

- 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 is to 1) 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. The goal is to reduce the abundance of smallmouth bass as quickly as possible in this reach which will ultimately benefit native listed fishes, and possibly contribute to their recovery. An additional objective was added for 2006: obtain an abundance estimate [for smallmouth bass] during 2006 and subsequent years by mark and recapture methods for the Upper Colorado River between Price Stubb Dam and Fruita State Park. This is the fifth year of this study which started in 2004. For 2007 and 2008, four additional removal passes were added in the Grand Valley portions of the Upper Colorado and Lower Gunnison rivers. The Silt to Rifle reach was added and an additional removal pass was performed between Silt and Beavertail Mountain.

In the Grand Valley reaches of the Upper Colorado and Lower Gunnison rivers, smallmouth bass abundance has continued to steadily decline in 2007 and 2008 from 2006 when population estimates commenced. Declining catch rates reflect this downward trend. Smallmouth bass  $\geq 100$  mm catch rate declined to 1.19 fish/hr in 2008, the lowest in five years. The highest catch rate was 6.37 fish/hr in both 2004 and 2005 for smallmouth bass  $\geq 100$  mm. This decline was consistent with the population estimate generated in 2006 and 2007 using a single mark and first removal pass. Smallmouth bass ( $\geq 100$  mm) abundance in the 18- and 15- mile reaches plus the 2.3 miles of the Lower Gunnison River for 2008 using a single mark and first removal pass was estimated to be  $1,299 \pm 588$  individuals or about 36.8 smallmouth bass/mile  $\geq 100$  mm. This compares to a population estimate of  $1,427 \pm 986$  individuals or about an average of 40.4 smallmouth bass/mile  $\geq 100$  mm in 2007 and a population estimate of  $3,197 \pm 2,100$  (91 fish/mile) smallmouth bass of the same length sizes in 2006. The decline between 2006 and 2007 was 55 %; the decline from 2007 to 2008 was only 9%. Population estimates for smallmouth bass  $\geq 150$  mm also followed the same downward trend during the same 3-year period:  $2,792 \pm 1836$  (2006),  $1,270 \pm 869$  (2007), and  $554 \pm 340$  (2008).

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 2008 as they did during 2004, 2005, 2006, and 2007. A strong year class of smallmouth bass was produced in 2007, the highest catch rate (4.54 fish/hr) for smallmouth bass < 100 mm recorded during this five-year study. However, in 2008, smallmouth bass < 100 mm declined to 0.63 fish/hr. In the Silt to Beavertail Mountain reaches, overall smallmouth bass (all length sizes) abundance has declined for the fourth year in row.

On the other hand, largemouth bass abundance for fish < 100 mm has steadily increased from 2004 to 2007 in the Grand Valley river reaches and were most abundant during 2007. Largemouth bass < 100 mm catch rate increased from 1.03 fish/hr (2004) to 4.54 fish/hr (2007) and only declined slightly in 2008 to 4.32 fish/hr. Largemouth bass  $\geq$  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. In the Silt to Beavertail Mountain reaches, no apparent trend from year to year appears to be evident. Largemouth bass catch rates declined from 5.62 fish/hr (2006) to 3.30 fish/hr (2007), but increased to 6.93 fish/hr in 2008. For the four years monitored between 2004 and 2007, abundance of young-of-the-year and age-1 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 6.05 fish/hr, almost twice that of 2006 (3.33 fish/hr) in these upper reaches. In the Grand Valley reaches, captures of green sunfish, bluegill, and black crappie appear to be increasing. Between 2004 and 2008, the catch rate for all three of these fishes was the highest during 2008 (black crappie [0.67 fish/hr], bluegill [4.90 fish/hr], green sunfish [6.70 fish/hr]).

Mean total length for smallmouth bass  $\geq$  100 mm decreased in four of the major river reaches from 2007 to 2008. In two of these reaches, the decrease was statistically significant ( $\alpha=0.05$ ). Between 2005 and 2006, mean total length increased in all five major river reaches, four being statistically significant ( $\alpha=0.05$ ) which may have been due in part to the loss of smallmouth bass between 100 and 180 mm.

A report of field results from 2004 – 2006 was finalized and submitted to the Recovery Program in March 2008. Future field activities and level of effort and intensity will be determined at the 2008 Recovery Program nonnative fish workshop in mid-December.

IV. Study Schedule:

- a. initial year: 2004
- b. final year: 2008

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 2008 Tasks and Deliverables, Discussion of Initial Findings and Shortcomings:

A. FY-2008 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 2008 nonnative fish workshop.

B. Findings (2008 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 Lower Gunnison River was not identified as part of the removal area in the original scope of work. However, it was added because smallmouth bass were collected there in the spring of 2004 during the Colorado pikeminnow population monitoring.

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.

The decision was made during the December 2005, Biology Committee meeting to obtain an abundance estimate for smallmouth bass in concentration areas of the Upper Colorado River from Price Stubb Dam to Westwater, Utah. This endeavor entailed marking and releasing smallmouth bass during an initial pass starting in the summer of 2006, and lethally removing and recording previously marked smallmouth bass in all subsequent passes. 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. These river segments had been identified as moderate to high concentrations areas for smallmouth bass based on capture data from the summers of 2004 and 2005. An additional first pass was added to accomplish the marking in 2006 and again in 2007. Four successive passes were performed during 2006 in the concentration areas to lethally remove smallmouth bass as was conducted in both 2004 and 2005.

In 2007, study direction was modified again. 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 3 years of sampling.

Project study goals in 2008 were similar to that of 2007. In the Grand Valley reaches of the Upper Colorado and Lower Gunnison rivers, eight removal passes were performed, six by the FWS and two by CDOW. The CDOW effort mainly focused on the three reaches where abundance of smallmouth bass highest which was determined from earlier removal passes. Prior to any removal passes, one marking pass was performed in the same reaches as was done in 2006 and 2007 by FWS personnel.

*Methodology.* Three electrofishing rafts were used to collect centrarchid fishes in each river segment during the marking pass during 2008 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. All smallmouth bass  $\geq 100$  mm collected were marked and released. All smallmouth bass  $< 100$  mm and other centrarchid fishes collected were removed. The marking pass was performed over a 1-week period starting on 4 August. 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 11 August to 17 October 2008. 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, 2007, and again in 2008. 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 two years. Therefore, only one pass was performed from the Loma Boat Landing to Westwater, Utah, during 2006, 2007, and 2008.

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, a 7.6-mile reach from Silt to the Rifle Bridge was added to assess distribution of smallmouth bass upstream of Rifle. In addition to including the Silt to Rifle reach. During 2008, the same sampling protocol was utilized in these most upstream reaches. This sampling occurred between 7 July and

25 July. A river segment from the Rifle Bridge to river mile 236.6 was sampled again with one electrofishing boat on 24 September. This river reach was outside the original defined removal area. However, this reach was added in 2004 because there were unsubstantiated reports that anglers had encountered smallmouth bass in these upstream reaches, and it was determined that a “reconnaissance” sampling trip was warranted to confirm or refute these claims. Furthermore, a notable increase in smallmouth bass abundance was recorded between the Rifle Bridge and Beavertail Mountain during 2005 from 2004.

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. 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, smallmouth bass  $\geq 150$  mm were marked with a Fiskars® hole punch (1/4-inch diameter) in the dorsal part of the caudal fin. For smallmouth bass between 100 and 149 mm, the dorsal portion of the caudal fin was clipped 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)(after White et al. 1982) and the coefficient of variation (CV:  $SE/N$ -hat  $\times 100$  [where  $N$ =estimated population size])(Pollock et al. 1990) were 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 2008. Data are presented for main channel habitats only which include hydrologically connected backwaters. Removal passes performed by the FWS in the Upper Colorado River between Silt and Beavertail Mountain are also reported here. Integration and comparison of results from earlier years (2004 – 2007) of this study are provided.

### *Size Distribution–Length Frequency.*

#### **Smallmouth Bass**

Changes in size (i. e., length) have been used to detect changes in age composition of a fish population over time. Length-frequency distributions provide an important description of population structure (Anderson and Gutreuter 1985). In this instance, we

are looking for an index that could reliably be used to detect changes in the overall size [age] structure of smallmouth bass in designated river segments over time. Size structure changes over time then could be used to evaluate whether mechanical removal is reducing the numbers of a particular size [length] group, and therefore, if this technique could be recommended as an effective management tool for removal or to detect failure of year classes.

Length frequency distribution of all sizes of smallmouth bass collected with electrofishing during 2008 between Price-Stubb 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.

The mean total length and confidence intervals were calculated for smallmouth bass for all passes combined for five different river segments for 2004, 2005, 2006, 2007, and 2008 (Figure 2). For 2008 and earlier years, length groups were partitioned to include smallmouth bass  $\geq 100$  mm; thus excluding the early-life stages (i. e., young-of-the-year) of smallmouth bass. This analyses was performed to determine if there had been any change (increase or decrease) in the length structure of the smallmouth bass  $\geq 100$  mm captured during the removal passes among 2004, 2005, 2006, 2007, and 2008. During 2006, overall mean total length increased in all five segments from 2005: Westwater Ranger Station to the Loma Boat Landing, Loma Boat Landing to the Colorado/Gunnison River confluence, Colorado/Gunnison River confluence to Price-Stubb Dam, the Lower Gunnison River, and Beavertail Mountain to Rifle (Figure 2). In four of these five river segments there was a statistically significant increase ( $\alpha=.05$ ) in the mean total length of smallmouth bass captured between 2006 and 2005. In only one reach (Loma to the Colorado/Gunnison River confluence) was the size increase not statistically significant ( $\alpha=.05$ )(Figure 2). This increase in average size is most probably due in part to the lack of or absence of smallmouth bass catches between 100 and 180 mm in the Grand Valley reaches of the Colorado River during 2006.

During 2007, the overall mean length of smallmouth bass  $\geq 100$  mm declined in four of the five river reaches from 2006. The decline was statistically significant ( $\alpha=.05$ ) in two of the reaches (Figure 2). In only one reach did the mean length increase (Westwater to Loma), but the increase was not statistically significant ( $\alpha=.05$ ).

During 2008, the overall mean length of smallmouth bass  $\geq 100$  mm declined in four of the five major river reaches from 2007, but were not the same reaches that declined from 2006 to 2007. The decline was statistically significant ( $\alpha=.05$ ) in two of the reaches. In only one reach did the mean length increase (Lower Gunnison River), but the increase was not statistically significant ( $\alpha=.05$ ).

All age groups of smallmouth bass (young-of-the-year, juveniles, and adults) were represented in the 2008 summer collections (Figure 1). These ranged from young-of-the-

year (40 mm) to adult (420 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 3). This indicates that the 2007 year class will probably continue to provide a strong contribution to the smallmouth bass population over the next few years in Grand Valley reaches of the Upper Colorado River.

In addition to the length frequency histograms, the number of smallmouth bass collected for marking and removal passes by seven length categories was tallied for 2004, 2005, 2006, and 2007, for the Grand Valley river reaches (see the 2007 annual report for RP no. 126(a)). During 2008, the number of smallmouth bass and largemouth bass collected in the Grand Valley reaches was categorized into five length groups by individual removal pass. Unlike largemouth bass collected in main channel riverine habitats of the Grand Valley where a vast majority (~ 90%) of the fish collected were < 150 mm, the length classes for smallmouth bass were more proportionately represented (Table 1). During 2008, 41% of all smallmouth bass collected during the single marking and eight removal passes were < 100 mm, 43 % were between 100 and 255 mm, and 16.1 % (n=135) were  $\geq$  255 mm. In 2007, 20.1% of all smallmouth bass collected in the Grand Valley reaches were  $\geq$ 255 mm, 10.7% were  $\geq$ 306 mm, and 1.9% were  $\geq$ 357 mm. Four smallmouth bass were  $\geq$ 406 mm. Of the total smallmouth bass in 2007, 79.9% were < 255 mm and 64.6% were < 100 mm. The number of “trophy-size” ( $\geq$ 255 mm [10-inch]) smallmouth bass collected increased each year since 2004, being greatest in 2007 which was mostly attributed to the increased removal passes. The number of smallmouth bass  $\geq$ 306 mm (232; 10.7%),  $\geq$  357 (41; 1.9%), and  $\geq$ 406 mm (4; 0.2%) was greatest in 2007. However, in 2008, the number of smallmouth bass captured in these same length groups declined:  $\geq$  306 mm (78, 9.3%),  $\geq$  357 mm (23, 2.7%), and  $\geq$  406 mm (0, 0%).

For the Silt to Beavertail Mountain reaches, the number of smallmouth bass collected from the removal passes by the same seven length categories was also tallied for 2004, 2005, 2006, and 2007. Because the number of removal passes have been increased steadily from 2004 (n=1) to two removal passes each in 2005 and 2006, and three in 2007 and 2008, comparison of numbers collected among years is more difficult. However, there is one apparent similarity with the downstream Grand Valley reaches: the number of “trophy-size” smallmouth bass relative to the total number collected were well represented in collections in these upper reaches. For example, a four-year relative average (2004 – 2007) of smallmouth bass  $\geq$ 255 mm was 41.1% (172 of 419 total smallmouth bass) and smallmouth bass  $\geq$ 306 mm was 22% (92 of 419 fish). Six percent (n=26) were  $\geq$ 357 mm.

There is one dissimilarity between these upper reaches and the Grand Valley reaches. In the upper reaches, the number of smallmouth bass < 255 and < 100 mm collected during 2004 – 2007 was less than that of the Grand Valley reaches. For example, the four-year relative average of smallmouth bass < 255 mm in the upper reaches was 58.9% (247 of 419 total smallmouth bass) compared to 72.5% (4,137 of 5,704 total smallmouth bass) in the Grand Valley reaches. The four-year relative average of smallmouth bass < 100 mm was 27.2% (114 of 419 total fish) in the upper reaches compared to 34.8% (1,987 of 5,704 total fish) in the Grand Valley reaches. This same pattern continued in 2008. Smallmouth bass < 255 mm in the upper reaches were 70% (57 of 81 total smallmouth bass) compared to 84% (703 of 838 total fish) in the Grand Valley reaches. Smallmouth bass < 100 mm were 26% (21 of 81 total fish) in the upper reaches compared to 41% (340 of 838 total fish) in the Grand Valley reaches. This dissimilarity in the percentage and actual numbers of younger age classes may be due to lower spawning success or survival of age-0 smallmouth bass in the upper reaches compared to that in the Grand Valley reaches where spawning success appears to be more successful.

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 during 2004, 2005, 2006, 2007, and again in 2008. 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 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 in 2008 were 0.63 fish/hr compared to 4.15, 1.61, and 1.46 fish/hr during 2007, 2006, and 2005, respectively (Table 2; 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, young-of-the-year smallmouth bass catches have been less than that of the Grand Valley reaches. 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 2).

In the Rifle to Beavertail Mountain reach, smallmouth bass (all length sizes combined) abundance appears to have declined over the past three summers of sampling. Mean catch/effort for all sizes of smallmouth bass were lowest during 2008 (0.95 fish/hr) compared to 1.04 fish/hr (2007), 2.11 fish/hr (2006), and highest during 2005 (5.75 fish/hr)(Figure 5).

### **Largemouth Bass**

Recording lengths of all largemouth bass captured afield have been taken along with smallmouth bass since inception of the removal program in 2004. Length frequency provides researchers and managers important information on size structure with which to direct management actions. While largemouth bass were not the focus of this study, total length was recorded for all largemouth bass collected and removed during this study because there was interest in the location and distribution of ‘trophy size’ ( $\geq 254$  mm

total length) largemouth bass in main channel river habitats. Furthermore, if enough trophy-size largemouth bass could be located, there could be consideration for re-locating these size of fish alive to other Colorado waters to provide additional sport fishing opportunities. Length-frequency distribution of all sizes of largemouth bass collected with electrofishing during 2004, 2005, 2006, and 2007 between Price-Stubb Dam and Westwater, Utah, and the Lower Gunnison River were plotted and for the 45-mile reach between Rifle and Beavertail Mountain (see the 2007 annual report for RP no. 126(a)).

Historically, at least between 2004 and 2008, a high percentage (85% between Rifle and Beavertail Mountain; 90% between Price-Stubb Dam and Westwater, Utah) of all largemouth bass captured in both major portions of the Upper Colorado River and Lower Gunnison River were comprised of fish < 150 mm total length. During 2008 alone, between Price-Stubb Dam and Westwater, Utah, 94% of all largemouth bass collected (1 marking + 8 removal passes) were < 150 mm. Of the total number collected in 2008 (1,920), only 1.1% were  $\geq 254$  mm. Seventeen largemouth bass were  $\geq 305$  mm. Seventy-seven percent of all these largemouth bass were < 100 mm and 99% were < 254 mm. Between Price-Stubb Dam and Westwater, Utah, and the 2.3 miles of the Lower Gunnison River during 2004, 2005, and 2006, length data were recorded for 2,033 largemouth bass captured. Of this number, only 3% (59 fish) were  $\geq 254$  mm. Thirty-six largemouth bass were  $\geq 305$  mm. Sixty-two percent of all largemouth bass were < 100 mm and 92% were < 254 mm. A similar fish length distribution was apparent during 2007 in these same river reaches. Of the total of 2,884 largemouth bass captured for which length data were recorded in 2007, only 0.03 % (10 fish) were  $\geq 254$  mm. Three largemouth bass were  $\geq 305$  mm. Fifty percent of all largemouth bass were < 100 mm and 97 % were < 254 mm. It appears apparent that largemouth bass spawning in the Grand Valley river reaches were also successful in 2007 and 2008. Comparing the catch/effort (fish/hr) for largemouth bass < 100 mm over the past 5 years, catch rates have continued to increase steadily. In 2007 the catch/effort was 4.54 fish/hr, which was the highest of the five years in which main channel data have been recorded. Catch rates for 2006, 2005, and 2004 were 3.54 fish/hr, 2.66 fish/hr, and 1.03 fish/hr, respectively (Table 2; Figure 4). There was a slight decrease in catch rate (4.32 fish/hr) for largemouth bass < 100 mm during 2008 (Table 2; Figure 4).

From Silt to Beavertail Mountain, of the total 314 largemouth bass collected in this 53-mile reach, only 8% (25 fish) were > 254 mm in 2004, 2005, and 2006. Twelve largemouth bass were  $\geq 305$  mm. Sixty percent of all largemouth bass were < 100 mm and 92% were < 254 mm. Unlike the Grand Valley reaches, there were more “trophy-size” largemouth bass in the Silt to Beavertail Mountain reaches. Of the total of 287 largemouth bass captured for which length data were recorded in 2007, 8% (24 fish) were  $\geq 254$  mm. Twenty-two largemouth bass were  $\geq 305$  mm. Forty-three percent of all largemouth bass were < 100 mm and 87 % were < 254 mm. From 2004 – 2006, sixty-four percent (16 of 25) of all largemouth bass  $\geq 254$  mm total length were caught at RM 236.6, a large backwater located on the south side of the Upper Colorado. In 2007, capture location of “trophy-size” largemouth bass was similar to that of earlier years for this reach. Fifty-eight percent (14 of 24) of all largemouth bass  $\geq 254$  mm total length

captured in this 52-mile section of the Upper Colorado River were caught in this same backwater at RM 236.6.

During 2008, from Silt to Beavertail Mountain, of the total 596 largemouth bass collected in this reach, only 5% (32 fish) were  $\geq 254$  mm. Twenty five largemouth bass were  $\geq 254$  mm. Seventy-eight percent of all largemouth bass were  $< 100$  mm and 95% were  $< 254$  mm. In 2008, of all largemouth bass  $\geq 254$  mm that were collected in these upper reaches 11 of 32 (34%) were collected at RM 236.6, the same large backwater where, during 2004 – 2007, a large proportion of “trophy-size” largemouth bass were also collected.

This backwater at RM 236.6 appears to be a likely site where trophy-size largemouth bass could be removed and translocated to perpetuate additional sport-fishing opportunities.

#### *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 in 2008, 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.

Table 1 provides the actual numbers of smallmouth bass, largemouth bass, black crappie, green sunfish, and bluegill collected from 2004 – 2008 by marking and removal pass.

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 13 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.

#### *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, we calculated and interpreted catch effort indices (e. g., fish/hr) over time (i. e., by pass) in each river sub-reach. Because population estimates for smallmouth bass were not available for 2004 and 2005, effort was still recorded during 2006, 2007, and 2008 and catch/effort was computed for use as a trend to compare annual abundance of smallmouth bass and other centrarchids during 2004, 2005, 2006, 2007, and 2008.

Mean catch/effort (fish/hr) was computed separately for each of the five centrarchid fishes by each of the five sampling years, 2004 – 2008. To view the “big picture” in some analyses, river reaches and removal passes were consolidated. In 2007, for smallmouth bass and largemouth bass, catch/effort was computed for fish < 100 and for fish  $\geq$  100 mm total length. Catch rates were computed separately from the Silt to Beavertail Mountain reaches and the Grand Valley river reaches (Price-Stubb Dam to Westwater ranger station, Utah + the Lower Gunnison River).

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. 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.

### **Smallmouth Bass**

For the Grand Valley river reaches, overall mean catch rate was highest for smallmouth bass  $\geq$  100 mm during 2004 (6.37 fish/hr) and 2005 (6.36 fish/hr). However, we detected a 51 % decline in catch rate 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 6). And again in 2008, the overall catch rate continued to decline to 1.19 fish/hr. Catch rate by individual removal pass for smallmouth bass  $\geq$  100 mm in 2008 was the lowest in five years (Figure 6). 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). Has there been a measurable response of smallmouth bass to removal efforts? While there has been reduction in catch rate, it is uncertain if this can be attributed to mechanical removal efforts, the high spring runoff flows of the Upper

Colorado River during 2008, or a combination of these two factors.

For the Grand Valley river reaches, overall mean catch rate for smallmouth bass < 100 mm total length was highest in 2007 (4.15 fish/hr) and lowest during 2004 (0.55 fish/hr)(Table 2). Initially, it appears that the 2007 cohort was one of the strongest in 5 years of sampling between 2004 and 2008. These young life stages can be subject to high mortality to age-1 due to a myriad of environmental factors over the winter and until the following summer sampling season. However, it appears that survival of the 2007 year class was high because this size class was highly represented in the 2008 marking pass (see Figure 3). It also appears that the 2008 year class was one of the weakest (0.63 fish/hr; Table 2; 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.

For the Silt to Beavertail Mountain reaches, the recent trend for smallmouth bass abundance has also been downward. Overall mean catch rate for smallmouth bass (all length sizes) in 2008 was the lowest in five years (0.95 fish/hr; Figure 5). The highest year was 2005 (5.75 fish/hr)(Figure 5). 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 lowest in 2004 (0.15 fish/hr); the highest was during 2005 (1.46 fish/hr)(Table 2). 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.

### **Largemouth Bass**

Unlike the downward trend in catch rate for smallmouth bass  $\geq 100$  mm, for the Grand Valley river reaches, overall mean catch rate for largemouth bass  $\geq 100$  mm has steadily increased from 2004 – 2007 and peaked in 2007 (4.04 fish/hr; n= 1,322)(Figure 7). This is almost a magnitude greater than the catch rate for 2004 (0.63 fish/hr). During 2008, this trend was reversed for largemouth bass  $\geq 100$  mm. The catch rate declined to 1.34 largemouth bass/hr (n=394). Catch rate for largemouth bass  $\geq 100$  mm for each of the eight removal passes was noticeably less than the eight removal passes during 2007 and four removal passes in 2006 (Figure 7).

For the Grand Valley river reaches, overall mean catch rate for largemouth bass < 100 mm total length also steadily increased since 2004 from 1.03 fish/hr to a high of 4.54 fish/hr in 2007 (Table 2; Figure 4). Initially, it appears that the 2007 cohort was one of the strongest in the five years of this study which was initiated in 2004. The 2008 year class of largemouth bass was only slightly less (4.32 fish/hr) than 2007. 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 Silt to Beavertail Mountain reaches. The highest catch rate was recorded during 2008 (6.93 fish/hr; Figure 5). The second highest year was in 2006 (5.62 fish/hr); lowest in 2005 (0.96 fish/hr). In 2007 the catch rate declined to 3.30 fish/hr (Figure 5). Prior to 2008, spawning success in these reaches appeared not to be as successful as that in the Grand Valley reaches. Mean catch rates for largemouth bass < 100 mm were lowest in 2005 (0.25 fish/hr); the highest was during 2008 (6.05 fish/hr)(Table 2).

### **Black Crappie, Bluegill, Green Sunfish**

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). Bluegill still 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 2007, the bluegill catch rate was only 1.39 fish/hr; 1.90 fish/hr in 2006, and in 2005, 1.81 fish/hr. 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.

### *Population Size.*

### **Smallmouth Bass**

During the marking pass performed in August 2008, a total of 163 smallmouth bass  $\geq$  100 mm total length were marked and released alive between the GVIC Diversion Dam and the Loma Boat Landing and 2.3 miles of the Lower Gunnison River (Table 4). Eighty smallmouth bass that were marked were  $\geq$  150 mm. Twenty-seven (123–381 mm) of these marked fish were later recaptured during eight removal passes. Thirteen fish were recaptured in pass 1, three each in passes 2 and 4, and four each in passes 4 and 6 (Table 4). No marked smallmouth bass were noted in passes 5, 7 and 8. During removal pass no. 1, five marked smallmouth bass were  $\geq$  150 mm and six were between 100 and 149 mm. All but one marked smallmouth bass was recaptured within the original marking reaches. Seventeen marked fish were recaptured within the 18-mile reach, six within the 15-mile reach, three in the Lower Gunnison River, and one between Price-Stubb and GVIC dams.

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 smallmouth bass  $\geq 100$  mm and  $\geq 150$  mm (Table 5).

The 2008 population point estimate (95% C.I. in parenthesis) was  $554 \pm 340$  (214-894) for fish  $\geq 150$  mm and  $1,299 \pm 588$  (711-1,887) for fish  $\geq 100$  mm. The probability of capture ( $\hat{p}$ ) was computed as 0.13 and 0.12, respectively, for these two length groups. The CV was 31.3% and 23.1%, 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 5.3 % (47/894) or as many as 22 % (47/214) for fish  $\geq 150$  which computes to about an average of 15.7 smallmouth bass/mile. For smallmouth bass  $\geq 100$  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 5.8 % (110/1,887) or as many as 15.5 % (110/711) which computes to an average of about 36.8 smallmouth bass/mile.

The 2007 population point estimate (95% C.I. in parenthesis) was  $1,427 \pm 986$  (441–2,413)(Table 5) for smallmouth bass  $\geq 100$  mm. The probability of capture ( $\hat{p}$ ) was computed as 0.04; the CV: 35.2%. 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 5.2 % (125/2,413) or as many as 28.3% (125/441). This computes to an average of about 40.4 fish/mile. For smallmouth bass  $\geq 150$  mm, the population estimate was  $1,270 \pm 869$  (401-2,139) or 36 fish/mile. The 2006 population estimate was  $3,197 \pm 2,100$  (1,097–5,297) or about 91 smallmouth bass/mile  $\geq 100$  mm. For smallmouth bass  $\geq 150$  mm, the population estimate was  $2,792 \pm 1,836$  (956-4,628) or 79 smallmouth bass/mile.

Population estimates for smallmouth bass in 35.3 miles of the Upper Colorado and Lower Gunnison rivers in the Grand Valley reaches have continued to decline from 2006 to 2008. Using smallmouth bass  $\geq 100$  mm, the 2007 population estimate is about a 55 % decline over the 2006 population estimate for the same reaches of river. The 2008 population estimate is about a 9% decline from the 2007 point population estimate. Figure 8 provides a graphical comparison of estimates of smallmouth bass ( $\geq 100$  and  $\geq 150$  mm) population abundance with 95% C.I.s plus smallmouth bass/mile for the Upper Colorado and Lower Gunnison river reaches of the Grand Valley for 2006, 2007, and 2008. These three population estimates serve as a baseline for any future abundance estimation comparisons.

Exploitation rates can be computed several ways. Table 6 provides a comparison of three different methods to compute exploitation rates and provides those values from the number of fish marked and released, the number of marked fish recaptured during the first and all removal passes, the number of fish removed during all removal passes, and the point population estimates for two length groups ( $\geq 100$  mm and  $\geq 150$  mm) of smallmouth bass from the Upper Colorado and Lower Gunnison rivers for 2006, 2007, and 2008. Method "C" attempts to extrapolate the exploitation rate over the number of

removal passes for these three years. Exploitation rates by year and length class were, 2006 (fish  $\geq$  100 mm): 18.3, (fish  $\geq$  150 mm): 19.9; 2007 (fish  $\geq$  100 mm): 46.4, (fish  $\geq$  150 mm): 49.1; 2008 (fish  $\geq$  100 mm): 48.7, (fish  $\geq$  150 mm): 46.4. Method “C” may be the best means to report exploitation rates for smallmouth bass in the Upper Colorado and Lower Gunnison rivers because it attempts to reduce bias from fish moving outside the sampling area, mortality during the sampling period, and growth.

### *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, 2005, 2006, 2007, and 2008 catch/effort values (Figure 9). A subjective relative concentration rating was developed and is provided.

The river reach between Corn Lake and the Colorado/Gunnison River confluence has consistently been 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 have consistently been 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 ranks fourth after 4 years which is no surprise because it is adjacent to the two highest concentration areas in the Upper Colorado River. One trend was observed in 2006: catch rate decreased in all river reaches from 2005. During 2007, this downward trend in smallmouth abundance continued except in two reaches where abundance increased: the Lower Gunnison River and the Colorado/Gunnison River confluence to Fruita State Park.

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 (Figure 9). 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 prior years, particularly 2004 and 2005, several reaches were in the “highest” category for smallmouth bass concentration areas. However, no reaches were in this category during 2008 and only two were in the “moderately high” rating. Six reaches in 2008

were in the “lowest” category (Figure 9).

Monitoring these concentration areas will be continued because it provides a 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.

*Other Nonnative Game Fishes.*

One adult walleye pike (total length 593 mm) was collected near Rifle (RM 239.8) compared to one each in both 2004 and 2005, six during 2006, and four in 2007. Four juvenile yellow perch (126-146 mm) were collected during 2008 compared to six in 2007, and only one in 2006. All yellow perch were collected in the Grand Valley reaches of the Upper Colorado River during 2008. One adult northern pike (1,005 mm) was collected downstream of the Rulison Bridge (RM 238.6) and two other northern pike (717 and 789 mm) were collected in the Grand Valley reaches of the Upper Colorado River, one between Price Stubb and GVIC dams, and one in the upper portion of the 15-mile reach.

*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 by sampling crews (Table 7). No gizzard shad were collected upstream of Price-Stubb Diversion Dam in either 2006, 2007, or 2008.

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 either of the fish traps at Redlands or Government Highline fish passageways.

One grass carp (764 mm) was collected in the 18-mile reach during 2008.

VII. Recommendations: (this assumes that some level of field activities will resume in 2009 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 2008.

2. 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.
3. Downstream from Government Highline Dam, electrofishing should commence following cessation of spawning of Colorado pikeminnow which should be sometime in mid- to late-July.
4. Reduce the number of removal passes from eight to five. The number of smallmouth bass removed in pass 6 (FWS) and passes 7 and 8 (CDOW) declined from previous years and, therefore, may not warrant performing these additional passes because it may not be cost effective. For example, in 2007, 1,021 smallmouth bass were collected during passes 7 and 8 compared to only 35 in 2008. For pass 6, 31 smallmouth bass were collected during 2008 compared to 278 in 2007.

However, it is necessary to maintain a level of removal intensity in river segments that have higher concentrations of smallmouth bass in 2009 as was performed in 2008 and 2007. This should maximize catches of centrarchids fishes while at the same time minimizing harassment and negative impacts to native fishes in reaches where centrarchid abundance is low. Concomitantly, continue to decrease electrofishing effort in river reaches of low smallmouth bass densities.

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. This is necessary to 1) build upon the existing fishery community database and monitor abundance of nonnative centrarchid fishes in these reaches which is within critical habitat for Colorado pikeminnow and razorback sucker, and 2) particularly determine if smallmouth bass continue to proliferate in the river reach from Rifle to Rulison. Suspend fish sampling the Colorado River in Garfield County from the Rifle Bridge upstream to the bridge at Silt, Colorado, in 2009. Only one smallmouth bass was collected between Rifle and Silt during 2007 and 2008. This sampling can commence in early-July since there are no known Colorado pikeminnow spawning areas in this 45-mile river reach.
7. Continue to use three electrofishing craft during the marking pass in an attempt to capture, mark, and release more smallmouth bass  $\geq 100$  mm.

#### 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 2009 are planned. Study direction and field sampling design and effort for 2009 may be adjusted pending the outcome of the nonnative fish workshop in mid-December 2008.

IX. FY 2008 Budget Status

- A. Funds Provided: \$ 147,216
- B. Funds Expended: \$ 147,216
- C. Difference: \$ -0-
- D. Percent of the FY 2008 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 2008. These fish were checked for a PIT tag in the field. Those razorback sucker that had 400 khz PIT tags were implanted with 134 khz tags. 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 B. Burdick 14 November 2008  
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: 7 tables attached  
9 figures attached

C. References

Anderson, R. O., and S. J. Gutreuter. 1985. Length, weight, and associated structural indices. Pages 283 – 300 in L. A. Nielsen and D. L. Johnson (editors). Fisheries Techniques. American Fisheries Society, Bethesda, Maryland.

- Burdick, B. D., and C. W. McAda. 2007. Removal of Smallmouth Bass in the Upper Colorado River between Price-Stubb Dam near Palisade, Colorado, and Westwater, Utah. Annual Project Report to the Upper Colorado River Endangered Fish Recovery Program. Project Number 126. U. S. Fish and Wildlife Service, Grand Junction, Colorado.
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- 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.
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- White, G.C., D. R. Anderson, K. P. Burnham, and D. L. Otis. 1982. Capture-recapture and removal methods for sampling closed populations. Los Alamos National Laboratory, Los Alamos, New Mexico. LA-8787-NERP. 235 pp.

Prepared and compiled by Bob D. Burdick, 11/14/2008  
2008-ColoR-smbass-rpt.doc

APPENDIX

Table 1. Number of five centrarchid fishes collected during marking and removal passes in the Upper Colorado (river mile 187.8 –127.6) and Lower Gunnison (river mile 3.0 – 0.7) rivers, during the summers and early-fall of 2004, 2005, 2006, 2007, and 2008. Note: FWS = Fish and Wildlife Service; CDOW = Colorado Division of Wildlife.

**Marking Pass (FWS)**

FISH SPECIES <sup>a</sup>

YEAR	SMTHBASS	LGTHBASS	GRNSUNFISH	BLK CRAPPIE	BLUEGILL
<b>2008</b> 3 craft	<b>346</b>	<b>253</b>	<b>578</b>	<b>38</b>	<b>337</b>
2007 2 craft	79	226	288	18	132
2006 2 craft	134	76	144	5	9

<sup>a</sup> includes all sizes of fish captured

**Pass No. 1 (FWS)**

FISH SPECIES

YEAR	SMTHBASS	LGMTHBASS	GRNSUNFISH	BLK CRAPPIE	BLUEGILL
<b>2008-Pass 1</b>	<b>164 <sup>a</sup></b> (54- ≤ 4") (90- 4"-10") (9- 10"-12") (8- 12"-14") (3- > 14")	<b>355 <sup>a</sup></b> (318- ≤ 4") (35- 4"-10") (1- 10"-12") (1- 12"-14") (0- > 14")	<b>426 <sup>a</sup></b>	<b>24 <sup>a</sup></b>	<b>174 <sup>a</sup></b>
2007-Pass 1	130 <sup>a</sup> (0 ≤ 4") (92 ≥ 10") (47 ≥ 12") (8 ≥ 14")	306 <sup>a</sup> (242 ≤ 4") (2 ≥ 10") (0 ≥ 12")	192 <sup>a</sup>	5 <sup>a</sup>	70 <sup>a</sup>
2006-Pass 1	258	203	309	26	45
2005-Pass 1	475	247	271	17	109
2004-Pass 1	219	28	119	2	20

<sup>a</sup> includes all sizes of fish captured

**Pass No. 2 (FWS)**

**FISH SPECIES**

YEAR	SMTHBASS	LGMTHBASS	GRNSUNFISH	BLK CRAPPIE	BLUEGILL
<b>2008-Pass 2</b>	<b>84<sup>a</sup></b> (41- ≤ 4") (31- 4"-10") (2- 10"-12") (8- 12"-14") (2- > 14")	<b>202<sup>a</sup></b> (166- ≤ 4") (32- 4"-10") (1- 10"-12") (1- 12"-14") (2- > 14")	<b>328<sup>a</sup></b>	<b>69<sup>a</sup></b>	<b>237<sup>a</sup></b>
2007-Pass 2	80 <sup>a</sup> (25 ≤ 4") (34 ≥ 10") (18 ≥ 12") (2 ≥ 14")	432 <sup>a</sup> (299 ≤ 4") (1 ≥ 10") (0 ≥ 12")	336 <sup>a</sup>	8 <sup>a</sup>	109 <sup>a</sup>
2006-Pass 2	159	326	320	18	90
2005-Pass 2	119	119	236	6	53
2004-Pass 2	256	23	87	4	14

<sup>a</sup> includes all sizes of fish captured

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**Pass No. 3 (FWS)**

**FISH SPECIES**

YEAR	SMTHBASS	LGMTHBASS	GRNSUN-FISH	BLK CRAPPIE	BLUEGILL
<b>2008-Pass 3</b>	<b>93<sup>a</sup></b> (35- ≤ 4") (40- ≥ 4"-10") (10- ≥ 10"-12") (4- ≥ 12"-14") (4-> 14")	<b>208<sup>a</sup></b> (141- ≤ 4") (65- 4"-10") (1- 10"-12") (1- 12"-14") (0-> 14")	<b>312<sup>a</sup></b>	<b>28<sup>a</sup></b>	<b>274<sup>a</sup></b>
2007-Pass 3	164 <sup>a</sup> (115 ≤ 4") (34 ≥ 10") (19 ≥ 12") (5 ≥ 14") (1 ≥ 16")	565 <sup>a</sup> (337 ≤ 4") (0 ≥ 10")	243 <sup>a</sup>	7 <sup>a</sup>	79 <sup>a</sup>
2006-Pass 3	225	419	568	14	116
2005-Pass 3	313	168	366	8	103
2004-Pass 3	504	146	321	1	62

<sup>a</sup> includes all sizes of fish captured

**Pass No. 4 (FWS)**

**FISH SPECIES**

YEAR	SMTHBASS	LGMTHBASS	GRNSUN-FISH	BLK CRAPPIE	BLUEGILL
<b>2008-Pass 4</b>	<b>62<sup>a</sup></b> (29- ≤ 4") (17- ≥ 4"-10") (2- ≥ 10"-12") (11- ≥ 12"-14") (3- > 14")	<b>237<sup>a</sup></b> (175- ≤ 4") (62- 4"-10") (0- 10"-12") (0- 12"-14") (0- > 14")	<b>199<sup>a</sup></b>	<b>19<sup>a</sup></b>	<b>193<sup>a</sup></b>
2007-Pass 4	181 <sup>a</sup> (128 ≤ 4") (37 ≥ 10") (23 ≥ 12") (3 ≥ 14") (1 ≥ 16")	293 <sup>a</sup> (130 ≤ 4") (3 ≥ 10") (0 ≥ 12")	104 <sup>a</sup>	2 <sup>a</sup>	31 <sup>a</sup>
2006-Pass 4	109	146	198	12	56
2005-Pass 4	167	55	178	10	51
2004-Pass 4	186	80	116	0	15

<sup>a</sup> includes all sizes of fish captured

**Pass No. 5 (FWS)**

**FISH SPECIES**

YEAR	SMTHBASS	LGMTHBASS	GRNSUNFISH	BLK CRAPPIE	BLUEGILL
<b>2008-Pass 5</b>	<b>12<sup>a</sup></b> (5- ≤ 4") (2- ≥ 4"-10") (0- ≥ 10"-12") (2- ≥ 12"-14") (3- > 14")	<b>192<sup>a</sup></b> (155- ≤ 4") (34- 4"-10") (0- 10"-12") (1- 12"-14") (2- > 14")	<b>181<sup>a</sup></b>	<b>16<sup>a</sup></b>	<b>214<sup>a</sup></b>
2007-Pass 5	194 <sup>a</sup> (153 ≤ 4") (31 ≥ 10") (19 ≥ 12") (5 ≥ 14") (0 ≥ 16")	405 <sup>a</sup> (212 ≤ 4") (1 ≥ 10") (0 ≥ 12")	391 <sup>a</sup>	8 <sup>a</sup>	46 <sup>a</sup>
2006-Pass 5	N/S <sup>b</sup>	N/S	N/S	N/S	N/S
2005-Pass 5	N/S	N/S	N/S	N/S	N/S
2004-Pass 5	N/S	N/S	N/S	N/S	N/S

<sup>a</sup> includes all sizes of fish captured

<sup>b</sup> N/S=there was no pass 5 performed in these years.

**Pass No. 6 (FWS)**

**FISH SPECIES**

YEAR	SMTHBASS	LGMTHBASS	GRNSUNFISH	BLK CRAPPIE	BLUEGILL
<b>2008-Pass 6</b>	<b>31<sup>a</sup></b> (7- ≤ 4") (10- ≥ 4"-10") (1- ≥ 10"-12") (10- ≥ 12"-14") (3- > 14")	<b>218<sup>a</sup></b> (146- ≤ 4") (68- 4"-10") (2- 10"-12") (1- 12"-14") (1- >14")	<b>168<sup>a</sup></b>	<b>21<sup>a</sup></b>	<b>210<sup>a</sup></b>
2007-Pass 6	278 <sup>a</sup> (189- ≤ 4") (51- ≥ 10") (29- ≥ 12") (4- ≥ 14") (0- ≥ 16")	555 <sup>a</sup> (164- ≤ 4") (3- ≥ 10") (2- ≥ 12") (0- ≥ 14")	229 <sup>a</sup>	6 <sup>a</sup>	76 <sup>a</sup>
2006-Pass 6	N/S <sup>b</sup>	N/S	N/S	N/S	N/S
2005-Pass 6	N/S	N/S	N/S	N/S	N/S
2004-Pass 6	N/S	N/S	N/S	N/S	N/S

<sup>a</sup> includes all sizes of fish captured

<sup>b</sup> N/S=there was no pass 6 performed in these years.

Pass No. 7 (CDOW)

FISH SPECIES

YEAR	SMTHBASS	LGMTHBASS	GRNSUNFISH	BLK CRAPPIE	BLUEGILL
2008-Pass 7	25 <sup>a</sup> (4- ≤ 4") (11- ≥4"-10") (4- ≥10"-12") (4- ≥ 12"-14") (2- > 14")	56 <sup>a</sup> (34- ≤ 4") (22- 4"-10") (0- 10"-12") (0- 12"-14") (0- > 14")	79 <sup>a</sup>	2 <sup>a</sup>	31 <sup>a</sup>
2007-Pass 7	399 <sup>a</sup> (296- ≤ 4") (47- ≥ 10") (27- ≥ 12") (5- ≥ 14") (0 ≥ 16")	234 <sup>a</sup> (87- ≤ 4") (1- ≥ 10") (0- ≥ 12") (0- ≥14")	180 <sup>a</sup>	4 <sup>a</sup>	30 <sup>a</sup>
2006-Pass 7	N/S <sup>b</sup>	N/S	N/S	N/S	N/S
2005-Pass 7	N/S	N/S	N/S	N/S	N/S
2004-Pass 7	N/S	N/S	N/S	N/S	N/S

<sup>a</sup> includes all sizes of fish captured

<sup>b</sup> N/S=there was no pass 7 performed in these years.

**Pass No. 8 (CDOW)**

**FISH SPECIES**

YEAR	SMTHBASS	LGMTHBASS	GRNSUNFISH	BLK CRAPPIE	BLUEGILL
<b>2008-Pass 8</b>	<b>10<sup>a</sup></b> (4- ≤ 4") (4- ≥ 4"-10") (1- ≥ 10"-12") (1- ≥ 12"-14") (0- > 14")	<b>54<sup>a</sup></b> (46- ≤ 4") (8- 4"-10") (0- 10"-12") (0- 12"-14") (0- > 14")	<b>113<sup>a</sup></b>	<b>3<sup>a</sup></b>	<b>29<sup>a</sup></b>
2007-Pass 8	622 <sup>a</sup> (491- ≤ 4") (56- ≥ 10") (36- ≥ 12") (7- ≥ 14") (2- ≥ 16")	209 <sup>a</sup> (83- ≤ 4") (0- ≥ 10") (0- ≥ 12") (0- ≥ 14")	199 <sup>a</sup>	10 <sup>a</sup>	15 <sup>a</sup>
2006-Pass 8	N/S <sup>b</sup>	N/S	N/S	N/S	N/S
2005-Pass 8	N/S	N/S	N/S	N/S	N/S
2004-Pass 8	N/S	N/S	N/S	N/S	N/S

<sup>a</sup> includes all sizes of fish captured

<sup>b</sup> N/S=there was no pass 8 performed in these years.

Table 2. Catch/effort (fish/hour) comparison by year for smallmouth bass and largemouth bass < 100 mm total length for the Silt to Beavertail Mountain reaches (river miles 248.0 – 195.7) in the Upper Colorado River and the Upper Colorado River from Price Stubb 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 to 2008. Note: passes were combined within years for the Silt to Beavertail Mountain and Price Stubb to Westwater, Utah, plus Lower Gunnison River reaches.

		Fish < 100 mm Total Length									
		Smallmouth Bass					Largemouth Bass				
		2008	2007	2006	2005	2004	2008	2007	2006	2005	2004
Silt ▶ Beavertail Mountain	No. of fish	<b>21</b>	17	36	58	3	<b>462</b>	122	125	10	45
	Catch/ Effort	<b>0.25</b>	0.20	0.96	1.46	0.15	<b>6.05</b>	1.40	3.33	0.25	2.28
Price-Stubb ▶ Westwater, Utah + Lower Gunnison River	No. of fish	<b>185</b>	1,358	261	254	93	<b>1,272</b>	1,485	573	465	173
	Catch/ Effort	<b>0.63</b>	4.15	1.61	1.46	0.55	<b>4.32</b>	4.54	3.54	2.66	1.03

Table 3 . Catch/effort (fish/hour) comparison for black crappie, bluegill, and green sunfish captured from the Upper Colorado River from Price Stubb Dam to Westwater BLM ranger station, Utah (river mile 187.7 - 127.6) and the Lower Gunnison River from the Redlands Diversion 2004 to the Colorado/Gunnison River confluence (river mile 3.0 – 0.7) from 2004 to 2008. Note: passes (eight removal) and river reaches were combined within years; all size lengths of each of the three fishes were combined.

		Fish Species		
		Black Crappie	Bluegill	Green Sunfish
<b>2008</b>	No. of Fish	<b>198</b>	<b>1,444</b>	<b>1,972</b>
	Catch/Effort (fish/hr)	<b>0.67</b>	<b>4.90</b>	<b>6.70</b>
2007	No. of Fish	50	456	1,872
	Catch/Effort (fish/hr)	0.15	1.39	5.72
2006	No. of Fish	70	307	1,395
	Catch/Effort (fish/hr)	0.43	1.90	8.62
2005	No. of Fish	41	316	1,051
	Catch/Effort (fish/hr)	0.23	1.81	6.02
2004	No. of Fish	7	111	643
	Catch/Effort (fish/hr)	0.04	0.66	3.81

Table 4. Number of marked smallmouth bass ( $\geq 100$  mm TL) recaptured during each of six removal passes performed by Fish and Wildlife personnel in six different river reaches of the Upper Colorado (Price Stubb Dam – GVIC: river mile 187.8 – 152.6) and Lower Gunnison (Redlands Dam to the Colorado/Gunnison River confluence: river mile 3.0 – 0.7) rivers, August, September, and October 2008.

River Reach	Removal Pass No.					
	1	2	3	4	5	6
Price Stubb►GVIC	0	0	1	0	0	0
GVIC►Corn Lake	1	2	0	0	0	0
Corn Lake►Colo/Gunn River Confl.	2	0	0	0	0	3
Colo/Gunn River Confl.►Fruita State Park	5	1	3	0	0	1
Fruita State Park►Loma	2	0	0	3	0	0
Lower Gunnison River	3	0	0	0	0	0
<b>Totals/pass</b>	13	3	4	3	0	4
<b>Totals (all 6 passes)</b>	---	---	---	---	---	27

Table 5. Population estimate with 95% confidence intervals (CI) and other statistics for smallmouth bass ( $\geq 100$  mm and  $\geq 150$  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, 2007, and 2008. Note: length of the area for the population estimate was 35.3 miles. Refer to Figure 8, below.

Year	Fish Length Size	Pop Estimate with 95% CI	SE	SmBass/mile	Number Marked; No. Removed 1 <sup>st</sup> 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
2004	NO POPULATION ESTIMATE PERFORMED											
2005	NO POPULATION ESTIMATE PERFORMED											
2006	$\geq 100$ mm	3,197 $\pm$ 2,100	1071	90.6	122;181	6	8	4	503	15.7	33.5	0.033
	$\geq 150$ mm	2,792 $\pm$ 1,836	937	79.1	112;172	6	8	4	474	17.0	33.5	0.035
2007	$\geq 100$ mm	1,427 $\pm$ 986	503	40.4	67;125	5	14	8	679	47.6	35.2	0.04
	$\geq 150$ mm	1,270 $\pm$ 869	443	36.0	62;120	5	14	8	476	37.5	34.9	0.041
2008	$\geq 100$ mm	1,299 $\pm$ 588	300	36.8	163;110	13	27	8	349	26.9	23.1	0.12
	$\geq 150$ mm	554 $\pm$ 340	173	15.7	80;47	6	18	8	216	39.0	31.3	0.13
Removal Passes 1-6 (FWS) 2007				$\geq 100$ mm			6	415 (61 %)		---	---	---
				$\geq 150$ mm				363 (76.3 %)		---	---	---
Removal Passes 7-8 (CDOW) 2007				$\geq 100$ mm			2	264 (39 %)		---	---	---
				$\geq 150$ mm				113 (23.7 %)		---	---	---
Removal Passes 1-8 (FWS + CDOW) 2007				$\geq 100$ mm			8	679		---	---	---
				$\geq 150$ mm				476		---	---	---

Removal Passes 1-6 (FWS) 2008	≥100 mm	6	322 (92.3%)	---	---	---
	≥150 mm		192 (88.9%)	---	---	---
Removal Passes 7-8 (CDOW) 2008	≥100 mm	2	27 (7.7%)	---	---	---
	≥150 mm		24 (11.1%)	---	---	---
Removal Passes 1-8 (FWS + CDOW) 2008	≥100 mm	8	349	---	---	---
	≥150 mm		216	---	---	---

Table 6. Comparison of three different methods (“A”, “B”, “C”) to compute exploitation rates for smallmouth bass ( $\geq 100$  mm and  $\geq 150$  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, 2007, and 2008.

A. Method 1: most conservative estimate, biased because of fish movement out of the sampling area or mortality.

Year	Length Class (mm)	No. of Smth Bass Marked & Released during the Marking Pass	No. of Recaptured Marked Smth Bass (all 8 removal passes)	% Exploitation Rate ( $\mu$ )
2006 <sup>a</sup>	$\geq 100$	122	8	6.6
	$\geq 150$	112	8	7.1
2007 <sup>b</sup>	$\geq 100$	67	14	20.9
	$\geq 150$	62	14	22.6
2008 <sup>b</sup>	$\geq 100$	163	28	17.2
	$\geq 150$	80	20	25.0

B. Method 2: biased by fish moving into or out of removal reaches and mortality.

Year	Length Class (mm)	No. of Smth Bass Removed (all passes)	Point Population Estimate	% Exploitation Rate ( $\mu$ )
2006 <sup>a</sup>	$\geq 100$	503	3,197	15.7
	$\geq 150$	474	2,792	17.0
2007 <sup>b</sup>	$\geq 100$	679	1,427	47.6
	$\geq 150$	476	1,270	37.5
2008 <sup>b</sup>	$\geq 100$	349	1,299	26.9
	$\geq 150$	216	554	39.0

<sup>a</sup> Four removal passes.

<sup>b</sup> Eight removal passes. Includes fish removed by FWS (passes 1 – 6) and CDOW (passes 7 – 8).

Table 6 (cont'd).

C. Method 3: this method reduces bias associated with movement, mortality, and growth, but assumes the probability of capture on the first removal pass is similar to all subsequent removal passes.

Year	Length Class (mm)	No. of Smth Bass Marked & Released during the Marking Pass	No. of Marked Smallmouth Bass Removed during the 1 <sup>st</sup> Removal Pass	Probability of Being Captured on each pass (p-hat)	Probability of Being Captured after "n" Passes (or) Exploitation Rate ( $\mu$ )
2006 <sup>a</sup>	≥ 100	122	6	0.049	18.3 <sup>a, c</sup>
	≥ 150	112	6	0.054	19.9 <sup>a, c</sup>
2007 <sup>b</sup>	≥ 100	67	5	0.075	46.4 <sup>b, c</sup>
	≥ 150	62	5	0.081	49.1 <sup>b, c</sup>
2008 <sup>b</sup>	≥ 100	163	13	0.080	48.7 <sup>b, c</sup>
	≥ 150	80	6	0.075	46.4 <sup>b, c</sup>

<sup>a</sup> Four removal passes ("n").

<sup>b</sup> Eight removal passes ("n"). Includes fish removed by FWS (passes 1 – 6) and CDOW (passes 7 – 8).

<sup>c</sup> Exploitation rate ( $\mu$ ) 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).

Table 7. Number of adult and juvenile gizzard shad collected in the Upper Colorado and Lower Gunnison rivers during 2006, 2007, and 2008, from fish traps catches at two fish ladders and from the smallmouth bass removal study.

	2006 <sup>a</sup>		2007 <sup>b</sup>		2008 <sup>b</sup>	
	Adult	Juv/Age-0	Adult	Juv/Age-0	Adult	Juv/Age-0
Govern't Highline Fish Trap <sup>c</sup>	---	---	---	---	<b>0</b>	<b>0</b>
Redlands Fish Trap	3	0	43 <sup>e</sup>	0	<b>0</b>	<b>0</b>
Smallmouth Bass Study	12 <sup>d</sup>	0	135 <sup>f</sup>	1 <sup>g</sup>	<b>10</b>	<b>8</b>
<b>Total</b>	<b>15</b>	<b>0</b>	<b>178</b>	<b>1</b>	<b>10<sup>h</sup></b>	<b>8<sup>i</sup></b>

<sup>a</sup> Centrarchid Removal Passes 1 – 4.

<sup>b</sup> Centrarchid Removal Passes 1 – 6.

<sup>c</sup> Upstream fish migration was blocked by Price Stubb Dam during 2006 and 2007. Price-Stubbs fish passage located downstream was completed April 2008.

<sup>d</sup> Range total length: 338 – 462 mm.

<sup>e</sup> Mean total length: 406 mm; range: 336 – 490 mm.

<sup>f</sup> Mean total length: 405 mm; range: 226 – 451 mm.

<sup>h</sup> Total length: 66 mm.

<sup>h</sup> Range total length: 300 – 435 mm.

<sup>i</sup> Range total length: 261 – 299 mm.

### Smallmouth Bass--2008 Grand Valley Reaches

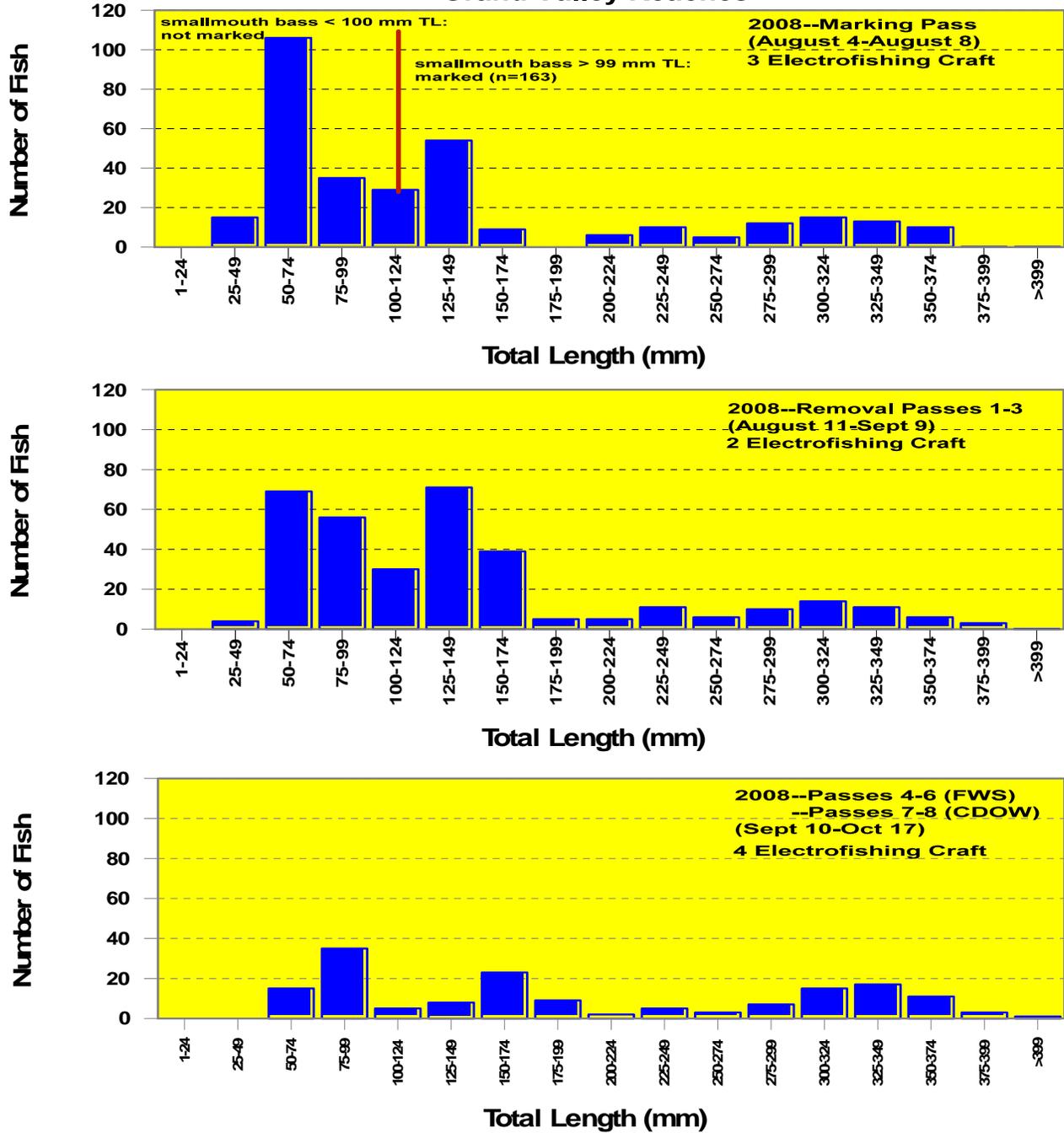


Figure 1. Length frequency comparison among the removal pass (top), passes 1-3 (middle), and passes 4-6 and 7-8 (bottom) for all smallmouth bass collected during 2008 in the Grand Valley and Ruby and Horsethief canyon reaches of the Upper Colorado and Lower Gunnison rivers.

**Smallmouth Bass Length Comparison (> 99 mm) by River Reach  
Colorado & Lower Gunnison Rivers  
2004 vs. 2005 vs. 2006 vs. 2007 vs. 2008**

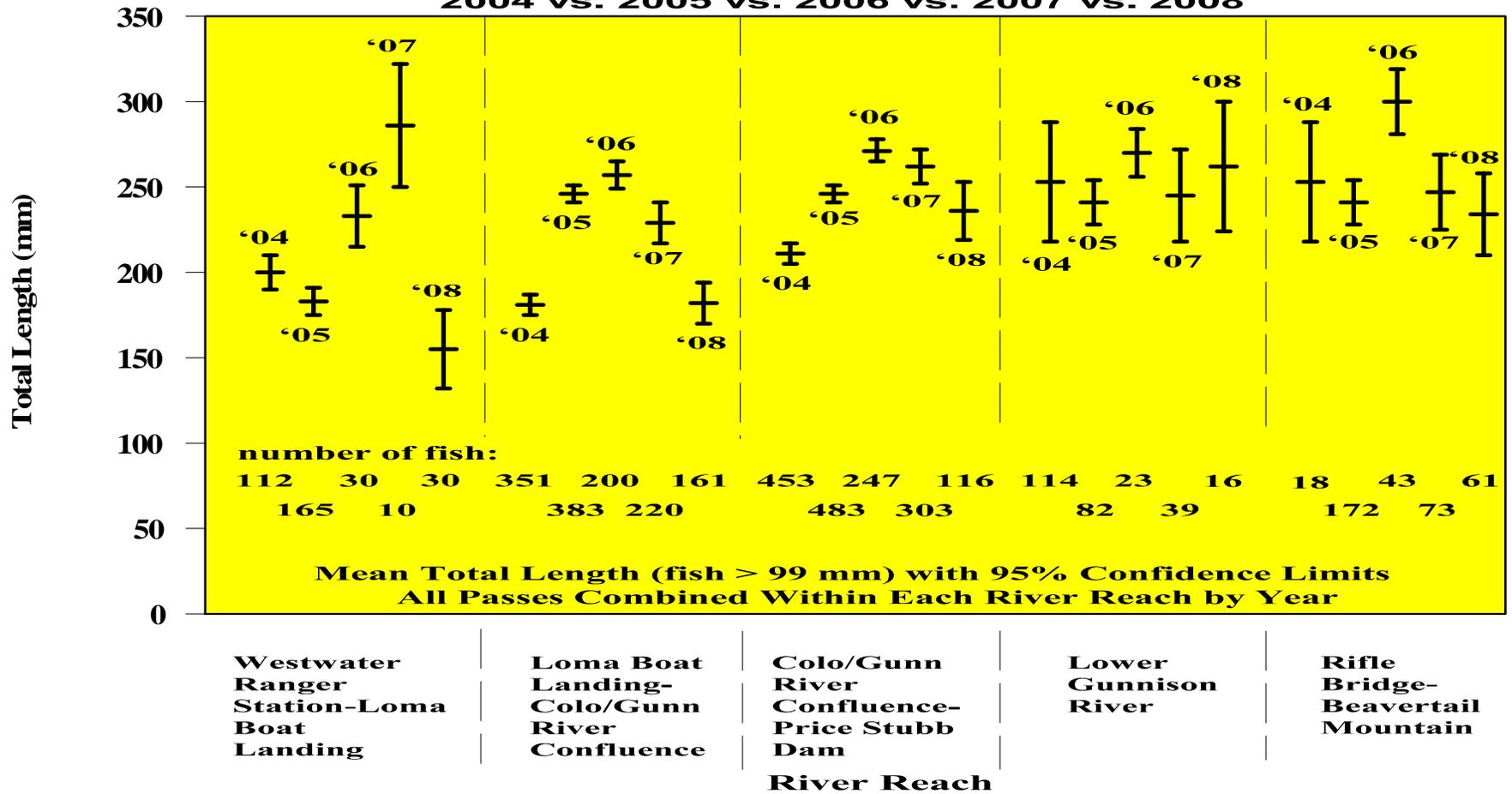


Figure 2. Comparison between the mean total length and 95% confidence interval for smallmouth bass ( $\geq 100$  mm) collected with electrofishing from five major river segments on the Colorado and Gunnison rivers during the summers of 2004, 2005, 2006, 2007, and 2008. The mean is the middle horizontal line; the 95% confidence intervals are represented by the error bars ( $\tau \perp$ ).

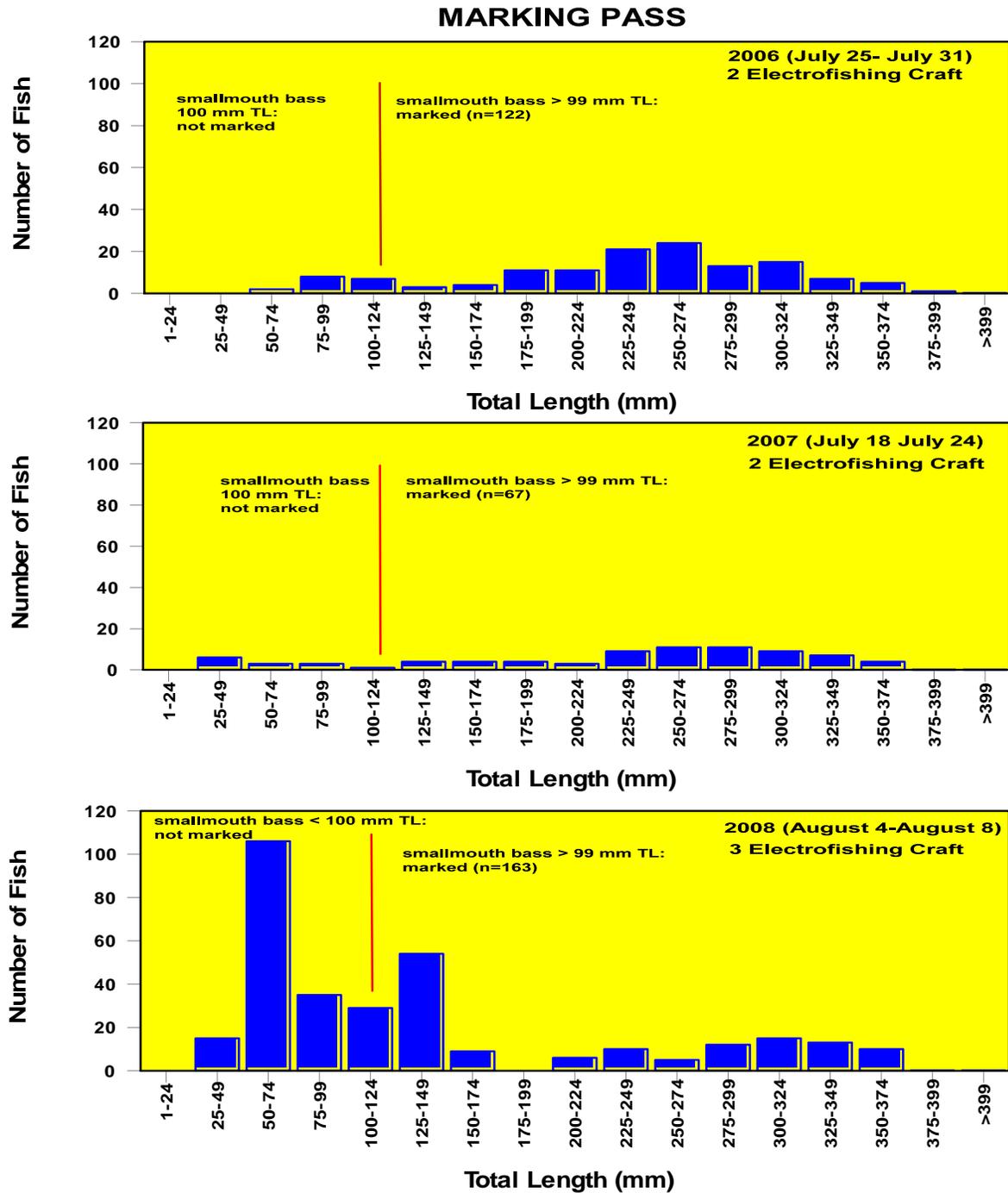


Figure 3. Length frequency comparison among 2006, 2007, and 2008, for all smallmouth bass collected during the marking pass in the Grand Valley reaches of the Upper Colorado and Lower Gunnison rivers.

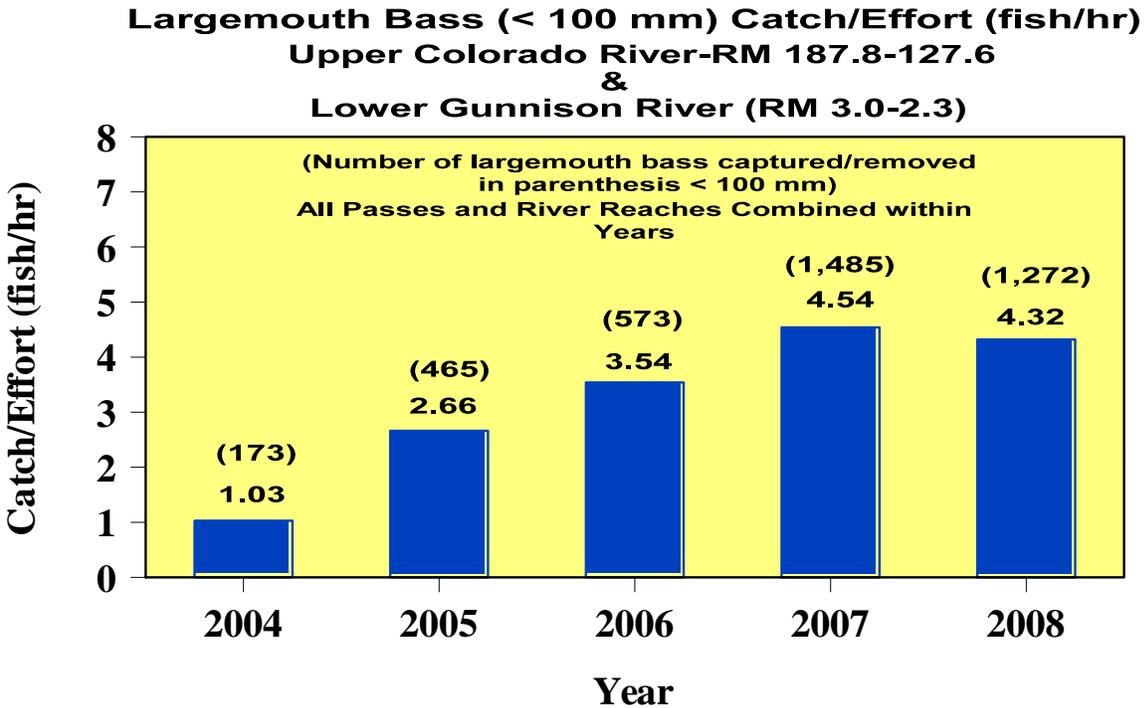
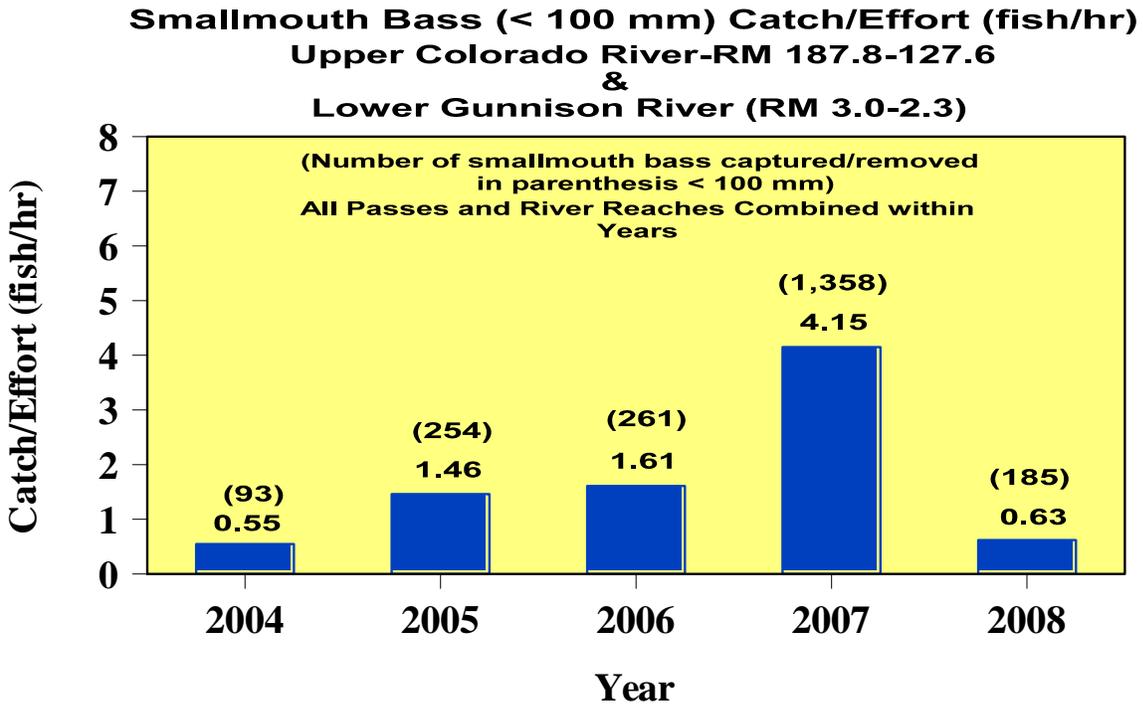
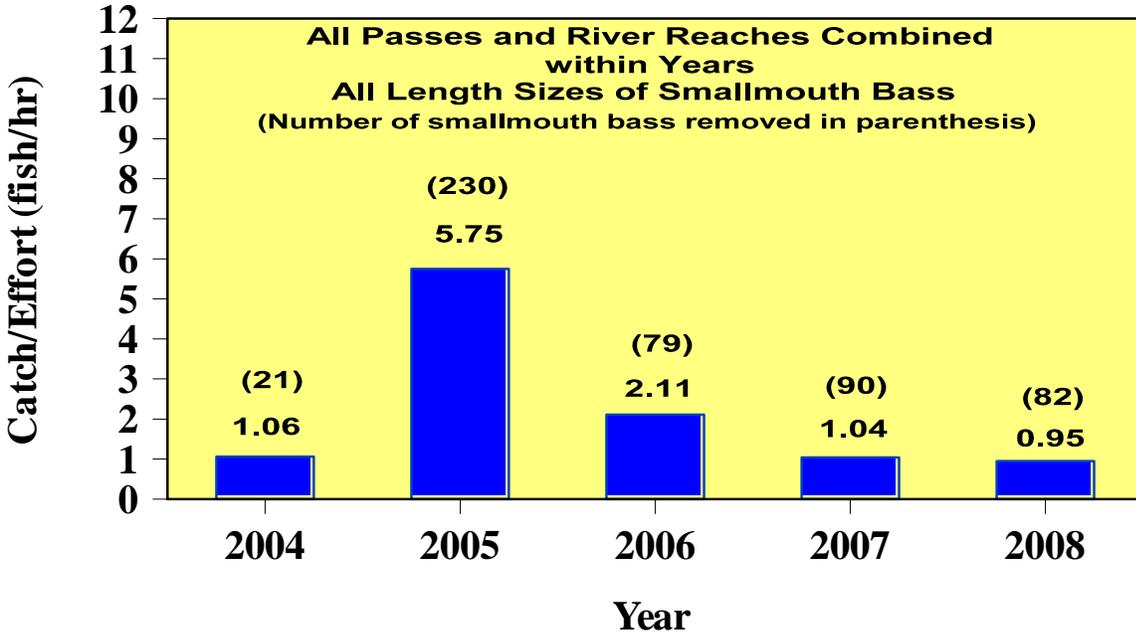


Figure 4. Five year comparison of catch/effort (fish/hr) for smallmouth bass (top) and largemouth bass (bottom) < 100 mm for the Grand Valley reaches of the Upper Colorado and Lower Gunnison rivers.

**Smallmouth Bass Catch/Effort (fish/hr)  
Upper Colorado River-RM 248-195.7**



**Largemouth Bass Catch/Effort (fish/hr)  
Upper Colorado River-RM 248-195.7**

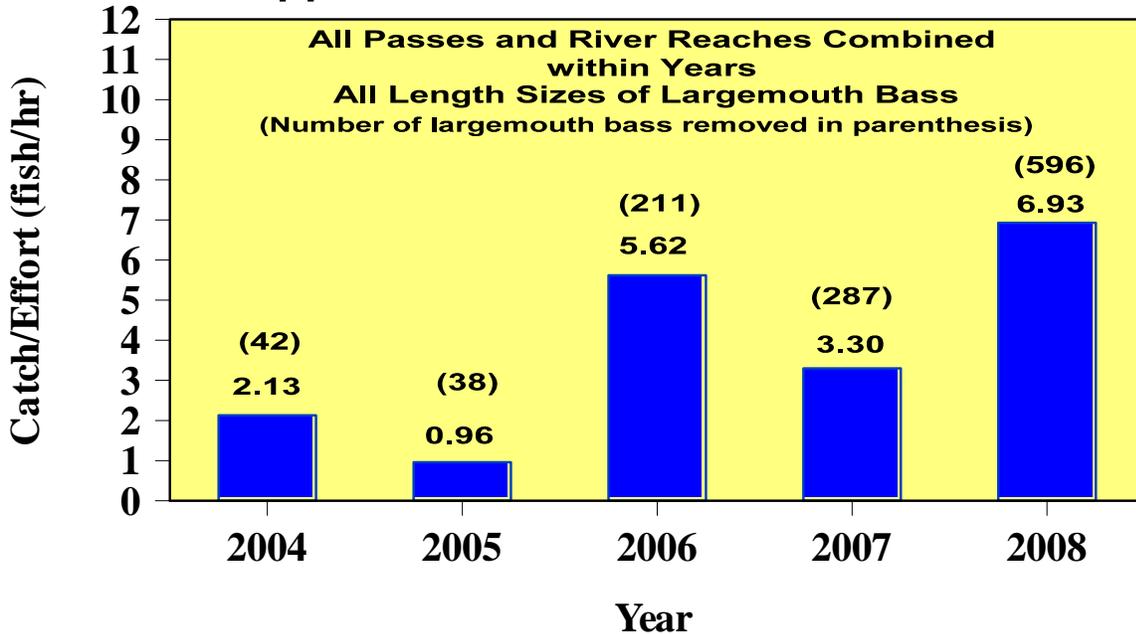
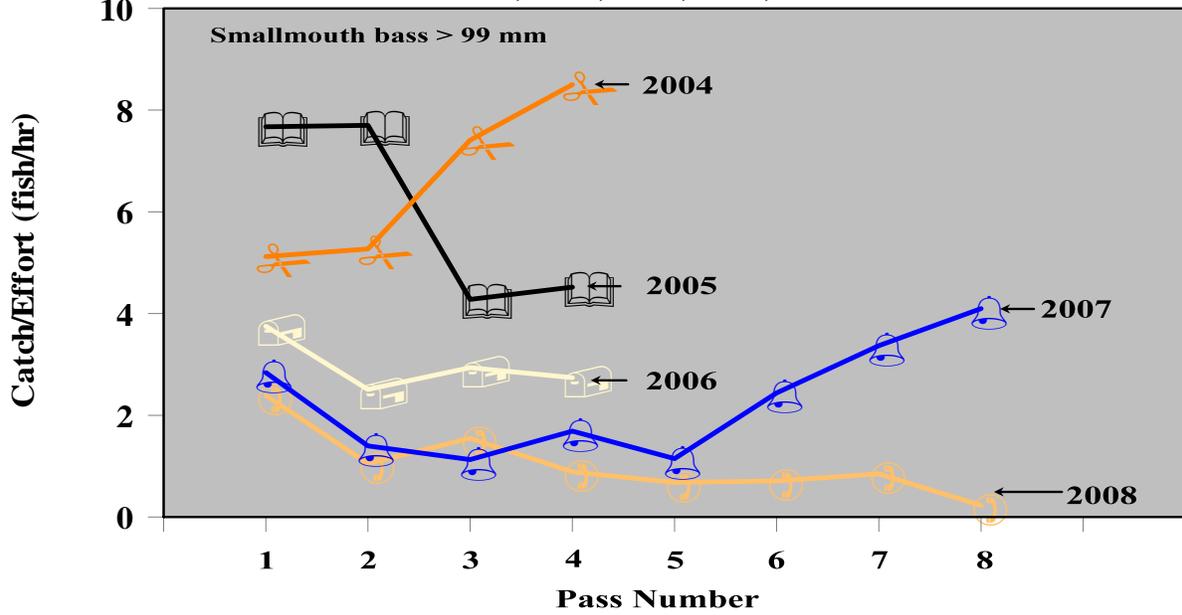


Figure 5. Five year comparison of catch/effort (fish/hr) for all sizes of smallmouth bass (upper) and all sizes of largemouth bass (lower) for the Upper Colorado River between Silt and Beavertail Mountain.

**Smallmouth Bass Catch/Effort (fish/hr)**

Colorado River (RM187.7-127.6)  
 Lower Gunnison River (RM3.0-0.7)  
 2004, 2005, 2006, 2007, 2008



**Upper Colorado River-RM 187.8-127.6 &  
 Lower Gunnison River (RM 3.0-2.3)**

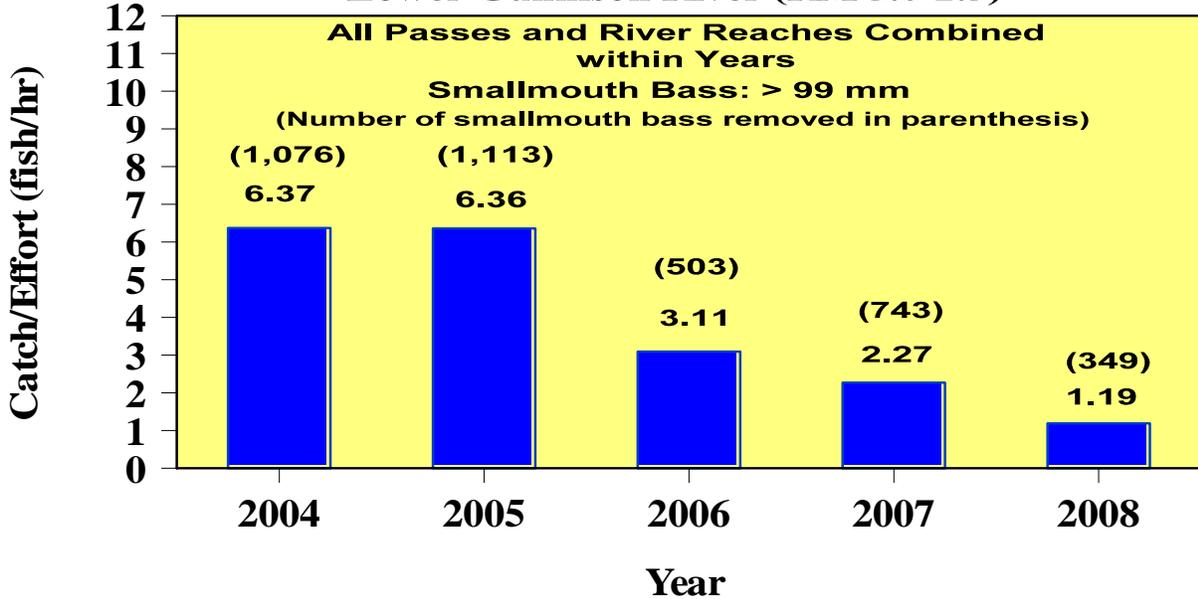
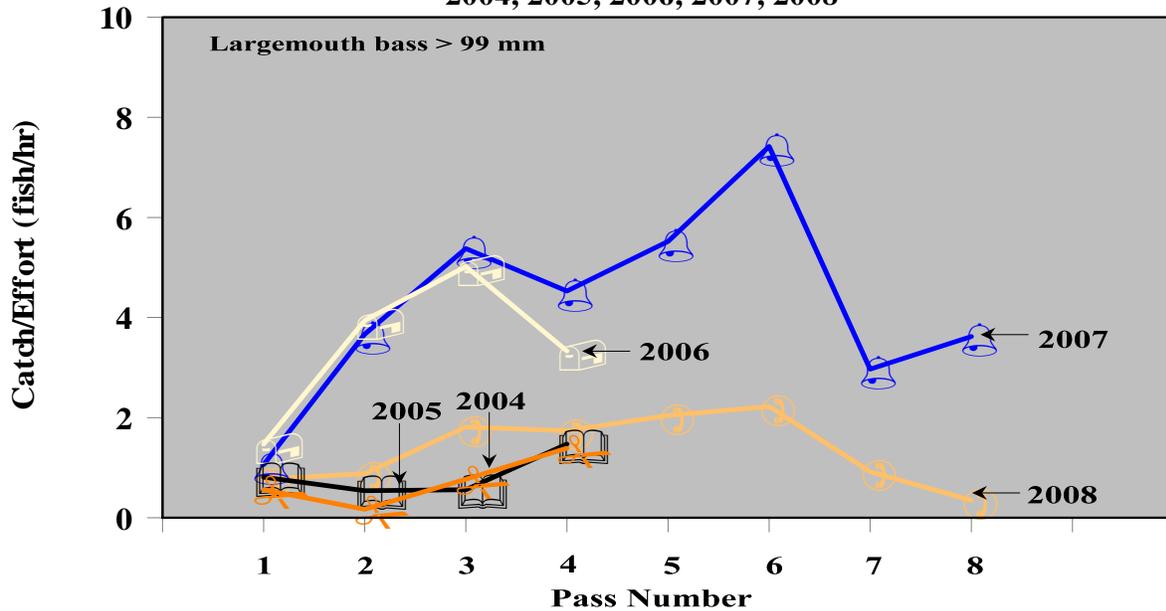


Figure 6. Five year comparison of catch/effort (fish/hr) for smallmouth bass ( $\geq 100$  mm) by pass (river reaches combined)(upper) and by year (river reaches and passes combined)(lower) for the Grand Valley reaches of the Upper Colorado and Lower Gunnison rivers.

### Largemouth Bass Catch/Effort (fish/hr)

Colorado River (RM187.7-127.6)  
 Lower Gunnison River (RM3.0-0.7)  
 2004, 2005, 2006, 2007, 2008



### Upper Colorado River-RM 187.8-127.6 & Lower Gunnison River (RM 3.0-2.3)

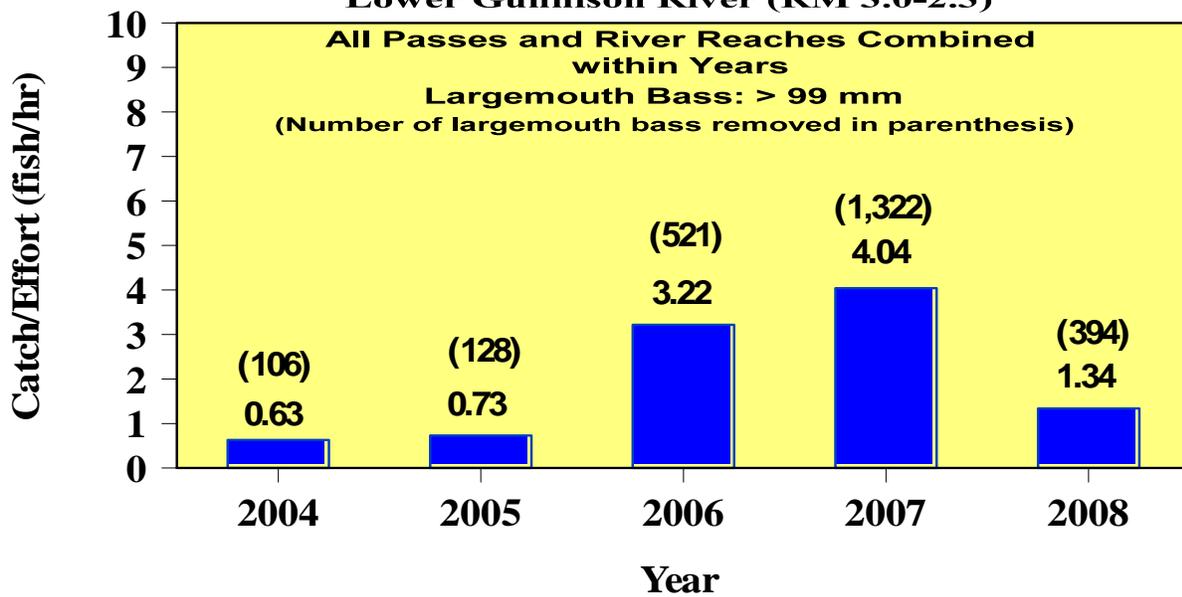


Figure 7. Five year comparison of catch/effort (fish/hr) for largemouth bass ( $\geq 100$  mm) by pass (river reaches combined)(upper) and by year (river reaches and passes combined)(lower) for the Grand Valley reaches of the Upper Colorado and Lower Gunnison rivers.

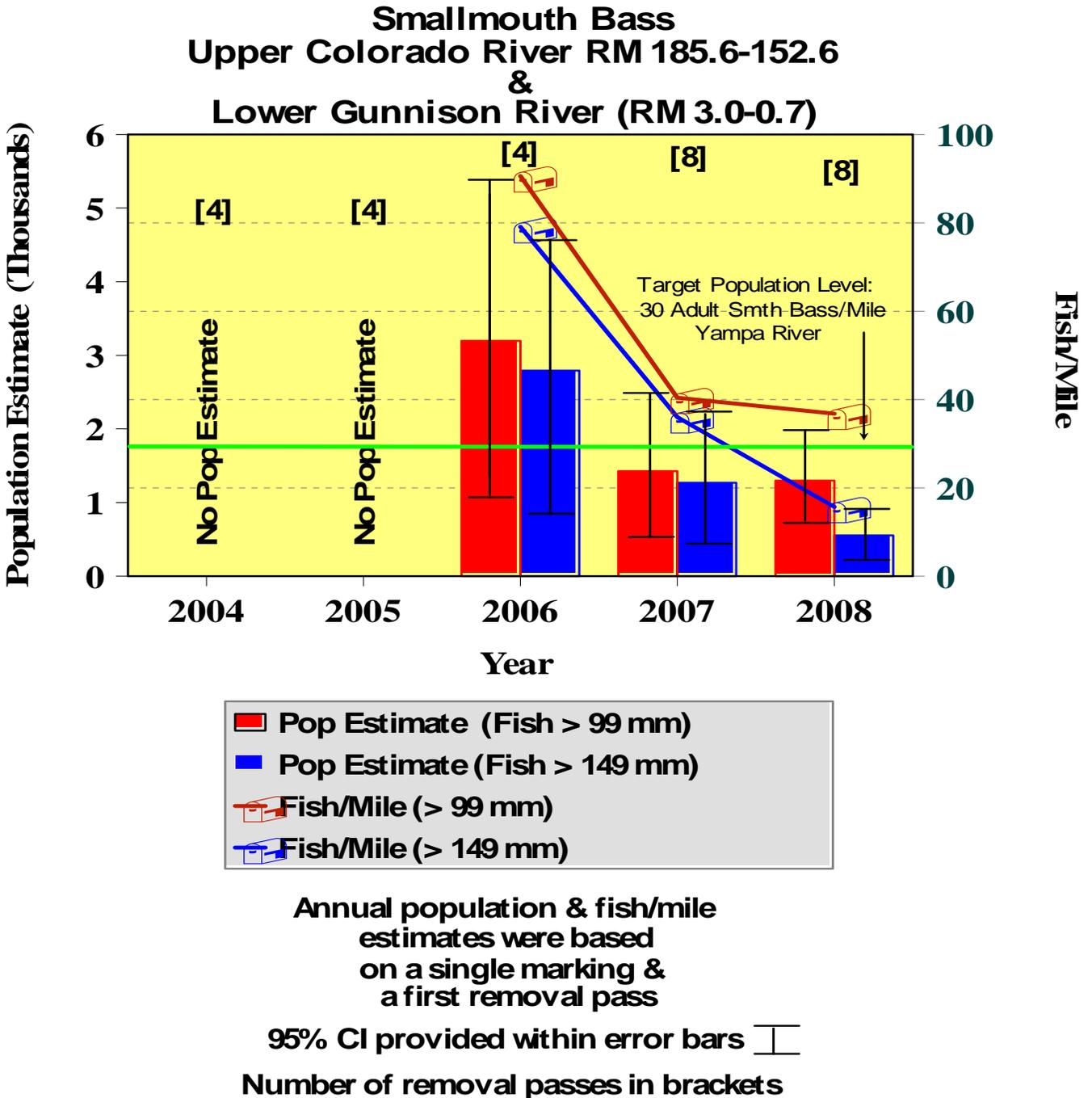


Figure 8. Population abundance estimate comparison (fish/mile and point estimate with 95% C.I.s,) for smallmouth bass ( $\geq 100$  mm and  $\geq 150$  mm) for the Grand Valley reaches of the Upper Colorado and Lower Gunnison rivers, 2006, 2007, and 2008. Refer to Table 5.

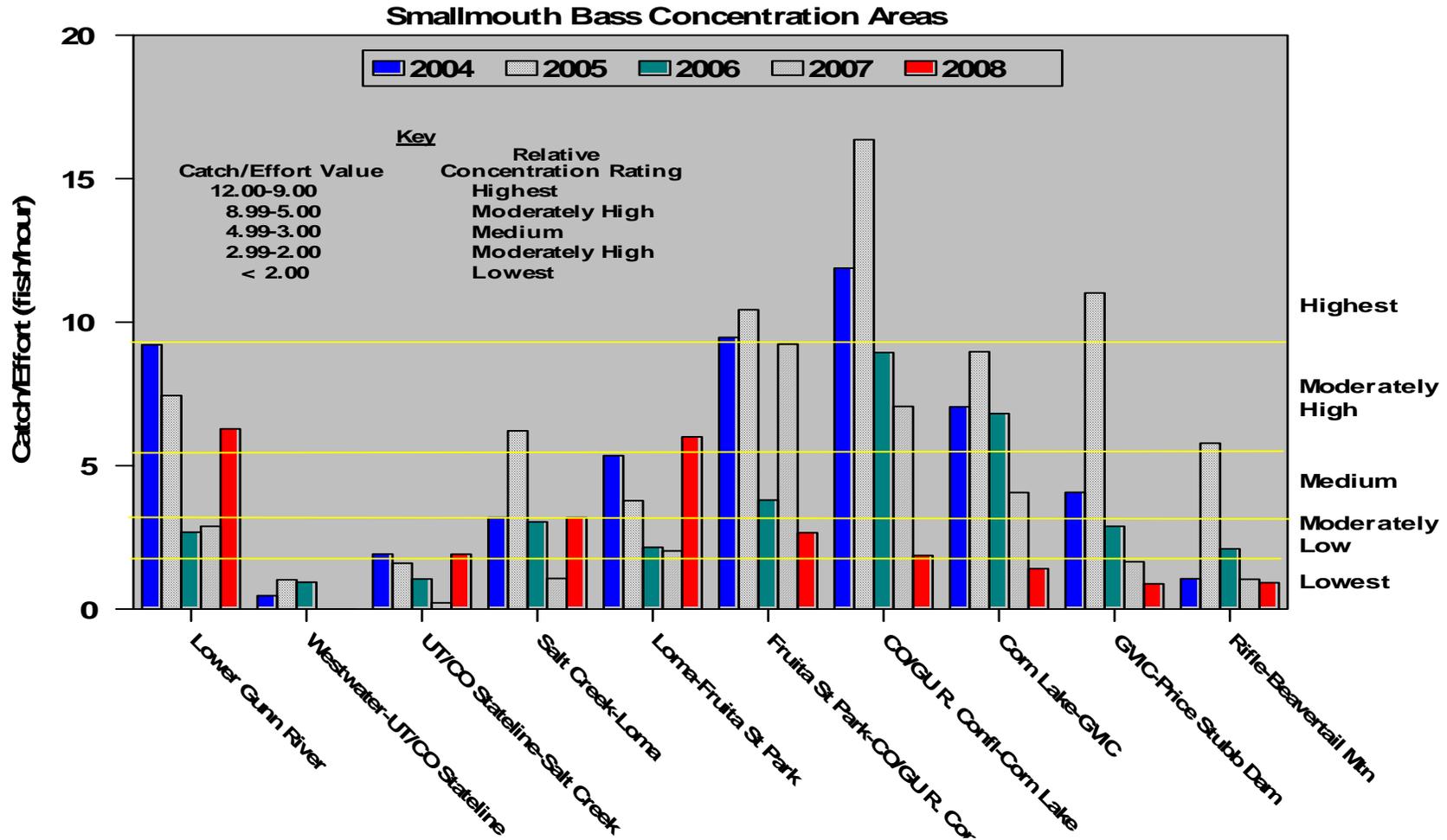


Figure 9. Concentration areas for smallmouth bass in 10 different river reaches of the Upper Colorado and Lower Gunnison Rivers during the summer of 2004, 2005, 2006, 2007, and 2008, using catch effort indices.