper Creek	Above FS Boundary	9/29/2011	0	40	0	0	0	0	0	40
Cherry Creek	100 yards upstream mouth	11/3/2010	3.88	1	1	2	3	9	11	27
Cherry Creek	2 ¾ mi upstream mouth	9/29/2011	0.66	25	15	5	2	0	0	47
Canyon Creek	200 yards upstream mouth	9/29/2011	0.40	42	2	0	1	0	0	45
Moose Creek	Upstream of RR crossing	11/3/2010	1.19	7	15	7	0	2	0	31
Rock Creek	0.5 mi upstream mouth	9/29/11	1.25	7	8	6	2	2	0	24
Willow Creek	Hwy 91 crossing	9/29/2011	0.09	31	3	0	0	0	0	34
Jerry Creek	2 mi upstream mouth at bridge	9/29/11	0	42	0	0	0	0	0	42

Summary of Population Data and Management Recommendations

When the population estimates from the various monitoring sections are viewed together, there is an increase in trout density downstream to upstream (Figure 21). This increase in density of trout going upstream has been a consistent pattern of trout abundance in the Big Hole River since consistent monitoring has been occurring. However, recent population trends with decreasing rainbow trout abundance in the upper sections (Jerry Creek and Melrose) and the recent spike in brown trout abundance in the Melrose Section and rainbow trout in the Hogback has resulted in the density of trout being relatively equal between these three sections. Pennington trout abundance, despite a recent increase in brown trout, has remained depressed relative to the other section through the time period covered in this report.

The increase in rainbow trout abundance in the Hogback Section is notable and adds another dimension to the brown trout fishery in this reach of river. The rainbows present in this reach are larger on average than the rainbow trout found farther upstream in Melrose and Jerry Creek. It is clear, however, that rainbow trout numbers are depressed in the Melrose Section. In the Melrose Section, it is unclear if the reduced rainbow trout numbers are related to higher flows in the river over the past 3 years (similar to the observed decline in rainbow trout numbers in the Jerry Creek Section upstream) or if it is related to the persistence of high infection rates of whirling disease in the area. Despite the cause, rainbow trout harvest should be limited to reduce the potential impacts on this fishery until their numbers recover.

Standardization and simplification of the regulation on the Big Hole River should be considered. Oswald (2000) noted fishery improvements after the last major regulation change in the early 1980s within 5 years of implementation. Since that time the populations have fluctuated with environmental changes but for the most part have been relatively stable. Further, the preponderance of voluntary catch and release angling that currently occurs on most trout rivers of Montana (including the Big Hole as supported by the tagging data) suggests that angler harvest has little impact to the overall fish population. The tagging data presented below suggests that angler harvest of fish caught in the Big Hole is less than 10%. Harvest of trout, particularly brown trout in the Jerry Creek section should be encourage to reduce the population size and increase the growth rate of fish in this section. Allowing year round harvest of trout in the upper reaches of the river may be a way to increase potential harvest of trout to reduce densities and improve growth. This action would also be in line with efforts to encourage harvest of non-native trout to benefit Arctic grayling in the upper river.

Management actions to improve the fishery of the Big Hole River are most needed in the lower 20 miles of the river from Notch Bottom to the confluence with the Beaverhead River. In this reach of river trout numbers are depressed due to low summer flows, high water temperature and a lack of suitable spawning habitat. These problems have been well documented; in the 1989 management plan for the Big Hole River it was noted that low water and the associated lack of habitat and high temperatures in the lower river likely lead to reduced trout abundance. It was also noted that the lack of tributary streams and available spawning habitat is also likely a cause of depressed trout numbers in the lower reaches of the river. The TMDL document produced by MDEQ also identified the lower river as impaired because of high water temperature (MDEQ 2009). Efforts to address these 3 main issues could have dramatic impacts to the fishery in the lower river. Recently Big Hole Drought Management Plan was amended to include a section of the lower river from Notch Bottom to the mouth and specific flow triggers were set for that section of river. These triggers were less than those upstream to account for the quantity of water that is diverted from the Big Hole and discharged to the Beaverhead, and it was felt that setting a goal for flows in the river that was attainable would produce more landowner participation in the plan than goals that were too high. FWP is pursuing a spawning enhancement project on the Smith Ditch system between Pennington Bridges and the High Road Bridge. This ditch/slough system originates from the Big Hole River and runs parallel to the river for approximately 2 miles before discharging back to the river. A plan was developed to restore the slough system in 2014 that would create more than 2,000 ft of spawning habitat, reduce water consumption from 15 cfs to 3 cfs, and divert warm and nutrient rich irrigation return flows away from the slough and onto other irrigated lands. This project will address 3 of the main limiting factors affecting the lower river trout population and could dramatically improve the fishery. All improvements to both flow and spawning habitat in this reach of river also stand to benefit the Jefferson River immediately downstream.

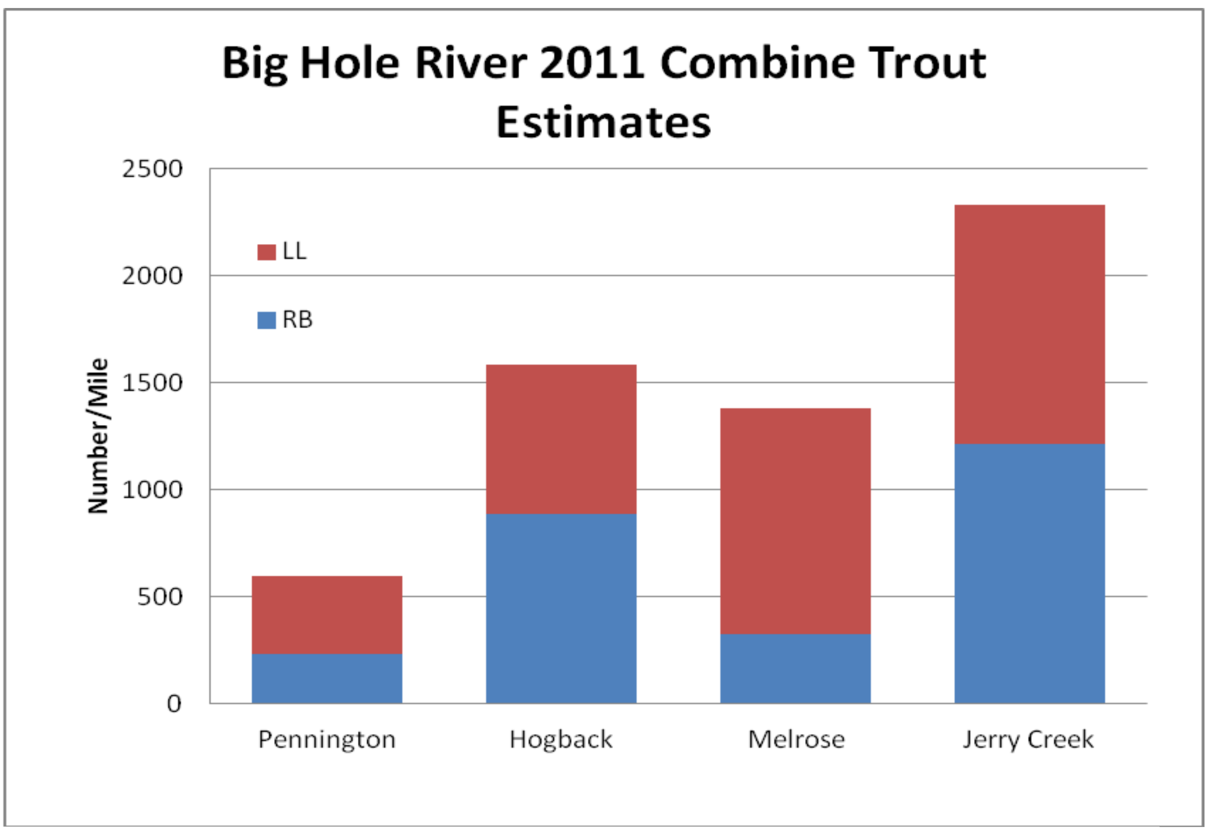

Figure 21. Age-1+ rainbow trout (RB) and age 2+ brown trout (LL) density (number/mile) for all monitoring sections of the Big Hole River, in 2011 (brown trout estimate shown for Jerry Creek was from spring 2010).

Future Monitoring

Given the relative stability of the fish populations in the Big Hole (i.e., there generally is not significant year to year changes) it may be possible to monitor the long-term trends in the fish populations with less frequent monitoring. It is recommended that unless specific management actions, restoration projects or other conditions warrant more frequent monitoring that population monitoring be performed in alternating years across the 4 main study sections (Jerry Creek, Melrose, Hogback and Pennington). Based on the extensive data collected in these sections every other year population monitoring should be adequate to determine the overall trends in fish populations. By reducing the frequency of monitoring on the river, more time and resources will be available for expanding restoration efforts (such as those on the lower river) and monitoring the results of these restoration projects. Further, monitoring of other species such as whitefish or brook trout in the upper river could be expanded.

Appendix A

Fish Tagging Study on the Big Hole River

Methods

A tagging study was initiated on the Big Hole River beginning in the fall of 2009. The objectives of the study were to: 1) better understand the growth of trout in the Big Hole and how growth may vary among study sections and among years (i.e., drought vs. non-drought) and 2) obtain fish movement information to determine areas of habitat use (i.e., spawning) and timing of fish movements. Individually numbered Floy™ Tags were inserted into trout approximately 10 inches and longer near the dorsal fin during semiannual, annual and biannual electrofishing surveys performed to monitor the fishery of the Big Hole River. The tag was inserted in such a way that the "T" bar would interlock between the fin rays of the dorsal fin. Tags were blue in color and sequentially numbered and each tag number had a letter prefix that identified the section in which it as tagged. Two thousand tags were deployed in the Jerry Creek Section, 3,000 in the Melrose Section 2,000 in the Hogback Section and 1,000 in the Pennington Section. Growth measurements were determined only from fish recaptured during electrofishing. Growth was calculated as annual growth rate (inches or lbs a fish grew in 1 year) for fish that were recaptured more than 0.75 years post tagging. Fish were segregated by size at initial tagging into approximate age classes based on past scale-determined ages (9.0-11.9 = Age 2, 12.0-14.9 = Age 3, 15.0-17.9 = Age 4 and ≥ 18 = Age-5+) and growth was compared among these approximate classes. Growth is reported as both annual growth in length and weight, but the change in weight is the more accurate measure of growth since a fish can lose weight through time but it less common for a fish to lose length. For sections where semiannual electrofishing occurred during the study period, seasonal growth (summer and winter) was also determined. Seasonal growth during these time periods was calculated as absolute growth (change (Δ) in size) because the time period was equal (± 14 d) among fish and sites.

Fish movement information was obtained from both electrofishing captures and from angler returns of tagged fish. Anglers were asked to inspect caught fish for tags regardless of whether the fish were kept or released. At most Fishing Access Sites angler tag return boxes were present and those who caught tagged fish were asked to report the information. Presentations were made to local sporting groups, press releases were made and posters were placed at tackle and fly shops informing anglers of the study and how to report tagged fish. Fish movement (distance traveled in miles) was determined from the middle of each electrofishing monitoring section to the approximate location of recapture. Fish movement was characterized as either upstream (graphically represented as a positive number), neutral (same location as originally tagged) or downstream (graphically represented as a negative number). The time (days) between marking and recapture was also noted. Electrofishing recaptured individuals were only included in the movement analysis if they were recaptured in a section other than their original tag location. It was assumed that an angler was equally likely to capture a tagged trout whether the fish stayed near its original tag location or moved outside of the section, but our electrofishing returns were heavily biased toward fish that did not move because no electrofishing occurred between monitoring sites; therefore, angler returns provided a less biased measure of fish movement from their original tagging location.

Growth Analysis

A total of 1,792 fish were recaptured using electrofishing and used for growth analysis. Some of these recaptures were the same individuals recaptured multiple times. The total recaptures from each section that were used in the growth analysis were: Jerry Creek 365, Melrose 1,047, Hogback 370, and Pennington 5. Too few recaptures were obtained from the Pennington Section to compare growth among the other sites by size class but the growth information from this site is listed in Table A1. Growth information was obtained for westslope cutthroat trout in the Jerry Creek Section and is also listed in Table A1.

Growth trends for brown trout were similar between length and weight (Figure A1). Figure A1 can be interpreted as how much an individual fish from a specific size group grows in length and weight over the course of a year in each section of the river. For example, a 9-11 inch brown trout in the Hogback Section grows 3.5 inches and 0.70 lbs in one year (Figure A1). Comparing brown trout growth across sections, fish in the Hogback Section showed consistently greater growth than either the Melrose or the Jerry Creek sections. Brown trout growth between the Jerry Creek and Melrose section was mixed depending on the size category of fish, but these data are difficult to interpret due to low sample size from the Jerry Creek Section. Within the size classes where there was an adequate sample size fish in the 12-14.9 inch range grew much better in the Melrose Section than the Jerry Creek Section whereas there was little difference in growth for fish in the 15-17.9 inch range. It is curios to note that brown trout ≥ 18 inches in the Melrose Section on average lost weight. These data suggest that few fish in the 18 inches size range that reside in the Melrose section continue to grow significantly once they reach 18 inches.

A more consistent pattern of rainbow trout growth was observed among sites with annual growth increasing from upstream to downstream (Jerry Creek to Hogback) across all sites and all size classes of fish (Figure 2A). The greatest growth among all sizes of rainbow trout was observed in the Hogback section, similar to the patter noted for brown trout. The sample size for the size categories was more robust for rainbow trout, with the exception of 9-11.9 inch fish in the Hogback Section. This low sample size was due to few fish in this size range being tagged. The higher recapture rate of rainbow trout within each section was also supported by the movement data presented below that suggests that rainbow trout are much more likely to stay in the original section in which they were tagged than browns.

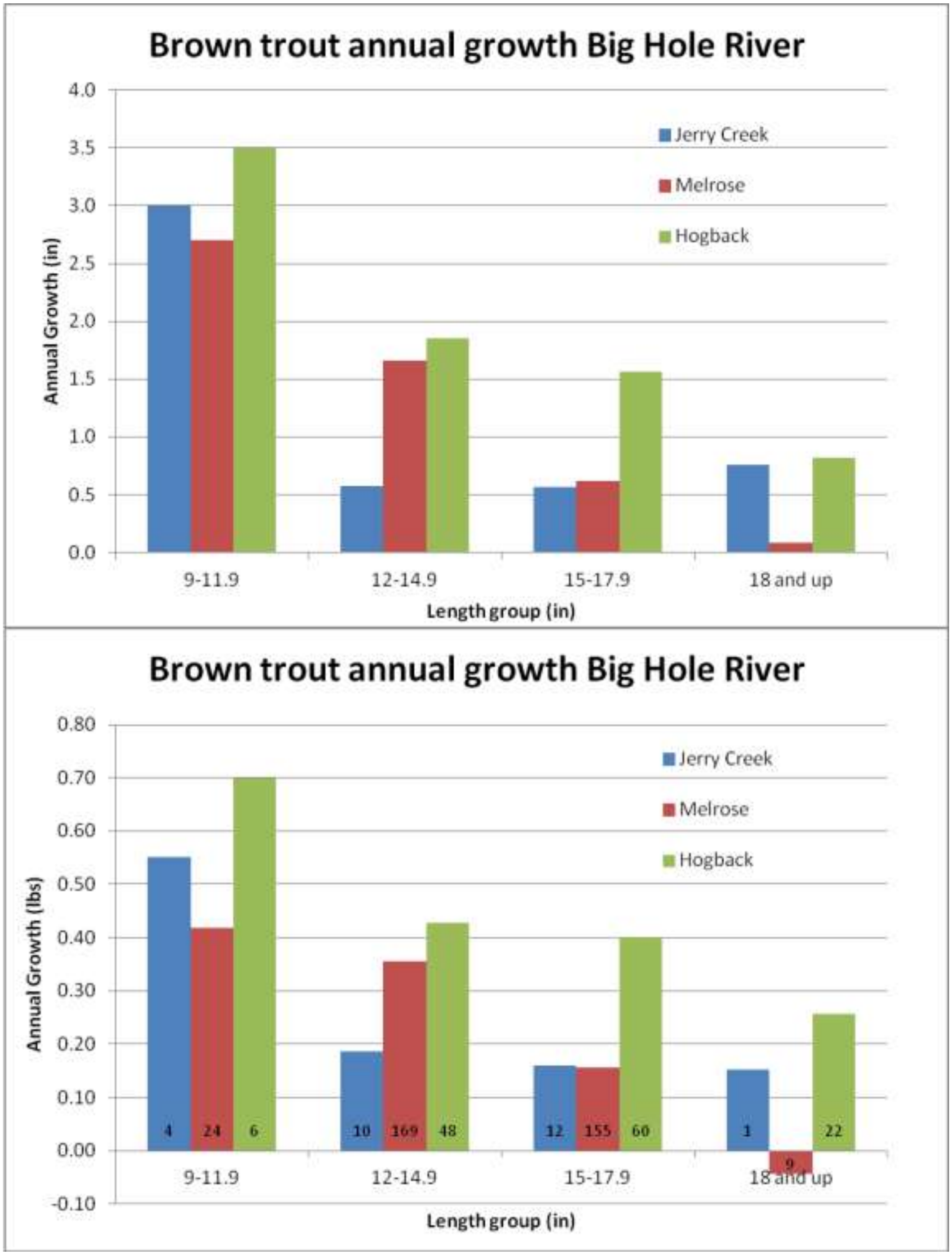

Figure A1. Brown trout annual growth rates from 3 monitoring sections on the Big Hole River. Growth was determined from individually tagged fish from the section. Upper graph represents growth measured in inches (total length) and the lower graph represents growth measured in pounds (0.01). The numbers within the histogram bars represent the sample size used to compute the average growth for length and weight.

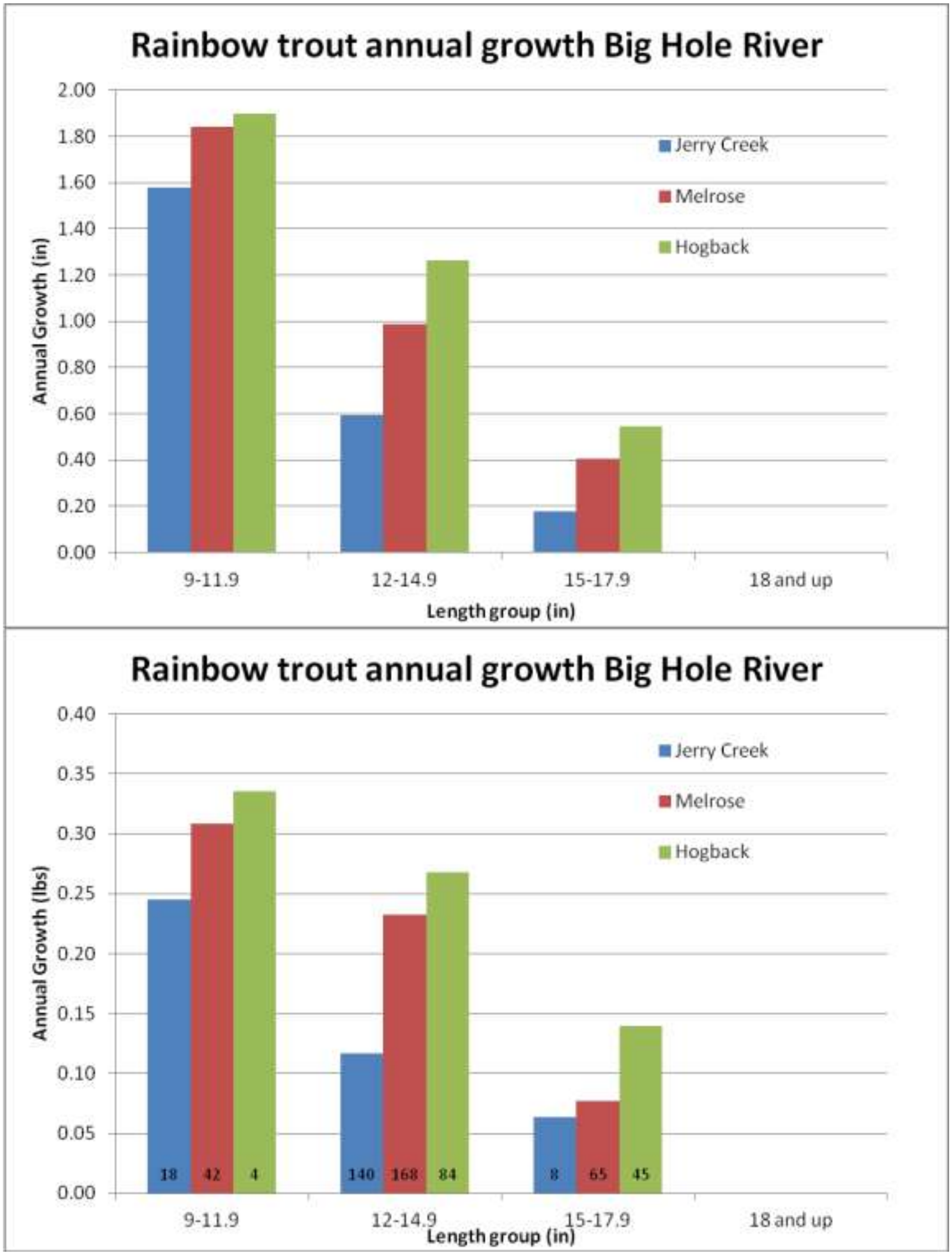

Figure A2. Rainbow trout annual growth rates from 3 monitoring sections on the Big Hole River. Growth was determined from individually tagged fish from the section. Upper graph represents growth measured in inches (total length) and the lower graph represents growth measured in pounds (0.01). The numbers within the histogram bars represent the sample size used to compute the average growth for both length and weight.

Across all length groups and sections, but particularly in smaller size classes brown trout, growth was substantially greater than rainbow trout growth. Similarly, westslope cutthroat trout growth was substantially less than that observed for rainbow trout across size classes. Too few recaptures were obtained from the Pennington Section to reliably compare growth the sites. The reason for the few recaptures is that the Pennington Section is surveyed only every other year and the trout density in the section is low. However, length frequency analysis, particularly of age-2 brown trout, indicates that trout growth is greater in this section than the Melrose Section.

Table A1. Annual growth rate of brown and rainbow trout from the Pennington Section and westslope cutthroat trout from the Jerry Creek Section.

Pennington Section				
Δ length (in)/year				
	9-11.9 (N)	12-14.9 (N)	15-17.9 (N)	18 and up
Brown trout	1.99 (1)	2.65 (1)	1.94 (1)	0.21 (1)
Rainbow trout		1.97 (1)		
Δ weight (lbs)/year				
	9-11.9	12-14.9	15-17.9	18 and up
Brown trout	0.35	0.52	1.80 (1)	-0.02
Rainbow trout		0.71		
Jerry Creek Section				
Δ length (in)/year				
	9-11.9 (N)	12-14.9 (N)	15-17.9 (N)	18 and up
Westslope cutthroat trout	1.0 (3)	0.5 (14)		
Δ weight (lbs)/year				
	9-11.9	12-14.9	15-17.9	18 and up
Westslope cutthroat trout	0.20	0.1		

Seasonal growth was calculated for those sections where semiannual surveys were conducted during the duration of this study. Summer growth rates were determined in the Melrose and Jerry Creek sections. Summer growth was measured from March to October. With the exception of brown trout 15-17.9 inches, both brown and rainbow trout growth was greater in the Melrose Section than the Jerry Creek section (Figure 3A). Winter growth rates (absolute growth) are shown in Figure A4 and growth calculated from the Hogback Section. With the exception of smaller age classes of fish winter growth was zero or slightly negative.

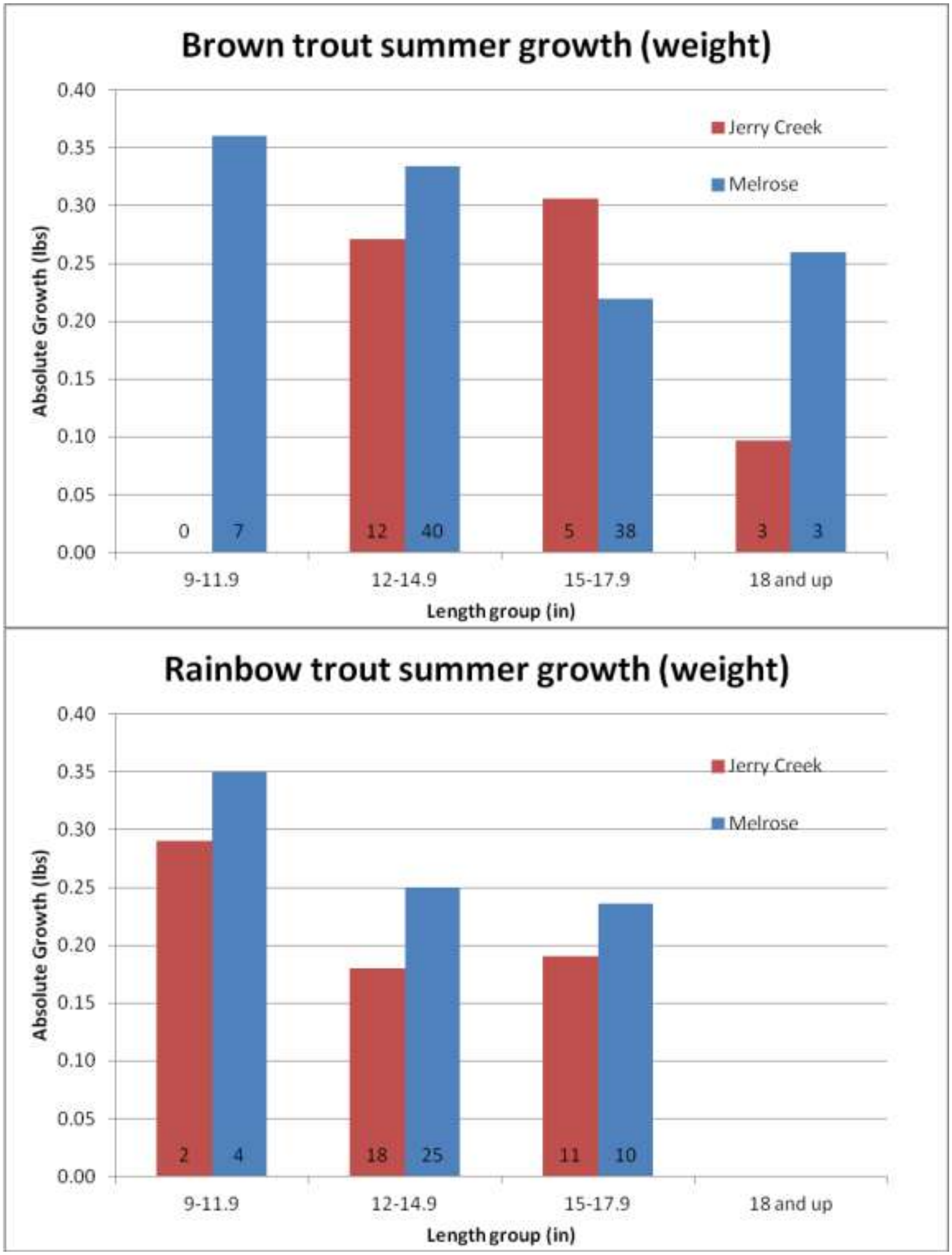

Figure 3A. Average summer growth (absolute growth, Δ weight) of brown trout and rainbow trout from the Jerry Creek and Melrose Sections of the Big Hole River 2009-2012 obtained from the recapture of individually tagged fish (Δ is change). Numbers within histogram bars are the sample sizes used to calculate average growth.

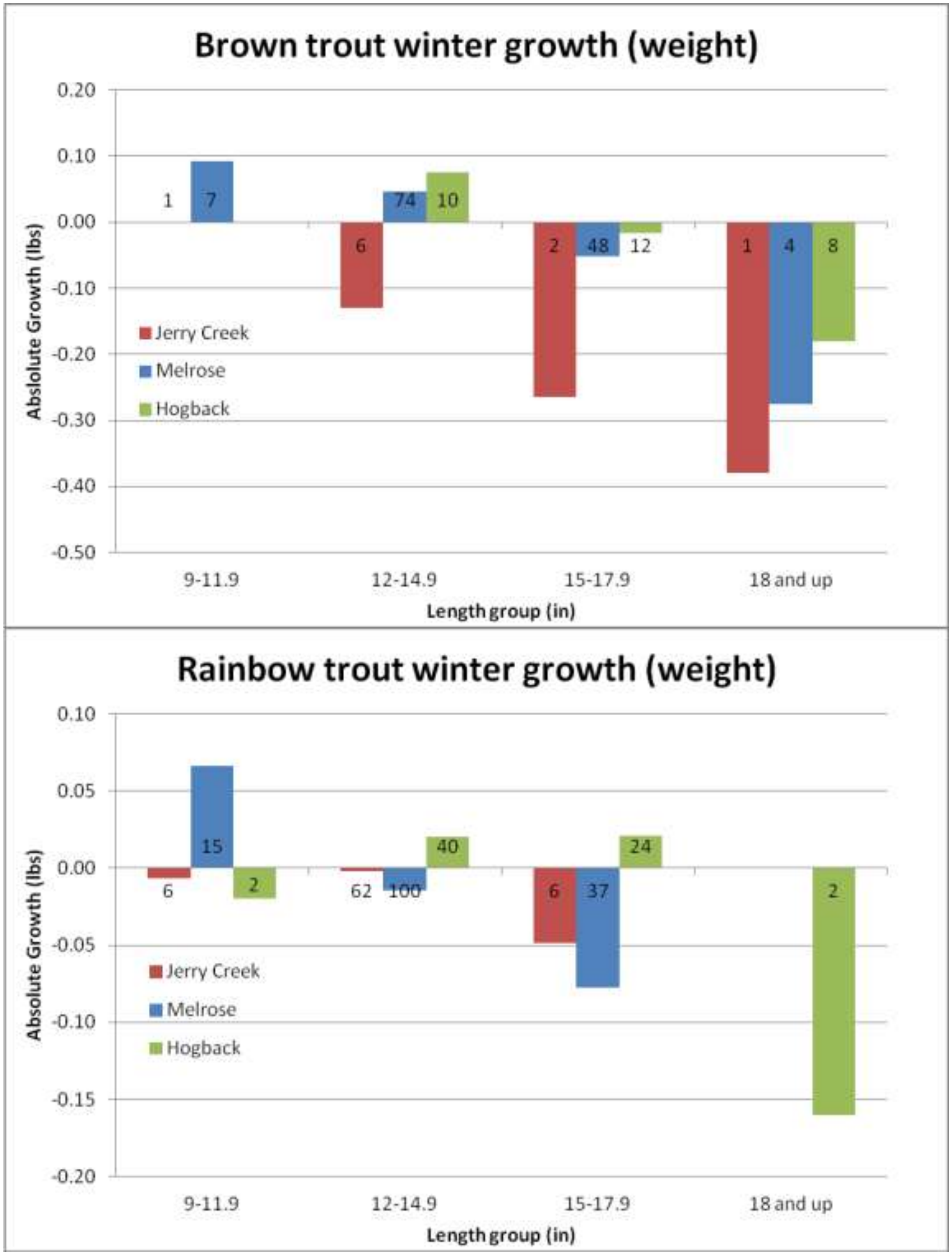

Figure 4A. Average winter growth (absolute growth, Δ weight) of brown trout and rainbow trout from the Jerry Creek and Melrose Sections of the Big Hole River 2009-2012 obtained from the recapture of individually tagged fish (Δ is change). Numbers within histogram bars are the sample sizes used to calculate average growth.

Movement Analysis

Fish movement information was collected from recaptured fish. Most of the relevant movement data collected was derived from the angler returns of tagged fish because the vast majority of trout recapture using electrofishing (1,770 of 1,792) were recaptured in the same section they were tagged. This was anticipated because electrofishing occurs only in the same sections of river (i.e., there is no electrofishing between established sections) so there is no chance of catching a tagged fish with electrofishing unless it travels to an adjacent monitoring section (distances between sections is generally > 10 miles). Although the lack of movement from the original tagging location is relevant information, for the purposes of this movement analysis electrofishing recaptures were only included if they moved from their original tagging section. Therefore, only 18 fish from electrofishing were included in this analysis. There were 386 angler returns of tagged fish of which 115 were returned from the Jerry Creek Section, 170 from the Melrose Section, 91 from the Hogback Section and 10 from the Pennington Section. Of the 386 tags returned, 227 were brown trout, 154 were rainbow trout, 2 were cutthroat trout and 2 were brook trout. Angler returns from the same section of capture were included in the analysis because it was assumed that a tagged fish had an equal chance of being caught within or outside of the electrofishing section if it moved.

The average time between tagging and recapture of tagged fish was 241 days (range 0-1,026). There was a very slight positive relationship between the elapsed time from tagging to recapture and the distance moved (Figure 5A), but the slope of this relationship is very close to 0 (0.0018) suggesting that a fish that was recaptured 2 years after being tagged was no more likely to have traveled a greater distance than fish that was tagged only 2 months prior. In fact, many of the large scale fish movements observed occurred within the first 3 months after tagging (Figure 5A). The vast majority of angler returned tagged fish were captured in the same general location as they were tagged regardless of the amount of time that elapsed since tagging.

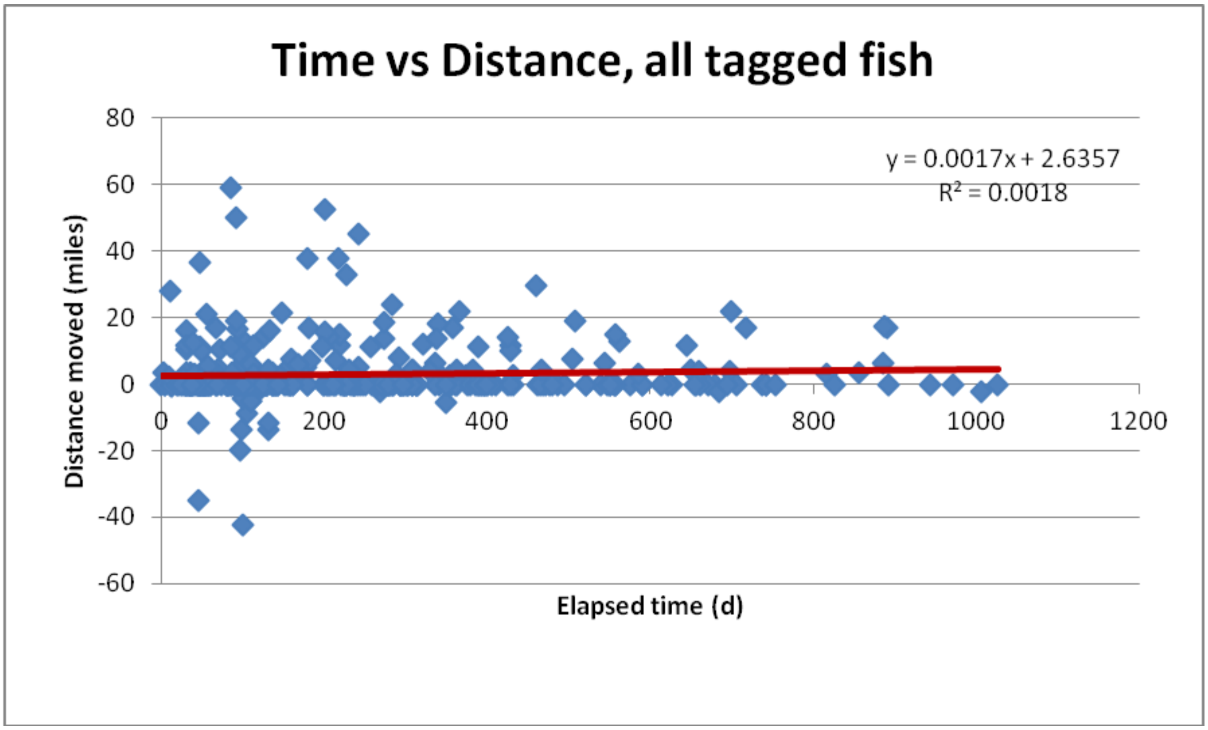

Figure 5A. Scatter plot of elapsed time (days) between marking and recapture of rainbow and brown trout versus the distance (miles) between the marking and recapture locations on the Big Hole River.

Although most fish were recaptured in the same location they were tagged, the majority of movements out of the original tagging location were in a downstream direction, particularly for rainbow trout (Figure 6A). Brown trout were only slightly more likely to travel downstream than upstream, but the majority of large fish movements (those > 10 miles) were in an upstream direction (Figure 6). Seventy-two percent of rainbow trout were recaptured in the same location they were tagged as opposed to only 47% of brown trout, and brown trout were 3 times as likely to express movements of over 10 miles both upstream and downstream as rainbow trout. These data suggest brown trout are more migratory and seek out multiple habitats across the landscape to fulfill their individual life histories. The greatest upstream distance moved by any trout was 59 miles by a 22-inch brown trout originally tagged in the Melrose Section and recaptured in Pintler Pool near the confluence of Pintler Creek and the Big Hole River near Wisdom, MT. The farthest downstream movement was also a brown trout originally tagged in the Jerry Creek Section and recaptured 0.5 miles downstream of Notch Bottom Fishing Access Site, a distance of 42.5 miles.

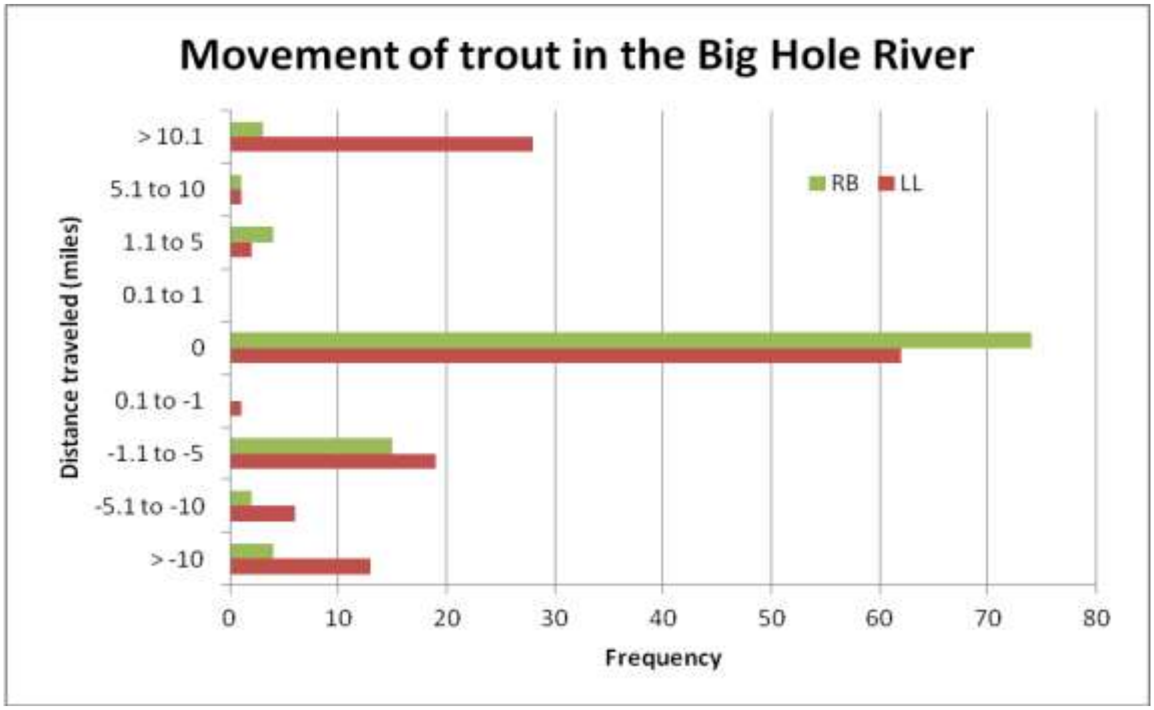

Figure 6. Frequency of rainbow (RB) and brown (LL) trout of movement over a range of distance categories both upstream (positive numbers) and downstream (negative numbers) in the Big Hole River.

Discussion

It is clear from the growth analysis data presented in this report that growth for both rainbow and brown trout tends to increase in a downstream manner. One possible explanation for this trend is that growth of trout in the Big Hole River is density dependent. The density of trout in the Big Hole River has historically decreased downstream with the highest densities of trout in the Jerry Creek Section and the lowest in the Hogback Section (Oswald 2004, 2005, 2006). Lower density of trout in lower sections of the river could lead to more food and habitat resources being available which results in increased growth. The trend of decreasing trout density downstream was present through the first years of the tagging study, but by its completion in 2013 density was relatively equal among sections (with the exception of the Pennington Section which supports a lower density of trout). The Jerry Creek Section has experienced a relatively substantial decline in its rainbow trout population and the rainbow trout population in the Hogback Section had increased leading to relative equal densities of trout among sections upstream of Pennington.

Another potentially contributing factor to increased growth in downstream sections it the fact that water temperatures are warmer in downstream reaches of river leading to an extended growing season. The area around Wise River (immediately upstream of Jerry Creek Section) is a well documented source for cold water inputs to the Big Hole River. Several ground water sources in addition to the Wise River enter the river and significantly reduce river temperatures during the summer. As the river moves downstream it warms and this warming could lead to improved growing conditions for trout and extend the growing season. In conjunction with warmer water temperatures the river increases in conductivity as is proceeds downstream and this increase could be coupled with an increase in productivity. There are more potential sources of nutrients in the lower river such as human development and agriculture in that could impact river productivity. In the lower river there are more abundant and larger prey such as crayfish and prey fish such as suckers and redside shiners which may positively impact growth, particularly for larger fish. This increase in productivity and prey, in addition to lower density, could also account for increased growth of fish in the lower river.

It is clear from both angler returns and from returns obtained through electrofishing that the majority of the fish tagged were recaptured in the same general location (63 %) and this had no relationship to the elapsed time since tagging. These data suggest that most fish in the Big Hole, regardless of the section where they were tagged, generally stay in relatively the same location from year to year. The general tendency for fish that did move to be recaptured upstream of their original tagging location has several potential explanations. As water temperatures warm in the late summer fish may be searching for thermal refuge in cooler areas of the river primarily located in areas upstream of Melrose in the canyon sections. An additional explanation for this upstream movement is that fish may be accessing potential spawning habitat which is more prevalent upstream of the confluence of the Wise River. Anecdotal information from anglers suggests that in the early season (May-June) a number of fish move upstream and populate the river upstream of the Wise River to near Mudd Creek. These tagging data support this anecdote as several tagged fish from as far downstream as the Melrose and Hogback sections migrated upstream into this reach of river and were captured by anglers. However, it is unclear why many of these fish make this movement. Recaptured rainbow trout moving into this section may be doing so to access spawning areas; however, brown trout were equally and in some cases more likely to be recaptured in this reach of stream during spring time period. It is possible that this seasonal movement by brown trout is done to access forage that is not available at other times of the year. The reach of river from the Wise River upstream to approximately Mudd Creek suffers from high water temperatures in the late summer. It is possible that these migratory fish move into this reach of river in the spring and early summer to take advantage of available forage then move to other areas of the river later in the summer where thermal conditions are more tolerable. It is also possible that these large brown trout migrated to these areas the previous fall to spawn and overwintered before migrating back downstream.

One of the objectives of the tagging study was to compare growth between drought and non-drought water years. There were average flows in the 2010 and above average flows in the 2011 but there was not a drought year during this study. There were below average flows during the summer of 2012, but inadequate recaptures were obtained in 2013 to accurately determine growth for just this time period. A drought summer occurred in 2013, but similar to 2012, too few recaptures were obtained in 2014 to obtain reliable growth estimates. Therefore, the growth data presented in this study represent the growth potential of the river under the given densities of fish and average to above average flow conditions.

Several studies involving the type of tags used in this study or similar tags indicate that tagging can have a negative effect on fish growth (Mourning et al. 1994; Hughes 1998; Rikardsen 2000), but this negative relationship seems to be less for fish larger than 10 inches (Rikardsen 2000). The range in difference in growth has been reported to be as large as 40%, but generally is between 10% and 20% of tagged versus untagged fish. Therefore, the growth information presented in this report may not accurately quantify growth of fish in these sections and potentially may underestimate growth. However, the comparison of growth between sections is unbiased because growth information was obtained only from recaptured tagged fish and therefore all fish were exposed to the same treatment. Tag retention rates reported in the studies mentioned above ranged from 70-90% for trout/char species and there was a positive relationship between retention and size. Although tag retention rate was not determined as a part of the study on the Big Hole, we assumed it was within the reported range for similar species in the literature.

A drawback of using Floy Tags to monitor fish movement is that it is impossible to know where a fish has traveled between when it was captured and recaptured. It is possible that a fish that was recaptured in the same general location in which it was tagged had actually traveled a great distance between tagging and recapture. This may be particularly true for our electrofishing recaptures because the majority of electrofishing monitoring in the Big Hole River is done at the same time each year and generally in the early spring when trout are congregated in wintering areas (i.e., deep pools). It is possible that fish that are tagged in the early spring move to other areas in the river during the remainder of the year then return to the same wintering areas where they are recaptured. However, the large sample size of fish tagged and the relatively unbiased nature of angler tag returns should mean that the data presented in this report represent accurate movement information. Other means of tracking fish movements such as acoustic or radio tags are much more effective at monitoring individual fish moment because the fish can be remotely located at any time the tag is active. However, studies that use these types of tags are often limited to only a handful of tagged fish because of the cost of tags and the manpower that is necessary to later locate and track individual fish. Additionally tag placement requires surgery and can be much more stressful and lead to higher mortality rates of tagged fish. The movement and growth data reported herein was obtained through regular electrofishing to monitor the fish populations in the river and required only minimal additional effort to obtain. The collection of movement data was also done with minimal effort thanks to the cooperation of the Big Hole River Foundation and anglers who turned in tagged fish information.

Several recaptured tagged fish provided interesting and valuable data. The Wise River is the largest tributary to the Big Hole River. There is abundant and high quality spawning habitat in several reaches of the Wise River, but it was unknown if fluvial trout from the Big Hole migrate into the Wise River to spawn. Tagging data suggest that rainbow trout migrate into the Wise River in the spring to spawn. Three rainbows tagged in the nearby Jerry Creek Section were caught by anglers in the Wise River during the spawning time.

No tagged brown trout from the Big Hole were recaptured in the Wise River, but during fall electrofishing in the Wise River near the confluence of Lacy Creek and near Adson Creek Bridge several large (> 20 inch), apparently migratory brown trout were captured suggesting brown trout also use this tributary for spawning. Other spawning movements included large scale movements of rainbow trout from lower reaches of the Big Hole to areas upstream of the confluence of the Wise River. One rainbow trout tagged in the Hogback Section just prior to the spawning season was recaptured 55 miles upstream near Dickie Bridge only 2 months later after spawning was complete. Similar rainbow trout movements were noted for trout from the Melrose Section.

With the lack of dams or other migratory obstructions, trout in the Big Hole River system have the ability to migrate into tributary streams or even among large river drainages. One 12-inch rainbow trout tagged in the Pennington Section was recaptured in the Jefferson River in the Waterloo Section by FWP workers electrofishing that section of river only 11 days after it was tagged (a downstream movement of 28 miles). The presence of larger rainbow trout (>18 inches) in the lower Big Hole River in the spring suggest that fish from the Jefferson River enter the Big Hole to spawn but this was not verified from the tagging done in this study. The largest migration noted during the study was for an 18.1 inch 1.81 lb brown trout tagged in the Pennington Section that "migrated" 300 miles to Lake Walcott Idaho. The tag was found by Idaho Fish and Game personnel on a bird nesting island in the lake 100 days after having been placed in the fish. The fish was apparently consumed by a pelican which then migrated to Lake Walcott where the tag was extruded onto the island. Idaho Game and Fish was conducting an avian predation study using PIT tags and Floy tags which lead to the recovery of the tag from the Big Hole River.

The shortest time between the tagging of a fish and its subsequent recaptured occurred on the Hogback Section. A 15-inch rainbow trout tagged in the fall of 2009 during electrofishing surveys and was recaptured the same day by an angler. The angler was apparently floating the same section of river as FWP electrofishing crews and captured the fish shortly after its release.

Although the focus of this study was brown and rainbow trout, a few other species encountered were also tagged. Only 1 mountain whitefish was tagged during this study in the Hogback Section. The fish was recaptured the following year and had grown from 14.0 to 16.9 inches and from 1.01 to 1.55 lbs. Three brook trout were tagged and one, which was tagged in the Melrose Section, was returned by an angler nearly 2 years after it was captured. It was caught approximately 2 miles upstream of its original tagging location. When it was originally tagged it was 10.9 inches and reported as being 12 inches long by the angler who caught the fish.

Anglers who reported tagged fish were also asked if they harvested the fish they caught. Of the 368 fish that were returned by anglers, 213 reported if the fish was kept or released. Anglers reported keeping 11.8% of the tagged fish caught (18 kept, 195 released). There may be some bias in the number reported as kept because several anglers reported finding the tag only once the fish was cooked or filleted, meaning the tag was not detected until the fish was processed. The tags, shortly after being placed in the fish, become heavily colonized by algae and the blue tag color which is initially highly visible becomes camouflaged. Also the insertion point of the tag near the distal end of the dorsal fin causes tag concealment. When the fish is removed from the water the tag and dorsal fin often lay flush against the back of the fish and the algae-covered tag blends into the dark background of the fish's back and dorsal fin. Because of potential poor tag detection there was likely underreporting of tagged fish that were caught and only observed momentarily then released; whereas a fish that was kept and the tag was not observed initially would be found and potentially reported when it was consumed or filleted. Anglers also reported difficulty cleaning the tags and being able to read the numbers. Often tagged fish were released without reading the tag because of fear of harming a fish that the angler intended to release. Given these biases, the harvest rate determined in this study likely represents a biased-high harvest rate of tagged fish in the Big Hole. However, it is clear from these data that the vast majority of fish caught on the Big Hole River are released rather than harvested.

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