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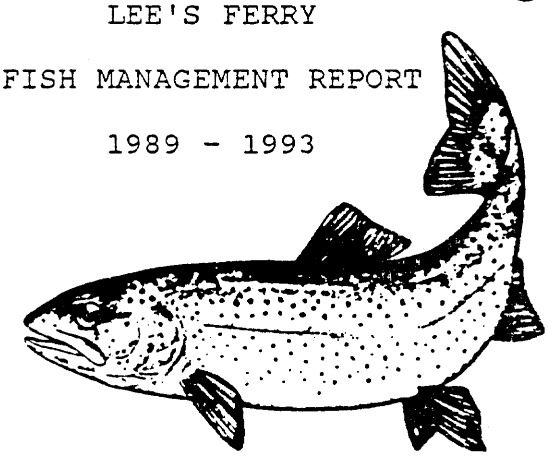
FOR PUBLIC REVIEW

STATEWIDE FISHERIES INVESTIGATIONS

SURVEY OF AQUATIC RESOURCES

FEDERAL AID PROJECT F-7-M-36

COLORADO RIVER
LEE'S FERRY
FISH MANAGEMENT REPORT
1989 - 1993



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INTRODUCTIONN

Lee's Ferry is a 15-mile tailwater fishery located below Glen Canyon Dam in northern Coconino County southwest of Page, at 111° 35' W and 37° 52' N. It is administered by the National Park Service, Glen Canyon National Recreation Area. The Colorado River at Lee's Ferry has undergone many changes since the completion of Glen Canyon Dam in 1963, including runoff/flow patterns, temperature, dissolved oxygen, sediment transport, and the aquatic food chain. Beginning in 1964 the Department began stocking rainbow trout and in 1968 introduced aquatic food organisms to take advantage of the newly created "tailwater" fishery. Trout were stocked as catchables from 1964-1976. In 1971 the amphipod *Gammarus* began to appear regularly in trout stomach samples. Beginning in 1976 a fingerling stocking program was initiated. In 1977 a regular creel census program (which had been discontinued in 1973) was resumed to evaluate the fishery.

By 1977, many trout over 3.5 pounds were being creeled. Lee's Ferry received public and Department attention. With sportswriters' help Lee's Ferry was "discovered". The Department did not feel the trophy fishery could sustain increased angling pressure where fishermen could harvest a legal ten fish limit that weighed over forty pounds. Therefore a four fish bag limit was enacted in 1978.

From March 1978 to August 1980, rainbow trout were not stocked to evaluate the question of stocking versus natural reproduction. During this time approximately 250,000 brook and 60,000 cutthroat trout were stocked.

The angling public changed rapidly, with more angler days expended, more non-resident use, and a tremendous increase in the use of boats to reach areas otherwise inaccessible. In 1979 the Department recommended implementing both immediate kill and artificial lure recommendations. These recommendations produced considerable controversy. Only the immediate kill regulation was implemented in 1980, as the public and the Commission did not find an artificial only regulation acceptable.

Both fishermen and the Department became concerned when the Bureau of Reclamation announced it would begin peak power production when Lake Powell filled in 1980. During 1980 and 1981, Arizona Game and Fish conducted a study to evaluate instream flows and their impact on the fishery (Persons et al, 1985).

In addition a study was conducted by Northern Arizona University in 1982 and 1983 to answer questions about fishermen's attitudes (Richards et al, 1985).

Fluctuations in water level, associated with hydroelectric "peaking power" generation, affected the Colorado River at Lee's Ferry and through Grand Canyon National Park. Primary concerns at Lee's Ferry included angler access, stranding of spawning fish and eggs, and impacts on the food base. These concerns were incorporated into the Glen Canyon Environmental Studies, administered and funded by the Bureau of Reclamation (1984-86 Phase I; Maddux et al, 1987). However, high flows and "spills" from 1983 - 1986 precluded any real evaluation of the impacts of fluctuating flows.

Between 1980 and 1984 anglers voiced increasing concern over the "decline" of the fishery, in particular the decreasing size of the fish. During this time angling pressure increased to five times the level experienced in 1977, while the average size of rainbow trout in the creel decreased by 70%.

During 1984, a major effort was made to compile and evaluate the various data available on Lee's Ferry and to plot a course of action. The results were printed in January 1985 (Janisch). The artificial only regulation was implemented on January 1, 1986, to decrease mortality on the growing percentage of fish caught and released. It also reduced fishing pressure (and harvest) and increased the average size of fish harvested. Creel census returns from 1984 - 1986 indicated the oxytetracycline marked hatchery fish made up over 70% of the fishery. A management plan for the period January 1986 to January 1990 was prepared (Reger, 1986). Changes in stocking and regulations produced the desired results: a higher catch rate and an increase in the average size of fish harvested. This caused another increase in angling pressure and concern for future management.

A 16"-22" no-kill slot was put in effect January 1, 1990. The bag limit was reduced to two fish in possession, only one of which could be over 22". Stocking rate was reduced to 70,000 - 80,000 a year in 1991 to avoid "stockpiling" in the slot and the potential of reduced growth rates.

GCES phase II was implemented in 1988. A major component of this study was actual measurements made before, during, and after specific releases made for evaluation from June 1990 - July 1991.

As early as late 1990 Arizona Game and Fish had concerns over the condition (fatness; relative weight) of trout. Analysis at this time indicated that condition factors had been decreasing since at least 1984. By 1992 poor condition and loss of larger trout from the population had become alarming. Suspect was the reduction in food base caused by scouring and extended desiccation that resulted from research flows. Especially damaging flows appear to have occurred June and July 1990, September 1990 through January 1991, and May and June 1991; either as a result of high fluctuation with a low minimum, or the number of consecutive hours of flows less than 5100 cfs.

A trout health exam conducted in December 1990 (Landye, 1991) revealed that the loss of condition was due to more than reduced food. All fish had a heavy infestation of nematodes in their pyloric caeca. This was at first thought to be a new parasite, but discussions with previous researchers and examinations of preserved specimens showed presence of the nematodes as early as 1980. Reductions in available food and increased stress (variable flows, spawning, hooking) are both synergistic with parasite infestation which caused poor condition and increasing mortality.

The Secretary of the Interior decided in 1989 that an EIS on the operations of the dam would be prepared. As a part of this process, data from the GCES research was used to formulate "interim flows", which would protect natural resources in the Glen/Grand Canyon ecosystem until a record of decision could be made. These interim flows greatly reduced flow fluctuations and ramping rates, beginning in late 1991 after the completion of the test flows.

The reduction in flow fluctuations appear to have nearly eliminated the stranding loss of adults attempting to spawn. These flows also resulted in a dramatic increase in natural recruitment (apparently from <30% to >70%). Effects of the interim flows on food are less certain, as increases in standing crops of algae and invertebrates may not be as available (drift) to the fish, drift may be less than 50% of drift under fluctuating flows (Liebfried, 1994). Food production appears to have improved with the recovery of cladophora, Gammarus, and midges as trout health and condition have been improving since mid 1991.

Attempts to follow year classes by spray marking with inert pigment were not successful due to fairly rapid loss of marks on a large percentage of the fish. Since 1992 coded wire tags have been used on all stocked fish. Fingerlings have been nose tagged. Some catchable fish stocked in 1992 were nose tagged and adipose clipped. Catchable fish stocked in 1994 have wire tags in their adipose fins.

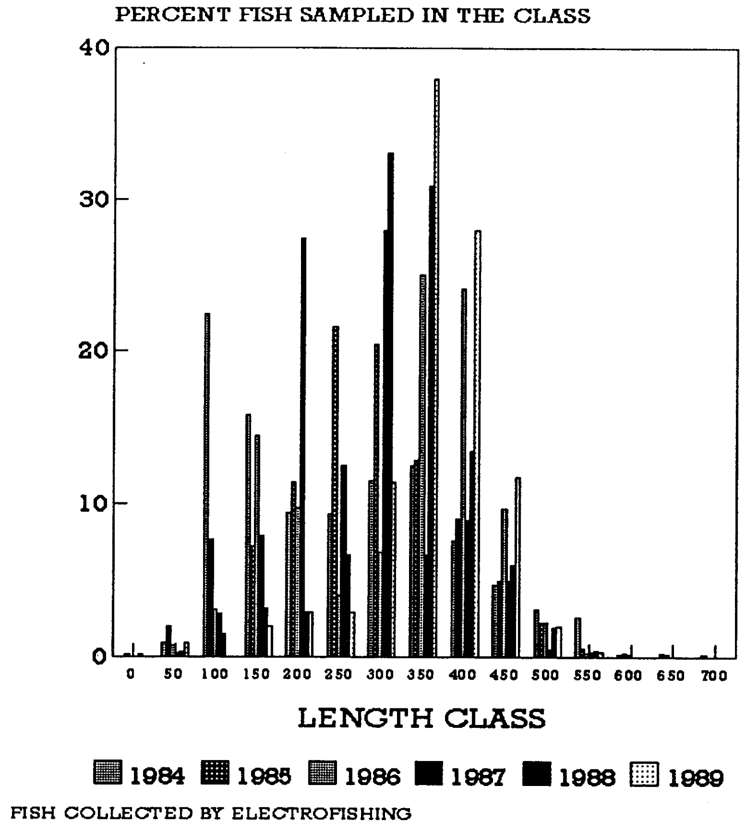
Stocking has continued to be distributed throughout the reach. Changes in flow releases have reduced the need to make multiple stockings over time as has increased natural recruitment. Stocking rate was reduced to 80,000 BelAir strain Rainbow Trout. No Snake River Cutthroat have been stocked as the US Fish and Wildlife Service feels they would represent a threat (increased predation) on Humpback Chub. Brook Trout and Kamloop strain Rainbow Trout stockings were discontinued.

Creel has continued at the same level with the exception of 1993-1994 due to problems hiring personnel. Angler opinion shows a general satisfaction with current harvest regulations, but a vocal minority would like even more restricted harvest.

Population surveys have been conducted by GCES. Morgenson (1991) estimated the population of 12" and larger trout at 98,000 ± 29,000 fish for the 15.4 miles.

ELECTROFISHING

While creel census provides valuable data on anglers and their harvest, it often does not present a true picture of the fish population, since certain species or sizes are selected against. Electroshocking also has sampling biases but provides another method of evaluating the fish population. As electrofishing more representatively samples medium size fish, it is often used to estimate growth and survival rates. Glen Canyon Environmental Studies (GCES) provided data from electroshocked fish (Figure 1). With the institution of the slot limit in 1990 much of the usefulness of creel data for assessing population structure was lost.



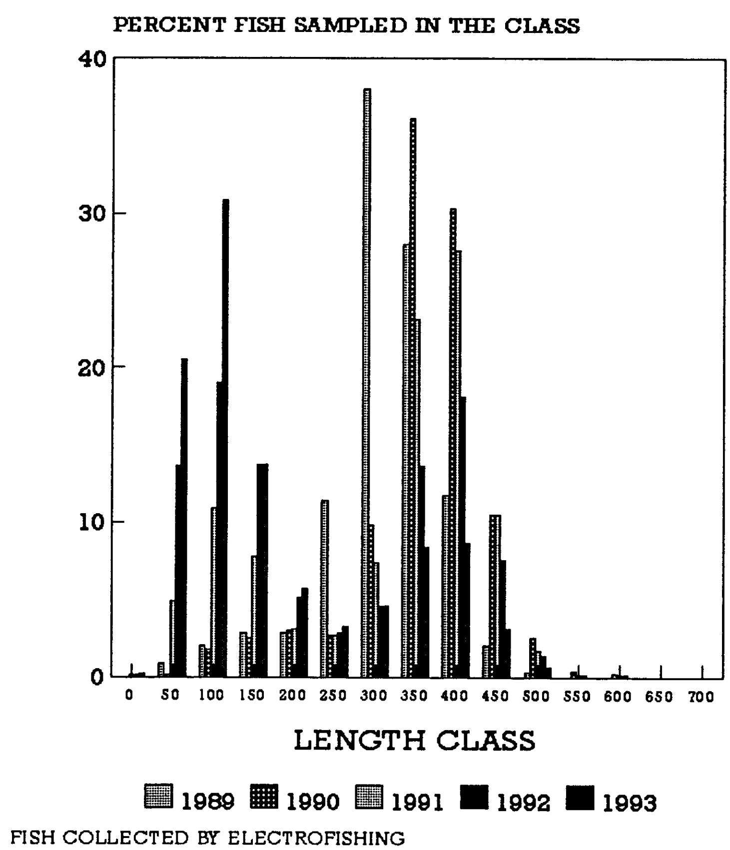


FIGURE 1. LENGTH FREQUENCIES OF FISH COLLECTED BY ELECTROFISHING AT LEE'S FERRY, 1984 - 1993

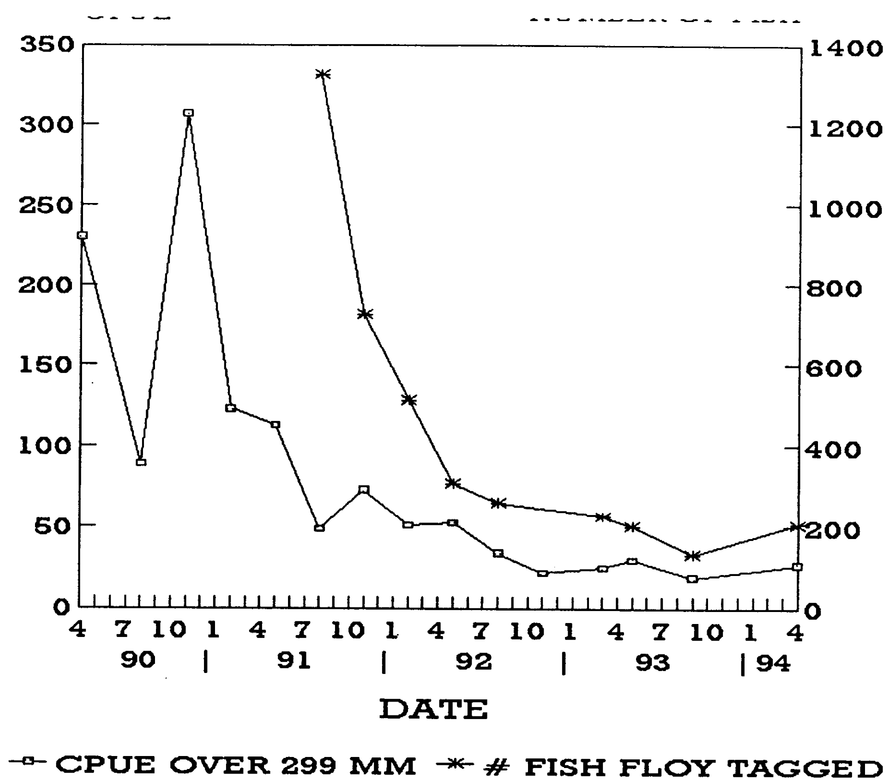
SPECIES COMPOSITION

Electrofishing samples species not frequently taken by anglers. Table 1 shows the percent species composition (and total fish sampled) by electrofishing in 1984-1993. This indicates that brook trout were relatively stable at 5% of the population until 1988 when stocking of that species terminated. The two species that change are rainbow trout and flannelmouth sucker, apparently due to large fluctuations in the flannelmouth population, which was high in 1985-1986 and low since then.

Table 1. Species Composition of Fish Sampled by Electrofishing at Lee's Ferry, 1984-1993.

Species	Percent of Sample									
	84	85	86	87	88	89	90	91	92	93
Rainbow Trout	85	78	79	94	92	97	97	97	96	98
Flannelmouth Suc.	8	16	17	1	2	1	*	2	3	2
Brook Trout	6	5	2	5	5	2	3	1	*	*
Carp	1	1	1	0	1	0	*	*	*	*
Brown Trout			*							
Bluehead Sucker		*	*		*			*	*	
Channel Catfish		*							*	
Striped Bass					*					*
Other		*	*							
N	1459	2314	1212	663	4318	360	1414	4509	2959	2181

* Less than one percent



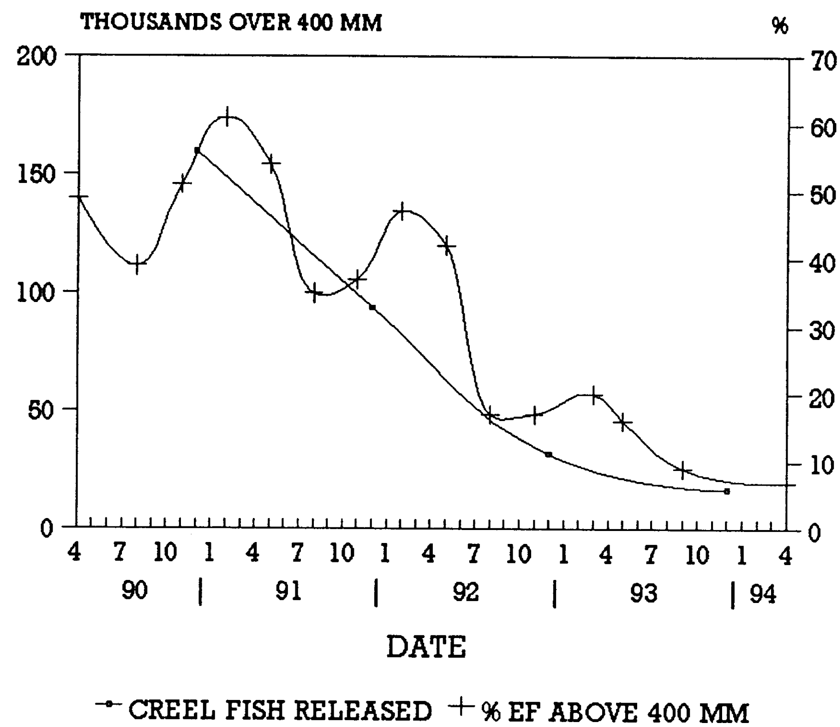


FIGURE 2. LEE'S FERRY ADULT POPULATION TRENDS, 1990 - 1994. (VARIOUS ESTIMATORS OF TRENDS FROM ELECTROSHOCKING AND CREEL SURVEY DATA)

POPULATION TRENDS

No attempt to estimate population numbers, or fish density, was made until GCES. Most attempts at mark and recapture methods proved to have too small a sample size, and thus too large a confidence interval to be of use. The exception was the use of oxytetracycline to estimate the contribution of hatchery fish to the population. Morgenson (1991) made an estimate of 98,000 ± 29,000 fish for 15.4 miles based on sampling of 15 small reaches.

Persons (1990) commented on the apparent lack of juvenile fish and the stockpiling of fish in the slot. Since 1991 all indications (Figure 2) are that a great reduction in adult rainbow trout has occurred. Since 1992 young fish have been sampled in increasing numbers (Figure 1).

Wire-tagged fish collected by electrofishing 8/92 through 9/93 indicate a 60% survival of fingerling and 48% survival of catchable stocked fish. (Persons unpublished data, 1994) If these rates were to remain constant, the result would be 22% of the fingerlings surviving to be larger than 16" after 3 years, and 23% of catchables surviving larger than 16" in two years.

GROWTH

Due to fairly constant temperatures, no annuli on scales or otoliths have been detectable. Early attempts to fin clip fish were not conclusive, either because of sample size, or the apparent regeneration of fins (Janisch, 1985).

Hatchery fish stocked from 1983 until 1986 were marked with oxytetracycline to evaluate the relative contribution of hatchery and natural reproduction to the fishery. However, all hatchery fish being marked precluded following any given year class. Attempts to follow stocked fish by marking with spray injected inert pigment proved unsuccessful due to inadequate retention time in a majority of fish. Fingerlings stocked since 1992 have been tagged with wire nose tags. Catchable fish were also stocked in 1992 which were nose tagged. Most of the catchable fish were also adipose clipped. Catchable fish stocked in 1994 were wire tagged at the base of their adipose fins.

Electrofishing data from 1984 - 1986 indicated four year classes which appeared to have a growth rate of about one-half inch per month (range 0.45-0.54). (Figure 3; from Reger et al, 1988). This was considerably less than the estimated 1" per month (Bancroft, 1980) or the estimated 3/4" per month (Maddux, 1985) which would compare to the 1" per month reported for the Green River below Flaming Gorge Dam (Johnson, et al, 1987).

The estimated growth rate of 1/2" per month was for fish stocked at much higher densities, under higher water

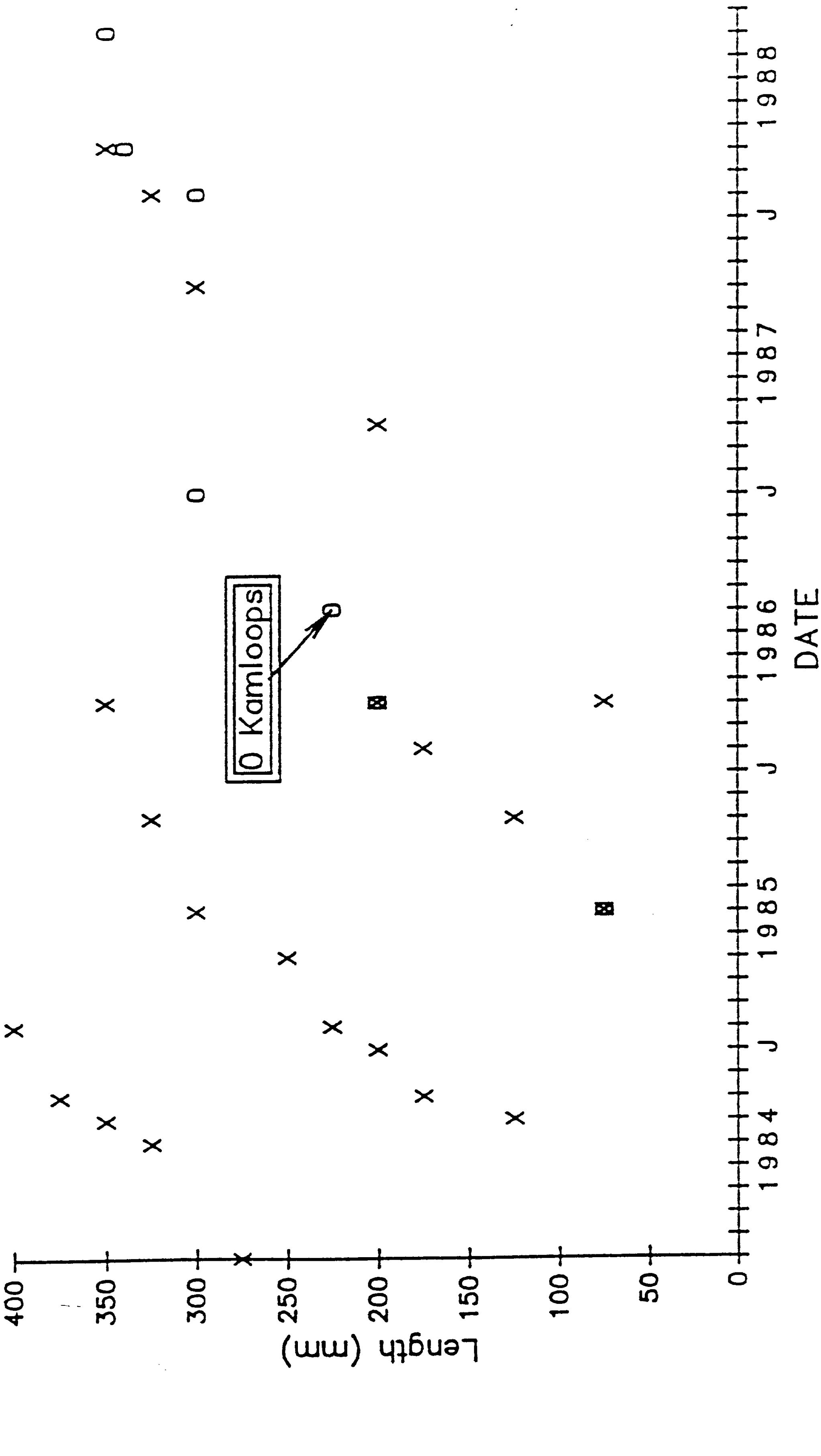


FIGURE 3. ELECTROFISHING LENGTH FREQUENCY PEAKS AT LEE'S FERRY, 1984 - 1988

conditions, and more heavily harvested than in earlier years. Food availability - due to stocking rate, changes in flows, or aging of Lake Powell (decrease in plankton and nutrients) - could have caused a decrease in growth rate. Peaks in length frequencies tend to run together at lengths over 16".

Electrofishing data since 1990 (See Figure 4) was examined to estimate growth rates. Fish from 1990 and 1991 stockings were not discernable from wild spawned fish due to rapid loss of inert dye pigment. Wire tagged 1992 and 1993 fingerling stocked fish and wild spawned fish were separable. Some of the adult fish stocked in 1992 were also adipose clipped, and adequate recaptures from this group allowed independent estimation of growth and survival.

Analysis of electrofishing data from GCES data from 1990-1994, again by plotting median points of clusters of fish lengths at various sampling dates indicates that naturally spawned fish are growing at about .333 inches a month. This is less than the .500 inches a year estimated by the same methodology for 1984 - 1988, but much better than the virtual "no growth" observations made between 1990 - 1991. Unless considerable improvement occurs in growth, it would take three to four years to re-establish the adult segment of the population. With continued stable flows, recovery of the

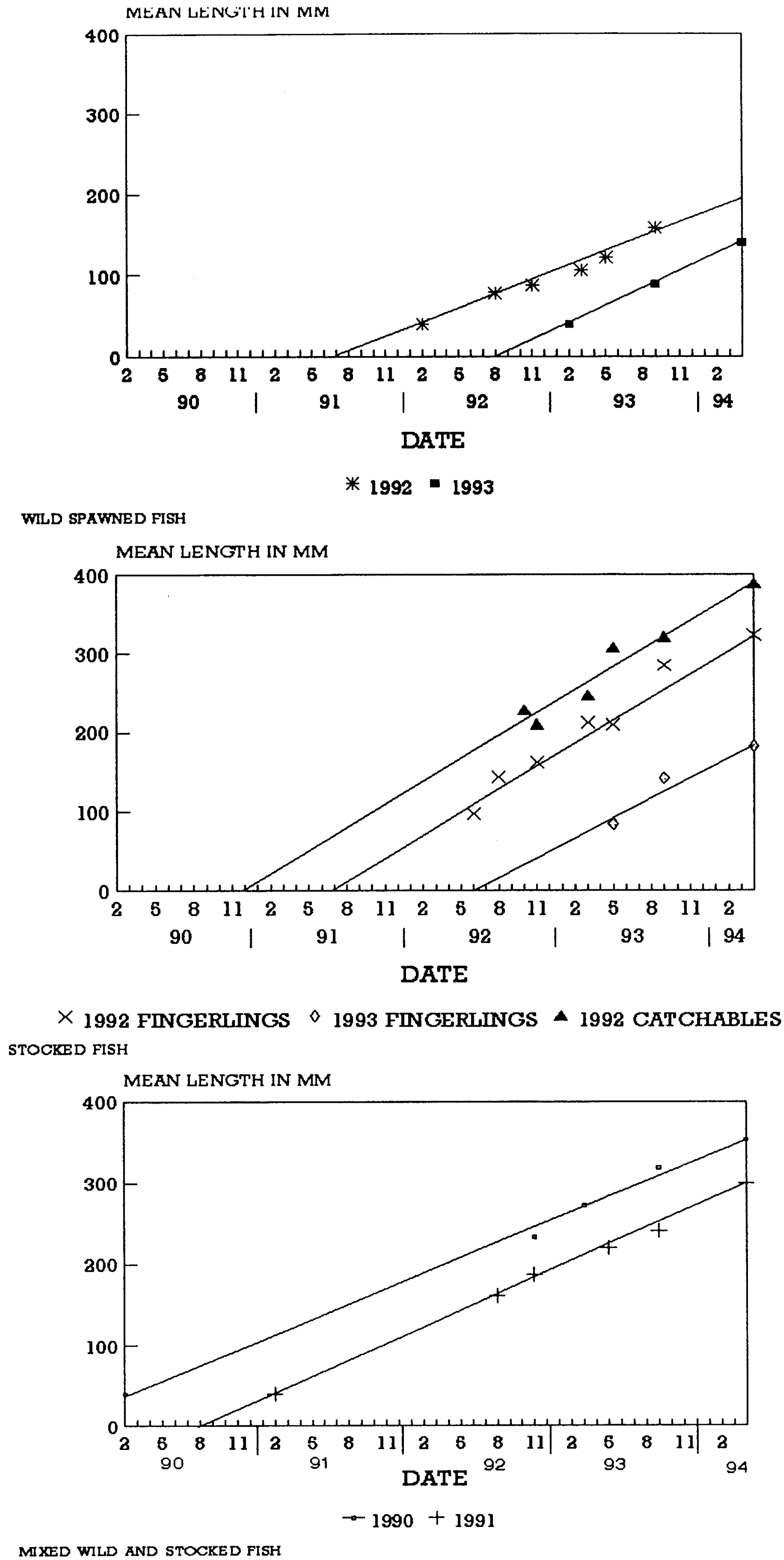


FIGURE 4. ESTIMATES OF RAINBOW TROUT GROWTH AT LEE'S FERRY 1990 - 1994.

food base, and a filling reservoir, improved growth is possible.

Analysis of the same data sets for wire tagged hatchery fish indicates that these fish have experienced somewhat better growth than naturally spawned fish (Figure 4).

CONDITION

Another way of looking at a fish populations "health" is the average condition factor,or fatness. Condition factor, (K) from creeled fish did not vary much in 1984-1988. It did show seasonal variation, with lower values in winter (post spawning). It also decreased with size of fish, due to allometric growth (Persons, 1990). Relative weight,(Wr), is the weight of a fish at a given length compared to the standard weight of a fish at that length. Persons (1990) calculated a regression equation for "standard" weights of rainbow trout at Lee's Ferry based on trout collected by electrofishing from April 1984 to August 1990. This equation shows trout from Lee's Ferry to be "fatter" than the national average; thus relative weight of any given fish, or group of fish, is less when using this regression for comparison rather then the nationwide standard regression.

Relative weight did not vary with length of fish, and showed less seasonal variation in magnitude than K (winter still being lower). The most interesting result of examining relative weight was that it had been declining (at least in electroshocked fish samples) from 1984 until 1990. 1990 and early 1991 was the time of the "skinny fish" at Lee's Ferry. Test flows with relatively long periods of low water greatly reduced the food base at a time when restrictive harvest regulations were increasing fish population levels. These conditions would cause "skinny fish" on their own, but were greatly exacerbated by the explosion of a parasitic nematode.

Since 1990 relative weight (mean) has increased, and the % of population with high relative weight appears to be increasing (Figure 5). Relative weight has not returned to 1984 levels, however.

Relative weight of the fish in the creel seems to be better than those collected by electrofishing. The apparent conclusion is anglers select plumper fish to eat (over 90% fish are released). The pattern of relative weight in creeled fish over time is the same as for electrofished trout (Figure 5).

IMPACTS OF ELECTROFISHING

Concern has been expressed by various groups over mortality and/or injury suffered by fish collected by electrofishing. These collections have been done under contract, and the contractors have aggressively worked to reduce injury caused by sampling. Sharber and Carothers

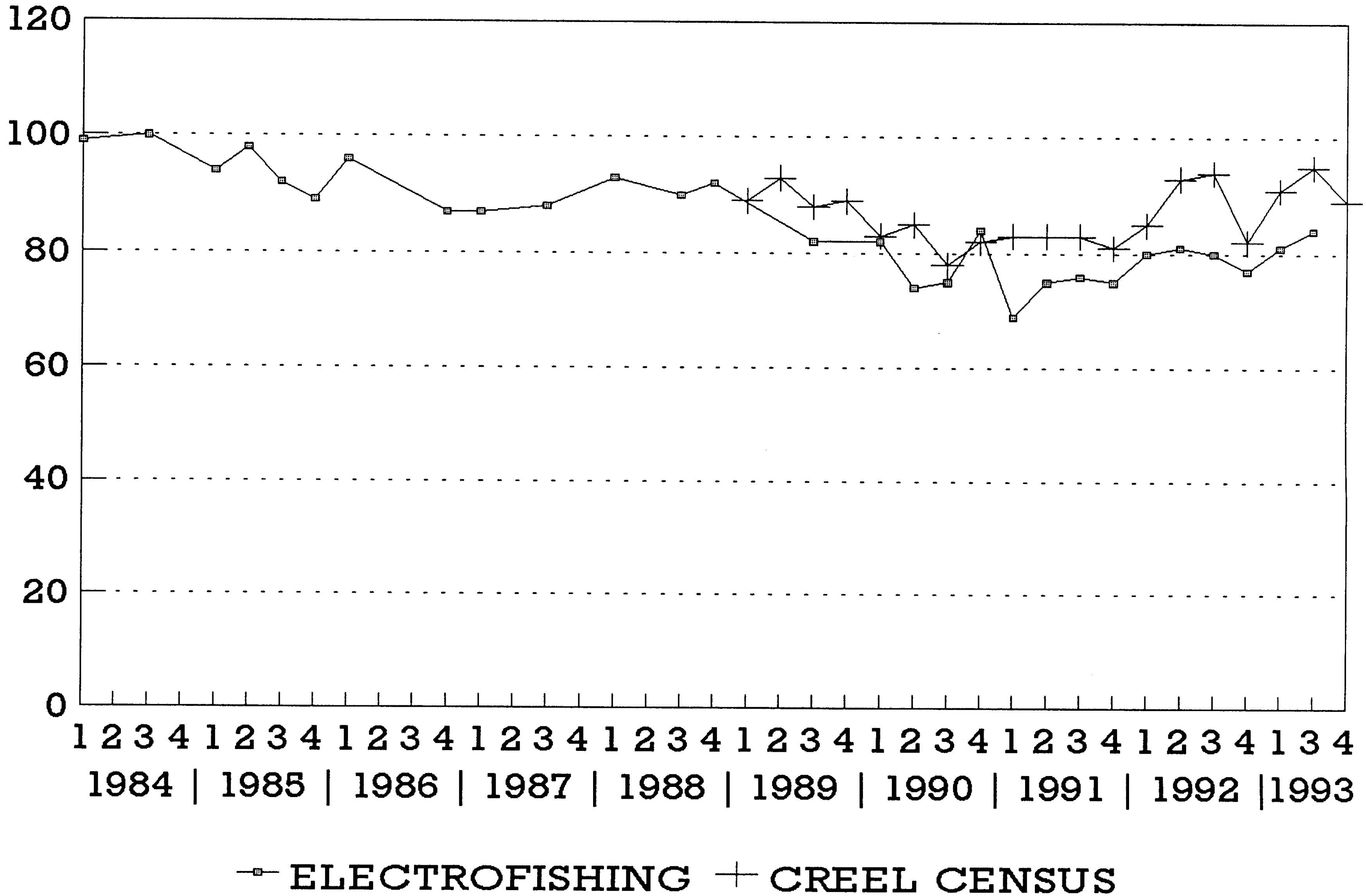


FIGURE 5. RELATIVE WEIGHTS OF RAINBOW TROUT FROM LEE'S FERRY BY QUARTER 1984 - 1993.

(1980) found 44 - 67% of the adult Rainbow trout collected by electrofishing in the Grand Canyon suffered spinal injuries, which they thought to be related to pulse shape. Sharber et al (1994) showed pulse shape more significant than voltage gradient in causing injuries, and tested a new pulse system that reduced injuries to 7-9% and was effective in sampling fish. The fact that handling fish, including sampling and marking, has an impact on growth and survival is not new knowledge (Mongillo 1976, Nuhter and Alexander, 1989). Another potential problem is external tags which have been implicated by Mongillo 1976 and (Manns et al., 1992).

CREEL SURVEY

METHODS

The boat launch at Lee's Ferry provides the only access point for boat fishermen, and affords an ideal point at which to interview large numbers of fishermen as they complete their trips. A Department creel clerk has been stationed there an average of 6 days a month since 1985.

The number of fish harvested is calculated from the harvest rate (calculated from AGFD creel census data) and the number of angling hours expended (calculated from NPS use data).

Calculations are stratified by boat and shore fishermen. Boat counts (NPS data), party size and trip length (creel data) are used to calculate boat fisherman hours. Shore angler counts are treated as an average number of anglers present each daylight hour. Harvest is not stratified by weekend-weekday, as count data (NPS) is not.

ANGLING PRESSURE

Angler use of Lee's Ferry (based on National Park Service public use data) increased dramatically until 1984 (Table 2). Reductions in pressure occurred in 1978 (four fish bag limit), 1980 (immediate kill regulation), 1985 (reduction in size of creeled fish), 1986 (artificial only regulation) and 1992 (word of skinny fish reached public). The number of angler days has remained a good estimate of pressure, as there has been little change in the length of the angling day (boat fishermen range 6.97-7.22 hours with a slight increase since 1989 to 7.68; shore fishermen range 4.45-4.87 hours with a slight decrease since 1989 to 4.17).

Angler use decreased with a decline in the catch rate, smaller fish, and high water in 1983-1985, and

Table 2. Summary of creel survey statistics from Lee's Ferry, 1977-93.

	NPS Angler Days	Angler Hours	Creel per Hour	Catch per Hour	Mean Length (mm)	Mean Weight (g)	Estimated Harvest	Percent Released
1977	10,613	72,202	0.24	n/a	398	735	17,320	n/a
1978	9,990	67,932	0.20	n/a	445	1,015	13,586	n/a
1979	22,085	150,178	0.15	n/a	431	926	22,527	n/a
1980	18,986	129,105	0.09	0.13	465	1,153	11,619	30
1981	28,784	195,731	0.14	0.22	436	957	27,402	36
1982	49,000	333,200	0.13	0.19	449	1,024	43,316	31
1983	52,725	358,530	0.15	0.27	431	926	53,780	44
1984	40.174	273,183	0.16	0.37	370	595	43,709	57
1985	27,572	183,630	0.23	0.60	370	548	41,115	64
1986	18,927	122,803	0.14	0.39	426	827	16,071	67
1987	32,103	212,706	0.18	0.68	416	770	36,754	75
1988	34,780	241,029	0.17	0.78	412	731	39,726	80
1989	32,537	222,438	0.14	0.76	395	663	30,133	81
1990	38,789	267,904	0.05	0.80	385	514	11,783	94
1991	32,928	242,432	0.04	0.56	380	503	10,076	93
1992	14,682	110,392	0.03	0.41	371	499	3,216	92
1993*	11,299	55,356	0.04	0.49	363	476	2,051	92

* Based on Creel Census Conducted January - August 1993

the change to artificial only in 1986; it rose again in 1987-1991, as the fishery recovered, to a level only exceeded by the 1982-1984 peaks. In 1992 use fell (as word of skinny fish and a die off from nematodes and lack of food became public) and has remained very low through 1993.

Non-resident use, which had been less than 10%, rose to 34% in the "discovery" years on 1977-1978. By the early 1980's, with the increase in pressure and decline in size of fish, it fell to around 25%, and further declined to the 20% level through the late 1980's. In 1991-1993, the percent of non-residents creel checked has again reached 34% - perhaps as a function of decreased "local" use (about 80% of Arizona anglers are from Coconino and Maricopa counties).

CATCH AND HARVEST RATES

Anglers at Lee's Ferry are more successful than at most waters, with only about 20% of the anglers catching no fish. Since 1990 the success rate for shore anglers has fallen to 50-60%, but anglers with boats have continued to be 80% successful. The waters in Region II with the next best success rates are Whitehorse Lake and Oak Creek. Their no-catch rates are approximately 40%.

Catch rates at Lee's Ferry compare favorably with other tailwaters and with other waters in Arizona (Table 3). At the San Juan River "quality fishing" area in New Mexico, the 10 year average catch rate is 0.85 fish per hour, and the harvest rate is 0.01 fish per hour (Ahlm, 1993, 1994). Since 1989, the average catch rate at Lee's Ferry has been .60 fish per hour, even with the reduced fish population since 1991.

Table 3. Comparison of catch rates for various waters.

Lee's Ferry, 1986	0.39
1987	0.68
1988	0.78
1989	0.76
1990	0.80
1991	0.56
1992	0.41
1993	0.49
Green River, Utah, 1980-84*	1.14
San Juan, N. Mex., 1984-87	0.73
1988-91	0.99
1992-93	0.81
Region II waters (n=7) (1986-88)	0.37
Region I waters (n=8) (1986-88)	0.48
Basic yield waters (n=5) (1986-88)	0.50
Lower Lake Mary 1992	0.32
Whitehorse Lake 1992	0.54
1993	0.39

*Prior to artificial and slot limit regulations.

In general, catch rate experienced a continuous increase until peaking in 1990 (Table 2). Since the 90-91 test flows (and related fish health problems) catch rate has fallen. Catch rate still exhibits high points during spawning season (Figure 6), with the exception of winter 1991-92. Harvest rate was relatively constant until the 1990 slot limit, 2 fish bag regulation; since then it has stabilized at a lower rate.

The percentage of fish that are caught and released increased from 30% in 1980 to 80% in 1988 and has exceeded 90% since 1990.

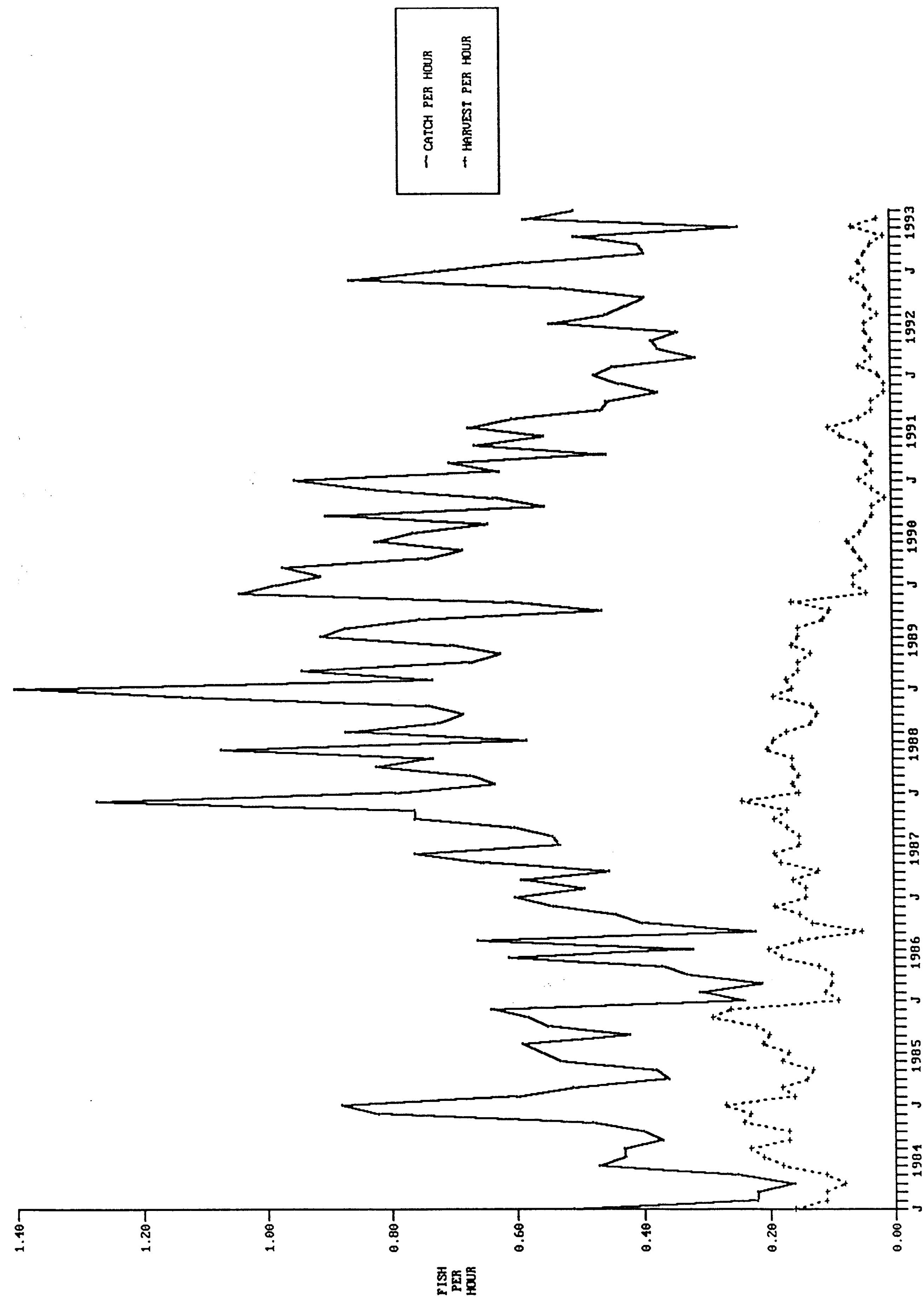


FIGURE 6. AVERAGE MONTHLY CATCH AND HARVEST RATES LEE'S FERRY 1984 - 1993

SIZE OF FISH

Mean length of trout in the creel fluctuated around 17 inches until late 1983, then began to decline (Table 2). Mean length rose again in late 1985 - early 1986, stabilized until 1989 at a level only slightly lower than in 1981 -1983, and has gradually declined again since then, artificially so due to the slot limit since 1990. Mean weight of trout in the creel followed the same pattern, with larger fluctuations at greater lengths, as larger fish gain (and lose) more weight per inch.

The decrease in mean lengths and weights in the creel beginning in 1983 corresponds to both the peak in use and the beginning of continuous high "flood" discharge. Lengths and weights rose again in early 1986, which corresponds to both the implementation of the artificial only regulation and the return to "normal" discharge patterns, and probably to a change in the type of angler fishing at Lee's Ferry.

Average size gradually decreased with increasing angler use until 1990 when the slot limit effectively put an upper limit on the majority of fish creeled. The test flows of 1990-91 and accompanying explosion of nematode parasites also reduced average size.

Size distributions of fish are often more valuable in evaluating changes in a fishery than are mean sizes.

Figure 7 provides the number of fish estimated to have been harvested from 1981 - 1993 by size increment. This allows not only the percentage, but the actual harvest (area under the curve) to be visualized. It shows a larger average size, fewer small fish, and reduced harvest in 1986. Harvest increased greatly in 1987 and 1988, and included larger numbers of smaller fish. Harvest has been declining since 1989, with a dramatic reduction in 1992 and 1993.

The distribution of size groups harvested has changed considerably. Since 1983 the contribution of fish over 25" long to the creel has virtually disappeared. Fish over 20" long made up about 25% of the harvest in 1979-1983, and less than 10% in 1985-1988. Since the 16-22 inch slot limit in 1990, comparisons of fish over 20" are no longer possible. However, it appears that the percent of fish over 22" is at least what it was prior to the regulation changes, and that some larger fish are being harvested.

In 1984-1985, fish less than 15" accounted for approximately 50% of the harvest. This decreased to about 20% in 1986; then, the contribution to the creel of fish smaller than 15" increased until 1990. Since then the slot has artificially increased harvest of fish just below the 16" limit. It has also greatly reduced total harvest.

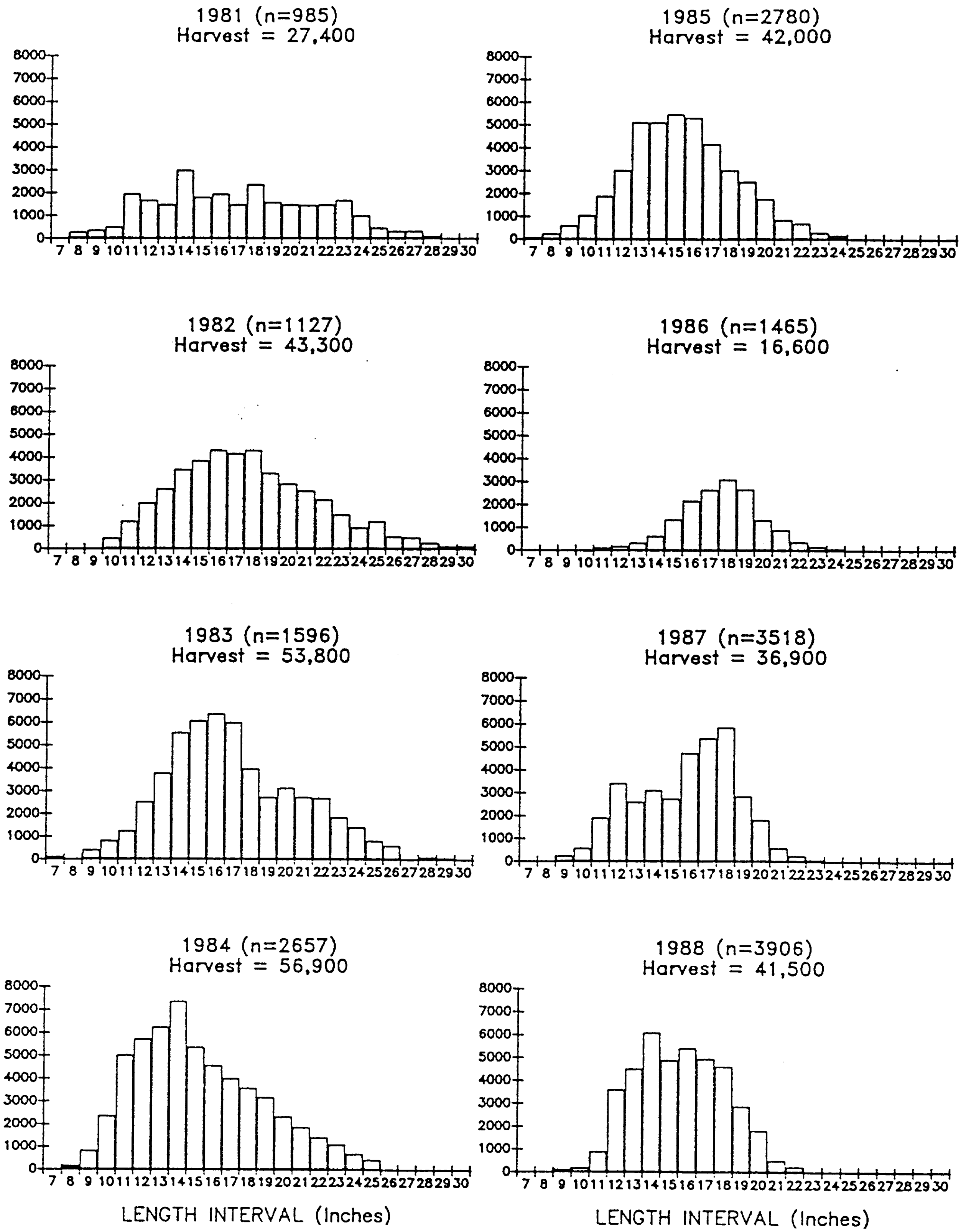
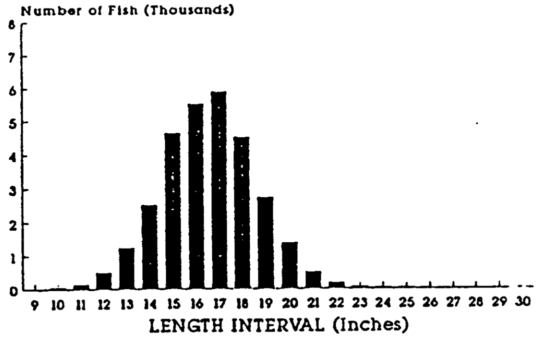
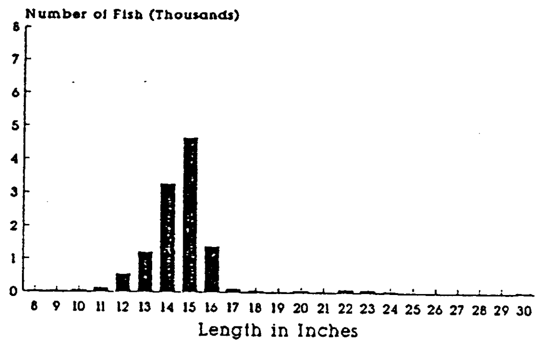


FIGURE 7. ESTIMATED HARVEST BY YEAR AND LENGTH CLASS AT LEE'S FERRY 1981 - 1993

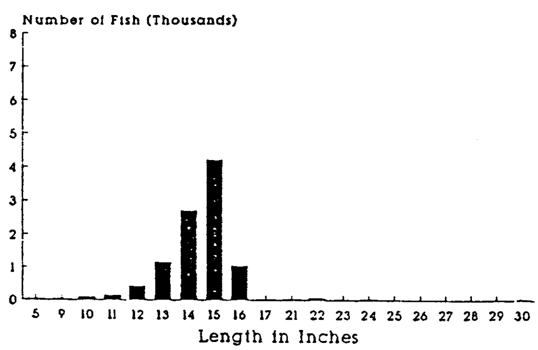
1989 (n=4662)
Harvest = 30,133



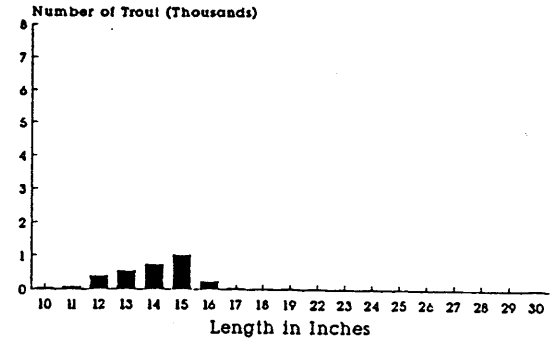
1990 (n = 1316)
Harvest = 11,783



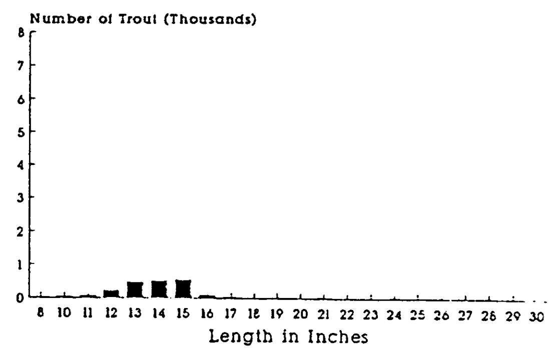
1991 (n = 677)
Harvest = 10,076



1992 (n = 350)
Harvest = 3,216



1993 (n = 299)
Harvest = 2,051



Based on data from January - August 1993

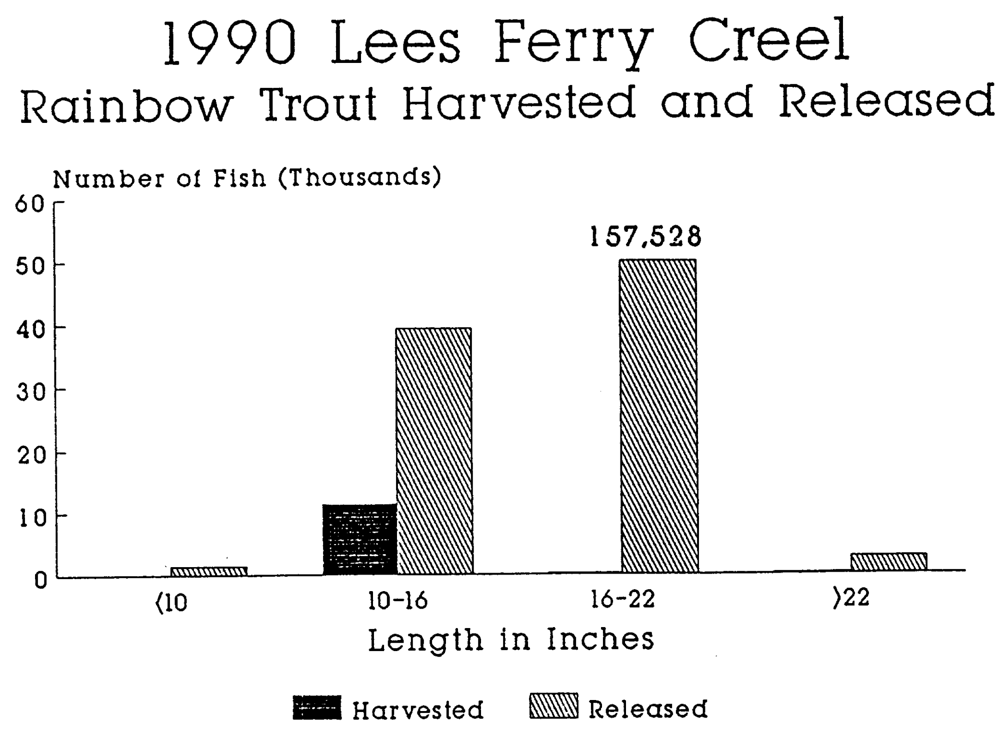
FIGURE 7. ESTIMATED HARVEST BY YEAR AND LENGTH CLASS AT LEE'S FERRY 1981 - 1993

The change in harvest regulations makes comparison of average sizes and size distribution in the creel much less meaningful, as the portion of the population being sampled by this technique has been greatly reduced. In an attempt to get some data on this part of the population, creeled anglers have been asked to estimate the sizes and numbers of released fish since the slot limit began in 1990.

The relative proportions of fish harvested and fish released by size categories has been relatively consistent from 1990 - 1993 (Figure 8). What has been reduced is the total number of fish caught. Some of this, of course, is due to the decrease on angling pressure, but there was also a real decline in catch rate of released fish per angler hour (Table 4). Catch rate appears to be increasing (1993) again.

YEAR	< 10"	10" - 16"	16" - 22"	>22"	TOTAL
1990	.005	.146	.588	.011	.750
1991	.007	.101	.389	.012	.509
1992	.008	.081	.284	.007	.380
1993	.014	.135	.295	.005	.449

Table 4. Number of Rainbow Trout Released By Size Class and Year per Angler Hour



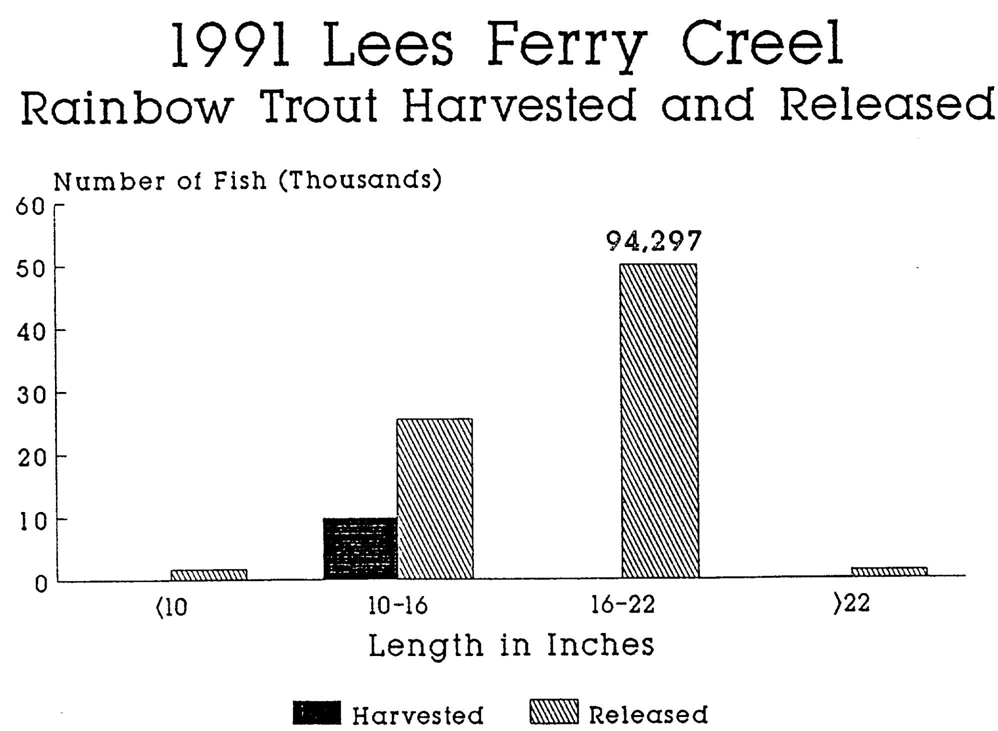
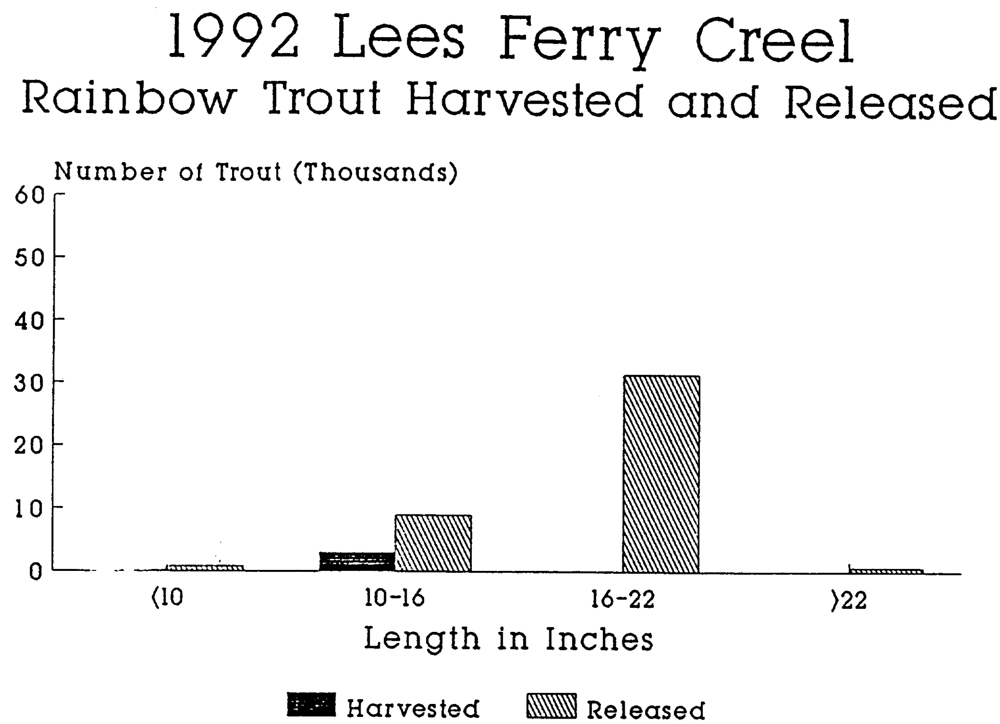


FIGURE 8. LENGTHS OF FISH HARVESTED AND FISH RELEASED BY SIZE GROUP AND YEAR



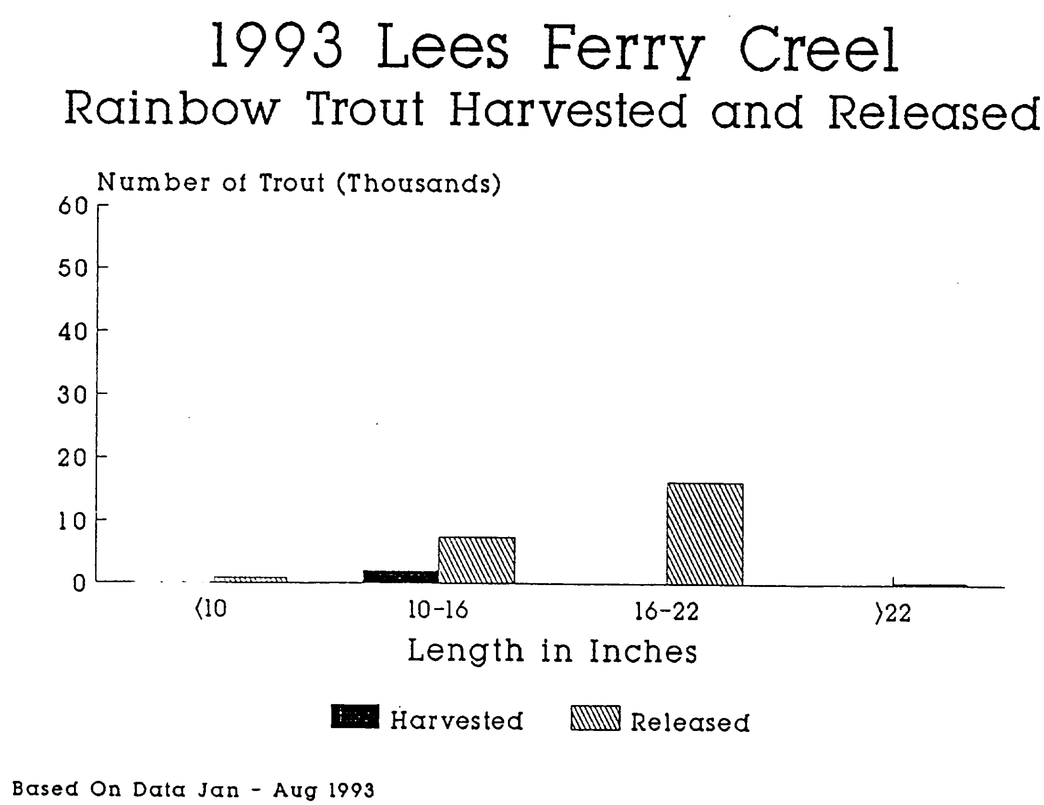


FIGURE 8. LENGTHS OF FISH HARVESTED AND FISH RELEASED BY SIZE GROUP AND YEAR

SEASONAL PATTERNS

Some fairly predictable seasonal trends have developed in the fishery. Use peaks in early spring and fall (Figure 9), corresponding to times when ambient air temperatures are less extreme. Until 1991 these were also periods when flow tended to fluctuate less (Cook, 1989). Since 1989, perhaps due to moderated flow regime, use has increased in late spring and summer. Winter use has declined. Catch rates were higher in midsummer and midwinter (Figure 10), but appear to have evened out somewhat after 1989. Condition factor also follows a seasonal pattern, apparently largely related to spawning activity. This may also be related to flows and food availability as drift (Liebfried and Blinn, 1987).

OPINION DATA

Anglers have been asked some general opinion questions when creeled at Lee's Ferry since 1990. Beginning in 1992 questions regarding the desirability of possible changes were also asked. In general, the users are quite satisfied overall, and with the current

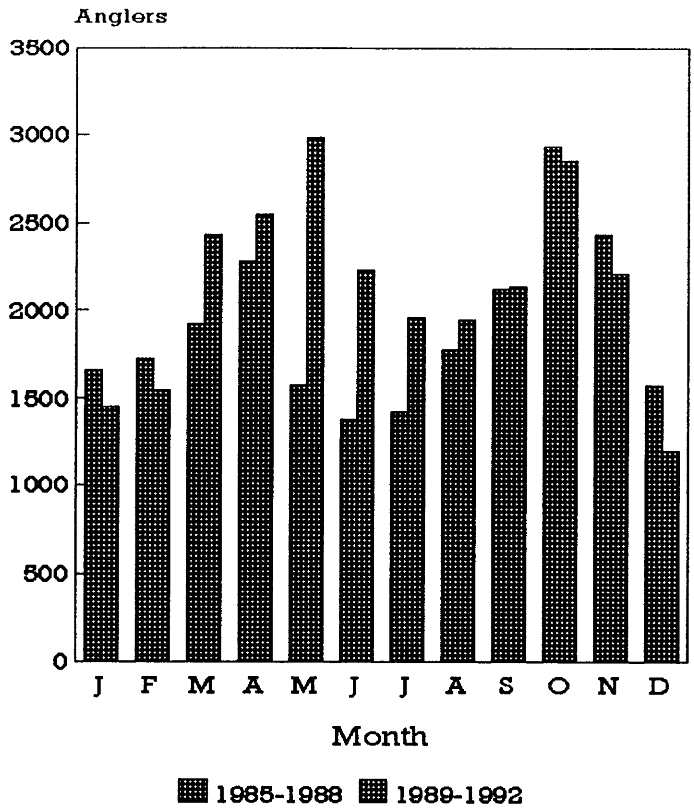


FIGURE 9. MONTHLY MEAN ANGLER COUNT AT LEE'S FERRY 1985 - 1988 AND 1989 - 1992.

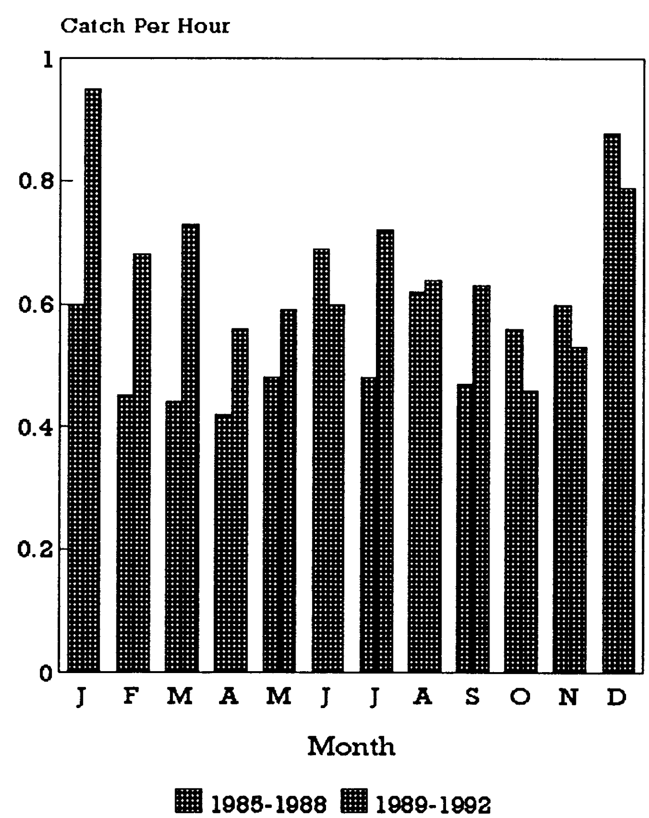


FIGURE 10. MONTHLY MEAN CATCH RATE AT LEE'S FERRY 1985 - 1988 AND 1989 - 1992.

regulations (Table 5). They are not as satisfied with the number or size of fish.

	VERY GOOD	GOOD	FAIR	POOR	VERY POOR
FISH NUMBERS	12.3	23.7	25.9	20.7	17.4
FISH SIZE	11.0	40.5	27.4	15.7	5.4
REGULATIONS	44.2	23.2	18.3	9.3	4.6
OVERALL	70.7	20.7	6.6	1.6	0.4

Table 5. Angler satisfaction ratings, 1990 - 1993 (%)

When asked about the desirability of various regulation changes, none presented were very acceptable [catch and release only 64% No; increased bag limit 86% No; no slot limit 81% No; one trophy fish only 95% No; maximum size (keep pan size only) 92% No].

In 1992-1993 we also recorded whether or not anglers creeled were using the services of a guide. Cross-tabulation of data indicated that the opinions of those using guide service were often different than the overall Lee's Ferry angler group. This was very noticeable in the desirability of catch and release only (no kill) and the requiring of barbless hooks (Table 6).

		Y	N
CATCH AND RELEASE ONLY			
	OVERALL	36	64
(n = 180)	GUIDED	61	39
(n = 319)	UNGUIDED	24	76
BARBLESS HOOKS ONLY		Y	N
	OVERALL	47	53
(n = 177)	GUIDED	71	29
(n = 313)	UNGUIDED	33	67

Table 6. Desirability of certain regulation changes by sub-groups of Lee's Ferry anglers, 1992-1993 (%).

A question regarding the management of Lee's Ferry was also included in the Departments Statewide 1992 (mail) Angler Survey. Most respondents, 46%, favored current management ("As is"); 29% would be willing to purchase a special use stamp; only 5% were in favor of a no kill regulation.

This last survey, in particular, raised some question with the most-frequent-users and guides, as they perceived a different response. This is perhaps, suggested by the differences in the creel opinion data presented above - they do contact a group with opinions that differ from the overall user group statewide. Nevertheless, the Department contracted Behavior Research Center, Inc. (1994) to conduct an independent telephone survey. They found that:

- 91% support current management.
- 83% of users were from Arizona.
- "Local" users fished at Lee's Ferry more frequently and were less likely to use guide services.
- 53% would support a no kill regulation.
- 83% would oppose a put-and-take catchable fishery.
- Desirability for a wild spawned only fishery was split (40% for, 43% against).

The desirability of potential alternate harvest regulations in hard to discern, as each was asked as "Would you favor, or oppose ..." and a selection between was not offered. Thus 67% would favor allowing harvest of fish over 20" only; 64% would favor allowing harvest of fish under 16" only. Obviously, some respondents answered yes to both, yet these are contradictory actions.

MANAGEMENT IMPLICATIONS

Objectives need to be established that satisfy public desires and maximize the unique biological potential of this fishery. "Trophy trout fisheries are rare in the American Southwest, and Lee's Ferry is regarded by many anglers to be the most highly prized. Indeed, some anglers travel across the nation to fish its waters." (Richards et al, 1985). The recreational benefit was conservatively estimated at 5 million dollars (1982 dollars) by Richards et al (1985). Data on economic benefits quantified by using the U.S. Bureau of Economic Analysis's RIMS II model on the 1991 Nation Survey of Fishing, Hunting and Wildlife - Associated Recreation were allocated proportionately by Lee's Ferry Creel data on anglers for 1991 to their total anglers. By this analysis Lee's Ferry contributed nearly $13 million to the total economic output, assuming all output from anglers using Lee's Ferry was attributable to Lee's Ferry and nowhere else.

With artificial only regulations, it appears that a catch rate of 0.5 per hour or greater can be maintained. Harvest rate stabilized at about 0.15 fish per hour prior to the slot limit and below 0.05 fish per hour since the slot limit while maintaining angler satisfaction. Angler densities are well below the maximum of 2.5

anglers/acre/week recommended for "Blue Ribbon" fisheries (Stephenson, 1985), reaching only 1.0 in 1982. The real item of discussion is what constitutes a large/trophy fish? Richards et al (1985) found that 65% of respondents felt that catching a trophy was important and Bishop et al (1987) found that increases in the probability of catching a large fish (greater than 4 pounds) is an important attribute of a Lee's Ferry fishing experience. Richards et al (1985) ascertained that anglers at Lee's Ferry felt a trophy fish weighed seven pounds (from length-weight regressions this is a 26-27 inch fish at Lee's Ferry).

Lee's Ferry is biologically capable of supporting, and the public desires, a quality fishery beyond the "blue-ribbon" concept. 1990 objectives were to maintain a catch rate of 0.6-0.9 fish per hour, allow a harvest of 30-40 thousand fish per year, increase the number of "trophy" sized fish caught and thereby increase the average size of fish available to the angler.

After 1990 regulation changes (2 fish, slot) numbers of larger fish accumulated in the slot. However, apparently as a result of the 1990 - 1991 experimental releases, a large proportion of the food base was eliminated (Angradi et al, 1992). The impact of this decrease in food was compounded by a tremendous infestation of a parasitic nematode (Landye, 1993). The result was a drastic decline in condition, and eventually a large mortality. Catch rate maintained nearly 0.5 fish per hour in spite of these problems. Harvest was well below 7,000 per year, due to decreased angler use and the low harvest rate. However, it appears that delayed mortality of released fish was greatly increased due to their poor condition and parasite infestation.

There are a variety of tools available to managers for control of fish population structure. These tools fall into three general categories: stocking, harvest restrictions, and habitat manipulation.

STOCKING

Results of oxytetracycline marking of stocked fish (Janisch, 1985), as well as analysis of year classes, indicated that stocked fish contributed approximately 75% to the harvest. The rate reported in "Effects of Varied Flow Regimes on Aquatic Resources of Glen and Grand Canyons" (Maddux et al, 1987) was 27.5% natural reproduction, or 72.5 % due to stocking under steady high flows. An average of 154,000 fish per year were stocked from 1985 - 1989 (Table 7).

Persons et. al. (1985) presented a model to calculate stocking rate at Lee's Ferry. This model was made while bait fishing was still allowed, so mortality rates may have been higher (release rates were also lower then). A harvest rate of 0.15 fish per hour (very close to the 1984-1988 average of 0.16) was used. The conclusion was to stock 111,000 fish annually to sustain 350,000 angler hours at a harvest rate of 0.15 fish per hour. By this formula it would require 85,000 fish to be stocked annually to sustain 200,000 angler hours at 0.2 fish per hour harvest,our best estimate in 1989. Harvest has been as low as .05 fish per hour in recent years, and pressure nearly down to 100,000 angler hours. In 1990-1993 the average annual stocking rate was reduced to 71,000 per year. Although they have not recruited to the creel yet, natural reproduction represent over 70% of the 1991 and 1992 year classes sampled by electrofishing (Persons, B., and M. Muysl, unpublised data).

Table 7. Stocking Summary for Lee's Ferry 1978-1993 in Thousands of Trout

Year	Rainbow*	Brook	Cutthroat	Total
1978	50	200	60	310
1979		43		43
1980	15	40	1	56
1981	108	60		168
1982	50	50		100
1983	99	50		149
1984	128			128
1985	121	50		171
1986	128	40		168
1987	121	25		146
1988	150			150
1989	129			129
1990	61			61
1991	72			72
1992	78			78
1993	73			73

* including Kamloops 1985 - 60, 1986 - 34, 1987 - 21, 1988 - 66

Distribution of stockings both in time and geographically, as recommended by Gosse (1985) Persons et al. (1985) and Reger (1986), by using tanks mounted on a raft has been accomplished. Since 1991 Shimano has assisted by providing the use of their stocking boat. Average size of fingerlings stocked has not quite been the 3" minimum recommended. We tried to evaluate the Kamloop strain in 1985-1988; fingerlings had adipose fin clips by volunteers prior to stocking. Other than Kamloops we have stocked only BelAir strain rainbows since 1986.

The growth rate of Kamloops was very similar to BelAirs however, condition factor, especially in the smaller fish, was not as good as BelAir rainbow and brook trout. Return to creel was been poor - Kamloops were 38% of the rainbow trout stocked in 1985-1986 but were only 2% of the rainbow trout creeled in 1987-1988. As of 1989 both Kamloops and Brook Trout stockings were discontinued.

<u>HARVEST RESTRICTIONS</u>

There are many types of harvest restrictions: when (seasons), how (terminal tackle), how many (bag limits), which (size limits). All have strengths and weaknesses for achieving specific objectives. Several of the most often discussed options for use at Lee's Ferry are presented below.

Terminal tackle restrictions

A fair amount of interest has been expressed in further restrictions on terminal tackle. Literature on salmonid hooking mortality has been summarized by the State of Washington (Mongillo, 1984), and data excerpted from that study is presented in Figure 11. Conclusions from that paper include:

> There are no differences in hooking mortality between any artificial lures or flies, with or without barbless hooks, on any salmonid species.
>
> Use of bait causes significantly higher mortality than use of artificial lures or flies. There is likely a positive relationship between temperature and hooking mortality.
>
> Fish hooked in gills, esophagus, tongue, or eye are four times more likely to die than those hooked in the jaw or mouth - bait fishing causes hook penetration in critical areas approximately 50% of the time, artificial less than 10%.
>
> There is no technical basis for requiring single barbless hooks.
>
> There is firm technical basis for prohibiting the use of bait for trout fishing.

A study in California (Titus and Vanicek, 1988) confirmed that high temperatures greatly increased mortality, and at high temperatures single barbless hooks caused greater mortality among hook types. Nuhfer and Alexander (1989) found that a significant difference in mortality of trophy sized brook trout caught on mepps spinners and cleo spoons with treble hooks (8.3%) and with single hooks (2.4%). However, they also had no

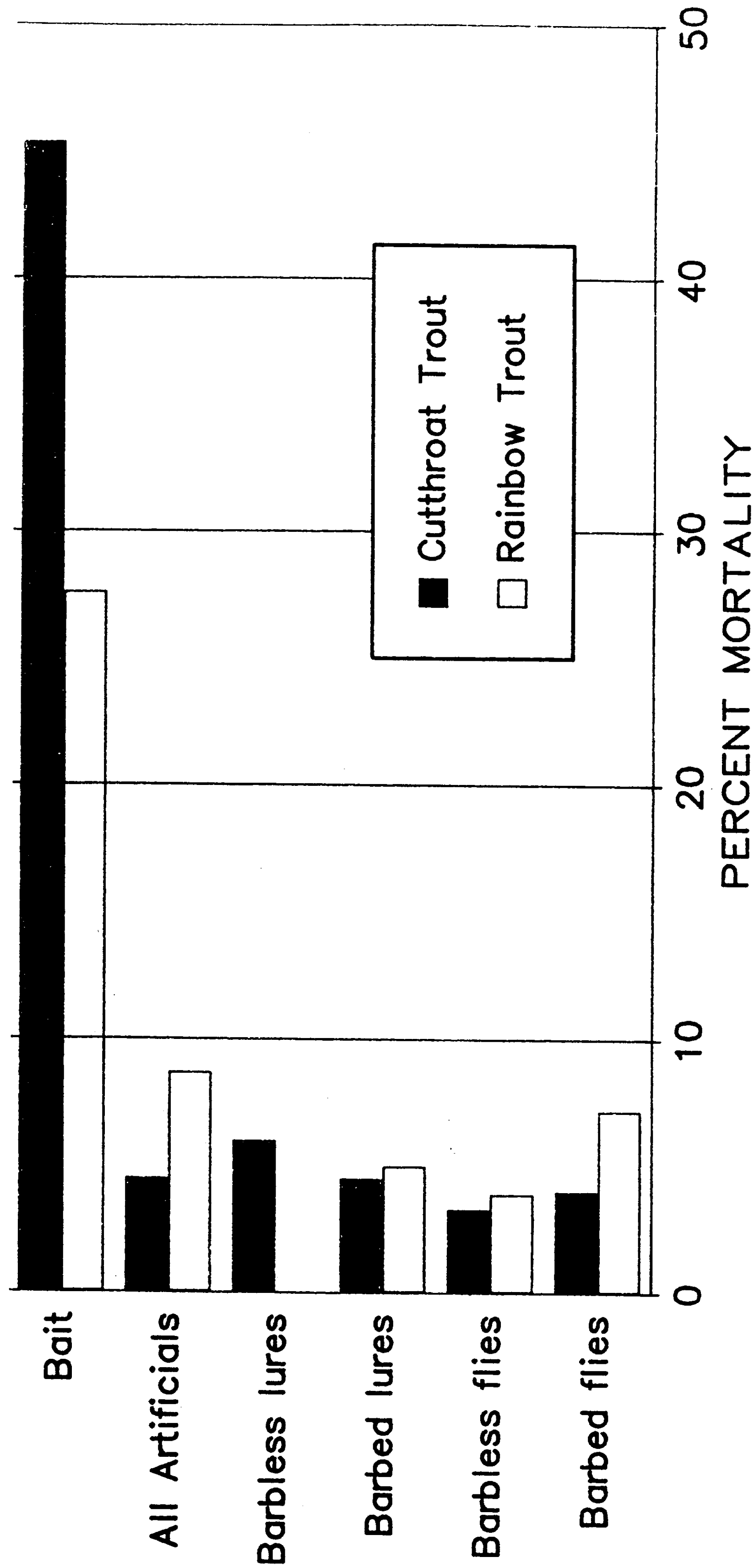


FIGURE 11. HOOKING MORTALITY ASSOCIATED WITH VARIOUS GEAR AND BAIT (MONGILLO, 1984).

mortality among fish caught on rapalas with two treble hooks. They attributed this to how deeply engulfed lures were, and the subsequent extent of damage to gill arches, as mortality was significantly correlated to size of fish. Mortality was also significantly correlated to water temperature. They suggested requiring larger lures and hooks to reduce the probability that trout would be hooked in the gills or throat.

Bag limits

The present bag limit of two fish allows an angler to harvest one fish and continue fishing either to harvest a second fish or simply to practice catch and release. A reduction in bag limit to one fish would require anglers to cease fishing if they harvested a fish. Anglers opinion surveys indicate a majority of anglers desire both the opportunity to harvest a fish to eat and to be able to harvest a trophy fish. Even under present circumstances with a reduced population of adult fish, the system appears capable of allowing harvest of "pan-size" (presently up to 16") fish to eat - especially with the current low level of harvest. The concern is whether the "trophy" segment can be recovered while allowing the harvest of fish over 22" in length. This concern is compounded by the possibility that growth potential, and thus maximum size, has been impacted by the cumulative effects of parasites, irregular flow regimes, and considerable angling and handling stress. (Nuhfer and Alexander, 1989; Manns et al., 1992)

No harvest, or total catch and release, is another form of bag limit restriction. One potential drawback is that this system is often intended to increase the availability of large "trophy" fish for recreational angling, yet by increasing fish density reduces growth rate and thus the maximum (and sometimes even the mean) size of fish available. (Johnson et al, 1987; Wisconsin DWR, 1991; Hunt, 1981; Barnhart and Engstrom-Heg, 1984) In other areas where productivity, habitat, hydrograph, temperature, and fishing pressure allow, tremendous increases in trophy fish as well as total biomass have been achieved (Nehring, 1987; Wells, 1987). At Lee's Ferry, decrease in growth due to increased competition for food could cause increased mortality via the nematode parasite, as witnessed under the 1990-1991 test flows. Under laboratory conditions Hiscox and Brocksen, 1973, found nematode infested fish died 60% faster than non-parasitized fish when starved.

<u>Size limits</u>

There are three kinds of size limits: minimum, maximum, and slot limits. A minimum size is used to protect fish until they reach certain size acceptable to the majority of anglers. It is often used where pressure is high and usually results in most of the fish harvested being just over the minimum size. A maximum size protects larger fish for spawning or for a trophy catch-and-release fishery. Its value is to increase recreational use at expense of harvest.

Slot limits have been proposed as a method to increase the catch of large fish without greatly reducing the total harvest (Jensen, 1981). Theoretically, the catch of "trophy" fish can be increased considerably (by 60%) while only slightly decreasing total harvest (14%) with a 15-20 inch no kill slot (Persons et al, 1985). If the trophy fish are of greater value to the angler, a slot limit maximizes the recreational value of the fishery.

Slot limits are, therefor, based on the presumption of adequate growth potential. As discussed earlier this can be invalid due to limits on productivity and/or availability of food, or due to "overpopulation". Another concern being discussed more frequently is that increased handling adds to cumulative stress which could increase mortality rate and impact growth rate, and thus maximum potential size (Manns et al., 1992; Nuhfer and Alexander, 1989). Indeed some forms of handling can greatly increase mortality: Removal of protective mucous and scales, internal organ injury by applying pressure (including holding out of the water), and damage to gill structure and/or blood chemistry upset by removing from the water while already exhausted and stressed. Ferguson and Tufts (1992) found 88% survival after 12 hours in fish exercised to exhaustion, but if briefly exposed to air while exhausted survival drastically declined (30 seconds exposure, 62% survival; 60 second exposure, 28% survival). Some states (Alaska) have regulations on special waters similar to our immediate kill or release, but specify that a fish must be killed and counted in possession if it is removed from the water.

HABITAT MANIPULATIONS

FLOWS

Until 1990 Glen Canyon dam was operated on a daily basis with production of hydroelectric power as the primary concern. This resulted in low minimum flows (when water is being "conserved") and rapid changes in flows (and water level). Low levels reduce the carrying capacity of the system by reducing habitat. Persons et al (1985) recommended a minimum flow of 8,000 cfs to maintain the fishery. Flows also affect anglers. Kelly (1986) reported that catch rate and flow rate were inversely related on the San Juan River, New Mexico. Maddux et al (1987) reported this to be true at extreme ranges of flows at Lee's Ferry. Flows also influence the accessibility to upstream areas and boating safety.

Flow variations also have the potential for direct impacts on the population. Estimates from as high as 15-20 to as low as 2-3 thousand adult fish per year being lost by stranding - mostly during spawning season - have been made. Stranding of adults seems to have been accentuated by rapid down ramping (Az. Game and Fish, 1993). Water level fluctuations also desiccate redds and kill eggs and fry. Juvenile fish are forced to move continuously in search of habitat - increasing the exposure to predation and impacting their growth potential. Some fluctuations may increase food availability (drift), but large fluctuations can desiccate or scour food producing areas.

As previously discussed, 1990-1991 test flows appear to have greatly reduced food resources, largely by desiccation of the areas of primary production (Angrdi et al., 1992). Low flows also reduce habitat and thus crowd fish already facing reduced food. These increased stresses make the fish more susceptible to disease, and in our case, parasites.

High flows are proposed to maintain beaches, back waters, and natural features necessary for many species downstream. When evaluating the effectiveness of these flows for their designed purpose, we must also be sure to evaluate the impact on the Lee's Ferry reach. Indications from past high flows (1983-1985) are that, at least when prolonged, they reduce natural recruitment, decrease primary and secondary production, and armor the stream channel. These impacts need to be addressed in any cost benefit assessment, and mitigated if costs need to be incurred because of benefits necessary downstream due either to the Endangered Species Act or Glen Canyon Protection Act.

All indications are that the interim flow criteria for operations that have been in place since 1991 have had very positive impacts on food resources, natural recruitment, and growth rates at Lee's Ferry. They incorporated protective measures from past recommendations, those that came from GCES research, and those then anticipated in the Glen Canyon Protection Act. All of these positive measures for Lee's Ferry and the Grand Canyon appear to be addressed in the Environmental Impact Statement.

RECOMMENDATIONS

The goal of the department is to bring back a trophy trout fishery, as best as possible, in the Lee's Ferry reach of Glen Canyon. We believe this is, and can continue to be, consistent with a native fish emphasis in Grand Canyon National Park. In this regard, we have set forth ceratin goals we wish to achieve, and to include in and long term monitoring program.

- Age III fish be composed at least 50% of wild spawned fish.
- Maintain spawning habitat to achieve above.
- Maintain estimated population of age II and older fish at or above 100,000 fish.
- Growth rates such that Age III rainbow trout achieve 18" in length, and relative weight (Wr) of at least 0.80 (see Appendix 1).

To reach these goals, the following recommendations are proposed.

<u>Research</u>

1) While much has been learned about the impacts of various flow regimes, more remains to be learned about many of the relationships between flow and biological processes. In particular:

   A. The production and standing crops of primary and secondary levels of production.

   B. Availability of trout food, including drift.

   C. Growth rates of naturally spawned and stocked fish.

2) The effects of any "habitat maintenance" or "beach building" flows (planned floods), even high flows within power plant capacity, need

to be carefully evaluated with regard to the primary and secondary producers, as well as the fish population.

3) Continue collection and analysis of electrofishing data to develop confidence in estimation of trends in population changes.

4) Work towards an estimate of carrying capacity (biomass of trout) of the system so we can manage stocking and harvest for optimum growth and large fish.

5) Cease floy tagging adult fish electrofished unless there is a specific need for data that cannot be obtained in another manner.

6) Develop study plans to evaluate the impacts, and potential reduction thereof, of the parasitic nematode Bulbodacnitis ampullastoma.

7) Develop study plan, and implement, to assess status of Flannelmouth sucker.

Stocking

1) Continue to distribute any stockings throughout the reach.

2) Coded wire tag all stockings to allow identification of batches for growth and survival.

3) Evaluate research and/or Regional population survey data annually to determine stocking needs.

   A. Fingerlings based natural recruitment.

   B. Larger fish based on "delayed failure" of other year class(es).

Creel Census

1) Try to obtain funding to increase survey effort.

2) Develop opinion data questions agreeable to department and special interest groups.

3) Try to obtain better information on number and sizes of fish released.

Population Surveys

1) Continue electrofishing 15 sites four times per year until Research recommendations 3 and 4 are met.

2) Maintain at least two times a year to monitor those parameters.

Information and Education

1) Inform public on what it takes to develop and maintain a trophy fishery: age of fish, impacts of natural and "release" mortality, cumulative impacts (spawn, release, parasite).

2) Educate public on reducing the probability of mortality in caught and released fish.

A. NOT play until exhausted.

B. NOT handle (internal organs, mucus).

C. NOT remove from water (gill arch damage - greatly increase delayed mortality).

D. PUT in low flow area to facilitate use of oxygen to recover.

3) Involve special interest sportsmen groups in this I&E effort.

<u>Regulations</u>

The effectiveness of the present slot-limit harvest regulations is unknown. The impacts of test flows and parasites, and subsequent recovery augmented by a "re-filling" reservoir have totally masked any impacts of the present harvest regulations. With present low use rates the need for additional harvest regulations to facilitate the recovery of big fish is not eminent. Therefor, most of the following recommendations are for analysis of success elsewhere, and public acceptability at Lee's Ferry, in anticipation of increased angling pressure sometime in the future.

1) Allow a one day license to be valid.

2) Maintain artificials only regulation.

3) Maintain immediate kill regulation.

4) Investigate (the possibility of) imposing the immediate kill requirement for fish removed from the water.

5) Maintain present slot and bag limit.

6) Investigate the possibility of a one fish limit, with a maximum size, and allow continued catch and release fishing.

7) Investigate reducing the harvest of trophy fish but still allowing some in a creative fashion; such as an annual tag or once-in-a-lifetime.

8) Investigate a stratified regulation system such as exists on the San Juan River in New Mexico (Eg: from 7.5 [or 9 or 12] mile upstream catch and release only, NO FISH IN POSSESSION; from 7.5 [or 9 or 12] mile to Lee's Ferry bridge [or the Paria or Cathedral] present slot and bag; downstream general statewide regulations).

<u>Proposed Changes</u>

The only change proposed at this time is allowing the one day license to be valid.

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THE STATE OF ARIZONA

GAME & FISH DEPARTMENT

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July 8, 1994

Dr. Duncan Patten
GCES Senior Scientist
Center For Environmental Studies
Arizona State University
Tempe, Arizona 85287-3211

Re: Arizona Game and Fish Department Fish and Wildlife Objectives for Glen and Grand Canyons

Dear Dr. Patten:

In response to your request for compilation and enumeration of agency objectives, we have prepared the following statement. Please recognize that our expertise, authority, and objectives are focused at fish and wildlife resources. We listed objectives for resource categories that are most directly affected by dam operations, and considered it unwise to provide a long list of objectives for issues less likely to be affected by dam operations or better addressed by the National Park Service with regard to management of Grand Canyon National Park. Our list of objectives appears in priority order.

In listing objectives, we found it most useful to identify two significant geographic areas to which we applied our objectives: Glen Canyon National Recreation Area (with a focus on recreational opportunity) and Grand Canyon National Park (with a native species, naturalized community focus). For some resources, our objectives differ across these two areas.

Aquatics

We developed a guiding principle (highest priority) for ourselves with regard to fish and wildlife management in Glen and Grand Canyons. That principle is:

> **To conserve and enhance the native fish community in Grand Canyon while providing for coldwater sportfish populations and recreational opportunities where they are consistent with conservation practices.**

Native Fishes:

Maintain and enhance the existing population of humpback chub at or above 1987 levels (1,750 > 200 mm total length) as determined by May/June hoop net monitoring, and attempt to establish a second, self sustaining population by 2005, contingent on feasibility. In establishing an additional spawning population, priority must be given to conservation of the integrity of existing genetic stocks of humpback chub, if more than one stocks is determined to exist within Grand Canyon.

Maintain healthy, self-sustaining populations of flannelmouth sucker, bluehead sucker and speckled dace in the mainstem Colorado River in Grand Canyon and its tributaries. This objective can be tracked by monitoring tagged fish over time, tracking size distribution over time, and developing a measure for fish health (i.e., a combination of fish condition and parasite infestation information).

Recognize that, as Critical Habitat, the Grand Canyon may have a role in the recovery of razorback sucker as a potential reintroduction site. Such efforts should be guided by the Recovery Plan for the species and Lower Basin Recovery Implementation Plan for the Big River Fishes. (Both plans are currently underdevelopment.)

Trout:

In Glen Canyon, natural reproduction should compose at lease 50% of the Age III rainbow trout population as determined from electrofishing samples. Sufficient suitable spawning habitat should be maintained to reach this objective. The total population of rainbow trout should be maintained at least 100,000 fish Age II or older as determined from population estimation. Rainbow trout should achieve 18 inches in length by Age III with a mean relative weight (Wr) of at least 0.80.

These population measures will be evaluated over a 5 year planning horizon, and running 5 year averages of measures will be used as criteria.

In Grand Canyon, with a focus on native fishes, no special measures will be implemented to manage for coldwater fishes. We recognize the importance of the Bright Angel Creek fishery for the recreational opportunities it provides, and steps may be taken to manage the recreational take of trout to enhance recreational opportunity. Recreational fishing may also be used to reduce problematic populations of brown trout that may prey upon native fishes.

Nonnative Warm Water and Cool Water Fishes:

Because our objectives for Grand Canyon relate to maintenance and enhancement of native fishes, no special measures will be implemented to manage for nonnative warm and coolwater fishes. Rather, recreational fishing and other tools may be utilized to reduce and/or control these species.

Aquatic Food Base:

Maintain and enhance the Aquatic Food Base in Glen Canyon. Maintain continuously inundated areas for *Cladophora* and aquatic invertebrates at or above 5,000 cfs discharge.

Habitats:

Backwaters in Grand Canyon may be of particular importance to native fishes. Numbers and area of backwaters will change through time and across flow scenarios. The processes that maintain the geometry and quality of backwaters need to be maintained. The mean numbers of backwaters, as measured by aerial videography at 8,000 cfs steady releases, should be maintained at 1993 (post flood) levels. For evaluation, backwaters should be enumerated following future "habitat/beach building" and "habitat maintenance" releases.

Terrestrial Wildlife

Habitats:

The riparian area is an important habitat for terrestrial wildlife that may be affected by dam operations. Repeated measurement of this habitat should serve as the surrogate indicator for riparian birds and neotropical migrants. New Highwater Zone riparian vegetation areas (acreage) should be maintained near 1991 levels. It will be necessary to identify camp areas that can/cannot be disturbed or cleared. The Southwestern willow flycatcher, if listed, should become a minor focus of riparian management, consistent with the importance of the Grand Canyon population from a regional and statewide perspective; and efforts to maintain Southwestern willow flycatcher should be guided by the Recovery Plan for the species if it is listed.

Wildlife:

Bald eagle is recognized as an opportunistic user of Grand Canyon. Maintenance of self sustaining fish populations as forage should continue to provide opportunities for bald eagle. No specific objective need be set for numbers of bald eagle foraging in Grand Canyon.

Waterfowl populations should be maintained at or enhanced from current (1993) levels. There is limited information on numbers or reproduction of waterfowl. Recognizing that conflicts between recreational take of waterfowl and other activities exist, limited recreational opportunity for take within the Glen Canyon National Recreation Area should be maintained consistent with other activities (camping, passive use, and angling).

The population of Kanab ambersnail should be inventoried and maintained near current levels. Efforts to establish additional population centers of amber snail should be guided by the Recovery Plan for the Species.

I hope that these objective statements are useful as you develop the Long Term Monitoring Plan. Please don't hesitate to contact me if we can clarify our objectives, or lend you any assistance in further development of the plan.

Sincerely,

Bruce D. Taubert
Assistant Director
Wildlife Management Division

BDT:LMR:lr

cc: Dave Wegner, GCES, Flagstaff