Status of the Lees Ferry Rainbow Trout Fishery
2007 Annual Report

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EXECUTIVE SUMMARY

We present results of rainbow trout monitoring in the Lees Ferry tailwater (Colorado River below Glen Canyon Dam, AZ) during 2007. We also describe modifications made to monitoring strategies and techniques which were implemented to improve long-term monitoring programs. Objectives and subsequent findings are as follows:

Objective 1: *Evaluate data from fixed and random transects to determine if data can be pooled thereby increasing power to detect trends in the rainbow trout population.*

Fixed sites provide long-term trend data for monitoring fish populations in the Lees Ferry tailwater. Beginning in 2002, we implemented an augmented, serially alternating sampling design which incorporates random sites with the fixed sites to provide improved point estimates of fishery status. However, for statistical analyses it is unclear as to whether the two types of data can be combined for more powerful evaluation of long-term trends. To evaluate differences in means and variances of the two types of data, we compared catch per unit effort (CPE), relative condition (K_n) and size structure, (PSD; # fish ≥ 406 mm TL/# fish ≥ 305 mm TL)*100 from fixed and random sites during similar time periods using one-way analysis of variance (ANOVA; S. Urquhart, *personal communication*).

Objective 2: *Monitor the trout fishery in the Lees Ferry reach to determine status and trends in abundance (CPUE), population structure (size composition and proportional stock density, PSD), growth rate and relative condition (K_n).*

Data collected during 2007 indicate the Lees Ferry fishery may be improving after a period of high densities and low fish condition that occurred from 1998 to 2001. Low relative abundance of all fish from 2007, particularly fish < 200 mm, appears to be leading to increases in PSD and growth. Low redd counts from 2004-2006 suggest limited spawning (J. Korman, *personal communication*), and hence, relatively low densities of fish < 200 mm (i.e. 1-2 year old fish). Relative condition of all sizes combined in 2007 was the highest observed since 1992, which was the highest relative condition on record. Thus, overrecruitment and density dependent growth from the past appear to be alleviated. Given the low current densities and increases in overall relative condition, we expect the rainbow trout size structure to increase in the near future. Our current estimates of PSD suggest higher PSD in 2007 compared to 2006. Angler catch rates in 2007 were similar to those observed since 2002 and were slightly higher in 2007 compared to 2006. With the strong 2007 cohort that was apparent during October 2007, we expect more fish becoming vulnerable to anglers within the next few years, suggesting improved conditions for anglers at Lees Ferry.

INTRODUCTION

The Arizona Game and Fish Department has been monitoring and performing research on trout in Glen Canyon since the mid 1960's. Rainbow trout (*Oncorhynchus mykiss;* RBT) were initially stocked in the Colorado River below Glen Canyon Dam (GCD) in 1964 and since that time, fish management efforts, dam operations, and flow regimes have interacted to influence the rainbow trout community (Arizona Game and Fish Department [AGFD] 1996; Persons et al. 1985; Marzolf 1991; Reger et al. 1995; McKinney and Persons 1999; McKinney et al. 1999 a, c, d). Impacts of regulated flow on rainbow trout in the Lees Ferry tailwater has been a source of interest for resource managers and the public for several decades (Persons et al. 1985; Maddux et al. 1987; Reger et al. 1995, McKinney and Persons 1999, McKinney et al. 1999 a, d; McKinney et al. 2001 a; McKinney and Speas 2001). Understanding fish ecology in relation to dam operations is essential in order to integrate water, power, and fishery management goals.

Ecology of non-native rainbow trout in the Lees Ferry tailwater (river mile [RM] -15 to RM 0; Figure 1) is strongly influenced by operations of Glen Canyon Dam (McKinney and Persons 1999, McKinney and Speas 2001; McKinney et al. 1999 b, c; McKinney et al. 2001 a, b). Rainbow trout in the tailwater provide a popular recreational fishery and coexist with native flannelmouth sucker (*Catostomus latipinnis*; FMS) and non-native common carp (*Cyprinus carpio*; CRP). From 1991 through 1997, higher mean and less variable releases from GCD favored high standing stocks of rainbow trout, but size-related changes occurred in relative condition and bioenergetics of fish (McKinney et al. 1999a; McKinney and Speas 2001). Small fish (< 305 mm) were strongly affected by low and variable releases from the dam, but not by biotic variables which allowed them to meet maintenance energy requirements. In contrast, large fish (≥ 305 mm) were not affected by flow variability but were strongly influenced by biotic factors (i.e. density-dependence) associated with degradation of the aquatic foodbase. Large fish rarely met maintenance energy requirements (McKinney and Speas 2001). Relative condition of large fish peaked in 1994 and then fell 10 % by 1997, whereas condition of small fish was generally stable between 1991 and 1997. From 1997 to 2000, Speas et al. (2004b) noted a marked reduction in year-to-year variance in catch-per-unit-effort (CPUE), relative condition (K_n) and proportional stock density (PSD; Speas et al.

2004b), likely caused by the impacts of increased densities on the foodbase in the mid 1990's.

Standardized monitoring of the rainbow trout fishery using electrofishing (EF; Sharber et al. 1994) at fixed sampling locations was initiated in 1991 and has provided data on response of the RBT population to dam operations (McKinney and Persons 1999; McKinney et al. 1999a, c, d; McKinney et al. 2001a). In recent years, the Grand Canyon Monitoring and Research Center (GCMRC) sponsored a series of protocol evaluation panels for external scientific review of Colorado River sampling protocols (http://www.gcmrc.gov/pep/troutPEP.htm). This scientific review panel recommended increasing the overall sample size through reduction in length of existing fixed transects and addition of randomly selected sites. Random components of this augmented, serially alternating sampling design (Urquhart et al. 1998) are intended to give representative estimates of fishery status, whereas fixed components ensure continuity with existing trend data. Increasing the number of sample transects per sampling occasion also provides increased statistical power to detect changes in fishery variables on a yearly time scale (Speas et al. 2004c).

In this report, we present results from fish monitoring activities in the Lees Ferry tailwater during 2007. Our monitoring objectives have not changed since 2002 and include evaluating the status and trends in relative abundance (CPUE), population structure (size composition and PSD), growth rate, and relative condition (K_n) of rainbow trout. In 2007, we initiated a new tagging regime (i.e. Floy tag) in our random transects to increase the ability to estimate adult rainbow trout population size. This regime will likely continue over consecutive years to ensure enough marked fish constitute the population. In this report we will compare and contrast data collected from fixed and random sites since 2002, and evaluate the existing serially alternating sampling design.

METHODS

Field Collections

We collected electrofishing (EF) samples in the Lees Ferry tailwater (Figure 1) during April 24-26, July 24-26, and October 30 – November 1, 2007. For all sample occasions we used two 16' Achilles inflatable boats outfitted for electrofishing, applying pulsed DC (~310 V, ~15 A; Sharber et al. 1994) to a 35-cm spherical electrode system. Sampling commenced shortly after dusk and persisted 5-7 hours per night. Daily river discharge at GCD ranged from ca. 9,300 to 10,700 cfs during April, 12,700 to 13,800 cfs during July, and 9,400 to 10,300 cfs during October-November (Figure 2).

During each monitoring survey, we electrofished 9 fixed and 27 random sites covering approximately 4 km of shoreline area (see Speas et al. 2004b). The 27 random transects were selected without replacement from strata containing the remaining sample units found in river kilometer (RK) 0.9 – 26.85. We stratified sample units in two ways: 1) by shoreline types / relative abundance combinations. This stratum was comprised of talus/cobble bar shorelines, which are characterized by the highest CPE values observed in 2001 (ca. 5.3 fish/min. EF; Speas et al. 2004b) and sand bar/cliff face shorelines characterized by the lowest CPE values from 2001 (ca. 3.6 fish/min EF; Speas et al. 2004b); and 2) longitudinally, as upper (RK 0.9 – 8.15), middle (RK 8.15 - 19.05) and lower (RK 19.05 – 26.85) subreaches of the tailwater below GCD. We selected specific shoreline types according to their availability (percentage of shoreline length) within river subreaches. Longitudinal stratification also allowed randomization while maintaining safety and logistical integrity (i.e., boats visit the same section of the river on each night) as well as among longitudinal gradients in fish density (Speas et al. 2004b).

We measured total length (TL; mm) for all fish captured and weight (g) for fish > 120 mm TL. We sexed fish based on manual extrusion of gametes. At fixed transects, we implanted untagged RBT > 200 mm TL with 400 kHz passive integrated transponder (PIT) tags and clipped adipose fins of all salmonids receiving PIT tags to monitor tag loss. Untagged native species (i.e. FMS) > 150 mm TL were also implanted with 134.2 kHz PIT tags. This marking program is primarily intended to provide information on fish growth. We injected PIT tags ventrally into the fish body cavity with the insertion point immediately posterior to the pelvic fin. In 2007, we began inserting individually numbered Floy tags into rainbow trout > 200 mm TL that were captured in our random transects. Tags were inserted through the dorsal pterygiophores near the dorsal fin insertion. This tagging regime was initiated to produce open population estimates in the near future. All fish were released near their original site of capture.

A subsample of RBT were sacrificed in the Lees Ferry tailwater in 2007 for age and diet analysis (AGFD), disease determination (Washington Animal Disease Diagnostic Laboratory [WADDL]; Washington State University), and parasite analysis (USGS Biological Resource Division,[BRD]). At each fixed transect for the age and diet analysis, we attempted to obtain one fish from each of the following size classes; < 152 mm TL, 152-304 mm TL, 305-405 mm TL, > 405 mm TL, and the largest fish captured. We sacrificed a total of 91 RBT from fixed transects in 2007, removed their stomachs, and extracted sagittal otoliths. We also sacrificed 39 RBT from random transects in April 2007 and 108 RBT in October 2007, removed and froze their heads, and shipped them to Mr. Jim Thompson with WADDL to test for whirling disease. Additionally, 31 whole RBT specimens from random transects were sacrificed, frozen, and shipped to Dr. Rebecca Cole of the U.S. Geological Survey BRD (Madison, WI) throughout 2007 for parasitological evaluations (Cole 2002).

Data Analysis

Evaluation of data from fixed and random sites

The role of fixed sites is primarily to provide long-term trend data to monitoring programs while data from random sites are the best point estimates of fishery status (Urquhart et al. 1998.) However, guidelines for statistical analyses of such data appear ambiguous as to whether the two types of data can be combined for more powerful (i.e. larger sample size) evaluation of long-term trends (S. Urquhart, *personal communication*). To evaluate differences in means and variances of the two types of data, we compared size-stratified data (CPE, K_n) and size structure (PSD) from fixed and random sites since the onset of the current sampling design in June 2002 using one-way analysis of variance (ANOVA; S. Urquhart, *personal communication*). We then used Levene's test of homogeneity of variance on site type (fixed vs. random) to test the null hypothesis that error variance in fixed and random sites are equal. If significant differences were not apparent, fixed and random site data were pooled to increase power for long-term trend detection. All statistical tests were considered significant at the $\alpha = 0.05$ level.

Long term monitoring

We computed CPE as fish captured per minute of EF, angler CPE as fish captured per angler hour, and indexed size structure of the catch by calculating PSD (Anderson and Nuemann 1996; McKinney et al. 1999a) as the ratio of "quality" sized fish to the sum of "quality" and "stock" sized fish, or

$$(\# \text{ fish} \geq 406 \text{ mm TL} / \# \text{ fish} \geq 305 \text{ mm TL})*100$$

Fish ≥ 406 mm have been protected from harvest by AGFD fishing regulations, and most fish ≥ 305 mm are sexually mature (McKinney et al. 1999a) and generally desired by Arizona anglers (Pringle 1994). We also computed CPE for the following length categories: < 152 mm TL, 152-304 mm TL, 305-405 mm TL and > 406 mm TL.

We determined relative condition factor (K_n; Le Cren 1951) as

$$K_n = W / W' * 100$$

where W′ is the standard weight relationship $e^{[(-4.6 + 2.856*LN(TL))]}$ incorporating all Lees Ferry RBT length and weight data collected since 1991. We also determined relative weight (W_r; same equation as K_n; Anderson and Nuemann 1996) based on the standard weight equation developed by Simpkins and Hubert (University of Wyoming, unpublished data) for comparison to other rainbow trout fisheries across their range. We evaluated fishery data (CPE, K_n, PSD) from fixed EF sites by inspection of confidence intervals and means calculated for each year and by simple linear regression where trends appeared evident.

RESULTS

The samples sent for whirling disease tested positive at a low level of incidence among the largest fish included in the sample. This represents the first positive case of whirling disease within the state of Arizona. Thus, an additional 108 RBT were sent to WADDL in October 2007 to determine the prevalence of whirling disease in the Lees Ferry reach of the Colorado River. Results of this analysis were negative for whirling disease suggesting the parasite did not persist. However, we will continue to sacrifice fish and send the samples to WADDL during fall sampling to ensure a given year's cohort from the spring is sufficiently exposed to the whirling disease parasite, if persistent in the system (Jim Thompson, *personal communication*). Results of parasitological evaluations (USGS-BRD, Madison, WI), and AGFD diet analysis are incomplete at the time of submission of this report.

Evaluation of data from fixed and random sites

Analysis of size-stratified RBT data revealed no differences in CPE and PSD among fixed and random sites (Table 1), during similar temporal scales (June 2002 through October 2007). Differences were observed, however, in RBT K_n between both sites (Table 1), but these differences likely reflect associated large sample sizes and may not be biologically significant. Thus, data from both fixed and random sites were pooled to increase our ability to detect trends over time in Lees Ferry RBT population indices.

Long term monitoring

A total of 1045 fish from 5 species were captured at Lees Ferry in 2007. Rainbow trout were the most prevalent species captured (98%) followed by flannelmouth sucker (1.5%), common carp (<1%), brown trout (*Salmo trutta*; <1%), and walleye (*Sander vitreus*; <1%; see Table 2). A total of 76 RBT were implanted with PIT tags and 11 PIT tagged fish were recaptured (1.1% recapture rate) during 2007 sampling. Also, a total of 354 RBT were implanted with Floy tags and 3 Floy tagged fish were recaptured (1% recapture rate). Growth information from recaptured RBT is given in Table 3. A total of 12 flannelmouth sucker were implanted with 134.2 kHz PIT tags, 3 of which were tagged with old 400 kHz PIT tags and thus given new 134.2 kHz tags.

The mean total length of RBT captured during 2007 was 231 ± 7.31 mm (mean ± 2 S.E.). This was significantly less than the mean of all RBT captured in 2005 and 2006 (255 ± 4.36 mm, $P < 0.001$ and 267 ± 4.81 mm, $P < 0.001$, respectively) and is similar to the mean annual total length measured in 2002 and 2004 (236 ± 3.00 mm, $P = 0.151$ and 227 ± 4.53 mm, $P < 0.390$). We attribute the decrease in mean total length in 2007 to the contribution of spawning fish. Redd counts within Lees Ferry were the highest recorded in 2007 since 2003 (J. Korman, *personal communication*), suggesting a large, successful spawning event occurred in the spring.

Length frequency analysis showed relatively few fish were captured < 150 mm TL during 2007 in April and July (Figure 3, panels A and B, respectively). Sampling effort in October, however, showed a distribution dominated by small fish with about 50% of fish captured comprising a mode < 150 mm TL (Figure 3, panel C). Overall length frequency analysis showed a typical bimodal RBT distribution in 2007 (Figure 3, panel D).

Catch per effort of electrofishing for RBT at Lees Ferry continued its decline since 2000 but appears to have stabilized in 2007 (Figure 4). Rainbow trout CPE for all sampling in 2007 was 1.27 ± 0.10 fish per minute of electrofishing (mean ± 2 S.E.), which is similar to the densities of RBT in 1992, 1993, and 2006. This overall decrease in density is largely attributable to the drastic decrease in numbers of RBT < 152 mm TL since 2001 (Figure 5, panel A). Density of RBT in the 152 to 304 mm TL size class also decreased from 2006 to 2007, and is similar to densities for this size class from 1991 to 1993 (Figure 5, panel B). Density of RBT in the 305 to 405 mm TL size class has generally declined since 2001 and is similar to densities observed since 2005 (Figure 5, panel C). Estimated CPE of RBT > 406 mm TL in 2007 was similar to densities observed since 2003 (Figure 5, panel D).

Angler CPE from creel surveys (AGFD Region 2, unpublished data) reflected the trend seen in the electrofishing CPE data for 305-405 mm TL RBT since 1991 (Figure 6). Angler catch rates since 2002 were substantially lower than those observed from 1996 to 2001 but appear to be stable. Angler catch rates in 2007 were about 0.63 ± 0.05 fish per angler hour and were similar to those observed in 1994. Mean proportional stock density in 2007 was 3.96 ± 2.42 (mean ± 2 S.E.; Figure 7), and increased compared to PSD observed in 2006. The current PSD is similar to those observed since 2001.

Rainbow trout K_n for all sizes of fish was greater in 2007 than that observed in 2006 (Figure 8). Mean K_n in 2007 was 84.81 ± 0.82 (mean ± 2 S.E.), and was the second highest overall condition observed since 1991. Size-stratified analysis of K_n did not show increases in trout condition since 2005 in the < 152 mm TL and > 406 mm TL size classes as evidenced by overlapping standard errors (Figure 9, panels A and D, respectively). Increasing trends in trout condition were observed, however, in the 152 -

304 mm TL and the 305 – 405 mm TL size classes (Figure 9, panels B and C, respectively).

DISCUSSION

The GCMRC-sponsored protocol evaluation panel suggested increasing overall sample size in the Lees Ferry tailwater by reducing the length of fixed electrofishing transects and incorporating randomly selected transects. We initiated this augmented, serially alternating sampling regime (Urquhart et al. 1998) in June 2002, where fixed transects served to ensure comparison with historical data and random transects provided representative estimates of fishery status. Our analysis of fixed and random transects over similar temporal scales (June 2002 through October 2007) showed no differences in size-stratified estimates of relative abundance and size structure. Differences were observed in size-stratified relative condition among fixed and random transects. However, we believe these differences likely reflect our large sample sizes and biologically may not be significant. For example, anglers likely will not recognize minor differences in relative condition for rainbow trout most vulnerable to angling (i.e. 305-405 mm TL). Thus, we pooled data from both fixed and random transects to increase our ability to detect rainbow trout population trends over time (Speas et al. 2004c). While our analysis of this data consisted of relatively simple statistics (ANOVA; S. Urquhart, *personal communication*), we recognize the potential for more robust statistical analysis of this data. We hope additional input from future protocol evaluation panels will help with this issue.

Overall catch rates of rainbow trout have declined since 2000 and likely represents a decline in overall abundance of the rainbow trout population which may be due to a suite of interacting factors including declining abundance of fish < 152 mm TL, low dissolved oxygen in 2005, and changes in the foodbase (i.e. New Zealand mudsnail, *Potamopyrgus antipodarum*; Makinster et al. 2007). Redd counts at Lees Ferry have declined by orders of magnitude since 2004 (J. Korman, *personal communication*), suggesting limited larval rainbow trout production in recent years. The low relative condition observed from 2002 to 2005 further suggests mature rainbow trout were unable to meet maintenance energy requirements needed to spawn (McKinney and Speas 2001).

During the fall of 2005, dissolved oxygen approached the lower lethal limit for rainbow trout (below 4 mg/L) for about a 3-week period which likely caused further declines in abundance. The New Zealand mudsnail was first detected in Lees Ferry in 1995 and has been known to restructure food webs in other systems (Hall et al. 2006). However, the absence of baseline foodbase data limits our ability to relate rainbow trout population dynamics to mudsnail presence.

Current conditions of the fishery, however, suggest the rainbow trout population is relieved of the density-dependent constraints seen in previous years (1997-2000; Speas et al. 2004a, b). The relative abundance of mature rainbow trout currently is similar to the low densities observed in the early 1990's. As a likely result of decreases in overall rainbow trout relative abundance, relative condition increased significantly from 2006 to 2007. Sampling surveys conducted in October revealed a strong 2007 cohort. This, coupled with current high compensatory survival of rainbow trout fry (J. Korman, *personal communication*), suggests additional successful spawning and recruitment for the fishery in the near future. The size structure of the fishery currently is higher than that observed in 2006 and, given current low rainbow trout densities, we expect size structure, relative condition, and growth to increase.

Creel results confirm the changes seen in the electrofishing trends. Angler catch rates in 2007 were similar to those in 2006, which were the lowest observed since 1994. The effects of lower densities should cause growth rates and size structure to increase thus producing larger, more vulnerable fish for anglers in the near future.

The low recapture rate of PIT-carrying rainbow trout led us to use an additional tagging method to increase our recapture rates for future growth and population size estimates. We began implanting captured fish > 200 mm TL from random transects with individually numbered Floy tags in 2007 and increased the percentage of marked fish in the population by about 30% compared to 2006. Retention of external tags has been shown to be highest in rainbow trout with t-bar anchor tags inserted through the dorsal pterygiophores in both short (i.e. < 3 months; McAllister et al. 1992) and long-term studies (i.e. > 3 months; Walsh and Winkelman 2004). However, few studies have tested the yearly retention of external anchor tags. Given that rainbow trout at Lees Ferry typically live between 4 and 5 years, and fish are tagged when they are roughly 2 years old (see Makinster et al. 2007), it is not feasible to calculate population estimates on a yearly basis. We expect our recapture rate of tagged fish (1.1% in 2007) will be highest after about 3 years with this tag regime as the proportion of tagged fish within the population will likely be the maximum. The model best suited for population size estimation will likely be based on Jolly-Seber open population assumptions. This model assumes 1) every rainbow trout in the population has an equal probability of capture at each sampling event; 2) rainbow trout survival is equal for each tagged individual from one sampling event to another; 3) tags are not lost and are easily observed; and 4) all rainbow trout are released alive after each sampling event and each sampling event is short in duration. Our first attempt using this modeling procedure will likely occur in the fall of 2009.

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Table 1. Results of analysis of variance on rainbow trout (RBT) relative abundance (CPUE; catch per minute), relative condition (Kn), and size structure (PSD; proportional stock density) by size class between fixed and random transects in the Lees Ferry tailwater fishery during 2007 electrofishing sampling. * denotes significance at the α = 0.05 level.

	RBT Size class (mm)			
Parameter	**< 152 mm**	**152 – 304 mm**	**305 – 405 mm**	**> 405 mm**
Abundance				
Mean CPUE (S.E.)				
Fixed	0.46 (0.13)	0.22 (0.06)	0.55 (0.10)	0.02 (0.02)
Random	0.46 (0.07)	0.24 (0.04)	0.54 (0.06)	0.04 (0.01)
F	0.002	0.14	0.01	0.76
DF	1, 106	1, 106	1, 106	1, 106
***P*-value**	0.97	0.71	0.92	0.39
Condition				
Mean K_n (S.E.)				
Fixed	80.02 (3.96)	84.45 (1.70)	81.85 (1.16)	58.44 (8.61)
Random	83.02 (1.88)	88.48 (0.79)	84.26 (0.56)	85.99 (2.87)
F	0.47	4.67	3.52	9.22
DF	1, 36	1, 144	1, 363	1, 18
***P*-value**	0.50	0.03*	0.06	0.007*

	Entire fishery
Size structure	
Mean PSD (S.E.)	
Fixed	6.78 (2.51)
Random	3.08 (1.41)
F	1.66
DF	1, 94
***P*-value**	0.20

Table 2. Number of each species captured per trip by transect type at Lees Ferry during electrofishing surveys in 2007. RBT = rainbow trout; BNT = brown trout; CRP = common carp; FMS = flannelmouth sucker; WAL = walleye.

Trip ID	**Date**	**Transect type**	**Total catch**				
			RBT	**BNT**	**CRP**	**FMS**	**WAL**
LF20070424	4/24 – 4/26	Fixed	65	1			1
		Random	204	2			
		Total	**269**	**3**			**1**
LF20070724	7/24 – 7/26	Fixed	90				
		Random	258		4	5	
		Total	**348**		**4**	**5**	
LF20071030	10/30 – 11/1	Fixed	127				1
		Random	301			11	
		Total	**428**			**11**	**1**
	Grand total		**1045**	**3**	**4**	**16**	**2**
	Percent of catch (%)		**98**	**0.003**	**0.004**	**1.5**	**0.002**

Table 3. Rainbow trout growth information resulting from recaptures during electrofishing surveys in 2007 of PIT tagged and Floy tagged fish in the Lees Ferry tailwater.

Tag type	Tag number	Date marked	Mark location (RM)	Date recaptured	Recap location (RM)	Days out	Mark length (mm)	Recap length (mm)	Distance moved (miles)	Instant growth (mm/day)
PIT tag										
	434458453E	06/29/2005	-14.0	07/25/2007	-14.0	756	288	334	0	0.061
	43627D1811	06/28/2006	-7.2	07/24/2007	-4.0	391	371	380	2.8	0.023
	436279393D	10/12/2006	-10.2	11/01/2007	-10.2	385	373	379	0	0.016
	43445A4F2B	4/25/2007	-14.7	10/31/2007	-14.7	189	401	410	0	0.048
	436422543A	11/30/2005	-10.2	4/26/2007	-10.3	512	303	330	0.1	0.052
	43623E0F70	6/27/2006	-14.7	4/25/2007	-14.7	302	212	290	0	0.258
	4362233823	4/25/2007	-12.0	7/25/2007	-12.0	91	355	359	0	0.044
	4363033973	4/25/2007	-14.7	7/25/2007	-14.7	91	354	367	0	0.143
	4365192B4E	11/28/2005	-4.0	10/31/2007	-14.4	702	276	360	10.4	0.120
Floy tag										
	AGFD 1075	4/25/2007	-15.1	10/31/2007	-15.0	189	401	410	0.1	0.048
	AGFD 0528	4/25/2007	-12.4	7/25/2007	-12.0	91	322	326	0.4	0.044
	AGFD 1115	4/25/2007	-14.1	10/31/2007	-14.0	189	343	347	0.1	0.021

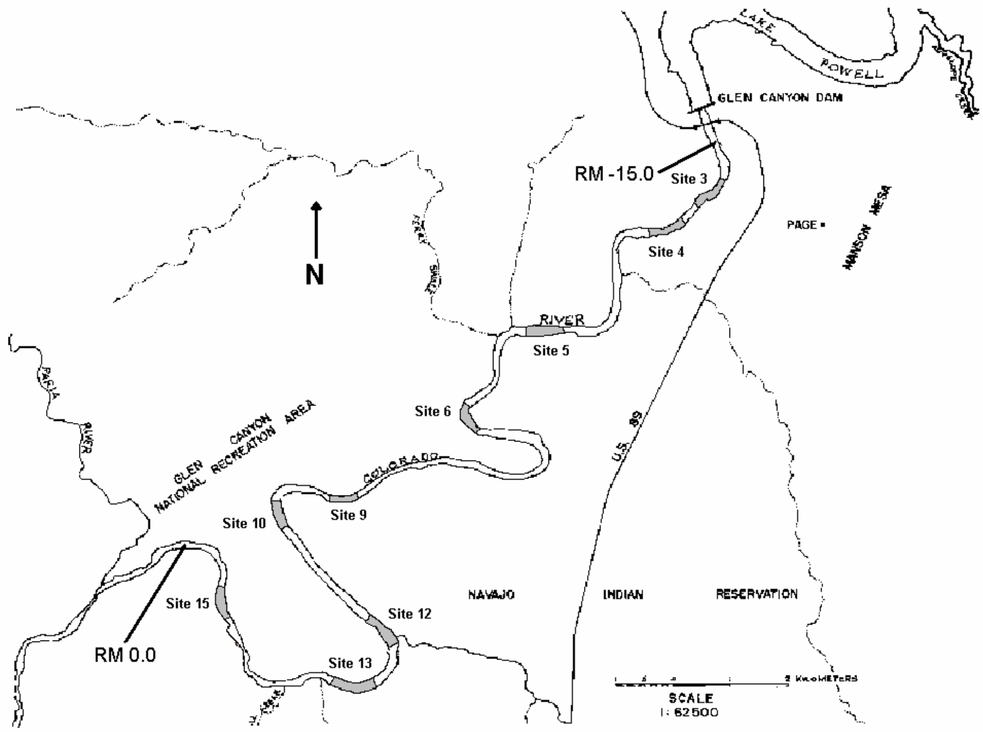

Figure 1. Map showing the Lees Ferry tailwater fishery below Glen Canyon Dam, on the Colorado River, Arizona. Fixed sampling locations are shaded gray.

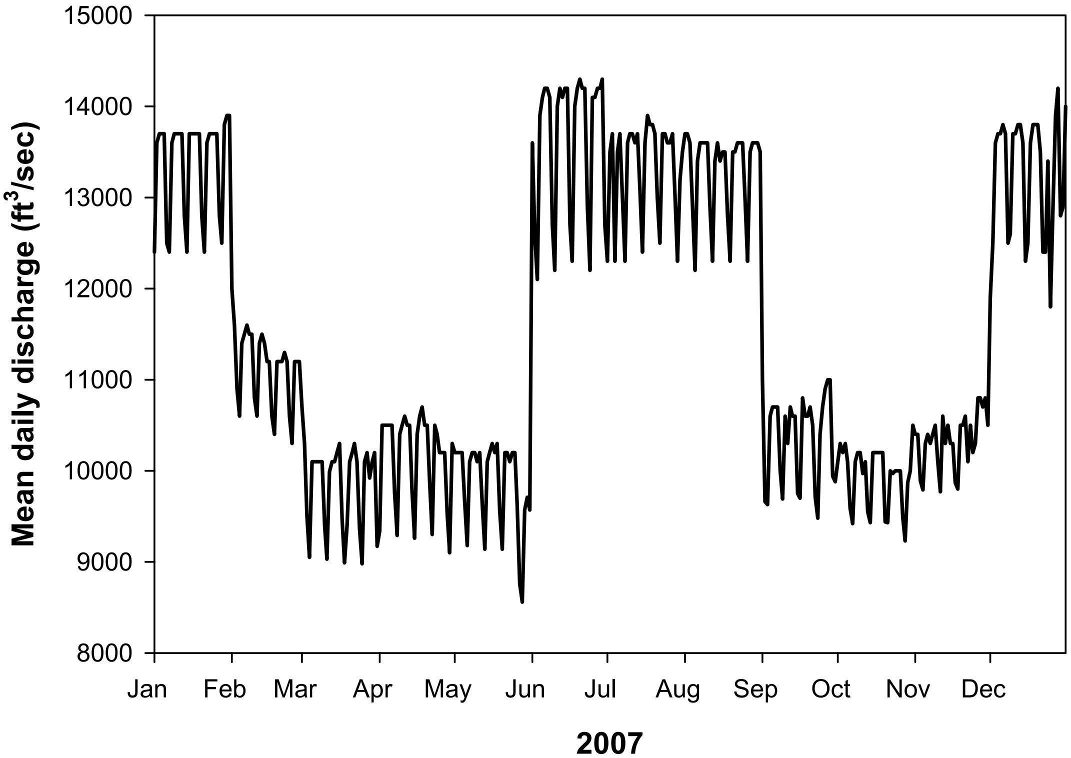

Figure 2. Mean daily discharge (cfs) from Glen Canyon Dam during 2007.

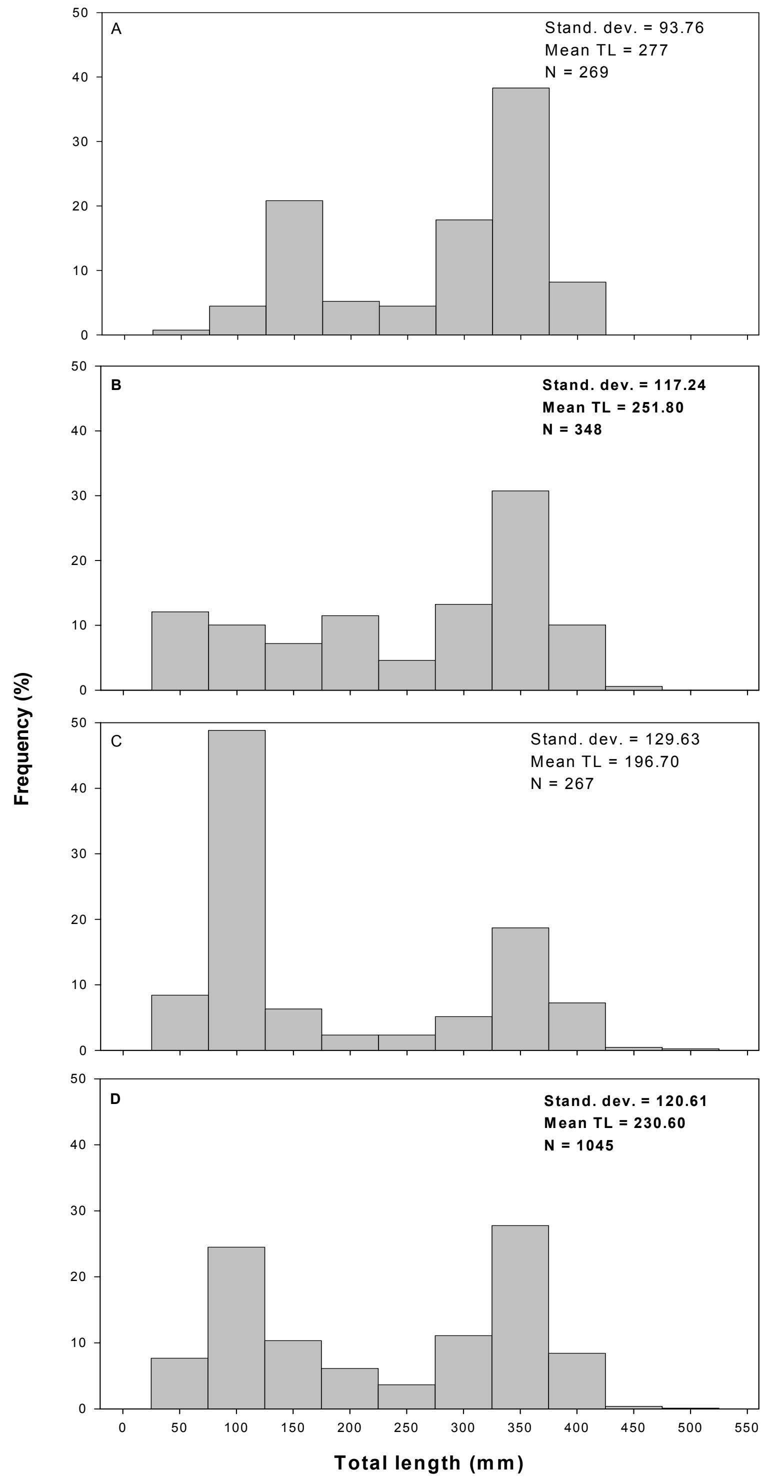

Figure 3. Lees Ferry rainbow trout length frequency distribution during April 2007 (A), July 2007 (B), October 2007 (C), and all sampling in 2007 (D). Data includes both fixed and random transects.

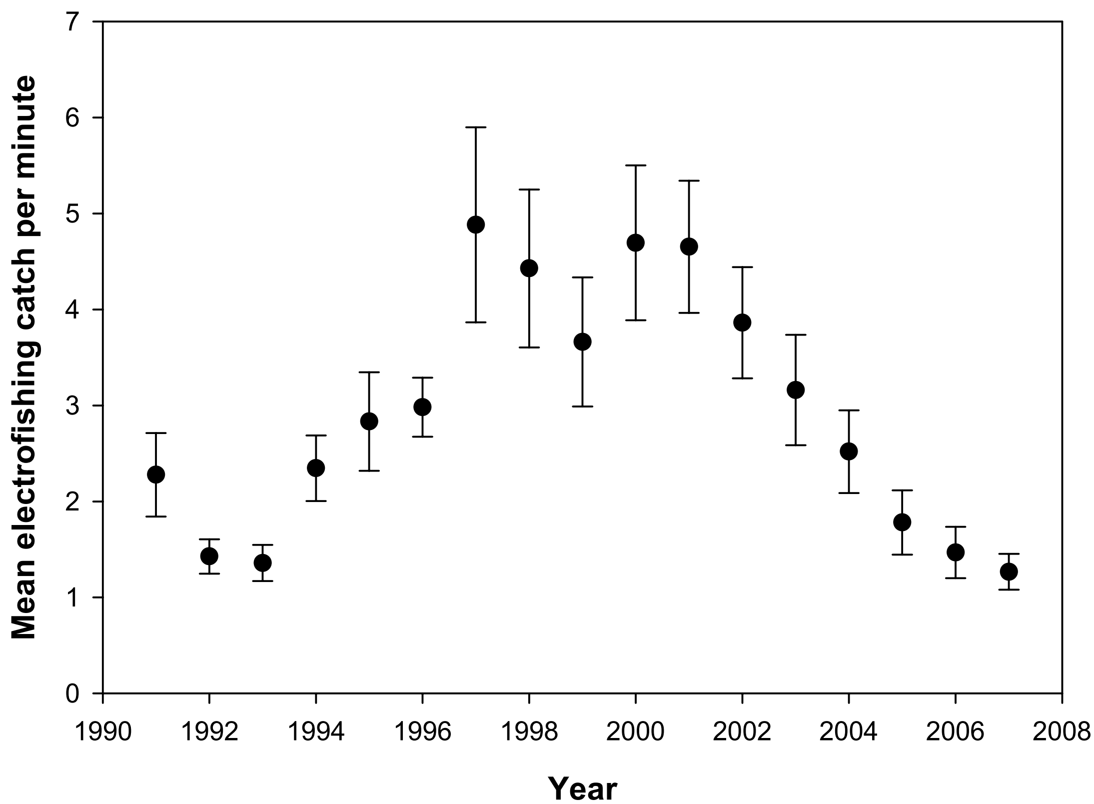

Figure 4. Rainbow trout mean electrofishing CPUE (catch per minute) in the Lees Ferry tailwater fishery, 1991-2007. Figure represents data from all size classes in both fixed and random transects. Bars represent ± 2 S.E. of the mean.

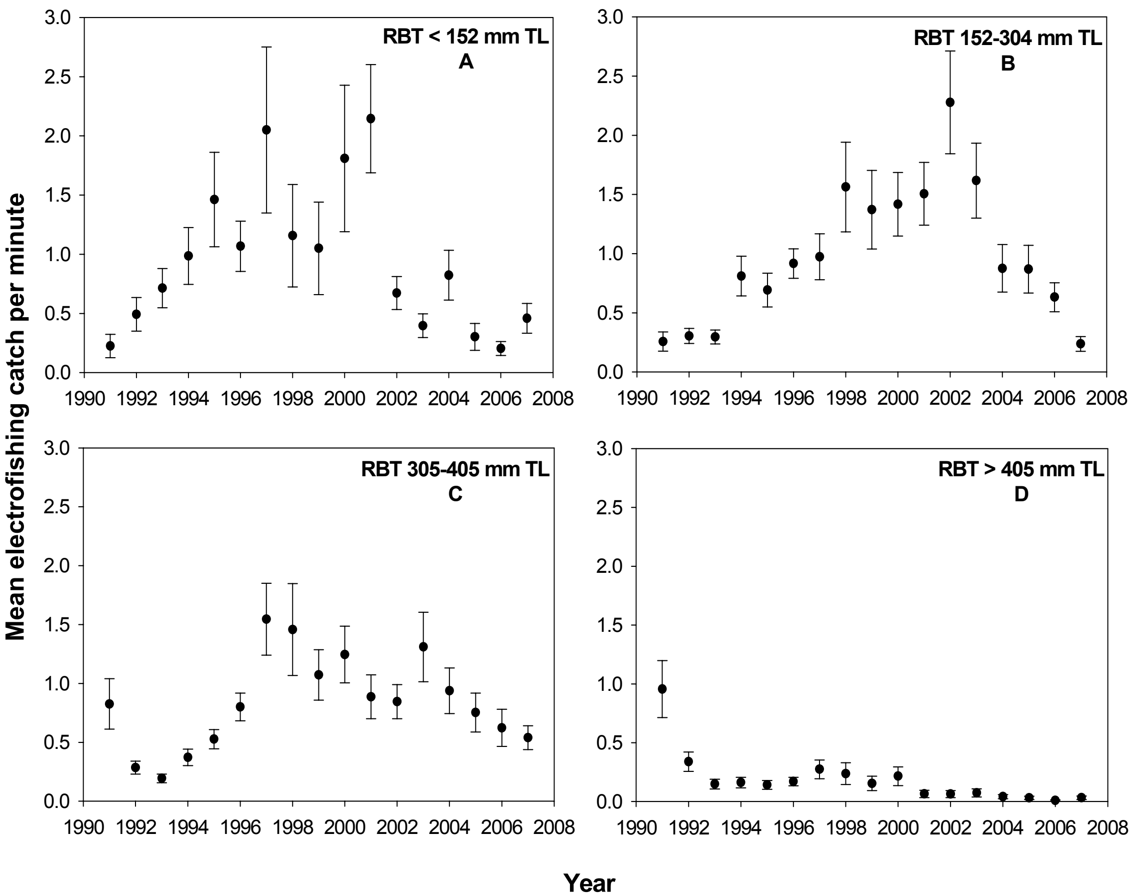

Figure 5. Rainbow trout mean electrofishing catch per minute for fish < 152 mm total length (TL; A), 152-304 mm TL (B), 305-405 mm TL (C), and > 405 mm TL (D) in the Lees Ferry tailwater fishery, 1991-2006. Figure represents data from both fixed and random transects. Bars represent ± 2 standard errors of the mean.

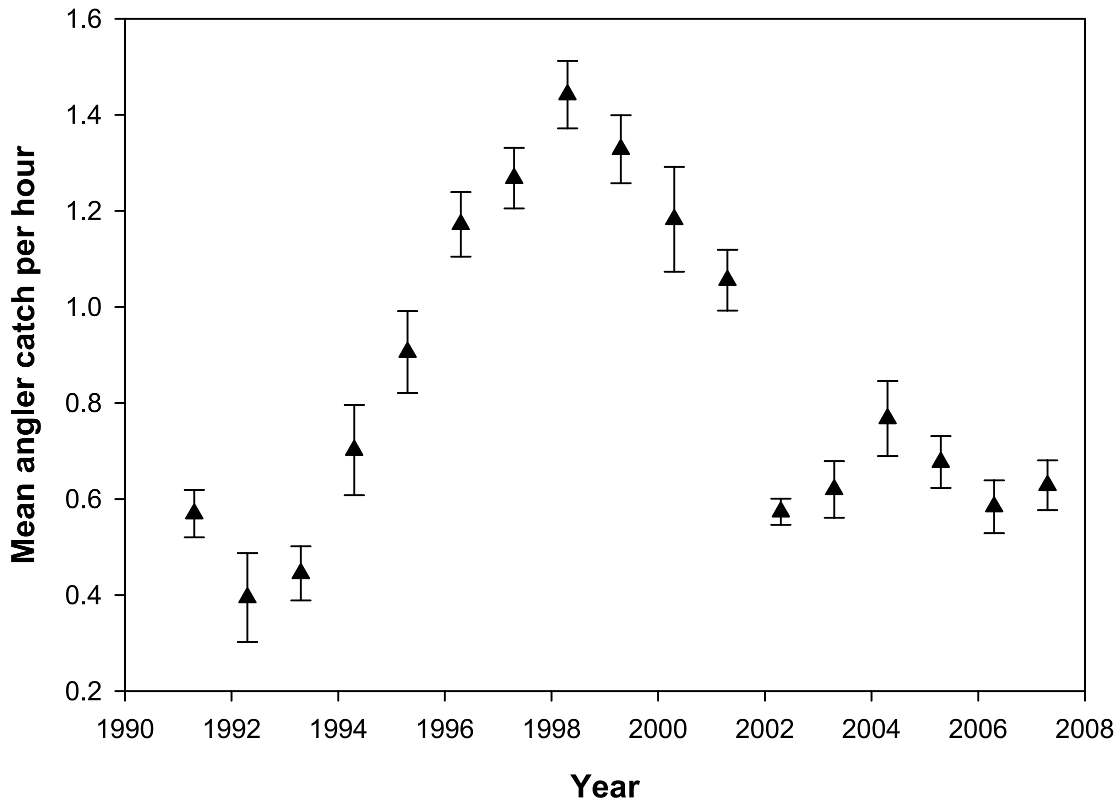

Figure 6. Mean angler catch-per-unit-effort (catch per hour) of rainbow trout in the Lees Ferry tailwater fishery, 1991-2007. Bars represent ± 2 standard errors of the mean.

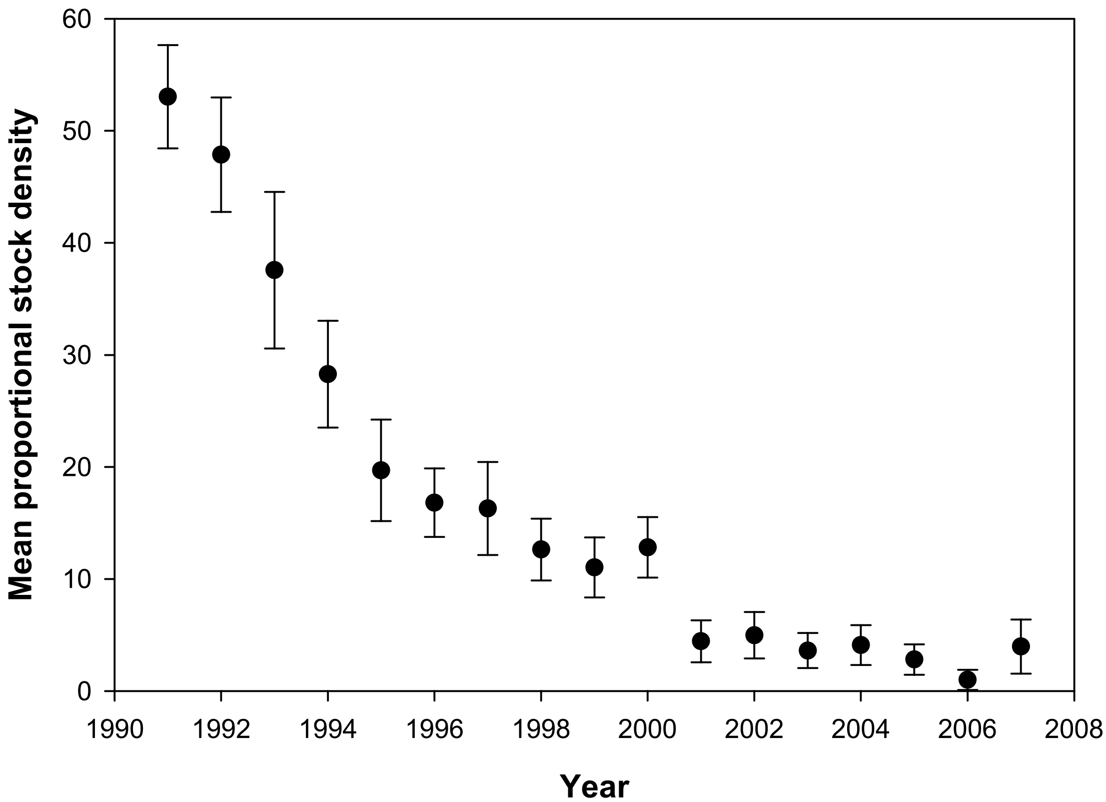

Figure 7. Rainbow trout mean proportional stock density (PSD) in the Lees Ferry tailwater fishery, 1991-2007. Figure represents data from both fixed and random transects. Bars represent ± 2 standard errors of the mean.

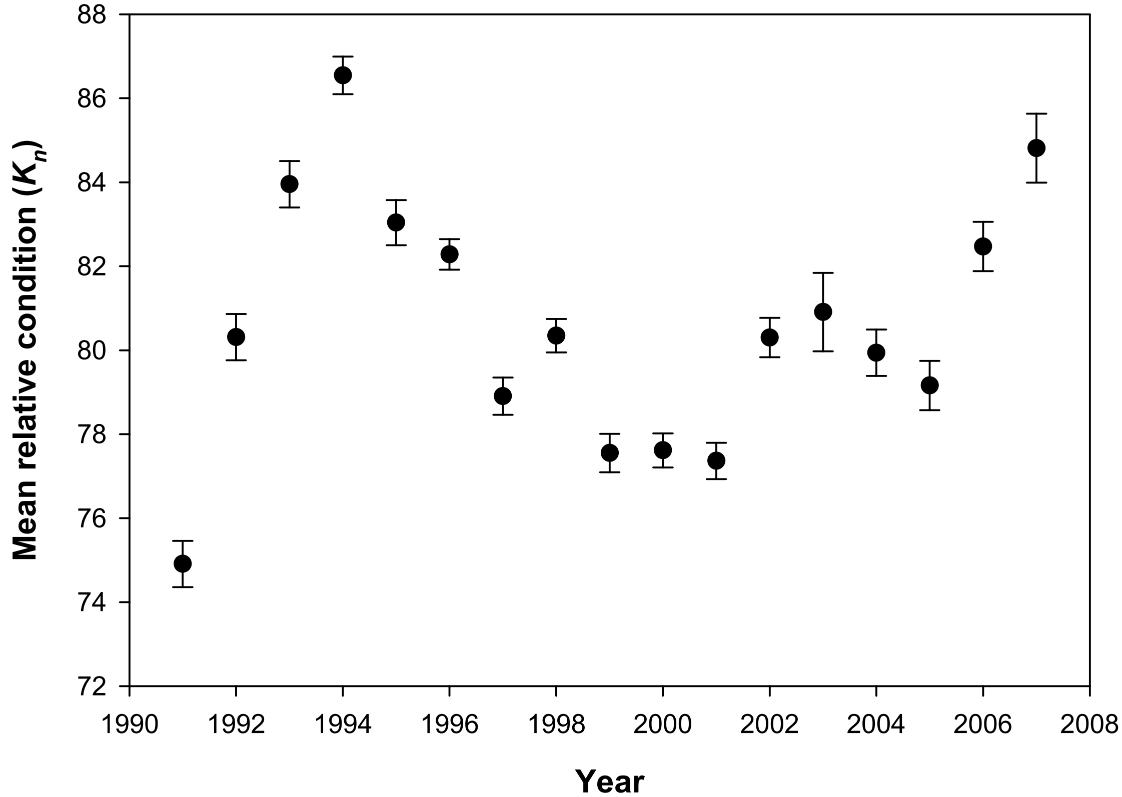

Figure 8. Rainbow trout mean relative condition (K_n) in the Lees Ferry tailwater fishery, 1991-2007. Figure represents data from all size classes in both fixed and random transects. Bars represent ± 2 standard errors of the mean.

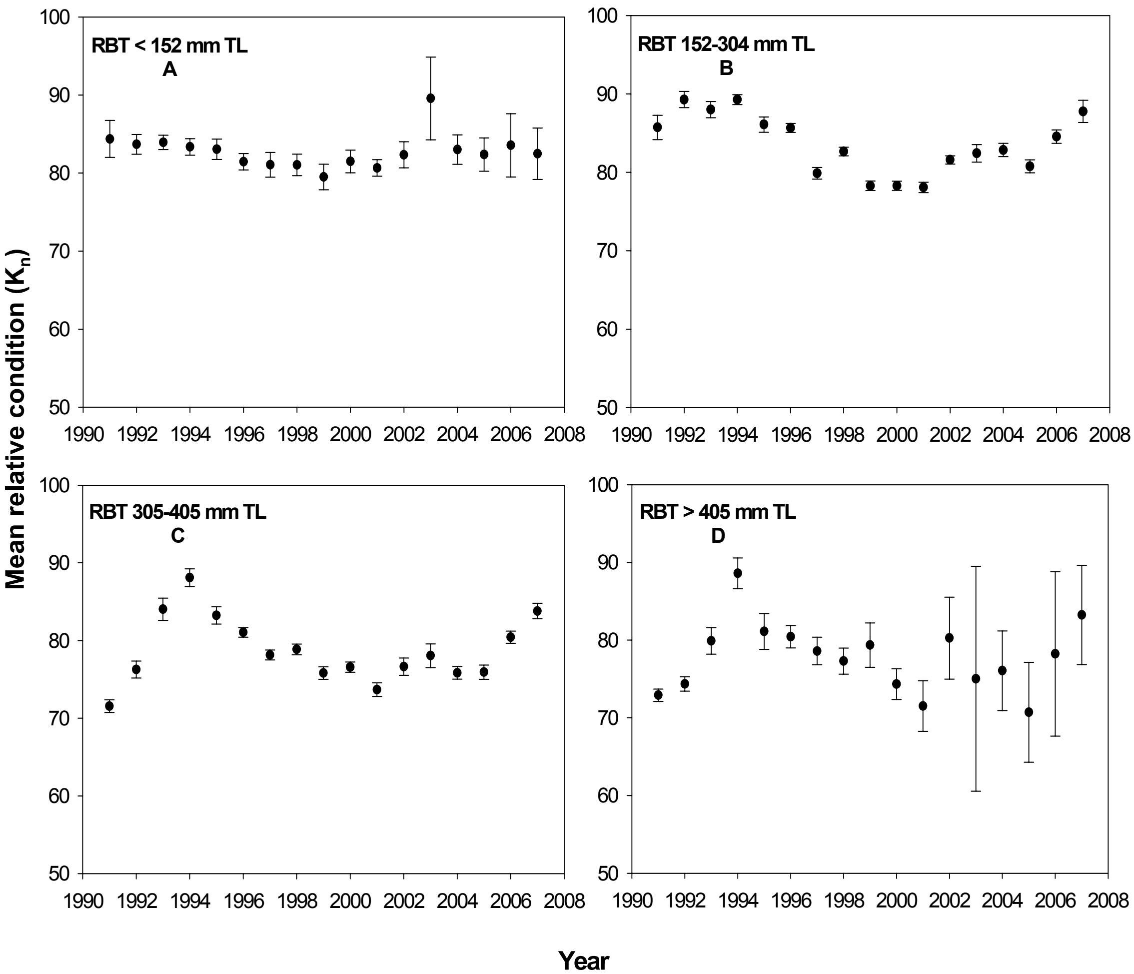

Figure 9. Rainbow trout mean relative condition (K_n) for fish < 152 mm total length (TL; A), 152-304 mm TL (B), 305-405 mm TL (C), and > 405 mm TL (D) in the Lees Ferry tailwater fishery, 1991-2007. Figure represents data from both fixed and random transects. Bars represent ± 2 standard errors of the mean.