COLORADO RIVER RECOVERY PROGRAM
FY 2011 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 eighth 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 bass abundance in the 18- and 15-mile reaches plus the 2.3 miles of the lower Gunnison River for 2011 using a single mark and first removal pass was estimated

to be 1,718 ± 1,115 (603 – 2,833)(95% C.I. in parenthesis) for smallmouth bass 100-199 mm or about 48.7 fish/mile and 110 ± 108 (2 – 218) (95% C.I. in parenthesis) for smallmouth bass ≥ 200 mm or about 3.1 fish/mile. The weighted probability of capture (p-hat) was computed as 0.056 and 0.071, respectively, for these two length groups. Computed exploitation rates were 42.0 and 52.1 percent for juvenile (100-199 mm) and adult (≥ 200 mm) smallmouth bass, respectively. Even though the adult abundance estimate is the lowest recorded for the six years population estimates have been provided, the reliability of the 2011 adult abundance estimate may be suspect because only one marked fish was recaptured. The 87 % decline from 2010 to 2011 for adult smallmouth bass abundance did not correlate well with removal catch rates (34 % decline). The strong cohort produced in 2010 apparently survived overwinter and then the sustained 2011 spring discharge because the juvenile (100-199 mm) smallmouth bass abundance estimate increased 6.7 fold (255 vs. 1,718) in 2011 from 2010. The reliability of the 2009 abundance estimate was also questionable because of the low number of recaptured marked smallmouth bass. The 2009 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. 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 reflected 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.

Smallmouth bass reproduced during 2011 as they did between 2004 and 2010 in the Grand Valley reaches. It appears that during 2010, a strong year class of smallmouth bass (< 100 mm) was produced (5.82 fish/hr) in the Grand Valley reaches which was the highest recorded in this eight-year study. This statistic was greater than that of the strong year class of smallmouth bass that was produced in 2007 (4.54 fish/hr). However, a weak year class of smallmouth bass was produced in 2011 (0.55 fish/hr). This was similar to weak year classes of smallmouth bass that were produced in 2004 (0.55 fish/hr), 2008 (0.63 fish/hr), and 2009 (0.55 fish/hr). In the Rifle to Beavertail Mountain reaches, overall smallmouth bass (all length sizes) relative abundance decreased during 2011 (0.49 fish/hr) from 2010 (1.21 fish/hr). While smallmouth bass reproduction was noted in 2011 for these upper reaches, no age-0 fish were found in 2011.

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). In 2011, the largemouth bass catch rate (6.05 fish/hr) declined by about 50% from that of 2010. Eighty-eight percent (n=2,938) of these fish in 2011 were less than 150 mm; 76% (n=2,507) were less than 100 mm. Only 0.1% (n=33) of the total number of fish were greater than 250 mm--similar to collections from the previous seven years. Survival of largemouth bass to adults (≥ 200 mm) in the river is apparently relatively low. In the Rifle 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 continued to decline sharply. In 2011, catch rate for all sizes of largemouth bass increased to 2.14 fish/hr from the previous two years. For the years monitored between 2004 and 2011, 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 or from off-channel habitats is not as successful as the downstream reaches of the Grand Valley.

IV. Study Schedule:
a. initial year: 2004
b. final year: 2011

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 2011 Tasks and Deliverables, Discussion of Initial Findings and Shortcomings:

A. FY-2011 Tasks and Deliverables:

Task 1. Remove all sizes of smallmouth bass.
Sub-Task 1a. Mark and release smallmouth bass (100-199 mm and ≥ 200 mm) during pass 1 in 2011.

Tasks completed.

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

Task completed. Preparation of the annual report also sufficed for the December 2011 nonnative fish workshop.

B. Findings (2011 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 (FWS) personnel and two by Colorado Parks and Wildlife (CPW) personnel. Two removal passes performed by the CPW were 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 2011 were similar to that of 2007, 2008, 2009, and 2010. 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 2006-2011. 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

General

Methodology differed slightly during 2011 from earlier years. Two electrofishing craft were used in 2011 to collect smallmouth bass for marking and other centrarchids in the Grand Valley reaches of the Upper Colorado and lower Gunnison rivers compared to three electrofishing rafts that were used to collect centrarchid fishes in 2008, 2009, and 2010, in each river segment during the marking pass. The additional sampling craft was used in an attempt to increase the number of marked smallmouth bass. Two electrofishing craft were used during the 2006 and 2007 marking passes. 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 2011marking pass was performed over a 1-week period starting on 9 August which was about two weeks later than previous years due to the prolonged high spring runoff. Following the marking pass, ten removal passes (eight by FWS and two by CPW) were made using aluminum boat and raft-based electrofishing to collect centrarchid fishes from 16 August to 26 October. The 2007-2011 CPW effort mainly focused on four Grand Valley reaches with the highest abundance of smallmouth bass, as determined from previous removal passes.

Two electrofishing craft were used in every river segment during the ten 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 – 2011. 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 the head end of Black Rocks (RM 136.0). The reach between Black Rocks and Westwater, Utah, was not sampled during 2011. Other reaches that were not sampled during 2011 were the 3.9-mile section between Government Highline Diversion Dam and the XCEL Bridge at Cameo. This 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. Also, only six passes were made between Price-Stubb Dam and GVIC Diversion Dam near Palisade in 2011.

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 2011, the number of passes in this 45-mile reach was reduced from three to one. Moreover, the only reaches sampled during 2011 were between Rifle and Rulison and Rulison and Cottonwood Park boat landing at Parachute (RM 222.2). The remaining reaches between Parachute and Beavertail Mountain were not sampled because of access issues. The reason the number of removal passes was reduced from three to one in these upper reaches was to reallocate these two removal passes to the Grand Valley to help target removal of the strong year-class of smallmouth bass produced in 2010. The same sampling protocol was utilized in these most upstream reaches. This sampling occurred later in 2011 (18 and 19 October) than previous years (early July).

Although smallmouth bass were the target fish for removal in this project, all other centrarchid fishes encountered were collected. 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).

Catch Rate

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 – 2011 and catch/effort was computed for use as a trend to compare annual abundance of smallmouth bass and other centrarchids during 2004 – 2011. 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).

Abundance Estimate

For the population estimate in 2011, 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 and Conclusions

Results presented herein are a compilation of the efforts of both FWS (removal passes 1 through 8 and a single marking pass) and CPW (removal passes 9 and 10) in the Grand Valley reaches of the Upper Colorado and Lower Gunnison rivers during 2011. Removal passes performed by the FWS in the Upper Colorado River between Rifle and Cottonwood Park boat landing near Parachute and Loma to Black Rocks 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 – 2010) of this study are provided where appropriate. While other centrarchid fishes (green sunfish, bluegill, black crappie) were removed in 2011, results reported for these three fishes in former annual reports are not presented in the 2011 annual report.

Size Distribution–Length Frequency.

Smallmouth Bass

Length frequency distribution of all sizes of smallmouth bass collected with electrofishing during 2011 between the Price-Stubb fishway and Black Rocks, and the Lower Gunnison River were plotted for the marking pass, and three time periods (August 16-September 7; September 8-September 29; September 30-October 26) during the 10 removal passes (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 2011 summer collections (Figure 1). These ranged from age-0 (22 mm) to adult (391 mm) fish. A strong year class of smallmouth bass (< 100 mm) 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 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], smallmouth bass reproduced during 2011 as they did between 2004 and 2010. It cannot be proven 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 numbers of smallmouth bass within the 2008 and 2009 year classes (< 100mm) were noticeably less than those of the three previous years (2005, 2006, and 2007) from catch rate data. Catch rates for smallmouth bass < 100 mm 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 and 2010 year classes, young smallmouth bass (<100mm) have proven to be highly susceptible to low survival to age-1.

Largemouth Bass

A total of 3,332 largemouth bass were collected during the ten removal passes. Eighty-eight percent (n=2,938) of these fish were less than 150 mm; and 76% (n=2,507) were less than 100 mm. Only 0.1% (n=33) of the total number of largemouth bass were greater than 250 mm (Figure 3). This suggests that survival of juvenile 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. And, in 2011, two additional removal passes were added totaling ten. 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 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 16 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. No smallmouth bass were collected at Redlands in 2011.

Catch/Effort.

General

Mean catch/effort (fish/hr) was computed separately for smallmouth bass and largemouth bass for each of the eight sampling years, 2004 – 2011. 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 Westwater, Utah, plus the Lower Gunnison River).

Effort 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. In 2011, the total effort was (1marking and 10 removal passes) was 449.934 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. During 2011, the total effort (12.626 hours) was much less than former years due to only one pass being performed and some reaches not being sampled.

Smallmouth Bass

For the Grand Valley river reaches, the trend for smallmouth bass relative 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 ≥ 100 mm (0.98 fish/hr) increased slightly from 2009.

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. Length frequency comparison between 2008 (see 2008 annual report no. 126(a) and 2009 suggest that the 2009 year class may have been 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 were 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 was some reason for concern. The highest number of juvenile smallmouth bass (< 100 mm) during this eight-year study was collected in 2010 from the Grand Valley reaches of the Upper Colorado and Lower Gunnison rivers . 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) (Table 1). A strong year class of smallmouth bass was produced in 2007 which was documented throughout upper Colorado River basin rivers.

These young life stages can be subject to high mortality to age-1 due to a myriad of environmental factors over the winter. Small age-0 smallmouth bass going into winter may be susceptible to higher overwinter mortality because their relatively small body size limits energetic reserves that may run out before spring arrives. Therefore, overwinter survival is not known until the following summer sampling season. Now that the 2011 sampling is complete, from the abundance estimate for juvenile smallmouth bass (100-199 mm), the 2010 cohort apparently survived overwinter and was able to withstand or somehow avoid the high, sustained spring discharge. Catch rates for this juvenile size class (100-199 mm) increased from 0.45 fish/hr in 2010 to 1.47 fish/hr in 2011, a 3.3 fold increase. This is also reflected in the population abundance estimate—255 fish in 2010 to 1,718 fish in 2011—a 7.5 fold increase. The survival of the 2007 and 2010 year classes were high because this size class was highly represented in the 2008 (50-149 mm range) and 2011 (75-149 mm range) marking passes, respectively (see Figure 2). The strong year classes produced in both 2007 and 2010 may continue to recruit to the adult smallmouth bass population which may contribute to the persistence of this species in the Grand Valley reaches of the Upper Colorado and Lower Gunnison rivers.

In 2011, the catch rate for juvenile size fish < 100 mm declined precipitously (91%) from 2010 from 5.82 fish/hr to 0.55 fish/hr, similar to catch rates during 2004 and 2009 (Figure 4). The hypothesized reason for this decline was the prolonged high stream discharge from the 2011 spring runoff. Elevated discharge extended into July, which delayed river waters from warming. Decreased and prolonged cooler river temperature may have resulted in smallmouth bass delaying spawning, larvae hatching later, or even weak, young smallmouth bass being swept away from nests or quiet near-shore habitat resulting in high mortality. This in turn probably led to a shorter growing season and, ultimately, reduced growth for age-0 smallmouth bass. In any event, these environmental conditions probably lead to a shorter growing season and a weak year class of smallmouth bass being produced in 2011.

The hydrologic conditions of 2008, 2009, and 2011 in the Upper Colorado River were similar, 2011 being the most dramatic because of the prolonged high discharge extending into July. These three 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 three wetter years with accompanying prolonged cooler water temperatures may have disrupted or delayed spawning resulting in slower growth of early-life stages (i. e., age-0) of smallmouth bass, and ultimately 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 the Grand Valley reaches in 2008 and 2009 which both produced weak year classes was 8 (42 mm total length) and 14 August (39 mm total length), respectively. It appears that smallmouth bass spawned later in 2011 than any previous years of this eight-year study. In 2011, age-0 smallmouth bass were first detected on 24 August (n=3; 22, 35, and 46 mm). Other age-0 smallmouth bass (n=12; 25-32 mm) were collected between 5 October and 11 October. 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. During the 2010 marking pass in the Grand Valley reaches, (Figure 2) age-0 smallmouth bass were first detected on 28 July (31 mm).

In the Rifle to Beavertail Mountain reach, smallmouth bass (all length sizes) relative abundance increased in 2010 (0.92 fish/hr) from the three earlier years. Catch rate for all length sizes of smallmouth bass declined to 0.49 in 2011. Mean catch/effort for all sizes of smallmouth bass was 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). Spawning success in these reaches appears not to be as successful as that in the Grand Valley reaches. Age-0 (< 100 mm) smallmouth bass catches have been less than that of the Grand Valley reaches throughout the eight-year project. 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 or 2011. Only one smallmouth bass (237 mm) was collected between Rifle and Silt at RM 241.2 during 2007; none were collected during 2008. 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.

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 6.7 times 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. Catch rate, however, declined in 2011 to 1.96 fish/hr.

For the Grand Valley river reaches, in 2011, catch rate for largemouth bass < 100 mm (6.05 fish/hr) declined 50 % from 2010 (12.13 fish/hr). It now appears that the 2010 year class has been the strongest in this eight-year study which was initiated in 2004. Overall mean catch rate for largemouth bass < 100 mm total length steadily increased since 2004 from 1.03 fish/hr to a high of 12.13 fish/hr in 2010 (Table 2; Figure 5). 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 and/or timing (temperature conditions) between smallmouth bass and largemouth bass spawning. 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) 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 eight-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 during 2008 (5.4 fish/hr)(Table 2). In 2010, catch rate (0.3 fish/hr) was the second lowest in this eight-year study. In 2011, overall catch rate (all length sizes) was 2.14 fish/hr, an increase over 2010 and 2009.

Population Size.

Smallmouth Bass

During the marking pass performed in August 2011, a total of 113 smallmouth bass (101 juvenile size [100-199 mm], 12 adult size [≥ 200 mm]) were marked and released alive. Thirteen (10 juvenile, 3 adult) of these marked fish were later recaptured during ten removal passes (Table 3). Since a 'batch' mark was employed and smallmouth bass were not marked with a serially numbered tag, movements of individual fish were not possible. Seven marked fish (six juvenile, one adult) were recaptured in removal pass 1. Three marked fish (one juvenile, two adult) were captured during pass 2, and two marked fish (two juveniles) were captured during pass 3. One marked juvenile was detected during removal pass 5. No marked fish were captured during passes 4, and 6-10. Crews were instructed to look for marked fish during all ten removal passes. In 2010 and 2011, a different mark was employed and it appeared that this new mark could be more reliably detected throughout all removal passes than previous batch marks employed (e.g., fin

punches) which extended from early-August through late-October. All 13 marked smallmouth bass were recaptured within the original marking reaches. The total number of smallmouth bass removed over ten removal passes was 611 juveniles (100-199 mm) and 147 adults (≥ 200 mm)(Table 5).

The 2011 population point estimate (95% C.I. in parenthesis) was 1,718 ± 1,115 (603 – 2,833) for smallmouth bass 100-199 mm and 110 ± 108 (2 – 218) for smallmouth bass ≥ 200 mm. The weighted probability of capture (p-hat) was computed as 0.056 and 0.071, respectively, for these two length groups. The CV was 10.4 % and 50.0 %, respectively, for these two length classes. 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 4 % (117/2,833) for juvenile fish 100-199 mm which computes to about an average of 48.7 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 7 % (16/218) or an average of 3.1 adult smallmouth bass/mile.

The 2010 population point estimate (95% C.I. in parenthesis) was 255 ± 196 (59 –451) for smallmouth bass 100-199 mm and 823 ± 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 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 computed 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 a 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. The same could be

said for the 2011 adult smallmouth abundance estimate where only one adult fish was recaptured in the first removal pass to compute the abundance estimate. This low precision of the abundance estimate was reflected in the high CVs (50 % and greater) for 2009 and 2010 (adults)(Table 3). In 2009 as in 2008, declining catch rates reflected 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, as well as the adult abundance estimate for 2011, 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 computed 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 computed 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 computed to an average of about 65 fish/mile. Abundance estimates for juvenile (100-199 mm) smallmouth bass peaked in 2011 (1,718 fish) due to a strong year class of smallmouth bass being produced in 2010. Juvenile smallmouth abundance was lowest in 2010 (255 fish) in the 35.3 miles of the Upper Colorado and Lower Gunnison rivers in the Grand Valley reaches. 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 adult 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 and adult smallmouth bass in 2011were 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 – 2011 (Table 4). 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; 2011 (fish 100-199 mm): 42.0, (fish ≥ 200 mm): 52.1. 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 six years abundance estimates have been computed.

Other Nonnative Game Fishes.

Ten adult northern pike were captured in the 2011 centrarchid removal efforts by FWS and CPW. Nine of these fish were collected from the Rifle Bridge to Cottonwood Park boat landing near Parachute in mid-October (Table 5). Three northern pike were captured immediately underneath the I-70 bridge at RM 238.2; seven northern pike were captured between RM 238.2 and the Rifle Bridge. For reference point, Rifle Creek empties into the Colorado River at RM 239.8. One other northern pike was collected in September between Price-Stubb fishway and GVIC Diversion Dam at Palisade (RMs 187.7-184.9). One other northern pike (680 mm) was captured in the fish trap of the Redlands fishway on the Lower Gunnison River in 2011. All 11 of these fish have been preserved (frozen) for future otolith microchemisty analyses. Such analyses can help in determining their possible origin, i.e., had this fish escaped from off-channel riverine habitats such as isolated gravel pits breached by the 2011 high spring flows and now connected to the mainstem river, escaped from nearby reservoirs, or possibly illicitly translocated.

One yellow perch (57 mm) was collected between Corn Lake and the Colorado/Gunnison River confluence during 2011.

Other Nonnative Non Game Fishes.

Captures of adult gizzard shad in the Upper Colorado and Lower Gunnison rivers exploded during 2007 (total=179). One hundred thirty-nine adult gizzard shad were collected during the 2007 smallmouth bass removal project. An additional 43 were collected in the fish trap of the Redlands Dam fish passageway. This compares to 12 captured during the smallmouth bass removal study in 2006 and only 3 in the Redlands fish passageway fish trap. One age-0 or age-1 gizzard shad (66 mm) was collected in the Upper Colorado River during 2009.

However, in 2008 the number of gizzard shad collected declined markedly from 2007, almost one magnitude less. Eighteen gizzard shad were collected during 2008, all from Grand Valley reaches of the Upper Colorado and Lower Gunnison rivers. No gizzard

shad were found in the fish trap at the Redlands fish passageway in 2008. During the 2009 centrarchid removal, 36 gizzard shad (three juvenile and 33 adult) were collected in the Grand Valley reaches. Three adult gizzard shad were also collected in the fish trap of the Redlands fish passageway during 2009.

In 2010, 40 adult gizzard shad were captured during the centrarchid removal study and five adults were collected in the fish trap at the Redlands fishway. In 2011, no gizzard shad were observed or collected from the centrarchid removal study or Redlands fish trap. No gizzard shad were collected in the Government Highline fish passageway between 2006 and 2011.

VII. Recommendations: (this assumes that some level of field activities will resume in 2012 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.

2. Restore using three electrofishing craft rather than two 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. 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.

5. Continue sampling the Upper Colorado reaches from the Rifle Bridge to Beavertail Mountain in Debeque Canyon. In 2011, only one removal pass was performed. But with the capture of nine adult northern pike from Rifle to Cottonwood Park boat landing in 2011, additional passes with appropriate funding should be reconsidered to determine the extent of northern pike occupation in these upper reaches. It might also be advisable to sample the 7-mile reach between Silt and Rifle to determine if northern pike now occupy that reach. Continue sampling the river reach between the Loma Boat Landing and Westwater Ranger Station, Utah, to annually monitor and detect potential increased smallmouth bass abundance.

6. Evaluate the feasibility of sampling floodplain ponds (specifically those tied to gravel pit operations and others that have hydrologic connections directly to the Colorado River) in the Silt and Rifle areas to determine fish species presence and abundance/density.

7. Complete otolith microchemistry analyses to determine the origin of northern pike

collected in the Colorado River, and evaluate other potential habitable locations these fish may have occupied beyond their origination.

8. 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.

9. Downstream from Price-Stubb fish passage, electrofishing should commence following cessation of spawning of Colorado pikeminnow which should be sometime in mid- to late-July.

VIII. Project Status:

A. 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 2012 are planned, but the level of removal effort has had to be reduced due to funding for this project being reduced by 20% from the 2009 budget level. As a result, the number of removal passes to be performed by the FWS in the Grand Valley reaches will be reduced from the original number of six to five (17% decrease) in 2012. The two additional removal passes performed in 2011 by the FWS in the Grand Valley was effort reallocated from the two removal passes that had been performed in former years for reaches between Rifle and Beavertail Mountain. Additionally, CPW will not be performing any removal passes in the Grand Valley in 2012 as in former years because of elimination of Recovery Program funds for their portion of the project.

An additional 3.9-mile reach (Government Highline Dam to Cameo Bridge) was added in 2009 and was sampled in 2010. However, this reach was not sampled in 2011. Adding this reach has increased the total number of work days (eight) to the project to perform this work. This reach will not be sampled in 2012 due to a 20% budget reduction and because smallmouth bass densities (0.11 fish/hr) have been low to date in this reach.

Clarification of future field activities and study direction may be determined at the 2011 Recovery Program nonnative fish workshop in early-December.

IX. FY 2011 Budget Status
126a--USFWS

A. Funds Provided: $ 157,171
B. Funds Expended: $ 157,171
C. Difference: $ –0–

D. Percent of the FY 2011 work completed, and projected costs to complete: 100%.
E. Recovery Program funds spent for publication charges: $ –0–

126b—CPW

A. Funds Provided: $ 15,348
B. Funds Expended: $ 15,348
C. Difference: $ –0–
D. Percent of the FY 2011 work completed, and projected costs to complete: 100%.
E. Recovery Program funds spent for publication charges: $ –0–

X. Status of Data Submission (Where applicable): Colorado pikeminnow, razorback sucker, and bonytail were endangered fish collected during this evaluation in 2011. 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 CPW personnel.

XI. Signed:

Bob D. Burdick	28 November 2011
Co-Principal Investigator	Date
Lori M. Martin	28 November 2011
Co-Principal Investigator	Date
Jenn Logan	28 November 2011
Co-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: 5 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, 11/28/2011
2011-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 193.7.7 – 136.0) and the Lower Gunnison River from the Redlands Diversion Dam to the Colorado/Gunnison River confluence (river miles 3.0 – 0.7) from 2004 – 2011. 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, d) in 2011, some reaches were not sampled which included Black Rocks to Westwater Ranger Station, Government Highline to Cameo, and Cottonwood Park boat landing to Beavertail Mountain.

		Smallmouth Bass								
River Section	Length Class (mm)		Year							
			2011	2010	2009	2008	2007	2006	2005	2004
Rifle ▸ Beavertail Mountain	< 100	No. of fish	0	57	0	21	17	36	58	3
		C/E	0.00	0.72	0.00	0.25	0.20	0.96	1.46	0.15
	100-199	No. of fish	6	0	3	29	28	2	54	4
		C/E	0.48	0	0.05	0.34	0.32	0.05	1.36	0.20
	≥ 200	No. of fish	5	39	12	32	45	41	118	14
		C/E	0.01	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	226	2,054	191	185	1,358	261	254	93
		C/E	0.55	5.82	0.55	0.63	4.15	1.61	1.46	0.55
	100-199	No. of fish	611	159	137	214	250	54	345	618
		C/E	1.47	0.45	0.39	0.73	0.76	0.33	1.98	3.66
	≥ 200	No. of fish	147	188	177	135	429	449	768	456
		C/E	0.35	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 193.7 – 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 – 2011. 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, d) in 2011, some reaches were not sampled which included Black Rocks to Westwater Ranger Station, Government Highline to Cameo, and Cottonwood Park boat landing to Beavertail Mountain.

		Largemouth Bass								
River Section	Length Class (mm)		Year							
			2011	2010	2009	2008	2007	2006	2005	2004
Rifle ▸ Beavertail Mountain	< 100	No. of fish	9	24	36	462	122	125	10	53
		C/E	0.71	0.30	0.58	6.05	1.40	3.33	0.25	2.68
	100-199	No. of fish	13	31	29	90	109	71	10	11
		C/E	1.03	0.39	0.47	1.05	1.26	1.89	0.25	0.56
	≥ 200	No. of fish	5	13	5	43	56	15	17	2
		C/E	0.40	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	2,463	4,281	1,952	1,272	1,507	573	465	173
		C/E	6.05	12.1	5.58	4.32	4.61	3.54	2.66	1.03
	100-199	No. of fish	712	1,141	609	344	1,332	487	86	85
		C/E	1.72	3.23	1.74	1.17	4.07	3.01	0.49	0.50
	≥ 200	No. of fish	102	29	32	39	43	36	38	21
		C/E	0.25	0.08	0.09	0.13	0.13	0.22	0.22	0.12

Table 3. 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 - 2011. 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 3. (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	22.8	41.6	0.053
2011	100-199	1,718 ± 1,115	569	48.7	101;117	6	10	10	611	35.6	10.4	0.056
	≥ 200	110 ± 108	55.1	3.1	12;16	1	3	10	147	135	50.0	0.071

Table 4. 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 – 2011.

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]
2011 [e]	100-199	101	111	0.056	42.0 [d, e]
	≥ 200	12	16	0.071	52.1 [d, e]

[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).

[e] Ten removal passes ("n"). Includes fish removed by FWS (passes 1-8) and CDOW (passes 9-10).

Table 5. Captures of northern pike from the Upper Colorado River from Rifle, Colorado (RM 240.4) to Cottonwood Park Boat Landing (RM 222.5), Price-Stubb Dam (RM 187.8) to Black Rocks (RM 136.5), and the Lower Gunnison River (RM 3.0-0.7) during the smallmouth bass/centrarchid removal studies and in the fish trap at the Redlands fishway on the lower Gunnison River, 2011.

	Capture Data					
Species	Year	No. of Fish	Date	River	River Mile	Total Length (mm)
	2011	1	7/05	GU	3.0 [a]	680
N. Pike	2011	1	9/26	CO	187.7-184.9	800
	2011	1	10/18	CO	240.4-239.0	512
	2011	1	10/18	CO	240.4-239.0	688
	2011	1	10/18	CO	239.0-238.0	628
	2011	1	10/18	CO	239.0-238.0	630
	2011	1	10/18	CO	239.8	654
	2011	1	10/18	CO	239.8	682
	2011	1	10/18	CO	238.2	630
	2011	1	10/18	CO	233.2	978
	2011	1	10/19	CO	227.6	700

[a] Northern pike captured in the fish trap at the Redlands fishway.

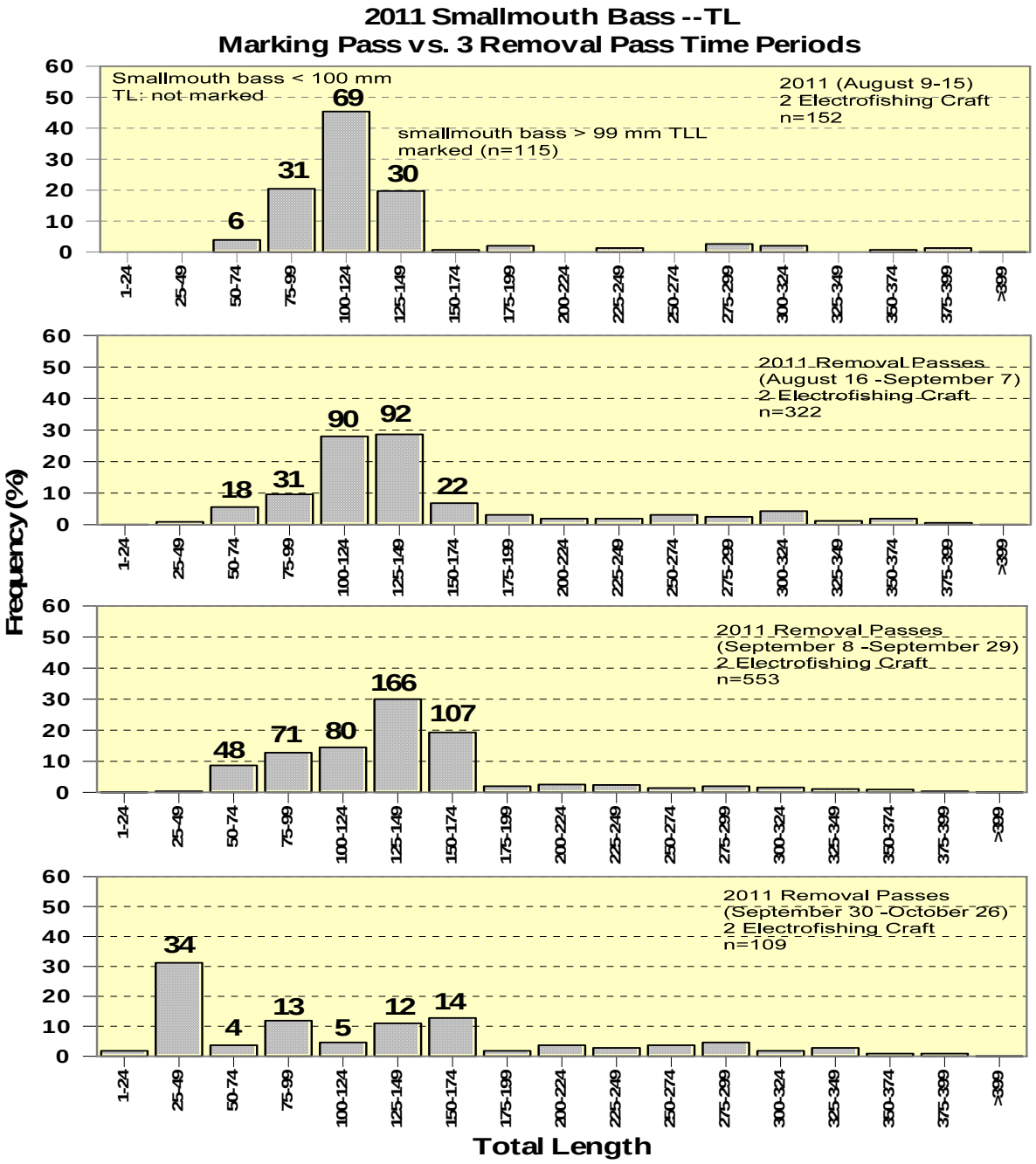

Figure 1. Length frequency comparison among the marking (top) and subsequent ten removal passes during three time periods: 16 August-7 September (second from top), 8 September-29 September (third from top), and 30 September-26 October (bottom) for all smallmouth bass collected during 2011 in the Grand Valley and Ruby and Horsethief canyon reaches of the Upper Colorado and Lower Gunnison rivers. Note: numbers of smallmouth bass removed above bars.

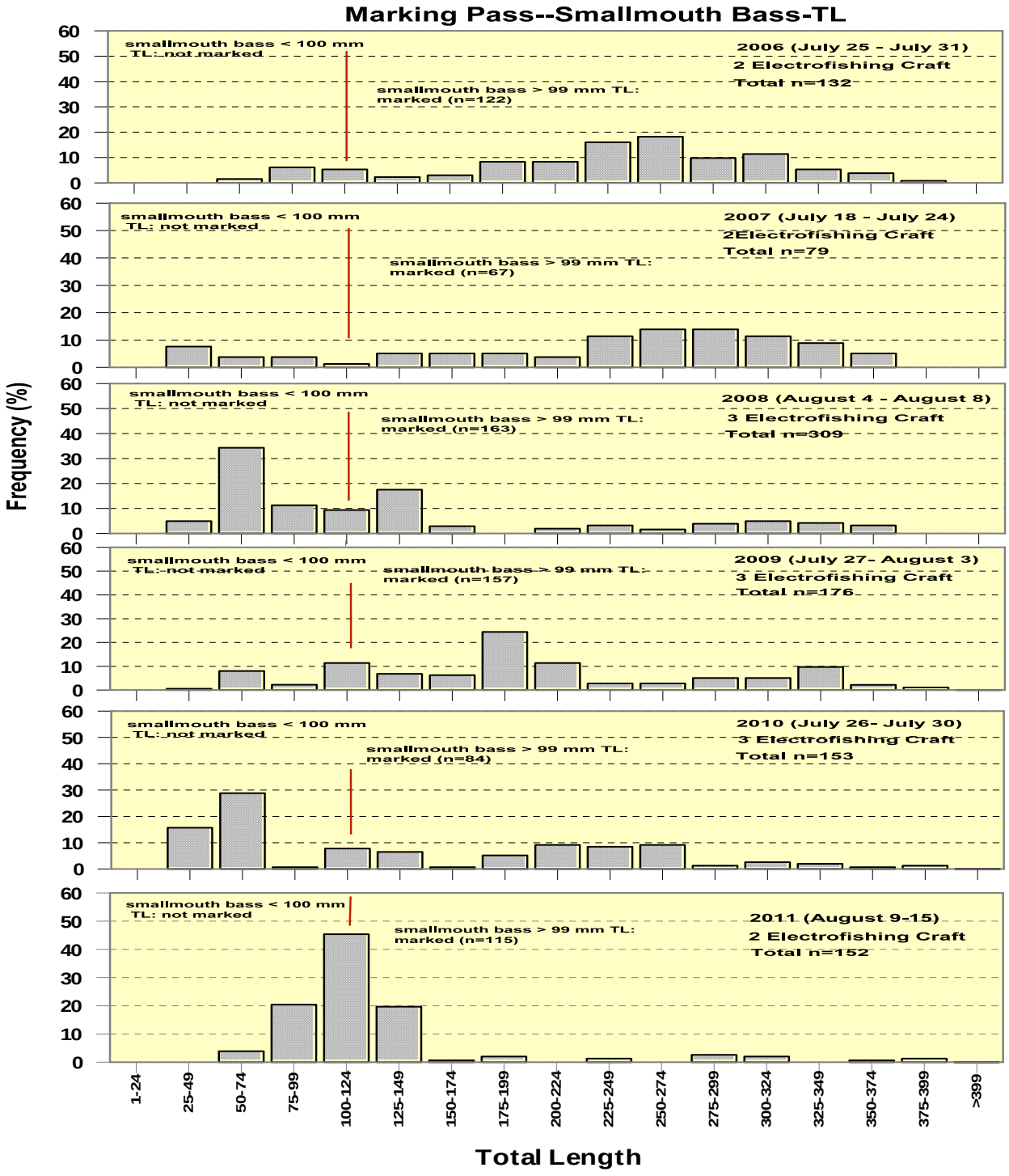

Figure 2. Length frequency comparison among 2006 – 2011, for all smallmouth bass collected during the marking pass in the Grand Valley reaches of the Upper Colorado and Lower Gunnison rivers. Note: vertical line above 100 mm demarcates smallmouth bass marked (≥ 100 mm) vs. those not marked (< 100 mm) during the marking pass.

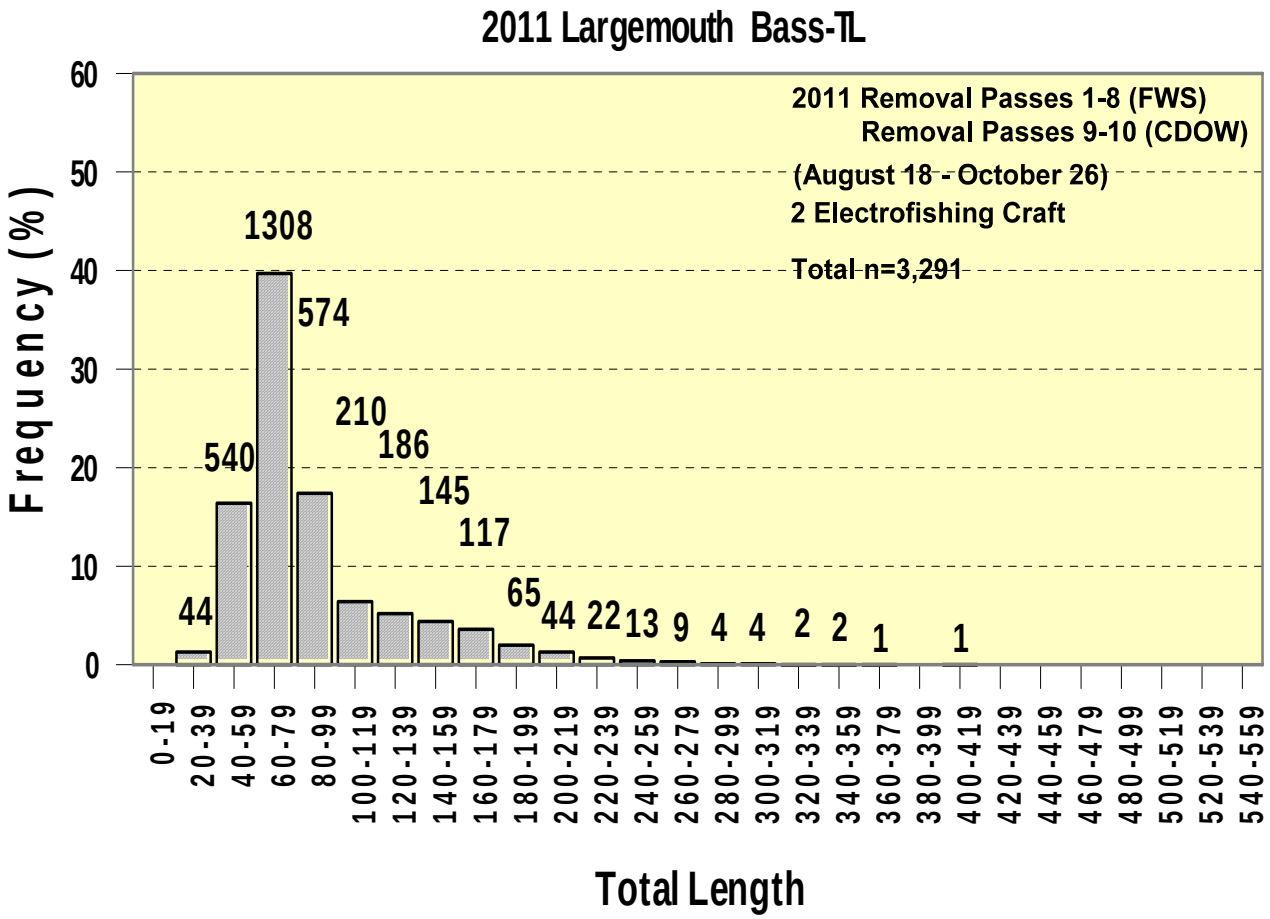

Figure 3. Length frequency for all largemouth bass collected during the ten removal passes during the summer of 2011 in the Grand Valley reaches of the Upper Colorado and Lower Gunnison rivers. Note: numbers of largemouth bass removed above bars; 41 largemouth bass < 100 mm were not measured for total length afield.

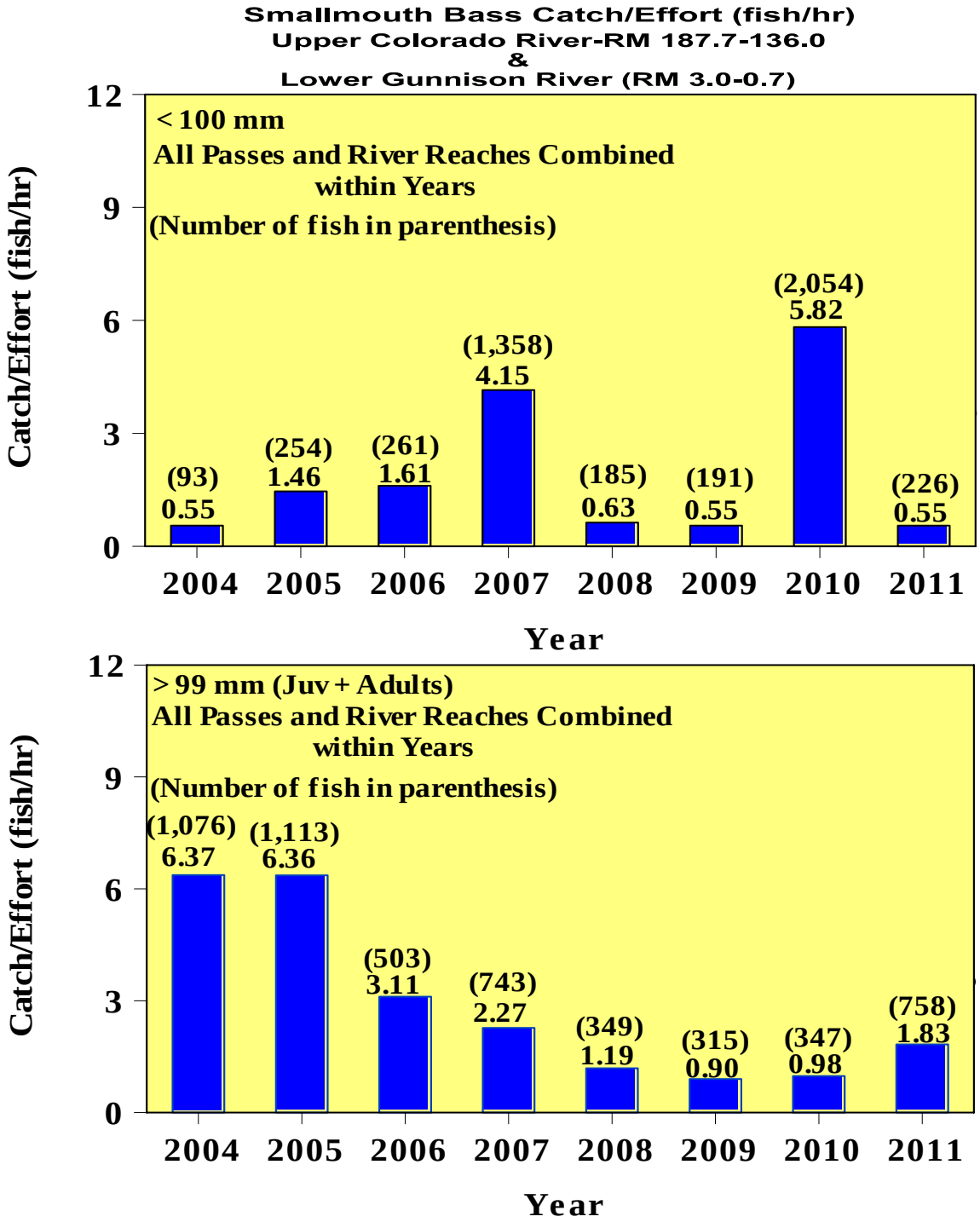

Figure 4. Eight year comparison of catch/effort (fish/hr) for smallmouth bass (< 100 mm) (upper) and juvenile and adult smallmouth bass (≥ 100 mm) (lower), 2004-2011, for the Grand Valley reaches of the Upper Colorado and Lower Gunnison rivers. Note: numbers of smallmouth bass removed in parentheses.

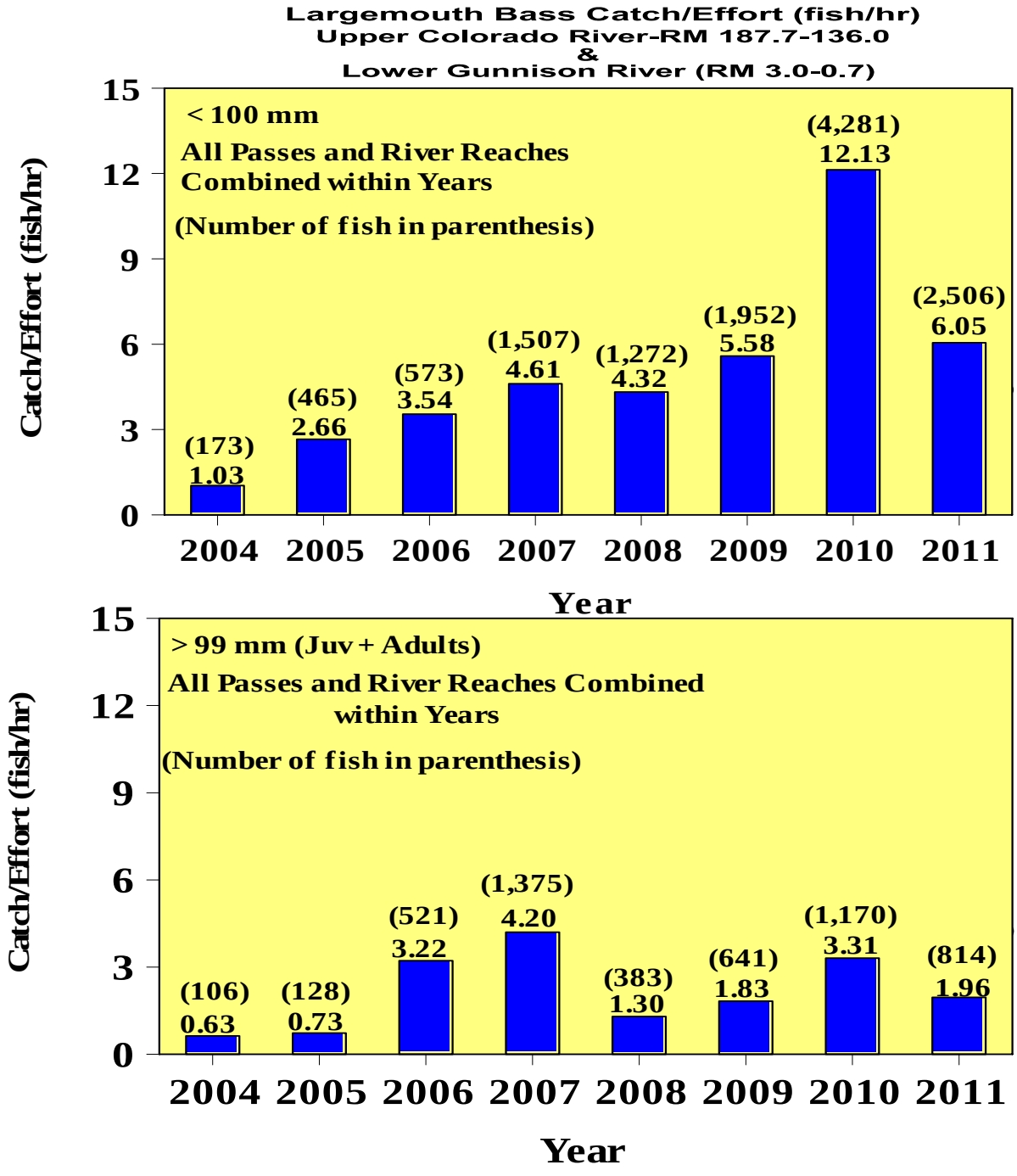

Figure 5. Eight year comparison of catch/effort (fish/hr) for largemouth bass (< 100 mm) (upper) and juvenile and adult smallmouth bass (≥ 100 mm) (lower), 2004-2011, for the Grand Valley reaches of the Upper Colorado and Lower Gunnison rivers. Note: numbers of largemouth bass removed in parentheses.