Residence Time of Rainbow Trout:

Habitat Selection, Behavioral Movement, and Fate of Adult Rainbow Trout within the Kings River Downstream of Pine Flat Dam

Kings River Fisheries Management Program
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Abstract

The effects of fishing regulations, release location, instream flow, and size-class on the survival of rainbow trout *Oncorhynchus mykiss* in a tailwater fishery were studied by releasing two hundred and fifty-nine rainbow trout implanted with radio transmitters into the Kings River below Pine Flat Dam in eastern Fresno County. Releases corresponded with early non-irrigation, late non-irrigation, and irrigation demand flows. Releases were stratified across two regulatory management zones. Survival rates varied significantly among regulatory zones, release locations, instream flow regimes, and size-classes.

INTRODUCTION

The General Aquatic Resource Goals, as outlined in the Kings River Fisheries Management Program's Framework Agreement, emphasizes a year round, "high yield, trout fishery" in the Put and Take section and year round "premium-quality trout fishery" in the Catch and Release section of the Kings River. Habitat enhancement projects such as the placement of over 5,000 boulders and over 2,500 tons of spawning gravel have been completed in an effort to increase wild rainbow trout *Oncorhynchus mykiss* abundance. Annual population monitoring, however, reveals that wild trout density in the Kings River below Pine Flat Dam remains relatively low (Kings River Conservation District 2009, 2010, unpublished).

In order to achieve the goals stated in the Framework Agreement, an understanding of how trout behave in the Kings River below Pine Flat Dam is necessary. In developing and evaluating the fishery management program, questions about how long trout remain in the Kings River arose. The Fisheries Management Program (FMP) set out to investigate the behavior of trout implanted with radio transmitters and released in the Kings River. The objectives of this study are to 1) determine the effects of the two river zones on the duration of residency of rainbow trout, 2) determine the effects of release location on the duration of residency of rainbow trout, 3) determine the effects of release timing on the duration of residency of rainbow trout, and 4) determine the effects of size-class on the duration of residency of rainbow trout.

STUDY AREA

The tailwater fishery created by the Pine Flat Dam is approximately 20km long. Two regulatory management zones and an "Exclusion" zone exist between the dam and the Highway 180 Bridge (Figure 1). The Exclusion zone is located between Pine Flat Dam and the Army Corps of Engineers (ACOE) Bridge and is approximately 0.8km long. Prior to the fall of 2001, public access was available in this section of the river. The Department of Homeland Security restricted access to this reach following the attacks on the World Trade Center on September 11, 2001. The Put and Take zone, located between the Army Corps of Engineers Bridge and the Cobbles Weir, is approximately 8km long, and the Catch and Release zone, located between Cobbles Weir and the Highway 180 Bridge, is approximately 11km long (Figure 1).

METHODS

Two hundred and fifty-nine trout (Table 1) implanted with radio transmitters were released into the tailwater fishery between October 2005, and January 2008 (KRFMP 2005, unpublished; KRFMP, 2009b, unpublished). Release locations were stratified across the regulatory management zones in an effort to study the effects of these zones on the residence time of rainbow trout below Pine Flat Dam. Release timing corresponded with seasonal changes in stream flow conditions (Figure 2; KRFMP, 2005, unpublished) to study the effects of discharge rate on the residence time of rainbow trout.

Seven release groups were utilized for this study. Approximately 40 trout comprised each group; twenty of which were classified as small (227g to 907g) and twenty were classified as large (907g or greater). The number of trout actually released in each group varied due to mortality during the post-surgery observation period. On January 18, 2006, an attempt was made to catch trout from the Kings River for use in the study however; we were unable to catch a sufficient amount of trout from each size class. A second attempt was made on January 25, 2006 with the same outcome. As a result, trout from the

Table 1: Release group statistics. Trout from the second release group were released on three separate dates (see text for explanation).

Release Date	Discharge (cfs)	Demand Type*	Release Group	size-class	Release Location							n=**	N=
					Plunge Pool	Frustration Lake	Choinumni Park	Cobbles Weir	Avocado Lake	Harris Ranch	Unknown		
10/24/2005	2,042	ENID	1	Small	8	5		7				20	38
				Large	4	5		9				18	
1/18/2006	288	LNID	2	Small	3							3	8
				Large	5							5	
1/25/2006	284	LNID	2	Small					0			0	2
				Large					2			2	
2/15/2006	606	LNID	2	Small			5	6		6		17	28
				Large			3	4		4		11	
6/20/2006	11,183	ID	3	Small			5	7		6		18	36
				Large			5	6		7		18	
10/2/2006	1,494	ENID	4	Small			4	5		6		15	32
				Large			5	5		7		17	
12/18/2006	282	LNID	5	Small			7	7		6		20	38
				Large			5	7		6		18	
6/18/2007	4,298	ID	6	Small			7					7	14
				Large			6				1	7	
6/21/2007	4,298	ID	6	Small				6		6		12	23
				Large				7		4		11	
1/24/2008	137	LNID	7	Small			8	5		7		20	40
				Large			5	7		8		20	
												Total	**259**

* ENID - early non-irrigation demand, LNID - Late non-irrigation demand, ID - Irrigation demand

**n (Small) = 132; n (Large) = 127

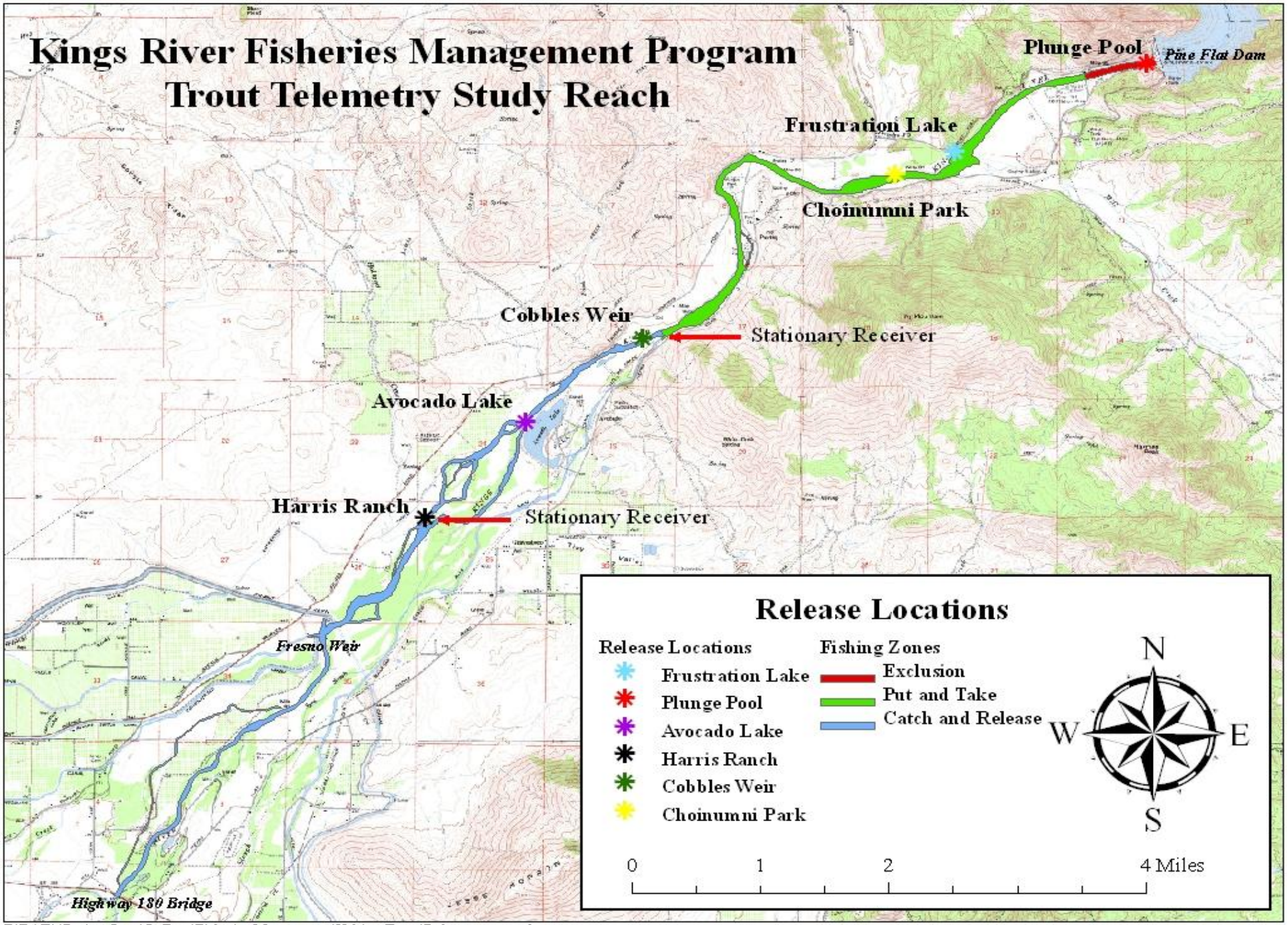

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Figure 1: Tailwater fishery created by the Pine Flat Dam in eastern Fresno County. Two regulatory management zones and an Exclusion zone are present in the study reach of the Kings River; Exclusion (red), Put & Take (green), and Catch & Release (blue). The asterisks represent release locations used in this study.

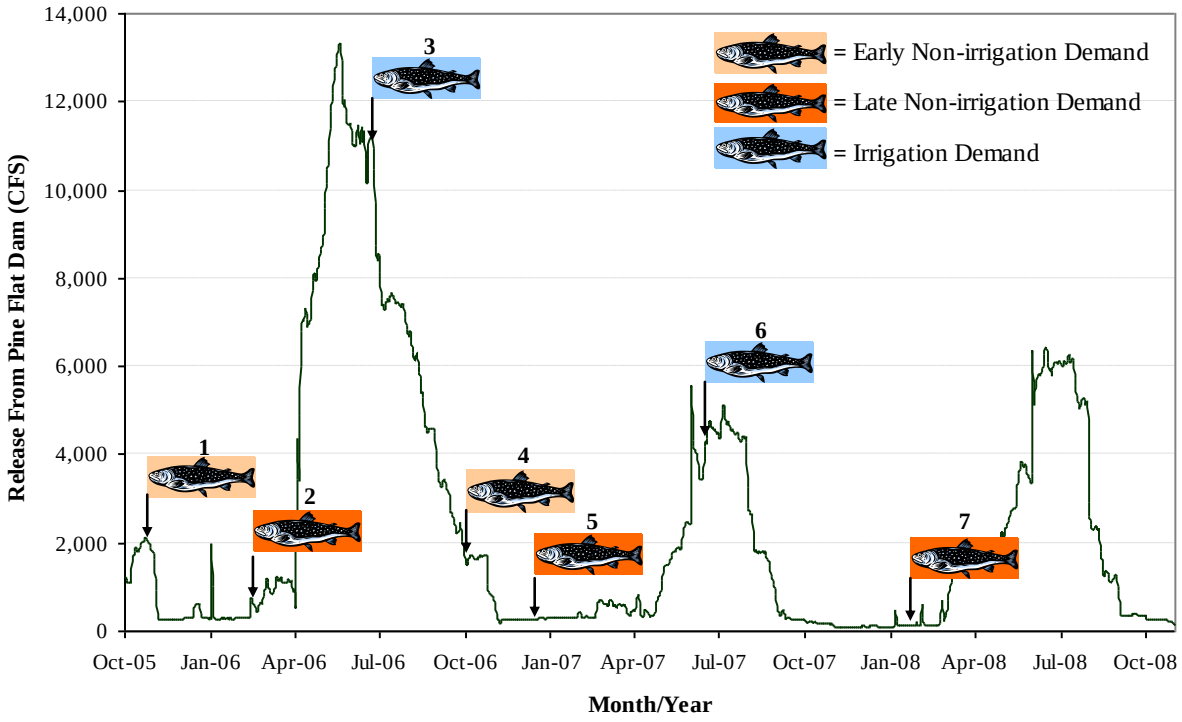

Figure 2: Release of study groups was timed with notable instream flows. Each fish represents a release group and the line represents daily releases from Pine Flat Dam. The 2005 and 2006 water years were Exhibit "D" years with minimum releases of 250cfs. The 2007 was an Exhibit "C" year with minimum releases of 100cfs.

San Joaquin Hatchery were used for the balance of the study group. Consequently, the second release group was released over three days between January 18, 2006 and February 15, 2006.

Two size-classes were chosen to study the effect of size-class on residence time. The Kings River annual allotment comprises approximately thirty-six thousand trout categorized as "catchable" by CDFG. The small trout used in this study would also be categorized as "catchable"; the large trout would be classified as "trophy" trout. The trout used in this study were obtained from the San Joaquin River Fish Hatchery (94%) and by hook and line (6%) from the lower Kings River.

Study trout were dispersed in seven separate releases. Their positions within the river were recorded and their residence time was determined based on movement, return of transmitters by anglers, and recovery of transmitters from the river bottom or surrounding area. Releases occurred at five locations along the Kings River representing the two regulatory management zones and one in the Plunge Pool below Pine Flat Dam. Two release sites were located in the Put and Take zone, and three release sites were

located in the Catch and Release zone (Figure 1). Use of the Plunge Pool release site (located within the Exclusion zone) was discontinued after the second release. The decision to discontinue use of this site was made when it became evident that trout were not dispersing from this area into the study area in a manner similar to that observed at the other release sites. It was also determined that the Plunge Pool was not representative of the majority of the study reach, further supporting the decision to discontinue its use. Use of the Frustration Lake release site (Put and Take zone) was discontinued after a single release due to the rapid disappearance of study trout. Fifty percent (5 of 10) of the trout released at this location went missing over night and were never located. Lastly, use of the Avocado Lake release site (Catch and Release zone) was discontinued after only a single release of two trout during the second round of releases (Figure 1). An attempt was made to utilize resident trout caught at this location however, all but two trout caught at this location exhibited signs of having been in a hatchery. Further attempts to catch resident trout were discontinued.

Data collected from the Avocado Lake release site and Plunge Pool were included in the summary analysis but excluded from the statistical analysis due to the non-representative nature. In addition, a single trout (780-27; release group 6) was excluded from the analysis due to a non-functioning transmitter.

Trout positions were recorded via two stationary radio telemetry receivers (Figure 1) and mobile receivers operated by an observer. The mobile receivers were equipped with GPS (see Equipment Selection paper; KRFMP, 2009a, unpublished). Attempts were made to relocate each study trout twice in a seven-day period. Once located, a bearing was recorded along the transect perpendicular to the trout's position and a digital photograph was taken for future reference. Additionally, upstream and downstream bearings were recorded when possible. Location of the seasonal observer was automatically recorded via the GPS receiver integrated in the radio receiver. Environmental data (i.e. habitat type, presence of terrestrial vegetation, etc…) were recorded on a standardized field data sheet (Appendix 1).

A study trout was considered still living so long as movement was observed. When movement ceased, attempts were made to confirm visually that the trout was no longer alive. This involved finding a carcass or physically recovering the transmitter. If neither of these options were possible due to water depth or other unsafe conditions,

rocks were repeatedly thrown at the perceived location of the trout in an attempt to incite movement. This process was repeated for three weeks. If no movement was observed, the transmitter was considered to be no longer implanted in a living trout and the corresponding trout was removed from the study. Locations of transmitters (study trout) were recorded until transmission ceased or it could be confirmed that the transmitter was no longer implanted in a living trout. In the event that an unrecoverable transmitter previously removed from the study began to move again, particularly if the movement was upstream, it was reinstated in the study and tracked as normal.

The date of removal from the system or "Fate Date" was estimated using relocation data and field notes recorded by the observer. Fates were categorized by type: Caught Out, Recovered Transmitter, Missing Transmitter, Survived Beyond Life of Transmitter, and Dead (with carcass). Transmitter battery life varied by transmitter size, with the larger transmitter possessing the longer battery life (KRFMP 2009a, unpublished). Small transmitters were guaranteed for 170 days initially and 294 days at the conclusion of the study thanks to improvements in battery technology. Large transmitters were guaranteed for 685 days initially and 743 days at the conclusion of the study. When approaching the guaranteed battery life, if the signal was inexplicably lost and never recovered, corresponding study trout confirmed to have been alive prior to signal loss were considered to have survived beyond the life of the transmitter battery.

ANALYTICAL PROCEDURES

Residence time represents the total number of days that a study trout remained alive in the river, with release day being Day 1. Residence time was calculated for each of the two hundred and fifty nine trout released into the study area. Descriptive statistics were used to summarize the data. The nonparametric Kruskal-Wallis one-way Analysis of Variance test and the Mann-Whitney U test were used to test for significant differences in mean residence time. Fisher's least significant difference (Fisher's LSD) test was used *a posteriori* to determine significance among groups of three or more. Alpha = 0.95 was used to determine significance. To compensate for the shorter battery life of the small transmitters, any residence time greater than 170 days was defaulted to 170 days for significance testing purposes. Significance tests were performed on data collected in the Put and Take zone and Catch and Release zone. Data collected from the two regulatory

Table 2: Minimum, maximum, and mean residence time for the total study population. This data includes trout released in the Plunge Pool and at Avocado Lake.

		Residence Time (Days)									
		Small*			Large**			Total***			
Date	Release Group	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Flow (cfs)****
Oct. 24, 2005	1	1	193	49	13	386	103	1	386	76	2,042
Feb. 15, 2006	2	1	325	102	1	394	111	1	394	106	606
June 20, 2006	3	13	183	88	33	438	195	13	438	142	11,183
Oct. 2, 2006	4	1	123	41	9	308	134	1	308	91	1,494
Dec. 18, 2006	5	1	63	15	3	178	44	1	178	29	282
June 18, 2007	6	5	210	95	7	108	47	5	210	73	4,298
Jan. 24, 2008	7	1	187	26	3	225	46	1	225	36	137

*n=132 **n=127 ***n=259 ****Flow from Pine Flat Dam and Mill Creek on morning of release

zones were then compared to data collected from the Plunge Pool release site (within the Exclusion zone) in an effort to verify its non-representative nature. All tests were performed using SYSTAT 12® Version 12.02.00.

RESULTS

Mean residence time varied among release groups and ranged from 29 days to 142 days (Table 2). The mean residence time for small trout ranged from 15 days to 102 days, while the mean residence time for large trout ranged from 44 days to 195 days. The maximum residence time for small trout was 325 days (release group 2; Feb. release) and the maximum residence time for large trout was 438 days (release group 3; June release). These data are summarized in Table 2. Survival plots for each release group are found in Appendix 2.

Approximately 39% (102 of 259) of the study population was removed from the study within 30 days. At 60 days, approximately 58% (150 of 259) of the study population was removed and at 90 days, 65% (168 of 259) of the study population was removed. Only about 16% (n=42) of the study trout survived beyond 170 days.

Analysis of removal rates for large trout tracked beyond 170 days showed that approximately 30% (38 of 126) of the population was removed from the study at 30 days. At 90 days, approximately 58% of the study population was removed, and at 180 days, approximately 84% of the study population was removed. Only about 16% (20 of 126) of the study population survived beyond six months and only 3% (4 of 126) of the study population survived beyond one year.

Table 3: Inter-quartile values for residence time of rainbow trout in two regulatory management zones present on the Kings River below Pine Flat Dam.

	Management Zone	
	Put & Take	Catch & Release
Median	36	45
1st Quartile	9	20
3rd Quartile	84	124

Table 4: Inter-quartile range values for residence time of rainbow trout categorized by release site.

	Release Site		
	Choinumni Park	Cobbles Weir	Harris Ranch
Median	40	33	71
1st Quartile	11	13	25
3rd Quartile	106	96	133

Management Zones

The inter-quartile ranges for residence time of rainbow trout observed in each Management Zone are summarized in Table 3. The survival rate observed between the two regulatory management zones was significantly different (Mann-Whitney U, χ^2=4.712, p=0.030). The Catch & Release Zone had more trout surviving for a longer period than the Put & Take Zone. When grouped by size-class, the survival rate differed significantly among small and large trout in both the Put & Take Zone (Mann-Whitney U, χ^2=7.424, p=0.006) and the Catch & Release Zone (Mann-Whitney U, χ^2=7.062, p=0.008). These results are summarized in Figure 3.

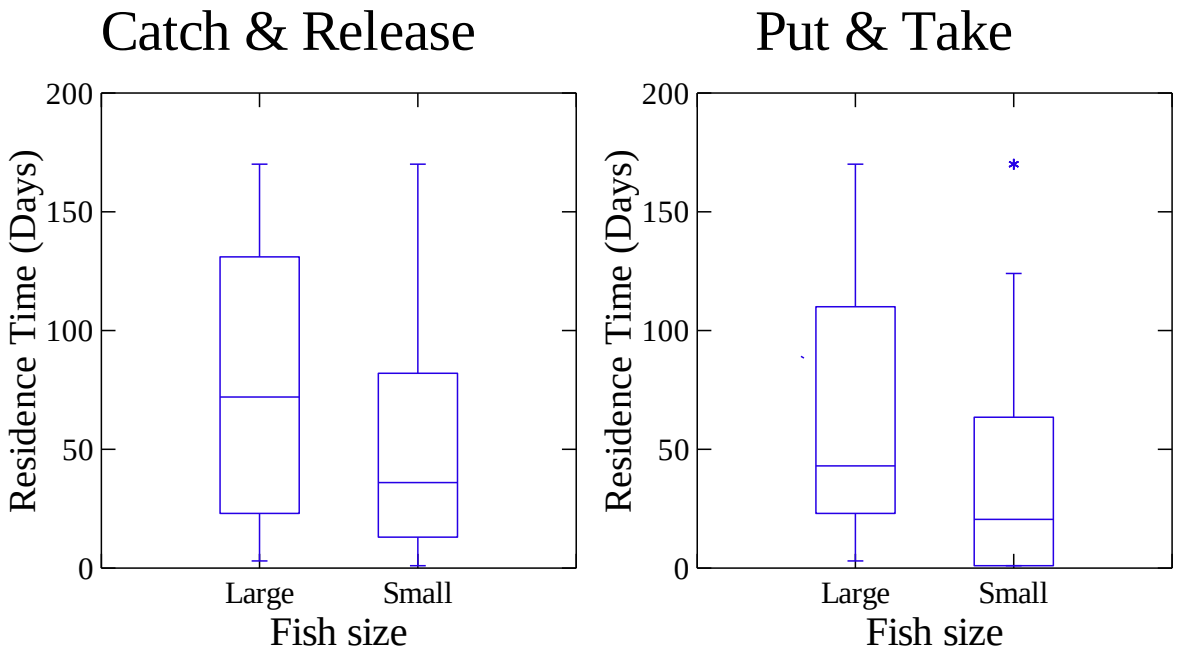

Figure 3: Median survival time is represented by the horizontal line in each box. Large trout survived significantly longer than small trout in both the Catch & Release and Put & Take Zones.

Table 5: Inter-quartile values for residence time of rainbow trout categorized by release group. Release group 3 had the highest median residence time. This coincided with the highest flow during the study period.

	Release Number						
	1	**2**	**3**	**4**	**5**	**6**	**7**
Median	30	95	119	81	18	49	20
1st Quartile	13	29	55	25	3	27	8
3rd Quartile	42	146	170	126	38	99	43

Release Site

The inter-quartile ranges for residence time of rainbow trout released at each of the three release sites in this study are summarized in Table 4. Survival rates differed significantly among release sites (Kruskal-Wallis Test Statistic = 10.497, p=0.005). Trout released at the Harris Ranch site survived longer than trout released at either the Choinumni Park or the Cobbles Weir sites.

Release Timing

The inter-quartile ranges for residence time of rainbow trout categorized by release group are summarized in Table 5. The survival rate was found to be significantly different among the release groups (Kruskal-Wallis Test Statistic = 60.286, p<0.0005). These differences are summarized in Table 6.

Size

The inter-quartile ranges for residence time of rainbow trout categorized by size-class are summarized in Table 7. The survival rate was significantly different among size-classes (Mann-Whitney U, χ^2=14.894, p<0.0005). Significant differences were found among size-classes grouped by release number as well.

PLUNGE POOL RESULTS AND DISCUSSION

The Plunge Pool release site was removed from the study early on due to its perceived non-representative nature. To test this hypothesis, data collected from trout released at the Plunge Pool release site were compared to data collected from the rest of the river. When compared to the results from the Put & Take Zone and Catch & Release Zone, the survival rate of trout planted in the Plunge Pool (within the Exclusion Zone)

Table 6: Results from the Fisher's LSD test showing significant differences in mean residence time. release groups in column *I* exhibited significantly longer mean residence times than release groups in column *ii*. ENID – Early Non-Irrigation Demand, LNID – Late Non-Irrigation Demand, ID - Irrigation Demand

Residence Time Comparison					
Release Group (i)		**Release Group (ii)**	**p-value**	**Flow Type (i)**	**Flow Type (ii)**
2	>	1	0.001	LNID	ENID
2	>	5	0.000	LNID	LNID
2	>	7	0.000	LNID	LNID
3	>	1	0.000	ID	ENID
3	>	4	0.015	ID	ENID
3	>	5	0.000	ID	LNID
3	>	6	0.000	ID	ID
3	>	7	0.000	ID	LNID
4	>	1	0.001	ENID	ENID
4	>	5	0.000	ENID	LNID
4	>	7	0.000	ENID	LNID
6	>	1	0.026	ID	ENID
6	>	5	0.002	ID	LNID
6	>	7	0.014	ID	LNID

was significantly different (Kruskal-Wallis Test Statistic = 19.561; $p<0.0005$). These differences are summarized in Table 8. When compared to the other release sites, the survival rate observed in the Plunge Pool release site was significantly different from those observed in any of the other three release sites (Kruskal-Wallis Test Statistic = 24.123; $p<0.0005$). These differences are summarized in Table 9.

As expected, the survival rate of trout released in the Plunge Pool was significantly different from the survival rate of trout released in either the Put &Take or Catch & Release zones. The establishment of the Exclusion Zone in late 2001 has removed legal angling pressure on the trout population in this section of the river and all but eliminated any illegal angling activities. Habitat and water quality conditions in the Exclusion zone are also drastically different from other reaches of the river. The plunge

Table 7: Inter-quartile values for residence time of rainbow trout categorized by size-class and release group. The first value represents the residence time (in days) of small trout, the second value represents the residence time of large trout.

	Size Class x Release Group						
	1	2	3	4	5	6	7
Median	8 / 39	97 / 93	61 / 154	25 / 121	6 / 24	64 / 40	11 / 15
1st Quartile	1 / 26	17 / 40	39 / 105	16 / 84	1 / 17	29 / 24	2 / 15
3rd Quartile	33 / 54	164 / 127	154 / 170	56 / 170	21 / 46	170 / 66	32 / 63

Table 8: Inter-quartile ranges comparing residence time of trout released in the Put & Take, Catch & Release, and Exclusion Zones.

	Management Zone		
	Exclusion	Put & Take	Catch & Release
Median	164	36	45
1st Quartile	116	9	20
3rd Quartile	170	84	124

Table 9: Inter-quartile ranges comparing residence time of trout released in the Plunge Pool to those released at the other release sites used in this study.

	Release Site			
	Plunge Pool	Choinumni Park	Cobbles Weir	Harris Ranch
Median	164	40	33	71
1st Quartile	116	11	13	25
3rd Quartile	170	106	96	133

pool, which is over 30ft deep, provides ample deep-water habitat for mature trout while riffles and runs downstream provide habitat for juvenile and sub-adult trout. Furthermore, this section of the river is the coldest section of the river providing the coldest water year round, particularly during late summer when temperatures can reach lethal levels. Though not unexpected, the greater survival rate observed in the Plunge Pool supports the hypothesis that the Exclusion Zone is non-representative in nature and justifies the discontinuation of its use as a release site in this study.

DISCUSSION

Significant differences in survival rates were found among river zones, release locations, release groups, and size-classes. The median residence time for trout released in the Catch & Release Zone was nine days longer than the median residence time for trout released in the Put & Take Zone. This difference is neither great nor likely to be biologically significant however, 75% of the study population in the Put & Take Zone was removed by day 84 in comparison to day 124 in the Catch & Release Zone. This is a difference of 40 days and much more likely to be biologically significant (Figure 4). Despite these differences, the residence times are still relatively low. This is likely the result of a combination of multiple factors including poor habitat and angling pressure.

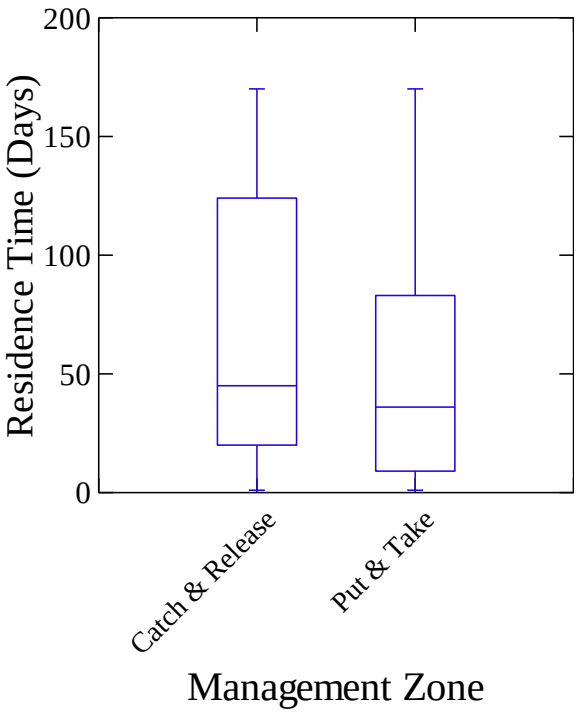

Figure 4: Median survival time is represented by the horizontal line in each box. Trout survived longer when released in the Catch & Release Zone than when released in the Put & Take Zone.

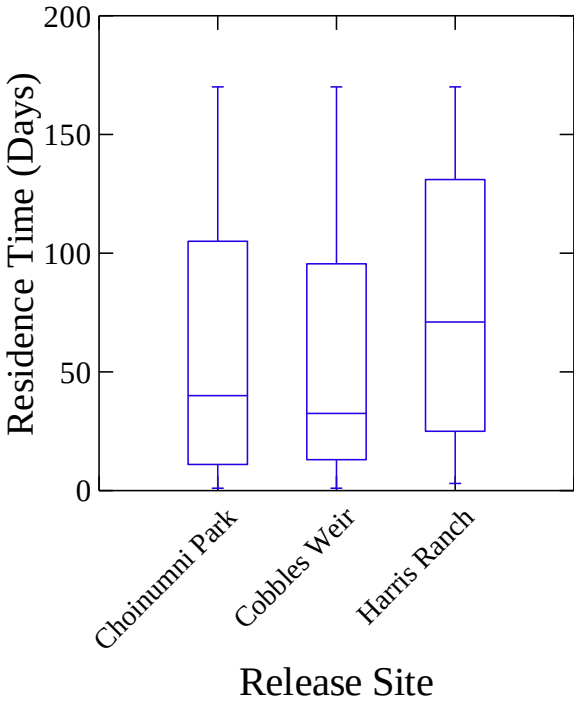

Figure 5: Median survival time is represented by the horizontal line in each box. Trout released at the Harris Ranch site survived longer than those released elsewhere.

Survival rates also varied significantly among the release sites tested in this study (Figure 5). The Harris Ranch release site, located in the Catch & Release Zone, yielded the longest median residence time (71 days). The Cobbles Weir release site, located in the Catch & Release Zone, yielded the lowest median residence time (33 days). This finding was not unexpected given that the Harris Ranch site is located near the middle of the Catch & Release Zone and surrounded by private property (Figure 1). The location of this site substantially reduces the amount of fishing pressure the site receives as compared to other release sites. Other factors such as habitat availability may have also influenced the survival time of trout released at these locations.

Survival rates also differed significantly among release groups. By design, release groups corresponded with changes in seasonal flow conditions (Figure 2). In general, trout survived longer when released immediately before or during irrigation demand flows (Figure 6; Table 5).

The greatest median residence time (119 days) was observed during the third release (ID, Figure 2). This occurred during an unusually wet period when flood releases

from Pine Flat Dam peaked at nearly 14,000 cubic feet per second (cfs). On the release day (June 20, 2006), discharge from Pine Flat Dam was 11,183cfs. Such a large volume of water increases the amount of habitat available to fish (Dare *et al.* 2002) which may have improved their chances of survival by improving their chances of avoiding predators. It also increased the difficulty of angling through increased water velocity and reduced access. These factors likely contributed to the increased residence time observed during the third release.

The shortest median residence time, just 18 days, was observed during the fifth release. This release occurred in the middle of the non-irrigation demand period (December 18, 2006) when discharge was 282cfs. Though this rate of flow resulted in the shortest median residence time, it was the second lowest discharge rate recorded on a release day. On the day of the seventh release, January 24, 2008, discharge from Pine Flat Dam was 137cfs. Despite being the lowest discharge rate recorded on a release day, the median residence time for the seventh release group was 20 days, 2 days longer than that observed during the fifth release. This small difference may merely be a result of natural variation in residence time due to fitness. It may also be a result of increased angling over the Christmas and New Year holidays as compared to angling pressure in late January or early February. Whatever the case may be, the results suggest that the relationship between flow and residence time may not be linear. In general, however, residence time increased as discharge from Pine Flat Dam increased (Figure 6).

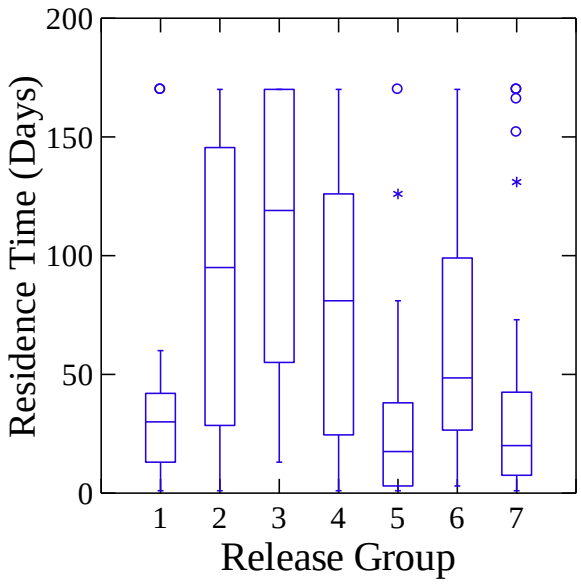

Figure 6: Median survival time is represented by the horizontal line in each box. Trout released prior to or during high flows (1,000cfs or greater) tended to survive longer than those trout released during low flows.

With increased velocity experienced during the irrigation season, the amount of allochthonous material that passes a foraging site also increases (Faush 1991). The increased availability of prey items in addition to reduced threat from predators and anglers may contribute to a greater

Table 10: Summary of fate types. A study fish was classified as "Dead" when a carcass was found with the transmitter. If no remains were found, the study fish was placed into the "Recovered Transmitter" category. This does not mean that the fish did not die, only that no remains were found. Missing transmitters were not included in the final calculation of the fate type statistics.

	Release Group								
Fate Types	**1st**	**2nd**	**3rd**	**4th**	**5th**	**6th**	**7th**	**Total**	**% of Total**
Missing Transmitter	*12*	*19*	*8*	*6*	*13*	*12*	*9*	*79*	*31%*
Recovered Transmitter	11	8	17	13	9	11	16	85	47%
Caught Out	10	7	5	11	12	12	12	69	38%
Dead (with carcass)	0	3	2	1	4	2	3	15	8%
Survived Beyond Life Of Transmitter	5	1	4	1	0	0	0	11	6%
								180	100%

chance for survival. When water volume and velocity increases, the ability of predators (i.e. birds, mammals, anglers) to prey on healthy trout in the river decreases (Turner 1991). These factors likely contributed to the longer residence time observed when releases were made during or immediately prior to irrigation releases from Pine Flat Dam.

With the exception of the second and sixth release groups, large trout generally survived longer than small trout (Table 7, Figure 7). Large trout were likely better able to compete for optimal habitat and foraging sites thus, improving their chances of survival. With the smaller trout less able to compete for prime habitat, they would have had greater exposure to predation and consequently experienced a shorter residence time.

Of the 259 trout tagged and released as part of this study, 31% (79) went missing. Their ultimate fate is unknown. Eighty-five transmitters were recovered from the streambed or surrounding area without any remains associated with it, accounting for 47% of the remaining study population. Thirty-eight percent of the sample population (69) was harvested by anglers. This may be an underestimate of the true harvest rate however, due to unreported take. Only 8% (15) of the study population was confirmed dead by the presence of a carcass and the remaining 6% (11) survived beyond the life of the transmitter. These results are summarized in Table 10. Possible causes for missing trout include; 1) an inability to locate trout moving downstream of the Highway 180 Bridge, 2) entrainment into one of the numerous canal systems originating from the Kings River, 3) unreported harvest by anglers, or 4) predation by avian or mammalian predators. Tracking did occur beyond the tailwater boundaries by way of pontoon boat, vehicle, and on foot. Despite these efforts, only seven transmitters were relocated in the main channel or sloughs downstream of the Highway 180 Bridge, which marks the lower

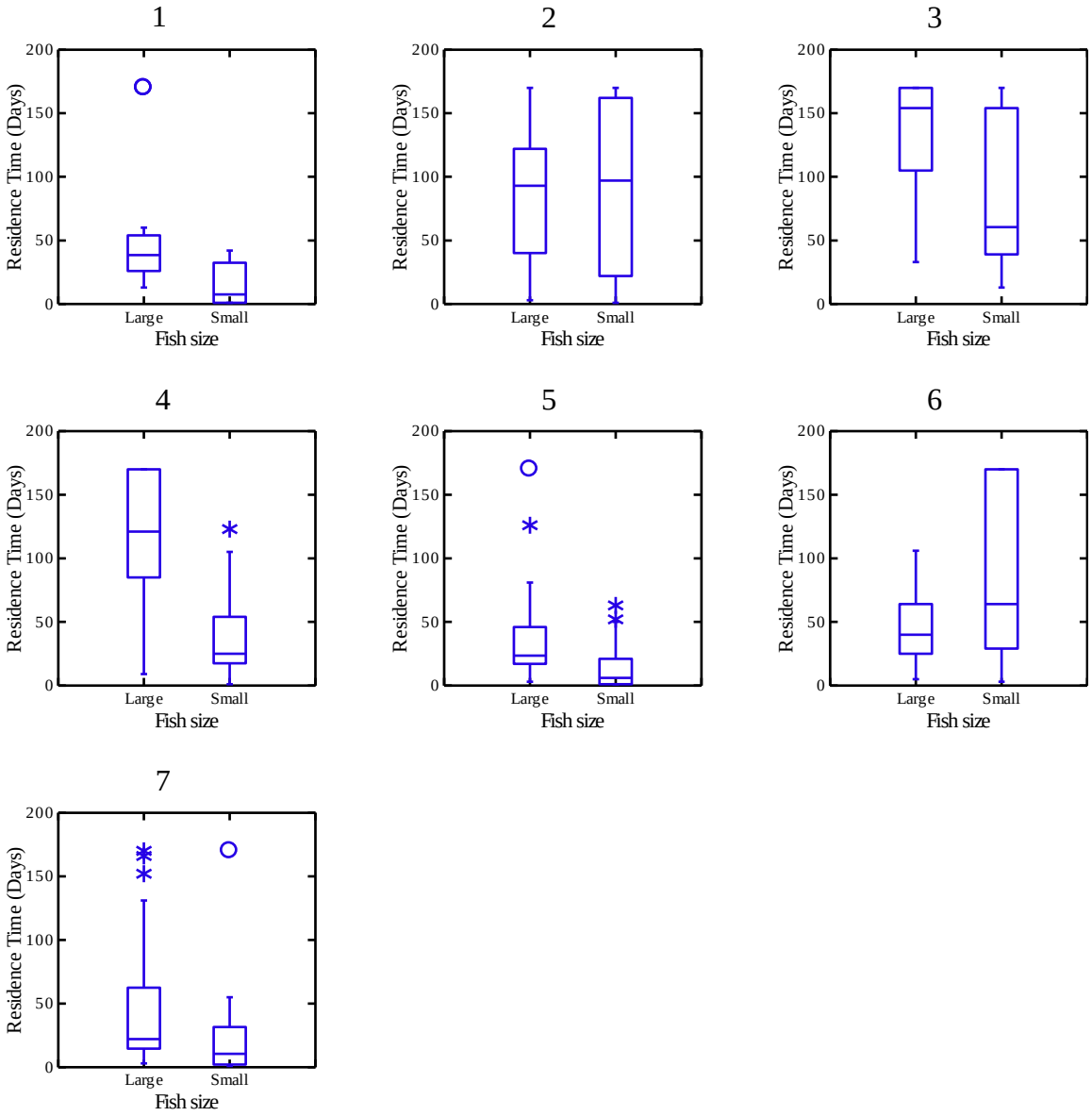

Figure 7: Each box plot represents the survival time of both large and small trout in each release group as denoted by the number above the plot. The median survival time is represented by the horizontal line in each box. Asterisks represent values outside of the data fence while open circles represent far outliers.

boundary of the tailwater fishery. Movement of study trout outside of the tailwater fishery was monitored to the extent possible; however, a lack of access to private property hindered accurate assessment of trout locations. The results discussed in this paragraph will be further analyzed in a separate paper.

In March 2007, a small transmitter (340-82) was tracked to an egret *Bubulcus ibis* rookery located near Byrd slough. Given this discovery, it is assumed that transmitters lost to predation would have been dropped within a detectable range of the river channel

as the trout was consumed. The possibility remains however, that some predators may have carried transmitters beyond the detectable range resulting in their disappearance.

Approximately 4% (11 of 259) of the study trout were entrained in canals originating from the Kings River. This was confirmed through angler reports and recovery of transmitters by the observer. These data are reflected in the data summarized in Table 9. A single transmitter (680-145) was recovered on land approximately 35m from the 76 Channel, an irrigation canal operated by Alta Irrigation District. It is uncertain how it ended up there, but prior to recovery the transmitter was located in the 76 Channel.

Occasionally, we received second-hand reports of anglers catching tagged trout but choosing not to return the transmitters to collect the $25.00 reward. These reports were largely unconfirmed until two missing transmitters were discovered at a private residence by chance. While en route back to the office after a day of tracking, a radio receiver was inadvertently left on. A transmitter signal was recorded near the intersection of Belmont and Academy Avenue in eastern Fresno County. The signal was tracked to a residence in the vicinity. Repeated attempts to contact the resident failed. In another instance, a transmitter was recovered on the banks of Lake Havasu by an angler. The angler called the KRCD office in June 2009 inquiring about the reward for returning the transmitter. After some discussion, it was determined that the tagged trout had been released in the Kings River on December 18, 2006, and was never relocated.

SUMMARY

Many factors can effect the residence time of trout released in the Kings River. This study investigated the effects of four potential factors; management zone, release site, release timing, and size-class. These factors were shown to affect the survival of rainbow trout in the Kings River. Trout released in the Catch & Release Zone survived longer than trout released in the Put & Take Zone. Trout released at the Harris Ranch release site survived longer than trout released at Choinumni Park or Cobbles Weir. Trout released at higher flows survived longer than trout released at lower flows, and in general, large trout survived longer than small trout.

These findings encourage more questions about habitat selection and movement of trout within the Kings River. The information gained from this study will be used in

conjunction with the information gained from the analysis of movement data and habitat selection data to inform management decisions under the adaptive management procedures adopted by the Fisheries Management Program.

References

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Kings River Conservation District. 2010. Lower Kings River Annual Trout and Non-game Fish Population Survey: 2009 Electrofishing Results. Unpublished.

(KRFMP) Kings River Fisheries Management Program. 2005. Pilot-scale Telemetry Investigation to Evaluate Behavior and Dynamics of Rainbow Trout Inhabiting the Kings river Downstream of Pine Flat Dam. Unpublished.

(KRFMP) Kings River Fisheries Management Program. 2009a. Telemetry Equipment: Habitat Selection, Behavioral movement, and Fate of Adult Rainbow Trout within the Kings River downstream of Pine Flat Dam**.** Unpublished.

(KRFMP) Kings River Fisheries Management Program. 2009b. Transmitter Implant Surgeries: Habitat Selection, Behavioral movement, and Fate of Adult Rainbow Trout within the Kings River downstream of Pine Flat Dam**.** Unpublished.

Turner, Spencer E. 1991. Tailwaters**.** Trout. Stackpole Books, Harrisburg, PA. pp 144-146.

Appendix 1

Date _____

LOCATION DATA

Frequency – Code:

_____

Time – Bearing:

1) _____

2) _____

3) _____

Photograph Number:

_____

HABITAT

☐ Pool

☐ Riffle

☐ Run

☐ Tailout

☐ Boulder Project

SHELTER

☐ Bubble Curtain

☐ Depth

☐ Terrestrial Veg.

☐ Aquatic Veg.

☐ Root Mass

☐ Cut Bank

☐ Boulder

☐ Woody Debris

☐ Other:

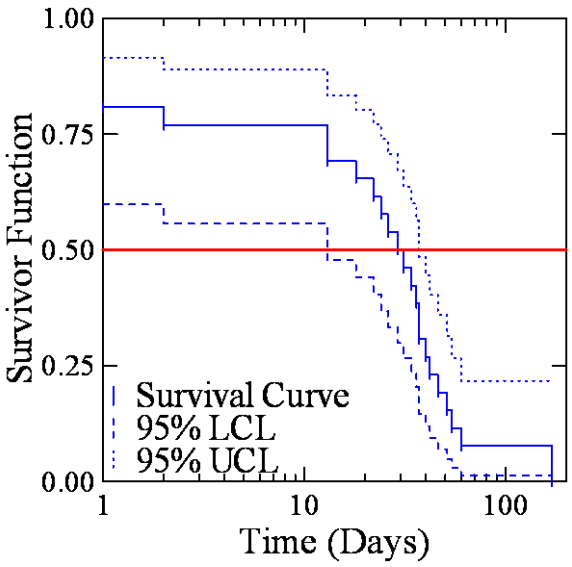
_____

_____

NOTES:

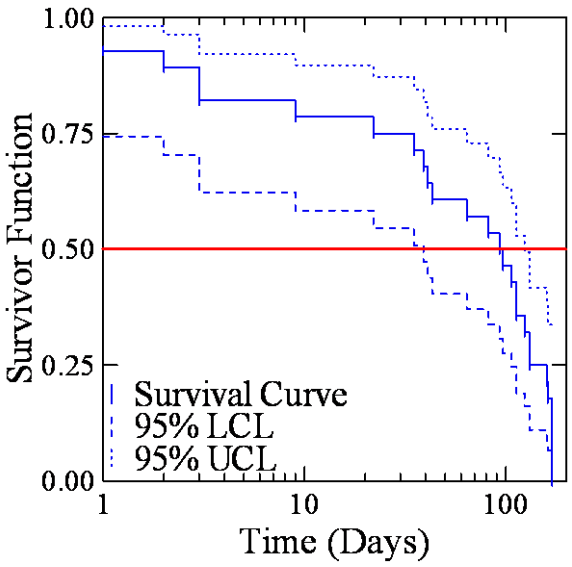
Appendix 2

Release Group 1



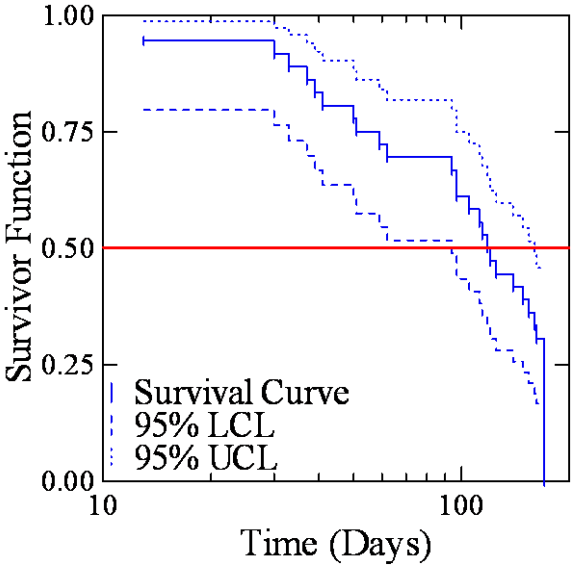
Median survival time was 31 days. Mean survival time was 37 days. (n=26)

Release Group 2



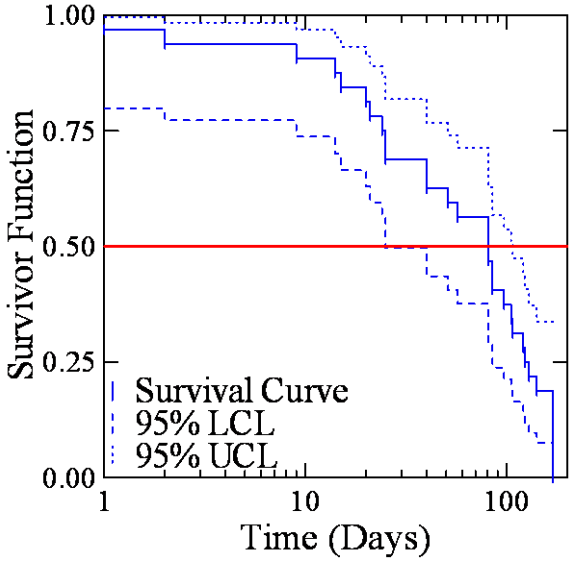
Median survival time was 97 days. Mean survival time was 87 days. (n=28)

Release Group 3



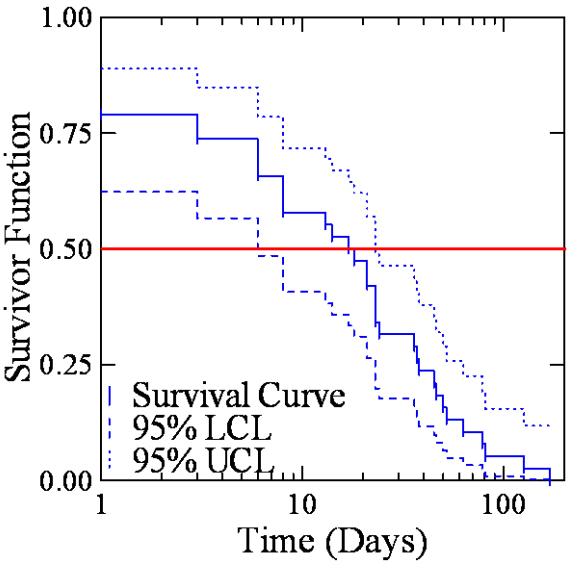
Median survival time was 118 days. Mean survival time was 112 days. (n=36)

Release Group 4



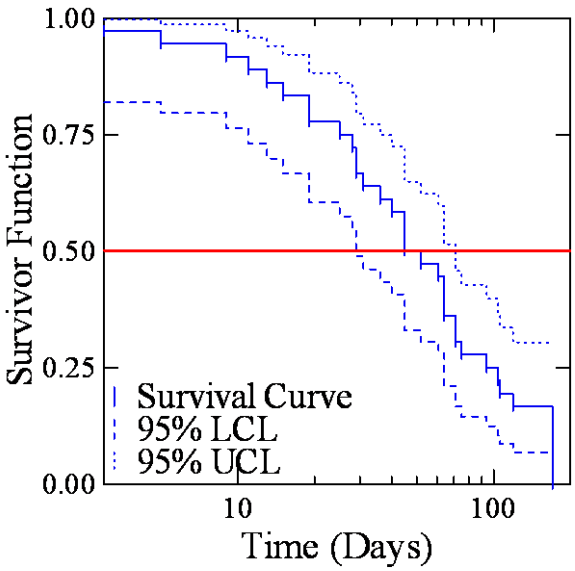
Median survival time was 81 days. Mean survival time was 81 days. (n=32)

Release Group 5



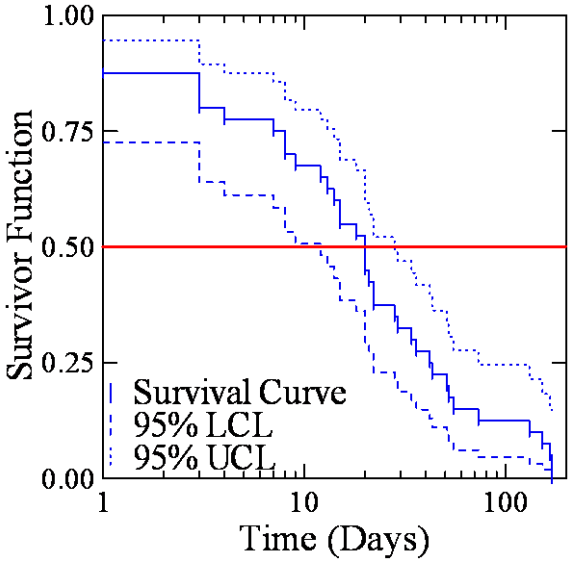
Median survival time was 17 days. Mean survival time was 28 days. (n=38)

Release Group 6



Median survival time was 52 days. Mean survival time was 67 days. (n=36)

Release Group 7



Median survival time was 20 days. Mean survival time was 37 days. (n=40)