COLORADO RIVER RECOVERY PROGRAM
FY 2010 ANNUAL PROJECT REPORT

RECOVERY PROGRAM
PROJECT NUMBER:126(a)
PROJECT NUMBER:126(b)

I. Project Title: **Removal of Smallmouth Bass in the Upper Colorado River between Price-Stubb Dam near Palisade, Colorado, and Westwater, Utah.**

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III. Project Summary: The purpose of this study has been to remove as many smallmouth bass of all sizes in main channel riverine habitats in a 61-mile reach of the Upper Colorado River between Price-Stubb Dam and Westwater boat landing in eastern Utah and a 45-mile reach between Rifle and Beavertail Mountain. The goal has been to reduce the abundance of smallmouth bass as quickly as possible in this reach which would ultimately benefit native listed fishes, and possibly contribute to their recovery. This is the seventh year of this study which started in 2004. Between 2007 and 2010 four additional removal passes were added in the Grand Valley portions of the Upper Colorado and Lower Gunnison rivers. An additional reach between the Government Highline Dam and the Cameo Bridge was added in 2009.

Smallmouth abundance in the 18- and 15- mile reaches plus the 2.3 miles of the Lower Gunnison River for 2010 using a single mark and first removal pass was estimated to be 255 ± 196 (59 – 451)(95% C.I. in parenthesis) for smallmouth bass 100-199 mm or about 7.2 fish/mile and 832 ± 671 (152 – 1,494) for smallmouth bass ≥ 200 mm or about 23.3 fish/mile. The weighted probability of capture (p-hat) was computed as 0.097 and 0.053, respectively, for these two length groups. Computed exploitation rates were 55.7 and 35.2 percent for juvenile (100-199 mm) and adult (≥ 200 mm) smallmouth bass, respectively. In the Grand Valley reaches of the Upper Colorado and Lower Gunnison rivers, smallmouth bass abundance steadily declined in 2007 and 2008 from 2006 when population estimates commenced. Declining catch rates reflect this downward trend. Smallmouth bass ≥ 100 mm catch rate declined to 0.9 fish/hr in 2009, the lowest in six years. The highest catch rate was 6.37 fish/hr in both 2004 and 2005 for smallmouth bass ≥ 100 mm. This decline was consistent with the population estimate generated in 2006, 2007, and 2008 using a single mark and first removal pass. The reliability of the 2009 abundance estimate was questionable because of the low number of recaptured marked smallmouth bass. This abundance estimate was not correlated with overall 2009 removal pass catch rates that continued to decline from earlier years for both juvenile and adult smallmouth bass. Smallmouth abundance in 2009 was estimated to be 2,041 ± 2,238

individuals (juveniles 100-199 mm) or about 57.9 fish/mile and 755 ± 802 individuals (adults ≥ 200 mm) or about 21.4 fish/mile. This compared to a population estimate of 804 ± 423 juvenile smallmouth bass or about an average of 22.8 fish/mile and 393 ± 276 adult smallmouth bass or about 11.1 fish/mile during 2008. The 2007 population estimate was 1,007 ± 686 adult smallmouth bass or about an average of 28.5 fish/mile and a population estimate of 2,295 ± 765 (65 fish/mile) adult smallmouth bass in 2006. The decline for adult fish between 2006 and 2007 was 56 %; the decline from 2007 to 2008 was 61 %.

Evidence exists that in some river segments (15-mile reach [GVIC Diversion Dam to the Colorado/Gunnison River confluence], 18-mile reach [Colorado/Gunnison River confluence to the Loma Boat Landing], and Rifle to Beavertail Mountain), smallmouth bass reproduced during 2010 as they did between 2004 and 2009. It appears that during 2010, a strong year class of smallmouth bass was produced (5.82 fish/hr) which is the highest recorded in this seven-year study. This statistic is greater than that of the strong year class of smallmouth bass that was produced in 2007 (4.54 fish/hr). Weaker year classes of smallmouth bas were produced in both 2008 (0.63 fish/hr) and 2009 (0.55 fish/hr). In the Silt to Beavertail Mountain reaches, overall smallmouth bass (all length sizes) relative abundance increased slightly during 2010 after declining for four continuous years.

On the other hand, juvenile (< 100 mm) largemouth bass abundance steadily increased from 2004 to 2010 in the Grand Valley river reaches and was most abundant during 2010 (12.2 fish/hr). Largemouth bass < 100 mm catch rate increased from 1.03 fish/hr (2004) to 4.61 fish/hr (2007) and only declined slightly in 2008 to 4.32 fish/hr. Juvenile and adult largemouth bass (≥ 100 mm) catch rate increased from 0.63 fish/hr (2004) to 4.04 fish/hr (2007), but declined markedly to 1.34 fish/hr in 2008 only to slightly increase to 1.19 fish/hr in 2009. In 2010, catch rate increased 73% from 2009 for largemouth bass ≥ 100 mm. Ninety-eight percent of all largemouth bass collected in 2010 were less than 150 mm; similar to collections from the previous six years. Survival of largemouth bass to adults (≥ 200 mm) in the river is relatively low. In the Silt to Beavertail Mountain reaches, no apparent trend from year to year appears to be evident. Largemouth bass catch rates (all sizes) declined from 5.62 fish/hr (2006) to 3.30 fish/hr (2007), but increased to 6.93 fish/hr in 2008. In both 2009 (1.12 fish/hr) and 2010 (0.86 fish/hr) the catch effort has continued to decline sharply. For the years monitored between 2004 and 2010, relative abundance of juvenile largemouth bass and smallmouth bass has been considerably less than that of Grand Valley reaches suggesting that spawning for these centrarchid fishes in the upper reaches is not as successful as the downstream reaches of the Grand Valley. However, largemouth bass (< 100 mm) catch rate soared to 5.37 fish/hr in 2008, more than 1.5 times that of 2006 (3.33 fish/hr) in these upper reaches. In 2009, juvenile largemouth bass < 100 mm declined sharply to 0.58 fish/hr and further declined in 2010 to 0.30 fish/hr.

In the Grand Valley reaches, captures of green sunfish during 2010 declined substantially (48%) from 2009. Bluegill numbers declined for the first time since 2007, but black crappie numbers increased slightly over 2010 from 2009.

IV. Study Schedule:
a. initial year: 2004
b. final year: 2010

V. Relationship to RIPRAP:
Colorado River Action Plan: Mainstem
Colorado River Action Plan: Mainstem
III. Reduce negative impacts of nonnative fishes and sportfish management activities.
III.A. Develop and implement control programs in reaches of the Colorado River occupied by endangered fishes.

VI. Accomplishment of FY 2010 Tasks and Deliverables, Discussion of Initial Findings and Shortcomings:

A. FY-2010 Tasks and Deliverables:

Task 1. Remove all sizes of smallmouth bass.
Sub-Task 1a. Mark and release smallmouth bass during pass 1 in 2008.

Tasks completed.

Task 2. a) analyze data; b) prepare annual RIP reports.

Task completed. Preparation of the annual report also sufficed for the December 2010 nonnative fish workshop.

B. Findings (2010 Highlights)

General

Study Direction. The study area encompassed a 61-mile section of the Colorado River in western Colorado from the Price-Stubb Dam to the Westwater, Utah, BLM River Ranger Station, and a 2.3-mile section of the Lower Gunnison River from the Redlands Diversion Dam to the Colorado/Gunnison River confluence.

The river segments from Price-Stubb Dam to the Loma Boat Landing include the 15- and 18-mile reaches. These river segments along with the Lower Gunnison River flow through a wide alluvial section of the Grand Valley. The river segments between the Loma Boat Landing and the Westwater Ranger station have different hydro-geomorphic features than the upstream segments. The river downstream from the Loma Boat Landing flows through a canyon-bound area and is considered a quasi-alluvial section. For sampling logistics and data analyses purposes, the Colorado River was divided into eight different river segments and the Lower Gunnison River into one.

In 2007, study direction was modified. Four additional removal passes were added for the Grand Valley portion of the project area. Two additional passes were performed by

Fish and Wildlife personnel and two by Colorado Division of Wildlife (CDOW) personnel. The last two removal passes performed by the CDOW were in river reaches where high concentration or high abundance of smallmouth bass had been determined during the past five years of sampling.

Project study goals in 2010 were similar to that of 2007, 2008, and 2009. An abundance estimate for juvenile (100-199 mm) and adult (≥ 200 mm) smallmouth bass in concentration areas of the Grand Valley reaches of the Upper Colorado and Lower Gunnison rivers was performed in 2006-2009. This endeavor entailed marking and releasing smallmouth bass during an initial pass and lethally removing and recording previously marked smallmouth bass in all subsequent passes. The abundance estimate was generated from the initial marking pass and a single removal pass that immediately followed the marking pass. Marking smallmouth bass included the river segments from the Grand Valley Irrigation Company (GVIC) Diversion Dam to the Loma Boat Landing and the 2.3 miles of the Lower Gunnison River from the Redlands Dam to the Colorado/Gunnison River confluence, a total of 35.3 river miles.

Methodology. Three electrofishing rafts were used to collect centrarchid fishes in each river segment during the marking pass during 2008, 2009, and 2010, in an attempt to increase the number of marked smallmouth bass. This was a deviation from marking passes during 2006 and 2007 in which two electrofishing craft were used. During the marking pass all smallmouth bass ≥ 100 mm collected were marked and released whereas all smallmouth bass < 100 mm and other centrarchid fishes collected were removed. The marking pass was performed over a 1-week period starting on 26 July. Following the marking pass, eight removal passes (six by FWS and two by CDOW personnel) were made using aluminum boat and raft-based electrofishing to collect centrarchid fishes from 2 August to 29 September. The 2010 CDOW effort mainly focused on four reaches where abundance of smallmouth bass highest which was determined from earlier removal passes.

Two electrofishing craft were used in every river segment during the eight removal passes. The number of removal passes for areas of low densities of smallmouth bass as determined from 2004 and 2005 capture data (Burdick 2007) was reduced during 2006 – 2010. These river segments included the canyon-bound reaches of Ruby and Horsethief canyons to Westwater, Utah (RM 152.6 – 127.6). The reduced effort in these reaches was re-directed to increase the number of removal passes in river segments where smallmouth bass had proliferated over the past several years. Therefore, only one pass was performed from the Loma Boat Landing to Westwater, Utah, during 2006 – 2010.

During 2004, 2005, and 2006, a 45-mile reach of the Upper Colorado River from the Rifle Bridge (river mile 240.4) to Beavertail Mountain in Debeque Canyon (river mile 195.7) was sampled with raft electrofishing. In 2007 and 2008, a 7.6-mile reach from Silt to the Rifle Bridge was added to assess distribution of smallmouth bass upstream of Rifle. This reach was eliminated from sampling in 2009 because only one smallmouth bass was collected in this reach in 2007 and 2008. During 2010, the same sampling protocol was utilized in these most upstream reaches. This sampling occurred between 7

July and 21 July. A backwater at river mile 236.6, which is located between the Rifle Bridge and Rulison Bridge, was sampled again with one electrofishing boat on 27 September. An additional reach between the Government Highline Dam and the Cameo Bridge was added in 2009 with the completion of fish passage at Price-Stubb Diversion Dam in 2008.

Although smallmouth bass were the target fish for removal in this project, all other centrarchid fishes encountered were collected. The reason for this was that the CDOW requested that the Fish and Wildlife Service remove and preserve all centrarchid fishes collected during the removal effort for their analyses of origin study, 2004 – 2006. These fishes included largemouth bass, green sunfish, bluegill, and black crappie. All centrarchids removed were frozen and then delivered to the Mesa County landfill.

The number of individuals and total length were recorded for each smallmouth bass and largemouth bass collected. Capture date and corresponding river mile for each centrarchid fish collected were recorded along with actual time electrofished (seconds; converted to hrs fished). For the population estimate in 2010, juvenile smallmouth bass (100-199 mm) were marked by removing the ventral lobe of the caudal fin with scissors. Adult smallmouth bass (≥ 200 mm) were marked by removing the dorsal lobe of the caudal fin with scissors. Chapman's (1951) modification of the Petersen-Lincoln estimator was used to determine the abundance of smallmouth bass. This estimator was believed to be the most appropriate because it would reduce bias due to the small number of recaptured smallmouth bass.

Probability of capture (p-hat) for juvenile and adult smallmouth bass was determined for the single marking pass and first removal pass. To obtain the best representative capture probability for calculating an annual exploitation rate, the capture probability from the two passes were weighted. This was accomplished by determining the inverse of their respective variances, thus providing more weight to the more precise estimate (personal communication, Bruce Haines, USFWS, [ret.], Vernal, Utah. Exploitation rate (μ)(personal communication, Bruce Haines, USFWS [ret.], Vernal, Utah) for juvenile and adult smallmouth bass was computed as:

$\mu = 1 - [(1 - p)^n]$, where
p is the probability of being captured on one pass as computed from the first removal pass,
$1 - p$ is the probability of fish surviving one removal pass,
$(1 - p)^n$ is the probability of surviving n passes, and
$1 - [(1 - p)^n]$ is the probability of being captured after n passes.

The coefficient of variation (CV: SE/N-hat x 100 [where N=estimated population size])(Pollock et al. 1990) was also computed.

Results

Results presented herein are a compilation of the efforts of both FWS (removal passes 1 through 6 and a single marking pass) and CDOW (removal passes 7 and 8) in the Grand Valley reaches of the Upper Colorado and Lower Gunnison rivers during 2010. Removal passes performed by the FWS in the Upper Colorado River between Rifle and Beavertail Mountain are also reported here. Data are presented for main channel habitats only which include hydrologically connected backwaters. Integration and comparison of results from earlier years (2004 – 2009) of this study are provided.

Size Distribution–Length Frequency.

Smallmouth Bass

Length frequency distribution of all sizes of smallmouth bass collected with electrofishing during 2010 between Government Highline Dam and Westwater, Utah, and the Lower Gunnison River were plotted for the marking pass, removal passes 1 – 3, and 4 – 8 (Figure 1). Generating a time series of length frequencies partitioned by passes might provide some insight for annual comparisons of the magnitude of early-life smallmouth bass produced and growth and abundance progression of their first year of life.

All age groups of smallmouth bass (age-0, juveniles, and adults) were represented in the 2010 summer collections (Figure 1). These ranged from young-of-the-year (22 mm) to adult (389 mm) fish. A strong year class of smallmouth bass was produced in 2007 in the Grand Valley reaches of the Upper Colorado and Lower Gunnison rivers. During the 2008 marking pass between GVIC and the Loma Boat Landing, it was apparent that the strong year class of smallmouth bass produced in 2007 apparently overwintered successfully and did not appear to be influenced by the high flows of the 2008 spring runoff. This was reflected by the high number of smallmouth bass between 50 and 74 mm and 100 to 150 mm that were strongly represented during the 2008 marking pass. During the marking passes in 2006 and 2007, these length groups were rarely observed during the marking pass (Figure 2). In 2009, the 2007 year class was still apparent (175 to 199 mm; Figure 2) but less conspicuous in the Grand Valley reaches of the Upper Colorado River.

In 2009, age-0 smallmouth bass were first detected in the Grand Valley reaches starting in mid-August (39 mm total length). Length frequency comparison between 2008 (see 2008 annual report no. 126(a)) and 2009 suggest that the 2009 year class may be stronger than 2008. However, overall catch rates for juvenile smallmouth bass (< 100 mm) in the Grand Valley sections of the Upper Colorado and Lower Gunnison rivers are almost identical during these two years (2008: C/E=0.63 fish/hr, n=185 vs. 2009: C/E=0.55 fish/hr, n=191)(see Figure 4).

However, in 2010, there may be some reason for concern. The highest number of juvenile smallmouth bass (< 100 mm) during this seven-year study was collected in 2010 from the Grand Valley reaches of the Upper Colorado and Lower Gunnison rivers

(Figure 1). The catch rate for this juvenile size class of fish (C/E=5.82 fish/hr, n=2,054) exceeded catches during the 2007 removal passes (C/E=4.15 fish/hr, n=1,358) for this size class (Table 1). A strong year class of smallmouth bass was produced in 2007 which was documented throughout upper Colorado River basin rivers. During the 2010 marking pass in the Grand Valley reaches, (Figure 2) age-0 smallmouth bass were first detected during the last week of July (31 mm).

Also, it was apparent from collections, that in some river segments (15-mile reach [GVIC Diversion Dam to the Colorado/Gunnison River confluence], 18-mile reach [Colorado/Gunnison River confluence to the Loma Boat Landing], and Rifle to Beavertail Mountain), smallmouth bass reproduced between 2004 and 2010. We cannot prove if these fish were produced in the river, or in off-channel habitats (e. g., ponds or irrigation returns that connect to the main river) and later escaped to the river. In the Grand Valley reaches, the 2008 and 2009 year class of smallmouth bass was noticeably less than of the three previous years (2005, 2006, and 2007) from catch rate data. Catch rates for smallmouth bass < 100 mm have declined significantly from the high in 2007 (4.15 fish/hr) to 0.63 fish/hr in 2008 and 0.55 fish/hr in 2009 (Table 1; Figure 4). Except for the 2007 year class, these sizes of young smallmouth bass have proven to be highly susceptible to low survival to age-1. In the Silt to Beavertail Mountain reaches, age-0 smallmouth bass catches have been less than that of the Grand Valley reaches throughout the seven-year project study. In 2008, the mean catch/effort was 0.25 fish/hr compared to 0.20 fish/hr (2007), 0.96 fish/hr (2006), 1.46 fish/hr (2005), and 0.15 fish/hr (2004)(Table 1). Only 57 age-0 smallmouth bass (0.72 fish/hr) were collected in these upper reaches during 2010. No age-0 smallmouth bass were collected in these upper reaches during 2009.

In the Rifle to Beavertail Mountain reach, smallmouth bass (all length sizes combined) abundance increased in 2010 from the three earlier years. Catch rate for all length sizes of smallmouth bass was 1.2 fish/hr in 2010. Mean catch/effort for all sizes of smallmouth bass were lowest during 2009 (0.24 fish/hr) compared to 2008 (0.95 fish/hr), 1.04 fish/hr (2007), 2.11 fish/hr (2006), and highest during 2005 (5.75 fish/hr)(Table 1).

Largemouth Bass

A total of 5,422 largemouth bass were collected during the eight removal passes. Ninety-eight percent (n=5,344) of these fish were less than 150 mm; and 79% (n=4,281) were less than 100 mm. Only 0.2% (n=9) of the total fish were greater than 250 mm (Figure 3). This suggests that survival of largemouth bass to adults in the river is relatively low due to the very low number of adult fish (i.e., >250 mm) in electrofishing collections vs. the high number of juvenile size fish.

Actual Numbers.

During 2004, 2005, and 2006 the number of removal passes were identical (4) and direct comparison of actual numbers of fish removed was justified. However, starting in 2007 and continuing through 2010, four additional removal passes were added. Therefore,

comparing actual numbers of fish removed per pass or by combining passes and river reaches with the three earlier sampling years is not warranted. Actual numbers of smallmouth bass removed are provided among the various figures and tables by major river section, by pass, and by year in the attached appendices.

There is one location that could be consistently used to compare total number of fish captured to establish annual trends. This is the fish trap at the Redlands Diversion Dam fish passageway on the Lower Gunnison River. The number of smallmouth bass collected in the fish trap of the Redlands Diversion Dam passageway has been recorded for 15 years. From 1996–2001, only one smallmouth bass was captured. However, 13 were collected in 2002, 6 in 2003, 9 in 2004, and 21 in 2005. To no surprise and keeping with the pattern of lower smallmouth bass catches in main channel habitats, no smallmouth bass were found in the Redlands fish trap during 2006 or 2007. In 2008, four smallmouth bass were collected in the Redlands fish trap, none in 2009, and three in 2010.

Catch/Effort.

General

Catch rate or catch/effort is often used as an index of population size if it is consistently proportional to absolute abundance (Ricker 1975). Unfortunately, catch/effort can be highly variable and is not the most reliable metric for population analyses or comparing trends in population abundance densities among years. It is more likely that unexplained variations in capture probability or "catchability" (not catch per unit of effort per se) preclude the use of catch per unit of effort as an abundance estimate.

During 2004 and 2005, since the initial study objective was to lethally remove as many smallmouth bass and other centrarchids as quickly as possible, fish were not marked and released and, therefore, a population estimate was not possible. For those years, effort was recorded and catch/effort was calculated and used to monitor increases and declines in centrarchid populations. To determine if densities of smallmouth bass and largemouth bass were being depleted as a result of the removal effort, catch effort indices (e. g., fish/hr) over time (i. e., by pass) in each river sub-reach were calculated and interpreted. Because population estimates for smallmouth bass were not available for 2004 and 2005, effort was still recorded during 2006 – 2010 and catch/effort was computed for use as a trend to compare annual abundance of smallmouth bass and other centrarchids during 2004 – 2010. Where abundance estimates were not performed for a population statistic, catch/effort was a useful metric in comparing relative abundance and interpreting year class strengths among years, particularly for juvenile smallmouth and largemouth bass (< 100 mm).

Mean catch/effort (fish/hr) was computed separately for each of the five centrarchid fishes by each of the seven sampling years, 2004 – 2010. To view the "big picture", for some analyses, river reaches and removal passes were consolidated. Catch rates were computed separately from the Rifle to Beavertail Mountain reaches and the Grand Valley

river reaches (Government Highline Dam to the Westwater BLM ranger station, Utah + the Lower Gunnison River).

Effort (hours) Fished

Electrofishing effort in 2004 (168.665 hours) was similar to 2005 (174.560 hours) between Price Stubb Dam and the Westwater, Utah, ranger station and the Lower Gunnison River. In 2006, electrofishing effort in these reaches was 161.906 hours. The electrofishing effort increased to 327.101 hours in 2007 because of the addition of four removal passes. The total effort (1 marking and 8 removal passes) during 2008 was 349.889 hours. In 2009, the total effort (1 marking and 8 removal passes) was 416.851 hours. A 3.9-mile reach between Government Highline Dam and the Cameo XCEL Bridge was added in 2009 which accounts for some of the increased effort in 2009 over earlier years. In 2010, the total effort was (1 marking and 8 removal passes) was 413.555 hours.

Between Rifle and Beavertail Mountain, the effort expended in 2004 was 19.750 hours compared to 39.799 hours during 2005 and 37.512 hours during 2006. During 2007, electrofishing effort increased to 86.84 hours which was related to adding the river reach from Silt to Rifle and an additional removal pass from Silt to Beavertail Mountain. In 2008, the total effort was 86.038 hours, which was almost identical to 2007. The total effort during 2009 was 62.321 hours and in 2010, 78.985 hours.

Smallmouth Bass

For the Grand Valley river reaches, the trend for smallmouth bass abundance from 2006-2009 was downward. Overall mean catch rate was highest for smallmouth bass juveniles (100-199 mm) and adults (≥ 200 mm) during 2004 (6.37 fish/hr) and 2005 (6.36 fish/hr). However, a 51% decline in catch rate was detected from 2005 to 2006. In 2007, the catch rate dropped even lower to a 4-year low (2.27 fish/hr; 27 % decline from 2006)(Figure 4). And again in 2008 and 2009, the overall catch rate continued to decline to 1.19 and 0.90 fish/hr, respectively. This catch effort decline is consistent with the decline observed with the population estimate between 2006 and 2007, and between 2007 and 2008 (see Population Estimate–Smallmouth Bass below). During 2010, the catch rate for smallmouth bass > 99 mm (0.98 fish/hr) increased slightly from 2009. Has there been a measurable response of smallmouth bass to removal efforts? While there has been a reduction in catch rate, it is uncertain if this has been attributed to mechanical removal efforts, the high spring runoff flows of the Upper Colorado River during 2008, or a combination of these two factors.

During the summer of 2010, for the Grand Valley river reaches, overall mean catch rate for smallmouth bass < 100 mm total length was the highest in this seven-year removal study (5.82 fish/hr). Formerly, 2007 had the highest catch rate (4.15 fish/hr) and the lowest was during 2004 (0.55 fish /hr)(Table 1; Figure 4). Initially, it appeared that the 2007 cohort was one of the strongest in five years of sampling between 2004 and 2009. Now, it appears that the 2010 cohort has initially exceeded the strong year class of 2007.

However, these young life stages can be subject to high mortality to age-1 due to a myriad of environmental factors over the winter and their overwinter survival is not known until the following summer sampling season. It appeared that survival of the 2007 year class was high because this size class was highly represented in the 2008 marking pass (see Figure 2). It also appeared that a weak year class was produced in 2008 (0.63 fish/hr); Table 1; Figure 4) since this study commenced in 2004. The high spring flows during the 2008 runoff in the Upper Colorado River could have swept weak swimming young smallmouth bass away from nests or quiet near-shore habitat resulting in high mortality. From catch/effort comparisons, the 2009 year class (0.55 fish/hr) also appeared to be similar to 2008.

Both 2008 and 2009 hydrologic conditions in the Upper Colorado River were similar. These two years have been characterized as average or moderately wet with sustained runoff compared to former years (2003-2007) that were dryer with shorter runoff magnitude and duration. The two wetter years with accompanying prolonged cooler water temperatures may disrupt or delay spawning resulting in slower growth of early-life stages (i. e., age-0) of smallmouth bass reducing survival and recruitment. Survival of smaller age-0 fish entering the winter period could be reduced under these hydrologic scenarios. The timing or detection of the first captures of age-0- smallmouth bass may provide one means to predict recruitment success into later years. For example, the first date age-0 smallmouth bass were detected in wetter years (2008, 2009) in which weak year classes were produced was 8 and 14 of August, 14, respectively. Compared to dryer years, 2007, in which a strong year class was produced, age-0 fish were first detected on 23 July, some 2-3 weeks earlier than 2008 and 2009. In 2010, age-0 smallmouth bass were first detected on 28 July.

For the Rifle to Beavertail Mountain reaches, the trend for smallmouth bass abundance from 2007-2009 was also downward. Overall mean catch rate for smallmouth bass (all length sizes) in 2009 was the lowest in six years (0.24 fish/hr; Figure 4). The highest year was 2005 (5.75 fish/hr)(Figure 4). Spawning success in these reaches appears not to be as successful as that in the Grand Valley reaches. Mean catch rates for smallmouth bass < 100 mm was the lowest in 2004 (0.15 fish/hr); the highest was during 2005 (1.46 fish/hr)(Table 1). During 2008, the catch rate for smallmouth bass < 100 mm was 0.25 fish/hr. Only one smallmouth bass (237 mm) was collected between Rifle and Silt at RM 241.2 during 2007; none were collected during 2008.

In 2010, overall catch rate for smallmouth bass (all sizes of fish) was 1.2 fish/hr which was an increase in abundance from the three earlier years.

Largemouth Bass

Unlike the downward trend in catch rate for smallmouth bass juveniles and adults, for the Grand Valley river reaches, overall mean catch rate for largemouth bass juveniles (100-199 mm) and adults (≥ 200 mm) steadily increased from 2004 – 2007 and peaked in 2007 (4.20 fish/hr; n= 1,375)(Figure 5). This was almost a magnitude greater than the catch rate for 2004 (0.63 fish/hr). During 2008, this trend was reversed for largemouth bass ≥

100 mm. The catch rate declined to 1.30 largemouth bass/hr (n=383). In 2009, the catch rate increased slightly to 1.83 fish/hr. Catch rate increased to 3.31 fish/hr in 2010.

For the Grand Valley river reaches, overall mean catch rate for largemouth bass < 100 mm total length has also steadily increased since 2004 from 1.03 fish/hr to a high of 12.13 fish/hr in 2010 (Table 2; Figure 5). It now appears that the 2010 year class is the strongest in this seven-year study which was initiated in 2004. The 2008 year class of largemouth bass was only slightly less (4.32 fish/hr) than 2007 and 2009. So, where the 2008 high spring runoff flows reduced the spawning success of smallmouth bass, it did not appear that largemouth bass young were as negatively impacted. This may be attributed to differences in spawning habitat between smallmouth bass and largemouth bass. In the Upper Colorado River, largemouth bass may be spawning in off main channel riverine habitats that may shelter young fish from the high velocities of runoff thus increasing survival, whereas young smallmouth bass, which are typically spawned in main channel riverine habitats, may suffer higher mortality during such high flow events. The high abundance of largemouth bass found during summer removal passes in main channel habitats may be due to young fish that have migrated out of off-channel habitats into main channel habitats following high spring runoff.

There has been no definite trend in largemouth bass abundance (all length sizes combined) for the Rifle to Beavertail Mountain reaches. The highest catch rate was recorded during 2008 (6.9 fish/hr; Table 2). The second highest year was in 2006 (5.6 fish/hr); lowest in 2010 (0.86 fish/hr). In 2007 the catch rate declined to 3.30 fish/hr (Table 2). In 2005, catch effort (0.93 fish/hr) was the second lowest in this seven-year study. Prior to 2008, spawning success in these reaches appeared not to be as successful as that in the Grand Valley reaches. Mean catch rate for largemouth bass < 100 mm was lowest in 2005 (0.25 fish/hr); the highest was during 2008 (5.4 fish/hr)(Table 2). In 2010, catch rate (0.3 fish/hr) was the second lowest in this seven-year study.

Black Crappie, Bluegill, Green Sunfish

Green sunfish are the most abundant of these three centrarchid species. Their catch rates have steadily increased since 2004 (3.81 fish/hr) to 2006 (8.62 fish/hr) only to slightly decrease to 5.72 fish/hr in 2007 (Table 3). They continued to increase again in 2008 to 6.7 fish/hr and increased 2.8-fold in 2009 to 18.78 fish/hr. However, during 2010, green sunfish relative abundance declined by about 48% from 2009 from 19 to 10 fish/hr. Bluegill continue to be captured in main channel riverine habitats of the Upper Colorado River, despite historically being found in lentic habitats. Bluegill catch rate exploded during 2008 (4.90 fish/hr). During 2009, bluegill catch rate declined to 1.86 fish/hr from the high in 2008. Bluegill catch rates during 2010 continued to decline to 1.09 fish/hr. During 2007, the bluegill catch rate was only 1.39 fish/hr; 1.90 fish/hr in 2006, and in 2005, 1.81 fish/hr. Black crappie catch rates in the Grand Valley river reaches peaked in 2008 (0.67 fish/hr) and were lowest during 2004 (0.04 fish/hr)(Table 3). Black crappie catch rates in 2009 (0.30 fish/hr) declined slightly from 2008. In 2010, catch rate was 0.39 fish/hr.

In the Rifle to Beavertail reaches, bluegill and black crappie are noticeably less abundant than the downstream Grand Valley reaches. Of these three fishes, green sunfish are the most abundant in these upstream reaches. Green sunfish abundance peaked in 2008 (19.56 fish/hr) but declined for the first time in four years in 2009 to 7.49 fish/hr only to increase again in 2010 to 11.89 fish/hr (Table 4). Bluegill numbers remained static during 2010 from 2009 and black crappie are only encountered rarely in these upper most reaches.

Population Size.

Smallmouth Bass

During the marking pass performed in July 2010 a total of 84 smallmouth bass (31 juvenile size [100-199 mm], 53 adult size [≥ 200 mm]) were marked and released alive between the GVIC Diversion Dam and the Loma Boat Landing and 2.3 miles of the Lower Gunnison River. Twenty (11 juvenile, 9 adult) of these marked fish were later recaptured during eight removal passes (Table 5). Since a 'batch' mark was employed and smallmouth bass were not marked with a serially numbered tag, movements of individual fish were not possible. Six marked fish (three juvenile, three adult) were recaptured in removal pass 1. Five marked fish (two juvenile, three adult) were captured during pass 2, seven marked fish (six juvenile, one adult) were captured during pass 3. One marked juvenile and one marked adult each was detected during removal passes 6 and 8, respectively. No marked fish were captured during passes 4, 5 and 7. Crews were instructed to look for marked fish during all eight removal passes. In 2010, a different mark was employed and it appeared that this new mark could be reliably detected throughout all eight passes which extended from early-August through late-September. All 20 marked smallmouth bass were recaptured within the original marking reaches. The total number of smallmouth bass removed over eight removal passes was 159 juveniles (100-199 mm) and 187 adults (≥ 200 mm)(Table 5).

In 2010, the population estimate generated was for the 15- and 18-mile reaches of the Colorado River and 2.3 miles of the Lower Gunnison River downstream from Redlands Diversion Dam using a single marking pass and first removal pass for juvenile smallmouth bass 100-199 mm and adults ≥ 200 mm (Table 5). The 2010 population point estimate (95% C.I. in parenthesis) was 255 ± 196 (59 – 451) for smallmouth bass 100-199 mm and 832 ± 671 (152 – 1,494) for smallmouth bass ≥ 200 mm. The weighted probability of capture (p-hat) was computed as 0.097 and 0.053, respectively, for these two length groups. The CV was 39.3% and 41.6%, respectively. The CV can be used as a measure of estimate precision and Pollock et al. (1990) suggests a good 'rule of thumb' is to achieve a CV of 20% or less. The proportion or percentage of smallmouth bass of these sizes removed during the first removal pass or the exploitation rate for this first pass based on the population estimate was as few as 7 % (31/451) for juvenile fish 100-199 mm which computes to about an average of 7.2 juvenile smallmouth bass/mile. For smallmouth bass ≥ 200 mm, the proportion or percentage of smallmouth bass of these sizes removed annually or the exploitation rate based on the population estimate was as few as 4 % (60/1,494) or an average of 23.3 adult smallmouth bass/mile.

The 2009 population point estimate (95% C.I. in parenthesis) was 2,044 ± 2,238 (- 194 – 4,282) for smallmouth bass 100-199 mm and 755 ± 802 (- 471 – 1,557) for smallmouth bass ≥ 200 mm. The weighted probability of capture (p-hat) was computed as 0.014 and 0.017, respectively, for these two length groups. The CV was 55.9% and 54.2%, respectively. The proportion or percentage of smallmouth bass of these sizes removed during the first removal pass or the exploitation rate for this first pass based on the population estimate was as few as 1% (46/4,282) for juvenile fish 100-199 mm which computes to about an average of 57.9 juvenile smallmouth bass/mile. For smallmouth bass ≥ 200 mm, the proportion or percentage of smallmouth bass of these sizes removed annually or the exploitation rate based on the population estimate was a few as 1 % (20/1,557) or an average of 21.4 adult smallmouth bass/mile.

The low number of recaptured marked juvenile and adult smallmouth bass during the first removal pass compared to earlier years obviously contributed to very poor capture probabilities, abundance estimates, and exploitation rates for 2009. In 2009 as in 2008, declining catch rates reflect a downward trend in relative abundance. The 2009 abundance estimate did not correlate well with the calculated catch effort indices for juvenile and adult smallmouth bass (≥ 100 mm; see Figure 4) during 2009 in the Grand Valley reaches of the Upper Colorado and Lower Gunnison rivers. Therefore, the abundance estimates for 2009 should be viewed with caution with earlier and future year comparisons.

The 2008 population point estimate (95% C.I. in parenthesis) was 804 ± 423 (381– 1,227)(Table 5) for juvenile smallmouth bass (100-199 mm). The weighted probability of capture (p-hat) was computed as 0.10; the CV: 26.9%. The proportion or percentage of smallmouth bass of these sizes removed during the first removal pass or the exploitation rate for this first pass based on the population estimate was as few as 6.7 % (82/1,227) or as many as 21.5% (82/381). This computes to an average of about 22.8 fish/mile. For adult smallmouth bass (≥ 200 mm) the population point estimate (95% C.I. in parenthesis) was 393 ± 276 (117– 669). The weighted probability of capture was computed as 0.07; the CV: 35.9%. The proportion or percentage of smallmouth bass of these sizes removed during the first removal pass or the exploitation rate for this first pass based on the population estimate was as few as 4.2 % (28/669) or as many as 23.9% (28/117). This computes to an average of about 11.1 fish/mile.

The 2007 population point estimate (95% C.I. in parenthesis) was 1,007 ± 686 (321– 1,693)(Table 5) for adult smallmouth bass ≥ 200 mm. The weighted probability of capture (p-hat) was computed as 0.06; the CV: 34.8%. The proportion or percentage of smallmouth bass of these sizes removed during the first removal pass or the exploitation rate for this first pass based on the population estimate was as few as 6.4 % (109/1,693) or as many as 3.4% (109/321). This computes to an average of about 28.5 fish/mile.

The 2006 population point estimate (95% C.I. in parenthesis) was 2,295 ± 1,500 (795– 3,795)(Table 5) for adult smallmouth bass ≥ 200 mm. The weighted probability of capture (p-hat) was computed as 0.04; the CV: 33.3%. The proportion or percentage of smallmouth bass of these sizes removed during the first removal pass or the exploitation

rate for this first pass based on the population estimate was as few as 4.3 % (163/3,795) or as many as 20.5% (163/795). This computes to an average of about 65 fish/mile.

Over the past four years in 35.3 miles of the Upper Colorado and Lower Gunnison rivers in the Grand Valley reaches, abundance of smallmouth bass juveniles (100-199) mm has slowly decreased from a high of 804 fish in 2008 (there were no population estimate for 2006 and 2007) to 255 fish in 2010. Abundance of adult smallmouth bass (≥ 200 mm) slowly decreased from a high of 2,295 fish in 2006, 1,007 in 2007, 393 in 2008, but increased to 823 during 2010. The abundance increase in 2010 could be attributed to the strong year class of smallmouth bass produced in 2007. Abundance estimates for both juvenile and adult smallmouth bass in 2009 were not included here because of the low number of recaptures necessary to generate a reliable estimate.

Exploitation Rates. Exploitation rates were computed for two length groups (100-199 mm and ≥ 200 mm) of smallmouth bass from the Upper Colorado and Lower Gunnison rivers for 2006 – 2010 (Table 6). Exploitation rates by year and length class were: 2006 (fish ≥ 200 mm): 27.9; 2007 (fish ≥ 200 mm): 39.1; 2008 (fish 100-199 mm): 57.0, (fish ≥ 200 mm): 44.0; 2009 (fish 100-199 mm): 10.7, (fish ≥ 200 mm): 12.8; 2010 (fish 100-199 mm): 55.7, (fish ≥ 200 mm): 35.2. This method attempts to reduce bias from fish moving outside the sampling area, mortality during the sampling period, and growth (personal communication, Bruce Haines, USFWS [ret.], Vernal, Utah). This method attempts to extrapolate the exploitation rate over the number of removal passes for the five years abundance estimates were computed.

Concentration Areas.

Smallmouth Bass

Identifying concentration areas is important because it may allow managers to focus on riverine areas of high densities of smallmouth bass to expedite removal and reduction to control their proliferation/invasiveness and potential negative impacts to native fish conservation and endangered fish recovery. High to low smallmouth bass concentration areas in riverine reaches in the Colorado and Lower Gunnison rivers were determined using 2004-2010 catch/effort values. The river reach between Corn Lake and the Colorado/Gunnison River confluence was consistently the highest area of concentration for smallmouth bass during the summers of 2004, 2005, and 2006. However, in 2007 the highest catch rate was between the Colorado/Gunnison River confluence and Fruita State Park (9.23 fish/hr). In 2007, the next highest area was between Corn Lake and the Colorado/Gunnison River confluence (7.06 fish/hr). These two river reaches were consistently the two highest concentration areas for smallmouth bass between 2004 and 2007. In 2007, the third highest concentration area was from the GVIC Dam to Corn Lake (4.06 fish/hr). The 2.3 miles of the Lower Gunnison River ranked fourth after 4 years which was no surprise because it was adjacent to the two highest concentration areas in the Upper Colorado River.
In 2008, the highest area for smallmouth bass abundance was the 2.3 miles of the Lower Gunnison River (6.28 fish/hr) followed the Fruita State Park to Loma Boat Landing (6

fish/hr), and Salt Creek to the Loma Boat Landing (3.19 fish/hr) reach. The two highest river reaches from 2004 – 2007 (Corn Lake to the Colorado/Gunnison river confluence and Fruita State Park to the Colorado/Gunnison River confluence) for smallmouth bass abundance declined precipitously in 2008. The respective catch rate for these two reaches was 1.87 and 2.66 fish/hr. Smallmouth bass catch rates declined in 6 of the 10 major river reaches between 2007 and 2008.

In 2009, a significant decline in the abundance of age-0, juvenile and adult smallmouth bass were detected in all 11 removal reaches. The three highest areas of smallmouth bass concentrations were detected between, 1) the Colorado/Gunnison River confluence to Fruita State Park (2.07 fish/hr), 2) Corn Lake to the Colorado/Gunnison River confluence (1.54 fish/hr), and 3) GVIC to Corn Lake (1.39 fish/hr).

In 2010, catch rates rebounded and increased to levels observed in 2004 and 2005, mostly due to the large number of age-0 and age-1 smallmouth bass (< 100 mm) collected in August and September. The 9.6 mile reach between the Colorado/Gunnison River confluence and Fruita State Park was once again had the highest concentration of smallmouth bass (9.86 fish/hr), followed by Fruita State Park to the Loma Boat Landing (8.5 fish/hr), and GVIC to Corn Lake (4.62 fish/hr).

The 11 reaches which includes the Grand Valley sections, Rifle to Beavertail, and canyon-bound reaches between Loma and Westwater, Utah, were ranked (1-11) by the mean catch/effort (fish/hr) for all sizes of smallmouth bass collected and removed for the seven-year duration of this study:

Rank	River Reach	Catch /Effort (fish/hr)
1	Corn Lake to the Colorado/Gunnison River confluence	8.79
2	Colorado/Gunnison River confluence to Fruita State Park	6.79
3	GVIC to Corn Lake	4.9
4	Lower Gunnison River	4.54
5	Fruita State Park to Loma	4.07
6	Price-Stubb Dam to GVIC	3.2
7	Loma to Salt Creek	2.82
8	Salt Creek to Utah/Colorado state line	2.52
9	Rifle to Beavertail Mountain	1.76
10	Utah/Colorado state line to Westwater, Utah	0.43
11	Grand Valley Water User's Dam to Cameo XCEL Bridge	0.11

Monitoring these concentration areas will be continued because it provides a, 1) tool to gage if mechanical removal is effective, 2) quantitative means to prioritize reaches where removal efforts might be intensified, and 3) valuable guide to assist managers in maximizing nonnative fish control efforts to reduce abundance of those piscivorous fishes that might jeopardize the continued existence of the native fish fauna in the Grand Valley reaches of the Upper Colorado River.

VII. Recommendations: (this assumes that some level of field activities will resume in 2011 in

the Upper Colorado River)

1. Continue to collect and lethally remove all centrarchids from the Colorado and Gunnison rivers during all station sampling studies which includes sampling on the Colorado and Gunnison rivers during 2011.

2. Continue to use three electrofishing craft during the marking pass in an attempt to capture, mark, and release more smallmouth bass ≥ 100 mm.

3. Investigate and implement management measures to prevent escapement of smallmouth bass and other piscivorous fishes into riverine areas from bodies of water known to be occupied by species that could negatively impact native riverine fishes.

4. The budget for 2010 was not increased and is identical to 2009. An additional reach (Government Highline Dam to Cameo Bridge) was added in 2009 and will again be sampled in 2011. Adding this reach has increased the total number of work days to the project to perform this work. Removal passes in other reaches where smallmouth bass abundance has declined significantly may have to be reduced or even eliminated to remain 'within budget'.

5. Target specific in-river features that provide habitat for centrarchid fishes. These include but are not limited to beaver lodges, tree stumps and logs, rock piles, and concrete rip-rap. Sampling these features with electrofishing may increase catches of centrarchid fishes.

6. Continue sampling the Upper Colorado reaches from the Rifle Bridge to Beavertail Mountain in Debeque Canyon, but reduce the number of removal passes to one. This reach in addition to the river reach between the Loma Boat Landing and Westwater Ranger Station, Utah, should be monitored annually to detect for increased smallmouth bass abundance. The reduced effort in the Rifle to Beavertail reach could be re-directed to increase removal passes in reaches of higher smallmouth bass abundance, for example, Grand Valley reaches of the Colorado River near Grand Junction.

   It may be imperative to re-allocate effort from the Rifle to Beavertail Mountain reach to the Grand Valley reaches for 2011 because the smallmouth bass cohort produced in 2010 in the Grand Valley reaches appears to be stronger than that of 2007, which was recognized as one of the strongest year classes in the upper Colorado River basin rivers. It is uncertain if this 2010 cohort will overwinter, and that will not be known until the 2011 summer sampling is underway.

7. Suspend all electrofishing operations when it is determined that Colorado pikeminnow show signs of preparing to spawn, e.g., mid- to late-June. Electrofishing will be suspended during this period to eliminate the likelihood of harassment, interference, and injury to spawning Colorado pikeminnow.

8. Downstream from Government Highline Dam, electrofishing should commence following cessation of spawning of Colorado pikeminnow which should be sometime in mid- to late-July.

VIII. Project Status:

A. "On track". A final report (Burdick 2008) discussing results of centrarchid removal and trends in smallmouth bass abundance from 2004 to 2006 in the Upper Colorado River and Lower Gunnison rivers was finalized and submitted to the Recovery Program office in March 2008.

B. Presently, field activities for 2011 are planned. Future field activities and level of effort and intensity will be determined at the 2010 Recovery Program nonnative fish workshop in early-December. Study direction and field sampling design and effort for 2011 may have to be adjusted pending the outcome of the nonnative fish workshop in early-December 2010.

IX. FY 2010 Budget Status
126a--USFWS

A. Funds Provided: $ 157,171
B. Funds Expended: $ 157,171
C. Difference: $ –0–
D. Percent of the FY 2010 work completed, and projected costs to complete: 100%.
E. Recovery Program funds spent for publication charges: $ –0–

126b—CDOW

A. Funds Provided: $ 15,348
B. Funds Expended: $ 15,348
C. Difference: $ –0–
D. Percent of the FY 2010 work completed, and projected costs to complete: 100%.
E. Recovery Program funds spent for publication charges: $ –0–

X. Status of Data Submission (Where applicable): Razorback sucker were the only endangered fish collected during this evaluation in 2010. These fish were checked for a PIT tag in the field. All data associated with the capture and release of endangered fish were computerized. These data are available and will be electronically transmitted to the UCRB database coordinator in Grand Junction upon his request. Data recorded for all centrarchid fishes collected were computerized on entered on EXCEL spreadsheet by FWS and CDOW personnel.

XI. Signed: *Bob D. Burdick* 10 November 2010
Principal Investigator Date

APPENDIX:

A. More comprehensive/final project reports. If distributed previously, simply reference the document or report.

Burdick, B. D. 2008. Removal of smallmouth bass and four other centrarchid fishes from the Upper Colorado and Lower Gunnison Rivers: 2004–2006. FINAL REPORT prepared for the Upper Colorado River Endangered Fish Recovery Program. Recovery Program Project Number 126. U. S. Fish and Wildlife Service, Colorado River Fishery Project, Grand Junction, Colorado. 61 pp + appendices.

B. Appendix A: 6 tables attached
5 figures attached

C. References

Burdick, B. D. 2008. Removal of smallmouth bass and four other centrarchid fishes from the Upper Colorado and Lower Gunnison Rivers: 2004–2006. Final Report prepared for the Upper Colorado River Endangered Fish Recovery Program. Recovery Program Project Number 126. U. S. Fish and Wildlife Service, Colorado River Fishery Project, Grand Junction, Colorado. 61 pp + appendices.

Chapman, A. D. 1951. Some properties of the hypergeometric distribution with applications to zoological sample censuses, University of California Publ. Stat. 1(7):131–160.

Ricker, W. E. 1975. Computation and interpretation of biological statistics of fish populations. Dept. of Environment, Fisheries and Marine Service, Ottawa, Canada, 382 pp.

Pollock, K. H., J. D. Nichols, C. Brownie, and J. E. Hines. 1990. Statistical inference for capture-recapture experiments. Wildlife Monographs 107.

Prepared and compiled by Bob D. Burdick, 11/10/2010
2010-ColoR-smbass-rpt.doc

APPENDIX

Table 1. Catch/effort (C/E, fish/hr) comparison by year for three different length classes (total length) of smallmouth bass (< 100mm = age-0; 100–199 mm = juveniles; ≥ 200 mm = adults) for the Rifle to Beavertail Mountain reaches (river miles 240.4 – 195.7 in the Upper Colorado River and the Upper Colorado River from Government Highline Dam to the Westwater BLM ranger station, Utah (river miles 187.7 – 127.6) and the Lower Gunnison River from the Redlands Diversion Dam to the Colorado/Gunnison River confluence (river miles 3.0 – 0.7) from 2004 – 2010. Note: a) all removal passes and all reaches were combined within years for the Rifle to Beavertail Mountain and Government Highline Dam to Westwater, Utah, plus the Lower Gunnison River reaches, b) Silt to Rifle reach sampled only during 2007 and 2008, and c) Government Highline to Cameo XCEL Bridge reach added in 2009.

		Smallmouth Bass							
River Section	Length Class (mm)			Year					
			2010	2009	2008	2007	2006	2005	2004
Rifle ▸ Beavertail Mountain	< 100	No. of fish	**57**	0	21	17	36	58	3
		C/E	**0.72**	0.00	0.25	0.20	0.96	1.46	0.15
	100-199	No. of fish	**0**	3	29	28	2	54	4
		C/E	**0**	0.05	0.34	0.32	0.05	1.36	0.20
	≥200	No. of fish	**39**	12	32	45	41	118	14
		C/E	**0.49**	0.19	0.37	0.52	1.09	2.96	0.71
Government Highline Dam ▸ Westwater, Utah + Lower Gunnison River	< 100	No. of fish	**2,054**	191	185	1,358	261	254	93
		C/E	**5.82**	0.55	0.63	4.15	1.61	1.46	0.55
	100-199	No. of fish	**159**	137	214	250	54	345	618
		C/E	**0.45**	0.39	0.73	0.76	0.33	1.98	3.66
	≥200	No. of fish	**188**	177	135	429	449	768	456
		C/E	**0.53**	0.51	0.46	1.31	2.77	4.39	2.70

Table 2. Catch/effort (C/E, fish/hr) comparison by year for three different length classes (total length) of largemouth bass (< 100mm = age-0; 100–199 mm = juveniles; ≥ 200 mm = adults) for the Rifle to Beavertail Mountain reaches (river miles 240.4 – 195.7 in the Upper Colorado River and the Upper Colorado River from Government Highline Dam to the Westwater BLM ranger station, Utah (river miles 187.7 – 127.6) and the Lower Gunnison River from the Redlands Diversion Dam to the Colorado/Gunnison River confluence (river miles 3.0 – 0.7) from 2004 – 2010. Note: a) all removal passes and all reaches were combined within years for the Rifle to Beavertail Mountain and Government Highline Dam to Westwater, Utah, plus the Lower Gunnison River reaches, b) Silt to Rifle reach sampled only during 2007 and 2008, and c) Government Highline to Cameo XCEL Bridge reach added in 2009.

		Largemouth Bass							
River Section	Length Class (mm)			Year					
			2010	2009	2008	2007	2006	2005	2004
Rifle ▸ Beavertail Mountain	< 100	No. of fish	**24**	36	462	122	125	10	53
		C/E	**0.30**	0.58	5.37	1.40	3.33	0.25	2.68
	100-199	No. of fish	**31**	29	90	109	71	10	11
		C/E	**0.39**	0.47	1.05	1.26	1.89	0.25	0.56
	≥200	No. of fish	**13**	5	43	56	15	17	2
		C/E	**0.16**	0.08	0.50	0.64	0.40	0.43	0.10
Government Highline Dam ▸ Westwater, Utah + Lower Gunnison River	< 100	No. of fish	**4,281**	1,952	1,272	1,507	573	465	173
		C/E	**12.1**	5.58	4.32	4.61	3.54	2.66	1.03
	100-199	No. of fish	**1,141**	609	344	1,332	487	86	85
		C/E	**3.23**	1.74	1.17	4.07	3.01	0.49	0.50
	≥200	No. of fish	**29**	32	39	43	36	38	21
		C/E	**0.08**	0.09	0.13	0.13	0.22	0.22	0.12

Table 3. Catch/effort (C/E, fish/hr) comparison for three centrarchid fishes captured from the Upper Colorado River from Government Highline Dam to the Westwater BLM ranger station, Utah (river mile 193.7 – 127.6) and the Lower Gunnison River from the Redlands Diversion to the Colorado/Gunnison River confluence (river mile 3.0 – 0.7), 2004 – 2010. Note: a) all removal passes and all reaches were combined within years for Government Highline Dam to Westwater, Utah, plus the Lower Gunnison River reaches and b) Government Highline to Cameo XCEL Bridge reach added in 2009.

			Fish Species		
			Black Crappie	Bluegill	Green Sunfish
	2010	No. of fish	**137**	**386**	**3,420**
		C/E	**0.39**	**1.09**	**9.69**
Government Highline Dam ▸ Westwater, UT + Lower Gunnison River	2009	No. of fish	104	650	6,565
		C/E	0.30	1.86	18.78
	2008	No. of fish	198	1,444	1,972
		C/E	0.67	4.90	6.70
	2007	No. of fish	50	456	1,872
		C/E	0.15	1.39	5.72
	2006	No. of fish	70	307	1,395
		C/E	0.43	1.90	8.62
	2005	No. of fish	41	316	1,051
		C/E	0.23	1.81	6.02
	2004	No. of fish	7	111	643
		C/E	0.04	0.66	3.81

Table 4 . Catch/effort (C/E, fish/hr) comparison for three centrarchid fishes captured from the Upper Colorado River from Rifle to Beavertail Mountain (river mile 240.4 – 195.7), 2004 – 2010. Note: a) all removal passes and all reaches were combined within years, and b) Silt to Rifle reach sampled only during 2007 and 2008.

			Fish Species		
			Black Crappie	Bluegill	Green Sunfish
	2010	No. of fish	**0**	**26**	**936**
		C/E	**0.00**	**0.33**	**11.85**
Rifle ▸ Beavertail Mountain	2009	No. of fish	1	27	467
		C/E	0.02	0.43	7.49
	2008	No. of fish	2	72	1,683
		C/E	0.02	0.84	19.56
	2007	No. of fish	1	199	862
		C/E	0.01	2.29	9.92
	2006	No. of fish	1	5	492
		C/E	0.03	0.13	13.12
	2005	No. of fish	2	10	606
		C/E	0.05	0.25	15.23
	2004	No. of fish	0	0	36
		C/E	0.00	0.00	1.82

Table 5. Population estimate with 95% confidence intervals (CI) and other statistics for smallmouth bass (100-199 mm and ≥ 200 mm) for the 15- and 18-mile reaches (river miles 185.6 to 152.6) of the Upper Colorado River and 2.3 miles of the Lower Gunnison River (Redlands Diversion Dam to the Colorado/Gunnison River confluence) for the summers of 2006 - 2010. Note: length of the area for the population estimate was 35.3 miles.

Year	Fish Length Size (mm)	Pop Estimate with 95% CI	SE	SmBass/ mile	Number Marked; No. Removed 1st Removal	Number Recaptured (1st Removal Pass)	Total Number Recaptured (all removal passes)	Total Number of Removal Passes	Total Number of SmBass Removed (all removal passes)	Percentage Removed (All Removal Passes)	CV (%)	p-hat (weighted)
2004/ 2005	NO POPULATION ESTIMATE PERFORMED											
2006	100-199	No Pop Est.	- - -	- - -	25;18	0	0	4	54	- - -	- - -	- - -
	≥ 200	2,295 ± 1,500	765	65.0	97;163	6	8	4	449	19.6	33.3	0.043
2007	100-199	No Pop Est.	- - -	- - -	13;16	0	0	8	250	- - -	- - -	- - -
	≥ 200	1,007 ± 686	350	28.5	54;109	5	14	8	429	42.6	34.8	0.060
2008	100-199	804 ± 423	216	22.8	96;82	9	10	8	214	26.6	26.9	0.101
	≥ 200	393 ± 276	141	11.1	67;28	4	17	8	135	34.4	35.9	0.073
2009	100-199	2,044± 2,238	1,142	57.9	86;46	1	6	8	138	6.8	55.9	0.014
	≥ 200	755 ± 802	409	21.4	71;20	1	4	8	178	23.6	54.2	0.017

Table 5. (cont'd).

Year	Fish Length Size (mm)	Pop Estimate with 95% CI	SE	SmBass/ mile	Number Marked; No. Removed 1st Removal	Number Recaptured (1st Removal Pass)	Total Number Recaptured (all removal passes)	Total Number of Removal Passes	Total Number of SmBass Removed (all removal passes)	Percentage Removed (All Removal Passes)	CV (%)	p-hat (weighted)
2010	100-199	255 ± 196	100.2	7.2	31;31	3	11	8	159	62.4	39.3	0.097
	≥ 200	823 ± 671	342	23.3	53;60	3	9	8	188	22.7	41.6	0.053

Table 6. Exploitation rates for smallmouth bass (100 – 199 mm and ≥ 200 mm) collected in the Upper Colorado (river miles 187.8 – 152.6) and the Lower Gunnison (river miles 3.0 – 0.7) rivers during 2006 – 2010.

Year	Length Class (mm)	No. of Smth Bass Marked & Released during the Marking Pass	No. of Marked Smallmouth Bass Removed during the 1st Removal Pass	Probability of Being Captured on each pass (p-hat) (weighted) [a]	Probability of Being Captured after "n" Passes (or) Exploitation Rate (μ)
2006 [b]	100-199	25	0	- - -	- - -
	≥ 200	97	6	0.043	27.9 [b, d]
2007 [c]	100-199	13	0	- - -	- - -
	≥ 200	54	5	0.060	39.1 [c, d]
2008 [c]	100-199	96	9	0.101	57.0 [c, d]
	≥ 200	67	4	0.073	44.0 [c, d]
2009 [c]	100-199	86	1	0.014	10.7 [c, d]
	≥ 200	71	1	0.017	12.8 [c, d]
2010 [d]	**100-199**	**31**	**31**	**0.097**	**55.7 [c, d]**
	≥ 200	**53**	**60**	**0.053**	**35.2 [c, d]**

[a] Formula for inverse/variance weighting: $p= [(1/var1) * p_1 + (1/var2) * p_2]/[(1/var1) + (1/var2)]$. Variance for p_1 hat & p_2 hat = p * (1-p)/n; n=sample size (e.g., number of removal passes). For example, 2006 smallmouth bass ≥ 200 mm, p_1 var=6/97=0.62, p_2 var=6/163=0.37. 6=number of marked fish recaptured during first removal pass; 97=number of fish marked during marking pass, 163=number of fish removed during the first removal pass.

[b] Four removal passes ("n").

[c] Eight removal passes ("n"). Includes fish removed by FWS (passes 1 – 6) and CDOW (passes 7 – 8).

[d] Exploitation rate (μ) computed as, $\mu = 1 – [(1 – p)^n]$, where p is the probability of being captured on one pass as computed from the first removal pass, 1 – p is the probability of fish surviving one removal pass, $(1 – p)^n$ is the probability of surviving n passes, and $1 – [(1 – p)^n]$ is the probability of being captured after n passes (personal communication, Bruce Haines, USFWS [ret.], Vernal, Utah).

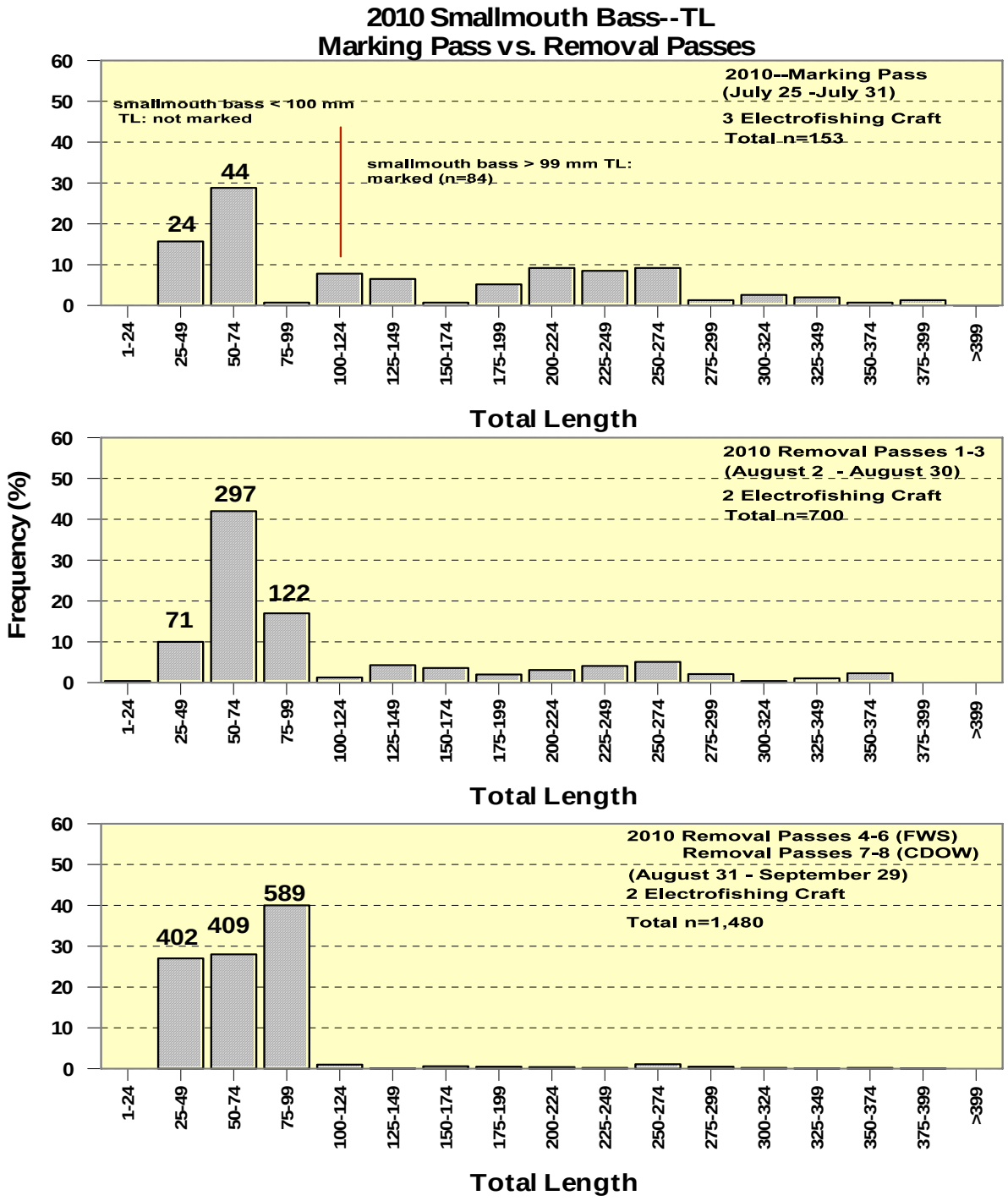

Figure 1. Length frequency comparison among the marking (top) and subsequent removal passes: passes 1-3 (middle), and passes 4-6 and 7-8 (bottom) for all smallmouth bass collected during 2010 in the Grand Valley and Ruby and Horsethief canyon reaches of the Upper Colorado and Lower Gunnison rivers. Note: numbers of smallmouth bass removed above bars.

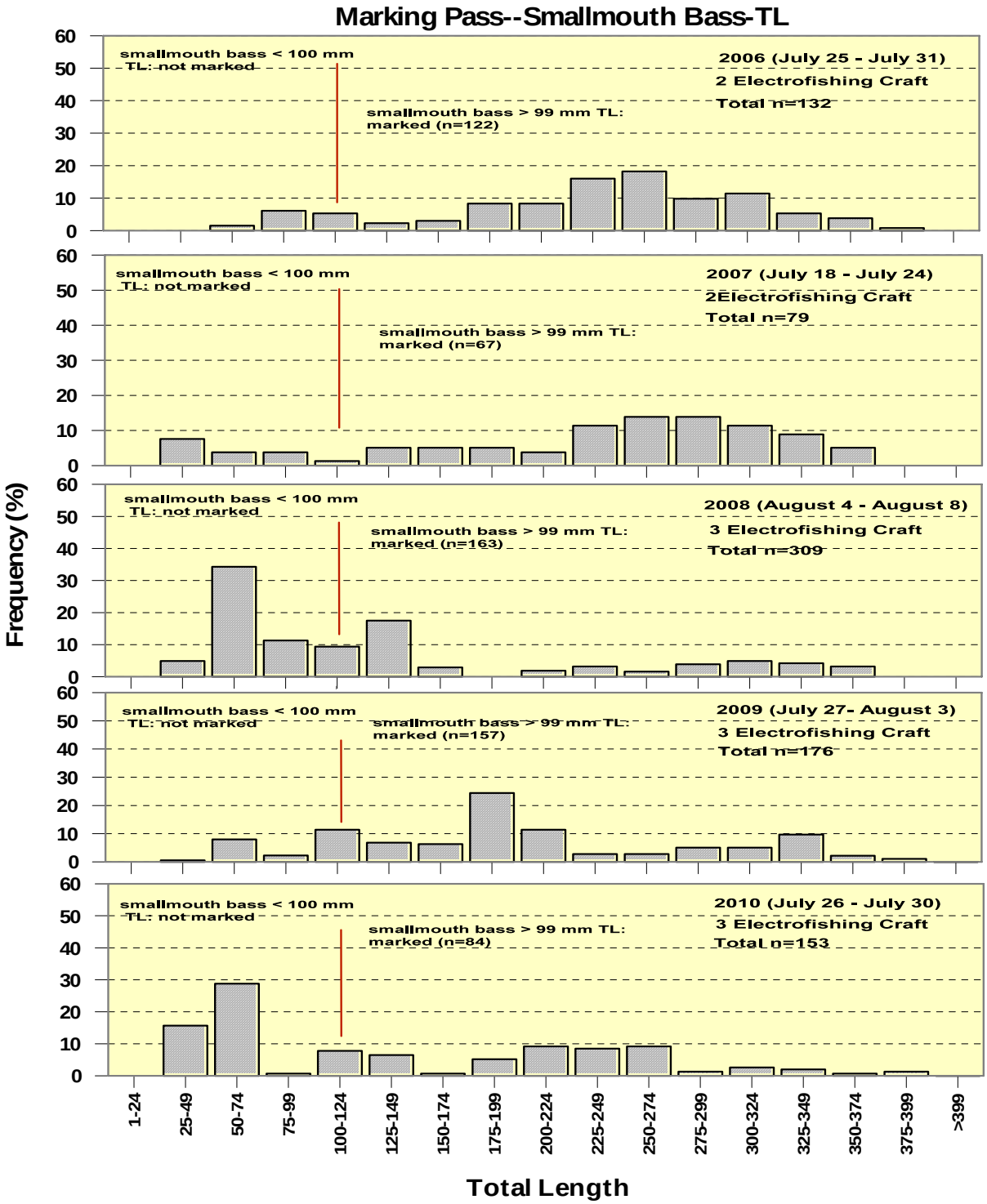

Figure 2. Length frequency comparison among 2006 – 2010, for all smallmouth bass collected during the marking pass in the Grand Valley reaches of the Upper Colorado and Lower Gunnison rivers.

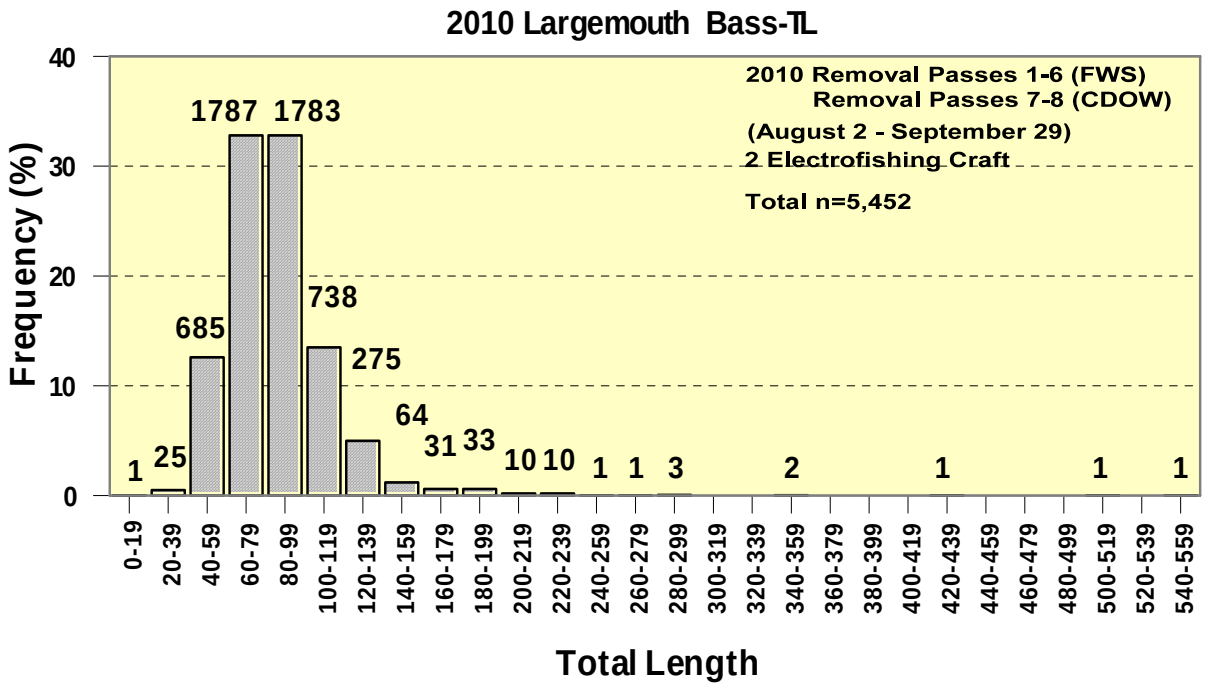

Figure 3. Length frequency for all largemouth bass collected during the eight removal passes during the summer of 2010 in the Grand Valley reaches of the Upper Colorado and Lower Gunnison rivers. Note: numbers of largemouth bass removed above bars.

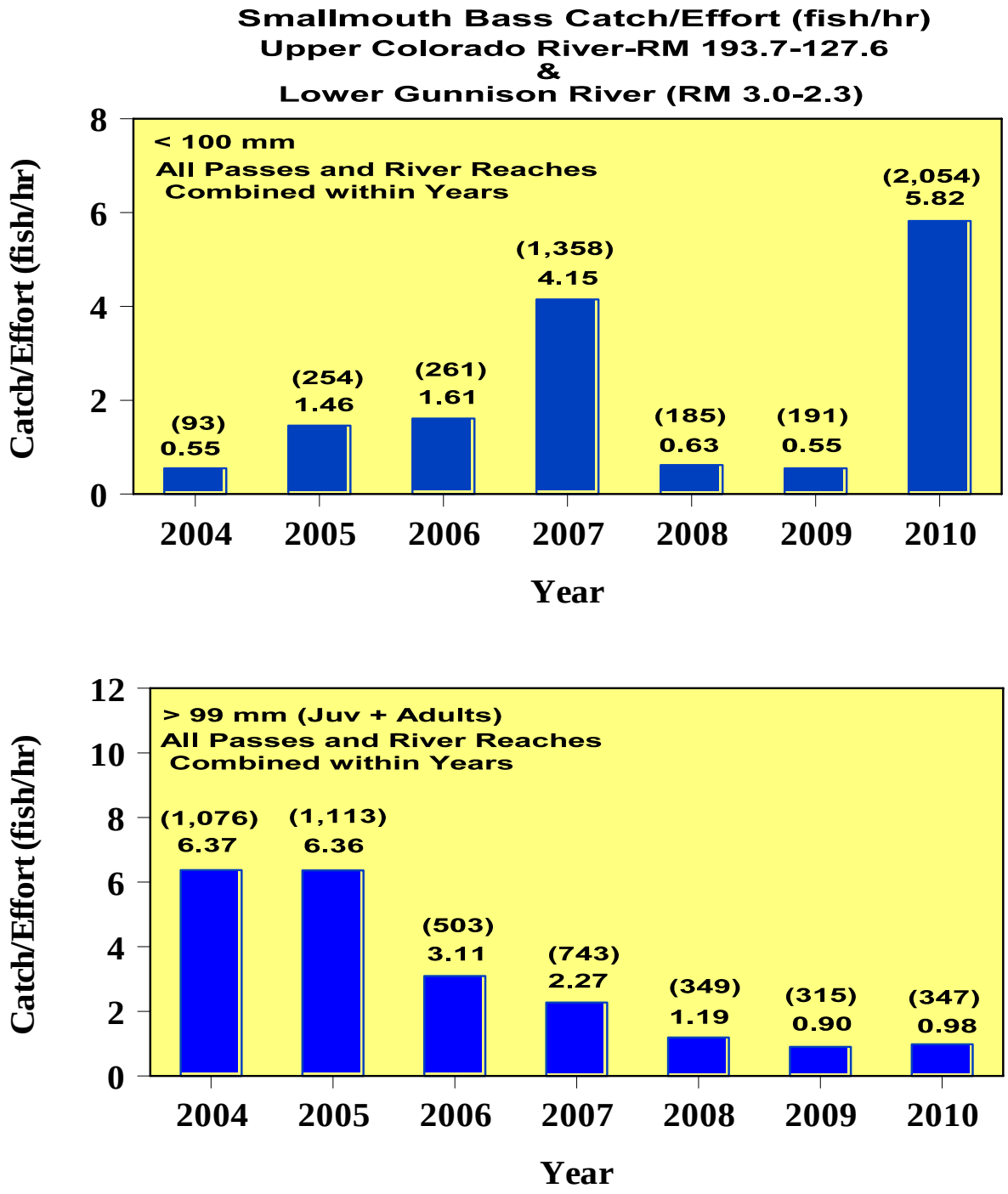

Figure 4. Seven year comparison of catch/effort (fish/hr) for smallmouth bass (< 100 mm) (upper) and juvenile and adult smallmouth bass (≥ 100 mm) (lower), 2004-2010, for the Grand Valley reaches of the Upper Colorado and Lower Gunnison rivers. Note: numbers of smallmouth bass removed in parentheses.

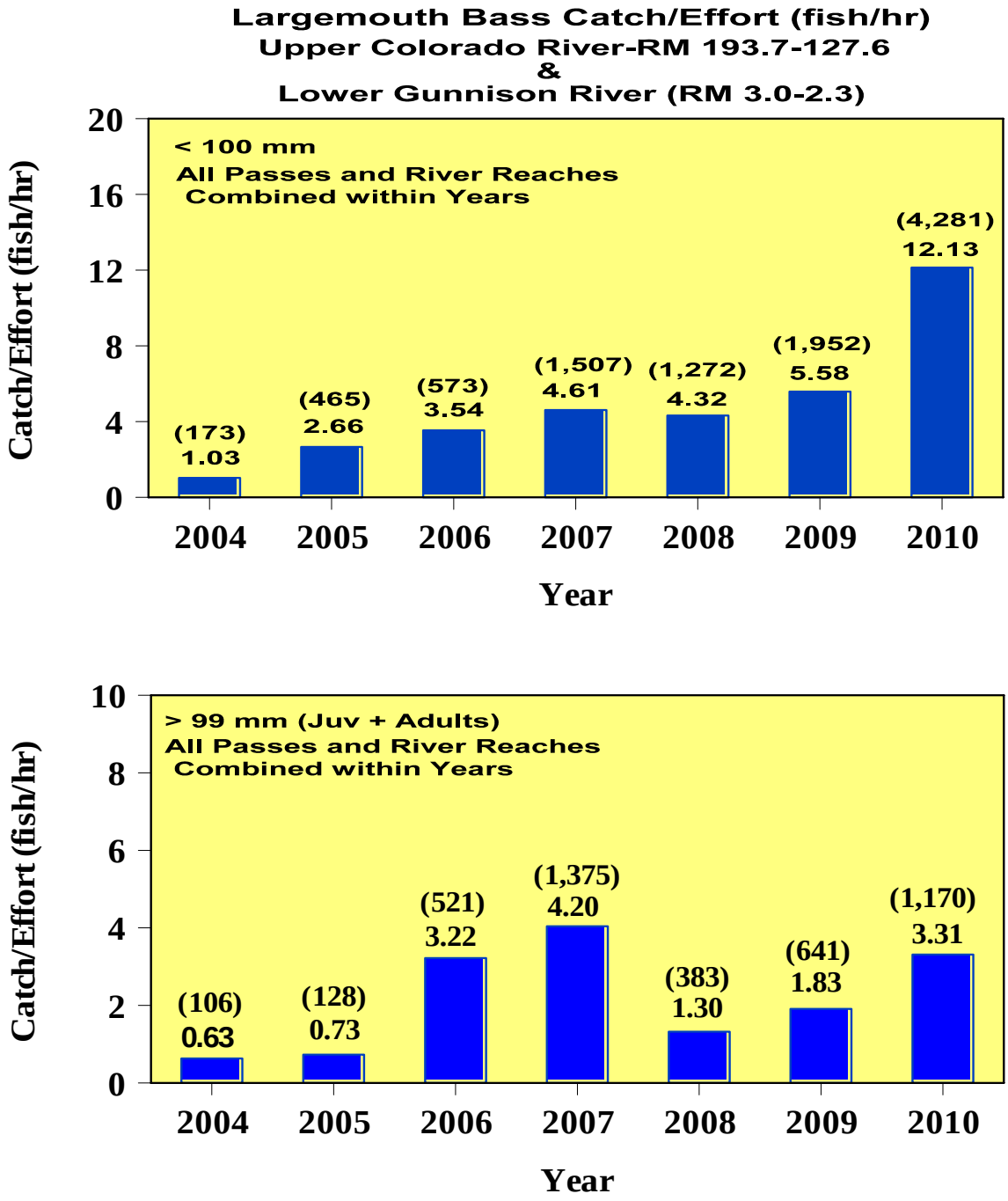

Figure 5. Seven year comparison of catch/effort (fish/hr) for largemouth bass (< 100 mm) (upper) and juvenile and adult smallmouth bass (≥ 100 mm) (lower), 2004-2010, for the Grand Valley reaches of the Upper Colorado and Lower Gunnison rivers. Note: numbers of largemouth bass removed in parentheses.