Grand Canyon Long-term Non-native Fish Monitoring, 2005 Annual Report

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Introduction

Long-term monitoring of fish in the Colorado River below Glen Canyon Dam (GCD) is an essential component of the Glen Canyon Dam Adaptive Management Program. Long-term fish monitoring enables managers to ensure that GCD is being operated in a manner consistent with objectives specified in the Grand Canyon Protection Act of 1992 [Grand Canyon Monitoring and Research Center (GCMRC) 2001a]. It also characterizes a "baseline" or antecedent context in which response of biota to changing management policies or experiments can be interpreted (Walters and Holling 1990; Thomas 1996; Walters 1997).

Non-native salmonids, rainbow trout (*Oncorhynchus mykiss,* RBT) and brown trout (*Salmo trutta,* BNT) have displayed increased abundance in the Colorado River in Glen and Grand Canyons since the early 1990s. It is likely that this increase in abundance was caused by changes in the operation of GCD (GCMRC 2001a, McKinney *et al*. 1999, 2001). Many researchers have suggested that salmonids limit recruitment of native fishes in Grand Canyon through predation (Minckley 1991; Marsh and Douglas 1997; U.S. Department of Interior 2002). As a result of these findings, the GCMRC Protocol Evaluation Program advocated long-term monitoring of non-native fish species that pose risks of predation to Colorado River native fishes in Grand Canyon (GCMRC 2001b).

Working under cooperative agreement with GCMRC, Arizona Game and Fish Department (AGFD) developed sampling protocols for standardized annual monitoring of RBT, BNT, and common carp (*Cyprinus carpio*, CRP) in Grand Canyon (AGFD 2001; Speas *et al*. 2002). These methods have been used for monitoring non-native fishes downstream of Lee's Ferry since 2000. This report summarizes the results of non-native fish monitoring activities in the mainstem Colorado River in Grand Canyon during 2005. Specific objectives during 2005 were to:

1. Evaluate trends in salmonid and carp relative density and distribution from 2000 – 2005.
2. Evaluate movement of BNT in Grand Canyon by utilizing mark recapture data from 2000 to 2005.
3. Continue to investigate the potential of using electrofishing in the mainstem as a monitoring tool for native fish species, particularly flannelmouth suckers.
4. Evaluate the ability of the monitoring program to measure changes in non-native fish densities in the mechanical removal reach (Little Colorado River).

Methods

We collected electrofishing (EF) samples from April 16– May 3 and from May 14–30, 2005 between river mile (RM) 0 and RM 226 on the Colorado River in Grand Canyon. Daily river discharge at GCD ranged from 5,000 to 13,000 cubic feet per second during both river trips. All data were collected at night with two 16´ Achilles inflatable sport boats outfitted for electrofishing with a Coeffelt CPS unit, with two netters and one driver per boat. On average these boats applied 350 volts and 15 amps to a spherical steel anode. Two experienced electrofishing boatmen piloted the boats on both trips. Sampling was conducted for an average of 5 hours per night beginning at about 7 pm. We were unable to sample on two nights during each trip because of high winds (Tables 1 & 2).

We used the sample power program Sampling.exe (Walters, unpublished) to determine appropriate sample sizes and distribution of effort for RBT, BNT, and CRP effort was scaled by the number of linear river miles per reach. Using variance estimates (coefficient of variation, CV) from existing Grand Canyon fisheries data (2000–2004), we used Sampling.exe to estimate sample precision of catch per unit effort (CPUE; fish per hour) as a function of sample size and spatial stratification. The program utilizes a Monte Carlo procedure to estimate the probability of detecting a true temporal population trend given a range of sample sizes. We selected the design in the present study based on its projected level of sampling precision, CV ≤ 0.10, whereby the power to detect a 21% decrease and 26% increase in CPUE is 0.80 over a five–year period (Gerrodette 1987).

We used single-pass electrofishing to estimate mean relative density (CPUE) and longitudinal distribution of salmonids and carp in Grand Canyon. Each sample consisted of a single electrofishing pass, approximately 300 seconds in duration, along shoreline transects. The sample universe (RM 0-226) consisted of 11 reaches (Table 3; Walters, unpublished). Each reach was then divided into fishable sub-reaches. Fishable (i.e., where electrofishing was possible) sub-reaches were defined by campsite availability and location of impassable navigational hazards such as rapids (Appendix 2). Fishable sub-reaches were randomly selected within reaches. The number of fishable sub-reaches sampled was determined with Sampling.exe, within a given reach. Start miles on river left and right were randomly generated within fishable sub-reaches. With few exceptions, shoreline transects were contiguous. Transect start and stop coordinates were recorded with a Garmin III GPS and river miles were estimated from a Colorado River map and recorded (Stevens 1983).

We recorded maximum total length (TL mm) of each captured fish and implanted all BNT > 120 mm TL with passive integrated transponder (PIT) tags (Prentice *et al*. 1990) and clipped their adipose fins. The adipose clip was used as a secondary mark to evaluate tag loss. We recorded TL, fork length, and weights (when environmental conditions were favorable) of native fish. We implanted native fish > 150 mm TL with PIT tags if none were found on capture according to standard protocols for handling fish in Grand Canyon (Ward 2002). All PIT tag numbers were recorded on data sheets and also stored electronically.

We investigated BNT growth and movement by using mark-recapture data from 2000 to 2005. Daily growth rates for 2000–2005 (total length at recapture - total length at mark / days at large) and distance moved were calculated for all recaptured BNT at large for at least 100 days.

We plotted percent of captures by length, year and species (RBT and BNT) for 2000–2005 to examine cohort strength among years. CPUE of flannelmouth sucker (FMS) was calculated by year and reach to investigate the utility of using electrofishing for monitoring this species.

Results

In April 2005, 447 samples were collected averaging 332 seconds each over 18 nights with a total of 926 fish captured from 8 species (Table 1). In May, 412 samples were collected averaging 320 seconds each over 17 nights with a total of 836 fish captured from 9 species (Table 2). Mean CPUE of RBT (Fig. 1), BNT (Fig. 2), and CRP (Fig. 3) all show a declining trend from 2000 to 2005 with densities of RBT, BNT, and CRP being highest in Marble Canyon, near BAC and downriver of BAC, respectively.

Seventeen HBC were captured on the May sampling trip but no HBC were captured on the April trip (Tables 1&2). The difference in catch of HBC may indicate seasonal or water temperature related changes in HBC behavior that make them more vulnerable to electrofishing in May.

Mean catch per unit effort of RBT in the LCR experimental reach was 3 fish/h in 2005, whereas in 2001 and 2002 the CPUE was 62 fish/h and 70 fish/h respectively. This represents a more than 90 % decrease in RBT CPUE in the experimental removal area (Fig. 4). There was no statistically significant reduction in BNT (Fig. 5) or CRP (Fig. 6) CPUE in the removal reach from 2003 to 2005 although there has been a reduction in variance and the mean CPUE is trending downward. Mean CPUE of BNT in the BAC reach (Figure 7) was significantly lower in 2005 than from 2000 to 2003.

Until 2000 few brown trout were caught above RMI 57, but since that time they have been caught in low numbers. Brown trout mainly inhabit the area around Bright Angel Creek (RMI 78-99) and CPUE for brown trout in this area is an order of magnitude higher than anywhere else in the river (Figure 11). CPUE trends for brown trout in the area around Bright Angel creek show a declining trend since 2003 (figure 7). Instantaneous growth rates (mm/day) indicate that most BNT reach a maximum length near 350 mm (Figure 10).

CPUE of Carp is highly variable. With recent warmer water temperatures we would expect CPUE of carp to have increased during the last few years but instead CPUE shows a decreasing trend river wide since about 2003 (Figure 3). There has been a reduction in the variability around the mean CPUE of CRP in the mechanical removal area around the confluence of the Little Colorado River. This may indicate a reduction in numbers of CRP in that area, but these trends are also masked by river wide reductions in CPUE of CRP over the last 3 years.

There was an apparent increase in FMS CPUE from river mile 99 - 226 since 2002 (Figure 13). Additionally, flannelmouth sucker length distribution has changed from one dominated by age-0 (TL < 120 mm) and adult (TL > 400 mm) to one that shows evidence of multiple juvenile size classes and strong recruitment in 2005 (Figure 14).

Discussion

CPUE trends from 2000–2005 indicate an overall decrease in CPUE of RBT, BNT and CRP river wide. This is an unexpected trend because mainstem Colorado River water temperatures have increased over this same time period (Figure 12) as water levels have dropped in Lake Powell. We would have expected warm water species such as CRP to increase in number and distribution but we see the opposite trend occurring. Reasons for the overall decline in CPUE for RBT, BNT and CRP in recent years are unknown and need further evaluation but may be related to increased bioenergetic demands of fish at higher water temperatures (Petersen and Paukert 2005).

Monitoring data indicates CPUE of RBT in the removal area near the confluence of the LCR are over 90% lower than they were in 2000 - 2001 prior to mechanical removal. There are however significant reductions in CPUE of RBT throughout the river and not just within the mechanical removal area which confounds our ability to measure just the effectiveness of the mechanical removal project. The decrease in RBT river wide could be explained by higher mainstem water temperatures and limited food resources.

There has been a reduction in CPUE of BNT near Bright angel Creek during the last three years. This may be related to efforts by SWCA to remove brown trout from bright angel Creek using a Weir in 2002 (Leibfried et al. 2005) or may be related to winter flooding events in Bright Angel Creek that impact recruitment. Brown trout mark-recapture data showed no evidence of long distance movement by this species (Figure 9). Seventy five fish have been recaptured to date with some individuals at large for over 2 years. These fish were at large for at least 30 days with a maximum time at large of 1183 days (Figure 9). Most movement of BNT occurs in fish less than 15 months old and with adults during the spawning season (Solomon and Templeton 1976). Almost all fish that we tagged were older than 15 months, and our long term monitoring does not occur during the spawning season (Nov – Jan).

The experimental weir placed in Bright Angel Creek in 2002 by the Park Service has captured at least two BNT that had traveled over 50 RM (personal communication, Melissa Trammell, SWCA Environmental Consultants, Flagstaff). Recapture rate has increased over the past four years yielding good growth information, and extensive sampling in the LCR removal reach may show movement of marked fish into this critical reach but the data to date shows very little movement of brown trout from their original capture location.

Catch rates of FMS near the Little Colorado River are highly variable likely because of flooding and turbidity effects on catchability. In the lower river (RMI 99-226) CPUE of FMS has increased significantly since 2002 (Figure 13). Length frequency histograms show a wider size range of fish and more numerous smaller individuals when compared with pre- 2000 data. The larger percentage of the catch composed of individuals <200 mm TL in 2005 also indicates strong recent recruitment of flannelmouth suckers in the lower river. Warmer mainstem water temperatures as a result of low water levels in Lake Powell are likely the cause for these increases in FMS CPUE.

The sampling design used for long term monitoring since 2002 was established to detect river-wide population trends for large bodied non-native fishes. This sampling design (N > 800) appears to be adequate for monitoring of salmonids and carp populations in the Grand Canyon as well as for monitoring flannelmouth suckers. The number of samples taken in 2000 (N= 413) and 2001 (N= 234) were inadequate to capture the status and trends of the non-native fish in question. Bootstrapping indicated that changes in salmonid relative abundance (CPUE) of 20%–30% and 30%–40% for RBT and BNT, respectively, are detectable between consecutive years with the current stratified random sample design, provided we complete 800–900 samples per year (Rogers and Makinster 2003)

Evaluating localized management actions, such as mechanical removal of RBT in the LCR reach, requires more intensive sampling than long-term monitoring would allocate. The extensive sampling that took place in the BAC and LCR reaches from 2002 - 2005 is indicative of the effort that is necessary to detect localized trends. However, reduced densities of trout in the LCR reach and corresponding lower CPUE will reduce the ability to detect change in this reach.

The effects of the mechanical removal in the area around the Little Colorado River are evident in the monitoring data, although they are confounded by the overall declining trends in RBT CPUE river wide during the last three years.

There is some evidence to suggest small rainbow trout are not produced near the confluence of the Colorado and Little Colorado Rivers (LCR). Length frequency histograms of the Catch of RBT in that area show few small fish and suggest recruitment is not occurring locally (Figure 8). The decreased proportion of small RBT in the catch as you go downstream from Lee's Ferry to the confluence with the LCR is indicative of immigration of small fish from Lee's Ferry. The decline in RBT densities at Lee's Ferry in recent years and the associated recent declines in immigration of RBT into the removal reach may also be evidence to suggest immigration of small RBT downstream. Movement of small RBT from Lee's Ferry to downstream areas around the confluence of the LCR has large implications for management and needs further analysis and evaluation.

There are differences in the CPUE between elecrofishing boats (Rogers and Makinster 2003). Variation in catch between boats may be caused by the individual boat driver (Hardin and Connor 1992) or hardware. Regardless of the source of this variation, there are apparent differences between boats that account for a large portion (15%) of the variability within the dataset (Rogers and Makinster 2003)` . Small differences in catchability can have large effects on population estimates derived using CPUE (Bayley and Austen 2002; Speas *et al*. 2004). When CPUE data are used to evaluate population trends, the assumption is made that catchability remains constant over time. This assumption may not be met because of variations in discharge, turbidity, boat driver, or netters between and among trips. All of these factors have the potential to effect catchability (McInery and Cross 2000; Bayley and Austen 2002; Speas *et al*. 2004).

Attempts to minimize changes in these factors are made by sampling during the same months each year and attempting to keep crews consistent (Hardin and Connor 1992).

The sampling design used in most recent years (2002–2005) appears to be working well, and the level of effort appears to be appropriate for monitoring of RBT, BNT, CRP, and FMS in Grand Canyon. This monitoring program was originally only designed to detect trends in the nonnative fishes, but electrofishing also appears to be an effective tool for monitoring flannelmouth sucker.

It is critical that monitoring programs remain constant over time. If monitoring designs are compromised to answer short-term questions, the effectiveness of the monitoring program may be lost. Localized questions or questions on a time scale shorter than 5 years will require additional, separate effort beyond that outlined for long-term monitoring. Consistent, long-term monitoring will be essential to the success of the adaptive management program by allowing the effects of management actions to be measured.

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Tables

Table 1. Number of runs, start mile, average seconds, and species captured by each boat during trip 1 (April 2005). Names and abbreviations of species listed are located in Appendix 3.

DATE	BOAT	# RUNS	RM	SECONDS	AVG SEC	RBT	BNT	CRP	FMS	BHS	SPD	FHM	RSH	CCF
4/16/2005	A	12	20.8	3945	329	136								
4/16/2005	B	12	20.8	4283	357	146	1		2					
4/17/2005	A	12	47.5	4358	363	57			1					
4/17/2005	B	12	47.9	4505	375	94			7					
4/18/2005	A	0		Blown out										
4/18/2005	B	0		Blown out										
4/19/2005	A	24	56.1	7750	323	11			14					
4/19/2005	B	24	57	7840	327	22			12			1		
4/20/2005	A	12	69.4	3755	313	1			1					
4/20/2005	B	12	69.4	3990	333	11		1		2		7	1	
4/21/2005	A	12	79.3	3901	325		5	1		1				
4/21/2005	B	12	79.3	3947	329	3	4	1		1				
4/22/2005	A	12	82.3	3945	329	1	1							
4/22/2005	B	12	82.3	4009	334	3	18							
4/23/2005	A	12	90.5	3905	325		10	1	1					
4/23/2005	B	12	91.2	4022	335	9	14		1	1				
4/24/2005	A	12	106.3	3851	321		2	1						
4/24/2005	B	12	106.3	3945	329	1	1	8						
4/25/2005	A	12	110	3907	326	3	2	1		1				
4/25/2005	B	12	110	3835	320	3	2		2	1	2			
4/26/2005	A	12	120.2	4075	340	1	1	10	7					
4/26/2005	B	12	121.3	4065	339	2		2	7	4		1		
4/27/2005	A	12	146	3947	329			1	2	1				
4/27/2005	B	12	145.1	3917	326	1		3	2	15	1			
4/28/2005	A	12	161	3938	328	2		1	3	1				
4/28/2005	B	12	162	3945	329	4			2	1	8	3		
4/29/2005	A	12	176.5	4321	360	1		2	2	1	18			
4/29/2005	B	12	176.5	3891	324		1	5	14	2	18	8		
4/30/2005	A	15	185.3	4981	332	1		27	6	1	6	2		
4/30/2005	B	16	185.3	5077	317			5	6	1	22	3		
5/1/2005	A	15	196.5	4912	327			2	6			1		
5/1/2005	B	15	194.8	5044	336			9	10		8			
5/2/2005	A	15	210.5	4933	329			2	1		3	2		
5/2/2005	B	15	210	4638	309			1	2		2	2		
5/3/2005	A	10	223.7	3223	322									
5/3/2005	B	10	224	3379	338				1		1	1		
TOTAL		**447**		**147979**	**332**	**513**	**62**	**84**	**112**	**34**	**89**	**31**	**1**	**0**

Table 2. Number of runs, start mile, average seconds, and species captured by each boat during trip 2 (May 2005). Names and abbreviations of species listed are located in Appendix 3.

DATE	BOAT	# RUNS	RM	SECONDS	AVG SEC	RBT	BNT	CRP	HBC	FMS	BHS	SPD	FHM	CCF	RSH
5/14/2005	A	12	4.5	3828	319	54				4					
5/14/2005	B	12	5.5	3780	315	145				1					
5/15/2005	A	12	37.8	3840	320	31				1					
5/15/2005	B	12	37.1	3731	311	102				4					
5/16/2005	A			Blown out											
5/16/2005	B			Blown out											
5/17/2005	A	24	62	8117	338	2	1	2	1	3					
5/17/2005	B	24	62	7552	315	1		1	9	3	5	10	5		
5/18/2005	A	12	66.3	4007	334				1	2	2				
5/18/2005	B	12	66.3	3832	319	3	1				3	1			
5/19/2005	A	12	73.5	3847	321	4	2		2	1					
5/19/2005	B	12	73.4	3786	316	20	2	4	3	9			4		
5/20/2005	A	12	85.1	3836	320	3	7	2							
5/20/2005	B	12	85.3	3899	325	6	20	1			3	1			
5/21/2005	A	12	86.4	3969	331	11	23	3		1					
5/21/2005	B	13	86.6	4091	315	1	26	1	1	3	2		1		
5/22/2005	A	12	95.1	3854	321	2	7	4		1					
5/22/2005	B	12	95	3848	321	3	17	7			3				
5/23/2005	A	12	113.1	3849	321			2		3	1				
5/23/2005	B	12	114	3800	317	1	3	2		6	8				
5/24/2005	A	12	122.9	3879	323	1	3	5		5	4				
5/24/2005	B	12	122.9	3959	330		2	8		11	10				
5/25/2005	A	7	138	2287	327			1							
5/25/2005	B	12	137.8	3912	326	6	2	7		12	4				
5/26/2005	A	12	152.5	3851	321			2			2				
5/26/2005	B	12	152.2	3752	313	4	1	1		2	6				
5/27/2005	A	12	168.5	3599	300		1	1		2		1			
5/27/2005	B	12	168.5	3763	314		2	1		14	2	15	1		
5/28/2005	A	15	182	4987	332			4		3					
5/28/2005	B	15	181	4697	313			11		5	2	5		1	
5/29/2005	A	15	205.5	4945	330					4					
5/29/2005	B	15	205.7	4678	312	1		5				2			
5/30/2005	A	10	222	3252	325					1		1			
5/30/2005	B	10	220.8	3075	308			5		7		3	1	1	
TOTAL		**412**		**132102**	**320**	**401**	**120**	**80**	**17**	**108**	**57**	**39**	**12**	**2**	**0**

Table 3. River miles, relative length and percent of sample universe, for sample reaches used in this report.

Sample reach	Start river mile	End river mile	total miles	percent of sample universe
1	1.0	29.1	28.1	12.78
2	29.1	56.0	26.9	12.23
3	56.0	68.6	12.6	5.73
4	68.7	76.7	8.0	3.64
5	78.8	108.5	29.7	13.51
6	108.6	129.0	20.4	9.28
7	130.5	166.6	36.1	16.42
8	166.6	179.5	12.9	5.87
9	179.8	200.0	20.2	9.19
10	200.0	220.0	20.0	9.10
11	220.0	225.0	5.0	2.27

Figures

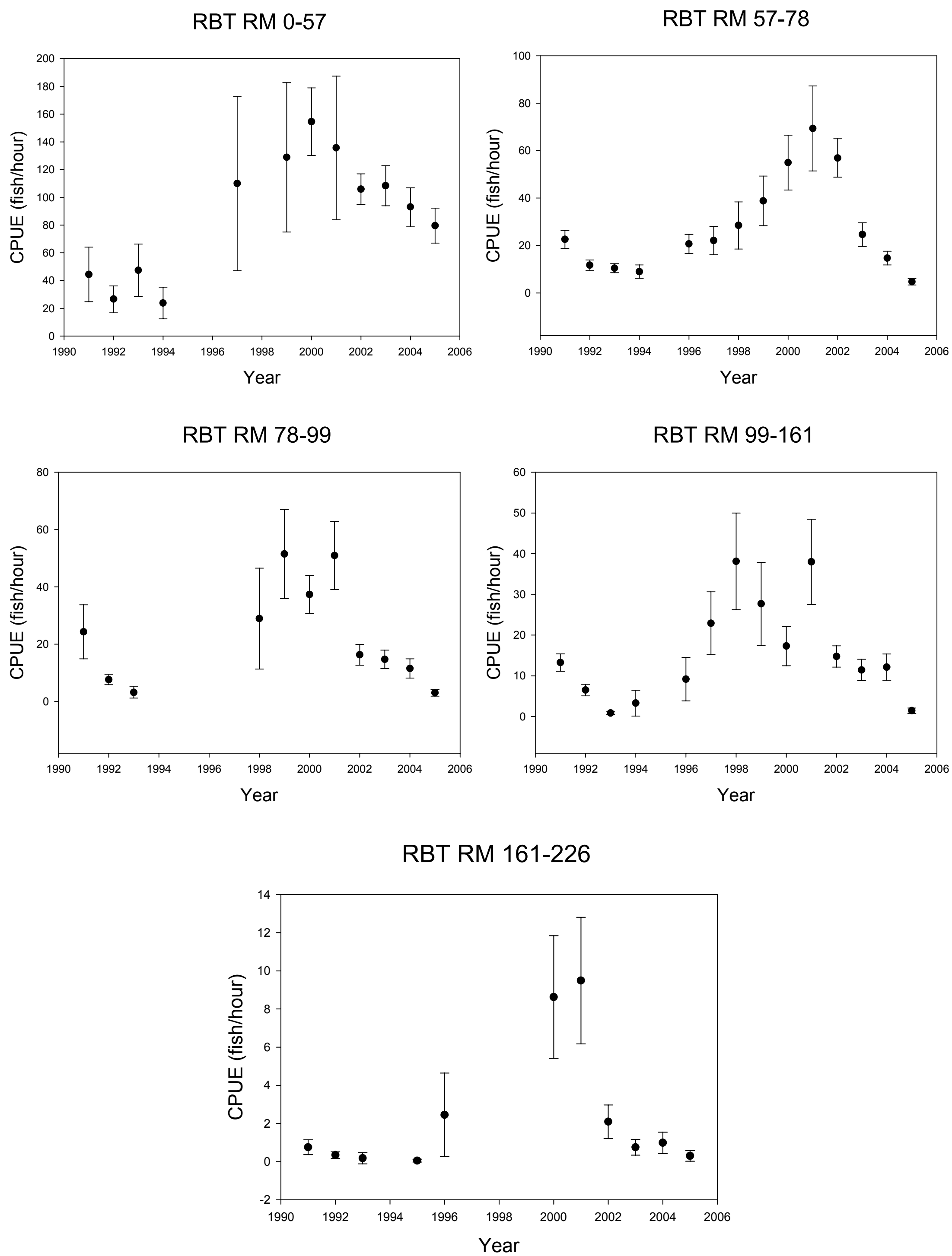

Figure 1. Mean rainbow trout catch per unit effort (fish per hour) by fish reach during 2000-2005 (Colorado River, Grand Canyon).

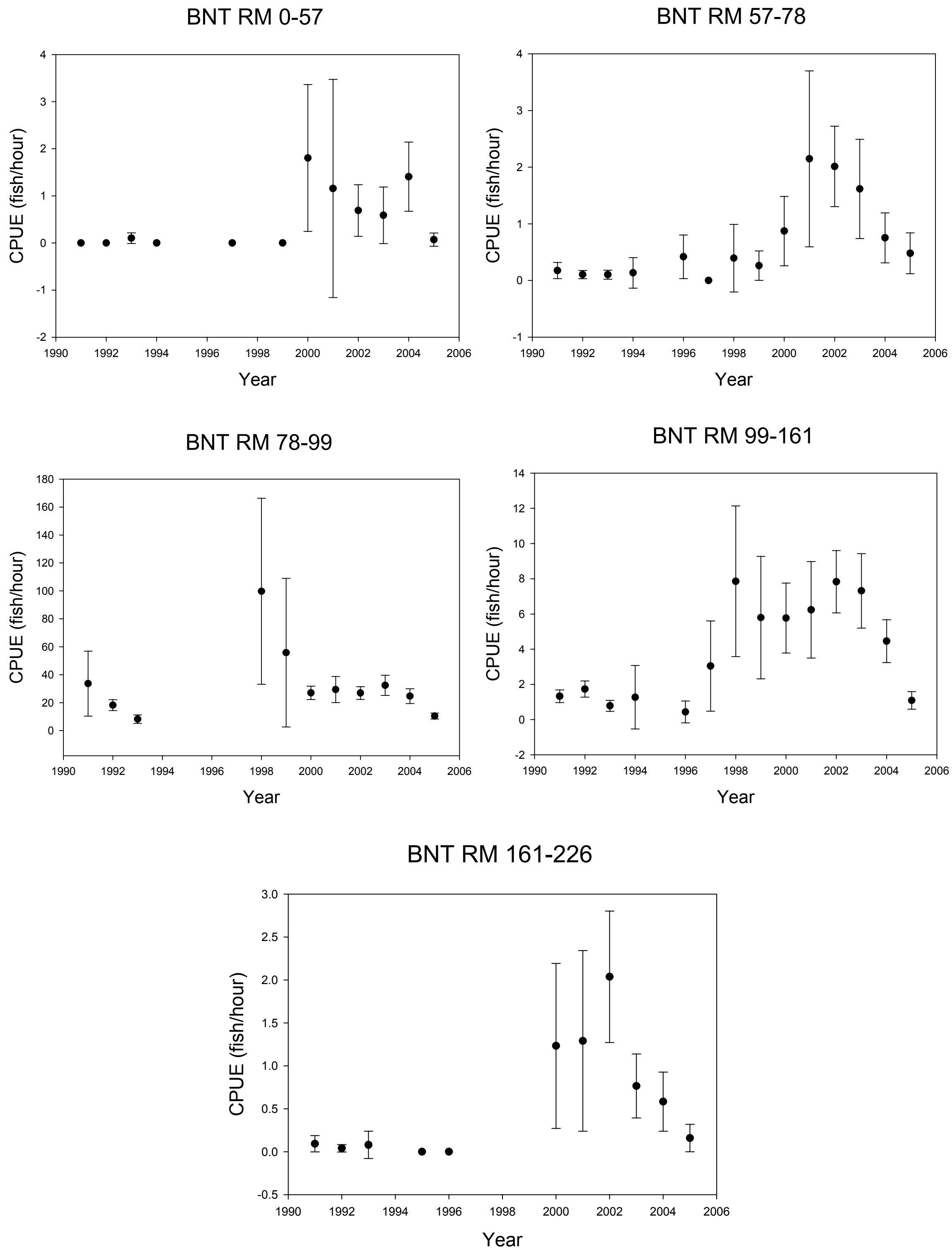

Figure 2. Mean brown trout catch per hour of electrofishing by fish reach during 2000-2005 (Colorado River, Grand Canyon).

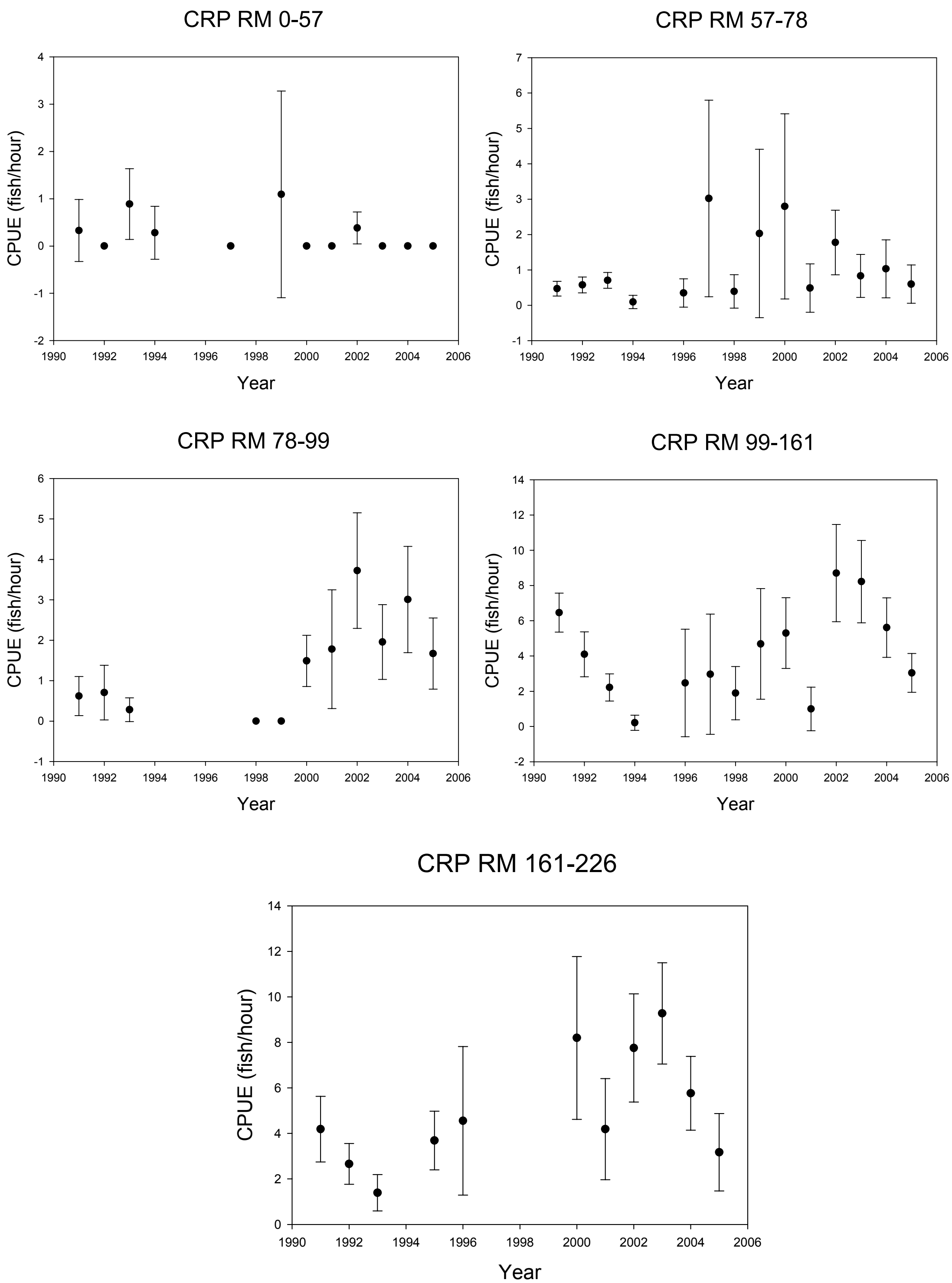

Figure 3. Mean carp catch per hour of electrofishing by fish reach during 2000-2005 (Colorado River, Grand Canyon).

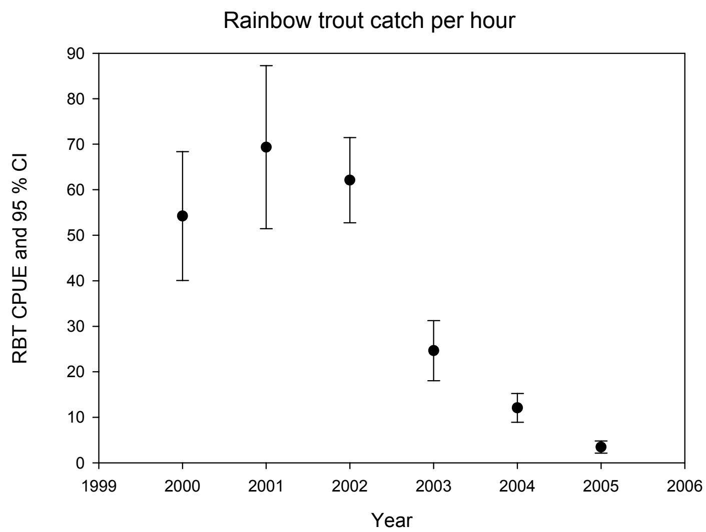

Figure 4. Mean catch per unit effort for rainbow trout during 2000-2005, near the Little Colorado River (LCR reach RM 56-69), a tributary of the Colorado River. Bars represent 95% confidence intervals of the mean.

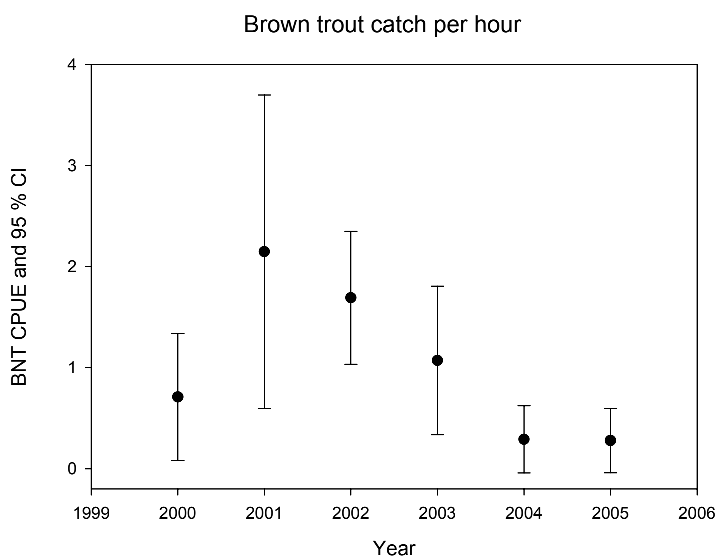

Figure 5. Mean catch per unit effort for brown trout during 2000-2005, near the Little Colorado River (LCR reach RM 56-69), a tributary of the Colorado River. Bars represent 95% confidence intervals of the mean.

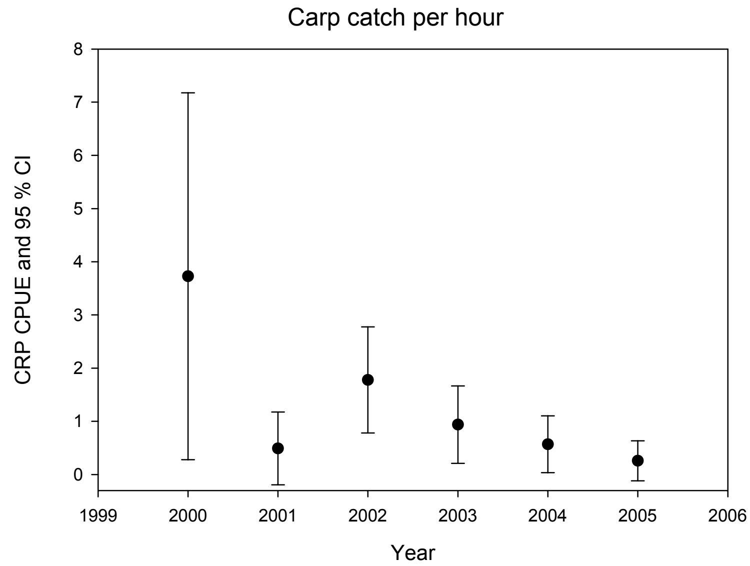

Figure 6. Mean catch per unit effort for common carp during 2000-2005, near the Little Colorado River (LCR reach RM 56-69), a tributary of the Colorado River. Bars represent 95% confidence intervals of the mean.

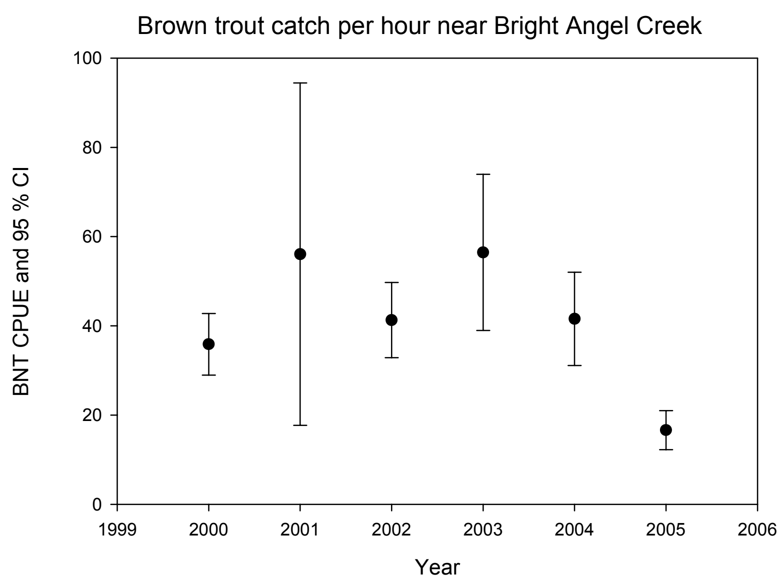

Figure 7. Mean catch per unit effort for brown trout during 2000-2005, near Bright Angel Creek (BAC reach RM 84.5-90), a tributary of the Colorado River. Bars represent 95% confidence intervals of the mean.

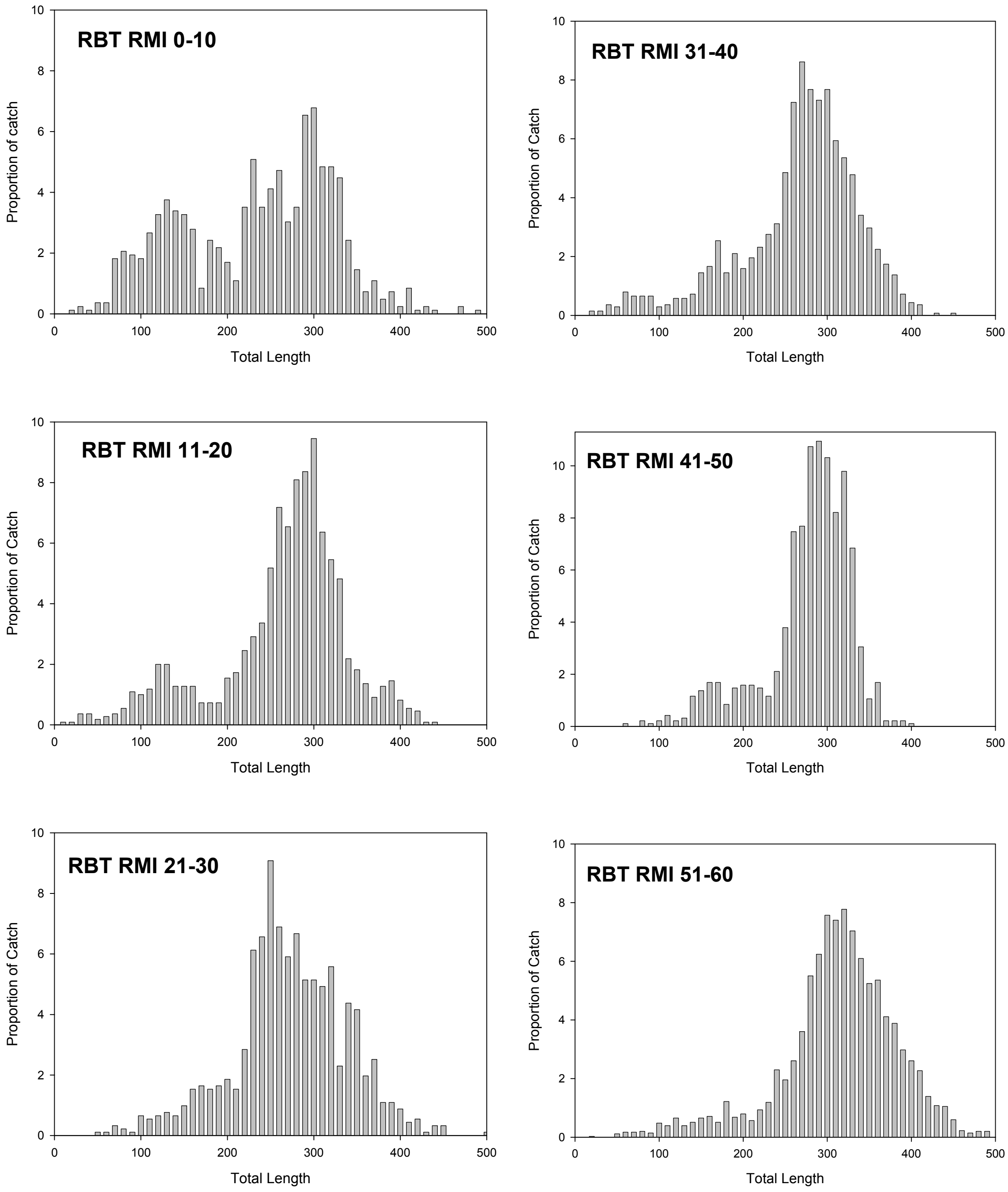

Figure 8. Length frequency histograms for rainbow trout indicating the proportion of fish of each size in the electrofishing catch for 10 mile increments progressing downstream from Lee's Ferry to the confluence with the Little Colorado River. All data 1991 – 2005.

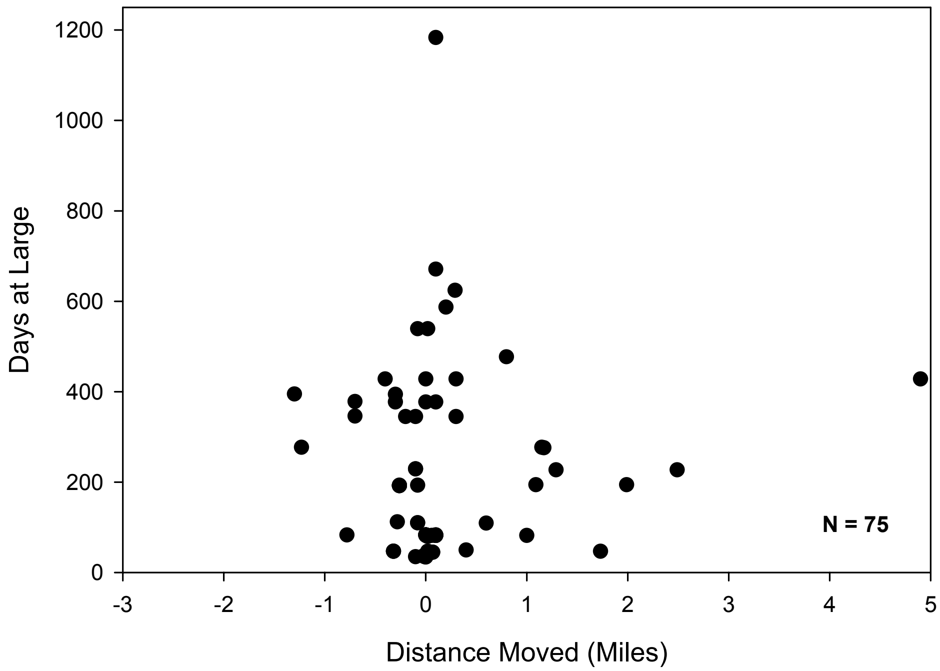

Figure 9. Distance traveled by days at large for brown trout recaptured (electroshocking data, Colorado River, Grand Canyon, 2000-2005. Negative miles indicated movement downstream. Seventy five recaptured fish at large for over 30 days.

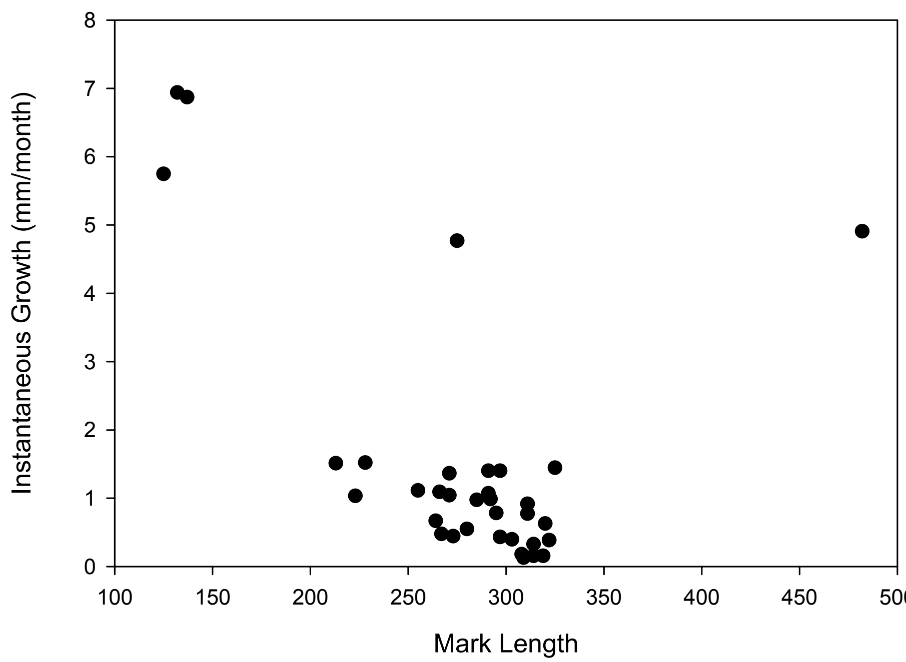

Figure 10. Instantaneous growth (mm/month) by length at capture for brown trout (BNT) with over 100 days between capture and recapture events (electroshocking data, Colorado River, Grand Canyon, 2000-2005).

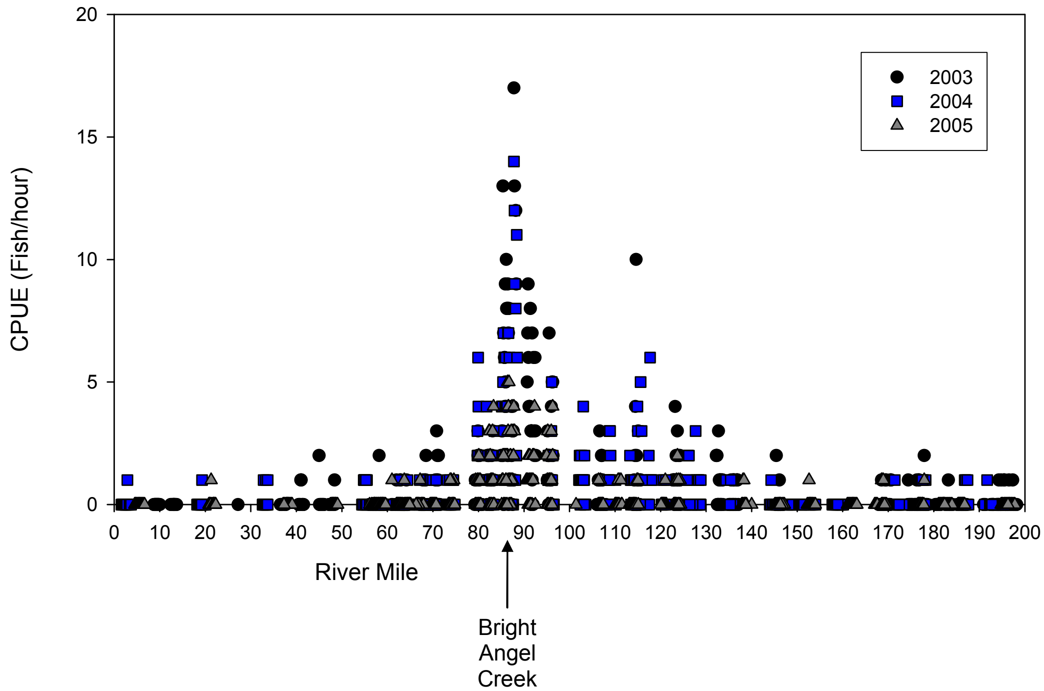

Figure 11. Mean CPUE of brown trout at sample sites along the Colorado River from Lee's Ferry to Diamond Creek (2003 – 3005). CPUE of brown trout is centered around Bright Angel Creek (RMI 88).

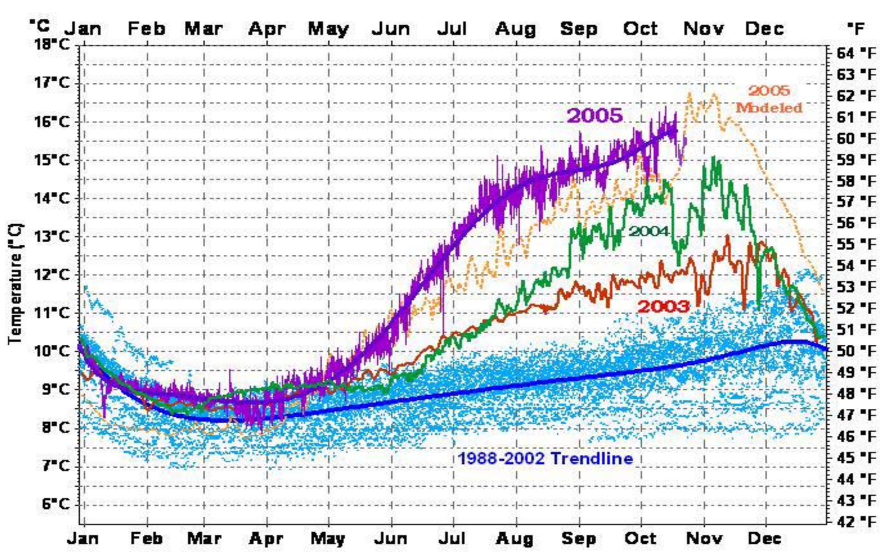

Figure created by Susan Hueftle (USGS)

Figure 12. Mainstem Colorado River water temperature below Glen Canyon Dam. Cloud of points represents 1988 – 2002 water temperatures.

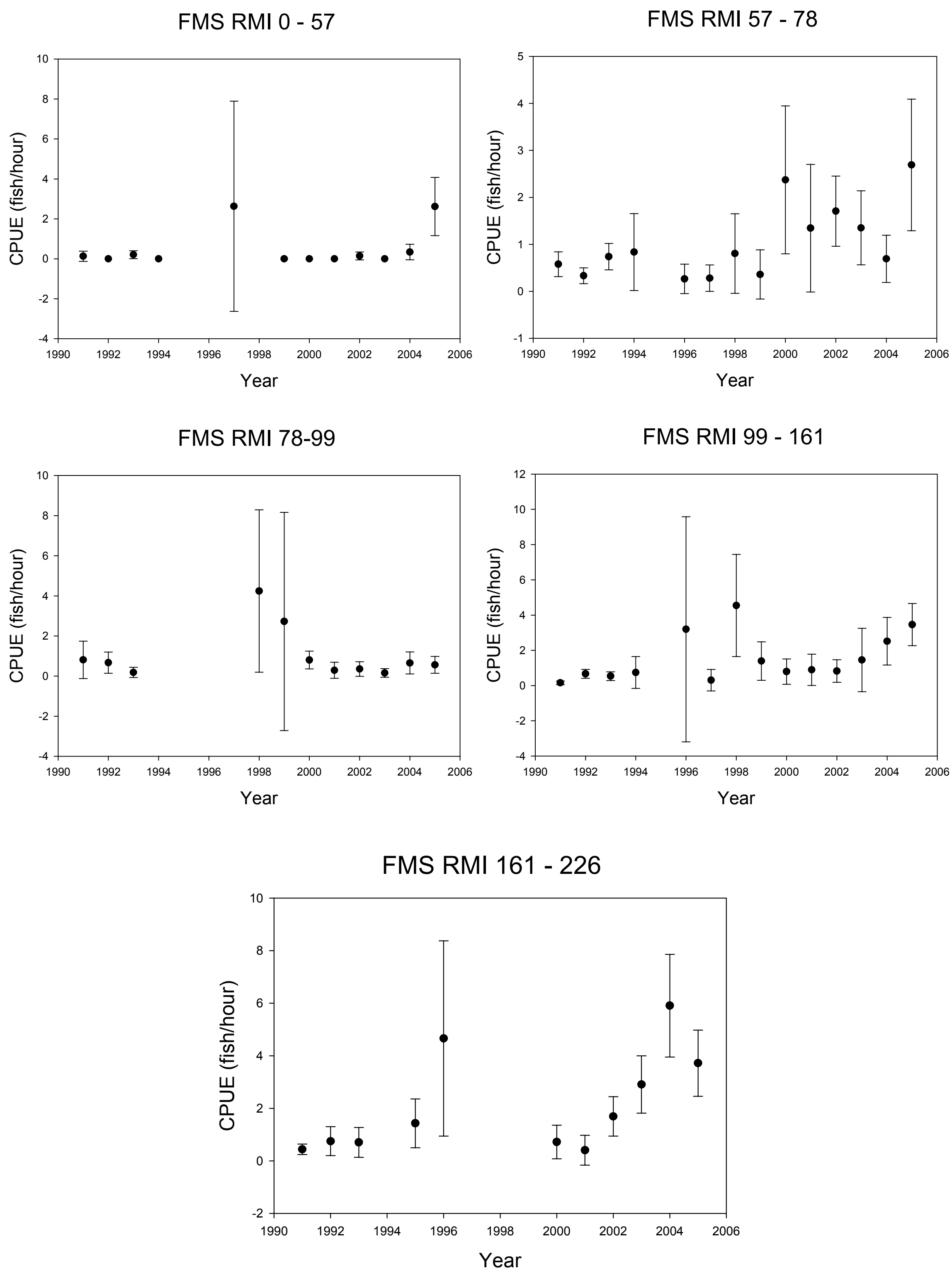

Figure 13. Flannelmouth sucker (FMS) catch per hour by sample reach and year for electrofishing done in the Colorado River, Grand Canyon (2000-2005, bars represent 95% confidence interval of mean).

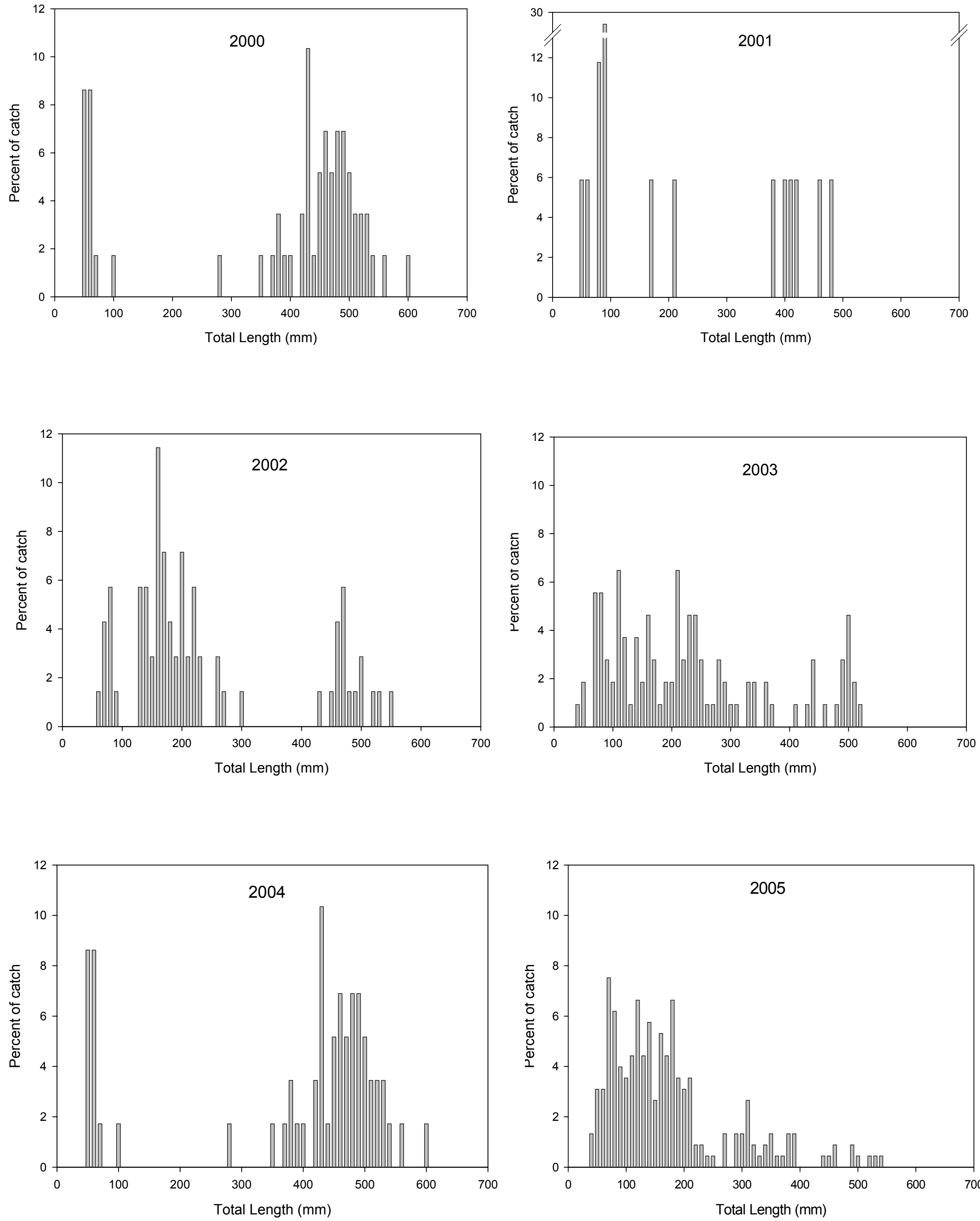

Figure 14. Percent of flannelmouth suckers (FMS) captured by length and year for electroshocking done in the Colorado River, Grand Canyon (2000-2005).

Appendices

Appendix 1. All native fish PIT tagged during 2005 fish monitoring using electrofishing.

DATE	RIVER	RM	SPECIES	TL	FL	PIT RECAP	PITTAG
5/17/05	COR	62.8	HBC	210	191	N	3D9.1BF1D86BFF
4/17/05	COR	48.5	FMS	490	461	Y	3D9.1BF199408B
4/19/05	COR	56.6	FMS	395	378	Y	3D9.1BF198C748
4/19/05	COR	56.6	FMS	466	443	N	3D9.1BF1D875BC
4/23/05	COR	91.4	FMS	385	370	N	3D9.1BF1CD525C
4/23/05	COR	91.8	FMS	386	366	N	3D9.1BF1CD2925
4/26/05	COR	120.3	FMS	396	372	N	3D9.1BF1A0A499
4/26/05	COR	120.7	FMS	348	332	N	3D9.1BF1A079F2
4/26/05	COR	120.7	FMS	180	170	N	3D9.1BF1A06831
4/26/05	COR	120.7	FMS	332	315	N	3D9.1BF1A05366
4/26/05	COR	120.7	FMS	369	350	N	3D9.1BF1A089E3
4/26/05	COR	121	FMS	210	198	N	3D9.1BF1CD413E
4/26/05	COR	121.1	FMS	224	210	N	3D9.1BF1CD4464
4/26/05	COR	120.8	FMS	310	292	N	3D9.1BF1AF9A98
4/26/05	COR	120.6	FMS	314	296	Y	3D9.1BF1CD55A4
4/26/05	COR	120.6	FMS	214	201	N	3D9.1BF1CD2422
4/26/05	COR	120.4	FMS	160	148	N	3D9.1BF1A05AA9
4/26/05	COR	120.4	FMS	314	290	N	3D9.1BF1CD2FB6
4/27/05	COR	146	FMS	395	372	N	3D9.1BF1CD3723
4/27/05	COR	146	FMS	358	336	N	3D9.1BF1A09A7D
4/27/05	COR	145.3	FMS	449	426	N	3D9.1BF1D8604B
4/28/05	COR	161.7	FMS	210	196	N	3D9.1BF1CD12A2
4/28/05	COR	161.8	FMS	387	371	N	3D9.1BF1CD37D9
4/28/05	COR	161.9	FMS	300	281	N	3D9.1BF1AF9507
4/28/05	COR	162.7	FMS	346	325	N	3D9.1BF1CD33E0
4/28/05	COR	162.9	FMS	325	305	N	3D9.1BF1CD2EE2
4/29/05	COR	176.9	FMS	160	142	N	3D9.1BF1E91728
4/29/05	COR	177.2	FMS	276	262	N	3D9.1BF1E8D571
4/30/05	COR	185.5	FMS	182	178	N	3D9.1BF1A0AB01
4/30/05	COR	186	FMS	201	190	N	3D9.1BF1CD2D9F
4/30/05	COR	186.2	FMS	505	485	N	3D9.1BF1D86319
4/30/05	COR	186.3	FMS	185	168	N	3D9.1BF1A54469
4/30/05	COR	186.7	FMS	185	174	N	3D9.1BF1A07784
4/30/05	COR	186.1	FMS	190	176	N	3D9.1BF1E879BE
5/1/05	COR	196.5	FMS	182	175	N	3D9.1BF1CD268A
5/1/05	COR	196.5	FMS	162	153	N	3D9.1BF1A0A9F5
5/1/05	COR	196.5	FMS	188	176	N	3D9.1BF1CD2B73
5/1/05	COR	197.1	FMS	160	149	N	3D9.1BF1CD2F17
5/1/05	COR	197.4	FMS	180	163	N	3D9.1BF1A0A42F
5/1/05	COR	194.8	FMS	190	179	N	3D9.1BF1A024AF
5/1/05	COR	194.8	FMS	212	200	N	3D9.1BF1D87BF7
5/1/05	COR	194.8	FMS	187	179	N	3D9.1BF1CD406A
5/1/05	COR	194.9	FMS	190	180	N	3D9.1BF1CCFF52
5/1/05	COR	194.9	FMS	351	336	N	3D9.1BF1E86758
5/1/05	COR	194.9	FMS	166	155	N	3D9.1BF1A04489
5/1/05	COR	195.7	FMS	152	145	N	3D9.1BF1CD08D8

Appendix 1 continued.

DATE	RIVER	RM	SPECIES	TL	FL	PIT RECAP	PITTAG
5/1/05	COR	196.1	FMS	171	160	N	3D9.1BF1A0537E
5/2/05	COR	210.1	FMS	198	145	N	3D9.1BF1A0AA5D
5/2/05	COR	211.1	FMS	172	159	N	3D9.1BF1AF9719
5/3/05	COR	224.4	FMS	162	152	N	3D9.1BF1CD28E8
5/14/05	COR	4.6	FMS	464	442	Y	3D9.1BF198F1C3
5/17/05	COR	62.5	FMS	159	147	N	3D9.1BF1CD30E5
5/19/05	COR	74.4	FMS	170	164	N	3D9.1BF1AF888D
5/19/05	COR	74.4	FMS	198	185	N	3D9.1BF1CD3A21
5/19/05	COR	74.4	FMS	163	153	N	3D9.1BF1CD4025
5/18/05	COR	67.8	FMS	276	260	Y	3D9.1BF1A0DC69
5/18/05	COR	67.8	FMS	215	200	Y	3D9.1BF1AC5353
5/19/05	COR	73.6	FMS	232	218	N	3D9.1BF1A06290
5/19/05	COR	73.6	FMS	199	186	N	3D9.1BF1AFA2CA
5/19/05	COR	73.6	FMS	215	204	N	3D9.1BF1A0CAC5
5/25/05	COR	137.8	FMS	545	512	N	3D91BBF1CD480C
5/25/05	COR	137.8	FMS	309	292	N	3D9.1BF1CD450B
5/25/05	COR	138.1	FMS	450	422	N	3D9.1BF1CD2ADD
5/25/05	COR	138.5	FMS	530	508	N	3D9.1BF1A09AED
5/21/05	COR	86.6	FMS	189	179	N	3D9.1BF1CD52BE
5/21/05	COR	87.4	FMS	237	221	N	3D9.1BF1A0AA97
5/24/05	COR	123	FMS	203	191	N	3D9.1BF1D8935F
5/24/05	COR	122.9	FMS	217	201	N	3D9.1BF1A04861
5/24/05	COR	123.1	FMS	208	196	N	3D9.1BF1CD6463
5/25/05	COR	138.7	FMS	373	353	N	3D9.1BF1CD43D6
5/25/05	COR	138.7	FMS	315	295	N	3D9.1BF1CD3FE9
5/25/05	COR	138.9	FMS	157	148	N	3D9.1BF1CD57FC
5/25/05	COR	140	FMS	192	180	N	3D9.1BF1E87E93
5/25/05	COR	140	FMS	205	191	N	3D9.1BF1A05874
5/25/05	COR	140	FMS	202	195	N	3D9.1BF1CD3239
5/25/05	COR	140	FMS	493	459	N	3D9.1BF1CD2926
5/26/05	COR	152.6	FMS	312	290	N	3D9.1BF1CCF273
5/26/05	COR	152.6	FMS	307	292	N	3D9.1BF1A08057
5/24/05	COR	124.3	FMS	242	227	N	3D91BF1CD226C
5/27/05	COR	168.5	FMS	172	163	N	3D9.1BF1CD2436
5/27/05	COR	168.5	FMS	176	163	N	3D9.1BF1CD73B8
5/27/05	COR	168.5	FMS	162	154	N	3D9.1BF1E89292
5/27/05	COR	168.5	FMS	186	173	N	3D9.1BF1A08F42
5/27/05	COR	168.7	FMS	170	159	N	3D9.1BF1CD22B5
5/27/05	COR	168.8	FMS	177	161	N	3D9.1BF1A061A3
5/27/05	COR	168.8	FMS	160	152	N	3D9.1BF1A04981
5/27/05	COR	168.8	FMS	164	156	N	3D9.1BF1CCF53F
5/27/05	COR	167.1	FMS	186	172	N	3D9.1BF1CD51BB
5/27/05	COR	167.3	FMS	155	148	N	3D9.1BF1E89284
5/21/05	COR	86.9	FMS	214	203	N	3D9.1BF1CD283C
5/28/05	COR	183.1	FMS	255	238	N	3D9.1BF1CD2D27
5/28/05	COR	183.5	FMS	206	191	N	3D9.1BF1CD5D7B
5/29/05	COR	206	FMS	167	156	N	3D9.1BF1A0C2C2
5/29/05	COR	206.7	FMS	170	160	N	3D9.1BF1CD2398
5/23/05	COR	113.7	FMS	183	171	N	3D9.1BF1D86EDD
5/23/05	COR	114.4	FMS	296	282	N	3D9.1BF1A0A749
5/23/05	COR	114.8	FMS	174	165	N	3D9.1BF1A033B2

Appendix 1 continued.

DATE	RIVER	RM	SPECIES	TL	FL	PIT RECAP	PITTAG
5/24/05	COR	123.3	FMS	200	187	N	3D9.1BF1CD35D2
5/24/05	COR	124	FMS	180	166	N	3D9.1BF1A0624C
5/28/05	COR	181.1	FMS	270	151	N	3D9.1BF1A055DF
5/17/05	COR	63.2	FMS	298	285	Y	3D9.1BF1A0D17D
5/22/05	COR	95.3	FMS	315	299	N	3D9.1BF1CD3B2E
5/27/05	COR	169.1	FMS	179	167	N	3D9.1BF1CD3C0C
5/28/05	COR	181.9	FMS	191	176	N	3D9.1BF1A0C618
5/28/05	COR	182.2	FMS	290	275	N	3D9.1BF1A099D2
5/28/05	COR	182.2	FMS	187	178	N	3D9.1BF1CD399E
5/28/05	COR	182.2	FMS	161	150	N	3D9.1BF1CD2DEA
5/30/05	COR	221.7	FMS	223	206	N	3D9.1BF1CD2B81
4/20/05	COR	69.9	BHS	246	233	N	3D9.1BF1CD3B13
4/21/05	COR	80.1	BHS	166	152	N	3D9.1BF1CD3695
4/23/05	COR	91.8	BHS	196	182	N	3D9.1BF1A04BED
4/25/05	COR	110	BHS	223	200	N	3D9.1BF1CD3845
4/26/05	COR	120.4	BHS	187	173	N	3D9.1BF1CD4B9E
4/26/05	COR	120.4	BHS	190	182	N	3D9.1BF1CD3518
4/26/05	COR	120.2	BHS	174	163	N	3D9.1BF1A02BD8
4/27/05	COR	145.1	BHS	166	153	N	3D9.1BF1A0B0D4
4/27/05	COR	145.1	BHS	206	192	N	3D9.1BF1A07505
4/27/05	COR	145.1	BHS	195	180	N	3D9.1BF1D87ACE
4/27/05	COR	145.1	BHS	181	168	N	3D9.1BF1A04BE9
4/27/05	COR	145.5	BHS	235	220	N	3D9.1BF1CD4B50
4/27/05	COR	145.5	BHS	185	172	N	3D9.1BF1A09D77
4/27/05	COR	145.6	BHS	282	264	N	3D9.1BF1A085A0
4/27/05	COR	145.8	BHS	172	155	N	3D9.1BF1A0B3CF
4/27/05	COR	145.9	BHS	195	180	N	3D9.1BF1CD5DEF
4/27/05	COR	146.1	BHS	205	193	N	3D9.1BF1E92219
4/27/05	COR	146.1	BHS	162	151	N	3D9.1BF1A0B520
4/28/05	COR	161.5	BHS	182	171	N	3D9.1BF1A05532
4/29/05	COR	177.5	BHS	242	232	N	3D9.1BF1CD54B4
4/29/05	COR	177.8	BHS	173	162	N	3D9.1BF1CD3B4F
4/30/05	COR	186.8	BHS	176	170	N	3D9.1BF1A068BF
5/17/05	COR	62.5	BHS	222	203	N	3D9.1BF1A0B2DD
5/17/05	COR	62.6	BHS	196	182	N	3D9.1BF1A0B688
5/20/05	COR	86	BHS	203	192	N	3D9.1BF1AF9393
5/18/05	COR	67.8	BHS	205	192	N	3D9.1BF1D86F18
5/25/05	COR	137.8	BHS	190	176	N	3D9.1BF1A08FD7
5/25/05	COR	137.9	BHS	226	215	N	3D9.1BF1CD3DCE
5/25/05	COR	138.1	BHS	160	148	N	3D9.1BF1CD5921
5/22/05	COR	95.6	BHS	156	140	N	3D9.1BF1CD2C6B
5/22/05	COR	95.6	BHS	156	142	N	3D9.1BF1CD349C
5/22/05	COR	96	BHS	169	156	N	3D9.1BF1CD5164
5/24/05	COR	123.1	BHS	199	186	N	3D9.1BF1CD4EFD
5/26/05	COR	152.3	BHS	174	162	N	3D9.1BF1D86495
5/26/05	COR	152.6	BHS	166	152	N	3D9.1BF1CD71C5
5/26/05	COR	153.3	BHS	152	141	N	3D9.1BF1CD1259
5/27/05	COR	168.6	BHS	225	213	N	3D9.1BF1A029D5
5/23/05	COR	114.1	BHS	196	182	N	3D9.1BF1E92ABC
5/23/05	COR	114.1	BHS	270	251	N	3D9.1BF1CD32DA
5/24/05	COR	122.9	BHS	172	159	N	3D9.1BF1A0B904

Appendix 1 continued.

DATE	RIVER	RM	SPECIES	TL	FL	PIT RECAP	PITTAG
5/24/05	COR	123.3	BHS	157	148	N	3D9.1BF1AF888B
5/24/05	COR	123.6	BHS	162	151	N	3D9.1BF1A0942D
5/27/05	COR	167.4	BHS	245	233	N	3D9.1BF1CD7FFE
5/26/05	COR	152.6	BHS	267	252	N	3D9.1BF1D8C46C
5/28/05	COR	182.2	BHS	257	242	N	3D9.1BF1CD2B54
5/28/05	COR	182.3	BHS	319	302	N	3D9.1BF1D8674B

Appendix 2. Dates and locations of camps and samples collected during 2005 sampling. Logistic reaches and start miles within logistic reaches were randomly selected.

TRIP1

Day	Date	Miles available	Reach	Travel miles	Camp RM	Camp	Left RM	Right RM
1	4/15/2005					**RIG**		
2	4/16/2005	2.4	1.5	23	23	23 Mile	21.1	21.1
3	4/17/2005	8.3	2.3	24	47	Saddle	47.9	47.5
4	4/18/2005	9.5	3.1	13.6	60.6	Science camp	61.0	62.0
5	4/19/2005	9.5	3.1	0	60.6	Science camp	63.0	64.0
6	4/20/2005	3.8	4.1	10.4	71	Cardenas	68.7	68.9
7	4/21/2005	2.4	5.1	10.2	81.2	Grapevine	78.9	79.1
8	4/22/2005	2.9	5.2	3	84.2	Clear Ck	82.3	82.9
9	4/23/2005	3.3	5.4	9.2	93.4	Above Granite	90.5	91.2
10	4/24/2005	2.5	5.7	14.3	107.7	Upper Bass	106.1	106.1
11	4/25/2005	3.7	6.1	1.6	109.3	109 mi	109.2	108.7
12	4/26/2005	6.2	6.3	10.7	120	Blacktail	120.1	120.3
13	4/27/2005	6.2	7.7	25.7	145.7	Olo	146.2	145.1
14	4/28/2005	9.6	7.9	18.8	164.5	Tuckup	162.5	160.7
15	4/29/2005	12.9	8.1	12.5	177	Honga Spring	176.7	176.6
16	4/30/2005	10.2	9.1	9.2	186.2	186 mi	185.3	185.3
17	5/1/2005	10	9.2	12.4	198.6	Parashant	196.3	194.7
18	5/2/2005	10.8	10.3	12.9	211.5	Fall Cnyn	209.3	210.5
19	5/3/2005	5	11.1	13	224.5	224 mi	223.7	224
20	5/4/2005					**TAKE OUT**		

TRIP 2

Day	Date	Miles available	Reach	Travel miles	Camp RM	Camp	L start mi	R start mi
1	5/13/2005					**RIG**		
2	5/14/2005	6.8	1.1	5.8	5.8	6 mile wash	4.5	5.5
3	5/15/2005	7.7	2.2	31.5	37.3	Tatahatso	37.2	38.1
4	5/16/2005	9.5	3.1	23.3	60.6	Science camp	56.0	57.0
5	5/17/2005	9.5	3.1	0	60.6	Science camp	58.0	58.5
6	5/18/2005	3	3.2	8	68.6	Tanner	66.2	66.4
7	5/19/2005	2.9	4.2	5.7	74.3	Below Escalante	73.1	73.5
8	5/20/2005	3.8	5.3	12.7	87	Cremation	85.5	85.0
9	5/21/2005	3.8	5.3	0	87	Cremation	87.4	86.0
10	5/22/2005	2.9	5.6	9	96	96 mi	95.1	95.1
11	5/23/2005	4.1	6.2	18	114	Garnet	113.1	114
12	5/24/2005	2.3	6.4	10	124	124 Mile	122.9	123
13	5/25/2005	1.3	7.5	15	139	Above fishtail	137.8	137.8
14	5/26/2005	7.1	7.8	16.5	155.5	155.5mi	154.2	154.6
15	5/27/2005	12.9	8.1	15.5	171	Stairway	169.3	170
16	5/28/2005	10.2	9.1	11.8	182.8	182 mi	180.5	182
17	5/29/2005	3.2	10.2	25.2	208	208 mi	205.7	206.1
18	5/30/2005	5	11.1	16.5	224.5	224 mi	220.8	222
19	5/31/2005					**Diamond Re-rig**		

Appendix 3. Common and scientific names as well as three-letter abbreviations of species listed in this report.

Scientific Name	Common Name	Abbreviation
Oncorhynchus mykiss	Rainbow trout	RBT
Salmo trutta	Brown trout	BNT
Cyprinus carpio	Common carp	CRP
Gila cypha	Humpback chub	HBC
Rhinichthys osculus	Speckled dace	SPD
Pimephales promelas	Fathead minnow	FHM
Cyprinella lutrensis	Red shiner	RSH
Catostomus latipinnis	Flannelmouth sucker	FMS
Catostomus discobolus	Bluehead sucker	BHS
Ictalurus punctatus	Channel catfish	CCF
Ictalurus melas	Black bullhead	BBH
Morone saxatilis	Striped bass	STB

Appendix 4. Personnel involved in AGFD monitoring trips in 2005 (April and May).

Trip 1		
Crew Member	**Duty**	**Agency**
Scott Rogers	Biologist	Arizona Game and Fish Department
Joe Slaughter	Biologist	Arizona Game and Fish Department
Teresa Hunt	Technician	Arizona Game and Fish Department
Theo Hunt	Volunteer	Volunteer
Crescent Scudder	Volunteer	Volunteer
Andi Rogers	Volunteer	Volunteer
Sarah Lantz	Volunteer	Volunteer
Brian Reif	Volunteer	Volunteer
Karla K	Volunteer	Volunteer
Brian Dierker	Boat Operator	Humphrey Summit
Stewart Reeder	Boat Operator	Humphrey Summit
Brent Berger	Boat Operator	Humphrey Summit
Brett Starr	Boat Operator	Humphrey Summit
Scott Perry	Boat Operator	Humphrey Summit
Carol Fritzinger	Logistics	Grand Canyon Monitoring and Research Center

Trip 2		
Crew Member	**Duty**	**Agency**
Scott Rogers	Biologist	Arizona Game and Fish Department
Teresa Hunt	Technician	Arizona Game and Fish Department
David Ward	Biologist	Arizona Game and Fish Department
Nathan	Volunteer	Volunteer
Robyn Forrest	Volunteer	Volunteer
Nathan Lockhart	Volunteer	Volunteer
Paul Evans	Volunteer	Volunteer
Pete Polsgrove	Volunteer	Volunteer
Steve Jones	Boat Operator	Humphrey Summit
Stewart Reeder	Boat Operator	Humphrey Summit
Trevor Lugers	Boat Operator	Humphrey Summit
Mat	Boat Operator	Humphrey Summit
Carol Fritzinger	Logistics	Grand Canyon Monitoring and Research Center