

Harvest of Rainbow Trout:

*The Effects of Time, Flow, Size Class, Planting Location and
Management Zone on Trout Harvest in the Kings River
Below Pine Flat Dam*

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ABSTRACT

The California Department of Fish and Game (CDFG) stocks 36,000 rainbow trout (*Oncorhynchus mykiss*) in the Kings River tailwater fishery annually. Angler surveys and return to creel studies have been conducted in past years in order to estimate the number of rainbow trout actually harvested as a result of these efforts. This study analyzed specific variables influencing harvested rainbow trout and their duration within the fishery.

Results of our three year telemetry investigation found that on average trout reside in the fishery for approximately 54 days prior to harvest. Of those caught 59% were classified as large or trophy sized and 41% were classified as small or catchable sized. Not surprisingly, the majority of trout harvested from the fishery were in easy to access Put and Take management zones during river flows which measured 500cfs or below.

1.0 INTRODUCTION

Harvest is an integral component of many inland fisheries and can have significant impacts on population viability, community interactions and fishery quality (Isermann and Paukert; Ed. Hubert and Quist, 2010). In order to better understand the environmental effects of our current management strategies, the objectives of this study are to: 1) determine the duration of trout residency within the river prior to harvest by recreational anglers, 2) determine if changes in seasonal flow effect harvest rates, 3) determine if harvest rates vary between large and small trout, 4) determine if planting location and management zone effect harvest rates and 5) examine the reasons why anglers may neglect to report catching radio-tagged trout.

In accordance with the Kings River Fisheries Management Program (KRFMP) Framework Agreement, the investigation of rainbow trout (*Oncorhynchus mykiss*) harvest rates is pertinent to “determining the health and status of the fishery in the Kings River below Pine Flat Dam” as indicated by Program Element (k) *Development of Criteria/Monitoring*. This data is also pertinent to decisions made in respect to Element (l) *Regulations* and may also aid in achieving the multi-species aquatic resource goals described in Exhibit A(i). The results from this telemetry investigation will be integrated with results from sibling investigations of residence time, habitat selection and movement in order to maximize management strategies and angler opportunities within the Kings River tailwater fishery.

2.0 STUDY AREA

The tailwater fishery created by the Pine Flat Dam is approximately 20km (12.3miles) long (Figure 1). Two regulatory management zones (Put & Take and Catch & Release) and an “Exclusion” zone exist between Pine Flat Dam and the Highway 180 Bridge. The Exclusion zone is located between Pine Flat Dam and the Army Corps of Engineers (ACOE) Bridge and is approximately 0.8km long. The Put and Take zone, located between the ACOE bridge and the Cobbles (Alta) Weir, is approximately 8km long, and the Catch and Release zone, located between Cobbles Weir and the Highway 180 Bridge, is approximately 11km long. The river abuts both private properties and public access areas.

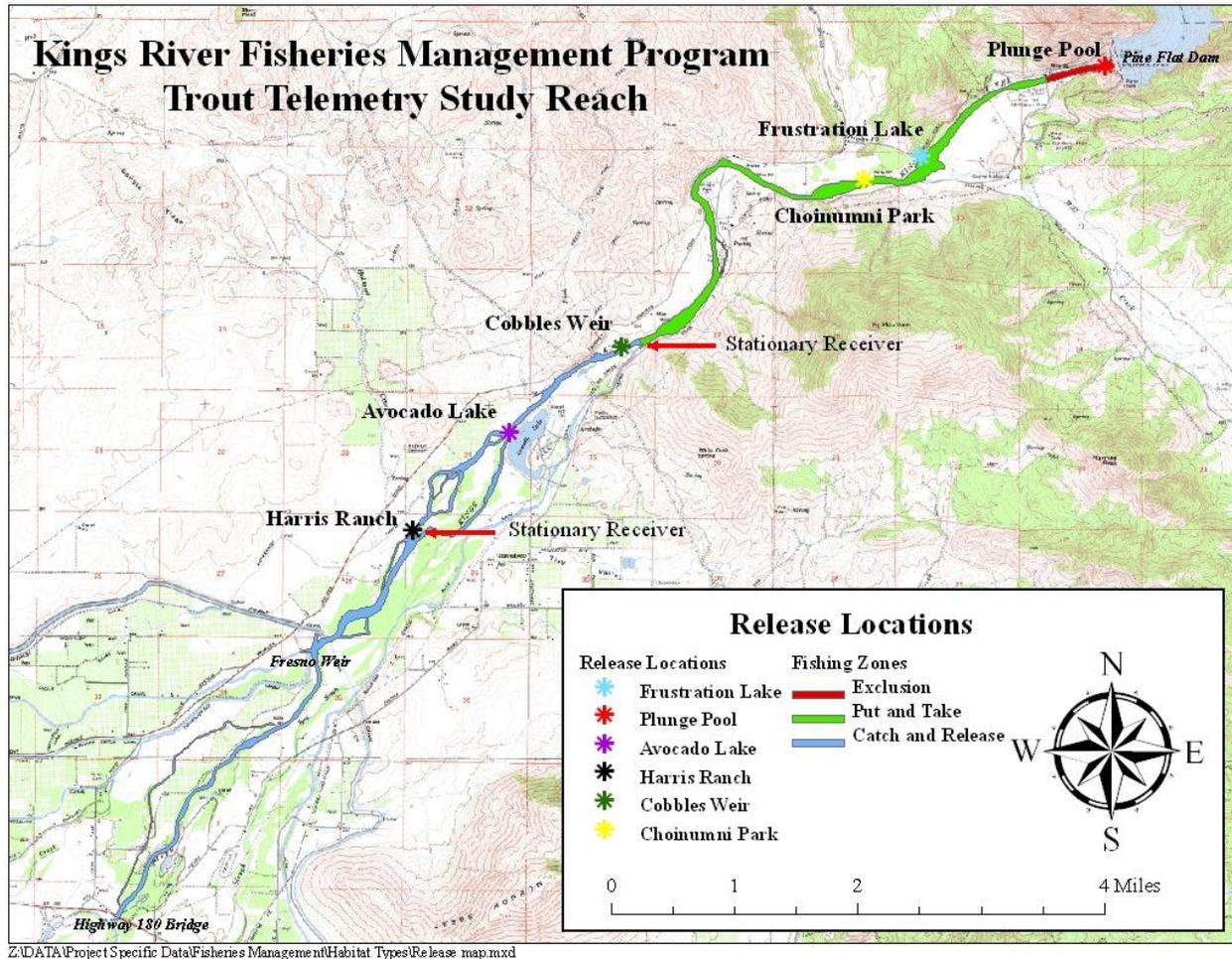


Figure 1: Tailwater fishery created by the Pine Flat Dam in eastern Fresno County. Two regulatory zones and an Exclusion zone are present in the study reach of the Kings River; Exclusion (red), Put & Take (green), and Catch & Release (blue).

3.0 METHODS

Two hundred and fifty-nine trout implanted with radio transmitters were released into the tailwater fishery between October 2005 and January 2008 (KRFMP 2005, unpublished; KRFMP, 2009b, unpublished). Due to the difficulty obtaining an adequate number of suitably sized “wild” trout directly from the river, 94% of the study trout were provided by the San Joaquin River Fish Hatchery. Each release group consisted of approximately forty trout. Release locations were stratified across regulatory management zones in an effort to study the effects of each management zone on rainbow trout harvest. Release timing corresponded with seasonal changes

in stream flow conditions. More specifically, groups one and four were released during early non irrigation demand; groups two, five and seven were released in the late non irrigation demand period (just before flows increased) and groups three and six were released during irrigation demand (high flow period) (Table 1).

Table 1: Experimental design for stratified release groups (ENID = early non-irrigation demand, LNID = late non-irrigation demand, ID = irrigation demand).

Release Schedule for Telemetry Trout										
Release Group	Release Month	Irrigation Demand	Size	Exclusion	Put & Take		Catch & Release			Planted
				Plunge Pool	Choinumni	Frustration Lake	Alta Weir	Avocado	Harris	
1	October '05	ENID	Large = 18	4	0	5	9	0	0	n = 38
			Small = 20	6	0	5	9	0	0	
2	February '06	LNID	Large = 18	5	3	0	4	2	4	n = 38
			Small = 20	3	5	0	6	0	6	
3	June '06	ID	Large = 18	0	5	0	6	0	7	n = 36
			Small = 18	0	5	0	7	0	6	
4	October '06	ENID	Large = 17	0	5	0	5	0	7	n = 32
			Small = 15	0	4	0	5	0	6	
5	December '06	LNID	Large = 18	0	5	0	7	0	6	n = 38
			Small = 20	0	7	0	7	0	6	
6	June '07	ID	Large = 18	0	6	0	7	0	4	n = 37
			Small = 19	0	7	0	6	0	6	
7	January '08	LNID	Large = 20	0	5	0	7	0	8	n = 40
			Small = 20	0	8	0	5	0	7	

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 reach 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 of the study reach, since trout could only move in a downstream direction. 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 overnight and were never located. Finally, 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. Although trout planted within the plunge pool were excluded from the majority of data analysis, trout that managed to make their way into the accessible section of the fishery were counted as angled if their tags were returned. Any trout representing the Frustration Lake or Avocado planting sites were also accounted for if angled.

Rainbow Trout were tracked via a hand held telemetry receiver through 7 July 2008. Individual trout were contacted at least twice every seven days where possible. In addition, two stationary receivers were employed to track the movement of trout passing Alta Weir or the Harris Ranch confluence. Rainbow trout positions within the river were recorded and residence time was calculated based upon movement, transmitter return by anglers, and transmitters recovered from the river bottom or surrounding area. Harvest data was greatly dependent on angler tag return, therefore a \$25.00 reward was offered for each radio-tag redeemed. The award amount and contact information for the Kings River Conservation District (KRCD) was marked on each radio-tag. In addition, signs were placed in public access areas to make anglers aware of the study. Anglers who returned transmitter tags were asked to fill out a short form which solicited their name, date, angling location and the trout's tag number. This data was later used in conjunction with telemetry data to determine the residence time of each trout caught during the study.

4.0 ANALYTICAL PROCEDURES

Descriptive analysis was used to determine the catch rates of harvested trout in addition to minimum, maximum and mean residence times (Table 2). These results were then quantified and categorized by release group and irrigation demand for comparative analysis. An *Equality of Two Proportions* Hypothesis Test (Two-proportion z-test) was used to analyze differences amongst the harvested portions of large and small trout. This test was also used to analyze harvest rates between management zones.

5.0 RESULTS

5.1 Residency

Residence time represents the total number of days that a study trout remained alive in the river, with release day being Day 1 (KRFMP, 2011). Of the two-hundred and fifty-nine trout planted, sixty-nine (27%) were harvested by anglers. The mean residence time for harvested rainbow trout was fifty-four days (7 - 8 weeks). When sorted by management zones, the average

residency time for trout released in the Catch and Release zone was eighty-three days (11-12weeks) and the average resident time for Put and Take trout was forty-nine days (7weeks); a mean difference of 34 days between management zones. Results are shown in Table 2.

Table 2: Residence time of harvested rainbow trout (*Irrigation Demand)

			Residence Time of Harvested Trout (Days)								
			Small			Large			Total		
Release	ID*	% Harvest	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
1	ENID	26%	N/A	N/A	N/A	13	178	60	13	178	60
2	LNID	18%	97	325	167	5	156	81	5	325	412
3	ID	14%	39	52	46	33	252	141	33	252	103
4	ENID	34%	1	105	42	24	164	85	1	164	68
5	LNID	33%	1	13	4	3	45	21	1	45	11
6	ID	32%	5	45	23	7	40	22	5	45	22
7	LNID	30%	1	51	11	14	191	55	1	191	35
Management Zone			Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Put & Take			0	325	37	3	252	61	0	325	49
Catch & Release			105	181	143	13	164	63	13	181	83

5.2 Flow and Irrigation Demand

Group three yielded the fewest angler returns with only a 14% return. Flow at the time of release was 11,183cfs during the irrigation demand period. Altogether trout released during irrigation demand periods represented 25% of the total catch. Group 4 was released into early non-irrigation demand flows of 1,494cfs. It yielded the greatest percentage of angler return with 34% of tags returned by fishermen. Although the single highest percentage of angler harvest occurred during an early non-irrigation demand period, the late non-irrigation periods represented the greatest collective return with 45% of the total catch.

In all, 51% of the trout harvested were caught in flows below 500cfs and 0% of the study trout were harvested in flows between 8,001- 10,500cfs. When broken down by the flows preset by the study design 41% of the study trout were harvested in flows \geq 1,000cfs, 49% were harvested in flows between 250 – 999cfs and 10% were harvested in flows \leq 249cfs (Figure 2).

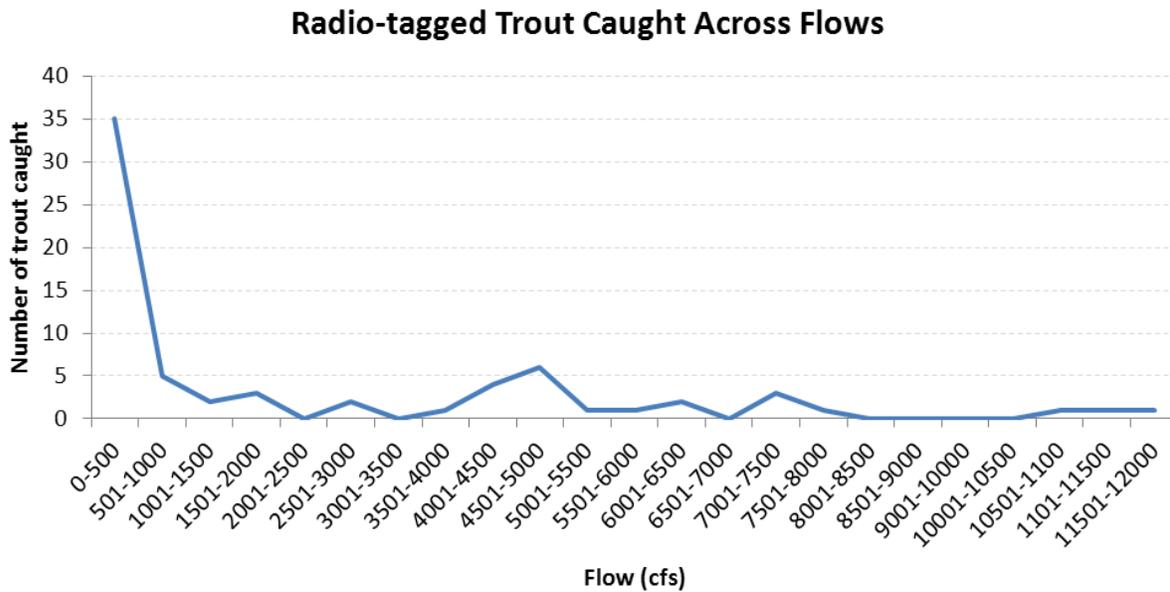


Figure 2: Number of rainbow trout caught across flows (cfs) from October 2005 to June 2008

5.3 Size Class

When initially tested, no significant ($p = 0.087$) difference was found between the harvest rates of large and small trout. When the data was retested to include trout from the Plunge pool a significantly ($p = 0.043$) greater portion of large rainbow trout were harvested than small. Forty-one of one-hundred twenty-seven (32%) large rainbow trout were harvested with a mean residence time of fifty-eight days. Twenty-eight of one-hundred thirty-two (21%) small trout were harvested by anglers and experienced a mean residence time of forty-eight days.

5.4 Planting and Harvest Locations

Residence times of harvested rainbow trout varied amongst planting locations (Figure 3). Of the harvested population trout planted at the (non-representative) plunge pool location experienced the longest mean residence time of 161 days. Five trout planted at the Harris site experienced a mean residence time of 151 days; followed by thirty-one plants from Choinumni at 48 days, forty-six plants from Alta Weir resided 46 days and three trout from the Frustration Lake plant resided for 30 days.

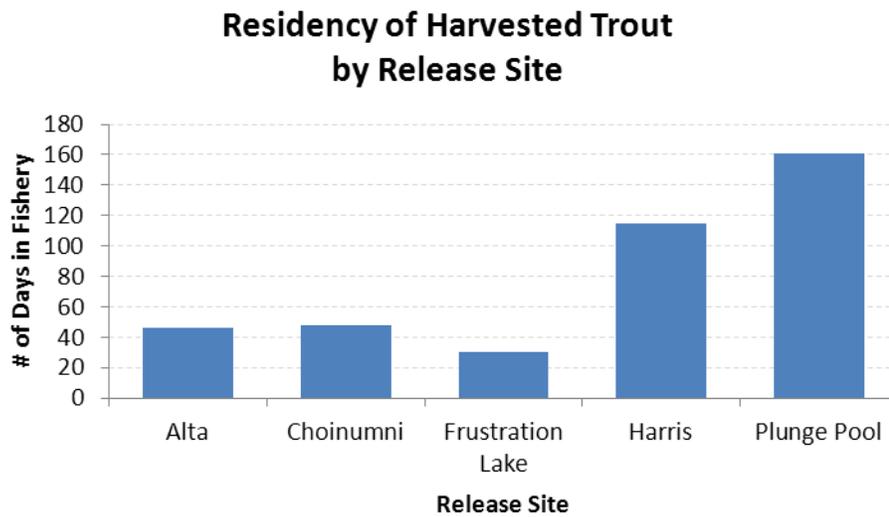


Figure 3: Residence time of harvested rainbow trout by release site

Harvest rates were greatest amongst trout planted at Choinumni Park. Thirty-one of sixty-five (48%) trout planted at the Choinumni site were harvested by anglers. Twenty-seven of eighty-eight (31%) trout planted at the Alta Weir site were harvested by anglers and five of the seventy-three (7%) trout planted at the Harris Ranch site were harvested. In addition, two plunge pool trout and three Frustration Lake trout were also harvested.

A significant ($p = 0.000$) difference was found in harvest rates between management zones with more trout caught in the Put and Take Management zone than in the Catch and Release zone. Results showed that nine trout were harvested from the Catch and Release zone while forty-five trout were harvested from Put and Take.

5.5 Undefined Fates and Non-reporting

Eighty-two (32%) of the two hundred and fifty-nine trout planted were classified as missing. Trout whose tags were never recovered or whose ultimate disposition remained unknown received this designation. If all trout with an unknown tag fate were assumed to have been harvested and unreported by anglers, the maximum rate of harvest would have been one-hundred fifty-one trout or 58% of the study population.

6.0 DISCUSSION

6.1 Residence Time

Residence time describes the amount of time that an individual trout inhabits the river from time of entrance till dispersal or death. Idaho Department of Fish and Game (IDFG) studies have shown that most hatchery catchable rainbow trout stocked in streams, regardless of strain, do not persist for more than a few weeks or a month (IDFG, 2011). CDFG and KRCD surveys show most trout within the lower Kings River get caught within the first three days after planting and the return rate is near zero after 7 days (KRCD, 1999). The results from this telemetry investigation show that hatchery produced rainbow trout harvested by anglers persist nearly twice as long (54 days) on average as compared to trout in alternate studies. These results also align with the data reported in the KRFMP 2011 Residence Time Paper, which reported a mean residence time of 29 to 142 days amongst all trout within the study population.

6.2 Harvest Rates

The Kings River annual allotment comprises approximately thirty-six thousand trout categorized as “catchable” by CDFG. “Catchable” trout are planted to provide additional recreation opportunities in some areas where natural recruitment is low compared to the desired level of harvest (KRCD, 1999). Our study population yielded a 27% return to creel rate with 51% of those trout caught in flows of 500cfs or less. Low flows can result in higher catch rates by providing greater access to anglers and creating less habitable space for trout. Of the trout caught 45% were harvested during the late non-irrigation demand period. This may be due in part to the fact that three releases occurred during late non-irrigation flows whereas the additional demand periods were only represented by two release groups. This may also reflect greater access by anglers.

6.3 Size Class

Size class results were adjacent to those of other studies, with small trout exhibiting a residence time ten days greater than large trout. On the Kings River 32% of large rainbow trout

and 21% of small rainbow trout were caught from the study population. In Idaho the IDFG (1995) estimated returns were 51% for large trout and 41% for small. Walters et al. (1997) reported that angler return rates of large rainbow trout were 47% and 22% for April and September stockings, and return rates for the small fish were 1% and 2% for April and September stockings. Mauser (1994) found that anglers returned 1.2 times more jaw tags from large hatchery trout than small hatchery catchables in three Idaho streams.

A common theme among strain studies is that faster growing strains are more vulnerable to angling (IDFG, 2003). This idea has been backed by collective evidence and a hypothesis that larger trout are more voracious feeders than small. Individuality of angling vulnerability has also been shown in rainbow trout. Lewynsky (1986) observed that during a nine-week fishing trial in a raceway, captures ranged from zero to five times per individual trout. About 37% of the fish were caught more than one time and 21% were never caught (IDFG, 2003). While size class is not pertinent to Lewynsky's study, Lewynsky's study introduces a possible variable that has thus far gone unstudied on the Kings River tailwater fishery. This speculates that rather than acting homogeneously by size class, that the catchability of trout is to some degree inherited to the individual.

6.4 Management Zone

As hypothesized, a greater number of trout were harvested from the Put and Take section of the river than the Catch and Release section. Nine trout were harvested from the Catch and Release Section and their tags returned; presumably meaning that anglers failed to release (poached) the trout. On average it appears that trout planted within the Catch and Release Management zone live approximately thirty-four days longer than do trout planted in the Put and Take management zone. When analyzed by planting locations, it became apparent that fishing access greatly affected residence time. Trout planted in locations with little to no fishing access such as the Harris site, resided much longer than trout planted at known access areas. Nine trout were harvested from the Catch and Release section compared to forty-five trout harvested from Put and Take. Because it is illegal to take trout from the Catch and Release management zone; it would be difficult for an angler to retrieve a surgically implanted transmitter tag without

effectively killing the trout. Trout poached and unreported may have affected our harvest numbers.

Askey et al, 2006 attributes diminishing catch rates in Catch and Release Fisheries to learned hook avoidance. Catch-and-release fisheries differ from harvest fisheries in that the fished population consists of fish that have never been caught as well as fish that have been caught and released. Evidence is accumulating to suggest that learned hook avoidance is a common behavioral response among sport fishes. Parameter estimates indicated that fish became less catchable if they had been previously captured and that fish catchability continued to decrease with additional capture experiences (Askey et al, 2006). At this time there is no evidence to suggest that hook avoidance has played a role in extending the residence times of trout in the Catch and Release zone of the Kings River tailwater fishery.

6.5 Noncompliance

Unreported harvests during a telemetry study can create gaps in analytical data. Through the duration of the study we found evidence of trout which had been caught and unreported by anglers. Evidence of unreported harvests were revealed in episodic events such as that where a seasonal technician approached an angler who had caught a tagged fish and notified him of the reward, however the angler failed to return the tag. Two tags were handed over to a Department of Fish and Game (DFG) officer by fishermen who did not want to bother with them and two unreported tags were tracked to a private residence via radio-telemetry. Finally a tag found on the banks of Lake Havasu was reported by a third party seeking the \$25.00 reward.

Each of the above instances could be attributed to indifference on the part of the angler; however it is obvious from the return of tags taken from the Catch and Release Management zone that a certain amount of poaching also occurs in the fishery. Noncompliance with fishing regulations is a constant concern for fisheries managers. Many factors can influence noncompliance rates including lack of regulation awareness, regulation complexity, catch rates, failure to identify species correctly, and angler measurement error (Hubert and Quist 2010; Page et.al 2004; Page and Radomski 2006). In addition, lack of enforcement could also promote noncompliance in fishers who believe that the probability of being caught with illegally-

harvested fish is low (Hubert and Quist 2010; Walker et al. 2007). It is very possible that non-compliant anglers may have neglected to turn in tags from poached trout in order to stay out of trouble. The Kings River Fishery also attracts many Hmong and Spanish speaking anglers. It is conceivable that non-English speaking fishermen simply did not understand what the radio-tags were and discarded them.

7.0 Conclusion

Rainbow trout harvested from the Kings River tailwater fishery experienced an average residence time of 54 days. In examining the relationship between size class and creel returns, our results were analogous to ones produced in a multitude of other studies. In order to increase angler harvest, many agencies have found that it is more cost effective to stock fewer trout overall and to increase the number of large or trophy sized trout stocked (Mauser, 1994; Walters et al. 1997).

We found that it would be unlikely for small trout, planted in areas with little public access during irrigation demand flows between 8,000 – 10,000 cfs to be harvested. Large trout, planted at Choinumni or within a highly accessible region of the Put and Take management zone, during late non-irrigation demand flows (>500 cfs) would be the most likely demographic for angler harvest. This understanding may help to maximize future stocking practices.

Due to receiving trout tags taken from the Catch and Release management zone, we can confirm to some degree that poaching also contributes to the number of trout regularly taken from the fishery. Investing in multilingual signs and media might curb unintentional poaching or help create a case against poachers who claim to not understand current regulations.

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