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TECHNICAL MEMORANDUM

Thermal Refugia Use by Salmonids in Response to an Experimental Release of Water on the Trinity River, California 2004

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INTRODUCTION

In September of 2002, a substantial proportion of adult fall run chinook salmon (*Oncorhynchus tshawytscha*) returning to the Trinity River perished during a large scale fish kill in the lower-Klamath River (BOR 2004). In response, the United States Bureau of Reclamation (BOR) released water from Lewiston Dam (rkm 182) in late August and September of both 2003 and 2004 in excess of typical summer base flow to reduce exposure of adult salmon to the conditions thought to have caused the 2002 die off (TMAG 2004). The effects of these unnatural fall flow releases on juvenile salmonid and lamprey ammocoete emigration, adult salmonid migration, spawning, run timing, and mixing of discrete races, is not known.

During the summer months of 2004, biologists and technicians from the Yurok Tribal Fisheries Program performed snorkel surveys at the confluences of two creeks with the Trinity River; Horse Linto Creek (rkm 31.75) and Willow Creek (rkm 40.5) (Figure 1). This report documents those surveys. The following were specific sampling goals:

1. Gain a better understanding of fish use of thermal refugia on the Trinity River as it relates to river flow, water temperature and time

2. Document the effects of a Proactive Flow Release of water by the BOR from Lewiston Dam on the use of two thermal refugia by fish

3. Monitor two creek confluences for any signs of diseased or deceased fish

MATERIALS AND METHODS

Temperature and River Flow

For the purposes of figures in this report, hourly water temperature and river flow data from a gauging station operated by United States Geological Survey (USGS) in Hoopa (rkm 20), California were utilized. The maximum and minimum water temperatures for each day were then queried out of the downloaded data. Daily average river flow was calculated using hourly data. Because air temperature information for Hoopa was scarce, hourly air temperature data measured at Weitchpec (rkm 0) by the USGS were used. Daily average air temperature was calculated from the hourly data. Any abnormal perturbations in these data were removed prior to performing calculations.

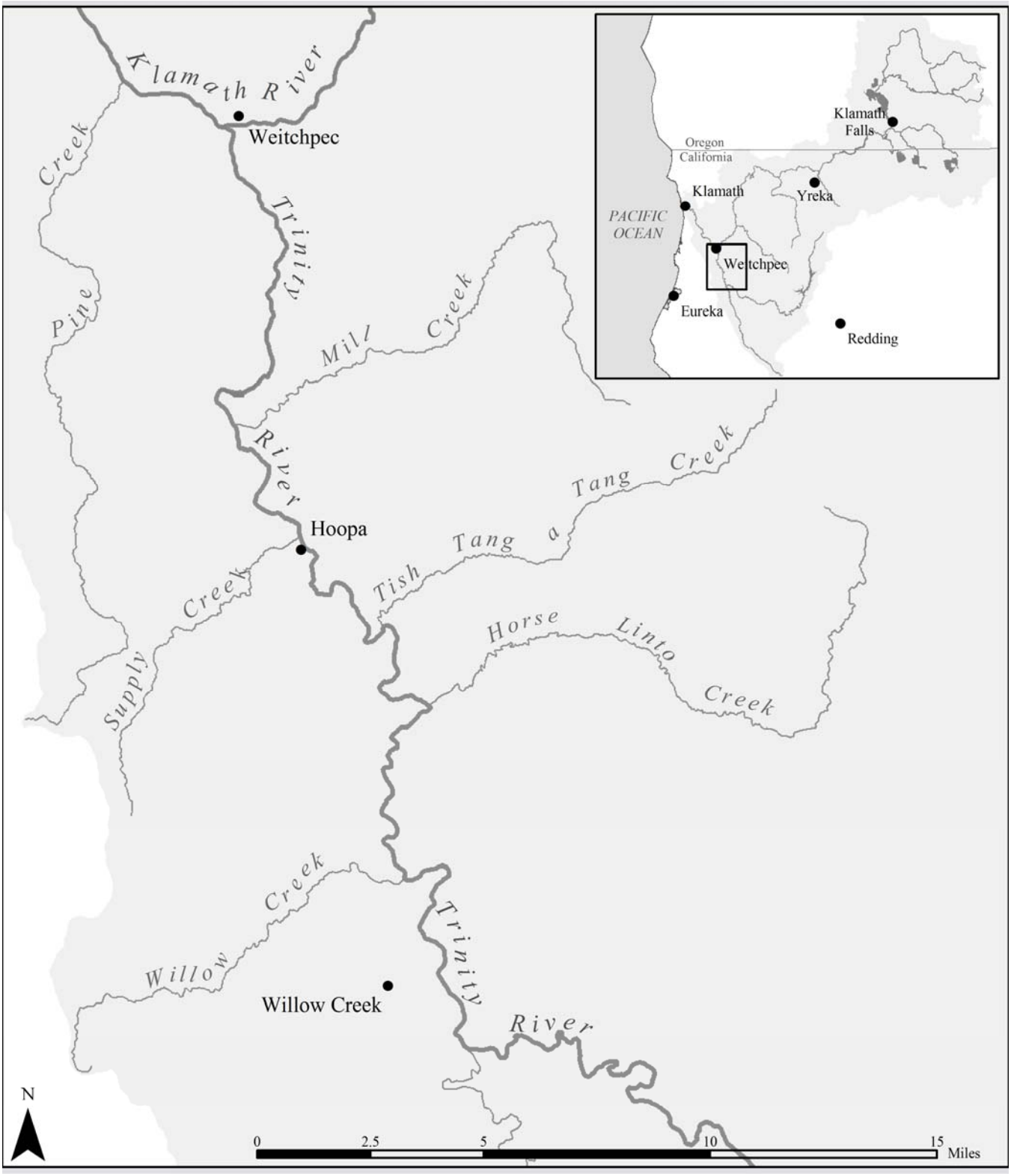

Figure 1. Map of the lower-Trinity River

Survey Protocol

Snorkel surveys were conducted on a weekly or bi-weekly basis from late June to mid-October of 2004 between the hours of 13:00 and 17:00. Although water temperature tends to peak after 17:00, sampling after that time creates logistical and scheduling problems. Water temperature and dissolved oxygen were measured with a YSI Inc. model 550 dissolved oxygen and temperature meter. Measurements were taken in the river near the creek to be sampled (but away from the influence of the creek), in the creek itself, at the point where the creek and the river met (a.k.a. "top of the refugia") and at a point where more mixing had occurred (a.k.a. "bottom of the refugia"). On some occasions, the YSI 550 was not available and dissolved oxygen was not measured. However, temperatures were measured with a handheld thermometer at those times. Air temperature was measured with a hand held thermometer placed out of direct sunlight.

Divers conducted multiple pass transects through the refugia area (defined as the area of water colder then the main channel as a direct result of colder creek water) using a mask and snorkel. Additionally, the first two pools (walking upstream from the river) in each creek were snorkeled. Fish were observed and enumerated by life stage and species (Table 1). Data of fish observations from the first two pools in each creek are not presented in this document.

Table 1. Life stage and length criteria used by snorkelers to enumerate steelhead and salmon in thermal refugia areas of the Trinity River, California, 2004

Steelhead		Salmon	
Life stage	Length	Life stage	Length
0+	15 cm or less	0+	15 cm or less
1+	16-30 cm	1+	16-30 cm
Half pounder	31-46 cm	Jack	31-56 cm
Adult	47 cm or greater	Adult	57 cm or greater

To supplement the length criteria specified for steelhead half pounders, additional criteria included a shiny appearance. That is, a steelhead that was 32 cm but displayed residual parr marks and/or heavy spotting would not have been counted as a half pounder. In order to facilitate analysis of data, all salmonids were separated into two major categories; juveniles and adults. Salmon jacks and half pounder steelhead were considered adults. All fish observed to be ill or deceased were counted separately from those considered healthy. Fish were enumerated using the following counting method:

Number of fish	Counting method
50 or less	estimate an exact number
51-100	count fish in increments of 10
101-500	count fish in increments of 50

Catch per Unit Effort Comparison

Adult chinook salmon data from thermal refugia were compared to Hoopa Valley Tribe adult chinook salmon weekly net harvest catch per unit effort (CPUE) data in order to evaluate how

observations in thermal refugia are related to the number of fish migrating through the area. The CPUE data was provided by Hoopa Valley Tribal Fisheries. Refugia data were matched with CPUE data from the week that most closely corresponded to the dates of refugia observations. We assume that net harvest weekly CPUE data is a reasonable metric of the abundance of adult salmon in the river.

RESULTS AND DISCUSSION

The Proactive Flow Release (PFR) increased river discharge and decreased water temperature in the lower-Trinity River from the end of August through mid-September (Figure 2). From the beginning of August through mid August, daily maximum water temperatures were generally greater than 23°C. After the cooler water from the PFR reached the lower-Trinity River, daily maximum water temperatures rarely exceeded 19°C. The effects of the PFR on river conditions were preceded by approximately two days by a cooling trend that brought with it precipitation (Figure 2). This effectively initiated a decrease in river temperatures that were followed closely by the PFR.

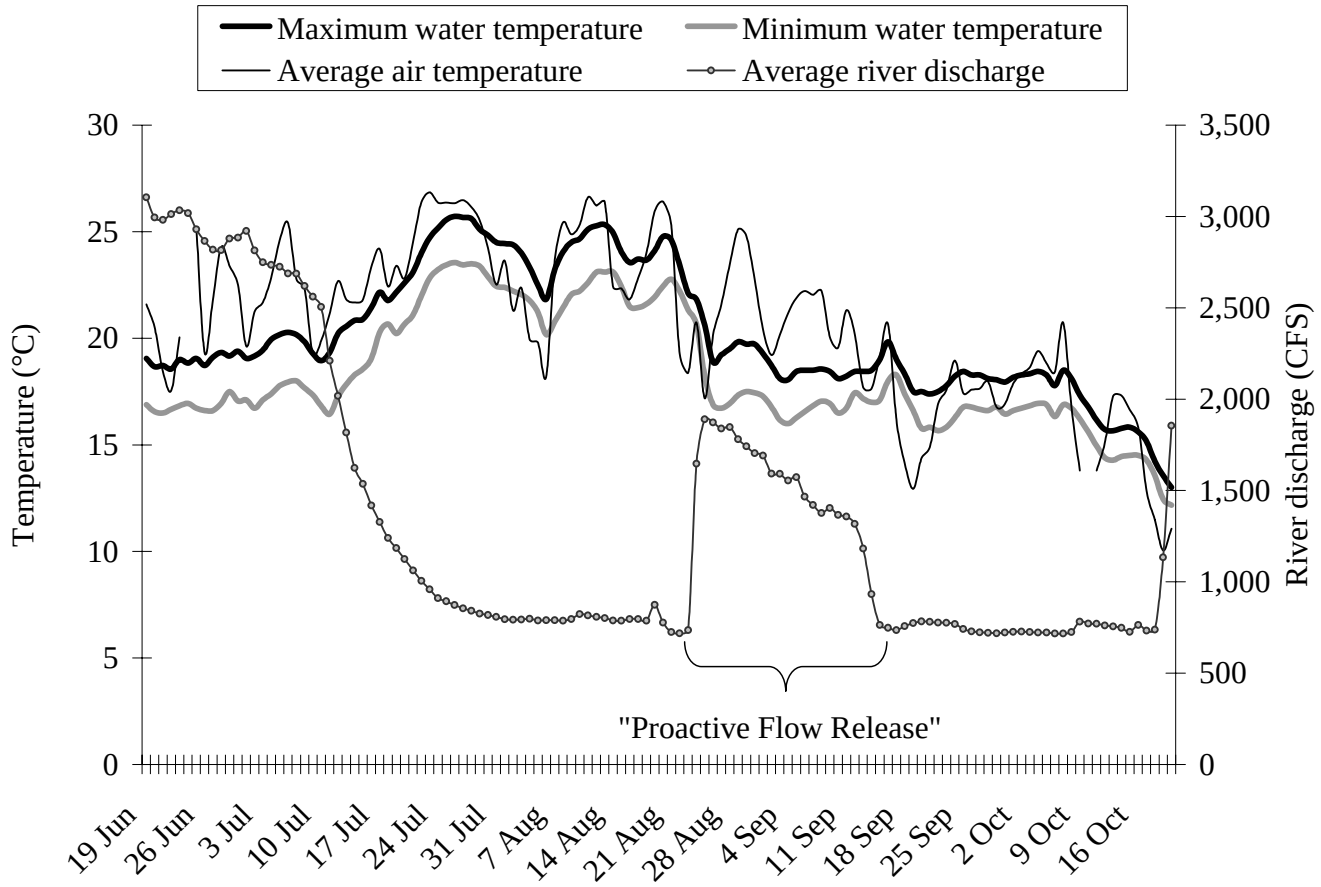

Figure 2. Water temperature and river discharge of the Trinity River measured near Hoopa (rkm 20), and air temperature measured near Weitchpec (rkm 0), California, 2004

The Trinity River is typically very clear during the summer months and visibility for the purpose of identifying adult salmonids is approximately four meters. However, during the PFR, especially in the first few weeks, visibility decreased by approximately half. The decreased visibility

may have affected our ability to observe adult salmonids at the Willow Creek refugia because the area is relatively deep (four meters or greater). But the adult salmonid holding area near the confluence of Horse Linto Creek and the Trinity River is not particularly deep (about two meters). Therefore, we do not feel that our observations of adult salmonids at the Horse Linto refugia were affected by the decrease in water clarity during the PFR.

Horse Linto Creek

We observed many juvenile and adult salmonids utilizing the Horse Linto Creek refugia from the end of June to mid-October (Table 2). Use of the refugia by juveniles was highest during the end of June and remained relatively high until the end of August, when the effects of the PFR were realized in the area of Horse Linto Creek. Few juvenile salmonids were observed after this period.

Table 2. River and creek temperatures in degrees Celsius and the number of salmonids observed during snorkel surveys at the confluence of Horse Linto Creek and the Trinity River (rkm 31.75), California, 2004

Date	River temp	Creek temp	Temp difference	CH[a] 0+	CH 1+	CO[b] 0+	CO 1+	ST[c] 0+	ST 1+	Total juveniles	ST 2+/HP[d]	CH adult	CH jack	CO adult	ST adult	Total adults
30 Jun	19	17.5	1.5	500	0	0	0	0	60	560	0	0	0	0	0	0
8 Jul	19	17.5	1.5	150	0	0	0	50	6	206	2	0	0	0	0	2
15 Jul	21.2	18	3.2	150	0	0	0	2	10	162	0	0	0	0	0	0
31 Jul	23	18	5	600	0	0	0	0	20	620	0	0	0	0	0	0
10 Aug	24	19	5	150	0	3	0	10	40	203	14	4	0	0	30	48
13 Aug	24.7	19.9	4.8	200	0	0	0	17	20	237	14	10	9	0	30	63
17 Aug	23.8	18.6	5.2	30	0	0	0	1	12	43	8	5	1	0	9	23
20 Aug	24.4	19.4	5	90	0	0	0	100	60	250	8	11	2	0	12	33
27 Aug	18	17	1	0	0	0	0	0	0	0	5	0	0	0	0	5
2 Sep	18	17	1	0	0	0	0	0	5	5	0	0	0	0	0	0
8 Sep	18	17	1	0	0	0	0	2	4	6	0	0	0	0	0	0
14 Sep	18	16	2	0	0	1	0	6	10	17	2	4	0	0	0	6
16 Sep	20	17	3	0	0	0	0	0	9	9	2	1	1	0	1	5
20 Sep	17	14.4	2.6	50	0	0	0	2	0	52	8	7	4	0	1	20
23 Sep	17.3	14.5	2.8	0	0	0	0	0	2	2	11	0	0	0	0	11
6 Oct	17.7	14.5	3.2	0	0	0	0	0	0	0	3	16	0	0	2	21
8 Oct	17.2	14.3	2.9	0	0	0	0	0	0	0	1	10	0	0	10	21
13 Oct	15.4	13.2	2.2	0	0	0	0	1	1	2	1	8	0	0	1	10

a CH = chinook salmon
b CO = coho salmon
c ST = steelhead
d HP = half pounder

The number of adult salmonids in the refugia area peaked in mid-August. During and following the PFR, the number of adult salmonids observed using the thermal refugia declined substantially (Figure 3). During this time, temperature of the Trinity River dropped below what has

been considered to be the migration threshold of 22°C (Josh Strange, unpublished data) and the difference between the river temperature and creek temperature was the lowest recorded during our surveys. In addition to temperatures being conducive for migration, adult fish would have received minimal thermal benefits by remaining in the refugia.

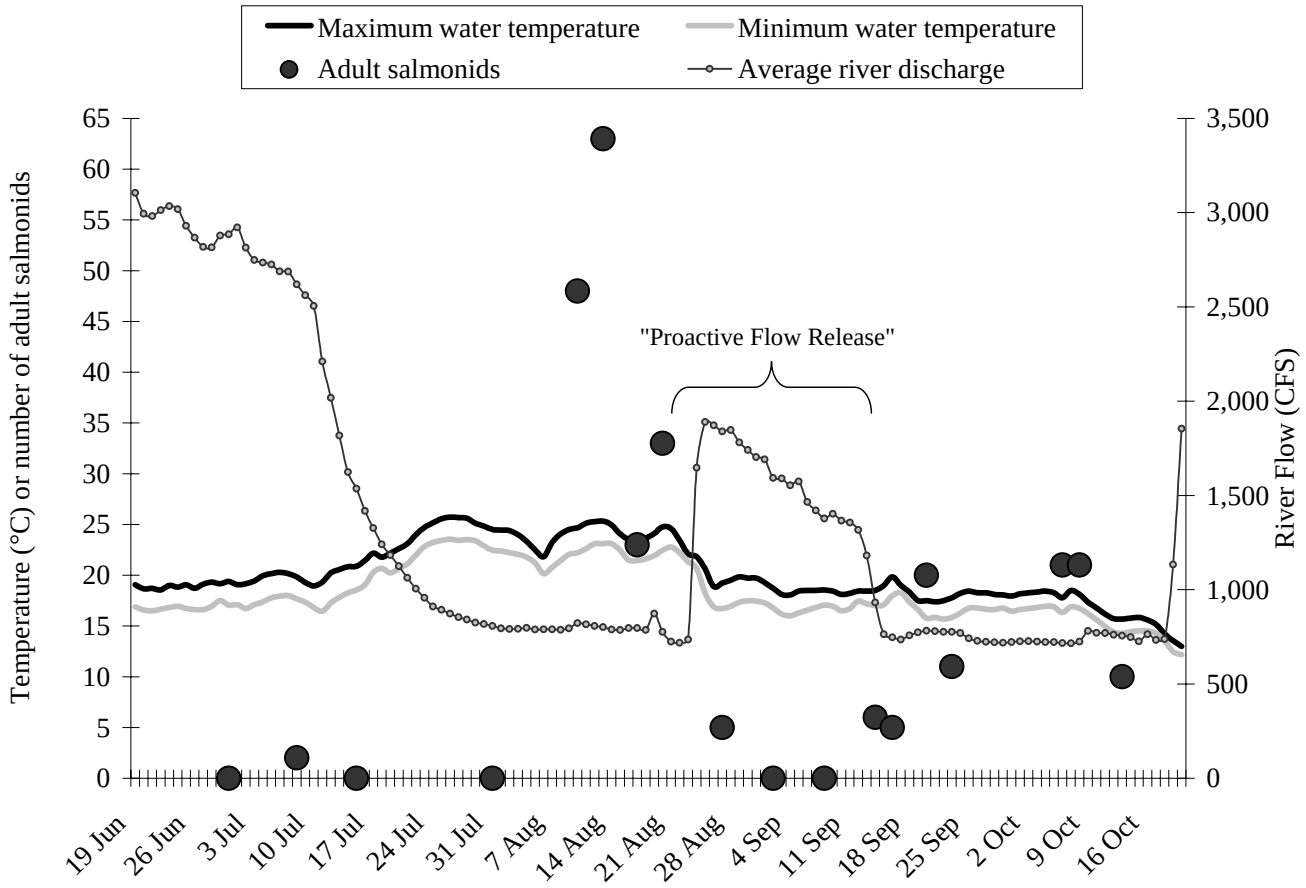

Figure 3 Water temperature and river discharge of the Trinity River measured near Hoopa (rkm 20) and the numbers of adult salmonids observed during cold water refugia snorkel surveys at the confluence of Horse Linto Creek and the Trinity River (rkm 31.75), California, 2004

The number of adult salmonids using the thermal refugia increased during the end of September and October, even though the temperature of the Trinity River was within temperature limits of adult salmonid migration (Figure 3). This was most likely due to the fact that the temperature difference between the creek and the river began to rise, thermally benefiting fish (Table 2).

These data must be viewed with the premise that the number of salmonids using thermal refugia may be related not only to river temperatures, creek temperatures, and flow, but also to run timing, number of fish that are migrating through the area, as well as the number of fish preparing to enter the creek creating the refugia. Essentially, the number of fish at the mouth of a creek may be an artifact of the number of fish that are in the river at any given time. To evaluate this premise, weekly adult chinook salmon net harvest catch per unit effort (CPUE) data provided by Hoopa Valley Tribal Fisheries were compared with our adult chinook salmon thermal refugia data (Figure 4).

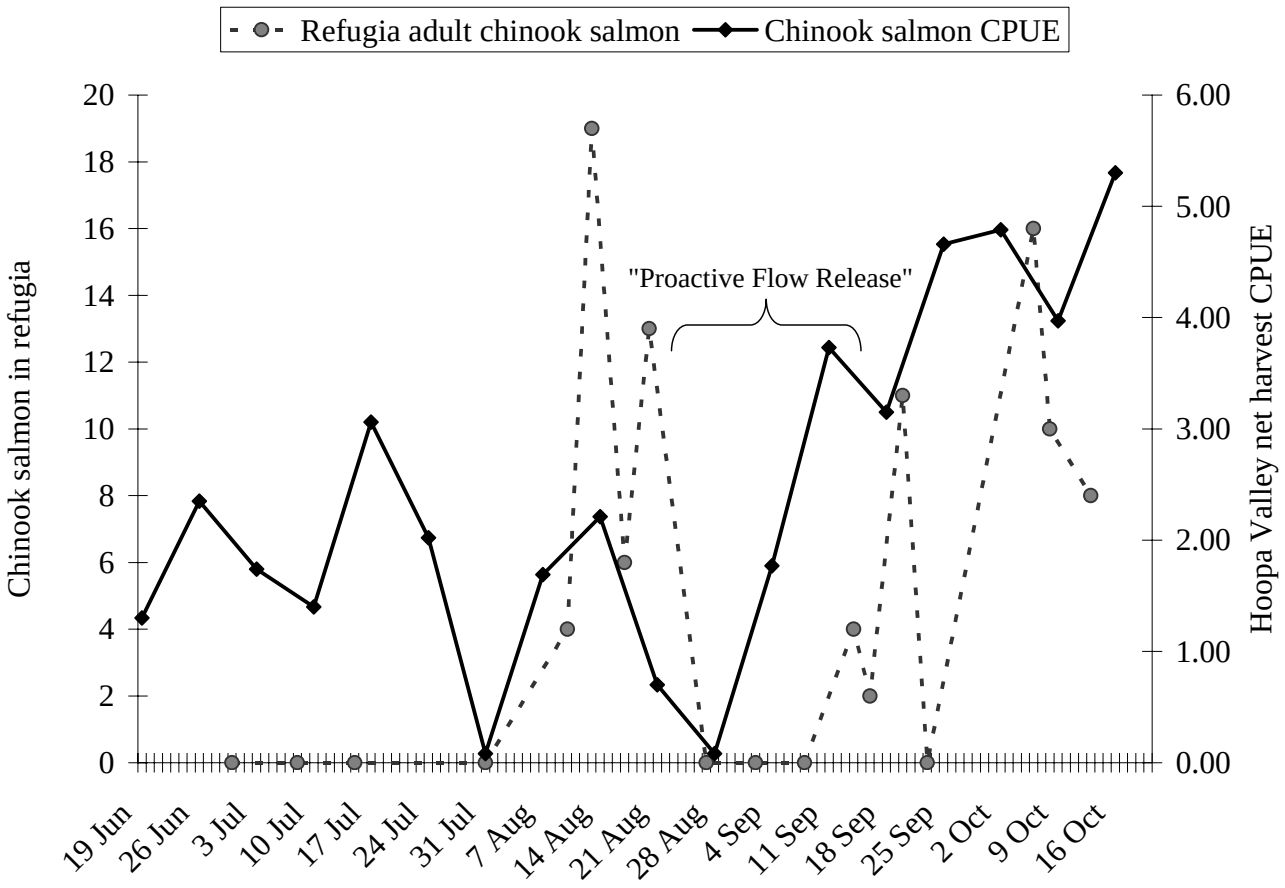

Figure 4. The numbers of adult chinook salmon observed to be using the thermal refugia area of Horse Linto Creek (rkm 31.75) and Hoopa Valley Tribe adult chinook salmon net harvest CPUE (recorded as catch per net day), lower-Trinity River, California, 2004.

These data do seem to follow a similar pattern showing that the number of fish using the thermal refugia area is related to the number of fish that are in the immediate area. Following the initial effects of the PFR, both our refugia observations and Hoopa Valley Tribe net harvest CPUE decreased. But CPUE increased consecutively for two weeks after the initial effects of the PFR were observed in the area while our refugia counts remained at zero—fish were migrating through the area but not stopping to use the Horse Linto Creek refugia. During those weeks, river temperatures were relatively low (averaging roughly 18°C) and the difference in temperature between Horse Linto Creek and the Trinity River was relatively low (about 1°C). Therefore, fish migration was not impeded by high river temperatures and without a notable difference between river temperatures and creek temperatures, fish did not have the incentive, in terms of energetic savings, to use the refugia.

Willow Creek

Use of the Willow Creek refugia by juveniles was highest during the end of June and remained relatively high until the end of August, when the effects of the PFR were realized. This is consistent with our observations at Horse Linto Creek, meaning that it is likely that the PFR stimulated juvenile salmonid emigration. No adult salmonids were observed at the mouth of Willow Creek (Table 3). The refugia area at Willow Creek is deep (four meters or greater) making observations of adult salmonids,

which are typically near the benthos, difficult during times of decreased water quality. The area is also a popular recreation destination and it was common for divers to see swimmers and sun-bathers in the area raising concerns that these activities scared fish out of the refugia prior to snorkel surveys. But more importantly, the greatest temperature difference between the Trinity River and Willow Creek recorded during our surveys prior to the PFR was 1.7 degrees Celsius. During the PFR, the Trinity River was often colder than Willow Creek meaning that fish had no incentive, in terms of thermal benefits, to be near the confluence of Willow Creek and the Trinity River.

Table 3. River and creek temperatures in degrees Celsius and the number of salmonids observed during snorkel surveys at the confluence of Willow Creek and the Trinity River (rkm 40.5), California, 2004

Date	River temp	Creek temp	Temp difference	CH[a] 0+	CH 1+	CO[b] 0+	CO 1+	ST[c] 0+	ST 1+	Total juveniles	ST 2+/HP[d]	CH adult	CH jack	CO adult	ST adult	Total adults
10 Aug	22.5	21	1.5	50	0	0	0	0	12	62	0	0	0	0	0	0
13 Aug	23.2	21.5	1.7	60	0	0	0	0	18	78	0	0	0	0	0	0
17 Aug	21.6	20.6	1	100	1	0	0	0	2	103	0	0	0	0	0	0
20 Aug	22.7	21.8	0.9	0	0	0	0	0	8	8	0	0	0	0	0	0
27 Aug	17	19	-2	0	0	0	0	0	0	0	0	0	0	0	0	0
2 Sep	17.1	18.5	-1.4	0	0	0	0	0	0	0	0	0	0	0	0	0
8 Sep	18	19	-1	0	0	0	0	0	0	0	0	0	0	0	0	0
14 Sep	17	17.5	-0.5	0	0	0	0	0	0	0	0	0	0	0	0	0
16 Sep	18.5	18	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0
20 Sep	16	NA	NA	0	0	0	0	0	0	0	0	0	0	0	0	0

a CH = chinook salmon
b CO = coho salmon
c ST = steelhead
d HP = half pounder

RECOMMENDATIONS

The PFR results in an increase in discharge of Trinity River during the late summer that has virtually no historical precedent in terms of magnitude and duration (TRFE 1999). The resulting substantial decrease (4°C or greater) in daily maximum water temperature during late August and early September is also exceedingly rare, if not unprecedented. As such, the potential to affect aquatic species and the greater ecology of the area is significant. The results of this study indicate that the PFR may have stimulated movement of juveniles and adults that were using thermal refugia, however ramifications of this movement are unclear. It is also not known how late summer PFR actions influence adult salmonid run timing and the integrity of discrete races such as spring and fall run chinook salmon. Furthermore, there have been virtually no evaluations of the result of PFR actions on other tribal trust species such as Pacific lamprey (*Lamptera tridentata*).

In order to evaluate potential impacts of the largely unnatural flow regime and water temperatures created by the PFR, hypotheses regarding effects to the ecology of the river and aquatic resources need to be rigorously tested. In addition, a comprehensive evaluation and monitoring scheme needs to be established.

REFERENCES

1. BOR. 2004. Finding of no significant impact. Purchase of water from the Sacramento River Water Contractors Association and supplemental fall 2004 releases to the Trinity River. Bureau of Reclamation mid-Pacific Region. Redding, CA.

2. Technical Modeling and Analysis Group (TMAG). 2004. Recommended Trinity River Instream Fisheries Release Schedule for Water Year 2004. Trinity River Restoration Program, Weaverville, CA.

3. U.S. Fish and Wildlife Service and Hoopa Valley Tribe (TRFE). 1999. Trinity River Flow Evaluation Appendix F. Arcata Fish and Wildlife Office, Arcata, CA.