Grand Canyon Long-term Non-native Fish Monitoring, 2003 Annual Report

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Introduction

Robust long-term monitoring of aquatic populations is important to adaptive management programs because it 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). Long-term fish monitoring in the Colorado River below Glen Canyon Dam (GCD) is an essential component of the Glen Canyon Dam Adaptive Management Program. This monitoring ensures that GCD is operated in a manner consistent with the pertinent sections of Grand Canyon Protection Act of 1992 [Grand Canyon Monitoring and Research Center (GCMRC) 2001a].

Non-native salmonids, rainbow (*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 depredation by salmonids is a factor limiting recruitment of native fishes in the Colorado River in Grand Canyon (Minckley 1991; Marsh and Douglas 1997; Coggins unpublished data; U.S. Department of Interior 2002). As a result of these findings, the GCMRC Protocol Evaluation Program has advocated long-term monitoring of non-native fish species that pose risk of predation to Colorado River native fishes in Grand Canyon (GCMRC 2001b).

Working under cooperative agreement with GCMRC, Arizona Game and Fish Department (AGFD) conducted studies on relative abundance, distribution, and sampling requirements for long-term monitoring of RBT, BNT, and common carp (*Cyprinus* *carpio*, CRP) in Grand Canyon during 2000 - 2003 (AGFD 2001; Speas *et al*. 2002). Herein we report the results from non-native fish monitoring activities in the mainstem Colorado River in Grand Canyon during 2003. Specific objectives during 2003 were to:

1. Evaluate trends in salmonid and carp relative density and distribution during 2000 – 2003.
2. Reevaluate required annual sample sizes and sample allocation for long-term monitoring of salmonids and carp in Grand Canyon.
3. Evaluate growth rates and movement of BNT in Grand Canyon by utilizing mark recapture data from 2000 to 2003.
4. Investigate the potential of electroshocking in the mainstem as a monitoring tool for native fish species.
5. Evaluate the ability of our monitoring to measure changes in non-native fish densities in the mechanical removal reach (Little Colorado River).

Methods

We collected electrofishing (EF) samples from April 5 – 21 and from May 3–20, 2003 between river mile (RM) 0 and RM 226 on the Colorado River in Grand Canyon. Daily river discharge at GCD ranged from 6,000 to 13,500 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 electroshocking boatmen piloted the electroshocking 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 one night each trip because of high winds and rain (Tables 1 & 2).

In 2002 we used the sample power program Sampling.exe (Walters, unpublished) to determine appropriate sample sizes and distribution of effort for RBT, BNT, and CRP. Using variance estimates (coefficient of variation, CV) from existing Grand Canyon fisheries data (2000–2002), 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). In 2003 we reevaluated the program Sampling.exe and discovered inconsistencies in the spatial allocation of effort. To solve this problem, we reformatted the sample allocation part of this program in Excel so that effort was scaled by the number of linear river miles per reach.

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 guide map and recorded (Stevens 1983).

We recorded maximum total length (TL mm) of each captured fish (Ward 2002). We 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. 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 2003. Daily growth rates for 2000–2003 (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 used a modified Fabens method to estimate von Bertalanffy length-at-age (Wang 1998). We compared this growth rate with that observed by tracking a BNT cohort (percent of BNT captured by length, 2000-2003).

We calculated mean CPUE for each of three boat drivers who were on our trips in 2002 and/or 2003 to estimate the effect of different boat drivers on CPUE. Each of three boat drivers shocked at the same time of the day and in similar locations over the course of these four trips.

We plotted percent of captures by length, year and species (RBT and BNT) for 2000–2003 to examine cohort strength among years. Flannelmouth sucker (FMS) CPUE by sampling reach and year was calculated to investigate the utility of electroshocking for monitoring this species.

We cross-validated predictions of Sampling.exe by bootstrapping trip CVs and 95% confidence intervals from the entire 2000– 2002 data set over a range of sample sizes (N=100–1,000) using Resampling Stats 2.0 for MS Excel. We resampled 2000–2003 data to remove effort bias by sampling reach from this analysis. The number of samples resampled for each sampling reach was proportional to the number of miles in each sampling reach. We inspected the bootstrapped confidence intervals to approximate minimum detectable yearly changes in salmonid and CRP abundance river-wide and for areas and species of special concern (RBT at the Little Colorado River reach [LCR, RM 56–69] and BNT at Bright Angel Creek reach [BAC, RM 84.5 –90]). Minimum yearly detectable linear changes over 5-year periods were investigated using boot strapped CVs and Trends shareware (http://swfsc.nmfs.noaa.gov/prd/software , Gerrodette 1987).

Results

In April 2003, 379 samples were collected averaging 328 seconds each over 16 nights with a total of 1429 fish captured from 8 species (Table 1). In May, 418 samples were collected averaging 325 seconds each over 17 nights with a total of 1296 fish captured from 9 species (Table 2). Mean relative densities of RBT (Fig. 1), BNT (Fig. 2), and CRP (Fig. 3) were similar from 2000 to 2003 with densities of RBT, BNT, and CRP being highest in Marble Canyon, near BAC and downriver of BAC, respectively.

Mean catch per unit effort in the LCR experimental reach was 24 fish/h in 2003, whereas in 2001 and 2002 the CPUE was 62 fish/h and 70 fish/h respectively. This represents a 62 % decrease in RBT CPUE in the experimental reach (Fig. 4). There was no evidence of a reduction in BNT (Fig. 5) and CRP (Fig. 6) mean relative densities. Mean CPUE of BNT in the BAC reach (Figure 7) was similar from 2000 to 2003.

Mean CPUE of RBT with boatman A was lower than boatman B in 2002 and boatman C in 2003 (Figure 8). Sampling sites were assigned randomly throughout the canyon to eliminate bias, and each boatman shocked similar environments.

Brown trout mark-recapture data showed no evidence of long distance movement by this species. The furthest distance traveled was 3 miles (Figure 9). Analyses of BNT catch by year revealed a strong mode of adult fish between 250 mm and 350 mm and modes of possible age-0, age-1 and age-2 fish for the years 2000, 2001 and 2002, respectively (Figure 10). Modeled BNT mark recapture data produced von Bertalanffy length-at age that is similar to the observed cohort growth (Figure 11). Most BNT showed growth similar to that observed in RBT in this system. Instantaneous growth rates (mm/day) indicate that most BNT reach a maximum length near 350 mm (Figure 12).

Analyses of RBT catch by year revealed a strong mode between 200 mm and 375 mm and modes of age 0 and age 1 fish for the years 2000 and 2001, respectively (Figure 10). Bootstrapped CVs (N=800) for RBT, BNT, CRP, and FMS from the 2000–2003 resampled data were 0.09, 0.10, 0.09, and 0.22 respectively. Estimated linear detectable increases in CPUE over five years based on bootstrapped 80% confidence intervals were 23% for RBT, 26% for BNT, 23% for CRP, and 68% for FMS. Estimated linear detectable decreases in CPUE were 19% for RBT, 21% for BNT, 19% for CRP, and 41% for FMS.

Yearly detectable changes in RBT abundance in the LCR experimental removal reach were reduced in 2003 with the reduction of RBT density. We could detect a 36% yearly change in CPUE with a sample size of 100 electroshocking samples prior to the removal experiment. We can currently measure a 54% or greater change (Figure 13).

There was an apparent increase in FMS CPUE in sampling reaches 8 and 9 in 2003 (Figure 14). 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 multiple juvenile size classes and strong recruitment from 2000 or 2001 (Figure 15).

Discussion

The sampling conducted in 2002 and 2003 (N > 800) represents what we believe is necessary for long-term monitoring of salmonids and carp in the Grand Canyon. Electroshocking may also be adequate for monitoring flannelmouth suckers in the canyon.

Although the impetus for large-scale monitoring came in the spring of 2000, much of our time prior to 2003 was spent calculating catchability coefficients for BNT and RBT mean relative densities for population estimates. The number of samples taken in 2000 (N= 413) and 2001 (N= 234) were inadequate to capture 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. However, power varies among reaches. The current sampling design yields a much more sensitive monitoring tool for 5-year linear changes in CPUE. Data from 2000–2003 show no overall changes in CPUE of RBT, BNT and CRP.

We did not expect or observe much movement of BNT over the past three years. 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). It is our recommendation that tagging of BNT continues. Our 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.

The analyses of lengths by trip for BNT and RBT suggest that the low summer steady flows of 2000 resulted in relatively strong recruitment of both RBT and BNT. The modes observed in the RBT data match length-at-age calculated for age-0 and age-1 RBT from Lees Ferry (McKinney *et al*. 1999). The computed length-at-age for BNT from mark-recapture data collected primarily in the BAC reach shows a growth rate that matches both length-at-age calculations and movement of the BNT cohort through time.

Brown trout at BAC show relatively slow growth for this species. However, large BNT were captured occasionally throughout Grand Canyon. Resident BAC BNT may differ in growth rates than BNT in other areas of the canyon. Future analysis of BNT otoliths may provide additional insight on growth of this species.

The sampling design used in 2003 was established to detect river-wide population trends for large bodied non-native fishes. Evaluating localized management actions, such as mechanical removal of RBT in the LCR reach, requires more intensive sampling than long-term monitoring would allocate. In 2000 and 2001, insufficient samples (N=41, and N=47 respectively) were taken in the LCR reach, and in 2001 inadequate sampling (N = 38) was done in the BAC reach to detect yearly or short-term trends as is evidenced by extremely wide confidence intervals. The extensive sampling that took place in the BAC (N=197) and LCR (N= 147) reaches in 2002 and 2003 is indicative of the effort that will be necessary to detect localized trends. However, reduced densities of trout in the LCR reach and corresponding lower CPUE will reduce our ability to detect change in this reach.

There is an apparent difference in the CPUE between elecrofishing boats. Variation in catch between boats may be caused by the individual boat driver (Hardin and Connor 1992). 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. 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). All of our sampling has used the same three boat drivers, but future changes in boat driver may increase variance in the dataset and potentially confound CPUE trends. We strongly recommend any new boat drivers receive training prior to monitoring trips. We also recommend that information on the specific electronic units (CPS units) used on each boat along with the name of the boat driver be recorded so that differences in catch can be evaluated further.

The sampling design used in most recent years (2002–2003) appears to be working well, and the level of effort appears to be appropriate for monitoring of RBT, BNT, and CRP in Grand Canyon. We also detected an increase in FMS CPUE in 2003 and electroshocking appears to be an effective tool for monitoring this species.

In 2004 we intend to repeat the sampling effort of 2003. In addition we will collect otoliths from brown trout to better understand growth of this species. 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.

Literature Cited

Arizona Game and Fish Department. June 2001. Salmonid population size in the Colorado River, Grand Canyon, Arizona. Fishery Fact Sheet.

Bayley, P.B., and D..J. Austen. 2002. Capture efficiency of a boat electrofisher. Transactions of the American Fisheries Society 131:435-451.

Gerrodette, T. 1987. A power analysis for detecting trends. Ecology 68:1364-1372.

Grand Canyon Monitoring and Research Center. 2001a. Fiscal year 2003 monitoring and research work plan. Grand Canyon Monitoring and Research Center, Flagstaff, AZ.

Grand Canyon Monitoring and Research Center. 2001b. Final report of the aquatic protocol evaluation program panel. Grand Canyon Monitoring and Research Center, Flagstaff, AZ.

Hardin, S. and L.L. Connor. 1992. Variability of electrofishing crew efficiency, and sampling requirements for estimating reliable catch rates. North American Journal of Fisheries Management 12:612-617.

Marsh, P.C., and M.E. Douglas 1997. Predation by introduced fishes on endangered humpback chub and other native species in the Little Colorado River, Arizona. Transactions of the American Fisheries Society 126: 343-346.

McInery, M.C., and T..K. Cross. 2000. Effects of sampling time, intraspecific density, and environmental variables on electrofishing catch per effort of largemouth bass in Minnesota lakes. North American Journal of Fisheries Management 20:328-336.

McKinney, T., D.W. Speas, R.S. Rogers and W.R. Persons. 1999. Rainbow trout in the Lee's Ferry recreational fishery below Glen Canyon Dam, Arizona, following establishment of minimum flow requirements. Final Report. Grand Canyon Monitoring and Research Center.

McKinney, T., D.W. Speas, R. S. Rogers, and W.R. Persons. 2001. Rainbow trout in a regulated river below Glen Canyon Dam, Arizona, following increased minimum flows and reduced discharge variability. North American Journal of Fisheries Management 21:216-222.

Minckley, W.L. 1991. Native fishes of the Grand Canyon region: An obituary. Pages 125-177 in G. R. Marzolf, editor. Colorado River ecology and dam management, symposium proceedings. Santa Fe, New Mexico. National Academy Press, Washington DC.

Prentice, E.F., T.A. Flagg, C.S. McCutcheon, D.F. Brastow, and D.C. Cross. 1990. Equipment, methods and an automated data-entry station for PIT-tagging. American Fisheries Society Symposium 7:335-340.

Solomon, D.J. and R.G. Templeton. 1976. Movements of brown trout *Salmo trutta* L. in a chalk stream. Journal of Fish Biology 9:411-423.

Speas, D.W., D.L. Ward, R.S. Rogers, and W.R. Persons. 2002. Salmonid population size, relative density and distribution in the Colorado River in Grand Canyon during 2001 with reference to sampling designs for long term monitoring. Draft Annual Report. Arizona Game and Fish Department, Phoenix, AZ.

Speas, D.W., C.J. Walters, D.L. Ward, and R.S. Rogers. 2004. Effects of intraspecific density and environmental variables on electrofishing catchability of salmonids in a large river. North American Journal of Fisheries Management. 24:586-596.

Stevens, L. 1983. The Colorado River in Grand Canyon a guide. Red Lake Books. Flagstaff, Arizona.

Thomas, L. 1996. Monitoring long-term population change: why are there so many analysis methods? Ecology 77:49-58.

U.S. Department of Interior. 2002. Proposed experimental releases from Glen Canyon Dam and removal of non-native fishes. Environmental Assessment. U.S. Department of Interior.

Walters, C.J. 1997. Challenges in adaptive management of riparian and coastal ecosystems. Conservation Ecology 1:1. URL:http://consecol.org/vol1/iss2/art1

Walters, C.J. and C.S. Holling. 1990. Large-scale management experiments and learning by doing. Ecology 71:2060-2068.

Wang, Y.-G. 1998. An improved Fabens method for estimation of growth parameters in the von Bertalanffy model with individual asymptotes. Canadian Journal of Fisheries and Aquatic Sciences 55:397-400.

Ward, D. 2002. Standardized methods for handling fish in Grand Canyon research. Arizona Game and Fish Department, Flagstaff. Draft Report submitted to GCMRC.

Tables

Table 1. Number of runs, start mile, average seconds, and species captured by each boat during trip 1 (April 2003). 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
4/5/2003	A	12	8.7	3864	322	99								
4/5/2003	B	12	8.9	3761	313	199								
4/6/2003	A	12	47.2	4000	333	92	1							
4/6/2003	B	12	45	4169	347	179	2							
4/7/2003	A	12	58.2	3939	328	14				1				
4/7/2003	B	12	58.3	3923	327	18				2				
4/8/2003	A	10	67.2	3187	319	16	1			5	1			
4/8/2003	B	12	67.4	3862	322	23	4		1	1	1			
4/9/2003	A	12	79.6	3957	330	3	6							
4/9/2003	B	12	79.2	4150	346	34	11							
4/10/2003	A	12	85	4098	342	11	39	2						
4/10/2003	B	12	85.4	3950	329	25	91	2						
4/11/2003	A	12	91.5	3854	321	10	32	2						
4/11/2003	B	12	90.7	3900	325	22	60	5						
4/12/2003	A	12	95.1	4057	338	5	12	1						
4/12/2003	B	12	95.3	3914	326	14	32	6				1		
4/13/2003	A	12	106	3975	331	8	4	3						
4/13/2003	B	12	106.1	4002	334	16	14	14			2			
4/14/2003	A	0	127.0	High winds										
4/14/2003	B	0	127.3	High winds										
4/15/2003	A	12	132.5	3838	320	9	2	5						
4/15/2003	B	12	132.2	3914	326	24	14	16			2			
4/16/2003	A	12	167.9	3959	330		1	2		2				
4/16/2003	B	12	169.4	3846	321	2	4	8		5		2	1	
4/17/2003	A	12	185.2	4024	335			11		2				
4/17/2003	B	12	186.1	3834	320			39		13	2			
4/18/2003	A	5	192.5	1624	325			6		1				1
4/18/2003	B	4	190.9	1247	312	1		3		1		1		
4/19/2003	A	17	192.9	5691	335		1	15		7				1
4/19/2003	B	18	194	5810	323	1	3	27		1		2		
4/20/2003	A	12	212.2	3852	321	0	0	1						
4/20/2003	B	12	217	3962	330	0		20		1		1		
4/21/2003	A	13	222.4	4374	336			5						
4/21/2003	B	12	221.2	3816	318			13		2		1		
TOTAL		**379**		**124353**	**328**	**825**	**334**	**206**	**1**	**44**	**8**	**8**	**1**	**2**

Table 2. Number of runs, start mile, average seconds, and species captured by each boat during trip 2 (May 2003). 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
5/3/2003	A	8	12.4	2658	332	84								
5/3/2003	B	10	12.8	3235	324	87								
5/4/2003	A	12	36.5	3963	330	72								
5/4/2003	B	12	40.5	3781	315	101	2							
5/5/2003	A	12	61	4206	351	11				1	1			
5/5/2003	B	12	61.8	3790	316	11	3	1		5				
5/6/2003	A	12	63	3984	332	4		1						
5/6/2003	B	12	63	3855	321	11	1	3	1	1				1
5/7/2003	A	12	56	3857	321	94								
5/7/2003	B	12	57	3987	332	60	2							
5/8/2003	A	0	70	Rained out										
5/8/2003	B	0	71	Rained out										
5/9/2003	A	20	68.9	6392	320	54		1		2				
5/9/2003	B	19	69.7	6121	322	74	10			1	1	1		
5/10/2003	A	12	81.9	3789	316	16	11				1	1		
5/10/2003	B	12	82	3877	323	14	15				1			
5/11/2003	A	12	87.2	3819	318	9	19	3		1				
5/11/2003	B	12	87.2	3752	313	28	97			1				
5/12/2003	A	12	114	3958	330	9	5	8			1			
5/12/2003	B	12	114.5	3792	316	14	15	5		1				
5/13/2003	A	12	123	3851	321	6	16	6		2				
5/13/2003	B	12	122.7	4036	336	8	11	10			1			
5/14/2003	A	13	135	4207	324	15	3	4	1	1				
5/14/2003	B	12	135.9	3883	324	21	5	27		11				
5/15/2003	A	12	145.7	3861	322	8		2						
5/15/2003	B	12	145.3	4031	336	12	3	10		1				
5/16/2003	A	12	174.3	4002	334	6	1	1		7			1	
5/16/2003	B	12	175.7	3769	314	2	2	7		1				
5/17/2003	A	12	177.5	3913	326	2	2	2		7		2		
5/17/2003	B	12	176.2	3851	321	2	1	10		5	1			
5/18/2003	A	12	182.5	4332	361	2		10		15	1			1
5/18/2003	B	12	180.4	3758	313			13		1	1			
5/19/2003	A	12	195.7	3808	317		1	12		1				
5/19/2003	B	12	197.7	3775	315		1	6		1			3	
5/20/2003	A	12	217	3839	320			2						
5/20/2003	B	12	218	3805	317			2						
TOTAL		**418**		**135537**	**325**	**837**	**226**	**146**	**2**	**66**	**9**	**4**	**4**	**2**

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

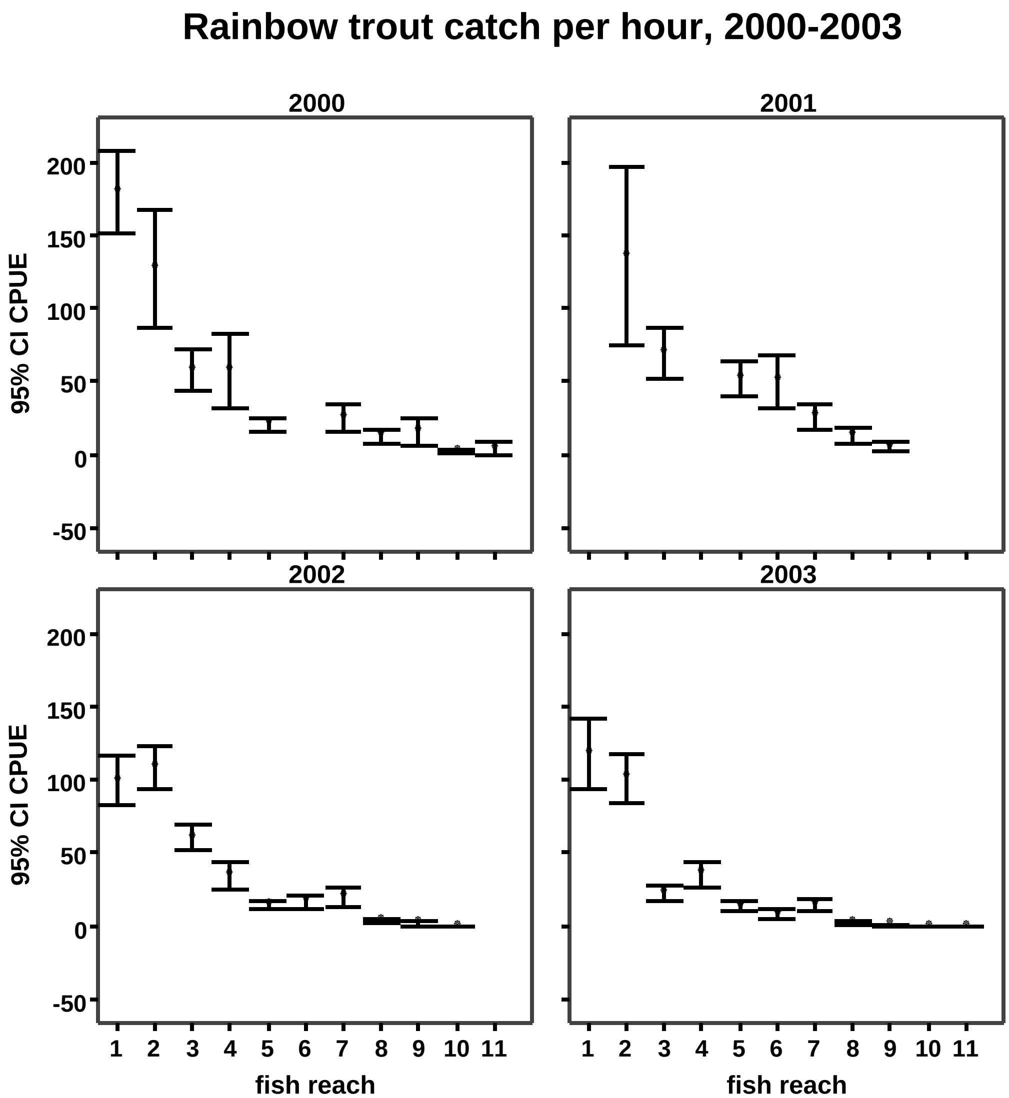


Figure 1. Mean rainbow trout catch per unit effort (fish per hour) by sampling reach during 2000-2003 (Colorado River, Grand Canyon).

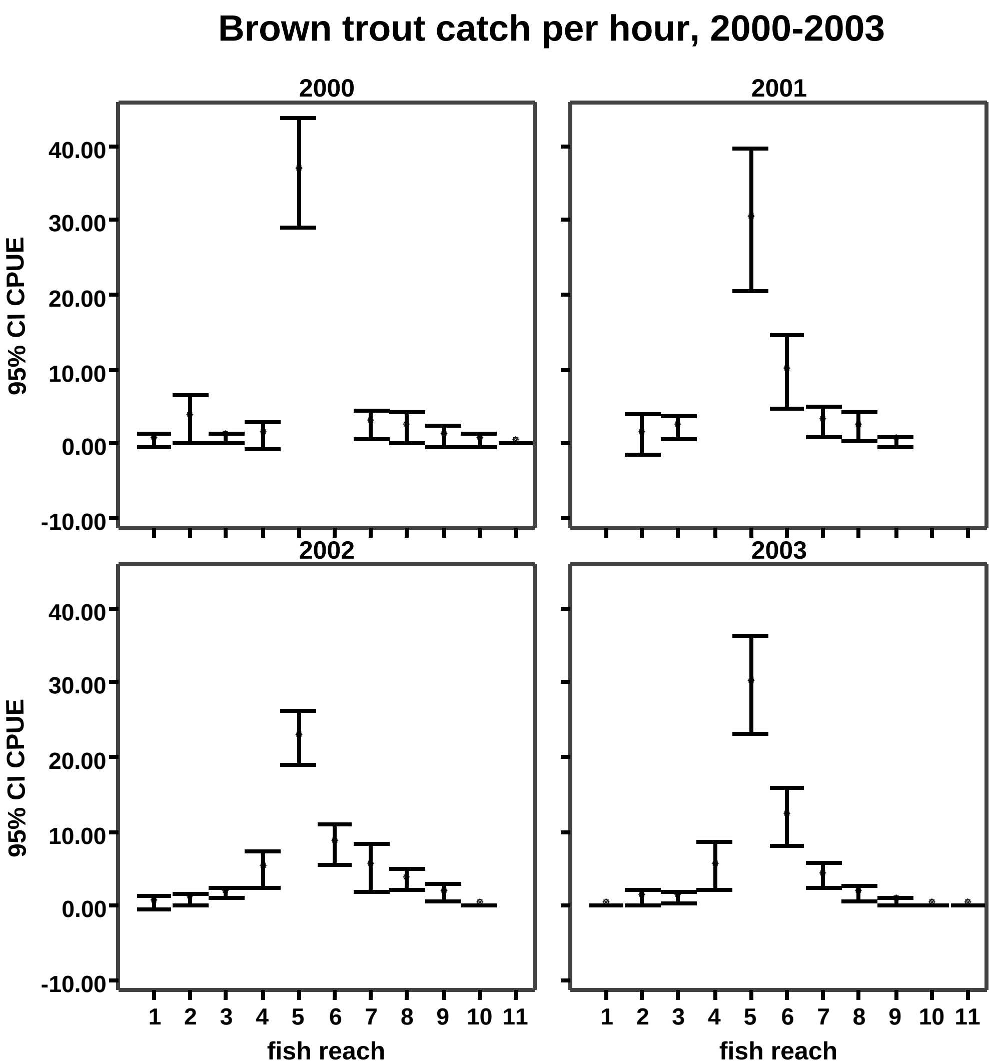


Figure 2. Mean brown trout catch per hour of electrofishing by sampling reach during 2000-2003 (Colorado River, Grand Canyon).

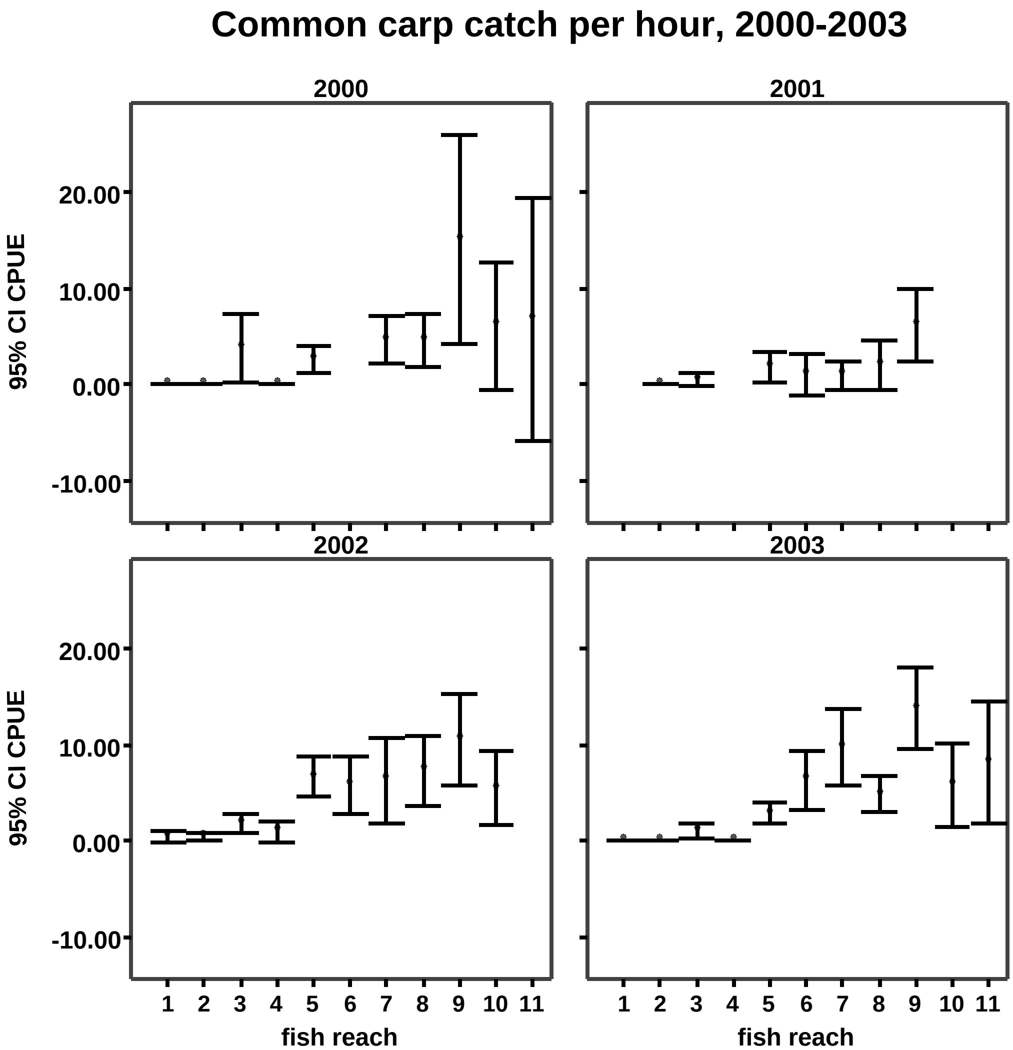


Figure 3. Mean carp catch per hour of electrofishing by sampling reach during 2000-2003 (Colorado River, Grand Canyon).

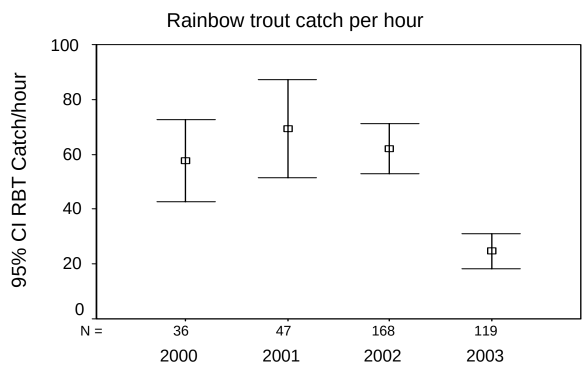


Figure 4. Mean catch per unit effort for rainbow trout during 2000-2003, near the Little Colorado River (LCR reach RM 56-69), a tributary of the Colorado River. Bars represent 95% confidence intervals of the mean.

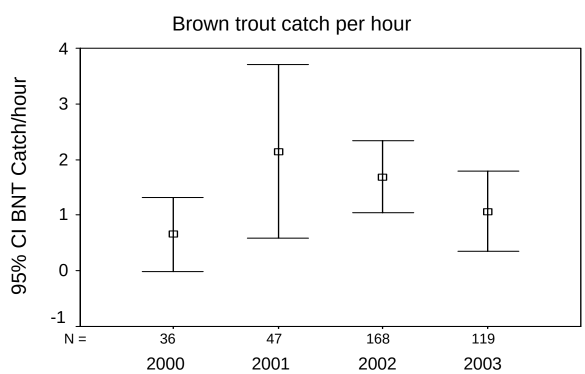


Figure 5. Mean catch per unit effort for brown trout during 2000-2003, near the Little Colorado River (LCR reach RM 56-69), a tributary of the Colorado River. Bars represent 95% confidence intervals of the mean.

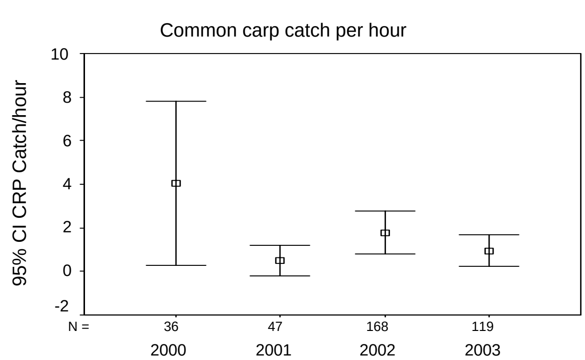


Figure 6. Mean catch per unit effort for common carp during 2000-2003, near the Little Colorado River (LCR reach RM 56-69), a tributary of the Colorado River. Bars represent 95% confidence intervals of the mean.

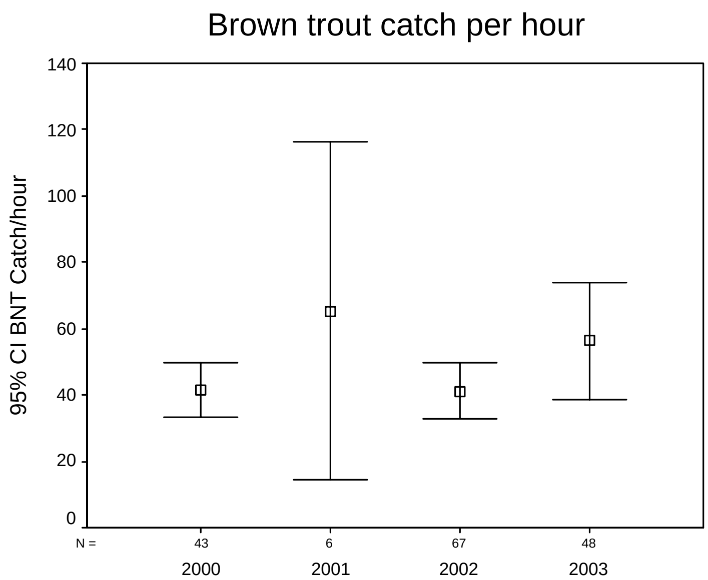


Figure 7. Mean catch per unit effort for brown trout during 2000 –2003, near Bright Angel Creek (BAC reach RM 84.5-90), a tributary of the Colorado River. Bars represent 95% confidence intervals of the mean.

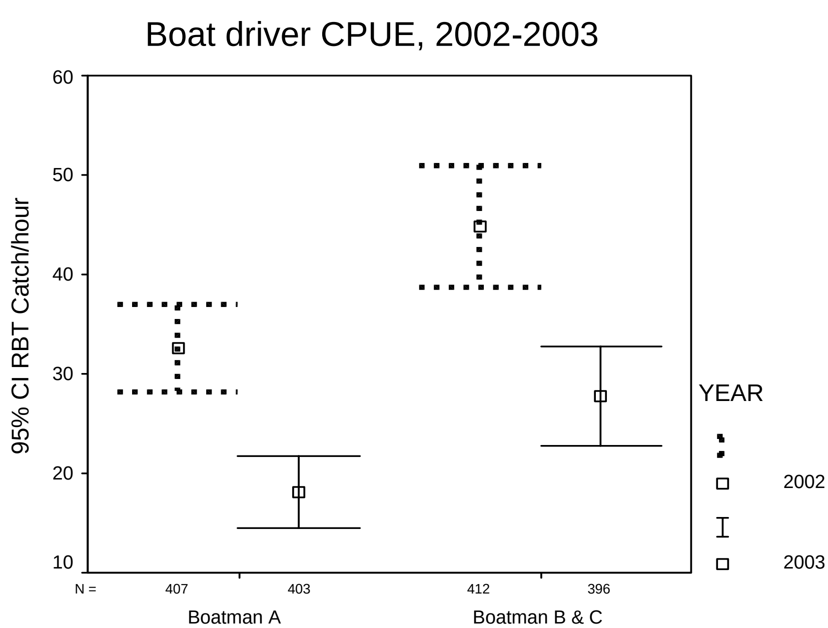


Figure 8. Mean catch per unit effort for boat A and boat B during 2002-2003. Samples were taken randomly throughout the canyon (RM 15- 220). Bars represent 95% confidence intervals of the mean.

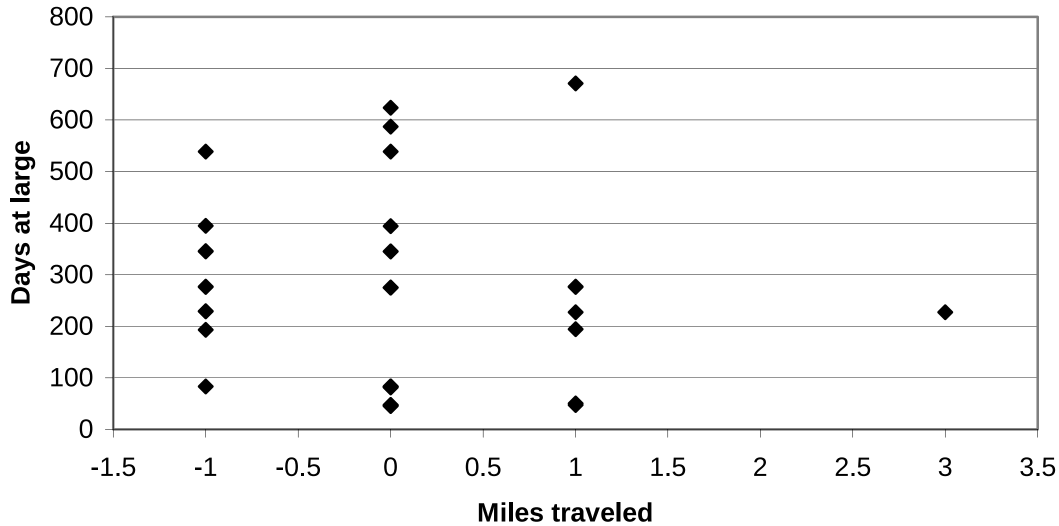
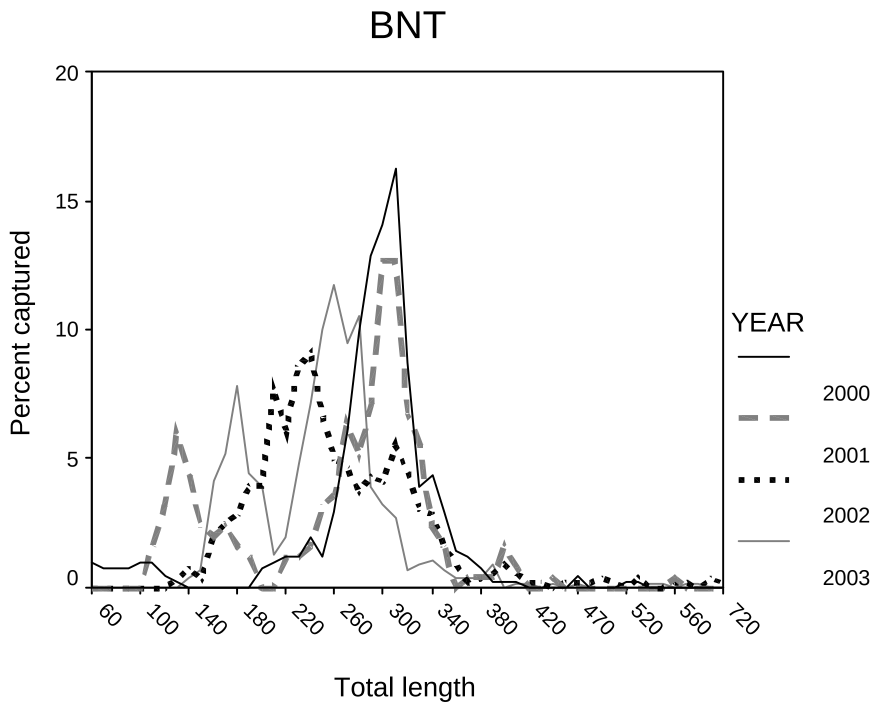


Figure 9. Distance traveled by days at large for brown trout recaptured (electroshocking data, Colorado River, Grand Canyon, 2000-2003. Negative miles indicated movement downstream.



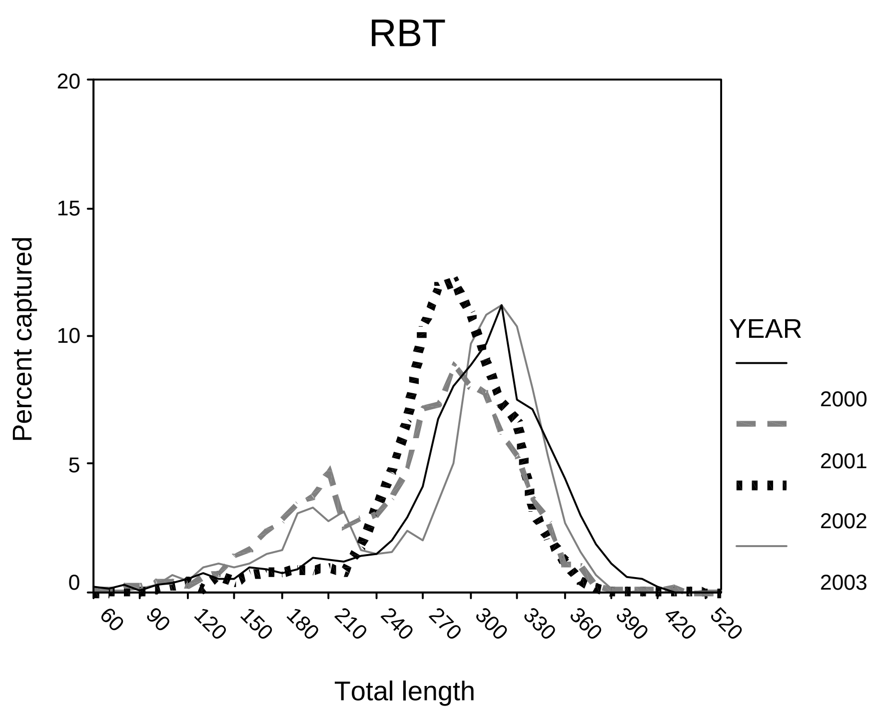


Figure 10. Percent of brown trout (BNT) and rainbow trout (RBT) captured by length for monitoring done in the Colorado River, Grand Canyon (2000-2003).

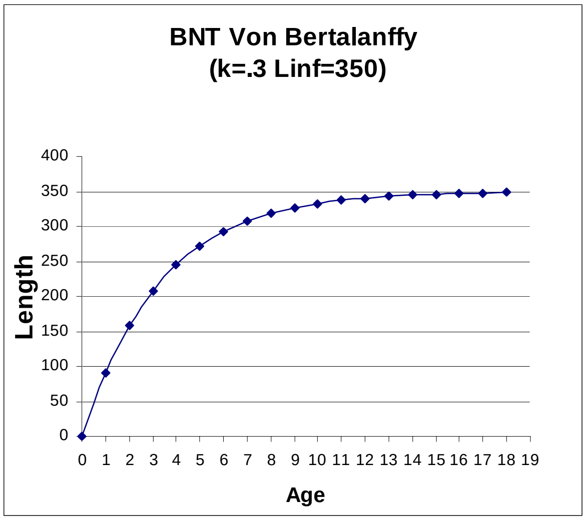


Figure 11. Brown trout (BNT) von Bertalanffy growth curve (Wang method, 2000-2003 mark recapture data).

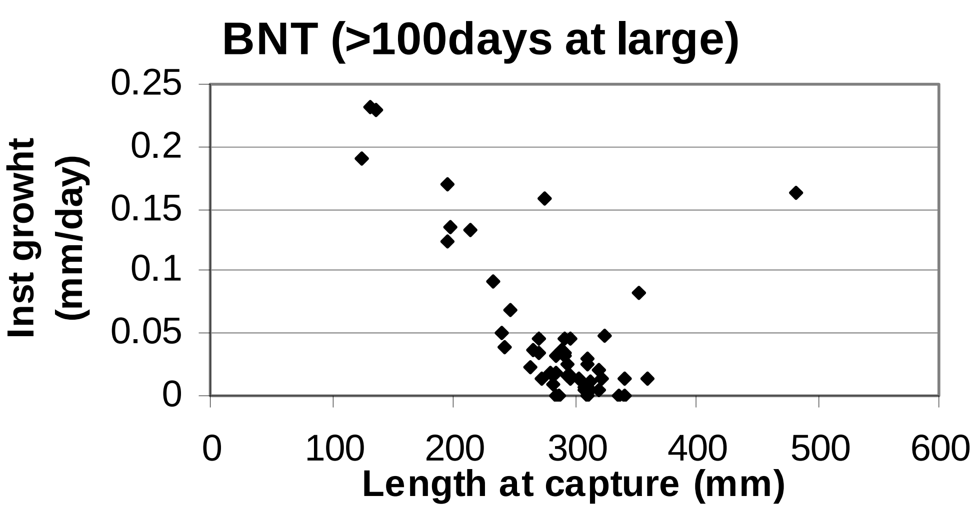


Figure 12. Instantaneous growth (mm/day) by length at capture for brown trout (BNT) with over 100 days between capture and recapture events (electroshocking data, Colorado River, Grand Canyon, 2000-2003).

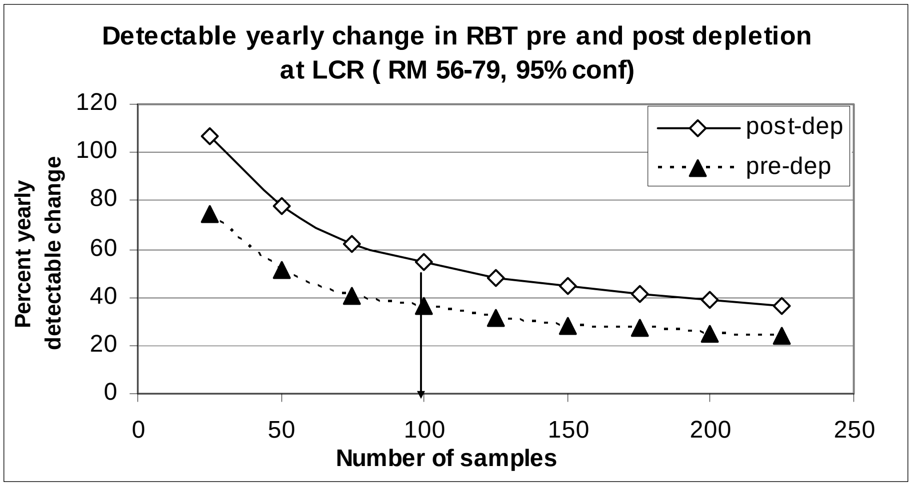


Figure 13. Detectable yearly change in rainbow trout catch per unit effort in the Little Colorado River experimental fish removal reach prior to and after the first year (2003) of rainbow trout removal in this reach.

FMS CPUE by year and sampling reach

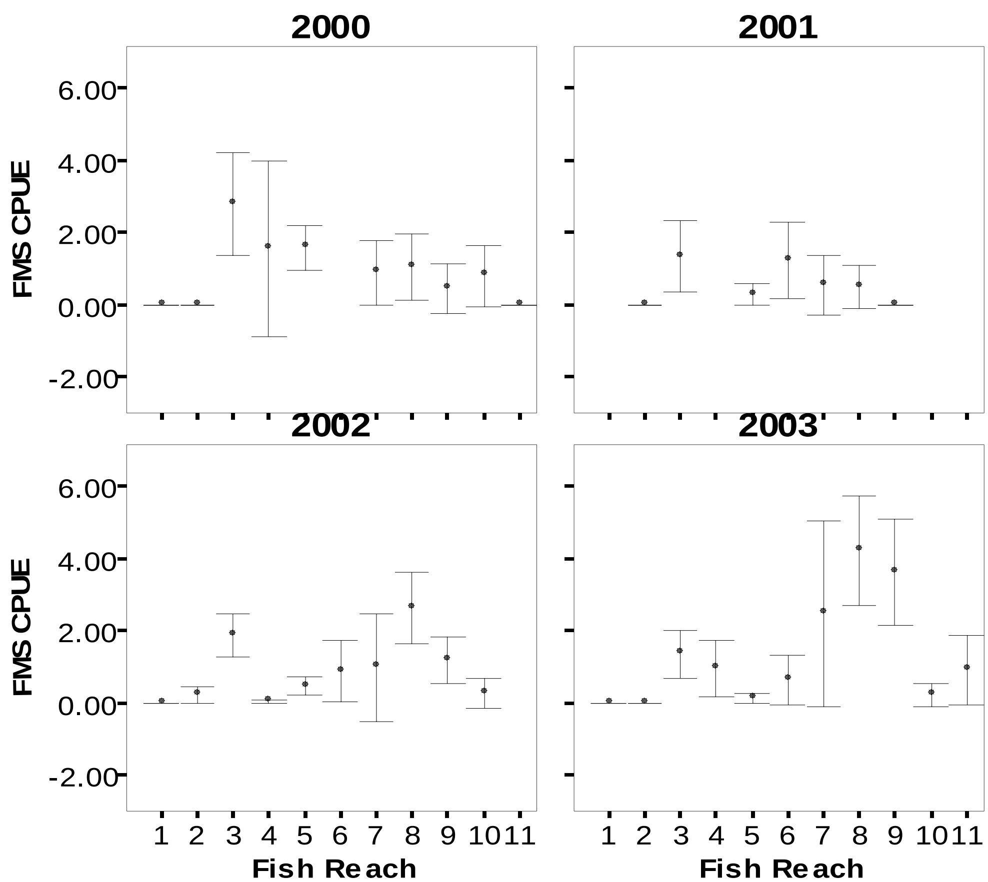


Figure 14. Flannelmouth sucker (FMS) catch per hour by sampling reach and year for electroshocking done in the Colorado River, Grand Canyon (2000-2003, bars represent 95% confidence interval of mean).

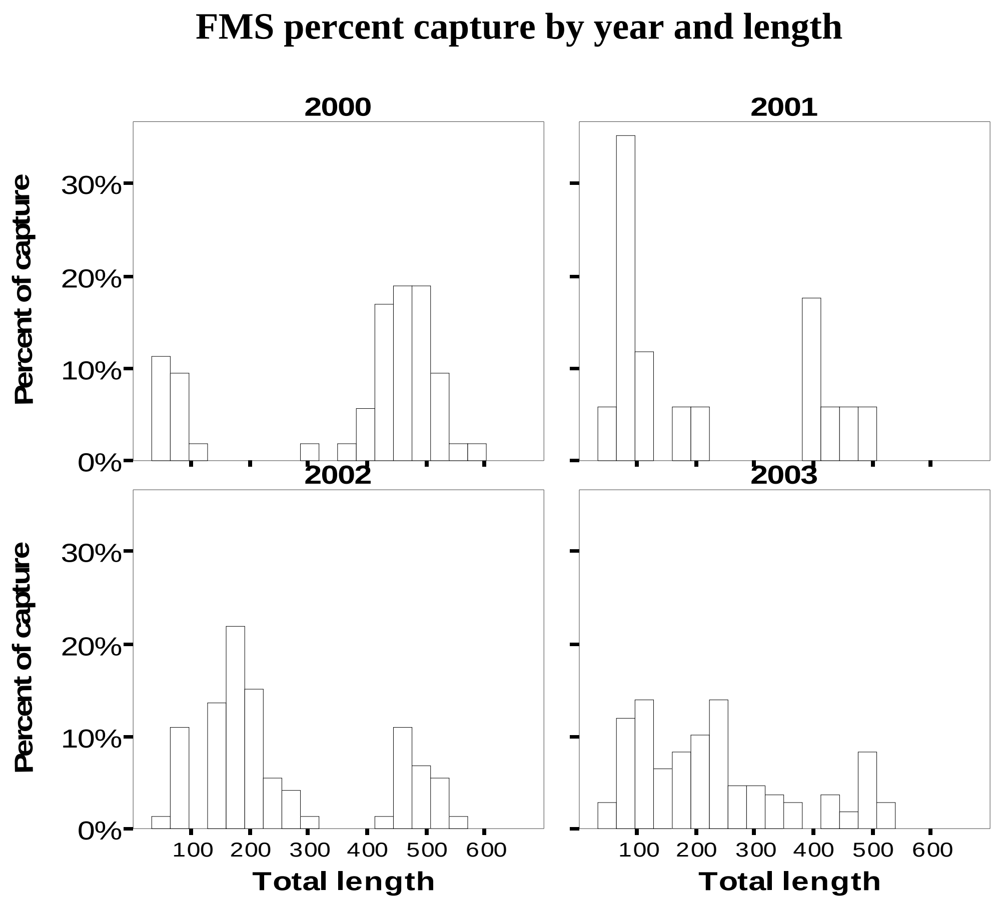


Figure 15. Percent of flannelmouth suckers (FMS) captured by length and year for electroshocking done in the Colorado River, Grand Canyon (2000-2003).

Appendices

Appendix 1. All native fish captured in regular electroshocking monitoring during 2003.

DATE	RIVER	RM	SPECIES	TL	FL	PIT RECAP	PITTAG
4/8/2003	COR	68.2	HBC	58	52		
5/6/2003	COR	64.4	HBC	422	381	Y	42423D4864
5/14/2003	COR	135.9	HBC	99	89		
4/7/2003	COR	58.9	FMS	496		N	3D91BF19941AD
4/7/2003	COR	59.2	FMS	526		Y	7F7D081343
4/8/2003	COR	67.5	FMS	74	70		
4/8/2003	COR	67.6	FMS	140	133	N	
4/8/2003	COR	67.8	FMS	123			
4/8/2003	COR	68.2	FMS	113	102		
4/8/2003	COR	68.2	FMS	115	99		
4/8/2003	COR	68.2	FMS	164	152	N	3D91BF1993F88
4/16/2003	COR	168	FMS	489	472	N	3D91BF1A0D37F
4/16/2003	COR	169.4	FMS	120	113		
4/16/2003	COR	168.4	FMS	465	443	N	3D91BF1A0F048
4/16/2003	COR	169.9	FMS	117	106		
4/16/2003	COR	169.9	FMS	87	81		
4/16/2003	COR	169.9	FMS	164	155	N	3D91BF19905A9
4/16/2003	COR	170.6	FMS	517	496	N	3D91BF198FC71
4/17/2003	COR	185.3	FMS	233	220	N	3D91BF1AC546B
4/17/2003	COR	185.3	FMS	149	140	N	
4/17/2003	COR	186.5	FMS	80	75		
4/17/2003	COR	186.5	FMS	96	90		
4/17/2003	COR	186.8	FMS	87	82		
4/17/2003	COR	186.9	FMS	237	228	N	3D91BF1A0DFE9
4/17/2003	COR	187	FMS	223	213	N	3D91BF1A0F19D
4/17/2003	COR	187	FMS	114	106		
4/17/2003	COR	187.1	FMS	84	84		
4/17/2003	COR	187.1	FMS	80	74		
4/17/2003	COR	187.1	FMS	73	68		
4/17/2003	COR	187.1	FMS	53			
4/18/2003	COR	191.3	FMS	175	184	N	3D91BF1A0E820
4/18/2003	COR	192.9	FMS	295	285	N	3D91BF1AC5C7E
4/19/2003	COR	193.1	FMS	214	204	N	3D91BF1A0F10E
4/19/2003	COR	193.1	FMS	212	201	N	3D91BF1A0E90D
4/19/2003	COR	194.7	FMS	70	69		
4/19/2003	COR	193.7	FMS	285	268	N	3D91BF198D0DA
4/19/2003	COR	193.7	FMS	211	200	N	3D91BF1A0E843
4/19/2003	COR	193.7	FMS	166	156	N	3D91BF1AC6A83
4/19/2003	COR	193.7	FMS	242	230	N	3D91BF1A0DEFE
4/19/2003	COR	194.7	FMS	89	82		
4/20/2003	COR	216.7	FMS	49	42		
4/21/2003	COR	222.1	FMS	96	92		
4/21/2003	COR	222.3	FMS	334	318	Y	43627F1C6C
5/5/2003	COR	61	FMS	95	90		
5/5/2003	COR	62	FMS	342	328	Y	426A2C0563
5/5/2003	COR	62	FMS	225	216	Y	3D91BF1962644
5/5/2003	COR	62	FMS	242	228	Y	3D91BF198E389
5/5/2003	COR	62.3	FMS	505	476	Y	426B200823

Appendix 1. continued

DATE	RIVER	RM	SPECIES	TL	FL	PIT RECAP	PITTAG
5/5/2003	COR	62.8	FMS	500	475	N	3D91BF1A0EBA9
5/6/2003	COR	64.2	FMS	166		N	3D91BF198D3A2
5/9/2003	COR	71	FMS	501	482	Y	3D91BF198D2D2
5/9/2003	COR	70.6	FMS	445	430	Y	423D371939
5/9/2003	COR	71.1	FMS	493	471	N	3D91BF1A0D801
5/11/2003	COR	86.5	FMS	505	470	N	426B501001
5/11/2003	COR	87.7	FMS	416	401	Y	5326350871
5/12/2003	COR	115	FMS	122	117		
5/13/2003	COR	123.6	FMS	170	160	N	3D91BF1AC57C3
5/13/2003	COR	123.6	FMS	156	146	N	3D91BF19899D0
5/14/2003	COR	136	FMS	234	220	N	3D91BF195C906
5/14/2003	COR	136	FMS	218	210	N	3D91BF1992AE2
5/14/2003	COR	136	FMS	252	238	N	3D91BF1AC638F
5/14/2003	COR	136	FMS	237	222	N	3D91BF1AC5A30
5/14/2003	COR	136	FMS	438	418	N	3D91BF1A0EEEC
5/14/2003	COR	136	FMS	368	351	N	3D91BF198D1BF
5/14/2003	COR	136	FMS	503		N	3D91BF1AC5208
5/14/2003	COR	136	FMS	447		Y	53243C315D
5/14/2003	COR	136	FMS	510	493	N	3D91BF198C74A
5/14/2003	COR	136	FMS	169	155	N	3D91BF19930A1
5/14/2003	COR	135.7	FMS	226	215	N	3D91BF198C83D
5/14/2003	COR	135.7	FMS	135	129		
5/14/2003	COR	135.7	FMS	188	178	N	3D91BF1993727
5/14/2003	COR	136.2	FMS	237	223		
5/15/2003	COR	145.6	FMS	287	276	N	3D91BF1A0E323
5/16/2003	COR	174.3	FMS	490	465	N	3D91BF1A0D8C4
5/16/2003	COR	174.7	FMS	73	70		
5/16/2003	COR	174.7	FMS	107	102		
5/16/2003	COR	175.1	FMS	191	180	N	3D91BF1A0DB09
5/16/2003	COR	175.1	FMS	256	249	N	3D91BF1AC6653
5/16/2003	COR	176.4	FMS	73	63		
5/16/2003	COR	175.3	FMS	79	75		
5/16/2003	COR	175.4	FMS	158	152	N	3D91BF1A0DBAC
5/17/2003	COR	177.7	FMS	101	95		
5/17/2003	COR	176.5	FMS	125	113		
5/17/2003	COR	176.5	FMS	148	137		
5/17/2003	COR	176.6	FMS	340	323	N	3D91BF1A0D38D
5/17/2003	COR	176.6	FMS	171	163	N	3D91BF1A0E35B
5/17/2003	COR	178	FMS	110	103		
5/17/2003	COR	176.7	FMS	195	185	N	3D91BF1A0E1D1
5/17/2003	COR	178.1	FMS	58	55		
5/17/2003	COR	178.6	FMS	212	201	N	3D91BF1A0F024
5/17/2003	COR	178.6	FMS	373	352	N	3D91BF1AC57C0
5/17/2003	COR	178.6	FMS	365	349	N	3D91BF1A0F289
5/17/2003	COR	178.6	FMS	315	298	N	3D91BF1A0E253
5/18/2003	COR	182.5	FMS	291	278	N	3D91BF1A0F329
5/18/2003	COR	183.2	FMS	200	190	N	3D91BF1991ECB
5/18/2003	COR	183.2	FMS	119	113		
5/18/2003	COR	183.3	FMS	218	206	N	3D91BF198CB18
5/18/2003	COR	183.3	FMS	140	132		

Appendix 1. continued

DATE	RIVER	RM	SPECIES	TL	FL	PIT RECAP	PITTAG
5/18/2003	COR	183.3	FMS	247	237	N	3D91BF1A0D711
5/18/2003	COR	183.3	FMS	212	200	N	3D91BF1A0E420
5/18/2003	COR	183.3	FMS	273	260	Y	43473D4777
5/18/2003	COR	183.3	FMS	303	286	N	3D91BF1AC5EFD
5/18/2003	COR	183.3	FMS	281	265	N	3D91BF1AC57C5
5/18/2003	COR	183.3	FMS	248	237	N	3D91BF1A0DEE0
5/18/2003	COR	180.8	FMS	242	215	N	3D91BF198C803
5/18/2003	COR	183.3	FMS	444	428	N	3D91BF198BBBD
5/18/2003	COR	183.5	FMS	118	111		
5/18/2003	COR	183.5	FMS	202	189	N	3D91BF198CCF2
5/19/2003	COR	197.2	FMS	330	310	N	3D91BF198DD92
5/19/2003	COR	196.3	FMS	254	238	N	3D91BF198C5AF
4/8/2003	COR	67.7	BHS	213	197	N	3D91BF1A0DE86
4/8/2003	COR	68	BHS	79	73		
4/13/2003	COR	106.9	BHS	237		N	3D91BF198C2E6
4/13/2003	COR	107.4	BHS	77	69		
4/15/2003	COR	132.4	BHS	213		N	3D91BF1AC4E69
4/15/2003	COR	132.4	BHS	208		N	3D91BF1994022
4/17/2003	COR	186.3	BHS	82	77		
4/17/2003	COR	187	BHS	161	153	N	3D91BF195D342
5/5/2003	COR	63	BHS	244	221	N	3D91BF1AC6124
5/9/2003	COR	70.7	BHS	280	271	N	3D91BF1AC684D
5/10/2003	COR	82.1	BHS	193	182	N	3D91BF1A0F261
5/10/2003	COR	82.3	BHS	191	177	N	4347225040
5/12/2003	COR	114.9	BHS	223	210	N	3D91BF1A0EAB2
5/13/2003	COR	123.6	BHS	173	161	N	3D91BF1A0D7D5
5/17/2003	COR	177	BHS	411	395	N	3D91BF198DB4E
5/18/2003	COR	182.9	BHS	202	193	N	3D91BF1A0D98D
5/18/2003	COR	181.5	BHS	252	243	N	3D91BF198ECD3
4/12/2003	COR	95.7	SPD	65			
4/16/2003	COR	169.4	SPD	39			
4/16/2003	COR	169.9	SPD	38			
4/18/2003	COR	191.2	SPD	36			
4/19/2003	COR	194.5	SPD	67			
4/19/2003	COR	194.8	SPD	46			
4/19/2003	COR	194.7	SPD	51			
4/20/2003	COR	216.9	SPD	69			
4/21/2003	COR	221.4	SPD	47			
5/9/2003	COR	70	SPD	75			
5/10/2003	COR	82	SPD	67	58		
5/17/2003	COR	178.1	SPD	41			
5/17/2003	COR	178.5	SPD	42			

Appendix 2. Sample universe of the Colorado River, Grand Canyon, divided into sampling reaches and subdivided into logistic reaches (fishable sub-reaches). Some logistic reaches are listed more than once to indicate alternate camp sites. Logistic reaches and start miles within logistic reaches were randomly selected. Highlighted reaches were not sampled because river morphology made them unsafe for electrofishing.

Fish Reach	Sub Reach	Miles Available	Camp RM	Camp	Start Mile	Start name	End Mile	End name
1	1.1	6.8	2.8	Cathedral	1.0	Paria riffle	7.8	Badger
1	1.1	6.8	5.8	6 mile wash	1.0	Paria riffle	7.8	Badger
1	1.2	3.2	8.0	Jackass	8.0	Badger	11.2	Soap
1	1.2	3.2	11.2	Soap	8.0	Badger	11.2	Soap
1	1.3	5.5	11.2	Soap	11.3	Soap	16.8	House Rock
1	1.3	5.5	12.2		11.3	Soap	16.8	House Rock
1	1.3	5.5	16.5	Hot Na Na	11.3	Soap	16.8	House Rock
1	1.4	3.5	17.0	Below House Rock	17.0	Below House Rock	20.5	North
1	1.4	3.5	18.0	18 Mile Wash	17.0	Below House Rock	20.5	North
1	1.4	3.5	19.0	19 mile canyon	17.0	Below House Rock	20.5	North
1	1.4	3.5	20.0	20 Mile	17.0	Below House Rock	20.5	North
1	1.4	3.5	20.7	North	17.0	Below House Rock	20.5	North
1	1.5	2.4	21.9	21.9 Mile	20.8	Below North	23.2	Indian Dick
1	1.5	2.4	23.0	23 Mile	20.8	Below North	23.2	Indian Dick
1	1.5	1.3	24.5	Above 24.5 Mile	23.2	Indian Dick	24.5	Above 24.5
1	1.5	3.6	26.5	Above Tiger Wash	25.5	Below 25.5	29.1	Silver Grotto
1	1.5	3.6	29.1	Silver grotto	25.5	Below 25.5	29.1	Silver Grotto
2	2.1	6.9	29.1	Silver grotto	29.1	Silver Grotto	36.0	36 Mile
2	2.1	6.9	30.2		29.1		36.0	
2	2.1	6.9	31.6	South	29.1		36.0	
2	2.1	6.9	33.8		29.1		36.0	
2	2.1	6.9	34.9	Nautiloid	29.1		36.0	
2	2.2	7.7	37.3	Tatahatso	36.0		43.7	Harding
2	2.2	7.7	38.4		36.0		43.7	Harding
2	2.2	7.7	41.0	Buck Farm	36.0		43.7	Harding
2	2.2	7.7	43.2	Above Harding	36.0		43.7	Harding
2	2.3	8.3	43.7	Below Harding	43.7	Harding	52.0	Nankoweap
2	2.3	8.3	44.7		43.7	Harding	52.0	Nankoweap
2	2.3	8.3	44.8		43.7	Harding	52.0	Nankoweap
2	2.3	8.3	46.2		43.7	Harding	52.0	Nankoweap
2	2.3	8.3	46.4		43.7	Harding	52.0	Nankoweap
2	2.3	8.3	47.0	Saddle	43.7	Harding	52.0	Nankoweap
2	2.3	8.3	47.5		43.7	Harding	52.0	Nankoweap
2	2.3	8.3	48.3		43.7	Harding	52.0	Nankoweap
2	2.3	8.3	48.8		43.7	Harding	52.0	Nankoweap
2	2.3	8.3	50.0		43.7	Harding	52.0	Nankoweap
2	2.3	8.3	50.2		43.7	Harding	52.0	Nankoweap
2	2.3	8.3	51.7	Little Nankoweap	43.7	Harding	52.0	Nankoweap
2	2.3	8.3	52.5	Nankoweap	43.7	Harding	52.0	Nankoweap
2	2.4	4.0	53.0	Below Nanko	52.0	Nankoweap	56.0	Kwagunt
3	3.1	9.5	56.1	Below Kwagunt	56.0	Kwagunt	65.5	Lava Chuar
3	3.1	9.5	56.5		56.0	Kwagunt	65.5	Lava Chuar
3	3.1	9.5	58.0	Awatubi	56.0	Kwagunt	65.5	Lava Chuar
3	3.1	9.5	58.5		56.0	Kwagunt	65.5	Lava Chuar
3	3.1	9.5	58.7		56.0	Kwagunt	65.5	Lava Chuar
3	3.1	9.5	61.0	LCR Point	56.0	Kwagunt	65.5	Lava Chuar
3	3.1	9.5	62.5	Crash	56.0	Kwagunt	65.5	Lava Chuar
3	3.1	9.5	64.8	Carbon	56.0	Kwagunt	65.5	Lava Chuar
3	3.1	9.5	65.4	Above Lava Chuar	56.0	Kwagunt	65.5	Lava Chuar
3	3.2	3.0	65.6	Below Lava Chuar	65.6	Below Lava Chuar	68.6	Above Tanner
3	3.2	3.0	68.5	Above Tanner	65.6	Below Lava Chuar	68.6	Above Tanner
4	4.1	3.8	69.1	Below Tanner	68.7	Below Tanner	72.5	Above Unkar

Appendix 2. Continued

Fish Reach	Sub Reach	Miles Available	Camp RM	Camp	Start Mile	Start name	End Mile	End name
4	4.1	3.8	69.2		68.7	Below Tanner	72.5	Above Unkar
4	4.1	3.8	71.1	Cardenas	68.7	Below Tanner	72.5	Above Unkar
4	4.1	3.8	72.0	Above Unkar	68.7	Below Tanner	72.5	Above Unkar
4	4.2	2.9	74.3	Above Nevills	72.6	Below Unkar	75.5	Above Nevills
4	4.2	2.9	75.7	Above Nevills	72.6	Below Unkar	75.5	Above Nevills
4	4.3	1.2	76.7	Above Hance	75.5	Below Nevills	76.7	Above Hance
5	5.1	2.4	81.2	Grapevine	78.8	Sock	81.2	Above Grapevine
5	5.2	2.9	84.0	Clear Ck	81.6	Grapevine	84.5	Zoraster
5	5.2	2.9	84.2	Clear Ck	81.6	Grapevine	84.5	Zoraster
5	5.3	3.8	87.0	Cremation	85.0	85 Mile	88.8	Pipe Creek
5	5.4	3.3	91.5	Trinity Ck	90.2	Below Horn	93.5	Granite
5	5.4	3.3	93.4	Above Granite	90.2	Below Horn	93.5	Granite
5	5.5	1.2	94.0	94 mile	93.6	Below Granite	94.8	Above Hermit
5	5.5	1.2	94.9	Above Hermit	93.6	Below Granite	94.8	Above Hermit
5	5.6	2.9	96.0	Below Hermit	95.1	Below Hermit	98.0	Crystal
5	5.6	2.9	96.8	Boucher	95.1	Below Hermit	98.0	Crystal
5	5.7	2.5	103.0	103R	102.0	Turquoise	104.5	Ruby
5	5.7	2.5	107.7	Upper Bass	106.0	Serpentine	108.5	Shinumo
5	5.7	2.5	108.1	Bass	106.0	Serpentine	108.5	Shinumo
5	5.7	2.5	108.5	Shinumo	106.0	Serpentine	108.5	Shinumo
6	6.1	3.7	109.3		108.6	Below Shinumo	112.3	Waltenberg
6	6.2	4.1	114.0	Garnet	112.4	Waltenberg	116.5	Elves
6	6.2	4.1	116.0		112.4	Waltenberg	116.5	Elves
6	6.3	6.2	116.5	Elves	116.5	Elves	122.7	Forster
6	6.3	6.2	118.2		116.5	Elves	122.7	Forster
6	6.3	6.2	119.0		116.5	Elves	122.7	Forster
6	6.3	6.2	120.0	Blacktail	116.5	Elves	122.7	Forster
6	6.3	6.2	122.2	122 Mile	116.5	Elves	122.7	Forster
6	6.3	6.2	122.8	Forster	116.5	Elves	122.7	Forster
6	6.4	2.3	124.0	124 Mile	122.7	Forster	125.0	Fossil
6	6.5	2.0	125.4	Below Fossil	125.0	Fossil	127.0	127 Mile
6	6.5	2.0	126.3	Randys Rock	125.0	Fossil	127.0	127 Mile
6	6.6	2.0	128.0	128 Mile	127.0	127 Mile	129.0	Specter
7	7.1	1.3	131.8	Above Deubendorff	130.5	Bedrock	131.8	Above Dubendorff
7	7.2	1.8	132.0	Stone Creek	131.9	Below Dooby	133.7	Tapeats
7	7.2	1.8	133.0		131.9	Below Dooby	133.7	Tapeats
7	7.2	1.8	133.7	Above Tapeats	131.9	Below Dooby	133.7	Tapeats
7	7.3	2.2	133.8	Below Tapeats	133.8	Below Tapeats	136.0	Deer Creek
7	7.4	3.7	134.3	134 Mile	134.0	134 Mile	137.7	Doris
7	7.4	3.7	134.6		134.0	134 Mile	137.7	Doris
7	7.4	3.7	136.0	Across Deer Ck	134.0	134 Mile	137.7	Doris
7	7.4	3.7	136.5		134.0	134 Mile	137.7	Doris
7	7.4	3.7	136.6		134.0	134 Mile	137.7	Doris
7	7.5	1.3	137.9	Below Doris	137.8	Doris	139.1	Fishtail
7	7.5	1.3	138.4		137.8	Doris	139.1	Fishtail
7	7.5	1.3	138.5		137.8	Doris	139.1	Fishtail
7	7.5	1.3	138.9	Fishtail	137.8	Doris	139.1	Fishtail
7	7.6	4.4	139.8		139.1	Fishtail	143.5	Kanab
7	7.6	4.4	143.3	Kanab	139.1	Fishtail	143.5	Kanab
7	7.7	6.2	145.7	Olo	143.5	Below Kanab	149.7	Upset
7	7.8	7.1	150.2	Below Upset	149.8	Below Upset	156.9	Havasu
7	7.8	7.1	151.5		149.8	Below Upset	156.9	Havasu
7	7.8	7.1	155.5		149.8	Below Upset	156.9	Havasu
7	7.8	7.1	156.0		149.8	Below Upset	156.9	Havasu
7	7.8	7.1	156.7	Last chance	149.8	Below Upset	156.9	Havasu

Appendix 2. continued

Fish Reach	Sub Reach	Miles Available	Camp RM	Camp	Start Mile	Start name	End Mile	End name
7	7.9	9.6	157.7	Below Havasu	157.0	Havasu	166.6	National
7	7.9	9.6	158.5		157.0	Havasu	166.6	National
7	7.9	9.6	159.9		157.0	Havasu	166.6	National
7	7.9	9.6	160.9		157.0	Havasu	166.6	National
7	7.9	9.6	164.5	Tuckup	157.0	Havasu	166.6	National
8	8.1	12.9	166.6	National	166.6	National	179.5	Lava Falls
8	8.1	12.9	167.3		166.6	National	179.5	Lava Falls
8	8.1	12.9	168.0	Fern Glen	166.6	National	179.5	Lava Falls
8	8.1	12.9	171.0	Stairway	166.6	National	179.5	Lava Falls
8	8.1	12.9	171.5	Mohawk	166.6	National	179.5	Lava Falls
8	8.1	12.9	173.0		166.6	National	179.5	Lava Falls
8	8.1	12.9	174.2	Cove	166.6	National	179.5	Lava Falls
8	8.1	12.9	177.0	Honga Spring	166.6	National	179.5	Lava Falls
8	8.1	12.9	177.8		166.6	National	179.5	Lava Falls
8	8.1	12.9	179.0	Above Lava Falls	166.6	National	179.5	Lava Falls
9	9.1	10.2	179.8	Below Lower Lava	179.8	Below Lava Falls	190.0	
9	9.1	10.2	180.8		179.8	Below Lower Lava	190.0	
9	9.1	10.2	182.8		179.8	Below Lower Lava	190.0	
9	9.1	10.2	186.2		179.8	Below Lower Lava	190.0	
9	9.1	10.2	188.0	Whitmore	179.8	Below Lower Lava	190.0	
9	9.1	10.2	190.0		179.8	Below Lower Lava	190.0	
9	9.2	10	190.9		190.0		200.0	
9	9.2	10	191.8	192 Mile Canyon	190.0		200.0	
9	9.2	10	192.2		190.0		200.0	
9	9.2	10	193.1		190.0		200.0	
9	9.2	10	194.2	Common 194 Mi	190.0		200.0	
9	9.2	10	194.6	194 Mi Can	190.0		200.0	
9	9.2	10	196.0		190.0		200.0	
9	9.2	10	198.6	Parashant	190.0		200.0	
10	10.1	5.6	204.5		200.0		205.6	205 Mile Rapid
10	10.2	3.2	208.0		205.7	Below 205 Mi	208.9	Above Granite Pk
10	10.2	3.2	208.9	Granite Park	205.7	Below 205 Mi	208.9	Above Granite Pk
10	10.3	10.8	209.8		209.2	Below Granite Pk	220.0	220 Mile
10	10.3	10.8	211.5	Fall Cnyn	209.2	Below Granite Pk	220.0	220 Mile
10	10.3	10.8	212.8	Pumpkin	209.2	Below Granite Pk	220.0	220 Mile
10	10.3	10.8	214.0		209.2	Below Granite Pk	220.0	220 Mile
10	10.3	10.8	215.5	Three Springs	209.2	Below Granite Pk	220.0	220 Mile
10	10.3	10.8	219.2	Trail Cnyon	209.2	Below Granite Pk	220.0	220 Mile
11	11.1	5	220.0	220 Mile	220.0		225.0	
11	11.1	5	222.0		220.0		225.0	
11	11.1	5	222.3		220.0		225.0	
11	11.1	5	224.5		220.0		225.0	
11	11.1	5	225.0	Diamond	220.0		225.0	Above Diamond

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 long-term monitoring trips in 2003 (April and May).

Trip 1		
Crew Member	**Duty**	**Agency**
Scott Rogers	Biologist	Arizona Game and Fish Department
David Ward	Biologist	Arizona Game and Fish Department
Eric K	Biologist	Arizona Game and Fish Department
Jenifer C	Technician	Arizona Game and Fish Department
Gerry S	Technician	Arizona Game and Fish Department
Nick H	Volunteer	Volunteer
Mike B	Volunteer	Volunteer
Bob L	Volunteer	Volunteer
Mike B	Volunteer	Volunteer
Melody Ward	Volunteer	Volunteer
Scott Davis	Boat operator	Humphrey Summit
JP Running	Boat operator	Humphrey Summit
Stewart Reider	Boat operator	Humphrey Summit
Brent Berger	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
Andy Makinster	Biologist	Arizona Game and Fish Department
Angela McIntire	Technician	Arizona Game and Fish Department
Emily Brown	Technician	Arizona Game and Fish Department
Bill Watt	Volunteer	Volunteer
Scott Schlueter	Volunteer	Volunteer
Mike Giovali	Volunteer	Volunteer
Mark Salabrino	Volunteer	Volunteer
Rich Christiansen	Volunteer	Volunteer
Stewart Reider	Boat operator	Humphrey Summit
Jimmy Grissom	Boat operator	Humphrey Summit
Nelbert N.	Boat operator	Humphrey Summit
Brent Berger	Boat operator	Humphrey Summit
Dennis Bobb	Boat operator	Humphrey Summit
Carol Fritzinger	Logistics	Grand Canyon Monitoring and Research Center