Assessment of Klamath River Water Temperatures Downstream of Iron Gate Dam During September and October 2002

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EXECUTIVE SUMMARY

An investigation was conducted during late summer and early fall of 2002 to assess water temperatures in the Klamath River. The study was performed because of potential issues arising from naturally dry hydrologic conditions and possible attendant effects of water temperatures on fall-run chinook salmon in the mainstem Klamath River downstream of Iron Gate Dam (IGD). It was expected that results would be valuable in providing scientific information that could be utilized to improve future management of Klamath River water resources. Mainstem water temperatures were measured hourly just prior to and during the fall-run chinook salmon migration season. This project was built upon a prior study performed by Vogel and Marine (1994).

Water temperatures in the Klamath River downstream of IGD during September 2002 were unsuitable for adult salmon. This finding was similar to that of previous studies. A normal seasonal cooling trend at the end of September and early October provided the moderating influence lowering Klamath River temperatures to tolerable levels for salmon.

There is no evidence to indicate that increasing upper Klamath reservoir releases during late summer or early fall would benefit salmon. In fact, because of a variety of meteorological, physical, and biological reasons, artificially increasing flows at that time would probably be harmful. This is due to the fact that IGD discharges are unsuitably warm for salmon in early September. Additionally, there is no evidence that releasing more water from IGD during early or mid-September could have prevented a fish kill more than 150 river miles downstream because both dam discharge temperatures and river temperatures in the mainstem downstream of IGD were within the range known to cause mortality or reproductive failure in salmon. The gradual declining temperatures in the Klamath River downstream of IGD during the fall are primarily attributable to normal seasonal declines in ambient air temperatures, not river flow.

Vogel and Marine (1994) recommended that any increased flows from IGD, pulsed or otherwise, to benefit adult salmon should occur during late September or early October to coincide with normal seasonal declines in air temperatures and concomitant cooler river flows. This study provides further data and rationale to support that scientific advice. Additionally, it is strongly recommended that a coordinated process for water project operations in the Klamath basin, including tributaries such as the Trinity River, be implemented, but be based on technical data and information.

INTRODUCTION

An investigation was conducted during late summer and early fall of 2002 to assess water temperatures in the Klamath River. The study was performed because of potential issues arising from naturally dry hydrologic conditions and possible attendant effects of water temperatures on fall-run chinook salmon in the mainstem Klamath River downstream of Iron Gate Dam. It was expected that results would be valuable in providing scientific information that could be utilized to improve future management of Klamath River water resources. Mainstem water temperatures were measured hourly just prior to and during the fall-run chinook salmon migration season. This project was built upon a prior study performed in 1994. Placing the thermographs and resulting data were fortuitous because of a fish kill that occurred in the lower Klamath River in late September (Belchik 2002) and allegations that water management in the upper Klamath basin could have prevented the incident (Klamath Tribes 2002).

STUDY APPROACH

Mainstem Klamath River water temperatures were measured hourly by placing electronic data logging thermographs[1] at the following three locations (Figure 1):

1) River Mile (RM) 190 (just downstream of Iron Gate Dam);
2) RM 183 (7 river miles downstream of Iron Gate Dam); and
3) RM 175 (15 river miles downstream of Iron Gate Dam and 1.75 river miles downstream of the Shasta River confluence).

It was assumed that the tributaries' effects in the study area would be minimal on the mainstem water temperatures because of the very small accretions attributable to dry-year and seasonal conditions (Vogel and Marine 1994). Thermographs were enclosed in weighted, perforated PVC pipe and recorded temperatures from September 4 to October 29, 2002.

Water temperature data in the Klamath River for a similar period in 1994 were obtained from Vogel and Marine (1994). The year 1994 was chosen for comparison purposes because of similar dry hydrologic conditions as in 2002 and because of similar data sets. Additionally, no large fish kill occurred in the lower river during 1994. Hourly water temperature data in southern Upper Klamath Lake (approximately 65 river miles upstream of Iron Gate Dam) for similar periods during September and October 2002 were obtained from the U.S. Bureau of Reclamation (USBR), Klamath Falls, Oregon; those data were recorded by Hydrolab Datasondes. Records for daily maximum and minimum air temperatures in the region were obtained for Yreka, California from the U.S. Forest Service (USFS) Interagency Communication Center in Yreka and the National Oceanic and Atmospheric Administration. Air temperature records for Klamath Falls, Oregon were obtained from the Klamath Falls airport. Flow data at IGD were obtained online from the U.S. Geological Survey (USGS) (http://waterdata.usgs.gov/ca/nwis/discharge).

1 Onset Computer Corp., Optic Stowaway model

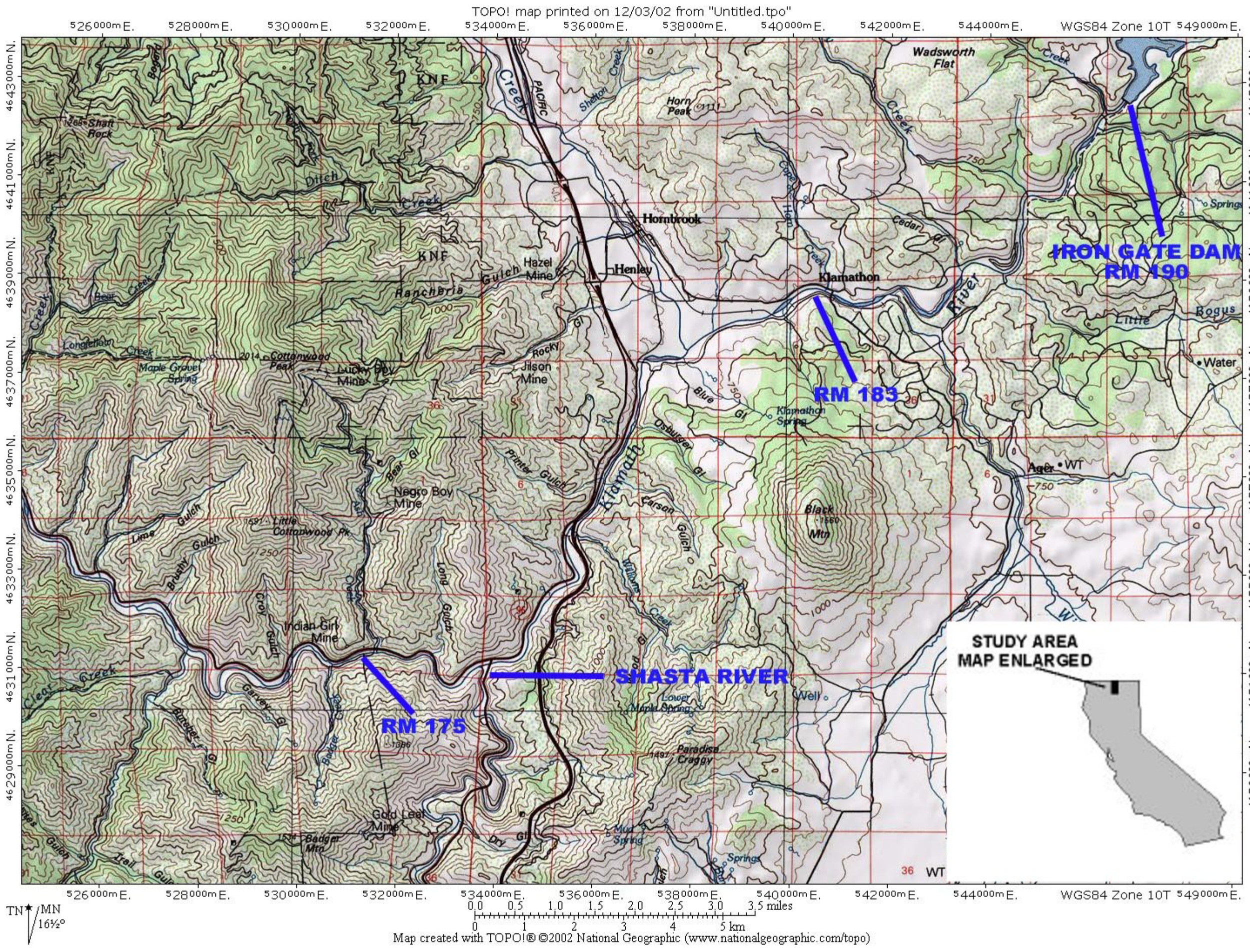

Figure 1. The Klamath River downstream of Iron Gate Dam showing thermograph locations for September and October 2002 at RM 190, 183, and 175.

RESULTS AND DISCUSSION

Comparison of Iron Gate Dam Discharges, Klamath River Water Temperatures, and Air Temperatures

Figure 2 shows the hourly water temperatures measured by the three thermographs in the Klamath River. From September 4 to October 29, 2002, IGD discharges ranged from a low of 757 cfs on 10 days throughout September to a high of 1370 cfs on September 30 (Figure 2). Air temperatures near Yreka ranged from a high of 98^{o}F on September 14 to a low of 28^{o}F on September 30 (Figure 3). As evidenced from a comparison between RM 190 and RM 183, only small diel water temperature fluctuations occurred at IGD (approx. 1-2^{o}F) whereas significant diel water temperature fluctuations (approx. 5-8^{o}F) occurred only 7 miles downstream, a function of ambient air temperatures affecting river temperatures. The greatest diel fluctuation occurred at the downstream-most thermograph, at RM 175, and was similar to that observed by Vogel and Marine (1994). This latter phenomenon is not surprising because most deterministic stream temperature models use air temperature as a more sensitive input parameter than stream flow (Bartholow 1989, as cited by Vogel and Marine 1994). During most of the study period, the maximum and minimum water temperatures were slightly cooler at RM 175 than at RM 183 (Figure 2). There were two brief periods in mid-September when IGD discharge average daily temperatures were slightly cooler[2] than average daily water temperatures 15 miles downstream of the dam (Figure 4). This was attributable to brief spans of very warm (90+^{o}F) days (Figure 3). The relatively sudden cooling of the river in downstream areas (compared to IGD discharge temperatures) after the decline in dam discharges the second week in October (Figures 2 and 4) was expected because under fall seasonally cool air temperature conditions, the lesser flow rate lends to extended cooler conditions and the smaller thermal mass of water cools more quickly (Deas 2000).

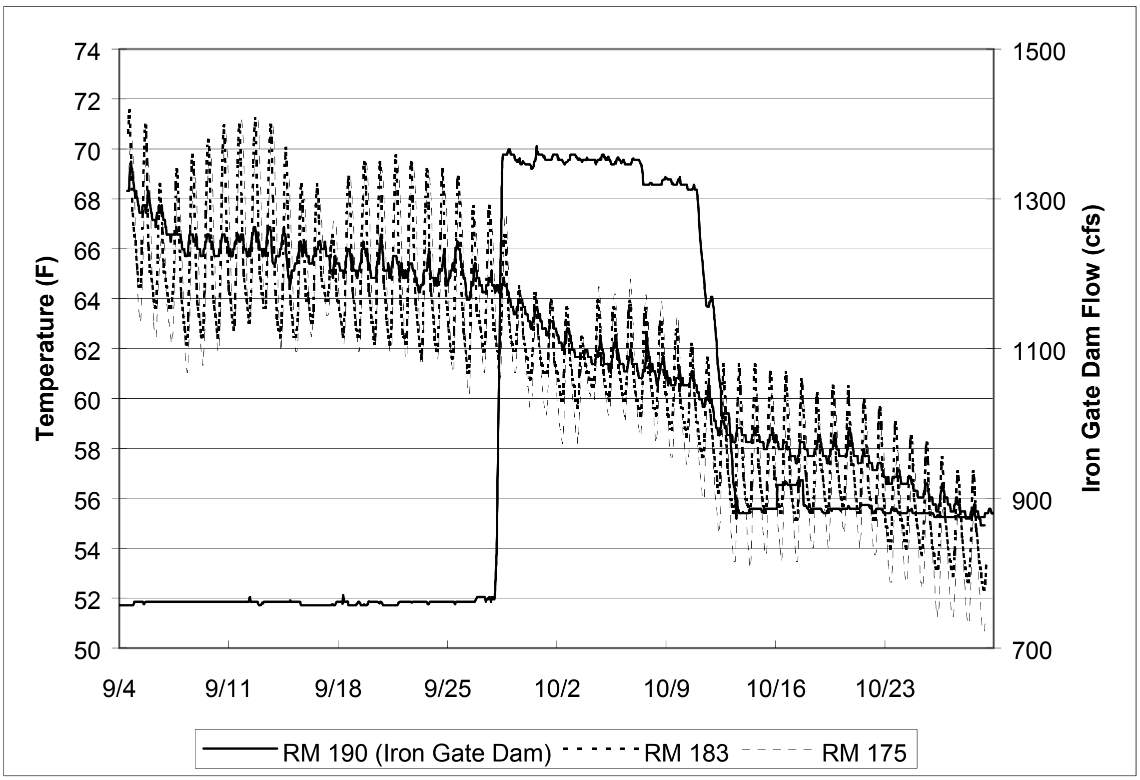

Figure 2. Hourly water temperatures measured in the Klamath River at RM 190, 183, 175 and Iron Gate Dam discharge (cfs) from September 4 to October 29, 2002.

2 But still inhospitable to salmon (discussed in a later section).

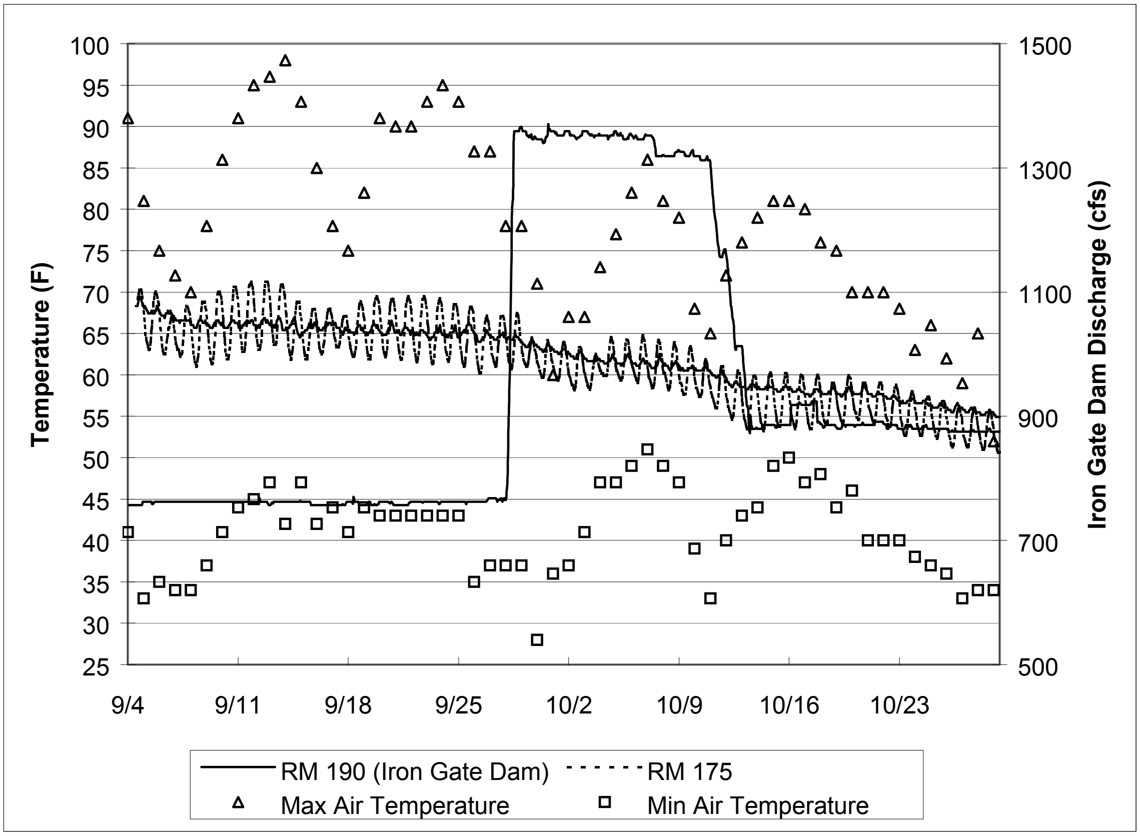

Figure 3. Hourly water temperatures measured in the Klamath River at RM 190, 175, Iron Gate Dam discharge (cfs), and Yreka daily maximum and minimum air temperatures from September 4 to October 29, 2002.

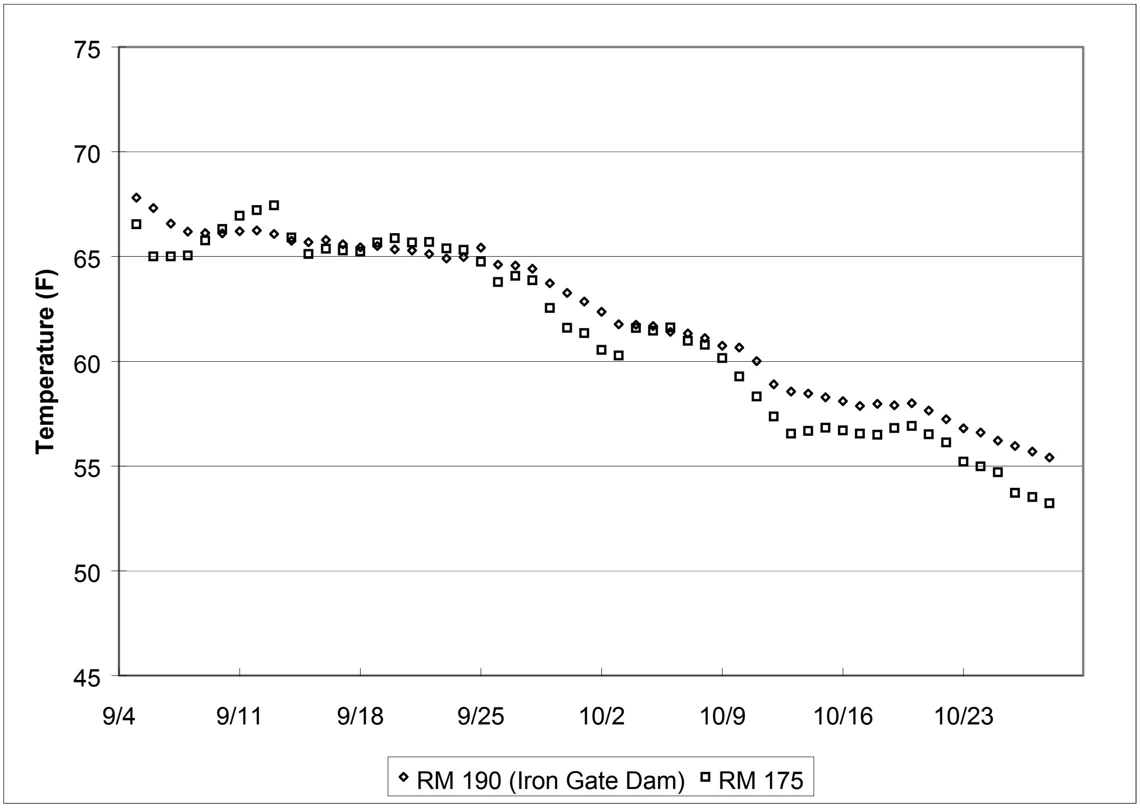

Figure 4. Average daily water temperatures measured in the Klamath River at RM 190 and 175 from September 4 – October 29, 2002.

A short-term pulse flow of approximately 1,400 cfs was released from IGD from September 28 to October 13, 2002 in response to concerns over a fish kill[3] that occurred in the lower Klamath River more than 150 river miles downstream of the dam. The IGD water temperatures declined slightly during the initial portion of the pulse-flow period (Figure 2), but appeared to be primarily a function of declining seasonal air temperatures instead of discharge (Figure 3). The causal mechanism was difficult to verify because the changes were concurrent and probably a function of both factors. However, the decline in water temperatures at RM 175 were more dramatic than those at IGD which meant that the significant decline in air temperatures were probably the primary factor for drop in water temperatures (Figure 3).

About halfway through the pulse-flow period, another air warming trend increased downstream water temperatures. Near the end of the pulse flow, average daily downstream water temperatures declined and remained cooler than IGD discharge temperatures (Figure 4). The timing of the pulse flow was scheduled, in part, to coincide with the projected seasonal cooling weather trend anticipated at that time.

During the initial increase of IGD discharge, outflow temperatures from Upper Klamath Lake at Link River Dam also declined in response to a cooling weather trend in the upper basin (Figure

3 The fish kill occurred primarily downstream of Blue Creek beginning in mid-September (Belchik 2002).

5). The moderating influence of daily air temperatures on water released from Upper Klamath Lake into Link River is clearly evident.

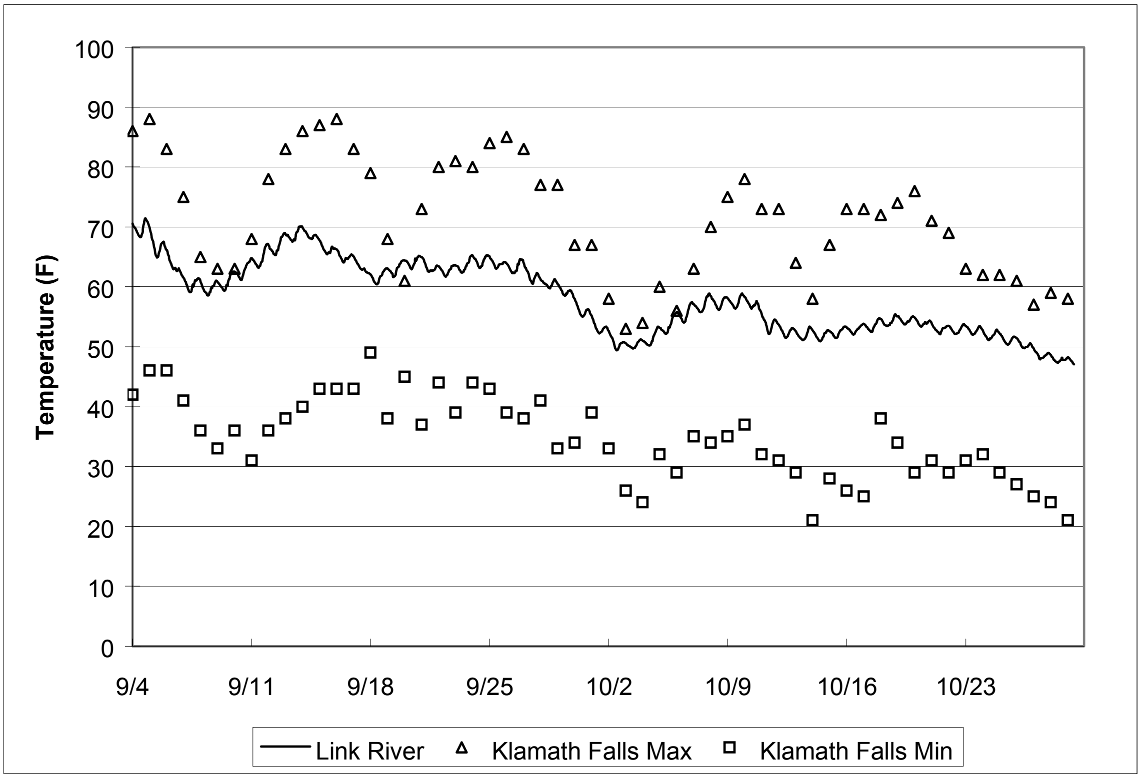

Figure 5. Hourly water temperatures for water released from Upper Klamath Lake into Link River and daily maximum and minimum air temperatures measured at Klamath Falls, OR.

When comparing hourly water temperatures for Upper Klamath Lake discharges with IGD discharge temperatures (not adjusted for lag time between dams), it is apparent that lower Klamath River water temperatures at IGD do not respond well to the thermal influence of Upper Klamath Lake discharges (Figure 6). This circumstance is likely attributable a variety of factors (e.g., air temperatures, elevation, varying discharges, etc.), but is probably and most importantly caused by the intervening reservoirs[4] and the 65 river miles between locations. As pointed out by Deas (2001), “Altering the flow rate through Iron Gate Reservoir can potentially alter the release temperature. Release temperature is a complex function of peaking operations from Copco Reservoir, meteorological conditions (current and past), degree and structure of thermal stratification, Iron Gate operations (current and past, including fish hatchery), as well as other factors.”

4 These reservoirs include, from upstream to downstream, Keno Reservoir, J.C. Boyle Reservoir, Copco Lake, Copco No. 2 reservoir, and Iron Gate Reservoir.

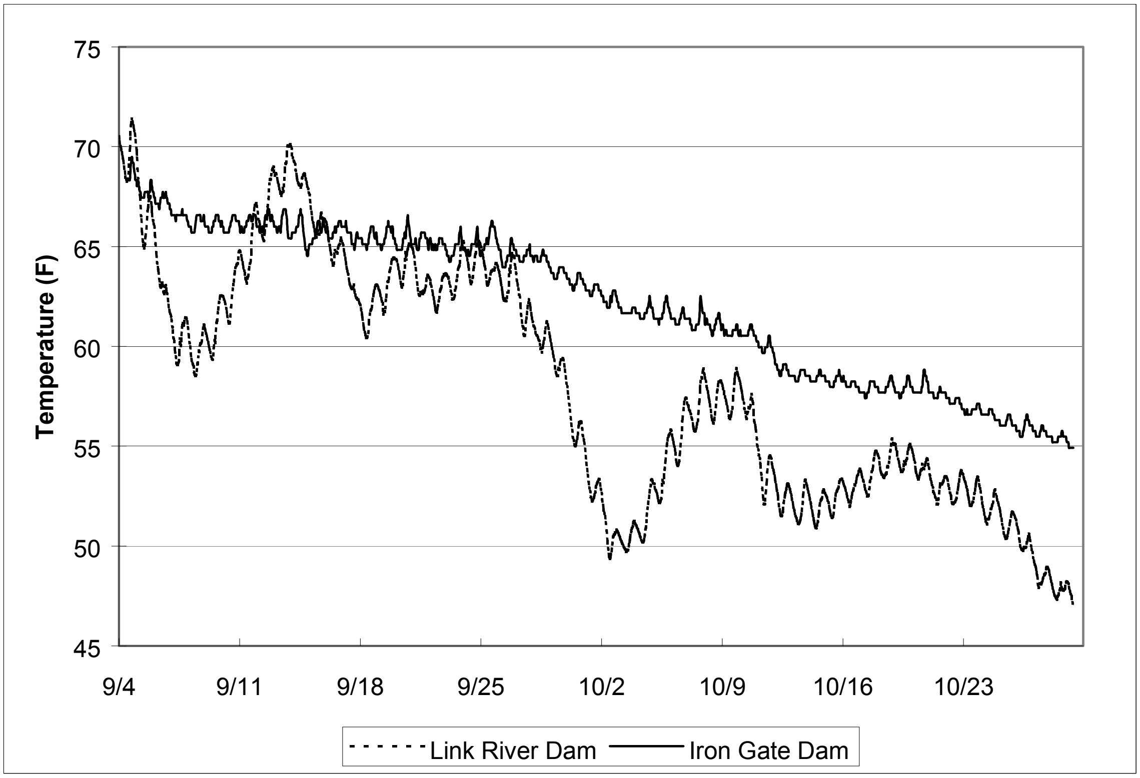

Figure 6. Hourly water temperatures measured at the Upper Klamath Lake discharge into Link River and Iron Gate Dam discharge temperatures, September 4 to October 29, 2002.

Comparisons between 1994 and 2002

Because 1994 had seasonally similar dry hydrological conditions as the late summer and fall of 2002 and IGD discharges were less than 1,000 cfs, a comparison was made between Klamath River water temperatures in 1994 and 2002 to determine possible differences or similarities. Using a comparable period when water temperature data sets were available, Figures 7 and 8 show IGD discharge levels and water temperatures for September 10 to October 25, 1994 and 2002, respectively.

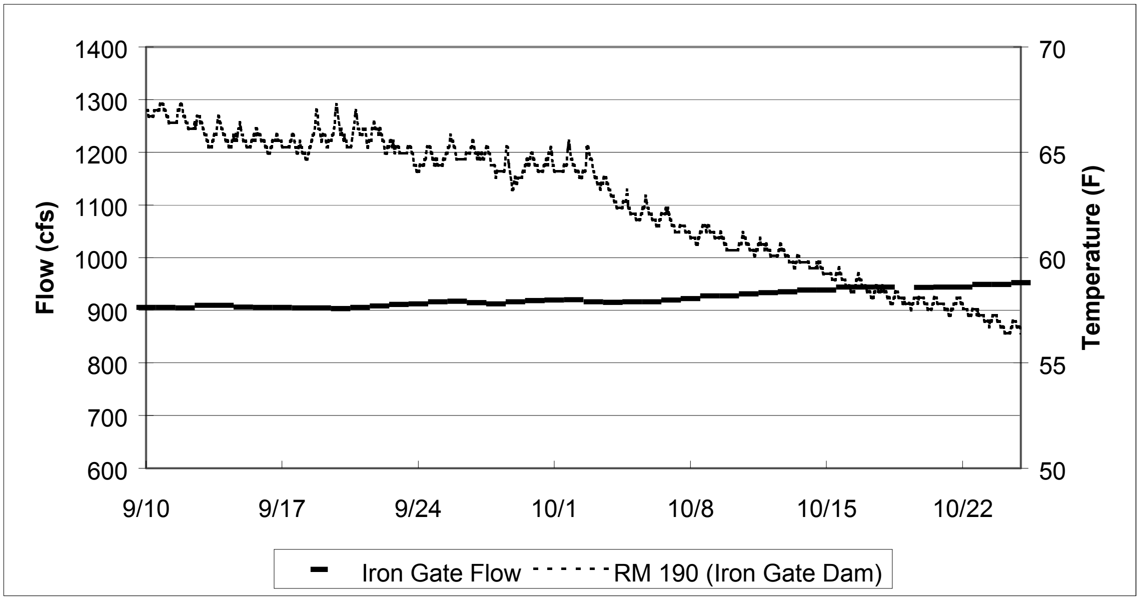

Figure 7. Iron Gate Dam discharge (cfs) and water temperatures, September 10 to October 25, 1994.

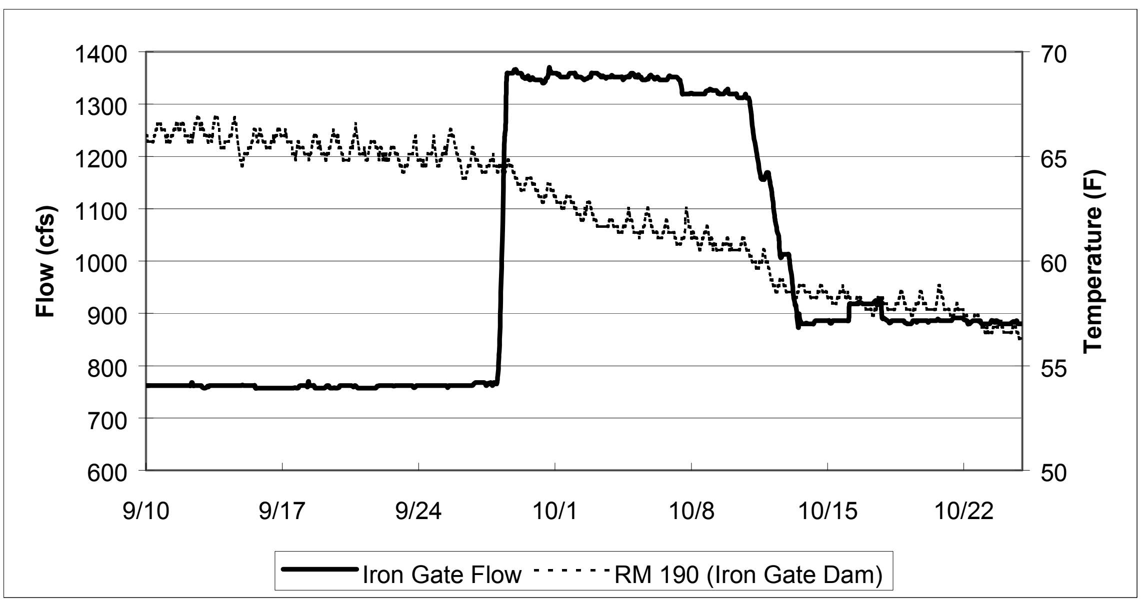

Figure 8. Iron Gate Dam discharge (cfs) and water temperatures, September 10 to October 25, 2002.

In 1994 and 2002, IGD discharge temperatures were relatively warm (>65°F) in early September with discharge flow at approximately 900 cfs and 760 cfs, respectively. In both years, IGD discharge temperatures began to steadily decline by late September (2002) or early October (1994). Also, water temperatures were similar except for two brief periods in early and mid-October 2002 when water temperatures were 1-2°F cooler than in 1994 (Figure 9). The early October 2002 period corresponded to cooler ambient air temperatures and a sudden increase in discharge, whereas the mid-October 2002 period corresponded to cooler ambient air temperatures and a sudden decrease in IGD discharge (Figure 2). In both 1994 and 2002, air temperatures declined significantly by late September or early October (Figure 10).

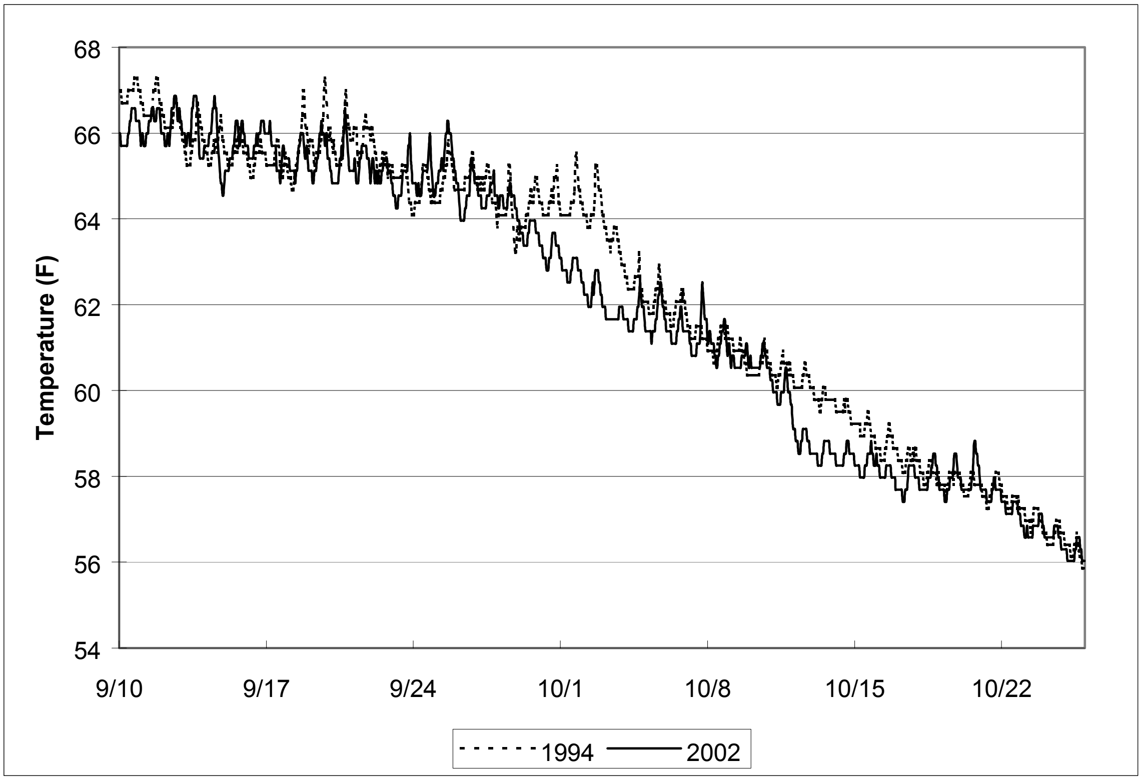

Figure 9. Iron Gate Dam hourly discharge temperatures (°F) for September 10 – October 25, 1994 and 2002.

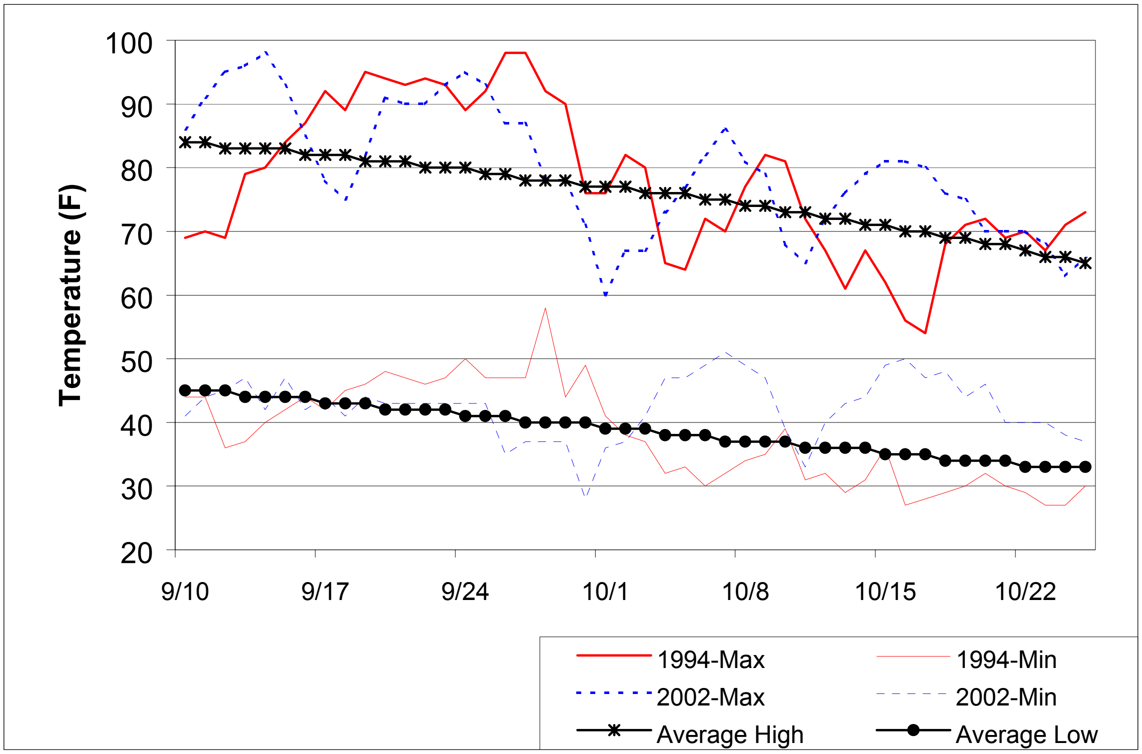

Figure 10. Yreka daily maximum and minimum air temperatures, September 10 – October 25, 1994 and 2002.

Klamath River water temperatures measured downstream of the Shasta River confluence in 1994 and 2002 showed that 2002 was slightly cooler (about 1^{o}F) than 1994, except for the significantly cooler (about 3^{o}F) brief period in early October 2002 (Figure 11) that was attributable to cooler air temperatures (Figure 10). In both years, the magnitude of the daily oscillation in water temperature was greater at downstream locations (Figure 11) than at IGD (Figure 9) indicating a significant influence of air temperature on water temperature in this reach of the river.

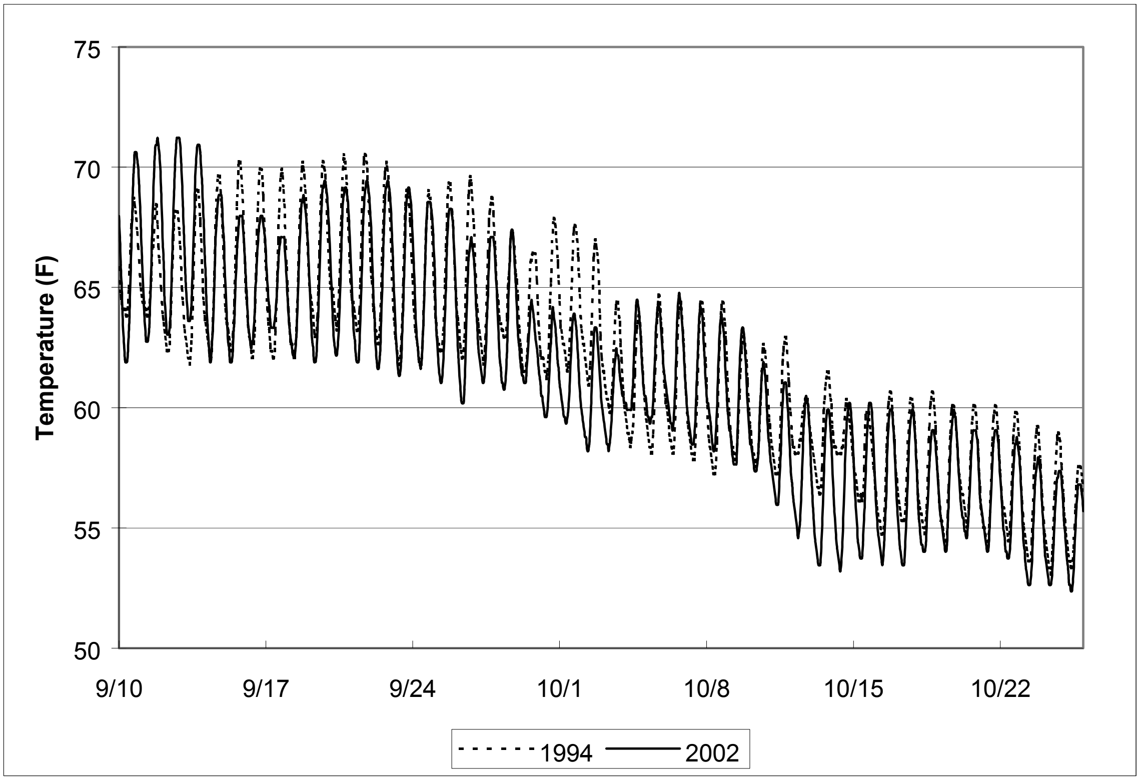

Figure 11. Klamath River water temperatures downstream of the Shasta River, 1994 and 2002.

Figures 9 and 11 show that river temperatures at IGD, and in the river downstream of the dam remained at unsuitably warm levels for salmon throughout much of September in both years. A gradual decrease in daily river temperatures at IGD from the upper- to mid-60's range occurred through the entire month of September. Daily extremes in river temperatures decreased more rapidly after the first of October. In both years, the most pronounced decreases in river temperatures occurred during the period with cooler daytime temperatures and after early October.

Other researchers have similar findings to that in this study and Vogel and Marine (1994). Deas and Orlob (1999) found the following:

> "During early fall, mean daily measured water temperatures are fairly uniform throughout the river system. However, by late fall it is apparent that temperatures are decreasing in the downstream direction by late fall, i.e., after October 1. During this period, releases from Iron Gate Dam are generally at temperatures above equilibrium and the reservoir is acting as a heat source to the river."

Potential Effects on Salmon

Water temperatures in the mid- to upper-60's are known to be within the range of observed incipient lethal temperatures for chronic exposures for reproductively active adult chinook salmon (Marine 1992). Measurements in the Klamath River during September and early October 2002 were within this temperature range. Even the lowest water temperatures that occurred during the diel cycles in the mainstem Klamath River during September are associated with sublethal thermal stresses that result in reduced fertility, increased incidence of disease, and increased incidence of embryonic abnormalities (Table 1).

Although the peak spawning period of chinook in the mainstem Klamath River is generally during the last of October to early November (Catalano et al. 1997) when water temperatures cool to marginally tolerable levels for spawning and egg incubation, the salmon must migrate through the mainstem corridor and hold for extended periods in much warmer water in September and October prior to spawning. Data collected in this study demonstrate that riverine water temperatures monitored during mid-September were cooler than the water released from IGD, but were still within unsuitable ranges for adult salmon. Comparisons of daily mainstem water temperatures in different reaches with maximum and minimum air temperatures monitored at Yreka provide evidence that air temperature, not magnitude of flow, was the dominating influence in the lower river reaches.

During 1994 there was some pre-spawning mortality of chinook salmon downstream of IGD during the early portion of the spawning season (Vogel and Marine 1994), a phenomenon also observed in 2002 [U.S. Fish and Wildlife Service (USFWS), unpublished data]. The incidence of pre-spawning mortality observed on the spawning grounds by the USFWS may have been directly associated with exposure of salmon to the elevated thermal conditions in the Klamath River during upstream migration. Some individuals have suggested that high, early-season, pre-spawning mortality is not unusual for the Klamath River (Sam Williamson, USGS, personal communication). The temperature records for the mainstem Klamath River during the period preceding these observations provide evidence that these fish were likely exposed to water temperatures causing adverse sublethal or potentially lethal effects during their spawning migrations.

Table 1. A compilation of published information and summary of the observed relationships between water temperature and various attributes of spawning performance in chinook salmon, with inferences on the sublethal elevated temperature range. Information derived from the scientific literature, agency reports, and interviews with fishery biologists and hatchery workers [from Vogel and Marine (1994) as modified from Marine (1992)].

Temperature Range	**Effect on Adult Salmon and Reproduction**	**Sources of Information**
< 43°F	Increased adult mortality, retarded gonad development and maturation, infertility.	Leitritz and Lewis (1976), Piper *et al.* (1982)
50°F - 64°F	Physiological and behavioral optimum temperature range for non-reproductive adult salmon.	Coutant (1977), Piper *et al.* (1982), Raleigh *et al.* (1986)
43°F - 57°F	Optimal pre-spawning broodstock survival, maturation and spawning temperature range.	Leitritz and Lewis (1976), Piper *et al.* (1982)
59°F - 63°F	For chronic exposure, inferred range of incipient sublethal elevated water temperature for broodstock, increased infertility, and embryonic developmental abnormalities.	Marine (1992)
63°F - 68°F	For chronic exposure, incipient range of upper lethal water temperature for pre-spawning adult chinook salmon (primarily derived from observations of captive broodstock).	Berman (1990), Bouck *et al.* (1977), Hinze *et al.* (1956), Rice (1960); and personal communications (Marine 1992).
56°F - 81°F	Increased pathogenicity of many of the important salmonid disease organisms with potential for impairing reproduction in chinook salmon.	Becker and Fujihara (1978), Fryer and Pilcher (1974), Post (1987)
77°F - 81°F	Range of highest elevated temperatures observed to be transiently passed through during migrations or tolerated for short-term by adult chinook salmon.	Department of Water Resources (1988), Moyle 1976, Piper *et al.* (1982)

Sudden increased flow events have stimulated upstream migration of chinook salmon in other river systems. The available data indicates that if pulse flows are released from IGD early in the season (e.g., late August or early September as advocated by some downriver fishing interests at the time) it may stimulate upstream salmon migration in the Klamath River and prematurely attract more fish into intolerable thermal conditions for salmon. It could also place a greater proportion of the entire run and their progeny at risk by subjecting many more fish to conditions detrimental to successful reproduction.

Shortly after the observed fish kill in the lower Klamath River during mid- to late-September 2002, the Klamath Tribes issued position-statement documents suggesting that water temperatures in Upper Klamath Lake were favorable for chinook salmon during the summer and early fall and implied that increased reservoir releases from Upper Klamath Lake could have avoided the fish kill (Ullman 2002, Klamath Tribes Natural Resources Dept. 2002). The Klamath Tribes used a lethal temperature value for the "Ultimate Upper Incipient Lethal Temperature"[5] (UUILT) to support their argument (Ullman 2002), suggesting that levels less than the UUILT would be suitable for salmon. Having worked on salmonid issues for nearly 25 years, this is the first time this author has observed an entity promoting water temperatures of less than 69.8 – 71.6°F as satisfactory for adult salmonids. The prevailing scientific research and opinions indicate otherwise. For example, Table 1 provides well-known and documented temperature tolerances for salmon that are much lower than that suggested as satisfactory by the Klamath Tribes.

The Klamath Tribes water temperature values for adult salmon were obtained from the Environmental Protection Agency (EPA) publication, "Summary of Technical Literature Examining the Physiological Effects of Temperature on Salmonids" by McCullough et al. (2002) and warrants further examination than that provided to point out how the Tribes have placed the issue out of biological context and its irrelevance to the Klamath River. Based solely on an abstract value in this document, the Klamath Tribes suggest that any temperature less than the UUILT for salmon would be suitable and would have prevented the fish kill in the lower Klamath River, more than 200 river miles downstream of Upper Klamath Lake (Ullman 2002, Klamath Tribes 2002).

The EPA document provides the following discussion on the topic of "Ultimate Upper Incipient Lethal Temperature" (UUILT) for salmon:

> "The upper incipient lethal temperature (UILT) is an exposure temperature, given a previous acclimation to a constant acclimation temperature, that 50% of the fish can tolerate for 7 d (Elliott 1981). Alternatively, UILT at a particular acclimation temperature has been determined as an exposure temperature producing 50% survival within 1,000 min (Brett 1952, Elliott 1981) or 24 h (Wedemeyer and McLeay 1981, Armour 1990). Within this variation in exposure times, we expect a slightly lower UILT at a 7-d than a 24-h exposure. The UILT becomes greater with increasing acclimation temperature until a point is reached at which further

5 "The range in UILT values for adult salmonids is 69.8-71.6°F (21-22°C) when acclimation temperatures are approximately 66.2°F (19°F)." (EPA 2002)

> increase in acclimation temperature results in no increase in temperature tolerated with the same survival level. This is the ultimate upper incipient lethal temperature." EPA 2002

Unfortunately, the Klamath Tribes did not point out the following relevant and essential information from the same EPA (2002) document:

> The upper incipient lethal threshold "relies on no incidence of disease or other sublethal effects."
>
> "Migratory fish, particularly anadromous fish, may not be fully acclimated to warm mainstem temperatures."
>
> "This means that in the field, mortality can be induced at temperatures significantly lower than UUILT levels."
>
> "Because we can never assume that fish in the field will be acclimated to the highest acclimation temperature, the more appropriate lethal temperature in the field may be up to 3.6^{o}F (2^{o}C) less than UUILT. The factor of safety would then have to be applied to this value, and even then the additional sublethal or cumulative lethal concerns remain."
>
> "Migration blockages [of adult salmon] occur consistently among species in the temperature range of 66.2-73.4^{o}F (19-23^{o}C)."
>
> "Macdonald et al. (in press) studied the high mortality rates in sockeye and chinook salmon that occurred in the Fraser River Watershed of British Columbia, Canada. They found temperature to be the likely cause of both en route and prespawning losses. On the basis of their review of the historical database, the authors suspected that losses in spawning runs occur when mean daily river temperatures exceed 62.6-64.4^{o}F (17-18^{o}C) for prolonged periods."
>
> "temperatures above 59-60.8^{o}F (15-16^{o}C) are often associated with high rates of infection and notable mortality; temperatures above 64.4-68^{o}F (18-20^{o}F) are often associated with serious rates of infection and catastrophic outbreaks of many fish diseases."
>
> "Laboratory and field studies show that when adult fish are exposed to constant or average temperatures above 55.4-60^{o}F (13-15.6^{o}C) during the final part of the upstream migration or during holding prior to spawning, there is a detrimental effect on the size, number, and/or fertility of eggs held in vivo."
>
> "Hatchery managers have long known that highest survival of chinook adults occurs when water temperatures do not exceed 57.2^{o}F (14^{o}C) (Leitriz and Lewis 1976, Piper et al. 1982)."

> “To promote female maturation and egg development, holding at temperatures from 42 to 55.9°F (5.6-13.3°C) is essential (Leitritz and Lewis 1976).”
>
> “When ripe adult chinook females were exposed to temperatures beyond the range 55.9-60°F (13.3-15.6°C), prespawning adult mortality became pronounced and survival of eggs to the eyed stage decreased.”
>
> “Conventional hatchery practice is to consider chinook broodstock thermally stressed at temperatures >59°F (15°C); survival declines dramatically when temperatures exceed 62.6°F (17°C) (Marine 1992).”

Recommended Water Project/Fishery Management Coordination

During the 1980s while serving as a USFWS Project Leader for a field research office in northern California, I helped institute a formal process to improve USBR Central Valley Project water operations for salmon. This process was developed to significantly increase technical communication between water project operations managers and fishery resource managers. Twice a year, California agency water project operators (USBR and California Department of Water Resources) and fishery resource agencies (USFWS, California Department of Fish and Game, National Marine Fisheries Service), along with other technical experts and groups, would convene to discuss coordination of water needs in the Central Valley. Water project operators would come to the meetings prepared with data on existing and projected hydrologic conditions, reservoir carryover storage, as well as legal and physical opportunities and constraints with the storage facilities. Fishery resource agencies would provide technical information on the fishery resources (e.g., projected timing of upstream or downstream movements of salmonids, run size predictions, biological data, etc. for the various rivers affected by the water projects). In as much as possible, the group would collaboratively integrate all of the information to develop annual operational strategies in order to meet the needs of fishery resources and water supplies.

A similar coordination effort is overdue in the Klamath River basin. However, the process will only work if participating individuals and agencies focus on technical and scientific topics and minimize advocacy positions that continue to plague progress toward productive dialogue for Klamath basin resource management. Although it is apparent that the upper Klamath basin currently does not have the ability to positively affect lower Klamath River water temperatures to benefit salmon during the late summer and early fall because of reasons previously discussed, there may be opportunities for improved water management to benefit fish at biologically relevant periods or through physical changes to dams and intake structures[6] (presently unknown). For example, improved timing of water project operations on the Trinity River may benefit salmon because of cooler water available in that tributary as compared to the upper Klamath River. This integrated and coordinated process for the Klamath River and its tributaries should be implemented.

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6 E.g., selective withdrawal from the reservoir(s).

CONCLUSIONS

Water temperatures in the Klamath River downstream of IGD during September 2002 were unsuitable for adult salmon. This finding was similar to that of previous studies. A normal seasonal cooling trend at the end of September and early October provided the moderating influence lowering Klamath River temperatures to tolerable levels for salmon.

There is no evidence to indicate that increasing upper Klamath reservoir releases during late summer or early fall would benefit salmon. In fact, because of a variety of meteorological, physical, and biological reasons, artificially increasing flows at that time would probably be harmful. This is due to the fact that IGD discharges are unsuitably warm for salmon in early September. Additionally, there is no evidence that releasing more water from IGD during early or mid-September could have prevented a fish kill more than 150 river miles downstream because both dam discharge temperatures and river temperatures in the mainstem downstream of IGD were within the range known to cause mortality or reproductive failure in salmon. The gradual declining temperatures in the Klamath River downstream of IGD during the fall are primarily attributable to normal seasonal declines in ambient air temperatures, not river flow.

Vogel and Marine (1994) recommended that any increased flows from IGD, pulsed or otherwise, to benefit adult salmon should occur during late September or early October to coincide with normal seasonal declines in air temperatures and concomitant cooler river flows. This study provides further data and rationale to support that scientific advice. Additionally, it is strongly recommended that a coordinated process for water project operations in the Klamath basin, (including tributaries such as the Trinity River) be implemented, but be based on technical data and information.

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