# Status and trends of native and non-native fishes of the Colorado River in Grand Canyon 1990-2000

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## ABSTRACT

Status, trends and seasonal patterns of relative abundance of humpback chub, rainbow trout, brown trout, and flannelmouth sucker in Grand Canyon were analyzed for the period 1990-2000 at the following mainstem reaches: Little Colorado River (LCR) inflow, Bright Angel, Shinumo, Middle Granite Gorge, Kanab, and Havasu.. These 7 reaches were selected because they were the only ones for which sufficient data exist for long-term analysis of relative abundance. Humpback chub (HBC) were divided into small (<200 mm total length) and adult (>200 mm total length) size groups for analysis. In addition, we characterized the long-term and seasonal patterns in condition factor for HBC >200 mm total length. For the native species, HBC and flannelmouth sucker, no long-term trends in abundance were evident nor was a long-term trend in condition factor for HBC >200 mm total length evident. Abundance of large and small HBC was greatest in the LCR Inflow (rm 60.0-68.2). Flannelmouth sucker showed increasing abundance downstream of the LCR Inflow. Rainbow trout was the most abundant of the four species considered in the analysis. Although abundance was highest in the Fence Fault reach, rainbow trout was abundant throughout the Grand Canyon. Brown trout were most abundant in the Bright Angel reach and were rare upstream of this area. Throughout the Canyon,

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rainbow trout abundance declined after 1990 but increased back to 1990 levels after 1996. Brown trout abundance downstream of the LCR Inflow increased after 1997. Changes in trout abundance, particularly rainbow trout, appeared to be correlated with changes in dam operations and resulting flow regimes over the period of study. Widely fluctuating daily flows prevailed before 1990, greatly reduced fluctuating flows were instituted during 1990-1995, and moderately fluctuating flows were practiced after 1997. Of the two sampling methods considered, electrofishing was judged effective in sampling all species except adult HBC. Trammel netting was effective in capturing adult HBC, but this sampling method was focused on known concentrations of fish and showed great variability in estimates of abundance. Because extensive amounts of shoreline habitat were sampled by electrofishing, this method provided a more representative sample of the mainstem Colorado River fish community. Trammel netting may be more successful in capturing rare and highly clustered adult HBC but implementation of this method for long-term assessment of abundance is fraught with sampling design difficulties.

## INTRODUCTION

With implementation of the Glen Canyon Environmental Studies (GCES) Phase II Program in 1990, a continuous program of studies on the fishes of the mainstem Colorado River in Grand Canyon was initiated. The intent of these GCES studies was not to monitor the status of native and non-native fishes but to establish a baseline of information and to conduct research that addressed the distribution, abundance, demographics, movement and habitat relationships of the species. The GCES studies were launched to comply with elements of a Biological Opinion issued by the Fish and Wild Service and were intended to provide information for developing an Environmental Impact Statement on the operation of Glen Canyon Dam, which was finalized in

1995. Using data collected by R.A.Valdez (Valdez and Ryel 1995) for the period 1990-1994 and Arizona Game and Fish Department for the period 1995-1997 in combination with our sampling for the period 1998-2000 we examined trends in abundance and condition factor of Grand Canyon fishes for a 10-year period. However, the GCES sampling programs were much more intensive and extensive than our more recent studies. Therefore, we were only able to examine records from common sample areas over the period of record.

This report evaluates the status and trends of relative abundance of HBC, rainbow trout, brown trout, and flannelmouth sucker in Grand Canyon for the period 1990-2000 at the following mainstem reaches: LCR (LCR) inflow, Bright Angel, Shinumo, Middle Granite Gorge, Kanab, and Havasu. These reaches are the only ones for which sufficient data exist for long-term analysis of relative abundance. Our evaluation addresses the following specific analytical objectives:

Characterize the long-term trend in relative abundance of juvenile HBC <200 mm total length, adult HBC ≥200 mm total length, rainbow trout, brown trout, and flannelmouth sucker in seven reaches of the Colorado River in Grand Canyon during the years spanning 1990 through 2000;

Characterize the long-term trend in condition factor of HBC ≥ 200 mm total length captured in the Colorado River in Grand Canyon during the years spanning 1990 through 2000.

## METHODS

## RELATIVE ABUNDANCE

### *Project History and Capture Methods*

The data considered in this report is the result of three separate study efforts conducted in the Colorado River and its tributaries in Grand Canyon. Initial work was conducted by BIO/WEST, Inc. (B/W) during October 1990 – July 1994 (GCES Phase II studies) and is thoroughly summarized in their final report (Valdez and Ryel 1995). Subsequent to the B/W efforts, the Arizona Game and Fish Department (AGFD) took over fish monitoring in the Grand Canyon (GCES Interim and Transitional Monitoring) beginning March 1995 and ending September 1997. Finally, the U.S. Fish and Wildlife Service (USFWS) collected data useful in portraying long-term trends in the fish resources of the Colorado River in Grand Canyon during the time period spanning June 1998 – January 2000 (GCMRC program).

Throughout the 10 years of data collection described above, a variety of fish capture methods were employed including electrofishing, trammel nets, gillnets, hoopnets, minnow traps, seines, and angling. Since it was our task to characterize long-term trends in the relative abundance of key fish species using catch per unit effort (CPUE), it was necessary to use capture methods consistent among all years considered. The two types of capture methods used most consistently were electrofishing and trammel nets. The electrofishing efforts were very consistent among the 10 years of study with gear and field personnel remaining nearly constant. The trammel netting efforts employed nets that were either 15.3 m or 22.9 m in length (50 ft or 75 ft) and 1.8 m deep (6 ft). The nets were constructed of three mesh panels with the middle panel containing meshes of either 2.5 cm or 3.8 cm stretched length (1 in or 1.5 in), and the outer two panels containing meshes of either 25.0 cm or 30.5 cm stretched length (10 in or 12 in). Both electrofishing and trammel netting was generally conducted during either the crepuscular or dark periods of a 24 hour day. A full description of the equipment and methods used during

electrofishing and trammel netting efforts can be found by referencing the B/W final report (Valdez and Ryel 1995). These procedures were generally followed during the AGFD (Tim Hoffnagle, AGFD, pers. comm.) and the recent USFWS sampling efforts.

Data collected for each sampling effort included: (1) gear type, (2) location, (3) effort, (4) number of each fish species captured, (5) total length and weight of each captured fish, (6) sex and ripeness (if possible to determine), (7) tag number (if fish was tagged), and (8) a suite of habitat characteristics. Fish total length was measured to the nearest millimeter and weight was measured to the nearest 0.1 gram for fish smaller than approximately 200 g, and to the nearest gram for fish larger than 200 g. Total length was measured using a standard measuring board and weight was measured using electronic balances.

*Data Standardizing and Catch per unit Effort Estimation*

After considering the extent of the electrofishing and trammel netting data within the ten-year period, we chose standardized reaches of the Colorado River that had been consistently sampled and were consistent with the data collected by USFWS (Table 1). All the data was then filtered based on these standardized reaches to obtain the dataset used to compute CPUE. Additionally, the trammel netting data was additionally filtered to include only nets whose physical features conformed to the specifications described above.

Geometric mean CPUE was calculated for: (1) HBC < 200mm, (2) HBC ≥ 200 mm, (3) rainbow trout, (4) brown trout, and (5) flannelmouth sucker.

Geometric mean CPUE for each standardized reach was estimated as:

$$GM_{CPUE} = \exp\left[\frac{\sum \log_e\left(f/e + 1\right)}{n}\right] - 1, \tag{1}$$

where $GM_{CPUE}$ is the geometric mean CPUE, $f$ is the number of fish captured for each sample, $e$ is the effort for each sample, and $n$ is the number of samples collected in each standardized reach. The use of geometric mean to estimate the central tendency of CPUE data is justified in this case due to the large number of sampling efforts resulting in zero catch of a particular species, and the variability in effort among individual sampling efforts (Sokal and Rohlf 1987, Valdez and Ryel 1995). Standard error was estimated using individual log-transformed data and then performing the back-transformation.

HBC CONDITION FACTOR

Throughout the time period under consideration, a total of 2,152 HBC ≥ 200 mm were captured in the Colorado River. Following Valdez and Ryel (1995), the length-weight relationship for HBC ≥ 200 mm captured during 1990-1991 was determined using allometric model with multiplicative error structure (Quinn and Deriso 1999) as:

$$W = \alpha L^{\beta}, \tag{2}$$

where $W$ is weight, $L$ is total length, and $\alpha$ and $\beta$ are the constant model parameters. Parameter estimation was accomplished by taking logarithms of equation (2) to obtain:

$$\log W = \log \alpha + \beta \log L + \varepsilon. \tag{3}$$

where $\varepsilon$ is assumed to be normally distributed with mean equal to zero. Thus, equation (3) was used in a linear regression setting to obtain estimates for log $\alpha$ and $\beta$. These parameter estimates were then used to compute the condition factor for each HBC ≥ 200 mm in the data set as:

$$Kn = \frac{W}{\alpha L^{\beta}}, \tag{4}$$

where $Kn$ is the condition factor. The average and standard error of $Kn$ was computed for each month of the year for which data was available. Two-way analysis of variance was used to test for differences in average condition factor. The multiple comparison test of Scheffe was used to isolate differences in condition factor when factors were shown to be significant (Kleinbaum et al. 1988).

## RESULTS

CPUE

*HBC < 200 mm in Total Length*

Fence Fault

There were no HBC (HBC) < 200 mm captured within the Fence Fault reach with either electrofishing or trammel netting gear over the 10-year period (Appendix 1). However, as reported by Valdez and Ryel (1995), in July 1994 a school of perhaps 100 larval fish was sited near Spring No. 5 from which 14 individuals (18 – 31 mm total length) were captured with a dip net.

Little Colorado River Inflow

Electrofishing efforts yielded much higher catch rates of small HBC within the LCR Inflow reach than trammel netting efforts. With the exception of the high electrofishing catch rates occurring during September and October 1993, the CPUE of HBC <200mm was essentially constant over the 10-year period with most of the point estimates being less than 20 fish/10 hours (Figure 1, Appendix A-1). Additionally, the large standard error of the CPUE estimates did not allow statistical differences to be detected among most of the sampling efforts adding further weight to the conclusion that there was not a detectable trend in long-term abundance of HBC < 200 mm within the LCR Inflow Reach. The unusually high capture rates of HBC < 200 mm in the LCR Inflow Reach during 1993 was related to a large influx of YOY fish (< 75 mm TL) from the LCR following a highly successful spawn during April-May 1993 (Robinson et al. 1996; Gorman 1994; Gorman and Stone 1999).

Trammel netting catch rates for HBC < 200 mm were low and highly variable in the LCR Inflow reach further suggesting that there was no detectable long-term trend in abundance (Figure 1, Appendix B-1). However, this conclusion is only moderately supported by the trammel netting data given the inherent inability of this gear to capture small fish.

Bright Angel Creek

No HBC < 200 mm were captured within the Bright Angel Creek reach during the 10-year period.

Shinumo Creek

Within the Shinumo Creek reach, no HBC < 200 mm were captured using electrofishing gear, and trammel netting efforts yielded non-zero catches on only 4 occasions (Figure 2, Appendix A-1, Appendix A-2). Little can be said about the relative abundance of HBC < 200 mm in this reach except that it appeared to be extremely low and sporadic

Middle Granite Gorge

There was no detectable trend in the abundance of HBC <200 mm within the Middle Granite Gorge reach considering the results of either electrofishing or trammel netting efforts (Figure 3, Appendix A-1, Appendix A-2). Estimates of electrofishing CPUE ranged between 0 and 5.23 fish/10 hours with no statistical difference among efforts yielding non-zero catches. Trammel netting efforts again produced uniformly low and imprecise estimates of CPUE.

Kanab Creek

Electrofishing efforts within the Kanab Creek reach resulted in only one non-zero catch of HBC < 200 mm among all sampling trips during the 10-year period, and trammel netting efforts were uniformly unproductive (Figure 4, Appendix A-1, Appendix A-2).

Havasu Creek

No HBC < 200 mm were captured within the Bright Angel Creek reach during the 10-year period.

*HBC ≥ 200 mm In Total Length*

Fence Fault

HBC ≥ 200 mm were captured with both electrofishing and trammel netting gear within the Fence Fault reach on several occasions (Figure 5, Appendix B-1, Appendix B-2). However, electrofishing efforts yielded only one non-zero catch. Trammel netting efforts demonstrated a relatively constant but low catch of large HBC in the Fence Fault reach with the exception of three sampling trips which yielded much higher catch rates. These data suggest that the abundance of large HBC increased beginning sometime in 1998, but the estimates of CPUE are imprecise and do not imply a statistically significant difference. Additionally, the HBC in the Fence Fault reach are likely highly aggregated near the warm springs that exist in the area, and over time the personnel charged with capturing these fish have learned where the fish reside.

Therefore, the increase in capture rates during the last few years is likely due more to an increase in fishing efficiency rather than an increase in the abundance of large HBC.

Little Colorado River Inflow

Electrofishing within the LCR Inflow reach did not demonstrate a clear trend in the abundance of large HBC (Figure 6, Appendix B-1, Appendix B-2). In particular, the electrofishing CPUE was consistently low and without statistical difference among all sampling trips. The estimated CPUE for trammel netting was often higher between 1990-1993 compared to 1996-2000. For example CPUEs for 1990-1993 exceeded 5 fish/100ft/100hrs in 14 out of 31 sample periods but remained below 5 for all sample periods between 1996-2000 (Fig. 6). However, the data do not suggest a clear long-term trend in abundance.

Bright Angel Creek

No HBC ≥ 200 mm were captured within the Bright Angel Creek reach during the 10-year period.

Shinumo Creek

The CPUE estimates for large HBC using both electrofishing and trammel netting gears did not differ significantly from zero among all sampling trips. Though this level of imprecision in the estimates of CPUE did not allow for any definitive conclusion about the trend in abundance, the point estimates for three of the last five sampling trips were among the highest observed (Figure 7, Appendix B-1, Appendix B-2).

Middle Granite Gorge

Similar to the Shinumo Creek reach, the Middle Granite Gorge reach did not contain CPUE estimates that differed significantly from zero among all sampling trips and both gear types. Based on these data, there did not appear to be any trend in the abundance of large HBC (Figure 8, Appendix B-1, Appendix B-2).

Kanab Creek

Only one sampling trip yielded non-zero catches of large HBC in the Kanab Creek reach. There appeared to be few large HBC in the Kanab Creek Reach (Figure 9, Appendix B-1, Appendix B-2).

Havasu Creek

Not since September 1993 have large HBC been captured in the Havasu Creek mainstem reach. There appeared to be extremely low numbers of HBC in this reach that have not been observed for approximately 6 years (Figure 10, Appendix B-1, Appendix B-2).

*Rainbow Trout*

Fence Fault

Electrofishing CPUE for rainbow trout using electrofishing gear within the Fence Fault reach ranged between 0 and 1800 fish/10 hours (Figure 11, Appendix C-1). The pattern of electrofishing CPUE over the 10-year period suggested that rainbow trout abundance was generally increasing since approximately 1996 and that it was higher in 1999-2000 than at any other period in the timeseries. The trammel netting CPUE generally supported this same conclusion (Figure 11, Appendix C-2).

Little Colorado River Inflow

Similar to the Fence Fault reach, patterns in electrofishing CPUE in the LCR Inflow reach suggested that the abundance of rainbow trout was increasing since approximately 1996 (Figure 12, Appendix C-1). Observed CPUE during two of the three most recent trips were significantly higher than found in the in the rest of the record. CPUE estimates for the trammel netting data indicated that rainbow trout abundance remained fairly constant over the 10-year

period with the exception of a single sampling trip that occurred in September 1998 (Figure 12, Appendix C-2).

Bright Angel Creek

CPUE for electrofishing in the Bright Angel Creek reach ranged between 0 and 586 fish/10 hours (Figure 13, Appendix C-1). This pattern suggests that rainbow trout decreased in abundance through 1993 but rebounded in recent years. The trammel netting data suggest an increase in abundance in recent years but only one of the last 5 sampling trips had an estimate of CPUE that was significantly different from zero (Figure 13, Appendix C-1).

Shinumo Creek

The data from the Shinumo Creek reach supported the same conclusions as those regarding the Bright Angel Creek Reach. Again, the trend was most apparent considering the electrofishing data where abundance declined from the beginning of the timeseries through approximately 1993, and then increased in abundance beginning in approximately 1996 (Figure 14, Appendix C-1). The trammel netting data suggested the same trend but the imprecise estimates all but negated their utility in drawing conclusions (Figure 14, Appendix C-2).

Middle Granite Gorge

Electrofishing catch rates for rainbow trout in the Middle Granite Gorge reach implied that abundance increased beginning in 1996 through the end of the timeseries (Figure 15, Appendix C-1). Though there were two sampling trips yielding catch rates near 250 fish/10 hours in 1996 and 1997, the remainder of the catch rates observed since 1997 were similar to those observed in 1991. The trammel netting data also suggested an increase in the abundance of rainbow trout in the most recent three years, but as found in other reaches the estimates were of exceedingly low precision (Figure 15, Appendix C-2).

Kanab Creek

The abundance of rainbow trout in the Kanab Creek reach increased markedly in the last two years according to the electrofishing data (Figure 16, Appendix C-1). The observed catch rate exceeded 100 fish/10 hours in each of the last five sampling trips. In contrast, in all previous trips, the highest observed CPUE was 23 fish/10 hours. Only two sampling trips during the 10-year period yielded non-zero catches of rainbow trout using trammel netting gear and both occurred within the most recent two years (Figure 16, Appendix C-2). This observation lends further support to the contention that rainbow trout abundance increased in recent years.

Havasu Creek

The data collected from the Havasu Creek reach, like the Kanab Creek reach, also supported the conclusion that rainbow trout abundance increased in recent years. With the exception of November 1990, all electrofishing efforts yielding CPUE estimates greater than 100 fish/10 hours occurred in the most recent 2 years of the timeseries (Figure 17, Appendix C-1). The trammel netting data did not provide much support for this conclusion except that the largest estimated CPUE was observed in January 1999 (Figure 17, Appendix C-2).

*Brown Trout*

Fence Fault

Brown trout abundance appeared to be low within the Fence Fault reach: non-zero catches were observed using electrofishing gear during only 3 of the sampling trips, and only once using trammel netting gear (Figure 18, Appendix D-1, Appendix D-2).

Little Colorado River Inflow

Neither the electrofishing nor trammel netting efforts supported the conclusion that Brown trout abundance was significantly changed over the ten-year period within the LCR Inflow reach. The CPUE estimates for both gear types were relatively low, highly imprecise,

and were uniformly not significantly different from zero (Figure 19, Appendix D-1, Appendix D-2).

Bright Angel Creek

The electrofishing data collected in the Bright Angel Creek reach indicated that brown trout abundance suffered a decline from October 1990 through October 1993 (Figure 20, Appendix D-1). It also appeared that the abundance rebounded in recent years. During 1994 through 1997, this reach was not sampled so inferences concerning brown trout abundance within this time period were not possible. The trammel netting data did not echo the relative abundance pattern observed in the electrofishing data (Figure 20, Appendix D-2). However, the brown trout did appear to be at least as abundant in recent years as during the early years of the timeseries

Shinumo Creek

Observed electrofishing catch rates for brown trout within the Shinumo Creek reach were uniformly less than 75 fish/10 hours from 1990 – 1996, and uniformly greater than 100 fish/10 hours during 1997 – 2000 (Figure 21, Appendix D-1). These data provide strong evidence of an increasing trend in brown trout abundance beginning in 1996. The trammel netting data provided no clear trends to either support or refute this conclusion (Figure 21, Appendix D-2).

Middle Granite Gorge

Neither the electrofishing nor the trammel netting data supported any clear trends in the abundance of brown trout in the Middle Granite Gorge reach. The observed electrofishing CPUE was low and not significantly different from zero during all sampling trips except the January 2000 trip (Figure 22, Appendix D-1). Similarly, the trammel netting catch rates were low and not significantly different from zero among all trips (Figure 22, Appendix D-2).

Kanab Creek

Within the Kanab Creek reach, only five sampling trips yielded non-zero catches of brown trout using electrofishing gear (Figure 23, Appendix D-1). Three of the five trips observed low catch rates not significantly different from zero, one trip (March 1996) captured one brown trout in one electrofishing effort, and one trip (January 2000) captured five brown trout in three electrofishing efforts. Only one sampling trip yielded non-zero catches of brown trout using trammel netting gear (Figure 23, Appendix D-2). These data support no conclusions regarding a long-term trend in brown trout abundance within the Kanab Creek reach.

Havasu Creek

The CPUE of brown trout using electrofishing gear within the Havasu Creek reach ranged from 0 to 33 fish/10 hours (Figure 24, Appendix D-1). Only one of the efforts resulting in non-zero catches was significantly different from zero. Trammel netting efforts within the Havasu Creek reach yielded only one non-zero catch of brown trout. These data support no conclusions regarding the long-term trend in brown trout abundance within the Havasu Creek reach.

*Flannelmouth Sucker*

Fence Fault

In general, flannelmouth sucker were captured only sporadically and in low numbers within the Fence Fault Reach using both electrofishing and trammel netting gear (Figure 25, Appendix E-1, Appendix E-2). These data support no conclusions regarding the long-term trend in flannelmouth abundance within the Fence Fault reach.

Little Colorado River Inflow

Electrofishing efforts within the LCR Inflow reach yielded CPUE estimates for flannelmouth sucker that were relatively constant and not significantly different than zero

(Figure 26, Appendix E-1). With the exception of two sampling trips in February 1991 and February 1992, the trammel netting data can be characterized the same way (Figure 26, Appendix E-1). These data suggest that the abundance of flannelmouth sucker remained fairly constant over the 10-year period.

Bright Angel Creek, Shinumo Creek, and Middle Granite Gorge

In Bright Angel Creek reach among all sampling trips and both gear types, there was only one estimate of CPUE that was significantly different from zero (Figure 27, Appendix E-1, Appendix E-2). Similarly, there was only one estimate of CPUE that was significantly different from zero among all sampling trips and both gear types in the Shinumo Creek (Figure 28, Appendix E-1 and E-2) and Middle Granite Gorge reaches (Figure 29, Appendix E-1 and E-2). Of some interest is that all of the abnormally high catch rates were observed using electrofishing gear on the same trip in September 1992. The only conclusion that these data support is that the abundance of flannelmouth sucker remained low and relatively constant over the 10-year period in the Bright Angel Creek, Shinumo Creek, and Middle Granite Gorge reaches.

Kanab and Havasu Creeks

The highest observed catch rates for flannelmouth sucker were found in the Kanab (Figure 30, Appendix E-1, Appendix E-2) and Havasu Creek reaches (Figure 31, Appendix E-1, Appendix E-2). Although these reaches had the highest estimated CPUE among those considered in this report, there does not seem to be any long-term trend in the abundance of flannelmouth sucker in either the Kanab or Havasu Creek reaches.

## HBC CONDITION FACTOR

### *Length-Weight Relationship*

The allometric length-weight model was fit to the length and weight data from 595 HBC ≥ 200 mm captured from the Colorado River during 1990-1991 (Figure 32). The high $R^2$ of 0.92 indicates that the model was able to account for most of the variability in the dataset and the parameter estimates of $\log\alpha = 4.78$ and $\beta = 2.90$ were highly significant ($p<0.001$).

### *Condition Factor*

Average monthly condition factor was calculated for each month containing data from 1990 – 2000 (Table 2, Figure 33). Condition factor was generally highest in the winter, presumably proceeding the spawning period, and lowest in the summer following the spawn. To test for trend in the condition factor over time, we performed a two-way ANOVA with month and year as main factors. Because the entire data record contained many months where there were no data with which to estimate condition factor, we used data from the months of June and September during the years 1991-1993 and 1995 – 1999 to conduct the analysis. This was the longest series of years that contained data for multiple months. Both year, month, and their interaction were significant indicating that there was a trend among both months and years (Table 3). The multiple comparison test of Scheffe was used to test for differences among years and found that there was a significant difference between the average condition factor in 1997 and 1991, 1992, 1993, and 1998 ($p \leq 0.001$). However, examining the average condition factor among years, we can see that there is no overall trend of either increasing or decreasing condition factor over time (Figure 34). We also found that the condition factor was always greater in September than in June ($p \leq 0.001$). This was not an unexpected finding as it demonstrates the familiar pattern of fish recovering from the arduous task of reproduction.

## DISCUSSION

*Relative Abundance*

Of the seven standardized reaches, only the LCR inflow had consistently detectable numbers of HBC <200 mm TL and only electrofishing was effective in capturing small HBC. With the exception of the 1993 abundance of small HBC, the LCR inflow reach abundances cycled between near 0 and 20-30 fish/10hrs of electrofishing. After the LCR inflow, small HBC were most abundant in Middle Granite Gorge, were CPUEs varied erratically between 0 and 5 fish/10hrs electrofishing. Overall, there was no discernible up or downward trend in abundance of HBC <200 mm TL over the 10-year sampling period. Peak abundances of small HBC in the LCR inflow during the early 1990s were similar to that observed in the late 1990s. Relative abundance of HBC<200 mm TL in the LCR inflow fluctuated seasonally and reflected reproduction and flooding periodicity in the source stream, the LCR. Between 1991-1993 when sampling was frequent, numbers of HBC <200 mm TL peaked in September 1991, June 1992, and September-October 1993. Less frequent but regular sampling in 1998-1999 revealed similar seasonal peak abundances in September sampling. The late summer peaks coincided with monsoon flooding events in the LCR where small young-of-year (YOY) HBC were flushed into the mainstem. Early summer flooding in 1992 resulted in peak numbers of YOY HBC being captured in June. These seasonal patterns in abundance of small HBC concur with analyses provided by Valdez and Ryel (1995) for the period 1991-1994.

While electrofishing appeared to be effective in sampling small HBC, trammel netting was more effective for adult HBC >200 mm TL; captures of adult HBC by electrofishing were low and sporadic. As with small HBC, the LCR inflow yielded the greatest abundances of adult

HBC (typically 1-10 fish/100 hrs/100 ft of trammel net). Abundances of adult HBC in other reaches were low and highly variable. Although no long-term trend or seasonal pattern of abundances is evident in the LCR inflow, adult HBC appear to be slightly more abundant in the early 1990s compared to the late 1990s: mean CPUEs for the period 1996-2000 never exceeded 5 fish/100ft/100hrs but during 1990-1993 CPUEs exceeded this figure for 14 of 31 sampling periods. Some of this apparent decline might be caused by more intensive sampling close to the confluence of the LCR during late winter and early spring during 1991-1993 that was intended to focus on aggregations that typically occur in this area prior to adults ascending and spawning in the LCR (Valdez and Ryel 1995). This sampling strategy was not practiced in the later 1990s. Of the 14 sampling periods in 1990-1993 that had higher CPUE, 6 occurred during February-April and 6 occurred during July, October, and November, months that were not sampled consistently after 1993.

Rainbow trout CPUEs were typically 10-100 times that of HBC and electrofishing appeared to be much a more effective sampling method than trammel netting. The highest CPUEs were observed in the Fence Fault reach, but rainbow trout were relatively abundant throughout the mainstem reaches. A common trend in abundance was observed: rainbow trout CPUE declined in the early 1990s, increased following the 1996 experimental flood, declined somewhat in 1997-1998 and abundance increased sharply in 1998-2000. It is interesting to speculate as to the effects of changes in dam operations and resulting flow regimes on rainbow trout abundance. 1991 marked the beginning of modified low fluctuating flows; 1996 was a high water year with an experimental flood followed by low fluctuating high flows. 1998 marked the return of more widely fluctuating flows (although not nearly as fluctuating as prior to 1991).

Like rainbow trout, electrofishing was the more effective sampling method for brown trout. Brown trout abundance was very low in the Fence Fault reach, low in the LCR inflow, greatest in the Bright Angel Creek and Shinumo Creek reaches, and declined further downstream. Prior to 1997, abundances of brown trout were very low in all reaches except for Bright Angel. After 1997 abundances of brown trout began to increase in all reaches downstream of the LCR inflow. In the Bright Angel reach, abundances of brown trout followed a pattern similar to that for rainbow trout: brown trout abundances decreased in the early 1990s and increased after 1997. As with rainbow trout, these trends may be related to changes in dam operations and resultant flow regimes over the period 1990-2000.

Both electrofishing and trammel netting appeared to be effective means of sampling flannelmouth sucker, but CPUEs were highly variable over time. Abundance of flannelmouth sucker was greater in reaches downstream of the LCR inflow. Long-term trends and seasonal patterns in CPUE were not evident.

*Condition factor in HBC*

Estimates of condition factor used all available mainstem capture data for HBC>200 mm TL for each sampling period between 1990-2000, thus providing us with a relatively large dataset for analysis. Contrary to analysis of condition factor for HBC in the LCR and LCR inflow by Meretsky et al. (2000), we did not detect a downward trend in condition factor but concur on a seasonal pattern whereby condition factor is low during summer months following spawning and recovers during the following fall and winter.

*Trends in abundance of native vs. non-native fishes.*

During 1998-2000, rainbow trout was the most abundant fish in the mainstem Colorado River in Grand Canyon where this species successfully spawns and shows successful recruitment. Brown trout was locally abundant in the Bright Angel-Shinumo portions of Grand Canyon. Brown trout is abundant and spawns in Bright Angel and Shinumo creeks (Otis 1994, Otis and Maughan 1994) and these streams may serve as population sources for mainstem habitats. Long-term trends in abundance in rainbow trout and to some extent brown trout appear to be linked to changes in dam operations and resulting flow regimes. For example, during periods of reduced daily flow fluctuation (1991-1995) abundances were low or declining. During periods of greater daily flow fluctuation (before 1991 and after 1997), abundances were high or increasing. In contrast, trends in abundance of native species, HBC and flannelmouth sucker, appear unrelated to mainstem flow regimes. These native species are known to spawn in tributaries (Otis 1994, Weis 1993, Thieme 1998, Gorman 1994, Gorman and Stone 1999) and seasonal patterns in abundance of small HBC in the mainstem appear to be tied to spawning success and flooding in the LCR (Valdez and Ryel 1995, Robinson, et al. 1998). Likewise, seasonal patterns in condition factor for adult HBC in the mainstem appear to be tied to spawning in the LCR (Valdez and Ryel 1995, Gorman and Stone 1999, Meretsky et al. 2000).

*Recommendations for long-term monitoring*

Our analysis of long-term trends in abundance of principal species in the Colorado River mainstem in Grand Canyon revealed that electrofishing was an effective sampling method for small HBC, flannelmouth sucker, rainbow trout and brown trout. The relative success of this method with these species indicates that shoreline habitats are used regularly by these species. In practice, electrofishing in Grand Canyon is conducted over large reaches of shorelines and

habitat types and therefore may provide a representative sample of mainstem fish communities. Trammel netting was effective in sampling adult HBC. Trammel netting in Grand Canyon was employed in specific areas or "hot spots" known through experience to harbor concentrations of the target species (in this case adult HBC). Because adult HBC were relatively rare, showed a highly clustered distribution, and were infrequent users of shallow shoreline habitats, selective trammel netting was an effective means of capturing adult HBC. In order to be useful for monitoring long-term trends in abundance, these sites must be consistently sampled in precisely the same way over time. If there is some randomness in adult HBC concentrations over time and space, estimates of abundances will be highly variable, as was observed. Fluctuations in the locations of adult HBC aggregations may be related to fluctuations in local food abundance, variation in timing of seasonal migration, and changes in local habitat and flow characteristics as influenced by changes in river flow regime. With these considerations in mind, developing a statistically sound sampling design for long-term assessment of adult HBC based on highly selective trammel netting is fraught with difficulty. However, this sampling method may provide useful data on condition factor, age/size-specific growth, aging, health, etc.

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Table 1. Standardized reaches used for historical CPUE comparisons.

**Electrofishing**

| Site Name | Min-Max Upstream | Min-Max Downstream |
|---|---|---|
| Fence Fault | 30.0 | 30.6 |
| LCR Inflow | 60.0 | 68.2 |
| Bright Angel | 86.2 | 88.0 |
| Shinumo | 107.1 | 108.6 |
| Middle Granite Gorge | 125.5 | 127.7 |
| Kanab | 141.0 | 142.5 |
| Havasu | 156.2 | 158.0 |

**Trammel Netting**

| Site Name | Min-Max Upstream | Min-Max Downstream |
|---|---|---|
| Fence Fault | 30.0 | 30.7 |
| LCR Inflow | 60.0 | 68.7 |
| Bright Angel | 85.9 | 87.2 |
| Shinumo | 106.4 | 108.6 |
| Middle Granite Gorge | 123.2 | 128.1 |
| Kanab | 142.1 | 143.0 |
| Havasu | 154.9 | 158.7 |

Table 2. Average and standard error of the condition factor of all humpback chub greater than or equal to 200 mm captured in the Colorado River, 1990 - 2000.

| Sample Date | Sample Size | Mean Condition Factor | Standard Error Condition Factor |
|---|---|---|---|
| 10/90 | 42 | 1.05 | 0.02 |
| 11/90 | 45 | 1.03 | 0.02 |
| 12/90 | 3 | 0.90 | 0.03 |
| 1/91 | 80 | 1.04 | 0.01 |
| 2/91 | 3 | 1.10 | 0.10 |
| 3/91 | 123 | 1.06 | 0.01 |
| 4/91 | 5 | 1.03 | 0.05 |
| 5/91 | 33 | 0.99 | 0.03 |
| 6/91 | 35 | 0.93 | 0.02 |
| 7/91 | 80 | 0.97 | 0.02 |
| 9/91 | 99 | 0.99 | 0.01 |
| 11/91 | 44 | 0.98 | 0.02 |
| 1/92 | 26 | 1.02 | 0.02 |
| 2/92 | 6 | 0.94 | 0.06 |
| 3/92 | 44 | 1.04 | 0.02 |
| 4/92 | 37 | 1.03 | 0.02 |
| 5/92 | 51 | 0.93 | 0.02 |
| 6/92 | 38 | 0.82 | 0.02 |
| 7/92 | 100 | 1.01 | 0.01 |
| 8/92 | 6 | 1.04 | 0.04 |
| 9/92 | 48 | 1.04 | 0.02 |
| 11/92 | 58 | 0.99 | 0.02 |
| 1/93 | 110 | 1.04 | 0.01 |
| 2/93 | 78 | 1.05 | 0.01 |
| 3/93 | 58 | 1.09 | 0.02 |
| 4/93 | 41 | 1.07 | 0.02 |
| 5/93 | 93 | 0.94 | 0.02 |
| 6/93 | 71 | 0.92 | 0.02 |
| 7/93 | 94 | 0.97 | 0.01 |
| 8/93 | 40 | 0.93 | 0.02 |
| 9/93 | 87 | 1.06 | 0.08 |
| 10/93 | 44 | 0.97 | 0.02 |
| 11/93 | 39 | 0.96 | 0.02 |
| 4/94 | 1 | 1.16 | |
| 5/94 | 6 | 1.04 | 0.09 |
| 7/94 | 51 | 0.94 | 0.02 |
| 3/95 | 2 | 0.96 | 0.21 |
| 6/95 | 15 | 1.01 | 0.03 |
| 9/95 | 13 | 1.02 | 0.04 |
| 2/96 | 6 | 1.11 | 0.06 |
| 3/96 | 21 | 1.00 | 0.03 |
| 4/96 | 30 | 1.04 | 0.02 |
| 6/96 | 6 | 0.99 | 0.06 |
| 9/96 | 25 | 1.07 | 0.03 |
| 3/97 | 7 | 1.01 | 0.03 |
| 6/97 | 20 | 1.06 | 0.03 |
| 9/97 | 39 | 1.10 | 0.03 |
| 6/98 | 13 | 0.90 | 0.03 |
| 8/98 | 36 | 1.00 | 0.02 |
| 9/98 | 18 | 1.08 | 0.03 |
| 1/99 | 6 | 1.06 | 0.06 |
| 6/99 | 16 | 0.95 | 0.03 |
| 9/99 | 35 | 1.08 | 0.03 |
| 1/00 | 25 | 1.09 | 0.03 |

Table 3. Results of the condition factor ANOVA testing for trend in year and month.

| Source | Sum-of-Squares | df | Mean-Square | F-ratio | P |
|---|---|---|---|---|---|
| MO | 0.454 | 1 | 0.454 | 21 | 0.000 |
| YR | 1.145 | 7 | 0.164 | 7.744 | 0.000 |
| MO*YR | 0.578 | 7 | 0.083 | 3.906 | 0.000 |
| | | | | | |
| Error | 13.014 | 616 | 0.021 | | |

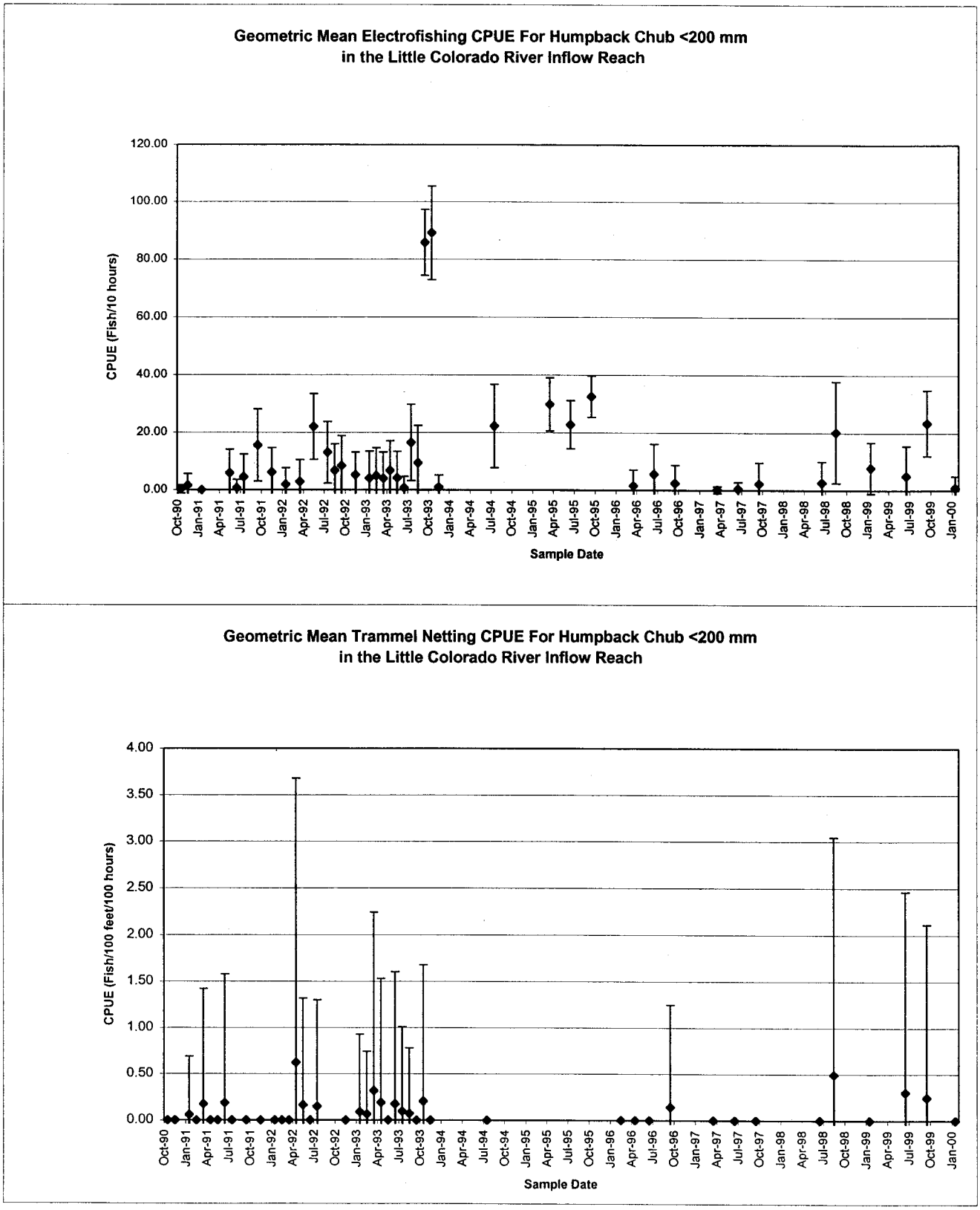
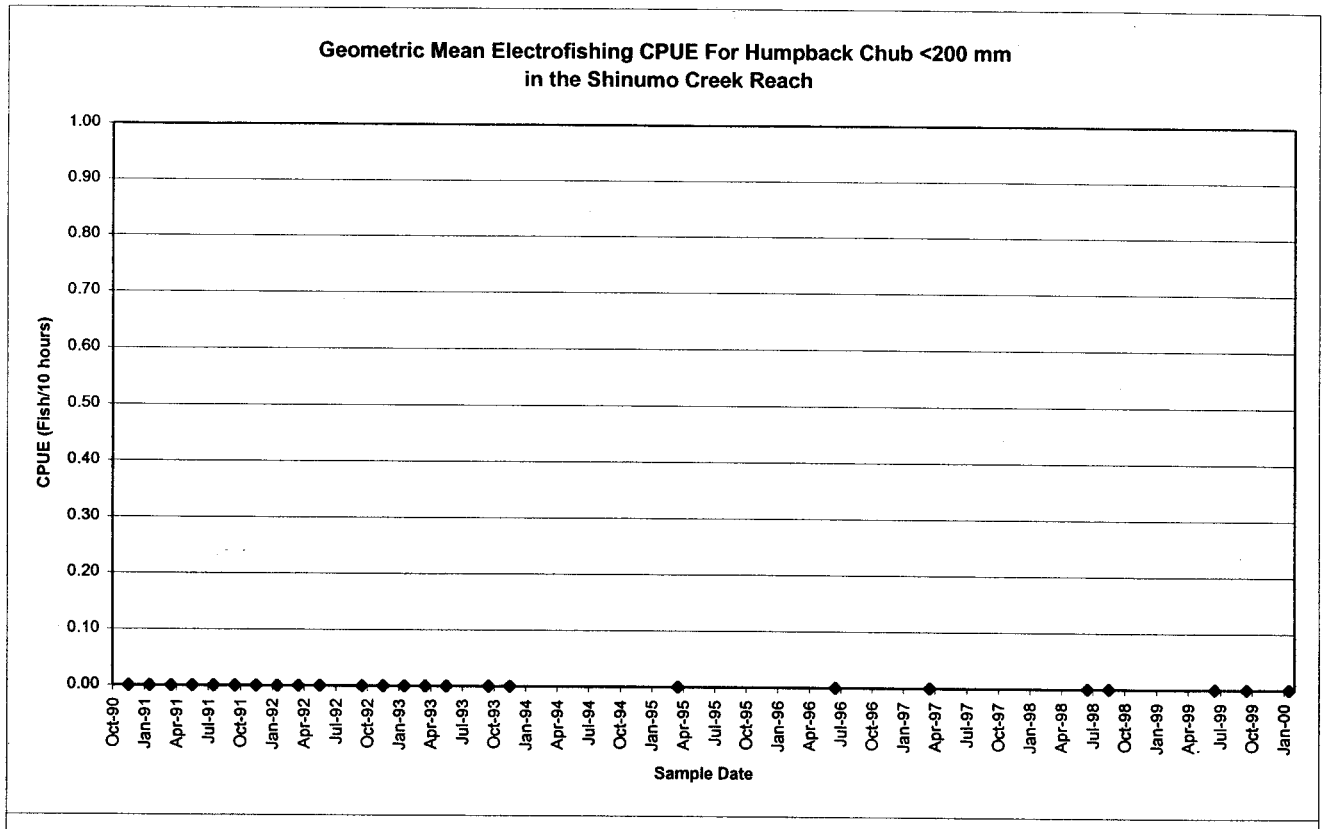



Figure 1. Electrofishing and trammel netting CPUE for humpback chub < 200 mm within the Little Colorado River Inflow Reach. Error bars are one standard error.



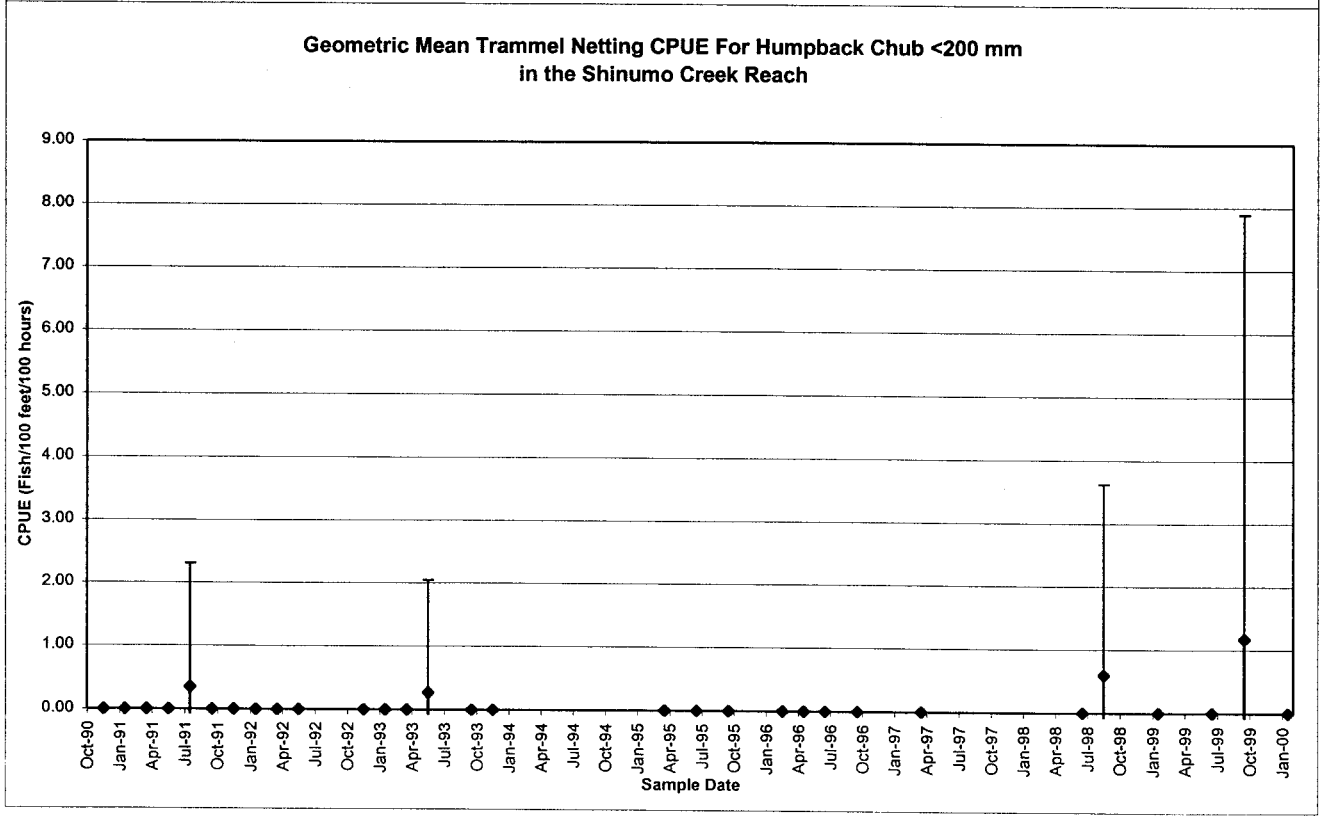




Figure 2. Electrofishing and trammel netting CPUE for humpback chub < 200 mm within the Shinumo Creek Reach. Error bars are one standard error.

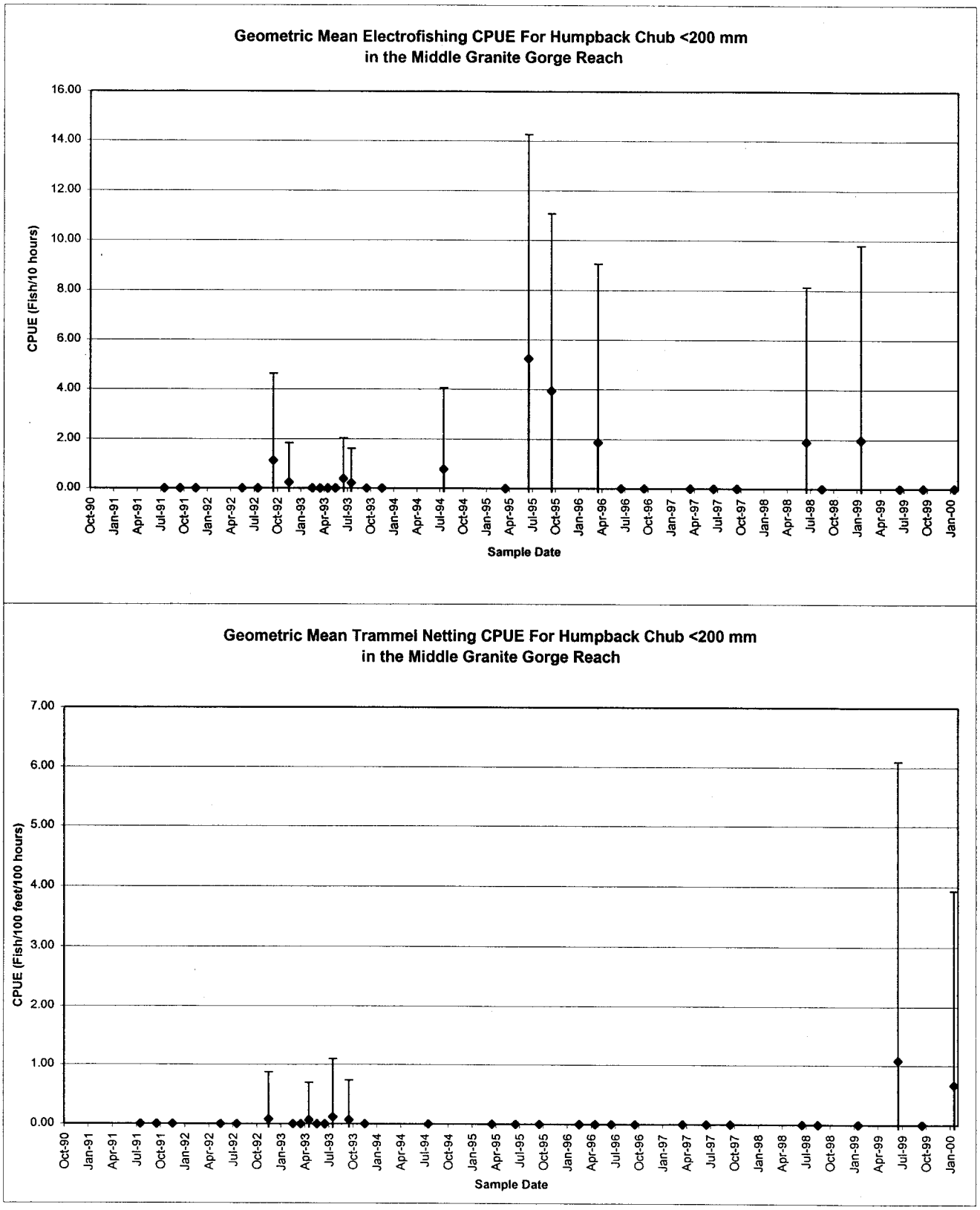



Figure 3. Electrofishing and trammel netting CPUE for humpback chub < 200 mm within the Middle Granite Gorge Reach. Error bars are one standard error.

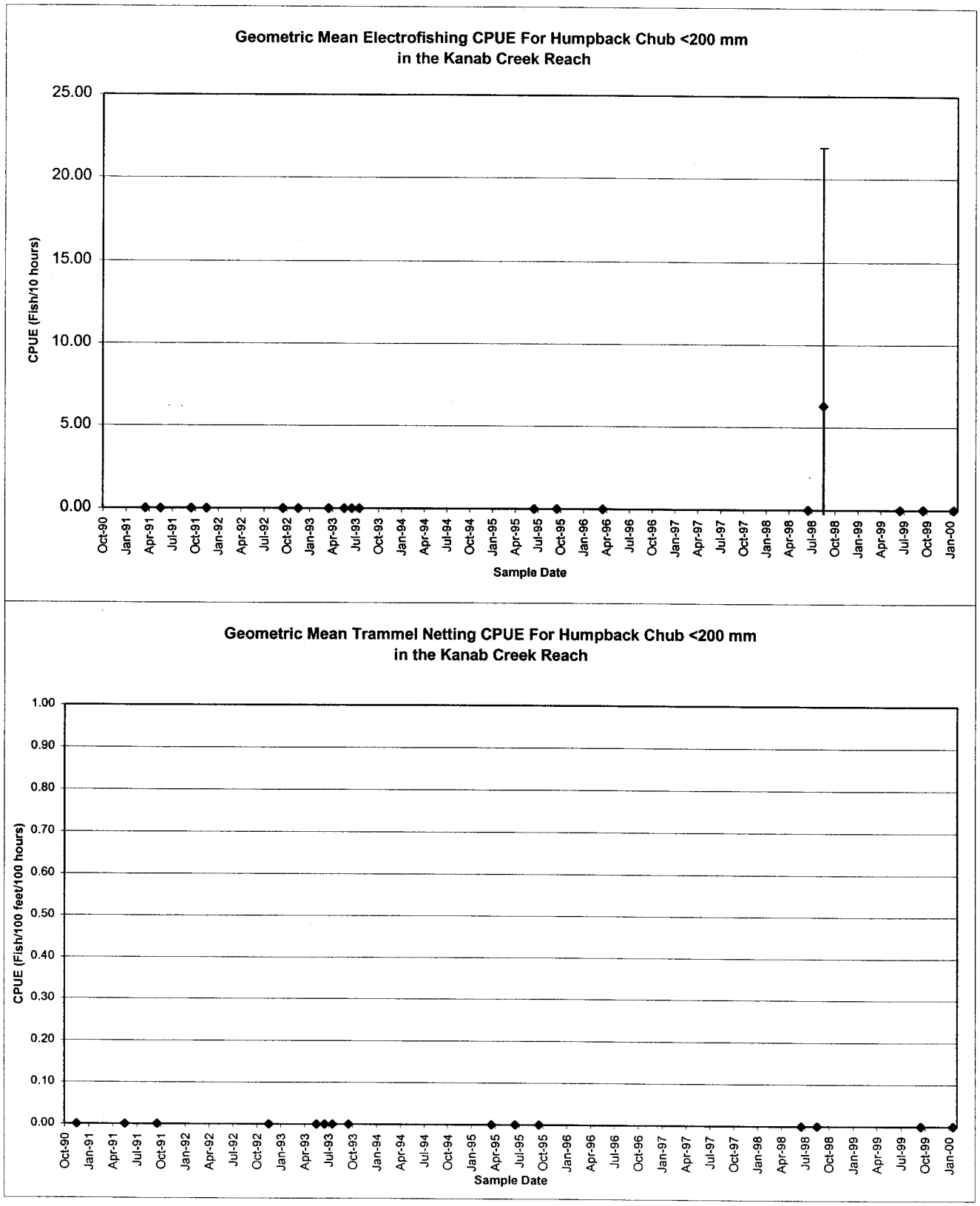
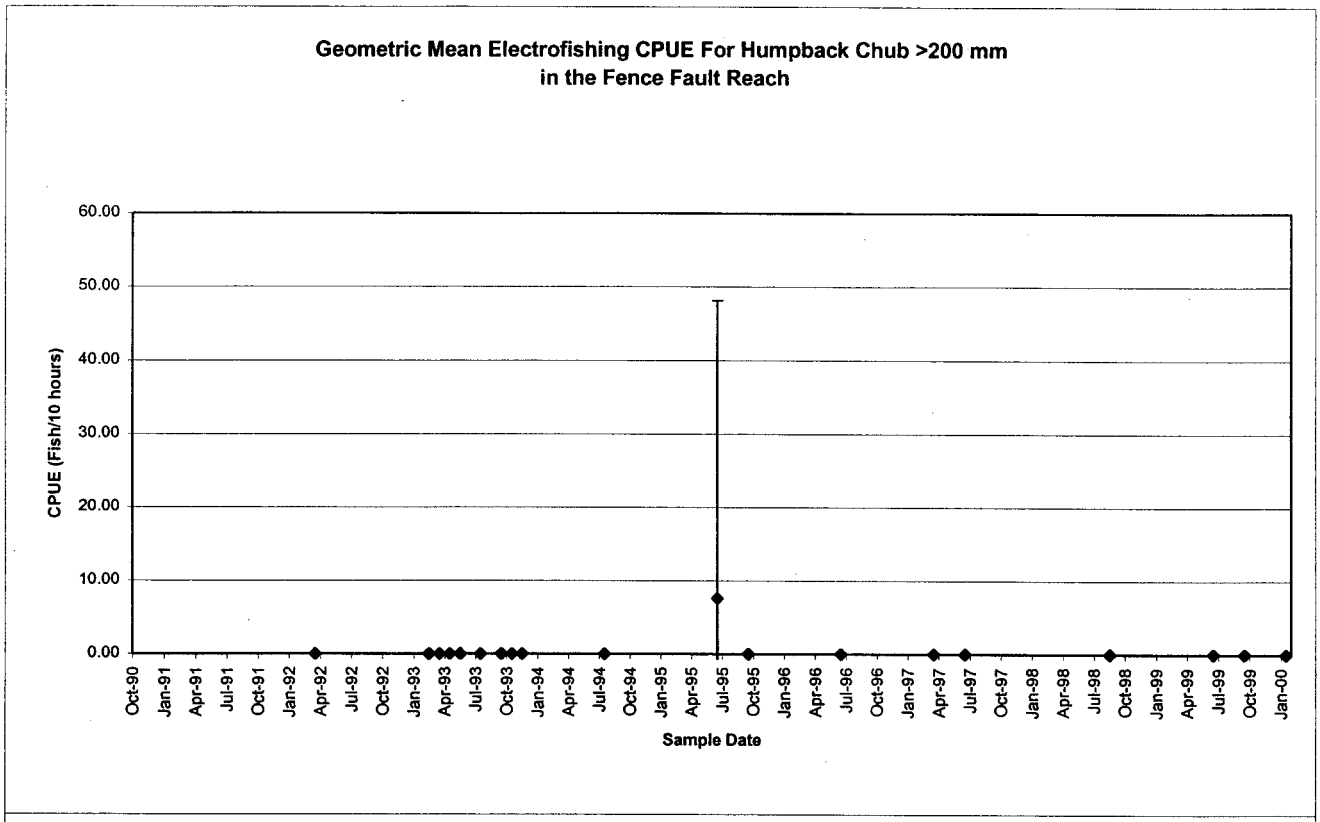



Figure 4. Electrofishing and trammel netting CPUE for humpback chub < 200 mm within the Kanab Creek Reach. Error bars are one standard error.



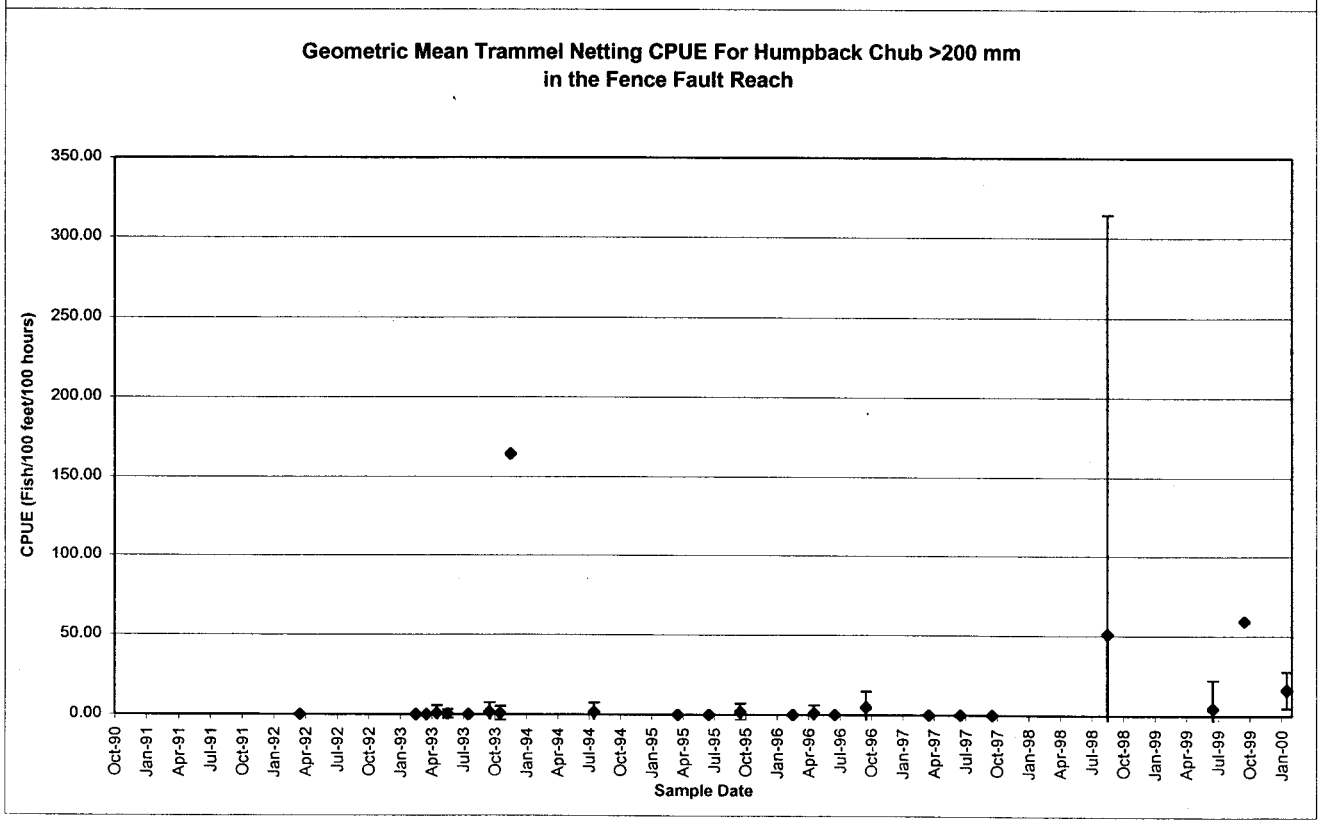
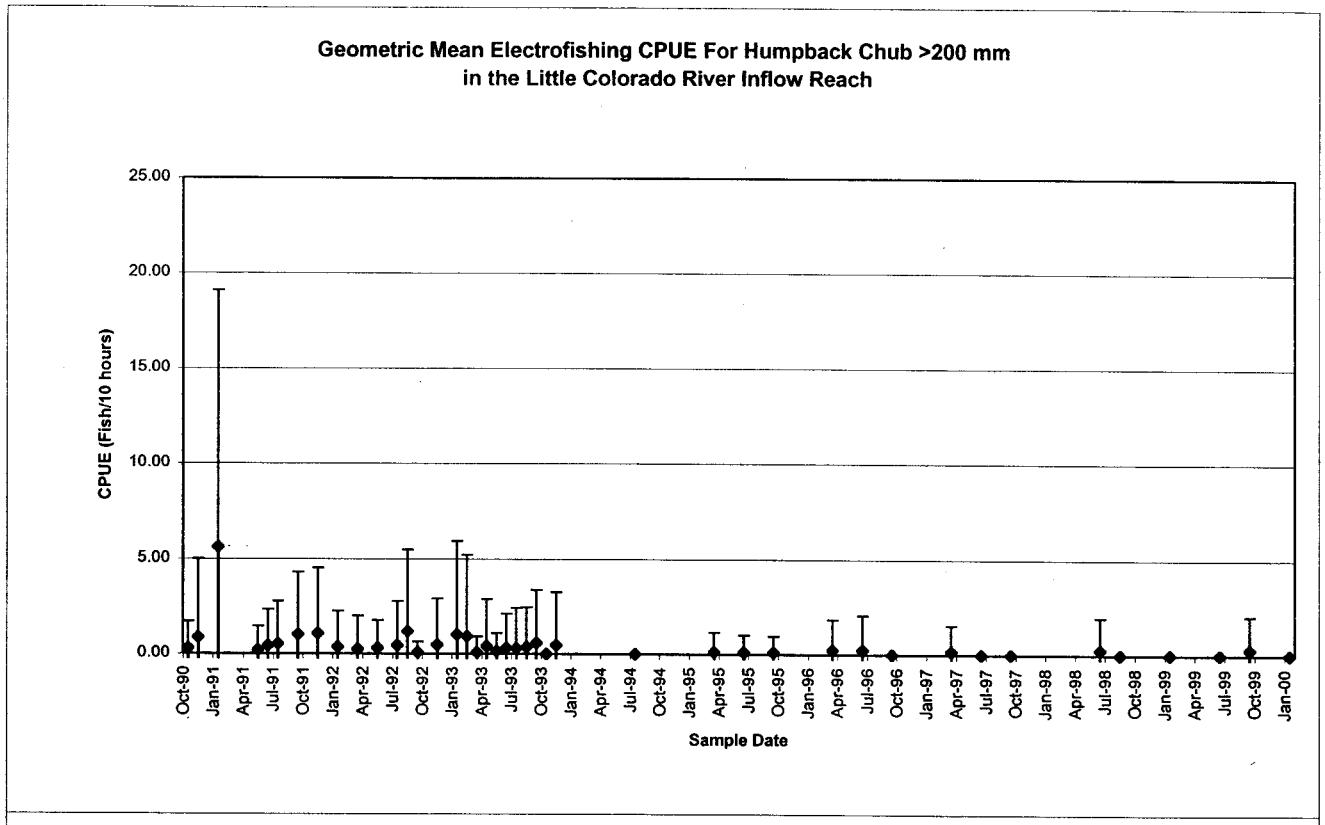




Figure 5. Electrofishing and trammel netting CPUE for humpback chub > 200 mm within the Fence Fault Reach. Error bars are one standard error.



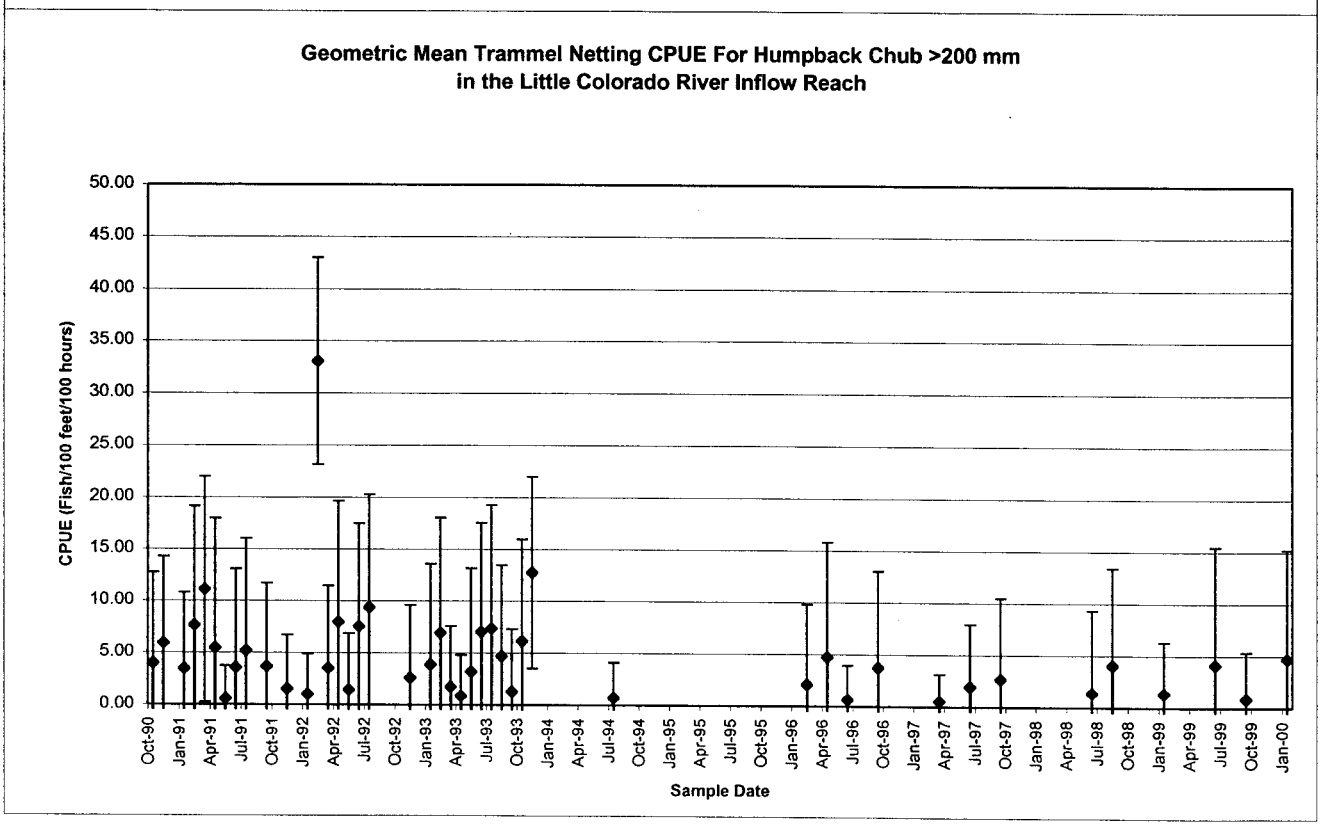
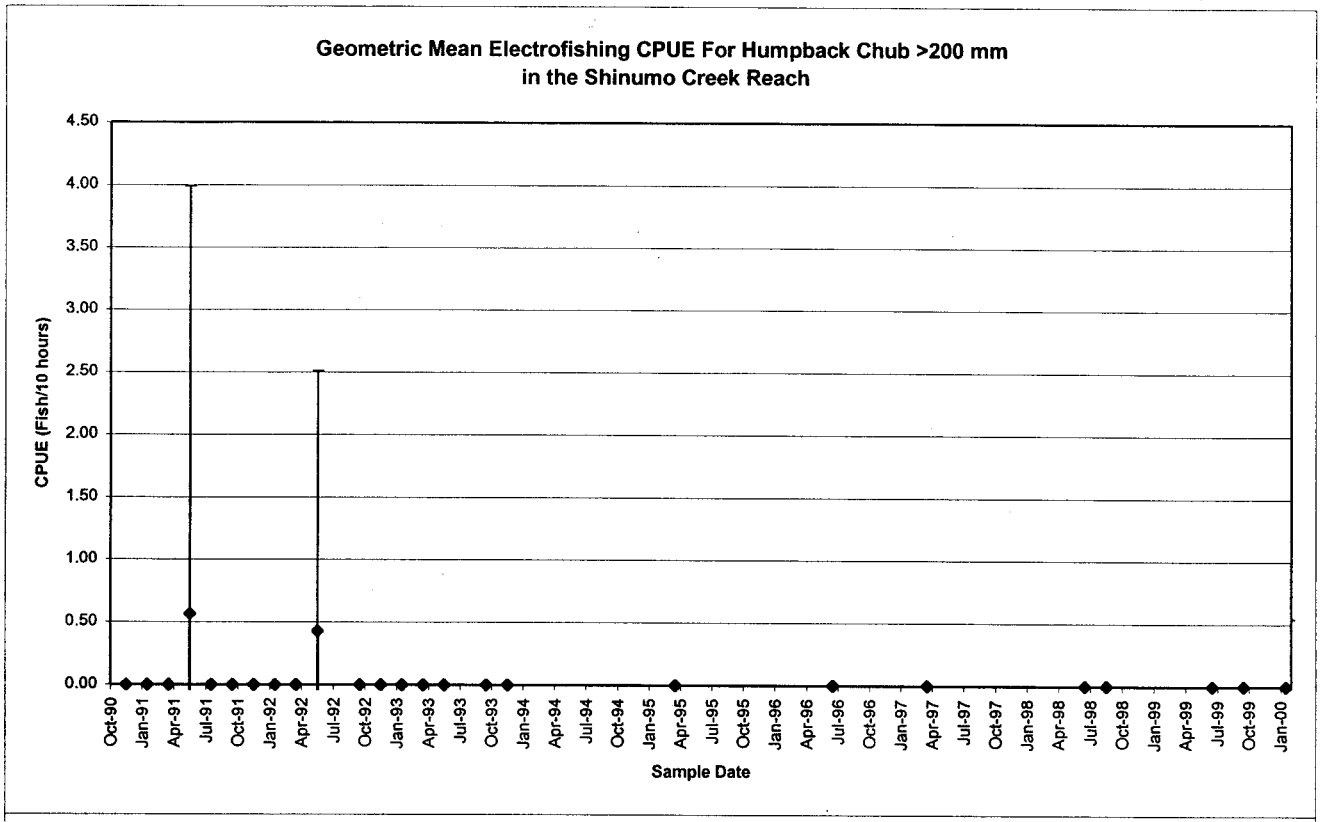




Figure 6. Electrofishing and trammel netting CPUE for humpback chub > 200 mm within the Little Colorado River Inflow Reach. Error bars are one standard error.



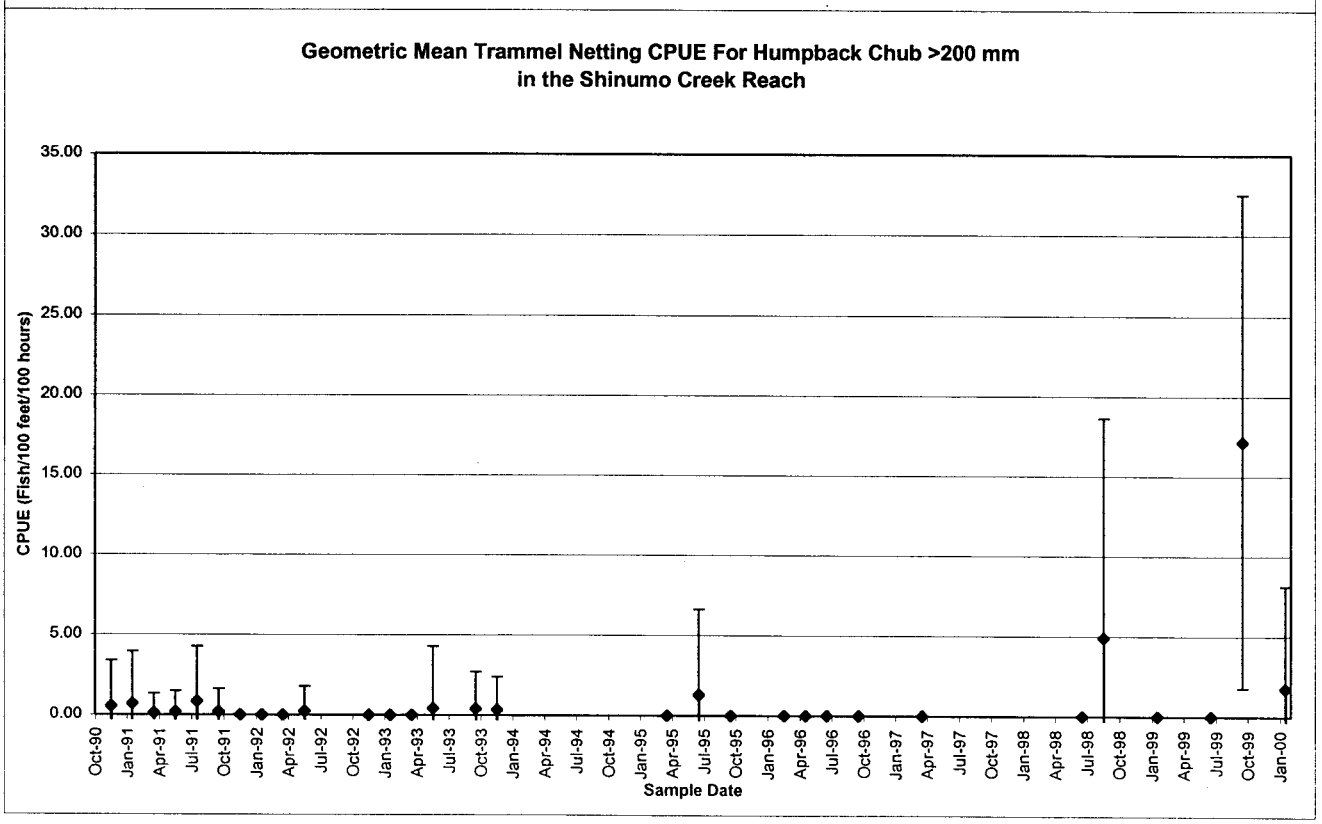




Figure 7. Electrofishing and trammel netting CPUE for humpback chub > 200 mm within the Shinumo Creek Reach. Error bars are one standard error.

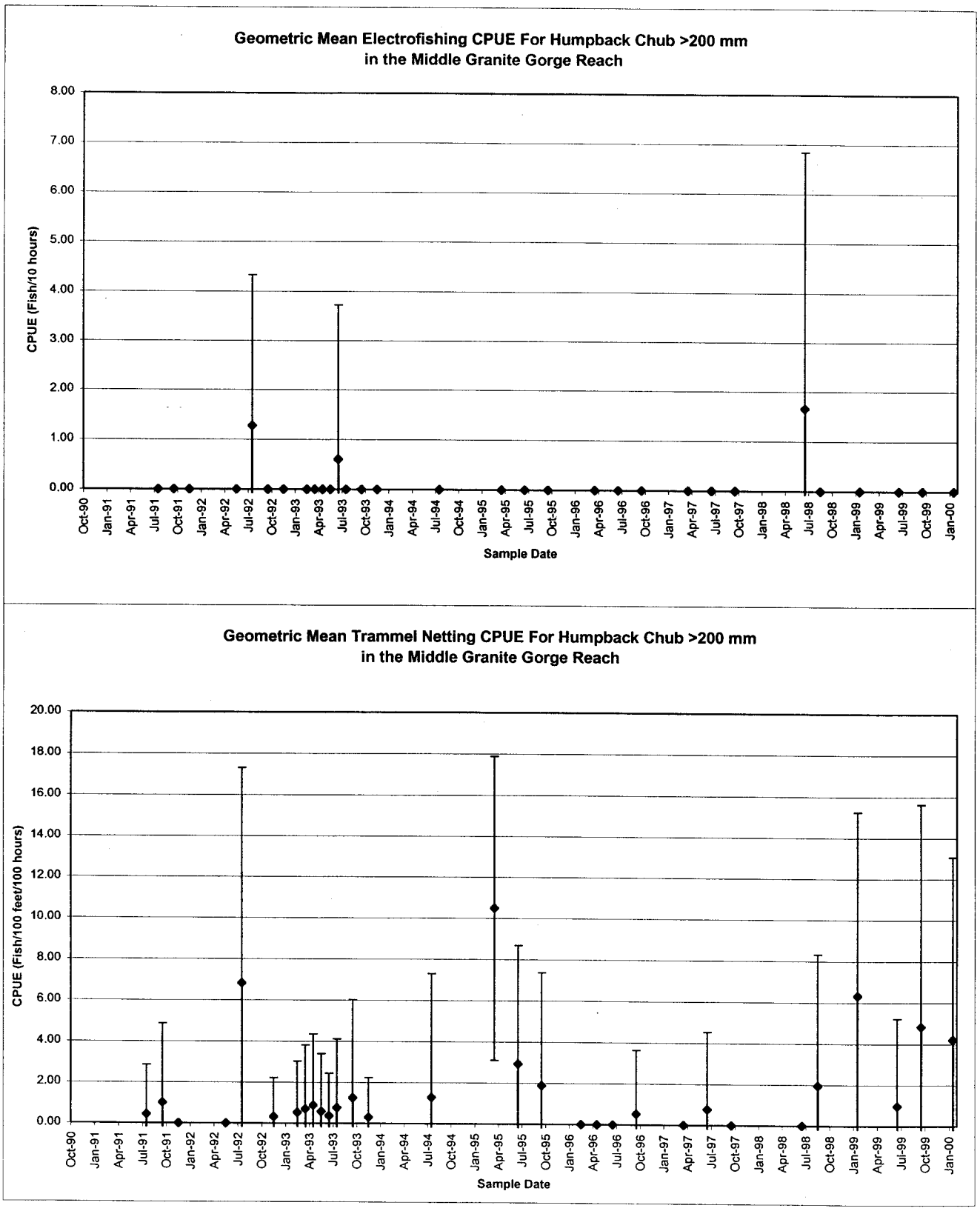
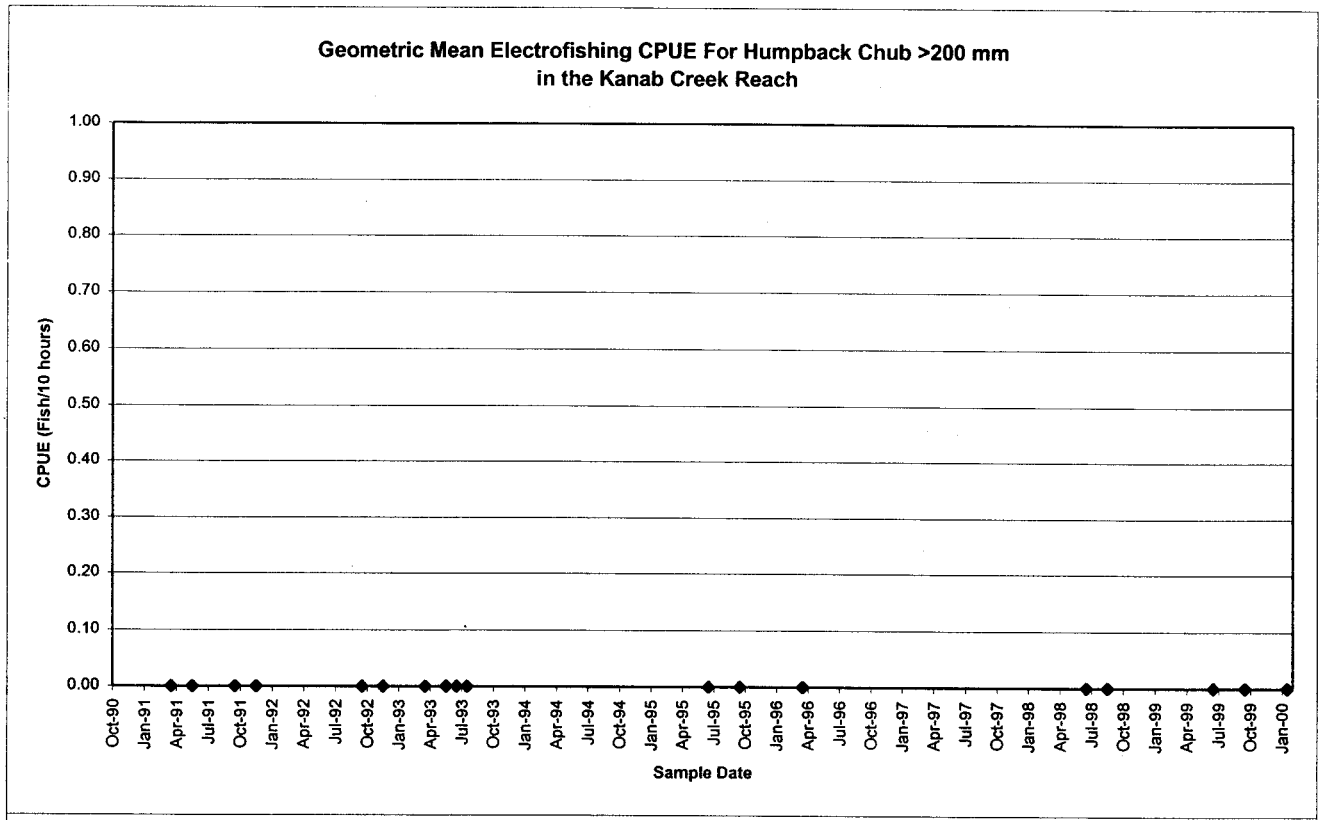



Figure 8. Electrofishing and trammel netting CPUE for humpback chub > 200 mm within the Middle Granite Gorge Reach. Error bars are one standard error.



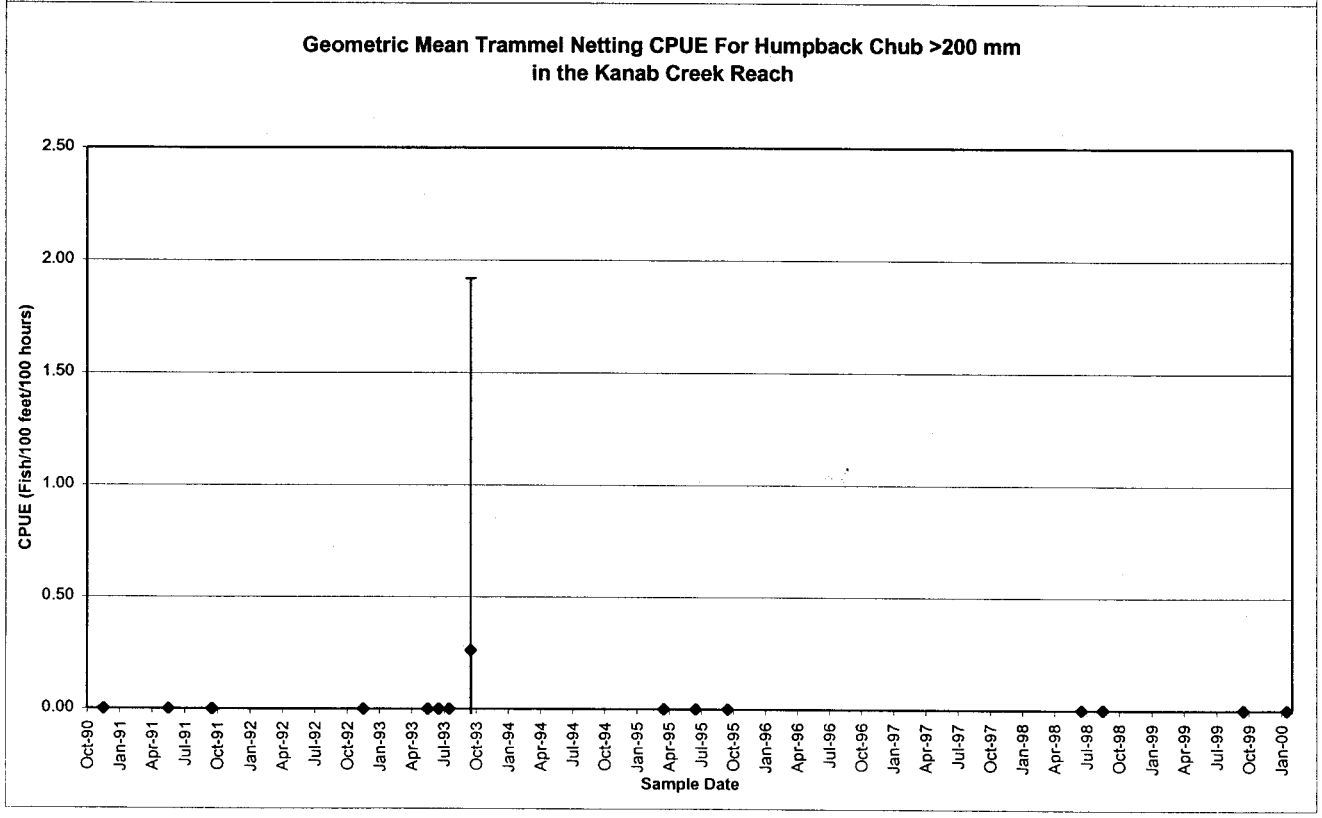




Figure 9. Electrofishing and trammel netting CPUE for humpback chub > 200 mm within the Kanab Creek Reach. Error bars are one standard error.

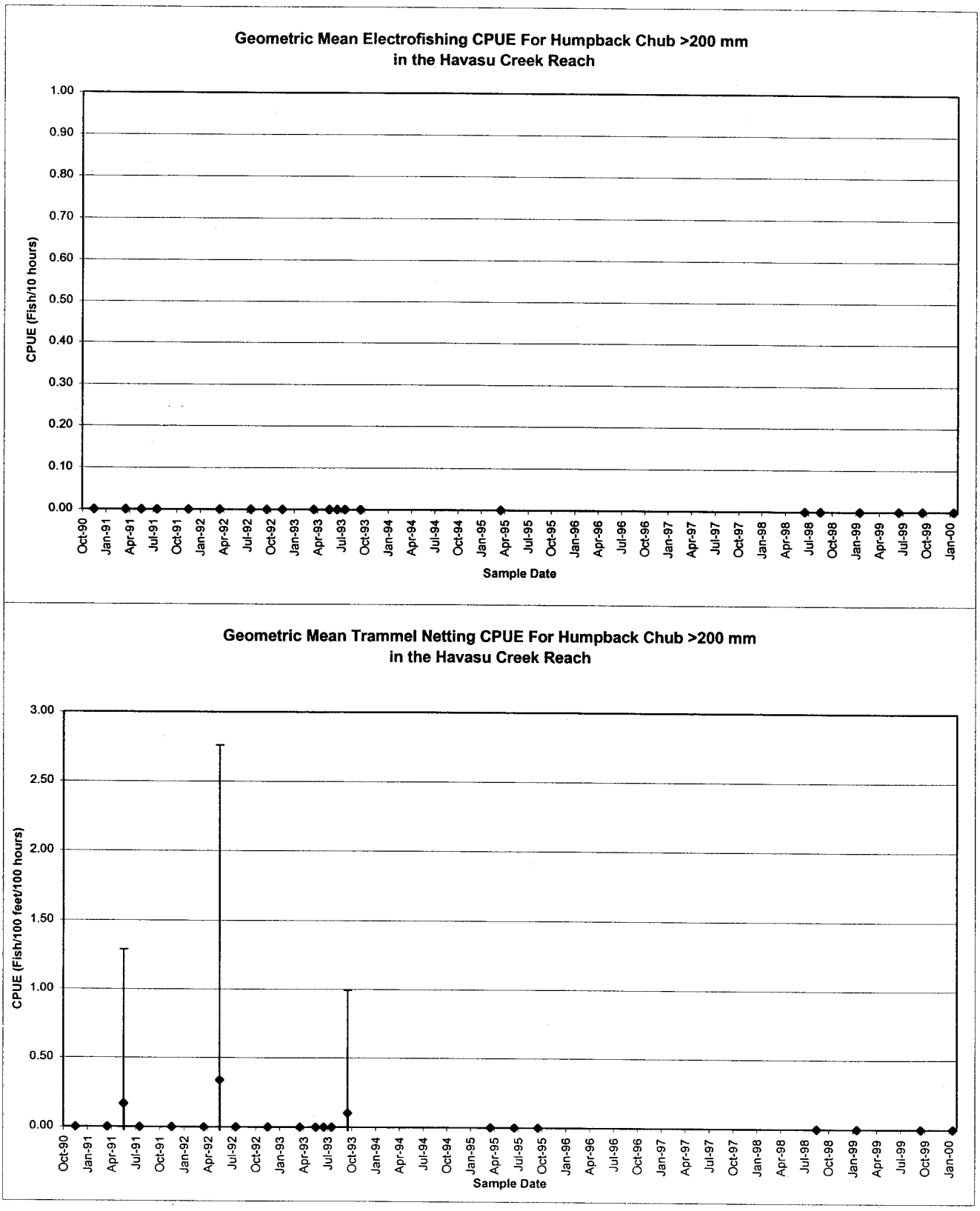
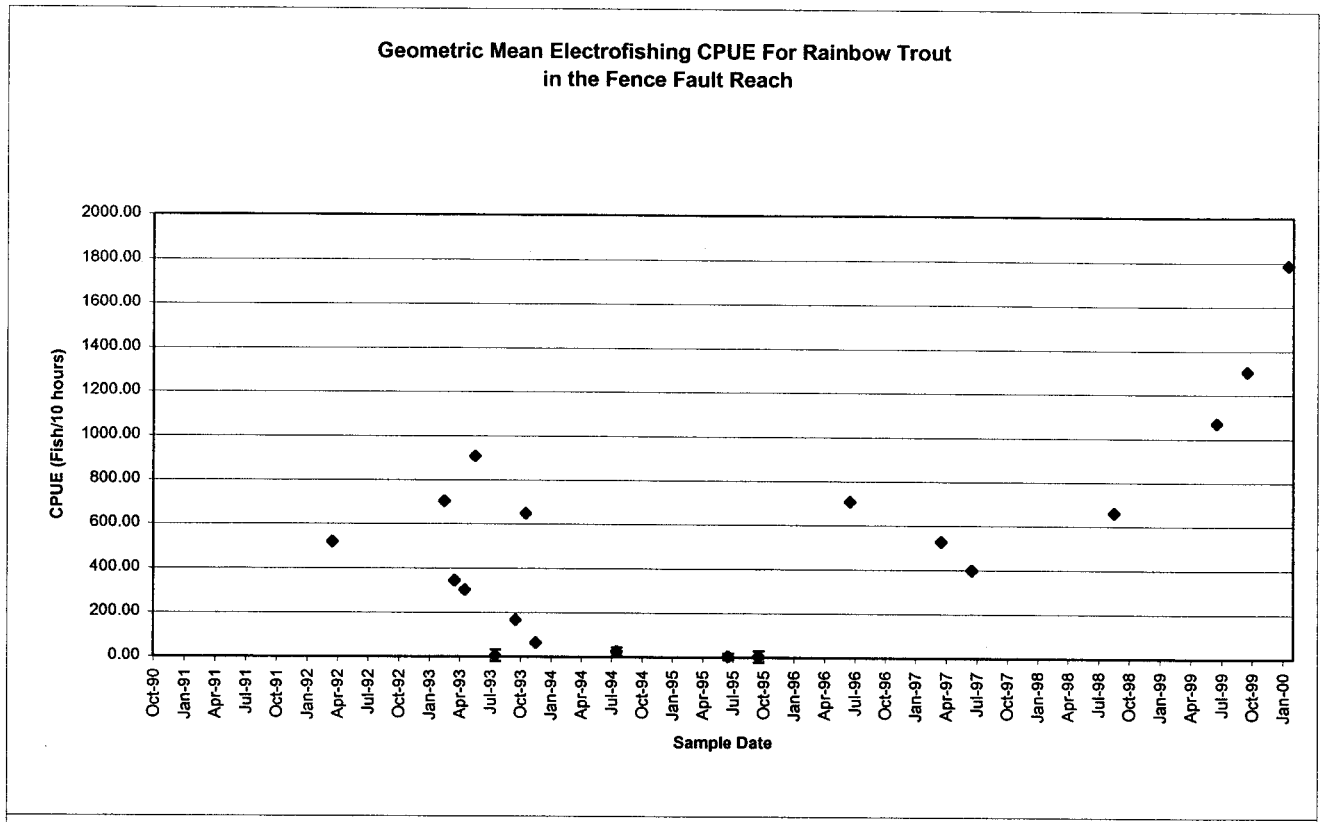



Figure 10. Electrofishing and trammel netting CPUE for humpback chub > 200 mm within the Havasu Creek Reach. Error bars are one standard error.



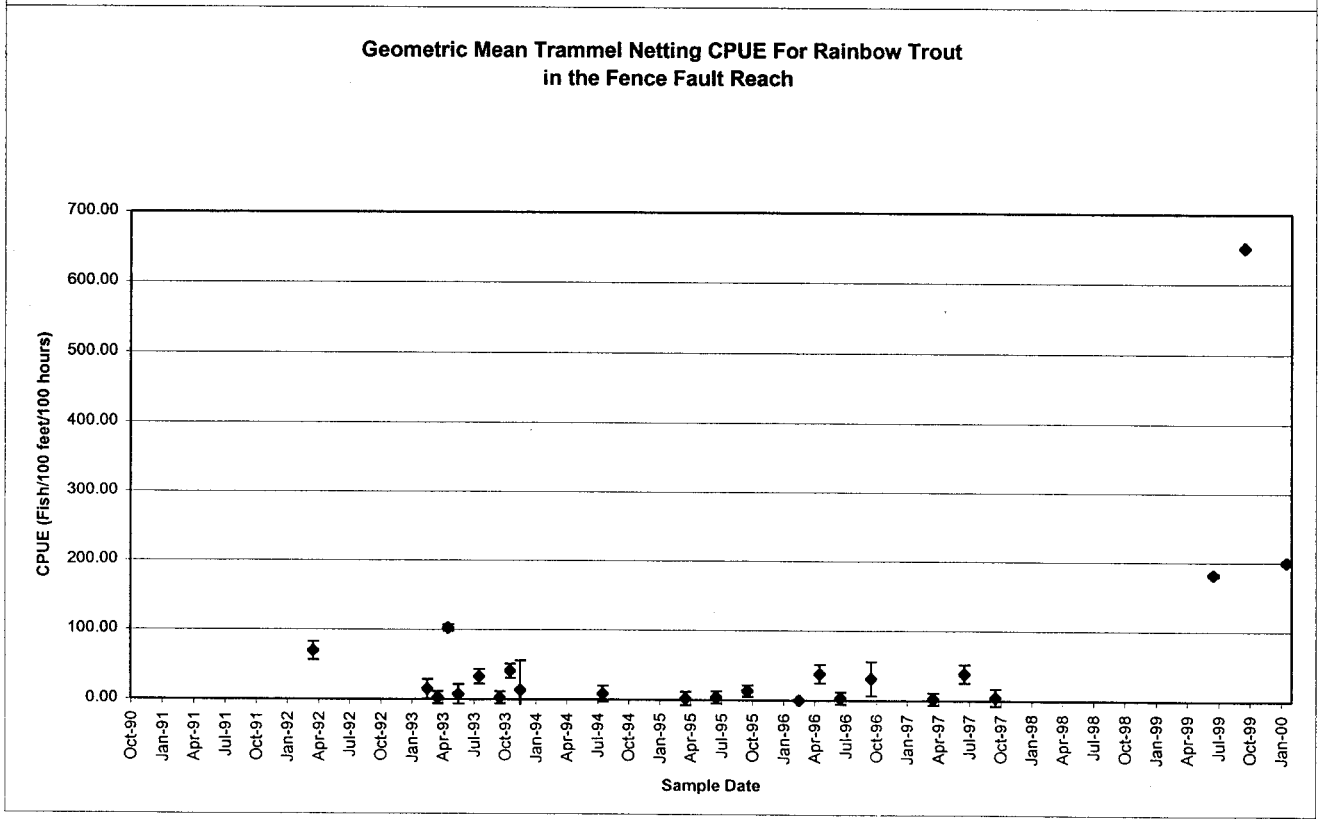
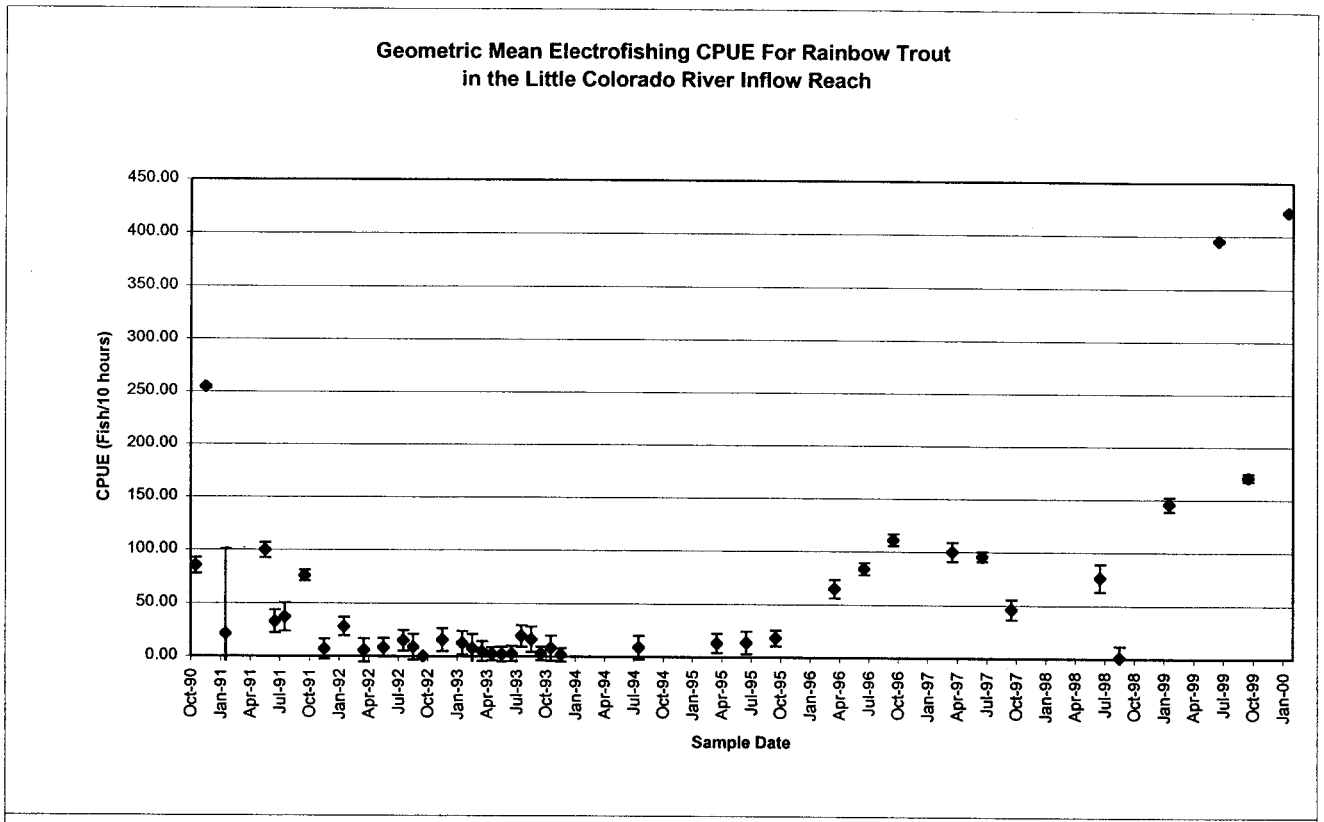




Figure 11. Electrofishing and trammel netting CPUE for rainbow trout within the Fence Fault Reach. Error bars are one standard error.



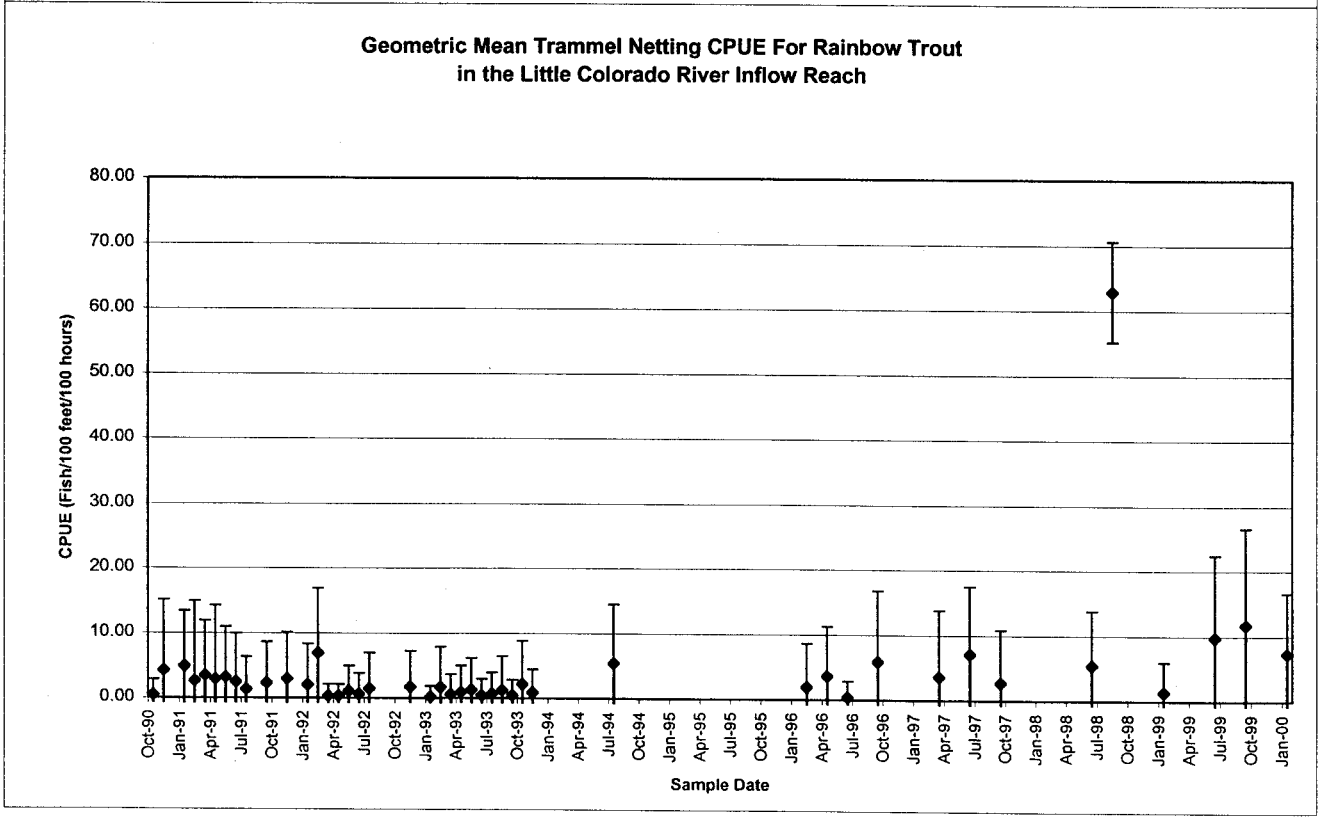
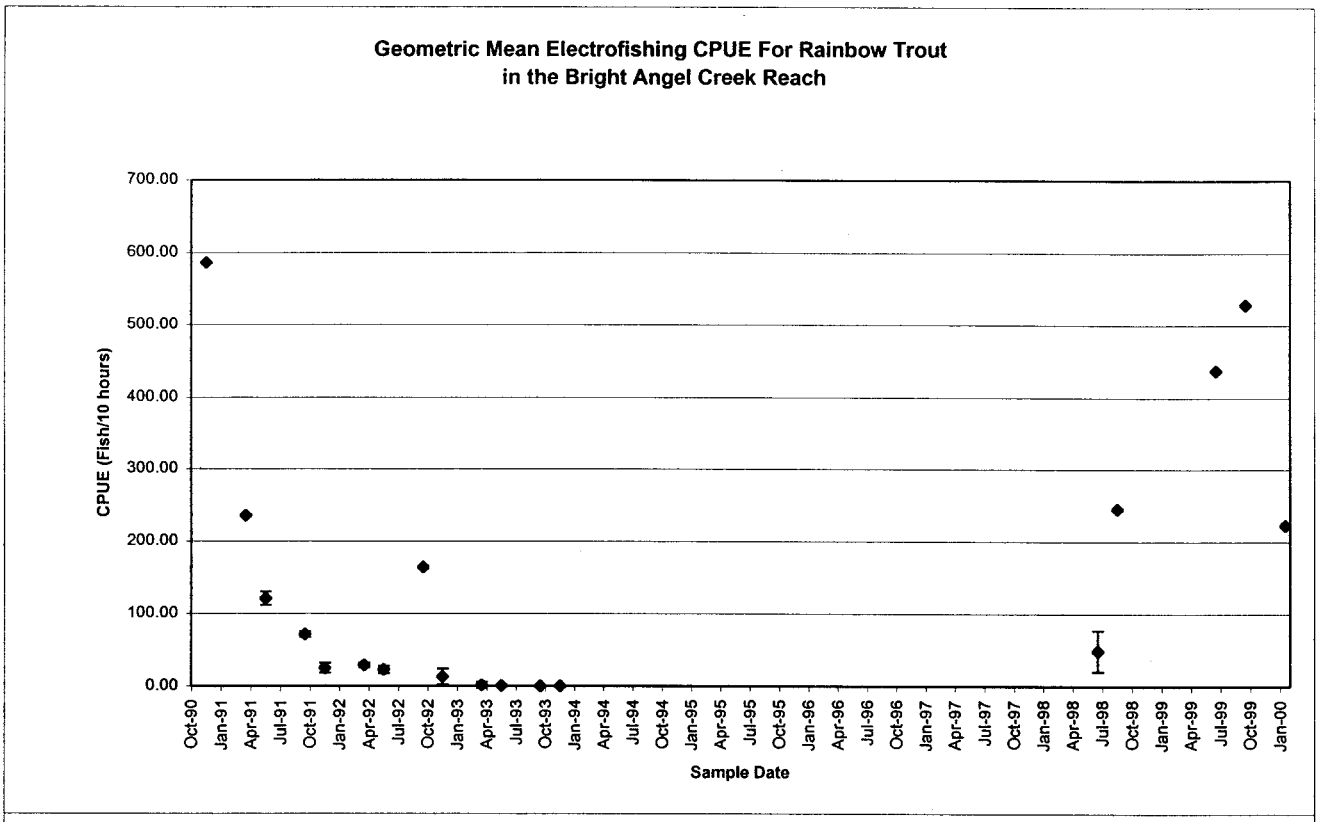




Figure 12. Electrofishing and trammel netting CPUE for rainbow trout within the Little Colorado River Inflow Reach. Error bars are one standard error.



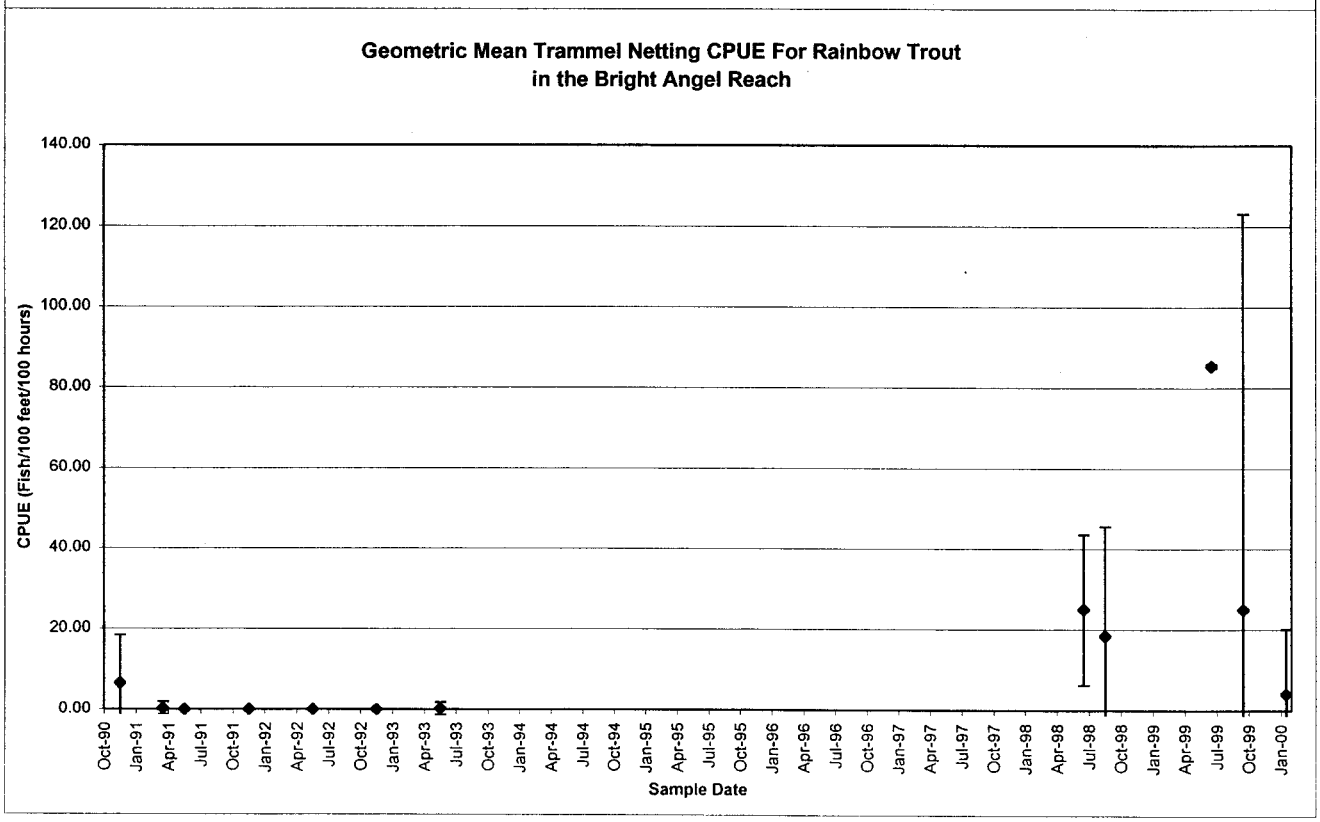
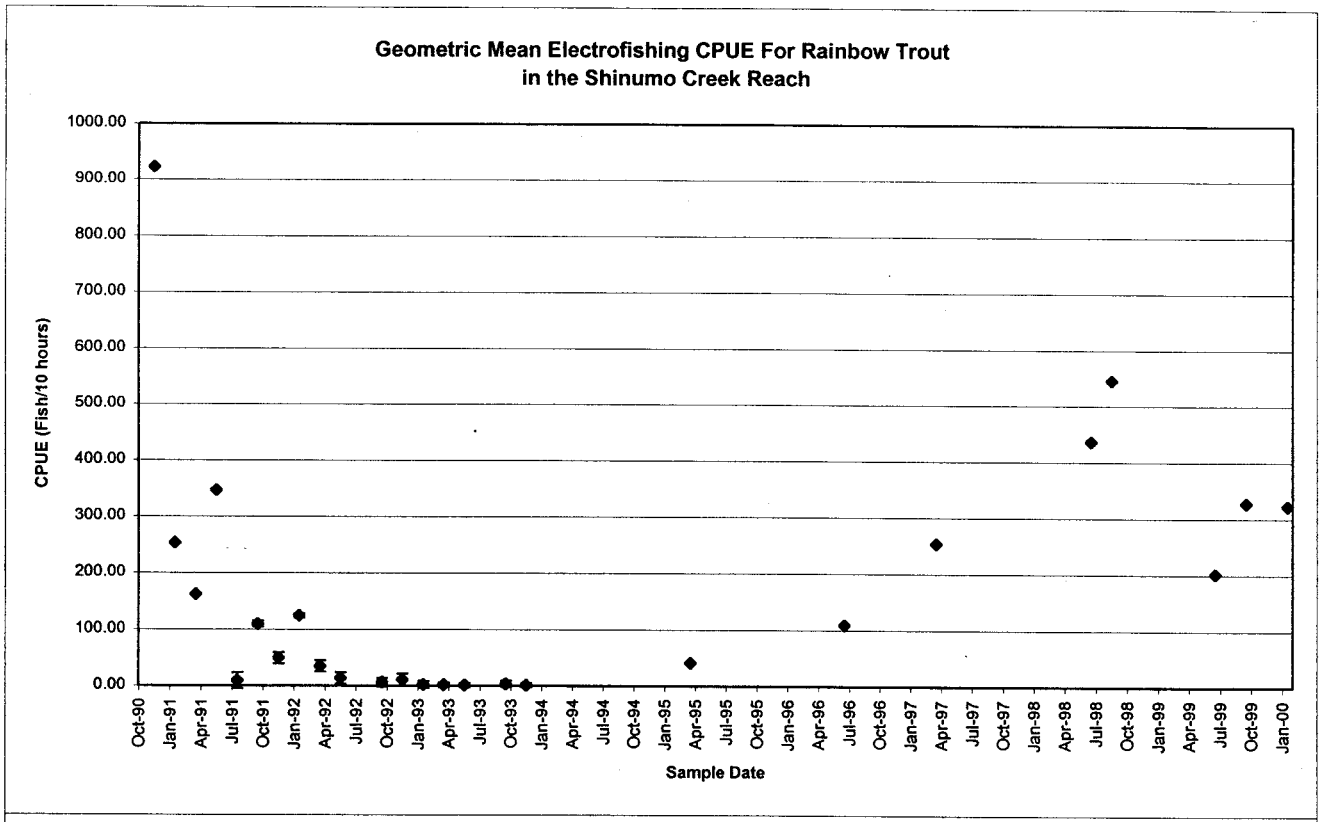




Figure 13. Electrofishing and trammel netting CPUE for rainbow trout within the Bright Angel Reach. Error bars are one standard error.



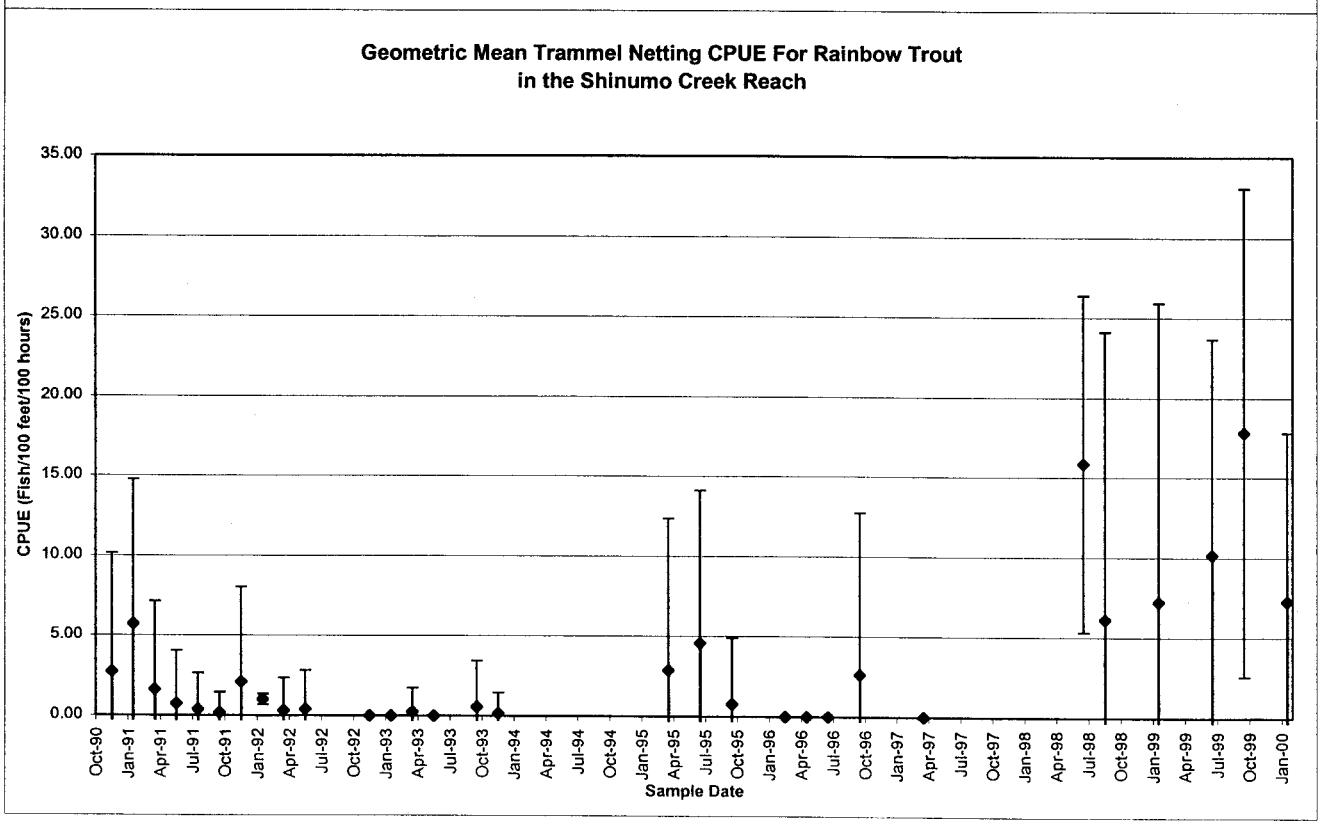
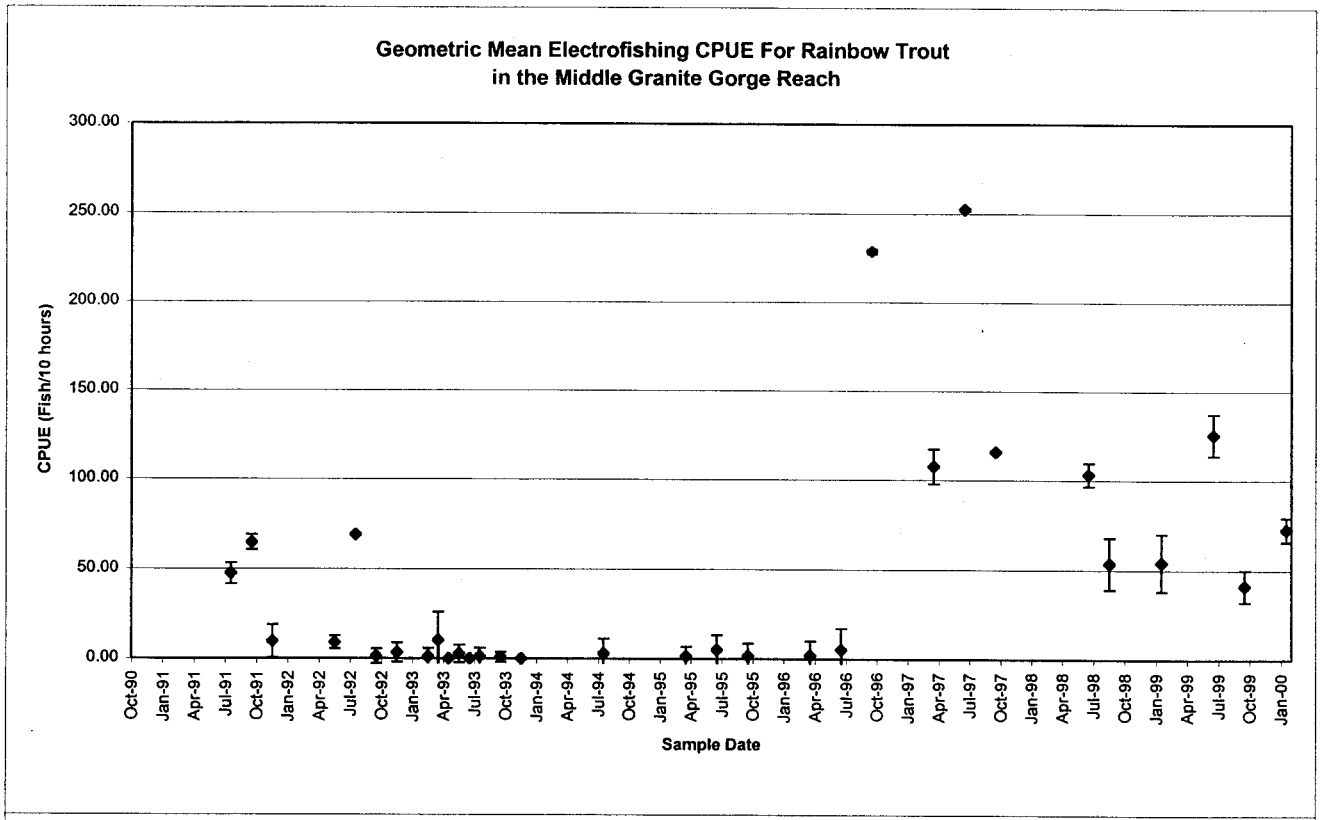




Figure 14. Electrofishing and trammel netting CPUE for rainbow trout within the Shinumo Creek Reach. Error bars are one standard error.



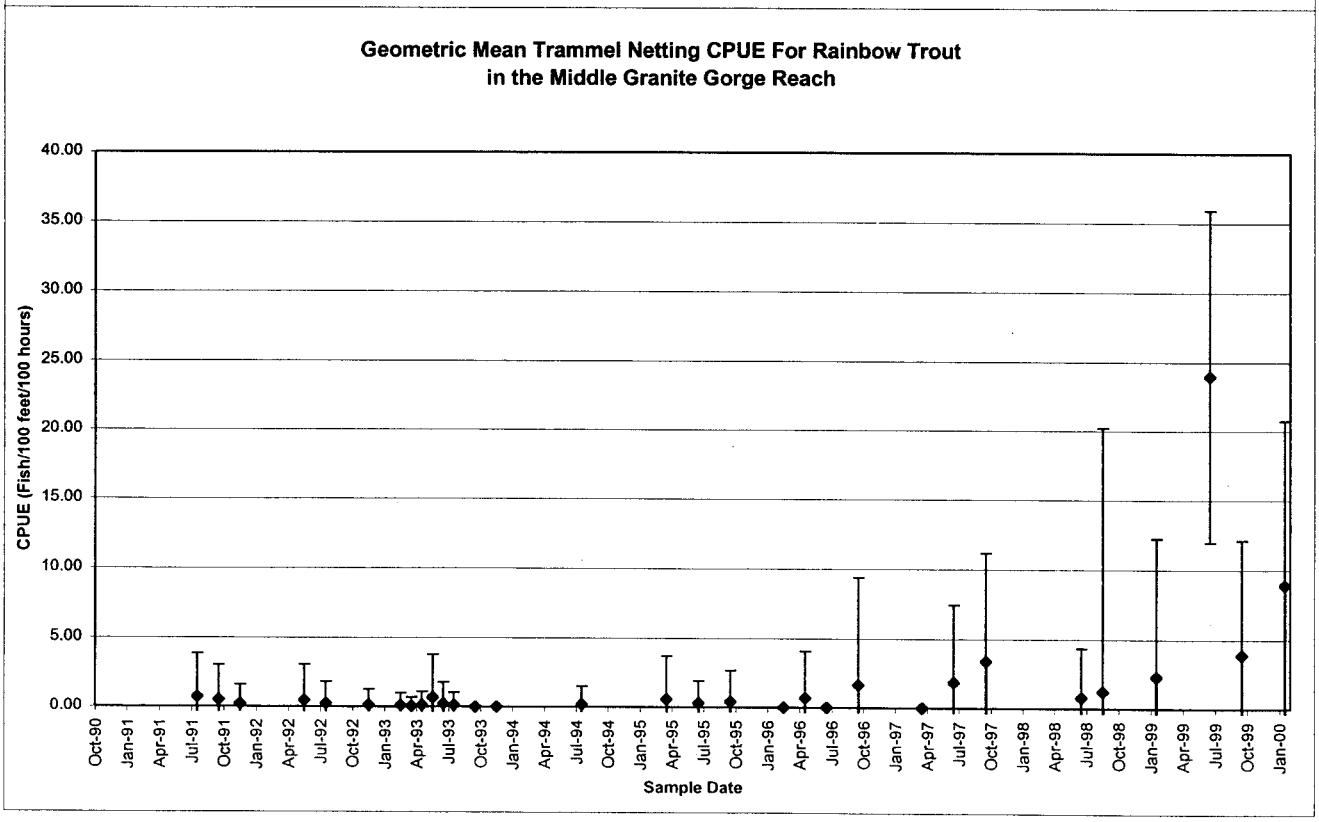
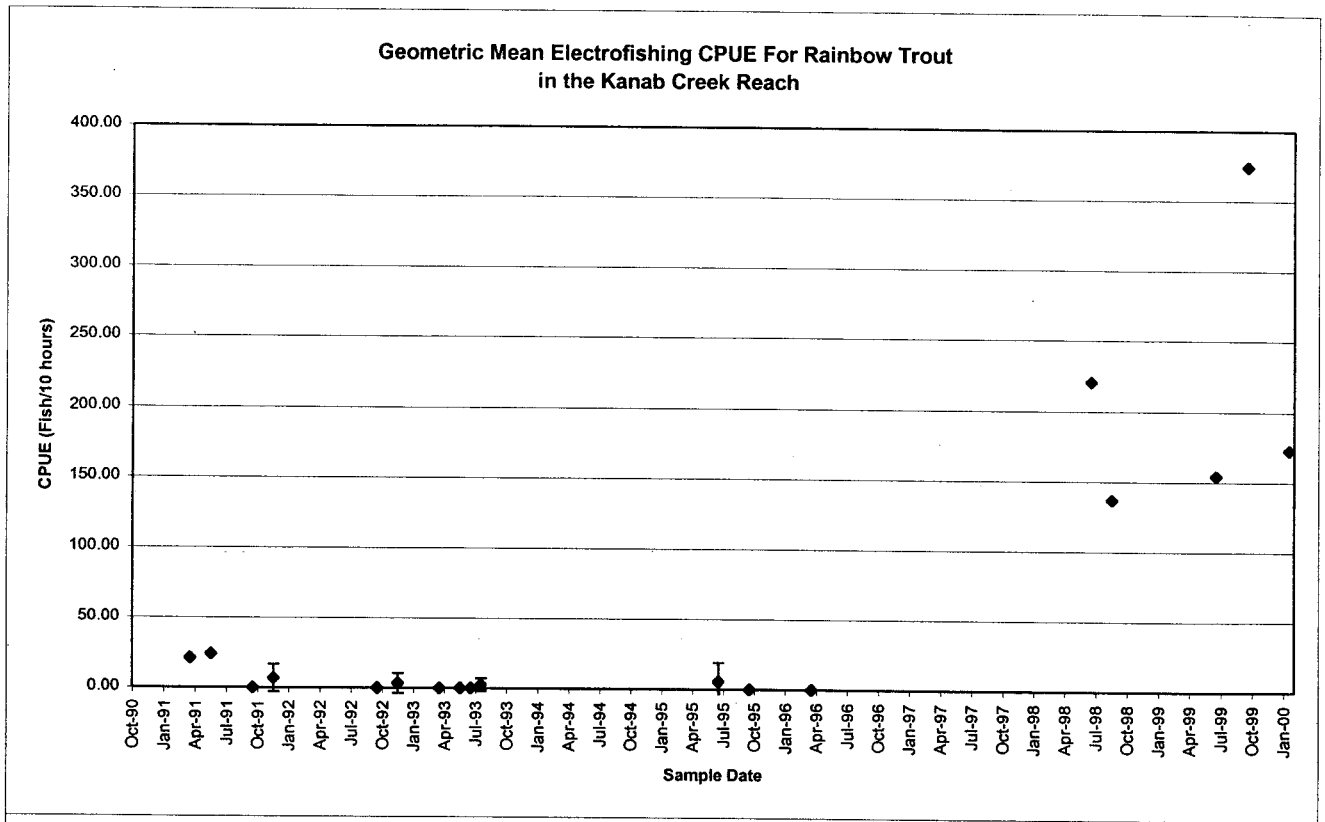




Figure 15. Electrofishing and trammel netting CPUE for rainbow trout within the Middle Granite Gorge Reach. Error bars are one standard error.



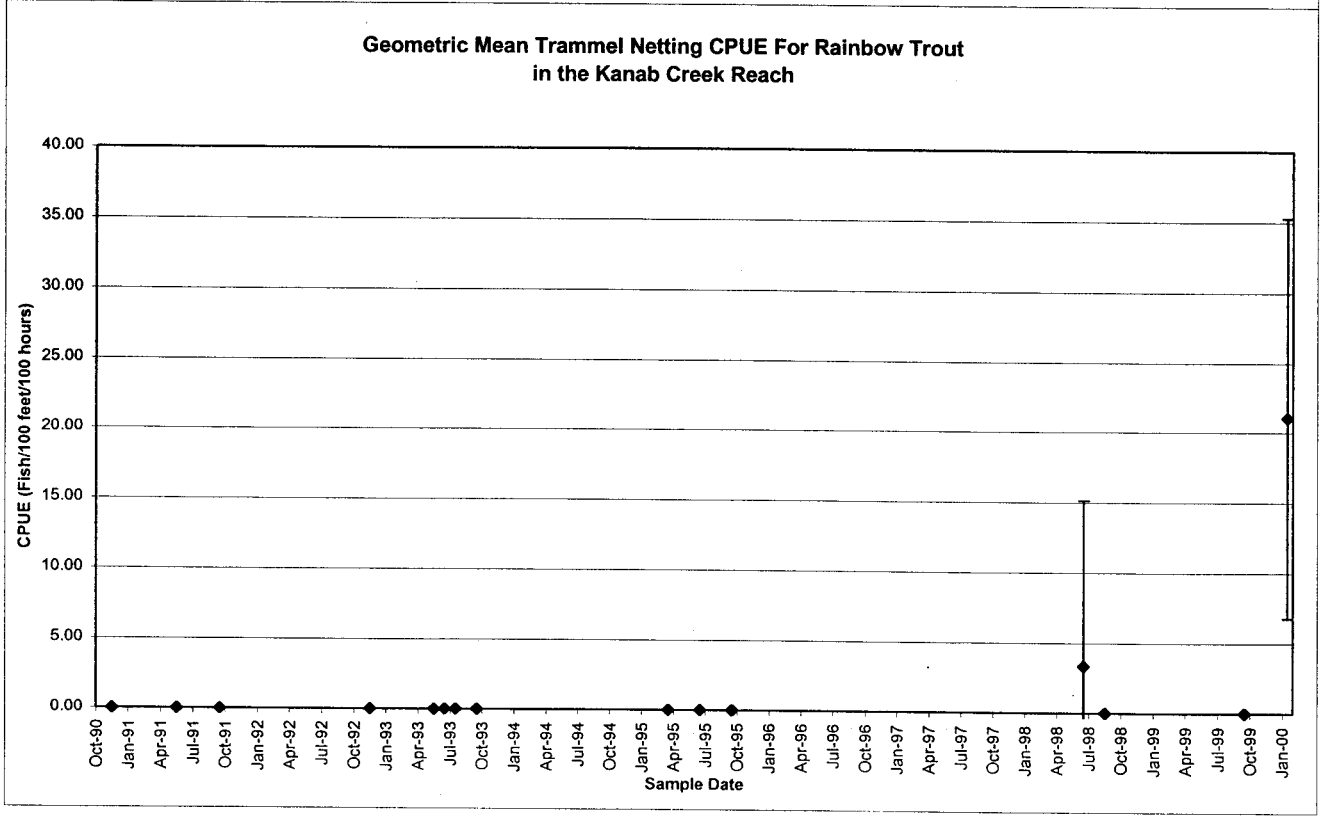
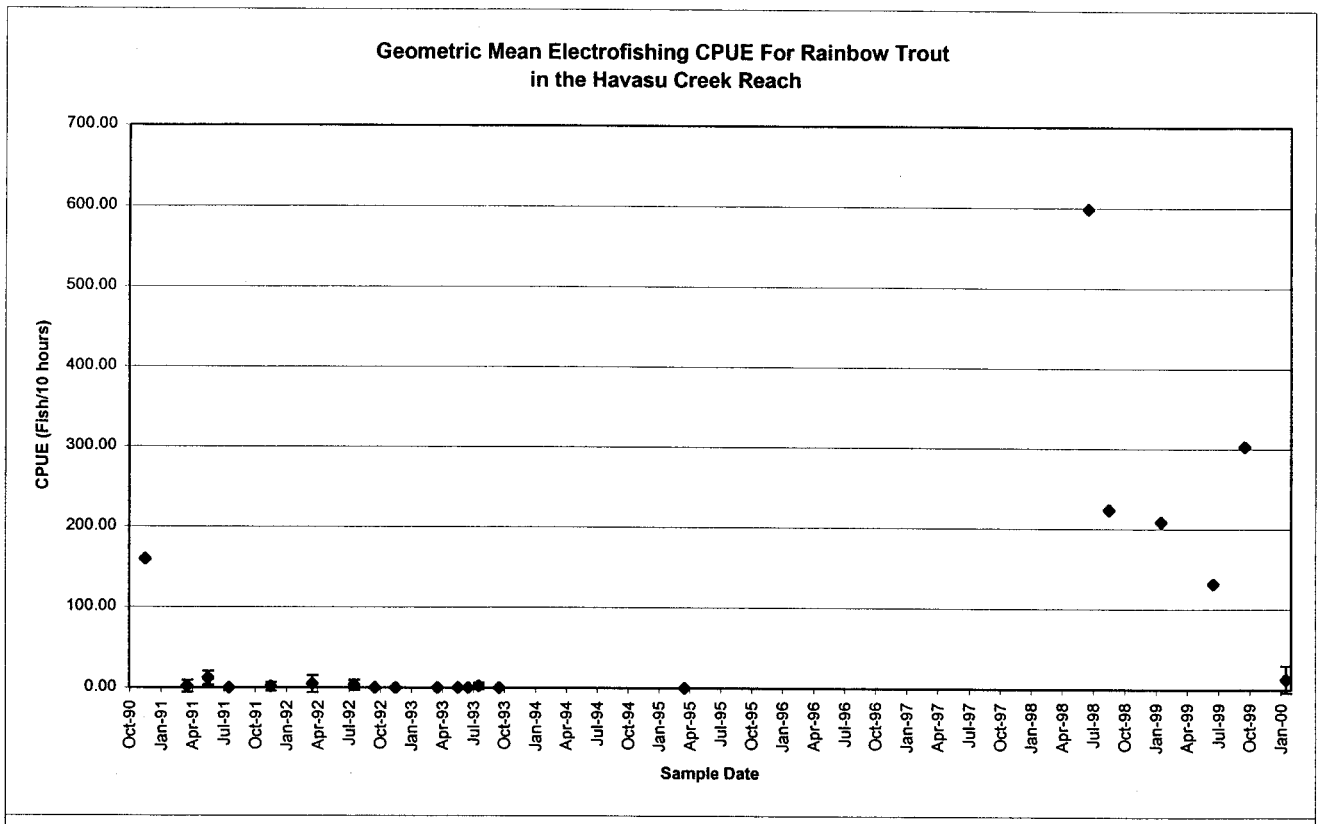




Figure 16. Electrofishing and trammel netting CPUE for rainbow trout within the Kanab Creek Reach. Error bars are one standard error.



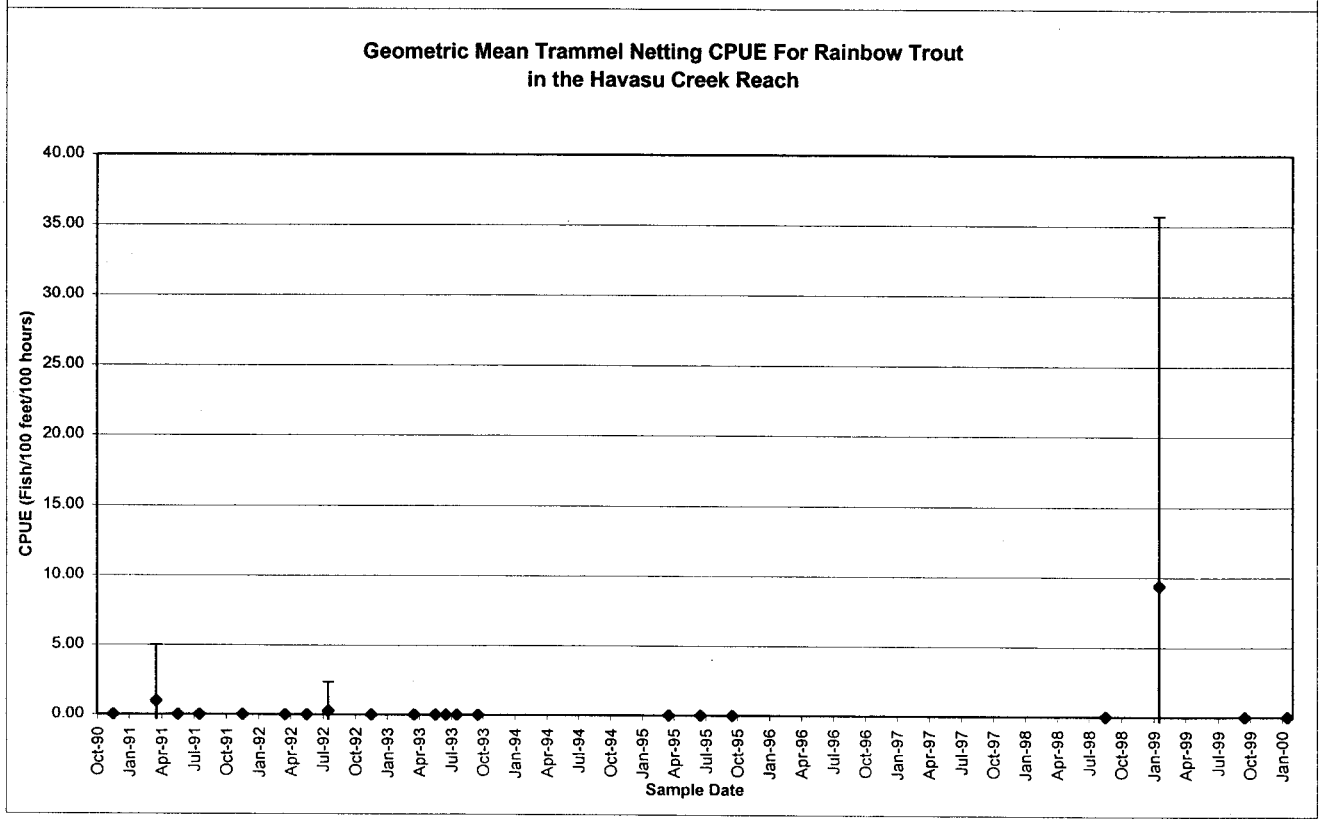




Figure 17. Electrofishing and trammel netting CPUE for rainbow trout within the Havasu Creek Reach. Error bars are one standard error.

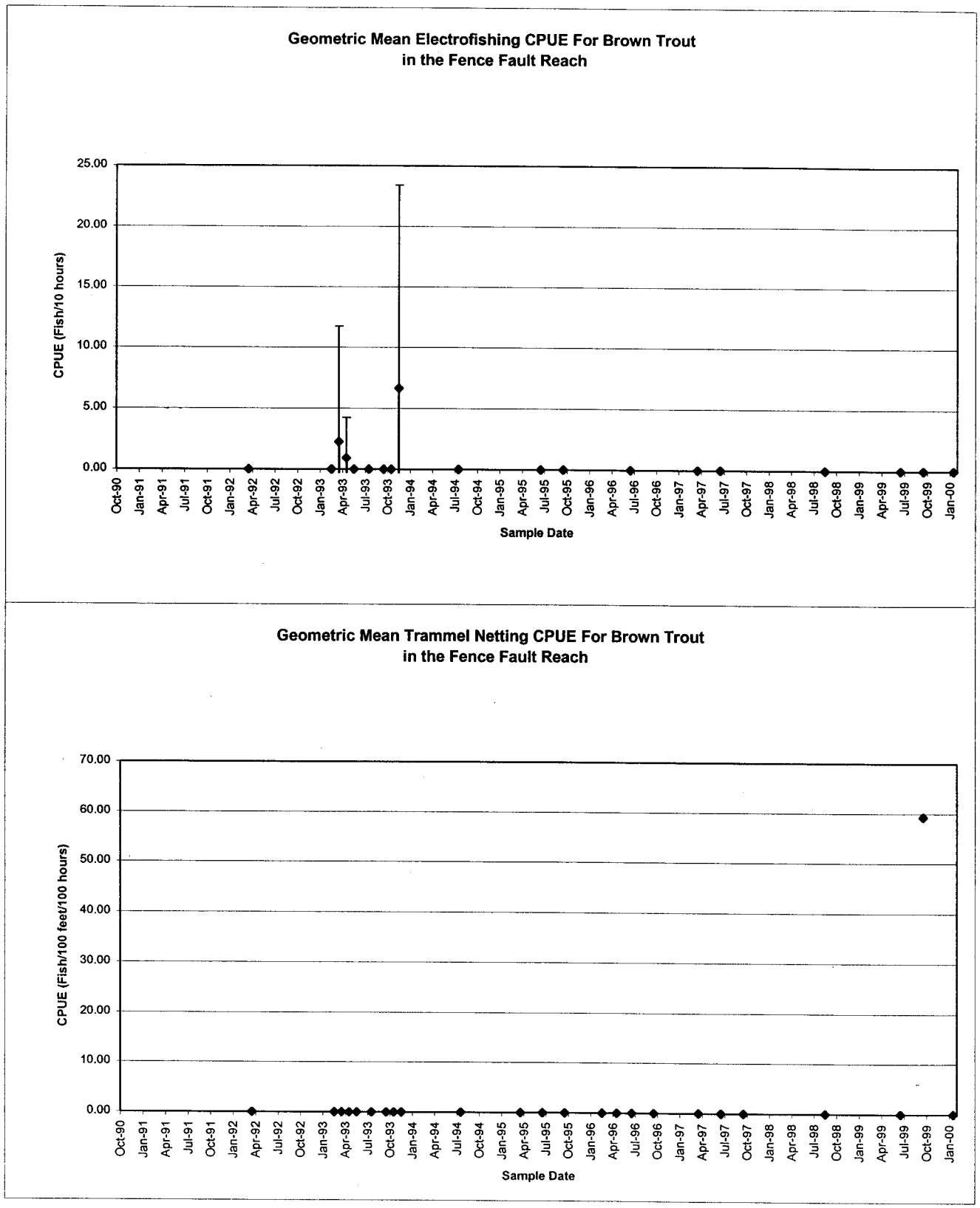
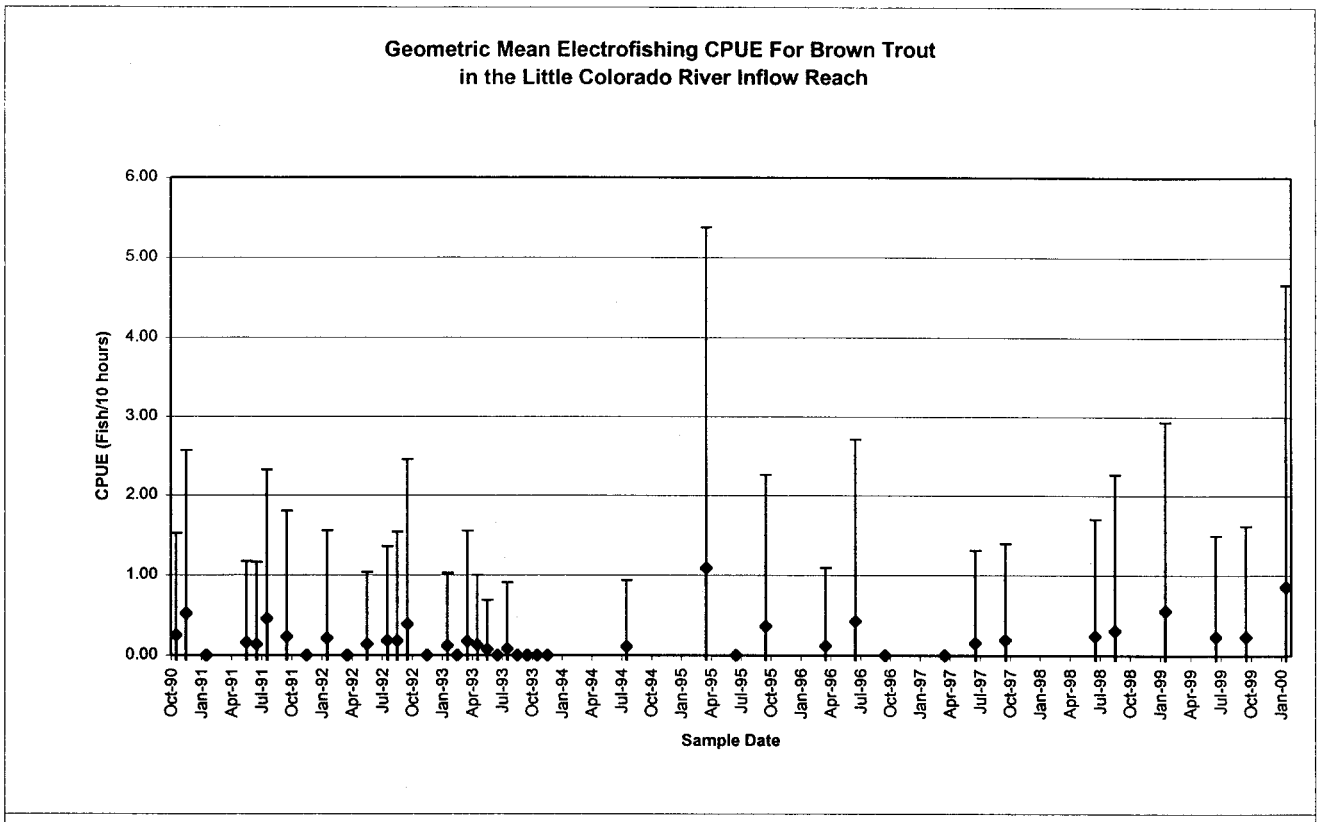



Figure 18. Electrofishing and trammel netting CPUE for brown trout within the Fence Fault Reach. Error bars are one standard error.



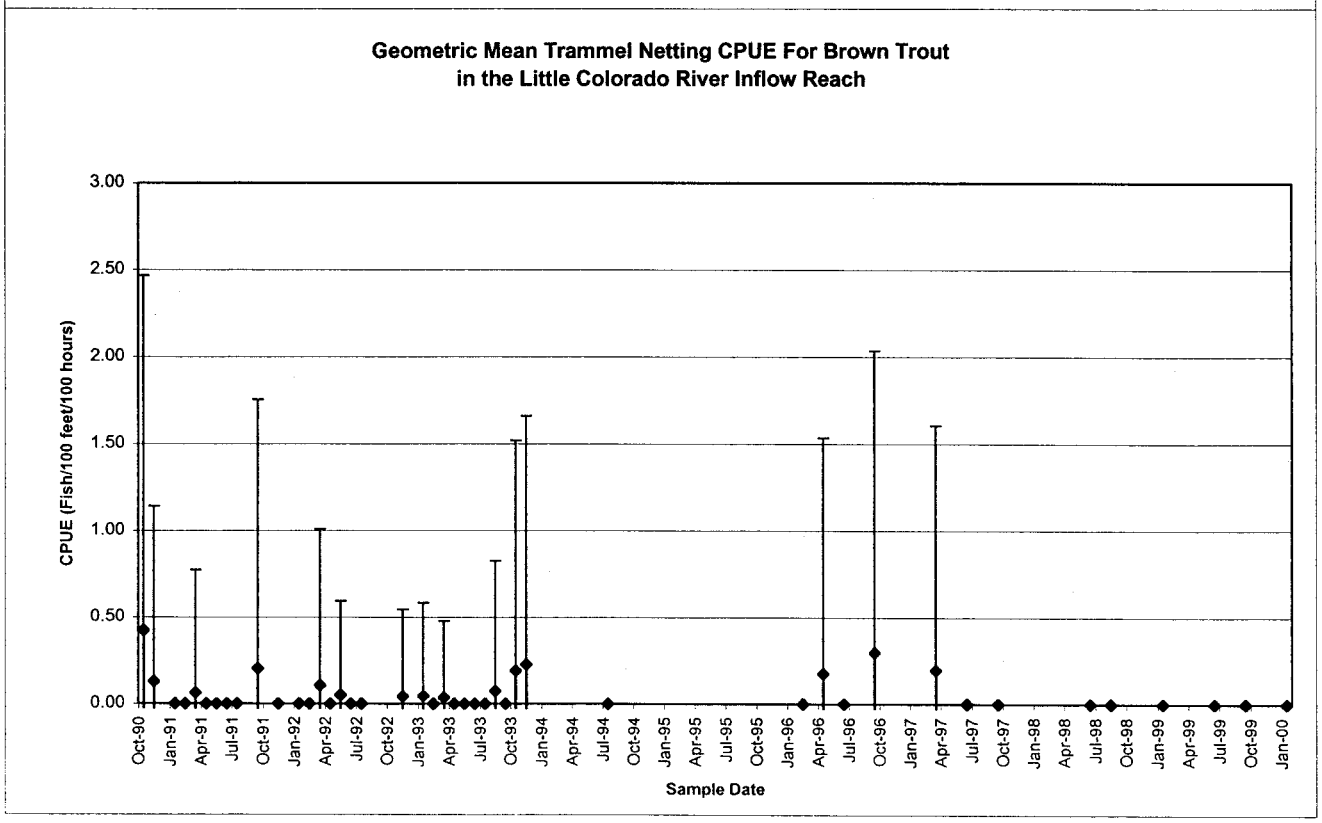
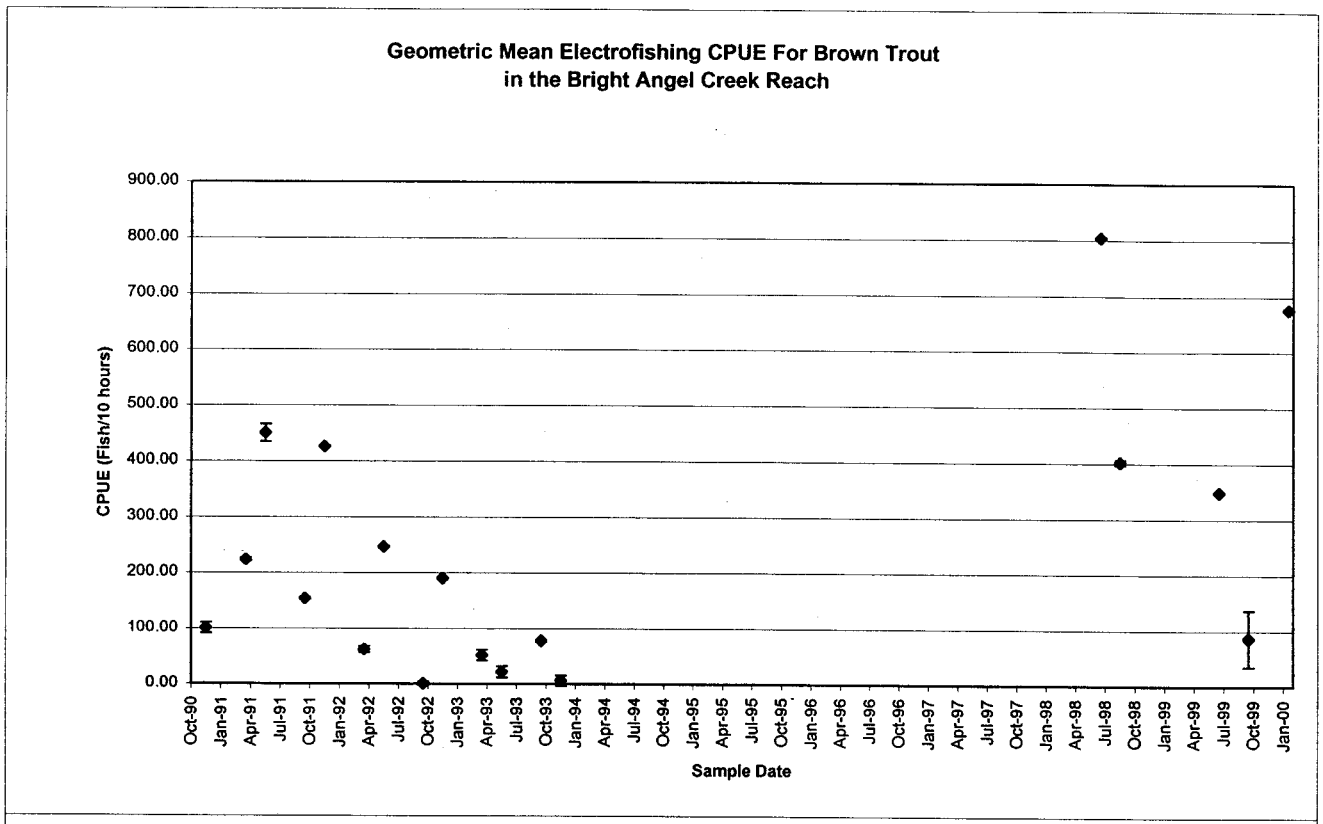




Figure 19. Electrofishing and trammel netting CPUE for brown trout within the Little Colorado River Inflow Reach. Error bars are one standard error.



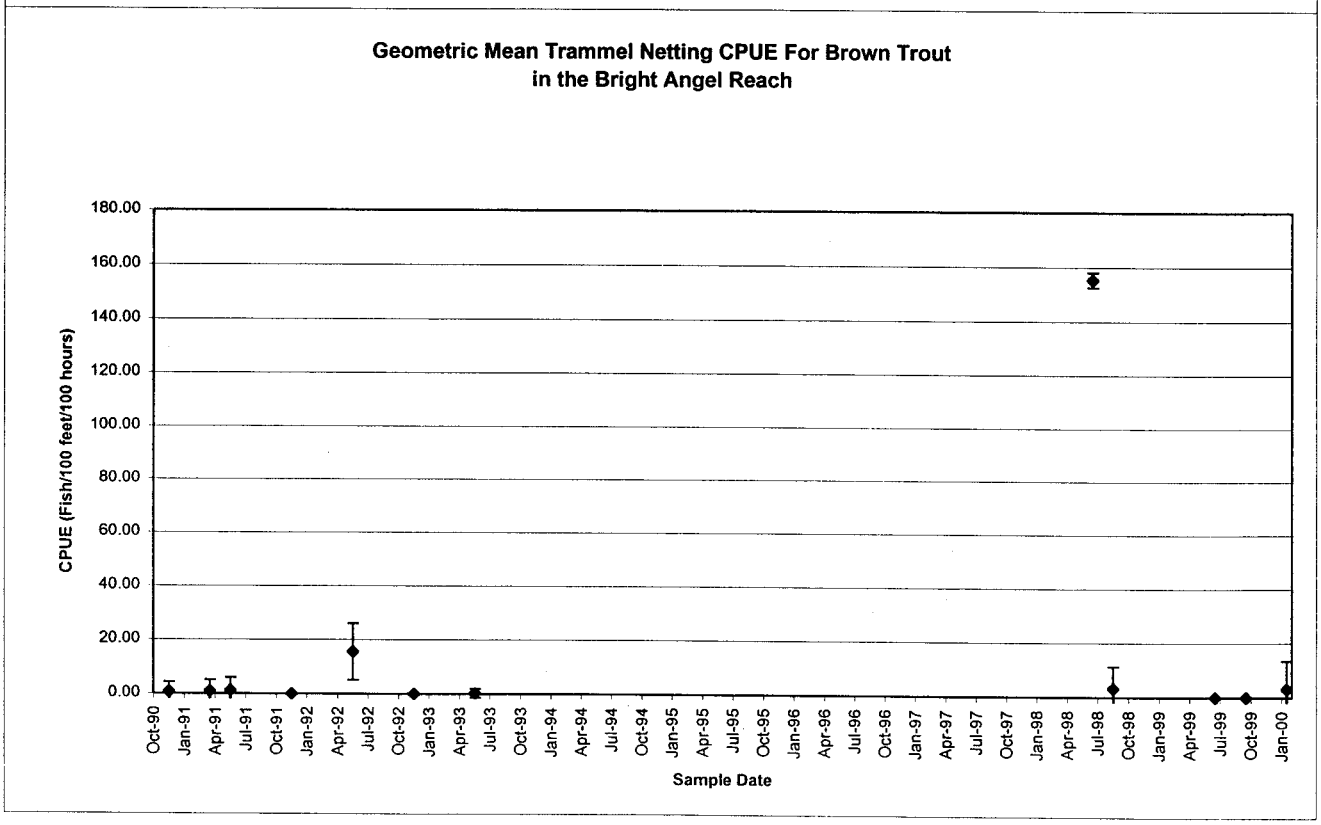




Figure 20. Electrofishing and trammel netting CPUE for brown trout within the Bright Angel Reach. Error bars are one standard error.

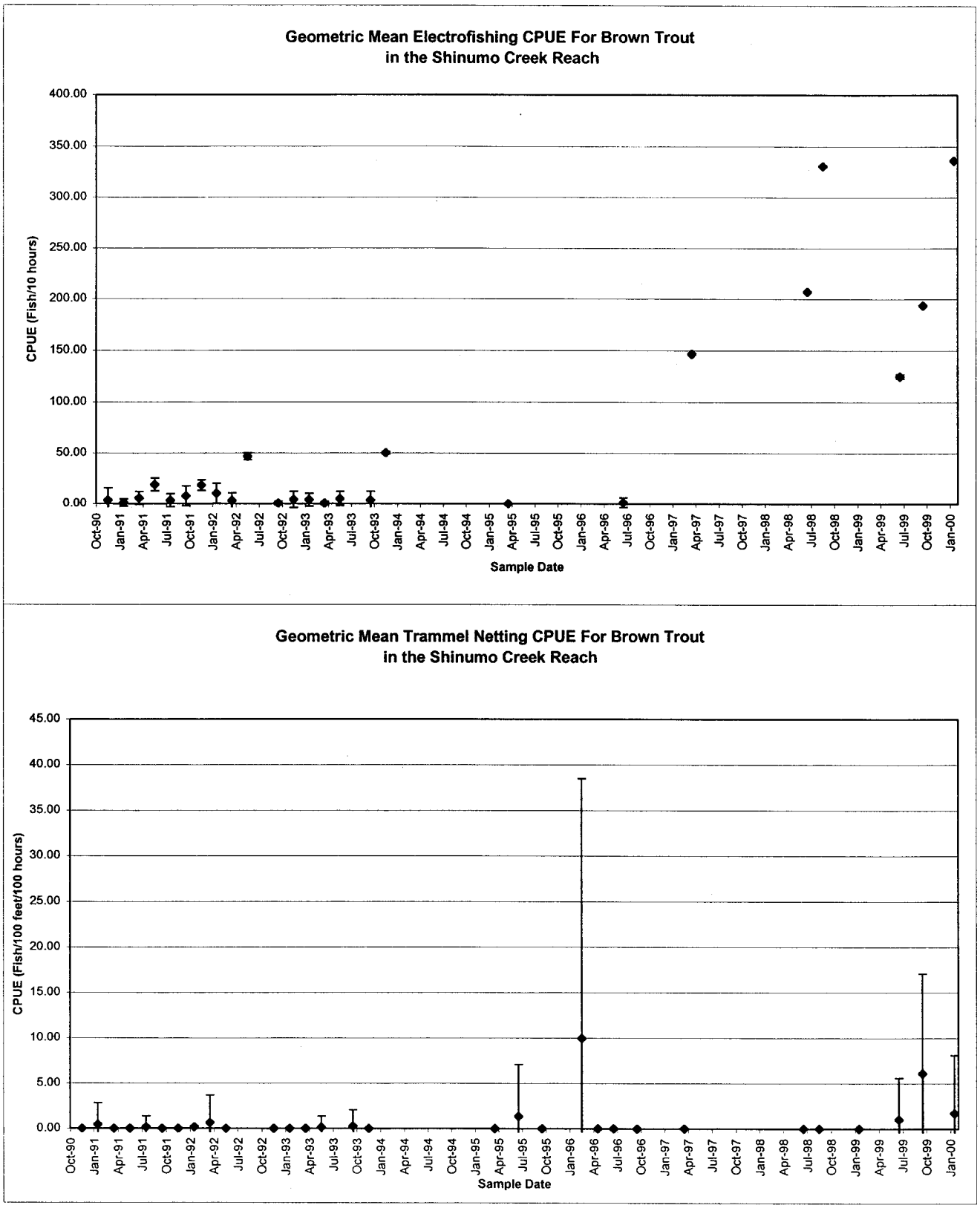
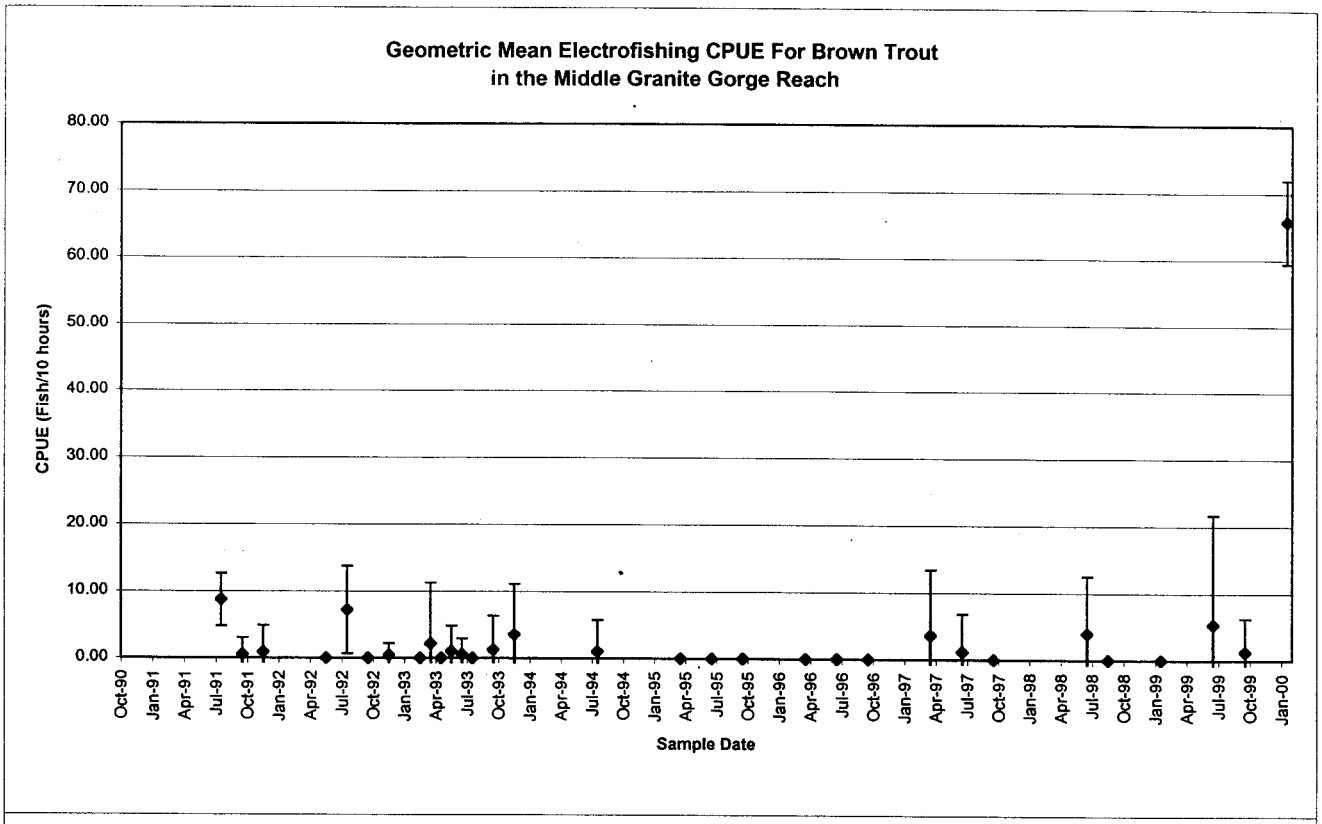



Figure 21. Electrofishing and trammel netting CPUE for brown trout within the Shinumo Creek Reach. Error bars are one standard error.



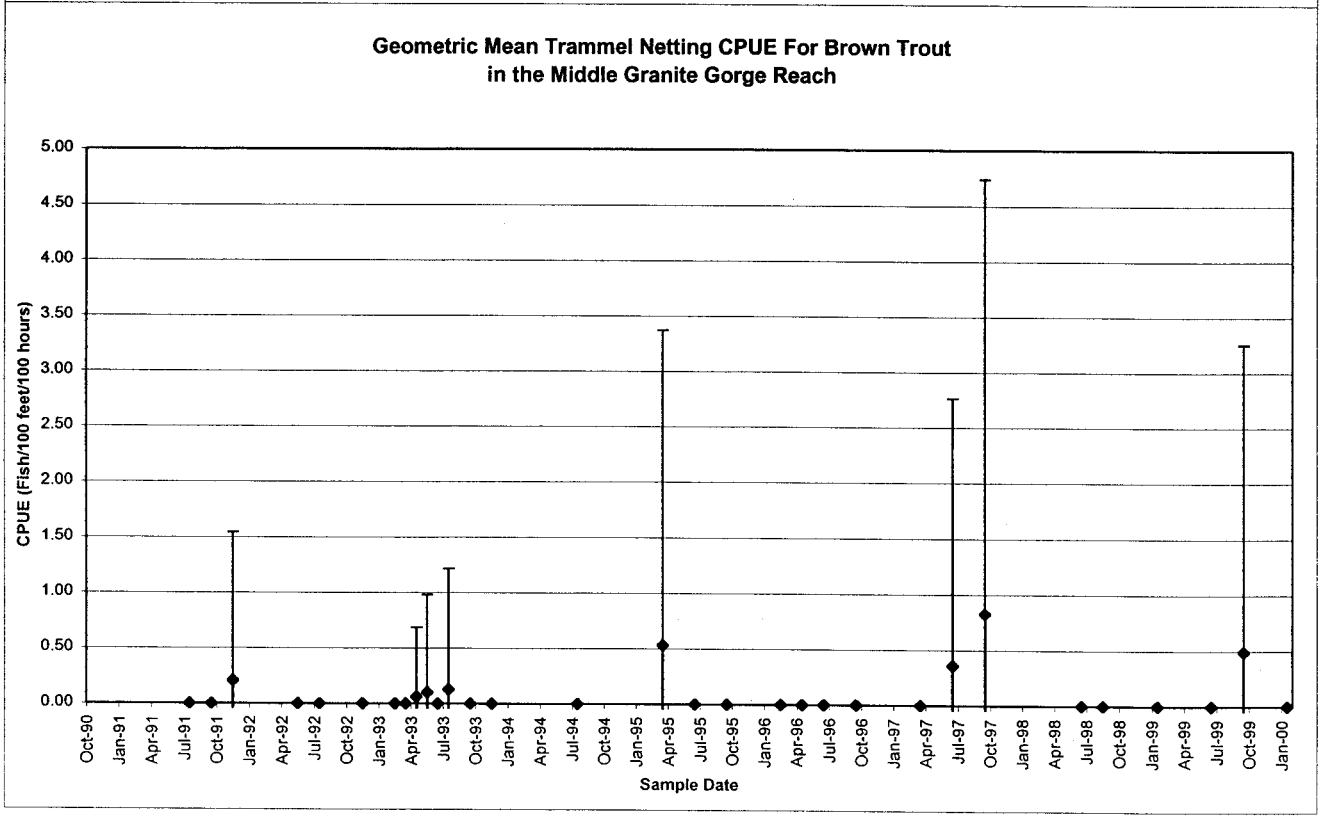
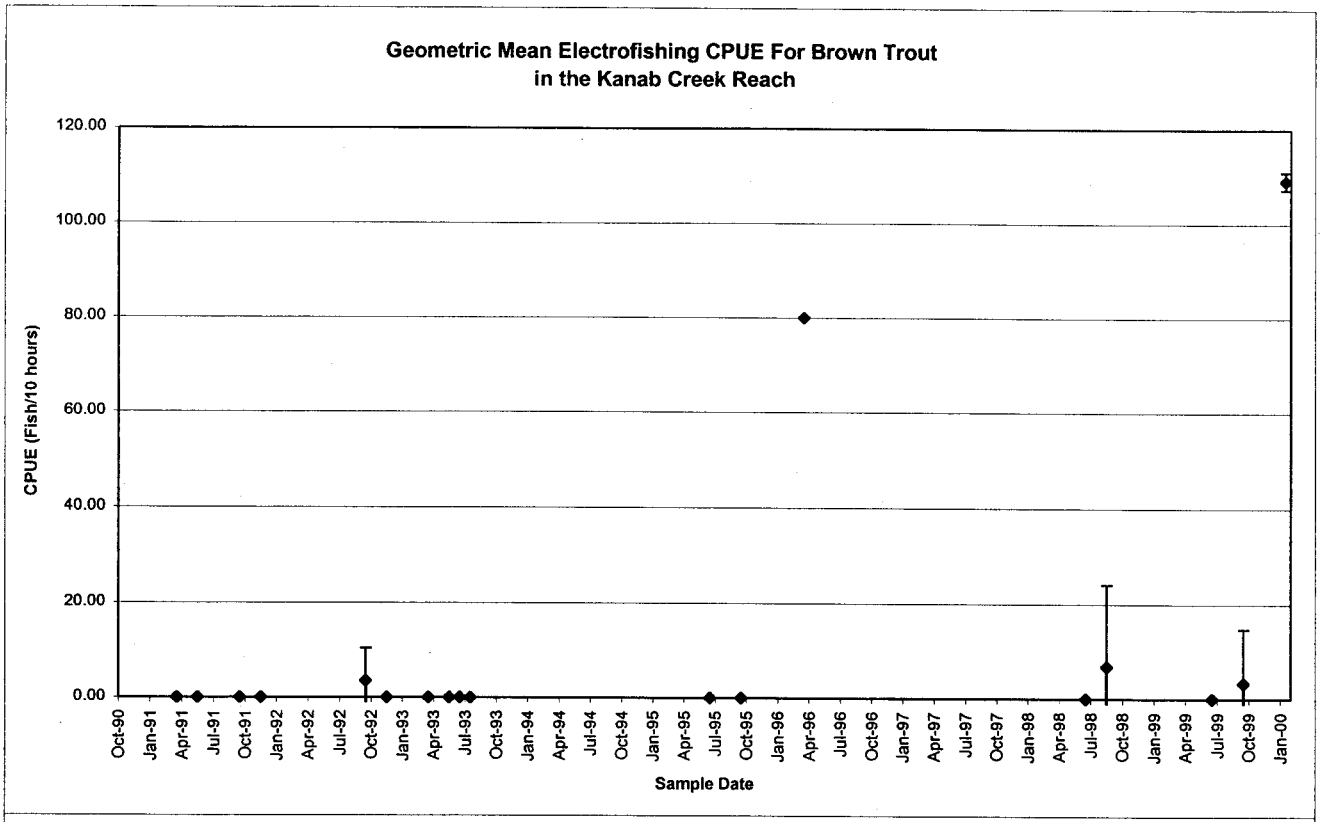




Figure 22. Electrofishing and trammel netting CPUE for brown trout within the Middle Granite Gorge Reach. Error bars are one standard error.



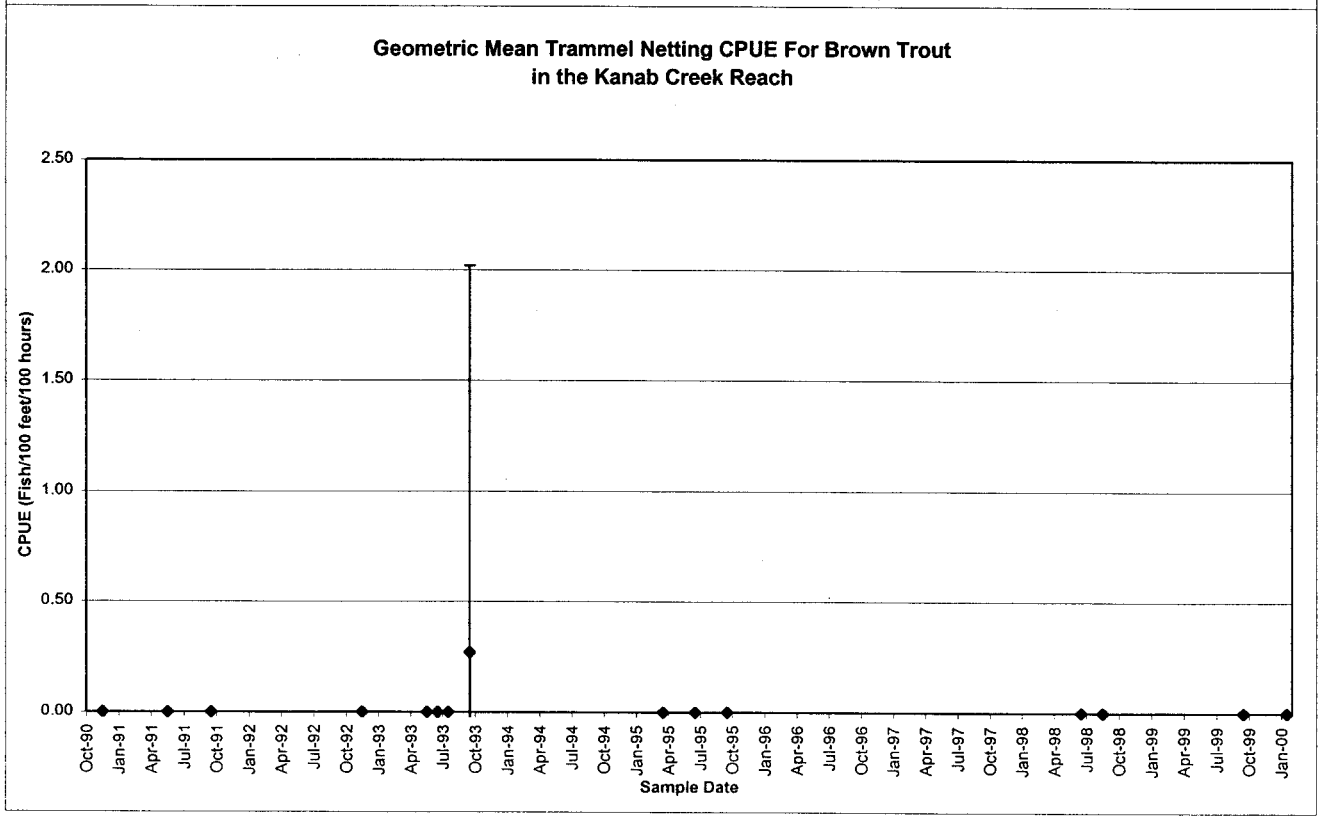
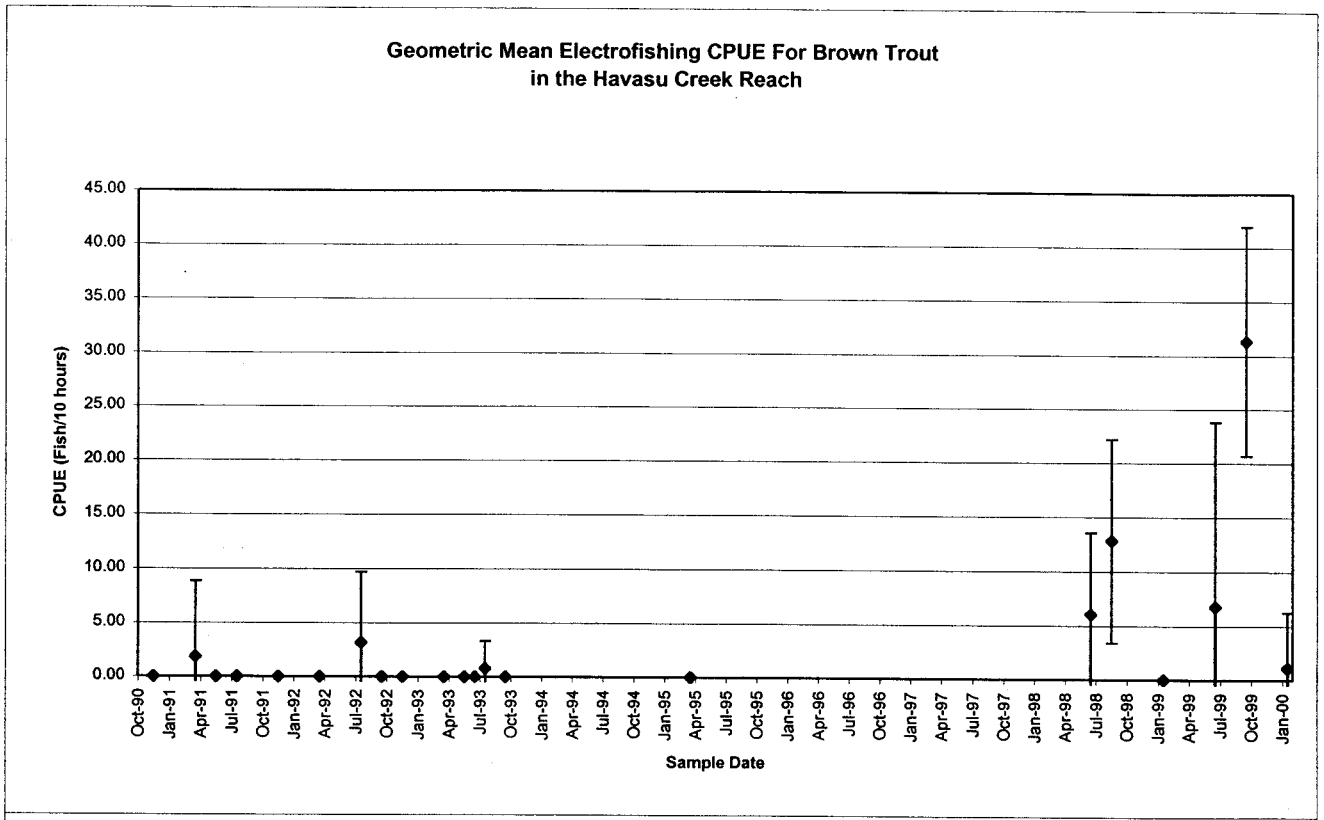




Figure 23. Electrofishing and trammel netting CPUE for brown trout within the Kanab Creek Reach. Error bars are one standard error.



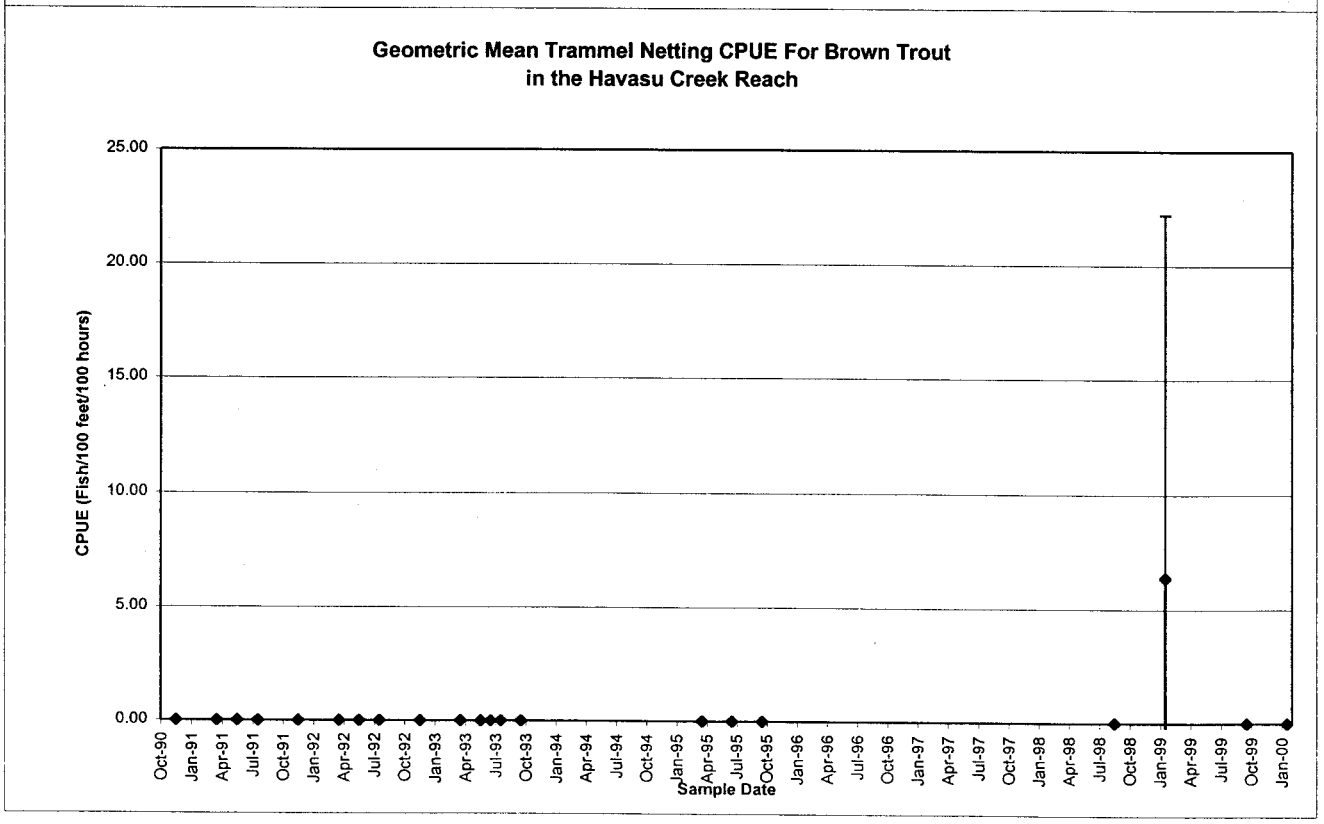
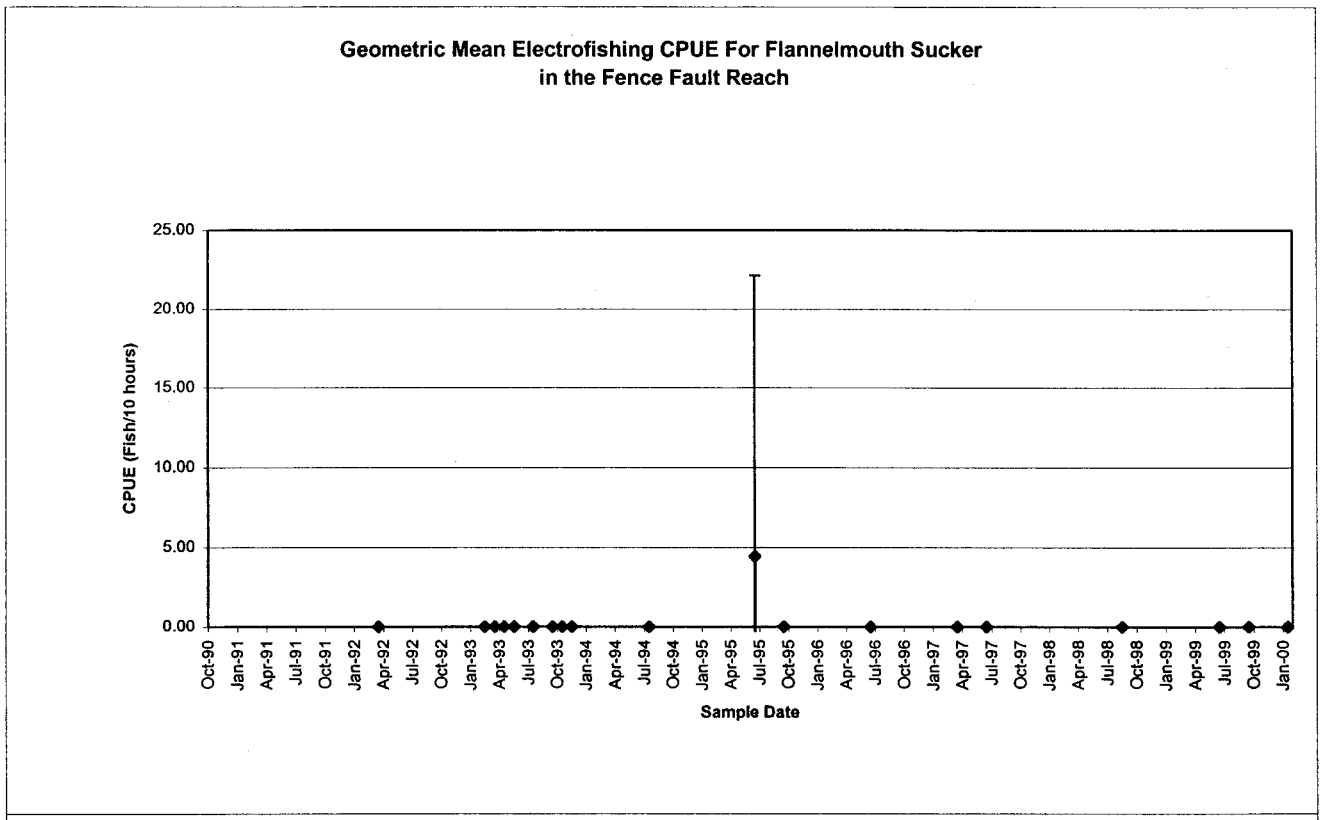




Figure 24. Electrofishing and trammel netting CPUE for brown trout within the Havasu Creek Reach. Error bars are one standard error.



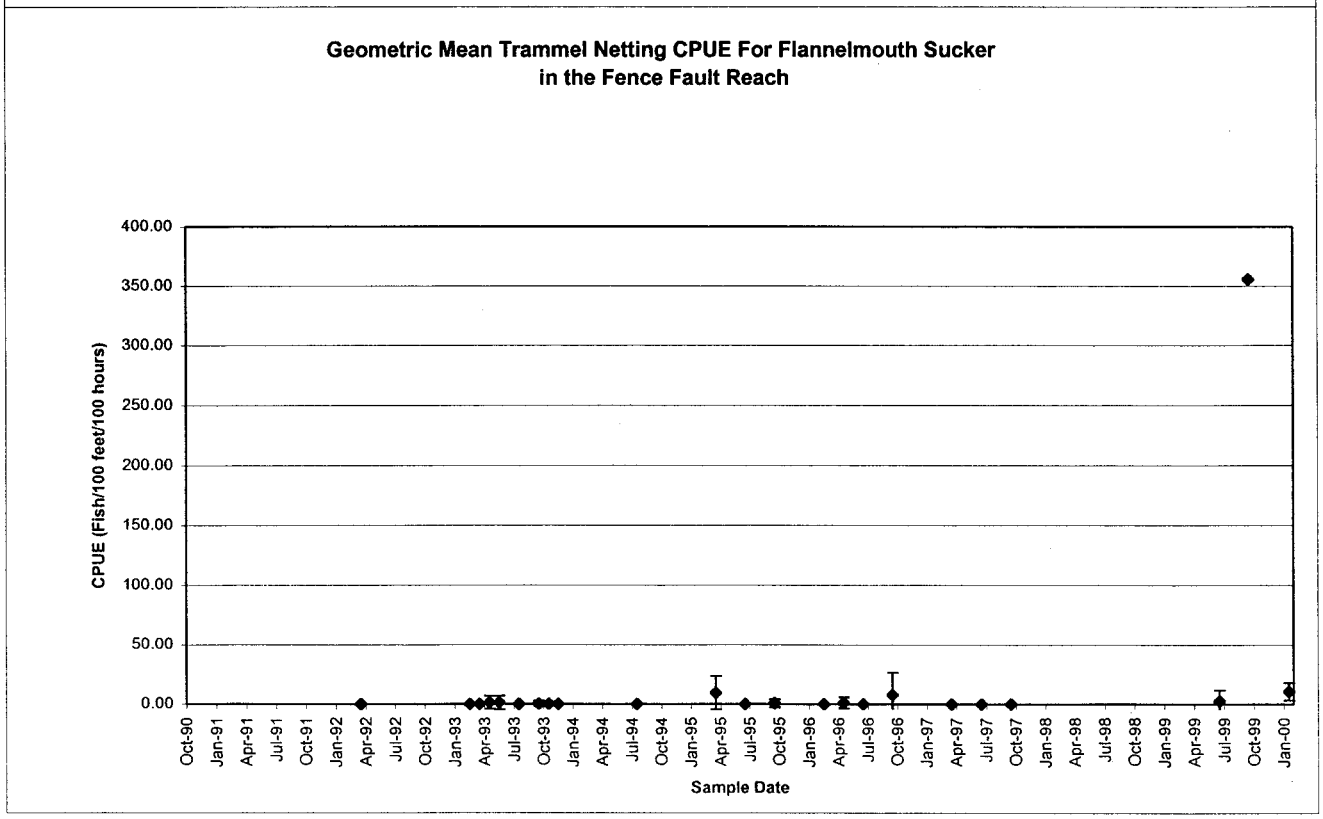




Figure 25. Electrofishing and trammel netting CPUE for flannelmouth sucker within the Fence Fault Reach. Error bars are one standard error.

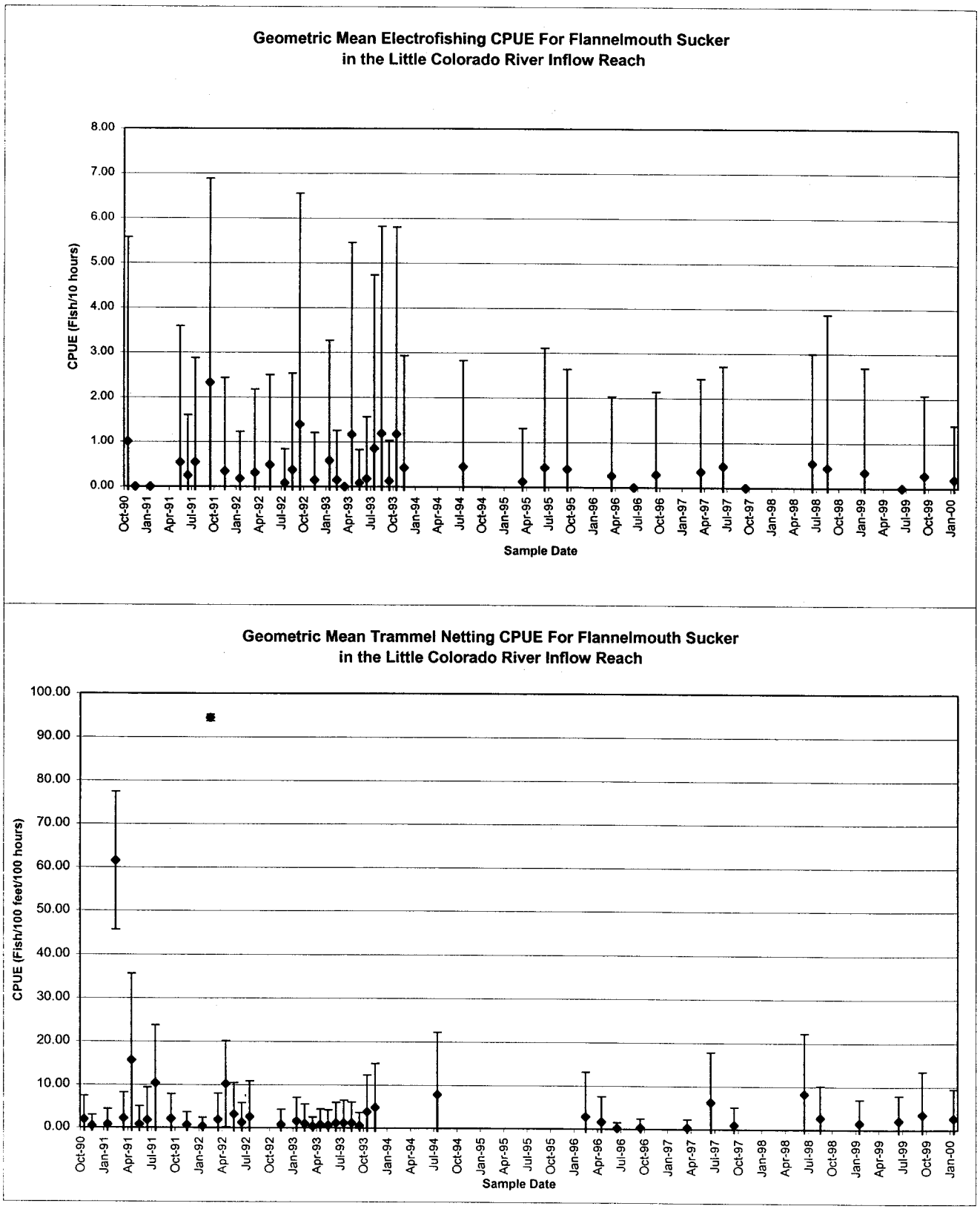



Figure 26. Electrofishing and trammel netting CPUE for flannelmouth sucker within the Little Colorado River Inflow Reach. Error bars are one standard error.

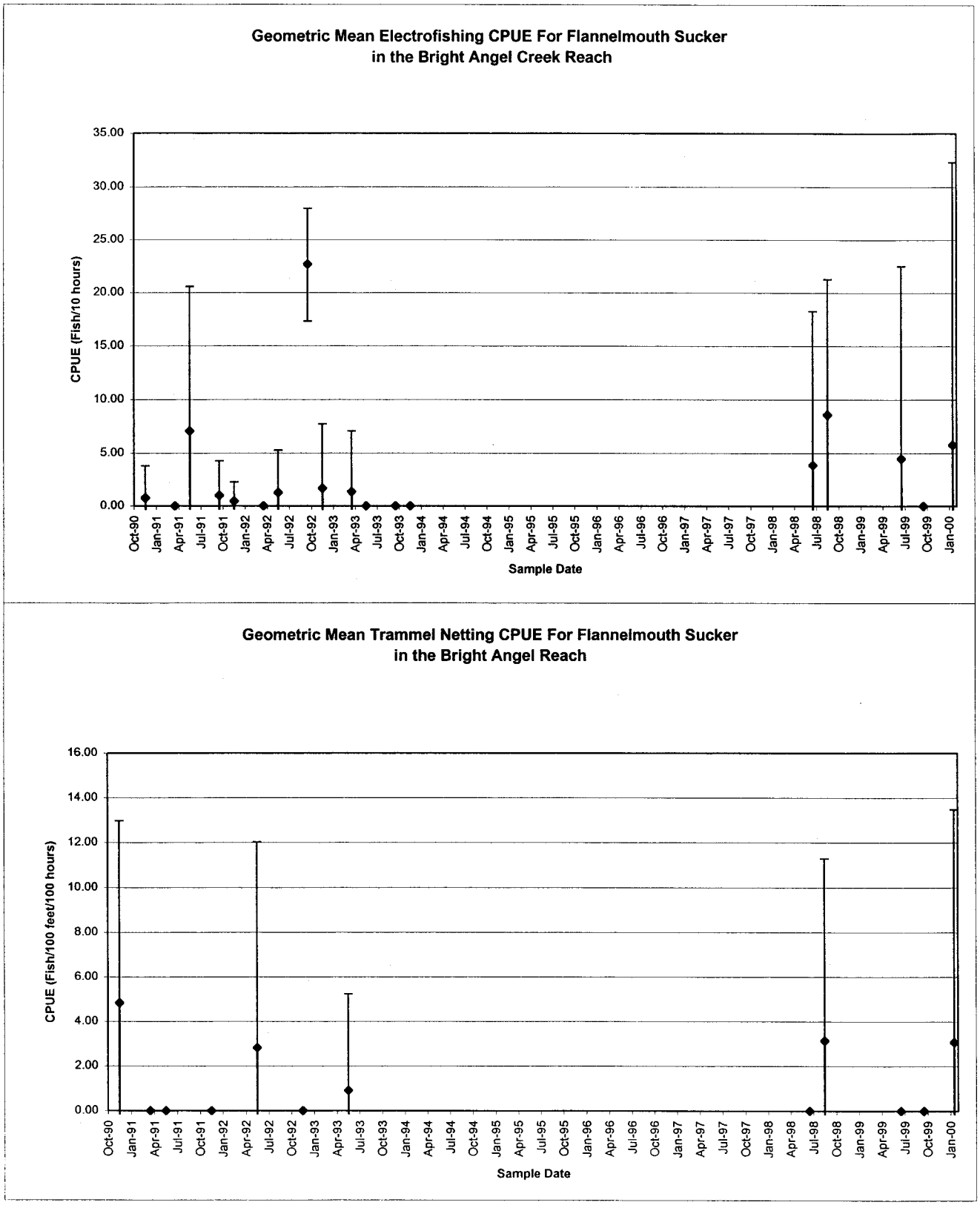
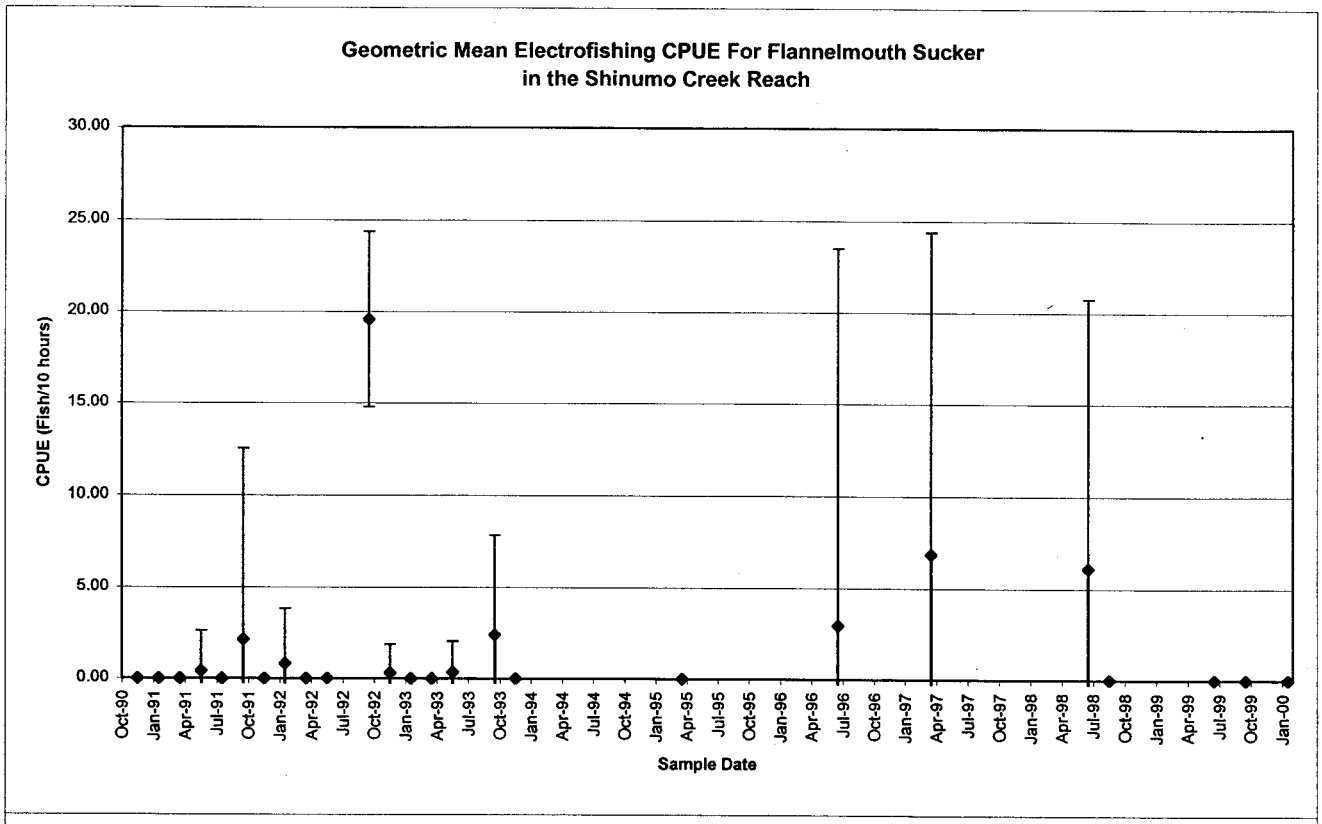



Figure 27. Electrofishing and trammel netting CPUE for flannelmouth sucker within the Bright Angel Reach. Error bars are one standard error.



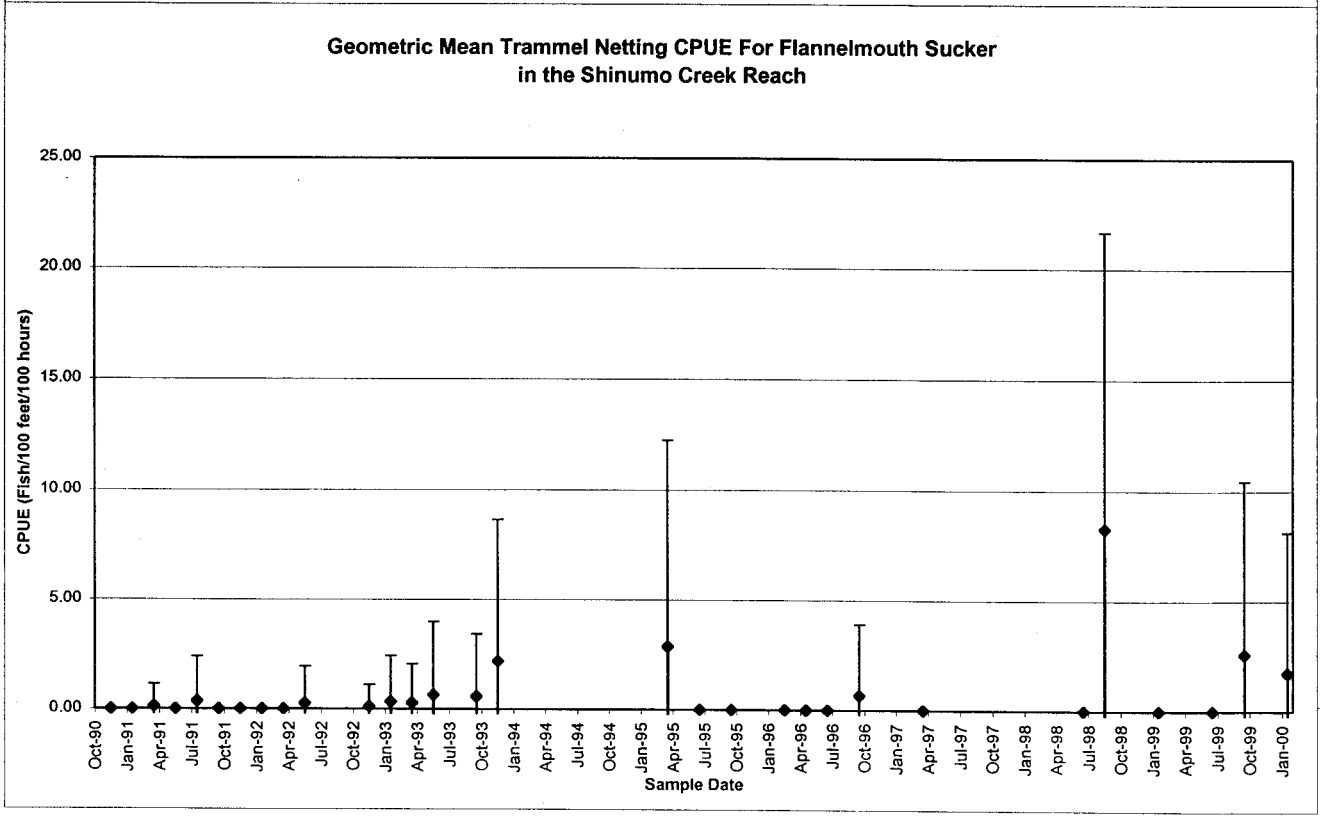




Figure 28. Electrofishing and trammel netting CPUE for flannelmouth sucker within the Shinumo Creek Reach. Error bars are one standard error.

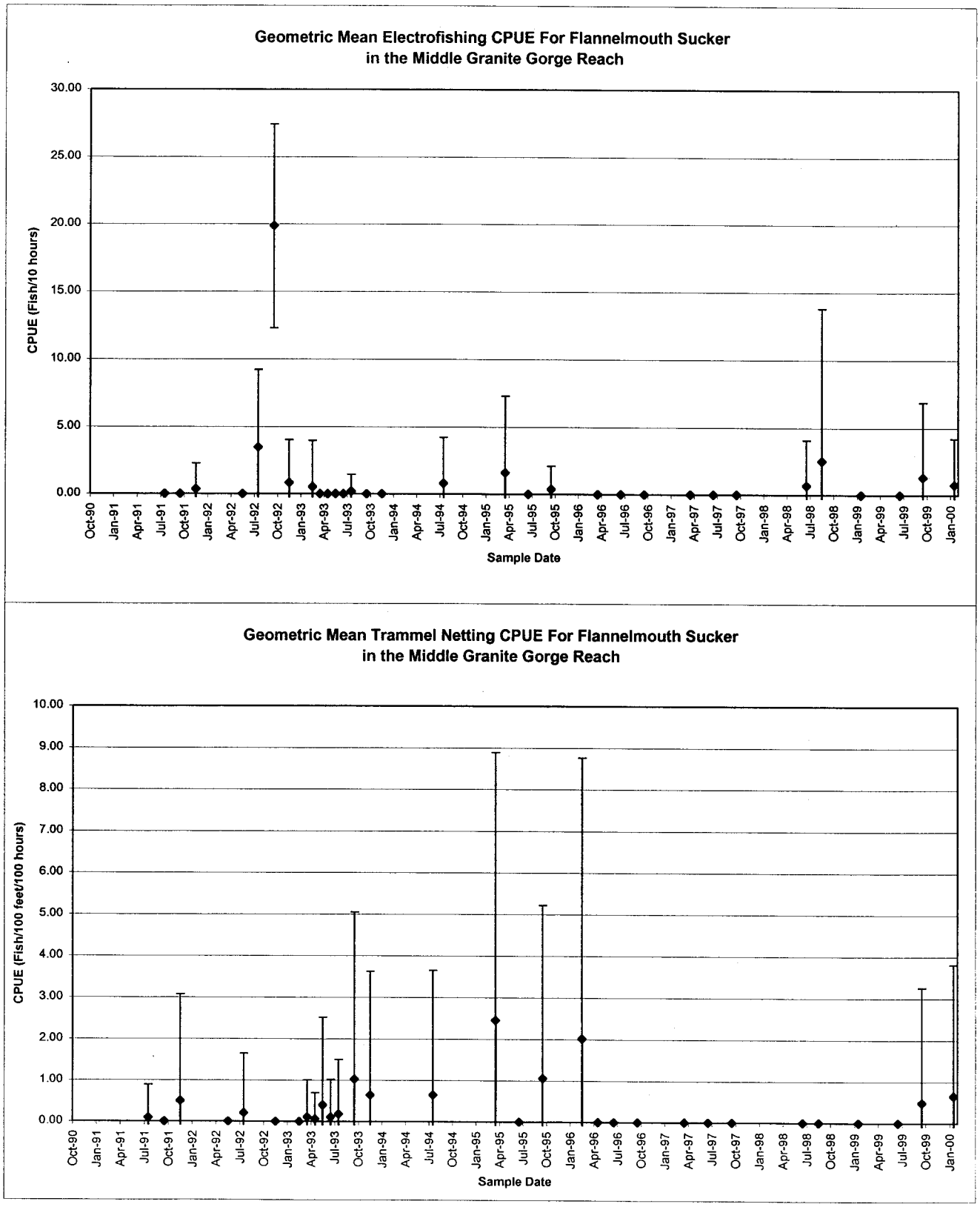
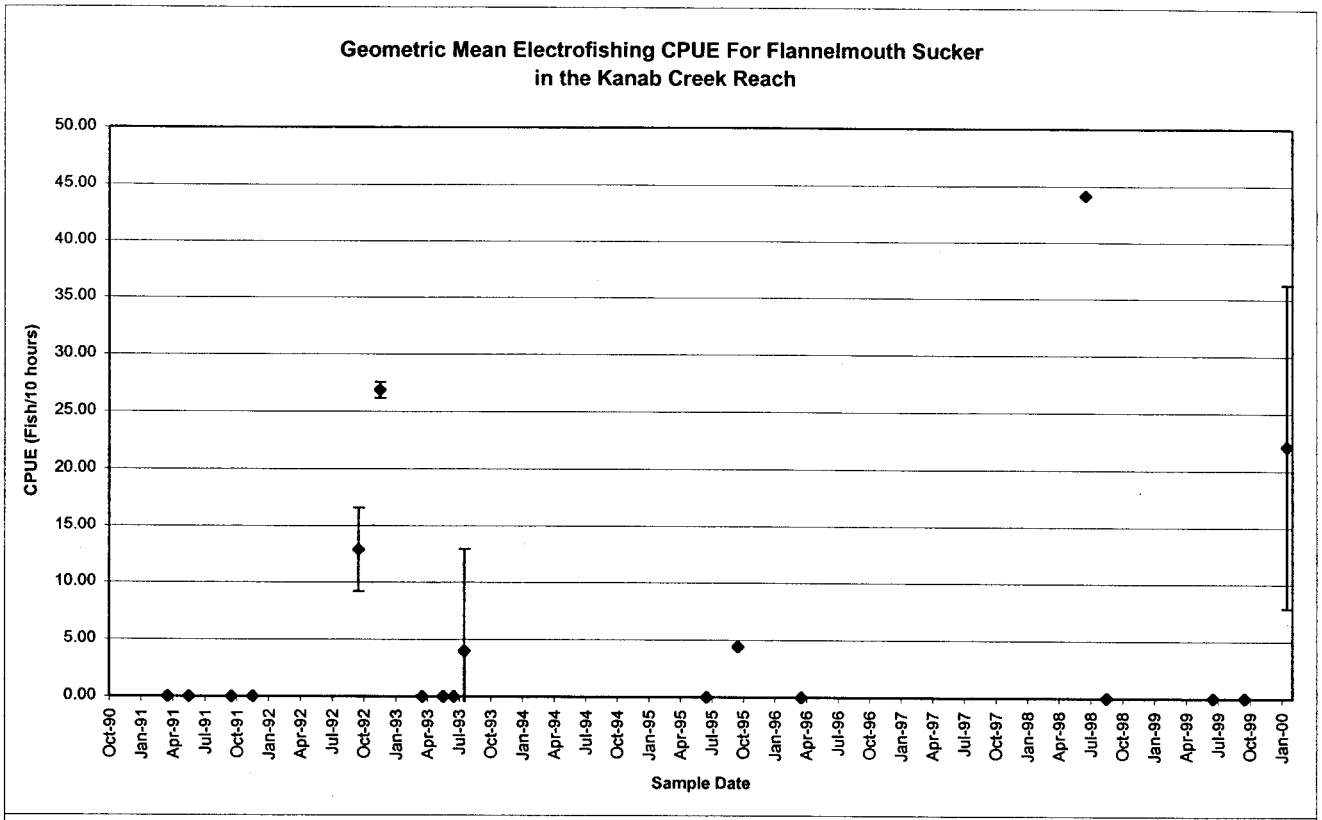



Figure 29. Electrofishing and trammel netting CPUE for flannelmouth sucker within the Middle Granite Gorge Reach. Error bars are one standard error.



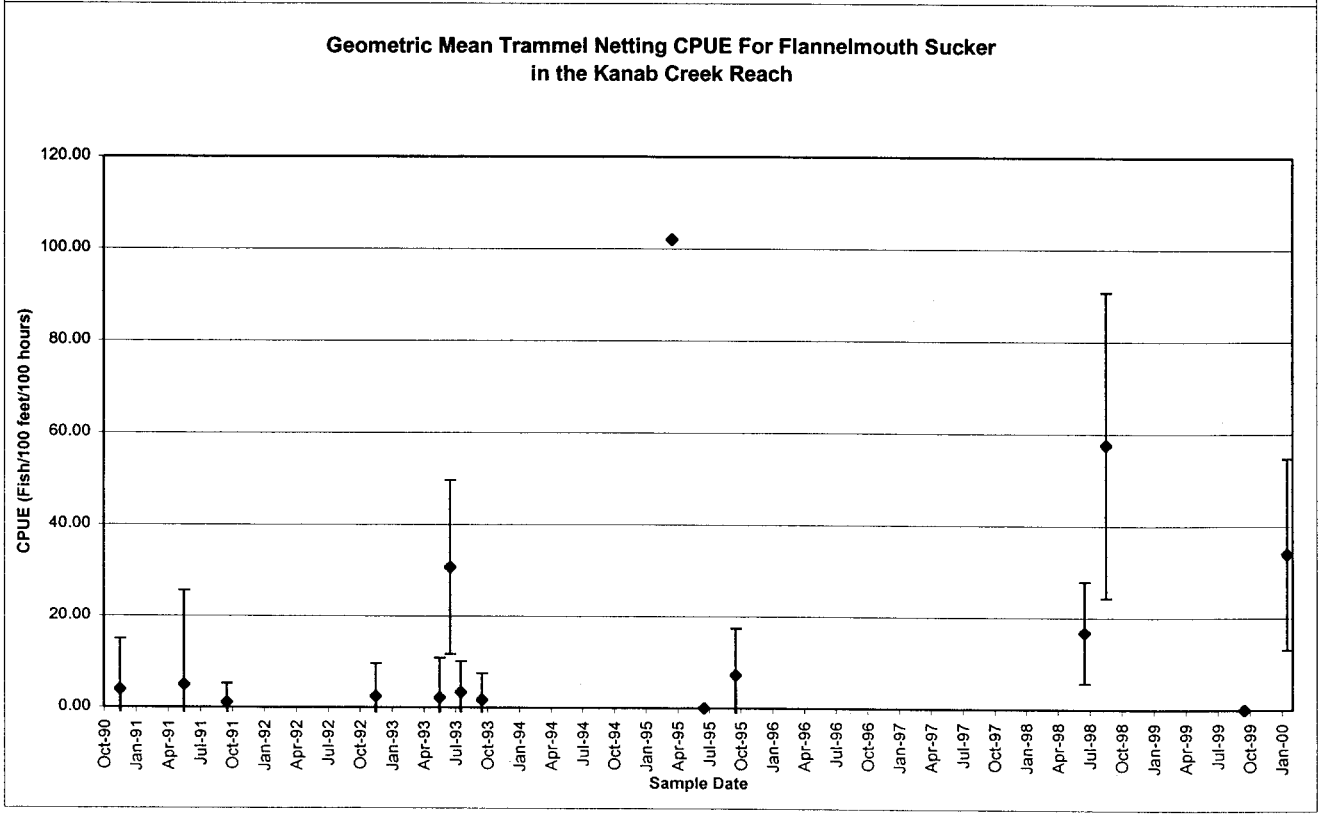
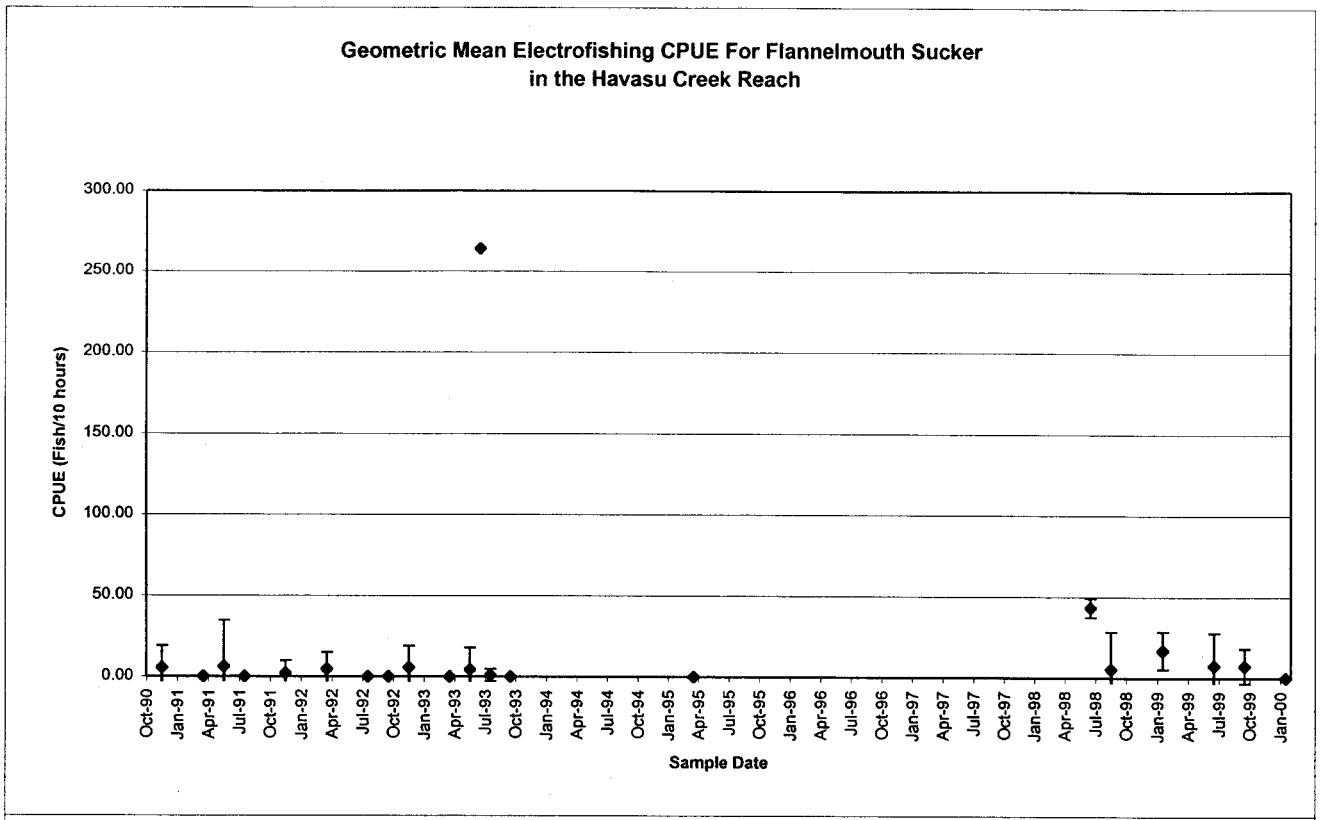




Figure 30. Electrofishing and trammel netting CPUE for flannelmouth sucker within the Kanab Creek Reach. Error bars are one standard error.



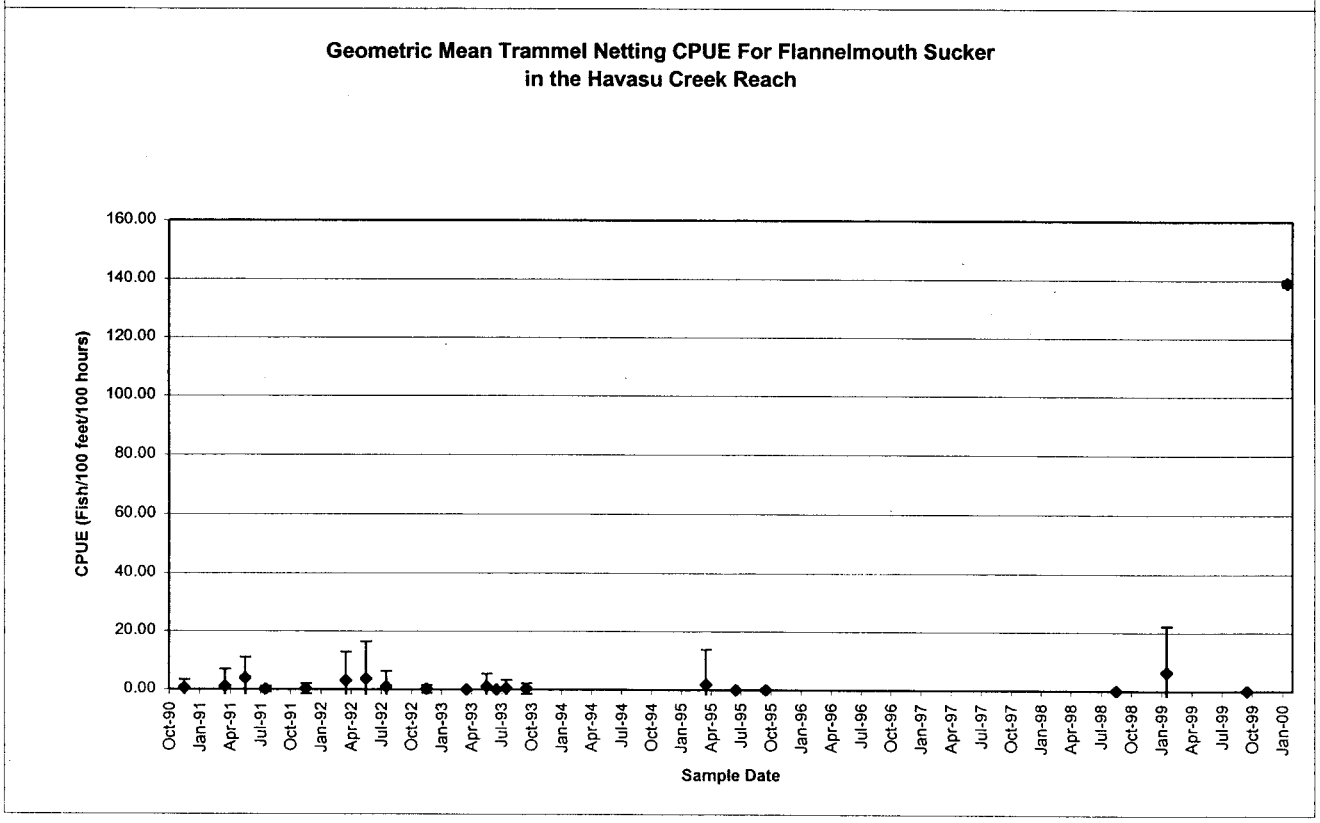




Figure 31. Electrofishing and trammel netting CPUE for flannelmouth sucker within the Havasu Creek Reach. Error bars are one standard error.

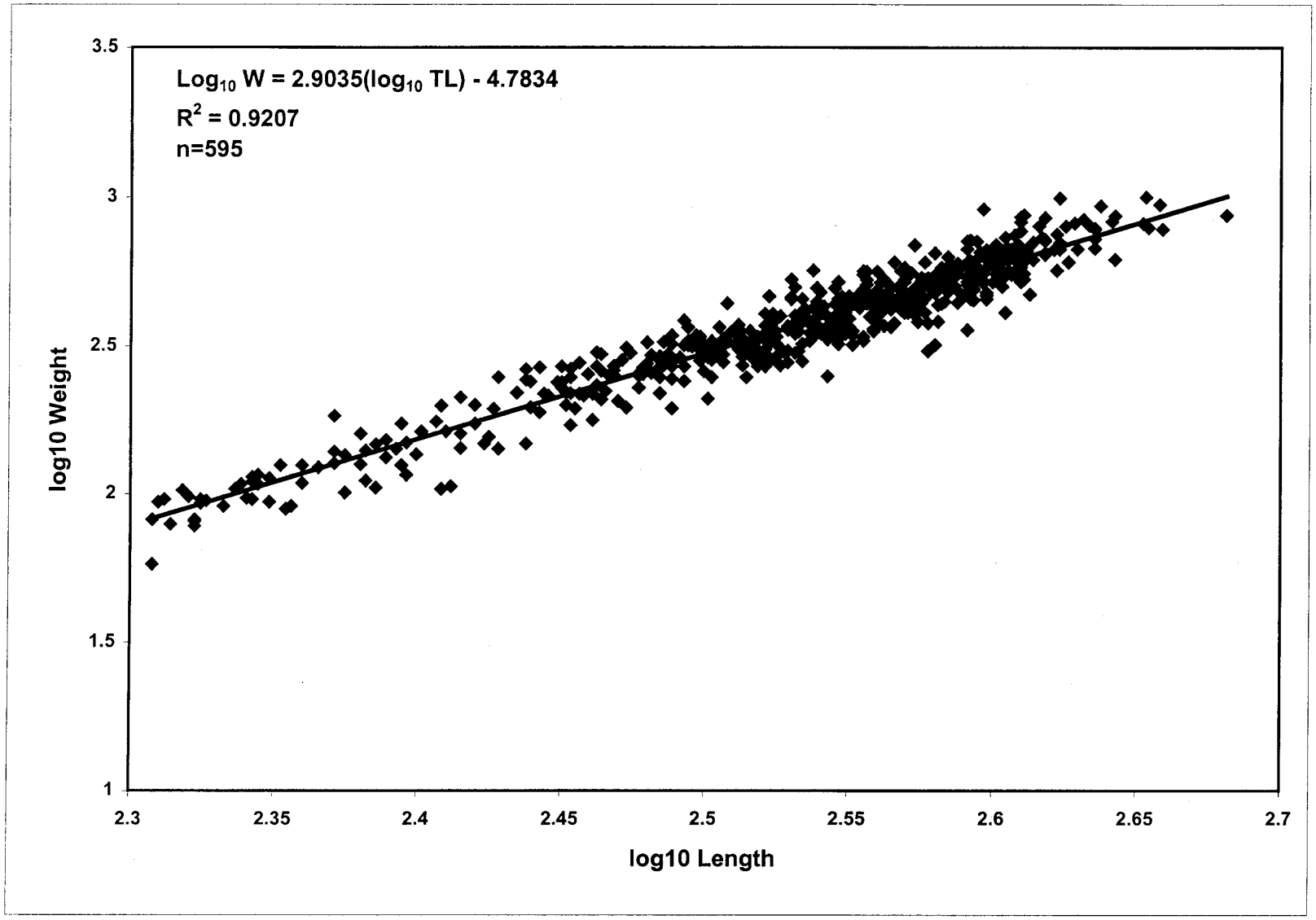



Figure 32. Length-weight relationship for humpback chub >= 200 mm from the Colorado River in Grand Canyon during 1990-1991.

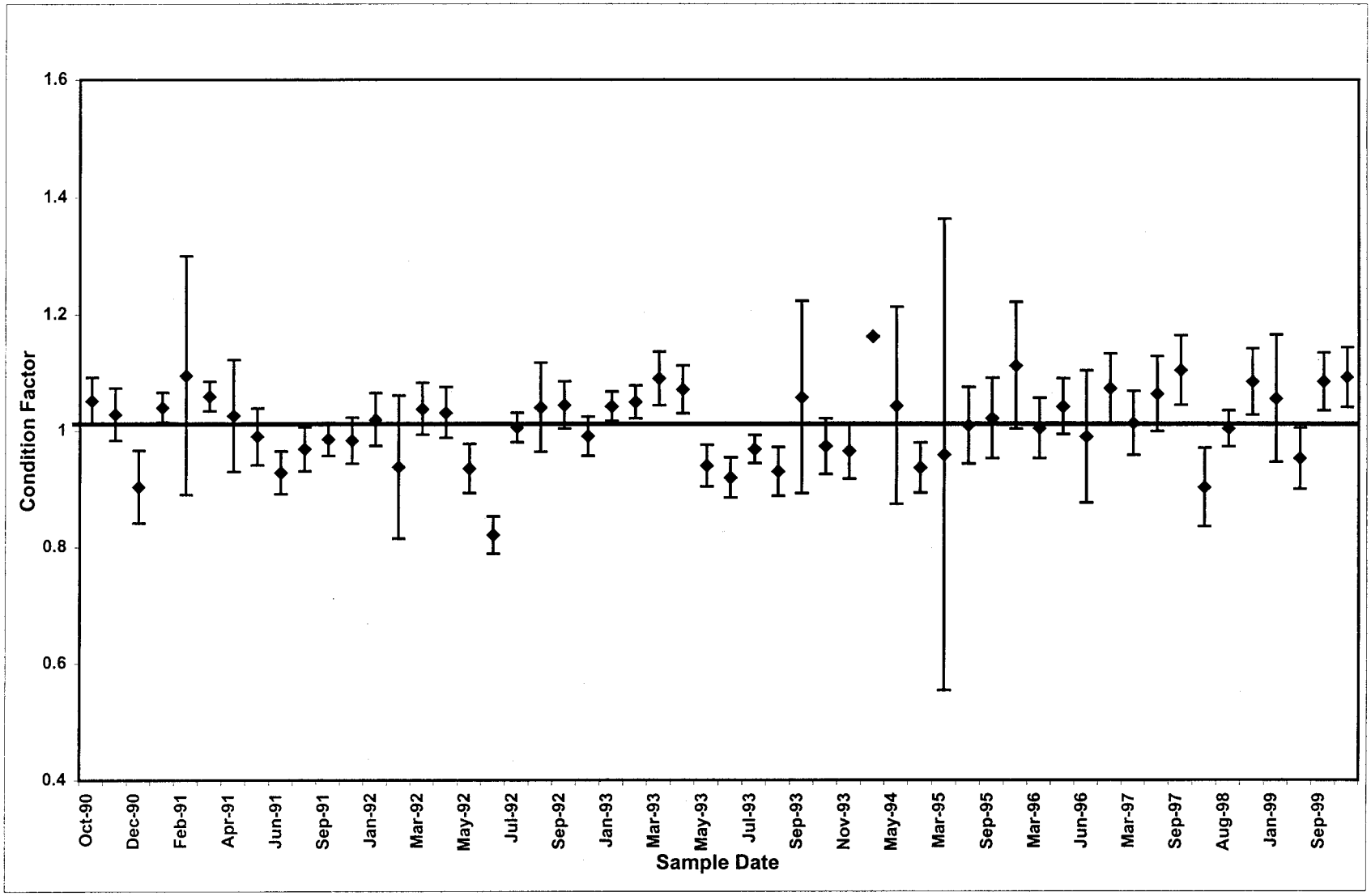



Figure 33. Estimated monthly condition factor for humback chub >= 200 mm total length from the Colorado River in Grand Canyon. Error bars represent one standard error and the heavy dark line is the average condition factor of all humpback chub >= 200 mm captured from the Colorado River in Grand Canyon during 1990-1991.

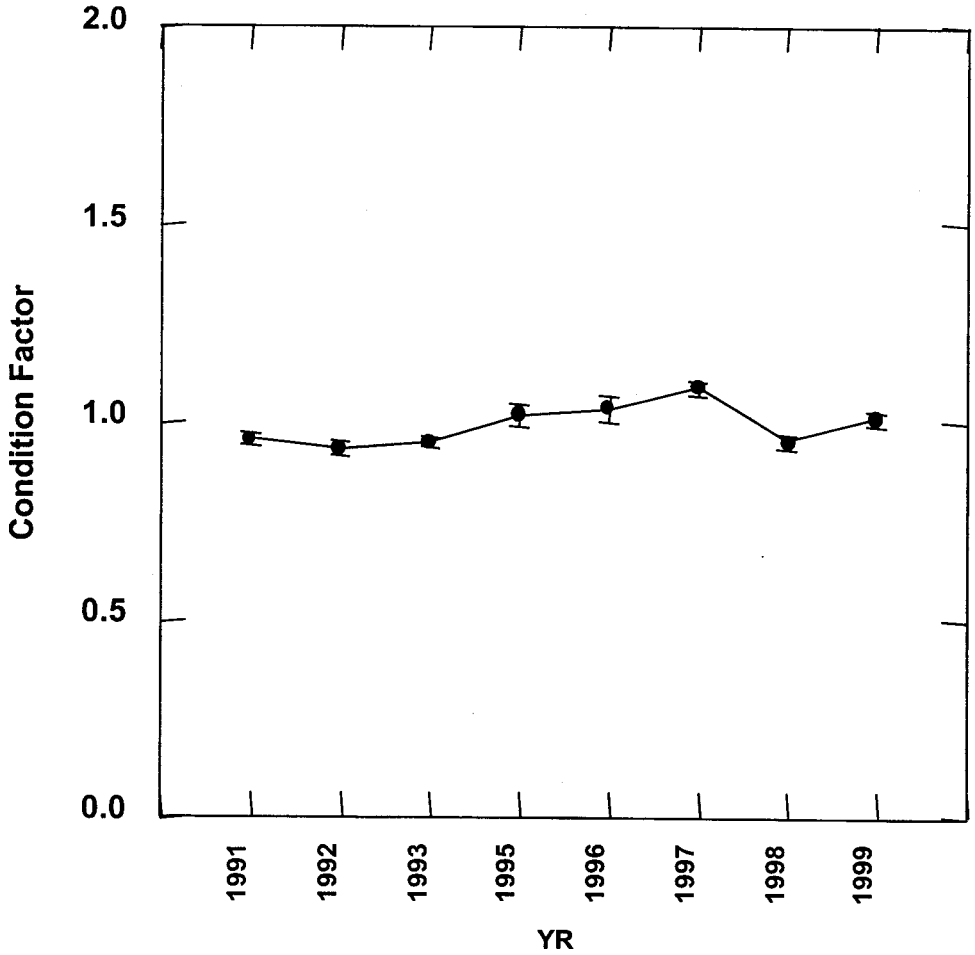
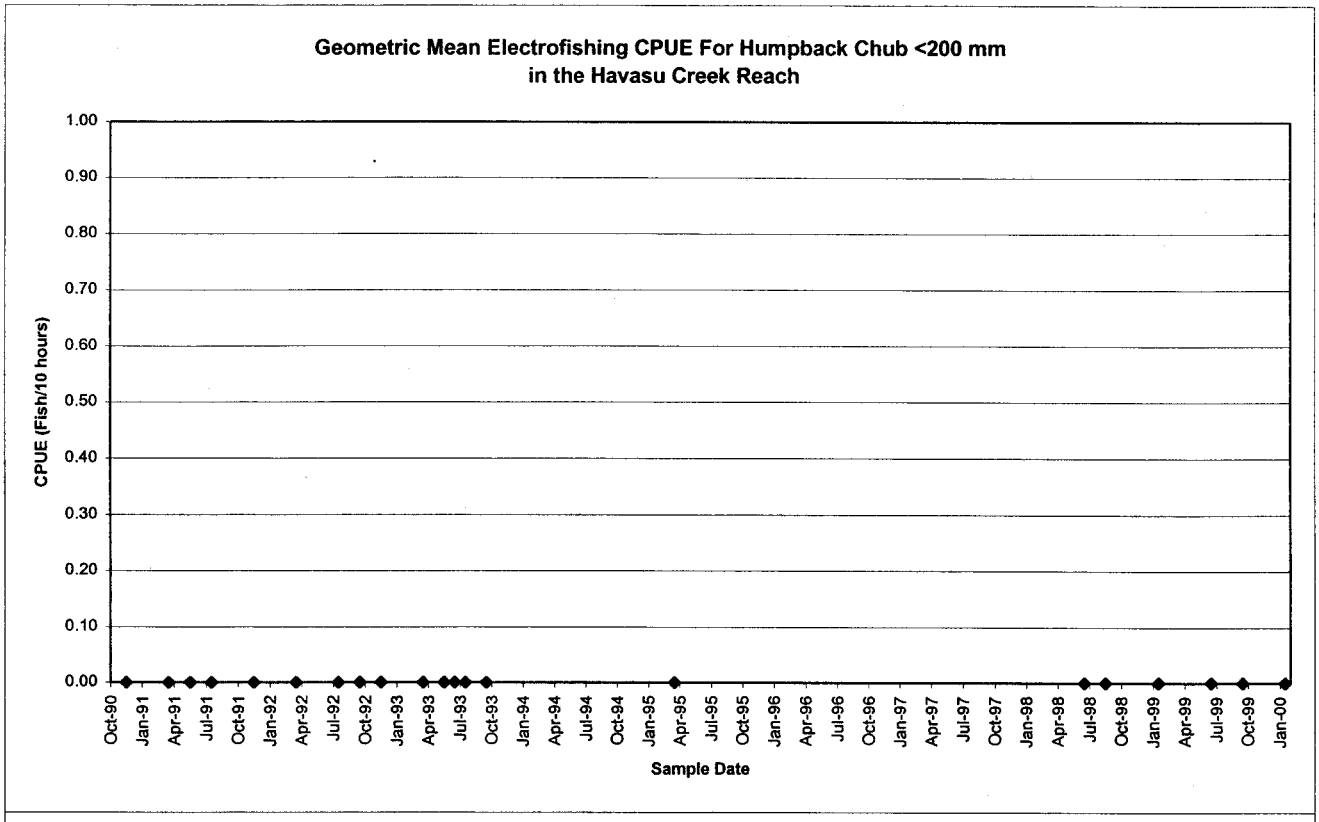



Figure 34. Mean condition factor for each year among June and September. Error bars are + - 2 standard errors.



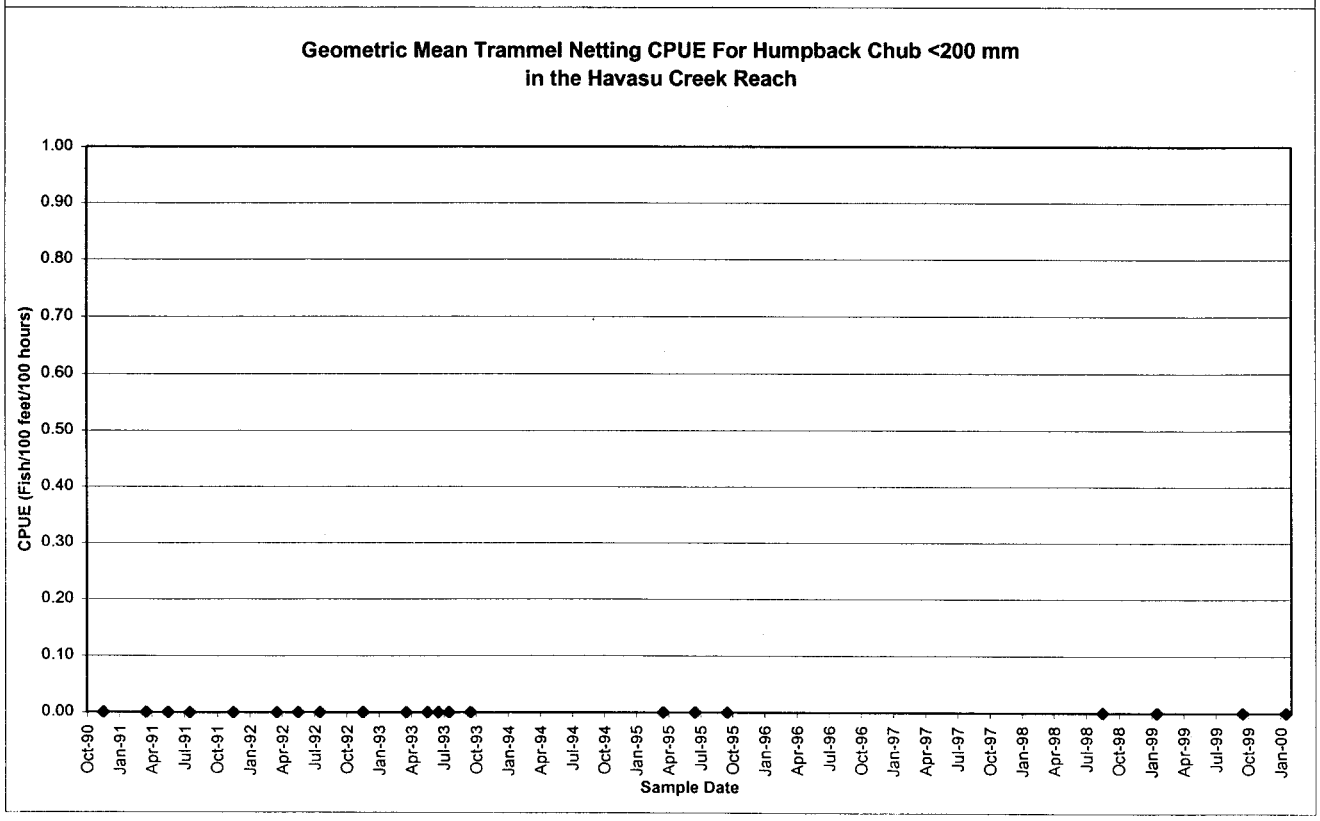
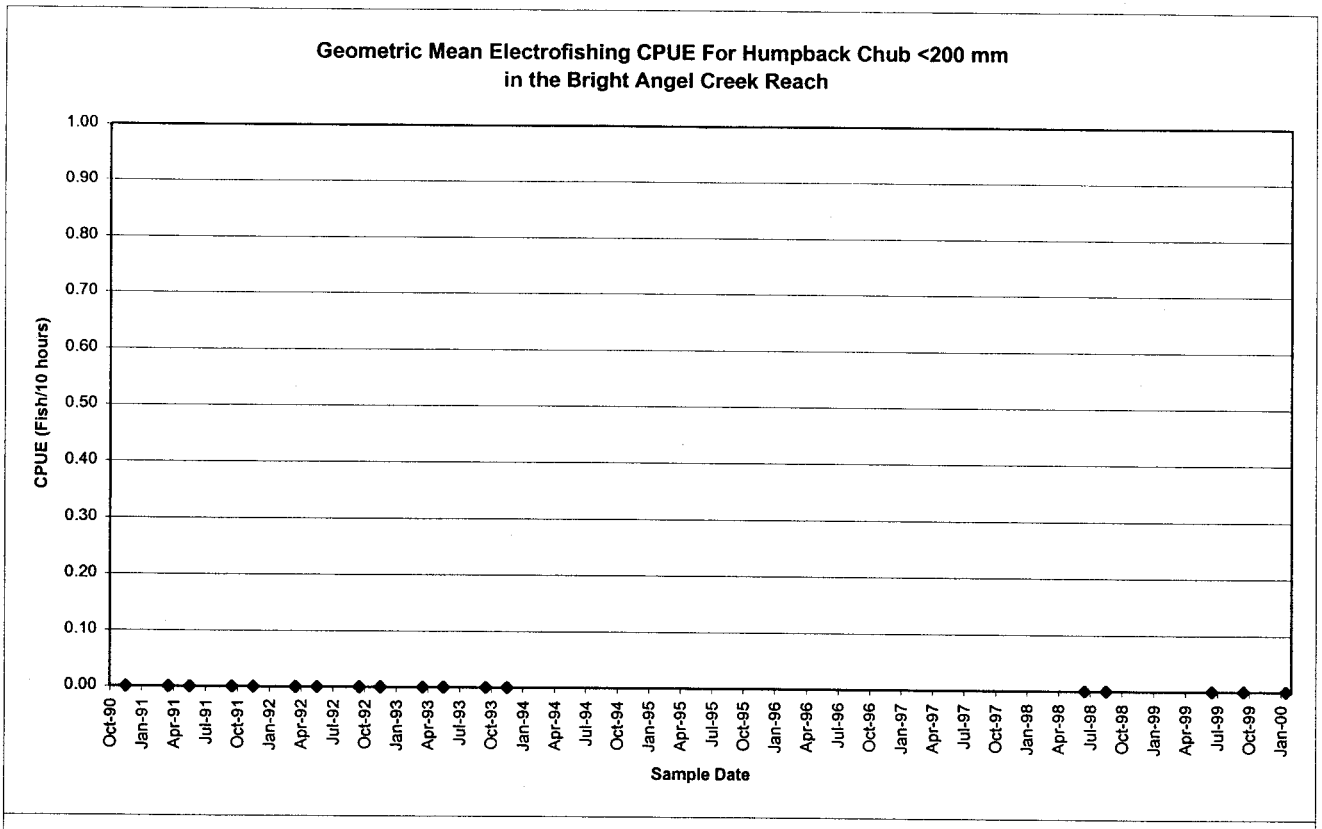




Figure N/A. Electrofishing and trammel netting CPUE for humpback chub < 200 mm within the Havasu Creek Reach. Error bars are one standard error.



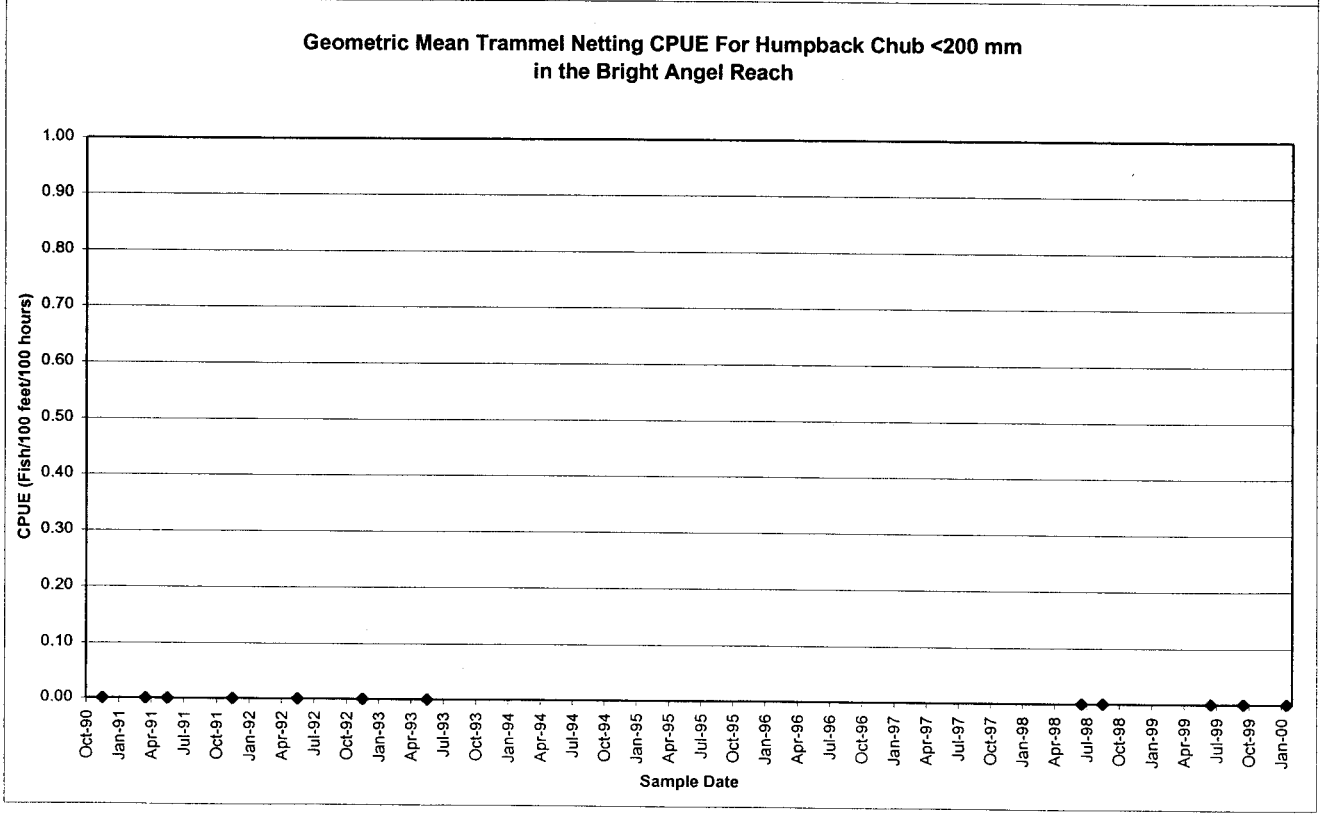
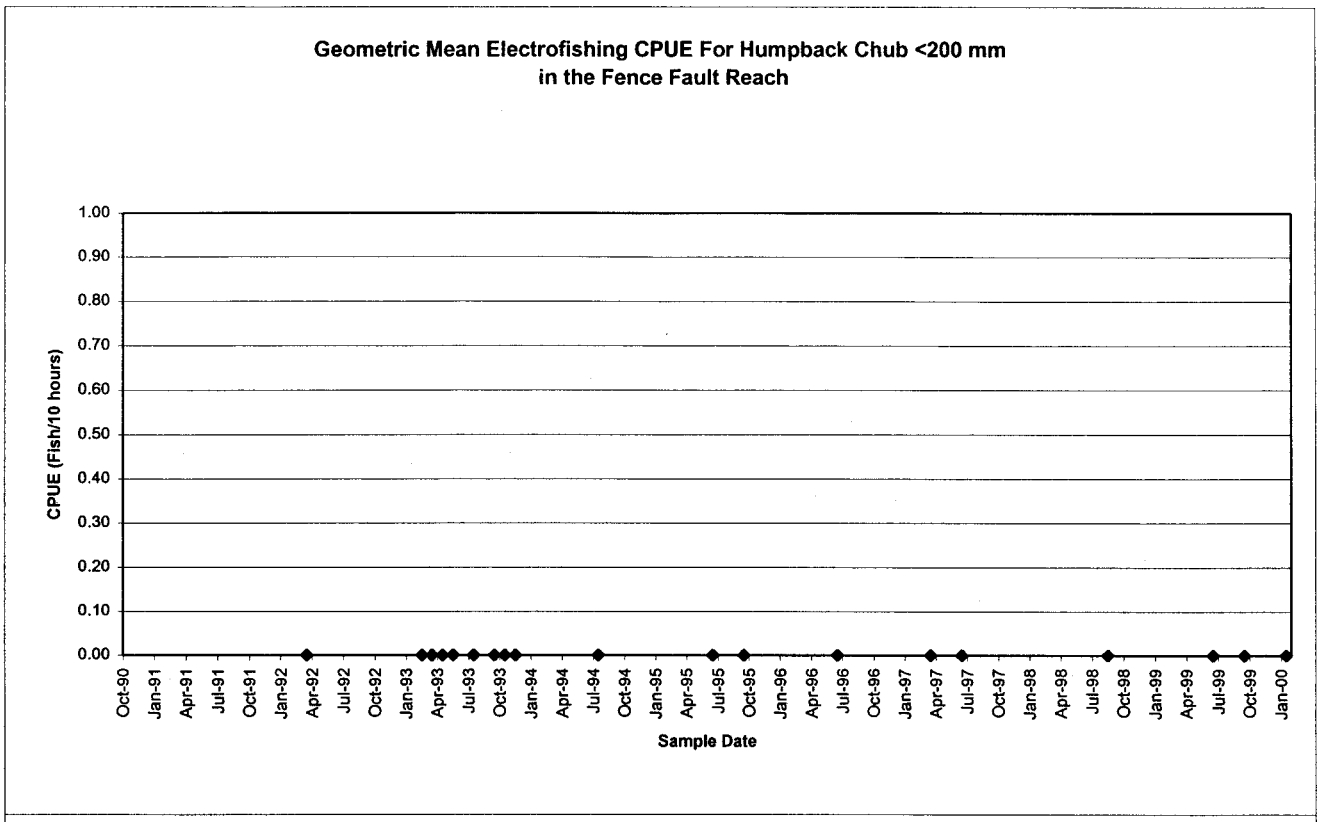




Figure N/A. Electrofishing and trammel netting CPUE for humpback chub < 200 mm within the Bright Angel Reach. Error bars are one standard error.



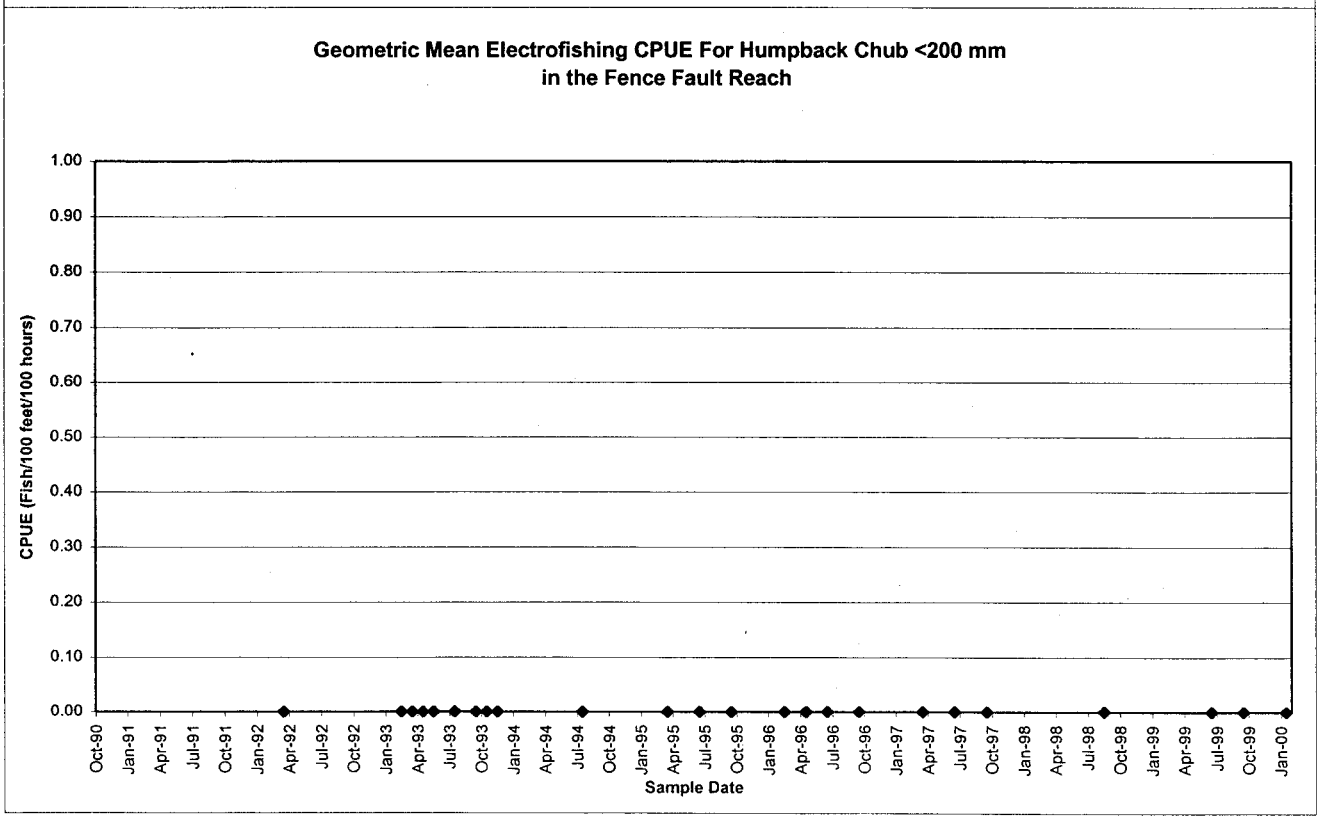
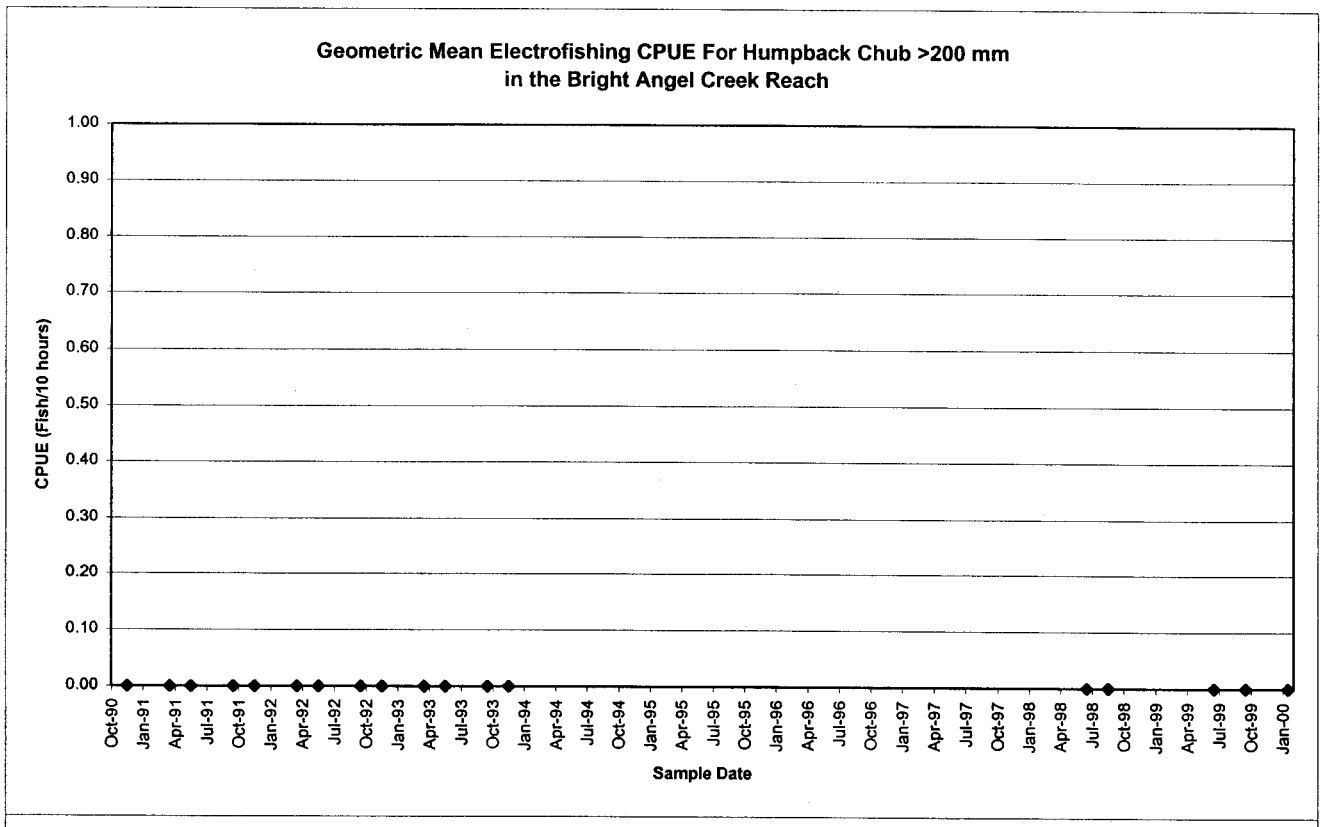




Figure N/A. Electrofishing and trammel netting CPUE for humpback chub < 200 mm within the Fence Fault Reach. Error bars are one standard error.



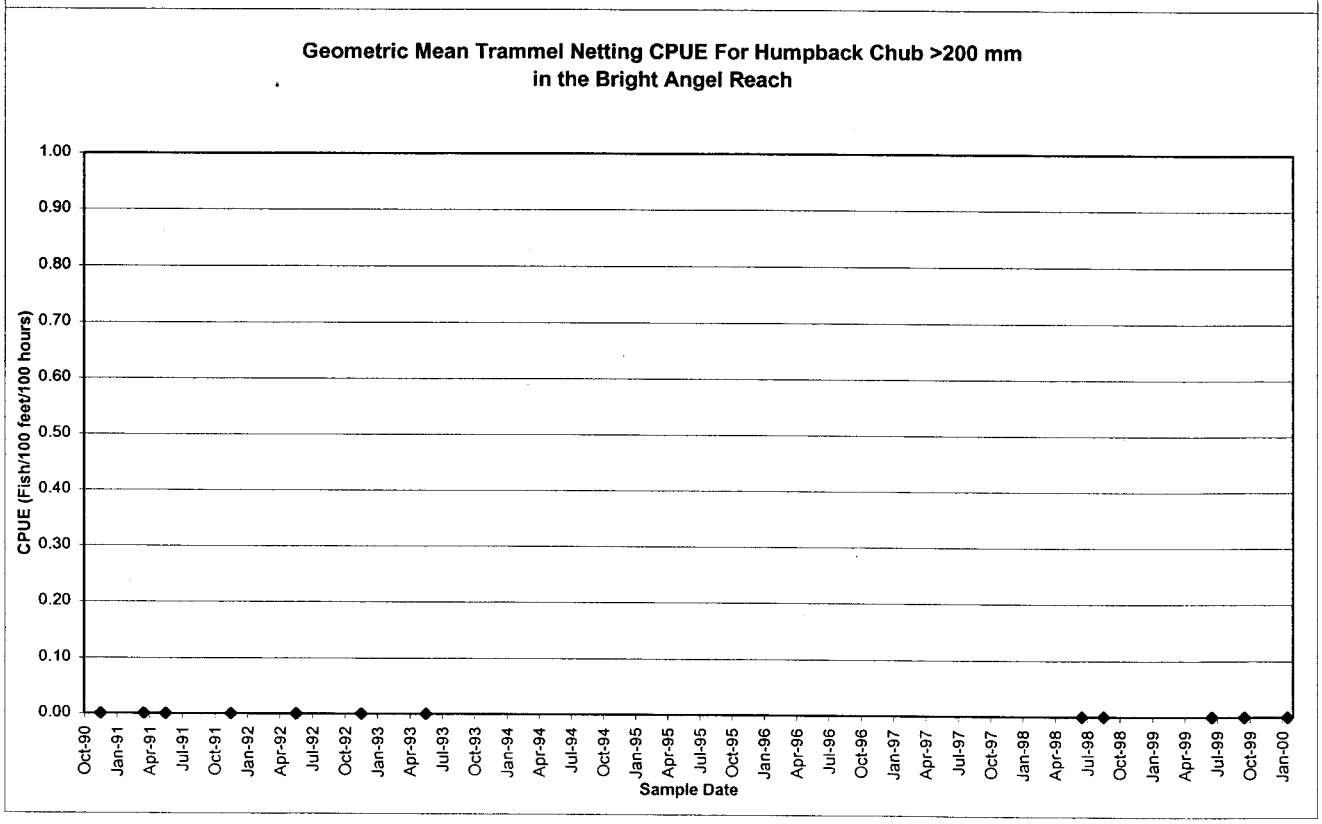




Figure N/A. Electrofishing and trammel netting CPUE for humpback chub > 200 mm within the Bright Angel Reach. Error bars are one standard error.

Appendix A-1. Geometric mean and standard error catch per unit effort (CPUE; Fish/10 hours) using electrofishing methods for humpback chub <200 mm amoong the 7 standardized reaches.

| Sample | Fence Fault | | | LCR INFLOW | | | BRIGHT ANGEL | | | SHINUMO | | | MIDDLE GRANITE GORGE | | | KANAB | | | HAVASU | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Date | N | CPUE | SE | N | CPUE | SE | N | CPUE | SE | N | CPUE | SE | N | CPUE | SE | N | CPUE | SE | N | CPUE | SE |
| Oct-90 | 0 | | | 13 | 0.28 | 1.42 | 0 | | | 0 | | | 0 | | | 0 | | | 0 | | |
| Nov-90 | 0 | | | 7 | 1.57 | 4.07 | 6 | 0.00 | 0.00 | 3 | 0.00 | 0.00 | 0 | | | 0 | | | 2 | 0.00 | 0.00 |
| Jan-91 | 0 | | | 2 | 0.00 | 0.00 | 0 | | | 5 | 0.00 | 0.00 | 0 | | | 0 | | | 0 | | |
| Mar-91 | 0 | | | 0 | | | 12 | 0.00 | 0.00 | 8 | 0.00 | 0.00 | 0 | | | 1 | 0.00 | 0.00 | 4 | 0.00 | 0.00 |
| May-91 | 0 | | | 22 | 5.89 | 8.14 | 7 | 0.00 | 0.00 | 11 | 0.00 | 0.00 | 0 | | | 1 | 0.00 | 0.00 | 3 | 0.00 | 0.00 |
| Jun-91 | 0 | | | 30 | 0.68 | 2.91 | 0 | | | 0 | | | 0 | | | 0 | | | 0 | | |
| Jul-91 | 0 | | | 25 | 4.55 | 7.88 | 0 | | | 11 | 0.00 | 0.00 | 7 | 0.00 | 0.00 | 0 | | | 1 | 0.00 | 0.00 |
| Sep-91 | 0 | | | 41 | 15.55 | 12.45 | 10 | 0.00 | 0.00 | 10 | 0.00 | 0.00 | 9 | 0.00 | 0.00 | 2 | 0.00 | 0.00 | 0 | | |
| Nov-91 | 0 | | | 30 | 6.17 | 8.46 | 8 | 0.00 | 0.00 | 5 | 0.00 | 0.00 | 13 | 0.00 | 0.00 | 4 | 0.00 | 0.00 | 4 | 0.00 | 0.00 |
| Jan-92 | 0 | | | 39 | 1.91 | 5.74 | 0 | | | 18 | 0.00 | 0.00 | 0 | | | 0 | | | 0 | | |
| Mar-92 | 5 | 0.00 | 0.00 | 47 | 2.90 | 7.56 | 8 | 0.00 | 0.00 | 9 | 0.00 | 0.00 | 0 | | | 0 | | | 2 | 0.00 | 0.00 |
| May-92 | 0 | | | 25 | 21.96 | 11.41 | 14 | 0.00 | 0.00 | 10 | 0.00 | 0.00 | 4 | 0.00 | 0.00 | 0 | | | 0 | | |
| Jul-92 | 0 | | | 45 | 13.02 | 10.69 | 0 | | | 0 | | | 7 | 0.00 | 0.00 | 0 | | | 2 | 0.00 | 0.00 |
| Aug-92 | 0 | | | 26 | 6.79 | 9.13 | 0 | | | 0 | | | 0 | | | 0 | | | 0 | | |
| Sep-92 | 0 | | | 36 | 8.40 | 10.42 | 9 | 0.00 | 0.00 | 10 | 0.00 | 0.00 | 4 | 1.12 | 3.50 | 5 | 0.00 | 0.00 | 1 | 0.00 | 0.00 |
| Nov-92 | 0 | | | 54 | 5.26 | 7.90 | 9 | 0.00 | 0.00 | 13 | 0.00 | 0.00 | 19 | 0.24 | 1.59 | 2 | 0.00 | 0.00 | 2 | 0.00 | 0.00 |
| Jan-93 | 0 | | | 35 | 4.10 | 9.36 | 0 | | | 7 | 0.00 | 0.00 | 0 | | | 0 | | | 0 | | |
| Feb-93 | 2 | 0.00 | 0.00 | 29 | 4.92 | 9.68 | 0 | | | 0 | | | 13 | 0.00 | 0.00 | 0 | | | 0 | | |
| Mar-93 | 4 | 0.00 | 0.00 | 59 | 4.03 | 9.09 | 5 | 0.00 | 0.00 | 11 | 0.00 | 0.00 | 4 | 0.00 | 0.00 | 4 | 0.00 | 0.00 | 3 | 0.00 | 0.00 |
| Apr-93 | 5 | 0.00 | 0.00 | 27 | 6.81 | 10.20 | 0 | | | 0 | | | 1 | 0.00 | 0.00 | 0 | | | 0 | | |
| May-93 | 4 | 0.00 | 0.00 | 48 | 4.24 | 9.13 | 12 | 0.00 | 0.00 | 11 | 0.00 | 0.00 | 11 | 0.00 | 0.00 | 2 | 0.00 | 0.00 | 6 | 0.00 | 0.00 |
| Jun-93 | 0 | | | 27 | 0.71 | 3.97 | 0 | | | 0 | | | 9 | 0.38 | 1.64 | 1 | 0.00 | 0.00 | 1 | 0.00 | 0.00 |
| Jul-93 | 7 | 0.00 | 0.00 | 59 | 16.44 | 13.19 | 0 | | | 0 | | | 21 | 0.21 | 1.40 | 5 | 0.00 | 0.00 | 5 | 0.00 | 0.00 |
| Aug-93 | 0 | | | 43 | 9.45 | 12.94 | 0 | | | 0 | | | 0 | | | 0 | | | 0 | | |
| Sep-93 | 1 | 0.00 | 0.00 | 28 | 85.81 | 11.46 | 5 | 0.00 | 0.00 | 9 | 0.00 | 0.00 | 5 | 0.00 | 0.00 | 0 | | | 1 | 0.00 | 0.00 |
| Oct-93 | 3 | 0.00 | 0.00 | 34 | 89.15 | 16.24 | 0 | | | 0 | | | 0 | | | 0 | | | 0 | | |
| Nov-93 | 2 | 0.00 | 0.00 | 26 | 0.97 | 4.20 | 4 | 0.00 | 0.00 | 4 | 0.00 | 0.00 | 2 | 0.00 | 0.00 | 0 | | | 0 | | |
| Jul-94 | 3 | 0.00 | 0.00 | 34 | 22.25 | 14.47 | 0 | | | 0 | | | 15 | 0.77 | 3.28 | 0 | | | 0 | | |
| Mar-95 | 0 | | | 41 | 29.79 | 9.25 | 0 | | | 1 | 0.00 | 0.00 | 4 | 0.00 | 0.00 | 0 | | | 1 | 0.00 | 0.00 |
| Jun-95 | 3 | 0.00 | 0.00 | 41 | 22.72 | 8.32 | 0 | | | 0 | | | 7 | 5.23 | 9.03 | 2 | 0.00 | 0.00 | 0 | | |
| Sep-95 | 4 | 0.00 | 0.00 | 37 | 32.48 | 7.17 | 0 | | | 0 | | | 10 | 3.93 | 7.14 | 1 | 0.00 | 0.00 | 0 | | |
| Mar-96 | 0 | | | 39 | 1.53 | 5.54 | 0 | | | 0 | | | 9 | 1.86 | 7.20 | 1 | 0.00 | 0.00 | 0 | | |
| Jun-96 | 1 | 0.00 | 0.00 | 23 | 5.59 | 10.40 | 0 | | | 5 | 0.00 | 0.00 | 5 | 0.00 | 0.00 | 0 | | | 0 | | |
| Sep-96 | 0 | | | 17 | 2.45 | 6.33 | 0 | | | 0 | | | 5 | 0.00 | 0.00 | 0 | | | 0 | | |
| Mar-97 | 1 | 0.00 | 0.00 | 28 | 0.15 | 1.13 | 0 | | | 2 | 0.00 | 0.00 | 6 | 0.00 | 0.00 | 0 | | | 0 | | |
| Jun-97 | 2 | 0.00 | 0.00 | 29 | 0.49 | 2.35 | 0 | | | 0 | | | 7 | 0.00 | 0.00 | 0 | | | 0 | | |
| Sep-97 | 0 | | | 20 | 2.22 | 7.36 | 0 | | | 0 | | | 5 | 0.00 | 0.00 | 0 | | | 0 | | |
| Jun-98 | 0 | | | 17 | 2.65 | 7.32 | 3 | 0.00 | 0.00 | 5 | 0.00 | 0.00 | 8 | 1.89 | 6.24 | 1 | 0.00 | 0.00 | 6 | 0.00 | 0.00 |
| Aug-98 | 1 | 0.00 | 0.00 | 18 | 20.19 | 17.61 | 4 | 0.00 | 0.00 | 2 | 0.00 | 0.00 | 4 | 0.00 | 0.00 | 2 | 6.29 | 15.59 | 3 | 0.00 | 0.00 |
| Jan-99 | 0 | | | 16 | 7.82 | 8.87 | 0 | | | 0 | | | 4 | 1.97 | 7.83 | 0 | | | 3 | 0.00 | 0.00 |
| Jun-99 | 3 | 0.00 | 0.00 | 19 | 5.05 | 10.43 | 3 | 0.00 | 0.00 | 2 | 0.00 | 0.00 | 6 | 0.00 | 0.00 | 1 | 0.00 | 0.00 | 2 | 0.00 | 0.00 |
| Sep-99 | 3 | 0.00 | 0.00 | 17 | 23.41 | 11.41 | 3 | 0.00 | 0.00 | 2 | 0.00 | 0.00 | 5 | 0.00 | 0.00 | 3 | 0.00 | 0.00 | 4 | 0.00 | 0.00 |
| Jan-00 | 3 | 0.00 | 0.00 | 21 | 0.91 | 4.11 | 3 | 0.00 | 0.00 | 3 | 0.00 | 0.00 | 7 | 0.00 | 0.00 | 3 | 0.00 | 0.00 | 6 | 0.00 | 0.00 |

Appendix B-1. Geometric mean and standard error catch per unit effort (CPUE; Fish/10 hours) using electrofishing methods for humpback chub >= 200 mm among the 7 standardized reaches.

| Sample | Fence Fault | | | LCR INFLOW | | | BRIGHT ANGEL | | | SHINUMO | | | MIDDLE GRANITE GORGE | | | KANAB | | | HAVASU | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Date | N | CPUE | SE | N | CPUE | SE | N | CPUE | SE | N | CPUE | SE | N | CPUE | SE | N | CPUE | SE | N | CPUE | SE |
| Oct-90 | 0 | | | 13 | 0.28 | 1.42 | 0 | | | 0 | | | 0 | | | 0 | | | 0 | | |
| Nov-90 | 0 | | | 7 | 0.86 | 4.14 | 6 | 0.00 | 0.00 | 3 | 0.00 | 0.00 | 0 | | | 0 | | | 2 | 0.00 | 0.00 |
| Jan-91 | 0 | | | 2 | 5.61 | 13.47 | 0 | | | 5 | 0.00 | 0.00 | 0 | | | 0 | | | 0 | | |
| Mar-91 | 0 | | | 0 | | | 12 | 0.00 | 0.00 | 8 | 0.00 | 0.00 | 0 | | | 1 | 0.00 | 0.00 | 4 | 0.00 | 0.00 |
| May-91 | 0 | | | 22 | 0.19 | 1.25 | 7 | 0.00 | 0.00 | 11 | 0.57 | 3.43 | 0 | | | 1 | 0.00 | 0.00 | 3 | 0.00 | 0.00 |
| Jun-91 | 0 | | | 30 | 0.42 | 1.91 | 0 | | | 0 | | | 0 | | | 0 | | | 0 | | |
| Jul-91 | 0 | | | 25 | 0.53 | 2.24 | 0 | | | 11 | 0.00 | 0.00 | 7 | 0.00 | 0.00 | 0 | | | 1 | 0.00 | 0.00 |
| Sep-91 | 0 | | | 41 | 1.02 | 3.29 | 10 | 0.00 | 0.00 | 10 | 0.00 | 0.00 | 9 | 0.00 | 0.00 | 2 | 0.00 | 0.00 | 0 | | |
| Nov-91 | 0 | | | 30 | 1.06 | 3.47 | 8 | 0.00 | 0.00 | 5 | 0.00 | 0.00 | 13 | 0.00 | 0.00 | 4 | 0.00 | 0.00 | 4 | 0.00 | 0.00 |
| Jan-92 | 0 | | | 39 | 0.35 | 1.88 | 0 | | | 18 | 0.00 | 0.00 | 0 | | | 0 | | | 0 | | |
| Mar-92 | 5 | 0.00 | 0.00 | 47 | 0.23 | 1.75 | 8 | 0.00 | 0.00 | 9 | 0.00 | 0.00 | 0 | | | 0 | | | 2 | 0.00 | 0.00 |
| May-92 | 0 | | | 25 | 0.30 | 1.45 | 14 | 0.00 | 0.00 | 10 | 0.43 | 2.08 | 4 | 0.00 | 0.00 | 0 | | | 0 | | |
| Jul-92 | 0 | | | 45 | 0.44 | 2.31 | 0 | | | 0 | | | 7 | 1.27 | 3.06 | 0 | | | 2 | 0.00 | 0.00 |
| Aug-92 | 0 | | | 26 | 1.18 | 4.30 | 0 | | | 0 | | | 0 | | | 0 | | | 0 | | |
| Sep-92 | 0 | | | 36 | 0.08 | 0.56 | 9 | 0.00 | 0.00 | 10 | 0.00 | 0.00 | 4 | 0.00 | 0.00 | 5 | 0.00 | 0.00 | 1 | 0.00 | 0.00 |
| Nov-92 | 0 | | | 54 | 0.47 | 2.44 | 9 | 0.00 | 0.00 | 13 | 0.00 | 0.00 | 19 | 0.00 | 0.00 | 2 | 0.00 | 0.00 | 2 | 0.00 | 0.00 |
| Jan-93 | 0 | | | 35 | 1.01 | 4.92 | 0 | | | 7 | 0.00 | 0.00 | 0 | | | 0 | | | 0 | | |
| Feb-93 | 2 | 0.00 | 0.00 | 29 | 0.91 | 4.29 | 0 | | | 0 | | | 13 | 0.00 | 0.00 | 0 | | | 0 | | |
| Mar-93 | 4 | 0.00 | 0.00 | 59 | 0.08 | 0.83 | 5 | 0.00 | 0.00 | 11 | 0.00 | 0.00 | 4 | 0.00 | 0.00 | 4 | 0.00 | 0.00 | 3 | 0.00 | 0.00 |
| Apr-93 | 5 | 0.00 | 0.00 | 27 | 0.40 | 2.47 | 0 | | | 0 | | | 1 | 0.00 | 0.00 | 0 | | | 0 | | |
| May-93 | 4 | 0.00 | 0.00 | 48 | 0.15 | 0.95 | 12 | 0.00 | 0.00 | 11 | 0.00 | 0.00 | 11 | 0.00 | 0.00 | 2 | 0.00 | 0.00 | 6 | 0.00 | 0.00 |
| Jun-93 | 0 | | | 27 | 0.32 | 1.79 | 0 | | | 0 | | | 9 | 0.60 | 3.12 | 1 | 0.00 | 0.00 | 1 | 0.00 | 0.00 |
| Jul-93 | 7 | 0.00 | 0.00 | 59 | 0.29 | 2.11 | 0 | | | 0 | | | 21 | 0.00 | 0.00 | 5 | 0.00 | 0.00 | 5 | 0.00 | 0.00 |
| Aug-93 | 0 | | | 43 | 0.36 | 2.09 | 0 | | | 0 | | | 0 | | | 0 | | | 0 | | |
| Sep-93 | 1 | 0.00 | 0.00 | 28 | 0.57 | 2.80 | 5 | 0.00 | 0.00 | 9 | 0.00 | 0.00 | 5 | 0.00 | 0.00 | 0 | | | 1 | 0.00 | 0.00 |
| Oct-93 | 3 | 0.00 | 0.00 | 34 | 0.00 | 0.00 | 0 | | | 0 | | | 0 | | | 0 | | | 0 | | |
| Nov-93 | 2 | 0.00 | 0.00 | 26 | 0.46 | 2.80 | 4 | 0.00 | 0.00 | 4 | 0.00 | 0.00 | 2 | 0.00 | 0.00 | 0 | | | 0 | | |
| Jul-94 | 3 | 0.00 | 0.00 | 34 | 0.00 | 0.00 | 0 | | | 0 | | | 15 | 0.00 | 0.00 | 0 | | | 0 | | |
| Mar-95 | 0 | | | 41 | 0.12 | 1.03 | 0 | | | 1 | 0.00 | 0.00 | 4 | 0.00 | 0.00 | 0 | | | 1 | 0.00 | 0.00 |
| Jun-95 | 3 | 7.60 | 40.53 | 41 | 0.11 | 0.90 | 0 | | | 0 | | | 7 | 0.00 | 0.00 | 2 | 0.00 | 0.00 | 0 | | |
| Sep-95 | 4 | 0.00 | 0.00 | 37 | 0.11 | 0.84 | 0 | | | 0 | | | 10 | 0.00 | 0.00 | 1 | 0.00 | 0.00 | 0 | | |
| Mar-96 | 0 | | | 39 | 0.24 | 1.58 | 0 | | | 0 | | | 9 | 0.00 | 0.00 | 1 | 0.00 | 0.00 | 0 | | |
| Jun-96 | 1 | 0.00 | 0.00 | 23 | 0.24 | 1.81 | 0 | | | 5 | 0.00 | 0.00 | 5 | 0.00 | 0.00 | 0 | | | 0 | | |
| Sep-96 | 0 | | | 17 | 0.00 | 0.00 | 0 | | | 0 | | | 5 | 0.00 | 0.00 | 0 | | | 0 | | |
| Mar-97 | 1 | 0.00 | 0.00 | 28 | 0.18 | 1.35 | 0 | | | 2 | 0.00 | 0.00 | 6 | 0.00 | 0.00 | 0 | | | 0 | | |
| Jun-97 | 2 | 0.00 | 0.00 | 29 | 0.00 | 0.00 | 0 | | | 0 | | | 7 | 0.00 | 0.00 | 0 | | | 0 | | |
| Sep-97 | 0 | | | 20 | 0.00 | 0.00 | 0 | | | 0 | | | 5 | 0.00 | 0.00 | 0 | | | 0 | | |
| Jun-98 | 0 | | | 17 | 0.27 | 1.67 | 3 | 0.00 | 0.00 | 5 | 0.00 | 0.00 | 8 | 1.66 | 5.19 | 1 | 0.00 | 0.00 | 6 | 0.00 | 0.00 |
| Aug-98 | 1 | 0.00 | 0.00 | 18 | 0.00 | 0.00 | 4 | 0.00 | 0.00 | 2 | 0.00 | 0.00 | 4 | 0.00 | 0.00 | 2 | 0.00 | 0.00 | 3 | 0.00 | 0.00 |
| Jan-99 | 0 | | | 16 | 0.00 | 0.00 | 0 | | | 0 | | | 4 | 0.00 | 0.00 | 0 | | | 3 | 0.00 | 0.00 |
| Jun-99 | 3 | 0.00 | 0.00 | 19 | 0.00 | 0.00 | 3 | 0.00 | 0.00 | 2 | 0.00 | 0.00 | 6 | 0.00 | 0.00 | 1 | 0.00 | 0.00 | 2 | 0.00 | 0.00 |
| Sep-99 | 3 | 0.00 | 0.00 | 17 | 0.28 | 1.76 | 3 | 0.00 | 0.00 | 2 | 0.00 | 0.00 | 5 | 0.00 | 0.00 | 3 | 0.00 | 0.00 | 4 | 0.00 | 0.00 |
| Jan-00 | 3 | 0.00 | 0.00 | 21 | 0.00 | 0.00 | 3 | 0.00 | 0.00 | 3 | 0.00 | 0.00 | 7 | 0.00 | 0.00 | 3 | 0.00 | 0.00 | 6 | 0.00 | 0.00 |

Appendix C-1. Geometric mean and standard error catch per unit effort (CPUE; Fish/10 hours) using electrofishing methods for rainbow trout among the 7 standardized reaches.

| Sample | Fence Fault | | | LCR INFLOW | | | BRIGHT ANGEL | | | SHINUMO | | | MIDDLE GRANITE GORGE | | | KANAB | | | HAVASU | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Date | N | CPUE | SE | N | CPUE | SE | N | CPUE | SE | N | CPUE | SE | N | CPUE | SE | N | CPUE | SE | N | CPUE | SE |
| Oct-90 | 0 | | | 13 | 84.90 | 7.49 | 0 | | | 0 | | | 0 | | | 0 | | | 0 | | |
| Nov-90 | 0 | | | 7 | 254.46 | 1.51 | 6 | 586.26 | 1.01 | 3 | 923.04 | 0.28 | 0 | | | 0 | | | 2 | 159.80 | 1.39 |
| Jan-91 | 0 | | | 2 | 21.23 | 79.32 | 0 | 0.00 | 0.00 | 5 | 252.91 | 0.79 | 0 | | | 0 | | | 0 | | |
| Mar-91 | 0 | | | 0 | | | 12 | 234.94 | 1.34 | 8 | 162.00 | 0.81 | 0 | | | 1 | 21.05 | 0.00 | 4 | 1.91 | 7.46 |
| May-91 | 0 | | | 22 | 99.47 | 7.09 | 7 | 121.11 | 9.20 | 11 | 346.83 | 0.87 | 0 | | | 1 | 23.90 | 0.00 | 3 | 11.98 | 8.24 |
| Jun-91 | 0 | | | 30 | 32.80 | 10.75 | 0 | | | 0 | | | 0 | | | 0 | | | 0 | | |
| Jul-91 | 0 | | | 25 | 36.86 | 13.33 | 0 | | | 11 | 9.22 | 14.35 | 7 | 47.48 | 5.85 | 0 | | | 1 | 0.00 | 0.00 |
| Sep-91 | 0 | | | 41 | 75.70 | 4.99 | 10 | 71.38 | 4.06 | 10 | 109.55 | 5.43 | 9 | 64.83 | 4.18 | 2 | 0.00 | 0.00 | 0 | | |
| Nov-91 | 0 | | | 30 | 6.89 | 9.49 | 8 | 24.84 | 6.88 | 5 | 49.53 | 9.97 | 13 | 9.75 | 9.20 | 4 | 6.83 | 9.77 | 4 | 1.51 | 5.31 |
| Jan-92 | 0 | | | 39 | 27.98 | 8.53 | 0 | | | 18 | 124.21 | 4.07 | 0 | | | 0 | | | 0 | | |
| Mar-92 | 5 | 518.55 | 0.37 | 47 | 5.64 | 10.91 | 8 | 28.94 | 3.24 | 9 | 35.00 | 10.10 | 0 | | | 0 | | | 2 | 4.61 | 10.45 |
| May-92 | 0 | | | 25 | 8.19 | 8.60 | 14 | 22.49 | 4.91 | 10 | 13.68 | 10.38 | 4 | 9.06 | 3.69 | 0 | | | 0 | | |
| Jul-92 | 0 | | | 45 | 14.92 | 9.74 | 0 | | | 0 | | | 7 | 69.09 | 0.63 | 0 | | | 2 | 3.17 | 6.53 |
| Aug-92 | 0 | | | 26 | 8.82 | 12.11 | 0 | | | 0 | | | 0 | | | 0 | | | 0 | | |
| Sep-92 | 0 | | | 36 | 0.00 | 0.00 | 9 | 164.01 | 1.98 | 10 | 6.37 | 7.52 | 4 | 1.28 | 4.19 | 5 | 0.00 | 0.00 | 1 | 0.00 | 0.00 |
| Nov-92 | 0 | | | 54 | 15.56 | 10.64 | 9 | 12.69 | 11.14 | 13 | 11.01 | 10.89 | 19 | 3.45 | 5.43 | 2 | 3.37 | 7.05 | 2 | 0.00 | 0.00 |
| Jan-93 | 0 | | | 35 | 12.52 | 11.11 | 0 | | | 7 | 2.16 | 6.17 | 0 | | | 0 | | | 0 | | |
| Feb-93 | 2 | 703.23 | 1.07 | 29 | 7.55 | 13.47 | 0 | | | 0 | | | 13 | 1.03 | 4.75 | 0 | | | 0 | | |
| Mar-93 | 4 | 344.93 | 2.00 | 59 | 4.79 | 9.35 | 5 | 1.14 | 4.46 | 11 | 1.54 | 4.00 | 4 | 10.28 | 15.83 | 4 | 0.00 | 0.00 | 3 | 0.00 | 0.00 |
| Apr-93 | 5 | 302.28 | 0.97 | 27 | 2.51 | 6.41 | 0 | | | 0 | | | 1 | 0.00 | 0.00 | 0 | | | 0 | | |
| May-93 | 4 | 908.46 | 1.03 | 48 | 2.20 | 6.92 | 12 | 0.35 | 1.80 | 11 | 1.06 | 4.06 | 11 | 2.61 | 4.96 | 2 | 0.00 | 0.00 | 6 | 0.00 | 0.00 |
| Jun-93 | 0 | | | 27 | 2.73 | 7.18 | 0 | | | 0 | | | 9 | 0.00 | 0.00 | 1 | 0.00 | 0.00 | 1 | 0.00 | 0.00 |
| Jul-93 | 7 | 5.77 | 25.82 | 59 | 19.31 | 10.18 | 0 | | | 0 | | | 21 | 1.26 | 4.71 | 5 | 2.50 | 4.57 | 5 | 2.30 | 4.13 |
| Aug-93 | 0 | | | 43 | 16.18 | 11.97 | 0 | | | 0 | | | 0 | 0.00 | 0.00 | 0 | | | 0 | | |
| Sep-93 | 1 | 166.67 | 0.00 | 28 | 2.84 | 6.58 | 5 | 0.00 | 0.00 | 9 | 3.60 | 5.31 | 5 | 0.81 | 2.78 | 0 | | | 1 | 0.00 | 0.00 |
| Oct-93 | 3 | 647.67 | 0.47 | 34 | 7.83 | 11.80 | 0 | | | 0 | | | 0 | | | 0 | | | 0 | | |
| Nov-93 | 2 | 64.17 | 0.17 | 26 | 1.56 | 6.32 | 4 | 0.00 | 0.00 | 4 | 1.11 | 3.44 | 2 | 0.00 | 0.00 | 0 | | | 0 | | |
| Jul-94 | 3 | 24.73 | 19.00 | 34 | 8.67 | 10.96 | 0 | | | 0 | | | 15 | 2.82 | 8.34 | 0 | | | 0 | | |
| Mar-95 | 0 | | | 41 | 13.04 | 8.98 | 0 | | | 1 | 41.33 | 0.00 | 4 | 1.50 | 5.24 | 0 | | | 1 | 0.00 | 0.00 |
| Jun-95 | 3 | 4.03 | 15.42 | 41 | 13.59 | 10.59 | 0 | | | 0 | | | 7 | 4.95 | 8.35 | 2 | 5.57 | 13.34 | 0 | | |
| Sep-95 | 4 | 4.12 | 25.25 | 37 | 18.03 | 7.46 | 0 | | | 0 | | | 10 | 1.68 | 7.01 | 1 | 0.00 | 0.00 | 0 | | |
| Mar-96 | 0 | | | 39 | 64.63 | 8.59 | 0 | | | 0 | | | 9 | 2.04 | 8.08 | 1 | 0.00 | 0.00 | 0 | | |
| Jun-96 | 1 | 707.62 | 0.00 | 23 | 83.55 | 5.74 | 0 | | | 5 | 108.89 | 0.71 | 5 | 5.27 | 11.83 | 0 | | | 0 | | |
| Sep-96 | 0 | | | 17 | 110.85 | 5.56 | 0 | | | 0 | | | 5 | 228.72 | 1.46 | 0 | | | 0 | | |
| Mar-97 | 1 | 528.12 | 0.00 | 28 | 99.80 | 8.86 | 0 | | | 2 | 253.83 | 0.68 | 6 | 107.64 | 9.88 | 0 | | | 0 | | |
| Jun-97 | 2 | 398.04 | 3.39 | 29 | 95.36 | 4.68 | 0 | | | 0 | | | 7 | 252.26 | 0.86 | 0 | | | 0 | | |
| Sep-97 | 0 | | | 20 | 45.93 | 9.51 | 0 | | | 0 | | | 5 | 115.85 | 0.54 | 0 | | | 0 | | |
| Jun-98 | 0 | | | 17 | 75.81 | 12.76 | 3 | 48.62 | 28.41 | 5 | 436.85 | 1.09 | 8 | 103.08 | 6.46 | 1 | 220.59 | 0.00 | 6 | 598.27 | 0.87 |
| Aug-98 | 1 | 660.55 | 0.00 | 18 | 0.87 | 10.87 | 4 | 244.64 | 1.54 | 2 | 545.58 | 0.63 | 4 | 53.56 | 14.49 | 2 | 136.82 | 0.47 | 3 | 222.89 | 0.31 |
| Jan-99 | 0 | | | 16 | 145.45 | 6.80 | 0 | | | 0 | | | 4 | 54.16 | 16.05 | 0 | | | 3 | 208.14 | 0.31 |
| Jun-99 | 3 | 1070.31 | 0.37 | 19 | 395.33 | 1.37 | 3 | 437.05 | 0.77 | 2 | 201.62 | 0.05 | 6 | 125.56 | 11.76 | 1 | 153.98 | 0.00 | 2 | 131.46 | 0.17 |
| Sep-99 | 3 | 1303.78 | 0.79 | 17 | 171.10 | 3.76 | 3 | 528.25 | 0.39 | 2 | 327.06 | 0.37 | 5 | 41.14 | 8.89 | 3 | 374.05 | 0.13 | 4 | 302.68 | 0.80 |
| Jan-00 | 3 | 1784.85 | 0.40 | 21 | 422.23 | 1.25 | 3 | 222.61 | 0.43 | 3 | 321.96 | 2.28 | 7 | 72.58 | 6.67 | 3 | 172.81 | 0.62 | 6 | 12.79 | 16.74 |

Appendix D-1. Geometric mean and standard error catch per unit effort (CPUE; Fish/10 hours) using electrofishing methods for brown trout among the 7 standardized reaches.

| Sample | Fence Fault | | | LCR INFLOW | | | BRIGHT ANGEL | | | SHINUMO | | | MIDDLE GRANITE GORGE | | | KANAB | | | HAVASU | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Date | N | CPUE | SE | N | CPUE | SE | N | CPUE | SE | N | CPUE | SE | N | CPUE | SE | N | CPUE | SE | N | CPUE | SE |
| Oct-90 | 0 | | | 13 | 0.26 | 1.27 | 0 | | | 0 | | | 0 | | | 0 | | | 0 | | |
| Nov-90 | 0 | | | 7 | 0.52 | 2.04 | 6 | 100.92 | 9.97 | 3 | 3.47 | 12.36 | 0 | | | 0 | | | 2 | 0.00 | 0.00 |
| Jan-91 | 0 | | | 2 | 0.00 | 0.00 | 0 | | | 5 | 0.99 | 3.64 | 0 | | | 0 | | | 0 | | |
| Mar-91 | 0 | | | 0 | | | 12 | 223.64 | 2.93 | 8 | 5.48 | 6.49 | 0 | | | 1 | 0.00 | 0.00 | 4 | 1.83 | 7.02 |
| May-91 | 0 | | | 22 | 0.16 | 1.01 | 7 | 450.48 | 15.73 | 11 | 19.14 | 6.36 | 0 | | | 1 | 0.00 | 0.00 | 3 | 0.00 | 0.00 |
| Jun-91 | 0 | | | 30 | 0.14 | 1.02 | 0 | | | 0 | | | 0 | | | 0 | | | 0 | | |
| Jul-91 | 0 | | | 25 | 0.46 | 1.86 | 0 | | | 11 | 3.23 | 6.54 | 7 | 8.74 | 3.93 | 0 | | | 1 | 0.00 | 0.00 |
| Sep-91 | 0 | | | 41 | 0.23 | 1.57 | 10 | 154.46 | 1.28 | 10 | 7.66 | 9.92 | 9 | 0.52 | 2.50 | 2 | 0.00 | 0.00 | 0 | | |
| Nov-91 | 0 | | | 30 | 0.00 | 0.00 | 8 | 425.86 | 1.48 | 5 | 18.52 | 5.22 | 13 | 0.92 | 3.94 | 4 | 0.00 | 0.00 | 4 | 0.00 | 0.00 |
| Jan-92 | 0 | | | 39 | 0.22 | 1.34 | 0 | | | 18 | 10.28 | 9.91 | 0 | | | 0 | | | 0 | | |
| Mar-92 | 5 | 0.00 | 0.00 | 47 | 0.00 | 0.00 | 8 | 62.22 | 5.72 | 9 | 3.07 | 7.65 | 0 | | | 0 | | | 2 | 0.00 | 0.00 |
| May-92 | 0 | | | 25 | 0.14 | 0.90 | 14 | 246.34 | 1.33 | 10 | 46.60 | 3.36 | 4 | 0.00 | 0.00 | 0 | | | 0 | | |
| Jul-92 | 0 | | | 45 | 0.18 | 1.18 | 0 | | | 0 | | | 7 | 7.21 | 6.54 | 0 | | | 2 | 3.17 | 6.53 |
| Aug-92 | 0 | | | 26 | 0.18 | 1.36 | 0 | | | 0 | | | 0 | | | 0 | | | 0 | | |
| Sep-92 | 0 | | | 36 | 0.39 | 2.06 | 9 | 0.61 | 3.19 | 10 | 0.40 | 1.87 | 4 | 0.00 | 0.00 | 5 | 3.52 | 6.90 | 1 | 0.00 | 0.00 |
| Nov-92 | 0 | | | 54 | 0.00 | 0.00 | 9 | 190.43 | 0.49 | 13 | 4.19 | 8.17 | 19 | 0.41 | 1.81 | 2 | 0.00 | 0.00 | 2 | 0.00 | 0.00 |
| Jan-93 | 0 | | | 35 | 0.12 | 0.91 | 0 | | | 7 | 3.90 | 6.42 | 0 | | | 0 | | | 0 | | |
| Feb-93 | 2 | 0.00 | 0.00 | 29 | 0.00 | 0.00 | 0 | | | 0 | | | 13 | 0.00 | 0.00 | 0 | | | 0 | | |
| Mar-93 | 4 | 2.24 | 9.49 | 59 | 0.17 | 1.38 | 5 | 52.20 | 9.60 | 11 | 0.35 | 1.73 | 4 | 2.18 | 9.09 | 4 | 0.00 | 0.00 | 3 | 0.00 | 0.00 |
| Apr-93 | 5 | 0.92 | 3.32 | 27 | 0.13 | 0.87 | 0 | | | 0 | | | 1 | 0.00 | 0.00 | 0 | | | 0 | | |
| May-93 | 4 | 0.00 | 0.00 | 48 | 0.07 | 0.62 | 12 | 21.85 | 10.16 | 11 | 4.99 | 7.06 | 11 | 1.02 | 3.80 | 2 | 0.00 | 0.00 | 6 | 0.00 | 0.00 |
| Jun-93 | 0 | | | 27 | 0.00 | 0.00 | 0 | | | 0 | | | 9 | 0.50 | 2.40 | 1 | 0.00 | 0.00 | 1 | 0.00 | 0.00 |
| Jul-93 | 7 | 0.00 | 0.00 | 59 | 0.08 | 0.83 | 0 | | | 0 | | | 21 | 0.00 | 0.00 | 5 | 0.00 | 0.00 | 5 | 0.77 | 2.57 |
| Aug-93 | 0 | | | 43 | 0.00 | 0.00 | 0 | | | 0 | | | 0 | | | 0 | | | 0 | | |
| Sep-93 | 1 | 0.00 | 0.00 | 28 | 0.00 | 0.00 | 5 | 78.06 | 1.10 | 9 | 3.54 | 8.88 | 5 | 1.24 | 5.09 | 0 | | | 1 | 0.00 | 0.00 |
| Oct-93 | 3 | 0.00 | 0.00 | 34 | 0.00 | 0.00 | 0 | | | 0 | | | 0 | | | 0 | | | 0 | | |
| Nov-93 | 2 | 6.64 | 16.75 | 26 | 0.00 | 0.00 | 4 | 6.10 | 9.36 | 4 | 50.14 | 1.32 | 2 | 3.56 | 7.54 | 0 | | | 0 | | |
| Jul-94 | 3 | 0.00 | 0.00 | 34 | 0.11 | 0.83 | 0 | | | 0 | | | 15 | 0.99 | 4.77 | 0 | | | 0 | | |
| Mar-95 | 0 | | | 41 | 1.09 | 4.29 | 0 | | | 1 | 0.00 | 0.00 | 4 | 0.00 | 0.00 | 0 | | | 1 | 0.00 | 0.00 |
| Jun-95 | 3 | 0.00 | 0.00 | 41 | 0.00 | 0.00 | 0 | | | 0 | | | 7 | 0.00 | 0.00 | 2 | 0.00 | 0.00 | 0 | | |
| Sep-95 | 4 | 0.00 | 0.00 | 37 | 0.36 | 1.89 | 0 | | | 0 | | | 10 | 0.00 | 0.00 | 1 | 0.00 | 0.00 | 0 | | |
| Mar-96 | 0 | | | 39 | 0.12 | 0.98 | 0 | | | 0 | | | 9 | 0.00 | 0.00 | 1 | 80.00 | 0.00 | 0 | | |
| Jun-96 | 1 | 0.00 | 0.00 | 23 | 0.43 | 2.28 | 0 | | | 5 | 1.20 | 4.82 | 5 | 0.00 | 0.00 | 0 | | | 0 | | |
| Sep-96 | 0 | | | 17 | 0.00 | 0.00 | 0 | | | 0 | | | 5 | 0.00 | 0.00 | 0 | | | 0 | | |
| Mar-97 | 1 | 0.00 | 0.00 | 28 | 0.00 | 0.00 | 0 | | | 2 | 146.53 | 0.37 | 6 | 3.62 | 9.79 | 0 | | | 0 | | |
| Jun-97 | 2 | 0.00 | 0.00 | 29 | 0.15 | 1.16 | 0 | | | 0 | | | 7 | 1.17 | 5.65 | 0 | | | 0 | | |
| Sep-97 | 0 | | | 20 | 0.19 | 1.20 | 0 | | | 0 | | | 5 | 0.00 | 0.00 | 0 | | | 0 | | |
| Jun-98 | 0 | | | 17 | 0.24 | 1.46 | 3 | 804.13 | 1.75 | 5 | 206.89 | 0.69 | 8 | 3.95 | 8.58 | 1 | 0.00 | 0.00 | 6 | 6.04 | 7.52 |
| Aug-98 | 1 | 0.00 | 0.00 | 18 | 0.31 | 1.95 | 4 | 401.94 | 4.49 | 2 | 330.82 | 0.56 | 4 | 0.00 | 0.00 | 2 | 6.80 | 17.27 | 3 | 12.80 | 9.38 |
| Jan-99 | 0 | | | 16 | 0.56 | 2.37 | 0 | | | 0 | | | 4 | 0.00 | 0.00 | 0 | | | 3 | 0.00 | 0.00 |
| Jun-99 | 3 | 0.00 | 0.00 | 19 | 0.23 | 1.26 | 3 | 348.71 | 0.74 | 2 | 124.78 | 2.09 | 6 | 5.31 | 16.38 | 1 | 0.00 | 0.00 | 2 | 6.74 | 17.07 |
| Sep-99 | 3 | 0.00 | 0.00 | 17 | 0.23 | 1.38 | 3 | 86.37 | 51.08 | 2 | 193.72 | 0.16 | 5 | 1.23 | 4.99 | 3 | 3.28 | 11.42 | 4 | 31.33 | 10.63 |
| Jan-00 | 3 | 0.00 | 0.00 | 21 | 0.85 | 3.81 | 3 | 676.93 | 0.64 | 3 | 336.19 | 0.23 | 7 | 65.69 | 6.24 | 3 | 109.15 | 1.85 | 6 | 1.10 | 5.13 |

Appendix E-1. Geometric mean and standard error catch per unit effort (CPUE; Fish/10 hours) using electrofishing methods for flannel mouth sucker among the 7 standardized reaches.

| Sample | Fence Fault | | | LCR INFLOW | | | BRIGHT ANGEL | | | SHINUMO | | | MIDDLE GRANITE GORGE | | | KANAB | | | HAVASU | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Date | N | CPUE | SE | N | CPUE | SE | N | CPUE | SE | N | CPUE | SE | N | CPUE | SE | N | CPUE | SE | N | CPUE | SE |
| Oct-90 | 0 | | | 13 | 1.00 | 4.57 | 0 | | | 0 | | | 0 | | | 0 | | | 0 | | |
| Nov-90 | 0 | | | 7 | 0.00 | 0.00 | 6 | 0.76 | 3.02 | 3 | 0.00 | 0.00 | 0 | | | 0 | | | 2 | 5.59 | 13.40 |
| Jan-91 | 0 | | | 2 | 0.00 | 0.00 | 0 | | | 5 | 0.00 | 0.00 | 0 | | | 0 | | | 0 | | |
| Mar-91 | 0 | | | 0 | | | 12 | 0.00 | 0.00 | 8 | 0.00 | 0.00 | 0 | | | 1 | 0.00 | 0.00 | 4 | 0.00 | 0.00 |
| May-91 | 0 | | | 22 | 0.54 | 3.05 | 7 | 7.06 | 13.48 | 11 | 0.42 | 2.20 | 0 | | | 1 | 0.00 | 0.00 | 3 | 6.07 | 28.62 |
| Jun-91 | 0 | | | 30 | 0.25 | 1.36 | 0 | | | 0 | | | 0 | | | 0 | | | 0 | | |
| Jul-91 | 0 | | | 25 | 0.55 | 2.33 | 0 | | | 11 | 0.00 | 0.00 | 7 | 0.00 | 0.00 | 0 | | | 1 | 0.00 | 0.00 |
| Sep-91 | 0 | | | 41 | 2.32 | 4.56 | 10 | 0.99 | 3.28 | 10 | 2.14 | 10.38 | 9 | 0.00 | 0.00 | 2 | 0.00 | 0.00 | 0 | | |
| Nov-91 | 0 | | | 30 | 0.34 | 2.09 | 8 | 0.44 | 1.81 | 5 | 0.00 | 0.00 | 13 | 0.35 | 1.91 | 4 | 0.00 | 0.00 | 4 | 1.98 | 7.86 |
| Jan-92 | 0 | | | 39 | 0.18 | 1.05 | 0 | | | 18 | 0.82 | 3.02 | 0 | | | 0 | | | 0 | | |
| Mar-92 | 5 | 0.00 | 0.00 | 47 | 0.31 | 1.87 | 8 | 0.00 | 0.00 | 9 | 0.00 | 0.00 | 0 | | | 0 | | | 2 | 4.61 | 10.45 |
| May-92 | 0 | | | 25 | 0.49 | 2.01 | 14 | 1.25 | 4.01 | 10 | 0.00 | 0.00 | 4 | 0.00 | 0.00 | 0 | | | 0 | | |
| Jul-92 | 0 | | | 45 | 0.09 | 0.75 | 0 | | | 0 | | | 7 | 3.46 | 5.74 | 0 | | | 2 | 0.00 | 0.00 |
| Aug-92 | 0 | | | 26 | 0.38 | 2.16 | 0 | | | 0 | | | 0 | | | 0 | | | 0 | | |
| Sep-92 | 0 | | | 36 | 1.40 | 5.16 | 9 | 22.65 | 5.33 | 10 | 19.57 | 4.79 | 4 | 19.86 | 7.57 | 5 | 12.89 | 3.69 | 1 | 0.00 | 0.00 |
| Nov-92 | 0 | | | 54 | 0.15 | 1.07 | 9 | 1.65 | 6.07 | 13 | 0.30 | 1.58 | 19 | 0.82 | 3.20 | 2 | 26.85 | 0.71 | 2 | 5.54 | 13.25 |
| Jan-93 | 0 | | | 35 | 0.58 | 2.69 | 0 | | | 7 | 0.00 | 0.00 | 0 | | | 0 | | | 0 | | |
| Feb-93 | 2 | 0.00 | 0.00 | 29 | 0.15 | 1.11 | 0 | | | 0 | | | 13 | 0.51 | 3.45 | 0 | | | 0 | | |
| Mar-93 | 4 | 0.00 | 0.00 | 59 | 0.00 | 0.00 | 5 | 1.34 | 5.71 | 11 | 0.00 | 0.00 | 4 | 0.00 | 0.00 | 4 | 0.00 | 0.00 | 3 | 0.00 | 0.00 |
| Apr-93 | 5 | 0.00 | 0.00 | 27 | 1.17 | 4.29 | 0 | | | 0 | | | 1 | 0.00 | 0.00 | 0 | | | 0 | | |
| May-93 | 4 | 0.00 | 0.00 | 48 | 0.08 | 0.74 | 12 | 0.00 | 0.00 | 11 | 0.35 | 1.70 | 11 | 0.00 | 0.00 | 2 | 0.00 | 0.00 | 6 | 4.31 | 13.51 |
| Jun-93 | 0 | | | 27 | 0.18 | 1.38 | 0 | | | 0 | | | 9 | 0.00 | 0.00 | 1 | 0.00 | 0.00 | 1 | 264.06 | 0.00 |
| Jul-93 | 7 | 0.00 | 0.00 | 59 | 0.85 | 3.88 | 0 | | | 0 | | | 21 | 0.19 | 1.25 | 5 | 3.98 | 8.95 | 5 | 1.02 | 3.81 |
| Aug-93 | 0 | | | 43 | 1.19 | 4.63 | 0 | | | 0 | | | 0 | | | 0 | | | 0 | | |
| Sep-93 | 1 | 0.00 | 0.00 | 28 | 0.13 | 0.90 | 5 | 0.00 | 0.00 | 9 | 2.41 | 5.45 | 5 | 0.00 | 0.00 | 0 | | | 1 | 0.00 | 0.00 |
| Oct-93 | 3 | 0.00 | 0.00 | 34 | 1.18 | 4.62 | 0 | | | 0 | | | 0 | | | 0 | | | 0 | | |
| Nov-93 | 2 | 0.00 | 0.00 | 26 | 0.43 | 2.50 | 4 | 0.00 | 0.00 | 4 | 0.00 | 0.00 | 2 | 0.00 | 0.00 | 0 | | | 0 | | |
| Jul-94 | 3 | 0.00 | 0.00 | 34 | 0.45 | 2.38 | 0 | | | 0 | | | 15 | 0.79 | 3.43 | 0 | | | 0 | | |
| Mar-95 | 0 | | | 41 | 0.13 | 1.19 | 0 | | | 1 | 0.00 | 0.00 | 4 | 1.59 | 5.70 | 0 | | | 1 | 0.00 | 0.00 |
| Jun-95 | 3 | 4.42 | 17.70 | 41 | 0.43 | 2.68 | 0 | | | 0 | | | 7 | 0.00 | 0.00 | 2 | 0.00 | 0.00 | 0 | | |
| Sep-95 | 4 | 0.00 | 0.00 | 37 | 0.41 | 2.23 | 0 | | | 0 | | | 10 | 0.37 | 1.72 | 1 | 4.41 | 0.00 | 0 | | |
| Mar-96 | 0 | | | 39 | 0.26 | 1.77 | 0 | | | 0 | | | 9 | 0.00 | 0.00 | 1 | 0.00 | 0.00 | 0 | | |
| Jun-96 | 1 | 0.00 | 0.00 | 23 | 0.00 | 0.00 | 0 | | | 5 | 2.95 | 20.55 | 5 | 0.00 | 0.00 | 0 | | | 0 | | |
| Sep-96 | 0 | | | 17 | 0.29 | 1.84 | 0 | | | 0 | | | 5 | 0.00 | 0.00 | 0 | | | 0 | | |
| Mar-97 | 1 | 0.00 | 0.00 | 28 | 0.36 | 2.07 | 0 | | | 2 | 6.88 | 17.51 | 6 | 0.00 | 0.00 | 0 | | | 0 | | |
| Jun-97 | 2 | 0.00 | 0.00 | 29 | 0.48 | 2.23 | 0 | | | 0 | | | 7 | 0.00 | 0.00 | 0 | | | 0 | | |
| Sep-97 | 0 | | | 20 | 0.00 | 0.00 | 0 | | | 0 | | | 5 | 0.00 | 0.00 | 0 | | | 0 | | |
| Jun-98 | 0 | | | 17 | 0.55 | 2.45 | 3 | 3.85 | 14.43 | 5 | 6.11 | 14.64 | 8 | 0.69 | 3.38 | 1 | 44.12 | 0.00 | 6 | 43.17 | 5.94 |
| Aug-98 | 1 | 0.00 | 0.00 | 18 | 0.45 | 3.42 | 4 | 8.61 | 12.65 | 2 | 0.00 | 0.00 | 4 | 2.51 | 11.29 | 2 | 0.00 | 0.00 | 3 | 5.26 | 23.01 |
| Jan-99 | 0 | | | 16 | 0.35 | 2.33 | 0 | | | 0 | | | 4 | 0.00 | 0.00 | 0 | | | 3 | 16.93 | 11.55 |
| Jun-99 | 3 | 0.00 | 0.00 | 19 | 0.00 | 0.00 | 3 | 4.48 | 18.02 | 2 | 0.00 | 0.00 | 6 | 0.00 | 0.00 | 1 | 0.00 | 0.00 | 2 | 7.62 | 20.04 |
| Sep-99 | 3 | 0.00 | 0.00 | 17 | 0.28 | 1.79 | 3 | 0.00 | 0.00 | 2 | 0.00 | 0.00 | 5 | 1.32 | 5.56 | 3 | 0.00 | 0.00 | 4 | 7.39 | 10.77 |
| Jan-00 | 3 | 0.00 | 0.00 | 21 | 0.19 | 1.21 | 3 | 5.78 | 26.54 | 3 | 0.00 | 0.00 | 7 | 0.76 | 3.44 | 3 | 22.10 | 14.19 | 6 | 0.00 | 0.00 |

Appendix A-2. Geometric mean and standard error catch per unit effort (CPUE; Fish/100 feet/100 hours) using trammel netting methods for humpback chub < 200 mm among the 7 standardized reaches.

| Sample | Fence Fault | | | LCR INFLOW | | | BRIGHT ANGEL | | | SHINUMO | | | MIDDLE GRANITE GORGE | | | KANAB | | | HAVASU | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Date | N | CPUE | SE | N | CPUE | SE | N | CPUE | SE | N | CPUE | SE | N | CPUE | SE | N | CPUE | SE | N | CPUE | SE |
| Oct-90 | 0 | | | 32 | 0.00 | 0.00 | 0 | | | 0 | | | 0 | | | 0 | | | 0 | | |
| Nov-90 | 0 | | | 34 | 0.00 | 0.00 | 7 | 0.00 | 0.00 | 10 | 0.00 | 0.00 | 0 | | | 6 | 0.00 | 0.00 | 21 | 0.00 | 0.00 |
| Jan-91 | 0 | | | 74 | 0.06 | 0.63 | 0 | | | 24 | 0.00 | 0.00 | 0 | | | 0 | | | 0 | | |
| Feb-91 | 0 | | | 4 | 0.00 | 0.00 | 0 | | | 0 | | | 0 | | | 0 | | | 0 | | |
| Mar-91 | 0 | | | 79 | 0.17 | 1.25 | 19 | 0.00 | 0.00 | 42 | 0.00 | 0.00 | 0 | | | 0 | | | 44 | 0.00 | 0.00 |
| Apr-91 | 0 | | | 8 | 0.00 | 0.00 | 0 | | | 0 | | | 0 | | | 0 | | | 0 | | |
| May-91 | 0 | | | 80 | 0.00 | 0.00 | 5 | 0.00 | 0.00 | 23 | 0.00 | 0.00 | 0 | | | 3 | 0.00 | 0.00 | 74 | 0.00 | 0.00 |
| Jun-91 | 0 | | | 26 | 0.19 | 1.39 | 0 | | | 0 | | | 0 | | | 0 | | | 0 | | |
| Jul-91 | 0 | | | 27 | 0.00 | 0.00 | 0 | | | 27 | 0.35 | 1.95 | 48 | 0.00 | 0.00 | 0 | | | 38 | 0.00 | 0.00 |
| Sep-91 | 0 | | | 77 | 0.00 | 0.00 | 0 | | | 25 | 0.00 | 0.00 | 30 | 0.00 | 0.00 | 17 | 0.00 | 0.00 | 0 | | |
| Nov-91 | 0 | | | 52 | 0.00 | 0.00 | 4 | 0.00 | 0.00 | 15 | 0.00 | 0.00 | 21 | 0.00 | 0.00 | 0 | | | 34 | 0.00 | 0.00 |
| Jan-92 | 0 | | | 54 | 0.00 | 0.00 | 0 | | | 29 | 0.00 | 0.00 | 0 | | | 0 | | | 0 | | |
| Feb-92 | 0 | | | 4 | 0.00 | 0.00 | 0 | | | 0 | | | 0 | | | 0 | | | 0 | | |
| Mar-92 | 12 | 0.00 | 0.00 | 42 | 0.00 | 0.00 | 0 | | | 17 | 0.00 | 0.00 | 0 | | | 0 | | | 58 | 0.00 | 0.00 |
| Apr-92 | 0 | | | 27 | 0.62 | 3.06 | 0 | | | 0 | | | 0 | | | 0 | | | 0 | | |
| May-92 | 0 | | | 78 | 0.16 | 1.15 | 3 | 0.00 | 0.00 | 41 | 0.00 | 0.00 | 11 | 0.00 | 0.00 | 0 | | | 18 | 0.00 | 0.00 |
| Jun-92 | 0 | | | 26 | 0.00 | 0.00 | 0 | | | 0 | | | 0 | | | 0 | | | 0 | | |
| Jul-92 | 0 | | | 31 | 0.15 | 1.15 | 0 | | | 0 | | | 23 | 0.00 | 0.00 | 0 | | | 22 | 0.00 | 0.00 |
| Nov-92 | 0 | | | 99 | 0.00 | 0.00 | 4 | 0.00 | 0.00 | 37 | 0.00 | 0.00 | 61 | 0.08 | 0.80 | 26 | 0.00 | 0.00 | 24 | 0.00 | 0.00 |
| Jan-93 | 0 | | | 99 | 0.09 | 0.84 | 0 | | | 16 | 0.00 | 0.00 | 0 | | | 0 | | | 0 | | |
| Feb-93 | 11 | 0.00 | 0.00 | 69 | 0.06 | 0.68 | 0 | | | 0 | | | 38 | 0.00 | 0.00 | 0 | | | 0 | | |
| Mar-93 | 7 | 0.00 | 0.00 | 112 | 0.32 | 1.92 | 0 | | | 36 | 0.00 | 0.00 | 79 | 0.00 | 0.00 | 0 | | | 25 | 0.00 | 0.00 |
| Apr-93 | 10 | 0.00 | 0.00 | 125 | 0.19 | 1.34 | 0 | | | 0 | | | 65 | 0.06 | 0.63 | 0 | | | 0 | | |
| May-93 | 12 | 0.00 | 0.00 | 65 | 0.00 | 0.00 | 22 | 0.00 | 0.00 | 38 | 0.27 | 1.78 | 86 | 0.00 | 0.00 | 4 | 0.00 | 0.00 | 42 | 0.00 | 0.00 |
| Jun-93 | 0 | | | 62 | 0.17 | 1.43 | 0 | | | 0 | | | 41 | 0.00 | 0.00 | 3 | 0.00 | 0.00 | 8 | 0.00 | 0.00 |
| Jul-93 | 7 | 0.00 | 0.00 | 52 | 0.09 | 0.91 | 0 | | | 0 | | | 76 | 0.12 | 0.97 | 20 | 0.00 | 0.00 | 14 | 0.00 | 0.00 |
| Aug-93 | 0 | | | 61 | 0.07 | 0.71 | 0 | | | 0 | | | 0 | | | 0 | | | 0 | | |
| Sep-93 | 15 | 0.00 | 0.00 | 76 | 0.00 | 0.00 | 6 | 0.00 | 0.00 | 40 | 0.00 | 0.00 | 61 | 0.07 | 0.67 | 18 | 0.00 | 0.00 | 44 | 0.00 | 0.00 |
| Oct-93 | 23 | 0.00 | 0.00 | 48 | 0.21 | 1.47 | 0 | | | 0 | | | 0 | | | 0 | | | 0 | | |
| Nov-93 | 2 | 0.00 | 0.00 | 19 | 0.00 | 0.00 | 0 | | | 31 | 0.00 | 0.00 | 34 | 0.00 | 0.00 | 0 | | | 0 | | |
| Jul-94 | 15 | 0.00 | 0.00 | 17 | 0.00 | 0.00 | 0 | | | 0 | | | 25 | 0.00 | 0.00 | 0 | | | 0 | | |
| Mar-95 | 4 | 0.00 | 0.00 | 0 | | | 0 | | | 3 | 0.00 | 0.00 | 10 | 0.00 | 0.00 | 2 | 0.00 | 0.00 | 6 | 0.00 | 0.00 |
| Jun-95 | 5 | 0.00 | 0.00 | 0 | | | 0 | | | 5 | 0.00 | 0.00 | 14 | 0.00 | 0.00 | 6 | 0.00 | 0.00 | 5 | 0.00 | 0.00 |
| Sep-95 | 8 | 0.00 | 0.00 | 0 | | | 0 | | | 8 | 0.00 | 0.00 | 24 | 0.00 | 0.00 | 4 | 0.00 | 0.00 | 6 | 0.00 | 0.00 |
| Feb-96 | 0 | | | 36 | 0.00 | 0.00 | 0 | | | 2 | 0.00 | 0.00 | 8 | 0.00 | 0.00 | 0 | | | 0 | | |
| Apr-96 | 7 | 0.00 | 0.00 | 29 | 0.00 | 0.00 | 0 | | | 5 | 0.00 | 0.00 | 8 | 0.00 | 0.00 | 0 | | | 0 | | |
| Jun-96 | 6 | 0.00 | 0.00 | 27 | 0.00 | 0.00 | 0 | | | 3 | 0.00 | 0.00 | 8 | 0.00 | 0.00 | 0 | | | 0 | | |
| Sep-96 | 5 | 0.00 | 0.00 | 31 | 0.14 | 1.10 | 0 | | | 8 | 0.00 | 0.00 | 11 | 0.00 | 0.00 | 0 | | | 0 | | |
| Mar-97 | 8 | 0.00 | 0.00 | 51 | 0.00 | 0.00 | 0 | | | 4 | 0.00 | 0.00 | 11 | 0.00 | 0.00 | 0 | | | 0 | | |
| Jun-97 | 7 | 0.00 | 0.00 | 50 | 0.00 | 0.00 | 0 | | | 0 | | | 16 | 0.00 | 0.00 | 0 | | | 0 | | |
| Sep-97 | 12 | 0.00 | 0.00 | 52 | 0.00 | 0.00 | 0 | | | 0 | | | 15 | 0.00 | 0.00 | 0 | | | 0 | | |
| Jun-98 | 0 | | | 14 | 0.00 | 0.00 | 3 | 0.00 | 0.00 | 3 | 0.00 | 0.00 | 7 | 0.00 | 0.00 | 3 | 0.00 | 0.00 | 0 | | |
| Aug-98 | 2 | 0.00 | 0.00 | 32 | 0.49 | 2.55 | 6 | 0.00 | 0.00 | 9 | 0.59 | 3.03 | 8 | 0.00 | 0.00 | 3 | 0.00 | 0.00 | 1 | 0.00 | 0.00 |
| Jan-99 | 0 | | | 15 | 0.00 | 0.00 | 0 | | | 2 | 0.00 | 0.00 | 4 | 0.00 | 0.00 | 0 | | | 2 | 0.00 | 0.00 |
| Jun-99 | 3 | 0.00 | 0.00 | 19 | 0.30 | 2.16 | 3 | 0.00 | 0.00 | 6 | 0.00 | 0.00 | 6 | 1.08 | 5.01 | 0 | | | 0 | | |
| Sep-99 | 1 | 0.00 | 0.00 | 23 | 0.25 | 1.87 | 2 | 0.00 | 0.00 | 7 | 1.17 | 6.72 | 11 | 0.00 | 0.00 | 1 | 0.00 | 0.00 | 3 | 0.00 | 0.00 |
| Jan-00 | 4 | 0.00 | 0.00 | 17 | 0.00 | 0.00 | 3 | 0.00 | 0.00 | 4 | 0.00 | 0.00 | 8 | 0.67 | 3.26 | 3 | 0.00 | 0.00 | 5 | 0.00 | 0.00 |

Appendix B-2. Geometric mean and standard error catch per unit effort (CPUE; Fish/100 feet/100 hours) using trammel netting methods for humpback chub >= 200 mm among the 7 standardized reaches.

| Sample | Fence Fault | | | LCR INFLOW | | | BRIGHT ANGEL | | | SHINUMO | | | MIDDLE GRANITE GORGE | | | KANAB | | | HAVASU | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Date | N | CPUE | SE | N | CPUE | SE | N | CPUE | SE | N | CPUE | SE | N | CPUE | SE | N | CPUE | SE | N | CPUE | SE |
| Oct-90 | 0 | | | 32 | 3.98 | 8.75 | 0 | | | 0 | | | 0 | | | 0 | | | 0 | | |
| Nov-90 | 0 | | | 34 | 5.94 | 8.33 | 7 | 0.00 | 0.00 | 10 | 0.53 | 2.83 | 0 | | | 6 | 0.00 | 0.00 | 21 | 0.00 | 0.00 |
| Jan-91 | 0 | | | 74 | 3.46 | 7.34 | 0 | | | 24 | 0.71 | 3.25 | 0 | | | 0 | | | 0 | | |
| Feb-91 | 0 | | | 4 | 7.64 | 11.48 | 0 | | | 0 | | | 0 | | | 0 | | | 0 | | |
| Mar-91 | 0 | | | 79 | 11.12 | 10.87 | 19 | 0.00 | 0.00 | 42 | 0.13 | 1.19 | 0 | | | 0 | | | 44 | 0.00 | 0.00 |
| Apr-91 | 0 | | | 8 | 5.47 | 12.50 | 0 | | | 0 | | | 0 | | | 0 | | | 0 | | |
| May-91 | 0 | | | 80 | 0.59 | 3.16 | 5 | 0.00 | 0.00 | 23 | 0.19 | 1.29 | 0 | | | 3 | 0.00 | 0.00 | 74 | 0.17 | 1.12 |
| Jun-91 | 0 | | | 26 | 3.56 | 9.50 | 0 | | | 0 | | | 0 | | | 0 | | | 0 | | |
| Jul-91 | 0 | | | 27 | 5.20 | 10.79 | 0 | | | 27 | 0.84 | 3.44 | 48 | 0.44 | 2.41 | 0 | | | 38 | 0.00 | 0.00 |
| Sep-91 | 0 | | | 77 | 3.70 | 8.02 | 0 | | | 25 | 0.19 | 1.42 | 30 | 1.00 | 3.86 | 17 | 0.00 | 0.00 | 0 | | |
| Nov-91 | 0 | | | 52 | 1.54 | 5.20 | 4 | 0.00 | 0.00 | 15 | 0.00 | 0.00 | 21 | 0.00 | 0.00 | 0 | | | 34 | 0.00 | 0.00 |
| Jan-92 | 0 | | | 54 | 1.01 | 3.86 | 0 | | | 29 | 0.00 | 0.00 | 0 | | | 0 | | | 0 | | |
| Feb-92 | 0 | | | 4 | 33.05 | 9.90 | 0 | | | 0 | | | 0 | | | 0 | | | 0 | | |
| Mar-92 | 12 | 0.00 | 0.00 | 42 | 3.52 | 7.97 | 0 | | | 17 | 0.00 | 0.00 | 0 | | | 0 | | | 58 | 0.00 | 0.00 |
| Apr-92 | 0 | | | 27 | 7.98 | 11.65 | 0 | | | 0 | | | 0 | | | 0 | | | 0 | | |
| May-92 | 0 | | | 78 | 1.45 | 5.42 | 3 | 0.00 | 0.00 | 41 | 0.23 | 1.54 | 11 | 0.00 | 0.00 | 0 | | | 18 | 0.34 | 2.42 |
| Jun-92 | 0 | | | 26 | 7.56 | 9.92 | 0 | | | 0 | | | 0 | | | 0 | | | 0 | | |
| Jul-92 | 0 | | | 31 | 9.40 | 10.86 | 0 | | | 0 | | | 23 | 6.81 | 10.49 | 0 | | | 22 | 0.00 | 0.00 |
| Nov-92 | 0 | | | 99 | 2.62 | 6.98 | 4 | 0.00 | 0.00 | 37 | 0.00 | 0.00 | 61 | 0.32 | 1.90 | 26 | 0.00 | 0.00 | 24 | 0.00 | 0.00 |
| Jan-93 | 0 | | | 99 | 3.90 | 9.68 | 0 | | | 16 | 0.00 | 0.00 | 0 | | | 0 | | | 0 | | |
| Feb-93 | 11 | 0.00 | 0.00 | 69 | 6.94 | 11.08 | 0 | | | 0 | | | 38 | 0.53 | 2.49 | 0 | | | 0 | | |
| Mar-93 | 7 | 0.00 | 0.00 | 112 | 1.76 | 5.82 | 0 | | | 36 | 0.00 | 0.00 | 79 | 0.71 | 3.11 | 0 | | | 25 | 0.00 | 0.00 |
| Apr-93 | 10 | 0.75 | 4.92 | 125 | 0.87 | 3.91 | 0 | | | 0 | | | 65 | 0.88 | 3.46 | 0 | | | 0 | | |
| May-93 | 12 | 0.47 | 2.81 | 65 | 3.18 | 9.95 | 22 | 0.00 | 0.00 | 38 | 0.42 | 3.87 | 86 | 0.57 | 2.81 | 4 | 0.00 | 0.00 | 42 | 0.00 | 0.00 |
| Jun-93 | 0 | 0.00 | 0.00 | 62 | 7.04 | 10.49 | 0 | | | 0 | | | 41 | 0.36 | 2.07 | 3 | 0.00 | 0.00 | 8 | 0.00 | 0.00 |
| Jul-93 | 7 | 0.00 | 0.00 | 52 | 7.37 | 11.89 | 0 | | | 0 | | | 76 | 0.76 | 3.36 | 20 | 0.00 | 0.00 | 14 | 0.00 | 0.00 |
| Aug-93 | 0 | | | 61 | 4.69 | 8.75 | 0 | | | 0 | | | 0 | | | 0 | | | 0 | | |
| Sep-93 | 15 | 1.53 | 5.97 | 76 | 1.30 | 6.00 | 6 | | | 40 | 0.39 | 2.27 | 61 | 1.25 | 4.77 | 18 | 0.26 | 1.66 | 44 | 0.10 | 0.89 |
| Oct-93 | 23 | 0.88 | 4.34 | 48 | 6.16 | 9.78 | 0 | | | 0 | | | 0 | | | 0 | | | 0 | | |
| Nov-93 | 2 | 164.31 | 0.29 | 19 | 12.76 | 9.23 | 0 | | | 31 | 0.33 | 2.04 | 34 | 0.30 | 1.92 | 0 | | | 0 | | |
| Jul-94 | 15 | 1.54 | 5.88 | 17 | 0.69 | 3.43 | 0 | | | 0 | | | 25 | 1.28 | 6.01 | 0 | | | 0 | | |
| Mar-95 | 4 | 0.00 | 0.00 | 0 | | | 0 | | | 3 | 0.00 | 0.00 | 10 | 10.49 | 7.39 | 2 | 0.00 | 0.00 | 6 | 0.00 | 0.00 |
| Jun-95 | 5 | 0.00 | 0.00 | 0 | | | 0 | | | 5 | 1.28 | 5.34 | 14 | 2.93 | 5.75 | 6 | 0.00 | 0.00 | 5 | 0.00 | 0.00 |
| Sep-95 | 8 | 1.72 | 5.38 | 0 | | | 0 | | | 8 | 0.00 | 0.00 | 24 | 1.88 | 5.49 | 4 | 0.00 | 0.00 | 6 | 0.00 | 0.00 |
| Feb-96 | 0 | | | 36 | 2.09 | 7.72 | 0 | | | 2 | 0.00 | 0.00 | 8 | 0.00 | 0.00 | 0 | | | 0 | | |
| Apr-96 | 7 | 0.98 | 5.05 | 29 | 4.74 | 11.06 | 0 | | | 5 | 0.00 | 0.00 | 8 | 0.00 | 0.00 | 0 | | | 0 | | |
| Jun-96 | 6 | 0.00 | 0.00 | 27 | 0.66 | 3.32 | 0 | | | 3 | 0.00 | 0.00 | 8 | 0.00 | 0.00 | 0 | | | 0 | | |
| Sep-96 | 5 | 4.74 | 10.03 | 31 | 3.76 | 9.25 | 0 | | | 8 | 0.00 | 0.00 | 11 | 0.53 | 3.10 | 0 | | | 0 | | |
| Mar-97 | 8 | 0.00 | 0.00 | 51 | 0.52 | 2.60 | 0 | | | 4 | 0.00 | 0.00 | 11 | 0.00 | 0.00 | 0 | | | 0 | | |
| Jun-97 | 7 | 0.00 | 0.00 | 50 | 1.94 | 6.01 | 0 | | | 0 | | | 16 | 0.77 | 3.77 | 0 | | | 0 | | |
| Sep-97 | 12 | 0.00 | 0.00 | 52 | 2.66 | 7.82 | 0 | | | 0 | | | 15 | 0.00 | 0.00 | 0 | | | 0 | | |
| Jun-98 | 0 | | | 14 | 1.37 | 7.97 | 3 | 0.00 | 0.00 | 3 | 0.00 | 0.00 | 7 | 0.00 | 0.00 | 3 | 0.00 | 0.00 | 0 | | |
| Aug-98 | 2 | 50.65 | 263.63 | 32 | 4.06 | 9.32 | 6 | 0.00 | 0.00 | 9 | 4.90 | 13.74 | 8 | 1.94 | 6.38 | 3 | 0.00 | 0.00 | 1 | 0.00 | 0.00 |
| Jan-99 | 0 | | | 15 | 1.36 | 4.93 | 0 | | | 2 | 0.00 | 0.00 | 4 | 6.31 | 8.95 | 0 | | | 2 | 0.00 | 0.00 |
| Jun-99 | 3 | 4.44 | 17.80 | 19 | 4.13 | 11.33 | 3 | 0.00 | 0.00 | 6 | 0.00 | 0.00 | 6 | 0.97 | 4.25 | 0 | | | 0 | | |
| Sep-99 | 1 | 59.26 | 0.00 | 23 | 0.86 | 4.48 | 2 | 0.00 | 0.00 | 7 | 17.14 | 15.39 | 11 | 4.83 | 10.82 | 1 | 0.00 | 0.00 | 3 | 0.00 | 0.00 |
| Jan-00 | 4 | 16.17 | 11.36 | 17 | 4.69 | 10.51 | 3 | 0.00 | 0.00 | 4 | 1.72 | 6.40 | 8 | 4.21 | 8.85 | 3 | 0.00 | 0.00 | 5 | 0.00 | 0.00 |

Appendix C-2. Geometric mean and standard error catch per unit effort (CPUE; Fish/100 feet/100 hours) using trammel netting methods for rainbow trout among the 7 standardized reaches.

| Sample | Fence Fault | | | LCR INFLOW | | | BRIGHT ANGEL | | | SHINUMO | | | MIDDLE GRANITE GORGE | | | KANAB | | | HAVASU | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Date | N | CPUE | SE | N | CPUE | SE | N | CPUE | SE | N | CPUE | SE | N | CPUE | SE | N | CPUE | SE | N | CPUE | SE |
| Oct-90 | 0 | | | 32 | 0.47 | 2.37 | 0 | | | 0 | | | 0 | | | 0 | | | 0 | | |
| Nov-90 | 0 | | | 34 | 4.27 | 10.85 | 7 | 6.53 | 11.87 | 10 | 2.74 | 7.41 | 0 | | | 6 | 0.00 | 0.00 | 21 | 0.00 | 0.00 |
| Jan-91 | 0 | | | 74 | 4.93 | 8.49 | 0 | | | 24 | 5.70 | 9.06 | 0 | | | 0 | | | 0 | | |
| Feb-91 | 0 | | | 4 | 2.65 | 12.30 | 0 | | | 0 | | | 0 | | | 0 | | | 0 | | |
| Mar-91 | 0 | | | 79 | 3.49 | 8.47 | 19 | 0.25 | 1.67 | 42 | 1.62 | 5.52 | 0 | | | 0 | | | 44 | 0.99 | 4.00 |
| Apr-91 | 0 | | | 8 | 2.88 | 11.34 | 0 | | | 0 | | | 0 | | | 0 | | | 0 | | |
| May-91 | 0 | | | 80 | 3.18 | 7.76 | 5 | 0.00 | 0.00 | 23 | 0.74 | 3.31 | 0 | | | 3 | 0.00 | 0.00 | 74 | 0.00 | 0.00 |
| Jun-91 | 0 | | | 26 | 2.48 | 7.47 | 0 | | | 0 | | | 0 | | | 0 | | | 0 | | |
| Jul-91 | 0 | | | 27 | 1.30 | 5.03 | 0 | | | 27 | 0.39 | 2.26 | 48 | 0.70 | 3.18 | 0 | | | 38 | 0.00 | 0.00 |
| Sep-91 | 0 | | | 77 | 2.33 | 6.30 | 0 | | | 25 | 0.18 | 1.28 | 30 | 0.51 | 2.53 | 17 | 0.00 | 0.00 | 0 | | |
| Nov-91 | 0 | | | 52 | 2.96 | 7.15 | 4 | 0.00 | 0.00 | 15 | 2.09 | 5.93 | 21 | 0.21 | 1.40 | 0 | | | 34 | 0.00 | 0.00 |
| Jan-92 | 0 | | | 54 | 2.02 | 6.35 | 0 | | | 29 | 1.03 | 0.34 | 0 | | | 0 | | | 0 | | |
| Feb-92 | 0 | | | 4 | 6.95 | 9.95 | 0 | | | 0 | | | 0 | | | 0 | | | 0 | | |
| Mar-92 | 12 | 69.41 | 13.08 | 42 | 0.33 | 1.83 | 0 | | | 17 | 0.31 | 2.04 | 0 | | | 0 | | | 58 | 0.00 | 0.00 |
| Apr-92 | 0 | | | 27 | 0.33 | 1.80 | 0 | | | 0 | | | 0 | | | 0 | | | 0 | | |
| May-92 | 0 | | | 78 | 1.08 | 3.89 | 3 | 0.00 | 0.00 | 41 | 0.41 | 2.42 | 11 | 0.47 | 2.60 | 0 | | | 18 | 0.00 | 0.00 |
| Jun-92 | 0 | | | 26 | 0.66 | 3.18 | 0 | | | 0 | | | 0 | | | 0 | | | 0 | | |
| Jul-92 | 0 | | | 31 | 1.46 | 5.52 | 0 | | | 0 | | | 23 | 0.22 | 1.63 | 0 | | | 22 | 0.27 | 2.10 |
| Nov-92 | 0 | | | 99 | 1.70 | 5.59 | 4 | 0.00 | 0.00 | 37 | 0.00 | 0.00 | 61 | 0.15 | 1.12 | 26 | 0.00 | 0.00 | 24 | 0.00 | 0.00 |
| Jan-93 | 0 | | | 99 | 0.22 | 1.66 | 0 | | | 16 | 0.00 | 0.00 | 0 | | | 0 | | | 0 | | |
| Feb-93 | 11 | 15.02 | 13.91 | 69 | 1.68 | 6.26 | 0 | | | 0 | | | 38 | 0.11 | 0.91 | 0 | | | 0 | | |
| Mar-93 | 7 | 2.74 | 8.60 | 112 | 0.61 | 3.06 | 0 | | | 36 | 0.24 | 1.49 | 79 | 0.06 | 0.64 | 0 | | | 25 | 0.00 | 0.00 |
| Apr-93 | 10 | 102.42 | 5.01 | 125 | 0.93 | 4.07 | 0 | | | 0 | | | 65 | 0.13 | 0.98 | 0 | | | 0 | | |
| May-93 | 12 | 7.57 | 14.01 | 65 | 1.30 | 4.89 | 22 | 0.23 | 1.60 | 38 | 0.00 | 0.00 | 86 | 0.67 | 3.15 | 4 | 0.00 | 0.00 | 42 | 0.00 | 0.00 |
| Jun-93 | 0 | | | 62 | 0.45 | 2.56 | 0 | | | 0 | | | 41 | 0.23 | 1.57 | 3 | 0.00 | 0.00 | 8 | 0.00 | 0.00 |
| Jul-93 | 7 | 32.82 | 10.33 | 52 | 0.68 | 3.32 | 0 | | | 0 | | | 76 | 0.11 | 0.93 | 20 | 0.00 | 0.00 | 14 | 0.00 | 0.00 |
| Aug-93 | 0 | | | 61 | 1.22 | 5.25 | 0 | | | 0 | | | 0 | | | 0 | | | 0 | | |
| Sep-93 | 15 | 2.70 | 8.67 | 76 | 0.43 | 2.43 | 6 | 0.00 | 0.00 | 40 | 0.56 | 2.88 | 61 | 0.00 | 0.00 | 18 | 0.00 | 0.00 | 44 | 0.00 | 0.00 |
| Oct-93 | 23 | 41.10 | 10.18 | 48 | 2.18 | 6.69 | 0 | | | 0 | | | 0 | | | 0 | | | 0 | | |
| Nov-93 | 2 | 13.37 | 42.34 | 19 | 0.89 | 3.60 | 0 | | | 31 | 0.16 | 1.29 | 34 | 0.00 | 0.00 | 0 | | | 0 | | |
| Jul-94 | 15 | 8.41 | 11.46 | 17 | 5.42 | 9.06 | 0 | | | 0 | | | 25 | 0.19 | 1.35 | 0 | | | 0 | | |
| Mar-95 | 4 | 2.25 | 9.59 | 0 | | | 0 | | | 3 | 2.88 | 9.47 | 10 | 0.57 | 3.17 | 2 | 0.00 | 0.00 | 6 | 0.00 | 0.00 |
| Jun-95 | 5 | 4.24 | 8.72 | 0 | | | 0 | | | 5 | 4.58 | 9.53 | 14 | 0.30 | 1.64 | 6 | 0.00 | 0.00 | 5 | 0.00 | 0.00 |
| Sep-95 | 8 | 13.34 | 8.16 | 0 | | | 0 | | | 8 | 0.78 | 4.12 | 24 | 0.42 | 2.27 | 4 | 0.00 | 0.00 | 6 | 0.00 | 0.00 |
| Feb-96 | 0 | | | 36 | 1.92 | 6.74 | 0 | | | 2 | 0.00 | 0.00 | 8 | 0.00 | 0.00 | 0 | | | 0 | | |
| Apr-96 | 7 | 37.94 | 13.13 | 29 | 3.62 | 7.61 | 0 | | | 5 | 0.00 | 0.00 | 8 | 0.69 | 3.41 | 0 | | | 0 | | |
| Jun-96 | 6 | 3.33 | 8.68 | 27 | 0.42 | 2.50 | 0 | | | 3 | 0.00 | 0.00 | 8 | 0.00 | 0.00 | 0 | | | 0 | | |
| Sep-96 | 5 | 31.33 | 24.22 | 31 | 5.83 | 10.99 | 0 | | | 8 | 2.63 | 10.10 | 11 | 1.65 | 7.76 | 0 | | | 0 | | |
| Mar-97 | 8 | 2.31 | 8.67 | 51 | 3.57 | 10.25 | 0 | | | 4 | 0.00 | 0.00 | 11 | 0.00 | 0.00 | 0 | | | 0 | | |
| Jun-97 | 7 | 38.37 | 13.07 | 50 | 7.07 | 10.43 | 0 | | | 0 | | | 16 | 1.86 | 5.58 | 0 | | | 0 | | |
| Sep-97 | 12 | 4.66 | 12.17 | 52 | 2.69 | 8.11 | 0 | | | 0 | | | 15 | 3.40 | 7.78 | 0 | | | 0 | | |
| Jun-98 | 0 | | | 14 | 5.41 | 8.37 | 3 | 24.93 | 18.63 | 3 | 15.84 | 10.54 | 7 | 0.78 | 3.58 | 3 | 3.36 | 11.79 | 0 | | |
| Aug-98 | 2 | 3382[a] | 0.66 | 32 | 62.90 | 7.70 | 6 | 18.40 | 27.19 | 9 | 6.10 | 17.99 | 8 | 1.22 | 18.98 | 3 | 0.00 | 0.00 | 1 | 0.00 | 0.00 |
| Jan-99 | 0 | | | 15 | 1.31 | 4.65 | 0 | | | 2 | 7.23 | 18.69 | 4 | 2.31 | 9.93 | 0 | | | 2 | 9.38 | 26.35 |
| Jun-99 | 3 | 181.25 | 2.39 | 19 | 9.73 | 12.66 | 3 | 85.45 | 0.53 | 6 | 10.16 | 13.50 | 6 | 23.94 | 11.98 | 0 | | | 0 | | |
| Sep-99 | 1 | 651.85 | 0.00 | 23 | 11.69 | 14.87 | 2 | 24.84 | 98.37 | 7 | 17.81 | 15.24 | 11 | 3.90 | 8.24 | 1 | 0.00 | 0.00 | 3 | 0.00 | 0.00 |
| Jan-00 | 4 | 199.27 | 2.98 | 17 | 7.26 | 9.35 | 3 | 4.12 | 15.93 | 4 | 7.27 | 10.54 | 8 | 8.93 | 11.81 | 3 | 21.04 | 14.26 | 5 | 0.00 | 0.00 |

[a] Outlier

Appendix D-2. Geometric mean and standard error catch per unit effort (CPUE; Fish/100 feet/100 hours) using trammel netting methods for brown trout among the 7 standardized reaches.

| Sample | Fence Fault | | | LCR INFLOW | | | BRIGHT ANGEL | | | SHINUMO | | | MIDDLE GRANITE GORGE | | | KANAB | | | HAVASU | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Date | N | CPUE | SE | N | CPUE | SE | N | CPUE | SE | N | CPUE | SE | N | CPUE | SE | N | CPUE | SE | N | CPUE | SE |
| Oct-90 | 0 | | | 32 | 0.42 | 2.04 | 0 | | | 0 | | | 0 | | | 0 | | | 0 | | |
| Nov-90 | 0 | | | 34 | 0.13 | 1.02 | 7 | 0.76 | 3.49 | 10 | 0.00 | 0.00 | 0 | | | 6 | 0.00 | 0.00 | 21 | 0.00 | 0.00 |
| Jan-91 | 0 | | | 74 | 0.00 | 0.00 | 0 | | | 24 | 0.44 | 2.41 | 0 | | | 0 | | | 0 | | |
| Feb-91 | 0 | | | 4 | 0.00 | 0.00 | 0 | | | 0 | | | 0 | | | 0 | | | 0 | | |
| Mar-91 | 0 | | | 79 | 0.06 | 0.71 | 19 | 0.99 | 4.13 | 42 | 0.00 | 0.00 | 0 | | | 0 | | | 44 | 0.00 | 0.00 |
| Apr-91 | 0 | | | 8 | 0.00 | 0.00 | 0 | | | 0 | | | 0 | | | 0 | | | 0 | | |
| May-91 | 0 | | | 80 | 0.00 | 0.00 | 5 | 1.19 | 4.75 | 23 | 0.00 | 0.00 | 0 | | | 3 | 0.00 | 0.00 | 74 | 0.00 | 0.00 |
| Jun-91 | 0 | | | 26 | 0.00 | 0.00 | 0 | | | 0 | | | 0 | | | 0 | | | 0 | | |
| Jul-91 | 0 | | | 27 | 0.00 | 0.00 | 0 | | | 27 | 0.17 | 1.22 | 48 | 0.00 | 0.00 | 0 | | | 38 | 0.00 | 0.00 |
| Sep-91 | 0 | | | 77 | 0.20 | 1.55 | 0 | | | 25 | 0.00 | 0.00 | 30 | 0.00 | 0.00 | 17 | 0.00 | 0.00 | 0 | | |
| Nov-91 | 0 | | | 52 | 0.00 | 0.00 | 4 | 0.00 | 0.00 | 15 | 0.00 | 0.00 | 21 | 0.20 | 1.34 | 0 | | | 34 | 0.00 | 0.00 |
| Jan-92 | 0 | | | 54 | 0.00 | 0.00 | 0 | | | 29 | 0.15 | 0.15 | 0 | | | 0 | | | 0 | | |
| Feb-92 | 0 | | | 4 | 0.00 | 0.00 | 0 | | | 0 | | | 0 | | | 0 | | | 0 | | |
| Mar-92 | 12 | 0.00 | 0.00 | 42 | 0.10 | 0.90 | 0 | | | 17 | 0.64 | 3.05 | 0 | | | 0 | | | 58 | 0.00 | 0.00 |
| Apr-92 | 0 | | | 27 | 0.00 | 0.00 | 0 | | | 0 | | | 0 | | | 0 | | | 0 | | |
| May-92 | 0 | | | 78 | 0.05 | 0.54 | 3 | 15.53 | 10.43 | 41 | 0.00 | 0.00 | 11 | 0.00 | 0.00 | 0 | | | 18 | 0.00 | 0.00 |
| Jun-92 | 0 | | | 26 | 0.00 | 0.00 | 0 | | | 0 | | | 0 | | | 0 | | | 0 | | |
| Jul-92 | 0 | | | 31 | 0.00 | 0.00 | 0 | | | 0 | | | 23 | 0.00 | 0.00 | 0 | | | 22 | 0.00 | 0.00 |
| Nov-92 | 0 | | | 99 | 0.04 | 0.50 | 4 | 0.00 | 0.00 | 37 | 0.00 | 0.00 | 61 | 0.00 | 0.00 | 26 | 0.00 | 0.00 | 24 | 0.00 | 0.00 |
| Jan-93 | 0 | | | 99 | 0.04 | 0.54 | 0 | | | 16 | 0.00 | 0.00 | 0 | | | 0 | | | 0 | | |
| Feb-93 | 11 | 0.00 | 0.00 | 69 | 0.00 | 0.00 | 0 | | | 0 | | | 38 | 0.00 | 0.00 | 0 | | | 0 | | |
| Mar-93 | 7 | 0.00 | 0.00 | 112 | 0.04 | 0.44 | 0 | | | 36 | 0.00 | 0.00 | 79 | 0.00 | 0.00 | 0 | | | 25 | 0.00 | 0.00 |
| Apr-93 | 10 | 0.00 | 0.00 | 125 | 0.00 | 0.00 | 0 | | | 0 | | | 65 | 0.06 | 0.62 | 0 | | | 0 | | |
| May-93 | 12 | 0.00 | 0.00 | 65 | 0.00 | 0.00 | 22 | 0.23 | 1.65 | 38 | 0.14 | 1.21 | 86 | 0.10 | 0.88 | 4 | 0.00 | 0.00 | 42 | 0.00 | 0.00 |
| Jun-93 | 0 | | | 62 | 0.00 | 0.00 | 0 | | | 0 | | | 41 | 0.00 | 0.00 | 3 | 0.00 | 0.00 | 8 | 0.00 | 0.00 |
| Jul-93 | 7 | 0.00 | 0.00 | 52 | 0.00 | 0.00 | 0 | | | 0 | | | 76 | 0.13 | 1.09 | 20 | 0.00 | 0.00 | 14 | 0.00 | 0.00 |
| Aug-93 | 0 | | | 61 | 0.07 | 0.75 | 0 | | | 0 | | | 0 | | | 0 | | | 0 | | |
| Sep-93 | 15 | 0.00 | 0.00 | 76 | 0.00 | 0.00 | 6 | 0.00 | 0.00 | 40 | 0.26 | 1.79 | 61 | 0.00 | 0.00 | 18 | 0.27 | 1.75 | 44 | 0.00 | 0.00 |
| Oct-93 | 23 | 0.00 | 0.00 | 48 | 0.19 | 1.33 | 0 | | | 0 | | | 0 | | | 0 | | | 0 | | |
| Nov-93 | 2 | 0.00 | 0.00 | 19 | 0.23 | 1.43 | 0 | | | 31 | 0.00 | 0.00 | 34 | 0.00 | 0.00 | 0 | | | 0 | | |
| Jul-94 | 15 | 0.00 | 0.00 | 17 | 0.00 | 0.00 | 0 | | | 0 | | | 25 | 0.00 | 0.00 | 0 | | | 0 | | |
| Mar-95 | 4 | 0.00 | 0.00 | 0 | | | 0 | | | 3 | 0.00 | 0.00 | 10 | 0.53 | 2.84 | 2 | 0.00 | 0.00 | 6 | 0.00 | 0.00 |
| Jun-95 | 5 | 0.00 | 0.00 | 0 | | | 0 | | | 5 | 1.35 | 5.74 | 14 | 0.00 | 0.00 | 6 | 0.00 | 0.00 | 5 | 0.00 | 0.00 |
| Sep-95 | 8 | 0.00 | 0.00 | 0 | | | 0 | | | 8 | 0.00 | 0.00 | 24 | 0.00 | 0.00 | 4 | 0.00 | 0.00 | 6 | 0.00 | 0.00 |
| Feb-96 | 0 | | | 36 | 0.00 | 0.00 | 0 | | | 2 | 9.96 | 28.53 | 8 | 0.00 | 0.00 | 0 | | | 0 | | |
| Apr-96 | 7 | 0.00 | 0.00 | 29 | 0.17 | 1.36 | 0 | | | 5 | 0.00 | 0.00 | 8 | 0.00 | 0.00 | 0 | | | 0 | | |
| Jun-96 | 6 | 0.00 | 0.00 | 27 | 0.00 | 0.00 | 0 | | | 3 | 0.00 | 0.00 | 8 | 0.00 | 0.00 | 0 | | | 0 | | |
| Sep-96 | 5 | 0.00 | 0.00 | 31 | 0.30 | 1.74 | 0 | | | 8 | 0.00 | 0.00 | 11 | 0.00 | 0.00 | 0 | | | 0 | | |
| Mar-97 | 8 | 0.00 | 0.00 | 51 | 0.19 | 1.41 | 0 | | | 4 | 0.00 | 0.00 | 11 | 0.00 | 0.00 | 0 | | | 0 | | |
| Jun-97 | 7 | 0.00 | 0.00 | 50 | 0.00 | 0.00 | 0 | | | 0 | | | 16 | 0.36 | 2.40 | 0 | | | 0 | | |
| Sep-97 | 12 | 0.00 | 0.00 | 52 | 0.00 | 0.00 | 0 | | | 0 | | | 15 | 0.82 | 3.92 | 0 | | | 0 | | |
| Jun-98 | 0 | | | 14 | 0.00 | 0.00 | 3 | 155.32 | 2.73 | 3 | 0.00 | 0.00 | 7 | 0.00 | 0.00 | 3 | 0.00 | 0.00 | 0 | | |
| Aug-98 | 2 | 0.00 | 0.00 | 32 | 0.00 | 0.00 | 6 | 3.16 | 8.16 | 9 | 0.00 | 0.00 | 8 | 0.00 | 0.00 | 3 | 0.00 | 0.00 | 1 | 0.00 | 0.00 |
| Jan-99 | 0 | | | 15 | 0.00 | 0.00 | 0 | | | 2 | 0.00 | 0.00 | 4 | 0.00 | 0.00 | 0 | | | 2 | 6.37 | 15.86 |
| Jun-99 | 3 | 0.00 | 0.00 | 19 | 0.00 | 0.00 | 3 | 0.00 | 0.00 | 6 | 1.02 | 4.59 | 6 | 0.00 | 0.00 | 0 | | | 0 | | |
| Sep-99 | 1 | 59.26 | 0.00 | 23 | 0.00 | 0.00 | 2 | 0.00 | 0.00 | 7 | 6.10 | 10.95 | 11 | 0.49 | 2.76 | 1 | 0.00 | 0.00 | 3 | 0.00 | 0.00 |
| Jan-00 | 4 | 0.00 | 0.00 | 17 | 0.00 | 0.00 | 3 | 3.07 | 10.40 | 4 | 1.72 | 6.40 | 8 | 0.00 | 0.00 | 3 | 0.00 | 0.00 | 5 | 0.00 | 0.00 |

Appendix E-2. Geometric mean and standard error catch per unit effort (CPUE; Fish/100 feet/100 hours) using trammel netting methods for flannel mouth sucker among the 7 standardized reaches.

| Sample | Fence Fault | | | LCR INFLOW | | | BRIGHT ANGEL | | | SHINUMO | | | MIDDLE GRANITE GORGE | | | KANAB | | | HAVASU | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Date | N | CPUE | SE | N | CPUE | SE | N | CPUE | SE | N | CPUE | SE | N | CPUE | SE | N | CPUE | SE | N | CPUE | SE |
| Oct-90 | 0 | | | 32 | 1.89 | 5.52 | 0 | | | 0 | | | 0 | | | 0 | | | 0 | | |
| Nov-90 | 0 | | | 34 | 0.46 | 2.46 | 7 | 4.83 | 8.13 | 10 | 0.00 | 0.00 | 0 | | | 6 | 3.92 | 11.11 | 21 | 0.53 | 2.84 |
| Jan-91 | 0 | | | 74 | 0.75 | 3.62 | 0 | | | 24 | 0.00 | 0.00 | 0 | | | 0 | | | 0 | | |
| Feb-91 | 0 | | | 4 | 61.57 | 15.89 | 0 | | | 0 | | | 0 | | | 0 | | | 0 | | |
| Mar-91 | 0 | | | 79 | 2.18 | 6.02 | 19 | 0.00 | 0.00 | 42 | 0.11 | 1.02 | 0 | | | 0 | | | 44 | 1.11 | 5.85 |
| Apr-91 | 0 | | | 8 | 15.62 | 19.97 | 0 | | | 0 | | | 0 | | | 0 | | | 0 | | |
| May-91 | 0 | | | 80 | 0.77 | 4.24 | 5 | 0.00 | 0.00 | 23 | 0.00 | 0.00 | 0 | | | 3 | 4.91 | 20.68 | 74 | 3.97 | 7.00 |
| Jun-91 | 0 | | | 26 | 1.74 | 7.67 | 0 | | | 0 | | | 0 | | | 0 | | | 0 | | |
| Jul-91 | 0 | | | 27 | 10.40 | 13.35 | 0 | | | 27 | 0.36 | 2.04 | 48 | 0.09 | 0.80 | 0 | | | 38 | 0.12 | 0.96 |
| Sep-91 | 0 | | | 77 | 2.08 | 5.79 | 0 | | | 25 | 0.00 | 0.00 | 30 | 0.00 | 0.00 | 17 | 1.08 | 4.13 | 0 | | |
| Nov-91 | 0 | | | 52 | 0.64 | 3.01 | 4 | 0.00 | 0.00 | 15 | 0.00 | 0.00 | 21 | 0.50 | 2.58 | 0 | | | 34 | 0.28 | 1.75 |
| Jan-92 | 0 | | | 54 | 0.37 | 2.04 | 0 | | | 29 | 0.00 | 0.00 | 0 | | | 0 | | | 0 | | |
| Feb-92 | 0 | | | 4 | 94.41 | 0.74 | 0 | | | 0 | | | 0 | | | 0 | | | 0 | | |
| Mar-92 | 12 | 0.00 | 0.00 | 42 | 1.92 | 6.13 | 0 | | | 17 | 0.00 | 0.00 | 0 | | | 0 | | | 58 | 3.00 | 9.96 |
| Apr-92 | 0 | | | 27 | 10.20 | 9.96 | 0 | | | 0 | | | 0 | | | 0 | | | 0 | | |
| May-92 | 0 | | | 78 | 3.19 | 7.31 | 3 | 2.82 | 9.20 | 41 | 0.25 | 1.68 | 11 | 0.00 | 0.00 | 0 | | | 18 | 3.67 | 12.87 |
| Jun-92 | 0 | | | 26 | 1.27 | 4.59 | 0 | | | 0 | | | 0 | | | 0 | | | 0 | | |
| Jul-92 | 0 | | | 31 | 2.58 | 8.30 | 0 | | | 0 | | | 23 | 0.20 | 1.44 | 0 | | | 22 | 1.03 | 5.27 |
| Nov-92 | 0 | | | 99 | 0.79 | 3.55 | 4 | 0.00 | 0.00 | 37 | 0.12 | 0.98 | 61 | 0.00 | 0.00 | 26 | 2.46 | 7.14 | 24 | 0.19 | 1.33 |
| Jan-93 | 0 | | | 99 | 1.59 | 5.49 | 0 | | | 16 | 0.33 | 2.11 | 0 | | | 0 | | | 0 | | |
| Feb-93 | 11 | 0.00 | 0.00 | 69 | 1.01 | 4.57 | 0 | | | 0 | | | 38 | 0.00 | 0.00 | 0 | | | 0 | | |
| Mar-93 | 7 | 0.00 | 0.00 | 112 | 0.40 | 2.13 | 0 | | | 36 | 0.28 | 1.78 | 79 | 0.11 | 0.90 | 0 | | | 25 | 0.00 | 0.00 |
| Apr-93 | 10 | 1.44 | 5.57 | 125 | 0.79 | 3.61 | 0 | | | 0 | | | 65 | 0.06 | 0.64 | 0 | | | 0 | | |
| May-93 | 12 | 1.25 | 5.70 | 65 | 0.60 | 3.59 | 22 | 0.90 | 4.33 | 38 | 0.64 | 3.35 | 86 | 0.40 | 2.12 | 4 | 2.12 | 8.74 | 42 | 1.10 | 4.37 |
| Jun-93 | 0 | | | 62 | 1.13 | 4.83 | 0 | | | 0 | | | 41 | 0.11 | 0.91 | 3 | 30.68 | 18.98 | 8 | 0.00 | 0.00 |
| Jul-93 | 7 | 0.00 | 0.00 | 52 | 1.16 | 5.27 | 0 | | | 0 | | | 76 | 0.18 | 1.32 | 20 | 3.32 | 6.74 | 14 | 0.43 | 2.84 |
| Aug-93 | 0 | | | 61 | 1.15 | 4.89 | 0 | | | 0 | | | 0 | | | 0 | | | 0 | | |
| Sep-93 | 15 | 0.40 | 2.64 | 76 | 0.55 | 3.06 | 6 | 0.00 | 0.00 | 40 | 0.56 | 2.87 | 61 | 1.03 | 4.02 | 18 | 1.68 | 5.74 | 44 | 0.32 | 1.84 |
| Oct-93 | 23 | 0.24 | 1.84 | 48 | 3.77 | 8.50 | 0 | | | 0 | | | 0 | | | 0 | | | 0 | | |
| Nov-93 | 2 | 0.00 | 0.00 | 19 | 4.80 | 10.16 | 0 | | | 31 | 2.18 | 6.46 | 34 | 0.64 | 2.98 | 0 | | | 0 | | |
| Jul-94 | 15 | 0.00 | 0.00 | 17 | 7.81 | 14.38 | 0 | | | 0 | | | 25 | 0.65 | 3.00 | 0 | | | 0 | | |
| Mar-95 | 4 | 9.49 | 14.09 | 0 | | | 0 | | | 3 | 2.87 | 9.40 | 10 | 2.46 | 6.43 | 2 | 102.02 | 0.10 | 6 | 1.85 | 11.99 |
| Jun-95 | 5 | 0.00 | 0.00 | 0 | | | 0 | | | 5 | 0.00 | 0.00 | 14 | 0.00 | 0.00 | 6 | 0.00 | 0.00 | 5 | 0.00 | 0.00 |
| Sep-95 | 8 | 0.69 | 3.38 | 0 | | | 0 | | | 8 | 0.00 | 0.00 | 24 | 1.05 | 4.17 | 4 | 7.15 | 10.32 | 6 | 0.00 | 0.00 |
| Feb-96 | 0 | | | 36 | 2.84 | 10.35 | 0 | | | 2 | 0.00 | 0.00 | 8 | 2.02 | 6.74 | 0 | | | 0 | | |
| Apr-96 | 7 | 0.94 | 4.81 | 29 | 1.63 | 5.93 | 0 | | | 5 | 0.00 | 0.00 | 8 | 0.00 | 0.00 | 0 | | | 0 | | |
| Jun-96 | 6 | 0.00 | 0.00 | 27 | 0.18 | 1.34 | 0 | | | 3 | 0.00 | 0.00 | 8 | 0.00 | 0.00 | 0 | | | 0 | | |
| Sep-96 | 5 | 7.80 | 18.75 | 31 | 0.33 | 2.07 | 0 | | | 8 | 0.67 | 3.24 | 11 | 0.00 | 0.00 | 0 | | | 0 | | |
| Mar-97 | 8 | 0.00 | 0.00 | 51 | 0.31 | 2.00 | 0 | | | 4 | 0.00 | 0.00 | 11 | 0.00 | 0.00 | 0 | | | 0 | | |
| Jun-97 | 7 | 0.00 | 0.00 | 50 | 6.30 | 11.48 | 0 | | | 0 | | | 16 | 0.00 | 0.00 | 0 | | | 0 | | |
| Sep-97 | 12 | 0.00 | 0.00 | 52 | 1.00 | 4.20 | 0 | | | 0 | | | 15 | 0.00 | 0.00 | 0 | | | 0 | | |
| Jun-98 | 0 | | | 14 | 8.23 | 13.97 | 3 | 0.00 | 0.00 | 3 | 0.00 | 0.00 | 7 | 0.00 | 0.00 | 3 | 16.75 | 11.10 | 0 | | |
| Aug-98 | 2 | 1130 | 1.89 | 32 | 2.66 | 7.52 | 6 | 3.14 | 8.15 | 9 | 8.25 | 13.41 | 8 | 0.00 | 0.00 | 3 | 57.60 | 33.23 | 1 | 0.00 | 0.00 |
| Jan-99 | 0 | | | 15 | 1.46 | 5.52 | 0 | | | 2 | 0.00 | 0.00 | 4 | 0.00 | 0.00 | 0 | | | 2 | 6.37 | 15.86 |
| Jun-99 | 3 | 2.79 | 9.04 | 19 | 2.07 | 5.87 | 3 | 0.00 | 0.00 | 6 | 0.00 | 0.00 | 6 | 0.00 | 0.00 | 0 | | | 0 | | |
| Sep-99 | 1 | 355.56 | 0.00 | 23 | 3.52 | 9.92 | 2 | 0.00 | 0.00 | 7 | 2.58 | 7.88 | 11 | 0.49 | 2.76 | 1 | 0.00 | 0.00 | 3 | 0.00 | 0.00 |
| Jan-00 | 4 | 10.51 | 7.32 | 17 | 2.60 | 6.87 | 3 | 3.07 | 10.40 | 4 | 1.72 | 6.40 | 8 | 0.65 | 3.15 | 3 | 33.85 | 20.77 | 5 | 139.00 | 1.09 |

[a] Outlier

# United States Department of the Interior

U.S. GEOLOGICAL SURVEY
Great Lakes Science Center
Lake Superior Biological Station
2800 Lake Shore Drive East
Ashland, WI 54806-2427
*Tel. 715/682-6163 Fax. 715/682-6511 FTS 700/380-9163*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26 April 2000

Dr. Barbara Ralston
Acting Biological Resources Program Manager
Grand Canyon Monitoring and Research Center
2255 N. Gemini Drive, Room 341
Flagstaff, AZ 86001
Tel. 520/556-7455

Dear Dr. Ralston:

Enclosed are two draft final reports pursuant to completion of deliverables for Interagency Acquisition No. 98-AA-40-0040, Monitoring and Studies of Native Fishes of the Colorado River Ecosystem in Grand Canyon.

The draft report, "Status and trends of native and non-native fishes of the Colorado River in Grand Canyon 1999-2000" addresses element 3, Status and trends of native and non-native fishes in the Colorado River and is listed in our agreed Outline of Final Report Elements, dated 17 December 1999.

The draft report, "Spring fish monitoring in the Little Colorado River, Grand Canyon. Draft Final Report" addresses element 5, Status and trends of native fishes in the LCR confluence during early spring and is listed in our agreed Outline of Final Report Elements, dated 17 December 1999. I have attached review comments for this report as well as for the previous AGFD draft report on backwater fish communities in Grand Canyon. Hoffnagle *

The next draft report you will receive is element 2, Evaluation of reproductive success and overwinter survivorship of YOY humpback chub in Grand Canyon. It is my intent to get this draft to you by the end of next week.

1) HBC Growth Study Van Haasen
2) *
3) Review Hoffnagle
4) Status + Trends
5) O.W. Survival

still need

Sincerely,

Owen T. Gorman

Owen T. Gorman, Chief
Lake Superior Biological Station


Grand Canyon Monitoring and Research Center
APR 28 2000
Received
Flagstaff, AZ

# United States Department of the Interior

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**MEMORADUM**

**Date:** 27 March 2000

**From:** Owen T. Gorman OTG

COPY

**To:** Tim Hoffnagle, PhD.

**RE:** Comments on backwater fish communities report

Tim, here are my comments on your backwater fish communities report:

General.
The report needs to provide more information and caveats to the reader related to the limitations of the study and interpretation of results. It was not possible to standardize sampling of backwaters. Backwaters are generally ephemeral habitats, and even those more permanent ones are affected by river stage. Antecedent conditions of river discharge and daily fluctuations will have a strong impact on existence of backwaters and presence of fish. Thus strict interpretation of results is not appropriate. The paper generally sticks to gross trends in changes in species composition which is OK as long as the discussion is limited to abundant species. For example, only 51 red shiners were captured out of total of 37,506 for the study. This represents about 0.1% of the total catch so little can be made of the occurrence. In one case we are told that red shiners comprised 80% of a sample, but realizing the sample is very small and distribution of red shiners is sporadic, the related interpretive statements are very misleading. I recommend classifying fish as abundant (=dominant, >10% of total catch), common (>1% of total catch) and rare (<1% of total catch). Patterns of species distribution and community composition should emphasize abundant species and forgo interpretation of rare species. However it would be OK to mention, for example, that red shiners were present and where and when they were present.

Executive Summary:

Some minor editing is needed to improve readability.
Recommend use of steady flow experiments to study to potential benefits of backwaters to small fishes.

Methods.

See general comment above.
Sampling methodology: time of day; river stage, temperature data, habitat data, backwater morphology, table and map summarizing location

Results

and distribution of backwaters in Grand Canyon.
Tables 1, 2 need s line with #fish/sample.
Figures 1-8 need a labels in the graph with species name.

Discussion

It is not clear that YOY fish rely on the backwaters as they now exist in Grand Canyon. No one has demonstrated that any fish that recruit to adulthood have relied on these habitats. However, these habitats are potentially important and can contribute to growth and recruitment of early life history stages of native fishes. Seasonally adjusted steady flows may improve the quality and utility of these habitats to native fishes.

Humpback chub section is confusing. You need to defined what juvenile, subadult, and adult are. There is little evidence that HBC recruit to the adult cohort from the mainstem.

There may be a connection between presence of red shiners in the mainstem and their population explosion in the LCR during 1996-1998.

Mention of warmer backwaters relative to use by trout is not backed up by temperature data.

Again, what flow experiments and temperature augmentation studies would be useful in understanding the potential for backwaters to contribute more effectively to growth and recruitment of YOY native fishes in Grand Canyon?

I will mail my marked-up copy to you today.

Keep up the great work.

Owen Gorman