The Klamath Tribes

Mr. Parker Thaler January 28, 2016
State Water Resources Control Board
Division of Water Rights
Water Quality Certification Program
PO Box 2000
Sacramento, CA 95812-2000

RE: Klamath Tribes response to NOP, transmitted electronically

Dear Mr. Thaler:

We offer the following response to the Notice of Preparation of the Environmental Impact Report (EIR) for the California State Water Board's consideration of certifying Klamath Hydroelectric Project (KHP) operations under Section 401 of the Clean Water Act. Additional material will be sent electronically in a series of emails.

The Klamath Tribes have been intimately involved in KHP relicensing proceedings since they began in 2000. We have arrived at the firm conclusion that removal of at least the lower four KHP dams is essential to the long-term health of the Klamath River and to our Tribal culture and resources, and it is clearly the best approach to maximizing the success of reintroducing anadromous salmonids into the upper basin.

Setting aside all other considerations, the appalling absence of environmental justice in the development and continued operation of the KHP is more than sufficient to justify regulatory action requiring that these facilities be removed. We ask the California State Water Resources Control Board to squarely address the severe inequities that were thrust upon the Klamath Tribes, and on the other Klamath River tribes, when the KHP was constructed, and that have continued to this day. For 100 years, we have absorbed the environmental and cultural costs of the KHP, while others have profited. Something must be done, this extreme injustice has gone on for far too long.

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The Klamath Tribes expect the process to be collaborative in nature and stand ready to assist if the Board wishes to discuss any of our comments. Please contact our Water Management Liaison, Larry Dunsmoor, to assist in this matter. He can be reached at 541.783.2149 ext. 21 or by email at larry.dunsmoor@klamathtribes.com.

Sincerely,

Donald C. Gentry, Chairman

cc: Klamath Tribal Council
Will Hatcher, Natural Resources Director, Klamath Tribes
Larry Dunsmoor, Water Management Liaison, Klamath Tribes
Stan Swerdloff, Aquatics Supervisor, Klamath Tribes
FERC e-library for Docket P-2082

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Comments from the Klamath Tribes Regarding the Scope and Content of the Environmental Information to be Included in the Environmental Impact Report for the Klamath Hydroelectric Project Relicensing

January 28, 2016

Government Contact: Don Gentry, Chairman, 541-783-2219

Staff Contact: Larry Dunsmoor, Water Management Liaison, 541-783-2149 ext. 21

Relicensing of the Klamath Hydroelectric Project (KHP) is an issue of great importance to the Klamath Tribes. In this response to the Notice of Preparation of the Environmental Impact Report (EIR) for the California State Water Board's consideration of certifying KHP operations under Section 401 of the Clean Water Act, we focus on two things. Because we understand the challenges facing Water Board staff as they grapple with the large amount of information regarding the KHP, we try to provide some guidance to information in the record that we believe to be helpful, but perhaps difficult to locate. To conserve our own time, we do not spend much effort to guide Water Board staff to content of the Final EIS/EIR for Klamath River Dam Removal, or to its sister Secretarial Determination Overview Report, because these are obvious sources upon which we are sure the Water Board staff will rely. Secondly, we recommend alternatives that we believe the Water Board should analyze in the EIR.

Environmental Justice

Environmental justice is the most compelling issue to be considered in these proceedings. The Klamath Tribes of Oregon did not benefit from the KHP, but they have been bearing the costs of the Project for a century, since construction began on COPCO 1.

Construction of the first dam of the Klamath Hydroelectric Project, Copco 1, extirpated anadromous fish runs from the entire river basin above the dam. Lane and Lane (1981; pages 150-157) recount the events surrounding development of Copco 1. Mr. J. McKee, the Vice President of the California Oregon Power Company (COPCO), assured the Commissioner of Indian Affairs that during construction of the dam there was adequate provision made for passage, and that upon completion of the dam a fish ladder would be operational. Both assertions were false. Anadromous fish that had contributed to the survival of the Klamath, Modoc, and Yahooskin people for millennia were simply extinguished by a rapacious power company. While some protests were made on behalf of the Klamath Tribes, nothing of substance was done to rectify the situation. The deprivation of a bargained-for resource was a clear violation of the Treaty of 1864. In the end, the interests of the Klamath Tribes were utterly ignored by COPCO, the states of California and Oregon, and our federal trustees.

Subsequent to these events, COPCO proceeded with development of the Klamath Hydroelectric Project, which eventually moved into the ownership of PacifiCorp. The company entered into contracts with agricultural interests in the Upper basin both upstream and downstream of Upper Klamath Lake, which benefitted Upper basin agriculture by locking in extremely low power rates for agricultural use. This fostered intensive agricultural development of the Upper basin, resulting in extreme degradation of aquatic ecosystems and causing the hypereutrophication of Upper Klamath Lake. In turn, these and other impacts led to further severe declines in the Klamath Tribes' fisheries, resulting in the loss of the c'waam and koptu (Lost River and shortnose sucker) fisheries and declines in the redband fishery. Cheap power for agricultural uses, as well as direct actions by the company, led to extensive diking and conversion of wetlands to agricultural uses, destroying important ecosystem components and contributing to the hypereutrophication of the lake. While the Klamath Tribes work towards reintroducing anadromous fish into the Upper basin, the remaining stocks of anadromous fish continue to be damaged by the KHP.

Most of the fishery and ecosystem related costs of the hydropower development, and of the attendant agricultural development, were externalized. The Native peoples of the Klamath River were simply left to absorb these costs, which have been catastrophic. The filing of a Final License Application for the KHP that ignored the restoration of anadromous fisheries, and a subsequent attempt to reverse (via litigation under the Energy Policy Act) the mandatory prescriptions by the United States requiring that provisions be made for fish passage, continued the corporate tradition of ignoring tribal needs and interests.

As the Water Board considers environmental justice issues in this proceeding, the Klamath Tribes ask that you consider the following points:

- Since the very beginning of the development of the KHP, the Klamath Tribes have absorbed catastrophic externalized costs of that development. Such costs are not confined to the past, they are continual. This has been, and continues to be, profoundly unjust.

- A new FERC license will require that provision be made for upstream and downstream passage of fish at each KHP facility, as per the mandatory prescriptions established under section 18 of the Federal Power Act. Because the Klamath Tribes will be actively reintroducing anadromous fish into the upper basin, we have a significant interest in the health and viability of remaining anadromous fish stocks in California, and thus in the deleterious effects of the KHP.

In a Background Technical Report developed for the Klamath Facilities Removal Final Environmental Impact Statement / Environmental Impact Report, Gates and Novell (2011) described this issue in reference to all Klamath River tribes (Pages 1-1 – 1-2):

> Beginning early in the 20th century, dams were put in place on the upper and mid-Klamath to generate electrical power and to supply water for newly established farmland in the upper basin. The dams extirpated anadromous fish from the upper basin. Later, in the 1950s, more dams were built farther downriver on the Klamath to generate hydropower. Four of those dams, now owned by PacifiCorp, are the subject of this report. Copco Dam No. 1 was completed in 1918 and Copco Dam No. 2 in 1925. J. C. Boyle Dam was completed in 1958 and Iron Gate Dam in 1962. Along with the farms and dams came decreased water flows, raised water temperatures, increased susceptibility to excess nutrients that promote algae blooms, and drastically depleted salmon, the tribal communities' most important food, in addition to other fisheries. Partial, but ramifying, ecosystem degradation resulted.
>
> In short, a large part of the incalculable value of the Klamath River as a resource for human life was taken away from the historic native users of the river and dedicated instead to promotion of agriculture and electrical power. The cost of this conversion was not accounted for but was, instead, externalized and absorbed by the native people.

Gates and Novell (2011) wrote specifically about the Klamath Tribes in their Appendix G, saying on page G-2 (bracketed text added for context):

> As a result [of KHP development], the power company and its customers have enjoyed power whose real price is never contemplated. The enormous cost of the lost fishery has been absorbed by the [Klamath] Tribes for nearly a century, while the power company and its customers enjoy what is essentially a subsidy provided by the [Klamath] Tribes. This continues to be the case today, in plain disregard of the commitments of the Treaty.

Norgaard (2005) documented some of the costs that Native people bear through our loss of access to native foods. She reported her findings in regard to the Karuk Tribe. While each tribe has its own history of loss, the global findings of Norgaard (2005) are applicable to the other Klamath River tribes. Loss of or damage to native foods and other resources are summarized by Gates et al. (2011), who in their Executive Summary (pages 2-3) describe the current effects of the KHP dams in this way:

> The findings of the Cultural/Tribal Sub-team, as articulated in the CE BTR, are that the current operation of the dams adversely affects tribal trust resources, tribal rights to take those resources, other resources traditionally used by tribes, and, by extension, the native cultures that depend on these resources and rights. Strong social, cultural, and economic ties have bound together the tribes of the Klamath River basin—ties based in large part on a shared reliance on the region's rivers and lakes and associated resources, particularly anadromous and resident fish. This reliance extends well beyond subsistence and commerce to the cultural and social fabric of the tribes, as evidenced by their traditional, ceremonial, and spiritual ways of life that depend on the rivers and lakes and the fish, wildlife, and vegetation the waters support.
>
> As described in this report, current operations of the four dam facilities under consideration for removal significantly contribute to compromised water quality, loss of habitat for anadromous and other aquatic species, and altered aquatic ecosystem functions. As determined by the CE BTR, these contributing factors have led to the decline of the anadromous and resident fisheries important to the continuance of an indigenous tribal way of life and their economies supported by aquatic resources in the Klamath River basin. The decline of the fisheries is directly and indirectly linked to the decline of the "Salmon People" of the Klamath River basin and their fishery-based economies. This decline is manifested in adverse effects, such as physical illness, mental illness, loss of traditional knowledge, economic instability of individual households, financial instability of tribal governments, and social conflict among native peoples and between native peoples and non-natives residing in the Klamath River basin.

Gates et al. (2011; Executive Summary pages 3-4) concluded the following with regard to removing the KHP dams:

> Under the Dams Out Scenario, it is expected that the attainment and benefits of the TMDLs will be achieved and accelerated, and water quality will substantially improve. Both anadromous and resident fish populations are expected to substantially increase, potentially to the point of delisting of some or all of the fishes currently listed under the ESA and/or the CESA. Additionally, the upper watershed will be opened for the re-establishment of anadromous fish populations. Also, under the Dams Out Scenario, the Klamath River basin's health and the functionality of the larger ecosystem will increase, thus benefiting more than fish.
>
> Also, under the Dams Out Scenario, the health, welfare, economic base, and cultural development of the tribes would have the potential to substantially improve. Fishery-related food resources should trend toward historic conditions, an improvement that could lead to decreased heart disease, fewer strokes, decreased rates of diabetes, reduced risk of obesity, and reduced levels of depression. Healthy Chinook and coho salmon, steelhead, sturgeon, lamprey, suckers, trout, and freshwater clams and mussels would be available for tribal economic growth and cultural activities, such as fishing, hunting, gathering, and ceremonies. Restoration and availability of traditional resources, including fish, would facilitate the transmission of tribal information to the younger generation, thus providing an increased sense of unity and continuity over time.

Clearly, the Klamath Tribes have been forced to bear exorbitantly disproportionate costs of the Klamath Hydroelectric Project. None of those costs were passed on to the rate payers or shareholders who benefitted from the dams. Their profits and benefits have come at the expense of the Klamath Tribes fisheries and fishing culture, at the expense of the quality and health of the aquatic ecosystems that have always been vital to the Tribes, at the cost of a traditional life style that had been sustained since time immemorial, and at a cost to the very lives, health and well-being of the Klamath, Modoc, and Yahooskin Paiute people. Other tribes on the Klamath River will rightly make similar points. The injustice of this continuing situation is profound, and the Klamath Tribes believe it should compel the Water Quality Board to take rectifying action.

Cyanobacteria

Existence of KHP reservoirs creates semi-lacustrine habitat that supports massive blooms of cyanobacteria, which tend to be dominated by *Microcystis aeruginosa*, which produces and releases toxins in KHP reservoirs and in the Klamath River far downstream of the reservoirs. Water quality problems common in hypereutrophic reservoirs with abundant cyanobacteria are also prevalent in the KHP reservoirs, with attendant effects in downstream receiving waters. Bioaccumulation of the microcystin toxin is also a concern. These topics are addressed in the Final EIS/EIR for Klamath River Dam Removal – we have no additional information to offer. The Water Board should evaluate the extent to which such blooms, the attendant water quality problems, and consequences to biota would occur and persist in the absence of the KHP reservoirs.

Effects on Anadromous Fish

Expert Panel

A Chinook Salmon Expert Panel was convened to evaluate the likely response of Chinook to removing the lower four dams on the Klamath River and implementing the KBRA. We submitted comments to their draft report (Dunsmoor 2011). In response to a comment from us requesting that they assess the likelihood of persistence of Chinook stocks under the alternatives of existing conditions and dam removal, they responded as follows (see Goodman et al. 2011, page 69-70, response to comment 190):

> There is much certainty that if the four dams are not removed, the Klamath Chinook salmon will continue to decline.

In response to comment 211 on page 74 of Goodman et al. (2011), the expert panel responded with this statement:

> The Panel believes that dam removal is the greatest limiting factor precluding Chinook salmon rehabilitation. Time will also be needed for new Chinook salmon stocks to evolve to the evolving water quality conditions. Delaying dam removal seems an unwise proposal.

We agree with these statements from the Chinook Salmon Expert Panel, and believe they should be taken to heart by the Water Board.

Thermal Effects

PacifiCorp hired Watercourse Engineering to develop a water temperature model for the Klamath River, which was called the Klamath River Water Quality Model (KRWQM). While several technical reports resulted from this work and were submitted to FERC (Watercourse Engineering 2003, PacifiCorp 2004, PacifiCorp 2005a-c, and references therein), we did not believe that these reports provided an adequate analysis of KHP thermal effects on salmon and steelhead. Therefore, we prepared Dunsmoor and Huntington (2006) which, using the outputs from the model developed by PacifiCorp, analyzed the simulated thermal regimes from the standpoint of stress to juvenile and adult anadromous salmonids, and evaluated likely ramifications to life cycles of these fish. In addition, a series of tables and figures were developed in the appendices that quantified the thermal change of various dam removal scenarios from current conditions; these were developed in anticipation of these 401 certification proceedings, and were intended to be helpful to the Water Board in evaluating the effects of the KHP.

In the section of Dunsmoor and Huntington (2006) entitled Conclusions Regarding KHP Effects on Water Temperature, the authors concluded (in part) the following (note that EC = Existing Condition, WOP = Without Project):

1. During summer and fall, water emanating from Upper Klamath Lake is warmed considerably in Keno Reservoir, resulting in riverine temperatures between Keno Dam and JC Boyle Reservoir substantially warmer than the system potential.
2. Additional thermal loading associated with JC Boyle Reservoir contributes water substantially warmer than the system potential to the top of the Boyle Bypass Reach and to the Boyle Peaking Reach.
3. The low flow, spring-dominated Boyle Bypass Reach is cold with relatively little diel or seasonal fluctuation. During the warm months, the thermal regime under WOP is substantially warmer than under EC,

but is generally within the thermal tolerances (and near the growth optimum) for salmonids.

4. Large, diel flow changes associated with the Boyle peaking operation create large (approaching 10°C) daily fluctuations in temperature in the Boyle Peaking Reach. Lowest temperatures are coincident with lowest flows (~330 cfs) during off-peak periods when all flow in the reach emanates from the Boyle Bypass Reach. Highest temperatures coincide with on-peak periods when flows are dominated by water diverted (~1300 for one turbine, ~2600 cfs for both turbines) from JC Boyle Reservoir.

5. Thermal inertia associated with Copco and Iron Gate reservoirs alters the timing and magnitude of the seasonal progression of warming in spring and early summer, and cooling in fall. Reservoirs delay warming of the Klamath River during spring under EC from Iron Gate Dam to Seiad Valley, an effect that disappears by early June. The extent to which the more rapid warming without dams in place may be influenced by altered watershed conditions and by water management is unknown, but these factors are likely influential. The KHP-related delay in thermal response is accompanied by suppressed diel variability, which from mid-July through August prevents cooling to levels below 20°C. From mid-August through September, Copco and Iron Gate reservoirs delay cooling 112 km downstream to Seiad Valley. WOP temperatures are frequently 3-5°C cooler than EC below the dams at this time of year.

In the section of Dunsmoor and Huntington (2006) entitled Significance to Fishery Management, the authors concluded (in part) the following:

> The KHP-caused temporal shift and spatial and temporal homogenization of the thermal regime are biologically significant to anadromous salmonids in the Klamath River. Benefits associated with modest delays in spring-time cooling are small compared to long delays in fall cooling during upstream migrations and spawning. Loss of spatial and temporal variability reduces distributional opportunities for juveniles, but also likely affects adult run timing.
>
> Periods of cooler weather that would open usable migratory corridors under dam removal scenarios do not have the same effect under EC. Such corridors could allow for iterative upstream migration in which adults swim up a corridor until prevented from continuing by a temporary warm spell. These fish would then be forced to occupy thermal refugia until cooler conditions returned and they could resume their migration. Fish following such a strategy would be moving upstream on the leading edge of tolerable conditions, would likely experience considerable thermal stress, and would be more likely than later-migrating fish to experience pre-spawn mortality or reduced egg viability. Nevertheless, the presence of a segment of a population pushing the envelope in this manner is an important adaptive component of a population in a system like the Klamath, because these fish will be poised to take full advantage of years like 2002 when

> conditions allow for early migration. The diversity in run timing that would result is an adaptive element that is likely to be selected against under present conditions, because fish attempting to follow such a strategy encounter adverse conditions. At present, effects of the KHP minimize the ability of fish to follow such a migration pattern.
>
> The KHP dams (reservoirs) have also helped create a situation in which the early component of the Klamath summer-fall chinook run, which once found progressively more favorable temperature conditions as it migrated up the mainstem Klamath above the Trinity River, no longer finds such conditions. Instead, fish encounter increasingly adverse conditions as they attempt to migrate upstream in the late summer. Relatively few summer-fall chinook now migrate up the Klamath River in August and the run appears even to be delayed in early September of some years. Migrations at this time of year appear to have once accounted for a large portion of the run up the mainstem Klamath River (Snyder 1931), and still do in the nearby Rogue River (ODFW 1992).
>
> The KHP exerts a profound effect on anadromous salmonid fisheries in the Klamath; it isolated all runs from the Upper Basin, appears to have altered the migration timing of fall-run fish, increased the duration and extent of Severely Stressful thermal conditions for adult and juvenile salmon and steelhead, and has likely decreased the ability of juveniles to use thermal refugia as effectively as might otherwise be possible. Results of two independent water quality modeling efforts indicate that removal of most or all of the mainstem KHP dams would significantly improve conditions for migration and spawning of adult fall chinook, and the KRWQM predicts that there may be neutral to positive effects on the habitats used by juvenile chinook and steelhead as well. Returning the Klamath to a thermal regime more similar to that measured by Snyder in 1926 may be the single most effective measure that could be taken to improve conditions for anadromous salmonids in the Klamath River. Improvements in the thermal regime that could be gained through dam removal would facilitate efforts to reintroduce anadromous fish within and above the KHP. Furthermore, fishery benefits derived from habitat restoration efforts in the tributaries would almost certainly be enhanced by an improved thermal regime in the Klamath mainstem.

Because we understand that the staff preparing the EIR will have an enormous amount of material to process, we offer example products from Dunsmoor and Huntington (2006) in the Appendix with the hope that it will help guide staff to potentially useful products from that report.

The largest concentration of groundwater-dominated streams that provide benign thermal environments year-round occur above Upper Klamath Lake. Huntington and Dunsmoor (2006) quantified thermal stress for adults and juveniles in the Williamson River (see Figure 11 in Huntington and Dunsmoor 2006, and below). The Wood River Valley will also provide extensive areas of groundwater-dominated rivers and streams that would provide ideal thermal conditions for anadromous fish (Huntington and Dunsmoor 2006). Restoring access to such thermally benign rivers

Figure 11 from Huntington and Dunsmoor (2006).

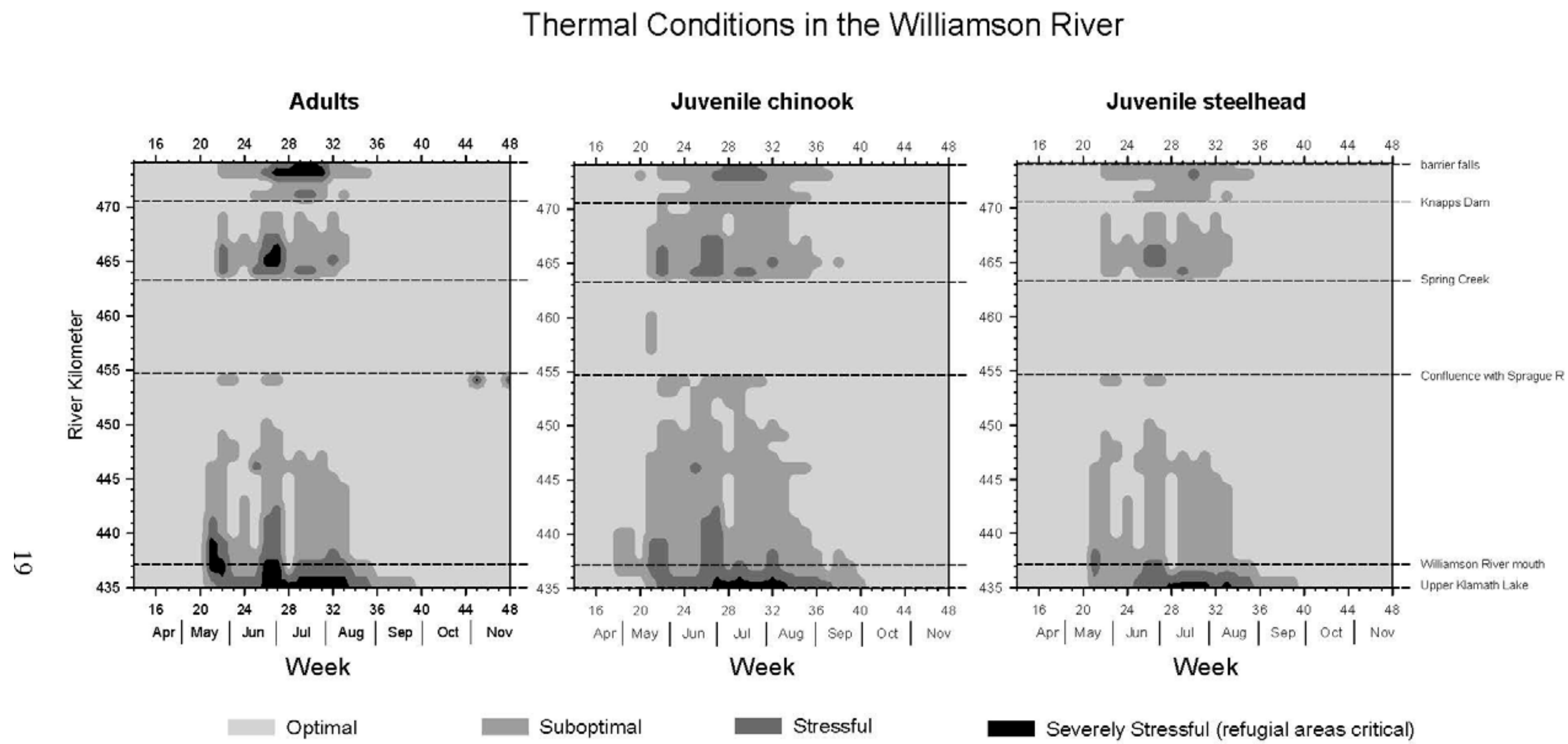


Figure 11. Contour plots characterizing seasonal and spatial patterns in the suitability of temperatures in the lower Williamson River for use by juvenile and adult chinook salmon and steelhead trout.

and streams is an important, and possibly essential, action that should be taken to increase the resilience of anadromous salmonids to climate change.

We submitted comments to the Chinook Salmon Expert Panel that was convened as part of the Secretarial Determination process (Dunsmoor 2011). In the draft report from the panel, there was some confusion about the thermal relationships between Upper Klamath Lake and releases from Iron Gate Reservoir in the late summer and fall. For each year from 2004-2010, the plots in Dunsmoor (2011) use measured water temperatures, and relate the thermal regimes of the riverine and lacustrine sites to returns of fall Chinook to Iron Gate Hatchery. We believe it to be a useful way to depict current conditions, demonstrating that late summer and fall water temperatures are warmer and less variable below Iron Gate Dam than in Upper Klamath Lake. Such plots would also be an informative way to compare current conditions to simulated thermal regimes for various dam removal alternatives. Figure 1 for 2009 from Dunsmoor (2011) is included here as an example.

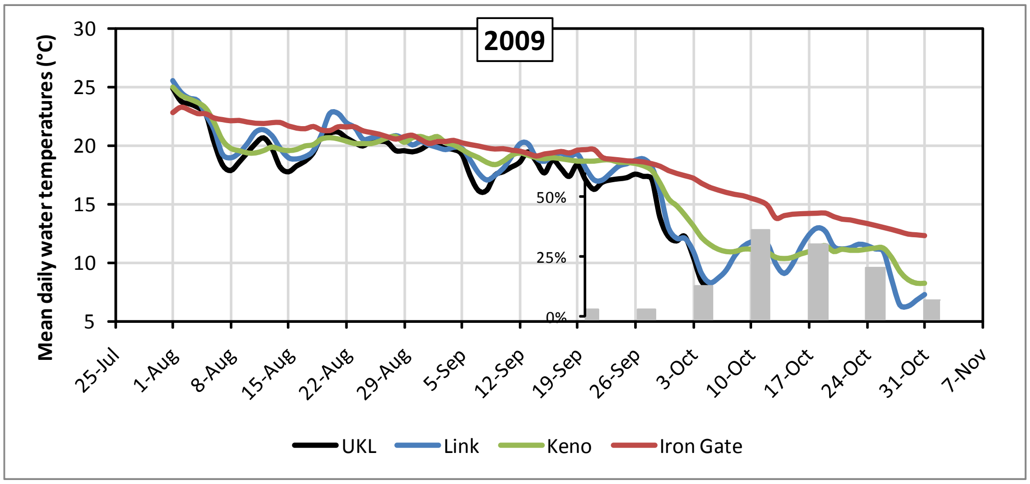
Iron Gate Hatchery and Fish Disease

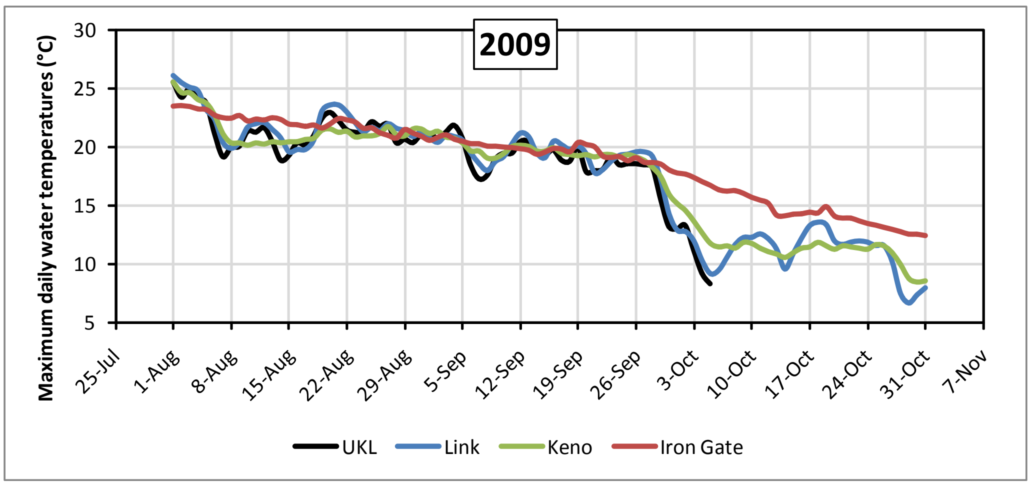
We believe Iron Gate Hatchery (IGH) to be harmful to the wild runs of anadromous salmonids in the Klamath River. Release of susceptible fish in large numbers from IGH (which happens frequently during spring) during disease outbreaks likely amplifies the disease in the river. Such releases also are likely to produce an influx of large numbers of hatchery fish into thermal refugia and other habitats, worsening conditions for wild fish of multiple species.

It appears that a nearly perfect situation has been engineered for myxozoan disease. First, the Copco dams were built, resulting in the progressive coarsening of the river bed, and providing stable substrates for the polychaete host. Second, Iron Gate Dam was built to re-regulate peaking flow regimes from the Copco dams, resulting in steady, homogenous flows downstream, conditions that also favor poychaetes. Layered upon these flow effects are those associated with altered upstream hydrology, which includes a complex milieu of things like out-of-basin diversions to the Rogue River Basin, extensive loss of wetlands, altered volume and management of Upper Klamath Lake, diversion of Lost River water into the Klamath River, diversions to agricultural uses above, around, and below Upper Klamath Lake, and on-going effects of climate change, to name a few. Third, IGH concentrates spawning salmon in the reach that provides ideal conditions for the polychaete host, ensuring effective transmission of myxospores from infected fish to the host. Fourth, millions of fry are released into this same area each spring, providing ready vessels for colonization by actinospores. Here is how the situation is described in a portion of the FEIS/EIR for Dam Removal (Vol I, Section 3.3.3.3.5 Disease and Parasites):

> In the Lower Klamath River, the polychaete host for *C. shasta* and *P. minibicornis* is aggregated into small, patchy populations. The reach of the Klamath River from the Shasta River to Seiad/Indian Creek is known to be a highly infectious zone with high actinospores exposure, particularly from May through August (Beeman et al. 2008, Bartholomew and Foott 2010). This portion of the river contains areas of dense populations of polychaetes within low-velocity habitats with *Cladophora* (a filamentous green periphytic algae), sand-silt, and fine benthic organic material in the substrate (Stocking and Bartholomew 2007). As described above, the reduced bedload mobility has increased the persistence of polychaetes under existing conditions. High parasite prevalence in the Lower Klamath River is considered to be a combined effect of high spore input from heavily infected, spawned adult salmon that congregate downstream from Iron Gate Dam and Iron Gate

Figure 1 from Dunsmoor (2011)





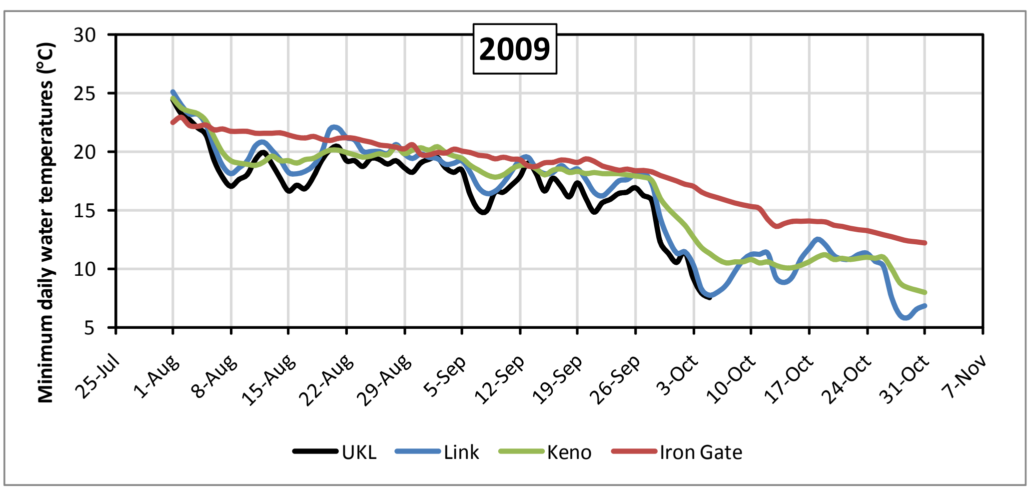


Figure 1 - continued. Mean, maximum, and minimum daily water temperatures during August-October for selected sites in the upper Klamath River system. All data are from continuously recording thermographs operated by either the USGS or USFWS. The UKL site is immediately north of Buck Island (USGS); the Link and Keno sites are at USGS gauge sites that are short distances downstream of their respective dams; and the Iron Gate site is at the Irona Gate Hatchery Bridge downstream of the dam (USFWS). Weekly returns (as percent of annual total) of fall Chinook to the Iron Gate Hatchery are represented by the histogram.

> Hatchery and the proximity to dense populations of polychaetes (Bartholomew et al. 2007). The highest rates of infection occur in the Lower Klamath River downstream from Iron Gate Dam, generally the reach from Shasta River to Seiad (Stocking and Bartholomew 2007; Bartholomew and Foott 2010).

We urge the Water Board to evaluate alternative approaches to addressing the disease-related problems caused or exacerbated by IGH, including an alternative that eliminates the hatchery altogether.

More reasons than those related to diseases would support such an action. A growing body of literature demonstrates a variety of negative effects to fish populations and their management resulting from hatchery supplementation (e.g. Christie et al. 2012; Christie et al. 2014; Chilcote et al. 2011 and 2013; Johnson et al. 2012; Bingham et al. 2014; many more available at http://nativefishsociety.org/index.php/science-research/wild-vs-hatchery-salmonid-interactions/). The Klamath Tribes believe that managing for the integrity of wild salmonid populations is important to their long-term viability, and will maximize the success of re-introducing anadromous salmonids to the upper Klamath Basin, which is one of our primary management goals.

Effects on Resident Fish

Rainbow Trout

Rainbow trout are highly migratory fish moving large distances within the Upper Klamath Basin, and provide a very important subsistence fishery for the Klamath Tribes. Therefore, the Klamath Tribes contend that the KHP should be configured and operated in a manner that is amenable to sustainable production of abundant rainbow trout that are able to realize their growth potential and migratory capability throughout the KHP.

At present, rainbow trout are influenced in many ways by KHP configuration and operation, each of which should be thoroughly evaluated by the Water Board. In addition to information presented below, see in McKenna (2006) the section entitled Findings of Fact Concerning USFWS/NMFS Issue 3 (begins on page 26) for a series of findings pertinent to rainbow trout. Summarized effects of the KHP on rainbow trout include the following:

- Upstream and downstream migrations are inhibited or prevented by the absence of fish passage structures and facilities on the lower three mainstem dams, a poorly functioning fish ladder at JC Boyle Dam, and a fish ladder that needs improvement at Keno Dam. Diversion of all Klamath River water out-of-stream at Copco 2 Dam also precludes trout movement.
- Mainstem spawning habitats have been lost under reservoirs, diminished due to loss of gravel recruitment, or eliminated entirely by diversion (below Copco 2 Dam).
- Access to tributary spawning habitats has been restricted due to impassable dams and poorly functioning fishways.
- Extreme flow and water quality fluctuations resulting from peaking appear to limit growth, abundance, and availability of food for adult trout, and greatly diminish successful rearing of young-of-the-year trout. A lot of material exists on this issue in the litigation record pertaining to the Energy Policy Act hearing in 2006. In McKenna (2006), see the section entitled Findings of Fact Concerning BLM Issue 16 beginning on page 44 as a guide to the decisions made by the judge as well as the citations to the supporting materials. The full record of the proceeding is in the FERC record. Figure 12 (see below) in Dunsmoor (2006) documents the frequency and intensity of peaking

operations in the JC Boyle peaking reach from October 1995 through May 2006, demonstrating how peaking operations dominate the conditions in the river. The extent to which peaking operations alter streamflow in the Klamath River are quantified in Huntington (2004) using an Indicators of Hydrologic Alteration (IHA) assessment.

- Peaking-related bypass of miles of the Klamath River have completely eliminated habitat (via the complete dewatering of the Copco 2 Bypass), greatly diminished habitat (JC Boyle Bypass between the dam and the springs), or radically altered the hydrological and thermal regime (JC Boyle Bypass below the springs). Huntington (2004) quantifies the flow alterations for the JC Boyle reaches using IHA methods.

Alternatives to be Analyzed

The Klamath Tribes recommend that the Water Board fully analyze in their Environmental Impact Report the following alternatives related to dam removal:

1. Current conditions.
2. Removal of the lower four dams on the Klamath River, and
3. Removal of the lower five dams on the Klamath River, and the Fall Creek facility.

Alternatives 2 and 3 will functionally eliminate Iron Gate Hatchery. If the Water Board decides to analyze alternatives to Iron Gate Hatchery in conjunction with the dam removal alternatives, then at least the following issues should be addressed in the evaluation:

- Supplementation hatchery effects on disease dynamics.
- Supplementation hatchery effects on fitness and viability of wild stocks.
- Supplementation hatchery effects on active and passive efforts to re-introduce anadromous fish to the upper Klamath Basin.

Figure 12 from Dunsmoor (2006)

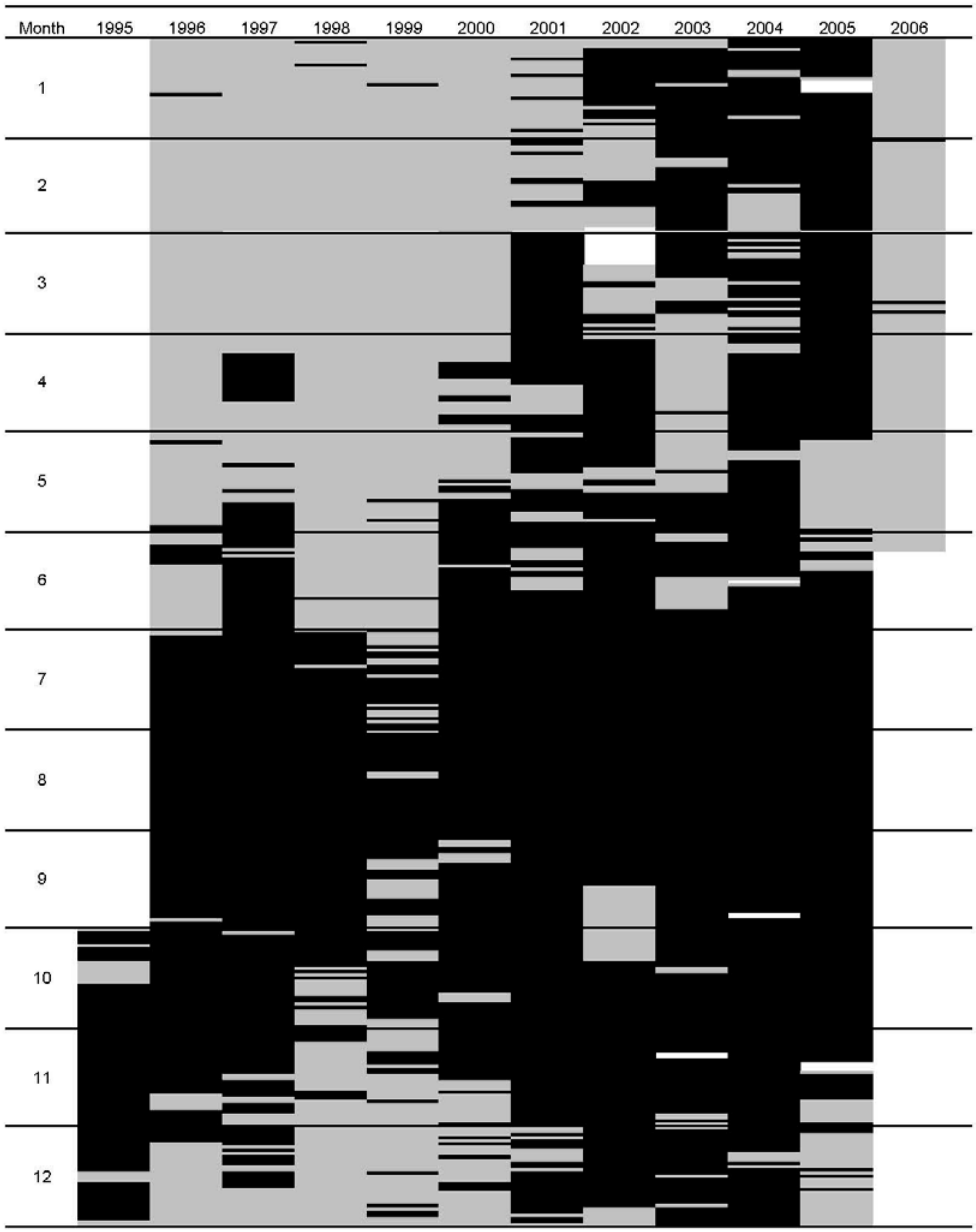


Figure 12. Frequency of two turbine peaking below the JC Boyle powerhouse. Each day in a year is colored white (no data), grey (minimum daily flow ≥500 cfs), or black (minimum daily flow <500 cfs). Two turbine peaking cycles generally reduce river flows to less than 500 cfs, so the black shaded areas approximate the incidence of two turbine peaking cycles. Grey areas denote either single turbine peaking cycles, steady flow through the turbines, or periods of spill.

Dunsmoor peaking *18*

References

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Appendix

Example Figures and Tables from Dunsmoor and Huntington (2006).

Example from Dunsmoor and Huntington (2006)

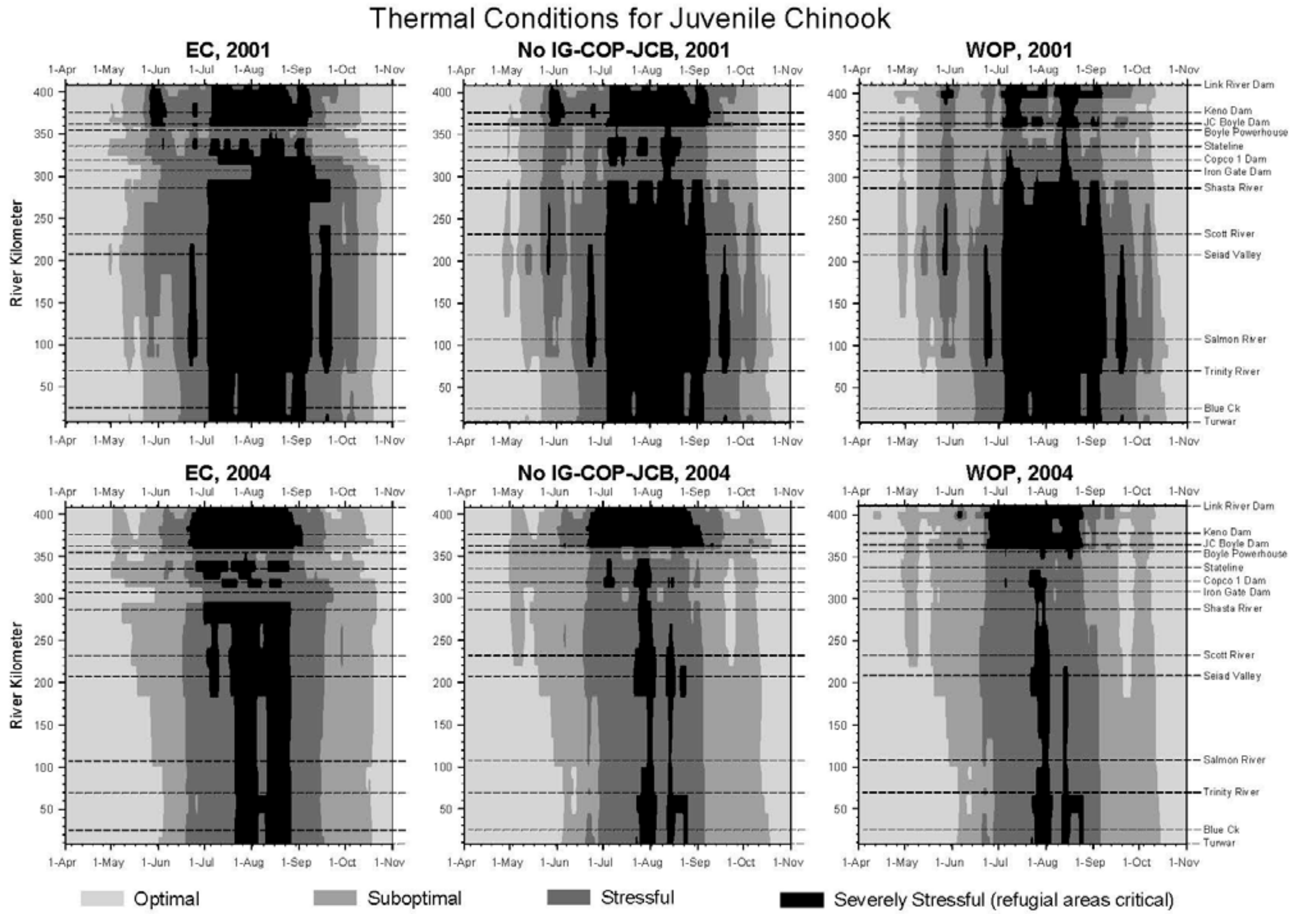

Figure 18. Conditions during the spring, summer, and fall of 2001 and 2004 for juvenile chinook within and below the KHP, based on water temperatures predicted by the KRWQM for three KHP configurations. Only data from riverine sites and Keno Reservoir are included; other mainstem reservoirs and Upper Klamath Lake are represented solely by outflow from the dams. Project configurations are: EC = existing condition; No IG-COP-JCB = Iron Gate, and Copco 1 and 2, and JC Boyle dams removed; WOP = Iron Gate, and Copco 1 and 2, JC Boyle, and Keno dams removed.

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Example from Dunsmoor and Huntington (2006)

Table 4. Average percentage of days within thermal condition categories for adult anadromous salmonids by two week period under various KHP configurations. For each scenario and site, entries are the average (across all sites in the reach) number of days falling within stress categories in each two week period over 2000-2004 (total of 70 days per period), converted to a percentage. Thermal stress categories are: OPT (optimal), SUB (suboptimal), STR (stressful), and SEV (severely stressful). Reach designations are described in Table 1. Project configurations are: EC = existing condition; No IG-COP-JCB = Iron Gate, and Copco 1 and 2, and JC Boyle dams removed; WOP = Iron Gate, and Copco 1 and 2, JC Boyle, and Keno dams removed.

Biweekly Period	Scenario	Keno Reach				Boyle Bypass Reach				Boyle Peaking Reach				Iron Gate Reach				Scott River Reach			
		OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV
Apr 23 - May 6	EC	87	13			100				85	15			100				100			
	No IG-COP-JCB	82	18			87	13			87	13			97	3			100			
	WOP	90	10			89	11			85	15			95	5			99	1		
May 7 - 20	EC	52	48			90	10			50	51			88	12			93	7		
	No IG-COP-JCB	44	56			49	51			35	65			68	32			81	17	2	
	WOP	71	30			66	34			60	41			75	25			84	13	3	
May 21 - Jun 3	EC	3	54	32	11	36	64			8	62	30		47	42	11		42	39	14	5
	No IG-COP-JCB	1	55	34	11		77	23			69	31		20	40	32	9	23	40	21	16
	WOP	10	51	38	1	7	76	17		2	74	24		27	37	26	10	31	32	21	16
Jun 4 - 17	EC		1	77	23		100				48	39	13	8	40	47	6	1	56	41	3
	No IG-COP-JCB		1	72	27		60	33	7		58	30	12	2	61	21	17	2	51	38	10
	WOP		62	35	3		77	23			78	22		9	64	19	8	4	63	25	8
Jun 18 - Jul 1	EC			36	64		100				21	50	30		12	56	32			42	58
	No IG-COP-JCB			29	71		33	51	16		21	51	28		14	42	44		4	42	54
	WOP		29	30	41		51	40	9		42	43	15		27	41	32		6	51	43
Jul 2 - 15	EC			11	89		100				5	35	60			31	69				100
	No IG-COP-JCB			6	94		9	67	24		3	44	53			24	76			1	99
	WOP		1	12	87		16	56	29		11	63	26		2	29	70			3	97
Jul 16 - 29	EC			1	100		100				1	26	73			3	97				100
	No IG-COP-JCB				100		9	57	34		3	33	64			14	86			1	99
	WOP			10	91		19	43	39		7	48	45			13	87			3	97
Jul 30 - Aug 12	EC			1	99		100				6	35	59			7	93			4	96
	No IG-COP-JCB				100		26	40	34		11	39	50		4	32	63		2	12	86
	WOP		1	24	74		20	56	24		14	55	31		7	34	59		3	18	79
Aug 13- 26	EC			3	97		100				8	46	47			10	91			2	98
	No IG-COP-JCB				100		27	67	6		11	71	18		1	59	39			18	82
	WOP		2	30	68		30	60	10		23	71	6		7	63	31		1	25	74
Aug 27 - Sep 9	EC		4	37	59	6	94				36	49	16			35	65		7	24	68
	No IG-COP-JCB		4	20	76		60	40			44	56		5	31	52	12		23	30	47
	WOP		34	51	15		81	19			64	36		7	36	48	10	1	27	29	43
Sep 10- 23	EC		41	59		27	73			1	96	4			6	76	19		21	59	21
	No IG-COP-JCB		36	60	4		100			1	97	1		16	71	12		8	56	27	9
	WOP	7	72	21		10	90			8	92			24	62	14		12	53	23	11
Sep 24 - Oct 7	EC	3	94	3		84	16			16	84				63	36	0.3	7	56	37	0.3
	No IG-COP-JCB	1	91	8		9	91			11	89			38	62			17	70	13	
	WOP	16	84			30	70			28	72			45	56			21	72	8	
Oct 8-21	EC	71	30			100				83	17			35	64	1		67	32	1	
	No IG-COP-JCB	62	38	1		89	11			85	15			93	7			86	13	0.3	
	WOP	89	11			94	6			94	6			96	4			88	11	0.3	
Oct 22 - Nov 4	EC	100				100				100				100				100			
	No IG-COP-JCB	100				100				100				100				100			
	WOP	100				100				100				100				100			

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Example from Dunsmoor and Huntington (2006)

Table 3. Criteria for water temperature and dissolved oxygen concentration used to classify levels of stress for anadromous salmonids. Thresholds are averages of daily minima (7d-min), mean (7d-avg), or maxima (7d-max), calculated for the previous seven days.

			Upper threshold				Intermediate threshold				Lower threshold			
Constituent	Life stage	Condition	7d-min	7d-avg	7d-max	Condition	7d-min	7d-avg	7d-max	Condition	7d-min	7d-avg	7d-max	Condition
Water temperature (^{o}C)	Adult migration (through July 31)	Optimal (OPT)[1]		16	18	Suboptimal (SUB)[2]		18	20	Stressful (STR)[3]		<2 or >20	21	Severely Stressful - refugial areas critical (SEV)[4]
	Adult migration (from Aug 1)			16	18			19	20			<2 or >21	22	
	Chinook juvenile rearing			15	16			18	21			21	23	
	Steelhead juvenile rearing			16	18			19	22			22	24	
Dissolved oxygen (mg/L)	All life stages		6	8			5.5				5			

[1] Optimal - conditions placing very little or no constraint on the life stage.

[2] Suboptimal - conditions that are mildly to moderately stressful unless there are significant ameliorating factors (e.g. presence of a highly abundant food supply for juvenile fish).

[3] Stressful - conditions that are moderately to severely stressful. Temperature becomes an increasingly critical factor affecting fish distribution, abundance, growth, and/or survival. Thermal refugia and/or ameliorating conditions are important under these conditions.

[4] Severely stressful - conditions under which fish survival is jeopardized to the extent that the ability to find spatial and/or temporal refuge is likely to be essential to fish presence. Fish migrations may be blocked, or fish may well be elsewhere, under these conditions.

Example from Dunsmoor and Huntington (2006)

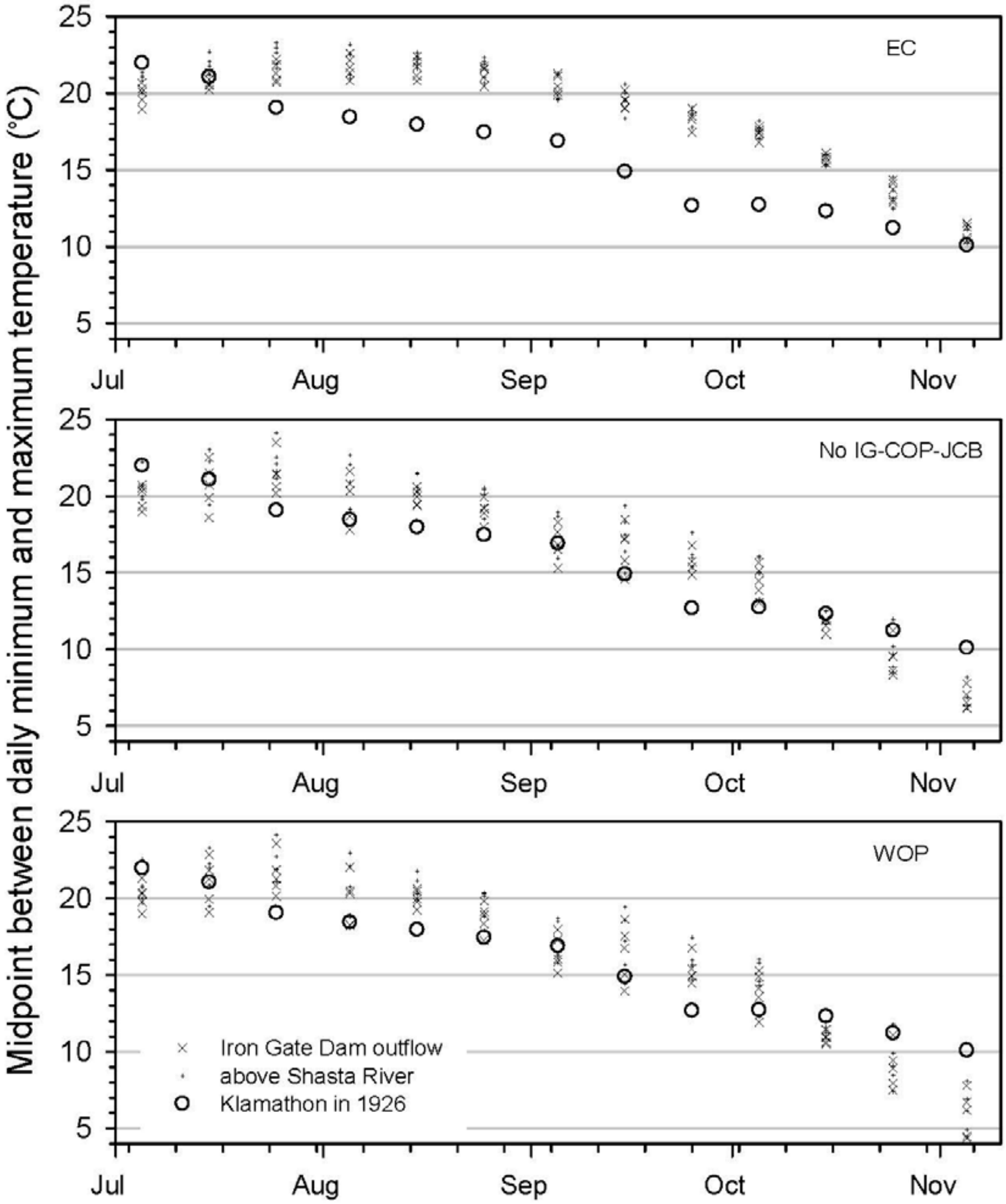

Figure 21. Approximate mean daily temperatures (midpoint of 8AM and 5PM measurements) at Klamathon in 1926 (Snyder 1931), compared to approximate means for EC, No IG-COP-JCB, and WOP temperatures in 2000-2004 calculated in a similar manner (midpoint of average daily minima and maxima by 10 day period). Recent temperatures are shown for sites at Iron Gate Dam and above Shasta River. Klamathon was located about midway between these two sites.

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Example from Dunsmoor and Huntington (2006)

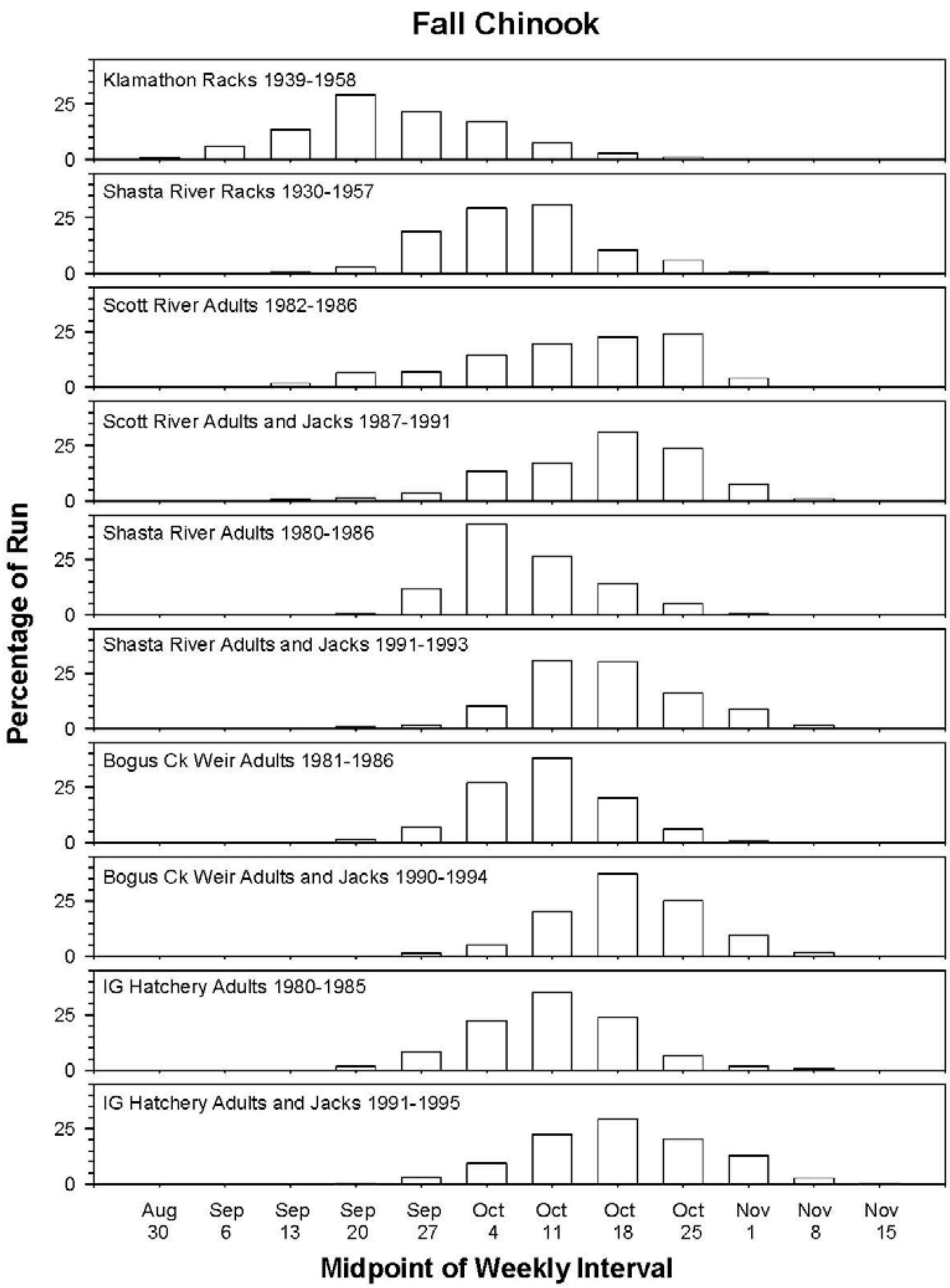

Figure 22. Fall chinook run timing to the middle Klamath River (all data from Shaw et al. 1998).

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Example from Dunsmoor and Huntington (2006)

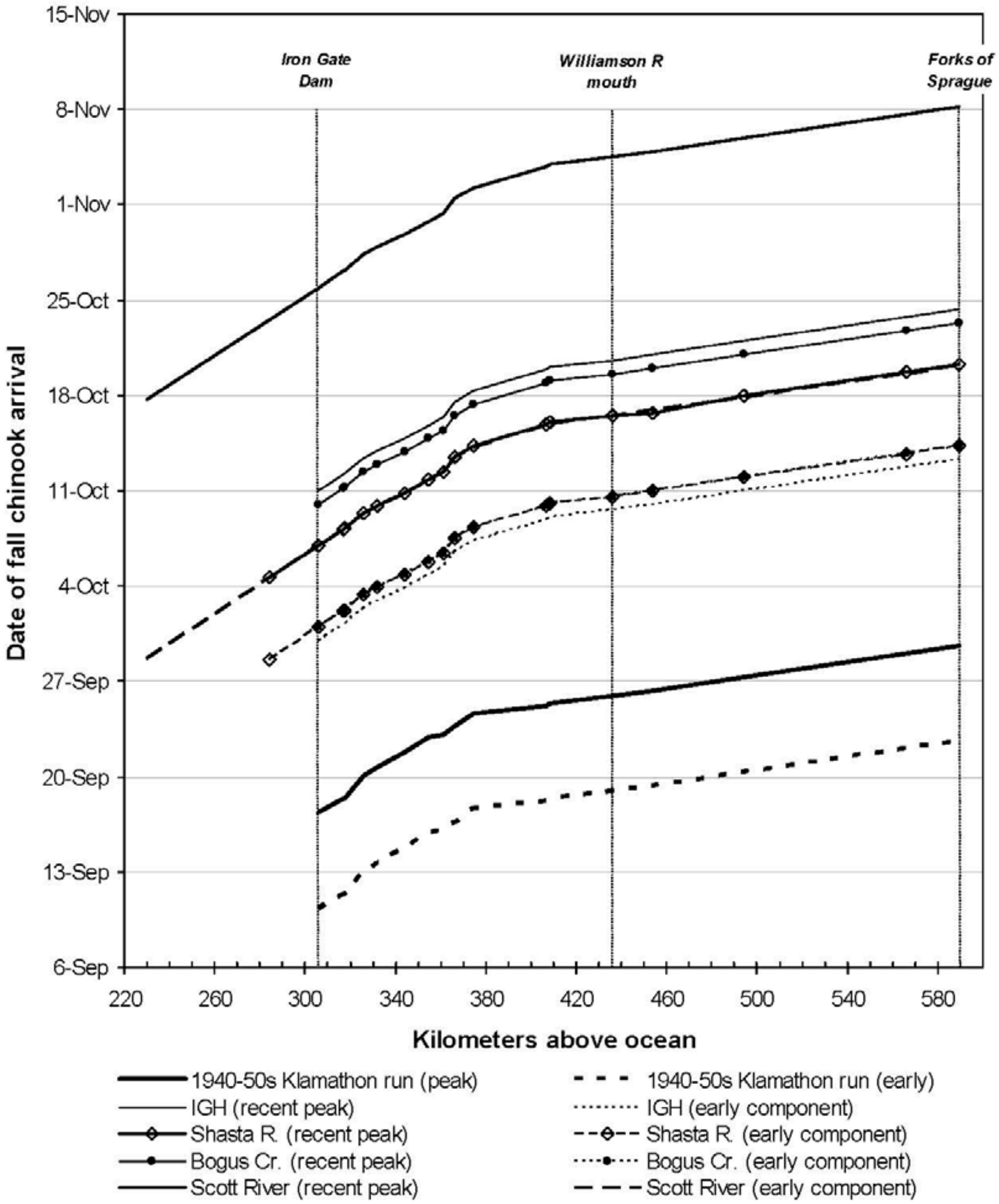

Figure 27. Projected run timing of various fall chinook stocks into the Upper Klamath Basin. Assumed migratory rates were: 9.4 km/d (the mean annual rate above Weitchpec during 2003, per J. Strange, pers. comm.) in riverine segments of the mainstem Klamath; 55 km/d in lakes and reservoirs (a median value calculated for fall chinook in Columbia and Snake River reservoirs from Keefer et al. 2004); and 41.3 km/d (75% of the passage rate through lakes and reservoirs) in low gradient rivers above UKL.

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Example from Dunsmoor and Huntington (2006)

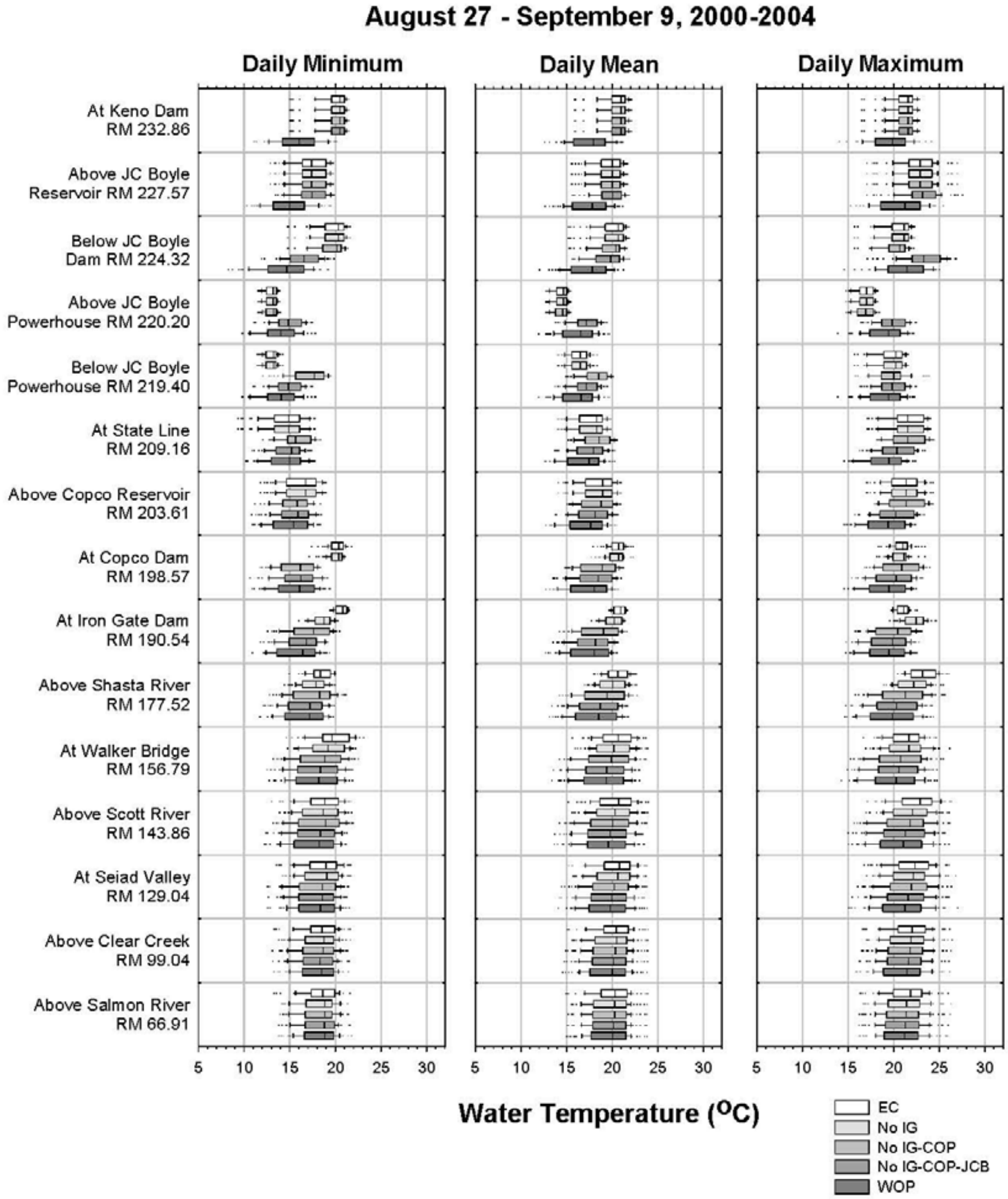

Figure A22. Box plots (line inside box is median, box ends are 25th and 75th percentiles, whisker ends are 10th and 90th percentiles, dots are outliers) of daily minimum, mean, and maximum temperatures for each day from August 27 - September 9 over the five years modeled (70 days per individual box plot) for five dam removal scenarios.

Appendix A 25

Example from Dunsmoor and Huntington (2006)

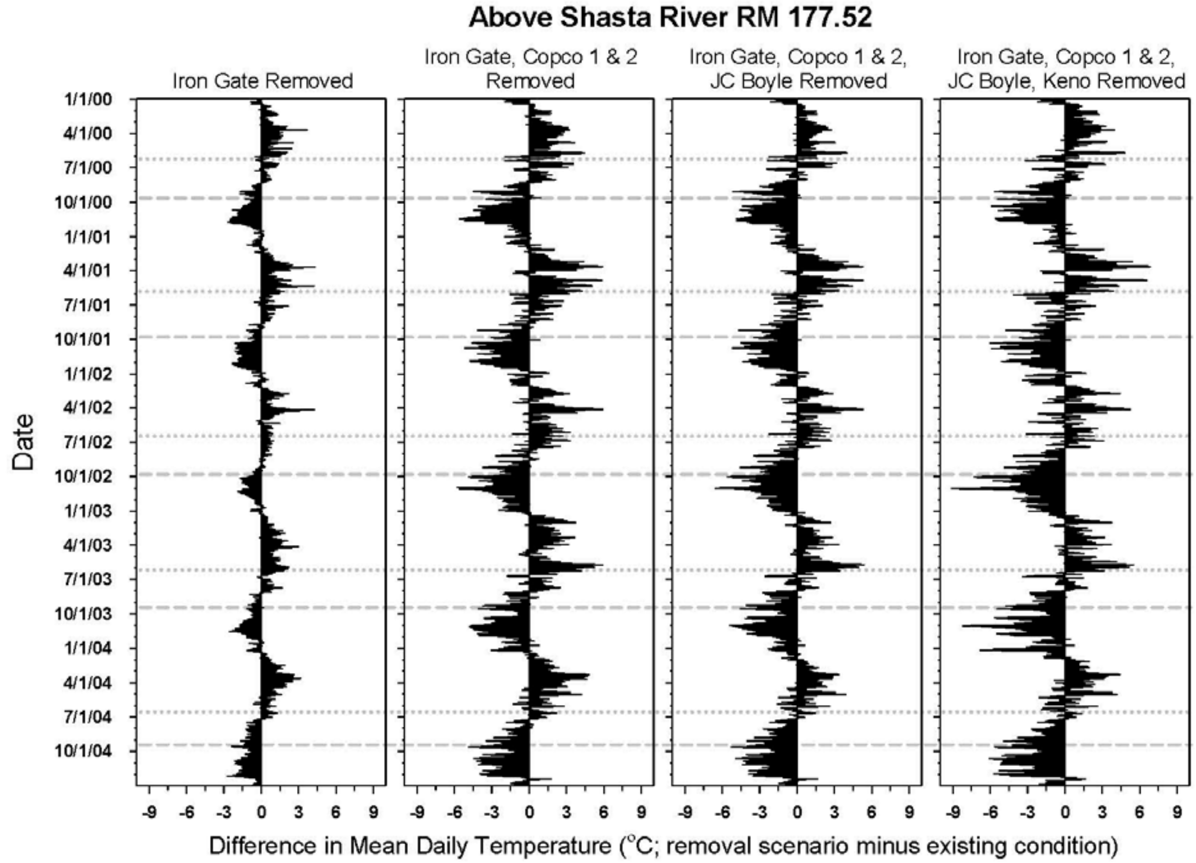

Figure A30. Predicted differences in daily mean water temperatures from the Existing Condition (EC) near the Shasta River confluence resulting from dam removal. Positive differences indicate that removal warms the water; negative differences indicate that removal cools the water. Each bar represents the difference for one day; all days modeled for 2000-2004 are included in each plot. For each site, dotted lines denote the date when the average of the daily mean for the previous 7 days (7d-avg) crosses the 18°C threshold as the river warms in the spring, and dashed lines mark when the 7d-avg crosses the 19°C threshold as the river cools in the fall (intermediate stress thresholds for adult salmon and steelhead, see Table 2).

Appendix A 33

Example from Dunsmoor and Huntington (2006)

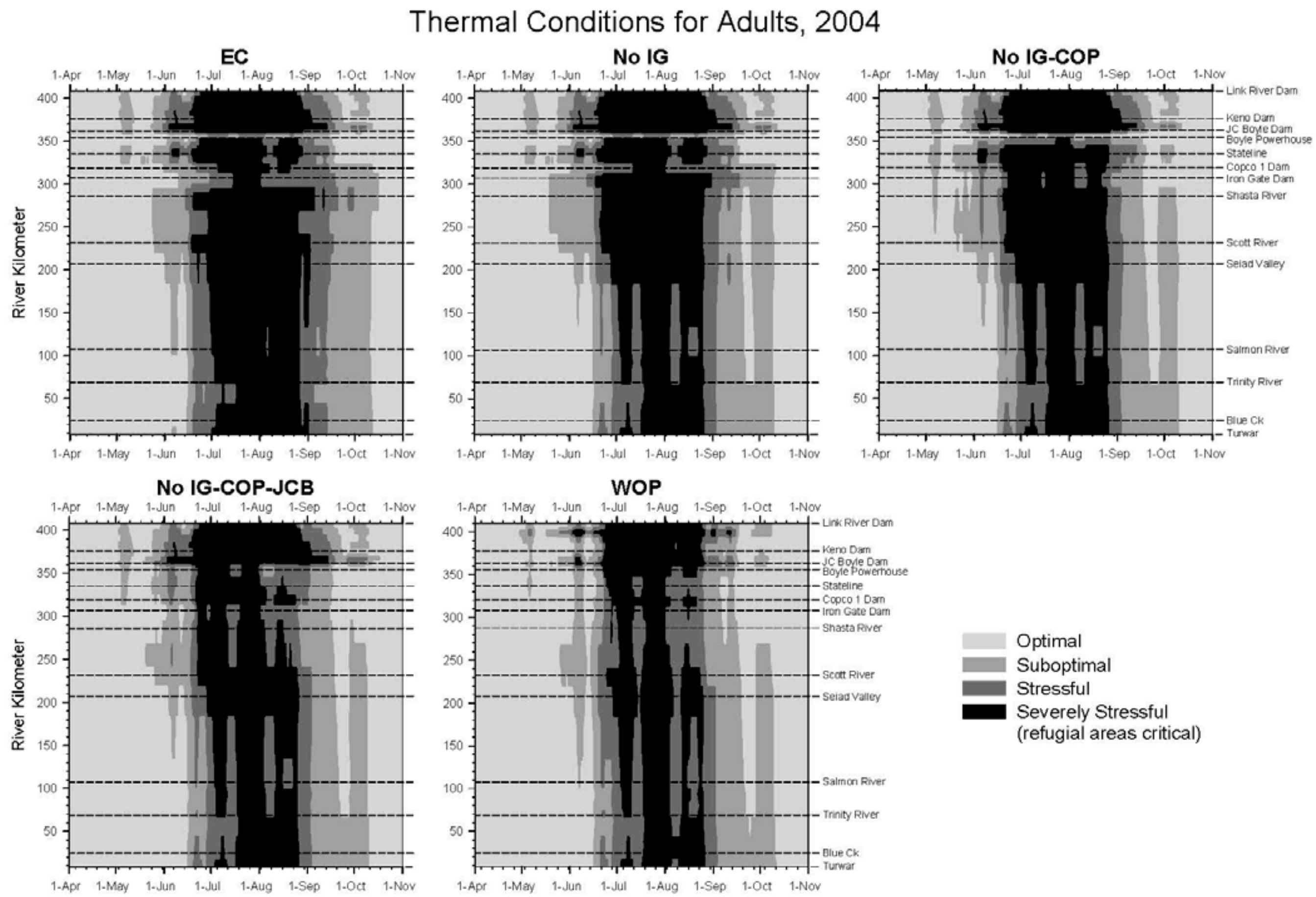

Figure B6. Conditions during spring, summer, and fall of 2004 for adult salmon and steelhead within and below the KHP, based on water temperatures predicted by the KRWQM. Only data from riverine sites and Keno Reservoir are included; other mainstem reservoirs and Upper Klamath Lake are represented solely by outflow from the dams.

Appendix B 11

Example from Dunsmoor and Huntington (2006)

Table B8. Thermal conditions predicted by the Klamath River water quality model August - October for juvenile chinook between Iron Gate Dam and the Salmon River confluence under various Project configurations. Thermal stress categories are: OPT (optimal), SUB (suboptimal), STR (stressful), and SEV (severely stressful). For each scenario and site, entries are the percentage of days falling within stress categories in each two week period over 2000-2004 (total of 70 days per period). Project configurations are: EC = existing condition; No IG = Iron Gate Dam removed; No IG-COP = Iron Gate, and Copco 1 and 2 dams removed; No IG-COP-JCB = Iron Gate, and Copco 1 and 2, and JC Boyle dams removed; WOP = Iron Gate, and Copco 1 and 2, JC Boyle, and Keno dams removed.

Biweekly Period	Scenario	At Iron Gate Dam RM 190.54				Above Shasta River RM 177.52				At Walker Bridge RM 156.79				Above Scott River RM 143.86				At Seiad Valley RM 129.04				Above Clear Creek RM 99.04				Above Salmon River RM 66.91			
		OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV
Jul 30 - Aug 12	EC			23	77				100			10	90			9	91			11	89			24	76			26	74
	No IG				100			13	87			16	84			16	84			14	86			29	71			31	69
	No IG-COP			41	59			23	77			23	77			21	79			20	80			29	71			31	69
	No IG-COP-JCB		10	47	43			36	64			27	73			24	76			23	77			30	70			31	69
	WOP		7	49	44		3	33	64			27	73			26	74			26	74			26	74			31	69
Aug 13-26	EC			20	80				100			6	94			7	93			14	86			29	71			40	60
	No IG				100			24	76			19	81			14	86			14	86			44	56			56	44
	No IG-COP			64	36			44	56			33	67			23	77			16	84			47	53			57	43
	No IG-COP-JCB			91	9			64	36			50	50			39	61			33	67			49	51			60	40
	WOP		3	81	16			71	29			53	47			47	53			43	57			47	53			60	40
Aug 27 - Sep 9	EC			43	57			33	67		1	44	54		3	44	53		3	43	54		4	56	40		4	60	36
	No IG			47	53		1	44	54		7	40	53		9	39	53		11	37	51		9	50	41		10	54	36
	No IG-COP		21	77	1		17	46	37		16	43	41		16	41	43		14	40	46		13	49	39		13	51	36
	No IG-COP-JCB		43	57			26	63	11		19	47	34		17	43	40		16	47	37		13	51	36		13	51	36
	WOP		44	56			34	57	9		20	51	29		19	43	39		16	46	39		14	50	36		13	51	36
Sep 10-23	EC			97	3		6	77	17		10	90			11	79	10		13	79	9		23	59	19		34	46	20
	No IG		11	89			13	87			17	83			20	80			24	67	9		33	51	16		36	44	20
	No IG-COP	6	77	17		3	57	40		3	50	47			50	50			40	56	4		40	46	14		46	36	19
	No IG-COP-JCB	6	86	9		4	70	26		4	51	44		1	51	47			44	54	1		41	46	13		47	34	19
	WOP	10	81	9		6	67	27		6	54	40		3	54	43		3	51	41	4		49	37	14		49	33	19
Sep 24 - Oct 7	EC		34	66			36	64			41	59			41	59			40	60		4	40	56		7	40	53	
	No IG		81	19			66	34			57	43			54	46			49	51		6	40	54		7	39	54	
	No IG-COP	14	86			11	80	9		13	60	27		9	59	33		7	51	41		7	43	50		7	41	51	
	No IG-COP-JCB	14	86			14	86			13	69	19		11	60	29		9	59	33		7	50	43		7	46	47	
	WOP	19	81			17	83			16	69	16		14	63	23		13	60	27		9	50	41		7	44	49	
Oct 8-21	EC		100				99	1		23	76	1		13	84	3		27	70	3		30	67	3		40	57	3	
	No IG	34	66			34	66			51	47	1		40	59	1		43	54	3		41	56	3		50	47	3	
	No IG-COP	84	16			76	24			76	23	1		70	29	1		61	37	1		57	40	3		59	39	3	
	No IG-COP-JCB	90	10			81	19			80	20			74	24	1		71	27	1		64	33	3		61	36	3	
	WOP	91	9			87	13			83	17			79	20	1		74	24	1		70	27	3		64	33	3	
Oct 22 - Nov 4	EC	90	10			79	21			94	6			90	10			93	7			93	7			96	4		
	No IG	100				100				100				97	3			96	4			96	4			99	1		
	No IG-COP	100				100				100				100				100				100				100			
	No IG-COP-JCB	100				100				100				100				100				100				100			
	WOP	100				100				100				100				100				100				100			

Appendix B *16*

Example from Dunsmoor and Huntington (2006)

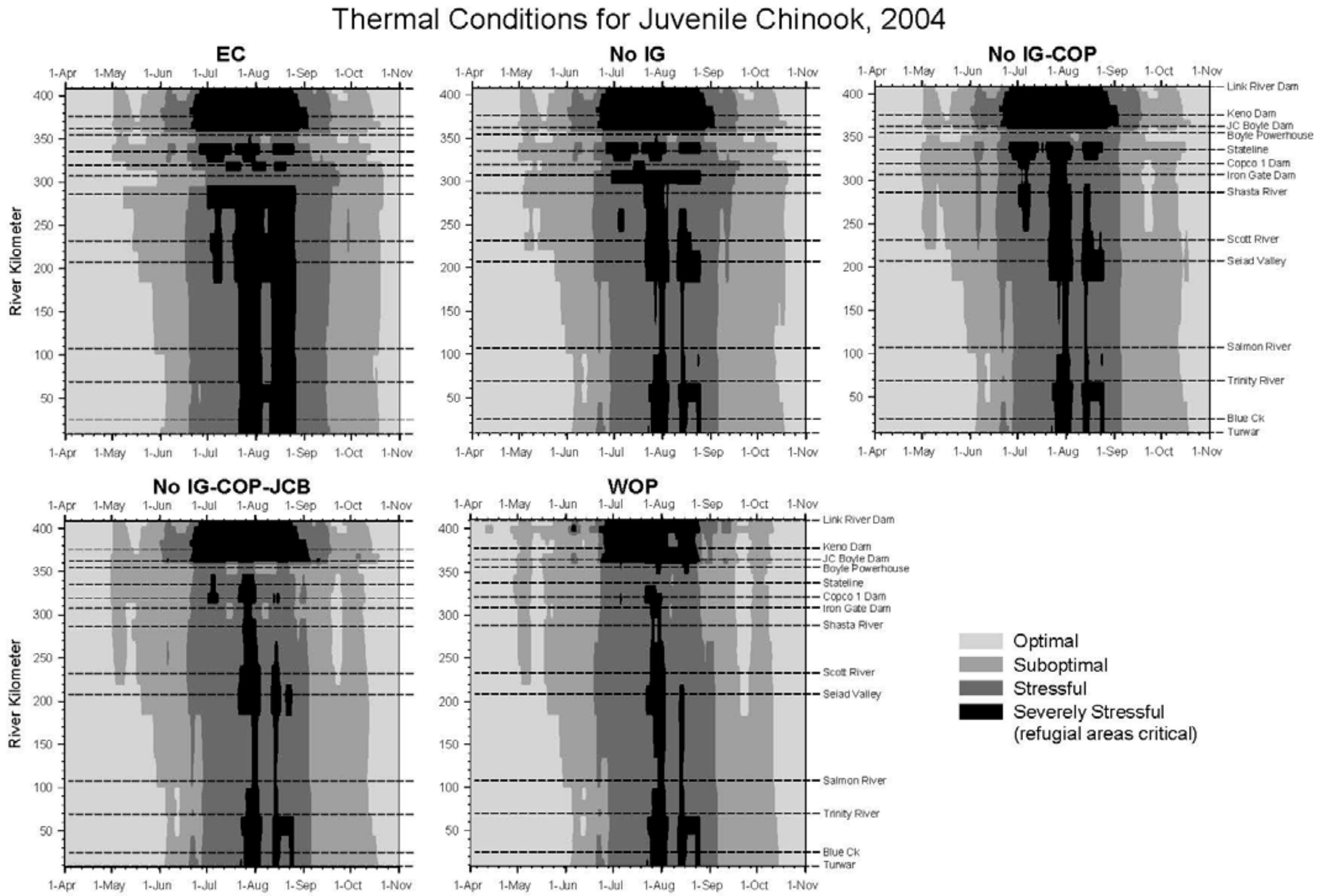

Figure B12. Conditions during spring, summer, and fall of 2004 for juvenile chinook within and below the KHP, based on water temperatures predicted by the KRWQM. Only data from riverine sites and Keno Reservoir are included; other mainstem reservoirs and Upper Klamath Lake are represented solely by outflow from the dams.

Appendix B *21*

Example from Dunsmoor and Huntington (2006)

Table B13. Frequency with which thermal refugia would be occupied, and the average daily minimum river temperature for periods when refugia would be occupied, under various KHP configurations. The threshold for thermal refugia occupancy (maximum daily temperature >22°C) is from Belchik (2003).

		Assume occupancy of thermal refugia when maximum daily temperature >22°C														
		Number of days (2000-2004) when refugia are occupied					Average number of days per year when refugia are occupied					Average minimum daily temperature of river when refugia are occupied				
Site	River kilometer	EC	No IG	No IG-COP	No IG-COP-JCB	WOP	EC	No IG	No IG-COP	No IG-COP-JCB	WOP	EC	No IG	No IG-COP	No IG-COP-JCB	WOP
Keno Dam outflow	374.7	347	347	347	347	261	69	69	69	69	52	22.7	22.7	22.7	22.7	20.0
Klamath River above JC Boyle Reservoir	366.2	450	450	450	464	360	90	90	90	93	72	19.2	19.2	19.2	19.1	18.2
JC Boyle Reservoir outflow	360.9	297	297	269	477	388	59	59	54	95	78	22.7	22.7	22.7	18.1	17.7
Klamath River Bypass above powerhouse	354.3	0	0	0	197	208	0	0	0	39	42				17.2	17.4
Klamath River below powerhouse	353.0	209	209	174	199	206	42	42	35	40	41	14.1	14.1	18.9	17.2	17.4
Klamath River at Stateline	336.5	393	393	417	310	193	79	79	83	62	39	16.3	16.3	17.5	17.2	18.3
Klamath River above Copco	327.6	363	363	412	308	219	73	73	82	62	44	18.6	18.6	17.2	18.0	18.8
Copco Dam outflow	319.5	164	136	366	288	226	33	27	73	58	45	21.8	21.5	18.2	18.6	19.2
Iron Gate Dam outflow	306.6	77	372	283	194	195	15	74	57	39	39	21.9	19.3	20.1	19.5	19.6
Klamath River above Shasta River	285.6	417	382	333	278	248	83	76	67	56	50	18.5	18.8	20.2	19.7	20.0
Klamath River at Walker Bridge	252.3	285	307	319	282	258	57	61	64	56	52	21.6	21.2	21.1	21.1	21.3
Klamath River above Scott River	231.5	380	363	335	314	292	76	73	67	63	58	19.9	20.1	20.7	20.4	20.7
Klamath River at Seiad Valley	207.6	345	331	337	313	302	69	66	67	63	60	20.3	20.4	20.3	20.3	20.4
Klamath River above Clear Creek	159.4	298	289	282	275	270	60	58	56	55	54	20.1	20.2	20.3	20.3	20.4
Klamath River above Salmon River	107.7	278	262	263	258	255	56	52	53	52	51	20.4	20.5	20.5	20.5	20.6
Klamath River at Orleans	92.6	274	261	263	261	253	55	52	53	52	51	20.7	20.7	20.7	20.7	20.8
Klamath River above Bluff Creek	78.9	263	247	247	244	231	53	49	49	49	46	20.5	20.5	20.5	20.5	20.7
Klamath River above Trinity River	69.7	263	243	246	241	225	53	49	49	48	45	20.3	20.3	20.3	20.3	20.7
Klamath River at Martins Ferry	63.5	220	226	213	209	193	44	45	43	42	39	20.6	20.0	20.6	20.7	20.9
Klamath River at Blue Creek	25.7	268	257	255	255	241	54	51	51	51	48	20.0	19.8	20.0	20.0	20.3
Klamath River at Turwar	8.5	281	268	270	268	262	56	54	54	54	52	20.1	20.0	20.1	20.1	20.3

Appendix B 32

UNITED STATES OF AMERICA
DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL MARINE FISHERIES SERVICE

IN THE MATTER OF:	**DOCKET NUMBER**
KLAMATH HYDROELECTRIC PROJECT	2006-NMFS-0001
(License Applicant Pacific Corp)	
	FERC PROJECT NUMBER:
	2082

DECISION

Dated: September 27, 2006

Issued By:

Hon. Parlen L. McKenna, Presiding

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SUMMARY OF THE CASE

This expedited trial-type proceeding was brought pursuant to Section 241 of the Energy Policy Act of 2005, Pub. L. 109-58, § 241, 119 Stat. 594, 674-75 (Aug. 8, 2005) ("EPAct") (codified in 16 U.S.C. §§ 797(e) and 811), and the underlying procedural regulations codified in 50 C.F.R. Part 221. Section 241 amends sections 4(e) and 18 of the Federal Power Act ("FPA") (amended and codified in 16 U.S.C. §§ 791-823d). Those sections provide certain federal agencies authority to include conditions and/or fishway prescriptions in any hydroelectric license issued/re-issued by the Federal Energy Regulatory Commission ("FERC"). See 16 U.S.C. §§ 797(e) and 811. [1]

More specifically, under section 4(e), the Secretary of Interior ("Interior"), acting through the Bureaus of Land Management ("BLM") and/or Reclamation ("BOR"), may establish conditions deemed necessary for the protection of Indian reservations and public lands to be included in a hydroelectric license. See 16 U.S.C. § 797(e). Likewise, under section 18 of the FPA, the Secretaries of Commerce (acting through the National Marine Fisheries Service ("NMFS")), and Interior (acting through the United States Fish and Wildlife Service ("USFWS")) may prescribe fishways to provide for the safe, timely, and effective passage of fish. Id. at 811. Pursuant to section 241 of EPAct, any party to

[1] On November 17, 2005, the Departments of Agriculture, Interior, and Commerce jointly published procedural regulations governing the expedited trial-type hearings conducted under section 241 of EPAct. See 70 Fed. Reg. 69,804 (Nov. 17, 2005). Agriculture's regulations are codified in 7 C.F.R. Part 1, Interior's regulations are codified in 43 C.F.R. Part 45, and Commerce's regulations are codified in 50 C.F.R. Part 221. The three versions of the regulations are substantively identical with minor variations to account for the different Department's organizational components, and a slight variation on the reference to conditions and prescriptions. Id. at 69,808. Since this case was referred by NMFS to the United States Coast Guard (its designated Administrative Law Judge Office) for adjudication, 50 C.F.R. Part 221 governs this proceeding. See 50 C.F.R. § 221.26 (a).

the FERC license proceeding is entitled to a determination on "disputed issues of material fact" concerning the conditions and fishway prescriptions following an expedited evidentiary hearing on the record before a judge. See Pub. L. 109-58, § 241, 119 Stat. 594, 674-75 (codified in 16 U.S.C. §§ 797(e) and 811).

As the party requesting the hearing, the burden of proof rests with PacifiCorp to establish its version of the facts on each disputed issues of material fact by a preponderance of the evidence. See Order Granting Motion to Confirm Burden of Proof (July 6, 2006); 5 U.S.C. § 556(d) (establishing that the burden of proof rests with the proponent); and 50 C.F.R. § 221.57 (adopting the preponderance of the evidence standard of proof).

The parties framed fourteen disputed issues of material fact for decision. In this case, PacifiCorp partially proved its version of the facts with respect to USFWS/NMFS Issue 8. The utility company also proved its version of the facts with respect to BLM Issue 19 and partially proved its version of the facts with respect to BLM Issues 10 and 11. However, PacifiCorp failed to prove its version of the facts with respect to the remaining disputed issues of material fact.

This decision is made following a two-day prehearing conference; the submission of thousands of pages of written direct and rebuttal testimony, exhibits, and transcripts; the filing of and ruling on numerous pretrial motions; and over forty-five hours of hearing over a five day period. The preliminary statement, a listing of the stipulated disputed issues of material fact to be decided, the findings of fact on each of those disputed issues of material fact, a discussion analyzing the basis for the findings of fact, and rulings on the proposed findings of fact and conclusions of law are set forth below.

PRELIMINARY STATEMENT

This case concerns disputed issues of material fact with respect to preliminary prescriptions and conditions that the NMFS and Interior agencies seek to include in any FERC issued re-license for the operation of the Klamath Hydroelectric Project No. 2082 ("Project"). The Project is located on the upper Klamath River beginning in Northern California and extending through Southern Oregon. The Project consists of five ("5") main stem dams: 1) Iron Gate Dam; 2) Copco II Dam; 3) Copco I Dam; 4) J.C. Boyle Dam and Diversion; and 5) Keno Dam. PacifiCorp is the current owner, operator, and holder of the FERC license to operate the Project.

On February 26, 2004, PacifiCorp filed an application with the FERC for a license to continue operations at the Project. In response to this application, FERC issued a Notice of Application Ready for Environmental Analysis, which included a Request for Preliminary Prescriptions and Conditions. By letter to the FERC dated March 24, 2006, NMFS filed its "Comments, Recommended Terms and Conditions, and Preliminary Prescriptions for the Klamath Hydroelectric Project, FERC Project No. 2082." Included with that letter were NMFS' section 18 preliminary prescriptions for the construction and/or modification of fishways at multiple Project facilities. The preliminary prescriptions were developed jointly with USFWS. A copy of the preliminary prescriptions is contained in Attachment A.

Separately, in a letter to the FERC dated March 27, 2006, the BLM and the BOR each filed section 4(e) preliminary conditions (together with USFWS section 18 preliminary prescriptions that were jointly developed with NMFS) (collectively referred to as "Interior Agencies"). A copy of the preliminary conditions and prescriptions is contained in Attachment B.[2]

Pursuant to 16 U.S.C §§ 797(e) and 811 (as amended), and 50 C.F.R. Part 221, in letters dated April 28, 2006, PacifiCorp requested an expedited trial-type hearing to challenge the factual bases supporting the preliminary prescriptions and conditions. Since three of the five, Project dams are located in Siskiyou County, California, its County Counsel filed a notice of intervention concerning the preliminary conditions in support of PacifiCorp's hearing request. The California Department of Fish and Game ("CDFG"), the Klamath Tribes, the Hoopa Valley Tribes, and the Conservation Groups all filed notices of intervention concerning the preliminary conditions and prescriptions. Attachment C provides a chart that details each intervenor and their disputed issue(s) of concern.[3]

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[2] Since they were jointly developed, the USFWS' section 18 preliminary prescriptions are identical to the NMFS section 18 preliminary prescriptions. The only distinction between the two is the Secretary of Interior is responsible for filing USFWS' preliminary prescription whereas the Secretary of Commerce is responsible for NMFS' preliminary prescription.

[3] The Conservation Groups are comprised of eight separate organizations: 1) American Rivers; 2) Trout Unlimited; 3) Northcoast Environmental Center; 4) Pacific Coast Federation of Fishermen's Associations and the Institute of Fisheries Resources ("PCFFA/IFR"); 5) WaterWatch of Oregon; 6) California Trout; 7) Friends of the River; and 8) Oregon Natural Resources Council.

Pursuant to 50 C.F.R. § 221.23, NMFS consulted with the Interior Agencies. They jointly decided to consolidate the hearing requests, and refer the consolidated matter to the United States Coast Guard ALJ Docketing Center for assignment of an Administrative Law Judge. On June 22, 2006, Chief Administrative Law Judge Joseph N. Ingolia assigned the Hon. Parlen L. McKenna to preside over the consolidated hearing and issue a decision on the disputed issues of material fact within ninety (90) days from the date of referral in accordance with section 241 of EPAct and 50 C.F.R. Part 221.

In accordance with 50 C.F.R. § 221.12, an initial prehearing conference was held on July 6 and 7, 2006. During the initial prehearing conference, the disputed issues of material fact were narrowed. The next section of this decision contains a list of the disputed issues of material fact.

The hearing commenced in Sacramento, California on August 21, 2006, and ended on August 25, 2006. Post-hearing briefs, including proposed findings of fact, were filed on September 5, 2006. Reply briefs were filed on September 11, 2006. Rulings on each parties proposed findings of fact are contained in Attachment D. Several Motions to Strike have yet to be ruled upon; the rulings on those Motions will be addressed in this decision. The witnesses and exhibit lists are set forth at the end of this decision.[4]

[4] The parties agreed to file joint post-hearing briefs as follows:

a) PacifiCorp and Siskiyou County filed a joint post-hearing brief;
b) NMFS and FWS filed a joint post-hearing brief (adopted by CDFG);
c) BLM filed a post-hearing brief;
d) The Conservation Groups filed a post-hearing brief; and
e) The Indian Tribes filed a joint post-hearing brief.

DISPUTED ISSUES OF MATERIAL FACT

Fourteen (14) disputed issues of material fact were identified in this proceeding as follows:

1. USFWS/NMFS ISSUE 2(A): Whether stocks of anadromous fish suitable to conditions above Iron Gate are available to use prescribed fishways?
2. USFWS/NMFS ISSUE 2(B): To what extent facilitating the movement of anadromous fish via prescribed fishways presents a risk of introducing pathogens to resident fish inhabiting the basin above Iron Gate?
3. USFWS/NMFS ISSUE 2(C): To what extent facilitating the movement of steelhead above Iron Gate Dam via prescribed fishways presents a risk of residualizing, and whether and to what extent that [residualization] would pose adverse effects to the resident trout fishery resource?
4. USFWS/NMFS ISSUE 3: Whether and how current Project operations affect the resident trout fishery resource in the absence of passage?
5. USFWS/NMFS ISSUE 4: Whether entrainment at Project facilities is adversely affecting resident fishery resources?
6. USFWS/NMFS ISSUE 6: Whether 58 miles of habitat suitable for use by anadromous fish exists with[in] the Project?
7. USFWS/NMFS ISSUE 7: Whether access to habitat within the Project would benefit coho salmon, and if so, to what extent?
8. USFWS/NMFS ISSUE 8: Whether access to habitat within the Project would benefit Pacific lamprey, and if so, to what extent?
9. BLM ISSUE 10: Whether the seasonally high flows will help to improve riparian conditions in the J. C. Boyle bypass reach; and if so, whether and to what extent such improved riparian conditions will affect native riparian-focal bird species?
10. BLM ISSUE 11: Whether project operations adversely affect riparian resources and native riparian-focal bird species in the J.C. Boyle peaking and bypass reaches?
11. BLM ISSUE 14: Whether the seasonal high flow specified in BLM Conditions 4 A.1(c) will have a net adverse effect on redband trout spawning?

12. BLM ISSUE 16: Whether and how current Project operations affect the redband trout fishery resources, insofar, as that resource would be addressed by the River Corridor Management Condition?

13. BLM ISSUE 17: Whether and to what extent BLM's two-inch-per-hour upramp rate for the J.C. Boyle facility will affect fish resources and other aquatic organisms?

14. BLM ISSUE 19: How the flows proposed by BLM may affect the existing whitewater boating and flyfishing in the J.C. Boyle peaking reach?

Pursuant to 50 C.F.R. § 221.60, the undersigned's findings of fact with respect to each disputed issue of material fact will be final and binding on the Secretaries of Interior and Commerce in their final actions under sections 4(e) and 18 of the FPA.

RULINGS ON PENDING MOTIONS

There are six pending motions to strike that have not yet been ruled upon. The Motions are as follows: (1) Yurok Tribe's Motion To Strike Testimony of PacifiCorp Witnesses Chane and Giorgi dated August 15, 2006; (2) Federal Fisheries Services Motion to Strike Certain Portions of the Written Direct Testimony filed by PacifiCorp dated August 16, 2006; (3) BLM's Motion to Strike Testimony of PacifiCorp Witness Forrest Olson dated August16, 2006; (4) Klamath Tribe's Motion to Strike Certain Testimony of PacifiCorp's Witness dated August 16, 2006; 5) Klamath Tribe's Motion to Strike Alteration of Direct Testimony dated, August 16, 2006; and 6) NMFS/FWS Motion to Strike Certain Portions of the Written Rebuttal Testimony Filed by PacifiCorp dated August 18, 2006. A Motion for Reconsideration of an Order Granting PacifiCorp's Motion to Supplement Rebuttal Exhibits of Ken Carlson filed by the Federal Fisheries Services, dated August 28, 2006, is also pending. The rulings on said motions are set forth below.

1. Motions to Strike and Motion for Reconsideration are DENIED.

The Federal Fishery Services, the BLM, the Yurok Tribe, and the Klamath Tribe all seek to strike certain written direct and/or rebuttal testimony of all five of PacifiCorp witnesses: (1) Mr. Ian Chane addressing USFWS/NMFS Issue 8; (2) Dr. Albert E. Giorgi addressing USFWS/NMFS Issue 8; (3) Mr. Ken Carlson addressing USFWS/NMFS Issue 6; (4) Mr. Kevin Malone addressing USFWS/NMFS Issues 2 and 6; (5) Forrest Olson addressing the Tennant Method. In support of each motion, the Federal Fishery Services, the BLM, the Yurok Tribe, and the Klamath Tribe argue that the aforementioned evidence is irrelevant because it is outside of the scope of the issues agreed upon by the parties for the hearing and, in many instances, seek to introduce subjects that have previously been dismissed/withdrawn from the proceeding. The Agencies also filed a motion on August 28, 2006, seeking reconsideration of this judge's Order Granting PacifiCorp's Motion to Supplement the Rebuttal Exhibits of Mr. Carlson.[5]

In these proceedings, "relevant, reliable, and probative evidence" is admissible at the hearing so long as the evidence is not privileged, unduly repetitious, or cumulative; and its probative value is not substantially outweighed by the risk of prejudice, confusion of the issues, or delay. See 50 C.F.R. § 221.55. Although the Federal Rules of Evidence do not apply in these proceedings, those rules do serve as guidance. Id. at § 221.55(a)

[5] The Federal Fisheries Services also sought to strike portions of Mr. Malone's testimony addressing USFWS/NMFS Issue 9. Since that issue has been withdrawn and removed from this proceeding, the motion to strike is dismissed as moot.

(4). Under those rules, relevant evidence is broadly defined as any evidence [however slight] tending to make the existence of consequential fact more or less probable. See Fed. R. Evid. 401. The Advisory Committee Notes to Federal Rules of Evidence 401 make clear that a fact to which the evidence is directed need not be in dispute to be relevant. See 56 F.R.D. 183, 216 (1972). Those notes provide that "[w]hile situations will arise which call for the exclusion of the evidence to prove a point conceded by the opponent, the ruling should be made on the basis of such consideration as waste of time and undue prejudice (see Rule 403), rather than under any general requirement that evidence is admissible only if directed to matters in dispute." Id.

The undersigned recognizes that issues concerning the effectiveness of volitional passage, the Tennant Method, and the prospective temperature effects from the BLM 4(e) conditions were either withdrawn/dismissed from this proceeding. However, the controversial testimony and evidence contains information that bears on the issues in this case. Thus, it is relevant and admissible. This is especially true given the fact that the parties are not prejudiced by the admission of this evidence. The parties have been aware of the information for sometime now (for instance the United States Geological Survey Report, dated September 20, 2005, entitled "JC Boyle Bypass Segment Temperature Analysis" was received by PacifiCorp from the government in discovery). Further, the parties received the written direct/rebuttal testimony in advance of the hearing, they had an opportunity to cross-examine the witness, and they introduced countervailing evidence at the hearing. Therefore, the motions to strike testimony filed by the Federal Fishery Services, the BLM, the Yurok Tribe, and the Klamath Tribes are **DENIED**.

2. Klamath Tribes Motion to Strike Errata of Mr. Malone's Direct Testimony is DENIED.

Klamath Tribes moved to strike PacifiCorp's Errata Regarding the Direct Testimony of Kevin Malone, arguing that the change to the testimony was substantive and impermissible.

With respect to discovery, the regulations place continuing obligations on the parties to promptly amend or supplement any prior response to discovery upon learning that the response is incomplete or incorrect when made. See 50 C.F.R. § 221.42(a). The regulations are silent whether the same rule applies with respect to written direct testimony. Recognizing that a rule requiring a party to go forward with evidence that is known to be incomplete or incorrect would be an exercise in futility, PacifiCorp's Errata is **GRANTED**, and Klamath Tribes' motion to strike is **DENIED.**

PRELIMINARY FINDINGS OF FACT

The Findings of Fact on the disputed issues of material fact are based upon a complete review of all evidence of record. The facts are as follows:

A. BACKGROUND

1. Four of the five Project dams are at issue in this trial-type expedited proceeding conducted under section 241 of EPAct and 50 C.F.R. Part 221: a) Iron Gate Dam; b) Copco I Dam; c) Copco II Dam; and d) J.C. Boyle Dam and Diversion or the Klamath Hydroelectric Project. (*Entire Administrative Record*).

2. Iron Gate development consists of a dam, reservoir, and an 18 megawatt ("MW") powerhouse. It was constructed in 1962, and is the farthest downstream development in the Project area located at river mile ("RM") 190 in Siskiyou County, Ca. The Iron Gate development also includes Iron Gate Fish Hatchery, which was constructed at the same time as the power generation facility. The Iron Gate Fish Hatchery releases fall-run Chinook

salmon, Coho salmon, and winter steelhead trout under the terms of its existing FERC hydroelectric license. (*KTr-CWH-Ex. 1 at 8-9; KTr-CWH-Ex. 5 at 11; KTr-CWH-Ex. 20 at 79*).

3. Copco I development consists of a dam and a 20 MW power plant. It is the first development that was constructed in the Project area in 1917. Copco I is located upstream from Iron Gate Dam at RM 198.6 in Siskiyou County, Ca. (*KTr-CWH-Ex. 1 at 8-9; KTr-CWH-Ex. 5 at 11*).

4. Approximately a quarter-mile downstream from Copco I at RM 198.3 in Siskiyou County, Ca is the Copco II development. Copco II was constructed in 1925, and diverts water to a 5,900 foot water conveyance system serving a 27 MW power plant. Because it has very minimal active storage capacity, Copco II powerhouse operates as a "slave" to Copco I. (*KTr-CWH-Ex. 1 at 8-9; KTr-CWH-Ex. 5 at 11*).

5. The J.C. Boyle development was constructed in 1958 and consists of a dam, reservoir, and powerhouse. It is located farthest upstream at RM 224.7 and the 80 MW powerhouse is located several miles downstream at RM 220.4, both in Southern Oregon. (*KTr-CWH-Ex. 1 at 8-9*).

B. USFWS/NMFS DISPUTED ISSUES OF MATERIAL FACT

1. FINDINGS OF FACT CONCERNING USFWS/NMFS ISSUE 2(A)

2A-1. The selected anadromous stocks of fish at issue in this proceeding are: a) wild Chinook salmon; b) Coho salmon; c) steelhead trout; and d) Pacific lamprey. (*Entire Administrative Record*).

2A-2. An anadromous fish is a fish that migrates to and from the ocean and spawns in its river of origination in order to complete its life cycle. (*Aug. 23, 2006 Tr. at 26:7-11*).

a. Historically, Anadromous Fish were distributed above Iron Gate Dam

2A-3. While the precise geographic distribution is uncertain, historical records and tribal accounts demonstrate that anadromous fish (Chinook salmon, Coho salmon, and steelhead trout) migrated past the present site of Iron Gate Dam which provided a viable ecosystem and habitat for those stocks of fish. (*Aug 24, 2006 Tr. at 11:1-6, 26:21 - 27:7, and 68:10-14; NMFS/FWS-Issue 2A-Garza-Ex. 7 at 1; NMFS/FWS-Issue 2C-Hooton-Ex. 1 at 2:1-17; NMFS/FWS-Issue 6 Hamilton-Ex. 1 at 3:1-14; NMFS/FWS-Issue 6-Hamilton-Ex. 10 at 5; NMFS/FWS-Issue 16-Hamilton-Ex. 16; NMFS/FWS-Issue 8 Hamilton-Ex. 6 at 6-7;HVT-Franklin-Ex. 1 at 2:3-9; 2:20 to 3:5; HVT-Franklin-Ex. 6;CDFG Pisano Exhibit 1 at 6:10-15; Yurok Tribe's Direct Testimony, Witness: Cleveland R. Steward, Issue: NMFS/FWS 8 ("Yurok-Steward 8 Direct") at 3:18-4:8; KTr-CWH-Ex. 5 at 10; NMFS/FWS PFF 2A.1 and 8.2; NGO PFF 2A.1; Indian Tribes PFF 2A.2*).

2A-4. Chinook salmon (both spring and fall-run) were abundant in the tributaries of Upper Klamath Lake, including Jenny, Fall, and Shovel Creeks, as well as the Wood, Sprague, and Williamson rivers. (*NMFS/FWS-Issue 2A-Garza-Ex. 7. at 5-6; NMFS/FWS-Issue 2C-Hooton-Ex. 17 at 20; NGO Ex. 3 at 6; NGO Ex. 19; KTr-CWH-Ex. 1 at 5-6; KTr-CWH-Ex. 4 at 225; KTr-CWH-Ex. 5 at 13-15; KTr-CWH-Ex. 18 at 5-14*).

2A-5. Steelhead trout utilized habitat in Spencer, Shovel, Fall, Camp, and Scotch Creeks, and they were likely distributed as far upstream as Link River. (*NMFS/FWS-Issue 2A-Garza-Ex. 7 at 6-7; KTr-CWH-Ex. 1 at 5-6; KTr-CWH-Ex. 5 at 15-16; KTr-CWH-Ex. 18 at 5-14; KTr-CWH-Ex. 20 at 79*).

2A-6. Coho salmon spawned in Fall Creek. (*Aug. 24, 2006 Tr. at 273:11-274:8; NMFS/FWS-Issue 2A-Garza-Ex. 7 at 7-8;NMFS/FWS-Issue 8-Hamilton-Ex. 1 at 4:3-13; NMFS/FWS-Issue 8-Hamilton-Exhibit 6 at 6-7;NMFS/FWS-Issue 8-Hamilton-Ex. 11 at 236; Yurok-Steward 8 Direct at 3:20- 4:8; Yurok Tribe- Steward 8 Rebuttal at 4:12 to 5:8; KTr.-CWH-Ex. 4 at 216; KTr-CWH-Ex. 5 at 16; NMFS/FWS-Issue 7-Simondet-Ex. 5 at 117; NMFS/FWS-Issue 7-Simondet-Ex. 1 at 4:7-18; NMFS/FWS-Issue 7-Williams-Ex. 1 at 5:8-6:4; KTr-CWH-Ex. 4 at 216-224; Indian Tribes PFF 7.1*).

2A-7. There is insufficient evidence in the record to determine whether Pacific lamprey historically were distributed above the present site of Iron Gate Dam. (*Aug. 24, 2006 Tr. at 121:2-122:1, 124:2-125:19, 250:23-252:13; 253:13-23; 255:8-13; PAC-Chane-R-1 at 2:23-3:1; CDFG Pisano Ex. 1 at 13:8-9; KTr-CWH-Ex. 5 at 16-17*). However, the evidence does show that Pacific lamprey do occur in the Lower Klamath River, below Iron Gate Dam.[6]

b. Project Dams Have Changed the Migratory Behavior of Anadromous Fish in the Klamath River

2A-8. The construction of the Project dams has changed the migratory behavior of anadromous fish in the Klamath River System, blocking upstream migration and limiting those fish to habitat below the dam. (*Aug. 24 Tr. at 11:2-12:9; NMFS/FWS-Issue 2C-Hooton-Ex. 1 at 2; NMFS/FWS-Issue 2A-Garza Ex. 1 at 3; NMFS/FWS-Issue 2A-Garza Ex. 7 at 1; KTr-LKD-Ex.-13, at 1; NMFS/FWS-Issue 2C-Hooton- Ex. 17, at 20; KTr-CWH-Ex. 3*).

2A-9. No anadromous fish presently inhabit the waters above Iron Gate Dam. (*Id*).

2A-10. Migration is one of several defining life history characteristics of anadromous fish, especially salmonids. (*NMFS/FWS-Issue 2A-Garza-Ex. 1 at 2:8-3:25; NMFS/FWS-Issue 2A-Garza-Ex. 6 at 6; NMFS/FWS-Issue 2A-Garza-Ex. 8 at 13; NMFS/FWS-Issue 2A-Garza-Ex. 4 at 3; Aug. 24, 2006 Tr. at 11:24-15:9; NMFS/FWS 2A.7*).

2A-11. Today, wild anadromous fish (Chinook salmon, Coho salmon, and steelhead trout) can only migrate up to the base of Iron Gate Dam, using nearby tributary and main stem habitat to spawn. (*Aug 24, 2006 Tr. at 10:18 to 11:1; 17:15-18; NMFS/FWS-Issue 2A-Garza-Ex. 1 at 4:4 to 5:7; NMFS/FWS-Issue 2A-Garza-Ex. 7 at 1-2; NMFS/FWS-Issue 2A-Curtis Rebuttal Testimony Ex. 1at 2:1-16; CDFG Pisano Exhibit 1 at 4:20 to 5:28; CDFG Pisano Exhibit 4; HVT, Franklin, Ex. 1 at 2, lines 10-17; Yurok-Steward 8 Direct at 3:1-9; Steward Yurok Ex 5; KTr.-LKD-Ex. 13; see also NMFS/FWS PFF 2.A.2 and 8.2; NGO PFF 2A.2; Appendix to Reply of PacifiCorp and Siskiyou County Responses to Proposed Findings on USFWS/NMFS Issues at 2*).

[6] The issues concerning whether Pacific lamprey stocks suitable to conditions above Iron Gate Dam are available, and whether Pacific lamprey would benefit from access to habitat within the Project area are discussed in great detail below in response to USFWS/NMFS Issue 8.

2A-12. If access was provided, anadromous fish would migrate past Iron Gate Dam. (*Aug. 24, 2006 Tr. at 11:12-23; 170:2-17; 273:11-274:8; NMFS/FWS-Issue 2A-Garza-Ex. 1 at 2-3, 5:3-4; NMFS/FWS-Issue 2A-Garza-Ex. 6 at 6; NMFS/FWS-Issue8-Moser-Ex. 1 at 8:4-9:16 and 13:11-17; HVT-Franklin-Ex. 1 at 3:10-20 and 5:3-6; NGO Ex. 3, at 5:22-23, 7:11-9:20 and 13:11-17; CDFG-Pisano-Ex. 1 at 10:12-11:8; NGO PFF 2A.5; see also Appendix to Reply of PacifiCorp and Siskiyou County Responses to Proposed Findings on USFWS/NMFS Issues at 3*).

c. The Habitat above Iron Gate Dam is Similar to the Habitat in Some Tributaries below Iron Gate Dam

2A-13. Habitat below Iron Gate Dam, like habitat in the Project-bounded area, has variable suitability across locations, time, and life stages. (*Aug. 24 at 283:25-20*). Anadromous salmonids have used downstream habitat that is no more favorable than that located above Iron Gate Dam. (*CDFG Pisano Ex. 1 at 4:18-51, 7:10-9:7 (Coho in other parts of the Klamath system occupy water with temperatures in excess of 26^{o} C), 9:8-10:12 (spawning in degraded streams); Yurok-Hillemeir Direct Testimony-NMFS/FWS Issue 7 at 4:24-5:3; KTr-CWH-Ex 4 at 219 (juvenile Coho salmon observations in the main stem Klamath River where temperatures exceed 20^{o}C)*).

2A-14. Warm water temperatures in the summer and cold water temperatures in the winter will not preclude anadromous fish from successfully utilizing habitat above Iron Gate Dam. (*NMFS/FWS-Issue 2A-Garza-Ex. 1 at 2:8-3:25; NMFS/FWS-Issue 2A-Garza-Exh. 6 at 6; NMFS/FWS-Issue 2A-Garza-Ex. 8 at 13; NMFS/FWS-Issue 2A-Garza-Exh. 4 at 3; Aug. 24, 2006 Tr. at 11:20-15:9*).

2A-15. The findings of fact in USFWS/NMFS Issue 2B addressing disease is incorporated herein.

2A-16. The findings of fact in USFWS/NMFS Issue 6 addressing the mileage of suitable habitat within the Project-boundaries are incorporated herein.

2A-17. The amount of delay associated with anadromous fish migrating above Iron Gate Dam is uncertain. (*c.f. Aug. 23, 2006 Tr. at 224:18- 227:17, 237:7-20*; *226:20-25; Aug. 24, 2006 Tr. at 42-11:15, 54:10-55:2; NMFS/FWS-Issue 7-Simondet Rebuttal, at 7:7-8; KTr Huntington Rebuttal Ex. 6, at 9:7-20, 11:18-19, 13:16 to 14:16; KTr LKD Rebuttal Ex. 15, at 3:11-4:2, 4:20-5:12; KTr CWH Rebuttal Ex. 6, at 3:22-4:2; NMFS/FWS-Issue 2-Hamilton Rebuttal, Ex. 1 at 2:18 to 3:20; NMFS/FWS-Issue 6-Hamilton Rebuttal at 6:7-24; NMFS/FWS-Issue 2-Hamilton Rebuttal Ex. 8; KTr LKD Rebuttal Ex. 15, at 3:8-5:12; KTr CWH Rebuttal Ex. 6, at 4:2-10; Indian Tribes PFF 2A.8, 2A.10, 2A.11*).

2A-18. Likely mortality rates of juvenile anadromous salmonids migrating through reservoirs will vary widely among species, and will depend largely on size (larger migrants will do better) of the migrating fish. Thus, small sub-yearling fall Chinook are likely to experience lower passage success than larger Coho, yearling Chinook or steelhead out-migrants. (*KTr-CWH Rebuttal Ex. 6 at 2:6-17, 3:10-14; Aug. 25, 2006 Tr. at 64:7- 65:8, 65:14-22; Indian Tribes PFF 2A.12*).

2A-19. Predation of outmigrating salmonids above Iron Gate Dam is likely to be low. (*NMFS/FWS-Issue 2 Hamilton-Rebuttal Ex. 4 at 224-225*; *Aug. 25, 2006 Tr. at 64:7 to 65:8, 65:17-22*).

2A-20. The fact that anadromous fish currently complete life cycles through eight dams and reservoirs on the Columbia and Snake rivers, and historically completed life cycles through Upper Klamath Lake, provides strong evidence that anadromous salmonids could also migrate through the reservoirs created by Project facilities. (*Aug. 24, 2006 Tr. at 26:21-27:7*; *KTr FAE Rebuttal Ex. 7, at 2:2-17; KTr FAE Ex. 32, at 5:21-25; Indian Tribes PFF 2A.9*).

d. There are Stocks of Fish Suitable to Conditions above Iron Gate Dam

2A-21. The NMFS and the USFWS (collectively referred to as "Federal Fishery Services") seek to, among other things, restore native anadromous fish species to their historical habitats above Iron Gate Dam. <u>*See*</u> *NMFS/FWS-Issue 7-White-Ex. 14, Attachment A, at A-9 through A-12.; Yurok-Hillemeir Direct-Issue 7 at 6*).

2A-22. The record shows that those anadromous fish proximate to Iron Gate Dam are genetically most similar to those populations that existed in the Upper Klamath basin prior to the construction of the dams. (*NMFS/FWS Issue 2A-Garza-Ex. 1 at 4:1-5:7 and 6:1-3; NMFS/FWS-Issue 2C-Hooton-Ex. 1 at 2:19-3:11, 4:12-5:10, and 6:1-3*). The evidence shows that these stocks of fish have genetic traits suitable for reintroduction into the upper Klamath River basin. (<u>*Id*</u>*.;* <u>*see*</u> <u>*also*</u> *NGO PFF 2A.3*).

2A-23. There are numerous examples from other streams and rivers systems that provide persuasive evidence that anadromous fish possess the capacity and capability to successfully adapt and colonize new habitat or recolonize historic habitat, including streams or river systems with lakes or reservoirs. (*NMFS/FWS-Issue 2A-Garza-Ex. 1 at 2:8-3:25; NMFS/FWS-Issue 2A-Garza-Ex. 6 at 6; NMFS/FWS-Issue 2A-Garza-Ex. 8 at 13; NMFS/FWS-Issue 2A-Garza-Ex. 4 at 3; NGO Ex. 3 at 12:13-13:9; NGO Ex. 20; HVT, Franklin, Ex. 1 at 4:-5:2; CDFG Pisano Ex. 1 at 10:20-22; NMFS/FWS PFF 2A.8*).

2A-24. The record evidence shows that Chinook salmon, Coho salmon, and steelhead have varying life histories and would use differing areas of habitat within the Project at somewhat different times of year as they did prior to construction of the Project. (*Aug. 24, 2006 Tr. at 212:5-10; HVT-Franklin-Ex. 2 at 2:20-26; NMFS/FWS-Issue 6-Hamilton-Ex. 1 at 3:1-14; NMFS/FWS-Issue 6-Hamilton-Rebuttal-Ex. 1 at 1:22-25, 4:21-5:11*).

i. ***Stocks of fall-run Chinook salmon Suitable to Conditions above Iron Gate Dam are Available to use Prescribed Fishways***

2A-25. Chinook salmon historically were and continue to be the most abundant anadromous fish in the Klamath basin. In the last 25 years, annual runs of Chinook salmon have ranged between 30,000 and 240,000. Historically, the runs were much higher. (*KTr-CWH-Ex. 4 at 225*).

2A-26. In the Klamath River basin, there are at least two distinct Chinook salmon populations: the fall-run and spring-run. The runs are named for the season of entry and migration up the river, which do not necessarily coincide with the spawning time. (*KTr-CWH-Ex. 4 at 225*).[7]

[7] Some literature indicates that there are three populations of Chinook salmon in the Klamath River Basin: 1) fall-run; 2) late fall-run; and 3) spring run. (*KTr-CWH-Ex. 4 at 225*).

2A-27. The majority of adult fall-run Chinook salmon enters the river to spawn in early September and continues through late October. Although the optimal temperature for adult Chinook salmon is below 14^{o} C, they can withstand temperatures exceeding 20^{o} C for short periods of time. It takes approximately 2 to 4 weeks after entering the river to reach the spawning grounds, where the adult fall-run Chinook salmon spawns and dies. This spawning period coincides with the declining temperatures, which by early November are within the optimal range for the developing embryos (i.e., 4-12^{o} C). (*KTr-CWH-Ex. 4 at 225-26*).[8]

2A-28. The record evidence shows that juvenile fall-run Chinook salmon begin outmigration to the ocean as early as January and migration is complete by the beginning of April. Juvenile Chinook salmon are thermally tolerant and can withstand temperatures exceeding 20^{o} C provided there is abundant food, thermal refugia (i.e., areas of cool water where the fish can seek refuge when the water temperature becomes to warm), and other conditions are not stressful. (*Aug. 24, 2006 Tr. at 202:9-12, 212:5-10*; *KTr-CWH-Ex. 4 at 226-27; KTr-LKD-Ex. 13 at 6, 7-8*).

2A-29. Historically, the success of fall-run Chinook salmon in the drainage basin above Iron Gate Dam was associated with the thermally moderate spawning and incubation environments (which included spring-fed streams and/or areas of strong groundwater input). In addition, the warming, nutrient-rich waters also provided excellent habitat during the spring for sub-yearling Chinook. (*NGO Ex. 3 at 6; NGO Ex. 19*).

2A-30. The fall-run Chinook salmon in Bogus and Scott Creeks are most suitable to conditions above Iron Gate Dam. (*KTr-CWH-Ex. 13 at 17; NGO Ex. 3 at 7; NGO Ex. 19*).

[8] Historically, fall-run Chinook salmon entered the river to spawn in July, peaked in August, and they were largely completed by September. Today, the time the fall-run Chinook salmon enter the river to spawn has shifted by 2 to 4 weeks presumably because the high temperatures in the main stem Klamath River has become unfavorable for the adult salmon or because of excessive harvest of early run fish. (*KTr-CWH-Ex. 4 at 225-26*).

ii. ***Minimal stocks of spring-run Chinook salmon Suitable to Conditions above Iron Gate Dam are Available to use Prescribed Fishways***

2A-31. Today, wild spring-run Chinook salmon have been significantly reduced. The vast majority of Chinook salmon is fall-run. (*KTr-CWH-Ex. 4 at 225 and 229; NGO Ex. 3 at 8-9; NGO Ex. 19*).

2A-32. Habitat degradation is the primary cause of the decline of spring-run Chinook salmon in the Klamath system. (*KTr-CWH-Ex. 4 at 229-30*).

2A-33. Like Coho salmon, spring-run Chinook salmon has a stream-type life history (meaning that the juveniles remain in the stream for one year or more before outmigrating to the ocean). (*KTr-CWH-Ex. 4 at 229*).

2A-34. Unlike adult fall-run Chinook salmon that spawn soon after reaching their spawning habitat, adult spring-run Chinook salmon enter the river before they are ready to spawn and reside in deep pools for 2-4 months before they spawn. (*KTr-CWH-Ex. 4 at* 229).

2A-35. Adult spring-run Chinook salmon enter the Klamath system to spawn in April through July and aggregate in deep pools where they hold until September. Water temperatures below 16^{o} C are generally regarded as optimal for adult spring-run Chinook salmon. However, in Salmon River located below Iron Gate Dam, temperatures of pools holding spring-run Chinook salmon often exceed 20^{o} C. (*KTr-CWH-Ex. 4 at 229*).

2A-36. Spawning peaks in October, juvenile Chinook salmon emerge between March and July, rear through the summer and fall, and migrate to the ocean in the following spring. (*KTr-CWH-Ex. 4 at 229*).

2A-37. The record evidence demonstrates that the Lower Williamson and Wood Rivers provide the best near term potential sites for producing spring-run Chinook salmon above Iron Gate Dam. The North Fork Sprague also has significant potential assuming effective habitat rehabilitation occurs. (*NGO Ex. 3 at 7-8; NGO Ex. 19*).

2A-38. However, finding suitable candidates of wild spring-run Chinook salmon might be problematic. Currently, the spring-run Chinook salmon in the Salmon River provide the only alternative for using wild fish in the reintroduction effort but that stock of Chinook salmon is also not highly abundant. (*KTr-CWH-Ex. 13 at 17-18; NGO Ex. 3 at 8-9; NGO Ex. 19*).

2A-39. Further, deteriorating water temperatures in the summer are likely to block migration of adult spring-run Chinook salmon before they reach suitable holding or natal areas. (*KTr-CWH-Ex. 13 at 11*).

iii. *Stocks of Coho Salmon Suitable to the Conditions above Iron Gate Dam are Available to use Prescribed Fishways*

2A-40. The findings of facts in USFWS/NMFS Issue 7 addressing Coho salmon are incorporated herein.

2A-41. The evidence shows suitable stocks Coho salmon are available to used prescribed fishways above Iron Gated Dam. (*FOF 7-1 through 7-15*).

iv. *Stocks of Steelhead Suitable to the Conditions above Iron Gate Dam are Available to use Prescribed Fishways*

2A-42. Steelhead trout are the most widely distributed anadromous salmonids in North America. They have been able to succeed in a wide variety of habitat because of their keen ability to adapt to changing conditions, higher physiological tolerance than other salmonids, and ability to spawn more than once. This variability ensures that runs of steelhead can continue through periods of adverse conditions. (*KTr-CWH-Ex. 4 at 230*-31).[9]

2A-43. Adult steelhead trout enter the Klamath River to spawn from August to February. Spawning, which takes place any time from January through April, peaks in February and March. (*Kr-CWH-Ex. 4 at 231*).

2A-44. Juvenile steelhead trout emerge in the spring and most spend approximately two years in freshwater before outmigrating to the ocean. Although juvenile steelhead trout demonstrate a preference for cold water temperatures (of 15-19^{o} C), they can withstand incrementally higher temperatures exceeding 22^{o} C provided food is abundant and by finding thermal refuge or by living in areas where nocturnal temperatures drop below the thermal threshold. (*Aug. 24, 2006 Tr. at 213:20-214:6; KTr-LKD-Ex. 13 at 8-9; KTr-CWH-Ex. 4 at 231*).

[9] The evidence suggests that like Chinook salmon, steelhead trout may be divided into two population: a) winter steelhead (ocean-maturing); and b) summer steelhead (stream-maturing). (*KTr-CWH-Ex. 4 at 230*). The summer steelhead trout is on the verge of extinction and is not addressed in this proceeding. (*KTr-CWH-Ex. 4 at 233*).

2A-45. Historical numbers of steelhead trout in the Klamath are unknown, but total run sizes in the 1960s were estimated at 170,000. In the 1980s, the estimated population numbers dropped to 100,000 and the numbers are still declining to the extent that now the winter steelhead trout is considered to be at risk of extinction. (*KTr-CWH-Ex. 4 at 231-32*).

2A-46. Habitat that is presently suitable for anadromous wild steelhead is more widespread in the upper basin than is habitat suitable for Chinook salmon. (*NGO Ex. 3 at 9; NGO Ex. 19*). This habitat is presently being used in varying degrees by resident rainbow/redband trout. (*NGO Ex. 3 at 9; NGO Ex. 19*).

2A-47. Many streams or segments of streams contain fair to good steelhead habitat above Iron Gate Dam. (*NGO Ex. 3 at 9*). While access to habitat for steelhead trout might be a problem because of gradients, it is critical because the diversity of life history strategies enables the fish to adapt to changing environmental conditions and habitat (*Aug. 23, 2006 Tr. at 24:21-26:19; 63:9-65:9; 68:22-69:10; NGO Ex. 3 at 9*)

2. FINDINGS OF FACT CONCERNING USFWS/NMFS ISSUE 2(B)

2B-1. The pathogens present below Iron Gate Dam include: *Ceratomyxa Shasta* (*C. Shasta*); *Ichthyophithirius multifiliis* (*Ich*); *Flavobacterius columnaris* (*F. columnaris*); *Paravicapsula minibicornis* (*P. minibicornis*); and *Trematode metacercaria*. (*Aug. 24, 2006 Tr. at 39:11-40:5, 199:2-200:1; Aug. 25, 2006 Tr. at 42:18-25; NMFS/FWS-Issue 2B-Foott-Ex. 1 at 2:1-3:3;NMFS/FWS-Issue 2B-Foott-Ex 5 at 5; CDFG Cox Ex. 1 at 3:8-23 and 4:20-21; NMFS/FWS PFF 2B.1; NGO PFF2B.2; Indian Tribe PFF 2B.1; Appendix to Reply of PacifiCorp and Siskiyou County Responses to Proposed Findings on USFWS/NMFS Issues at 14*).

2B-2. For the most part, the pathogens existing in the lower basin historically and currently exist in the upper basin of the Klamath River above Iron Gate Dam. (*Aug. 24, 2006 Tr. at 199:1-8 and 199:22-200:12; NGO PFF 2B.2*).

2B-3. The existence of virus *Infectious Hematopoietic Necrosis* (*IHN*) in the Klamath River system is exceedingly rare. (*Aug. 24, 2006 Tr. at 199:10-11; NMFS/FWS-Issue 2B Foott-Ex. 1 at 2:4-5; CDFG Cox Ex. 1 at 4:2-13; see also NMFS/FWS PFF 2B.11; Indian Tribes PFF 2B.2; Appendix to Reply of PacifiCorp and Siskiyou County Responses to Proposed Findings on USFWS/NMFS Issues at 16; but see Aug. 25, 2006 Tr. at 43:22-44:6; NMFS/FWS FF 2B.12; Appendix to Reply of PacifiCorp and Siskiyou County Responses to Proposed Findings on USFWS/NMFS Issues at 17*).

2B-4. To date, no research or studies have been performed to detect the occurrence of *IHN* in the upper basin of the Klamath River. (*Aug. 24, 2006 Tr. at 199: 12-15; Aug. 25, 2006 Tr. at 44:7-9*).

2B-5. There is insufficient evidence in the record to make a determination whether *IHN* exists in either the upper or the lower basins of the Klamath River.

2B-6. In addition, multiple surveys on adult and juvenile Chinook salmon in the Klamath River show that *Renibacterium salmoniranrum* (*R. salmoniranrum*), a rare, insignificant bacterial pathogen, is present in the lower basin. (*NMFS/FWS-Issue 2B-Foott-Ex. 1 at 2:15-17 and 3:25-4.4; see also NMFS/FWS PFF 2B.2; Indian Tribes PFF 2B.3, NGO PFF at 2B.3; Appendix to Reply of PacifiCorp and Siskiyou County Responses to Proposed Findings on USFWS/NMFS Issues at 14 and 18*).

2B-7. Like *IHN*, there is a lack of information concerning the presence of *R. salmoniranrum* in the upper basin. (*NMFS/FWS-Issue 2B-Foott-Ex. 1 at 3:13-16, see also NMFS/FWS PFF 2B.2; Indian Tribes PFF 2B.3, NGO PFF at 2B.3; Appendix to Reply of PacifiCorp and Siskiyou County Responses to Proposed Findings on USFWS/NMFS Issues at 14 and 18*).

2B-8. Nevertheless, because of its low levels, *R. salmoniranrum* does not appear to pose a significant risk of disease in the salmonid population in the Klamath River system, and consequently the bacteria will not pose a significant threat to fish in the upper basin. (*NMFS/FWS-Issue 2B-Foott-Ex. 1 at 3:6-11; NMFS/FWS-Issue 2B-Foott-Ex. 4 at 7-8; see also NMFS/FWS PFF 2B.2; Indian Tribes PFF 2B.3, NGO PFF at 2B.3; Appendix to Reply of PacifiCorp and Siskiyou County Responses to Proposed Findings on USFWS/NMFS Issues at 14 and 18*).

2B-9. Similarly, parasitic *Trematode Metacercaria* present in juvenile and adult Chinook salmon do not appear to present a significant health threat to resident fish in the upper Klamath. (*NMFS/FWS-Issue 2B-Foott-Ex. 1 at 3:6-11; NMFS/FWS-Issue 2B-Foott-Ex. 4 at 7-8; see also NMFS/FWS PFF 2B.2; Indian Tribes PFF 2B.5; Appendix to Reply of PacifiCorp and Siskiyou County Responses to Proposed Findings on USFWS/NMFS Issues at 14 and 18*).

2B-10. *F. columnaris* and *Ich* are ubiquitous in freshwater systems, and both are present throughout the Klamath River system above and below Iron Gate Dam. (*NMFS/FWS-Issue 2B Foott-Ex. 1 at 2:12-18; 3:1-3; CDFG Cox Ex. 1 at 3:11-15; see also NMFS/FWS PFF 2B.3; NGO PFF 2B.4*). *F. columnaris* causes disease at higher temperatures. (*Aug. 25, 2006 Tr. at 40:4-5*).

2B-11. Likewise, *C. Shasta* and *P. minibicornis* are myxozoan parasites that are found throughout the Klamath River. (*NMFS/FWS-Issue 2B Foott-Ex. 1 at 2:18-23; <u>see</u> <u>also</u> NMFS/FWS PFF 2B.4; Appendix to Reply of PacifiCorp and Siskiyou County Responses to Proposed Findings on USFWS/NMFS Issues at 15*).

2B-12. It is recognized that disease is the outcome of the interaction of a susceptible host and a pathogen in a poor environment that favors the pathogen and places stress on the fish. The passage of adult fish into a poor upper river environment would have disease, possibly pre-spawning mortality as a likely outcome. (*Aug. 25, 2006 at 36:15-37:8; PacifiCorp PFF 178; CDFG-Cox-Ex. 1 at4:23-5:25*).

2B-13. The incidence of infection from pathogens is seasonal during summer months when water temperatures and algae blooms are high thereby resulting in poor water quality. (*Aug. 25, 2006 Tr. at 40:21-41:9; 47:21-48:20; 50:1-18; NMFS/FWS-Issue 2B-Foott-Ex. 1 at 3:17-20*).

2B-14. In the upper Klamath, the water quality is only poor during the summer, but for much of the year the water system is quite good. (*Aug. 25, 2006 Tr. at 40:20-41:2*). By the time the water quality deteriorates, many of the adult salmonid most likely would have died because its life cycle was complete whereas others would have died as a result of infection from the pathogen. (*Aug. 25, 2006 Tr. at 41:8-9*).

2B-15. Opening up the upper Klamath to anadromous salmonids would not produce adverse results because adult salmonids would be passed late enough in the fall that water conditions in the upper basin would be good. (*Aug. 25, 2006 Tr. at 41:22-25*).

2B-16. As for outmigration, juvenile salmonids would be out of the system prior to water conditions deteriorating and becoming conducive to disease development. (*Aug. 25, 2006 Tr. at 42:1-5*).

2B-17. *C. shasta* has been detected in the lower Williamson River, a tributary of Upper Klamath Lake, and in areas below Iron Gate Dam in nearly equal levels. (*Aug.25, 2006 Tr. at 39:13-18; NMFS/FWS PFF 2B.8*).

2B-18. Within the Klamath River system, steelhead trout are resistant to *C. Shasta*, a disease causing pathogen that adversely affects juvenile Chinook salmon. (*Aug. 24, 2006 Tr. at 36:1-21, 68:18-22, 70:7-20, 197:17-20; Aug. 25, 2006 Tr. at 50:13-18; NMFS/FWS-Issue 2B Foott-Ex. 1 at 4:24 to 5:2; NMFS/FWS-Issue 2B-Foott-Ex. 7 at 12-13; NMFS/FWS-Issue 2C-Hooton-Ex. 1 at 5:12-16; KTr-LKD-Ex. 13 at 8; NMFS/FWS PFF 2B.5, 2B.9, and 2B.10; NGO PFF 2B.5; Appendix to Reply of PacifiCorp and Siskiyou County Responses to Proposed Findings on USFWS/NMFS Issues at 16*).

2B-19. Coho salmon are less resistant to *C. Shasta* than steelhead trout, but are more resistant to the virus than Chinook salmon. (*Aug.24, 2006 Tr. at 197:21-22; Aug. 25, 2006 Tr. at 50:13-18; NMFS/FWS PFF 2B.9*).

2B-20. Generally, with the exception of *F. columnaris* and *Ich*, pathogens associated with anadromous fish do not impact non-salmonids. (*NMFS/FWS-Issue 2B Foott-Ex. 1 at 3:25-4:3; NMFS/FWS PFF 2B.6; NGO PFF 2B.4; Appendix to Reply of PacifiCorp and Siskiyou County Responses to Proposed Findings on USFWS/NMFS Issues at 15*). For instance, both *IHN* and *P. minibicornis* are salmonid pathogens for which there exists no data associating them with non-salmonid fish in the upper Klamath. (*NMFS/FWS-Issue 2B Foott-Ex. 1 at 4:1-3*).

2B-21. In the life cycle of *C. Shasta*, the parasite multiplies primarily within the adult fish under low water temperatures of approximately 10-15 C and potentially, under certain circumstances, infects other fish if the parasite is released into the water column and is ingested by the Polykete worm of the species, manucia speciosa. (*Aug. 24, 2006 Tr. at 192:5-194:18; KTr-LKD-Ex. 13 at 8*).

2B-22. Since a majority of the pathogens currently found in the lower basin also exist in the upper basin of the Klamath River system, a logical conclusion is that migration of anadromous fish would not be a significant factor contributing to disease on resident fish. (*Aug. 25, 2006 at 52:1-20; NMFS/FWS-Issue 2B-Foott-Ex. 1 at 3:24-25, 4:7-8, and 4:16-19; CDFG-Cox-Ex. 1 at 5:6-9 and 6:6-11; NMFS/FWS PFF 2B.7 and 2B.15; NGO PFF 2B.6, Indian Tribes PFF 2B.6 and 2B.7*).

2B-23. To the extent that migrating anadromous fish carry a unique highly virulent pathogen, disease management protocols could be used as is customary. (*KTr-CWH-Ex.17 at 16 and 85-87; KTR-CWH-Ex. 34 at 8:168-74; Indian Tribes PFF 2B.9*).

3. *FINDINGS OF FACT CONCERNING USFWS/NMFS ISSUE 2(C)*

2C-1. Resident rainbow/redband trout are distinct from anadromous steelhead trout. Although the two species are similar (both are designated *O. Mykiss*), the life histories are different. (*Aug. 22, 2006 Tr. at 160:2-15; Aug. 24, 2006 Tr. at 42:16-43:13, 43:5-13; CDFG-Chesney-Ex. 1 at 4:18-20; see also NMFS/FWS PFF 2C.1; NGO PFF 2C.3; Appendix to Reply of PacifiCorp and Siskiyou County Responses to Proposed Findings on USFWS/NMFS Issues at 21-22).* After hatching and early rearing in the riverine habitat, juvenile steelhead trout out migrate to the ocean where they mature into adults before returning to their riverine habitat for spawning. By contrast, resident rainbow/redband trout spend all of their life stages in the Klamath River. (*Aug. 24, 2006 Tr. at 42:16-43:13; PAC-Ols-D-1 at 18:22-23; PAC-Carl-D-3 at 2:18; Appendix to Reply of PacifiCorp and Siskiyou County Responses to Proposed Findings on USFWS/NMFS Issues at 21-22*).

2C-2. Historically, anadromous steelhead trout extended up to and used tributaries of Upper Klamath Lake. (*FOF 2A-3; KTr-CWH-Ex. 5 at 15-16*). The close similarities between anadromous steelhead trout and resident rainbow/redband trout suggest these species historically co-existed. (*Aug. 23, 2006 Tr. at 268:8 -11; NMFS/FWS-Issue 2C-Hooton-Ex. 1 at 2:3-17; CDFG-Dean-Ex. 1 at 4:8-14; HVT-Franklin—Ex. 1 at 6:1-10; KTr-CWH-Ex. 6 at 8; NMFS/FWS PFF 2C.2, 2C.7-2C.9*). The distribution and resistance of rainbow/redband trout in Upper Klamath Lake to *C. Shasta* lends additional support that the two species co-existed and intermingled prior to the construction of Copco I Dam in 1917. (*Id.*).

2C-3. The erection of Iron Gate Dam necessarily changed the migratory behavior of anadromous fish in the Klamath River System, limiting them to habitat below the dam. (*FOF 2A-2*). Today, anadromous steelhead trout only migrate to the base of Iron Gate Dam, using nearby tributaries and main stem habitat to spawn. (*FOF 2A-3*). However, if access was provided, steelhead would migrate past Iron Gate Dam into the upper Klamath River basin. (*FOF 2A-4*).

2C-4. The habitat for the anadromous fish has been significantly reduced subsequent to the construction of the Project dams. (*Aug. 24, 2006 Tr. at 11:15-19*).

2C-5. Although environmental conditions and habitat above Iron Gate Dam have changed, anadromous fish are resilient and can adapt to most existing environmental conditions and habitat. (*Aug. 24, 2006 Tr. at 0012:10-13*; 0020:4-6).

2C-6. For instance, steelhead trout have the genetic ability to recolonize and use new habitat. (*Aug. 24 Tr. at 0011:2-0012:13; NMFS/FWS-Issue 2A-Garza-Ex. 1 at 2:8 to 3:25; NMFS/FWS-Issue 2A-Garza-Ex. 6 at 6; NMFS/FWS-Issue 2A-Garza-Ex. 8 at 13; NMFS/FWS-Issue 2A-Garza-Ex. 4 at 3; NMFS/FWS-Issue 2-Curtis Rebuttal at 4:15-17; CDFG-Dean-Ex. 1 at 3:8-17; CDFG-Pisano-Ex. 1 at 5:15-28 and 8:14-9:7; NGO Ex. 3 at 12:3-21; HVT-Franklin-Ex. 8; HVT-Franklin-Ex. 2 at 2:20-26;* see also *NMFS/FWS PFF 2A.3; Indian Tribes PFF 2A.3; NGO PFF 2A.7).*

2C-7. Resident trout have the genetic capacity to adopt anadromy and some may outmigrate to the ocean if passage exists. (*Aug. 23, 2006 Tr. at 196:16-24; KTr-CWH-Ex. 8 at 22-25; NGO PFF 2C.4*).

2C-8. While residualization (remain in freshwater) is common in juvenile hatchery steelhead trout, there is an absence of evidence of high levels of residualization in juvenile naturally-spawned steelhead trout. (*Aug. 23, 2006 Tr. at 200:13-14; NGO-Ex. 3, at 11:5-7; HVT-Franklin Ex. 1 at 5:18-22; KTr-FAE Ex. 32 at 7:3-22; NMFS/FWS PFF 2C.4, 6*).

2C-9. There are no scientific studies of the Klamath basin demonstrating that reintroduction of anadromous steelhead trout would detrimentally affect the genetic makeup of the resident trout fishery. (*Aug. 23, 2006 Tr. at 208:18-23; NGO-Ex. 3, at 11:5-7; NGO PFF 2C.7; Indian Tribes PFF 2C.7, 2C.10*). The potential for residualization is largely dependent on environmental conditions in the river and ocean. (*Aug. 23, 2006 Tr. at 196:12-197:3; NMFS/FWS-Issue 2C-Hooton-Ex. 1 at 4:12-16; Indian Tribes PFF 2C.5*).

2C-10. There is little information on the nature of any competitive interactions between steelhead and resident trout in the Klamath basin. (*NGO Ex 3, Testimony of Dr. R.. Williams at 11:13-17; KTR CWH Ex 01 at 30; NMFS/FWS PFF 2C.11*). However, research does suggest that in some circumstances, resident trout may have a competitive edge over steelhead trout. (*Testimony of Dr. R.. Williams at 11:13-17; KTR CWH Ex 01 at 30; NMFS/FWS PFF 2C.12*).

2C-11. There are many examples from nearby river systems in the Pacific Northwest that show wild anadromous steelhead trout and resident rainbow/redband trout can co-exist and maintain abundant populations without adverse consequences. The Deshutes River in Oregon, the Yakima River in Washington, and the river systems in Idaho are examples. (*NMFS/FWS-Issue 2C-Hooten-Ex. 1 at 4:8-11; KTR-Espinoza-Issue 2 Direct at 7:3-11; NGO Ex. 3 at 11:13-16; Indian Tribes PFF 2C.4; NGO PFF 2C.8*).

2C-12. The risk of residualization of rainbow/redband trout may be minimized through adaptive management. (*KTr.-Huntington-Ex. 1; NGO Ex. 3 at 11:8-12*).

4. FINDINGS OF FACT CONCERNING USFWS/NMFS ISSUE 3

3-1. The Project contains various habitat areas for resident trout including: a) the J.C. Boyle bypass reach which extends 4.3 miles from J.C. Boyle Dam to the J.C. Boyle powerhouse; 2) the J.C. Boyle peaking reach extending 17.3 miles and traversing the California/Oregon state line; 3) a 1.4 mile section between Copco II diversion dam and Iron Gate reservoir; and 4) other reservoirs within the Project reach. (*PAC-Ols-D-Ex. 1 at 20:20-22:2; CDFG-Dean-Ex. 1 at 4:19-25; NGO-Ex. 14 at 4; NMFS/FWS-Issue 3-Snedaker-Ex. 1 at 3:24-4:6, 6:15-18; CDFG-Dean-Ex. 1 at 4:19-26, 5:22-6:4; NGO-Ex. 2 at 19:7-9*).

3-2. The 1.4 mile section of river between the Copco II Diversion Dam and Iron Gate Reservoir contains marginal trout habitat. (*PAC-Ols-D-Ex. 1 at 21:21-23; PacifiCorp PFF 200; Appendix to National Marine Fisheries Service and United States Fish and Wildlife Service's Joint Post-Hearing Reply Brief at 20*).

3-3. There are a limited number of trout in the J.C. Boyle, Copco, and Iron Gate Reservoirs. (*PAC-Ols-D-Ex. 1 at 22:4-5; PacifiCorp PFF 201; Appendix to Reply of PacifiCorp and Siskiyou County Responses to Proposed Findings on USFWS/NMFS Issues at 32*).

3-4. Prior to the construction of the dams, redband trout within the Project area belonged to a single, large, intermixing population throughout the Klamath River Basin. (*NGO-Ex. 2 at 13:4-9; NGO-Ex. 14 at 4; NMFS/FWS PFF 3.1; NGO PFF 3.2; Appendix to Reply of PacifiCorp and Siskiyou County Responses to Proposed Findings on USFWS/NMFS Issues at 29 and 34*).

3-5. Although the trout sport fishery is robust in the Upper Klamath Basin, the juvenile trout from above J.C. Boyle Dam in the Oregon portion of the Klamath River are actually decreasing. (*NMFS/FWS-Issue 3-Hooton-Ex. 0A at 4:7-8, 6:15-17; Hooton-BLM-Ex. 4 at 22*).

3-6. Life history strategies (such as spawning above the J.C. Boyle Dam) are denied to the resident trout population below the dam. (*NMFS/FWS-Issue 3-Hooton-Ex. 0A at 6:17-20; Hooton-BLM-Ex. 4 at 22; NGO-Ex. 2 at 14:10-12, 17:15-18:2, 19:4-18; CDFG Dean Ex. 1 at 5:1-2; Aug. 23, 2006 Tr. at 161:13-162:17; NMFS/FWS PFF 3.5*).

3-7. Migration is one of several defining life history characteristic of trout. (*Aug. 23, 2006 Tr. at 166:23-168:7; CDFG Dean Ex. 1 at 4:19-26; NGO-Ex. 14 at 4; NGO PFF 3.3*). Their ability to migrate is one of several evolutionary advantages contributing to survival of trout in the Klamath River for millions of years through dramatic environmental changes. (*Id.)*.

3-8. The Project restricts migration of resident fish within the main stem and into and out of tributaries. (*NGO Ex. 2 at 19:12-14*). Iron Gate, Copco I, and Copco II Dams do not have fishways and currently block all upstream fish passage. Thus, the stocks above Iron Gate are isolated from counterparts in the lower basin. Further, the stocks between each of Iron Gate, Copco I, and Copco II Dams are similarly isolated. (*NGO PFF 3.5; Appendix to Reply of PacifiCorp and Siskiyou County Responses to Proposed Findings on USFWS/NMFS Issues at35*).

3-9. J.C. Boyle Dam has a fishway for migration of rainbow/redband trout. (*NGO PFF 3.6*). The current fish screen and ladder at the dam do not meet current state and federal fish passage criteria and impairs upstream migration. (*PAC-MAL-D-Ex. 4 at 7-31; NMFS/FWS PFF 3.8 and 3.9; Appendix to Reply of PacifiCorp and Siskiyou County Responses to Proposed Findings on USFWS/NMFS Issues at 32*).

3-10. The effectiveness of the fishway has declined by 98% since initial operation of the fishway in 1959. (*NGO Ex. 17 at 379; NGO Ex. 2 at 20:19-20 NMFS/FWS-Issue 3-Snedaker-Ex. 0 at 2:11-12; NMFS/FWS-Issue 3-Snedaker-Ex. 8 at 8, Hooton-BLM-Ex. 4 at 11; NGO-Ex. 2 at 14:4-10; NGO-Ex. 17 at 3; NMFS/FWS PFF 3.7; NGO PFF 3.6*). A rock cascade that starts at the entry of the fishway and extends downstream may be the cause for such limited use. (*Aug. 23, 2006 Tr. at 149:22-152:15; NGO PFF 3.6*).

3-11. PacifiCorp has agreed to improve the channel configuration below the fishway so that upstream migration of trout will no longer be impeded. (*PAC-Ols-R-Ex. 1 at 25:14*).

3-12. Improvements in efficiency to the fishway at JC Boyle Dam would result in significant trout population migration above the dam over time. (*Aug. 23, 2005 Tr. at 176:17-23; NMFS/FWS PFF 3.11*).

3-13. Spencer Creek is a highly productive spawning and rearing habitat for rainbow/redband trout. (*NGO Ex. 16 at 3; NMFS/FWS PFF 3.7*). The stock of rainbow/redband trout in the bypass and peaking reaches below JC Boyle Dam is denied the use of Spencer Creek and other suitable habitat upstream of the J.C. Boyle Dam. (*NMFS/FWS PFF 3.7*).

3-14. Historically, trout in the Copco II area would have moved up and downstream to access needed habitat. To now meet essential life history needs, trout move further downstream over Copco II Dam and utilize either the bypass reach or other tributaries of Iron Gate Reservoir. However, once they exit Copco II they cannot return as there are no upstream passage facilities. Thus, the trout population is not self-sustaining. (*NMFS/FWS-Issue 3-Snedaker-Ex. 1 at 6:15-21; NMFS/FWS- Issue 3-Snedaker-Ex. 16 at 127; NMFS/FWS-Issue 4-Hamilton-Ex. 7 at 1; NMFS/FWS PFF 3.13*).

3-15. Downstream migration of rainbow/redband trout is also adversely impacted because of the Project dams. This is due to the hydraulics at the Project dams and mortality related to unscreened flow resulting in fish passage through Project dam turbines. (*NMFS/FWS-Issue 3-Snedaker Ex. 16 at 126-130; NMFS/FWS-Issue 3-Hooton Ex. 0A at 7:10-9:14; BLM-Hooton-Ex. 3 at 7-8*).

3-16. The Project's limitation on riverine migration may have reduced the genetic diversity of the remaining stocks within the Project reaches. (*NGO Ex. 2 at 3:6-10, 21:1-9; NGO Ex. 14, Figure 3 at 103; NGO PFF 3.8; NMFS/FWS PFF 3.3-3.5*).

5. FINDINGS OF FACT CONCERNING USFWS/NMFS ISSUE 4

4-1. J.C. Boyle, Copco, and Iron Gate Dams support populations of resident fish including native and non-native species. Popular sport fisheries occur in each reservoir targeting primarily bass, perch, and catfish. Rainbow trout, resident lamprey, and Lost River/shortnose sucker fish also occur in the reservoirs. (*NMFS/FWS-Issue 4- Hamilton-Ex. 12 at 1*).

4-2. It is estimated that "several tens of thousands of resident fish" are annually entrained at "each of the Projects" facilities. (*NMFS/FWS-Issue 4-Hamilton-Ex. 12, at 28; NMFS/FWS-Issue 4-Hamilton-Ex. 1, at 6:7-9; NMFS/FWS-Issue 4-Hamilton-Ex. 14 at 1; NMFS/FWS-Issue 4-Hamilton-Ex. 10 at 3; NMFS/FWS-Issue 4-Hooton-Ex. 14, at 112; NMFS/FWS-Issue 4-Hooton-Ex. 1, at 5:3-5; HVT-Steward-Ex. 1 at 3:19-20; NMFS/FWS PFF 4.5; Indian Tribes PFF 4.1*).

4-3. Entrainment occurs when fish are drawn into Project facilities, such as power canals, turbines, and tailraces. When drawn into turbine intakes, fish can be subject to injury and mortality. (*NMFS/FWS-Issue 4-Hamilton-Ex. 1, at 4:22-25; NMFS/FWS-Issue 4-Hamilton-Ex. 5, at 1; NMFS/FWS PFF 4.1; Appendix to Reply Brief of PacifiCorp and Siskiyou County, at 37*).

4-4. Mortality from entrainment can occur at each Project facility, thus fish surviving through one powerhouse could be exposed to potential cumulative mortality. (N*MFS/FWS-Issue 4-Hooton-Ex. 1, at 5:19-21; HVT-Steward-Ex. 39, at 2:3-7; NMFS/FWS-Issue 4-Hooton-Ex. 14, at 113*).

4-5. Once entrained, the fish face a high risk of mortality. For juvenile fish, the risk is between 10-30%. (*PAC-Ols-D-1 at 27*).

4-6. Entrainment mortality removes fish that would otherwise add to the population base downstream of the dam. (*NMFS/FWS-Issue 4-Hamilton-Ex. 12 at 29*).

4-7. Iron Gate, Copco 1, and Copco 2 Dams are not equipped with fish screens or downstream bypass facilities to minimize fish entrainment. (*NMFS/FWS-Issue 4-Hamilton-Ex. 1, at 5:5-6; Appendix to Reply Brief of PacifiCorp and Siskiyou County, at 37*).

4-8. J.C. Boyle Dam has fish screening and bypass systems in place, but they do not conform to current fish screen criteria for resident and anadromous fish. (*NMFS/FWS-Issue 4-Johnson-Ex. 1, at 4:21 to 6:8; NMFS/FWS-Issue 4-Hamilton-Ex. 1, at 5:6-7; NMFS/FWS-Issue 4-Johnson-Ex. 5, at 65-66; Appendix to Reply Brief of PacifiCorp and Siskiyou County, at 37*).

4-9. The seals at J.C. Boyle Dam have rendered the fish screens partially ineffective, allowing fish to be entrained in the power canal and turbines. (*PAC-Ols-R-1, at 26:13-17 and 27:1-3; Aug. 23, 2006 Tr. at 213:13 to 214:13; NMFS/FWS-Issue 4-Hooton-Ex.1, at 4:4-5; NMFS/FWS-Issue 3-Snedaker-Ex. 1, at 3:12-14; Appendix to Reply Brief of PacifiCorp and Siskiyou County, at 38*).

4-10. The J.C. Boyle facility uses Francis turbines, at an operational head of 440 feet. A 1987 report prepared by the Electric Power Research Institute (EPRI) concluded that fish mortality from entrainment at hydroelectric projects using Francis turbines averaged 24 percent. The EPRI report found that entrainment mortality at hydroelectric projects using Francis turbines with operational head greater than 335 feet ranged from 33-48%. (*NMFS/FWS-Issue 4-Hooton-Ex. 1, at 5:23 to 6:2; NMFS/FWS-Issue 4-Hooton-Ex. 7, at 51, Table 4-1; NMFS/FWS-Issue 4-Johnson-Ex. 1, at 2:11-15; Aug. 22, 2006 Tr. at 186:1-17); CDFG Hughes Ex. 1, at 4:12-18; HVT-Steward-Ex. 1, at 2:17-20; NMFS/FWS-Issue 4-Hamilton-Ex. 12, at 28; NMFS/FWS PFF 4.10; Indian Tribes PFF 4.3; Appendix to Reply Brief of PacifiCorp and Siskiyou County, at 39*).

4-11. In light of the large percentage of river flow that is diverted into the J.C. Boyle power canal, the operation of Francis turbines, and the high operational head of 440 feet, fish mortality from entrainment at the J.C. Boyle project is likely in the higher end of the mortality ranged as described in the Electric Power Research Institute report. (*NMFS/FWS-Issue 4-Hamilton-Ex. 12, at 28; NMFS/FWS-Issue 4-Hooton-Ex. 1, at 5:23 to 6:5; NMFS/FWS-Issue 4-Hamilton-Ex. 1, at 5:15-17; NMFS/FWS-Issue 4-Johnson-Ex. 1, at 2:11-15; NMFS/FWS PFF 4.11; Appendix to Reply Brief of PacifiCorp and Siskiyou County, at 40*).

4-12. PacifiCorp recognizes that entrainment at the J.C. Boyle Dam is a "problem that needs to be addressed." (*Aug. 23, 2006 Tr. at 214: 4-10; PAC-Ols-R-1 at 26: 21-27:1*).

4-13. PacifiCorp has not conducted site-specific studies on the mortality levels of entrained resident fish at Project facilities, but did conduct a literature review that provides insight into the potential of the fish entrainment at J.C. Boyle, Iron Gate, and Copco Dams. *NMFS/FWS-Issue 4-Hamilton-Ex. 1, at 5:20-23; NMFS/FWS-Issue 4-Hamilton-Ex. 13, at 2; NMFS/FWS-Issue 4-Hamilton-Reb. Ex. 1, at 2:7-10; NMFS/FWS-Issue 4-Hamilton-Reb. Ex. 5, at 21; PAC-Ols-D-1, at 26:2-9; Aug. 22, 2006 Tr. at 178:16-19*).

4-14. Precise estimates of the number of fish entrained at the facility are not available. However, extrapolating from data at other comparable FERC Facilities, PacifiCorp estimates a median annual entrainment of 75,655 fish for reservoirs the size of J.C. Boyle, and 115,979 fish for reservoirs the size of Copco and Iron Gate. (*NMFS/FWS-Issue 4-Hooton-Ex. 14 at 112*).

4-15. In the Project Area, non-native species are entrained to a greater extent than native species. (*NMFS/FWS-Issue 4-Hamilton-Ex. 12 at 17 and 29; PAC-Ols-D-1 at 26:20-21; PAC-Ols-D-15*). This may be the result of the relative abundance of non-native species vis-à-vis native species. (*PAC-Olson-D-1 at 27-28*).

4-16. The J.C. Boyle reservoir contains sucker fish (shortnose and lost River) that are listed under the federal Endangered Species Act and those fish are susceptible to entrainment. (*PAC-Olson-D-15 at 8 and 10*).

4-17. Habitat degradation has been recognized as a common contributor to the decline in the abundance of shortnose and lost river sucker fish in the Klamath basin. (*KTr-CWH-Ex. 1 at 4*).

4-18. Records from canal salvage operations at the J.C. Boyle power canal show that resident fish, in particular resident trout and sucker fish, are entrained and possibly killed in the power canal each year. (*NMFS/FWS-Issue 4-Hooton-Ex. 1, at 5:6-17; NMFS/FWS-Issue 4-Hooton-Ex. 15; NMFS/FWS-Issue 4-Hamilton-Ex. 1, at 5:17-19 and 6:3-5; NMFS/FWS-Issue 4-Hamilton-Ex. 14, at 1; Aug. 23, 2006 Tr. at 212:25-213:21; Appendix to Reply Brief of PacifiCorp and Siskiyou County, at 38*).

4-19. Salvage records show the entrainment of over 690 trout into the J.C. Boyle reach during salvage operations between 1995 and 2002. (*NMFS/FWS-Issue 4-Hamilton-Ex. 14, at 1*). During that same period of time, it appears that only 2 sucker fish were entrained. (*NMFS/FWS-Issue 4- Hooton-Ex. 15, at 3-4 (Fish Salvage Data Table*). In 2003, J.C. Boyle fish salvage totaled 86 trout and 17 suckers. (*NMFS/FWS-Issue 4-Hamilton-Ex. 14, at 1; NMFS/FWS-Issue 4-Hooton-Ex. 15 at 2-3*).

4-20. Canal salvage data provides a snapshot of the number of fish entrained at the time that salvage operations are performed, and thus such data represents only a small fraction of the total number of fish actually entrained each year. (*NMFS/FWS-Issue 4-Hamilton-Ex. 1, at 6:3-5; NMFS/FWS-Issue 4-Hamilton-Ex. 14, at 1; NMFS/FWS-Issue 4-Hooton-Ex. 1, at 5:10-17; NMFS/FWS PFF 4.8*).

4-21. Since sucker fish are bottom dwellers, they are less prone to entrainment through the shallow intakes at Copco and Iron Gate Dams. (*NMFS/FWS-Issue 4-Hamilton-Ex. 12 at 17*). Moreover, nearly all of the non-larval sucker fish appear to be too large to pass through the existing trash racks at the powerhouse intakes at Copco and Iron Gate. (*PAC-Ols-D-1 at 30:1-6; PAC-Ols-D-15*).

4-22. While the vast majority of fish entrained consists of small juvenile fish, the record shows that adult fish are also susceptible of being entrained and killed. (*PAC-Ols-D-1 at 27; NMFS/FWS-Issue 4-Hooton-Ex. 1 at 3; NMFS/FWS-Issue 4- Hooton-Ex. 18*). (Id.).

4-23. In 1959, the year after J.C. Boyle Dam was completed, adult redband trout migrated from what are now known as the peaking and bypass reaches in large numbers to spawn in Spencer Creek and then return to the reaches after spawning. (*NMFS/FWS-Issue 4-Hooton-Ex. 13 at 22*). Currently, the peaking reach life history appears to be gone and the bypass reach life history has been reduced to less than 10% of historical abundance and is composed of significantly smaller trout. (*Id.*).

4-24. Resident trout are a migratory species. Because Spencer Creek, located upriver of the J.C. Boyle facility, is a primary spawning and early rearing area for resident trout within the Project area, it is important that adult spawners from the river below the dam and juvenile trout from Spencer Creek both are able to successfully migrate upstream and downstream past J.C. Boyle Dam. (*NMFS/FWS-Issue 4-Hooton-Ex. 1, at 3:6-17; NMFS/FWS-Issue 4-Hooton-Ex. 11, at 2; NMFS/FWS-Issue 4-Hamilton-Ex. 1, at 4:8-12; NMFS/FWS-Issue 4-Hamilton-Ex. 14, at 2; NMFS/FWS-Issue 4-Hamilton-Ex. 17, at 4; NMFS/FWS-Issue 4-Hamilton-Ex. 13, at 4; Aug. 23, 2006 Tr. at 161:5 to 162:18; Aug. 24, 2006 Tr. at 64:20-24; NMFS/FWS PFF 4.12; Appendix to Reply Brief of PacifiCorp and Siskiyou County at 40.).*

4-25. While it is true that the present population of resident trout is robust and supports one of the finest trout fisheries on the West Coast, the losses of juvenile trout through entrainment at the Project could, in the long run, adversely affect trout abundance and distribution. (*NMFS/FWS-Issue-4-Hooton Ex. 1 at 6:9-13; NMFS/FWS-Issue 4-Hamilton-Ex. 1 at 4:16-16 and 7:3-4; NMFS/FWS-Issue 4-Hamilton-Ex. 17 at 4; HVT-Steward-Ex. 39 at 1:17-22*).

6. FINDINGS OF FACT CONCERNING USFWS/NMFS ISSUE 6

6-1. The findings of fact in USFWS/NMFS Issue 2A are incorporated herein.

6-2. Habitat is deemed "suitable" if it can be used successfully at least some of the time by one or more life stages of a Coho salmon. (*NMFS/FWS-Issue 6-Smith-Ex. 1 at 2:18-2:24; PAC-MAL-D-30 at 65; HVT-Franklin-Ex. 2 at 2:20-2:26; KTr.-CWH-Ex. 35 at 2:22-3:6; KTr-CWH-Rebuttal-Ex. 6 at 5:14-6:2; Aug. 22, 2006 Tr. at 197:12-198:23; Aug. 24, 2006 Tr. at 1283:25-285:20; NMFS/FWS PFF 6.1; Indian Tribes PFF 6.1; NGO PFF 6.1*).[10]

6-3. Anadromous fish are highly adaptive to differing conditions typically can readily migrate into and colonize new habitat or recolonize historic habitat. (*Aug. 24, 2006 Tr. at 11:24-15:9; NMFS/FWS-Issue2A-Garza-Ex. 1 at 2:8-3:25; NMFS/FWS-Issue 2A-Garza-Ex. 6 at 6; NMFS/FWS-Issue 2A-Garza-Ex. 8 at 13; NMFS/FWS-Issue 2A-Garza-Ex. 4 at 3; HVT-Franklin-Ex. 8; HVT-Franklin-Ex. 2 at 2:20-2:26; CDFG-Pisano-Ex. 1 at 8:14-9:*7).

[10] The transcript indicates that the Federal Fisheries Services' definition of "suitable habitat" appears on 51 of *PAC-MAL-D-30* (NMFS/FWS Responses to Discovery Requests). The definition of "suitable habitat" actually appears on page 65 of that exhibit. It is a response to Interrogatory 51.

6-4. While the exact amount of suitable habitat available for anadromous fish is uncertain, the record evidence shows that steelhead trout, Chinook salmon, Coho salmon, and Pacific lamprey will likely find suitable spawning and rearing habitat in the Project-bound area. (*Aug. 24, Tr. at 28:24-29:1; Aug. 25, 2006 Tr. at 75:2-11; Malone Supplemental Rebuttal Ex., Attachment 2 at 1; NMFS/FWS-Issue 6-Smith-Ex. 1 at 2:1-8; KTr-CWH-Rebuttal-Ex. 6 at 2:16-17 and 3:7-18; KTr-FAE-Rebuttal Ex. 7 at 6:18-20*).

6-5. Spawning and rearing habitat requirements are similar among resident rainbow/redband trout, anadromous steelhead trout, anadromous Coho salmon, and anadromous Chinook salmon. Habitat suitable for redband trout will generally be suitable for steelhead trout, Coho salmon, and Chinook salmon. (*HVT-Franklin-Ex. 12 at 3:4-8 and 3:19-25; NMFS/FWS-Issue 2-Curtis Rebuttal-Ex. 1 at 2:10-15*).

6-6. Stocks of resident rainbow/redband trout are self-sustaining in habitat above Iron Gate Dam, suggesting that anadromous stocks will probably do the same. (*HVT-Franklin-Ex. 12 at 1:14-4:25; PAC-Kirk-D-1 at 2:6-3:7; PAC-Carl-D-7 at 2-68; PAC-Bald-D-2 at 28; KTr-CWH-Ex. 21 at 2*).

6-7. The record evidence shows that Coho and Chinook salmon may use tributary habitat with a gradient of up to 7%. (*Aug. 22, 2006 Tr. at 208:19-21*). Steelhead trout may use tributary habitat with gradients as high as 15% and could therefore re-colonize areas inaccessible to Coho or Chinook salmon. (*Aug. 22, 2006 Tr. at 44:1-46:11; KTr-CWH-Ex 7, Tables at 6-8*).

6-8. USFWS/NMFS Issue 2A-47 is incorporated herein.

6-9. Expansive bottomland areas with abundant low-gradient channels, which are preferred salmon habitat, are more common in the Upper Klamath Basin than in the remainder of the Klamath system. Such areas are particularly extensive above Keno Dam and Upper Klamath Lake, where spring-fed streams include the Williamson and Wood Rivers, smaller springbrooks flowing into these two rivers, Sprague River, and various streams. (*KTr-CWH-Ex. 1 at 5*).

6-10. The record, however, shows that there are approximately 28 miles of suitable habitat for anadromous fish to spawn in the main stem provided gravel is placed in those areas. (*NMFS/FWS-Issue 7-White Ex. 14, Table 3 at A-21*). Such habitat includes areas cooled by springs (thermal refugia) in the J.C. Boyle bypass (*Aug. 25, 2006 Tr. at 98:10-14 and 101:20-102:7; NMFS/FWS-Issue 6-Sneadker-Ex. 1 at 5:18-6:2; NMFS/FWS-Issue 4-Hooton-Ex. 1 at 3:6-9; KTr-Dunsmoor Direct-Issue 2 at 3:6-9 and 4:3-4:5; HVT-Franklin-Ex. 2 at 3:9-22; KTr-CWH-Ex. 7 at 6-8; NMFS/FWS-Issue 6-Smith-Ex. 1 at 1:19-3:5; CDFG-Pisano-Ex. 6*).

6-11. There are at least 12 miles of perennial stream reaches within the Project area that have gradients at or below 15%. (*NMFS/FWS-Issue 7-White-Ex. 14, Table 3 at A-21*). These include: Jenny, Fall, Shovel, and Spencer Creeks, which presently support spawning by resident salmonids thereby suggesting that those habitat would be suitable for use by anadromous fish. (*Aug. 24, Tr. at 65:10-15; NMFS/FWS-Issue 6-Smith-Ex. 1 at 2:18-24; PAC-Ols-D-1 at 6:18-20, 7:22-8:11, and 22:19-23; NMFS/FWS-Issue 6-Hamilton-Ex. 1 at 4:12-5:9; NMFS/FWS-Issue 4-Hooton-Ex. 1 at 3:6-9; KTr-CWH-Ex. 20 at 82; KTr-CWH-Ex. 21 at 2*).

6-12. The only area in Fall Creek that is not suitable habitat for anadromous fish is the portion of the stream below the PacifiCorp diversion to the penstock and the powerhouse. Further, Fall Creek upstream of the Spring Creek diversion experiences low flows in the summer months which would also make it unsuitable habitat for anadromous fish. (*KTr-CWH-Ex. 20 at 82*).

6-13. Fall and Shovel Creeks have the water temperatures most suited for juvenile Coho salmon rearing. Spencer Creek also has a reach extending 2.6 to 9.5 km above its mouth that contains abundant beaver ponds which, if they include pockets of cool groundwater, could provide good summer rearing habitat for Coho salmon. (*KTr-CWH-Ex. 21 at 3*).

6-14. There are also approximately 18 miles of intermittent stream reaches within the Project area that have gradients at or below 15%. (*NMFS/FWS-Issue 7-White-Ex. 14, Table 3 at A-21; NMFS/FWS-Issue 7-Simondet Rebuttal Ex. 1 at 4:6-11; HVT-Franklin-Ex. 2 at 2:20-26; NMFS-FWS-Issue 6-Hamilton-Ex. 1 at 5:11-7:17; NMFS/FWS-Issue 6-Smith-Ex. 1 at 2:13-16 and 3:7-22*).

7. FINDINGS OF FACT CONCERNING USFWS/NMFS ISSUE 7

7-1. The findings of fact under USFWS/NMFS Issue 2A are incorporated herein.

7-2. Today, the runs of Coho salmon have greatly diminished in the Klamath River system, which is now composed largely of hatchery fish. (*NMFS/FWS-Issue 7-Simondet-Ex. 5 at 117; KTr.-CWH-Ex. 4 at 216 and 224*).

7-3. The Coho salmon stock of the Klamath River is a sub-population of the Southern Oregon/Northern California Coast ("SONCC') Evolutionarily Significant Unit ("ESU"), and is listed as a threatened species under the Endangered Species Act. (*NMFS/FWS-Issue 7-Williams-Ex. 7 at 1; NMFS/FWS-Issue 7-Williams-Ex. 6 at 34; NMFS/FWS-Issue 7-Williams-Ex. 1 at 2:17-3:9; NMFS/FWS-Issue 7-Williams-Ex. 14 at 41; NMFS PFF 7.1; NGO PFF 7.2; NMFS/FWS-Issue 7-Simonet Ex. 5 at 117; Appendix to Reply Brief of PacifiCorp and Siskiyou County at 60 and 64; KTr.-CWH-Ex. 4 at 224*).

7-4. The SONCC Coho salmon population has experienced a 70% decline since the 1960s. (*NMFS/FWS-Issue 7-Williams-Ex. 7 at 1; NMFS/FWS-Issue 7-Williams-Ex. 6 at 34; NMFS/FWS-Issue 7-Williams-Ex. 1 at 2:17-3:9; NMFS PFF 7.1; NGO PFF 7.2; NMFS/FWS-Issue 7-Simonet Ex. 5 at 117; Appendix to Reply Brief of PacifiCorp and Siskiyou County at 60*).

7-5. Habitat degradation is a primary cause for the decline of the SONCC Coho salmon. (*NMFS/FWS-Issue 7-White-Ex. 1 at 6:3-5; NMFS/FWS-Issue 7-White-Ex. 18 at 6; NMFS/FWS-White-Ex. 4 at 3; NMFS/FWS-White-Ex. 5 at 363 (page 401 of the report); NMFS/FWS-Issue 7-Simondet-Ex. 1 at 5:22 to 6:1. KTr-CWH-Ex. 1 at 4; NMFS PFF 7.21; Appendix to Reply Brief of PacifiCorp and Siskiyou County at 60*).

7-6. Coho salmon below Iron Gate Dam still utilize the habitat below the dam even though it has suffered degradation commensurate with that above the dam. (*Aug. 25, 2006 Tr. at 118:16-119:2*; *CDFG-Pisano-Ex. 1 at 7:10-11:17; Yurok-Hillemeir at 4:15-5:3; NMFS/FWS-Issue 7-Simondet at 5:22-6:7; Indian Tribes PFF*).

7-7. Although portions of the habitat above Iron Gate Dam have been degraded, much of this habitat remains suitable and restoration projects are currently in progress or planned. (*NMFS/FWS-Issue 7-White-Ex. 1 at 6:7-9; NMFS/FWS-Issue 7-Snedaker-Ex. 1 at 8:7-9:17; NMFS/FWS-Issue 6-Hamilton-Ex. 1 at 8:11-13; NMFS/FWS-Issue 7-Snedaker-Ex. 7 at 35-48; NMFS/FWS-Issue 6-Smith-Ex. 1 at 6:1 to 9:18; NMFS/FWS PFF 7.6*).

7-8. Habitat is deemed "suitable" if it can be used successfully at least some of the time by one or more life stages of a Coho salmon. (*FOF 6-1; NGO PFF 7.7*). Such suitability varies across locations, life stages, and time. Faced with such variability in a given tributary, Coho salmon will move to the extent feasible to more suitable habitat within that given tributary so long as access is provided. (*KTr-CWH-Ex. 4 at 216; FOF 2A-14; NGO PFF 7.7*).

7-9. Suitable habitat above Iron Gate Dam includes Spencer, Fall, Beaver, Deer, Shovel, Scotch, and Jenny Creeks. The main stem also has suitable habitat. (*NGO Ex. 27 at 2:3-3:10, 6, 7; NMFS/FWS-Issue 7-Simondet Rebuttal-Ex. 1 at 2:22-5:5; HVT-Franklin-Ex. 1 at 3:9-4:6*; *KTr-CWH-Ex. 12 at 1-20; KTr-CWH-Ex. 21 at 1-4; KTr-CWH-Ex. 36 at 2:18-26; KTr-FAE-ex. 34 at 2; Yurok-Hillemeir Direct Testimony-NMFS/FWS Issue 7 at 3:6; NGO PFF 7.6; Indian Tribes PFF 7.5*).

7-10. Adult Coho salmon enter the river to spawn in late September and reach peak migration strength between late October and mid-November. While it appears that adult Coho salmon migration is keyed to water temperature (below 16^{o} C) and river flow, adult Coho salmon migration have been observed where these stimuli are reduced. (*KTr-CWH-Ex. 4 at 217*).

7-11. The record evidence shows that juvenile Coho salmon begin outmigrating to the ocean in late February, and continue migration through early July. While juvenile Coho salmon rear in streams for one year and have a preference for cold water (ranging between 12 and 14^{o} C), they can tolerate higher water temperatures (exceeding 20^{o} C) where food is abundant, there are areas of thermal refugia, and other conditions are not stressful. (*KTr-CWH-Ex. 4 at 218-19*).

7-12. Although water temperature in the summer above Iron Gate Dam is an issue, the record evidence shows that water temperature will not preclude Coho salmon from successfully utilizing the habitat within the Project area. (*CDFG Pisano Ex. 1 at 4:18-51, 7:10-9:7 (Coho in other parts of the Klamath system occupy water with temperatures in excess of 26^{o} C), 9:8-10:12 (spawning in degraded streams); Yurok-Hillemeir Direct Testimony-NMFS/FWS Issue 7 at 4:24-5:3; KTr-CWH-Ex 4 at 219 (juvenile Coho salmon observations in the main stem Klamath River where temperatures exceed 20^{o}C)*).

7-13. Predation may also be a slight problem that could be minimized through use of remedial measures. (*NMFS/FWS-Issue 7-White-Ex. 14 at A-10, B-2, and B-40; NGO PFF 7.10*).

7-14. In restoration efforts elsewhere in the Pacific Northwest, Coho salmon and other anadromous juveniles successfully pass through reservoirs under similarly difficult circumstances. (*NGO Ex. 3 at 12:13-13:9; KTr-FAE-Ex. 1 at 3:4-12; NGO PFF 7.11*).

7-15. Coho salmon below Iron Gate Dam would migrate above the dam if access was provided through fishways. (*FOF 2A-10; NMFS/FWS PFF 7.8; Appendix to Reply Brief of PacifiCorp and Siskiyou County at 62*).

7-16. Over time, access to habitat above Iron Gate Dam would benefit the Coho salmon population by: a) extending the range and distribution of the species thereby increasing the Coho salmon's reproductive potential; b) increase genetic diversity in the Coho stocks; c) reduce the species vulnerability to the impacts of degradation; and d) increase the abundance of the Coho population. (*Aug. 23, 2006 Tr. at 163:1-2; Aug. 25, 2006 Tr. at 107:5-20; NGO Ex. 27 at 3:11-4:7 (allowing access to additional habitat does not decrease the size of the population existing below Iron Gate Dam); Yurok-Hillemeir Direct Testimony-NMFS/FWS Issue 7 at 5:7-8 (access to project area is one of the quickest ways to increase population abundance, 6:4-22; CDFG-Pisano-Ex. 1 at 5, 11:18-12:23; NMFS/FWS-Issue 7-Simondet-Ex. 1 at 5:21-6:15; NMFS/FWS-Issue 7-Williams-Ex. 1 at 6:15-19, 7:15-9:22 (explaining that additional spatial structure reduces species vulnerability to changing environmental conditions); HVT-Franklin-Ex. 1 at 6:16-7:12 (explaining that diverse habitat leads to populations adapted to diverse life history forms and greater viability for the species; NGO ex. 4 at 11:15-28*).

8. *FINDINGS OF FACT CONCERNING USFWS/NMFS ISSUE 8*

8-1. The Findings of Fact in 2A are incorporated herein.

8-2. Today, Pacific lamprey is found throughout the Klamath River main stem and tributaries downstream of the Project area and some have also been found in tributaries near Iron Gate Dam. (*NMFS/FWS-Issue 8-Hamilton-Rebuttal Exhibit 4; Yurok-Steward 8 Rebuttal at 2:9 to 3:2; FOF 2A-8; NMFS/FWS PFF 8.3; Indian Tribes PFF 8.2*). The Pacific lamprey fishery resources in the lower Klamath River are in decline. (*PAC-Chan-D-1 at 4:7-9; NMFS/FWS PFF 8.1*).

8-3. Although the historical upstream distribution of Pacific lamprey is unknown, suitable habitat for spawning and juvenile rearing is available within tributaries and stream reaches in the Project area. (Y*urok-Hillemeier 2and 8 Direct at 6:4 to 7:15; Yurok-Steward 8 Direct at 5:1-8; NMFS/FWS PFF 8.4*).

8-4. Resident lamprey ammocoetes (juveniles) already rear within tributaries within the Project. (*Yurok-Steward 8 Rebuttal at 4:2-11; CDFG Pisano Ex. 16; NMFS/FWS PFF 8.5*).

8-5. Ammocoetes of resident and Pacific lamprey have similar habitat requirements. (*PAC-Chan-D-1 at 8:8-9; Yurok- Steward 8 Rebuttal at 4:4-6; NMFS/FWS PFF 8.5*).

8-6. There is no measurable genetic difference between Pacific lamprey inhabiting different river basins along the Pacific coast. (*Yurok-Hillemeier 8 Direct at 4:14 to 5:25. NMFS/FWS-Issue 8-Hamilton-Rebuttal Ex. 3 at 15; Aug. 24, 2006 Tr. at 105:9-24; NMFS/FWS PFF 8.6*).

8-7. Pacific Lamprey below Iron Gate Dam would migrate above the dam if access was provided through fishways. (*FOF 2A-10; NMFS/FWS PFF 8.9; Indian Tribes PFF 8.5*).

8-8. Volitional passage for Pacific lamprey has been designed and is in place in other river systems. (*NMFS/FWS-Issue 8-Johnso-Rebuttal Ex. 1 at 2:3-19, 3:5-7; Aug. 24, 2006 Tr. at 178:8-179:1, 184:1-185:15; NMFS/FWS-Issue 8-Moser-Ex. 1 at 9:12-16; Yurok-Steward 8 Direct at 5:12-26; NMFS PFF 8.8; Indian Tribes PFF 8.6*).

8-9. Access to habitat would benefit Pacific lamprey by increasing their viability through: a) extending the range and distribution of the species; b) providing additional spawning and rearing habitat; c) increasing the generic diversity of the species; and d) increasing the abundance of the Pacific lamprey population. (*NMFS/FWS-Issue 8-Hamilton-Ex. 1 at 8:1-11; Yurok-Steward 8 Direct at 4:27 and 5:17; NMFS/FWS-Issue 8-Mesa-Ex. 1 at 5:16-6:6; CDFG-Pisano-Ex. 1 at 11:19*).

C. <u>BLM DISPUTED ISSUES OF MATERIAL FACT</u>

1. <u>FINDINGS OF FACT CONCERNING BLM ISSUE 10</u>

10-1 About eighty ("80") percent of the J.C. Boyle bypass reach (an area of 4.3 miles in length) is confined by steep canyon walls. Thus, only twenty ("20") percent of the bypass reach (less than one mile in length) has potential for "riparian restoration." (*PAC-Dwer-D-1 at 5:12-14, 5:20-23; Aug. 21, 2006 Tr. at 71:13-22; BLM Reply Brief at 4-5*).

10-2 Relatively coarse bed sediment (*i.e.*, gravel and cobble) can be mobilized in the bypass reach with flows of 1,700 cubic feet per second (cfs) and greater. (*PAC-Tomp-R-1 at 4:8-10*).

10-3 The seasonal high flows proposed by BLM for the bypass reach will create more frequent and larger magnitude high flow events. (*BLM-Turaski-Ex. 4 at 59, 89-91; BLM-Gard-Ex. 0 at 2:4-9*).

10-4 BLM high flows, as compared to current conditions, will mobilize and transport sediment more frequently within the Project. (*PAC-Tomp-D-1 at 12:20-23*).

10-5 Seasonal high flows, in combination with the BLM's proposed gravel augmentation program, will likely create a more dynamic channel with a wider range of sediment deposits. This sediment will be deposited higher on the channel margin which will serve as an ecological benefit. (*BLM-Cluer-Ex. 0 15:5-7, 24-16:4; Aug. 22, 2006 Tr. at 54:4-23; BLM-Cluer-Ex. 0 at 15:5-7*).

10-6 With the construction of dams and their operation, changes have occurred to the riparian community of the bypass reach. Specifically, reed canary grass has encroached into the channel in places that have been exposed by Project-diverted flows. (*PAC-Dwer-D-5 at 6-66; NGO-Ex. 1 at 13:7-9, 16:7-10; Aug. 21, 2006 Tr. at 102:24-103:3*).

10-7 Reed canary grass can adversely affect downstream channel formation by effectively trapping sand, gravel, and small cobble in its dense root mass. Such material would otherwise have been transported downstream where it would replenish similar sized bed material scoured by floods. (*NGO-Ex. 1 at 16:11-17:3*). This may adversely affect abundance and quality of fish and terrestrial habitat. (*NGO-Ex. 1 at 10:13-22*).

10-8 Approximately two-thirds of the riparian habitat in the J.C. Boyle bypass reach is riparian grass land, which is predominately reed canary grass. (*Aug. 21, 2006 Tr. at 97:24 to 98:9*).

10-9 Riparian-focal bird species are birds that use riparian habitats. (*BLM-Alexander-Ex. 0 at 5:19-24; BLM-Alexander-Ex. 6 at 35; BLM-Turaski-Ex. 4 at 74*). These species often have a special management or conservation status. (*Id.)*

10-10 Avian riparian focal species consistently use riparian habitat in the J.C. Boyle bypass and peaking reaches during breeding season. (*PAC-Tres-D-1 at 7:6-9:12*).

10-11 The eight species of riparian-focal bird species in the Project area do not nest in reed canary grass. Nesting is such grasses make the birds accessible to predators. (*PAC-Tres-D-1 at 4:17-23, 11:14-20); Aug. 21, 2006 Tr. at 124:14–125:23).*

10-12 Avian riparian focal species prefer structurally diverse habitat. (*Aug. 21, 2006 Tr. at 124:20-22; PAC-Tres-D-1 at 13:7-11*).

10-13 In the J.C. Boyle bypass and peaking reaches, riparian-focal bird species are associated with and primarily nest in woody riparian vegetation. (*BLM-Alexander-Ex. 0 at 6:22 to 7:2; Aug 21, 2006 Tr. at 124:14–125:23*).

10-14 Numerous factors determine how useful riparian patches are to avian riparian focal bird species. An increase in the amount of riparian habitat does not necessarily correspond to a similar increase in birds that would use that habitat. (*Aug. 21, 2006 Tr. at 128:21 to 129:10; Aug. 22, 2006 Tr. at 18:3-14*).

10-15 A relative increase in early woody riparian vegetation and a relative decrease in reed canary grass will likely increase abundance of riparian-focal bird species in the J.C. Boyle bypass reach. (*BLM-Alexander-Ex. 0 at 9:10-14; Aug. 21, 2006 Tr. at 120:21-25*).

10-16 BLM proposed flows would not increase woody riparian habitat. (*PAC-Tres-R-1 at 1:16-17; NGO-Ex. 1 at 7:11-18, 10:5-22 (which suggests that high flows, such as that associated with the proposed flows, scour woody riparian vegetation*)).

2. *FINDINGS OF FACT CONCERNING BLM ISSUE 11*

11-1. J.C. Boyle Dam has captured an average of 6,124 tons/year of channel bedload and thus blocked its transport into the bypass and peaking reaches. (*PAC-Tomp-D-1 at 14:9-15; Aug. 21, 2006 Tr. at 74:22-75:2).*

11-2. Channel bedload is the totality of cobble, gravel, and other sediment that form the channel bed. Bedload mobilization is the natural geomorphic process whereby flow moves gravel for deposit on alluvial features and cleanses gravel of sediment. (*Aug. 21, 2006 Tr. at 64:12-23*). Diversion has reduced the capacity of flow to mobilize the bedload by an estimated eighty-three (“83”) percent to ninety-six (“96”) percent in the bypass reach. (*PAC-Tomp-D-3 at 6-139; Aug. 21, 2006 Tr. at 64:3-70:1*).

11-3. The bed material in the J.C. Boyle bypass and peaking reaches has coarsened due to the J.C. Boyle Dam limiting the sediment supply. (*BLM-Cluer-Ex. 5 at 111, 129; BLM-Cluer-Ex. 0 at 6:14-16; BLM-Turaski-Ex. 4 at 70*). In addition, the sediment that is delivered to the channel or was in the channel at the time of Project construction is transported downstream during Project spill events in the bypass reach and during peaking flows in the peaking reach. (*BLM-Cluer-Ex. 0 at 8:5-7, 14:10-12*).

11-4. In the J.C. Boyle bypass reach, the average annual flow released from the J.C. Boyle Dam has been reduced by eighty-one (“81”) percent—from approximately 1,560 cfs to 296 cfs—with the 100 cfs minimum flow occurring eighty-nine (“89”) percent of the time. (*BLM-Turaski-Ex. 4 at 68, 83*).

11-5. Low base flows combined with sediment being blocked by the J.C. Boyle Dam result in smaller alluvial features. (*NGO-Ex. 1 at 10:13-16, 11:1-2; BLM-Cluer-Ex. 0 at 8:1-4*).

11-6. High flows can scour (uproot and dislodge) reed canary grass. Moderate flows are likely to scour plants with less well-established root mats. (*NGO-Ex. 1 at 15:14-16*). Larger flow events are likely to scour older plants with more well-established root mats. (*NGO-Ex. 1 at 16:1-7; PAC-Dwer-D-1 at 13:21-23*).

11-7. Project diversions decrease high flow events in the bypass reach by approximately fifty (“50”) percent. (*PAC-Dwer-D-5 at page 5-46, Table 5.7-16 (as explained at page 5-45*).

11-8. By decreasing the frequency of larger flows, the Project operations have reduced the number of flow events that can scour established reed canary grass. (*NGO-Ex. 1 at 16:4-10*).

11-9. If Project related coarsening of the bed had not occurred, it is likely that active features (e.g., point bars, islands) would have been characterized by finer sediment. (*Aug. 21, 2006 at 68:8 to 69:6; PAC-Tomp-D-3 at 6-129*).

11-10. Willow is a desirable riparian plant that germinates and establishes itself on freshly deposited alluvium (material transported and deposited by river flows). (*BLM- Turaski-Ex. 4 at 74*).

11-11. Current operations continue to maintain, to a certain degree, woody riparian vegetation in the bypass reach. (*PAC-Dwer-R-1 at 8:24-26; PAC-Dwer-R-1 at 3:14-20; NGO-Ex. 1 at 12:14-18*).

11-12. Reed canary grass is adapted to survive in frequently inundated coarse substrate and is capable of out-competing woody riparian vegetation. (*BLM-Turaski-Ex. 4 at 73; PAC-Dwer-D-4 at 3-28*).

11-13. In the bypass reach, there is more riparian vegetation as a result of Project operations. This increase of vegetation is attributed mainly to the encroachment of reed canary grass. (*Aug. 21, 2006 Tr. at 107:112-108:8*).

3. *FINDINGS OF FACT CONCERNING BLM ISSUE 14*

14-1. In the J.C. Boyle bypass reach, the channel bed is dominated by sixty-four ("64") percent boulders and twenty-eight ("28") percent cobble. A reduction in find grain deposits diminishes the quantity and quality of fish habitat. (*BLM-Cluer-Ex. 11 at 2; BLM-Cluer-Ex. 0 at 1-5*).

14-2. Sediment trapping by J.C. Boyle Dam is the primary cause of low sediment availability in the bypass reach. (*FOF 11.1, 11.3; BLM-Cluer-Ex. 0 at 6:14-20; BLM-Cluer-Ex. 5 at 111*).

14-3. BLM has proposed a gravel management plan in which 1,226 to 6,134 tons of sediment per year would be added to the Klamath River below J.C. Boyle Dam. (*BLM-Turaski-Ex. 4 at 60-61*).

14-4. Implementation of coordinated sediment delivery with seasonal high flows can result in deposition of gravel in velocity pockets on the bed and fine sands on the banks. These deposits have ecological benefits including creating spawning pockets around boulders and in pools. (*BLM-Cluer-Ex. 0 at 13:10-14;* Aug. *21, 2006 Tr. at 201: 10-15*; *BLM-Gard-Ex. R0 at 2:6-9*).

14-5. Fine sediment can infiltrate salmonid spawning gravel and reduce incubation success or affect the ability of fry to emerge from the gravel. (*PAC-Carl-D-1 at 7:4-6; BLM-Snedaker-Ex. 0 at 3:20-26*).

14-6. Gravel embedded with greater than ten ("10") percent fine sediment results in a substantial reduction in suitability of steelhead spawning habitat. (*BLM-Gard-Ex. R0 at 1:20-21*).

14-7. Trout spawning gravel in the bypass reach is embedded with fine silt. (*BLM-Gard-Ex. 0 at 4:1-6; BLM-Snedaker-Ex. 0 at 3:20-25*). In July 2006, the spawning gravel in the bypass reach below the emergency spillway was fifty ("50") percent embedded with silt and sand. (*BLM-Gard-Ex. 0 at 4:1-14*).

14-8. An annual flushing flow can clean and redeposit gravel to provide quality spawning habitat. (*PAC-Carl-D-8 at 116-121*). To be effective, flushing flows need adequate duration and frequency to mobilize and redistribute fine sediments in the spawning beds. (*BLM-Turaski-Ex. 4 at A-41*).

14-9. The BLM River Corridor Management Condition calls for a one week seasonal high flow between February 1st and April 15th in years when inflow to J.C. Boyle Reservoir exceeds 3,300 cfs. (*BLM-Gard-Ex. 0 at 2: 4-13; BLM-Turaski-Ex. 4 at 59*). Based on an analysis of the historical flow record, the seasonal high flow would be implemented approximately every other year. (*Id.*; *PAC-Carl-R-1 at 1:10 to 2:*3). The seasonal high flow would occur in February twenty-four ("24") percent of the years, in March twenty-four ("24") percent of the years, and in April three ("3") percent of the years. (*Id).* The median start date for the seasonal high flow would be February 18. (*Id).*

14-10. BLM's proposed seasonal flushing flow would commence at 3,300 cfs and the medium flow would exceed 4,200. (*BLM-Turaski-Ex. 4 at A-16; PAC-Carl-D-1 at 4:15-19; BLM-Gard-Ex. 0 at 2:11-13*).

14-11. The spawning period for redband trout between Copco 1 Reservoir and J.C. Boyle Dam is from February through May. (*BLM-Gard-Ex. 0 at 2:19-23*). Most of the spawning takes place between March 15 and April 15. (*Id).*

14-12. Based on an analysis of the historical flow record, the seasonal high flow would be implemented between March 15 and April 15 in fourteen ("14") percent of the years. (*BLM-Gard-Ex. 0 at 2:23-25*).

14-13. Salmonids will hold during high flows and resume spawning once the flows have dropped. (*BLM-Gard-Ex. 0 at 3:6-10*). The one week seasonal high flow will still leave 21 weeks for rainbow trout to spawn. (*Id).*

14-14. BLM's proposed flushing flow would always occur during spawning season. (Aug. *22, 2006 Tr. at 59:23-25*).

14-15. Flushing flows scheduled during or immediately after fish spawning could dislodge eggs and result in reduced recruitment. (*PAC-Carl-D-8 at 116*). Flushing flows released just prior to spawning would produce more beneficial effects. (*Id*.).

14-16. In the bypass reach, PacifiCorp provides flows limited to 100 cfs eight-nine ("89") percent of the time. (*BLM-Turaski-Ex. At 68*). When flows greater than 100 cfs do occur in the bypass reach, they are abrupt, are short in duration, and do not reflect a flow regime with seasonal variability. (*Id).*

14-17. The timing of the BLM seasonal high flow condition reflects the natural hydrologic flood regime under which redband trout evolved. (*BLM-Gard-Ex. 0 at 3:11-17*). The BLM seasonal high flow condition will be implemented during the normal peak flow period. (*BLM-Gard-Ex. 0 at 3:11-17; Aug. 21, 2006 Tr. at 175:20-22*).

14-18. Historically, redband trout rearing in the Oregon portion of the Klamath River downstream of the J.C. Boyle Dam migrated upstream to spawn in Spencer Creek. (*BLM-Hooton-Ex. 0A at 2:5-6*). Redband trout rearing below J.C. Boyle Dam moved upstream in two peak spawning migrations, one in the spring and one in the fall. (*Id. at 2:12-13*). Both spring and fall spawning migrations were associated with increases in the river flow. (*Id).*

14-19. Spring and fall freshets attract spawning rainbow trout upstream past J.C. Boyle Dam and juvenile trout migrant downstream to rearing areas below J.C. Boyle Dam. (*BLM-Hooton-Ex. 0B at 4:1-3; BLM-Hooton-Ex. 18 at 1; BLM-Hooton-Ex. 19 at 1*).

14-20. Soon after the installation of J.C. Boyle Dam, upstream spawning migrations of redband trout were reduced and recent data shows little successful migratory movement occurs from downstream to upstream of J.C. Boyle Dam. (*BLM-Hooton-Ex. 0B at 4:10-16*).

14-21. The only observed trout spawning activities, including the presence of redds, currently occur in the main stem bypass reach just downstream of the existing J.C. Boyle emergency canal spillway. (*PAC-Carl-D-1 at 8:11-21; PAC-Carl-R-1 at 5:22-6:1*).

14-22. Erosion from PacifiCorp's use of the emergency spillway has significantly increased the rate of fine and coarse sediment delivery to the area below the emergency spillway. (*BLM-Cluer-Ex. 0 at 8:14-16; PAC-Carl-D-1 at 8:15-17*). Since J.C. Boyle Dam operations began in 1958, approximately 69,000 cubic yards of hillside sediment has been delivered to the stream from the erosional washout. (*BLM-Cluer-Ex. 0 at 8:14-16*).

14-23. The location of the redds, near the erosional feature, is relatively unstable for two reasons. First the spillway can be used at any time and its use probably destroys or buries redds and spawning gravel patches. (*BLM-Cluer-Ex. 0, 10:1-8*). Second, the slope of the channel in this location is very steep (*Aug. 21, 2006 Tr. at 56:10 to 57:7*), making this location inherently unstable during flood flows in the bypass channel. (*BLM-Cluer-Ex. 0, 10:1-8; BLM-Gard-Ex. 0 at 4:9-14*).

14-24. Seasonal high flows can mobilize sediment accumulated at the emergency spillway deposit and distribute that sediment downstream where it can be deposited in more stable locations. (*BLM-Cluer-Ex. 0 at 15:17-25*).

14-25. If the gravel at the emergency spillway were transported downstream by seasonal high flows, they would be more valuable fish habitat because the gravel would be transported to more stable locations and better sorted into spawning sizes. (*Id.*; *Ex. PAC-Carl-D-8 at 120-121).*

14-26. If PacifiCorp installs bypass valves at the J.C. Boyle powerhouse, the emergency spillway will no longer be used and the unnatural sediment loads in the area will not be replenished. (*PAC-Carl-D-1 at 8:21-9:3*).

4. FINDINGS OF FACT CONCERNING BLM ISSUE 16

a. Low Flows Reduce Fish Habitat

16-1. Trout presently do not spawn in the peaking reach. (*PAC-Ols-D-1 at 7:20*).

16-2. Before the J.C. Boyle Dam was built, rainbow trout would use the Frain Ranch area of the J.C. Boyle peaking reach to spawn. (*BLM-Denman-Ex. 0 at 3:6-15; BLM-Snedaker-Ex. 0 at 3:9-13*).

16-3. There are locations in the peaking reach with suitable spawning gravel, but these areas were on the margins of the stream channels and were exposed during lower flows. (*BLM-Snedaker-Ex. 0 at 3:13-19; BLM-Gard-Ex. 6 at 21-24*).

16-4. Low flows contribute to the lack of spawning in the peaking reach. (*BLM-Simons-Ex. 0 at 7:12-20; BLM-Simons-Ex. 16 at 69, section 4.10*; *"[M]uch of the gravel at this location [in the peaking reach] was exposed during low flow conditions. Since peaking operations often begin in mid-May, trout embryos would still be in the gravel when daily desiccation begins. Therefore, much of the available gravel would not be suitable for incubation of trout embryos during most years." BLM-Gard-Ex. 6 at 24*.").

16-5. Depositional features, such as gravel bars and side channels, are suitable spawning and rearing habitat for redband trout and serve as an oasis from the higher-velocity flows that occur during springtime snowmelt. (*NGO-Ex. 1 at 21:9-16, 21:1-2).*

16-6. The Project reduces the frequency and extent of inundation of depositional features in the bypass and peaking reach. (*NGO-Ex. 1 at 21:3-16, 32:4-7.*). This hydrologic impact reduces the availability of suitable rearing habitat for juveniles. (*Id. at 21:3-16).*

b. Stranding

16-7. Peaking is the most widely documented source of fish stranding. (*BLM-Snedaker-Ex. 6 at 25*). Peaking fluctuations can result in severe cumulative impacts to fish populations. (*Id*). Stranding is the separation of fish from flowing surface water as a result of declining river state. (*Id. at 5*).

16-8. PacifiCorp's peaking operations cause high mortality to fish and other aquatic organisms through stranding. (*BLM-Snedaker-Ex. 0 at 4:25 to 5:11; KTR-LKD-DT-BLM 16 at 4:3-22; KTR-FAE-DT-BLM 16 at 7:13-17*).

16-9. On July 5, 2006, a severe stranding along 225 feet of the peaking reach was documented near Frain Ranch. (*KTR-LKD-DT-BLM 16 at 4:3-10*). "[A]bout 5,000 fish, more crayfish, and an order of magnitude more aquatic insects perished in a single peaking cycle . . . ." (*KTR-LKD-Ex. 3 at 5*). No redband trout mortalities were documented, however few trout fry exist in the peaking reach. (*Id*.).

16-10. The severe loss of fish and other aquatic life on July 2006 is directly attributable to PacifiCorp's peaking operations. (*Aug. 21, 2006 Tr. at 153:18-21*).

16-11. July 5, 2006, was the first major downramp event of the season. No stranded fish were found on July 6, during the second major peaking cycle, or on July 7-8, 2006, during the third major peaking cycle. (*KTR-LKD-DT-BLM 16 at 4:8-13; PAC-Ols-R-1 at 16:7-11*).

16-12. Peaking operations that cause high mortality likely only happen a few times a year, following the first peaking event after several months of steady flow. (*PAC-Ols-R-1 at 16:16-17:7*)

16-13. Reduced ramp rates can resolve the problem of fish stranding. (*PAC-Ols-R-1 at 17:1-9*).

16-14. The downramp rate at the site where the severe mortality of aquatic organisms occurred was about 4.0 inches/hour. (*KTR-LKD-DT-BLM 16 at 4:14-22*). At a site further downstream where no mortalities of fish were observed, the ramp rate was 2.4 inches/hour, similar to BLM's proposed condition of a 2 inch/hour maximum downramp rate. (*Id.*).

16-15. Project peaking operations kill, through stranding, large numbers of young fish and aquatic invertebrates that are the primary prey food for trout. (*KTR-LKD-Ex. 17 at 4:3-133 (enormous prey losses from stranding); KTR-LKD-Ex. 3 at 4-5 (field study finds enormous prey loss from stranding); KTR-FAE-Ex. 31 at 8:19-20 (redbands feed primarily on invertebrates; invertebrate "drift" 5 to 6 times higher in Keno reach than in peaking reach); Aug. 21, 2006 Tr. at 153:18-21 (significant loss of fish prey is a Project effect); BLM-Denman-Ex. 0 at 2:19-22 (crayfish were food source for trout before peaking); BLM-Denman-Ex. 0 at 3:6-8 (numerous dead crayfish were seen in the peaking reach after peaking events)).*

c. Downstream Displacement

16-16. Flushing of juvenile salmonids downstream is likely in the peaking reach. (*BLM-Snedaker-Ex. 0 at 9:16-17; BLM-Hooton-Ex. 0B at 7:12-15; BLM-Snedaker-Ex. 8 at 19 (FERC Salt Caves Project EIS concludes that flows of 1500 cfs in the peaking reach "lead to fry and fingerling trout being flushed downstream"*)).

16-17. Few fry have been captured in the Oregon section of the peaking reach; the section of the peaking reach with the highest ramp rates. (*BLM-Snedaker-Ex. 5 at 52; PAC-Ols-D-20 at App. 3A at 20; KTR-LKD-Ex. 6 at 6-46*).

16-18. PacifiCorp's mark-recapture studies did not mark or recapture any fry in the Oregon peaking reach; the area of peaking reach where peaking effects would be most pronounced. (*PAC-Ols-D-1 App. 3A at 36-37*).

16-19. In the California peaking reach, nine ("9") of seventy-three ("73") fry were recaptured, indicating some ability to maintain their location during peaking events. (*PAC-Ols-D-1 App. 3A at 36-37*).

16-20. Very few salmonid fry or other fish species are observed in the margins of the peaking reach. (*BLM-Hooton-Ex. 0A at 11:7-10; BLM-Snedaker-Ex. 0 9:16-23; KTR-LKD-DT-BLM 16 at 3:16 to 4:8*).

d. Energetic Costs/Size

16-21. Flow fluctuations from peaking operations increase energetic demands on salmonids, decreasing energy available for overall health, growth, and reproduction. (*BLM-Simons-Ex. 19 at 16, 165*).

16-22. Peaking operations induce trout movement that would not be expected in a stable-flow regime. Holding territory, while flows increase, force trout to swim faster to stay in place. (*BLM-Simons-Ex. 0 at 5:8-6:7*). Fish move laterally with changes in flow. (*KTR-LKD-DT-BLM 16 at 7:13-17; KTR-LKD-Ex. 10 at 26*). During low flows fish will move towards the center of the channel and during high flows fish will move toward the edges of the channel. (*Id.*).

16-23. Larger fish operate closer to the energetic margin, so energetic costs of peaking would be expected to reveal themselves in larger fish. (*KTR-LKD-R-BLM 16 at 7:12-17*).

e. Macroinvertebrate

16-24. Peaking operations reduce the production of sessile organisms, like macroinvertebrates, by ten ("10") percent to twenty-five ("25") percent. (*BLM-Simons-Ex. 13 at 26*).

16-25. Macroinvertebrate drift rates, a measure of food availability for trout, in the non-peaking Keno reach were five to six times greater than in the peaking reach. (*BLM-Simons-Ex. 13 at 70*). Fluctuations in the peaking reach are undoubtedly a contributing factor to the lower macroinvertebrate drift rates. (*Id.*).

f. Keno vs. Peaking Reach

16-26. When comparing growth of trout in the non-peaking Keno reach to growth in the J.C. Boyle peaking reach, the following is observed: growth is greater for trout in the peaking reach through age two ("2"), similar growths are recorded between ages two ("2") and three ("3"), and growth is greater in the Keno reach after age three ("3"). (*BLM-Simons-Ex. 13 at 64*).

16-27. Average trout size has decrease since Project operations began. (*BLM-Hooton-Ex. 28*). For trout residing below J.C. Boyle Dam, the average length has decreased from about twelve inches (30 cm) in 1961, shortly after the J.C. Boyle facility was completed, to about seven inches (18 cm) in 1990. (*Id.*)).

16-28. The average condition factor for trout in the peaking reach is similar to that in the Keno Reach. (*PAC-Ols-D-1 at 12:12-14; PAC-Ols-R-1 at 13:4-7; PAC-Ols-R-5*).

16-29. While the average condition factor for trout may be similar, condition factors vary in the peaking reach and Keno Reach from season to season. (*PAC-Ols-D-6 at 4*).

16-30. Trout in the Keno reach are older than those in the peaking reach. (*PAC-Ols-D-12 at 3-4; PAC-Ols-D-5*).

16-31. Forage fish will provide a higher energy source than invertebrate drift for mature fish and allow for increased growth rates. (*BLM-Snedaker-Ex. 0 at 10:19-23, BLM-Simons-Ex.14 at 17, 53).*

16-32. The Project-caused impacts to forage fish in the peaking reach help explain the lower growth rates and absence of larger and older fish in the peaking reach, as compared to the Keno reach. (*BLM-Snedaker-Ex. 0 at 10:15-17, 11:8-13; KTR-LKD-DT-BLM 16 at 9:7-11*).

5. <u>FINDINGS OF FACT CONCERNING BLM ISSUE 17</u>

17-1. The existing upramp rate for the J.C. Boyle facility is nine inches per hour. (*BLM-Turaski-Ex. 4 at 67*).

17-2. The BLM has proposed an upramp rate of two inches per hour. (*BLM-Turaski-Ex. 4 at 59*).

17-3. Most rivers in the Pacific Northwest do not naturally experience a ramp rate in excess of two inches per hour, except during or immediately after events such as an intense storm or flood event. (*BLM-Snedaker-Ex. 0 at 7:13-15; BLM-Snedaker-Ex. 6 at 12-13; HVT-Steward Ex. 4 at 2:18-22; HVT-Steward Ex. 37 at 14-15 (showing that the "upramp" rate for the naturally flowing Williamson River in the Upper Klamath Basin rarely, if ever, exceeded two inches per hour over the three years of flow data reviewed*)).

17-4. Limiting ramp rates to no more than two inches per hour have been widely accepted as being protective of fish resources. (*BLM-Snedaker-Ex.10 at 48-49; BLM-Snedaker-Ex. 0 at 7:15-16*).

17-5. Daily peaking causes chronic increases in macroinvertebrate drift events. This in turn reduces the quality and abundance of drift forage for trout. (*BLM-Snedaker-Ex. 6:8-11; BLM-Simons-Ex. 13 at 26*).

17-6. Such drift events may increase fish feeding activity in the short term. Over the long term, however, this can result in a depletion of macroinvertebrates, resulting in lower fish productivity. (*BLM-Snedaker-Ex. 7 a t4-5*).

17-7. Macroinvertebrate sampling showed that upramping caused an increase in macroinvertebrate drift. (*BLM-Snedaker-Ex. 0 at 10:9-17; PAC-Ols-D-1 at 9:12-13*).

17-8. Species of dace, chubs, and suckers native to the Klamath River broadcast their eggs over the substrates where they remain until hatching. (*BLM-Snedaker-Ex. 0 at 11:1-5*). Eggs deposited in this fashion and weak swimming fry of these species are especially vulnerable to entrainment and transport by peaking flows. (*Id.*).

17-9. Impacts to native forage fish species (species on which trout prey) can impair growth and feeding of trout in the peaking reach. (*BLM-Snedaker-Ex. 0 at 11:8-13; KTR-LKD-DT-BLM 16 at 7:8-12 (the evidence indicates that forage fish production is impaired by the peaking operations, and this affects trout growth in the peaking reach)*)

6. <u>FINDINGS OF FACT CONCERNING BLM ISSUE 19</u>

a. Current Flow Regime

19-1. The current flow regime at the J.C. Boyle powerhouse has two components. (*PAC-Whit-D-1 at 4:23*).

19-2. First, there is a minimum base flow of 100 cfs from J.C. Boyle Reservoir into the J.C. Boyle bypass reach at all times, which combines with springs in the bypass reach to provide approximately 330 cfs where the J.C. Boyle powerhouse discharges water into the river at the start of the peaking reach. (*PAC-Whit-D-1 at 4:23-5:4; PAC-Carl-D-1 at 15:1-6).* [11]

19-3. Second, remaining inflows to J.C. Boyle reservoir are stored and diverted to the J.C. Boyle powerhouse for electric generation unless they exceed Project capacity, in which case the excess is spilled over J.C. Boyle dam into the bypass reach. (*PAC-Whit-D-1 at 5:5-7; PAC-Carl-D-1 at 14:21-22*).

[11] PacifiCorp Proposed Finding of Fact 95 states that the total cfs from the bypass reach which discharges into the peaking reach is *approximately 330* cfs (100 cfs from J.C. Boyle Reservoir and 230 from springs in the bypass reach). BLM wholly disputes this proposed finding and states that the total discharge is *generally 320* (100 cfs from J.C. Boyle Reservoir and 220 from springs in the bypass reach). (*BLM Reply Brief at 15*). Inconsequential and/or picayune objections do not aid in moving this expedited process forward.

19-4. In wetter periods with higher reservoir inflows (usually from late winter through early summer), J.C. Boyle powerhouse is operated continuously, up to a two-turbine capacity of about 2,600 cfs. (*PAC-Whit-D-1 at 5:7-9; PAC-Carl-D-1 at 14:19-21*).

19-5. During drier times of the year, the powerhouse is operated in a daily "peaking" mode with alternate periods of storage and generation through a twenty-four-hour cycle. (*PAC-Whit-D-1 at 5:10-11*).

19-6. In typical peaking operations, peaking reach flows are about 330 cfs (all from the bypass) during the storage periods from early evening through early morning, and then ramp up to about 1,600 cfs (one turbine operating plus bypass flows) or 2,800 cfs (two turbines operating plus bypass flows) during the middle of the day. (*PAC-Whit-D-1 at 5:14-17*).

19-7. As active storage is used up, the project ramps back down to 330 cfs in the evening. (*PAC-Whit-D-1 at 5:17-18*).

b. BLM's Proposed Flows

19-8. The BLM condition is intended to provide an overall increased base flow and flows that are more reflective of seasonal events, including high and low flows. (*BLM-Turaski-Ex. 4 at 89*).

19-9. The BLM flow proposal would substantially alter the established flow regime. (*PAC-Whit-D-1 at 5:19).*

19-10. Under BLM's proposal, there would be a higher base flow in the bypass reach of either forty ("40") percent of the inflow to the J.C. Boyle reservoir, or a minimum of 470 cfs, whichever is greater. (*PAC-Whit-D-1 at 5:19-22; BLM-Turaski-Ex. 4 at A-16*).

19-11. Most of the time, the proposed base flows would provide a minimum flow of approximately 700 cfs in the peaking reach, about twice the current baseflow. (*PAC-Whit-D-1 at 5:22-6:1*).

19-12. The BLM proposal would provide a seasonal high flow event, for seven full days, between February 1 and April 15, when inflows first exceed 3,300 cfs, during which time power generation would be suspended to allow all inflows down the bypass reach (and on through the peaking reach) for one week. (*PAC-Whit-D-1 at 6:3-6; BLM-Turaski-Ex. 4 at A-16*).

19-13. During the period between May 1 and October 31, BLM Condition 4 would provide a single peaking event per week of 1,500 cfs to 3,000 cfs, with a priority set for Saturday, Sunday, and then Friday. (*PAC-Whit-D-1 at 6:7-8; BLM-Turaski-Ex. 4 at A-16*).

c. Whitewater Boating

19-14. Boating is a common recreation activity in the peaking reach. (*PAC-Whit-D-1 at 6:21 to 7:1*).

19-15. Whitewater boating takes place at the section of water between J.C. Boyle powerhouse and the California-Oregon border known as the peaking reach, which has been rafted commercially since 1979. (*PAC-Bald-D-1 at 3:1-3; PAC-Whit-D-1 at 7:7-10*).

19-16. Siskiyou County strongly opposes the proposed flow regime and believes it will induce severe and adverse affects on the county's commercial whitewater rafting business, which produces needed revenue for the county. (*Aug. 21, 2006 Tr. at 33:12–36:19*)[12]

19-17. Boaters in kayaks may be able to use the river with flows as low as 400 to 500 cfs, but acceptable "technical" trips begin about 700 cfs and transition into higher quality "standard trips" about 1,300 cfs to 1,500 cfs. (*PAC-Whit-D-1 at 11:14-18).*

19-18. Standard rafting opportunities are acceptable about 1,300 to 1,400 cfs, but they become optimal for commercial trips about 1,500 cfs. (*PAC-Whit-D-1 at 12:3-4; PAC-Bald-D-1 at 2:14-15*).

19-19. Big water boating is optimal from about 2,400 to 3,000 cfs. (*PAC-Whit-D-1 at 12:6-8*).

19-20. At flow levels above 3,500 cfs, the river starts to "flush" and it is up to the comfort of the individual outfitter or boater to take this on. (*PAC-Bald-D-1 at 2:18-19*).

19-21. Predictable daily flows during current peaking operations support a substantial commercial whitewater boating industry on the Upper Klamath River. (*PAC-Carl-D-1 at 15:22 to 16:1*).

[12] Siskiyou County also objects to the potential loss of peak power from Project facilities, should the proposed flows be allowed. (*Aug. 21, 2006 Tr. at 33:12–36:19*).

19-22. About 4,000 to 5,000 (of an estimated 12,000) recreation days per year are specifically associated with commercial rafting. "Recreation day" is defined as "one person visiting for any portion of a day." (*PAC-Whit-D-1 at 7:3-4*).

19-23. In 2004, there were 4,141 commercial rafting visits on the Upper Klamath between May and October with 2,712 visits, or sixty-six ("66") percent of the total visits, occurring in the months of July and August. (*PAC-Bald-D-1 at 4:5-8; BLM-Turaski-Ex. 4 at A-36; BLM-Turaski-Ex. 4 at 80, 89; BLM-Weidenbach-Ex. 0 at 5:6*).

19-24. The highest use days for whitewater boating are weekends (Friday-Sunday), with approximately sixty-five ("65") percent of commercial rafting visits occurring on the weekends (statistics are from rafting visits made between May and October 2004 on the Upper Klamath). (*BLM-Turaski-Ex. 4 at 80, 85*).

19-25. Even though the BLM conditions emphasize protecting the weekend boating opportunities, the conditions would substantially reduce the number of days when optimal whitewater boating (flows over 1,500 cfs) is available compared to existing conditions. (*BLM-Turaski-Ex. 4 at 59; BLM-Weidenbach-Ex. R0 at 3:23 to 4:2; Aug. 22, 2006 Tr. at 93:17-23; PAC-Whit-D-1 at 16:17-19*).

19-26. Given BLM's proposed flow regime, there will only be enough water through the system in very wet years to allow for boating during the week (excluding weekends), without peaking under the BLM flows. (*Aug. 22, 2006 Tr. at 84:25-85:15*).

19-27. Under the flows proposed by BLM, in an average year (such as 2000), the approximate decreases in raftable days would be as follow: total number of days would decrease forty-four ("44") percent (from 183 days to 102 days); the total number of weekend days would decrease eighteen ("18") percent (from 78 to 64); the total number of days in the July-August period would decrease seventy-one ("71") percent (from sixty-two ("62") to eighteen ("18")); and the total number of weekend days in July-August would decrease thirty-five ("35") (from twenty-six ("26") to eighteen ("18")). (*BLM Proposed Ultimate Finding of Fact - Issue 19*)

19-28. There may be a shift of some percentage of existing midweek use to weekend days. (*BLM-Turaski-Ex. 4 at 100; BLM-Weidenbach-Ex. 0 at 6:14-17*).

19-29. Under BLM's proposed flows, there would be limited opportunity for boating parties to spread out trips to avoid or mitigate potential crowding or congestion. (*BLM-Weidenbach-Ex. R0 at 2:2-5; Aug. 22, 2006 Tr. at 103:2-10*).

19-30. The BLM Flow Management Scenario (FMS) model provides estimates of available whitewater boating opportunities that would result from the BLM flow condition. (*BLM-Turaski-Ex. 0 at 2:15-18, 4:1-8*).

19-31. Model results-for both the FMS model and PacifiCorp's spreadsheet model-are approximations of what impacts might actually occur to whitewater boating opportunities. (*BLM-Turaski-Ex. 0 at 10:12-15; PAC-Carl-R-1 at 13:4-6; Aug. 21, 2006 Tr. at 181:5 to 182:4*).

19-32. BLM provided FMS model outputs for decreases in whitewater boating opportunities (raftable days) in an average, dry, and wet year for the 10-year period; the decreases were greater in a dry year and less in a wet year. (*PAC-Whit-R-3 (average year) (these are the values presented in the proposed ultimate finding of fact for Issue 19); BLM-Turaski-Ex. 5, Table 2 (presents values for average, dry, and wet years*)).

19-33. In the ten-year period used by the BLM for its FMS model, there were three average years, four wet years, and three dry years. (*BLM-Turaski-Ex. 11 (listing the entire 1960-2000 period of record, including the ten-year period of 1991 to 2000 used in the BLM FMS model); BLM-Turaski-Ex. 0 at 7:18-8:11 (explaining how the ten-year period is representative of the 1960-2000 period of record*)).

19-34. The FMS model does not explicitly consider mechanical or efficiency considerations when estimating rafting impacts. (*PAC-Smit-R-1 at 5:8 to 6:2; Aug. 22, 2006 Tr. at 88:12-16*).

19-35. The FMS model does not consider variables that affect the demand and need for generation at the Project, the value available at the J.C. Boyle project, or the variability inherent in electricity markets. (*Aug. 22, 2006 Tr. at 87:17 to 87:20*).

19-36. The FMS model does not consider whether transmission generation is available or the mechanical or physical limitations that can be imposed on generating facilities, and does not attempt to maintain reservoirs within current summer operating levels. (*Aug. 22, 2006 Tr. at 87:21-88:4*).

19-37. As a result of these limitations of the FMS model, the model likely overstates the number of days and hours rafting will be available. (*PAC-Smit-R-1 at 2:14-20; PAC-Carl-R-1 at 13:4-16*).

d. Fly-fishing

19-38. Trout fishing occurs in the J.C. Boyle bypass reach. (*PAC-Whit-D-1 at 8:1*).

19-39. Siskiyou County strongly opposes the proposed flow regime and believes it will induce severe and adverse affects on the county's fly-fishing tourism industry, which produces needed revenue for the county. (*Aug. 21, 2006 Tr. at 33:12–36:19*).

19-40. In the peaking reach, many fly-fishing anglers describe the experience as good or excellent. (*PAC-Carl-D-7 at 2-68; NGO-Ex. 5 at 10:11-19*).

19-41. The ability to wade is an integral component to fly-fishing. This includes not only the aesthetic experience of wading, but also the practical advantage of being able to better access places where fish my reside. (*Aug. 22, 2006 Tr. at 113:3-117:10*).

19-42. Optimal fly-fishing conditions, particularly for those who wade, generally occur at 330 cfs base flows. (*PAC-Whit-D-1 at 12:11-13*).

19-43. Lower flows are preferred by anglers because lower flows provide: (1) improved access to fishable water because of improved wadeability that allows river crossings, access to the middle of the channel, and more casting space for fly anglers; (2) more fishable water, with current velocities and depths appropriate to preferred tackle and techniques; (3) the ability to use lighter tackle, which decreases the possibility of snagging rocks or vegetation in the channel; (4) more concentrated fish in specific locations; and (5) better aesthetics and possibly improved fishing success due to a larger proportion of "clear water" from Boyle bypass springs rather than more turbid water from Upper Klamath Lake. (*PAC-Whit-D-1 at 12:18 to 13:3*).

19-44. Higher flows diminish the quality of this opportunity, which becomes sub-optimal at about 700 cfs and unacceptable at about 1,400 to 1,500 cfs. (*PAC-Whit-D-1 at 12:13-15; BLM-Denman-Ex. 0 at 4:9-10; PAC-Whit-R-1 at 2:1-4*).

19-45. Measured flows at a gage are not indicative of velocity conditions at all spots within the river. (*Aug. 22, 2006 Tr. at 114:23 to 115:8 (higher flows do not mean that wading is more difficult in all areas—some areas may be faster, some slower); Aug 22, 2006 Tr. at 133:15-23 (Knight cross) (noting fisherman's ability to find back water area to fish when measured flows were 1,500 cfs*)).

19-46. In an average year (2000), the existing regime provides at least three daylight hours of "preferred" fishing flows (330 to 699 cfs) for 109 days or about fifty-nine ("59") percent of the season from May through October, and fifty-two ("52") days or eighty-four ("84") percent of the season from June through August. (*PAC-Whit-R-1 at 3:7-13*).

19-47. In an average year (2000), the existing regime provides at least three hours of "preferred" fishing flows for forty-five ("45") of seventy-eight ("78") (about fifty-eight ("58") percent) of the "weekend" days (Friday, Saturday, or Sunday) from May to October. (*PAC-Whit-R-2*).

19-48. Under current operations, all day "high flow fishing" only occurs on twenty-six days or twenty ("20") percent of the May-October season. (*PAC-Whit-R-2*).

19-49. The BLM condition will make wading more difficult in the peaking reach. (*Aug. 22, 2006 2 at 120:3-20; BLM-Weidenbach-Ex. 2 at 93 (each higher flow increment may provide less wadeable area); PAC-Carl-D-7 at 2-93; NGO-Ex. 5 at 7:12-13*).

19-50. Under BLM's proposal, wading access (or fishability) at dawn and dusk will be more difficult at those locations where the flow velocity and depth will increase relative to current minimum flows. However, pools and other locations with good access will continue to exist under the proposed schedule. (*PAC-Carl-D-7 at 2-94; NGO Ex. 5 at 7:10-15; Aug. 22, 2006 Tr. at 121:1-122-16, 132:22-134:1*).

19-51. Based on experience with changed flow regulation on other rivers, it is reasonable to expect that anglers in the peaking reach will attempt to adjust their tackle and techniques to accommodate the proposed flows if implemented. (*PAC-Carl-D-7 at 2-97; id. at 2-63-64, 2-95; Aug. 22, 2006 Tr. at 130:19-21).* Thus success of any such mitigation attempts is no contained in the record.

19-52. Wading access, as set out in the "fishability" study conducted by PacifiCorp, is only one component of assessing flow needs for fishing opportunities. (*PAC-Whit-D-8 at 17, 30 (other components include fishing success or effects on the fishery); Aug. 21, 2006 Tr. at 230:18 to 231:14*).

19-53. Many anglers believe that geological concerns of the fish stock out weight their concern about maintaining water levels which are optimal for wading. (*BLM-Weidenbach-Ex. 2 at 98; PAC-Carl-D-7 at 2-98 (same); Aug. 21, 2006 Tr. at 231:18 to 233:4; Aug. 22, 2006 Tr. at 131:1-4*).

19-54. The proposed flows will increase the population of the redband trout fishery. (*See BLM Issue 16 Proposed Findings*).

DISCUSSION

A. USFWS/NMFS DISPUTED ISSUES OF MATERIAL FACT DISCUSSIONS

1. USFWS/NMFS ISSUE 2(A)

USFWS/NMFS Disputed Issues of Material Fact 2A asks whether stocks of anadromous fish suitable to conditions above Iron Gate Dam. PacifiCorp answers this question in the negative. According to PacifiCorp, the stocks of anadromous fish at issue in this proceeding do not possess the biological and behavioral traits suitable to the conditions above Iron Gate Dam. To support its position, PacifiCorp heavily relies on the KlamRas and EDT models to show that juvenile and adult fish survival rates associated with volitional passage would be minimal. While the information contained in the studies was informative, PacifiCorp's reliance on the Miller Radio-Telemetry study is misplaced.

The issue concerning suitability of stock for reintroduction above Iron Gate Dam is separate and distinct from the issue concerning survival rates associated with volitional passage. See *NMFS/FWS-Issue 2-Curtis Rebuttal at 2:18-23; Aug. 24, 2006 at 16:24-17:18*). The latter is not an issue before the judge.

a. The Miller Radio-Telemetry Study is Scientifically Unreliable.

While the Miller Radio-Telemetry study (*PAC-Mal-D-15*) was admitted into evidence, I find that it is not scientifically reliable. Accordingly, it will be accorded little, if any, weight. This study was based on a small sample of juvenile salmonids, it used hatchery fish which lack the predator avoidance skills of wild fish, and the authors themselves admitted that fish passage success and travel time may be underestimated. (*Aug. 23, 2006 Tr. at 220:25-233:5; Aug. 24, 2006 Tr. at 53:2-55:2; PAC-Mal-D-15 at 15, 19, 27 and 31; NMFS/FWS-Issue 7-Simondet Rebuttal-Ex. 1 at 7:3-11; NMFS/FWS-Issue 2-Hamilton Rebuttal Ex. 1 at 2:18-3:7; NMFS/FWS-Issue 2-Hamilton Rebuttal Ex. 8*). Further the study: 1) lacked a control group; 2) was conducted during one-water year type and so it does not represent the normal range of flow conditions; 3) was conducted with highly variable peaking flows; and 4) produced widely varying results between 18 and 100 percent survival for different groups of salmonids in one reservoir. (*Id*.).

As the presiding judge in this case, I have an affirmative duty of ensuring that this decision is based on "relevant, reliable, and probative evidence." See 50 C.F.R. § 221.55(a) (1). The reliability requirement of 50 C.F.R. § 221.55(a) (1) adopts the "spirit" of Daubert v. Merrell Dow, 509 U.S. 579 (1993), as the standard to be used for determining the reliability of expert testimony in this administrative proceeding.

In Daubert, the Supreme Court held that Rule 702 of the Federal Rules of Evidence imposes upon the trial court a gatekeeper obligation in order to "ensure that any and all scientific testimony or evidence admitted is not only relevant, but reliable." Daubert, 509 U.S. 579. The judge's gate keeping function was later extended to apply to all expert testimony. Kumho Tire Co., Ltd. v. Carmichael, 526 U.S. 137 (1999). Daubert and its progeny interpret the Federal Rules of Evidence. Although the Federal Rules of Evidence do not apply in these proceeding, they do serve as guidance. 50 C.F.R. at § 221.55(a) (4). As the 7th Circuit noted in Niam v. Ashcroft, "'Junk science' has no more place in administrative proceedings than in judicial ones." 354 F.3d 652, 660 (7th Cir. 2004). Although the Daubert factors could be used in this case to excluded Mr. Malone's testimony and the related exhibits concerning the Miller Radio-Telemetry study because it is unreliable, Lobster v. Evans, 346 F. Supp. 2d. 340, 344-45 (D. Mass. 2004), my practice has been to err on the side of admissibility. United States Steel Mining Co., Inc. v. United States Department of Labor, 187 F.3d 384, 388-389 (4th Cir. 1999).; Consolidation Coal Co. v. Office of Workers' Comp. Programs, 294 F.3d 885, 893-94 (7th Cir. 2002).

Because the Miller Radio-Telemetry study is not scientifically reliable, it does not offer viable support for PacifiCorp's position.

b. The Evidence Shows that There are Stocks of Anadromous Fish Suitable to the Conditions above Iron Gate Dam.

PacifiCorp failed to prove that there are no stocks of anadromous fish suitable to the conditions above Iron Gate Dam. The record shows that historically, anadromous fish, including wild Chinook salmon, Coho salmon, and steelhead trout migrated above the present site of Iron Gate Dam. (*FOF 2A-3, - 2A-6*). The record shows that construction of dams has necessarily changed the migratory behavior of anadromous fish in the Klamath River System, permanently blocking upstream migration and limiting those fish to habitat below the dam. (*FOF 2A-8*). It is undisputed that, today, wild Chinook salmon, Coho salmon, and steelhead trout only migrate to the base of Iron Gate Dam, using nearby tributary and main stem habitat to spawn. (*FOF 2A-11*). If access was provided through a properly designed, operated, and maintained fishways, anadromous fish would migrate past Iron Gate Dam into the upper Klamath River basin. (*FOF 2A-12*). The evidence further shows that because of its genetic similarity to those populations that existed in the upper Klamath basin prior to the construction of the dams, the stocks of anadromous fish (especially fall-run Chinook salmon and steelhead trout) at the base of Iron Gate Dam are suitable candidates to the conditions above that dam. (*FOF 2A-22, 2A-25 through 2A-30, 2A-42 through 2A-47*).

PacifiCorp argues that to be suitable for reintroduction and for anadromous fish to persist and thrive, the selected anadromous fish stocks' spawning, rearing and life cycle window must fit the spatial, temporal and environmental conditions present in the Project above Iron Gate Dam. PacifiCorp's argument fails to give any weight to the fact that anadromous salmonids are highly adaptable to changing conditions and will migrate to and colonize unused habitat. (*FOF 2A-23, 2A-24, 2A-28 and 2A-29, 2A-44, 6-3*). The ability to adapt to a wide array of environmental conditions and colonize unused habitat or recolonize historical habitat are just a few life history strategies that have allowed the species to survive for millions of years in sub-optimal conditions. (*FOF 2A-15, 2A-35, 2A-36, 2A-37*). The fact that the anadromous fish adapted to life below the dams following construction of the dams is strong evidence of their capabilities. (*Id*). The fact that anadromous fish in other streams and river systems have successfully colonized new habitat or recolonize historic habitat lends further support that the wild anadromous fish in the Klamath River could and would do the same. (*FOF 2A-8 and 2A-11*).

Pacific lamprey is the only stock for which there is no clear evidence regarding its historical presence above Iron Gate Dam. (*FOF 2A-7*). PacifiCorp has proven, by a preponderance of the evidence, that historical observance of Pacific lamprey above Iron Gate Dam was most likely a misidentification because of the lack of genetic analysis at the time and the similarities between Pacific lamprey and resident lamprey. (*Aug. 24,* *2006 Tr. at 121:17-122:2, 124:2-8; 125:13-19, 252:2-255:19; NMFS/FWS-Issue 3–Snedaker-Ex. 14 at 21-23; NMFS/FWS-Issue 8-Hamilton Ex. 6 at 17 (recognizing that it is difficult to distinguish anadromous Pacific lamprey from resident taxa*). Therefore, the evidence concerning the historical presence of Pacific lamprey above Iron Gate Dam is inconclusive.

2. USFWS/NMFS ISSUE 2(B) Discussion

In response to USFWS/NMFS Issue 2(B), PacifiCorp argues that facilitating movements of anadromous fish via prescribed fishways will provide increase risk of disease exposure of resident fish inhabiting the basin above Iron Gate Dam to pathogens, such as *C. Shasta* and *IHN*. This argument is rejected. The weight of the evidence shows that many pathogens are already present in the upper and lower Klamath Basin. Thus, establishing fish passage will not increase the risk of disease. (*FOF 2B-2, 2B-10, 2B-11, 2B-17, and 2B-22*). *C. Shasta and P. minibicornis* exist throughout the Klamath River System in both the upper and lower basins, so migration of wild anadromous fish upstream from below Iron Gate Dam would not increase the risk of introducing pathogens to resident trout residing above Iron Gate Dam (*FOF 2B-11, 2B-17 and 2B-22*). This is especially true given the fact that trout are resistant to *C. Shasta* and with respect to the remaining known pathogens, except *F. columnaris* and *Ich*, they do not impact non-salmonids. (*FOF 2B-20*).

As for *IHN*, there is insufficient evidence to determine whether that virus exists in either the lower or upper basin of the Klamath River. (*FOF 2B-4*). The record evidence shows that there has only been a single detection of *IHN* documented in the lower basin in 1997, and since then there has been no further detection. (*FOF 2B-3*). The virus was detected in one adult Chinook salmon returning to Iron Gate Hatchery. (Id). Based on the Chinook salmon population size existing in the lower basin, I do not find a single detection nearly ten years ago in a fish suspected to be a "hatchery fish" to be significant or cause for alarm. Moreover, to date, there has been no work or surveys completed concerning the actual occurrence of *IHN* in the upper basin. (*FOF 2B-6).* Therefore, any suggestion that *IHN* exists in either the lower or upper Klamath Basin would be mere speculation.

Furthermore, there is insufficient evidence to determine whether *R. salmoniranrum* exists in the upper Klamath Basin. Like *IHN*, no research or studies have been performed to detect the occurrence of *R. salmoniranrum*. (*FOF 2B-7*). Consequently, PacifiCorp failed to prove that facilitating the movement of anadromous fish would present a high risk of introducing pathogens to resident fish inhabiting the basin above Iron Gate Dam.

3. USFWS/NMFS ISSUE 2(C) Discussion

USFWS/NMFS Issue 2(C) asks to what extent facilitating the movement of steelhead above Iron Gate Dam via prescribed fishways presents a risk of residualizing, and whether residualization would adversely effects to the resident trout fishery resource. The experts are in agreement that residualization is characteristic of hatchery fish, and is quite rare in wild anadromous steelhead trout. (*FOF 2C-8*). During the hearing, PacifiCorp's sole witness on USFWS/FWS Issue 2(c) conceded that the residualization of steelhead is not really an issue of concern. (*PAC-Ols-R-1*). The issue of concern to

PacifiCorp and Siskiyou County is the genetic effects on the resident trout. (Id). It is undisputed that resident trout have the genetic capacity to adopt anadromy and outmigrate to the ocean, where passage exists. (*FOF 2C-7*). However, there exist no scientific studies demonstrating that reintroduction of anadromous steelhead trout would detrimentally affect the genetic make up of the resident trout fishery. (*FOF 2C-10*). The undisputed evidence shows that residualization is largely dependent on environmental conditions. (Id).

Historically, anadromous steelhead trout extended up to and used tributaries of upper Klamath Lake. (*FOF 2A-3, 2A-5, and 2C-2*). The close similarities between anadromous steelhead trout and resident trout, together with the distribution and resistance of the resident trout to *C. Shasta* provides strong evidence that the two species likely co-existed prior to the construction of the dams. (*FOF 2C-2*). While the competitive interactions between the steelhead and resident trout in the Klamath basin is unknown, there are many examples from nearby river systems in the Pacific Northwest that show wild anadromous steelhead and resident rainbow/redband trout can co-exist and maintain abundant populations without adverse consequences. (*FOF 2C-10 and 2C-11*). To minimize the risk of residualization by resident trout adaptive management may be utilized. (*FOF 2C-12*).

4. USFWS/NMFS ISSUE 3 Discussion

In response to USFWS/NMFS Issue 3, PacifiCorp argues that current project operations do not adversely affect the resident trout fishery resource in the absence of passage. Indeed, PacifiCorp has proved that the redband fishery is excellent and robust, as indicated by angling success in the J.C. Boyle bypass and peaking reaches. While this is true, the evidence also shows that the Project confines the population between the Project's dams and associated reservoirs. (*FOF 3-8*). Resident trout are not able to utilize their full range of life history strategies and spawning productivity and genetic diversity of the stock is impaired. (*FOF 3-13. through 3-16*). Further, unscreened flows through Project turbines result in mortality of juvenile and adult trout migrating downstream. Therefore, the record evidence demonstrates that the resident trout fishery is adversely affected by current Project operations.

5. <u>USFWS/NMFS ISSUE 4 Discussion</u>

USFWS/NMFS Issue 4 asks whether entrainment at Project facilities is adversely affecting resident fishery resources. There is no dispute that entrainment is occurring at J.C. Boyle, Copco, and Iron Gate Dams. (FOF 4-2). In its literature based review, PacifiCorp admits that tens of thousands of resident fish are being entrained on an annual basis at each Project. (FOF 4-2). The facts show that non-native species are entrained to a greater extent than non-native species. (*FOF 4-13*). This is primarily because of the relative abundance of non-native versus native species. <u>Id</u>. The Federal Agencies appear to be most concerned with the impact entrainment is having on two species of fish, sucker fish and resident rainbow trout.

Precise estimates on the number of fish entrained are unavailable. However, records from canal salvage operations at the J.C. Boyle power canal show that some resident fish, in particular resident trout and sucker fish, are entrained and possibly killed in the power canal each year. (*NMFS/FWS-Issue 4-Hooton-Ex. 1, at 5:6-17;*

NMFS/FWS-Issue 4-Hooton-Ex. 15; NMFS/FWS-Issue 4-Hamilton-Ex. 1, at 5:17-19 and 6:3-5; NMFS/FWS-Issue 4-Hamilton-Ex. 14, at 1; Aug. 23, 2006 Tr. at 212:25-213:21; Appendix to Reply Brief of PacifiCorp and Siskiyou County, at 38). Salvage records show the entrainment of over 690 trout into the J.C. Boyle reach during salvage operations between 1995 and 2002, whereas only 2 sucker fish were entrained during the same period of time. (*FOF 4-17*). In 2003, J.C. Boyle fish salvage totaled 86 trout and 17 suckers. (*NMFS/FWS-Issue 4-Hamilton-Ex. 14, at 1; NMFS/FWS-Issue 4-Hooton-Ex. 15 at 2-3*). Of the two species, sucker fish are less prone to entrainment because they are bottom dwellers making it less likely for them to pass through the shallow intakes at Copco and Iron Gate Dams. (*FOF 4-19*). Therefore, it is reasonable to conclude that the adverse effect of entrainment for sucker fish would be minimal.

The Federal Fisheries Services rely on the "Link River Hydroelectric Project, Final Entrainment Study Report" (*NMFS/FWS-Issue 4-Hamilton-10*) to rebut PacifiCorp's evidence that entrainment is not adversely affecting sucker fish. The Link River Dam and Westside/Eastside are not in the proposed Project area. They are currently proposed for decommissioning. Therefore, reliance on this study is misplaced since they are not necessarily comparable.

Moreover, a review of the canal salvage data demonstrates that there is a significantly higher rate of sucker fish entrainment at the Link River and Eastside/Westside facilities than at the J.C. Boyle facility. (*NMFS/FWS-Issue 4- Hooton-Ex. 15, at 2-4 (Fish Salvage Data Table)*). Of the 785 sucker fish recovered during entrainment salvage operations in 1995 through 2002, it appears that only 2 were entrained at the J.C. Boyle facility. (Id.). The number of entrained sucker fish recovered during salvage operations at the J.C. Boyle in 2003 increased to 17. This increase might be a result of the ineffectiveness of the fish screens. But given the low numbers, it is difficult to conclude that entrainment is adversely affecting sucker fish. This is especially true given the fact that the record shows that sucker fish are bottom dwellers that are less prone to entrainment through shallow intakes, such as those found at Copco and Iron Gate Dams. The non-larval sucker fish residing in those two reservoirs appear to be too large to pass through the existing trash racks at the powerhouse intakes. (*FOF 4-20*). If there is an adverse affect from the low number of sucker fish being entrained, it is minimal.

The same is not true for resident trout. The record shows that Spencer Creek located upriver of the J.C. Boyle facility has historically been a primary spawning and early rearing habitat for trout. (*FOF 4-22 and 4-23*). The construction of J.C. Boyle has adversely affected the migratory behavior of the resident trout. Currently, the peaking reach life history appears to be gone and the bypass reach life history has been reduced to less than 10% of historical abundance and is composed of significantly smaller trout. (*FOF 4-22*). Thus, the rainbow trout are not experiencing their full range of life history. Losses of juveniles through entrainment at the Project could, in the long run, adversely affect trout abundance and distribution. (*NMFS/FWS-Issue-4-Hooton Ex. 1 at 6:9-13; NMFS/FWS-Issue 4-Hamilton-Ex. 1 at 4:16-16 and 7:3-4; NMFS/FWS-Issue 4-Hamilton-Ex. 17 at 4; HVT-Steward-Ex. 39 at 1:17-22*). Therefore, PacifiCorp's argument that entrainment is not adversely affecting resident trout must be rejected.

6. USFWS/NMFS ISSUE 6 Discussion

USFWS/NMFS Issue 6 asks whether 58 miles of habitat suitable for use by anadromous fish exists within the Project reach. PacifiCorp answers this question in the negative, and in actuality, it is difficult to ascertain exactly how much suitable habitat exists within the Project reach. Since the determination of what constitutes "suitable habitat" is within the realm of agency expertise, the Federal Fisheries Services definition of suitable habitat is hereby adopted. Under that definition, habitat is deemed "suitable" if it can be used successfully at least some of the time by one or more life stages of a Coho salmon. (*FOF 6-2*).

Based upon this definition, it is clear that a significant amount of habitat that is suitable for anadromous fish exists above Iron Gate Dam. Those habitat areas include: 1) The main stem (containing approximately 28 miles of suitable habit), which PacifiCorp admits is suitable for anadromous fish; 2) perennial tributaries (containing approximately 12 miles of suitable habitat) and intermittent streams (containing approximately 18 miles of suitable habitat). (*FOF 6-9 through 6-14*).

While connectivity is a problem, the record evidence shows that anadromous fish will not be precluded from using the areas identified as suitable habitat. (*FOF 6-8*). Moreover, the fact that much of the habitat deemed suitable for anadromous fish are currently being used by resident fish strongly suggests that anadromous fish would utilize the habitat if access is provided. (*FOF 6-7*). Accordingly, PacifiCorp's argument that the riverine and tributary habitat with the Project area is not suitable for production of anadromous fish must be rejected.

7. USFWS/NMFS ISSUE 7 Discussion

In response to USFWS/NMFS Issue 7, PacifiCorp argues that providing access to habitat within the Project would not benefit Coho salmon but instead would harm the overall health of the Klamath Coho salmon population. PacifiCorp's argument rests on two grounds: first, that the Coho salmon habitat above Iron Gate Dam is "limited and marginal"; and second, that mortality risks of out-migrating smolts in the reservoir are great because of the high water temperatures and predation that providing access would be counterproductive. Both arguments must be rejected.

a. There is Significant Suitable Habitat above Iron Gate Dam for Coho Salmon.

As explained in the discussion addressing USFWS/NMFS Issue 6, there is significant suitable habitat for anadromous fish (including Coho salmon) above Iron Gate Dam. Suitable habitat above Iron Gate Dam includes Spencer, Fall, Beaver, Deer, Shovel, Scotch, and Jenny Creeks. The main stem also has suitable habitat (which is a fact recognized by PacifiCorp). (*FOF 7-9; see also PAC Ols-D-1, at 38:11; NGO Ex. 27,* *at 3:6-10*). Much of this habitat is currently being used by resident rainbow/redband trout that have similar habitat requirements to those of Coho salmon. (*FOF 6-5*). Said resident rainbow/redband trout are a self-sustaining population above Iron Gate Dam, and the evidence suggests that similar results could occur for the Coho salmon population. (*FOF 6-6*). As such, PacifiCorp's argument that the habitat above Iron Gate Dam is limited and marginal for Coho salmon is not persuasive.

b. Habitat above and below Iron Gate Dam are Equally Degraded.

PacifiCorp's argument that the high water temperatures and predation above Iron Gate Dam is so severe that providing access above Iron Gate Dam would be counterproductive is not supported by the evidence. The record evidence shows that the runs of Coho salmon have greatly diminished in the Klamath River to the extent that the species is listed as threatened under the Endangered Species Act. (*FOF 7-2 through 7-4*). Habitat degradation has been recognized as the primary cause for the decline of Coho salmon. (*FOF 7-5*). Historically, Coho salmon spawned in abundance at Fall Creek, and some evidence suggests that the upstream distribution extended as far as Spencer Creek. (*FOF 2A-6*). However, the construction of the Project dams has prevented Coho salmon from accessing its historic spawning grounds above the present site of Iron Gate Dam. (*FOF 2A-8 and 2A-11*). Coho salmon continue to use the habitat below Iron Gate Dam even though it has suffered degradation commensurate with that above the dam. (*FOF 7-6*). While water temperature above Iron Gate Dam is a problem for juvenile Coho salmon, the record evidence shows that water temperature will not preclude Coho salmon from successfully utilizing habitat within the Project area. (*FOF 7-11 and 7-12*). As a matter of fact, it is well documented that Coho salmon have been known to occupy waters below Iron Gate Dam where temperatures exceed 20^{o} C. (Id).

Further, the evidence shows that adult Coho salmon enter the river to spawn in late September and reach peak migration strength between late October and mid-November when the water temperatures above Iron Gate Dam is low. (*FOF 7-10*). On the other hand, juvenile Coho salmon begin outmigrating to the ocean in late February, and continue migration through early July. (*FOF 7-11*). For a significant amount of the outmigration period, water temperatures are low. Therefore, contrary to PacifiCorp's argument, water temperature should not significantly affect adult or juvenile Coho salmon. Further, with respect to predation, that can be minimized through use of remedial measures. (*FOF 7-13*).

c. Providing access above Iron Gate Dam will Benefit Coho Salmon.

Last, the record shows that restoring access to historical habitat above Iron Gate Dam will improve the viability of the Coho salmon population by: a) extending the range and distribution of the species thereby increasing the Coho salmon's reproductive potential; b) increasing genetic diversity in the Coho stocks; c) reducing the species vulnerability to the impacts of degradation; and d) increasing the abundance of the Coho population. (*FOF 7-16*). As such, PacifiCorp's arguments must fail.

8. <u>USFWS/NMFS ISSUE 8 Discussion</u>

USFWS/NMFS Issue 8 asks whether access to habitat within the Project would benefit Pacific Lamprey. PacifiCorp answers this question in the negative and focuses much of its argument on the fact that lamprey-friendly ladders are unavailable.

The issue concerning habitat benefit and whether lamprey-friendly ladders exist are two separate and distinct questions. The latter, is not an issue in this proceeding. While the evidence concerning the upstream distribution of Pacific lamprey above Iron Gate Dam is inconclusive, the evidence shows that those species would indeed benefit from access to habitat within the Project reach. (*FOF 2A-7, 8-3, and 8-9*). Essentially, Pacific lamprey would be gaining additional habitat for spawning and rearing. Therefore, PacifiCorp failed to show that Pacific lamprey would not benefit from access within the Project reaches.

B. <u>BLM DISPUTED ISSUES OF MATERIAL FACT</u>

1. <u>BLM ISSUE 10 and 11 Discussion</u>

BLM Issues 10 and 11 are closely related – has the Project adversely affected riparian habitat and riparian-focal species in the two J.C. Boyle reaches (Issues 11) and would the proposed BLM seasonal high flows improve those resources (Issue 10).[13] The evidence shows that Project operations have negatively affected riparian habitat and the proposed BLM high flows will help improve riparian habitat. However, the evidence

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[13] Many of the findings of facts associated with Issue 10 and 11 apply to both issues. Therefore, each is cross-referenced and incorporated therein.

does not show that riparian-focal species have been negatively affected by Project resources or that the proposed seasonal high flows will assist riparian-focal bird species.

The Project has greatly affected and continues to affect the Project reaches. One of the Project's largest impacts involves effects to sediment supply. (*FOF 11-1, 11-3*). On average, 6,124 tons of channel bedload is blocked each year at the J.C. Boyle dam. (*FOF 11-2*). By limiting sediment supply, the bed material in the reaches has coarsened and active features (e.g., point bars, islands) are made up of less fine sediment. (*FOF 11-3; 11-9*). Negative impacts can occur from such limited sediment supply. For example, desirable riparian plants use freshly deposited sediment to germinate and a lack of sediment adversely affects fish habitat. (*FOF 10-5, 11-10, 14-4*). A gravel augmentation program has been developed which will offset some of the negative effects of the bedload blockage.[14] Therefore, an important question to ask is whether the gravel augmentation program together with the current flow regime can improve the channel conditions, and whether BLM's proposed seasonal high flow would provide additional benefit.

PacifiCorp argues that the results of a study it sponsored indicate current flows effectively mobilize some coarse bed sediment.[15] However, BLM high flows, as compared to current operations, will mobilize and transport sediment more frequently within the Project. (*FOF 10-4*). Higher flows will allow for a wider range of sediment

[14] PacifiCorp entered into a stipulation with BLM to clarify the composition of the sediment to be used and the intent of the BLM gravel augmentation plan. (*See Order Granting PacifiCorp's Motion to Withdraw Disputed Issue of Material Fact 12 (issued Aug. 2, 2006*)).

[15] This study contained several biases. The tracer particles used in the study at the bypass reach were placed in the steepest section of the river and were limited to the center of the channel. Both of these actions bias the study toward a finding that a given flow can greatly mobilize particles. (*Aug. 21, 2006 Tr. 1 at 56:10-58:14*).

deposits and allow sediment to be deposited higher on the channel margin. (*FOF 10-5*). Both of which can serve as an ecological benefit. (*Id*.)

Current low flows not only affect the ability to mobilize coarse bed sediment, low flows also increase the prevalence of reed canary grass. (*FOF 11-7, 11-8*). Reed canary grass is a non-native invasive riparian plant. (*FOF 10-7; 11-12*). Moreover, it is not used by riparian-focal bird species for nesting. (*FOF 10-11*). Finally, reed canary grass can adversely affect the abundance and quality of fish habitat and out-compete woody riparian vegetation. (*FOF 11-7, 11-8*). High and medium flows can scour (uproot and dislodge) reed canary grass. (*FOF 11-6*). The current low base flows result in a diminished scouring effect on the reed canary grass. (*FOF 11-6, 11-7, 11-8*). Increasing flows would allow for an increased scouring effect. (*Id.*). Low flows also allow reed canary grass to encroach into the channel in places that have been exposed by Project-diverted flows. (*FOF 10-6*). Project operations result in more riparian vegetation; however, this increase is attributed mainly to the encroachment of reed canary grass. (*FOF 11-13*). Approximately two-thirds of the riparian habitat in the J.C. Boyle bypass reach is currently riparian grassland, which is predominately reed canary grass. (*FOF 10-8*).

While the proposed high flows will effectively scour and limit channel encroachment of reed canary grass, evidence fails to show that riparian-focal bird species habitat will be improved or that Project operations have adversely affected such habitat. Eight species of riparian-focal birds exist within the Project. (*FOF 10-11*). These birds prefer structurally diverse habitat and primarily nest in woody riparian vegetation. (*FOF 10-12; 10-13*). An increase in woody riparian vegetation would likely result in an increase of riparian-focal bird species. (*FOF 10-14, 10-15*). Seasonal high flows, in combination with the BLM's proposed gravel augmentation program, will likely create a more dynamic channel with a wider range of sediment deposit, therefore increasing ecological benefits. (*FOF 10-5*). However, woody riparian vegetation (the key habitat for riparian-focal bird species) will not increase under BLM's proposed flows.[16] Without an increase in woody riparian vegetation, an increase in riparian-focal birds species is not likely. Furthermore, while low flows allow for the encroachment of reed canary grass, higher flows have a tendency to scour woody riparian vegetation. (*NGO Ex. 1 at 10:5-8*). Because pre-project flows would have likely scoured any woody riparian vegetation where reed canary grass is currently located, it is not likely that the Project has decreased the potential establishment of woody riparian habitat.

PacifiCorp has established that the extent of any improvement on ripariam-focal bird species is indeterminate since an increase of woody riparian vegetation is not expected.

2. *BLM ISSUE 14 Discussion*

BLM Condition 4.A.1(c) will provide a net positive effect on redband trout spawning. Specifically, the proposed flows will assist in the distribution of gravel used for spawning, will clean established spawning beds, and will assist in migratory

[16] BLM believes that larger floods will decrease reed canary grass and allow the woody riparian community to have a relative competitive advantage. (*BLM PFF 10.4*). BLM's only cite for this proposition is Dr. Trush's testimony at NGO Ex. 1. While this testimony does state that the proposed flows will "benefit native birds," it clearly states that, "[t]he River Corridor Management Condition will change the baseline conditions of the riparian resources in the bypassed reach. **It will support less, rather than more, woody riparian vegetation than today**." (*NGO Ex. 1., at 17:11-13 (bold added)*).

movement of trout. (*FOF 14-1 to 14-8, 14-17 to 14-21*). Negative effects include a loss of spawning habitat below the emergency spillway and the possible scouring of trout eggs. (*FOF 14-14, 14-15, 14-24, 14-25*). PacifiCorp has not met its burden to show that the negative effects outweigh positive effects.

The J.C. Boyle bypass reach channel bed consists mainly of course material not suitable for trout spawning. (*FOF 14-1*). On average, 6,124 tons of channel bedload is blocked a year at the J.C. Boyle Dam. (*FOF 11-1*). This blockage is the primary factor in the coarsening of the channel. (*FOF 14-2*). A gravel management plan has been introduced that would place sediment in the Klamath River below the J.C. Boyle Dam. (*FOF 14-3*). For this plan to be effective, the gravel needs to be deposited downstream where it can create spawning pockets. (*FOF 14-4*). The implantation of seasonal high flows would assist in the deposition of this gravel.[17] (*Id*.).

Fine sediment buildup on spawning gravel reduces the successful emergence of fry. (*FOF 14-5, 14-6*). An annual flushing flow can clean fine sediments from the spawning beds, thus improve the quality of habitat. (*FOF 14-8*). Since fine sediment buildup has been observed on the limited spawning habitat in the bypass reach, an annual flushing flow would assist in developing a quality habitat. (*FOF 14-7).* PacifiCorp classifies the J.C. Boyle bypass reach as a "transport" reach and believes fine sediment buildup will not occur on spawning grounds.[18] (*PC Reply Brief Appendix at 19*).

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[17] Current flows would mobilize augmented gravel to an extent. However, BLM high flows, as compared to current operations, will mobilize and transport sediment more frequently and to a greater extent within the Project. (*FOF 10-4*).

[18] PacifiCorp defines "transport reach" as "the capacity of the channel to transport sediments is significantly higher than the supply of sediment to the channel." (*PC PFF 40*).

However, the observance of fine sediment buildup on the spawning habitat in the bypass shows that a buildup can occur, even in a "transport" reach.[19]

Historically, trout in the Klamath River downstream of the J.C. Boyle Dam migrated upstream to spawn and juvenile trout migrated downstream to rearing areas. (*FOF 14-18, 14-19*). Heavy spring and fall river flows signal to spawning trout and juvenile trout to begin their migrations. (*Id*.). Such migrations have diminished after the installation of the J.C. Boyle Dam and reduction in river flows. (*FOF 14-16, 14-20, 14-21*). The BLM seasonal high flows will better reflect the natural flood flows and improve fish migration. (*FOF 14-17*). PacifiCorp believes the presence of spawning trout, in the bypass reach, show that current flows provide favorable spawning conditions. (*PC PFF 48*). However, the only area where trout spawning is observed is directly downstream of the emergency canal spillway. (*FOF 14-21*). This very limited spawning, in a very unnatural environment, does not demonstrate that the current flow regime provides favorable conditions.

PacifiCorp correctly states that the BLM flows will adversely impact the spawning redds just downstream of the existing J.C. Boyle emergency canal spillway. (*PC PFF 45*). BLM counters this argument by showing that the current location is unstable and seasonal high flows could mobilize the sediment accumulated in the emergency spillway and distribute the sediment to a more stable location. (*FOF 14-22,*

[19] It is noted that the only spawning habitat in the bypass is found downstream of the emergency spillway and the emergency spillway significantly increases the rate of fine and coarse sediment in the area. (*FOF 14-21, 14-22).* It may be argued that this is the only reason fine sediment buildup has occurred on the spawning gravel. However, with the introduction of additional sediment by means of the gravel

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14-23). However unstable the current location is, the proposed flows would still disrupt the only spawning grounds in hope that more productive grounds would develop. These arguments are rendered basically irrelevant when another factor is considered. PacifiCorp has proposed to install bypass valves at the J.C. Boyle powerhouse. (*FOF 14-26*). This means the emergency spillway will no longer be used and the unnatural sediment loads in the area will not be replenished. (*Id.*). Since this unnatural habitat will no longer be self-sustaining, any detrimental results of the seasonal high flows will not be relevant.

Another negative factor to consider is the possible scouring effect high flows will have on spawning trout and their fry. The spawning period for trout between the Copco 1 Reservoir and J.C. Boyle Dam takes place between February and May, with the majority of spawning taking place between March 15 and April 15. (*FOF 14-11*). BLM's proposed flushing flows, which last for seven days, would always occur during the spawning season. (*FOF 14-13, 14-14*). The high flows would be implemented between March 15 and April 15 in fourteen percent of the years. (*FOF 14-12*). Flushing flows scheduled during spawning may scour eggs and result in less successful spawning. (*FOF 14-15*). Ideally, flushing flows should occur just prior to spawning. (*Id.*). While spawning trout will hold during high flows and resume spawning once flows have dropped, this does not discount the negative effects the high flows will have on already established egg nests. (*FOF 14-13*).

management plan, the entire bypass reach will be inundated with an increased supply of fine and coarse sediment – resulting in an increased need to have annual flushing flows.

The proposed seasonal high flows will result in the scouring of some trout eggs. Such effects will be felt most severely during the fourteen percent of the years when the high flows occur during peak spawning times. However, the median start date for the seasonal high flows is February 18, which corresponds close to the beginning of the spawning season. (*FOF 14-9, 14-11*). Since fewer egg nests will have been established at the beginning of the spawning season, the effects of the high flows will be less intrusive than if the flows were to commence near the end of the twenty-two week spawning season. It has been shown that the proposed seasonal high flows will assist in the creation of fish spawning grounds, will clean established spawning beds, and will improve migratory movement of trout. The creation of new and healthier spawning grounds will offset the loss of some eggs to scouring. PacifiCorp has not met is burden to show, by a preponderance of the evidence, that the negative effects of scouring is greater than the positive effects created by the seasonal high flows.

3. BLM ISSUE 16 and 17

The evidence in the record establishes that current operations have adversely affected the redband trout fishery resource. First, the J.C. Boyle Dam traps sediment necessary for spawning habitat. Second, the existing flow regime has increased the embedment of fine sediment in spawning gravel, impairs spawning migrations, and causes low flows, which contribute to the lack of successful spawning.[20] Third, the peaking operations cause stranding of aquatic organisms, results in downstream displacement of juvenile fish, increases the energetic demands placed upon adult trout, and lowers the production of macroinvertebrate prey. The proposed River Corridor Management Condition would address these negative impacts.

The Project's artificial low flow regime contributes to the lack of available spawning gravel in the J.C. Boyle peaking and bypass reaches. (*FOF 16-3 to 16-6*). Prior to the J.C. Boyle Dam, trout were observed spawning in the peaking reach. (*FOF 16-2*). Currently, trout do not spawn in the peaking reach and only limited spawning has been observed in the bypass reach. (*FOF 14-21; 16-1*). While sediment blockage at the J.C. Boyle Dam has contributed to lack of suitable spawning gravel in both reaches, low flows reduce access to spawning gravel that remains. Spawning gravel has been observed along channel margins and on depositional features in the peaking and bypass reach. (*FOF 16-3 to 16-6*). However, when low flows occur, portions of this margin-habitat are no longer inundated with water, making the spawning gravel unusable. (*Id.*). The proposed conditions would substantially alter the current flows by providing an overall increase in base flows. (*FOF 19-8 to 19-10*). Higher base flows allow for greater inundation of habitat suitable for spawning.

[20] Issue 14 addresses the negative effects associated with the J.C. Boyle Dam's trapping of sediment, embedment of fine sediment in spawning gravel, and low flow (limiting spawning migrations). Therefore, these effects will not be discussed in Issue 16.

PacifiCorp's peaking operations cause extreme daily flow fluctuations and create upramp rates as high as nine inches/hour in the J.C. Boyle peaking reach. (*FOF 17-1*). BLM conditions propose an upramp rate of no more than two inches/hour. (*FOF 17-2*). Upramp rates of two inches/hour are similar to naturally occurring rates and will be protective of fish resources. (*FOF 17-2 to 17-4*). The current peaking operations and their unnatural upramp rates create several conditions that are harmful to the trout fishery.

First, PacifiCorp's peaking operations create strandings that lead to the loss of thousands of fish and other aquatic animals.[21] (*FOF 16-9, 16-10*). Few trout fry exist in the peaking reach where the strandings occurred and none were reported stranded. (*FOF 16-9*). However, such strandings do kill large numbers of young fish and aquatic invertebrates that are the primary prey for trout. (*FOF 16-15*). The peaking operations that cause high mortality only happen a few times a year following the first peaking event after several months of steady flow. (*FOF 16-12*). Reduced ramp rates can resolve the problem of fish standing. (*FOF 16-13, 16-14*). The BLM proposed conditions calls for a two inch/hour maximum downramp rate, a drop from the four inch/hour ramp rate used at the sites where severe mortality of aquatic organism occurred. (*FOF 16-13, 16-14*). Ramp rates of two inch/hour have been shown to be effective at stopping the occurrence of stranding. (*Id.*)

[21] Stranding is the separation of fish from flowing surface water as a result of a declining river state. (*FOF 16-7*).

BLM provides evidence that Project peaking flows above 1,500 cfs result in the downstream displacement of juvenile salmonids. (*FOF 16-16*). Trout prey is affected in a similar manner, since peaking flows can displace forage fish eggs and push fry downstream. (*FOF 17-8, 17*-9). BLM proposed conditions would eliminate the Project's peaking flows, thus eliminating the downstream displacement. (*FOF 19-1 to 19-13*). PacifiCorp counters this evidence by citing a study it sponsored, which indicates trout fry can maintain their location during peaking flows. (*FOF 16-17 to 16-19*). The mark retrieved study recaptured nine of seventy-three marked fry in portions of the California peaking reach. (*FOF 16-19*). This indicates that fry do have an ability to maintain their position in the lower portions of the peaking reach. (*Id*.). However, the study did not mark or recapture any fry in the Oregon portion of the peaking reach; the section of the peaking reach with the highest ramp rate. (*FOF 16-17*). Therefore, the study is inconclusive as to the effects higher ramp rates have on fry.[22] PacifiCorp did not meet its burden to show that peaking flows, in the Oregon portions of the peaking reach, do not result in downstream displacement of juvenile salmonids.

Peaking operations also affect the energetic demands placed on trout and decrease macroinvertebrates prey. Peaking operations force trout to increase movement, which in turn decreases energy available for overall health, growth, and reproduction.[23] (*FOF 16-*

[22] PacifiCorp's distribution-over-time study had similar flaws, capturing only a few fry in the Oregon portion of the peaking reach. (*PAC-Ols-D-20 at App. 3A at 20; KTR-LKD-Ex. 6 at 6-46*).

[23] PacifiCorp's radio-telemetry study indicated that peaking operations did not induce any significant trout movement. (*PAC PFF 75*). However, PacifiCorp's radio-telemetry study only detects upstream-downstream fish movement, so it would not detect all fish movement that would increase energetic costs. (*PAC-Ols-D-20 at Sec. 5, 5-8, 5-9*). High water flows force trout to swim faster to stay in place. (*BLM-Simons-Ex. 0 at 5:8-6:7).* Fish also move laterally with changes in flow; fish move from the center of the

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21). Peaking operations reduce the production of macroinvertebrates by ten to twenty-five percent. (*FOF 16-24*). Macroinvertebrate drift rates, a measure of food availability for trout, is five to six times greater in the non-peaking Keno reach than in the peaking reach. (*FOF 16-25*). Peaking operations contribute to the lower macroinvertebrate drift rates, which in turn decrease the macroinvertebrate prey available for trout. (*Id.*).

Comparing growth of trout in the non-peaking Keno reach to the trout in the J.C. Boyle peaking reach provides insight into the effects peaking has on trout growth. Growth rates are greater in the peaking reach through age two. (*FOF 16-26*). Growth rates are similar in both reaches between ages two and three. (*Id.*). Growth rates are greater in the non-peaking Keno reach after age three, and the Keno reach trout are older. (*FOF 16-26, 16-30*). Since larger fish operate closer to the energetic margins than smaller fish, it makes sense that lower energetic demands in the non-peaking reach would result in larger adult trout. (*FOF 16-23*). Mature fish grow larger when they prey on forage fish, a higher energy source than invertebrate drift. (*FOF 16-31*). The Project-caused impacts to forage fish (via stranding and displacement) help explain the lower growth rates and absence of larger trout in the peaking reach.[24] (*FOF 16-32*). High growth rates of younger trout in the peaking reach indicate that peaking effects on macroinvertebrate prey are not substantial. Since younger fish prey mainly on macroinvertebrate, if peaking operations were having a substantial effect on

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channel at low flows to the edges of the channel at high flows. (KTR-*LKD-DT-BLM 16 at 7:13-17; KTR-LKD-Ex. 10 at 26*).

[24] PacifiCorp cites a study they sponsored which asserts that Keno trout are larger because they have access to a minnow forage base and reservoirs. (*PAC Reply Brief Appendix at 28*). Such conditions may

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macroinvertebrate prey, a lower growth rate in younger fish would be expected. By comparing the growth of trout in the non-peaking Keno reach to the growth of trout in the J.C. Boyle peaking reach, it has been established the peaking operations decrease growth rates for mature trout. Therefore, PacifiCorp has failed to meet its burden of proof with respect to BLM Issues 16 and 17.

4. <u>BLM ISSUE 19 Discussion</u>

a. Whitewater Rafting

The BLM Flow Management Scenario model was used to predict the effects of the BLM conditions on whitewater boating opportunities. (*FOF 19-30*). While this model has limitations, it provides the best quantitative evidence of anticipated impacts on whitewater opportunities. (*FOF 19-30 to 19-37*). This evidence shows the proposed flows will severely limit whitewater boating opportunities and impact the viability of the commercial rafting operations. (*FOF 19-25 to 19-27*).

BLM acknowledges in its proposed ultimate finding of fact that the proposed flows will decrease raftable days by an estimated forty-four percent a year. (FOF 19-27). At the peak of the rafting season, July and August, the proposed flows will decrease the total raftable days by seventy-one percent. (*Id.*). While PacifiCorp/Siskiyou County believes the proposed decreases should be even greater, the decreases cited by BLM are sufficient to justify a finding that significantly detrimental effects on rafting operations will occur. (*PC PFF 126*). When an industry's ability to conduct business is reduced by

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contribute to the increased size of Keno reach trout, however PacifiCorp has failed to adequately discount the effects that stranding and downstream displacement will have on forage fish supply.

nearly half (forty-four percent), the financial viability of that industry will be severally diminished.

PacifiCorp/Siskiyou County has shown, by the preponderance of the evidence, that a forty-four percent reduction in raftable days will substantially reduce the whitewater boating opportunities. Having met this initial burden of proof, the burden of persuasion shifts to BLM and BLM must establish other factors which may offset the decrease in raftable days. BLM conditions emphasis the protection of weekend boating opportunities. (*FOF 19-25*). As such, BLM contends that there may be a shift of some historical weekday to weekend use. (*FOF 19-28, 19-29*). However, BLM fails to provide evidence indicating the size of this potential shift. Without having an estimate of how many customers may shift to weekend use, BLM has failed to show, by a preponderance of the evidence, that a shift to weekend use will substantively offset the forty-four percent reduction of raftable days.

b. Fly Fishing

The ability to wade is an integral component to fly-fishing. (*FOF 19-41*). Without the ability to effectively wade, an aesthetic experience and an important element in positioning oneself to catch fish would be lost. (*Id.*) Evidence shows the proposed flows will reduce the ability to wade. (*FOF 19-42 to 19-44*). The degree of such reduction has not been established in this record.

Low flows are preferred by fly-fishing anglers. (*FOF 19-43*). BLM proposed flows will increase the current base flow and will make wading difficult in certain areas of the peaking reach. (*FOF 19-49, 19-50*). The central question is therefore, how much more difficult will wading become? PacifiCorp/Siskiyou County cites statistics that show current operations produce "preferred" fishing flows on fifty-nine percent of the days in the May-October season. (*FOF 19-46*). PacifiCorp/Siskiyou County then argues that BLM's proposed flows will produce "preferred" fishing flows on about eight percent of the days in the May-October season. (*PC PFF 143*). However, PacifiCorp/Siskiyou County's analysis relies on a flawed use of the BLM FMS model.[25] No other statistics have been provided which show, quantitatively, how much more difficult wading will become.

BLM and the Conservation/Fisheries Groups concede that higher flows will make wading (therefore affecting the ability to fly-fish) more difficult in the short term. (*FOF 19-49, 19-50*). However, they contend that there will be no long-term negative affects on fly-fishing. (*FOF 19-50 to19-54; BLM PFF 19.14-15, 19.18*). First, BLM correctly asserts that wading access is only one component of "fishabilty" and other biological factors (e.g. – fish health) are important to consider when determining if an area is good for fishing. (*FOF 19-52 to 19-54*). BLM contends that high flows will improve such biological factors and improve overall fishing. (*Id*.). However, even if higher flows were to improve biological conditions, if flows are too high to allow wading, fly-fishing would not be possible (other forms of fishing may improve). Second, BLM argues that wading

[25] PacifiCorp/Siskiyou County relies upon a flawed interpretation of the BLM FMS model. The FMS model produces outputs on an average *daily* basis. (*BLM-Turaski-Ex. 3 at 12*). The criteria PacifiCorp/Siskiyou County used when analyzing current operations was a *three-hour window* in the "preferred" fishing flow range. (*PAC-Whit-R-1 at 2:18-21, 3:11-13*). In contrast, the PacifiCorp/Siskiyou County analysis of the proposed flows was based on *average daily flow* data (FMS model outputs), and therefore implicitly required an entire day (as opposed to three hours) in the preferred range. (*PAC-Whit-R-2 (columns 4 and 6 showing BLM FMS model outputs); PAC-Carl-R-5 (Excel spreadsheet showing*

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may become easier (e.g. – sediment will make the ground less rocky). (*BLM PFF 19.14*). However, BLM fails to provide sufficient evidence in support of this claim. (*Id*.). Third, BLM assumes that anglers will adjust their techniques to accommodate the proposed flows changes. (*FOF 19-51; BLM PFF 19.15*). While anglers will likely adjust their techniques to an extent, evidence has not been provided to show anglers would continue to fly-fish in area with flows higher than traditionally accepted for fly-fishing. (*FOF 19-8 to 19-13, 19-40 to 19-44, BLM PFF 19.15*). The record evidence does not support the proposition that BLM's proposed conditions will improve fly-fishing in the peaking reach.

ULTIMATE FINDINGS OF FACT AND CONCLUSIONS OF LAW

1. Under Daubert, the Miller Radio-Telemetry study is scientifically unreliable.

2. The effectiveness of volitional passage is not at issue in this case because those issues were withdrawn/dismissed following the initial prehearing conference conducted under 50 C.F.R. Part 221.

3. USFWS/ISSUE 2(A): Stocks of anadromous fish suitable to conditions above Iron Gate Dam are available to use prescribed fishways.

4. USFWS/NMFS ISSUE 2(B): Facilitating the movement of anadromous fish via prescribed fishways presents a relatively low risk of introducing pathogens to resident fish above Iron Gate Dam. Many of the pathogens (such as *C. Shasta, F. Columnaris, P. minibicornis, and Ich*) present below Iron Gate Dam, are also present above the dam. The evidence is inconclusive as to whether *IHN* exists either above or below Iron Gate Dam. The evidence is also inconclusive as to whether *R. salmoniranrum* exists above Iron Gate Dam.

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inappropriate use of BLM FMS model outputs)). Comparing an average daily flow to a three-hour window flow data does not lead to a fair comparison.

5. USFWS/NMFS ISSUE 2(C): Facilitating the movement of wild anadromous steelhead trout above Iron Gate Dam via prescribed fishways presents a low risk of residualization (a phenomenon most common among hatchery steelhead trout). Moreover, while resident trout have the genetic capacity to adopt anadromy, the risk of residualizing can be minimized through use of adaptive management.

6. USFWS/NMFS ISSUE 3: Project operations have and continue to adversely affect the resident trout fishery by, among other things: a) confining the resident trout between the Project dams and associated reservoir thereby impairing their utilization of the full range of life history strategies and spawning productivity; b) unscreened flow through Project turbines result in mortality of juvenile and adult trout migrating down stream; and the inability to effectively migrate adversely affects the genetic health and long term survival of the resident species.

7. USFWS/NMFS ISSUE 4: Entrainment at Project facilities have and continue to adversely affect the resident fishery resources.

8. USFWS/NMFS ISSUE 6: While the exact miles of habitat for use by anadromous fish within the Project reach is unknown, 58 miles is a reasonable estimate based on the evidence contained in the record.

9. USFWS/NMFS ISSUE 7: Access to habitat within the Project would benefit Coho salmon by: a) extending the range and distribution of the species thereby increasing the Coho salmon's reproductive potential; b) increasing genetic diversity in the Coho stocks; c) reducing the species vulnerability to the impacts of degradation; and d) increasing the abundance of the Coho population.

10. USFWS/NMFS ISSUE 8: Although the evidence is inconclusive as to whether Pacific lamprey were historically present above Iron Gate Dam, the record evidence shows that access to habitat would benefit that species of fish by providing it with additional spawning and rearing grounds.

11. BLM ISSUE 10: The seasonal high flows will contribute to improving the quality of riparian habitat in the J.C. Boyle bypass reach by increasing the sediment deposit within the channel and decreasing reed canary grass. However, the extent of any improvement on riparian-focal bird species is indeterminate since an increase of woody riparian vegetation is not expected.

12. BLM ISSUE 11: Project operations have adversely affected riparian resources in both the bypass and peaking reaches by supporting the perpetuation of reed canary grass and by affecting the structure, size, and nature of depositional features. However, the extent of any loss to riparian-focal bird species is indeterminate, based upon evidence that woody riparian vegetation has not decreased noticeably

13. BLM ISSUE 14: The BLM seasonal high flows will assist in the creation of redband trout spawning habitat, decrease fine sediment embedment in spawning gravel, and improve redband trout migration. These benefits provide for a net positive effect to redband trout spawning; overcoming the possible scouring effects high flows will have on spawning trout.

14. BLM ISSUE 16: Current Project operations, particularly sediment blockage at the J.C. Boyle Dam, the flow regime, and peaking operations, negatively affect the redband trout fishery. The proposed River Corridor Management Conditions would improve fishery resources.

15. BLM ISSUE 17: The BLM's proposed upramp rate will improve conditions for fish resources and other aquatic organisms by reducing adverse effects caused by the existing nine inch/hour upramp rate.

16. BLM ISSUE 19: The BLM's proposed flows will substantially reduce the frequency and quality of whitewater boating in the J.C. Boyle peaking reach. The ability to fly-fish in the J.C. Boyle peaking reach will be reduced; the extent of this reduction has not been established.

Done and dated October 16, 2006
Alameda, California

HON. PARLEN L. MCKENNA
ADMINISTRATIVE LAW JUDGE
U.S. COAST GUARD

Attachment C

to

COMMENTS and RECOMMENDATIONS

Regarding:

The Klamath Hydroelectric Project
FERC Project No. 2082-027

Submitted by:

Allen Foreman
Chairman of the Klamath Tribes
Ph 541-783-2219

on behalf of

The Klamath Tribes
401 Chiloquin Blvd
Chiloquin, Oregon 97624

March 29, 2006

TECHNICAL MEMORANDUM

To: The Klamath Tribes

From: C.W. Huntington, Aquatic Biologist, Clearwater BioStudies, Inc, and L.K. Dunsmoor, Aquatic Biologist, Klamath Tribes

Subject: Aquatic habitat conditions related to the reintroduction of anadromous salmonids into the Upper Klamath Basin, with emphasis on areas above Upper Klamath Lake.

Date: 27 March 2006.

The following memorandum briefly gives the methods and results of an effort to develop primarily tabular and graphical summaries of aquatic habitat conditions in the Upper Klamath Basin (Figure 1), and particularly for areas above Upper Klamath Lake (UKL). It relies in part (but far from completely) on information within databases constructed as part of an Ecosystem-Diagnosis-and-Treatment (EDT) modeling process (PacifiCorp 2005) that has generated preliminary model-based estimates of the potential performance of chinook salmon and steelhead if they are reintroduced to the upper basin. Detailed model outputs that would help us better understand model behaviors underlying the EDT-based estimates of fish performance reported by PacifiCorp (2005) are as yet unavailable for a thorough assessment of the direction and magnitude of unintentional (but potentially important) biases. However, we have been given somewhat more detailed EDT model output than was reported by PacifiCorp (2005). This has allowed us to examine (and summarize) ***general patterns*** evident in the EDT database and output. The patterns are useful in helping to explain (1) ***the relative condition of the upper basin's aquatic habitats*** and (2) the ***relative levels of fish performance that might be possible within this habitat***.

In addition to EDT-related information, we have also assembled and summarized data on several aspects of aquatic habitat that have relevance to consideration of how anadromous salmonids might perform in upper basin areas. These include:

- Results of a survey of qualitative (expert) judgments by local biologists as to the quality of summer rearing habitat available for chinook salmon and steelhead if these fish are reintroduced to areas above UKL and to the migratory corridor between the lake and Iron Gate Dam.

- Survey-based estimates of the quantity of spawning habitat that may be available for chinook salmon above Iron Gate Dam.

- Estimates of low-flow quantities (surface areas) of rearing habitat available for chinook or steelhead in streams above Iron Gate Dam, including potential steelhead streams not yet included in EDT-based modeling of fish production potential.

- Seasonal and spatial variation in the thermal suitability of habitat in selected salmon rivers above UKL for use by chinook salmon and steelhead. These rivers include the Williamson, Sprague, North Fork Sprague, and Sycan.

- Model-based predictions of the relationships that available river temperature data suggest between potential chinook spawning dates and subsequent fry emergence dates for locations above UKL.

Our original intention here had been to develop detailed discussions of the spatial and temporal patterns evident in our results, but limitations of time prevent us from doing so at present. Additional and detailed discussions of our results will be developed in a future memorandum.

METHODS

EDT-based Information

Information from the EDT model that has been incorporated into this document came originally from the EDT database that was the basis for most of the modeling contained in PacifiCorp (2005), or selected model output provided by Kevin Malone at Mobrand Jones & Stokes at the direction of PacifiCorp. We used this information to, appropriately in our view, assess the patterns of relative habitat quality and/or fish performance suggested by the current (preliminary) model. In most cases, this involved calculating quartiles for specific measures of EDT-predicted fish performance in the habitat within modeled areas. We used model output to characterize RELATIVE magnitude and intensities of chinook spawner use of differing streams above Iron Gate Dam. We focused on relative abundances of adult fish using the habitat because of uncertainties about the model. We did not do a detailed analysis of the relative abundances of adult steelhead that the EDT model of PacifiCorp (2005) is currently projecting for upper basin areas, because the existing output suggests zero or near-zero production from streams that (1) currently support redband trout populations and (2) seem clearly to have production potential.

Judgments of Local Biologists as to Habitat Quality Above Iron Gate Dam

As a contribution to the relicensing process for the Klamath Hydroelectric Project, we queried local biologists familiar with the habitat requirements of salmonids and had them rate the quality of summer rearing habitat for chinook salmon and steelhead in upper basin areas. The rating process was standardized through discussions with the biologists, and by instructions that habitat quality thresholds identified in Burke et al (2003) be used to the degree possible. We did not address habitat to be found in Klamath River tributaries within the watershed area bounded by Iron Gate and Link River dams, and have not had the time to fill this information gap.

Spawning Habitat for Chinook Salmon

We compiled the best information we could find on the quantities of spawning habitat in potential chinook salmon streams above UKL, including data one of us (CWH) had field crews collect on the Williamson, Wood, and portions of the Sprague River in the last couple of years. These data, some of which were drawn from the field notes of a study by Fortune et al. (1966), were then used to estimate or extrapolate the number of adult chinook salmon that could be accommodated by the streams. These estimations or extrapolations were based on assumptions of maximum effective spawning densities of 2 adults (1 male + 1 female) per $8m^2$ of spawning habitat for spring chinook and 2 adults per $10m^2$ for fall chinook. The amounts of habitat we assumed were needed to accommodate a pair of spawners were based on some early investigative work on the Trinity River by Moffett and Smith (1950). Where we lacked a better estimate of at least historically available spawning habitat, we defaulted to using estimates of spawner capacity embedded in and EDT-based summary provided by Kevin Malone (MJS, pers comm.).

The information we have developed by this method on the numbers of salmon that might be accommodated by existing spawning habitat indicates how many fish the best available data (which are not perfect) suggest could spawn in specific areas of the stream network above Iron Gate Dam without superimposing their redds (gravel nests). These numbers represent something of an upper limit on how many adult fish could spawn effectively in the area **if** their abundance was not constrained by other factors. ***Given the existing condition of their rearing habitats, fish passage issues, and other factors, it seems likely to certain (depending on location) that the actual abundance of adult chinook salmon would be lower in the upper basin after reintroduction than the tables suggest could be accommodated by available spawning habitat. This would be true until or unless there was a substantial improvement in stream and migratory corridor conditions.***

Estimates of Low Flow Quantities of Habitat

We estimated quantities of low flow habitat in potential anadromous salmonid streams using stream length and width data already incorporated into the EDT database or based on distance-from-headwater data from USGS maps and relationships between these types of distances and stream widths measured within the upper basin.

Thermal Suitability of Potential Salmon Habitat Above UKL

We used available temperature modeling data from ODEQ's relatively recent TMDL assessments of upper basin streams and all of the continuous temperature data we could acquire to develop contour plots of the thermal suitability of selected river corridors in the upper basin for use by chinook salmon and steelhead. Suitability was broken spatially and temporally into four classes: Optimal, Suboptimal, Stressful, and Severely Stressful (refugia critical). The temperature thresholds for these classes, and the method by which they were assigned, have been described in detail by Dunsmoor and Huntington (2006).

Thermal Environments for Chinook Egg Incubation Above UKL

We used available temperature data and relationships between egg incubation rates and temperatures from SALMOD (Bartholow 1993) to predict potential patterns of chinook fry emergence for multiple locations above UKL. ***Analyses that we are still refining suggest that chinook fry reaching UKL by about mid-May may be able to reach 70-80 mm in length and then leave the lake before thermal conditions deteriorate in late May.*** We intend to provide additional information on potential fry growth in the lake as it is developed.

RESULTS

Results of our efforts are summarized in Tables 1-3 and Figures 2-13. As indicated earlier, discussions of these results are being developed.

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PacifiCorp. 2005. Response to November 10, 2005, FERC AIR AR-2: Ecosystem Diagnosis and Treatment (EDT) analysis. Submission to FERC for the relicensing of the Klamath Hydroelectric Project (Project No. 2082). PacifiCorp, Portland, Oregon. 16 December 2005.

Table 1. Summary of information on the quantity and quality of existing habitat potentially available for ocean-type (Type-1) fall chinook salmon in the Upper Klamath Basin.

Stream/waterbody[1]	Kilometers of potential habitat	Estimated quantity of available spawning habitat (adults accomodated)		Estimated quality of available spawning habitat (percent of habitat providing specific levels of survival-to-emergence, as predicted by EDT)				Estimated quantity of low-flow rearing habitat (m^2)	Estimated quality of available rearing habitat (percent of habitat in specific quartiles for EDT-predicted subyearling survival during spring)				EDT-predicted[3] spawner use: Percent of all adults spawning abv IGD		EDT-predicted[3] spawner use: Rank order for intensity (#/km)	
		Surveys	EDT	>45%	31-45%	15-30%	<15%		Upper	Upper intermediate	Lower intermediate	Lowest	Alt 1A no rehab	Alt 5 w/ rehab	Alt 1A no rehab	Alt 5 w/ rehab
Iron Gate to Link River Dam																
Klamath R. (riverine reaches)	42.5	---	7,768	100	0	0	0	1,453,700	0	0	0	100	46	32	2	2
Existing Reservoirs	24.3	---	0	---	---	---	---	9,362,300	0	0	0	100	---	---	---	---
Jenny Cr.	1.8	---	57	54	0	0	46	16,085	23	77	0	0	<1	<1	11	13
Fall Cr.	1.4	---	5	7	0	0	93	6,313	7	8	85	0	<1	<1	6	3
Shovel Cr.	4.7	---	160	100	0	0	0	22,860	14	0	63	24	1	<1	5	14
Spencer Cr.	20.4	652	---	60	40	0	0	152,312	0	33	11	56	3	3	9	10
Keno Reservoir/Lake Ewauna	31.9	---	0	---	---	---	---	7,383,000	0	100	0	0	---	---	---	---
Link R.	1.9	---	0	---	---	---	---	233,000	0	100	0	0	---	---	---	---
Above Link River Dam																
Upper Klamath/Agency Lks	---	---	0	---	---	---	---	229,695,000	16	84	0	0	---	---	---	---
Williamson R.	33.5	4,576	---	29	37	35	0	1,452,050	47	0	19	34	10	7	4	8
Springbrook tributaries	1.9	103	---	100	0	0	0	41,922	100	0	0	0	3	2	1	1
Sprague R. below Trout Cr.	54.6	1,475	---	11	30	0	59	1,680,370	0	55	43	3	10	12	8	7
Springbrook tributaries	1.2	32	---	100	0	0	0	28,475	100	0	0	0	0	0		
Sprague R. above Trout Cr.	82.7	152	---	0	0	8	92	2,736,020	0	7	66	26	0	13		9
Springbrook tributaries	9.7	12	---	25	0	0	75	47,821	25	0	0	75	1	2	12	4
Sycan R.[2]	20.5	262	---	0	0	65	35	403,571	0	12	61	27	7	10	10	5
Springbrook tributaries	1.9	0	---	---	---	---	---	24,829	---	---	---	---	---	---	---	---
N.Fk. Sprague R.	19.6	5,129	---	7	59	0	34	268,284	0	0	93	7	<1	2	15	11
Springbrook tributaries	22.4	142	---	100	0	0	0	122,025	44	56	0	0	<1	2	13	15
S.Fk. Sprague R.[2]	23.9	1,106	---	37	24	39	0	296,124	0	13	43	44	2	3	14	15
Wood River	32.5	1,022	---	56	44	0	0	751,783	63	6	31	0	7	4	7	11
Springbrook tributaries	17.6	201	---	18	82	0	0	228,345	100	0	0	0	8	4	3	6
Other tributaries	25.5	---	---	0	61	39	0	139,075	0	34	15	50	<1	<1	15	17
Sevenmile Cr.	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Crystal/Recreation Cr.	13.1	---	0	---	---	---	---	249,365	---	---	---	---	---	---	---	---
Other westside UKL tributaries	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
TOTAL	489.3															

[1] Dashed lines in habitat columns represent a lack of data for the stream/waterbody if potential habitat is identified as present.

[2] Use of this system by chinook will be substantially constrained without habitat rehabilitation and some level of flow enhancement.

[3] Draft (initial) model output from EDT; review dependent on release of modeling files that will allow examination of model behavior.

Table2. Summary of information on the quantity and quality of existing habitat potentially available for stream-type spring chinook salmon in the Upper Klamath Basin.

Stream/waterbody[1]	Kilometers of potential habitat	Estimated quantity of available spawning habitat (adults accomodated)		Estimated quality of available spawning habitat (percent of habitat providing specific levels of survival-to-emergence, as predicted by EDT)				Estimated quantity of low-flow rearing habitat (m^2)	Estimated quality of available summer rearing habitat (percent of habitat in specific quartiles for EDT-predicted subyearling survival during summer[3])				EDT-predicted[3] spawner use			
													Percent of all adults spawning abv IGD		Rank order for intensity (#/km)	
		Surveys	EDT	Upper	Upper intermediate	Lower intermediate	Lowest		Upper	Upper intermediate	Lower intermediate	Lowest	Alt 1A no rehab	Alt 5 w/ rehab	Alt 1A no rehab	Alt 5 w/ rehab
Iron Gate to Link River Dam																
Klamath R. (riverine reaches)	42.5	---	7,768	16	24	38	22	1,453,700	0	16	0	84	0	0		
Klamath R. Reservoirs	24.3	---	0	---	---	---	---	9,362,300	0	0	0	100	---	---	---	---
Jenny Cr.	1.8	---	57	0	0	100	0	16,085	0	0	100	0	0	0		
Fall Cr.	1.4	---	5	100	0	0	0	6,313	92	0	0	8	<1	<1	5	9
Shovel Cr.	4.7	---	160	0	100	0	0	22,860	0	100	0	0	<1	<1	10	16
Spencer Cr.	20.4	816	---	6	64	30	0	152,312	6	64	30	0	3	1	6	12
Keno Reservoir/Lake Ewauna	31.9	---	0	---	---	---	---	7,383,000	0	0	0	100	---	---	---	---
Link R.	1.9	---	0	---	---	---	---	233,000	0	0	0	100	---	---	---	---
Above Link River Dam																
Upper Klamath/Agency Lks	---	---	0	---	---	---	---	229,695,000	0	0	1	99	---	---	---	---
Williamson R.	33.5	5,720	---	27	35	38	0	1,452,050	34	9	22	34	62	27	1	2
Springbrook tributaries	10.5	129	---	39	61	0	0	302,411	39	61	0	0	12	6	3	4
Sprague R. below Trout Cr.	54.6	1,844	---	0	0	0	100	1,680,370	0	0	0	100	0	1		15
Springbrook tributaries	1.2	42	---	100	0	0	0	28,475	100	0	0	0	2	1	2	3
Sprague R. above Trout Cr.	82.7	190	---	0	0	29	71	2,736,020	0	17	0	83				
Springbrook tributaries	9.7	14	---	25	0	0	75	47,821	25	0	0	75	<1	8	12	1
Sycan R.[2]	44.6	4,428	---	0	26	20	54	993,018	40	0	33	26	0	8		10
Springbrook tributaries	1.9	0	---	---	---	---	---	24,829	0	0	0	100	---	---	---	---
N.Fk. Sprague R.	52.5	10,180	---	13	43	44	0	535,812	13	68	19	0	3	19	9	6
Springbrook tributaries	22.4	178	---	0	23	77	0	122,025	0	57	43	0	0	7		7
S.Fk. Sprague R.[2]	34.4	5,557	---	0	9	51	40	413,276	0	27	29	44	0	3		11
Wood River	32.5	1,278	---	63	6	31	0	751,783	100	0	0	0	14	10	4	8
Springbrook tributaries	17.6	252	---	100	0	0	0	228,345	100	0	0	0	1	6	7	5
Other tributaries	25.5	1,818	---	81	19	0	0	139,075	81	19	0	0	2	1	7	14
Sevenmile Cr.	29.8	260	---	66	0	0	34	588,874	66	0	34	0	1	2	11	13
Crystal/Recreation Cr.	13.1	---	0	---	---	---	---	249,365	100	0	0	0	---	---	---	---
Other westside UKL tributaries	0.0	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
TOTAL	595.1															

[1] Dashed lines in habitat columns represent a lack of data for the stream/waterbody if potential habitat is identified as present.

[2] Use of this system by chinook will be substantially constrained without habitat rehabilitation and some level of flow enhancement.

[3] Draft (initial) model output from EDT; review dependent on release of modeling files that will allow examination of model behavior.

Table 3. Summary of information on the quantity and quality of existing habitat potentially available to fall-winter steelhead in the Upper Klamath Basin.

			Estimated quality of available rearing habitat							
			Summer habitat (percent of habitat in specific quality classes, per local				Winter habitat (percent of habitat in specific quartiles for EDT-predicted juvenile survival[2])			
Stream/waterbody[1]	Kilometers of potential habitat	Estimated quantity of low-flow rearing habitat (m^2)	Good	Fair	Poor	Not functional	Upper	Upper intermedia	Lower intermedia	Lowest
Iron Gate to Link River Dam										
Klamath R. (riverine reaches)	42.5	1,453,700	13	51	36	0	0	39	38	23
Existing Reservoirs	24.3	9,362,300	0	0	0	100	0	0	0	100
Jenny Cr.	1.8	16,085	---	---	---	---	100	0	0	0
Fall Cr.	1.4	6,313	---	---	---	---	13	88	0	0
Shovel Cr.	4.7	22,860	---	---	---	---	33	43	0	24
Spencer Cr.	20.4	152,312	---	---	---	---	0	40	30	30
Other tributaries	24.9	---	---	---	---	---	---	---	---	---
Keno Reservoir/Lake Ewauna	31.9	7,383,000	0	0	0	100	0	0	0	100
Link R.	1.9	233,000	0	0	0	100	0	0	0	100
Above Link River Dam										
Upper Klamath/Agency Lks	---	229,695,000	0	1	0	99	0	0	0	100
Williamson R. (excluding Sprague)	37.4	1,528,870	69	31	0	0	79	0	0	21
Springbrook tributaries	11.5	302,411	100	0	0	0	100	0	0	0
Sprague R. below Trout Cr.	54.6	2,736,020	0	0	100	0	11	89	0	0
Trout Cr.	11.3	16,149	39	48	13	0	---	---	---	---
Springbrook tributaries	1.2	28,475	54	46	0	0	53	0	0	47
Sprague R. above Trout Cr.	82.7	2,736,020	0	17	83	0	0	45	8	48
Springbrook tributaries	9.7	47,821	100	0	0	0	0	100	0	0
Other tributaries	8.4	7,286	0	0	51	49	---	---	---	---
Sycan R. below Sycan Marsh	53.7	993,018	0	21	79	0	14	49	29	9
Springbrook tributaries	1.9	24,829	0	100	0	0	0	0	0	100
Sycan R. incl./above Sycan Marsh	68.4	394,518	25	42	6	27	---	---	---	---
Tributaries	89.9	220,329	58	25	17	0	---	---	---	---
N.Fk. Sprague R.	57.9	589,095	64	36	0	0	19	13	54	15
Fivemile Cr.	22.4	122,025	31	69	0	0	31	69	0	0
Other tributaries	27.7	127,505	55	38	8	0	---	---	---	---
S.Fk. Sprague R.	55.5	504,293	35	44	4	16	12	23	49	16
Tributaries	50.2	82,958	20	39	35	5	---	---	---	---
Wood River	32.5	751,783	100	0	0	0	17	12	0	71
Springbrook tributaries	23.1	244,983	76	24	0	0	13	0	0	87
Other tributaries	41.3	193,914	51	22	23	4	17	30	52	0
Sevenmile Cr.	30.4	590,309	8	59	34	0	12	7	5	75
Recreation/Crystal Cr.	13.1	249,365	0	100	0	0	0	0	0	100
Westside tributary streams	21.8	---	29	19	23	30	---	---	---	---

[1] Dashed lines in habitat columns represent a lack of data for the stream/waterbody if potential habitat is identified as present. For the identified Klamath R. tributaries between Iron Gate Dam and Link River Dam, habitat suitable for steelhead production is considered to be present (B. Tinniswood, ODFW, pers comm.).

[2] Draft (initial) model output from EDT; review and adjustment (if appropriate) dependent on release of modeling files that will allow a thorough examination of model behavior.

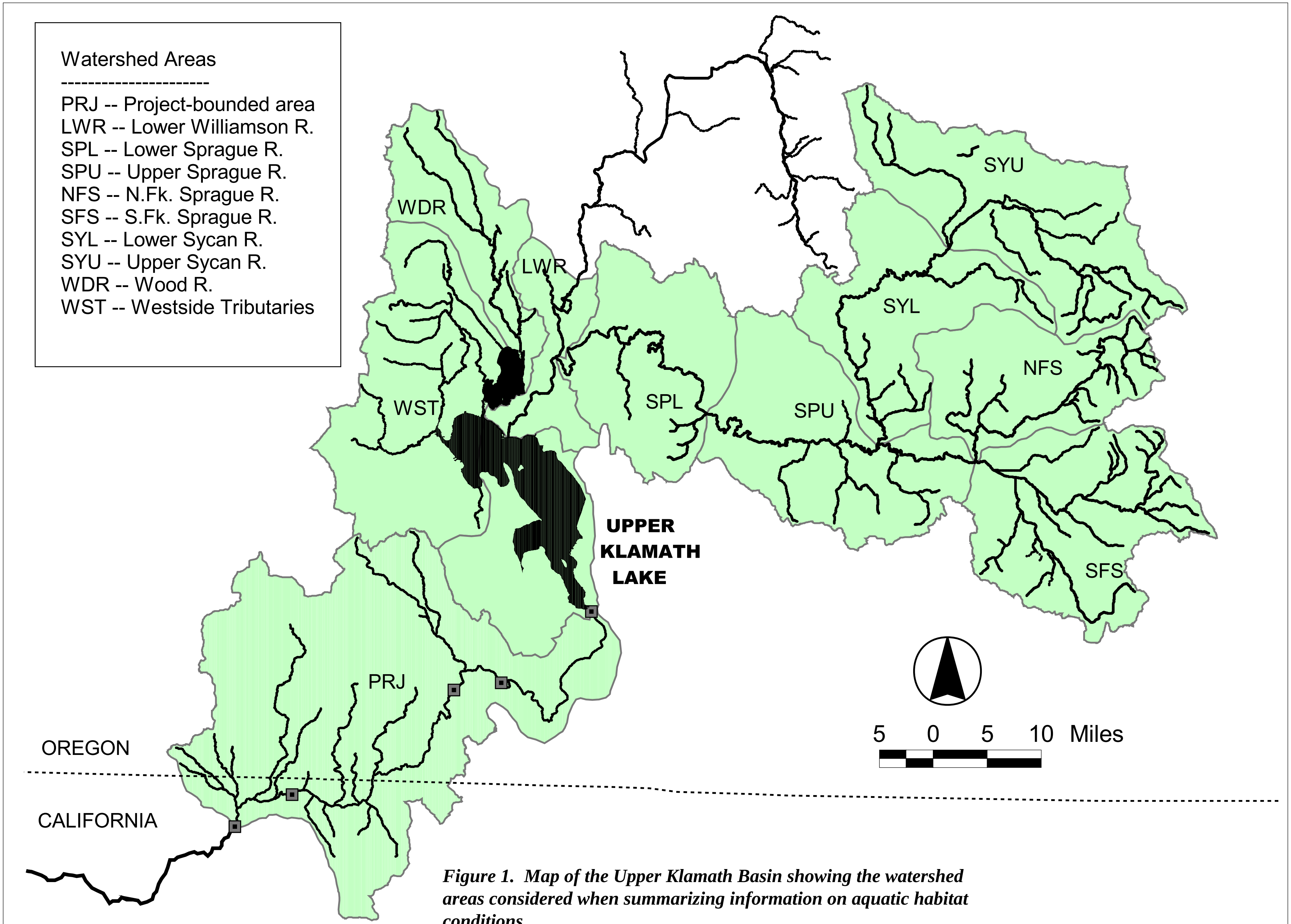


Figure 1. Map of the Upper Klamath Basin showing the watershed areas considered when summarizing information on aquatic habitat conditions.

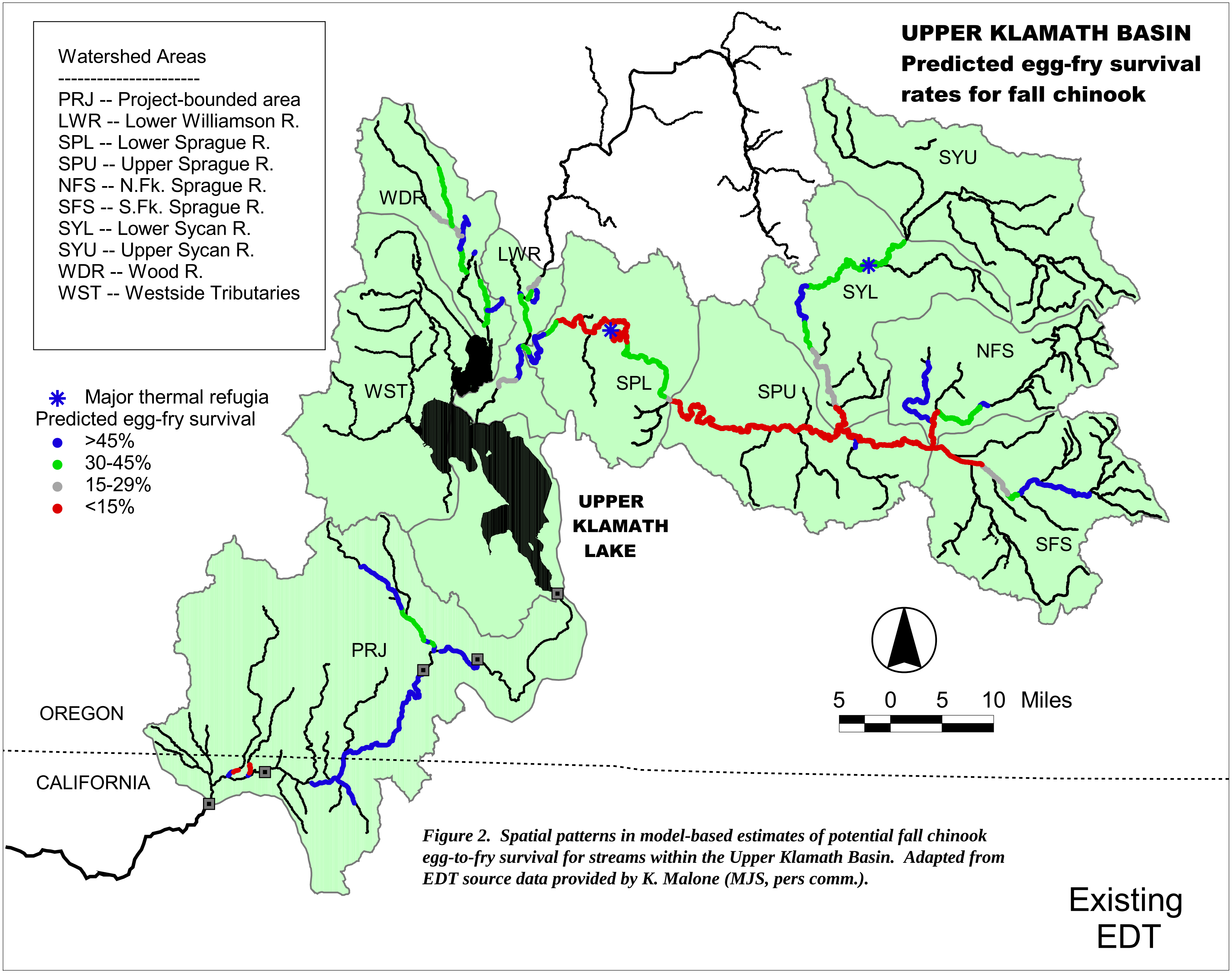


Figure 2. Spatial patterns in model-based estimates of potential fall chinook egg-to-fry survival for streams within the Upper Klamath Basin. Adapted from EDT source data provided by K. Malone (MJS, pers comm.).

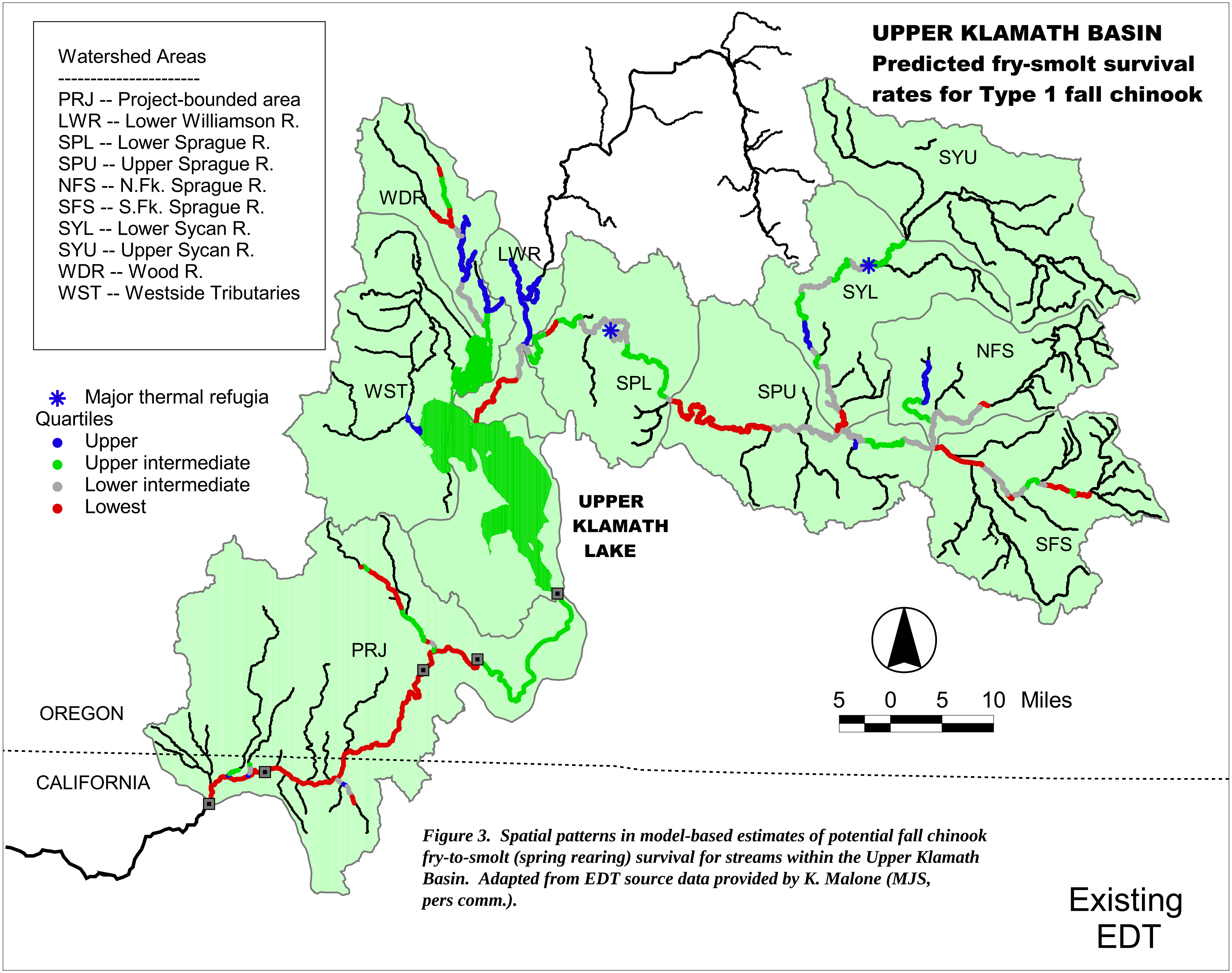


Figure 3. Spatial patterns in model-based estimates of potential fall chinook fry-to-smolt (spring rearing) survival for streams within the Upper Klamath Basin. Adapted from EDT source data provided by K. Malone (MJS, pers comm.).

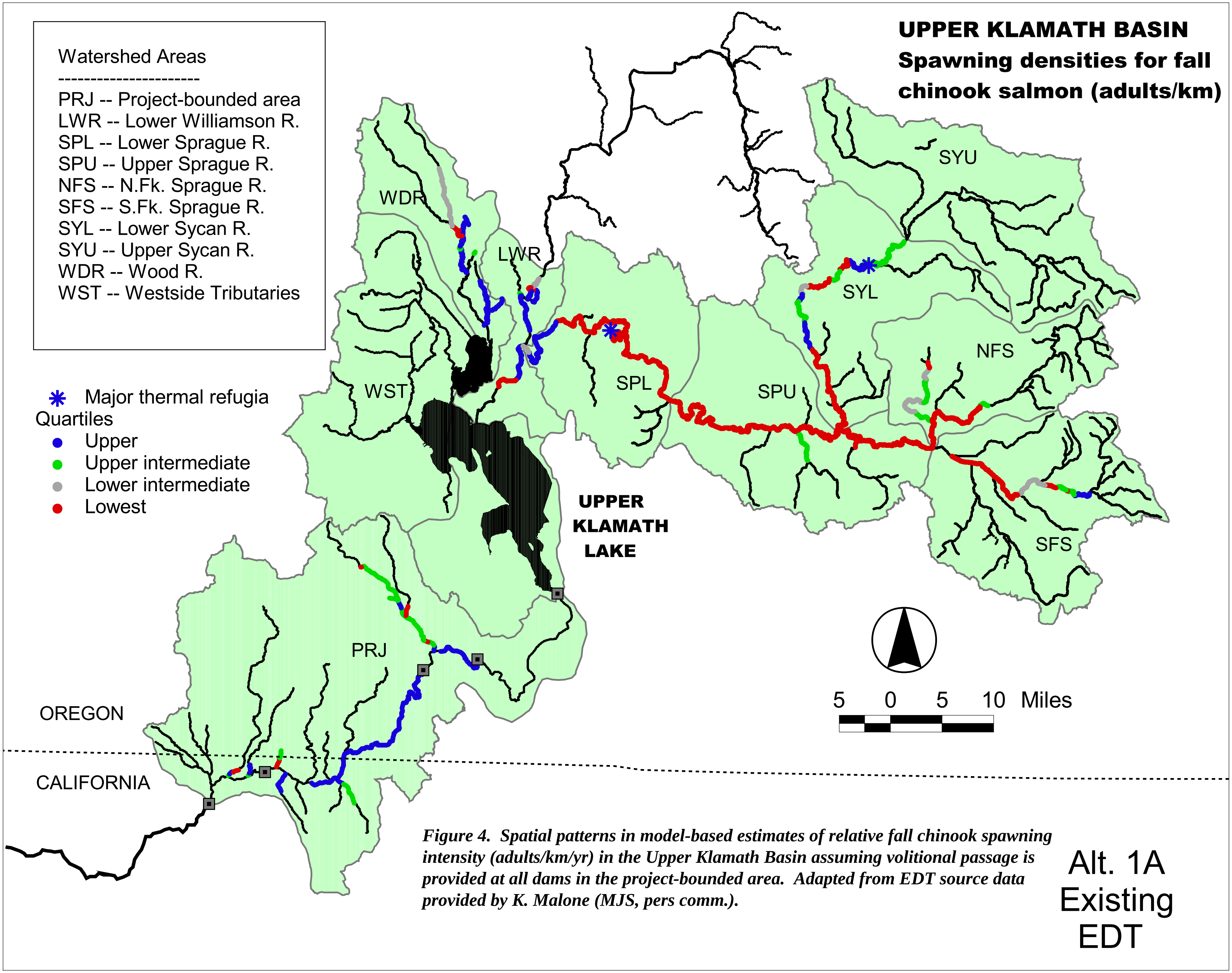


Figure 4. Spatial patterns in model-based estimates of relative fall chinook spawning intensity (adults/km/yr) in the Upper Klamath Basin assuming volitional passage is provided at all dams in the project-bounded area. Adapted from EDT source data provided by K. Malone (MJS, pers comm.).

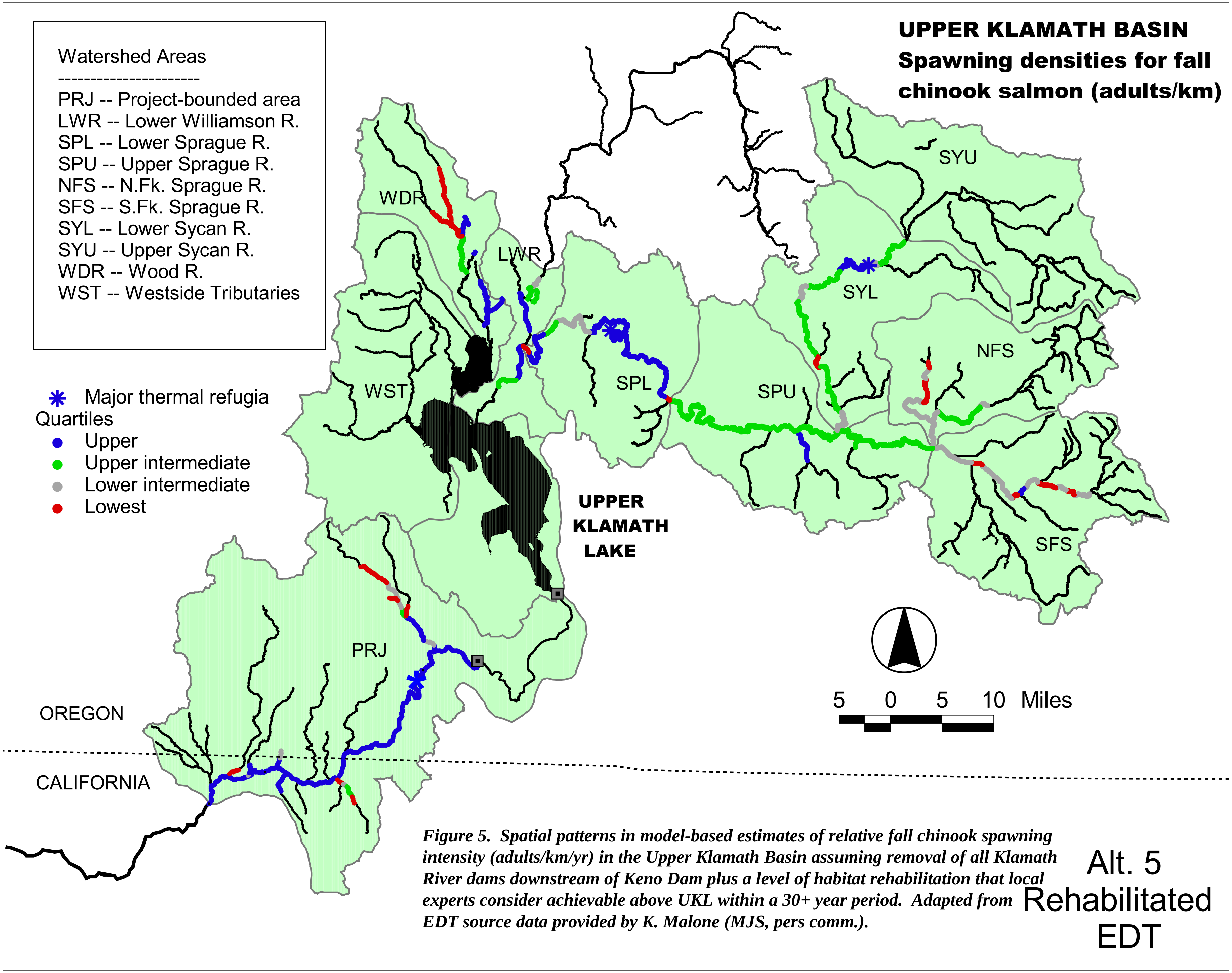


Figure 5. Spatial patterns in model-based estimates of relative fall chinook spawning intensity (adults/km/yr) in the Upper Klamath Basin assuming removal of all Klamath River dams downstream of Keno Dam plus a level of habitat rehabilitation that local experts consider achievable above UKL within a 30+ year period. Adapted from EDT source data provided by K. Malone (MJS, pers comm.).

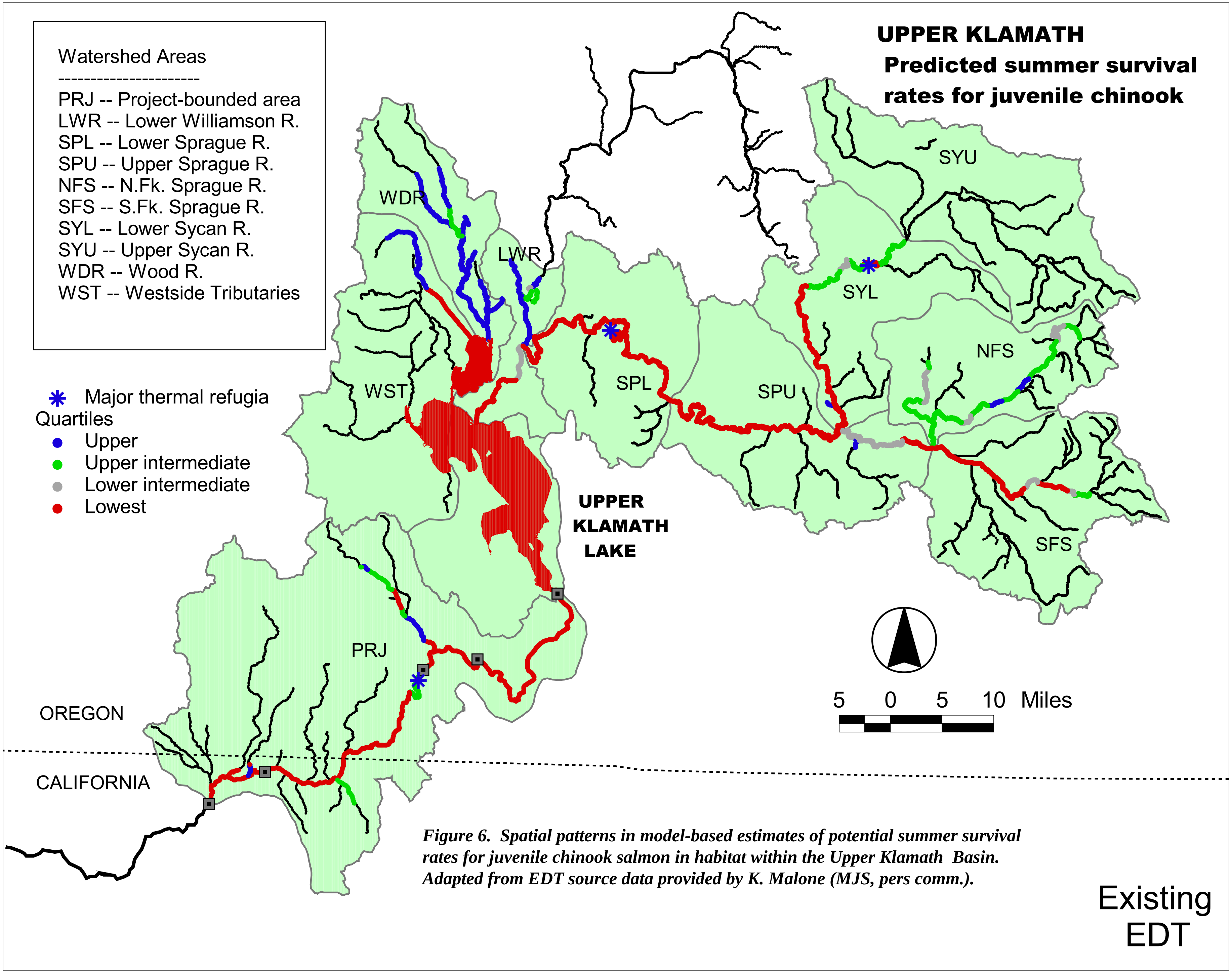


Figure 6. Spatial patterns in model-based estimates of potential summer survival rates for juvenile chinook salmon in habitat within the Upper Klamath Basin. Adapted from EDT source data provided by K. Malone (MJS, pers comm.).

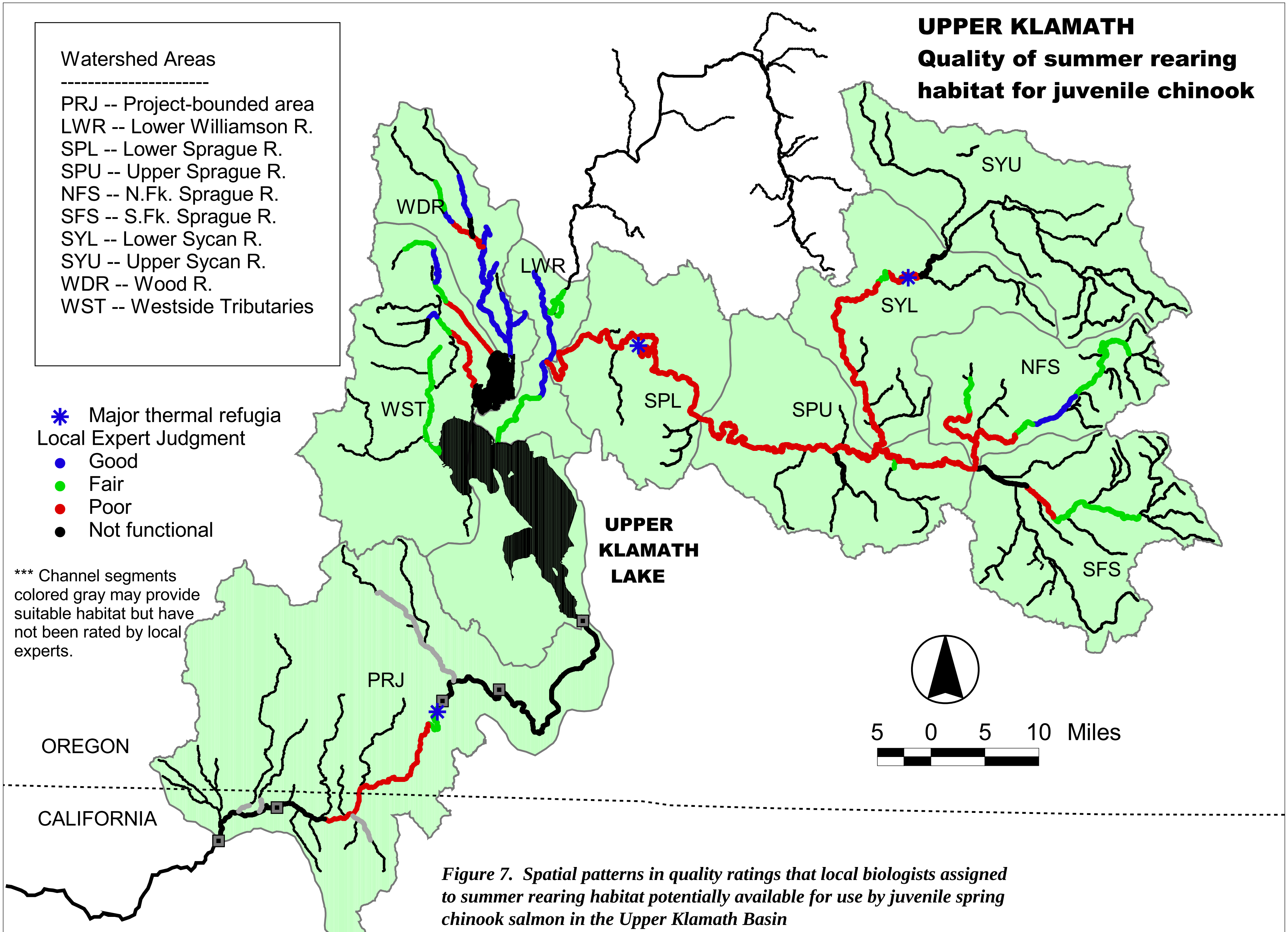


Figure 7. Spatial patterns in quality ratings that local biologists assigned to summer rearing habitat potentially available for use by juvenile spring chinook salmon in the Upper Klamath Basin

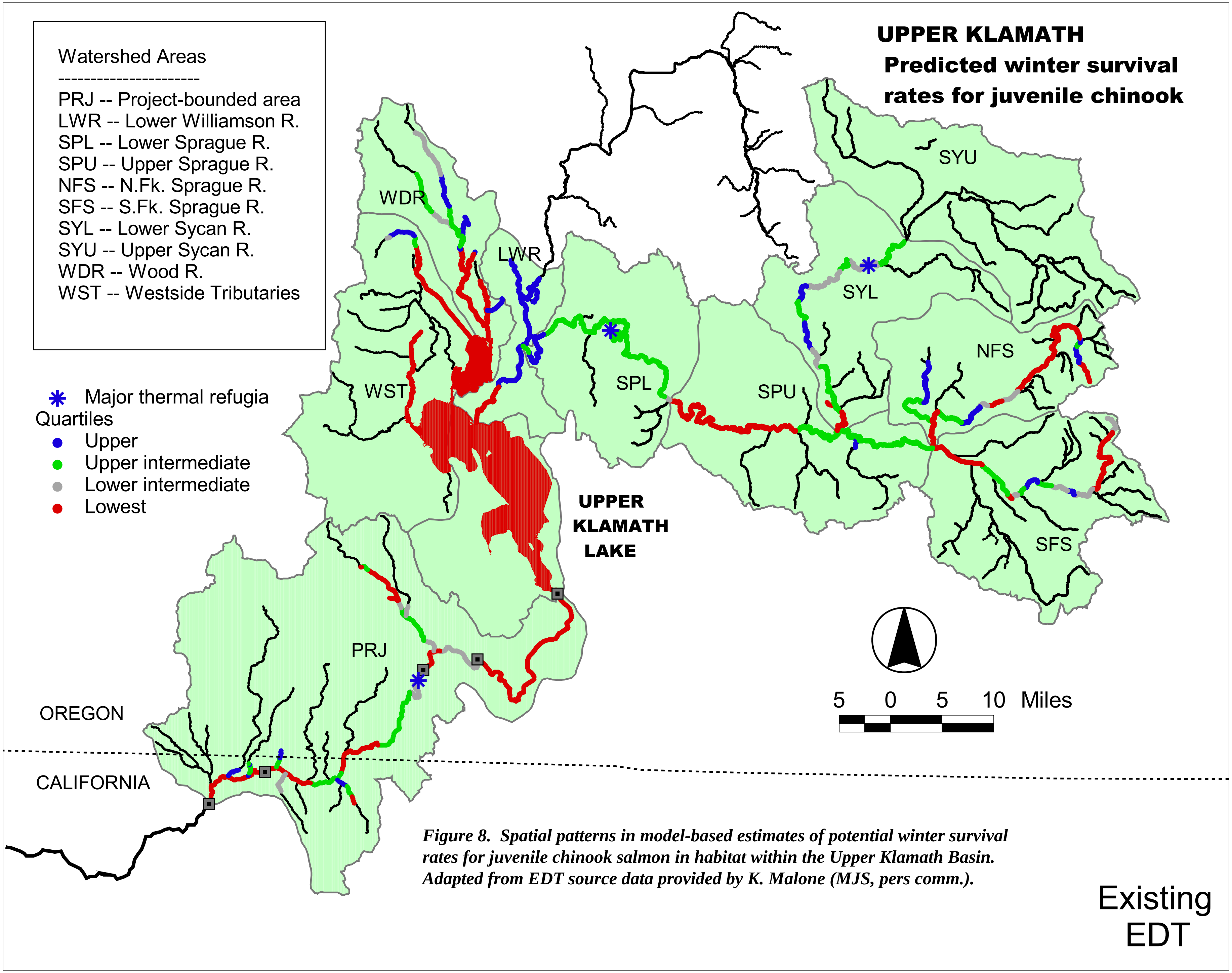


Figure 8. Spatial patterns in model-based estimates of potential winter survival rates for juvenile chinook salmon in habitat within the Upper Klamath Basin. Adapted from EDT source data provided by K. Malone (MJS, pers comm.).

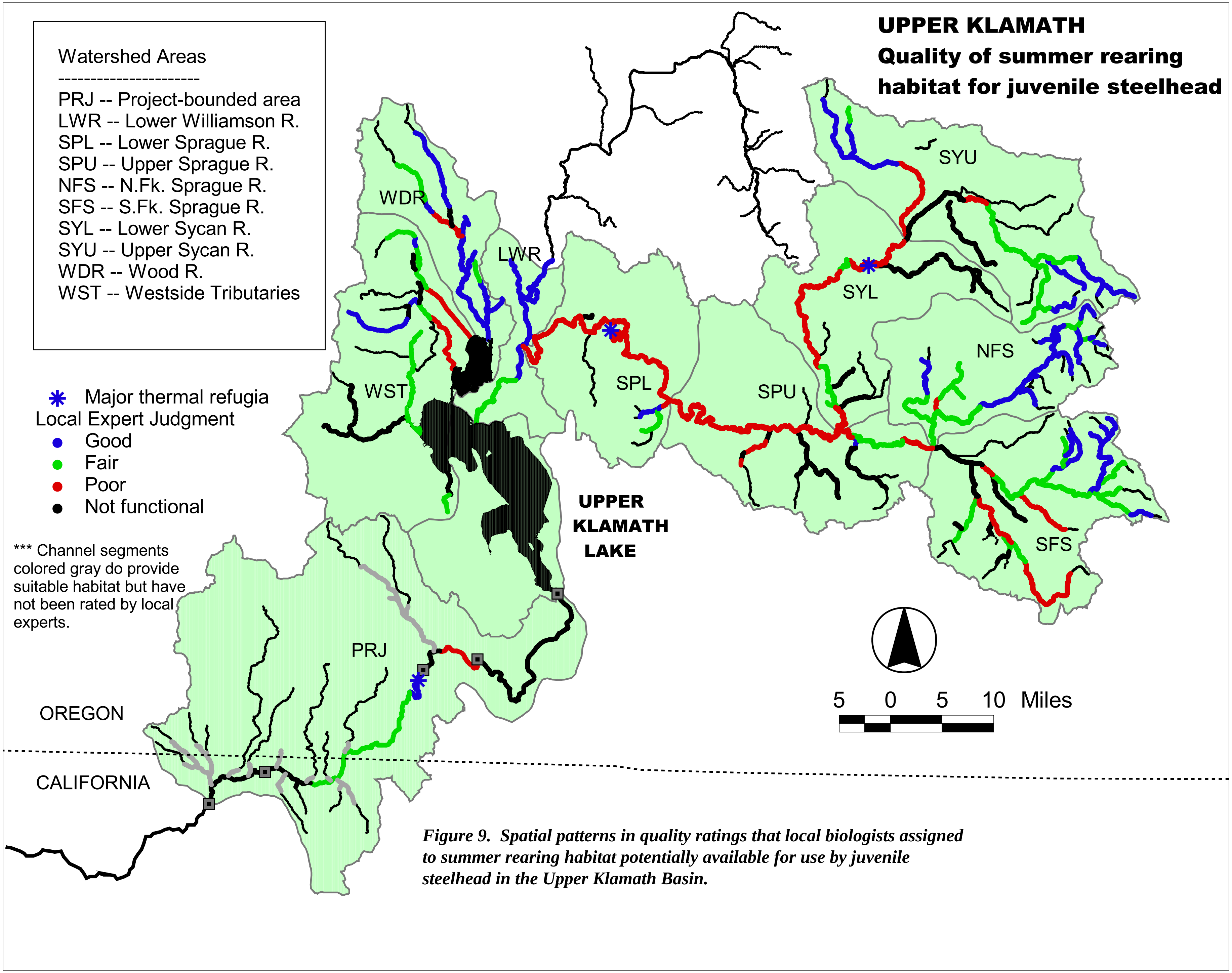
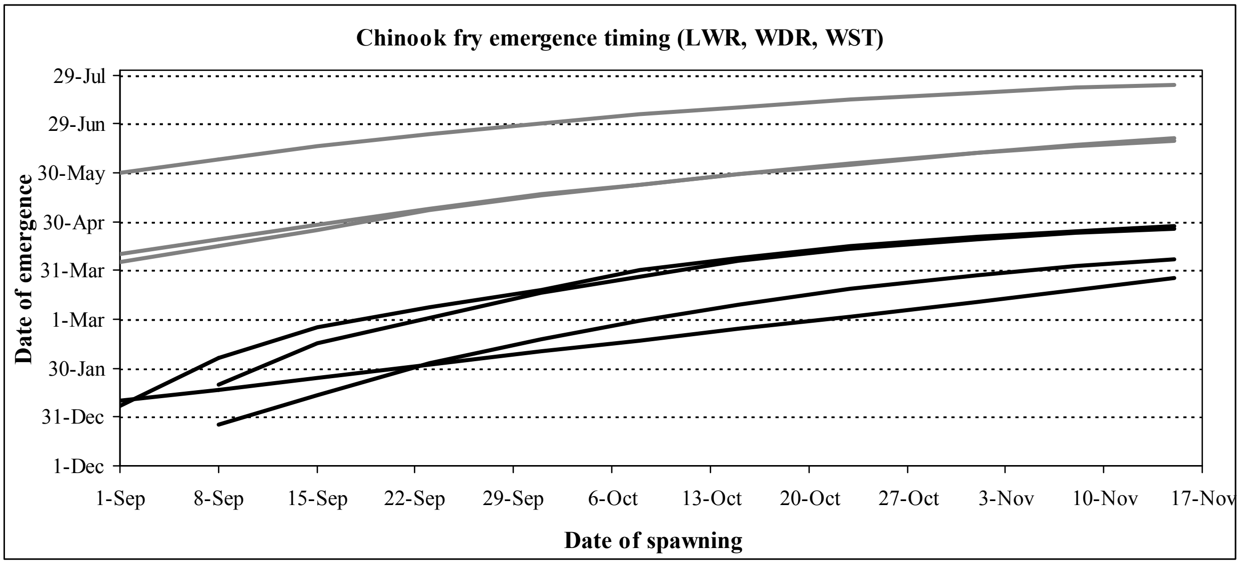


Figure 9. Spatial patterns in quality ratings that local biologists assigned to summer rearing habitat potentially available for use by juvenile steelhead in the Upper Klamath Basin.



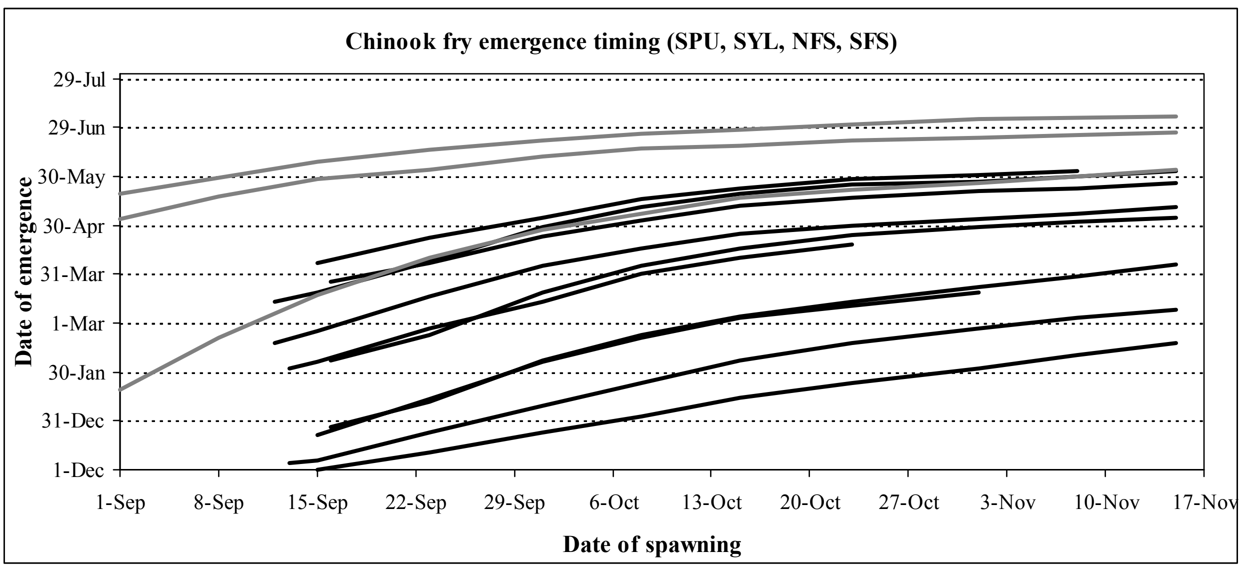


Figure 10. Patterns of variation in estimates of potential chinook salmon emergence timing for multiple sites on streams near (upper) and distant from (lower) UKL, based on recorded stream temperatures and the egg incubation model contained in SALMOD (Bartholow et al. 1993). Conditions for individual valley floor stream sites are shown in black and those for upland/montane stream sites in gray. Patterns shown do not include potential emergence of fry from eggs deposited by adult fish spawning before mean temperatures drop below 14^{o}C in the fall.

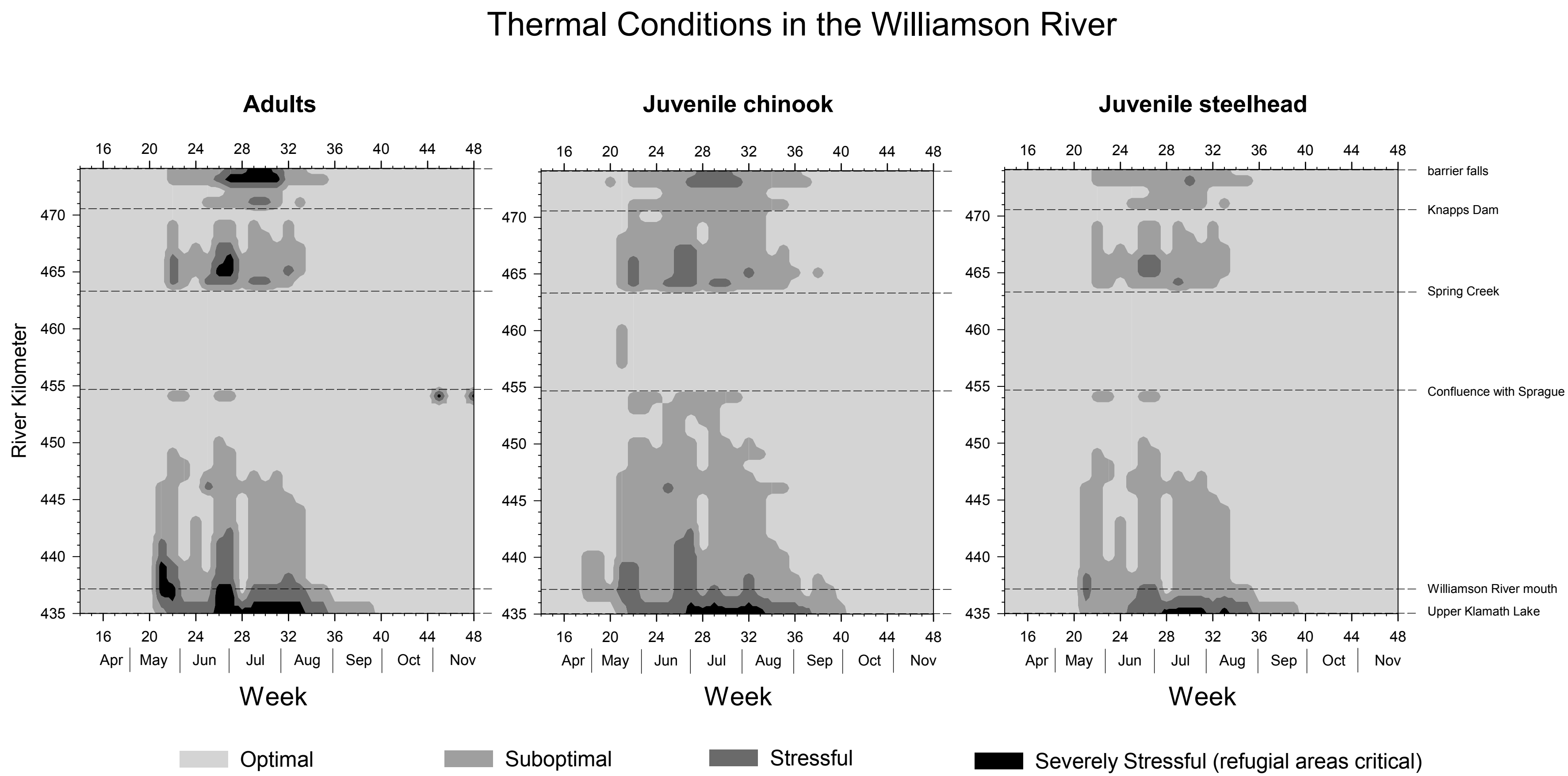


Figure 11. Contour plots characterizing seasonal and spatial patterns in the suitability of temperatures in the lower Williamson River for use by juvenile and adult chinook salmon and steelhead trout.

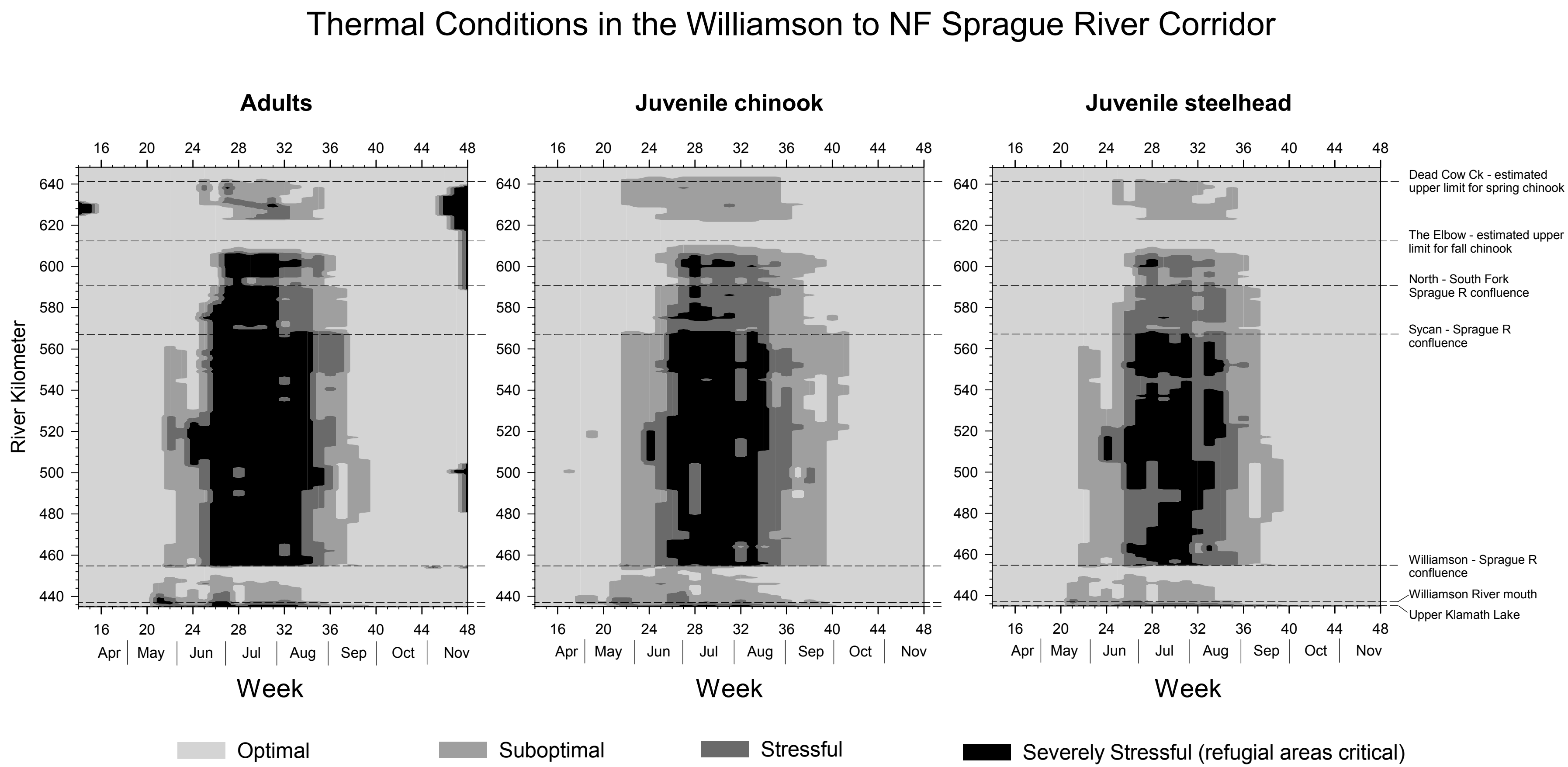


Figure 12. Contour plots characterizing seasonal and spatial patterns in the suitability of river temperatures in the Williamson-Sprague-North Fork corridor for use by juvenile and adult chinook salmon and steelhead trout.

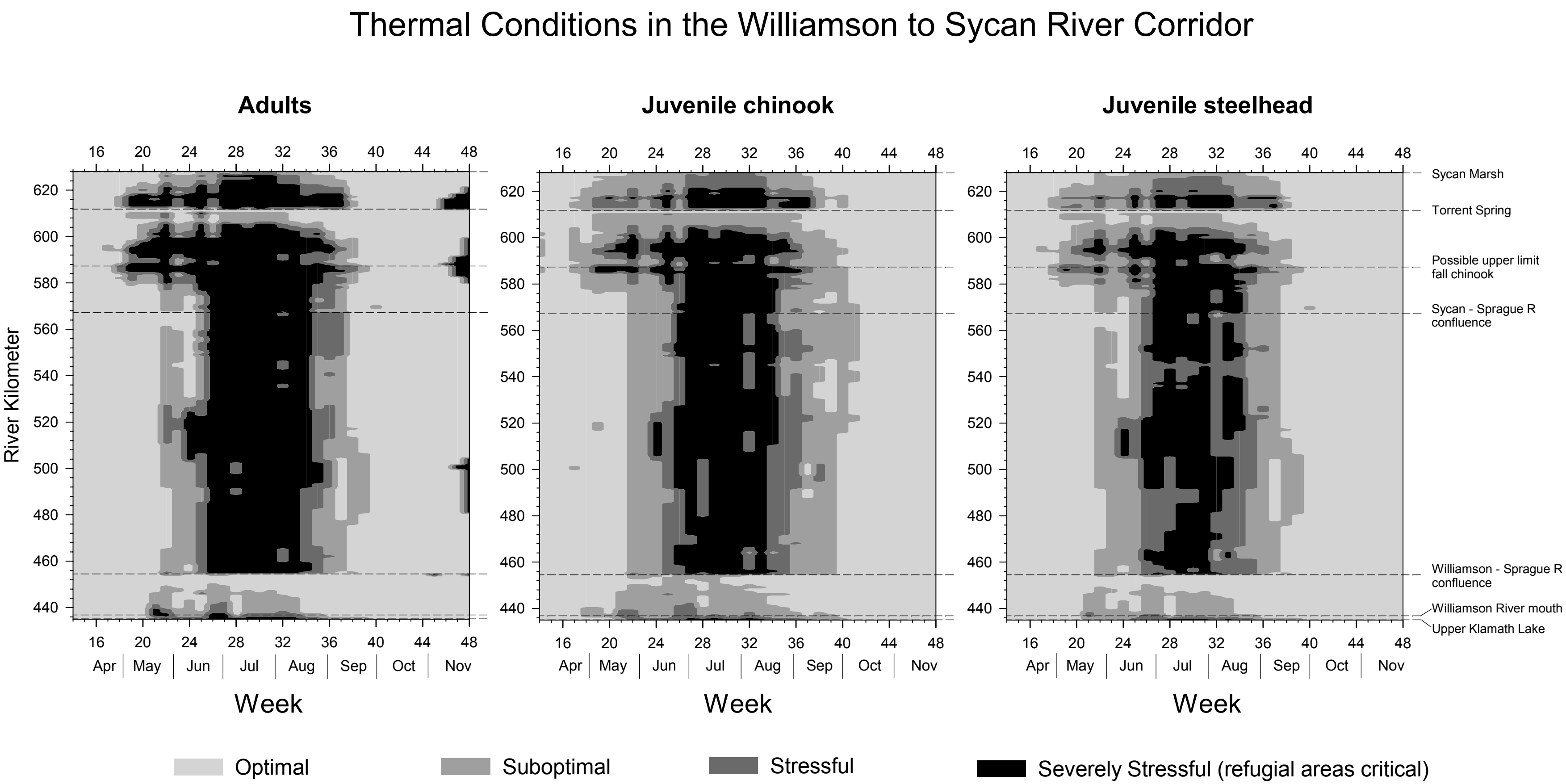


Figure 13. Contour plots characterizing seasonal and spatial patterns in the suitability of river temperatures in the Williamson-Sprague-Sycan corridor for use by juvenile and adult chinook salmon and steelhead trout.

Suitability of Environmental Conditions within Upper Klamath Lake and the Migratory Corridor Downstream for Use by Anadromous Salmonids

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Technical Memorandum to the Klamath Tribes

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Introduction

From 1917-1967, hydropower and irrigation development led to construction of six dams on the on the Klamath River (Table 1). Link River (owned by the US Bureau of Reclamation) and Keno dams were both constructed at or near the natural outlets of large, shallow lakes for both hydropower and irrigation purposes. JC Boyle, Copco 1 and 2, and Iron Gate dams were strictly hydropower developments that, including Keno Dam, are owned and operated by PacifiCorp, and are hereafter referred to as the Klamath Hydroelectric Project (KHP).

Since 1917 when Copco 1 Dam was built, anadromous salmonids have been excluded from the upper half of the Klamath River Basin (Hamilton et al. 2005). Large declines in anadromous salmonids occurred in the Klamath River in the decades following completion of the KHP, although the many factors contributing to the declines (degradation of tributary habitats, altered hydrographs, disease, harvest management, loss of Upper Basin populations, water temperature, etc.) have somewhat obscured the role played by the KHP. Water temperature, always mentioned as a concern in regard to anadromous salmonids in the Klamath River, has reached summer highs stressful to salmonids since early last century (Snyder 1931), which is not surprising since the Klamath is near the southern edge of distribution for both salmon and steelhead (Moyle 2002).

Recently, Bartholow et al. (2005) used the System Impact Assessment Model (SIAM, developed for the Klamath River by the US Geological Survey, see Bartholow et al. 2005 for the most recent version), to predict the effects of KHP removal on the thermal regime of the Klamath River. They focused on conditions for fall chinook between Iron Gate Dam and Seiad Valley, applying model results to life stage-specific thermal criteria (upper thresholds for mean daily temperatures were 14°C for spawning and incubation, 15°C for juvenile rearing, and 20°C for adult migration), concluding that:

- Without dams, the river is much more responsive to ambient meteorology, so water temperatures closely track the seasonal signature of air temperature. With the dams in place, the dynamics of heat storage and release from the reservoirs delay downstream warming in the spring, and cooling in the late summer and fall, by about 18 days.
- The reservoirs reduce day-to-day temperature variability and annual maximum temperatures downstream of the dams.
- Removal of the KHP would exert a strong influence extending at least 110 km downstream from Iron Gate Dam.

- Acute (>20°C) exposure measured using a degree-day metric (sum of the differences of mean daily temperature above criterion) increased by a large percentage with KHP removal, whereas chronic (>15°C) exposure changed little.
- Duration of exposure to thermally stressful conditions was reduced for adult migration, spawning and egg incubation without the KHP, but increased for rearing juveniles, especially near Iron Gate Dam.
- Longitudinal extent of suitable macrohabitat (average km with temperatures ≤ upper thresholds of life stage criteria) is greater without the KHP for adult migration, and spawning/incubation. For juvenile rearing, the effect is reversed for much of the summer except in July, when the models predict no suitable macrohabitat whether the KHP is present or not.

As part of the ongoing relicensing of the KHP, another water quality modeling framework (the Klamath River Water Quality Model, or KRWQM) was developed for the Klamath River from Link River Dam to the estuary (Watercourse Engineering 2003, and PacifiCorp 2004, 2005a-c, and references therein). Pursuant to issues surrounding fish passage and water quality, the KRWQM was used to model present conditions, as well as the effects of sequential dam removals. Relying heavily on KRWQM results, we pursue three objectives. First, we quantify KHP impacts on temperature (and to a lesser extent, dissolved oxygen) by comparing model predictions for present conditions with those simulating removal of the KHP. Second, we apply life stage-specific criteria for salmon and steelhead to model results, using them to translate predicted temperatures and dissolved oxygen concentrations into condition classes which are then used to quantify KHP impacts on salmon and steelhead, and to evaluate biological outcomes of removing the lower four KHP dams. Third, we evaluate suitability of water quality and flow patterns in Upper Klamath Lake to sustain effective passage of salmon and steelhead into and out of the basin above the lake.

Methods

Klamath River Water Quality Model

Five KHP configuration scenarios were modeled over 2000-2004 as documented in Watercourse Engineering (2003) and PacifiCorp (2004, 2005a-c, and references therein). All scenarios used the same meteorological and hydrological conditions as experienced in each year, although dam removal scenarios necessarily involved local changes in the simulated hydrology. In summary form, the scenarios modeled had the following characteristics:

- Existing Condition (EC), which simulates KHP facilities and operations as they presently exist, including:
    - Diversion of all but 100 cfs from the river at JC Boyle Dam around the Boyle Bypass Reach (about 7.2 km long);
    - Peaking operations at JC Boyle resulting in frequent daily flow fluctuations below the powerhouse ranging from minimum flows near 330 cfs, to ~1300 cfs for one turbine and ~2600 cfs for both turbines;
    - Peaking operations at Copco 1 and 2 that divert all but 5-10 cfs (unintentional leakage through the dam) from the Klamath River at Copco 2 Dam around the Copco Bypass Reach (about 2.3 km long).
- Iron Gate Dam removed (No IG) simulates removal of the lowest mainstem dam, and assumes that power generation at the Copco facilities is converted from peaking to a run-of-the-river operation. No changes from the EC run were made upstream of Copco Reservoir.
- Iron Gate, and Copco 1 and 2 dams removed (No IG-COP) simulates removal of the lower three mainstem dams, and assumes a conversion from peaking to run-of-the-river power generation at the JC Boyle facility. Assumed operations diverted all water in excess of ladder and instream releases (100 cfs as in the EC scenario) into the powerhouse penstocks, and flows in excess of penstock capacity were spilled below the dam. No changes from the EC run were made upstream of JC Boyle Reservoir.
- Iron Gate, Copco 1 and 2, and JC Boyle dams removed (No IG-COP-JCB) simulates removal of the lower four mainstem dams. Assumed operations route EC releases from Keno Dam through a free-flowing river. No changes from the EC run were made upstream of JC Boyle Reservoir.
- Without Project (WOP) simulates removal of all mainstem facilities downstream of, and power diversions at, Link River Dam. Assumed operations route all water released from Upper Klamath Lake through the Link River (no power diversions). Accretions to and diversions from the river above Keno are unmodified from the EC scenario, resulting in a fluctuating flow regime during spring-fall, which was deemed unrealistic by the Water Quality Working Group and subsequently smoothed, resulting in the WOP 2 simulation (Watercourse Engineering 2003). However, final results of the WOP 2 scenario were not released in time for inclusion here. Therefore, we defer treatment of the WOP 2 scenario to subsequent reports, and consider the WOP scenario as an expression of the potential of the Klamath River system with none of the KHP mainstem dams in place.

We focus on the results of the EC, No IG-COP-JCB, and WOP simulations in this report. However, results of most analyses are presented for all simulations in Appendices A and B.

PacifiCorp (2005c) describes calibration and validation of the KRWQM in general, qualitative terms, relying upon graphical comparison of hourly data. Beyond the expected inter-annual variability in model performance, some relatively consistent patterns were evident in comparisons between simulated and measured water temperatures and dissolved oxygen (DO) concentrations. Some of these patterns were mentioned in PacifiCorp (2005c), and others were not. While these issues will to some extent affect interpretation of individual model runs, we expect that relative changes between model runs will be relatively unaffected. It will be important to consider the following when interpreting the results of the KRWQM:

- Simulated winter water temperatures at most of the sites reported tend to be under-predicted by several degrees C.
- Measured DO concentrations in Keno Reservoir remain consistently high until mid- to late June, when it plunges to low levels and becomes highly variable thereafter. Simulated DO concentrations tend to begin steady, relatively steep declines in mid to late April.
- Summer water temperatures in Keno Reservoir and between Keno Dam and JC Boyle Reservoir tend to be over-predicted.
- Limited continuous temperature data available from the lower end of the JC Boyle Bypass reach shows that while measured and simulated daily temperature minima match well, the diel range of measured values is about half that of simulated, meaning that the simulated maximum is consistently over-estimated by several degrees during the summer.
- DO concentrations are frequently under-predicted in riverine reaches and dam outflows between Keno Dam and the Shasta River. In reaches further downstream, DO concentrations tend to be over-predicted, while the DO range is under-predicted.
- From the Shasta River downstream, simulated summer temperatures tend to be under-predicted, and the diel range over-predicted.

We focus on water temperature in this report, and to a lesser extent, DO. Water temperature is a primary driver of biota in aquatic systems, and is an extremely important determinant of water quality for anadromous salmonids. Water temperature is also more amenable to accurate modeling than most other water quality constituents, because it is driven primarily by physical processes that are relatively well understood and amenable to reduction into a numerical model.

Dissolved oxygen, also a very important constituent of water quality for anadromous salmonids, is more difficult to model because the controlling physical processes are mediated by many complex biological processes which are themselves difficult to predict. This often contributes to inaccurate model results. Watercourse Engineering (2003) concludes that the KRWQM simulation results are more reliable for temperature than for DO, which the calibration and validation results presented in PacifiCorp (2005c) verifies. Therefore, we use the DO results to view general patterns, and delve more deeply into the temperature outputs.

KRWQM output made available by PacifiCorp on September 29, 2005 provides the basis for much of the following analysis. For each scenario, the KRWQM provided hourly predictions of flow, temperature, and dissolved oxygen concentration at 26 locations from the Link River Dam on Upper Klamath Lake to Turwar near the Pacific Ocean for each day in the years 2000-2004 (Table 2). Model outputs for JC Boyle, Copco, and Iron Gate reservoirs were not included in the September 29, 2005 release, and are therefore not included in portions of the analyses here. However, model outputs for releases from each of the KHP dams are included, so reservoir conditions are reflected in our analyses to the extent that releases from the dams reflect conditions in their respective reservoirs.

Temperature Suitability for Chinook Salmon and Steelhead

Temperature has a profound effect on all biological processes and strongly influences the suitability of aquatic habitats for fish, including salmonids. It has been one of the most widely studied aspects of water quality, with many laboratory and field investigations having been conducted. Often these investigations have focused on the effects of water temperature on salmonids, providing a substantial body of information on the preferences and tolerances of multiple life stages of these fish.

Recent reviews of the information available on temperature's influence on salmonids have been conducted by authors examining region-wide data (McCullough 1999; Sullivan et al. 2000; McCullough et al. 2001; Sauter et al. 2001; Richter and Kolmes 2005; others), or with a focus on chinook salmon and steelhead in California (Myrick and Cech 2001). Overall, the result of these reviews has been a clear indication that optimal temperatures for the fish, expressed in degrees Centigrade (°C), range up into the mid-teens, or even a bit higher for juvenile anadromous salmonids rearing in areas with a readily available and abundant food supply. Fish performance can be reduced at temperatures higher than these, with the level of stress experienced increasing with temperature and the duration of exposure. Spatial and temporal heterogeneity in stream conditions allow fish to behave in ways that reduce their exposure to unfavorable temperature conditions, and can allow fish to utilize habitats that might otherwise prove unfavorable (Torgerson et al. 1999; Ebersole et al. 2001, 2003). For example, salmonids are often present (albeit at reduced abundance) in streams where daily maximum temperatures reach into the 22-24°C range provided there is substantial nighttime cooling or thermal refugia are available. At the extreme upper end, what appeared to be healthy juvenile rainbow-steelhead have been documented as present at low levels of abundance in interior Columbia Basin streams where maximum daily temperatures in the main water column approached (Li et al. 1992) or reached (Huntington et al. 1988) 28°C.

To facilitate interpretation of the effects of temperature and DO conditions on anadromous salmonids, we established literature-based criteria which we used to categorize levels of stress that anadromous salmonids would experience under water quality conditions predicted by the KRWQM, and measured in Upper Klamath Lake (Table 3). We classified life stage-specific thermal conditions as Optimal, Suboptimal, Stressful, or Severely Stressful (refugial areas critical) for chinook salmon and steelhead. The classification system allowed us to characterize spatial and temporal variation in the suitability of the thermal environments of specific waterbodies, using the most comprehensive and detailed temperature data available. In using these suitability criteria to classify thermal conditions, we first calculated daily minima, means, and maxima from KRWQM hourly outputs. Then we calculated seven day moving averages for each day in the record as the average of the daily means (7d-avg) or maxima (7d-max) for the previous seven days, which we subsequently used as thresholds to classify stress conditions. Temperatures for a given location and time period were assigned to the most favorable suitability class for which neither temperature threshold (7d-avg or 7d-max) was exceeded. For example, to be classified as Optimal for rearing juvenile chinook, mean daily temperatures during a given 7-day period could neither average more than 15°C nor exhibit an average daily maximum greater than 16°C.

Approaches other than ours have been used in previous analyses of the suitability of Klamath River temperatures for anadromous salmonids. For example, Deas and Orlob (1999) examined variation in a temperature index that was based on the extent to which daily maximum, mean, and minimum temperatures exceeded "No Effect" and "Acute" temperature thresholds for both juvenile rearing (16 and 20°C) and adult migration (18 and 22°C). Bartholow (2005) and Bartholow et al. (2005) examined a number of temperature metrics based on modeled 40-year occurrences of daily mean temperatures exceeding threshold values the USEPA (2003) associates with chronic (15°C) and acute (20°C) stress to salmonids, and increasingly unfavorable effects on the fish. We used our approach because it provided a greater level of resolution on the suitability and seasonal variability of temperature conditions along the river channels considered, could be readily applied to the data available to us, and was readily amenable to both graphical and tabular summaries of our results.

The temperature thresholds we used to classify thermal suitability for adult migration, rearing by juvenile chinook, and rearing by juvenile steelhead (Table 3), were derived from the literature. General discussions of these thresholds are given below.

Adult migration (chinook salmon and steelhead). Optimal adult migration conditions for anadromous salmonids are protected when 7d-avg temperatures do not exceed 16°C and 7d-max temperatures do not exceed 18°C (Richter and Kolmes 2005). At the opposite end of the suitability spectrum, migrations of adult chinook salmon can be blocked at temperatures exceeding 20-21°C (Stabler 1981; Bumgarner et al. 1997; McCullough 1999; McCullough et al. 2001). The available information suggests that adult chinook migrating upstream during spring or early summer (e.g., spring-run fish) can be blocked by incrementally lower temperatures than fish that migrate in the late summer and fall (e.g., fall-run), possibly reflecting differing risks that the fish will accumulate unacceptably high levels of thermal stress prior to spawning. We set the thresholds for Severely Stressful migration conditions to reflect the temperature levels that researchers have documented as blocking runs, with incrementally higher temperatures for fall-run than for spring-run fish. Temperature thresholds we used to distinguish Suboptimal from Stressful migration conditions were midrange values between those at the upper end of Optimal conditions and those that can block runs.

Chinook juvenile rearing. Richter and Kolmes (2005) indicate that optimal rearing conditions are generally conserved for juvenile anadromous salmonids found in Pacific Northwest streams if 7d-avg temperatures do not exceed 15°C and 7d-max temperatures do not exceed 16°C. We used their values to identify Optimal thermal regimes for juvenile chinook, even though these fish can grow more rapidly at higher temperatures (Marine 1997; Cech and Myrick 1999), because warmer conditions may expose the fish to an increasing risk of disease (McCullough 1999; Myrick and Cech 2001). Juvenile chinook from California's Central Valley survived and grew at constant temperatures of 21°C (Cech and Myrick 1999) and under variable 21-24°C temperatures (Marine 1997) when studied in an artificial (lab) environment. Areas where maximum temperatures exceeded about 23°C were generally avoided by juvenile chinook within the Sixes River Basin of south-coastal Oregon (Frissell et al. 1992) and the John Day River system in the interior Columbia Basin (Lindsay et al. 1986).

We accepted a 7d-avg temperature of 21°C and a 7d-max temperature of 23°C as the upper thresholds for our Stressful classification, beyond which (under Severely Stressful conditions) juvenile chinook presence is likely to depend on their ability to find refuge from high temperatures. A 7d-avg temperature of 18°C and a 7d-max of 21°C were used to distinguish Suboptimal conditions from Stressful conditions for these fish. The 18°C threshold for 7d-avg temperature falls midway between the thresholds we used to classify Optimal and Severely Stressful thermal conditions for juvenile chinook. It is similar to (0.2°C below) a maximum weekly average temperature (MWAT) that McCullough (1999) calculated using Armour's (1990) method for identifying suitable temperature regimes, and also a temperature associated with high juvenile growth rates in lab studies. The 21°C threshold for 7d-max temperatures accounts for a reasonable 3-degree differential between daily mean and maximum temperatures. It also reflects that one of us (CWH) has measured daily maximum temperatures this high in some still-productive chinook rearing areas on Idaho streams that experience nighttime cooling sufficient to drop daily minimum temperatures to or below about 14°C.

<u>Steelhead juvenile rearing</u>. Juvenile rainbow-steelhead trout have a preference for cold water but can also be found at temperatures incrementally warmer than those inhabited by juvenile chinook (Moyle 2002). Within the mid-Klamath Basin, below Iron Gate Dam, these fish also appear to be more resistant to some of the disease-causing pathogens affecting chinook salmon, particularly the myxosporean protozoan *Ceratomyxa shasta* (Stocking et al. 2005), the virulence of which increases noticeably at temperatures above ~15.5°C (Scott Foott, USFWS, pers comm.).

Results available from a variety of lab studies suggest that the growth rates of rainbow-steelhead from around the region vary with food availability and can peak at temperatures ranging from 15-19°C. Lab studies of California strains of rainbow-steelhead and resident rainbow trout, those of perhaps greatest relevance to our assessment, have shown juvenile growth rates to peak at about 19°C (Myrick 1998; Myrick and Cech 2000). Similar studies of juvenile steelhead from north-central Oregon (Wurtzbaugh and Davis 1977) and of resident rainbows from northern California (Myrick and Cech 2000) have shown the fish to have significant potential for growth even at 22°C, provided that food is abundant (as it is throughout the mainstem Klamath and most of the Upper Klamath Basin). However, temperatures this high are approaching those that cause mortality or that are often avoided by the fish. For example, Hokanson et al. (1977) reported that rainbow trout reared under a fluctuating temperature regime with a mean of 22°C (±3.8°C) experienced substantially elevated rates of mortality. Frissell et al. (1992) found that areas where maximum temperatures exceeded about 24°C were usually avoided by juvenile steelhead within the Sixes River Basin of south-coastal Oregon.

Consistent with the literature reviewed above, we used incrementally higher temperature thresholds for juvenile steelhead rearing than we did for juvenile chinook. The 7d-avg temperature used as a threshold for distinguishing between Suboptimal and Stressful conditions for these fish was midway between the threshold at the upper end of our Optimal range and the one at the lower end of our Severely Stressful range. It is also an MWAT for suitable temperature regimes for that Hokanson et al. (1977) calculated for rainbow trout and subsequently identified as clearly worse than optimal.

Dissolved Oxygen Suitability for Chinook Salmon and Steelhead

Dissolved oxygen (DO) is essential to aerobic processes in aquatic environments, the diversity of aquatic life, and the health of fish populations, including salmonids. Usually, DO concentrations in excess of 7-8 mg/L are recommended for maintaining the health of aquatic ecosystem naturally inhabited by coldwater fishes. For example, the State of Oregon (OAR 340-041-0016) has identified DO levels that should protect the integrity of coldwater aquatic communities (including salmonids) so long as they are exceeded. These levels include a 30-day average of daily minimum DO equal to 8.0 mg/L, a 7-day average of daily minima equal to 6.5 mg/L, and an instantaneous minimum DO of 6.0 mg/L.

The standards are based in science. Davis (1975) identified dissolved oxygen concentrations in freshwater that elicit differing types of responses in salmonid populations. Salmonids function without impairment at concentrations above approximately 7.8 mg/L, exhibit initial signs of oxygen distress at about 6.0 mg/L, and experience widespread oxygen impairment at DO concentrations of about 4.3 mg/L. Both juvenile and adult fish are affected. For example, studies by Whitmore et al. (1960) showed that juvenile chinook avoided water with low DO (1.5-4.5 mg/L) during summer and Herrmann et al. (1962) found growth rates of juvenile coho salmon to drop rapidly as DO declined to levels below about 4-5 mg/L. Davis et al. (1963) found that the swimming performance of juvenile and adult coho salmon tested over a relatively broad range of temperatures declined sharply when DO fell to 6.5-7.0 mg/L. Hallock et al. (1970) found that upstream migrations of adult chinook actually ceased when the DO concentration fell below 4.5 mg/L and then did not resume until it exceeded 5 mg/L.

As for temperature thresholds, running averages of the previous seven days for daily minima (7d-min) and means provide the basis for classifying DO conditions. Based on the above literature, we selected DO concentrations of 6.0 mg/L (7d-min) and 8 mg/L (7d-avg) to delineate the lower end of Optimal conditions, 5.0 mg/L to delineate the upper bound of Severely Stressful conditions, and 5.5 mg/L as the intermediate threshold. Note that when temperature and DO are used in concert to classify conditions, all thresholds must be surpassed for conditions to be classified as the more favorable condition.

Graphical Presentation of Data

We used a variety of techniques to evaluate spatial and temporal patterns in temperature, dissolved oxygen, and the resulting conditions for fish. Using the contour plot feature in SigmaPlot™ 9.0 (Systat Software, Inc.), we plotted daily and weekly water quality and condition data from all 26 sites listed in Table 2. Contour plots are essentially three dimensional plots that represent water quality conditions along the entire length of the Klamath River (based on interpolating data between adjacent sites for the 26 sites in Table 2, and across time) over a specified time frame. Contour plots simultaneously depict seasonal and longitudinal patterns in water quality conditions, and sequential plots reveal changes associated with various dam removal scenarios. However, contour plots present only large-scale patterns. Small-scale patterns like thermal refugia that may have enormous biological significance will generally not show up at all on contour plots.

We also used box plots to compare conditions among sites and dam removal scenarios. Box plots display the median as a line within the box, the 25th and 75th percentiles as the box ends, the 10th and 90th percentiles as whiskers, and outliers as points beyond the whiskers. In addition to contour and box plots, we computed changes resulting from various dam removal scenarios by subtracting water quality conditions under the Existing Condition scenario from the appropriate dam removal scenario. Graphical and tabular analyses of the differences enabled evaluation of the magnitude, and longitudinal and temporal extent, of water quality changes resulting from dam removal.

Results and Discussion

Overall Patterns of Water Quality Relative to System Potential

The Without Project (WOP) scenario approximates conditions with all of the mainstem Klamath River dams removed, and so is an expression of the Klamath River's potential in the absence of KHP effects while all other effects on the system remain as they presently exist. Comparing weekly temperature patterns averaged across 2000-2004 between the WOP (Figure 1) and the Existing Condition (EC; Figure 2) scenarios provides one view of the KHP effects on the Klamath River. Overall, the Klamath River with the KHP in place (EC) is substantially warmer than its potential condition under WOP. For 200+ km downstream of Iron Gate Dam, duration of average daily mean temperatures exceeding 21°C changes from about 5-6 weeks under WOP to 6-9 weeks under EC. Similarly, duration of average daily mean temperatures exceeding 19°C changes from about 11 weeks under WOP to about 13 weeks under EC. The shift is more pronounced for average daily maximum temperatures, which exceed 23°C for 3-5 weeks under WOP, and for 5-9 weeks under EC, and exceeds 19°C for 12-14 weeks under WOP compared to 15-18 weeks under EC.

Longitudinal thermal patterns also depart from the potential condition. Under EC, diversion of all but 100 cfs at JC Boyle Dam around the 6 km Boyle Bypass Reach creates an artificial spring-dominated reach with relatively cold water through the summer months (Figure 2). Influence of the spring inputs are obvious, but not as pronounced under WOP (Figure 1). As a result of the Boyle peaking operation, minimum and mean temperatures from the Boyle Powerhouse downstream to Copco Reservoir are lower under EC than under WOP, since off-peak flows are comprised solely of water emanating from the Boyle Bypass reach. Moving upstream, thermal loading at Keno Reservoir elevates temperatures above those emanating from Upper Klamath Lake at Link River Dam (Figure 2), which does not occur to the same extent under WOP, although maximum daily temperatures do spike in Lake Ewauna during July and the first part of August at the upper end of Keno Reservoir (Figure 1).

The greater irregularity of average thermal patterns in the WOP scenario indicates that seasonal and longitudinal thermal variability is suppressed under EC. Notwithstanding the severe thermal discontinuity produced by diversions at JC Boyle Dam, thermal patterns under EC (Figure 2) are spatially and temporally homogeneous relative to those under WOP (Figure 1). Large masses of water in the reservoirs contribute thermal inertia under EC that is not present under WOP, which dampens the rivers' response to short-term meteorological conditions and also shifts the river's response to seasonal thermal patterns, which will be discussed in further detail below (see NRC 2004 and Bartholow et al. 2005 for useful discussions of typical reservoir effects on downstream thermal regimes). The end result is that a more thermally homogenous river offers less opportunity for fish to seek out and exploit local variations in water temperature, tending toward conditions that are good everywhere when temperatures are cool, and bad everywhere when temperatures are high. Under such conditions, thermal refugia provided by tributaries become increasingly important to anadromous salmonids, which is presently true in the Klamath River (Belchik 2003).

Similar comparisons for DO indicate that the KHP reservoirs cause lower DO in reaches downstream from dams under EC than would be the case under WOP (Figure 3). Recall, however, that DO tended to be under-predicted below dams in the EC scenario (see Methods, and PacifiCorp 2005c). Nonetheless, hypolimnetic waters of both Copco and Iron Gate reservoirs tend towards anoxia in late summer (PacifiCorp 2005c, Appendix J), and low DO in dam outflow is frequent. Higher DOs under WOP in reaches with dams is a realistic expectation, since the reservoir processes causing the low DO would be gone, and turbulent riverine flow would aerate the water. DO sags are acute in Keno Reservoir under EC, though model validation showed the predicted sag to occur much earlier than the typical onset in mid to late June (PacifiCorp 2005c; also, see Figure 15 in Conditions for Anadromous Salmonids, below).

Longitudinal and Seasonal Temperature Patterns Relative to System Potential

We defer comprehensive presentation of longitudinal and seasonal patterns for the dam removal scenarios to Appendix A. Our purpose here is to identify major patterns and KHP effects. Subsequent inspection of the more comprehensive analyses in the appendix will enable the reader to affirm the spatial and temporal extent, and magnitude, of these effects.

The thermal mass of the larger KHP reservoirs buffers downstream river reaches from temperature increases during the spring, an effect seen most strongly in the 70 km reach between Copco Dam and Seiad Valley (Figure 4). This effect disappears by early June (Figure 5). Keno and JC Boyle reservoirs exert the opposite effect on downstream reaches in the spring.

During the hottest part of the year, releases from Iron Gate Dam vary between 20-23°C, with no deviation or thermal relief during the last half of July and all of August. Anadromous salmonids exposed to constant temperature regimes above 20°C are at risk of infection and catastrophic outbreaks of many fish diseases, and are likely to experience reduced growth of juveniles as well (McCullough et al. 2001).

During the hottest part of the year (late July), EC and WOP temperature regimes are similar downstream of the Shasta River (Figure 6). Greater extremes of daily minima and maxima characterize reaches immediately below dams under WOP, though the daily means are similar at Copco and Iron Gate dams. The significant cooling effect of springs entering the Boyle Bypass Reach lower EC daily minima and means relative to WOP for about 24 km below JC Boyle Dam, although they have little effect on daily maxima associated with large peaking events which are higher than WOP. Reaches below Keno and JC Boyle dams are also much cooler under WOP than EC, a pattern which is consistent through September (Figures 7-10).

In mid-August, the delay in cooling associated with Copco and Iron Gate dams is evident for 90 km downstream to the Scott River, although the effect is most pronounced upstream of the

Shasta River (Figure 7). As the season progresses, this pattern intensifies and influences the river at least 112 km downstream to Seiad Valley by early September (Figure 8), and the effect retains its magnitude and longitudinal extent through September (Figure 9) and into October (Figure 10). The magnitude of this delay is large, with WOP temperatures frequently 3-5°C cooler than EC below Copco and Iron Gate dams (Appendix A, Figures A8-A9)

Conclusions Regarding KHP Effects on Water Temperature

Results of the KRWQM for EC and WOP scenarios support the following conclusions about the effects of the KHP on the thermal regime of the Klamath River:

1. During summer and fall, water emanating from Upper Klamath Lake is warmed considerably in Keno Reservoir, resulting in riverine temperatures between Keno Dam and JC Boyle Reservoir substantially warmer than the system potential.
2. Additional thermal loading associated with JC Boyle Reservoir contributes water substantially warmer than the system potential to the top of the Boyle Bypass Reach and to the Boyle Peaking Reach.
3. The low flow, spring-dominated Boyle Bypass Reach is cold with relatively little diel or seasonal fluctuation. During the warm months, the thermal regime under WOP is substantially warmer than under EC, but is generally within the thermal tolerances (and near the growth optimum) for salmonids.
4. Large, diel flow changes associated with the Boyle peaking operation create large (approaching 10°C) daily fluctuations in temperature in the Boyle Peaking Reach. Lowest temperatures are coincident with lowest flows (~330 cfs) during off-peak periods when all flow in the reach emanates from the Boyle Bypass Reach. Highest temperatures coincide with on-peak periods when flows are dominated by water diverted (~1300 for one turbine, ~2600 cfs for both turbines) from JC Boyle Reservoir.
5. Thermal inertia associated with Copco and Iron Gate reservoirs alters the timing and magnitude of the seasonal progression of warming in spring and early summer, and cooling in fall. Reservoirs delay warming of the Klamath River during spring under EC from Iron Gate Dam to Seiad Valley, an effect that disappears by early June. The extent to which the more rapid warming without dams in place may be influenced by altered watershed conditions and by water management is unknown, but these factors are likely influential. The KHP-related delay in thermal response is accompanied by suppressed diel variability, which from mid-July through August prevents cooling to levels below 20°C. From mid-August through September, Copco and Iron Gate reservoirs delay cooling 112 km downstream to Seiad Valley. WOP temperatures are frequently 3-5°C cooler than EC below the dams at this time of year.

Conditions for Anadromous Salmonids

The previous section describes how the KHP has altered the thermal regime of the Klamath River in complex ways. The next step is to translate temperature and dissolved oxygen conditions estimated by the KRWQM into an expression of suitability for juvenile and adult chinook and steelhead, which we have done using the condition thresholds given in Table 3. We defer to Appendix B an exhaustive presentation of conditions for various life stages of anadromous fish under all 5 KHP configurations modeled. Here, we focus upon comparing the EC and WOP scenarios to evaluate KHP effects on anadromous fish, and upon the No IG-COP-JCB scenario as an alternative KHP configuration. We present results using three main tools:

1. Contour plots of weekly conditions averaged over the five years modeled. These show the central tendency of conditions prevailing under different KHP configurations and the sort of coarse-scale selective pressures fish runs will experience over the long term if conditions continue as in 2000-2004.
2. Contour plots of daily conditions within individual years, which illustrate the extent of spatial and temporal variation of conditions both inter-annually and among KHP configurations. In most cases, the two years selected for presentation represent the most extreme conditions. However, 2002 is shown for the fall period in the discussion of adult migratory conditions, because that year best illustrates dynamics of intermittent passage corridors. Results for all years are available in Appendix B.
3. Tables quantifying how frequently different condition classes are experienced at selected sites for the three KHP configurations. Condition class frequency is expressed as the percentage of days falling within four condition categories (Table 3) for each 2 week period across all five years.

<u>Adult Chinook and Steelhead</u>

Because of the importance of thermal conditions to adult migrations, we view the spring and fall migratory periods separately here. Average thermal conditions for both periods combined (April-November) are displayed for all five KHP configurations in Appendix B, Figure B1.

Average spring-time thermal conditions for adult salmon and steelhead in the Klamath River (Figure 11) illustrate KHP impacts and the likely outcome of removing the lower four dams. First, the average onset of Stressful conditions occurs in mid-May under No IG-COP-JCB along much of the mainstem Klamath above the Scott River, compared to early June under EC and

WOP. Second, the earliest onset of Severely Stressful conditions in all three scenarios occurs in late May upstream of Copco Dam, though the specific locations and longitudinal extent of these early occurrences varies. Such conditions might impede or block upstream migration of spring chinook, and appear most problematic under EC because of early onset in the Boyle Peaking Reach and above Boyle Dam. Third, short reaches immediately downstream of Boyle, Copco, and Iron Gate dams do not become Severely Stressful by the end of June, whereas such conditions occur in the 2^{nd}-3^{rd} week in June under the other two scenarios.

Viewing the same spring time period for specific years shows significant variation within and between years that is not conveyed by weekly averages, and yet is undoubtedly important biologically to the group of fish present in that year (Figure 12). The years shown in Figure 12, 2001 and 2004, were selected because they tended to best display the extremes in timing and in spatial and temporal complexity of thermal conditions over the 2000-2004 period. Results for each of the five years modeled are presented in Appendix B, Figures B2-B6. Under EC, the onset of Stressful and Severely Stressful conditions occurred three weeks earlier during 2001 than during 2004 within the river's middle and upper reaches. An early warm spell in 2001 pushed several smaller reaches into Severely Stressful conditions in late May 2001, and then cooler conditions led to less stressful conditions in early June, after which the system warmed up again. In contrast, weather and the river remained cool in 2004 until mid-June.

Conditions under the dam removal scenarios show a river system more responsive to weather conditions (Figure 12, and Bartholow et al. 2005), leading to more frequent and extreme variation in longitudinal and temporal riverine thermal patterns. For example, under both dam removal scenarios, Severely Stressful conditions prevail in the upper 230 km of the river in late May, 2001, a more extreme condition than seen under EC. However, by early June, most of that same corridor had cooled to a Suboptimal condition under the dam removal scenarios, but only cooled to a Stressful condition under EC. Similar patterns are present in all years modeled (Appendix B).

Average thermal conditions for adult migrants during the fall months (Figure 13) illustrate the frequently adverse conditions encountered by these fish under present conditions (EC). Average conditions worsen moving upstream from the Scott River to the Shasta River, where Severely Stressful conditions prevail on average through mid-September, and Stressful conditions extend through late September. As in the spring-time, adult migrations appear most likely to be delayed or blocked under EC than under the dam removal scenarios. Both No IG-COP-JCB and WOP see average conditions improving to Suboptimal on about September 1, more than 2 weeks earlier than under EC, an effect that extends almost all the way to the ocean. Furthermore, between RKM 240 and 360, the average end of Severely Stressful conditions is in mid-August, 2-4 weeks earlier than for EC.

Combining criteria for dissolved oxygen and thermal conditions emphasizes the temporal extent of poor conditions in Keno Reservoir (Figure 14). KRWQM results predict that Severely Stressful conditions driven by low dissolved oxygen concentrations will persist through September, which corresponds fairly well with data collected by US Bureau of Reclamation, though in 2002-2004 severe conditions prevailed through much of October (Figure 15). We do not show similar plots for the spring months, because the KRWQM performed poorly in Keno Reservoir during the spring (compare Figure 3 to Figure 15). Clearly, adult passage through Keno Reservoir under present conditions is likely not possible until sometime in October, which poses a problem for anadromous fish that would require management intervention in the form of active transport of fish or remedial actions to improve dissolved oxygen conditions in the reservoir.

As in the spring, dynamic weather conditions result in spatial and temporal fluctuations in river temperatures within years that create corridors of better conditions in dam removal scenarios that are absent or incomplete under EC (Figure 16). An excellent example of this effect is seen in 2002, when partial corridors opened up in the lower 250 km of the river in early August and again in late August, corridors which extended 360 km upstream to the large thermal refugium available in the Boyle Bypass reach in both dam removal scenarios. Conditions improved moving upstream in these corridors in both dam removal scenarios, which is the expected pattern in natural systems during fall moving upstream into higher elevations. Under EC, however, this pattern is reversed, with harsher conditions prevailing upstream in the reaches immediately below the KHP. In contrast to 2002, a warm late summer in 2001 prevented development of one of these corridors until mid-September in the dam removal scenarios, and not at all under EC. Corridors of usable thermal conditions opened up in early to mid-August under No IG-COP-JCB and WOP in 3 of the 5 years modeled (Appendix B, Figures B2-B6).

While contour plots provide a useful view of system behavior under different model scenarios, it is difficult to make firm quantitative statements based on such products. Therefore, we summarized the average frequency of thermal conditions for adults by model scenario and river reach for two week periods from April-November in Table 4. Within each reach and two week period, the percentage of days (out of 70 total over 2000-2004) falling within thermal condition categories are provided for the EC, No IG-COP-JCB, and WOP scenarios (similar analyses are presented for each site in Appendix B, Tables B1-B4).

The largest effect (in terms of magnitude and extent) of the KHP on thermal conditions important to adults is seen in the Iron Gate Reach (extends from Copco Dam to the Shasta River, see Table 2 for reach designations). Within this 51 km reach, the KHP increases the percentage of Severely Stressful days relative to system potential (WOP) in every period from mid-July through September (Tables 4-5). The effect is greatest in late August, when the KHP increases the frequency of Severely Stressful days by 60 percentage points above the system potential, but is also large during early August (35 percentage points), early September (55 percentage points), and mid-September (19 percentage points). Similarly, the KHP reduces the frequency of Suboptimal conditions 36 percentage points in early September, and 57 percentage points in mid-September. Early season cooling associated with EC in this reach results in more modest shifts into higher stress categories during late May (e.g. 20 percentage point increase in Optimal days, and a 10 point decrease in Severely Stressful days) and early June, but by late June the effect is reversed. Overall, the cooling effect of the KHP on this reach during the spring is much smaller and shorter lived than the warming effect produced by the KHP from mid-summer into the fall. Downstream in the 85 km long Scott River reach, the effects are dampened but follow the same pattern. Here the KHP increases days with Severely Stressful thermal conditions by 23 percentage points in mid-August, and 26 percentage points in early September.

In the Boyle Peaking reach (25 km long), the KHP increases incidence of Severely Stressful days by 13-41 percentage points from June through early September (Tables 4-5). The effect of the KHP goes the other direction in the 6.4 km Boyle Bypass Reach, which never warms beyond the Suboptimal category under EC, but experiences Severely Stressful conditions 9-39% of the days from late June – August under WOP. Keno Reservoir increases Severely Stressful days by about 20 percentage points during June, and by 25-44 points in August and early September.

In general, the removal of the four lower dams (No IG-COP-JCB) restores a thermal regime to the river similar to that under WOP (Tables 4-5). Notable exceptions include June and September in the Keno Reach, when the effects of Keno Reservoir are strongly expressed. Changes associated with this alternative closely approach those under WOP in the Iron Gate and Scott River reaches.

Juvenile Chinook

Onset of Stressful conditions for juvenile chinook is 2 weeks earlier in much of the 80 km upstream of Copco Dam under EC and No IG-COP-JCB compared to WOP (Figure 17). In contrast, onset of Stressful conditions under No IG-COP-JCB is 2 weeks earlier than EC between the Shasta and Scott rivers. Onset of Severely Stressful temperatures is similar in all 3 scenarios in the lower 250 km, but is 2-3 weeks later in the dam removal scenarios than under EC between RKM 280-340. As temperatures cool in the late summer and fall, EC conditions remain Severely Stressful for 2-3 weeks longer than either dam removal scenario from RKM 80-260, and 4 weeks longer from RKM 260-320 (reach below Copco and Iron Gate Dams). Similarly, conditions that change to Suboptimal from Stressful near September 1 under the dam removal scenarios are delayed by 4 weeks for 90 km upstream of the Scott River. Average thermal conditions for all modeled dam removal scenarios are presented in Appendix B, Figure B7.

Viewed on an annual basis, it is clear that inter-annual variability in thermal conditions for juvenile chinook is quite large, with Severely Stressful conditions prevailing from July-early September in 2001 dam removal scenarios, compared to about 2 weeks total through much of the system in 2004 (Figure 18). A large KHP effect is seen in the lower 350 km in 2004, when Severely Stressful conditions persist for about 6 weeks under EC compared to 1-2 weeks under WOP. In the more severe year of 2001, the KHP imposes Severely Stressful conditions from RKM 290-340 (from the Boyle Peaking Reach to below Iron Gate Dam) that are generally absent under WOP, a pattern mirrored in 2004 and visible in the average condition as well (Figure 17). Overall, as for the adults, the KHP homogenizes the thermal environment available to juvenile chinook during the warm months. Results for all dam removal scenarios and years are available in Appendix B (Figures B8-B12).

The KHP appears to strongly affect thermal conditions important to juvenile chinook. KHP influences worsen thermal conditions in the Keno Reach during June (Severely Stressful days increase by 20-22 percentage points) and August (Severely Stressful days increase by 25-44 percentage points; Tables 6-7). Recall, however, that model results tended to over-predict temperatures in this reach, so conditions may be better than predicted. In the Boyle Peaking Reach, the KHP causes a large increase in the frequency of Severely Stressful days (13-41 percentage points) from June-August. Similar increases in the Iron Gate (7-72 percentage points) and Scott River (5-39 percentage points) July through September. The largest differences occur in Iron Gate and Scott River reaches in August – early September.

At some times and locations, the KHP improves thermal rearing conditions for juvenile chinook. In the Boyle Bypass Reach, EC temperatures never climb above the Suboptimal level, but under WOP 17-60% of the days are Stressful from late May to early September, and 7-39% of the days are Severely Stressful from June-August (Table 6). In the Iron Gate Reach during May, conditions shift from mostly Optimal and Suboptimal under EC in late May to Suboptimal and Stressful under WOP. A similar effect, but lower in magnitude, occurs at the same time in the Scott River reach. During late June in the Iron Gate and Scott River reaches, a higher percentage of days fall in the Suboptimal and Severely Stressful categories under WOP than under EC, which is symptomatic of the diminished thermal variability in the system under EC. Similar analyses for each site are presented in Appendix B (Tables B5-B8).

Juvenile Steelhead

On average, Severely Stressful thermal conditions for juvenile steelhead persist for 2-3 weeks longer from RKM 180-290 under EC than either dam removal scenario (Figure 19). Transitions to Suboptimal and Stressful conditions tend to have the same timing during spring and early summer among the three scenarios, but the transitions into these conditions are delayed by about 2 weeks under EC as the system cools. Average conditions between the Shasta River and Boyle Dam (60 km) seldom become Severely Stressful in the dam removal scenarios, in contrast to EC. Patterns in 2001 and 2004 (Figure 20) are similar to those for juvenile chinook. As for the other life stages, the KHP eliminates important thermal variability in the system, resulting in a more thermally adverse environment for juvenile steelhead throughout most of the Klamath River. Results for all dam removal scenarios and years are available in Appendix B (Figures B14-B18).

Patterns in frequency of thermal conditions for juvenile steelhead by reach (Tables 8-9) are similar to those for juvenile chinook. KHP effects (relative to WOP) tend to be moderate increases in thermal stress during the summer in the Keno Reach, with larger increases during August. The largest negative effects in the Boyle Peaking Reach occur July-August. As with other life stages, the largest effects are seen in the Iron Gate Reach, which experiences much higher frequencies of the more stressful conditions from August-September. A similar pattern at lower magnitude is seen in the Scott River Reach. The Iron Gate and Scott River reaches warm to Stressful levels earlier under WOP than EC in late May and early June. In the Boyle Bypass Reach, conditions are more stressful late May – September under WOP than under EC. Similar analyses for each site are presented in Appendix B (Tables B9-B12).

Thermal Refugia

Warm summer water temperatures in the Klamath River make thermal refugia important components of the ecosystem that are heavily used by anadromous salmonids (Belchik 2003, NRC 2004). Belchik (2003) observed juvenile salmon and steelhead interacting with thermal refugia at tributary confluences with the Klamath River, documenting rapidly increasing use of refugia as river temperatures climbed above 22°C, as well as excursions out of refugia to feed during cooler portions of the diel cycle. NRC (2004) discussed the importance of nighttime cooling to salmonids in warm systems, emphasizing that the daily relief offered by the cooler portion of the diel thermal cycle had significant bioenergetic benefits that helped fish persist under marginal conditions.

Under EC, Severely Stressful temperatures are frequent in the Klamath River, and under such conditions the availability of refugial areas is likely a critically important determinant of the success of juvenile salmonids. Assuming that juveniles will seek thermal refugia when daily maximum temperatures exceed 22°C, we used the KRWQM outputs to compare among different KHP configurations the 1) frequency (number of days) with which juveniles would require thermal refugia, and 2) average minimum daily river temperatures for periods when thermal refugia would be occupied. These comparisons yield insight into how the present and potential future KHP configuration may influence the use of thermal refugia by juvenile salmon and steelhead. Results of the following analysis for all model scenarios can be found in Appendix B, Table B13.

The KHP appears to strongly influence the frequency with which thermal refugia are likely to be used by juveniles, as well as the relative benefits of refugia use to these fish (Table 10). At the outflows from each of the largest dams, and at lower end of the Boyle Bypass Reach, the KHP decreases the frequency of refugia use (EC vs. WOP) by a substantial margin (24 d/yr at Iron Gate, 12 d/yr at Copco 1, 19 d/yr at JC Boyle, and 42 d/yr at end of the Boyle Bypass Reach). At each of the dams under EC, however, the average minimum temperature of the river remains high (21.8-22.7°C) during periods when the maximum daily temperatures are likely to force juveniles into refugia (>22°C). Under WOP, minimum temperatures at the dam outflow sites coincident to refugia use range from 17.7-19.6°C. Therefore, despite the apparent decrease in the need to occupy thermal refugia at the dam sites under EC, the loss of diel variation in the thermal regime caused by the reservoirs results in conditions that will likely force continuous occupancy of the refugia. In contrast, the more frequent need to occupy refugia under WOP at these sites is accompanied by lower nighttime temperatures, which would allow fish to leave the refugia to forage and thereby allow more effective use of the refugia.

In other parts of the river, the need to occupy thermal refugia occurs more frequently under EC than WOP (Table 10). Between Keno Dam and JC Boyle Reservoir, refugia occupancy increases by 17-18 days under EC relative to WOP, accompanied by increased minimum daily temperatures of 1.0-2.7°C. In the Boyle Peaking Reach, the difference in refugia occupancy between EC and WOP is almost zero immediately below the powerhouse, and the minimum daily temperature is 3.3°C cooler under EC when refugia are needed. Further down the reach, however, the situation changes substantially. At Stateline and above Copco Reservoir the need for refugia increases by 40 and 29 d/yr, respectively, and the 2°C improvement of minimum temperatures under EC disappears above Copco Reservoir. Further downstream at the Shasta River, refugia are needed 33 d/yr more under EC than WOP, although minimum daily temperatures average 18.5°C under EC compared to 20.0°C under WOP. Finally, at the Scott River the need for refugia increases by 18 d/yr under EC, with minimum daily temperatures differing by 0.8°C.

Frequency of refugia use associated with removing the lower four dams (No IG-COP-JCB) is intermediate between EC and WOP for many sites (Table 10). Below Keno Dam, however, dam removal effects are nearly identical to EC, which is not surprising since this reach is thermally dominated by Keno Reservoir (present in both scenarios). The biggest difference is seen at the JC Boyle Dam site, where dam removal increases the need for refugia by 36 d/yr, although dam removal yields minimum daily temperatures 2.6°C cooler than the 22.7°C that prevails under EC. Similarly, at the Copco 1 Dam site, a 25 d/yr increase in refugia use caused by dam removals is accompanied by a 2.2°C decrease in minimum daily temperatures from the 21.8°C seen under EC.

NRC (2004) warned that increases in minimum daily temperatures above those prevailing now could be disastrous for salmonids in the Klamath River mainstem, based on the thesis that sufficiently low diel minima provide relief important for the growth and persistence of salmonids under challenging thermal regimes. It follows that reductions in minimum daily temperatures below those prevailing now would benefit salmonids in the Klamath River mainstem, helping them to tolerate the warmer periods of the year when dwelling in the mainstem, but also allowing feeding excursions when confined to refugia during the warmer times of the day. Our analysis shows that, relative to the system potential (WOP), the KHP decreases the number of days per year that juveniles would need thermal refugia in 1) the Boyle Bypass Reach, and 2) reaches immediately below Iron Gate, Copco 1, and JC Boyle dams. However, minimum temperatures remain high below these dams, which is likely to diminish effective use of refugia. For most other river segments from Keno Dam to the Scott River, the KHP has substantially increased the frequency of need for thermal refugia.

Overall, removal of the lower four dams provides a net benefit to juvenile salmonid use of refugia, because of the combined effects of decreased need for refugia in many reaches with the tendency for cooler daily minima in reaches where dam removal increases the need for refugia.

Run Timing

A glimpse of the historic thermal regime at Klamathon (midway between Iron Gate Dam and the Shasta River) is provided by Snyder (1931). He reported average morning (8AM) and late afternoon (5PM) water temperatures for 10 day periods from July – early November in 1926. Since his measurements were roughly equivalent to average daily minima and maxima, we calculated the approximate daily average as the midpoint of his daily data, and compared his measurements to results from 2000-2004 model runs for EC, No IG-COP-JCB, and WOP for the same days of the year (Figure 21). For this purpose, we calculated an approximate daily mean from the model data for the same 10 day periods as the midpoint between the average daily minimum and maximum.

Present (EC) conditions are much warmer during this time period than in 1926; Snyder's measurements do not overlap with model results from August-October (Figure 21). Thermal patterns do overlap, however, with model results for the four lower dams removed (No IG-COP-JCB) and complete removal of the KHP (WOP), though the overlap tends to occur toward the lowest temperatures modeled. Temperatures in the first half of July are exceptions, for which Snyder's measurements were higher than almost all model outputs July 1-10, and midrange July 11-20.

None of the model runs duplicate the configuration of dams and flow management extant in 1926. At that time, Copco 1 was the only mainstem dam in place, and was operated for peaking. Extensive alteration of the reach between Klamath Falls and Keno was underway, but Keno Dam was not in place, and the Keno Reservoir reach had not yet been dredged (this followed the flood in 1964). Link River Dam was regulating outflows from Upper Klamath Lake, but the Klamath Irrigation Project was diverting only a fraction of the flows they divert during this time period at present. So, it is reasonable to conclude that the thermal regime measured in 1926 was not a "pristine" regime, but one that integrated the thermal consequences of Copco Reservoir and its operations and flow modifications, although the effects were clearly not as severe as those present now.

Snyder (1931) reported summer-fall chinook run timing in the lower river to begin in July, peak in August, and slowly decline in September, a pattern that fits the thermal regime at Klamathon in 1926 (Figure 21). Shaw et al. (1998) summarize migration timing to the middle Klamath River, and show a multiple week shift in both the beginning and peak of fall chinook runs from that recorded at Klamathon during 1939-58 (Figure 22). We believe that increased water temperatures are a primary cause of this shift in run timing, and that much of the change in the thermal regime can be attributed to the KHP. As we saw in much of the preceding discussion on thermal conditions for adults, present conditions are not conducive to extensive upstream migration until temperatures cool in late September. Before full development of the KHP, however, temperatures which at present initiate September migrations were present in August, coincident with extensive adult migrations. KRWQM results indicate that the system is still capable of a thermal regime similar to that seen in 1926 if most or all of the KHP is removed.

More recent information also sheds light on this issue. Table 11 summarizes information regarding the upstream migration rate of fall chinook in the Klamath River. Focusing on radio telemetry data from 2003-2005 (Josh Strange, University of Washington, pers. comm.), an annual average migration rate for the fish traveling up the mid-Klamath River, above the Trinity River (Weitchpec), can range from 9.4-13.1 km/d, with individual fish traveling at both lesser and greater rates. Using counts of adult fall chinook returning to Iron Gate Hatchery in 2002 (CDFG 2006), we back-calculated the approximate departure times of various parts of the run as they passed Weitchpec, and compared upstream migration to thermal conditions (Figure 23). It appears that the first part of the run in 2002 passed Weitchpec during a period of rapid improvement from Severely Stressful to Suboptimal in the first week of September. Here we see a situation in which some fish likely began moving upstream in one of the “corridors” of improved water temperature associated with a period of cooler weather. It warmed up again, briefly, and it may have forced these fish to hold for a few days in thermal refugia.

In 2003, a similar plot (Figure 24) shows Severely Stressful conditions prevailing through the first week in September. Partial development of smaller thermal corridors than in 2002, and with larger intervening periods of Severely Stressful conditions apparently was insufficient to allow the migration to fully commence, although a small proportion of the run arriving at Iron Gate hatchery around October 1 may well have moved in the second corridor. As in 2002, the peak of the run appeared to move upstream after thermal conditions improved. Note that both the peak of the run into Iron Gate hatchery and the onset of improved thermal conditions near the mouth were about a week later in 2003 than in 2002.

More data from telemetered fish were available for 2004 (Figure 25). Arrivals to Iron Gate hatchery began peaking in early October, earlier than in 2002 or 2003. No temporary thermal corridors developed in 2004. Instead, the transition from Severely Stressful to Suboptimal conditions (about 2 weeks) was slow relative to other years. Telemetered fish moved relatively slowly up to the Trinity River (4.7-9.1 km/d, Table 11) when fish were moving through Stressful conditions, and then migration rates increased from the Trinity up to Iron Gate Hatchery (4.9-20.1 km/d, Table 11), which started coincident to the onset of Suboptimal conditions. This pattern suggests a relationship between water temperature and chinook migration rates. In the Columbia River, Salinger and Anderson (2006) concluded that chinook migration rates were influenced by temperature, with peak rates occurring from 16-17°C. In the No IG-COP-JCB scenario, the transition from Stressful to Suboptimal occurs about 1.5 weeks earlier than under EC. In Figure 26 we shift the arrival frequency at Iron Gate hatchery to reflect this shift, and find that under such circumstances the adults would be arriving in the upper reach soon after conditions become Optimal. Note that with the dams removed, migrating fish encounter cooler water as they move upstream, whereas under EC they typically encounter warmer water.

We conclude that the KHP has warmed the river during the late summer, early fall migratory period to the extent that adult chinook runs are multiple weeks later than they were prior to 1958, and that removal of the four lower dams on the Klamath River would likely restore a thermal regime that would allow chinook to migrate earlier than at present. Further, we note that water temperatures in the Iron Gate Reach descend to suitable levels for spawning (<14°C, McCullough 2001) by early to mid October with the lower four dams removed, but not until late October to early November under EC (Appendix A, Figures A24-A26).

Delay of the adult migration by a few weeks to Iron Gate Dam may not sound very significant, but we believe it has serious ramifications to the prospects for salmon restoration into the basin above Iron Gate Dam (Upper Basin). Making some basic assumptions about expected migration rates through steep reaches of the Klamath River between Iron Gate and Keno dams, reservoirs and lakes, and low gradient rivers above Upper Klamath Lake allows us to project the potential consequences of delaying the fall run fish by 3 weeks. Figure 27 uses the recent timing of the upstream-most fall chinook runs below Iron Gate Dam, and moves them up-basin using assumed migration rates. We used a 9.4 km/d rate (the mean annual rate above Weitchpec during 2003, per J. Strange, pers. comm.) to move fish up riverine segments of the mainstem Klamath above locations with known times of arrival. For lakes and reservoirs, we used a 55 km/d migration rate (a median value calculated for fall chinook in Columbia and Snake River reservoirs from Keefer et al. 2004), and a rate three-quarters that for the lakes and reservoirs was used in slower-flowing rivers above UKL. The peak of the pre-1958 run at Klamathon would have arrived at the Williamson River on about September 25, and at the confluence of the North and South Forks of the Sprague River by September 29. The delay reaching Iron Gate places the various stocks of fish into these locations from mid October to early November.

Potential consequences of late arrival to areas above UKL are significant to fish employing ocean-type life history strategies. In areas not influenced by groundwater, the delay in spawning is likely to perpetuate itself through subsequent life stages, making it less likely that ocean-type fry will grow sufficiently to enable downstream emigration in the following spring with a reasonable expectation of survival. Reaches influenced by groundwater would contribute substantially more thermal units to developing embryos and growing fry, enabling them to compensate to some degree for the spawning delay. However, in reaches with cold winter temperatures a delay of a few weeks at the beginning of incubation may render the population unviable for ocean-type strategies that rely on emigration during the spring following spawning (see Huntington and Dunsmoor 2006 for more detail on upper basin thermal regimes). Since the uppermost reaches in the watershed near the headwaters of the Sprague are likely to be coldest, and are also the furthest from the ocean, the run delay makes it seem unlikely to us that ocean-type fish will do well under present circumstances in that part of the system. Prospects for ocean-type life histories are much better in the groundwater-dominated rivers near Upper Klamath Lake.

Upper Klamath Lake

Upper Klamath and Agency lakes (UKL) are naturally eutrophic (Bradbury et al. 2004; Eilers et al. 2004), but over the past century has become hypereutrophic, as a direct result of anthropogenic nutrient enrichment (NRC 2004). Under existing conditions, summers are characterized by intense blooms of the cyanobacterium *Aphanizomenon flos-aquae*. Bloom dynamics dominate water quality in the summer, at times causing high pH and at others low DO and high ammonia concentrations, but during the spring and fall conditions are improved.

<u>Lake Conditions Monitored by the Klamath Tribes</u>

Since 1990 the Klamath Tribes, in cooperation with the US Bureau of Reclamation, have monitored water quality conditions in Upper Klamath and Agency lakes, measuring water quality profiles (and depth integrated grab samples for ammonia) every other week from a network of 9-10 sites sampled April-October each year.

Spring chinook adults and juveniles could move through UKL during March through May and into early June, when water quality conditions are generally adequate for these life stages (Table 12). During mid-summer the main body of UKL is too warm to support salmonids, but becomes suitable again in the late summer and early fall. Data from the biweekly, long-term monitoring program shows temperatures becoming suitable by late August (median) to early September (90^{th} percentile; Table 13). Median dissolved oxygen concentrations are adequate, and by late August, 10^{th} percentile concentrations generally exceed 6 mg/L in the upper 1 m, which amounts to most of the water column during this time of year along the east shore of UKL (the most likely migratory route, see discussion on currents below). Median pH levels hover near 9.0, the upper end of the ODEQ pH standard (Boyd et al. 2002), with 90^{th} percentile levels of 9.7 at times. The response of migrating adults to such conditions is uncertain, but it seems clear that conditions are likely to be stressful at times during fall migrations. Ammonia dynamics in UKL are poorly understood, in part because of the difficulty and expense involved in obtaining accurate measurements. However, un-ionized ammonia concentrations can be quite high into September, at times exceeding 96 hr LC50 concentrations, although these events are generally transitory in time and space.

Overall, the biweekly monitoring indicates that water quality in UKL will generally support migrating salmonids during both the spring and fall, although apparently infrequent excursions into stressful conditions, particularly for pH and ammonia, may affect portions of the runs in certain years. However, we caution that the long-term monitoring program was not designed to provide the level of spatial and temporal detail necessary to thoroughly assess adequacy of conditions in UKL for anadromous salmonids. One clear shortcoming of this data set in the present context is that the sites monitored were situated to the west of the most likely migratory route of salmonids, a band of water along the eastern shoreline where currents helpful to fish migration are present (see discussion below). In addition, the data were generally collected between 1000 and 1500 hours each day, so measurements during the times of day when minimum DO and pH levels typically occur in the main body of the lake are lacking.

Lake Conditions Monitored by the U.S. Geologic Survey

Over the past few years the U.S. Geological Survey (USGS) has been researching water quality dynamics in UKL, deploying remote probes that collect continuous (hourly) dissolved oxygen and temperature data which is much more useful for our present need. Coincident with this effort, USGS has deployed acoustic Doppler current profilers to measure current patterns in UKL, using these data to calibrate a hydrodynamic model. Once calibrated, wind speed and direction are the main inputs, so USGS deployed a meteorological station on the lake which recorded wind speed and direction continuously. USGS (Tammy Wood, USGS, pers. comm.) kindly provided us with simulations of currents in UKL under low wind and high wind conditions. Simulations for September 26 (low wind) and October 10 (high wind) in 2003 used the wind data set in Figure 28. Prevailing winds are out of the northwest (a typical condition during both spring and fall), setting up a clockwise flow pattern with velocities frequently ranging from 2 - >10 cm/sec under both weak (Figure 29) and strong (Figure 30) wind conditions. Most of the lake where the southerly flow path dominated was about 1.5-3 m deep at the time of this simulation, a typical condition in the fall. A broad, southerly flow path sweeps along the Williamson River Delta and then down the eastern shoreline toward the outlet at the southern tip of the lake seems well suited to guide fish between the Williamson River and the lake outlet during juvenile and adult migrations. Whether lake currents will provide migratory cues for fish returning to the Wood River is less certain.

Data from the USGS's continuously recording water quality probes were divided into two groups: 7 sites (filled circles; the 3 shoreline sites had data only for 2002) along the eastern and northern shoreline (east side group) were in shallow water in the southerly flow path, and 4 sites (open circles) were in deeper water and more frequently in a northerly flow path (Figure 30). The deeper sites were in a portion of the lake that frequently experiences episodes of low dissolved oxygen after the *Aphanizomenon* bloom dies out, and in fact conditions were poor in this portion of the lake from August-September in 2003.

We used the temperature and DO data collected at the two groups of USGS sites to classify conditions for adult salmon and steelhead in UKL during 2002-2004 (Figure 31), and found conditions to be similar to those in the Klamath River. In 2002 and 2004 conditions were similar, and there was little difference between the deep and shallow sites. Conditions differed significantly in 2003, however. While the sites in the eastside group exhibited brief excursions into the Stressful range in very early October, those in the deepwater areas experienced Severely Stressful conditions from very late September to mid October.

DO conditions similar to those measured in the deeper areas in 2003 were associated with large fish kills in UKL during 1995-97 (Perkins et al. 2000). In 2003, the likely migration path for anadromous salmonids remained usable, despite a widespread sag in the deeper portions of the lake. What conditions were like in this portion of the lake during 1995-97 is unknown.

Conclusions

We conclude that the prevailing currents within UKL will likely provide sufficient cues to upstream migrants to enable their rapid movement through UKL to the Williamson River. Whether currents will be as useful to fish seeking the Wood River is less certain. Juvenile downstream migrants should likewise benefit from these currents, which will help them move toward the lake outlet. Juveniles that find their way into the northerly currents along the west shore may well be delivered to Pelican Bay, a cold, spring-water dominated embayment (~3 km^2) of UKL surrounded by wetland, in which Klamath Lake redband trout reside through the summer months. Pelican Bay would offer these juveniles near optimal rearing habitat.

Water quality in UKL is adequate for fish migrations in the spring, and appears generally adequate with intermittent water quality stressors that decrease as the fall migration period progresses. As (if) efforts to reintroduce anadromous salmonids into the Upper Basin move ahead, much additional information will be required, and developing a more detailed understanding of water quality dynamics along the likely upstream migratory pathway in UKL is a high priority. Since Keno Reservoir is clearly adverse to salmonids during the fall migratory period, adults transported around Keno Reservoir could be released into UKL near the southern edge of the Williamson River delta (Modoc Point). In addition to shortening travel times to both the Williamson and Wood rivers, such a strategy would allow fish to start their movements through UKL from a location where DOs are adequate regardless of possible sags in the deeper portions of the lake.

Significance to Fishery Management

Under present conditions, the thermal effects of the KHP have placed much of the Klamath River closer to the ecological edge in terms of its ability to support anadromous salmonids, a conclusion supported by the present paper as well as by Bartholow et al. (2005) and NRC (2004). Bartholow (2005) analyzed meteorological data and simulated water temperatures in the Klamath River, and concluded that water temperatures in the Klamath have been increasing about 0.5°C /decade since the early 1960s. Nevertheless, KRWQM results indicate that, in the absence of the lower four KHP dams, the Klamath River is likely still capable of providing thermal conditions for anadromous salmonids that would be similar to those prevailing in 1926, when anadromous fisheries were in much better condition than today.

In their simulations of the effects of KHP removal, Bartholow et al. (2005) reported clear benefits of removal to the migratory adult, spawning, and embryo incubation life stages of chinook, but also reported potential detriments to juveniles. While we also have reported some detriments to juveniles that may be associated with dam removals, on the whole it appears to us that the net effect of dam removals on habitat for juvenile salmonids may be neutral or positive. Additional modeling of the effects of removal on juvenile salmonids rearing in the lower river, including their times of emergence and growth, is clearly warranted to help resolve this issue.

We see several explanations for the apparent contradiction between our findings regarding KHP effects on juvenile salmonid habitat and those of Bartholow et al. (2005). First, Bartholow et al. (2005) focused their conclusions upon the river downstream of Iron Gate Dam, whereas we looked in detail at the system downstream from Keno Dam. Second, we used more complex metrics to define thermal conditions that better captured the thermal variability of the system, and its likely impact on anadromous fish. Third, we explicitly considered ramifications of changes in minimum daily temperatures, the importance of which was emphasized by NRC (2004). Fourth, we believe that the degree-day metric in Bartholow et al. (2005) is somewhat unrealistic in its assessment of likely impacts to juveniles, in that it assumes juveniles to be occupying the river regardless of temperature.

We believe that when river temperature exceeds a threshold that triggers or forces movements into thermal refugia, a better measure of suitability is the extent to which thermal refugia could be used effectively (the extent to which minimum daily temperatures allow forays away from the refugia to feed, get relief from high densities, etc.). Viewed in this manner, one can conclude that a condition forcing juveniles into refugia for fewer days with little or no opportunity for relief proffered by low temperature minima could be worse for the fish than a condition in which fish require refugia for more days but experience a cycle of diel relief. In support of this notion, we point out that higher daily maxima are a natural result of the increased responsiveness to meteorological conditions, and that the Without Dams simulation in Bartholow et al. (2005) more closely simulates the pre-KHP thermal regime, with its attendant high summertime maxima, under which anadromous salmonids once thrived.

Though we do not conclude that dam removal is uniformly beneficial to juvenile salmonids, neither is it uniformly detrimental. Rather, our analyses lead us to expect a complex spatial and temporal response to dam removal that varies according to reach characteristics and the local effects of the KHP. Taken as a whole, our analyses suggest a possible net benefit of dam removal to juvenile chinook and steelhead. However, given the potential importance of rapid growth to the survival and rearing success of juvenile salmon in the mainstem Klamath, and the effect that a shifting thermal regime could have on fish emergence timing and subsequent growth, we believe it would be productive and important to model how the three KHP configurations studied here would influence the growth rates of these fish.

Finally, our results disagree with those of Bartholow et al. (2005) in terms of their thermal exposure metric, which quantified the duration of conditions above maximum recommended temperature for juveniles. We have shown a net reduction in duration of highly stressful conditions, as well as in the frequency of the need for thermal refugia, in most of the river reaches outside of the Boyle Bypass Reach and at the dams.

The KHP-caused temporal shift and spatial and temporal homogenization of the thermal regime are biologically significant to anadromous salmonids in the Klamath River. Benefits associated with modest delays in spring-time cooling are small compared to long delays in fall cooling during upstream migrations and spawning. Loss of spatial and temporal variability reduces distributional opportunities for juveniles, but also likely affects adult run timing.

Periods of cooler weather that would open usable migratory corridors under dam removal scenarios do not have the same effect under EC. Such corridors could allow for iterative upstream migration in which adults swim up a corridor until prevented from continuing by a temporary warm spell. These fish would then be forced to occupy thermal refugia until cooler conditions returned and they could resume their migration. Fish following such a strategy would be moving upstream on the leading edge of tolerable conditions, would likely experience considerable thermal stress, and would be more likely than later-migrating fish to experience pre-spawn mortality or reduced egg viability. Nevertheless, the presence of a segment of a population pushing the envelope in this manner is an important adaptive component of a population in a system like the Klamath, because these fish will be poised to take full advantage of years like 2002 when conditions allow for early migration. The diversity in run timing that would result is an adaptive element that is likely to be selected against under present conditions, because fish attempting to follow such a strategy encounter adverse conditions. At present, effects of the KHP minimize the ability of fish to follow such a migration pattern.

The KHP dams (reservoirs) have also helped create a situation in which the early component of the Klamath summer-fall chinook run, which once found progressively more favorable temperature conditions as it migrated up the mainstem Klamath above the Trinity River, no longer finds such conditions. Instead, fish encounter increasingly adverse conditions as they attempt to migrate upstream in the late summer. Relatively few summer-fall chinook now migrate up the Klamath River in August and the run appears even to be delayed in early September of some years. Migrations at this time of year appear to have once accounted for a large portion of the run up the mainstem Klamath River (Snyder 1931), and still do in the nearby Rogue River (ODFW 1992).

The KHP exerts a profound effect on anadromous salmonid fisheries in the Klamath; it isolated all runs from the Upper Basin, appears to have altered the migration timing of fall-run fish, increased the duration and extent of Severely Stressful thermal conditions for adult and juvenile salmon and steelhead, and has likely decreased the ability of juveniles to use thermal refugia as effectively as might otherwise be possible. Results of two independent water quality modeling efforts indicate that removal of most or all of the mainstem KHP dams would significantly improve conditions for migration and spawning of adult fall chinook, and the KRWQM predicts that there may be neutral to positive effects on the habitats used by juvenile chinook and steelhead as well. Returning the Klamath to a thermal regime more similar to that measured by Snyder in 1926 may be the single most effective measure that could be taken to improve conditions for anadromous salmonids in the Klamath River. Improvements in the thermal regime that could be gained through dam removal would facilitate efforts to reintroduce anadromous fish within and above the KHP. Furthermore, fishery benefits derived from habitat restoration efforts in the tributaries would almost certainly be enhanced by an improved thermal regime in the Klamath mainstem.

Dam removal would provide clear and at times dramatic thermal benefits to migratory salmonids now in, or reintroduced to, the Upper Klamath Basin. A similarly strong benefit would accrue to chinook salmon adults and eggs in the lower river, but the effect on juveniles of this species in the lower river, and thus lower river salmon runs as a whole, should be explored further. Our analysis suggests that dam removal may provide thermal benefits to juvenile chinook downstream of Iron Gate Dam, but Bartholow et al. (2005) concluded the opposite. This causes us to (1) agree with Bartholow et al. (2005) that it is not clear whether chinook production in the lower mainstem would be increased, decreased, or remain the same, and (2) urge additional analysis of this situation at the earliest opportunity

Personal Communications

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Table 1. Summary of Klamath Hydroelectric Project dams and reservoirs. Source: PacifiCorp (2000).

Dam	River kilometer	Year completed	Dam height (m)	Reservoir length (km)	Maximum surface area (ha)	Mean water retention time for spring (April-May) flows during 20^{th}-80^{th} percentile water years
Link River	409	1921	4.6	---	36,422	---
Keno	371	1931 (replaced in 1967)	7.6	36.2	1,002	3.2-11.3 days
J.C. Boyle	362	1958	20.7	5.8	170	0.6-1.6 days
Copco 1	320	1918	38.4	7.2	405	7.3-20.8 days
Copco 2	319	1925	10.1	0.5	16	negligible
Iron Gate	306	1962	52.7	10.9	382	7.4-23.0 days

Table 2. Sites from which KRWQM outputs were used to support analyses. Reach designations apply to the groups of sites indicated.

Reach Designation	Site	River mile	River Kilometer
	Link River below Link Dam	253.88	408.5
	Link River at Keno Reservoir	252.67	406.5
Keno Reservoir	Keno Reservoir	248.00	399.0
	Keno Reservoir	243.00	391.0
	Keno Reservoir	238.00	382.9
Keno Reach	Keno Dam outflow	232.86	374.7
	Klamath River above JC Boyle Reservoir	227.57	366.2
	JC Boyle Reservoir outflow	224.32	360.9
Boyle Bypass Reach	Klamath River Bypass above powerhouse	220.20	354.3
Boyle Peaking Reach	Klamath River below powerhouse	219.40	353.0
	Klamath River at Stateline	209.16	336.5
	Klamath River above Copco	203.61	327.6
Iron Gate Reach	Copco Dam outflow	198.57	319.5
	Iron Gate Dam outflow	190.54	306.6
	Klamath River above Shasta River	177.52	285.6
Scott River Reach	Klamath River at Walker Bridge	156.79	252.3
	Klamath River above Scott River	143.86	231.5
	Klamath River at Seiad Valley	129.04	207.6
	Klamath River above Clear Creek	99.04	159.4
	Klamath River above Salmon River	66.91	107.7
	Klamath River at Orleans	57.58	92.6
	Klamath River above Bluff Creek	49.21	78.9
	Klamath River above Trinity River	43.52	69.7
	Klamath River at Martins Ferry	39.47	63.5
	Klamath River at Blue Creek	15.95	25.7
	Klamath River at Turwar	5.28	8.5

Table 3. Criteria for water temperature and dissolved oxygen concentration used to classify levels of stress for anadromous salmonids. Thresholds are averages of daily minima (7d-min), mean (7d-avg), or maxima (7d-max), calculated for the previous seven days.

			Upper threshold				Intermediate threshold				Lower threshold			
Constituent	Life stage	Condition	7d-min	7d-avg	7d-max	Condition	7d-min	7d-avg	7d-max	Condition	7d-min	7d-avg	7d-max	Condition
Water temperature (°C)	Adult migration (through July 31)	Optimal (OPT)[1]		16	18	Suboptimal (SUB)[2]		18	20	Stressful (STR)[3]		<2 or >20	21	Severely Stressful - refugial areas critical (SEV)[4]
	Adult migration (from Aug 1)			16	18			19	20			<2 or >21	22	
	Chinook juvenile rearing			15	16			18	21			21	23	
	Steelhead juvenile rearing			16	18			19	22			22	24	
Dissolved oxygen (mg/L)	All life stages		6	8			5.5				5			

[1] Optimal - conditions placing very little or no constraint on the life stage.
[2] Suboptimal - conditions that are mildly to moderately stressful unless there are significant ameliorating factors (e.g. presence of a highly abundant food supply for juvenile fish).
[3] Stressful - conditions that are moderately to severely stressful. Temperature becomes an increasingly critical factor affecting fish distribution, abundance, growth, and/or survival. Thermal refugia and/or ameliorating conditions are important under these conditions.
[4] Severely stressful - conditions under which fish survival is jeopardized to the extent that the ability to find spatial and/or temporal refuge is likely to be essential to fish presence. Fish migrations may be blocked, or fish may well be elsewhere, under these conditions.

Table 4. Average percentage of days within thermal condition categories for adult anadromous salmonids by two week period under various KHP configurations. For each scenario and site, entries are the average (across all sites in the reach) number of days falling within stress categories in each two week period over 2000-2004 (total of 70 days per period), converted to a percentage. Thermal stress categories are: OPT (optimal), SUB (suboptimal), STR (stressful), and SEV (severely stressful). Reach designations are described in Table 1. Project configurations are: EC = existing condition; No IG-COP-JCB = Iron Gate, and Copco 1 and 2, and JC Boyle dams removed; WOP = Iron Gate, and Copco 1 and 2, JC Boyle, and Keno dams removed.

Biweekly Period	Scenario	Keno Reach				Boyle Bypass Reach				Boyle Peaking Reach				Iron Gate Reach				Scott River Reach			
		OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV
Apr 23 - May 6	EC	87	13			100				85	15			100				100			
	No IG-COP-JCB	82	18			87	13			87	13			97	3			100			
	WOP	90	10			89	11			85	15			95	5			99	1		
May 7 - 20	EC	52	48			90	10			50	51			88	12			93	7		
	No IG-COP-JCB	44	56			49	51			35	65			68	32			81	17	2	
	WOP	71	30			66	34			60	41			75	25			84	13	3	
May 21 - Jun 3	EC	3	54	32	11	36	64			8	62	30		47	42	11		42	39	14	5
	No IG-COP-JCB	1	55	34	11		77	23			69	31		20	40	32	9	23	40	21	16
	WOP	10	51	38	1	7	76	17		2	74	24		27	37	26	10	31	32	21	16
Jun 4 - 17	EC		1	77	23		100				48	39	13	8	40	47	6	1	56	41	3
	No IG-COP-JCB		1	72	27		60	33	7		58	30	12	2	61	21	17	2	51	38	10
	WOP		62	35	3		77	23			78	22		9	64	19	8	4	63	25	8
Jun 18 - Jul 1	EC			36	64		100				21	50	30		12	56	32			42	58
	No IG-COP-JCB			29	71		33	51	16		21	51	28		14	42	44		4	42	54
	WOP		29	30	41		51	40	9		42	43	15		27	41	32		6	51	43
Jul 2 - 15	EC			11	89		100				5	35	60			31	69				100
	No IG-COP-JCB			6	94		9	67	24		3	44	53			24	76			1	99
	WOP		1	12	87		16	56	29		11	63	26		2	29	70			3	97
Jul 16 - 29	EC			1	100		100				1	26	73			3	97				100
	No IG-COP-JCB				100		9	57	34		3	33	64			14	86			1	99
	WOP			10	91		19	43	39		7	48	45			13	87			3	97
Jul 30 - Aug 12	EC			1	99		100				6	35	59			7	93			4	96
	No IG-COP-JCB				100		26	40	34		11	39	50		4	32	63		2	12	86
	WOP		1	24	74		20	56	24		14	55	31		7	34	59		3	18	79
Aug 13- 26	EC			3	97		100				8	46	47			10	91			2	98
	No IG-COP-JCB				100		27	67	6		11	71	18		1	59	39			18	82
	WOP		2	30	68		30	60	10		23	71	6		7	63	31		1	25	74
Aug 27 - Sep 9	EC		4	37	59	6	94				36	49	16			35	65		7	24	68
	No IG-COP-JCB		4	20	76		60	40			44	56		5	31	52	12		23	30	47
	WOP		34	51	15		81	19			64	36		7	36	48	10	1	27	29	43
Sep 10- 23	EC		41	59		27	73			1	96	4			6	76	19		21	59	21
	No IG-COP-JCB		36	60	4		100			1	97	1		16	71	12		8	56	27	9
	WOP	7	72	21		10	90			8	92			24	62	14		12	53	23	11
Sep 24 - Oct 7	EC	3	94	3		84	16			16	84				63	36	0.3	7	56	37	0.3
	No IG-COP-JCB	1	91	8		9	91			11	89			38	62			17	70	13	
	WOP	16	84			30	70			28	72			45	56			21	72	8	
Oct 8-21	EC	71	30			100				83	17			35	64	1		67	32	1	
	No IG-COP-JCB	62	38	1		89	11			85	15			93	7			86	13	0.3	
	WOP	89	11			94	6			94	6			96	4			88	11	0.3	
Oct 22 - Nov 4	EC	100				100				100				100				100			
	No IG-COP-JCB	100				100				100				100				100			
	WOP	100				100				100				100				100			

Table 5. Change in frequency of thermal conditions from Existing Conditions (EC) for adult anadromous salmonids expressed as the difference (Scenario minus EC from Table 3) in the percentage of days (out of 70 days total 2000-2004 for each period) within thermal condition categories by two week period under various KHP configurations. Italics are EC percentages from Table 3, other entries are scenario change from these EC percentages. Negative numbers denote decreased frequency within a condition category from EC; positive numbers denote increased frequency. Thermal stress categories are: OPT (optimal), SUB (suboptimal), STR (stressful), and SEV (severely stressful). Reach designations are described in Table 1. Project configurations are: EC = existing condition; No IG-COP-JCB = Iron Gate, and Copco 1 and 2, and JC Boyle dams removed; WOP = Iron Gate, and Copco 1 and 2, JC Boyle, and Keno dams removed.

Biweekly Period	Scenario	Keno Reach				Boyle Bypass Reach				Boyle Peaking Reach				Iron Gate Reach				Scott River Reach			
		OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV
Apr 23 - May 6	EC	*87*	*13*			*100*				*85*	*15*			*100*				*100*			
	No IG-COP-JCB	-5	5			-13	13			2	-2			-3	3						
	WOP	3	-3			-11	11							-5	5			-1	1		
May 7 - 20	EC	*52*	*48*			*90*	*10*			*50*	*51*			*88*	*12*			*93*	*7*		
	No IG-COP-JCB	-9	9			-41	41			-15	15			-20	20			-12	10	2	
	WOP	18	-18			-24	24			10	-10			-12	12			-10	7	3	
May 21 - Jun 3	EC	*3*	*54*	*32*	*11*	*36*	*64*			*8*	*62*	*30*		*47*	*42*	*11*		*42*	*39*	*14*	*5*
	No IG-COP-JCB	-2	1	1		-36	13	23		-8	6	1		-28	-3	22	9	-19	1	7	11
	WOP	7	-3	6	-9	-29	11	17		-6	11	-6		-20	-5	16	10	-11	-7	7	11
Jun 4 - 17	EC		*1*	*77*	*23*		*100*				*48*	*39*	*13*	*8*	*40*	*47*	*6*	*1*	*56*	*41*	*3*
	No IG-COP-JCB		1	-5	4		-40	33	7		10	-9	-1	-6	21	-26	11	1	-5	-3	7
	WOP		62	-42	-20		-23	23			30	-17	-13	1	25	-28	1	4	7	-16	5
Jun 18 - Jul 1	EC			*36*	*64*		*100*				*21*	*50*	*30*		*12*	*56*	*32*			*42*	*58*
	No IG-COP-JCB			-7	7		-67	51	16			2	-2		2	-14	12		4		-4
	WOP		29	-7	-22		-49	40	9		21	-7	-15		15	-14	-1		6	9	-15
Jul 2 - 15	EC			*11*	*89*		*100*				*5*	*35*	*60*			*31*	*69*				*100*
	No IG-COP-JCB			-5	5		-91	67	24		-2	9	-7			-7	7			1	-1
	WOP		1	1	-2		-84	56	29		6	28	-34		2	-3	1			3	-3
Jul 16 - 29	EC			*1*	*100*		*100*				*1*	*26*	*73*			*3*	*97*				*100*
	No IG-COP-JCB			-1	1		-91	57	34		2	7	-9			11	-11			1	-1
	WOP			9	-9		-81	43	39		7	21	-28			10	-10			3	-3
Jul 30 - Aug 12	EC			*1*	*99*		*100*				*6*	*35*	*59*			*7*	*93*			*4*	*96*
	No IG-COP-JCB			-1	1		-74	40	34		6	4	-10		4	25	-30		2	8	-10
	WOP		1	23	-25		-80	56	24		8	20	-28		7	27	-35		3	15	-18
Aug 13- 26	EC			*3*	*97*		*100*				*8*	*46*	*47*			*10*	*91*			*2*	*98*
	No IG-COP-JCB			-3	3		-73	67	6		3	25	-29		1	50	-52			16	-16
	WOP		2	27	-29		-70	60	10		15	25	-41		7	53	-60		1	22	-23
Aug 27 - Sep 9	EC		*4*	*37*	*59*	*6*	*94*				*36*	*49*	*16*			*35*	*65*		*7*	*24*	*68*
	No IG-COP-JCB		1	-18	17	-6	-34	40			9	7	-16	5	31	17	-52		16	5	-21
	WOP		30	14	-44	-6	-13	19			29	-13	-16	7	36	13	-55	1	20	4	-26
Sep 10- 23	EC		*41*	*59*		*27*	*73*			*1*	*96*	*4*			*6*	*76*	*19*		*21*	*59*	*21*
	No IG-COP-JCB		-5	1	4	-27	27			1	1	-2		16	66	-63	-19	8	36	-32	-12
	WOP	7	31	-38		-17	17			8	-4	-4		24	57	-62	-19	12	32	-36	-9
Sep 24 - Oct 7	EC	*3*	*94*	*3*		*84*	*16*			*16*	*84*				*63*	*36*	*0.3*	*7*	*56*	*37*	*0.3*
	No IG-COP-JCB	-2	-3	5		-76	76			-5	5			38	-2	-36	-0.3	10	15	-24	-0.3
	WOP	13	-10	-3		-54	54			11	-11			45	-8	-36	-0.3	13	16	-29	-0.3
Oct 8-21	EC	*71*	*30*			*100*				*83*	*17*			*35*	*64*	*1*		*67*	*32*	*0.7*	
	No IG-COP-JCB	-9	8	1		-11	11			2	-2			58	-57	-1		19	-19	-0.4	
	WOP	18	-18			-6	6			11	-11			61	-60	-1		21	-20	-0.4	
Oct 22 - Nov 4	EC	*100*				*100*				*100*				*100*				*100*			
	No IG-COP-JCB																				
	WOP																				

Table 6. Average percentage of days within thermal condition categories for juvenile chinook by two week period under various KHP configurations. For each scenario and site, entries are the average (across all sites in the reach) number of days falling within stress categories in each two week period over 2000-2004 (total of 70 days per period), converted to a percentage. Thermal stress categories are: OPT (optimal), SUB (suboptimal), STR (stressful), and SEV (severely stressful). Reach designations are described in Table 1. Project configurations are: EC = existing condition; No IG-COP-JCB = Iron Gate, and Copco 1 and 2, and JC Boyle dams removed; WOP = Iron Gate, and Copco 1 and 2, JC Boyle, and Keno dams removed.

Biweekly Period	Scenario	Keno Reach				Boyle Bypass Reach				Boyle Peaking Reach				Iron Gate Reach				Scott River Reach			
		OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV
Apr 23 - May 6	EC	87	13			100				85	15			100				99	1		
	No IG-COP-JCB	82	18			87	13			87	13			92	8			91	10		
	WOP	90	10			89	11			85	15			88	12			89	11		
May 7 - 20	EC	52	48			90	10			50	51			69	31			66	34		
	No IG-COP-JCB	44	56			49	51			35	65			40	60			56	42	2	
	WOP	71	30			66	34			60	41			58	42			61	36	3	
May 21 - Jun 3	EC	3	54	32	11	36	64			8	62	30		30	63	7		13	68	19	
	No IG-COP-JCB	1	55	34	11		77	23			69	31		1	58	41		5	58	35	2
	WOP	10	51	38	1	7	76	17		2	74	24		8	57	36		9	55	33	3
Jun 4 - 17	EC		1	77	23		100				48	39	13		51	49			57	43	
	No IG-COP-JCB		1	72	27		60	33	7		58	30	12		62	32	6		52	44	3
	WOP		62	35	3		77	23			78	22			73	27			67	32	1
Jun 18 - Jul 1	EC			36	64		100				21	50	30		13	79	8			86	14
	No IG-COP-JCB			29	71		33	51	16		21	51	28		14	63	23		4	75	21
	WOP		29	30	41		51	40	9		42	43	15		28	50	22		6	73	21
Jul 2 - 15	EC			11	89		100				5	35	60			48	52			38	62
	No IG-COP-JCB			6	94		9	67	24		3	44	53		1	67	33			51	49
	WOP		1	12	87		16	56	29		11	63	26		2	63	35			51	50
Jul 16 - 29	EC			1	100		100				1	26	73			22	78			4	96
	No IG-COP-JCB				100		9	57	34		3	33	64		1	33	66			11	89
	WOP			10	91		19	43	39		7	48	45			30	71			13	87
Jul 30 - Aug 12	EC			1	99		100				6	35	59			10	90			10	90
	No IG-COP-JCB				100		26	40	34		11	39	50		5	42	53			25	75
	WOP		1	24	74		20	56	24		14	55	31		5	42	52			26	74
Aug 13- 26	EC			3	97		100				8	46	47			10	91			9	91
	No IG-COP-JCB				100		27	67	6		11	71	18			78	22			41	60
	WOP		2	30	68		30	60	10		23	71	6		3	78	19			48	52
Aug 27 - Sep 9	EC		4	37	59	6	94				36	49	16			42	58		2	44	54
	No IG-COP-JCB		4	20	76		60	40			44	56			33	63	4		17	46	37
	WOP		34	51	15		81	19			64	36			40	57	3		18	47	35
Sep 10- 23	EC		41	59		27	73			1	96	4			3	90	7		11	82	6
	No IG-COP-JCB		36	60	4		100			1	97	1		5	80	15		2	49	49	1
	WOP	7	72	21		10	90			8	92			9	77	14		4	53	41	1
Sep 24 - Oct 7	EC	3	94	3		84	16			16	84				48	52			41	59	
	No IG-COP-JCB	1	91	8		9	91			11	89			14	86			11	62	27	
	WOP	16	84			30	70			28	72			19	81			14	64	22	
Oct 8-21	EC	71	30			100				83	17			11	88	1		21	77	2	
	No IG-COP-JCB	62	38	1		89	11			85	15			85	15			75	24	1	
	WOP	89	11			94	6			94	6			91	10			79	21	1	
Oct 22 - Nov 4	EC	100				100				100				90	11			92	8		
	No IG-COP-JCB	100				100				100				100				100			
	WOP	100				100				100				100				100			

Table 7. Change in frequency of thermal conditions from Existing Conditions (EC) for juvenile chinook expressed as the difference (Scenario minus EC from Table 3) in the percentage of days (out of 70 days total 2000-2004 for each period) within thermal condition categories by two week period under various KHP configurations. Italics are EC percentages from Table 3, other entries are scenario change from these EC percentages. Negative numbers denote decreased frequency within a condition category from EC; positive numbers denote increased frequency. Thermal stress categories are: OPT (optimal), SUB (suboptimal), STR (stressful), and SEV (severely stressful). Reach designations are described in Table 1. Project configurations are: EC = existing condition; No IG-COP-JCB = Iron Gate, and Copco 1 and 2, and JC Boyle dams removed; WOP = Iron Gate, and Copco 1 and 2, JC Boyle, and Keno dams removed.

Biweekly Period	Scenario	Keno Reach				Boyle Bypass Reach				Boyle Peaking Reach				Iron Gate Reach				Scott River Reach			
		OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV
Apr 23 - May 6	EC	87	13			100				85	15			100				99	1		
	No IG-COP-JCB	*-5*	*5*			*-13*	*13*			*2*	*-2*			*-8*	*8*			*-9*	*9*		
	WOP	3	-3			-11	11							-12	12			-10	10		
May 7 - 20	EC	*52*	*48*			*90*	*10*			*50*	*51*			*69*	*31*			*66*	*34*		
	No IG-COP-JCB	-9	9			-41	41			-15	15			-29	29			-10	8	2	
	WOP	18	-18			-24	24			10	-10			-11	11			-5	2	3	
May 21 - Jun 3	EC	*3*	*54*	*32*	*11*	*36*	*64*			*8*	*62*	*30*		*30*	*63*	*7*		*13*	*68*	*19*	
	No IG-COP-JCB	-2	1	1		-36	13	23		-8	6	1		-29	-5	34		-9	-9	16	2
	WOP	7	-3	6	-9	-29	11	17		-6	11	-6		-22	-7	29		-5	-13	14	3
Jun 4 - 17	EC		*1*	*77*	*23*		*100*				*48*	*39*	*13*		*51*	*49*			*57*	*43*	
	No IG-COP-JCB		1	-5	4		-40	33	7		10	-9	-1		11	-17	6		-5	1	3
	WOP		62	-42	-20		-23	23			30	-17	-13		22	-22			10	-11	1
Jun 18 - Jul 1	EC			*36*	*64*		*100*				*21*	*50*	*30*		*13*	*79*	*8*			*86*	*14*
	No IG-COP-JCB			-7	7		-67	51	16			2	-2		1	-16	15		4	-11	7
	WOP		29	-7	-22		-49	40	9		21	-7	-15		15	-29	14		6	-12	6
Jul 2 - 15	EC			*11*	*89*		*100*				*5*	*35*	*60*			*48*	*52*			*38*	*62*
	No IG-COP-JCB			-5	5		-91	67	24		-2	9	-7		1	19	-20			13	-13
	WOP		1	1	-2		-84	56	29		6	28	-34		2	15	-17			13	-13
Jul 16 - 29	EC			*1*	*100*		*100*				*1*	*26*	*73*			*22*	*78*			*4*	*96*
	No IG-COP-JCB			-1	1		-91	57	34		2	7	-9		1	11	-12			7	-7
	WOP			9	-9		-81	43	39		7	21	-28			7	-7			9	-9
Jul 30 - Aug 12	EC			*1*	*99*		*100*				*6*	*35*	*59*			*10*	*90*			*10*	*90*
	No IG-COP-JCB			-1	1		-74	40	34		6	4	-10		5	32	-37			15	-15
	WOP		1	23	-25		-80	56	24		8	20	-28		5	32	-38			16	-16
Aug 13-26	EC			*3*	*97*		*100*				*8*	*46*	*47*			*10*	*91*			*9*	*91*
	No IG-COP-JCB			-3	3		-73	67	6		3	25	-29			68	-68			32	-32
	WOP		2	27	-29		-70	60	10		15	25	-41		3	68	-72			39	-39
Aug 27 - Sep 9	EC		*4*	*37*	*59*	*6*	*94*				*36*	*49*	*16*			*42*	*58*		*2*	*44*	*54*
	No IG-COP-JCB		1	-18	17	-6	-34	40			9	7	-16		33	21	-54		15	2	-17
	WOP		30	14	-44	-6	-13	19			29	-13	-16		40	15	-55		16	3	-19
Sep 10-23	EC		*41*	*59*		*27*	*73*			*1*	*96*	*4*			*3*	*90*	*7*		*11*	*82*	*6*
	No IG-COP-JCB		-5	1	4	-27	27			1	1	-2		5	77	-75	-7	2	38	-34	-6
	WOP	7	31	-38		-17	17			8	-4	-4		9	74	-76	-7	4	42	-41	-5
Sep 24 - Oct 7	EC	*3*	*94*	*3*		*84*	*16*			*16*	*84*				*48*	*52*			*41*	*59*	
	No IG-COP-JCB	-2	-3	5		-76	76			-5	5			14	38	-52		11	21	-32	
	WOP	13	-10	-3		-54	54			11	-11			19	33	-52		14	23	-37	
Oct 8-21	EC	*71*	*30*			*100*				*83*	*17*			*11*	*88*	*1*		*21*	*77*	*2*	
	No IG-COP-JCB	-9	8	1		-11	11			2	-2			73	-73	-1		54	-53	-1	
	WOP	18	-18			-6	6			11	-11			79	-79	-1		58	-56	-1	
Oct 22 - Nov 4	EC	*100*				*100*				*100*				*90*	*11*			*92*	*8*		
	No IG-COP-JCB													11	-11			8	-8		
	WOP													11	-11			8	-8		

Table 8. Average percentage of days within thermal condition categories for juvenile steelhead by two week period under various KHP configurations. For each scenario and site, entries are the average (across all sites in the reach) number of days falling within stress categories in each two week period over 2000-2004 (total of 70 days per period), converted to a percentage. Thermal stress categories are: OPT (optimal), SUB (suboptimal), STR (stressful), and SEV (severely stressful). Reach designations are described in Table 1. Project configurations are: EC = existing condition; No IG-COP-JCB = Iron Gate, and Copco 1 and 2, and JC Boyle dams removed; WOP = Iron Gate, and Copco 1 and 2, JC Boyle, and Keno dams removed.

Biweekly Period	Scenario	Keno Reach				Boyle Bypass Reach				Boyle Peaking Reach				Iron Gate Reach				Scott River Reach			
		OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV
Apr 23 - May 6	EC	98	2			100				98	2			100				100			
	No IG-COP-JCB	97	3			99	1			99	1			100	1			100			
	WOP	99	1			100				100	1			100				99	1		
May 7 - 20	EC	77	23			100				81	19			98	2			93	7		
	No IG-COP-JCB	74	26			81	19			81	19			85	15			81	19		
	WOP	86	14			99	1			94	6			88	12			84	16		
May 21 - Jun 3	EC	26	45	28	1	100				29	53	18		59	40	2		42	50	8	
	No IG-COP-JCB	16	53	29	1	29	56	16		20	62	18		27	49	24		23	50	27	
	WOP	29	51	21		43	51	6		39	51	11		39	37	24		31	41	28	
Jun 4 - 17	EC		27	58	16	83	17			1	73	16	10	8	83	10		1	89	11	
	No IG-COP-JCB		27	55	18		76	24			78	22		2	76	22		2	83	15	
	WOP	9	67	23	1	29	56	16		24	58	19		16	64	21		4	81	14	
Jun 18 - Jul 1	EC		5	57	38	63	37				45	41	15		43	55	2		21	73	5
	No IG-COP-JCB		4	41	55		67	33			54	31	14		40	51	10		26	64	10
	WOP	1	40	31	27	6	70	20	4	3	61	34	2		51	40	10		31	59	10
Jul 2 - 15	EC			18	82	21	79				11	47	42		5	79	16			70	31
	No IG-COP-JCB			11	89		39	60	1		23	67	10		10	79	11			72	28
	WOP		6	22	72		26	66	9		20	74	6		10	79	11			72	28
Jul 16 - 29	EC			6	94	11	89				12	40	49			52	48			21	80
	No IG-COP-JCB			1	99		20	69	11		11	58	32		6	58	36			30	71
	WOP		3	15	81		31	34	34		21	47	32		7	56	37			30	71
Jul 30 - Aug 12	EC			7	93	27	73				18	43	39			35	65			26	74
	No IG-COP-JCB			2	98		43	49	9		29	42	30		16	50	34		4	36	61
	WOP		14	21	65		41	49	10		36	49	15		21	47	31		6	37	58
Aug 13-26	EC			24	76	53	47				22	64	14			43	57			44	56
	No IG-COP-JCB			11	89		66	34			40	59	2		16	79	6			74	26
	WOP		11	43	47		56	44			46	54			23	73	4		2	74	24
Aug 27 - Sep 9	EC		7	81	12	99	1			3	58	39			1	82	18		12	59	29
	No IG-COP-JCB		7	55	38	6	94			5	72	23		7	44	49			29	60	11
	WOP	2	54	43	1	14	81	4		15	71	14		11	50	39		1	32	57	10
Sep 10-23	EC	2	73	25		100				26	74				25	75			40	60	
	No IG-COP-JCB		67	33		31	69			23	77			22	76	2		8	62	30	
	WOP	25	75			53	47			51	49			33	63	3		12	57	31	
Sep 24 - Oct 7	EC	28	71	1		100				71	29				90	11		7	68	25	
	No IG-COP-JCB	17	82	1		79	21			64	36			52	48			17	79	4	
	WOP	43	57			87	13			83	17			60	40			21	76	4	
Oct 8-21	EC	92	8			100				99	1			46	54			67	33		
	No IG-COP-JCB	85	15			100				100	1			98	2			86	14		
	WOP	98	2			100				100				98	2			88	12		
Oct 22 - Nov 4	EC	100				100				100				100				100			
	No IG-COP-JCB	100				100				100				100				100			
	WOP	100				100				100				100				100			

Table 9. Change in frequency of thermal conditions from Existing Conditions (EC) for juvenile steelhead expressed as the difference (Scenario minus EC from Table 3) in the percentage of days (out of 70 days total 2000-2004 for each period) within thermal condition categories by two week period under various KHP configurations. Italics are EC percentages from Table 3, other entries are scenario change from these EC percentages. Negative numbers denote decreased frequency within a condition category from EC; positive numbers denote increased frequency. Thermal stress categories are: OPT (optimal), SUB (suboptimal), STR (stressful), and SEV (severely stressful). Reach designations are described in Table 1. Project configurations are: EC = existing condition; No IG-COP-JCB = Iron Gate, and Copco 1 and 2, and JC Boyle dams removed; WOP = Iron Gate, and Copco 1 and 2, JC Boyle, and Keno dams removed.

Biweekly Period	Scenario	Keno Reach				Boyle Bypass Reach				Boyle Peaking Reach				Iron Gate Reach				Scott River Reach			
		OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV
Apr 23 - May 6	EC	*98*	*2*			*100*				*98*	*2*			*100*				*100*			
	No IG-COP-JCB	-1	1			-1	1			1	-1			-1	1						
	WOP	1	-1							1	-1							-1	1		
May 7 - 20	EC	*77*	*23*			*100*				*81*	*19*			*98*	*2*			*93*	*7*		
	No IG-COP-JCB	-3	3			-19	19			0	0			-12	12			-12	12		
	WOP	9	-9			-1	1			13	-13			-10	10			-10	10		
May 21 - Jun 3	EC	*26*	*45*	*28*	*1*	*100*				*29*	*53*	*18*		*59*	*40*	*2*		*42*	*50*	*8*	
	No IG-COP-JCB	-10	9	1		-71	56	16		-9	9	-1		-32	10	22		-19		19	
	WOP	3	6	-8	-1	-57	51	6		10	-3	-8		-20	-2	22		-11	-9	20	
Jun 4 - 17	EC		*27*	*58*	*16*	*83*	*17*			*1*	*73*	*16*	*10*	*8*	*83*	*10*		*1*	*89*	*11*	
	No IG-COP-JCB			-2	2	-83	59	24		-1	4	6	-10	-6	-7	13		1	-5	4	
	WOP	9	40	-34	-14	-54	39	16		23	-16	2	-10	8	-19	11		4	-7	3	
Jun 18 - Jul 1	EC		*5*	*57*	*38*	*63*	*37*				*45*	*41*	*15*		*43*	*55*	*2*		*21*	*73*	*5*
	No IG-COP-JCB		-1	-16	17	-63	30	33			10	-9	-1		-3	-4	8		4	-9	5
	WOP	1	35	-26	-11	-57	33	20	4	3	16	-7	-12		8	-15	8		10	-14	5
Jul 2 - 15	EC			*18*	*82*	*21*	*79*				*11*	*47*	*42*		*5*	*79*	*16*			*70*	*31*
	No IG-COP-JCB			-7	7	-21	-40	60	1		12	20	-32		5		-5			2	-2
	WOP		6	4	-10	-21	-53	66	9		9	27	-36		5		-5			2	-2
Jul 16 - 29	EC			*6*	*94*	*11*	*89*				*12*	*40*	*49*			*52*	*48*			*21*	*80*
	No IG-COP-JCB			-5	5	-11	-69	69	11		-1	18	-17		6	5	-11			9	-9
	WOP		3	9	-12	-11	-57	34	34		10	7	-17		7	4	-11			9	-9
Jul 30 - Aug 12	EC			*7*	*93*	*27*	*73*				*18*	*43*	*39*			*35*	*65*			*26*	*74*
	No IG-COP-JCB			-5	5	-27	-30	49	9		11	-1	-9		16	15	-31		4	10	-14
	WOP		14	14	-28	-27	-32	49	10		18	6	-24		21	12	-34		6	11	-17
Aug 13- 26	EC			*24*	*76*	*53*	*47*				*22*	*64*	*14*			*43*	*57*			*44*	*56*
	No IG-COP-JCB			-13	13	-53	19	34			18	-6	-12		16	35	-51			30	-30
	WOP		11	19	-29	-53	9	44			24	-11	-14		23	30	-52		2	30	-31
Aug 27 - Sep 9	EC		*7*	*81*	*12*	*99*	*1*			*3*	*58*	*39*			*1*	*82*	*18*		*12*	*59*	*29*
	No IG-COP-JCB		0	-27	26	-93	93			2	14	-16		7	44	-33	-18		17	1	-18
	WOP	2	48	-39	-11	-84	80	4		12	12	-25		11	50	-43	-18	1	20	-2	-19
Sep 10- 23	EC	*2*	*73*	*25*		*100*				*26*	*74*				*25*	*75*			*40*	*60*	
	No IG-COP-JCB	-2	-7	9		-69	69			-3	3			22	51	-73		8	22	-30	
	WOP	23	2	-25		-47	47			25	-25			33	39	-72		12	17	-30	
Sep 24 - Oct 7	EC	*28*	*71*	*1*		*100*				*71*	*29*				*90*	*11*		*7*	*68*	*25*	
	No IG-COP-JCB	-11	11			-21	21			-7	7			52	-41	-11		10	11	-21	
	WOP	15	-14	-1		-13	13			12	-12			60	-50	-11		13	8	-21	
Oct 8-21	EC	*92*	*8*			*100*				*99*	*1*			*46*	*54*			*67*	*33*		
	No IG-COP-JCB	-7	7							1	-1			52	-52			19	-19		
	WOP	6	-6							1	-1			52	-52			21	-21		
Oct 22 - Nov 4	EC	*100*				*100*				*100*				*100*				*100*			
	No IG-COP-JCB																				
	WOP																				

Table 10. Frequency with which thermal refugia would be occupied, and the average daily minimum river temperature for periods when refugia would be occupied, under various KHP configurations. The threshold for thermal refugia occupancy (maximum daily temperature >22°C) is from Belchik (2003).

		Assume occupancy of thermal refugia when maximum daily temperature >22ºC								
		Number of days (2000-2004) when refugia are occupied			Average number of days per year when refugia are occupied			Average minimum daily temperature of river when refugia are occupied		
Site	River kilometer	EC	No IG-COP-JCB	WOP	EC	No IG-COP-JCB	WOP	EC	No IG-COP-JCB	WOP
Keno Dam outflow	374.7	347	347	261	69	69	52	22.7	22.7	20.0
Klamath River above JC Boyle Reservoir	366.2	450	464	360	90	93	72	19.2	19.1	18.2
JC Boyle Reservoir outflow	360.9	297	477	388	59	95	78	22.7	18.1	17.7
Klamath River Bypass above powerhouse	354.3	0	197	208	0	39	42		17.2	17.4
Klamath River below powerhouse	353.0	209	199	206	42	40	41	14.1	17.2	17.4
Klamath River at Stateline	336.5	393	310	193	79	62	39	16.3	17.2	18.3
Klamath River above Copco	327.6	363	308	219	73	62	44	18.6	18.0	18.8
Copco Dam outflow	319.5	164	288	226	33	58	45	21.8	18.6	19.2
Iron Gate Dam outflow	306.6	77	194	195	15	39	39	21.9	19.5	19.6
Klamath River above Shasta River	285.6	417	278	248	83	56	50	18.5	19.7	20.0
Klamath River at Walker Bridge	252.3	285	282	258	57	56	52	21.6	21.1	21.3
Klamath River above Scott River	231.5	380	314	292	76	63	58	19.9	20.4	20.7
Klamath River at Seiad Valley	207.6	345	313	302	69	63	60	20.3	20.3	20.4
Klamath River above Clear Creek	159.4	298	275	270	60	55	54	20.1	20.3	20.4
Klamath River above Salmon River	107.7	278	258	255	56	52	51	20.4	20.5	20.6
Klamath River at Orleans	92.6	274	261	253	55	52	51	20.7	20.7	20.8
Klamath River above Bluff Creek	78.9	263	244	231	53	49	46	20.5	20.5	20.7
Klamath River above Trinity River	69.7	263	241	225	53	48	45	20.3	20.3	20.7
Klamath River at Martins Ferry	63.5	220	209	193	44	42	39	20.6	20.7	20.9
Klamath River at Blue Creek	25.7	268	255	241	54	51	48	20.0	20.0	20.3
Klamath River at Turwar	8.5	281	268	262	56	54	52	20.1	20.1	20.3

Table 11. Summary of information available regarding upstream migration rate of fall chinook in the Klamath River.

Section of river	Year	Migration rate (km/d) Mean	Migration rate (km/d) Range	Source
Estuary to Klamathon/Iron Gate	1926	8.0	6.3-10.1	tag recoveries per Snyder (1931)
	1984	5.8	4.5-6.8	tag recoveries per Adair et al. (1985)
	1985	6.1	4.2-10.6	tag recoveries per Adair et al. (1986)
	1986	7.0	4.6-9.6	tag recoveries per Tuss et al. (1987)
	1987	4.3	---	tag recoveries per Kisanuki et al. (1991)
	1989	7.1	---	tag recoveries per Kisanuki et al. (1991)
	2003	6.0	5.2-7.2	radio telemetry per J. Strange, U. of Washington, pers comm.
	2004	7.2	4.7-9.1	radio telemetry per J. Strange, U. of Washington, pers comm.
	2005	9.1	6.9-14.1	radio telemetry per J. Strange, U. of Washington, pers comm.
Ishi Pishi Falls to Klamathon/Iron Gate	1995	11.1	7.4-13.7	radio telemetry per McIntosh and Li (1996)
Weitchpec to Klamathon/Iron Gate	2003	9.4	7.3-10.4	radio telemetry per J. Strange, U. of Washington, pers comm.
	2004	10.8	4.9-20.1	radio telemetry per J. Strange, U. of Washington, pers comm.
	2005	13.1	9.2-19.9	radio telemetry per J. Strange, U. of Washington, pers comm.

Note: Telemetry data are more resolute and allow one to identify when the fish actually begin their upriver migrating.

Table 12. Water quality in Upper Klamath Lake (UKL) and Agency Lake (AGL) during spring. Data is from the cooperative Klamath Tribes – U.S. Bureau of Reclamation water quality monitoring program. Calculations are based upon profile measurements and depth-integrated grab (ammonia) samples from 9-10 sites sampled every other week from 1990-2004.

		Entire water column						Upper 1 m of water column					
		10th percentile		median		90th percentile		10th percentile		median		90th percentile	
Parameter	Time period	UKL	AGL	UKL	AGL	UKL	AGL	UKL	AGL	UKL	AGL	UKL	AGL
Water Temperature (ºC)	April	7.3	7.9	10.0	10.7	13.0	13.0	7.4	8.0	10.3	10.8	13.6	13.6
	early May	10.7	12.5	12.9	13.9	17.0	18.7	11.1	12.8	13.2	14.3	17.2	20.1
	late May	11.4	12.5	15.9	17.5	18.8	19.3	11.7	12.8	16.3	18.2	19.1	20.3
Dissolved oxygen (mg/L)	April	8.1	8.7	9.5	9.2	10.1	9.8	8.3	8.7	9.5	9.3	10.2	9.9
	early May	7.3	7.7	8.8	8.7	9.7	9.3	7.4	7.7	8.9	8.8	9.9	9.3
	late May	7.8	8.0	8.6	9.5	9.3	10.9	7.9	8.3	8.9	9.7	9.6	11.4
Dissolved oxygen (% saturation)	April	85	92	95	96	102	100	88	93	97	97	105	103
	early May	84	90	96	98	107	106	86	93	96	99	110	108
	late May	92	99	98	110	108	133	95	102	101	112	116	145
pH	April	7.6	7.7	7.9	7.8	8.2	8.0	7.7	7.7	7.9	7.8	8.2	8.0
	early May	7.5	7.6	8.0	7.9	8.5	8.4	7.5	7.6	8.0	7.9	8.6	8.3
	late May	7.9	7.9	8.2	8.5	8.6	9.0	7.9	8.0	8.3	8.4	8.7	9.2
Un-ionized ammonia (µg/L)	April	0	0	1	2	5	11	-	-	-	-	-	-
	early May	0	0	1	1	5	6	-	-	-	-	-	-
	late May	0	0	1	1	5	8	-	-	-	-	-	-

Table 13. Water quality in Upper Klamath Lake (UKL) and Agency Lake (AGL) during fall. Data is from the cooperative Klamath Tribes – U.S. Bureau of Reclamation water quality monitoring program. Calculations are based upon profile measurements and depth-integrated grab (ammonia) samples from 9-10 sites sampled every other week from 1990-2004.

		Entire water column						Upper 1 m of water column					
		10^{th} percentile		median		90^{th} percentile		10^{th} percentile		median		90^{th} percentile	
Parameter	Time period	UKL	AGL	UKL	AGL	UKL	AGL	UKL	AGL	UKL	AGL	UKL	AGL
Water Temperature (°C)	early Aug	20.1	21.4	21.5	23.1	23.4	24.0	20.2	22.1	22.1	23.4	23.9	25.2
	late Aug	17.5	17.8	19.4	20.5	21.2	22.2	17.6	17.9	19.7	21.0	21.9	22.3
	early Sep	14.8	15.1	17.8	19.0	20.7	22.3	15.0	15.1	18.1	19.1	21.3	22.4
	late Sep	14.6	14.9	16.2	17.3	18.6	19.5	14.9	14.9	16.5	17.5	19.1	19.7
	early Oct	9.8	9.5	12.4	12.1	15.3	14.7	10.0	9.8	12.5	12.1	15.4	14.7
	late Oct	5.5	7.0	9.9	9.5	11.8	11.2	5.7	7.0	10.1	9.6	11.9	11.3
Dissolved oxygen (mg/L)	early Aug	3.2	3.5	6.6	7.0	9.5	10.8	4.0	4.1	7.3	7.0	10.8	11.9
	late Aug	5.2	5.6	8.0	8.0	10.4	11.5	6.1	5.9	8.5	8.1	11.0	12.1
	early Sep	5.6	5.3	8.5	8.7	10.6	10.8	6.5	5.3	9.2	8.7	11.8	11.1
	late Sep	4.9	6.4	8.8	9.0	11.0	13.8	5.7	6.5	9.0	9.0	11.7	13.8
	early Oct	6.0	7.8	8.6	8.9	10.9	10.3	6.1	7.8	8.8	9.1	11.4	10.3
	late Oct	6.5	8.5	8.6	9.2	11.0	10.6	6.6	8.5	8.9	9.3	11.4	10.7
Dissolved oxygen (% saturation)	early Aug	43	49	86	95	125	144	53	55	97	98	143	161
	late Aug	64	76	101	99	131	154	76	81	108	104	142	158
	early Sep	72	70	103	103	129	136	84	72	110	104	146	138
	late Sep	58	78	104	108	130	171	69	78	109	110	141	171
	early Oct	65	82	92	97	112	112	67	82	96	99	120	112
	late Oct	68	85	89	97	111	112	71	86	92	97	112	111
pH	early Aug	8.2	7.6	9.1	8.4	9.6	9.7	8.3	7.6	9.2	8.6	9.6	9.8
	late Aug	7.8	7.3	8.9	8.3	9.5	9.6	7.9	7.3	9.0	8.3	9.6	9.6
	early Sep	8.3	7.5	9.1	8.9	9.7	9.7	8.5	7.5	9.2	8.9	9.7	9.7
	late Sep	7.9	7.7	9.2	9.0	9.5	9.6	8.0	7.7	9.3	9.1	9.5	9.6
	early Oct	7.5	7.6	9.0	8.7	9.3	9.4	7.5	7.6	9.0	8.7	9.3	9.4
	late Oct	7.4	7.6	8.5	7.8	9.0	8.8	7.4	7.6	8.5	7.8	9.0	8.8
Un-ionized ammonia (μ g/L)	early Aug	2	1	30	11	222	39	-	-	-	-	-	-
	late Aug	1	0	21	6	148	93	-	-	-	-	-	-
	early Sep	8	2	57	11	240	42	-	-	-	-	-	-
	late Sep	0	1	36	8	273	44	-	-	-	-	-	-
	early Oct	0	0	32	2	164	25	-	-	-	-	-	-
	late Oct	1	0	10	2	62	15	-	-	-	-	-	-

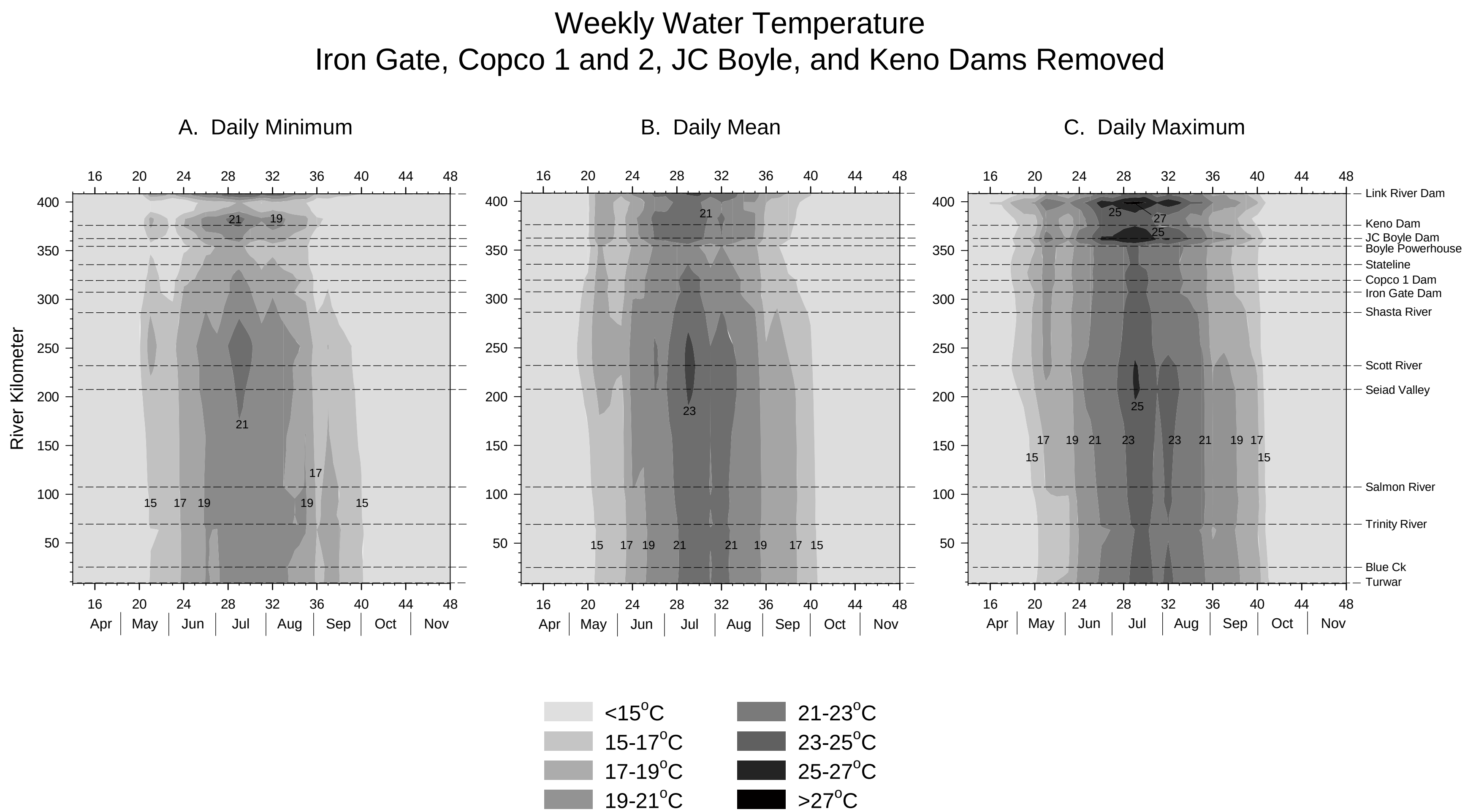

Figure 1. Water temperatures predicted by the KRWQM for the Without Project (WOP) scenario in the Klamath River. Contours are based upon daily minimum (A), mean (B), and maximum (C) temperatures calculated from hourly model outputs and averaged by week across 2000-2004 for the 26 sites listed in Table 2.

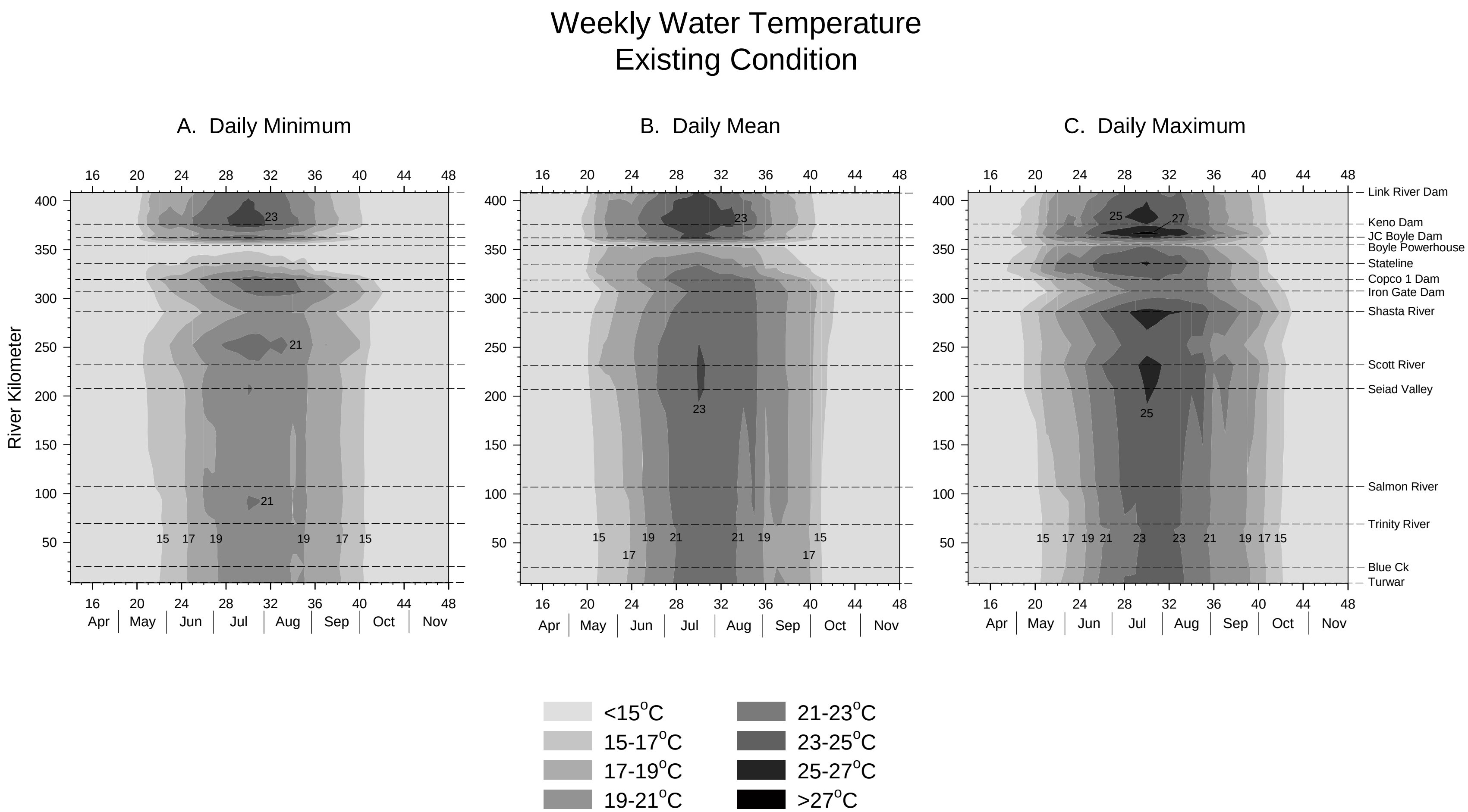

Figure 2. Water temperatures predicted by the KRWQM for the Existing Condition (EC) scenario in the Klamath River. Contours are based upon daily minimum (A), mean (B), and maximum (C) temperatures calculated from hourly model outputs and averaged by week across 2000-2004 for the 26 sites listed in Table 2.

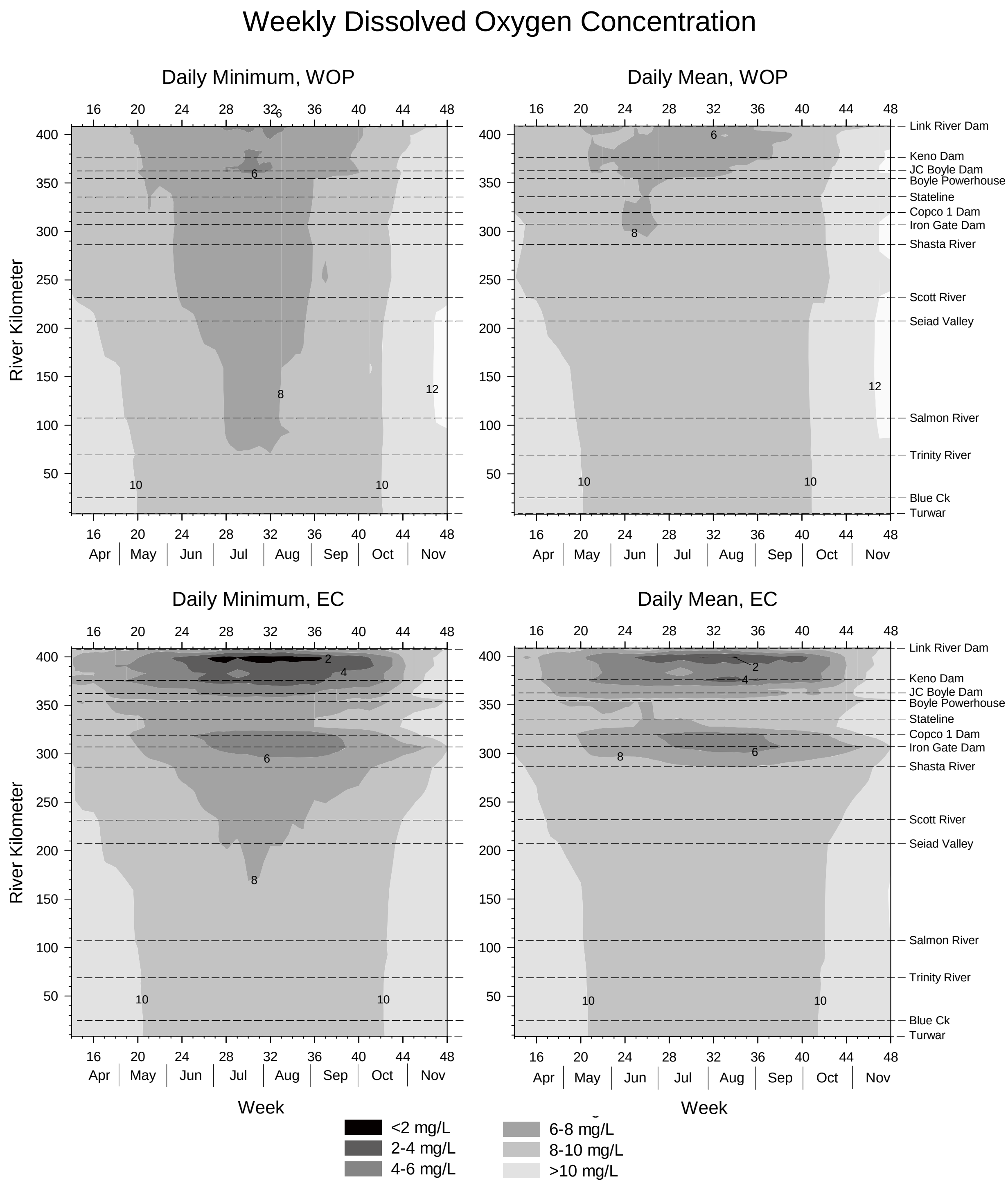

Figure 3. Dissolved oxygen concentrations predicted by the KRWQM for the Without Project (WOP) and Existing Condition (EC) scenarios in the Klamath River. Contours are based upon daily minimum and mean DO concentrations calculated from hourly model outputs and averaged by week across 2000-2004 for the 26 sites listed in Table 2.

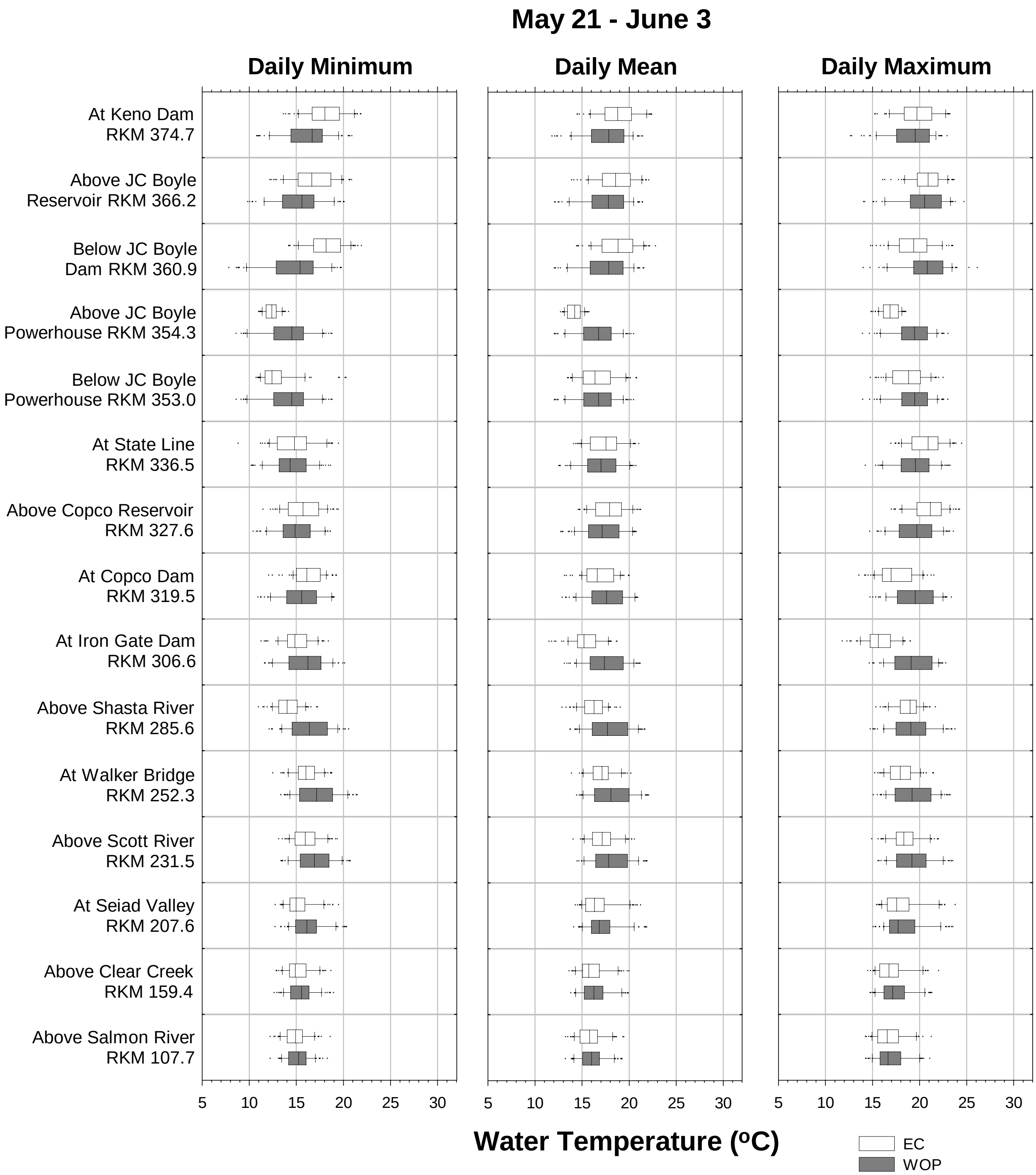

Figure 4. Box plots (line inside box is median, box ends are 25th and 75th percentiles, whisker ends are 10th and 90th percentiles, dots are outliers) of daily minimum, mean, and maximum temperatures predicted by the KRWQM. Results for each day from May 23-June 3 over the five years modeled (70 days per individual box plot) are plotted for two KHP configurations: Existing Condition (EC) and Without Project (WOP).

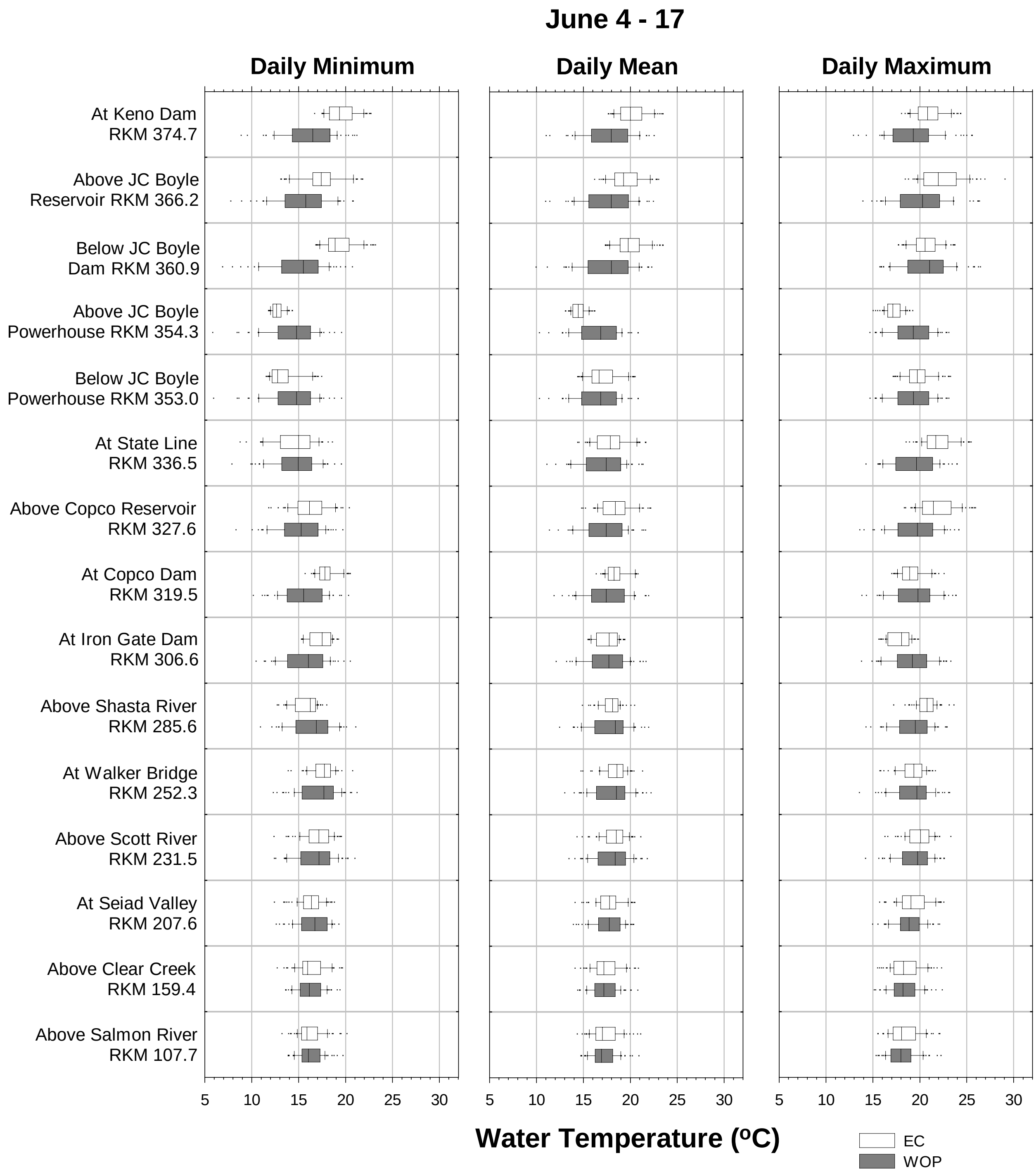

Figure 5. Box plots (line inside box is median, box ends are 25th and 75th percentiles, whisker ends are 10th and 90th percentiles, dots are outliers) of daily minimum, mean, and maximum temperatures predicted by the KRWQM. Results for each day from June 4-17 over the five years modeled (70 days per individual box plot) are plotted for two KHP configurations: Existing Condition (EC) and Without Project (WOP).

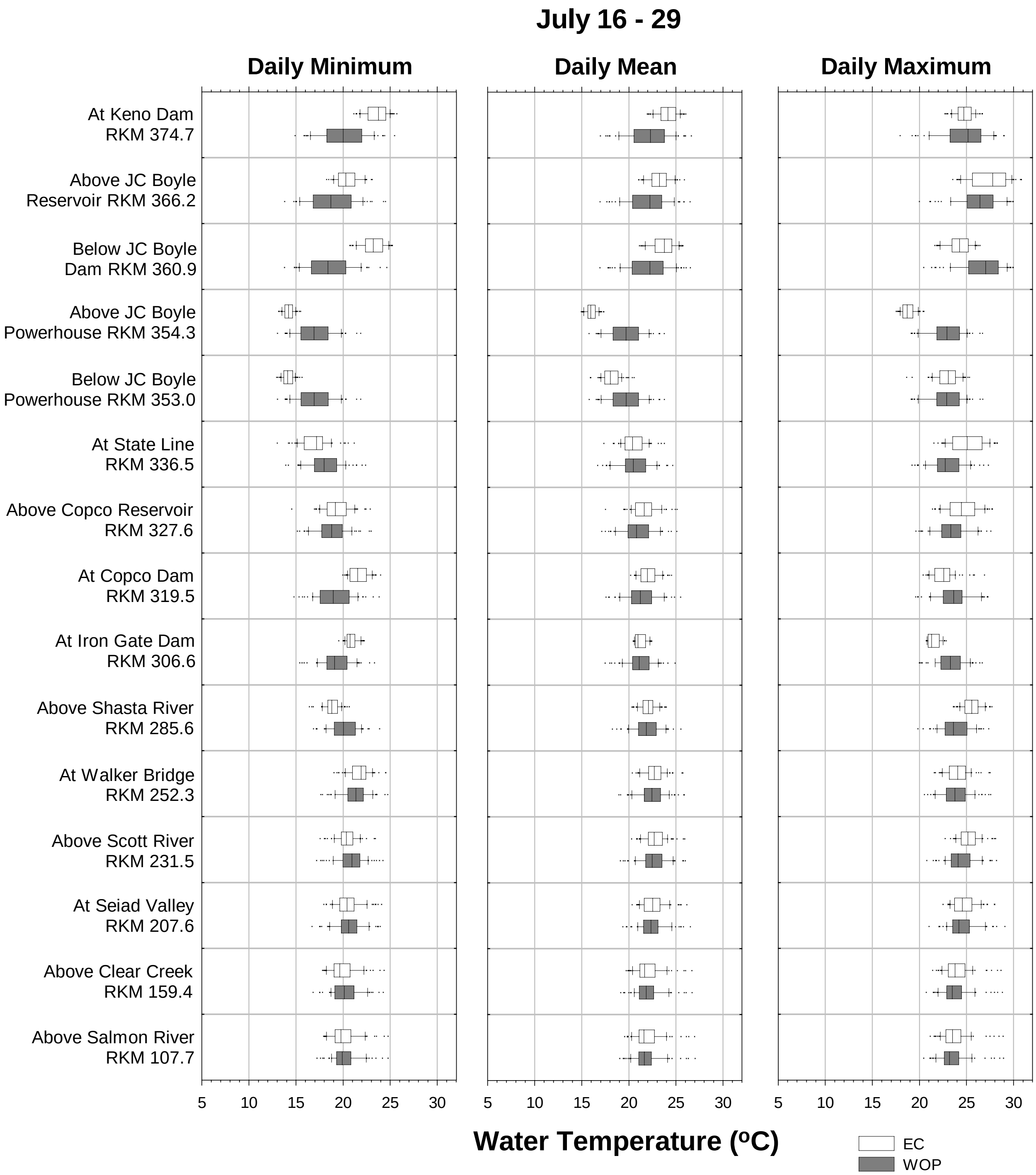

Figure 6. Box plots (line inside box is median, box ends are 25th and 75th percentiles, whisker ends are 10th and 90th percentiles, dots are outliers) of daily minimum, mean, and maximum temperatures predicted by the KRWQM. Results for each day from July 16-29 over the five years modeled (70 days per individual box plot) are plotted for two KHP configurations: Existing Condition (EC) and Without Project (WOP).

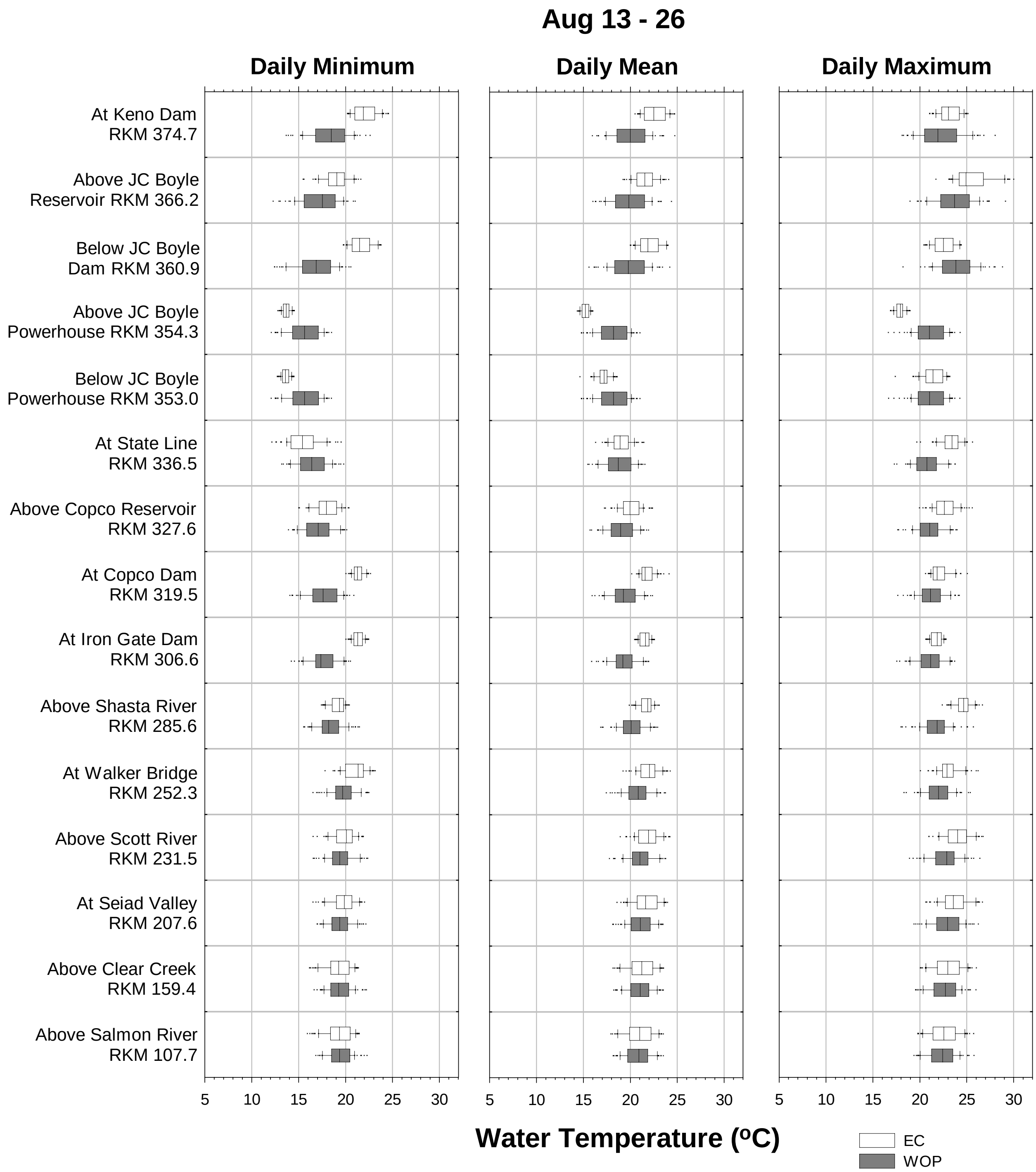

Figure 7. Box plots (line inside box is median, box ends are 25th and 75th percentiles, whisker ends are 10th and 90th percentiles, dots are outliers) of daily minimum, mean, and maximum temperatures predicted by the KRWQM. Results for each day from August 13-26 over the five years modeled (70 days per individual box plot) are plotted for two KHP configurations: Existing Condition (EC) and Without Project (WOP).

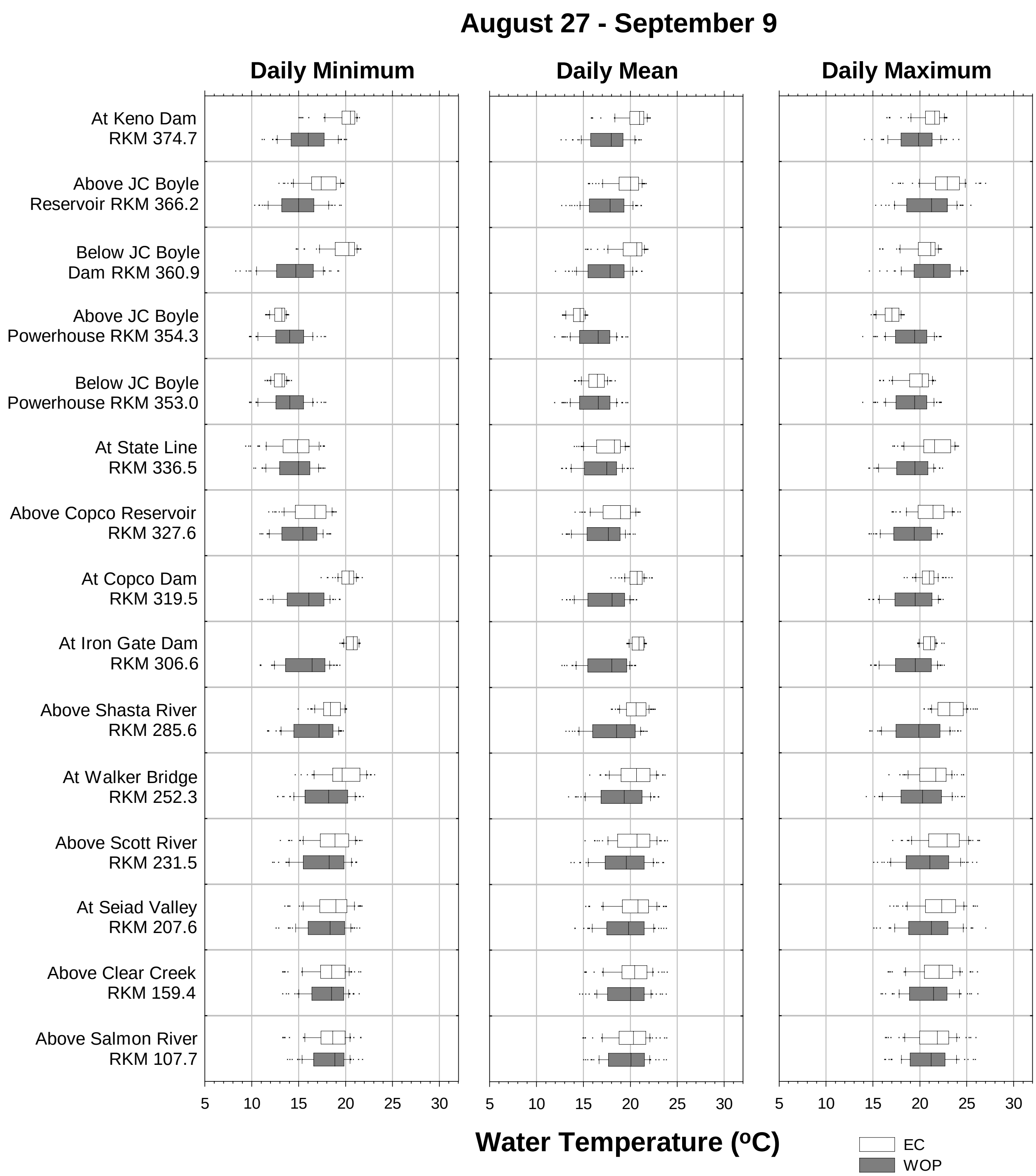

Figure 8. Box plots (line inside box is median, box ends are 25th and 75th percentiles, whisker ends are 10th and 90th percentiles, dots are outliers) of daily minimum, mean, and maximum temperatures predicted by the KRWQM. Results for each day from August 27 – September 9 over the five years modeled (70 days per individual box plot) are plotted for two KHP configurations: Existing Condition (EC) and Without Project (WOP).

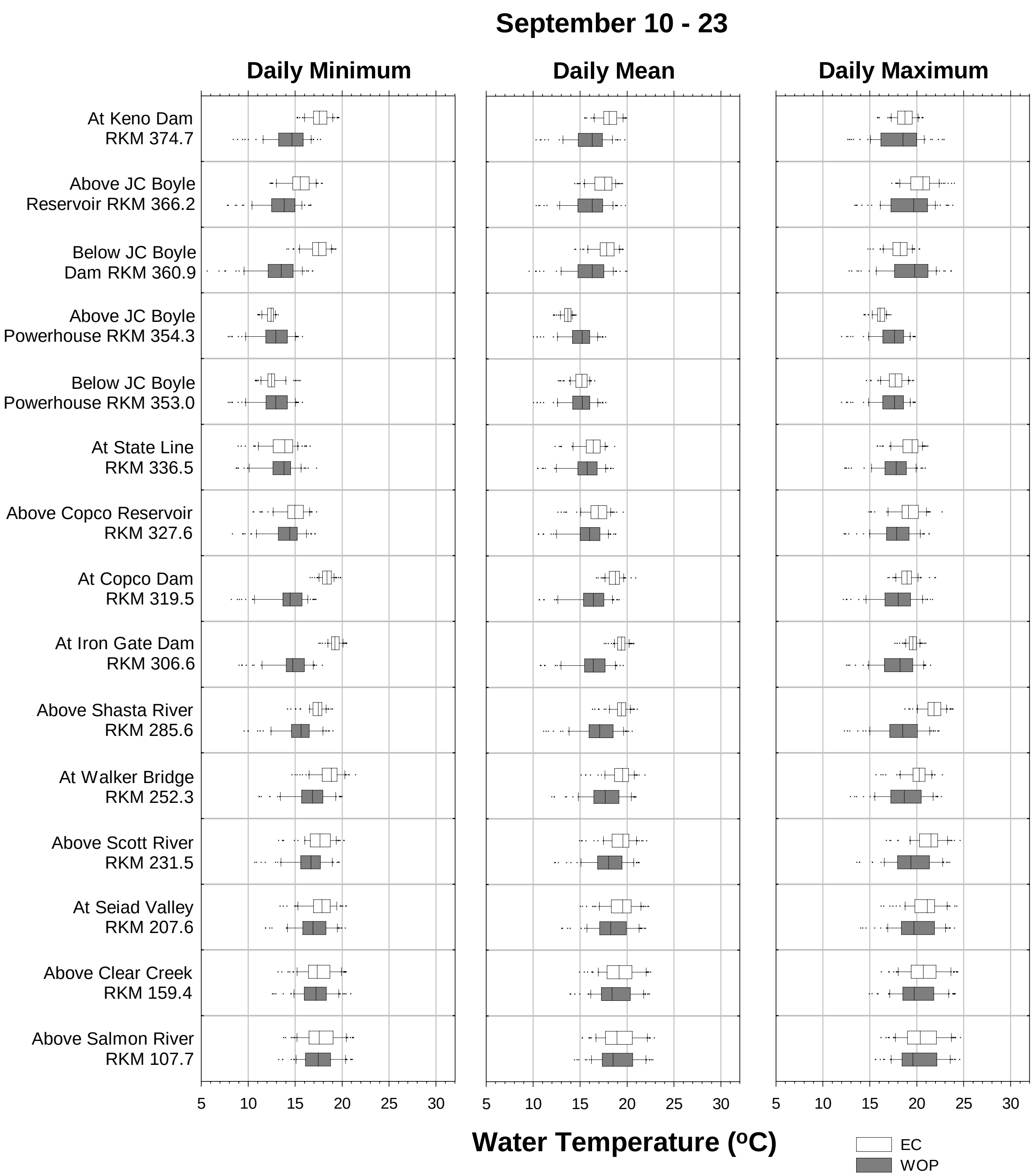

Figure 9. Box plots (line inside box is median, box ends are 25th and 75th percentiles, whisker ends are 10th and 90th percentiles, dots are outliers) of daily minimum, mean, and maximum temperatures predicted by the KRWQM. Results for each day from September 10-23 over the five years modeled (70 days per individual box plot) are plotted for two KHP configurations: Existing Condition (EC) and Without Project (WOP).

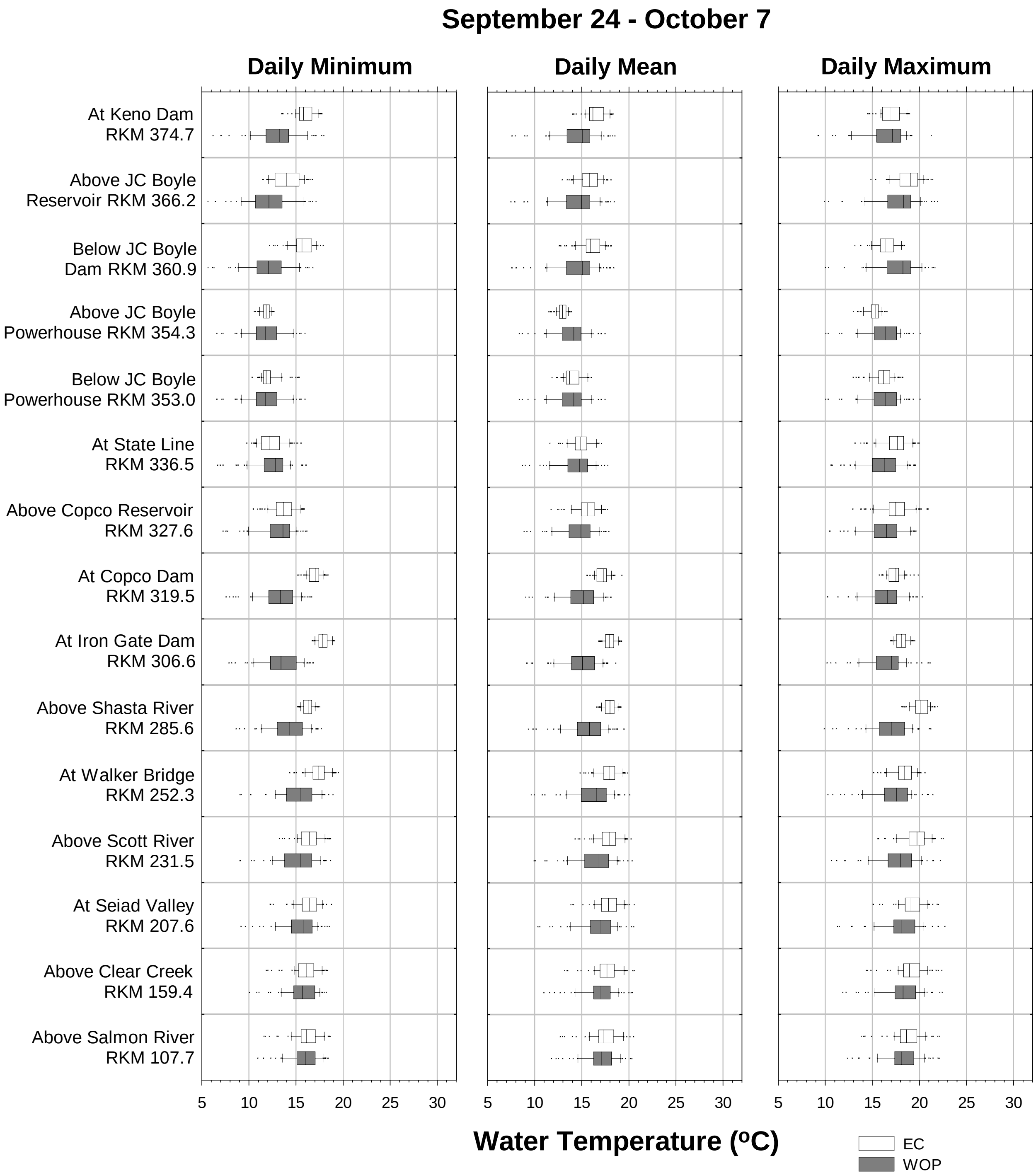

Figure 10. Box plots (line inside box is median, box ends are 25th and 75th percentiles, whisker ends are 10th and 90th percentiles, dots are outliers) of daily minimum, mean, and maximum temperatures predicted by the KRWQM. Results for each day from September 24 – October 7 over the five years modeled (70 days per individual box plot) are plotted for two KHP configurations: Existing Condition (EC) and Without Project (WOP).

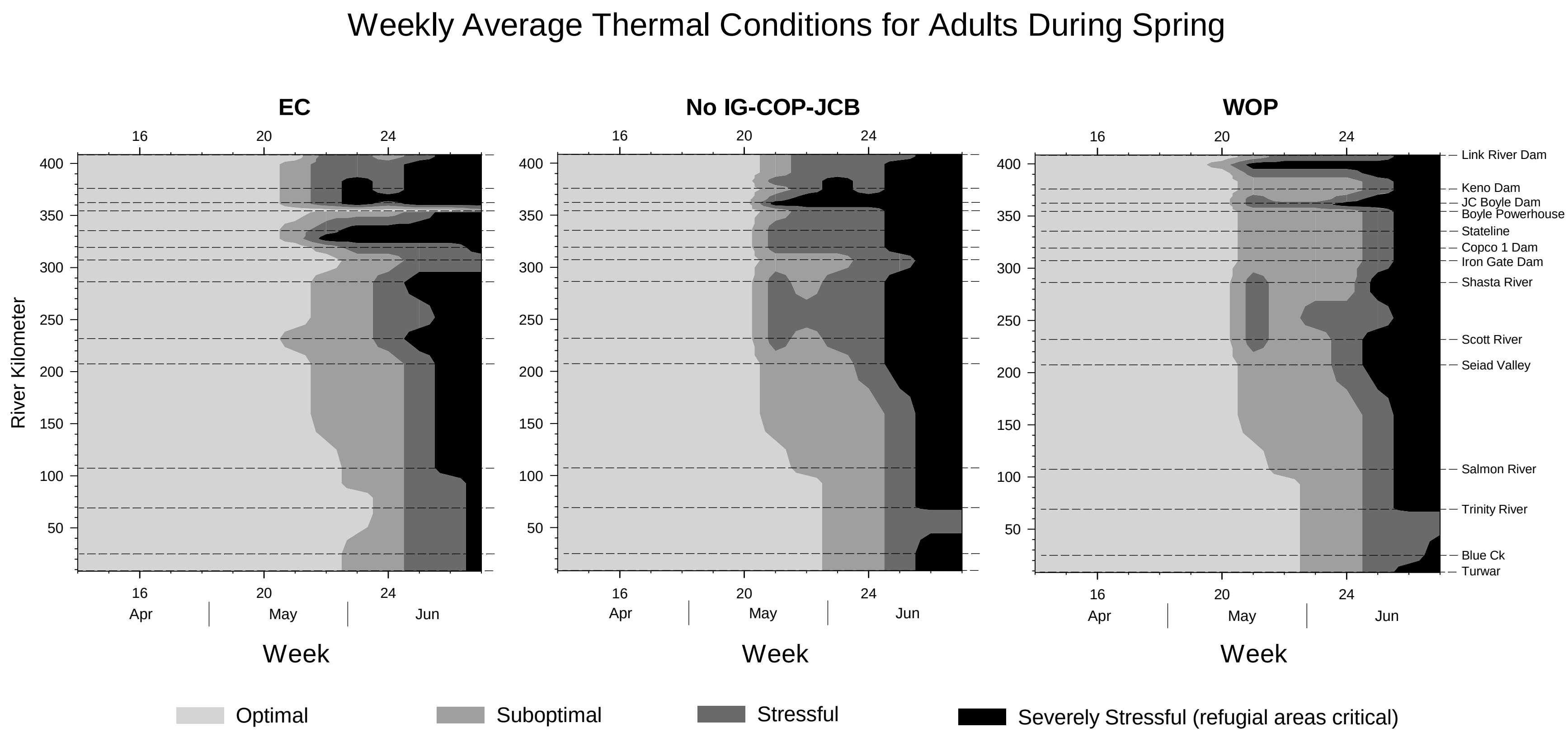

Figure 11. Average weekly conditions during the spring migratory period for adult salmon and steelhead within and below the KHP. Water temperatures predicted by the KRWQM for three KHP configurations were categorized by level of stress, and then averaged by week across years (2000-2004). Only data from riverine sites and Keno Reservoir are included; other mainstem reservoirs and Upper Klamath Lake are represented solely by outflow from the dams. Project configurations are: EC = existing condition; No IG-COP-JCB = Iron Gate, and Copco 1 and 2, and JC Boyle dams removed; WOP = Iron Gate, and Copco 1 and 2, JC Boyle, and Keno dams removed.

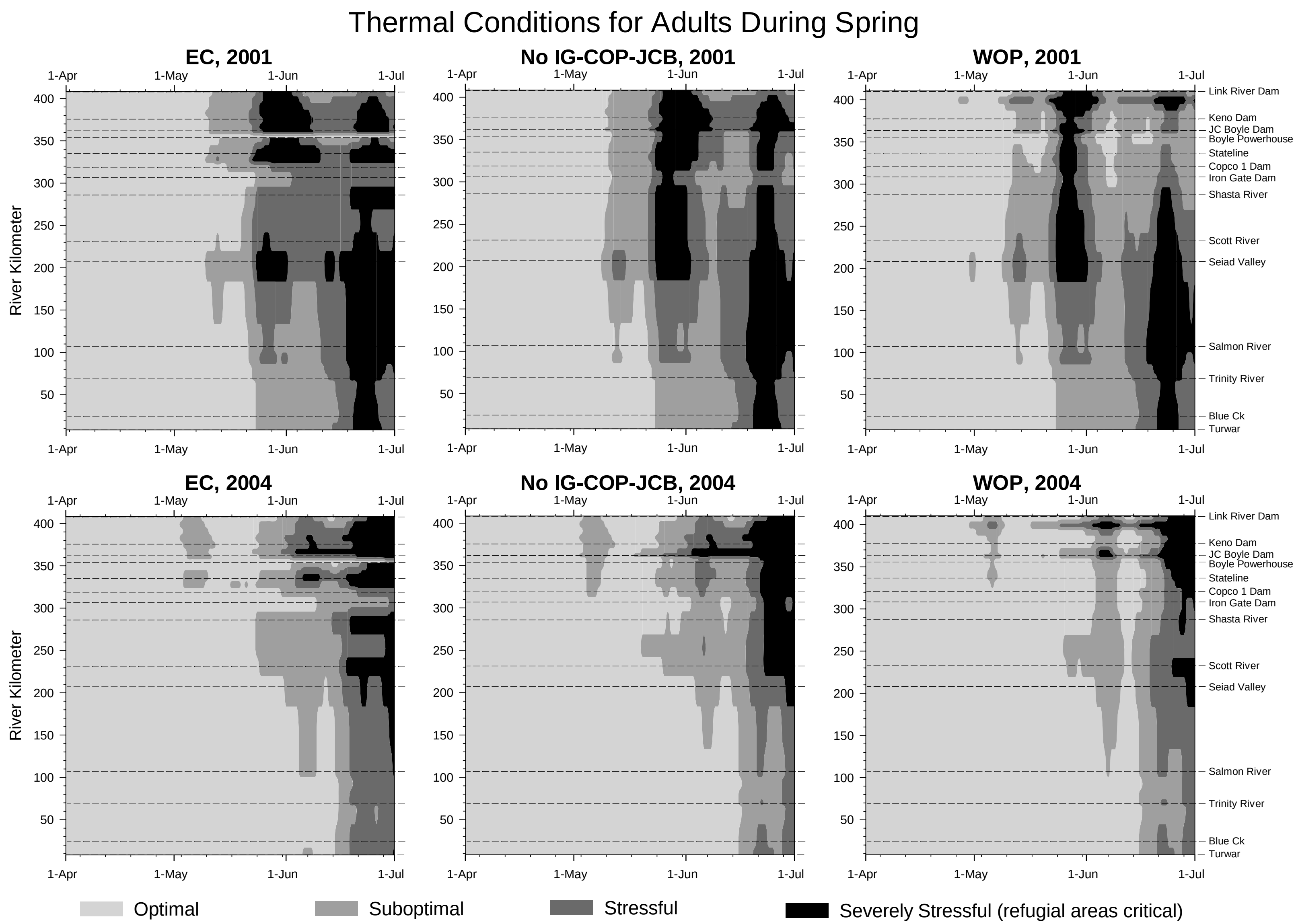

Figure 12. Conditions during spring of 2001 and 2004 for adult salmon and steelhead within and below the KHP, based on water temperatures predicted by the KRWQM for three KHP configurations. Only data from riverine sites and Keno Reservoir are included; other mainstem reservoirs and Upper Klamath Lake are represented solely by outflow from the dams. Project configurations are: EC = existing condition; No IG-COP-JCB = Iron Gate, and Copco 1 and 2, and JC Boyle dams removed; WOP = Iron Gate, and Copco 1 and 2, JC Boyle, and Keno dams removed.

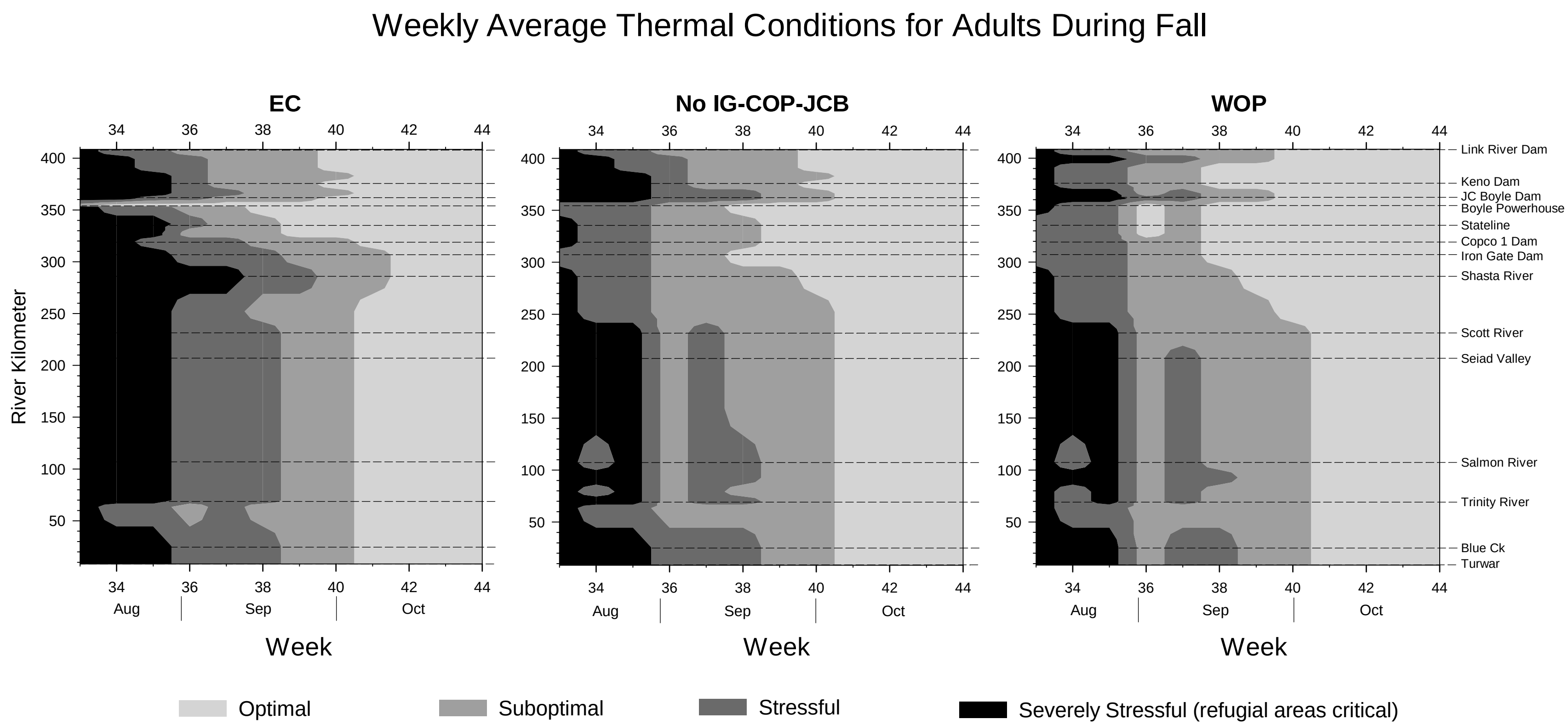

Figure 13. Average weekly conditions during the fall migratory period for adult salmon and steelhead within and below the KHP. Water temperatures predicted by the KRWQM for three KHP configurations were categorized by level of stress, and then averaged by week across years (2000-2004). Only data from riverine sites and Keno Reservoir are included; other mainstem reservoirs and Upper Klamath Lake are represented solely by outflow from the dams. Project configurations are: EC = existing condition; No IG-COP-JCB = Iron Gate, and Copco 1 and 2, and JC Boyle dams removed; WOP = Iron Gate, and Copco 1 and 2, JC Boyle, and Keno dams removed.

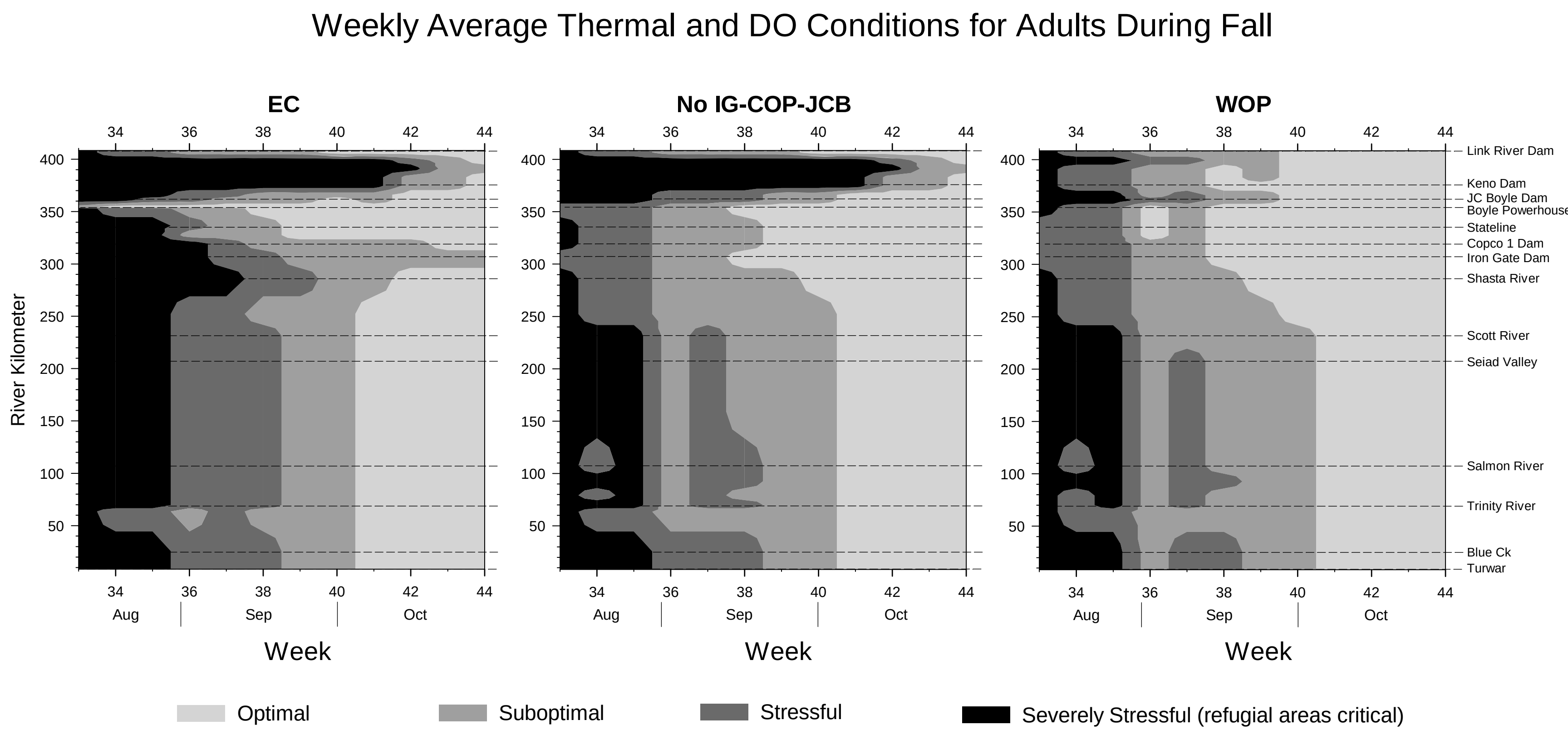

Figure 14. Average weekly conditions during the fall migratory period for adult salmon and steelhead within and below the KHP. Water temperatures and dissolved oxygen concentrations predicted by the KRWQM for three KHP configurations were categorized by level of stress, and then averaged by week across years (2000-2004). Only data from riverine sites and Keno Reservoir are included; other mainstem reservoirs and Upper Klamath Lake are represented solely by outflow from the dams. Project configurations are: EC = existing condition; No IG-COP-JCB = Iron Gate, and Copco 1 and 2, and JC Boyle dams removed; WOP = Iron Gate, and Copco 1 and 2, JC Boyle, and Keno dams removed.

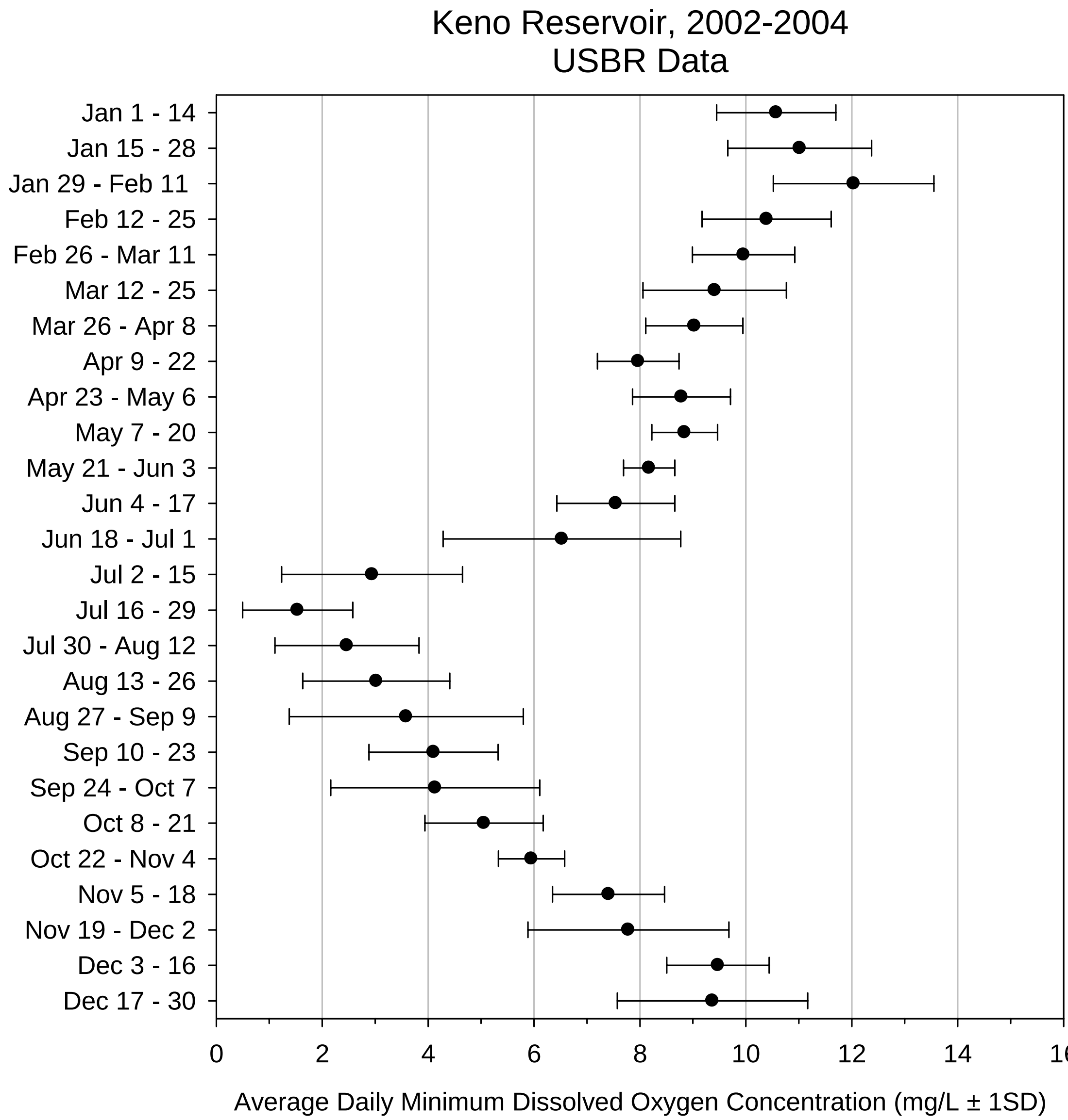

Figure 15. Daily minimum dissolved oxygen conditions in Keno Reservoir. Daily minima were calculated from hourly data and averaged over 1-3 sites in Keno Reservoir from Jan 2002 – December 2004. Daily averages for the reservoir were then used to compute the average and standard deviation for each two week period across 2002-2004. Hourly data were from 2-3 continuous recorders from June – October 2002, and June 2003 – December 2004; at other times there was usually only one recorder (USBR, Klamath Falls Area Office, unpublished data).

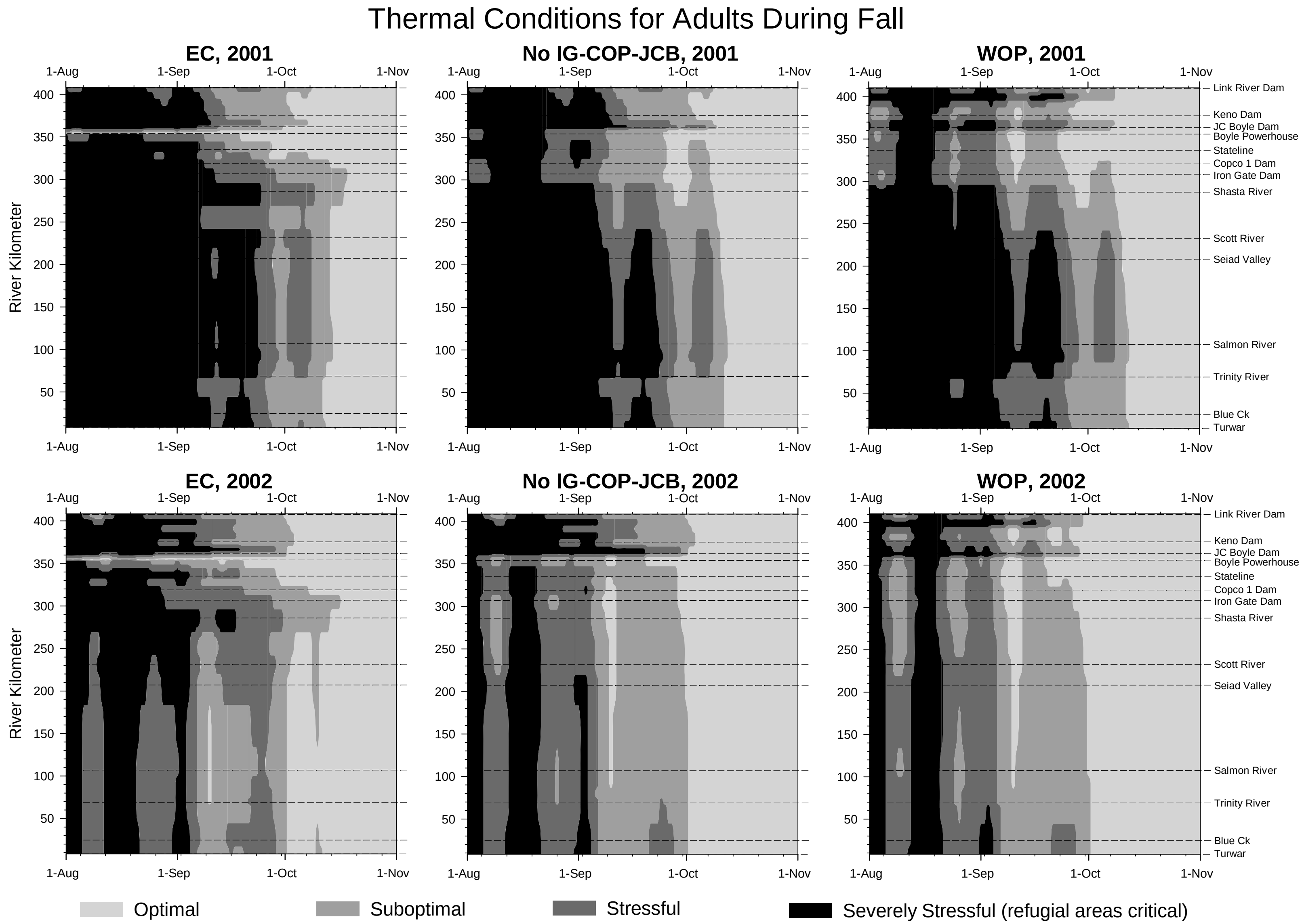

Figure 16. Conditions during fall of 2001 and 2002 for adult salmon and steelhead within and below the KHP, based on water temperatures predicted by the KRWQM for three KHP configurations. Only data from riverine sites and Keno Reservoir are included; other mainstem reservoirs and Upper Klamath Lake are represented solely by outflow from the dams. Project configurations are: EC = existing condition; No IG-COP-JCB = Iron Gate, and Copco 1 and 2, and JC Boyle dams removed; WOP = Iron Gate, and Copco 1 and 2, JC Boyle, and Keno dams removed.

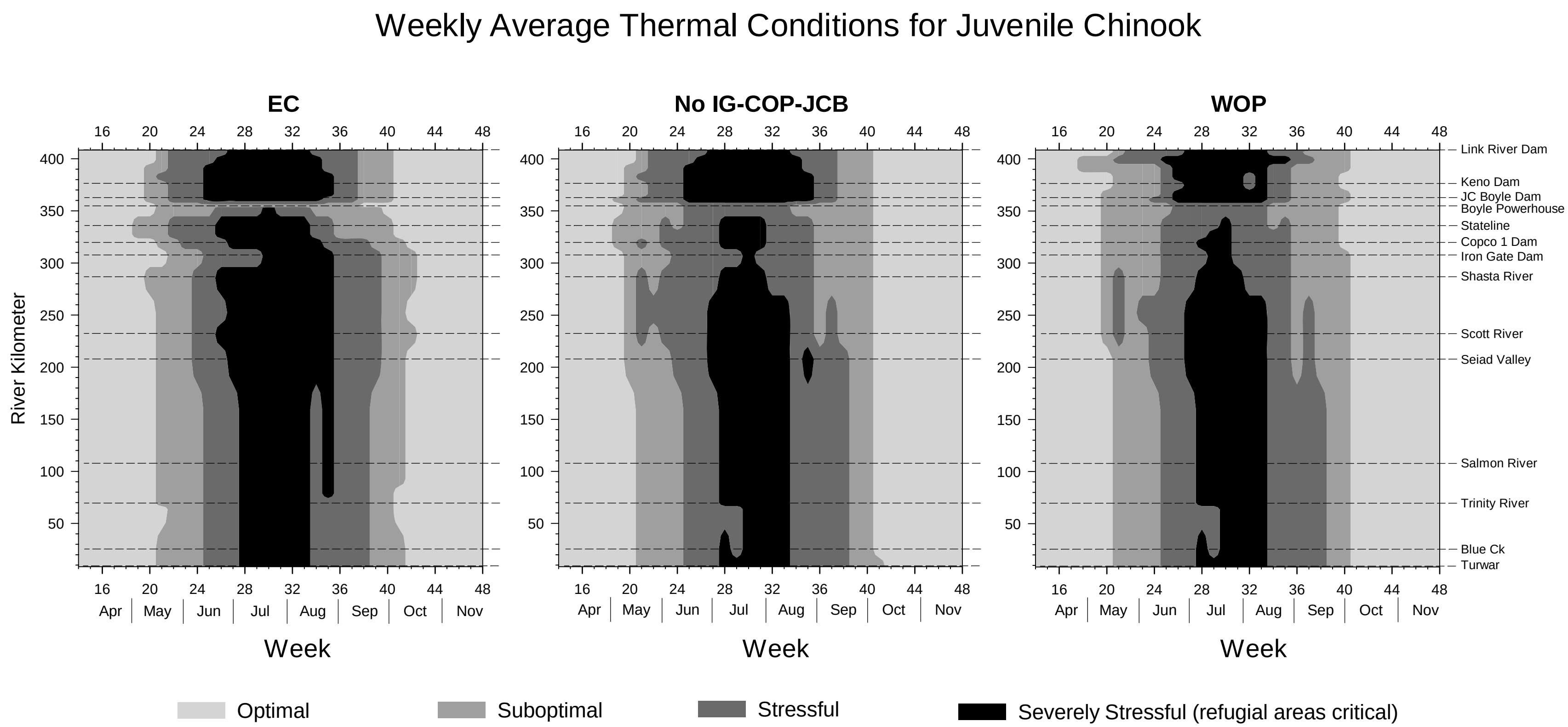

Figure 17. Average weekly conditions during the spring, summer, and fall for juvenile chinook within and below the KHP. Water temperatures predicted by the KRWQM for three KHP configurations were categorized by level of stress, and then averaged by week across years (2000-2004). Only data from riverine sites and Keno Reservoir are included; other mainstem reservoirs and Upper Klamath Lake are represented solely by outflow from the dams. Project configurations are: EC = existing condition; No IG-COP-JCB = Iron Gate, and Copco 1 and 2, and JC Boyle dams removed; WOP = Iron Gate, and Copco 1 and 2, JC Boyle, and Keno dams removed.

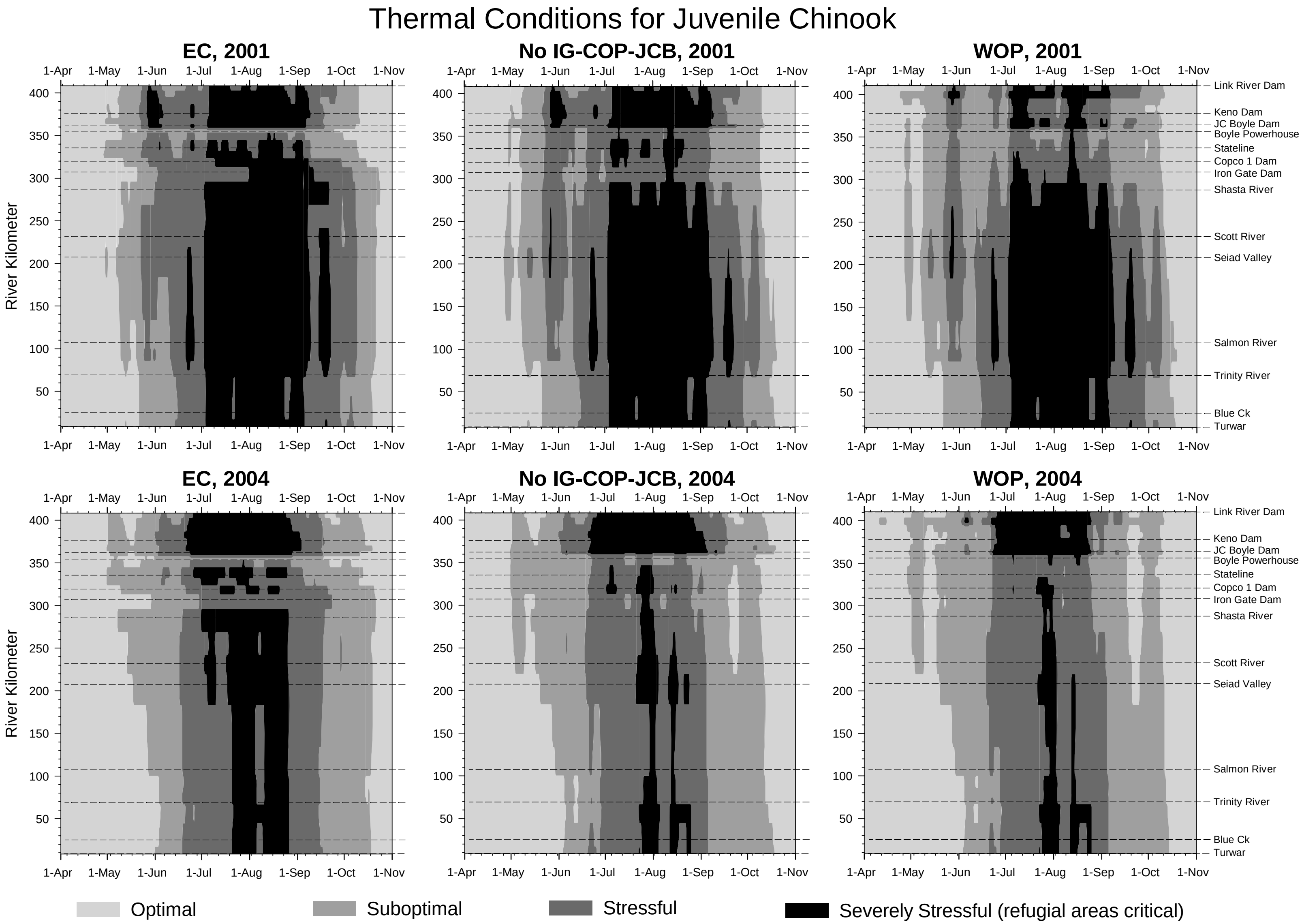

Figure 18. Conditions during the spring, summer, and fall of 2001 and 2004 for juvenile chinook within and below the KHP, based on water temperatures predicted by the KRWQM for three KHP configurations. Only data from riverine sites and Keno Reservoir are included; other mainstem reservoirs and Upper Klamath Lake are represented solely by outflow from the dams. Project configurations are: EC = existing condition; No IG-COP-JCB = Iron Gate, and Copco 1 and 2, and JC Boyle dams removed; WOP = Iron Gate, and Copco 1 and 2, JC Boyle, and Keno dams removed.

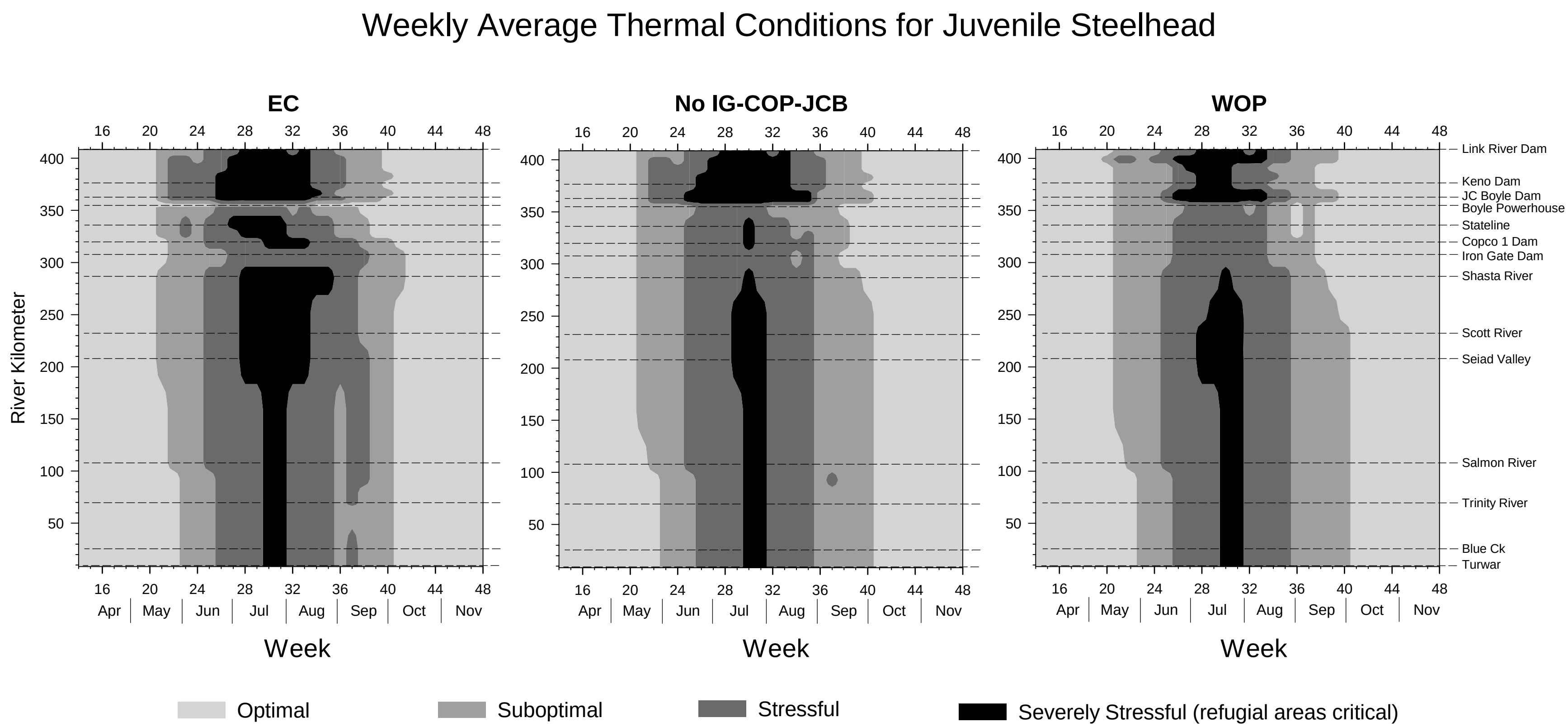

Figure 19. Average weekly conditions during the spring, summer, and fall for juvenile steelhead within and below the KHP. Water temperatures predicted by the KRWQM for three KHP configurations were categorized by level of stress, and then averaged by week across years (2000-2004). Only data from riverine sites and Keno Reservoir are included; other mainstem reservoirs and Upper Klamath Lake are represented solely by outflow from the dams. Project configurations are: EC = existing condition; No IG-COP-JCB = Iron Gate, and Copco 1 and 2, and JC Boyle dams removed; WOP = Iron Gate, and Copco 1 and 2, JC Boyle, and Keno dams removed.

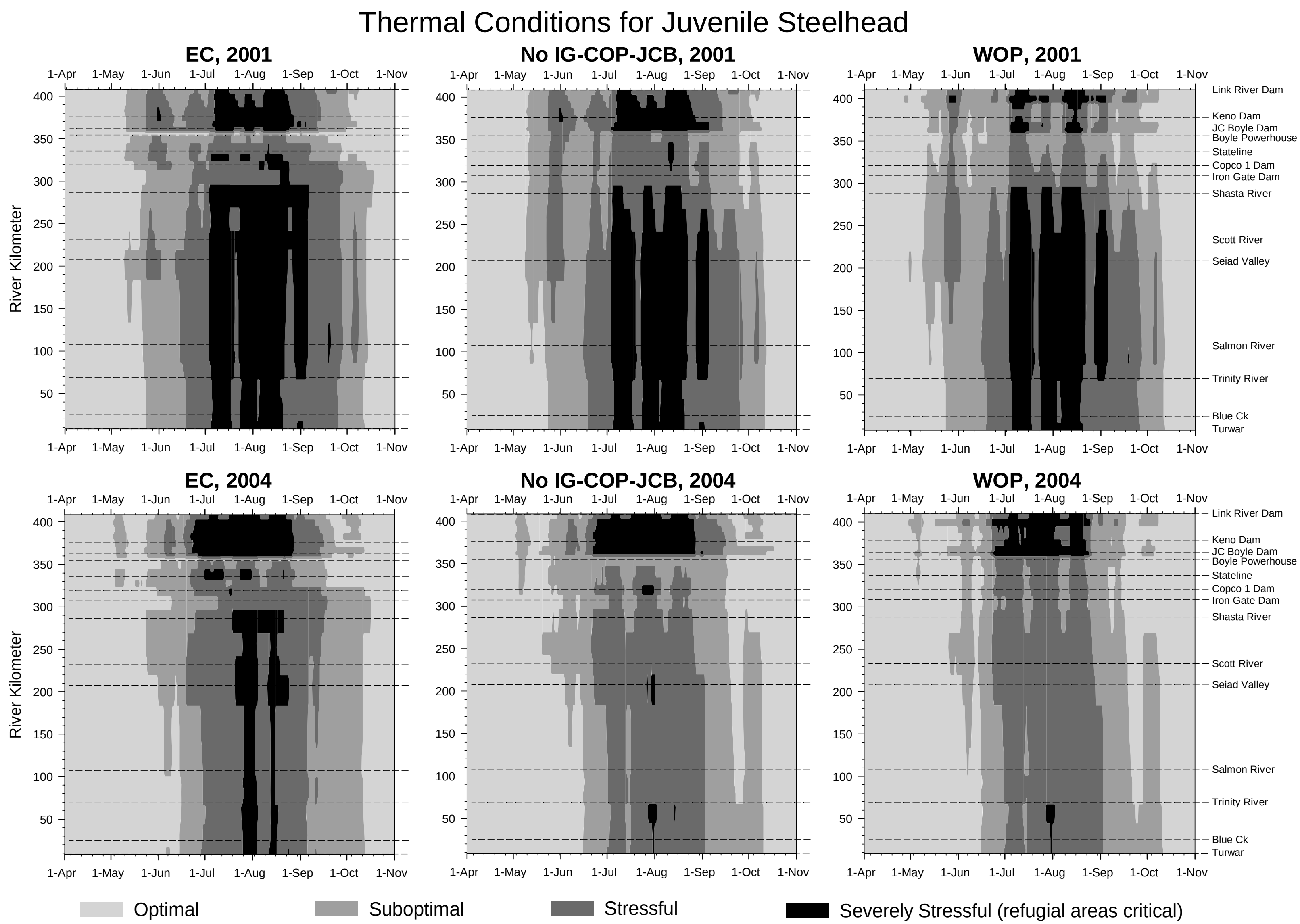

Figure 20. Conditions during the spring, summer, and fall of 2001 and 2004 for juvenile steelhead within and below the KHP, based on water temperatures predicted by the KRWQM for three KHP configurations. Only data from riverine sites and Keno Reservoir are included; other mainstem reservoirs and Upper Klamath Lake are represented solely by outflow from the dams. Project configurations are: EC = existing condition; No IG-COP-JCB = Iron Gate, and Copco 1 and 2, and JC Boyle dams removed; WOP = Iron Gate, and Copco 1 and 2, JC Boyle, and Keno dams removed.

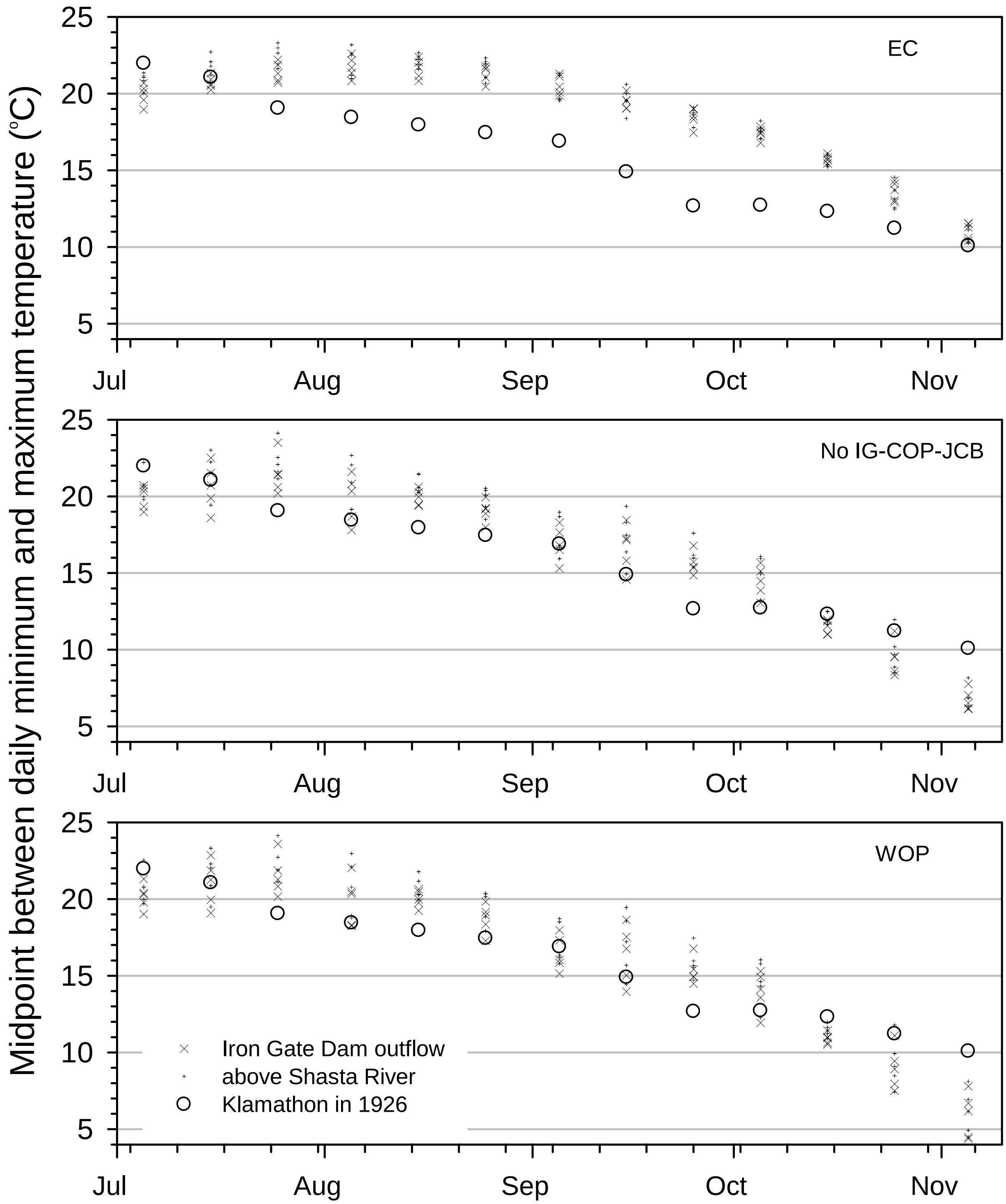

Figure 21. Approximate mean daily temperatures (midpoint of 8AM and 5PM measurements) at Klamathon in 1926 (Snyder 1931), compared to approximate means for EC, No IG-COP-JCB, and WOP temperatures in 2000-2004 calculated in a similar manner (midpoint of average daily minima and maxima by 10 day period). Recent temperatures are shown for sites at Iron Gate Dam and above Shasta River. Klamathon was located about midway between these two sites.

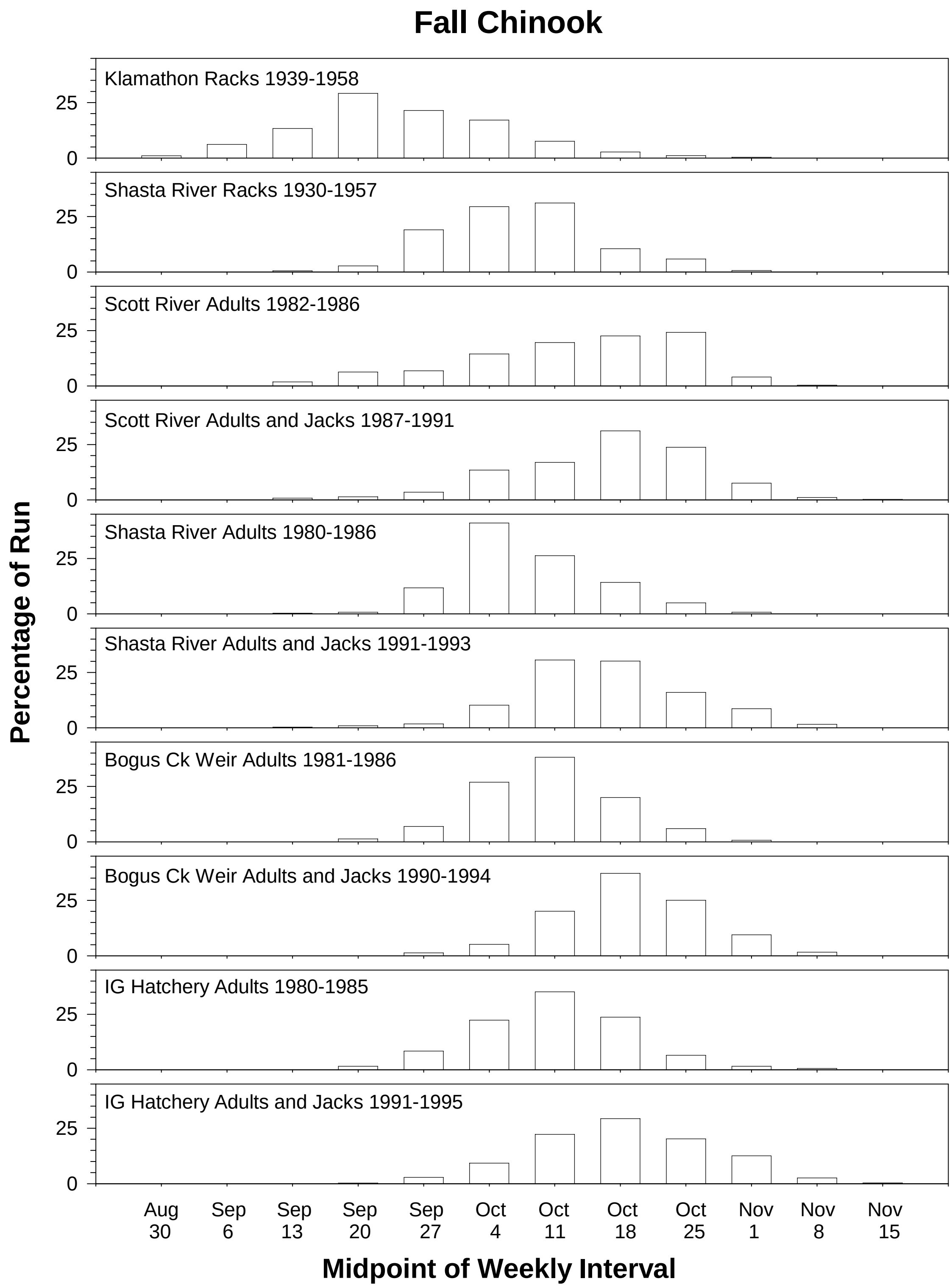

Figure 22. Fall chinook run timing to the middle Klamath River (all data from Shaw et al. 1998).

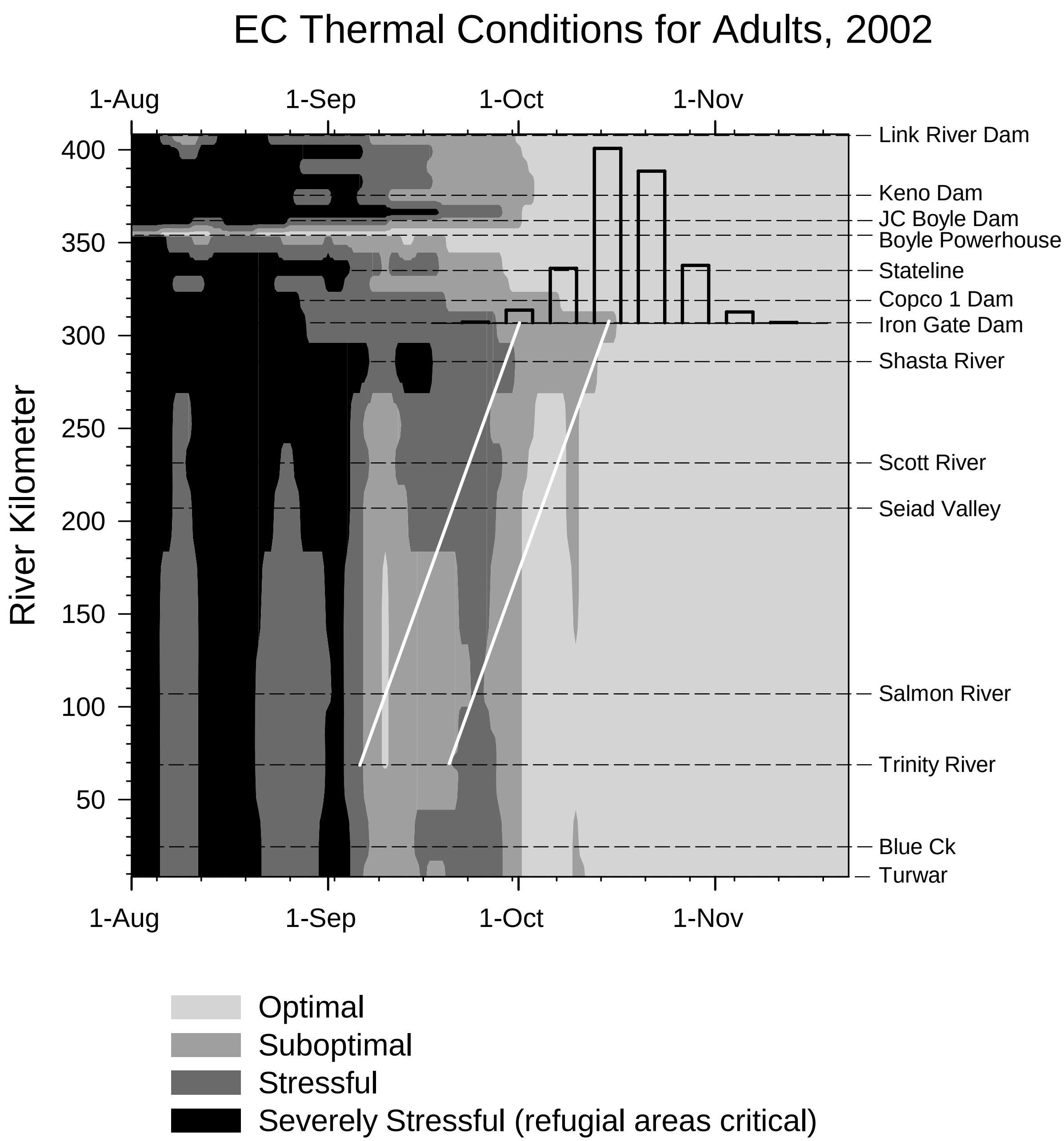

Figure 23. Contour plot of thermal conditions for adult salmon and steelhead in 2002, with a superimposed frequency histogram of fall chinook returning to Iron Gate Hatchery, allowing comparison of thermal conditions to timing of adult returns to the hatchery. The white diagonal lines each relate a bar of the histogram (i.e. the date of arrival to the hatchery for that group of fish) to its estimated departure date from the Trinity River confluence 25 days earlier, based on an assumed travel time of 9.4 km/d.

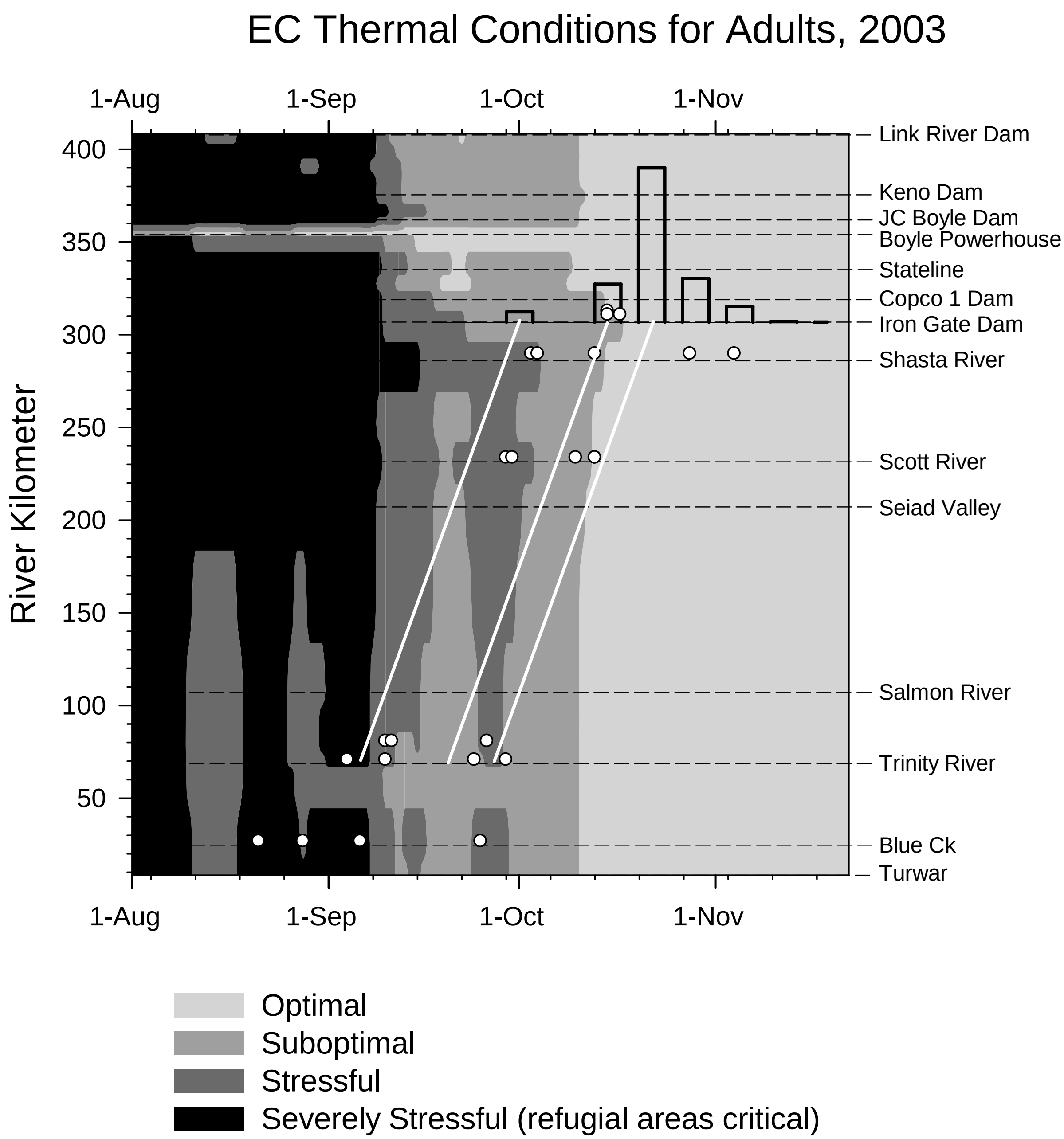

Figure 24. Contour plot of thermal conditions for adult salmon and steelhead in 2003, with a superimposed frequency histogram of fall chinook returning to Iron Gate Hatchery, allowing comparison of thermal conditions to timing of adult returns to the hatchery. The white diagonal lines each relate a bar of the histogram (i.e. the date of arrival to the hatchery for that group of fish) to its estimated departure date from the Trinity River confluence 25 days earlier, based on an assumed travel time of 9.4 km/d. White dots represent locations of radio-tagged adult chinook (Josh Strange, pers. comm.).

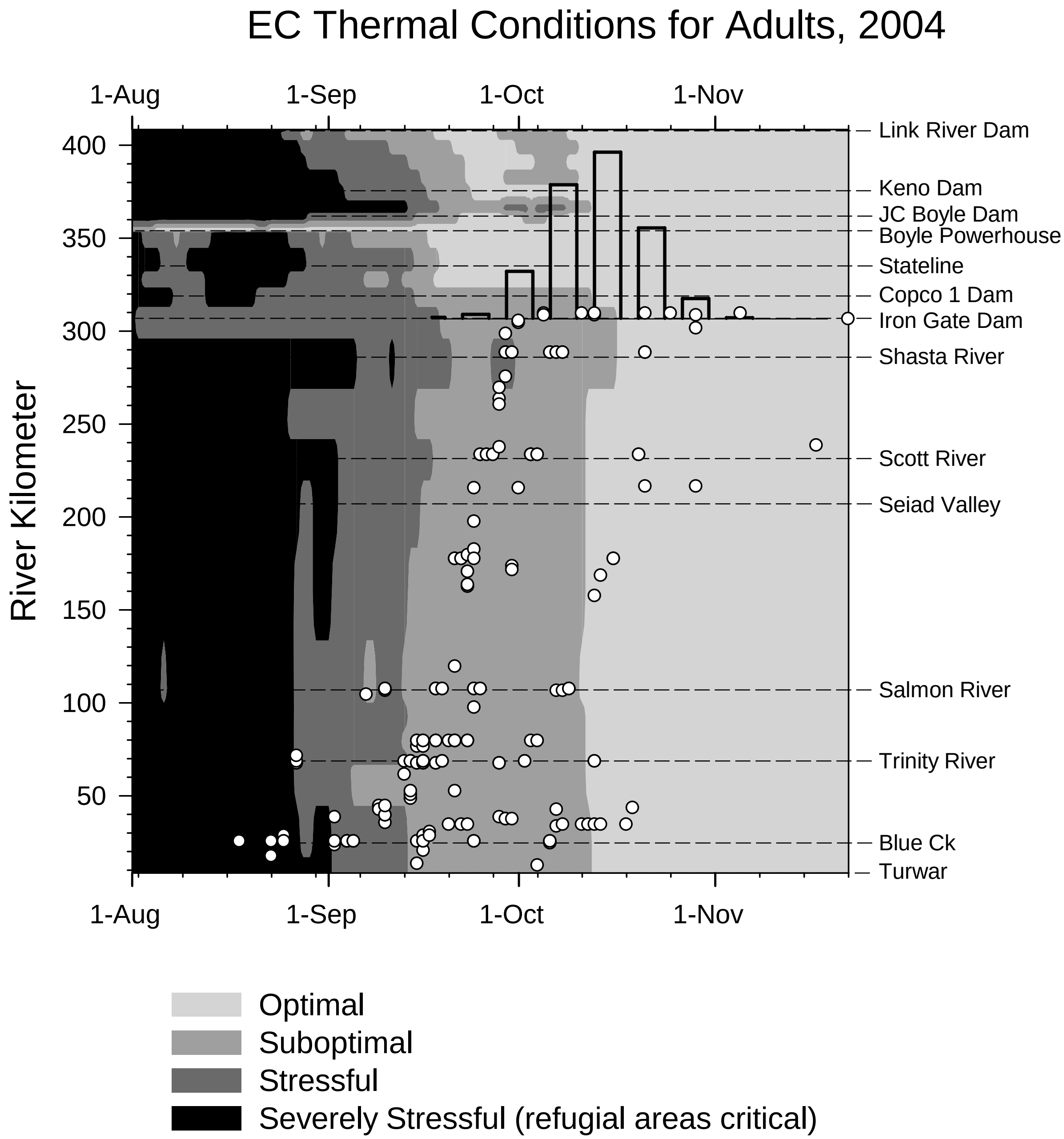

Figure 25. Contour plot of thermal conditions for adult salmon and steelhead in 2004, with a superimposed frequency histogram of fall chinook returning to Iron Gate Hatchery, allowing comparison of thermal conditions to timing of adult returns to the hatchery. White dots represent locations of radio-tagged adult chinook (Josh Strange, pers. comm.).

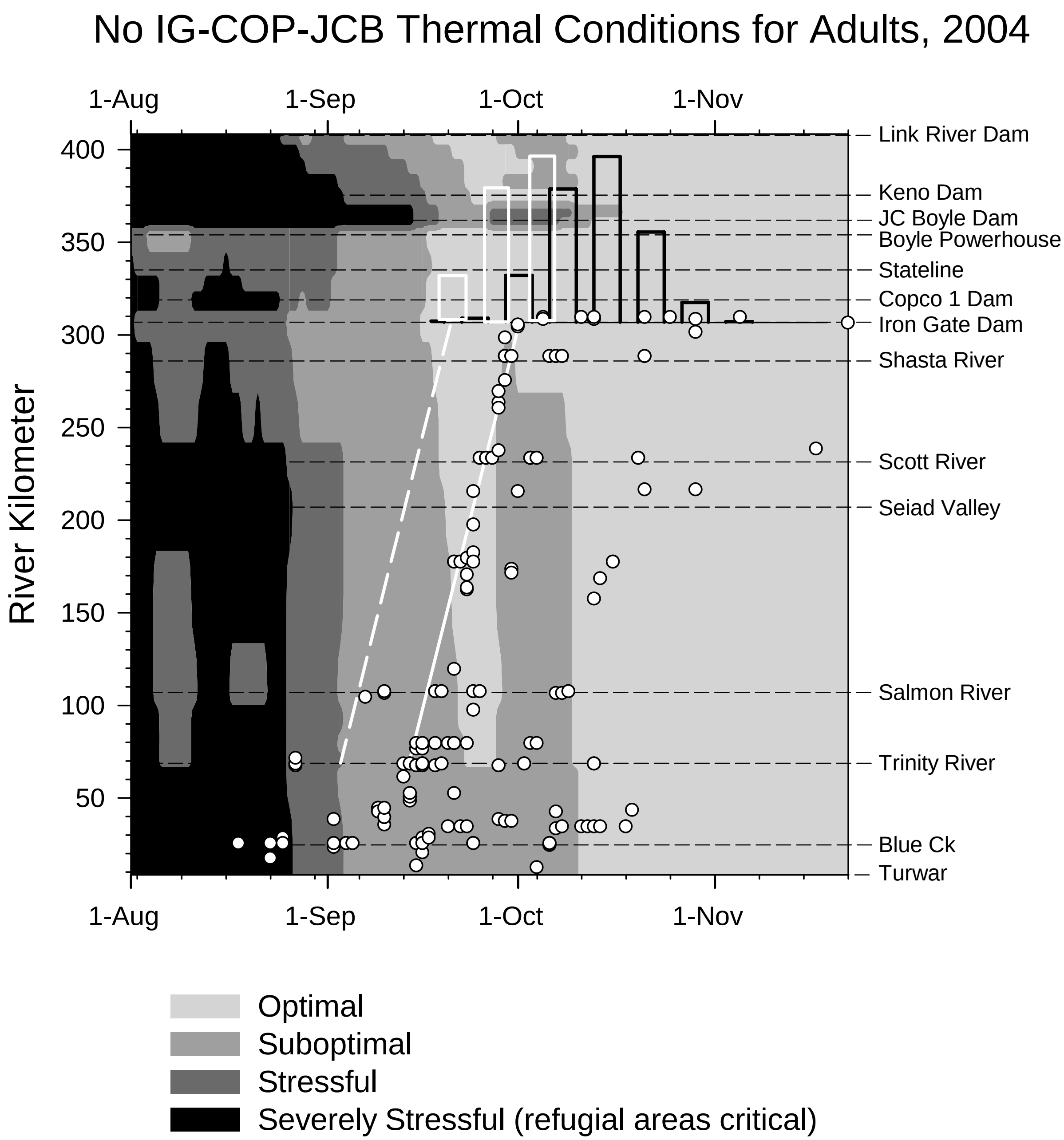

Figure 26. Contour plot of thermal conditions for adult salmon and steelhead in 2004 with the lower 4 KHP dams removed. The black histogram is the actual frequency of fall chinook returns to Iron Gate Hatchery. White dots represent locations of radio-tagged adult chinook (Josh Strange, U. of Washington, pers. comm.). The solid white diagonal line traces the leading edge of telemetered fish moving from the Trinity River confluence to the hatchery, whereas the dashed white line applies the same slope (migration rate) beginning when conditions change from Stressful to Suboptimal. The white histogram simply shifts part of the observed return frequency at the hatchery to correspond with earlier departure from the Trinity confluence.

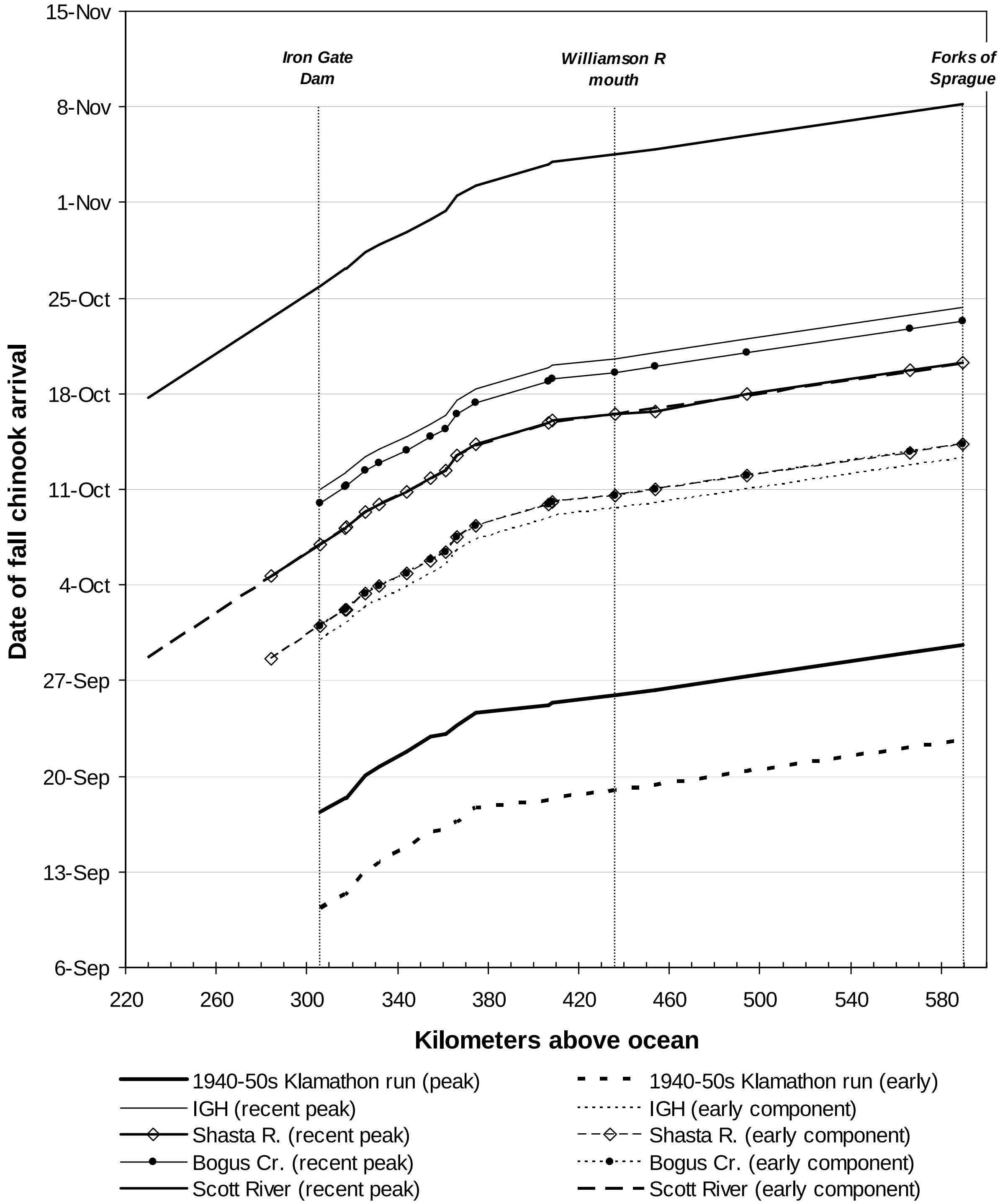

Figure 27. Projected run timing of various fall chinook stocks into the Upper Klamath Basin. Assumed migratory rates were: 9.4 km/d (the mean annual rate above Weitchpec during 2003, per J. Strange, pers. comm.) in riverine segments of the mainstem Klamath; 55 km/d in lakes and reservoirs (a median value calculated for fall chinook in Columbia and Snake River reservoirs from Keefer et al. 2004); and 41.3 km/d (75% of the passage rate through lakes and reservoirs) in low gradient rivers above UKL.

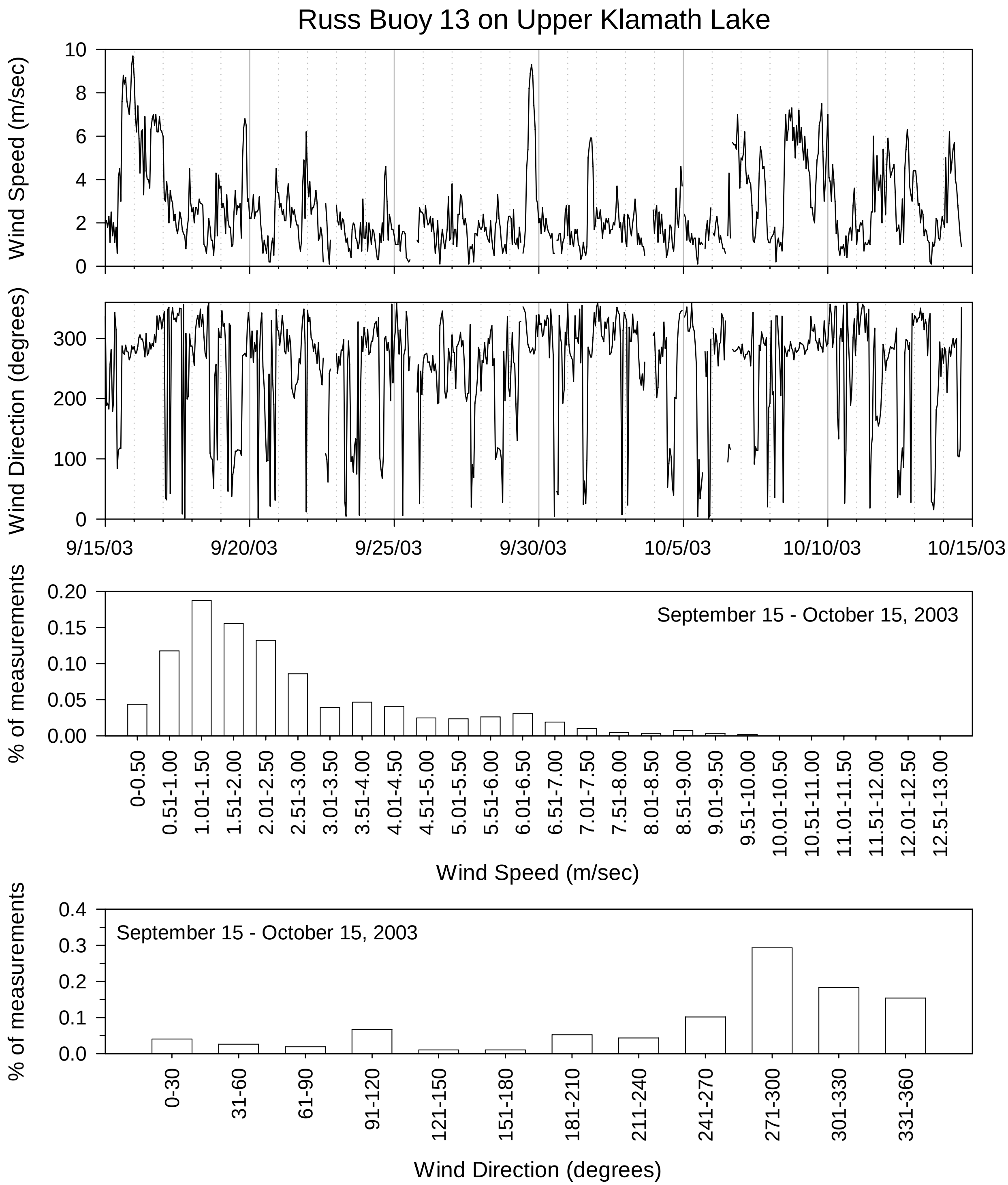

Figure 28. Wind speeds and directions from a meteorological station floating on Upper Klamath Lake that were used in UKL hydrodynamic model runs for September 26 (low wind) and October 10 (high wind) periods (Tammy Wood, USGS, pers. comm).

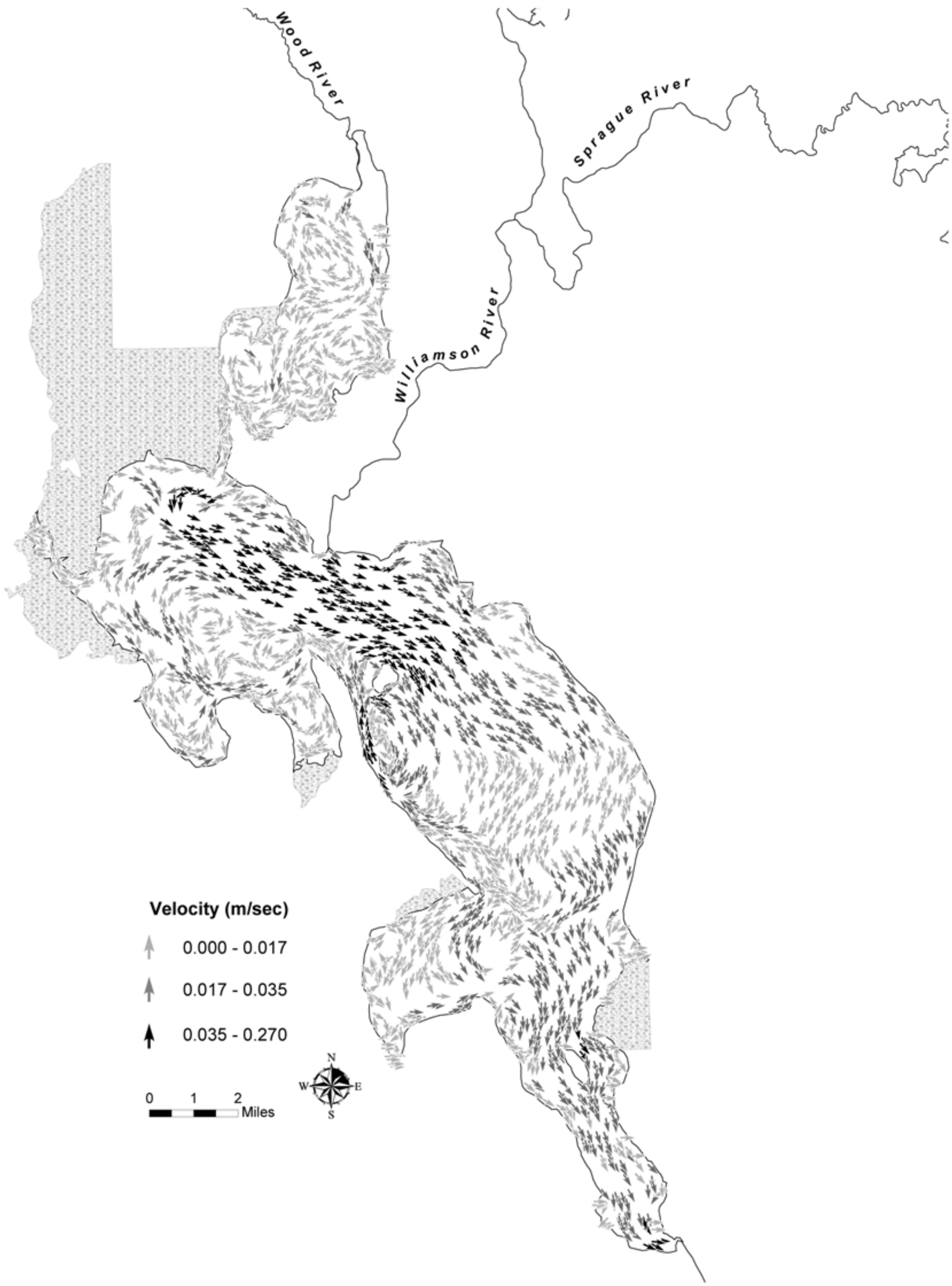

Figure 29. Flow pattern in Upper Klamath Lake predicted by a USGS hydrodynamic model for actual conditions on September 26, 2003, at 1200 hours (Tammy Wood, USGS, pers. comm.).

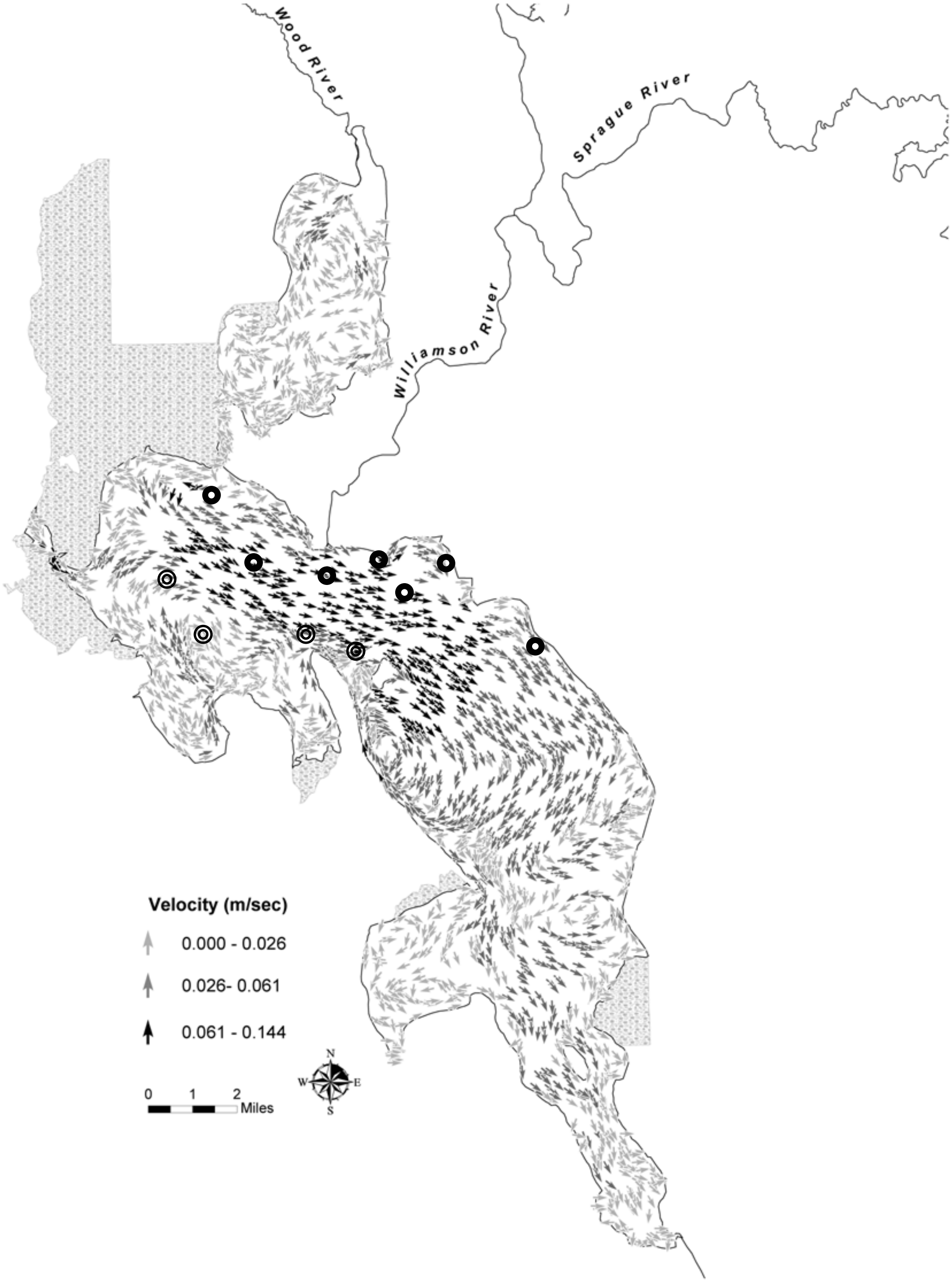

Figure 30. Flow pattern in Upper Klamath Lake predicted by a USGS hydrodynamic model for actual conditions on October 10, 2003 at 1200 hours (Tammy Wood, USGS, pers. comm.). Doughnuts are approximate locations of USGS continuous recording temperature and DO probes. For stress category computations, solid doughnuts were grouped as the "east side". Data from the three shoreline sites was available only for 2002, and for 2002-2004 for all others.

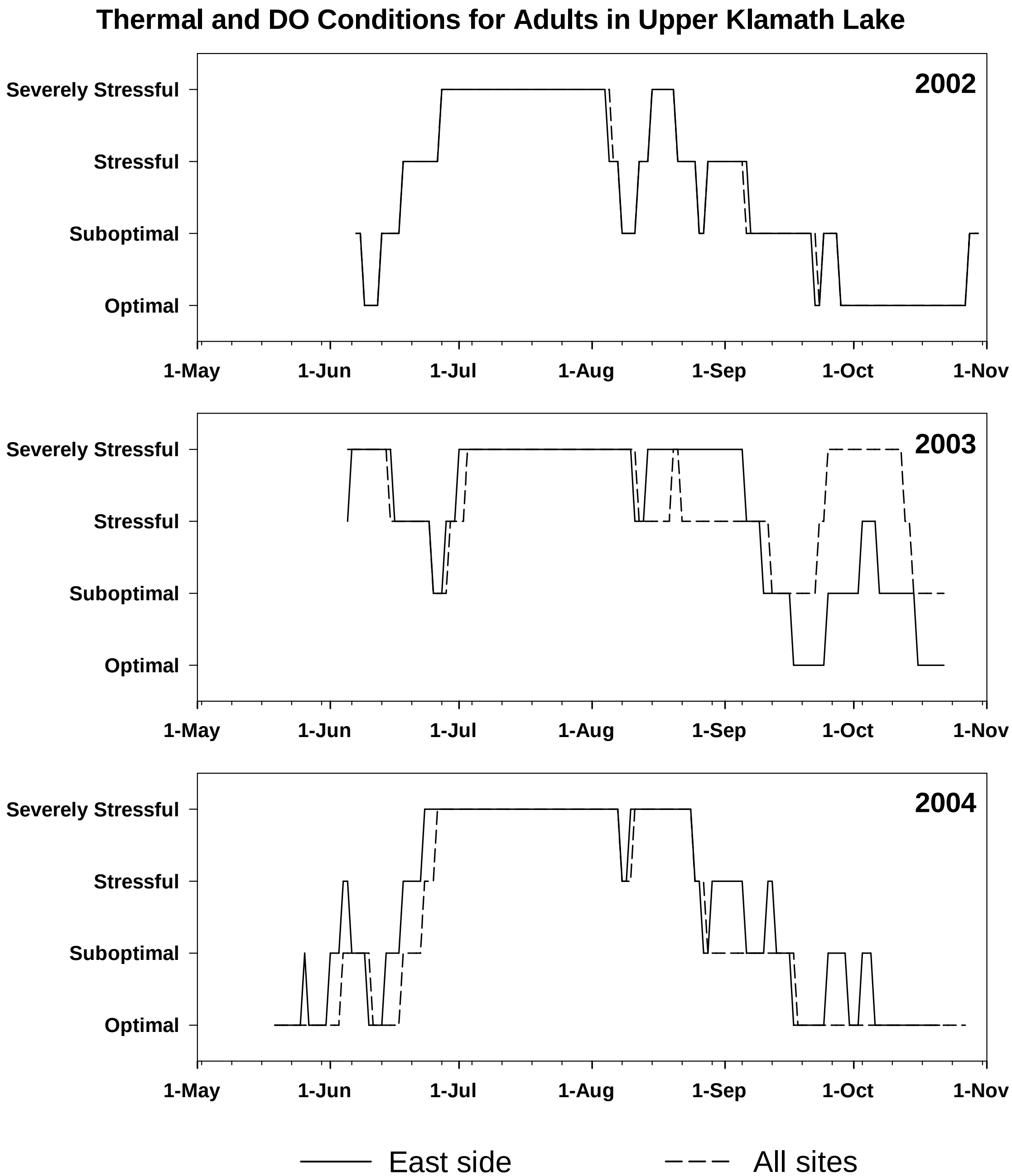

Figure 31. Thermal and dissolved oxygen conditions for adult salmon and steelhead in Upper Klamath Lake.

Appendix A

Longitudinal and Seasonal Temperature Patterns Relative to
System Potential and KHP Configuration

Moving downstream from Upper Klamath Lake, thermal effects of the KHP on the Klamath River vary according to the nature of KHP operations. In the following discussion, we loosely divide the system into four areas, within which the observed thermal patterns are responding to different KHP influences. We limit our analyses to the period from mid-April to early November, because of the biological importance of this time period and because winter-time temperatures are consistently under-predicted by the KRWQM.

Above JC Boyle Dam: a short reach (about 8.9 km) with no diversions, strongly influenced by the condition of water emanating from Keno Reservoir.

1. Below Keno Dam (Figure A1) – WOP temperatures are substantially cooler than EC. Differences are greatest for daily minima. During the warmest period in mid-July, daily maxima are similar, but WOP daily minima and means are several degrees cooler than EC. During the warm time of year, EC temperatures exhibit less diel variation than WOP, because the thermal mass of Keno Reservoir buffers the short term influence of air temperature.
2. Above JC Boyle Reservoir (Figure A2) – the pattern is similar to that at Keno Dam, but WOP daily maxima are consistently several degrees cooler than EC. EC daily maxima can approach 30°C during mid-summer, so the increase in daily maxima of several degrees above the system potential (WOP) is biologically significant.

Boyle Bypass Reach: a short reach (about 7.2 km) around which all but 100 cfs is diverted during typical operations (except during high flows). Conditions above the ~230 cfs springs that enter about 0.8 km below JC Boyle Dam reflect the condition of water emanating from JC Boyle Reservoir. The rest of the reach is dominated by condition of the water from the springs.

1. Below JC Boyle Dam (Figure A3) – Releases from JC Boyle Dam (100 cfs during summer and fall) are thermally moderated by the reservoir, with little diel or interannual variation relative to that of the system potential (WOP). During summer, WOP daily maxima are about 1-2°C higher than EC, but EC daily minima are about 3-5°C warmer than WOP, resulting in WOP daily means that are several degrees cooler than EC.
2. Above JC Boyle Powerhouse (Figure A4) – The spring-dominated flow in this reach, resulting from diversion and bypass of all but 100 cfs at JC Boyle Dam under EC, varies little on a diel, interannual, or seasonal basis compared to the potential condition under WOP. Temperatures under WOP almost always exceed those under EC (frequently by 2-4°C) during the warm months, and then the condition flips during cold periods.

Boyle Peaking Reach: extends 25.7 km from Boyle Powerhouse to Copco 1 Reservoir, and is subjected to extreme flow fluctuations from a daily base flow of about 330 cfs to daily peak flows of 1300 cfs (single turbine) to 2600 cfs (both turbines).

1. Below JC Boyle Powerhouse (Figure A5) –At the top of the Boyle Peaking Reach, EC thermal patterns are unique, being driven by the peaking operation. During summer and fall off-peak periods, the only flow entering this reach is the 330 cfs from the Boyle Bypass Reach. Therefore, the daily minima are nearly identical to those in the Boyle Bypass Reach (Figure 8), because peaking usually occurs on a daily basis. Daily

maxima, on the other hand, are driven by on-peak flows diverted from JC Boyle Reservoir. Therefore, daily maxima are nearly the same as those below JC Boyle Dam (Figure A3). The end result is a diel fluctuation of 6-10°C during the summer accompanied by a corresponding fluctuation in flow from about 1300 (single turbine) to 2600 cfs (both turbines). WOP daily maxima are similar to EC, but summer-time daily means under WOP are 1-2°C warmer than EC because the daily minima are 2-3°C warmer.

2. At State Line (Figure A6) – Thermal patterns for WOP change little from those at the top end of the peaking reach (Figure A5). Conversely, EC daily maxima and minima increase by several degrees. WOP daily minima are about 1°C warmer than EC during the warmest time periods, and about equal otherwise. WOP daily means are slightly cooler than EC, and WOP daily maxima are several degrees cooler than EC.
3. Above Copco Reservoir (Figure A7) – At the bottom end of the Boyle Peaking Reach, WOP temperatures are consistently cooler than EC, with similar magnitudes of interannual variation.

Below Copco Dam: extends 319 km to the Pacific Ocean. No riverine reaches exist above Iron Gate Dam under EC because all peaking flows from Copco 1 Dam are diverted at Copco 2 Dam and enter the upper end of Iron Gate Reservoir. However, riverine conditions are simulated at the dam locations under various dam removal scenarios. Effects of Copco and Iron Gate reservoirs dominate this reach downstream to approximately Seiad Valley at rkm 207.6.

1. Below Copco Dam (Figure A8) – Thermal patterns for EC vary little on a diel or interannual basis, a direct result of the reservoir's thermal inertia. EC temperatures almost never drop below 20°C from July 16 – August 26, whereas WOP temperatures range to 15°C. The biggest departure from system potential is the 2-5°C elevation of daily minima from August-October under EC, which is accompanied by 1-4°C increases over WOP for daily means and maxima. During May, daily maxima are 1-2°C warmer under WOP, but lower daily minima under WOP result in daily means similar between the two scenarios.
2. Below Iron Gate Dam (Figure A9) – Similarly to Below Copco Dam, EC temperatures are relatively invariant on a diel and interannual basis. WOP daily maxima are 2-4°C warmer than under EC from late April – July, but cooler WOP daily minima make daily means similar from June-July. Reservoir effluent is nearly always cooler from late April – May for all daily statistics. WOP daily minima are lower than EC from June-October, with the greatest differences occurring during August (3-4°C) and September-October (4-7°C). During mid-August to early September, nearly all EC daily means exceed 20°C, whereas most WOP daily means are below 20°C. Indeed, almost all EC temperatures, including daily minima, exceed 20°C from July 16 – September 9. In contrast, few WOP daily minima exceed 20°C.
3. Above Shasta River (Figure A10) – Moving downstream from Iron Gate Dam, the river shows more of a diel and interannual response to climatic conditions, as shown by lower daily minima, higher daily maxima, and more variation than at the dam (Figure A9). The tendency towards cooler temperatures during May under EC is still present, but dampened from the dam site. WOP maximum temperatures are nearly always lower than EC from June on, with differences frequently exceeding 3°C from mid-August on.
4. Above Scott River (Figure A11) – Patterns noted above the Shasta River are still present, though dampened. WOP temperatures during late-summer and fall cooling are still

several degrees cooler than EC. The tendency toward warmer May temperatures under WOP is present but weak.

5. At Seiad Valley (Figure A12) – Dampened patterns from the upstream sites remain, with the largest effect being the delay in late summer and fall cooling under EC. Similar effects can be seen as far downstream as the Salmon River, but the significance of small differences in model output below this point is questionable.

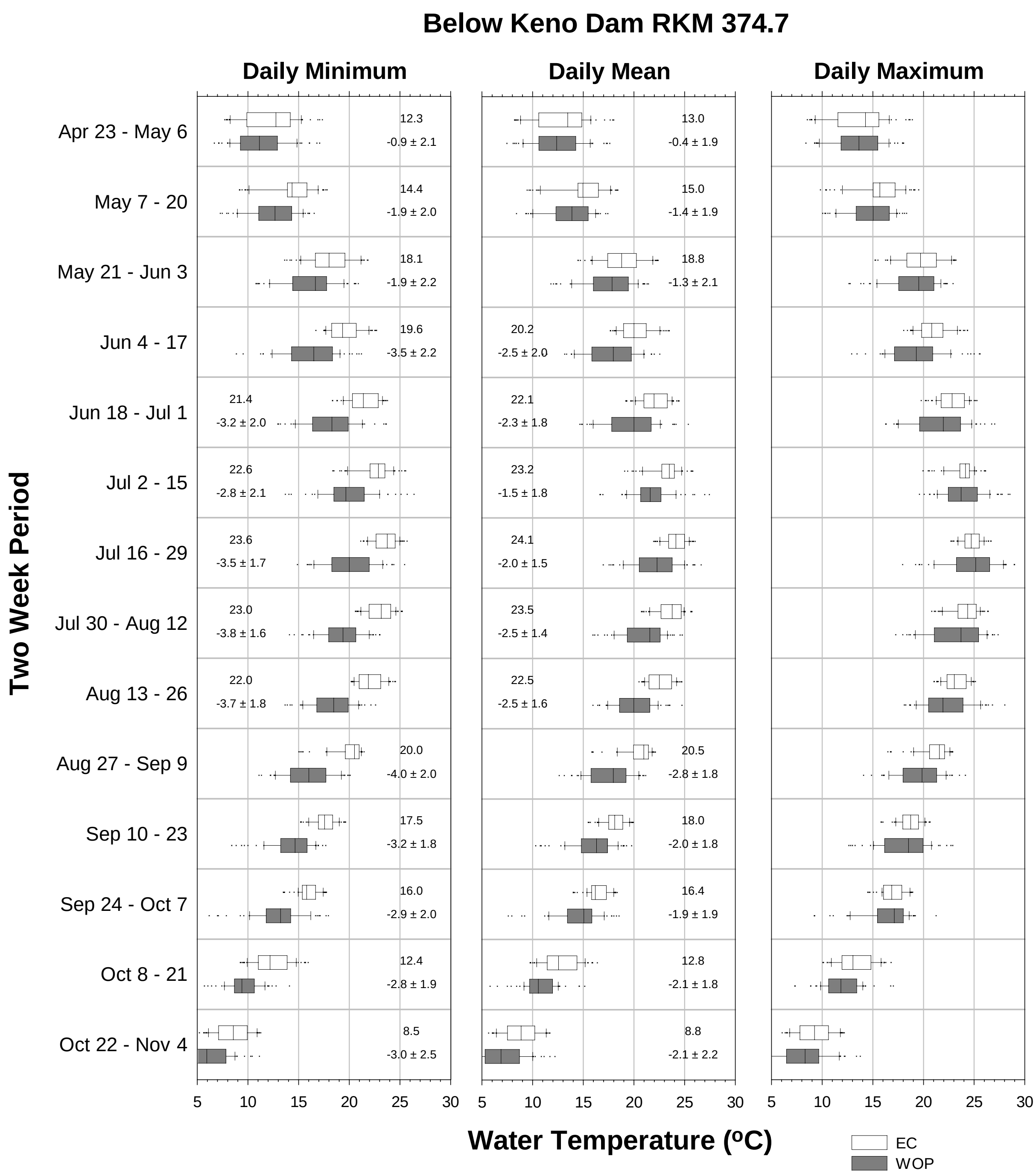

Figure A1. Box plots (line inside box is median, box ends are 25th and 75th percentiles, whisker ends are 10th and 90th percentiles, dots are outliers) of daily minimum, mean, and maximum temperatures predicted by the KRWQM below Keno Dam. Results for each day within two week periods from April - November over the five years modeled (70 days per individual box plot) are plotted for two KHP configurations: Existing Condition (EC) and Without Project (WOP). Numbers overlaying plots are the mean temperature under EC (top) and the mean difference (WOP-EC) ± 1 SD (bottom).

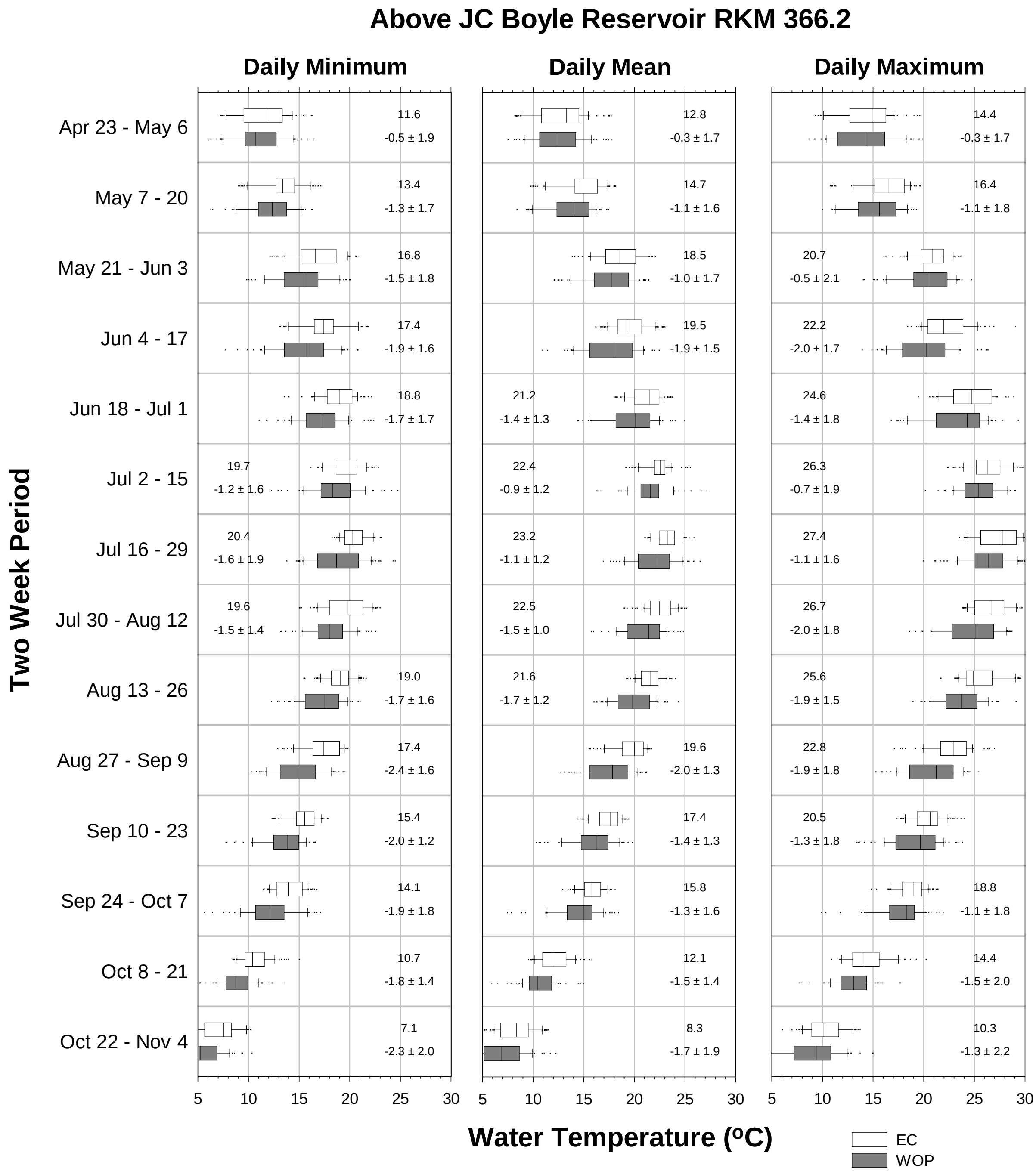

Figure A2. Box plots (line inside box is median, box ends are 25th and 75th percentiles, whisker ends are 10th and 90th percentiles, dots are outliers) of daily minimum, mean, and maximum temperatures predicted by the KRWQM above JC Boyle Reservoir. Results for each day within two week periods from April - November over the five years modeled (70 days per individual box plot) are plotted for two KHP configurations: Existing Condition (EC) and Without Project (WOP). Numbers overlaying plots are the mean temperature under EC (top) and the mean difference (WOP-EC) ± 1 SD (bottom).

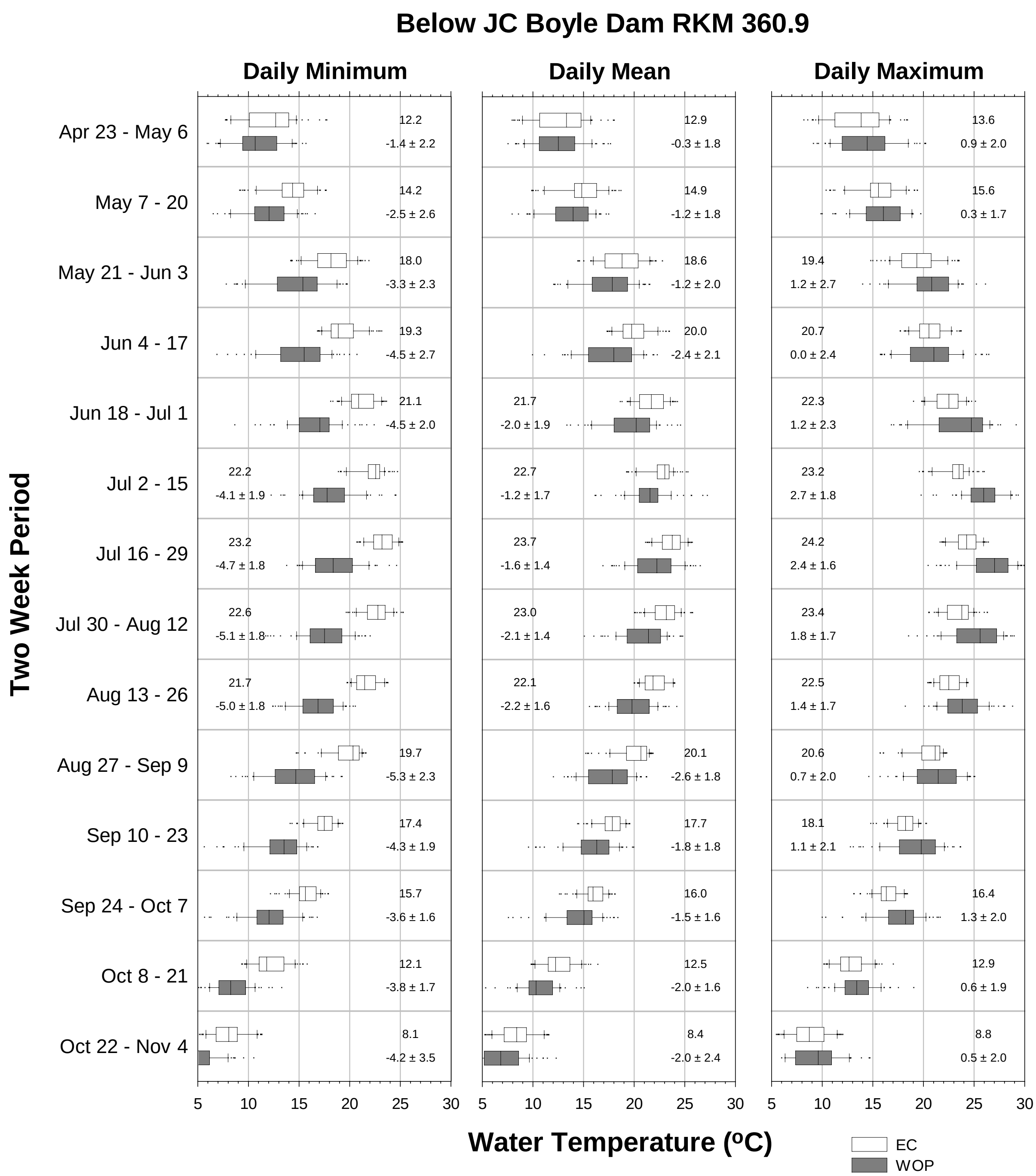

Figure A3. Box plots (line inside box is median, box ends are 25th and 75th percentiles, whisker ends are 10th and 90th percentiles, dots are outliers) of daily minimum, mean, and maximum temperatures predicted by the KRWQM below JC Boyle Dam. Results for each day within two week periods from April - November over the five years modeled (70 days per individual box plot) are plotted for two KHP configurations: Existing Condition (EC) and Without Project (WOP). Numbers overlaying plots are the mean temperature under EC (top) and the mean difference (WOP-EC) ± 1 SD (bottom).

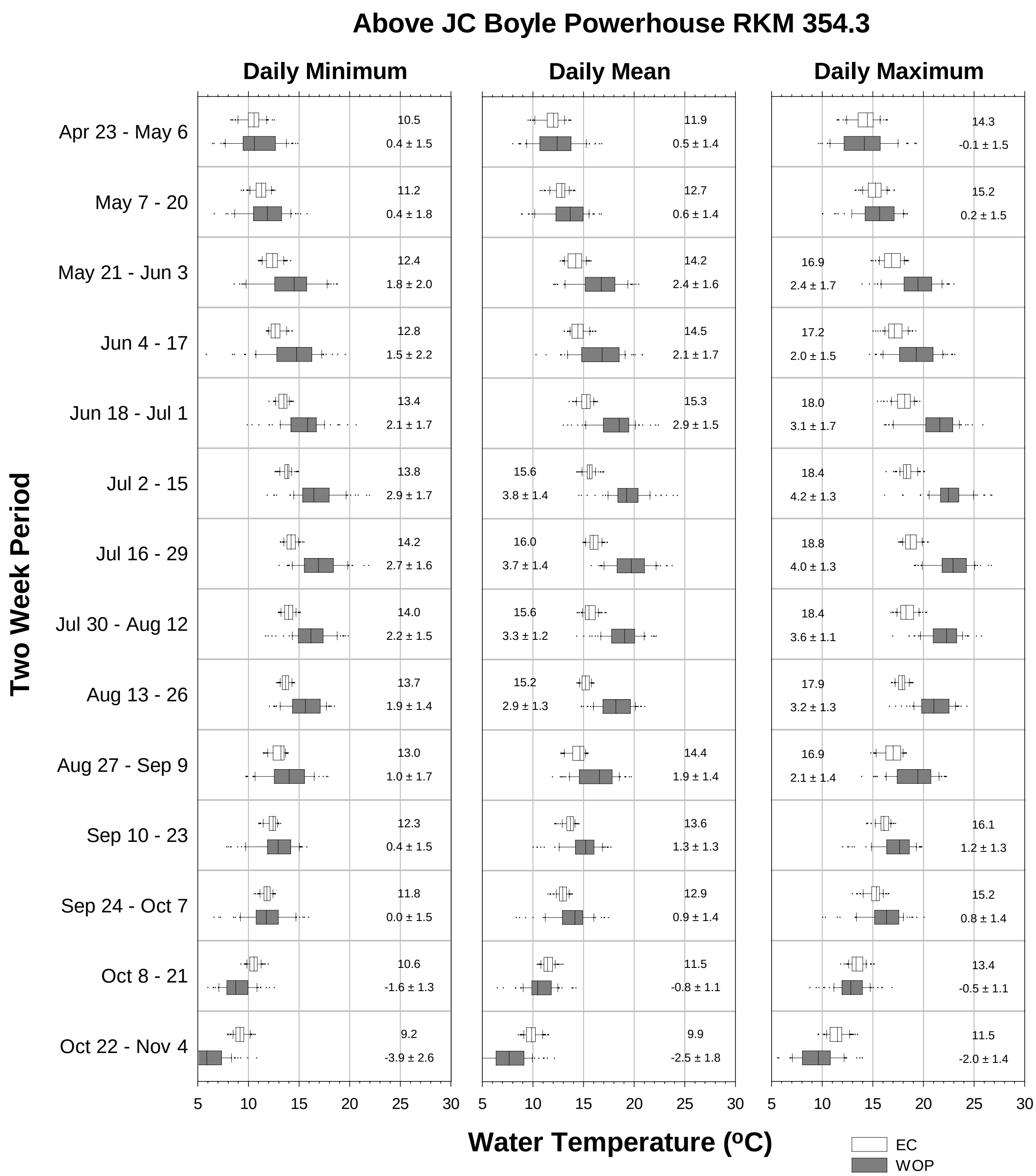

Figure A4. Box plots (line inside box is median, box ends are 25th and 75th percentiles, whisker ends are 10th and 90th percentiles, dots are outliers) of daily minimum, mean, and maximum temperatures predicted by the KRWQM above JC Boyle Powerhouse. Results for each day within two week periods from April - November over the five years modeled (70 days per individual box plot) are plotted for two KHP configurations: Existing Condition (EC) and Without Project (WOP). Numbers overlaying plots are the mean temperature under EC (top) and the mean difference (WOP-EC) ± 1 SD (bottom).

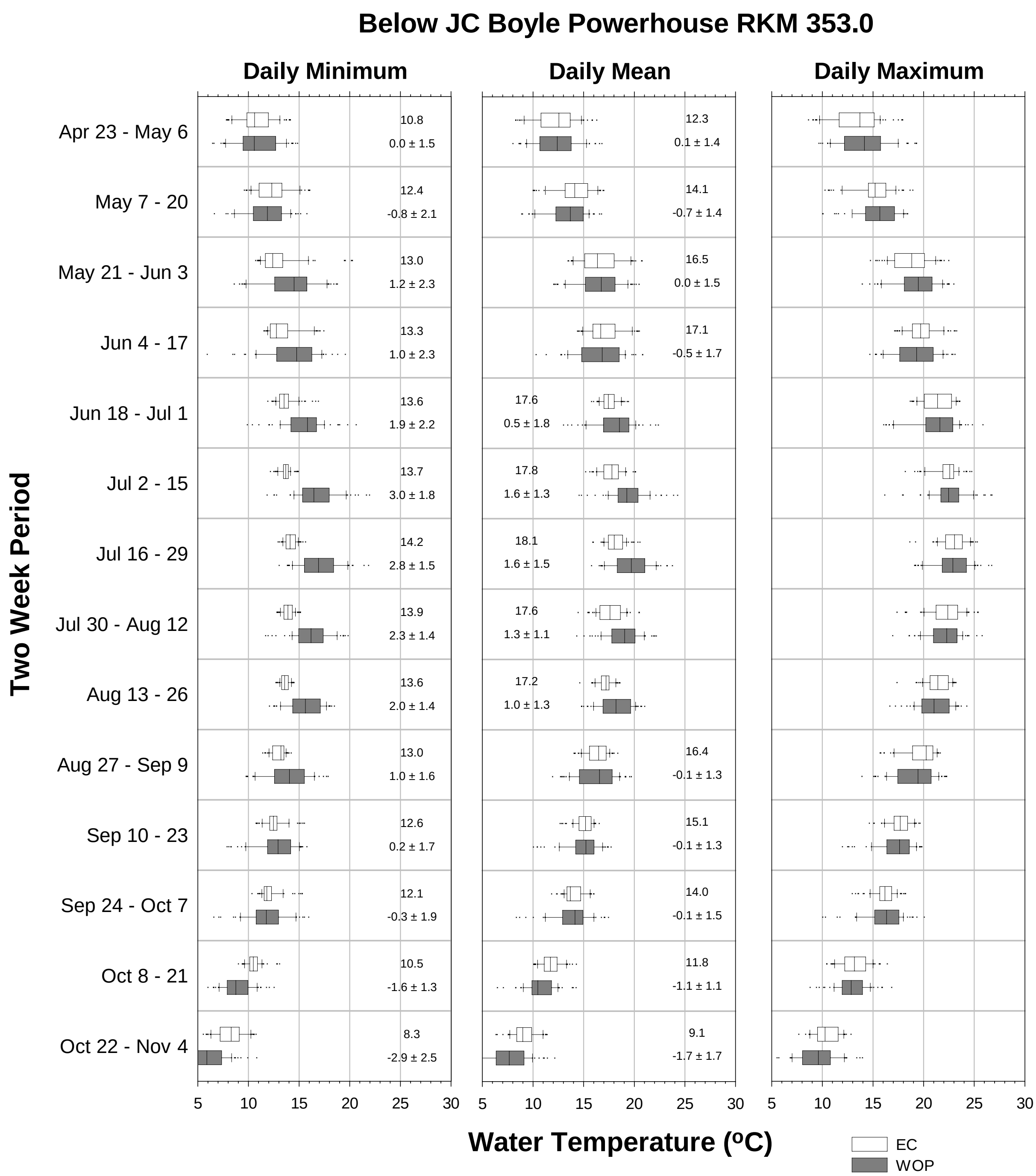

Figure A5. Box plots (line inside box is median, box ends are 25th and 75th percentiles, whisker ends are 10th and 90th percentiles, dots are outliers) of daily minimum, mean, and maximum temperatures predicted by the KRWQM below JC Boyle Powerhouse. Results for each day within two week periods from April - November over the five years modeled (70 days per individual box plot) are plotted for two KHP configurations: Existing Condition (EC) and Without Project (WOP). Numbers overlaying plots are the mean temperature under EC (top) and the mean difference (WOP-EC) ± 1 SD (bottom).

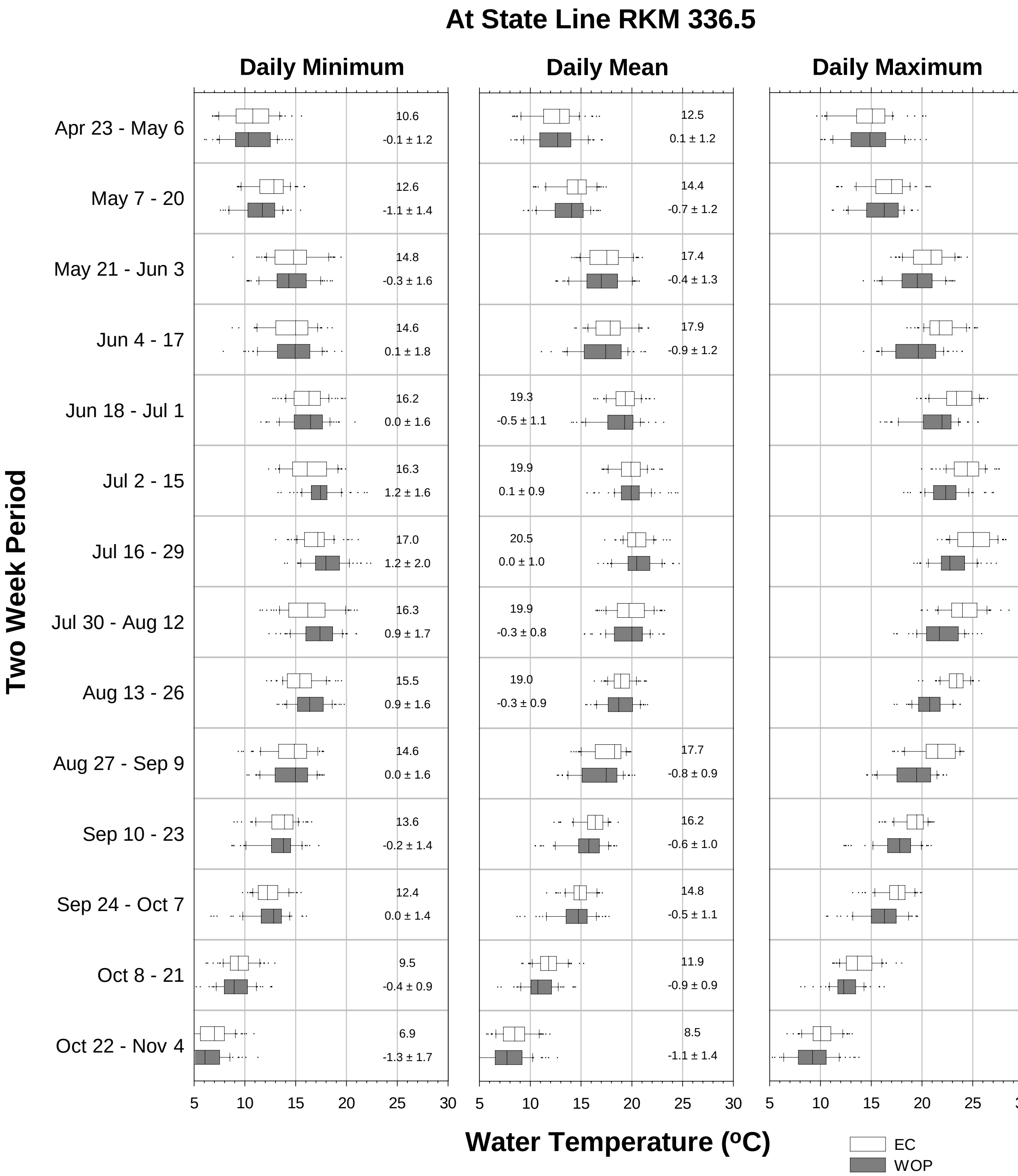

Figure A6. Box plots (line inside box is median, box ends are 25th and 75th percentiles, whisker ends are 10th and 90th percentiles, dots are outliers) of daily minimum, mean, and maximum temperatures predicted by the KRWQM at State Line. Results for each day within two week periods from April - November over the five years modeled (70 days per individual box plot) are plotted for two KHP configurations: Existing Condition (EC) and Without Project (WOP). Numbers overlaying plots are the mean temperature under EC (top) and the mean difference (WOP-EC) ± 1 SD (bottom).

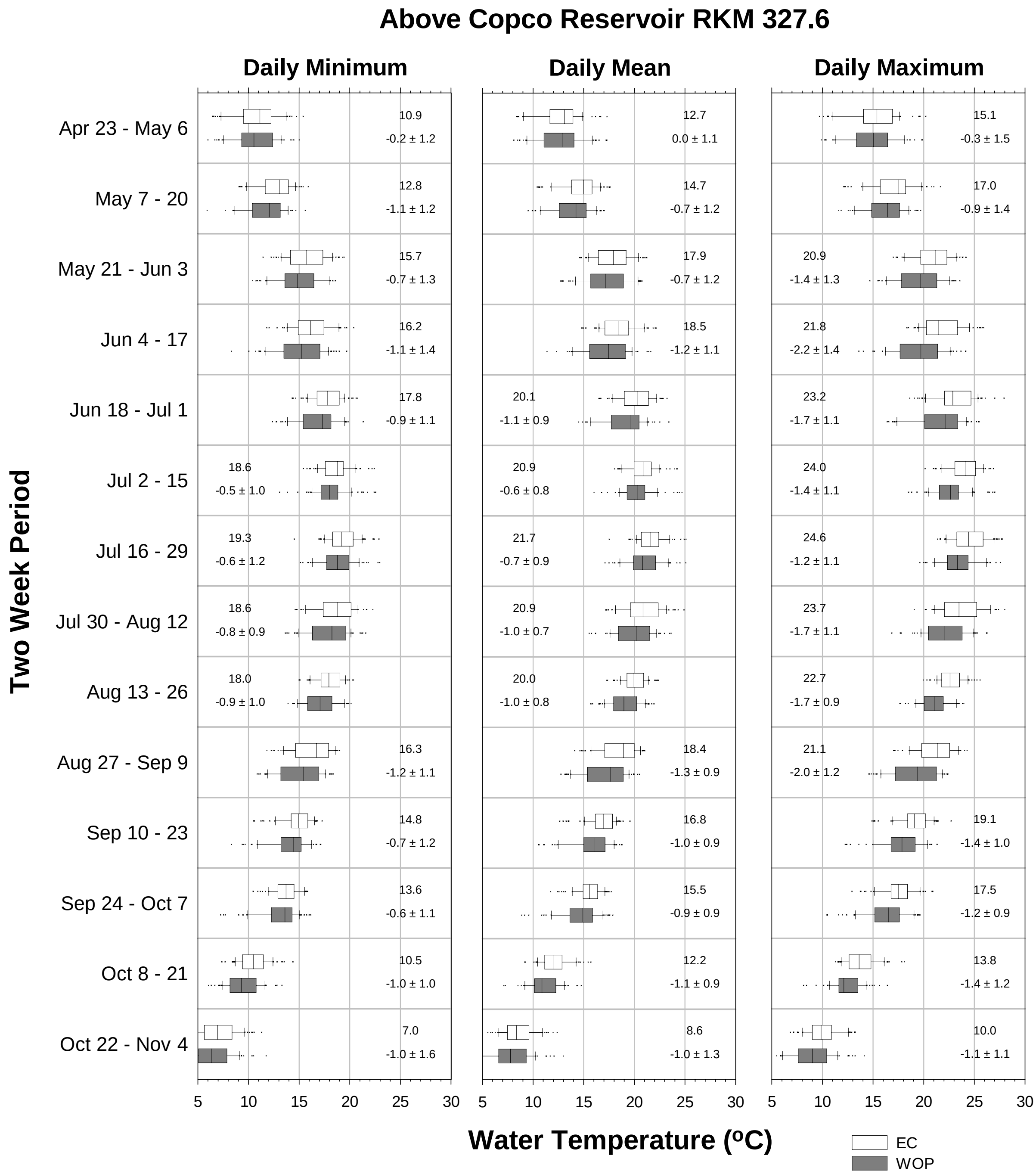

Figure A7. Box plots (line inside box is median, box ends are 25th and 75th percentiles, whisker ends are 10th and 90th percentiles, dots are outliers) of daily minimum, mean, and maximum temperatures predicted by the KRWQM above Copco Reservoir. Results for each day within two week periods from April - November over the five years modeled (70 days per individual box plot) are plotted for two KHP configurations: Existing Condition (EC) and Without Project (WOP). Numbers overlaying plots are the mean temperature under EC (top) and the mean difference (WOP-EC) ± 1 SD (bottom).

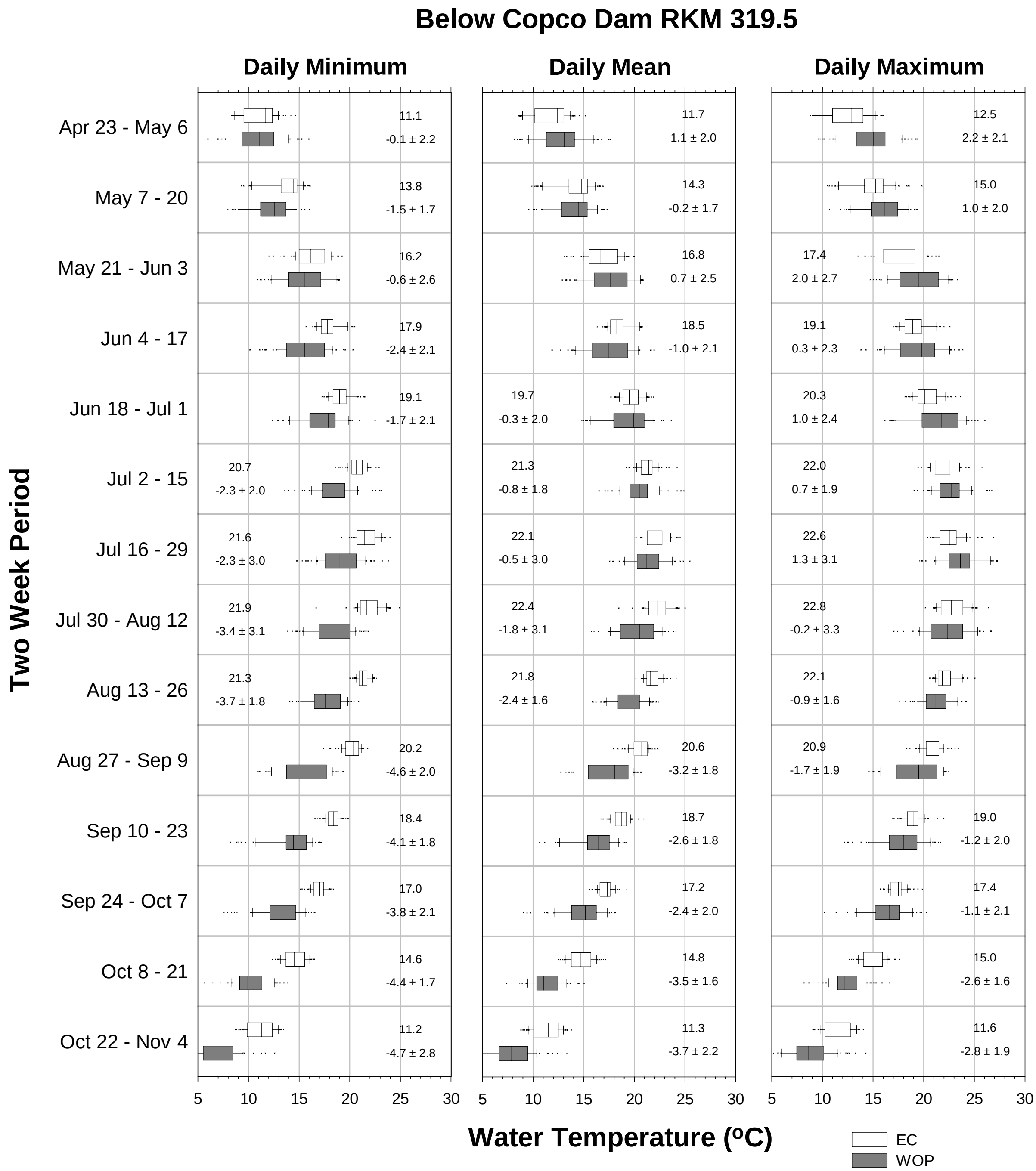

Figure A8. Box plots (line inside box is median, box ends are 25th and 75th percentiles, whisker ends are 10th and 90th percentiles, dots are outliers) of daily minimum, mean, and maximum temperatures predicted by the KRWQM at Copco Dam. Results for each day within two week periods from April - November over the five years modeled (70 days per individual box plot) are plotted for two KHP configurations: Existing Condition (EC) and Without Project (WOP). Numbers overlaying plots are the mean temperature under EC (top) and the mean difference (WOP-EC) ± 1 SD (bottom).

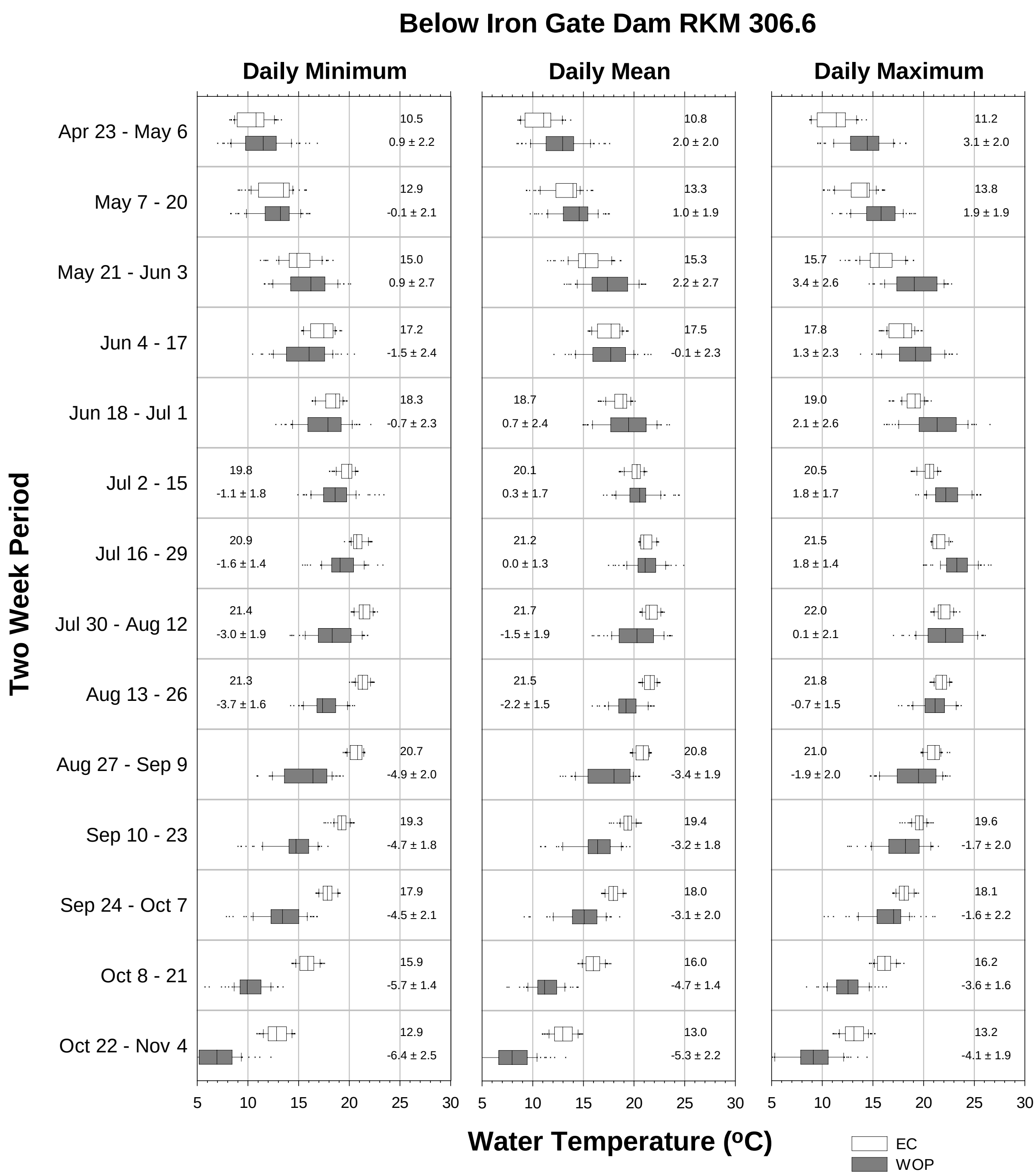

Figure A9. Box plots (line inside box is median, box ends are 25th and 75th percentiles, whisker ends are 10th and 90th percentiles, dots are outliers) of daily minimum, mean, and maximum temperatures predicted by the KRWQM at Iron Gate Dam. Results for each day within two week periods from April - November over the five years modeled (70 days per individual box plot) are plotted for two KHP configurations: Existing Condition (EC) and Without Project (WOP). Numbers overlaying plots are the mean temperature under EC (top) and the mean difference (WOP-EC) ± 1 SD (bottom).

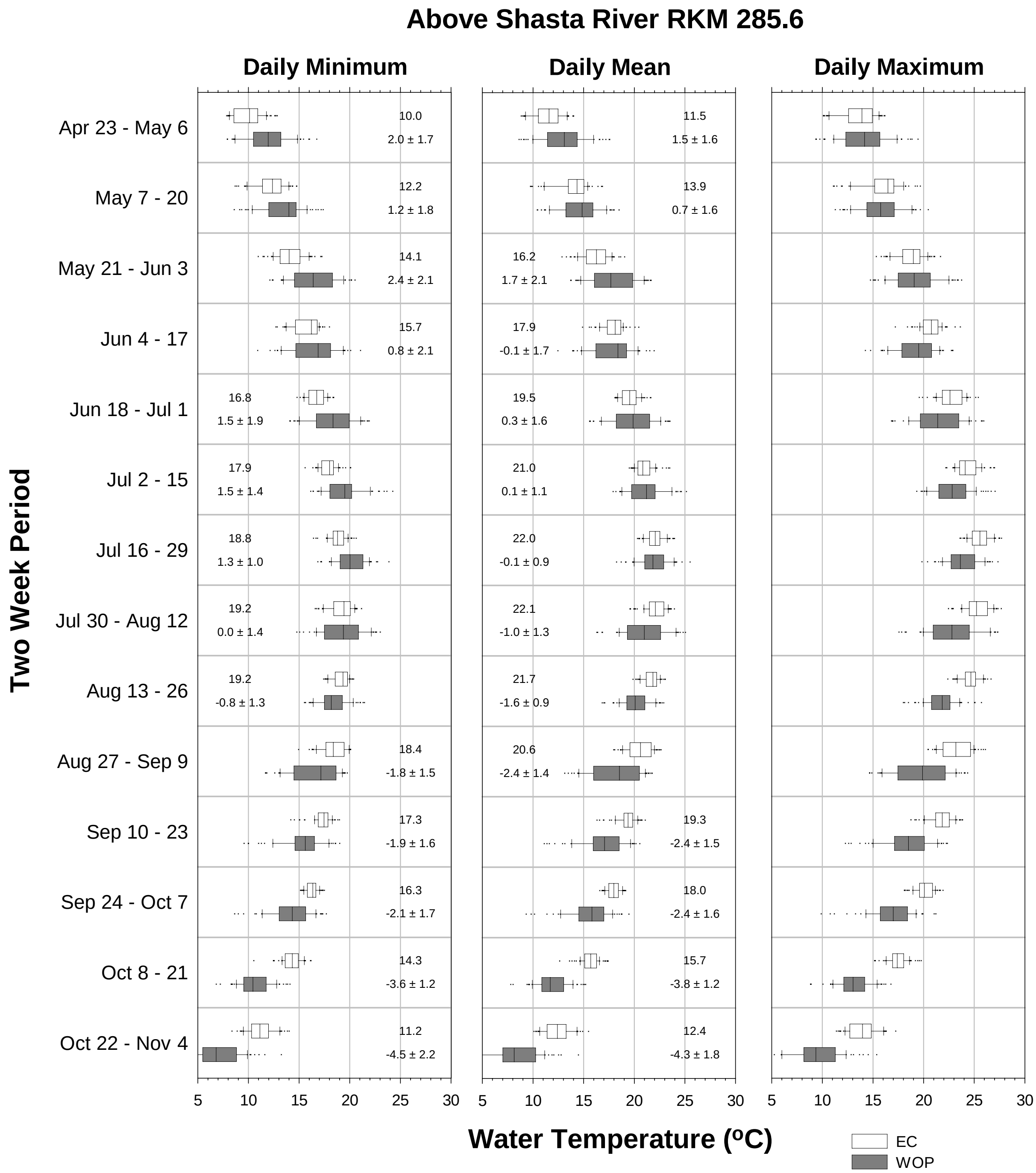

Figure A10. Box plots (line inside box is median, box ends are 25th and 75th percentiles, whisker ends are 10th and 90th percentiles, dots are outliers) of daily minimum, mean, and maximum temperatures predicted by the KRWQM above the Shasta River. Results for each day within two week periods from April - November over the five years modeled (70 days per individual box plot) are plotted for two KHP configurations: Existing Condition (EC) and Without Project (WOP). Numbers overlaying plots are the mean temperature under EC (top) and the mean difference (WOP-EC) ± 1 SD (bottom).

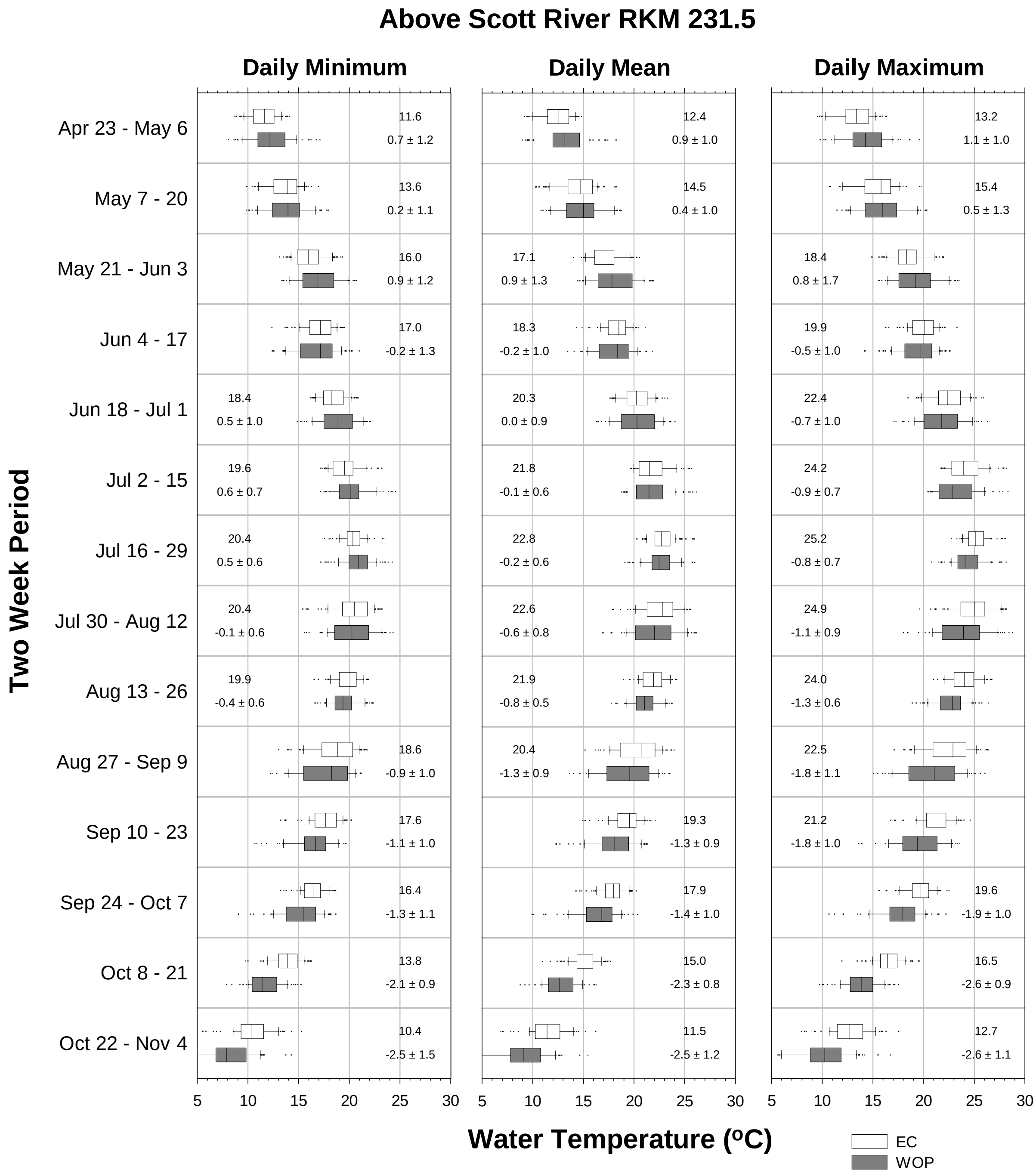

Figure A11. Box plots (line inside box is median, box ends are 25th and 75th percentiles, whisker ends are 10th and 90th percentiles, dots are outliers) of daily minimum, mean, and maximum temperatures predicted by the KRWQM above the Scott River. Results for each day within two week periods from April - November over the five years modeled (70 days per individual box plot) are plotted for two KHP configurations: Existing Condition (EC) and Without Project (WOP). Numbers overlaying plots are the mean temperature under EC (top) and the mean difference (WOP-EC) ± 1 SD (bottom).

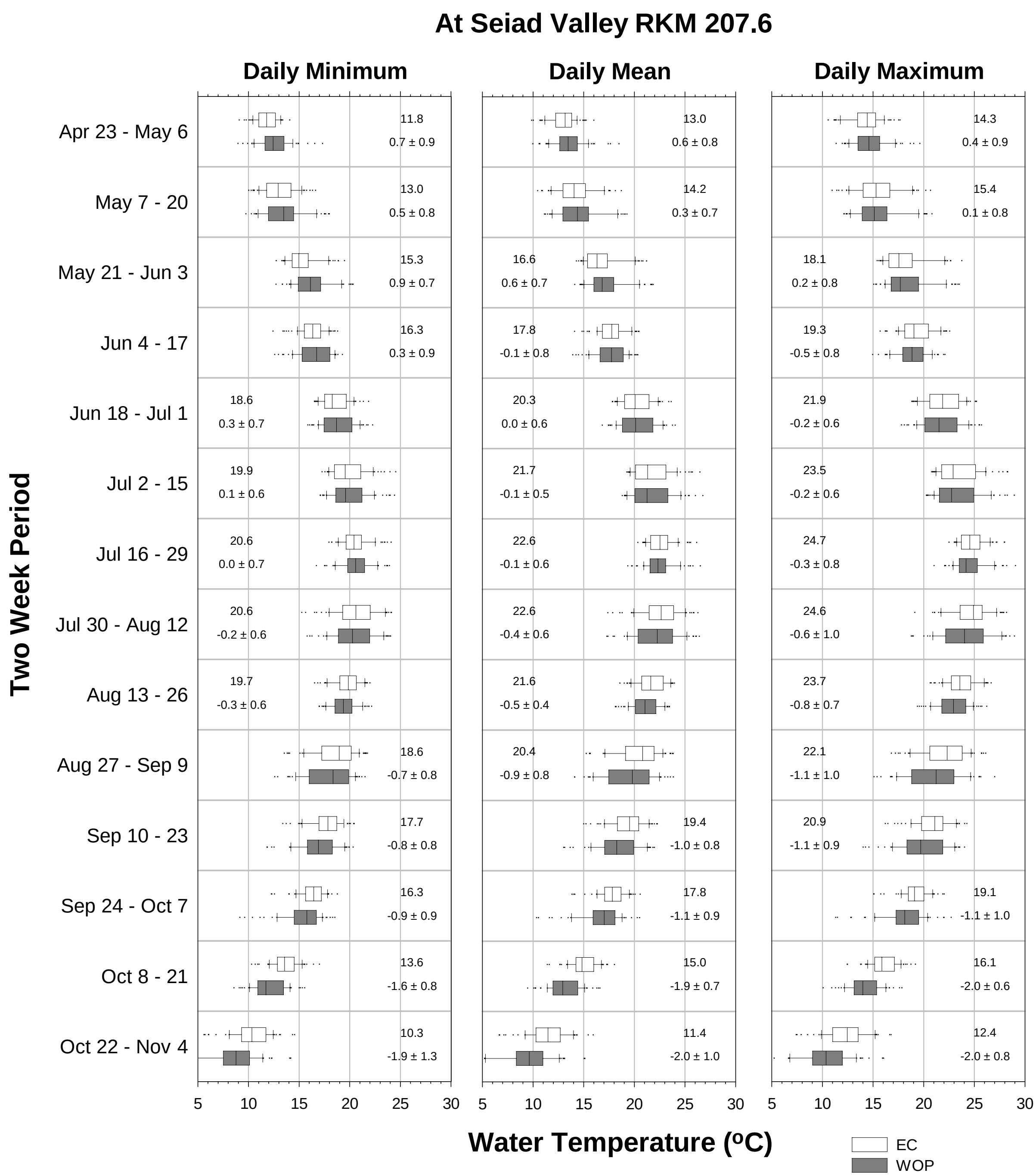

Figure A12. Box plots (line inside box is median, box ends are 25th and 75th percentiles, whisker ends are 10th and 90th percentiles, dots are outliers) of daily minimum, mean, and maximum temperatures predicted by the KRWQM at Seiad Valley. Results for each day within two week periods from April - November over the five years modeled (70 days per individual box plot) are plotted for two KHP configurations: Existing Condition (EC) and Without Project (WOP). Numbers overlaying plots are the mean temperature under EC (top) and the mean difference (WOP-EC) ± 1 SD (bottom).

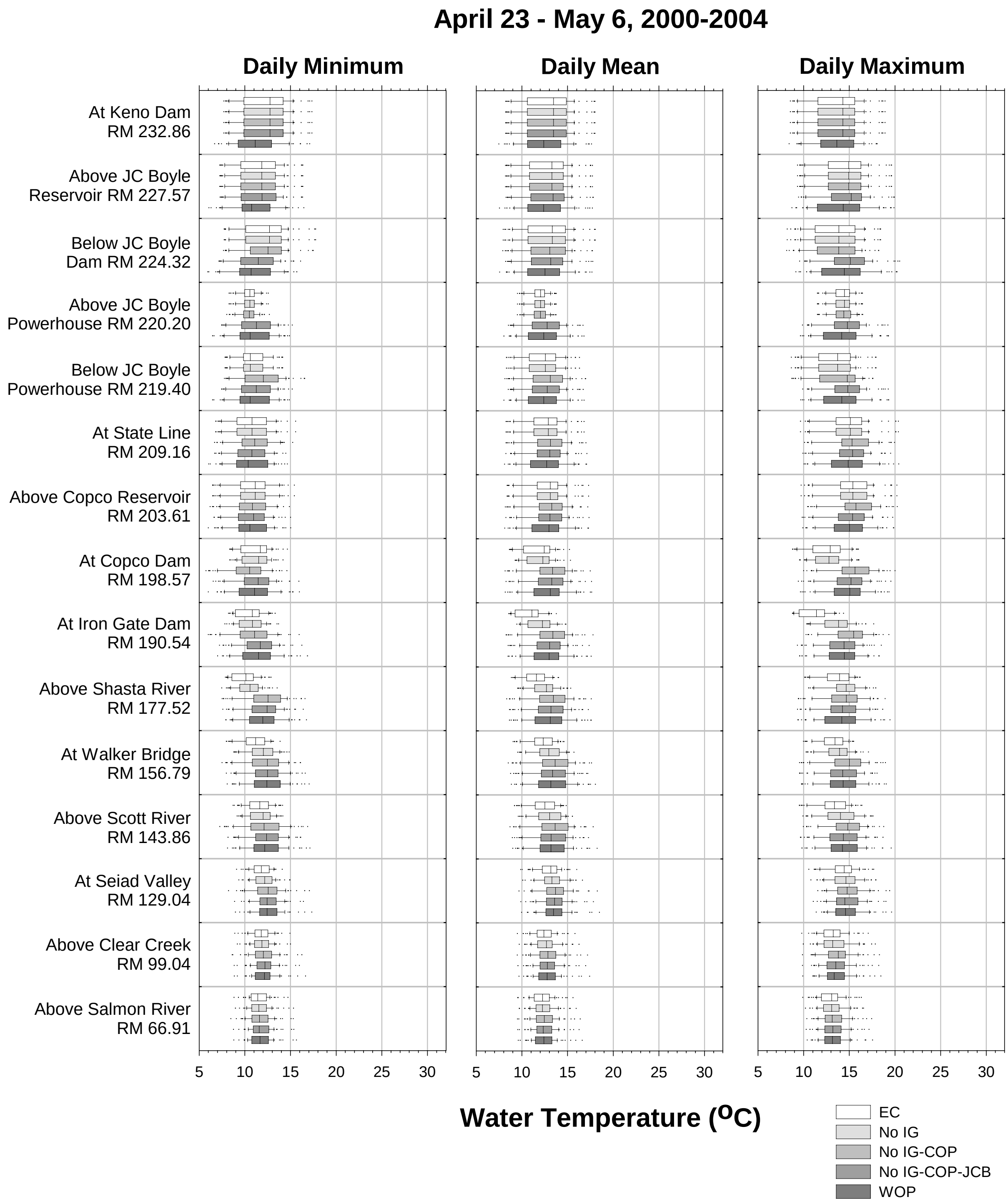

Figure A13. Box plots (line inside box is median, box ends are 25th and 75th percentiles, whisker ends are 10th and 90th percentiles, dots are outliers) of daily minimum, mean, and maximum temperatures for each day from April 23-May 6 over the five years modeled (70 days per individual box plot) for five dam removal scenarios.

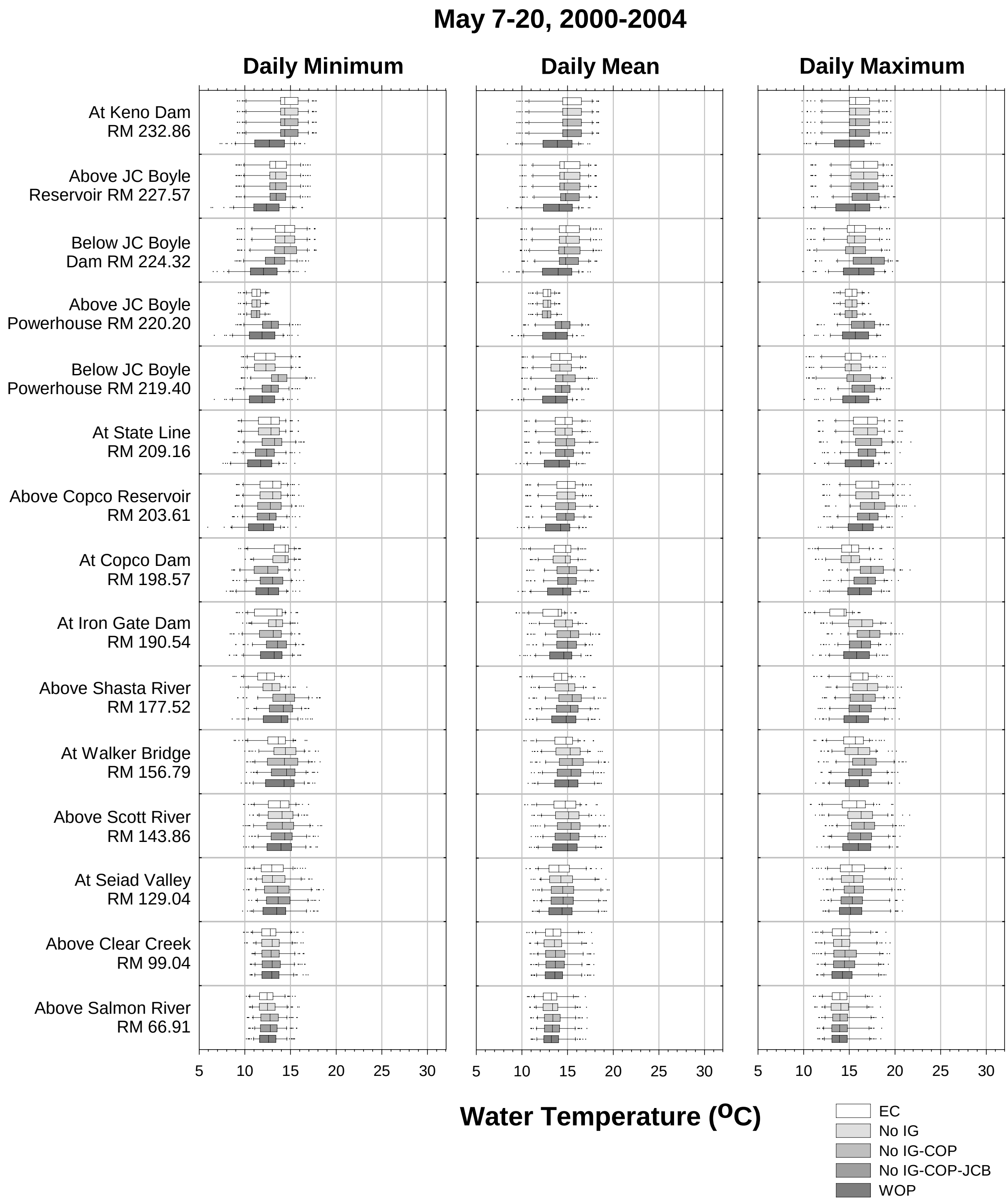

Figure A14. Box plots (line inside box is median, box ends are 25th and 75th percentiles, whisker ends are 10th and 90th percentiles, dots are outliers) of daily minimum, mean, and maximum temperatures for each day from May 7-20 over the five years modeled (70 days per individual box plot) for five dam removal scenarios.

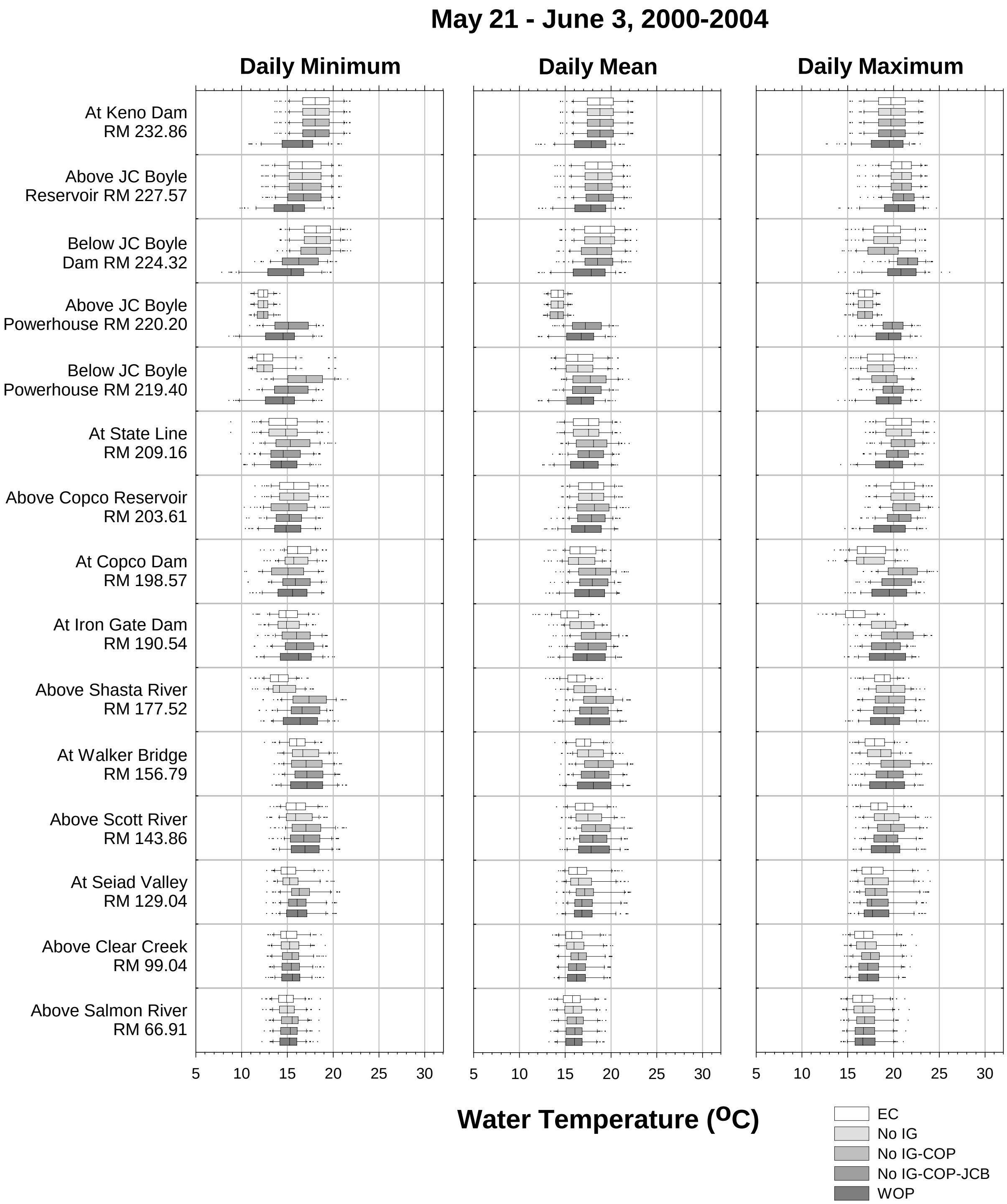

Figure A15. Box plots (line inside box is median, box ends are 25th and 75th percentiles, whisker ends are 10th and 90th percentiles, dots are outliers) of daily minimum, mean, and maximum temperatures for each day from May 21 – June 3 over the five years modeled (70 days per individual box plot) for five dam removal scenarios.

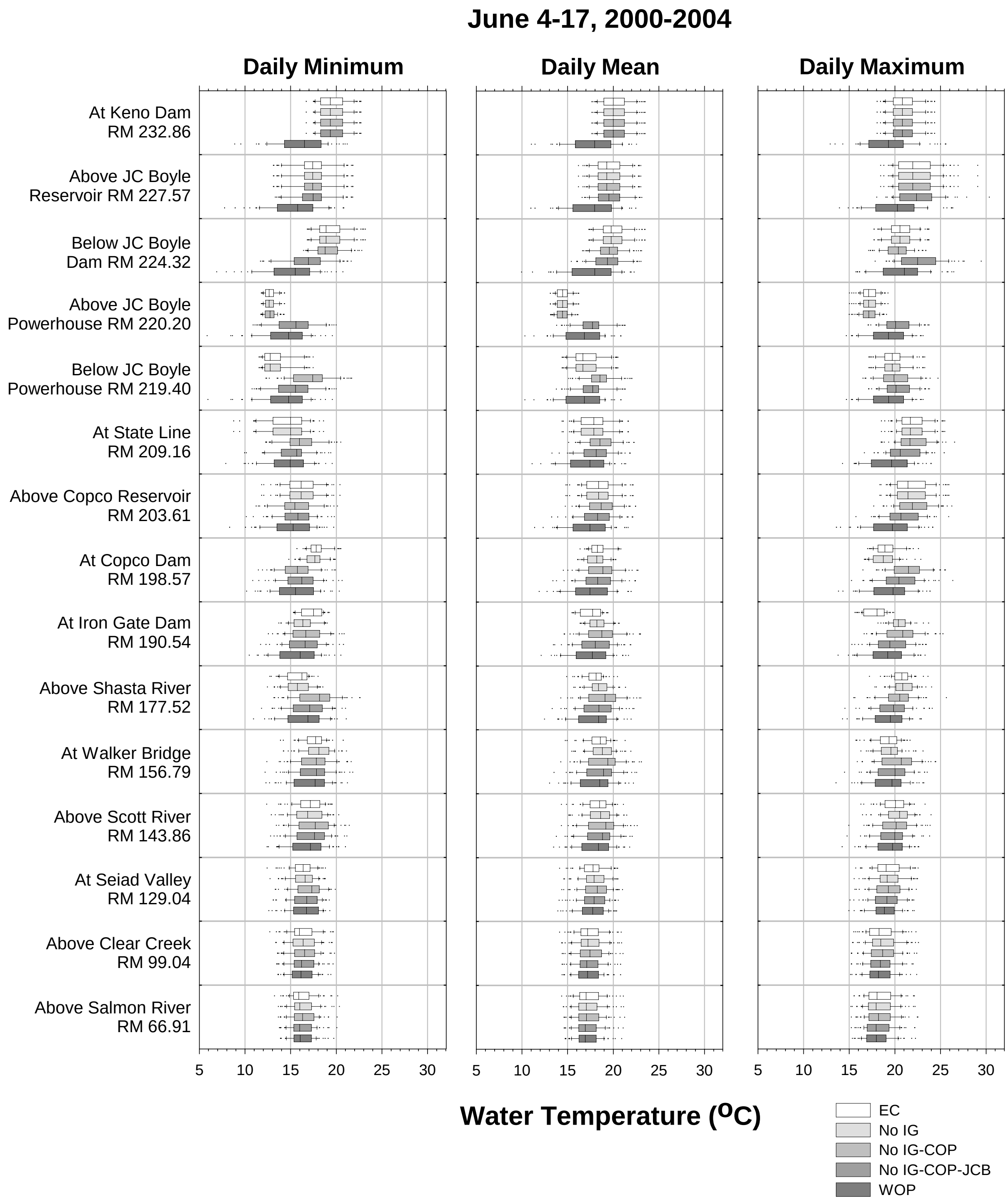

Figure A16. Box plots (line inside box is median, box ends are 25th and 75th percentiles, whisker ends are 10th and 90th percentiles, dots are outliers) of daily minimum, mean, and maximum temperatures for each day from June 4-17 over the five years modeled (70 days per individual box plot) for five dam removal scenarios.

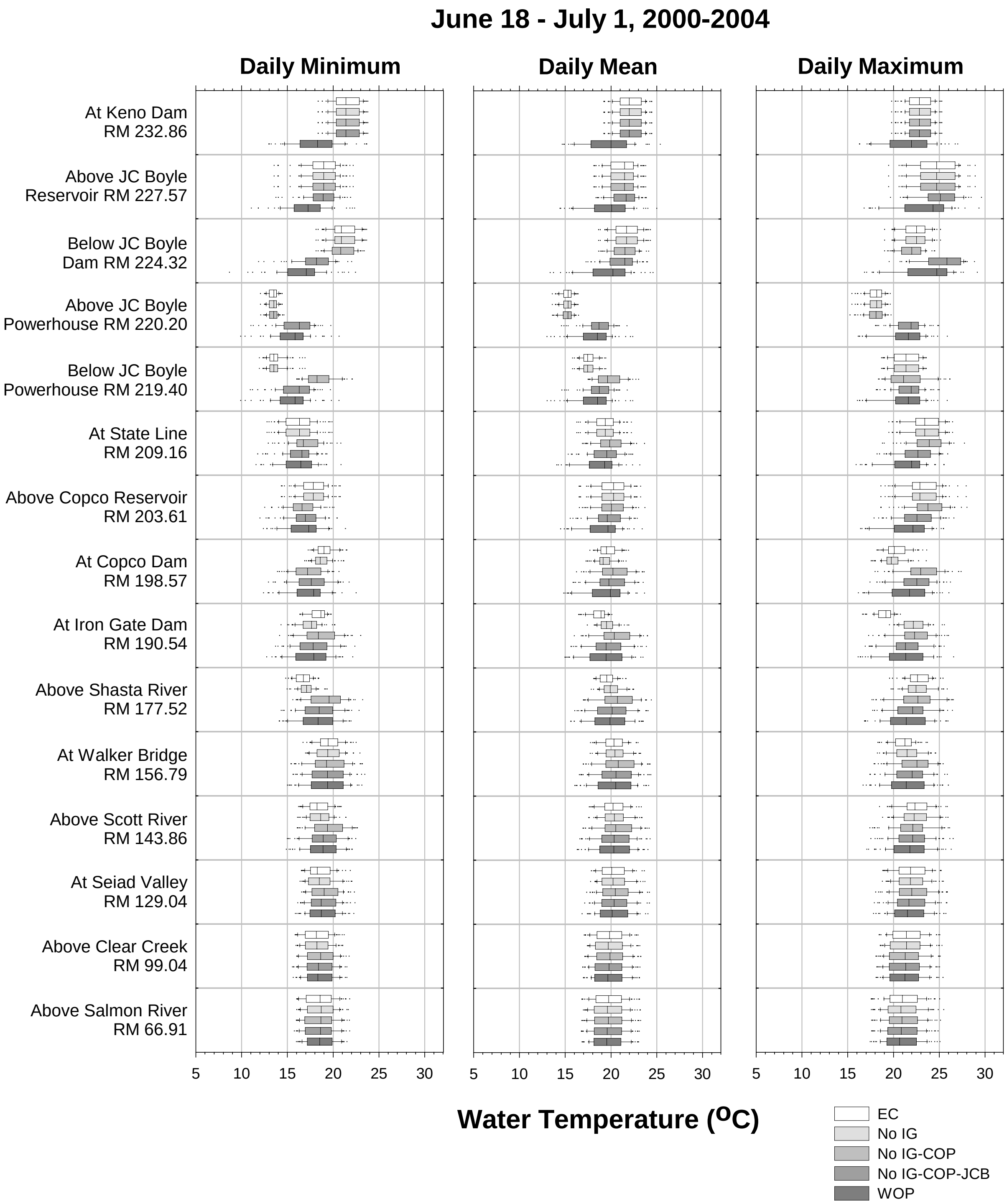

Figure A17. Box plots (line inside box is median, box ends are 25th and 75th percentiles, whisker ends are 10th and 90th percentiles, dots are outliers) of daily minimum, mean, and maximum temperatures for each day from June 18 - July 1 over the five years modeled (70 days per individual box plot) for five dam removal scenarios.

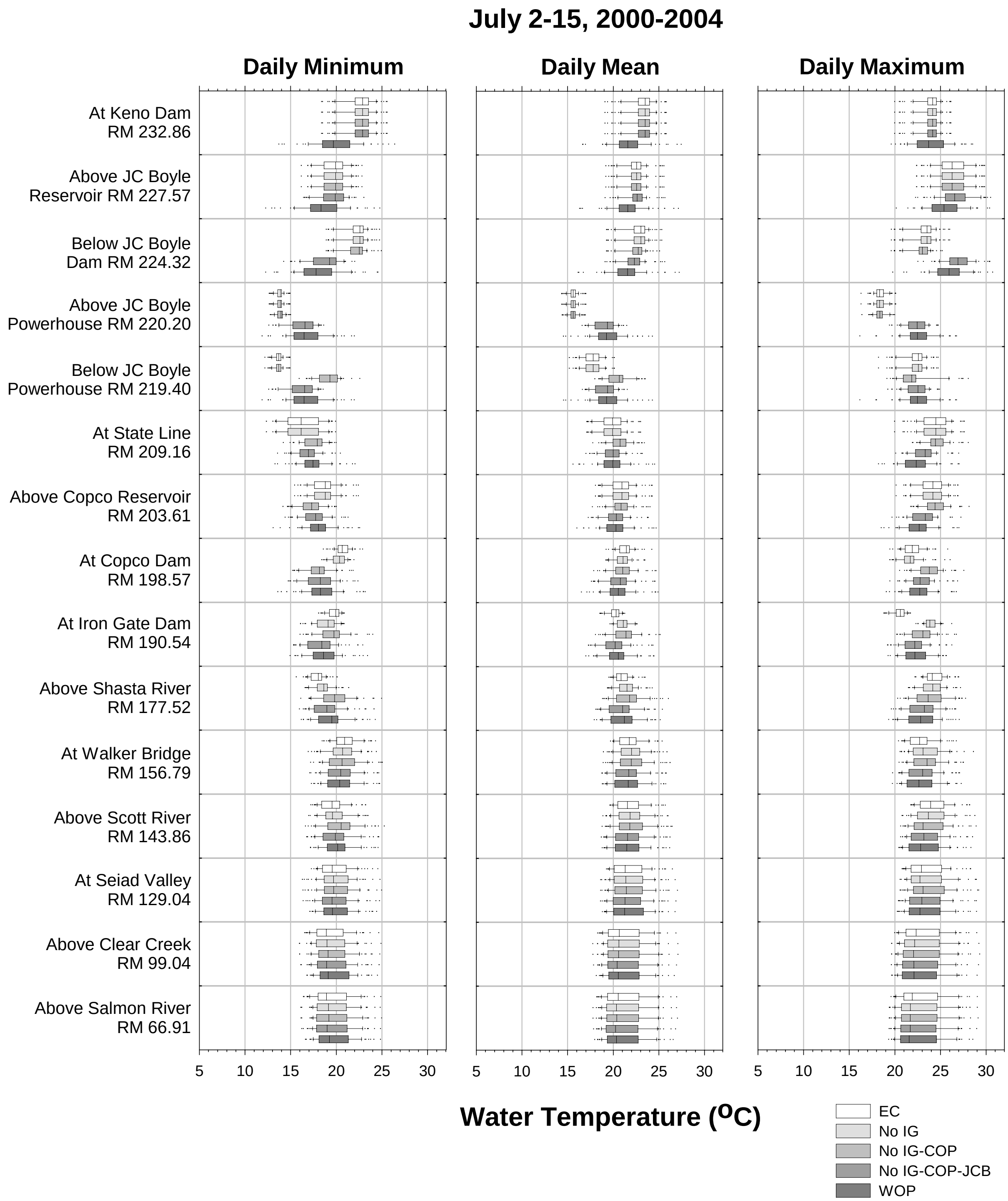

Figure A18. Box plots (line inside box is median, box ends are 25th and 75th percentiles, whisker ends are 10th and 90th percentiles, dots are outliers) of daily minimum, mean, and maximum temperatures for each day from July 2-15 over the five years modeled (70 days per individual box plot) for five dam removal scenarios.

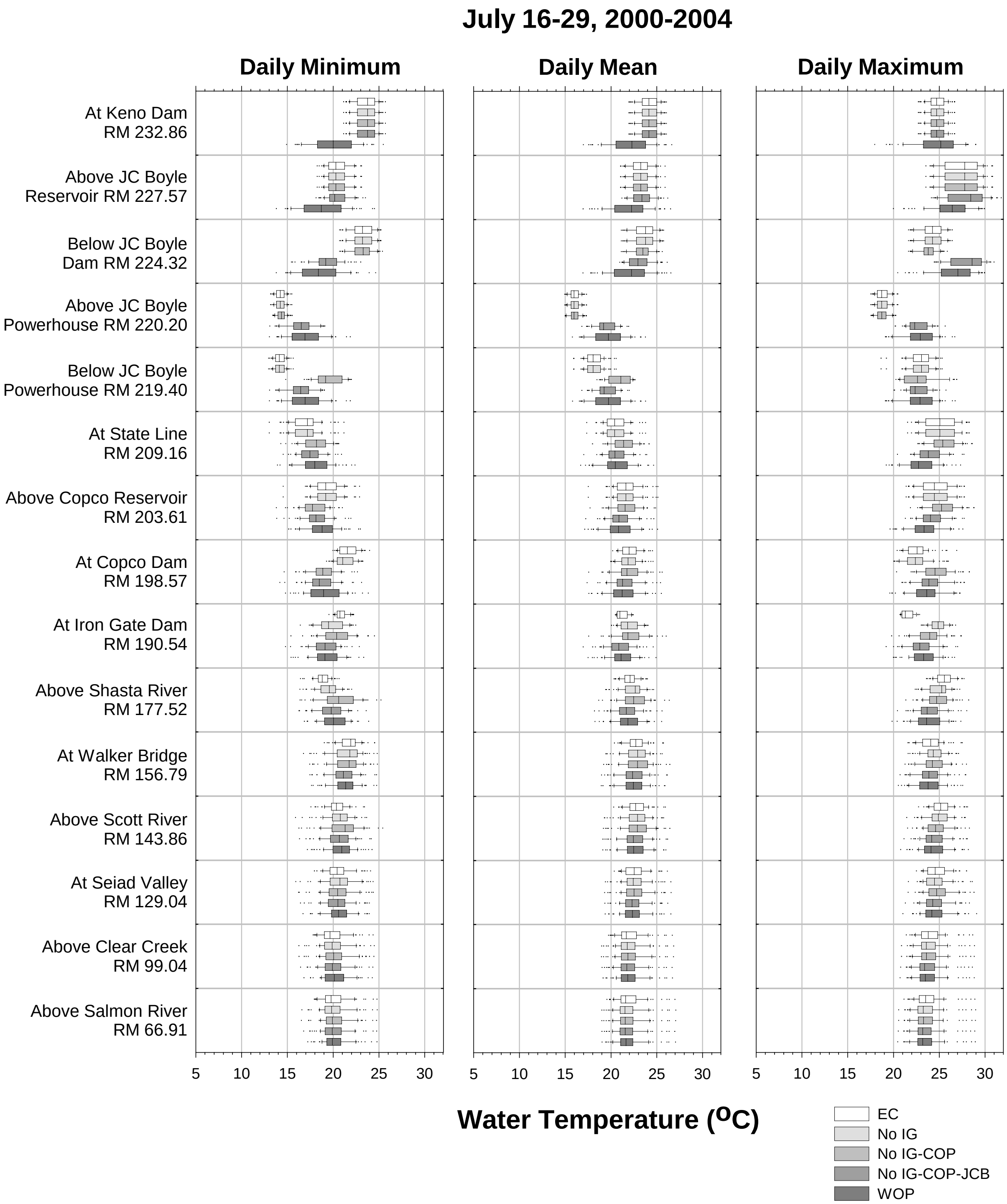

Figure A19. Box plots (line inside box is median, box ends are 25th and 75th percentiles, whisker ends are 10th and 90th percentiles, dots are outliers) of daily minimum, mean, and maximum temperatures for each day from July 16-29 over the five years modeled (70 days per individual box plot) for five dam removal scenarios.

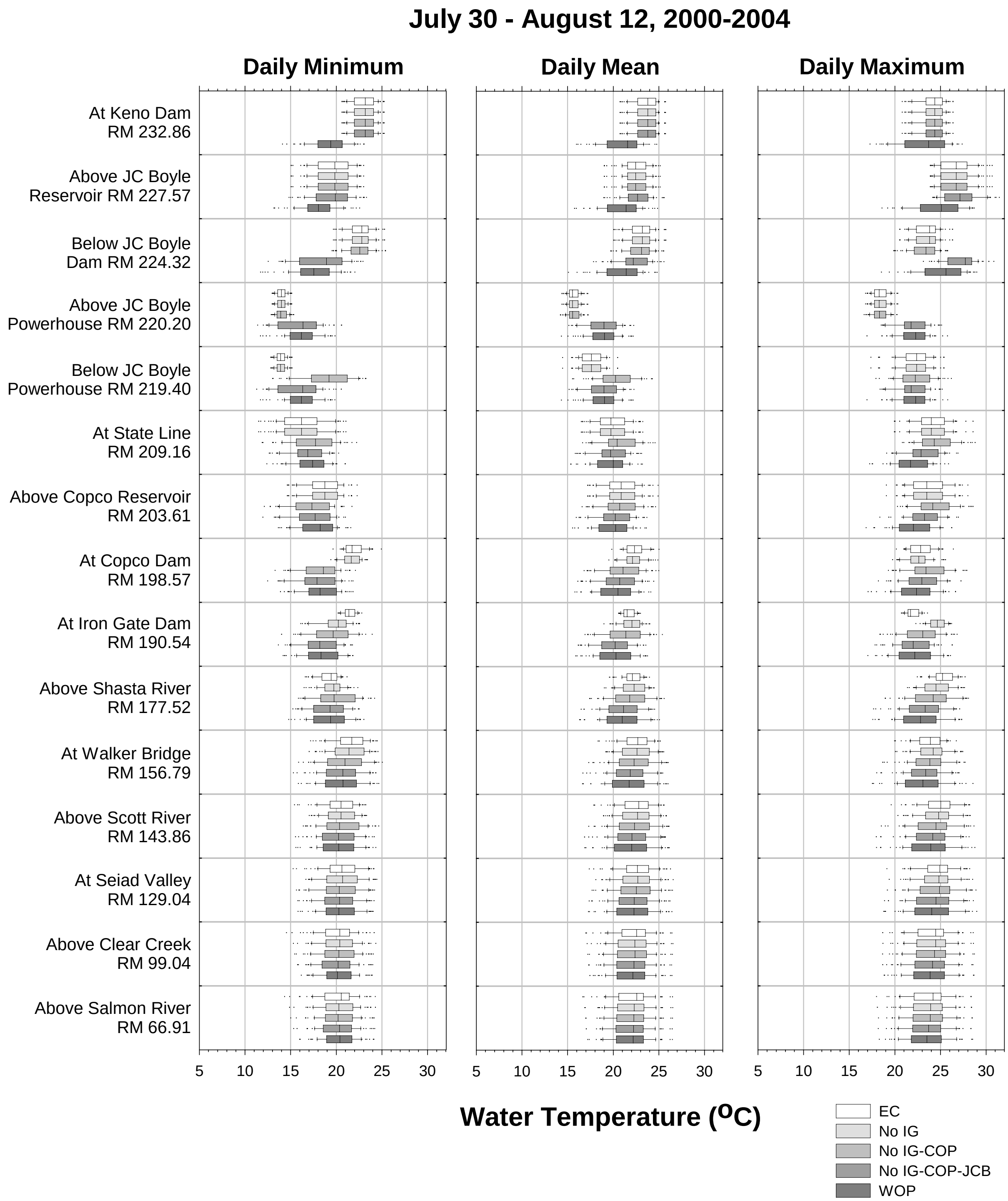

Figure A20. Box plots (line inside box is median, box ends are 25th and 75th percentiles, whisker ends are 10th and 90th percentiles, dots are outliers) of daily minimum, mean, and maximum temperatures for each day from July 30 - August 12 over the five years modeled (70 days per individual box plot) for five dam removal scenarios.

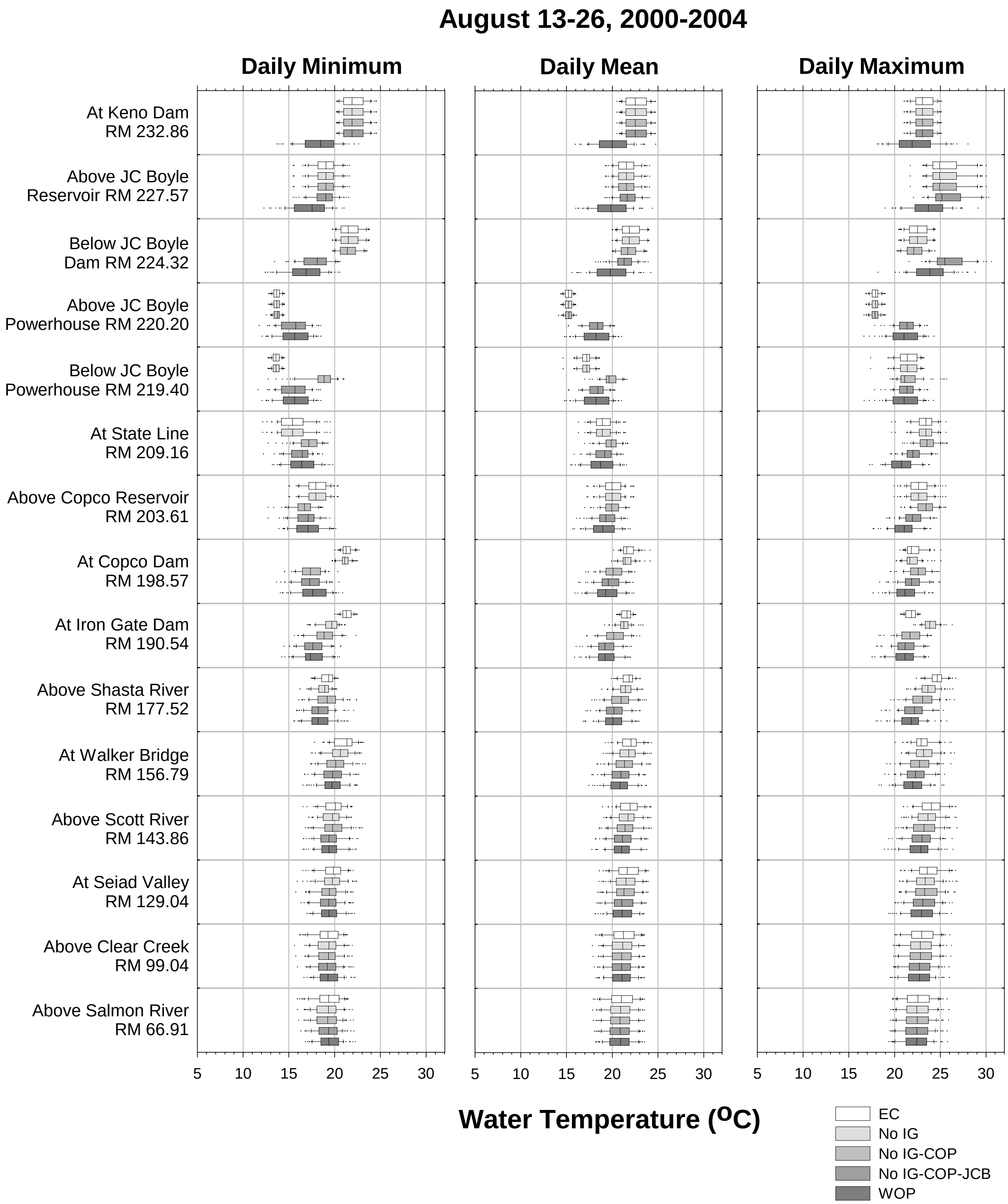

Figure A21. Box plots (line inside box is median, box ends are 25th and 75th percentiles, whisker ends are 10th and 90th percentiles, dots are outliers) of daily minimum, mean, and maximum temperatures for each day from August 13-26 over the five years modeled (70 days per individual box plot) for five dam removal scenarios.

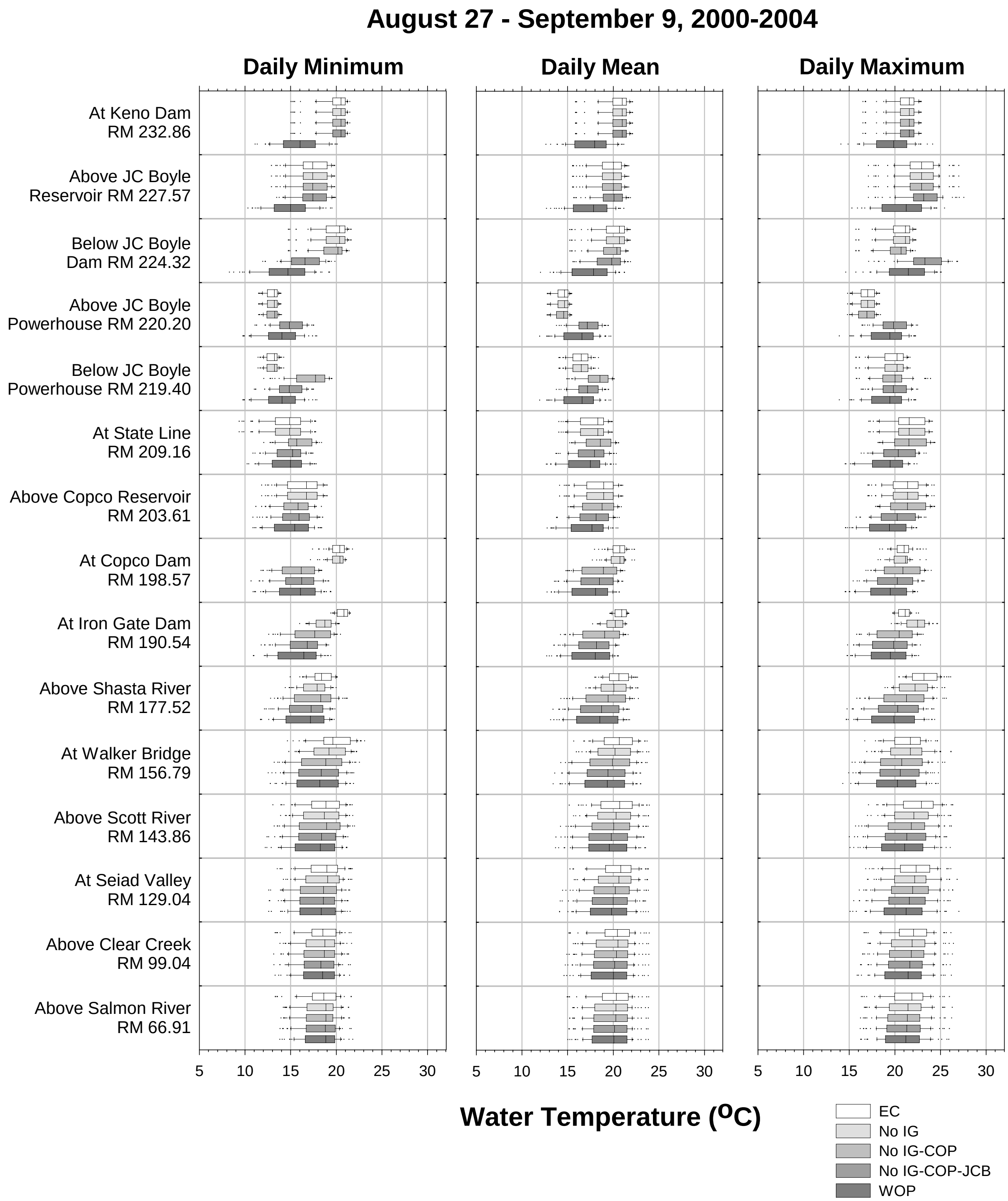

Figure A22. Box plots (line inside box is median, box ends are 25th and 75th percentiles, whisker ends are 10th and 90th percentiles, dots are outliers) of daily minimum, mean, and maximum temperatures for each day from August 27 - September 9 over the five years modeled (70 days per individual box plot) for five dam removal scenarios.

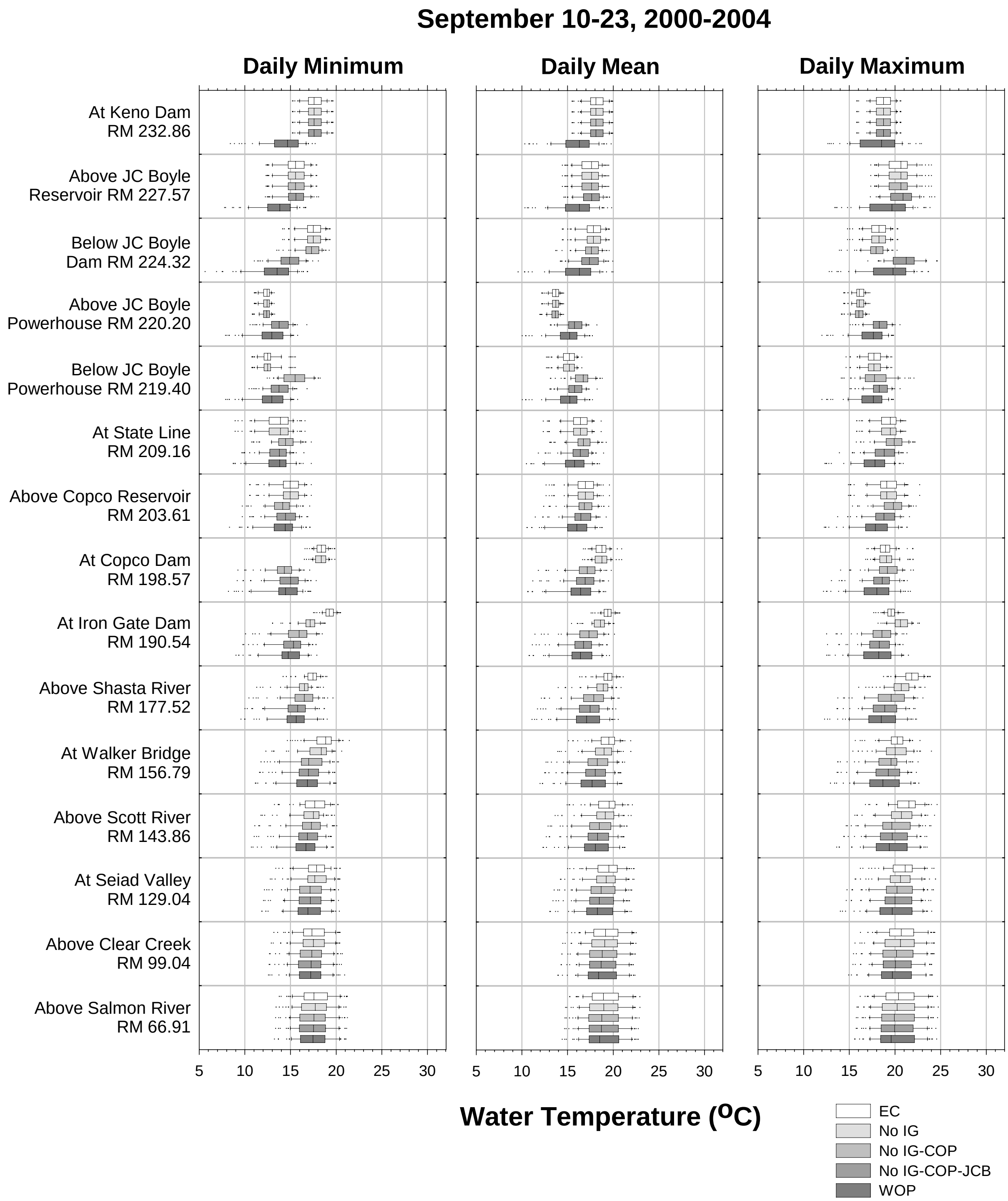

Figure A23. Box plots (line inside box is median, box ends are 25th and 75th percentiles, whisker ends are 10th and 90th percentiles, dots are outliers) of daily minimum, mean, and maximum temperatures for each day from September 10-23 over the five years modeled (70 days per individual box plot) for five dam removal scenarios.

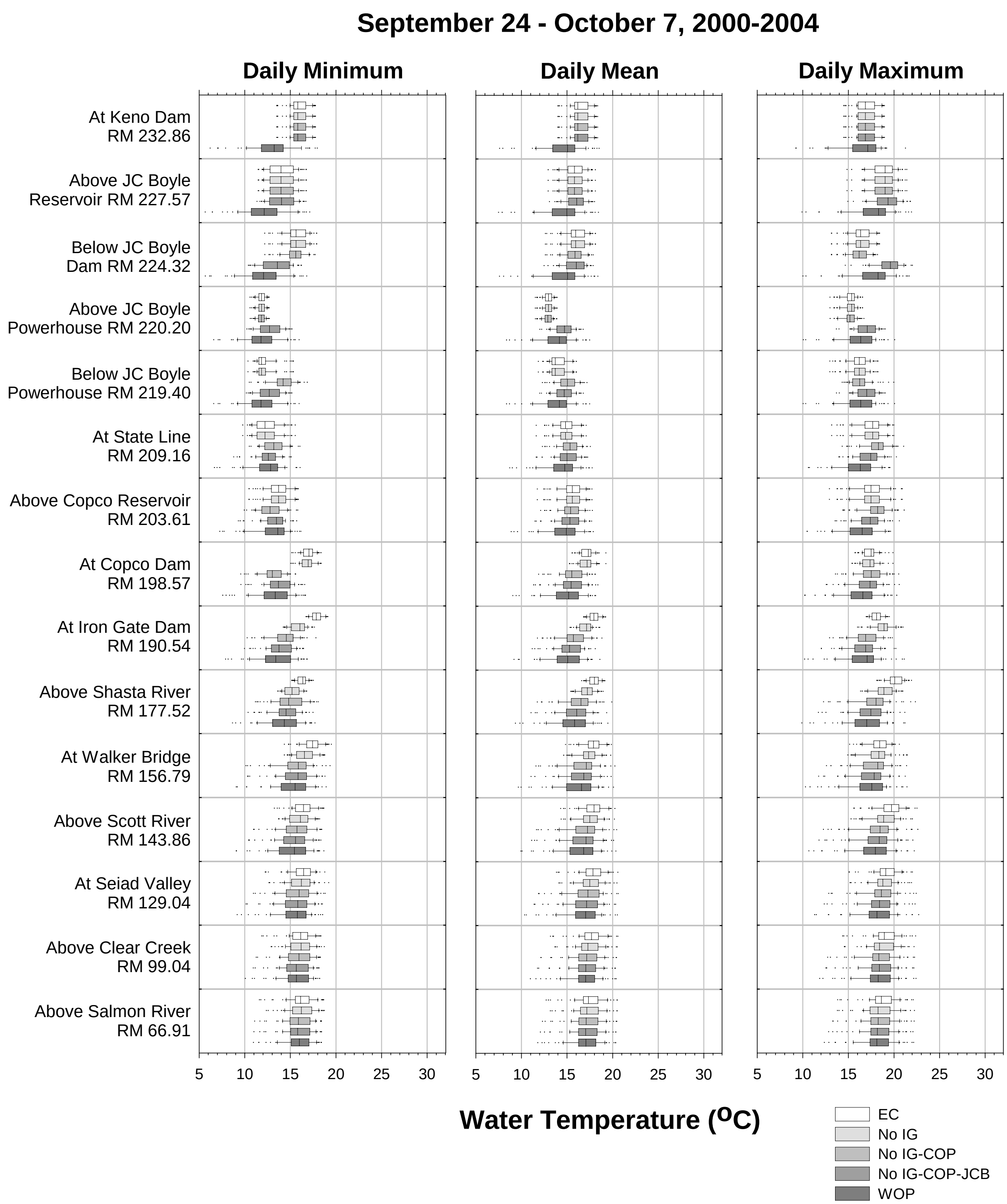

Figure A24. Box plots (line inside box is median, box ends are 25th and 75th percentiles, whisker ends are 10th and 90th percentiles, dots are outliers) of daily minimum, mean, and maximum temperatures for each day from September 24 - October 7 over the five years modeled (70 days per individual box plot) for five dam removal scenarios.

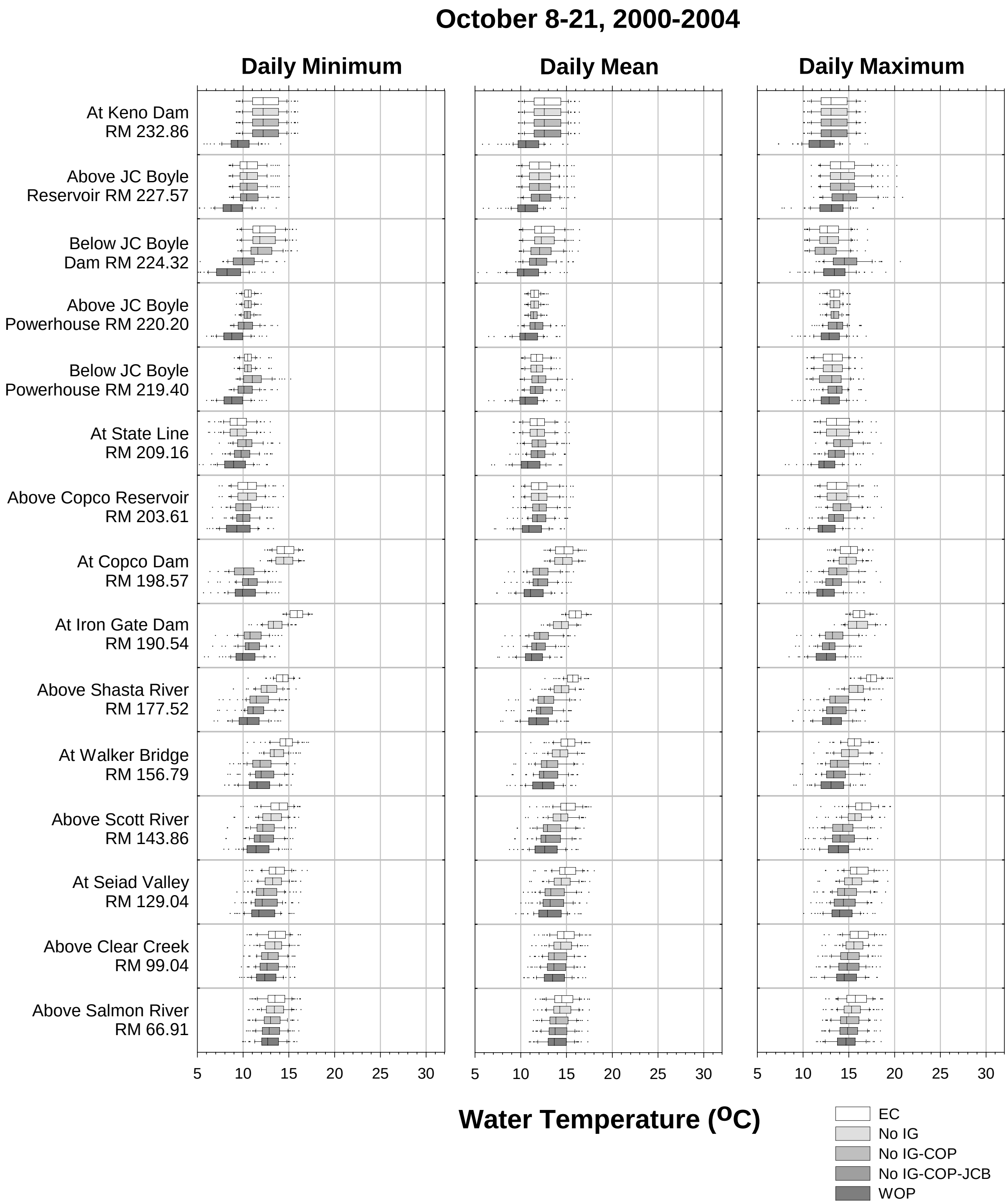

Figure A25. Box plots (line inside box is median, box ends are 25th and 75th percentiles, whisker ends are 10th and 90th percentiles, dots are outliers) of daily minimum, mean, and maximum temperatures for each day from October 8-21 over the five years modeled (70 days per individual box plot) for five dam removal scenarios.

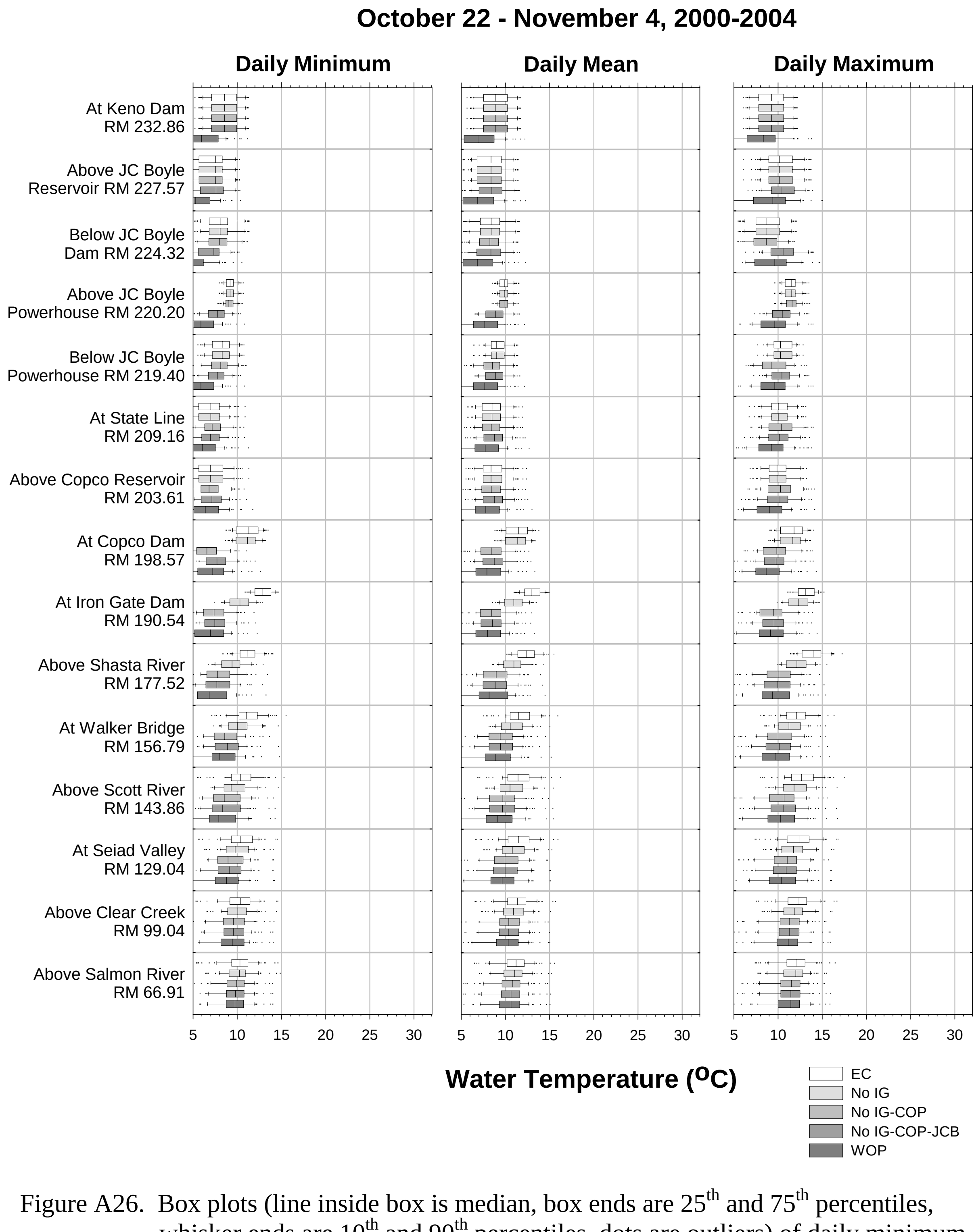

Figure A26. Box plots (line inside box is median, box ends are 25th and 75th percentiles, whisker ends are 10th and 90th percentiles, dots are outliers) of daily minimum, mean, and maximum temperatures for each day from October 22 - November 4 over the five years modeled (70 days per individual box plot) for five dam removal scenarios.

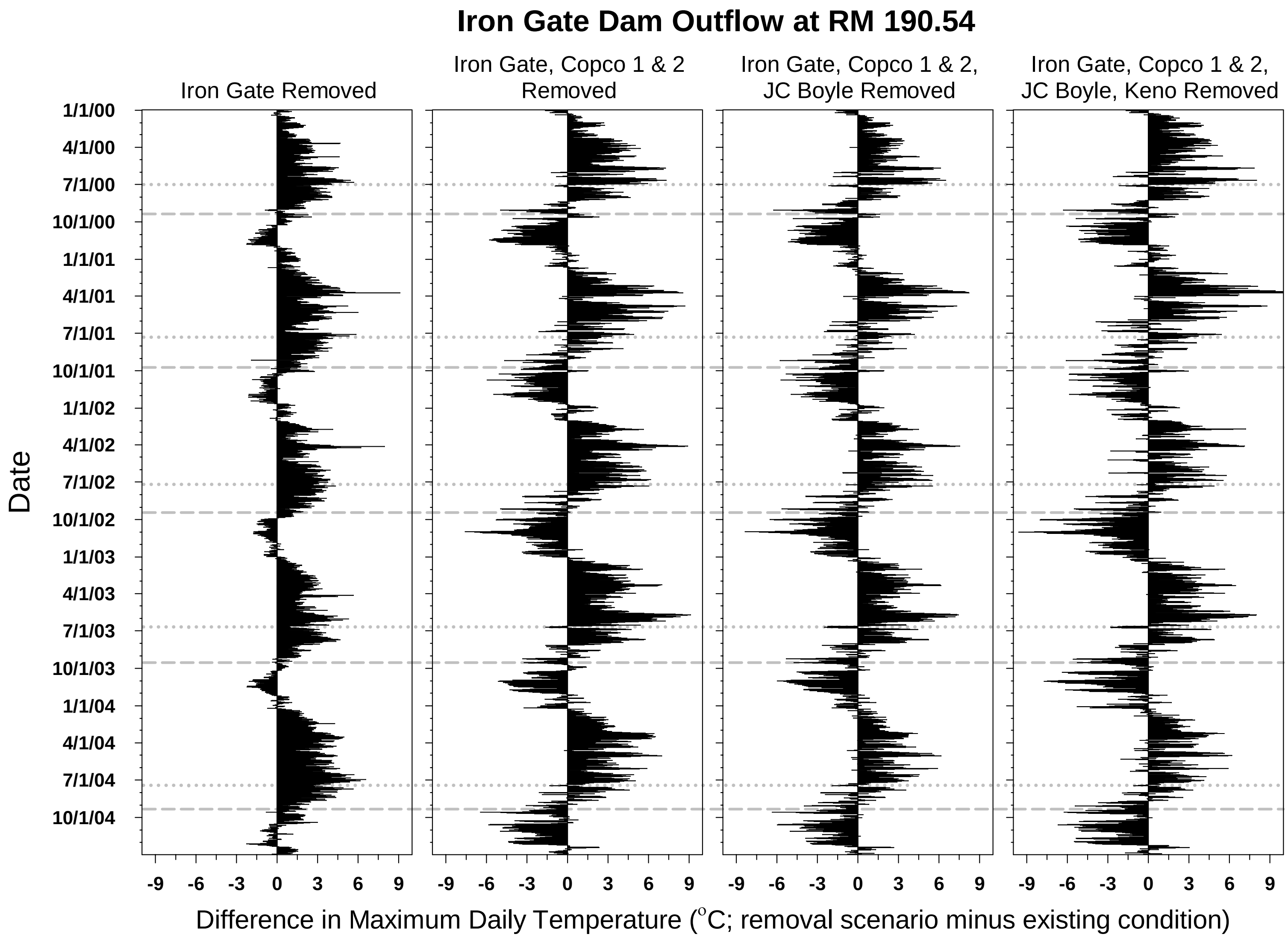

Figure A27. Predicted differences in daily maximum water temperatures from the Existing Condition (EC) at the location of Iron Gate Dam resulting from dam removal. Positive differences indicate that removal warms the water; negative differences indicate that removal cools the water. Each bar represents the difference for one day; all days modeled for 2000-2004 are included in each plot. For each site, dotted lines denote the date when the average of the daily maximum for the previous 7 days (7d-max) crosses the 20°C threshold as the river warms in the spring, and dashed lines mark when the 7d-max crosses the 20°C threshold as the river cools in the fall (intermediate stress thresholds for adult salmon and steelhead, see Table 2).

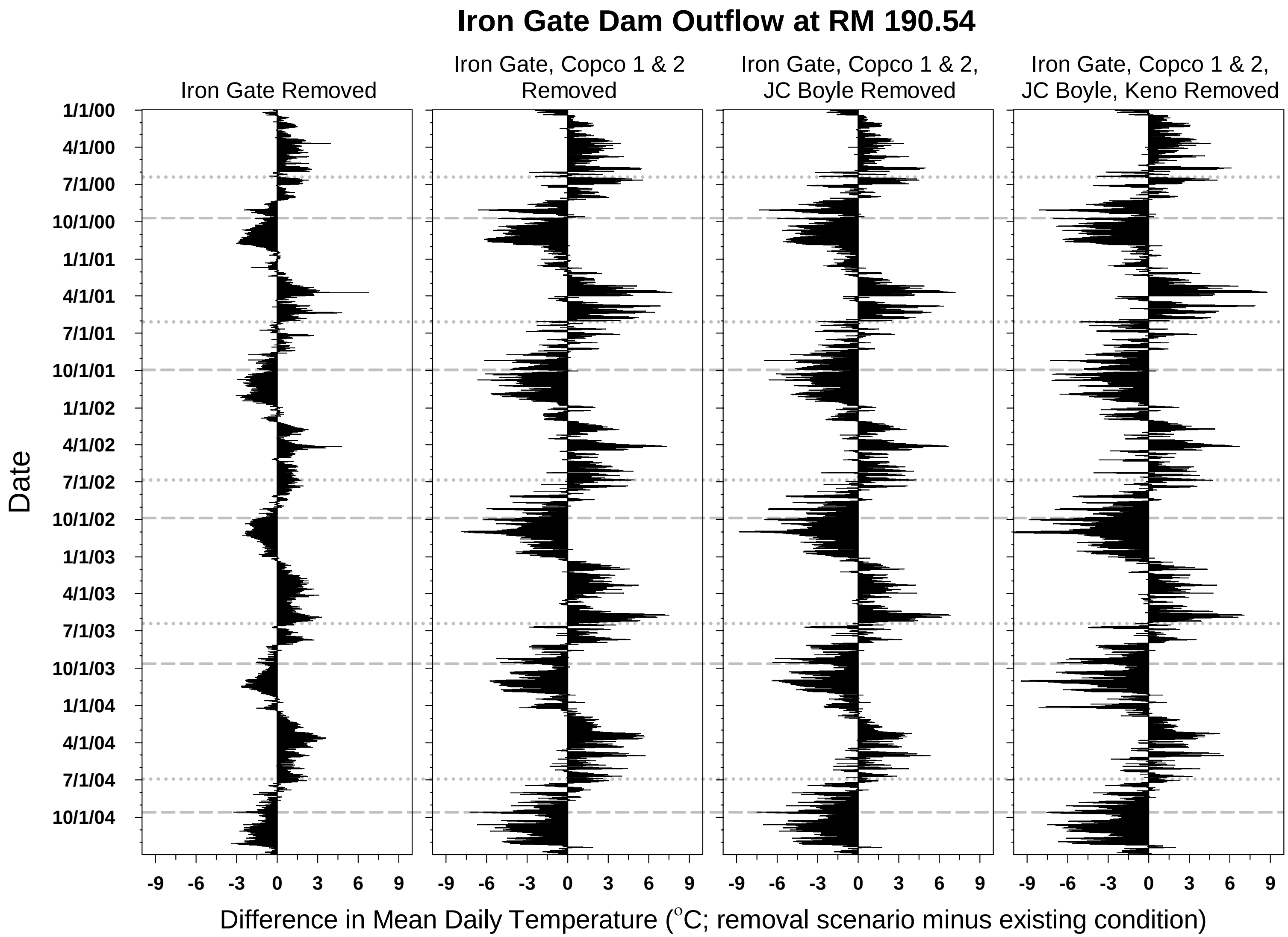

Figure A28. Predicted differences in daily mean water temperatures from the Existing Condition (EC) at the location of Iron Gate Dam resulting from dam removal. Positive differences indicate that removal warms the water; negative differences indicate that removal cools the water. Each bar represents the difference for one day; all days modeled for 2000-2004 are included in each plot. For each site, dotted lines denote the date when the average of the daily mean for the previous 7 days (7d-avg) crosses the 18°C threshold as the river warms in the spring, and dashed lines mark when the 7d-avg crosses the 19°C threshold as the river cools in the fall (intermediate stress thresholds for adult salmon and steelhead, see Table 2).

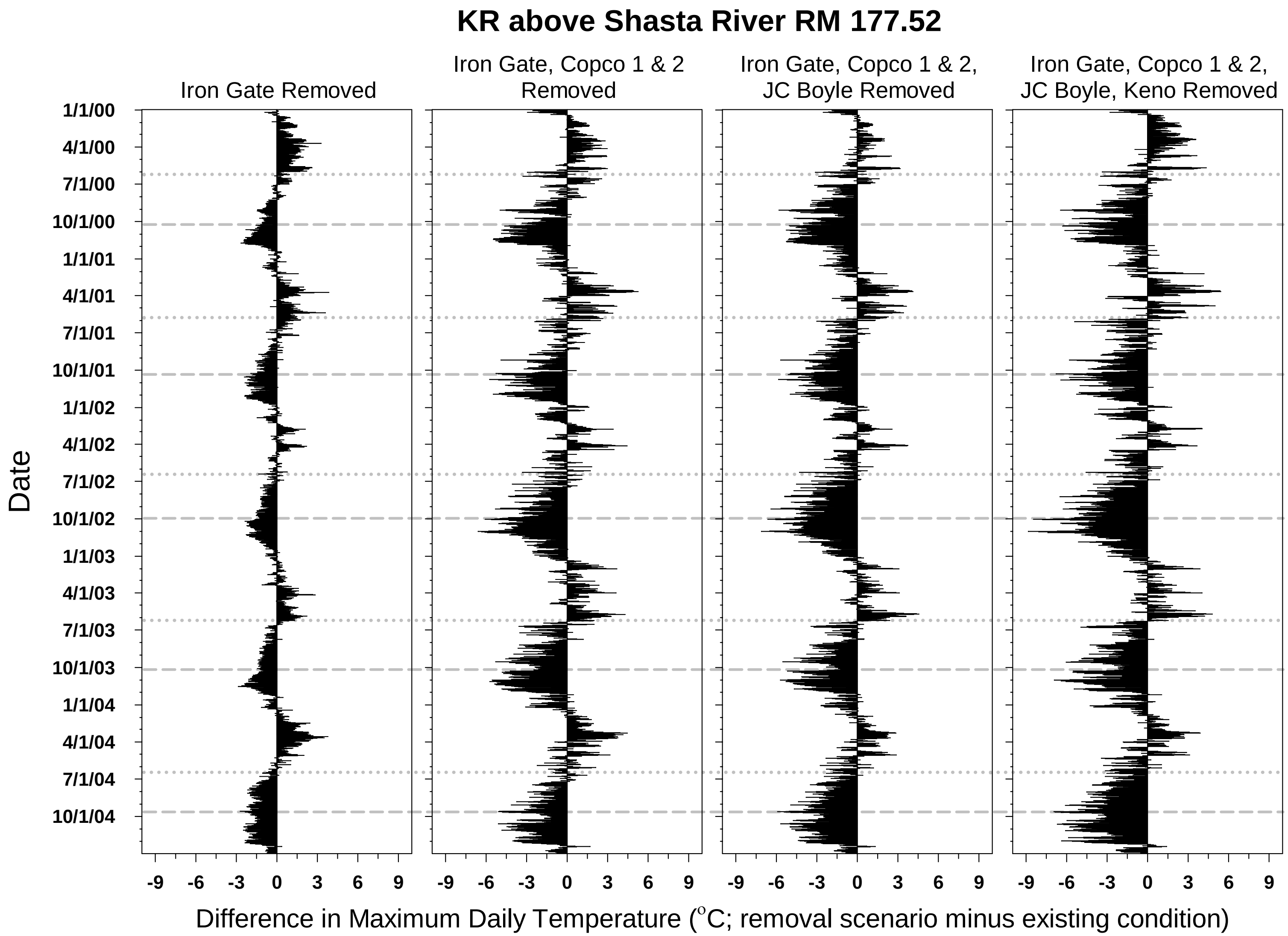

Figure A29. Predicted differences in daily maximum water temperatures from the Existing Condition (EC) near the Shasta River confluence resulting from dam removal. Positive differences indicate that removal warms the water; negative differences indicate that removal cools the water. Each bar represents the difference for one day; all days modeled for 2000-2004 are included in each plot. For each site, dotted lines denote the date when the average of the daily maximum for the previous 7 days (7d-max) crosses the 20°C threshold as the river warms in the spring, and dashed lines mark when the 7d-max crosses the 20°C threshold as the river cools in the fall (intermediate stress thresholds for adult salmon and steelhead, see Table 2).

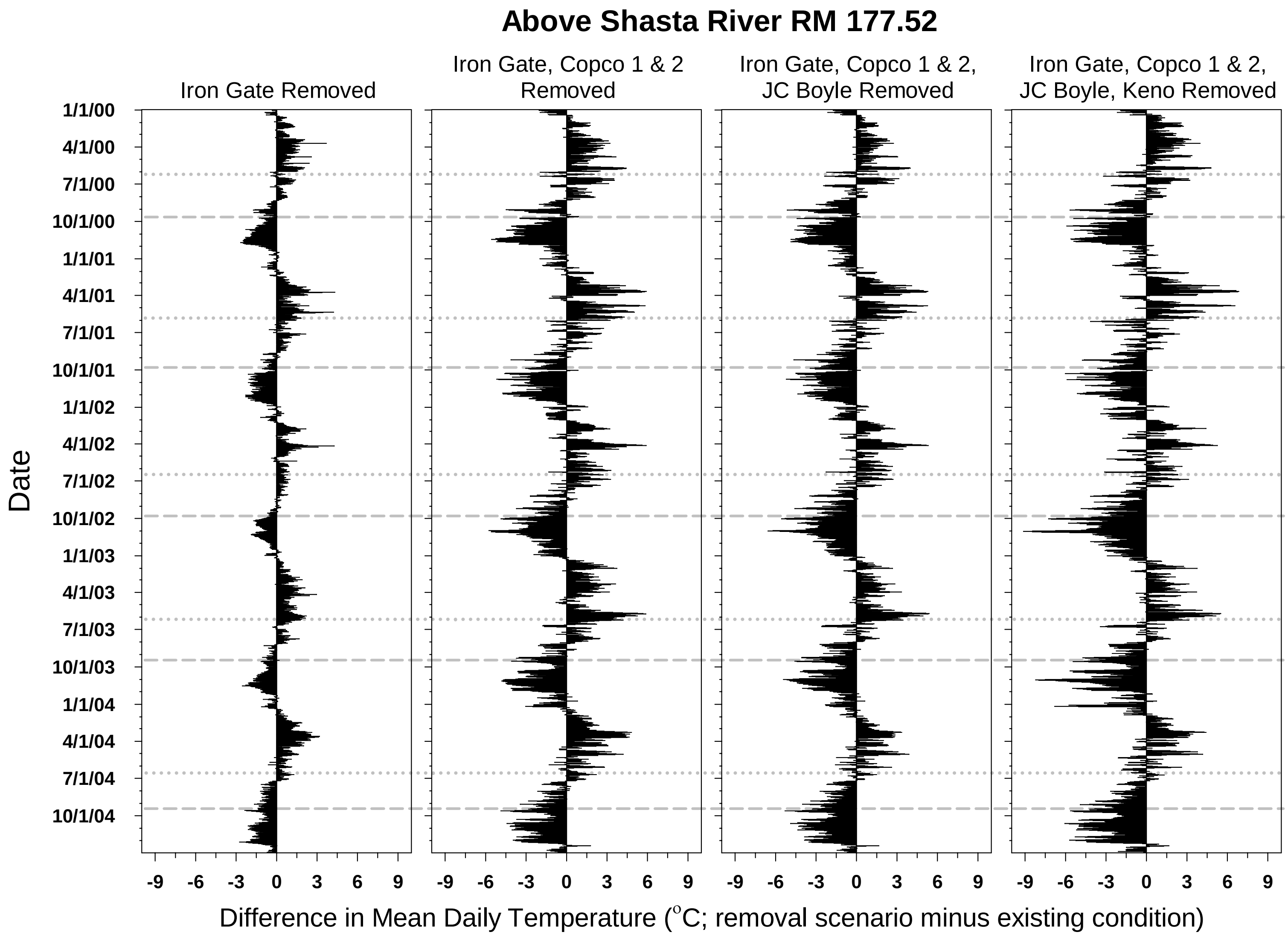

Figure A30. Predicted differences in daily mean water temperatures from the Existing Condition (EC) near the Shasta River confluence resulting from dam removal. Positive differences indicate that removal warms the water; negative differences indicate that removal cools the water. Each bar represents the difference for one day; all days modeled for 2000-2004 are included in each plot. For each site, dotted lines denote the date when the average of the daily mean for the previous 7 days (7d-avg) crosses the 18°C threshold as the river warms in the spring, and dashed lines mark when the 7d-avg crosses the 19°C threshold as the river cools in the fall (intermediate stress thresholds for adult salmon and steelhead, see Table 2).

Appendix B

Thermal and Dissolved Oxygen Conditions for Juvenile and Adult Chinook and Steelhead Under Different Configurations of the Klamath Hydroelectric Project

Abbreviations used in the following figures include:
KHP: Klamath Hydroelectric Project;
KRWQM: Klamath River Water Quality Model;
EC: Existing Condition;
No IG: Iron Gate Dam removed;
No IG-COP: Iron Gate, and Copco 1 and 2 dams removed;
No IG-COP-JCB: Iron Gate, Copco 1 and 2, and JC Boyle dams removed;
WOP: Without Project.

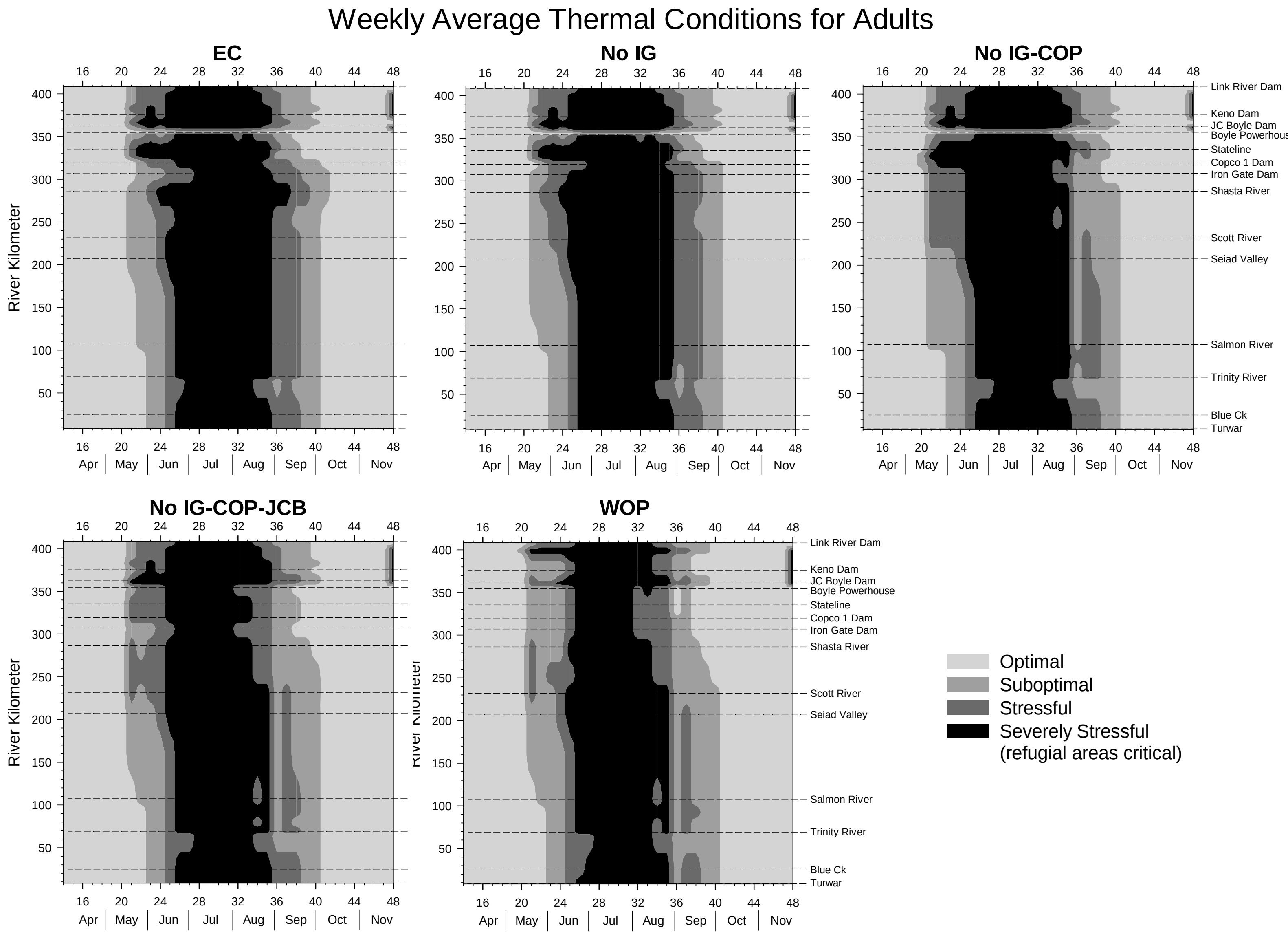

Figure B1. Average weekly thermal conditions for adult chinook and steelhead within and below the KHP. Water temperatures predicted by the KRWQM were categorized by level of stress, and then averaged by week across years (2000-2004). Only data from riverine sites and Keno Reservoir are included; other mainstem reservoirs and Upper Klamath Lake are represented solely by outflow from the dams.

Table B1. Thermal conditions predicted by the Klamath River water quality model April - July for adult anadromous salmonids between Keno and Copco 2 Dams under various Project configurations. Thermal stress categories are: OPT (optimal), SUB (suboptimal), STR (stressful), and SEV (severely stressful). For each scenario and site, entries are the percentage of days falling within stress categories in each two week period over 2000-2004 (total of 70 days per period). Project configurations are: EC = existing condition; No IG = Iron Gate Dam removed; No IG-COP = Iron Gate, and Copco 1 and 2 dams removed; No IG-COP-JCB = Iron Gate, and Copco 1 and 2, and JC Boyle dams removed; WOP = Iron Gate, and Copco 1 and 2, JC Boyle, and Keno dams removed.

Biweekly Period	Scenario	At Keno Dam RM 232.86				Abv JC Boyle reservoir RM 227.57				At JC Boyle Dam RM 224.32				Abv JCB Powerhouse RM 220.20				Blw JCB Powerhouse RM 219.40				At State Line RM 209.16				Abv Copco Reservoir RM 203.61				At Copco Dam RM 198.57			
		OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV
Apr 23 - May 6	EC	90	10			80	20			91	9			100				97	3			80	20			77	23			100			
	No IG	90	10			80	20			91	9			100				97	3			80	20			77	23			100			
	No IG-COP	90	10			80	20			93	7			100				96	4			76	24			70	30			71	29		
	No IG-COP-JCB	90	10			80	20			77	23			87	13			87	13			87	13			87	13			90	10		
	WOP	96	4			89	11			86	14			89	11			89	11			83	17			83	17			84	16		
May 7 - 20	EC	56	44			44	56			57	43			90	10			77	23			39	61			33	67			63	37		
	No IG	56	44			44	56			57	43			90	10			77	23			39	61			33	67			67	33		
	No IG-COP	56	44			44	56			60	40			91	9			50	50			26	74			17	83			26	74		
	No IG-COP-JCB	56	44			43	57			33	67			49	51			47	53			29	71			29	71			30	70		
	WOP	80	20			70	30			61	39			66	34			66	34			60	40			53	47			53	47		
May 21 - Jun 3	EC	3	53	33	11		57	33	10	6	53	31	10	36	64			23	61	16			67	33			59	41		20	66	14	
	No IG	3	53	33	11		57	33	10	6	53	31	10	36	64			23	61	16			67	33			59	41		23	63	14	
	No IG-COP	3	53	33	11		57	33	10	9	50	30	11	41	59			13	51	36			60	39	1		54	36	10		56	39	6
	No IG-COP-JCB	3	53	33	11		59	31	10		53	37	10		77	23			77	23			67	33			61	39			59	41	
	WOP	19	43	39		10	50	40			60	36	4	7	76	17		4	79	17			74	26		1	69	30		4	63	33	
Jun 4 - 17	EC			76	24		1	76	23			79	21		100				71	29			36	46	19		37	43	20		40	60	
	No IG			76	24		1	76	23			79	21		100				71	29			36	46	19		37	43	20		40	60	
	No IG-COP			76	24		1	76	23		10	70	20		100				23	64	13		19	60	21		23	57	20		37	43	20
	No IG-COP-JCB			76	24			74	26		3	66	31		60	33	7		60	33	7		56	30	14		59	27	14		57	31	11
	WOP		69	30	1		61	36	3		57	39	4		77	23			77	23			79	21			77	23			73	27	
Jun 18 - Jul 1	EC			31	69			33	67			44	56		100				51	46	3		7	41	51		4	61	34		6	93	1
	No IG			31	69			33	67			44	56		100				51	46	3		7	41	51		4	61	34		13	87	
	No IG-COP			31	69			33	67		1	56	43		100				14	57	29		1	41	57		1	49	50		4	61	34
	No IG-COP-JCB			31	69			29	71			27	73		33	51	16		33	49	19		16	53	31		14	53	33		13	60	27
	WOP		31	43	26		29	27	44		27	19	54		51	40	9		51	40	9		40	47	13		36	41	23		31	46	23
Jul 2 - 15	EC			14	86			4	96			14	86		100				16	70	14			17	83			19	81			41	59
	No IG			14	86			4	96			14	86		100				16	70	14			17	83			19	81			51	49
	No IG-COP			14	86			4	96			13	87		100					70	30			3	97			4	96			20	80
	No IG-COP-JCB			14	86			3	97			1	99		9	67	24		9	66	26			34	66			33	67			56	44
	WOP		1	17	81			10	90			10	90		16	56	29		16	56	29		10	67	23		7	67	26		4	66	30
Jul 16 - 29	EC			0	100				100			1	99		100				1	56	43			10	90			13	87			9	91
	No IG			0	100				100			1	99		100				1	56	43			10	90			13	87	1		14	84
	No IG-COP			0	100				100			1	99		100					53	47			4	96			7	93			16	84
	No IG-COP-JCB			0	100				100				100		9	57	34		9	54	37			24	76			20	80			30	70
	WOP			20	80			4	96			4	96		19	43	39		19	43	39		3	60	37			40	60			29	71

Table B2. Thermal conditions predicted by the Klamath River water quality model August - October for adult anadromous salmonids between Keno and Copco 2 Dams under various Project configurations. Thermal stress categories are: OPT (optimal), SUB (suboptimal), STR (stressful), and SEV (severely stressful). For each scenario and site, entries are the percentage of days falling within stress categories in each two week period over 2000-2004 (total of 70 days per period). Project configurations are: EC = existing condition; No IG = Iron Gate Dam removed; No IG-COP = Iron Gate, and Copco 1 and 2 dams removed; No IG-COP-JCB = Iron Gate, and Copco 1 and 2, and JC Boyle dams removed; WOP = Iron Gate, and Copco 1 and 2, JC Boyle, and Keno dams removed.

Biweekly Period	Scenario	At Keno Dam RM 232.86				Abv JC Boyle reservoir RM 227.57				At JC Boyle Dam RM 224.32				Abv JCB Powerhouse RM 220.20				Blw JCB Powerhouse RM 219.40				At State Line RM 209.16				Abv Copco Reservoir RM 203.61				At Copco Dam RM 198.57			
		OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV
Jul 30 - Aug 12	EC				100				100			3	97		100				17	49	34			27	73			30	70			7	93
	No IG				100				100			3	97		100				17	49	34			27	73			30	70	1		20	79
	No IG-COP				100				100			6	94		100				9	41	50			16	84			21	79			37	63
	No IG-COP-JCB				100				100				100		26	40	34		26	40	34		4	39	57		4	39	57		4	43	53
	WOP		4	29	67			24	76			20	80		20	56	24		20	56	24		14	53	33		7	56	37		6	46	49
Aug 13-26	EC				100				100			10	90		100				23	70	7			19	81			49	51			9	91
	No IG				100				100			10	90		100				23	70	7			19	81			49	51			20	80
	No IG-COP				100				100			11	89		100					67	33			11	89			23	77			56	44
	No IG-COP-JCB				100				100				100		27	67	6		26	69	6		3	71	26		4	73	23			77	23
	WOP		6	43	51			26	74			21	79		30	60	10		30	61	9		21	76	3		17	76	7		7	80	13
Aug 27 - Sep 9	EC		3	31	66		4	23	73		4	57	39	6	94				71	29			17	54	29		19	63	19			50	50
	No IG		3	31	66		4	23	73		4	57	39	6	94				71	29			17	54	29		19	63	19			43	57
	No IG-COP		3	31	66		4	23	73		4	61	34	6	94				16	77	7		19	40	41		21	46	33		21	71	7
	No IG-COP-JCB		3	31	66		4	16	80		6	11	83		60	40			60	40			37	63			36	64			30	70	
	WOP		37	63			36	46	19		29	44	27		81	19			80	20			64	36			49	51			41	59	
Sep 10-23	EC		37	63			46	54			41	59		27	73			1	99				99	1			90	10			4	96	
	No IG		37	63			46	54			41	59		27	73			1	99				99	1			90	10			10	90	
	No IG-COP		37	63			46	54			56	44		37	63			3	89	9			89	11			90	10		3	86	11	
	No IG-COP-JCB		37	63			40	57	3		31	60	9		100				100			1	99			3	93	4		6	84	10	
	WOP	11	80	9		6	70	24		4	67	29		10	90			10	90			7	93			7	93			10	83	7	
Sep 24 - Oct 7	EC	3	91	6			99	1		6	91	3		84	16			31	69			9	91			9	91				74	26	
	No IG	3	91	6			99	1		6	91	3		84	16			31	69			9	91			9	91				73	27	
	No IG-COP	3	91	6			99	1		14	83	3		96	4			33	66	1		6	94			6	94			11	89		
	No IG-COP-JCB	3	91	6			91	9			90	10		9	91			10	90			11	89			11	89			14	86		
	WOP	19	81			14	86			14	86			30	70			30	70			30	70			23	77			21	79		
Oct 8-21	EC	71	29			60	40			80	20			100				96	4			76	24			77	23			34	66		
	No IG	71	29			60	40			80	20			100				96	4			76	24			77	23			39	61		
	No IG-COP	71	29			60	40			83	17			100				94	6			69	31			73	27			80	20		
	No IG-COP-JCB	71	29			59	40	1		56	44			89	11			89	11			84	16			83	17			83	17		
	WOP	91	9			89	11			86	14			94	6			94	6			96	4			93	7			93	7		
Oct 22 - Nov 4	EC	100				100				100				100				100				100				100				100			
	No IG	100				100				100				100				100				100				100				100			
	No IG-COP	100				100				100				100				100				100				100				100			
	No IG-COP-JCB	100				100				100				100				100				100				100				100			
	WOP	100				100				100				100				100				100				100				100			

Table B3. Thermal conditions predicted by the Klamath River water quality model April - July for adult anadromous salmonids between Iron Gate Dam and the Salmon River confluence under various Project configurations. Thermal stress categories are: OPT (optimal), SUB (suboptimal), STR (stressful), and SEV (severely stressful). For each scenario and site, entries are the percentage of days falling within stress categories in each two week period over 2000-2004 (total of 70 days per period). Project configurations are: EC = existing condition; No IG = Iron Gate Dam removed; No IG-COP = Iron Gate, and Copco 1 and 2 dams removed; No IG-COP-JCB = Iron Gate, and Copco 1 and 2, and JC Boyle dams removed; WOP = Iron Gate, and Copco 1 and 2, JC Boyle, and Keno dams removed.

Biweekly Period	Scenario	At Iron Gate Dam RM 190.54				Above Shasta River RM 177.52				At Walker Bridge RM 156.79				Above Scott River RM 143.86				At Seiad Valley RM 129.04				Above Clear Creek RM 99.04				Above Salmon River RM 66.91			
		OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV
Apr 23 - May 6	EC	100				100				100				100				100				100				100			
	No IG	100				100				100				100				100				100				100			
	No IG-COP	100				100				100				100				97	3			100				100			
	No IG-COP-JCB	100				100				100				100				100				100				100			
	WOP	100				100				100				100				97	3			100				100			
May 7 - 20	EC	100				100				99	1			97	3			84	16			96	4			100			
	No IG	91	9			86	14			77	23			80	20			83	16	1		93	7			100			
	No IG-COP	80	20			80	19	1		71	24	4		77	19	4		83	11	6		89	11			99	1		
	No IG-COP-JCB	87	13			86	14			80	20			81	19			83	11	6		90	10			99	1		
	WOP	87	13			86	14			84	16			84	13	3		83	11	6		91	9			99	1		
May 21 - Jun 3	EC	80	19	1		41	43	16		34	49	17		33	44	20	3	59	24	4	13	64	21	14		66	30	4	
	No IG	36	44	13	7	27	36	10	27	20	43	33	4	27	37	16	20	51	30	3	16	56	29	16		64	30	6	
	No IG-COP	21	33	9	37	14	40	26	20	10	41	14	34	16	39	21	24	37	37	10	16	47	37	16		57	33	10	
	No IG-COP-JCB	33	29	33	6	26	31	23	20	10	46	26	19	21	34	29	16	37	40	9	14	53	31	16		64	27	9	
	WOP	40	26	20	14	37	23	26	14	24	31	26	19	29	29	26	17	41	36	10	13	53	31	16		63	30	7	
Jun 4 - 17	EC	23	41	36			37	44	19		47	53			47	50	3	1	73	19	7	14	74	11		14	76	10	
	No IG		31	51	17		34	21	44		44	43	13		44	44	11	6	57	26	11	16	64	19	1	21	69	10	
	No IG-COP		36	37	27		31	47	21		31	46	23		36	44	20	4	53	43		14	61	24		21	64	13	1
	No IG-COP-JCB	4	66	10	20	1	59	20	20		43	39	19		49	40	11	6	60	34		14	71	14		21	69	10	
	WOP	21	53	13	13	6	67	17	10	3	63	20	14	3	60	27	10	7	66	27		16	71	13		21	70	9	
Jun 18 - Jul 1	EC		30	70				4	96			66	34			20	80			40	60		24	27	49		24	37	39
	No IG			23	77			9	91			39	61		1	23	76		1	40	59		21	31	47		34	30	36
	No IG-COP		4	21	74			29	71			23	77		1	34	64		1	44	54		16	39	46		29	31	40
	No IG-COP-JCB		21	31	47		7	34	59		4	39	57		4	39	57		3	49	49		24	30	46		31	29	40
	WOP		27	39	34		21	40	39		9	53	39		7	46	47		3	53	44		14	44	41		27	34	39
Jul 2 - 15	EC			53	47				100				100				100				100			7	93			17	83
	No IG				100				100				100				100				100			11	89			27	73
	No IG-COP				100				100				100				100				100			16	84			27	73
	No IG-COP-JCB			14	86			3	97			3	97				100				100			14	86			31	69
	WOP		1	10	89			10	90			9	91			1	99				100			17	83			34	66
Jul 16 - 29	EC				100				100				100				100				100				100				100
	No IG				100				100				100				100				100			3	97			4	96
	No IG-COP			3	97				100				100				100				100			3	97			4	96
	No IG-COP-JCB			9	91			4	96			4	96				100				100			3	97			4	96
	WOP			4	96			7	93			4	96			3	97			1	99			3	97			4	96

Table B4. Thermal conditions predicted by the Klamath River water quality model August - October for adult anadromous salmonids between Iron Gate Dam and the Salmon River confluence under various Project configurations. Thermal stress categories are: OPT (optimal), SUB (suboptimal), STR (stressful), and SEV (severely stressful). For each scenario and site, entries are the percentage of days falling within stress categories in each two week period over 2000-2004 (total of 70 days per period). Project configurations are: EC = existing condition; No IG = Iron Gate Dam removed; No IG-COP = Iron Gate, and Copco 1 and 2 dams removed; No IG-COP-JCB = Iron Gate, and Copco 1 and 2, and JC Boyle dams removed; WOP = Iron Gate, and Copco 1 and 2, JC Boyle, and Keno dams removed.

Biweekly Period	Scenario	At Iron Gate Dam RM 190.54				Above Shasta River RM 177.52				At Walker Bridge RM 156.79				Above Scott River RM 143.86				At Seiad Valley RM 129.04				Above Clear Creek RM 99.04				Above Salmon River RM 66.91			
		OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV
Jul 30 - Aug 12	EC			14	86				100			4	96			3	97			4	96			11	89			14	86
	No IG				100				100			4	96			1	99			4	96			17	83			23	77
	No IG-COP		1	27	71			10	90			10	90			9	91			9	91			20	80			26	74
	No IG-COP-JCB		4	34	61		4	20	76		4	17	79		3	9	89			10	90			23	77			26	74
	WOP		10	33	57		6	24	70		6	19	76		4	17	79			19	81			24	76		3	23	74
Aug 13-26	EC			20	80				100				100			3	97			4	96			14	86			20	80
	No IG				100				100			1	99			1	99			6	94			14	86			30	70
	No IG-COP		1	40	59			13	87			16	84			13	87			7	93			16	84			30	70
	No IG-COP-JCB		4	61	34			40	60			33	67			9	91			13	87			16	84		1	30	69
	WOP		9	61	30		4	47	49		3	41	56			19	81			14	86		1	20	79		3	33	64
Aug 27 - Sep 9	EC			43	57			13	87		10	31	59		3	21	76		9	21	70		9	34	57		13	43	44
	No IG			24	76		3	30	67		14	26	60		13	23	64		16	27	57		17	31	51		17	40	43
	No IG-COP	4	30	43	23	1	19	29	51		21	36	43		17	27	56		16	24	60		17	34	49		19	40	41
	No IG-COP-JCB	9	34	57		6	29	29	37		31	29	40		20	34	46		19	26	56		17	36	47		19	39	43
	WOP	11	34	54		9	31	31	29	3	31	29	37		30	26	44		21	31	47		20	37	43		21	39	40
Sep 10-23	EC		10	87	3		3	44	53		26	74			13	54	33		23	49	29	1	37	27	34	1	46	21	31
	No IG		13	77	10	3	21	60	16	4	44	41	10	4	29	41	26	3	41	39	17	1	47	20	31	1	57	9	33
	No IG-COP	16	76	9		7	59	34		6	61	33		6	57	19	19	4	51	21	23	3	57	10	30	3	57	9	31
	No IG-COP-JCB	26	74			17	56	27		9	63	29		9	53	29	10	7	53	23	17	4	57	14	24	3	57	14	26
	WOP	37	54	9		24	50	26		17	54	29		11	51	24	13	9	54	16	21	7	54	13	26	4	57	11	27
Sep 24 - Oct 7	EC		87	13			29	70	1	6	73	21		7	41	50	1	9	53	39		9	51	39	1	9	59	31	1
	No IG	1	74	24		7	71	21		10	80	10		11	51	37		11	60	29		14	54	31		16	57	26	1
	No IG-COP	47	53			19	73	9		16	81	3		16	70	14		16	64	20		16	60	23	1	17	61	20	1
	No IG-COP-JCB	60	40			41	59			17	83			17	64	19		17	64	19		16	63	21		17	63	19	1
	WOP	63	37			49	51			23	76	1		20	70	10		19	69	13		19	64	16	1	19	61	19	1
Oct 8-21	EC	30	70			41	56	3		66	34			67	31	1		69	30	1		71	27	1		73	26	1	
	No IG	74	26			77	23			79	21			77	21	1		76	23	1		77	21	1		77	21	1	
	No IG-COP	96	4			91	9			86	14			84	14	1		80	19	1		81	17	1		79	20	1	
	No IG-COP-JCB	99	1			96	4			89	11			86	14			84	14	1		81	17	1		80	19	1	
	WOP	99	1			96	4			93	7			87	13			84	14	1		81	17	1		81	17	1	
Oct 22 - Nov 4	EC	100				100				100				100				100				100				100			
	No IG	100				100				100				100				100				100				100			
	No IG-COP	100				100				100				100				100				100				100			
	No IG-COP-JCB	100				100				100				100				100				100				100			
	WOP	100				100				100				100				100				100				100			

Thermal Conditions for Adults, 2000

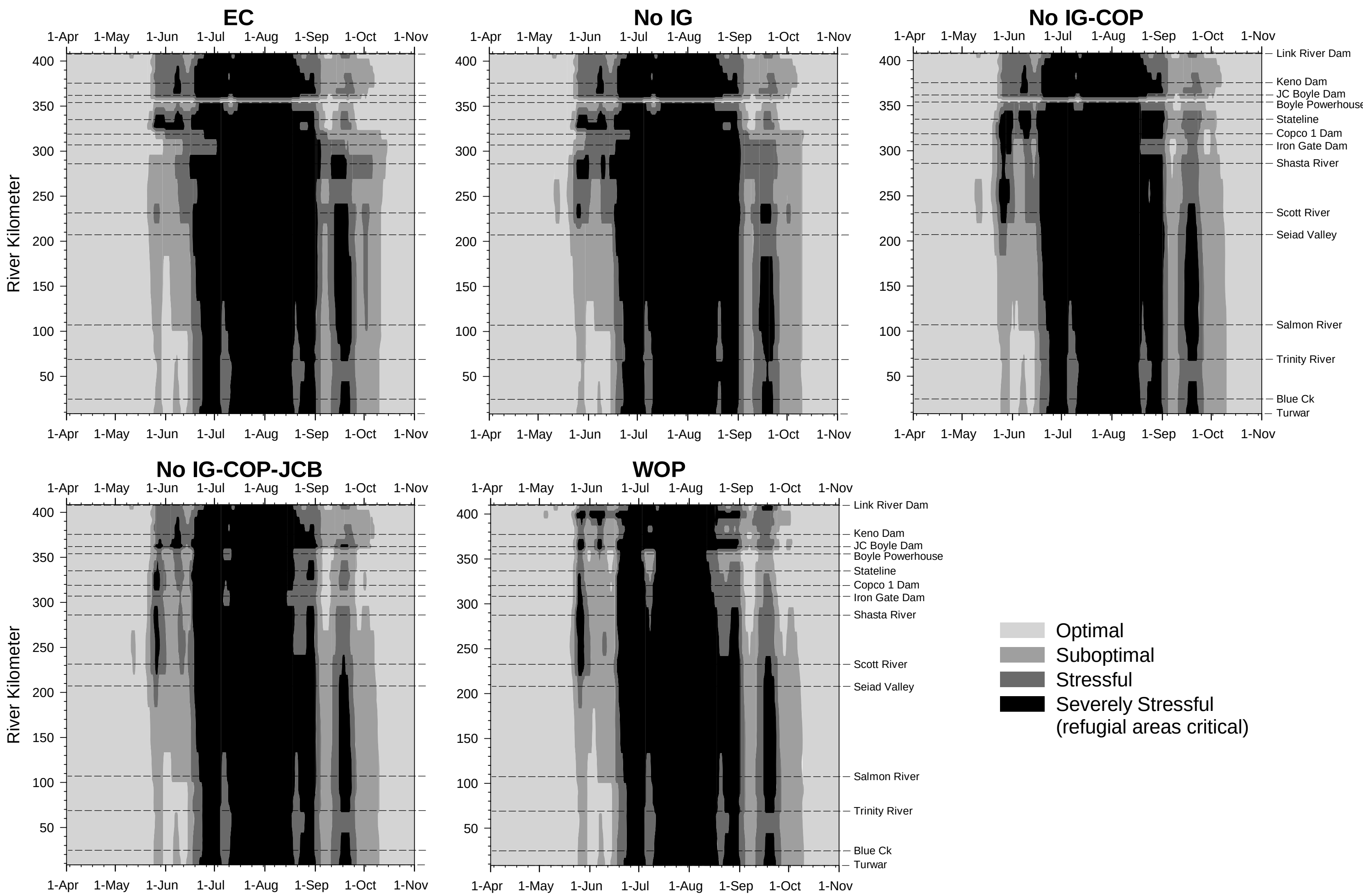

Figure B2. Conditions during spring, summer, and fall of 2000 for adult salmon and steelhead within and below the KHP, based on water temperatures predicted by the KRWQM. Only data from riverine sites and Keno Reservoir are included; other mainstem reservoirs and Upper Klamath Lake are represented solely by outflow from the dams.

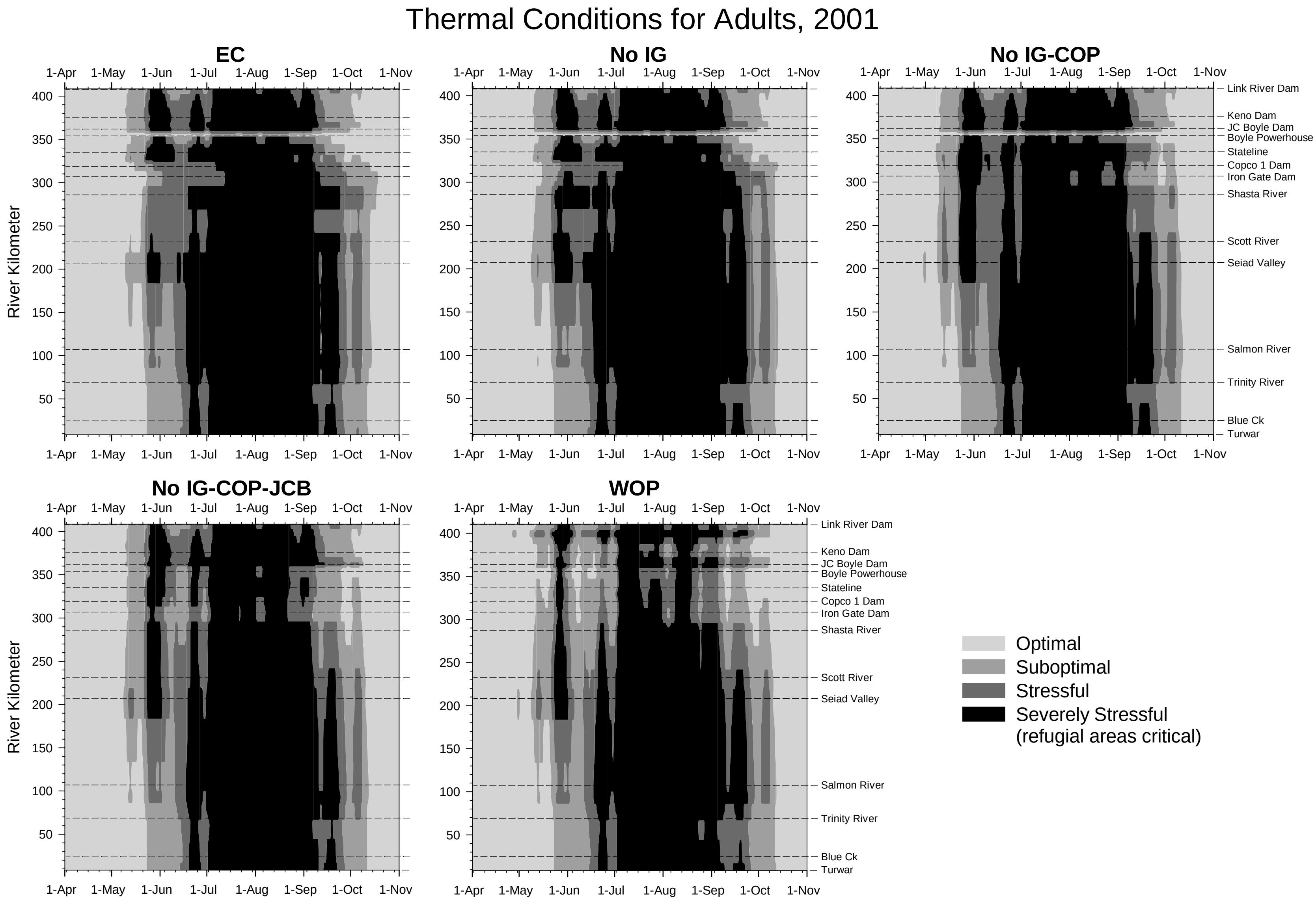

Figure B3. Conditions during spring, summer, and fall of 2001 for adult salmon and steelhead within and below the KHP, based on water temperatures predicted by the KRWQM. Only data from riverine sites and Keno Reservoir are included; other mainstem reservoirs and Upper Klamath Lake are represented solely by outflow from the dams.

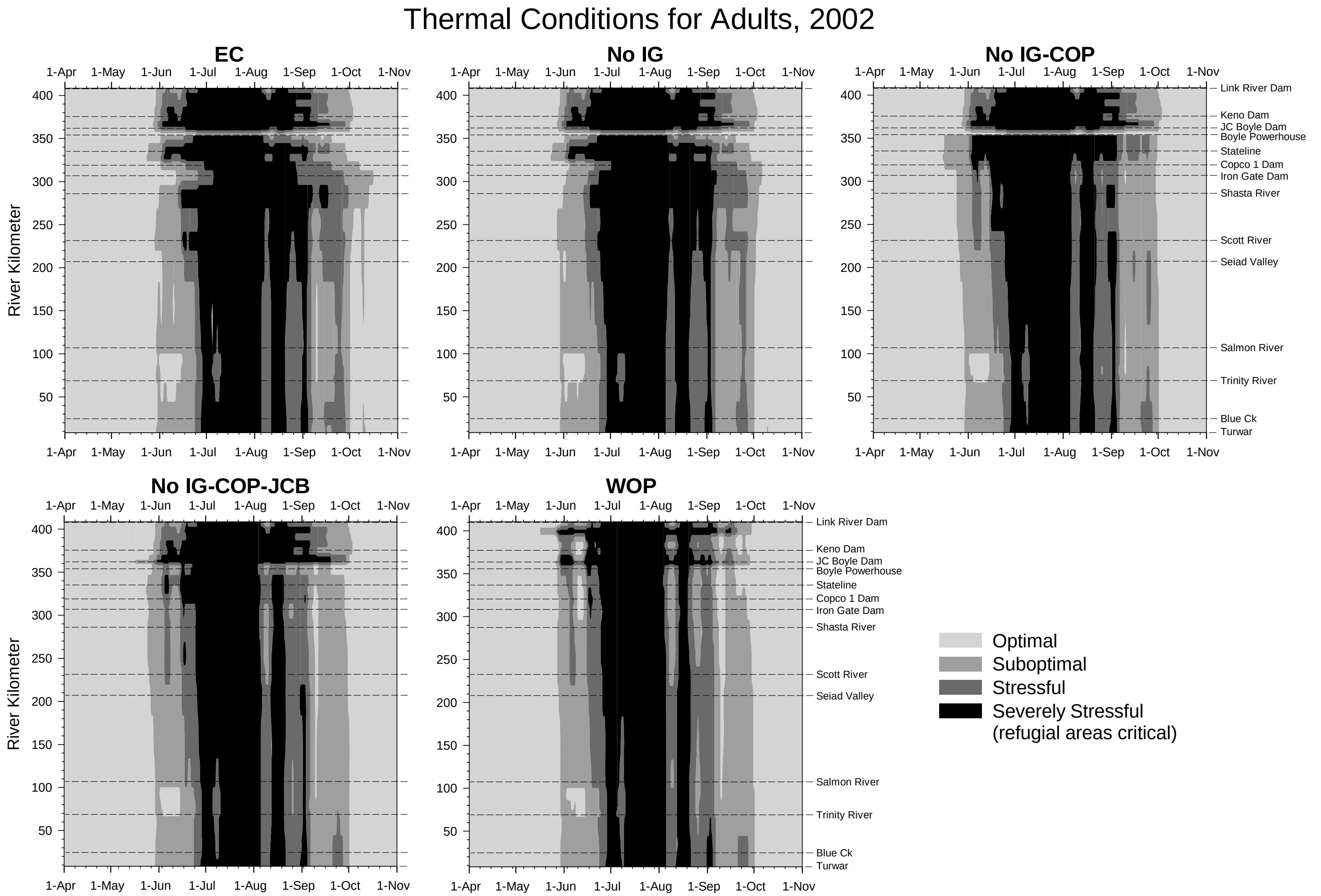

Figure B4. Conditions during spring, summer, and fall of 2002 for adult salmon and steelhead within and below the KHP, based on water temperatures predicted by the KRWQM. Only data from riverine sites and Keno Reservoir are included; other mainstem reservoirs and Upper Klamath Lake are represented solely by outflow from the dams.

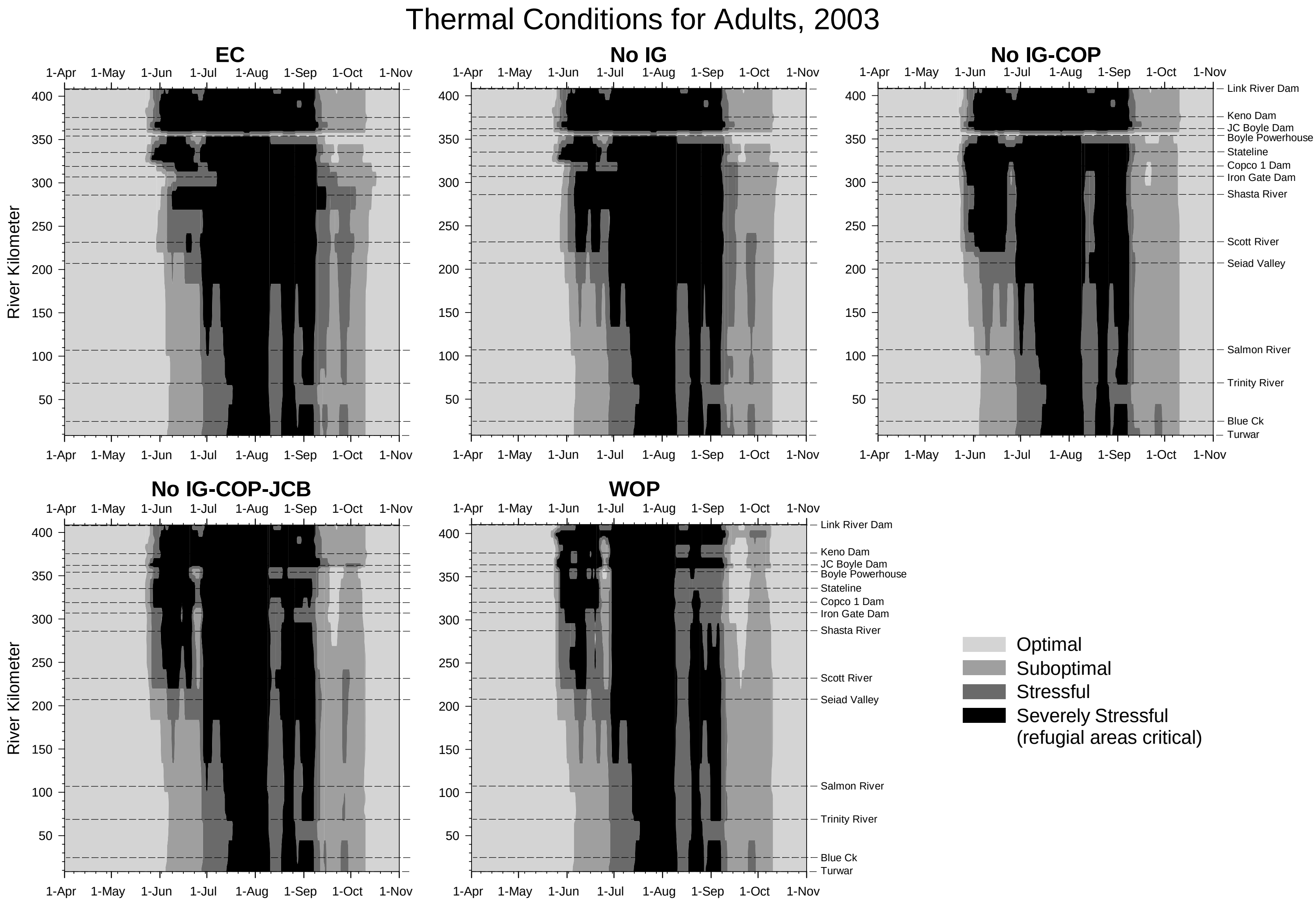

Figure B5. Conditions during spring, summer, and fall of 2003 for adult salmon and steelhead within and below the KHP, based on water temperatures predicted by the KRWQM. Only data from riverine sites and Keno Reservoir are included; other mainstem reservoirs and Upper Klamath Lake are represented solely by outflow from the dams.

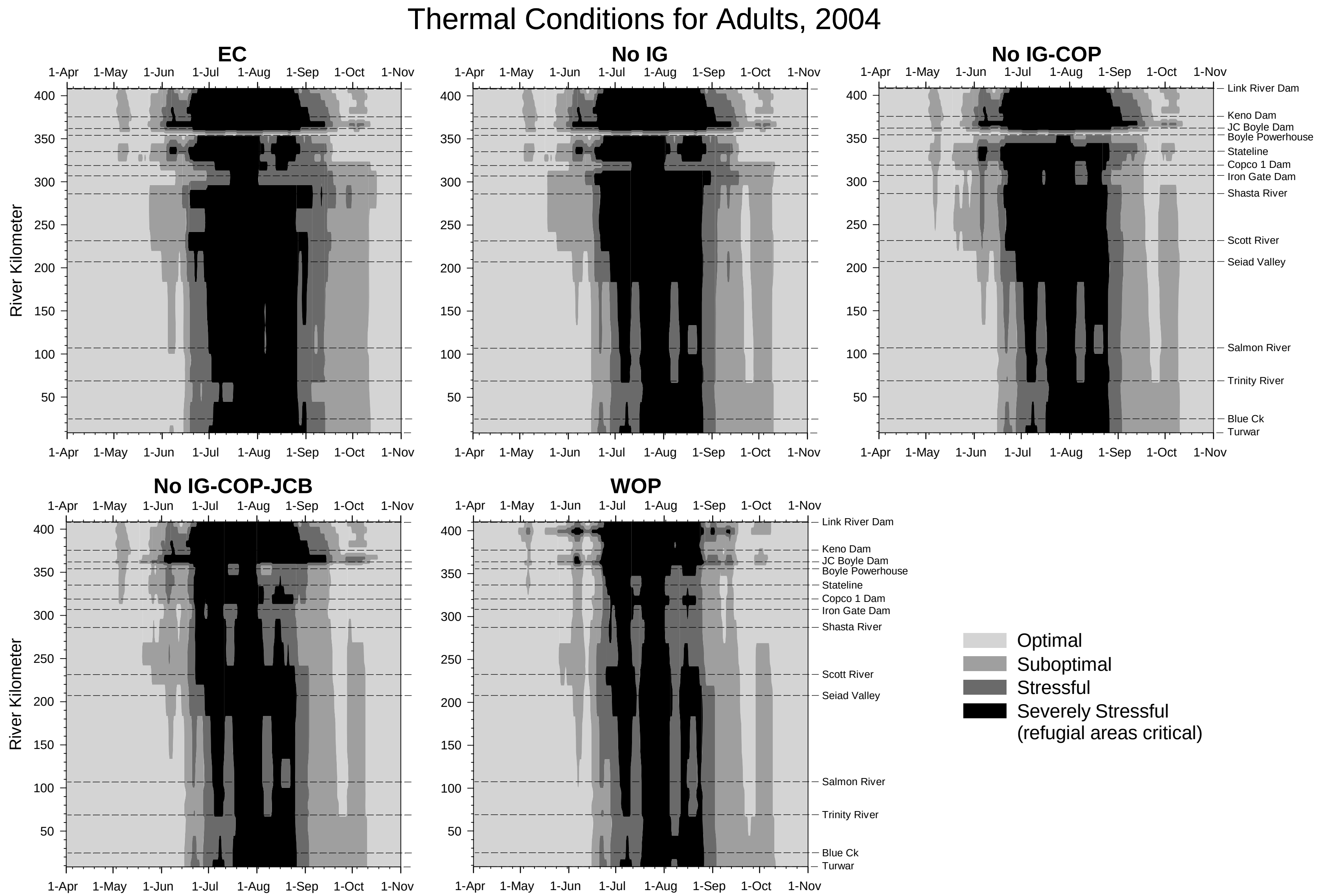

Figure B6. Conditions during spring, summer, and fall of 2004 for adult salmon and steelhead within and below the KHP, based on water temperatures predicted by the KRWQM. Only data from riverine sites and Keno Reservoir are included; other mainstem reservoirs and Upper Klamath Lake are represented solely by outflow from the dams.

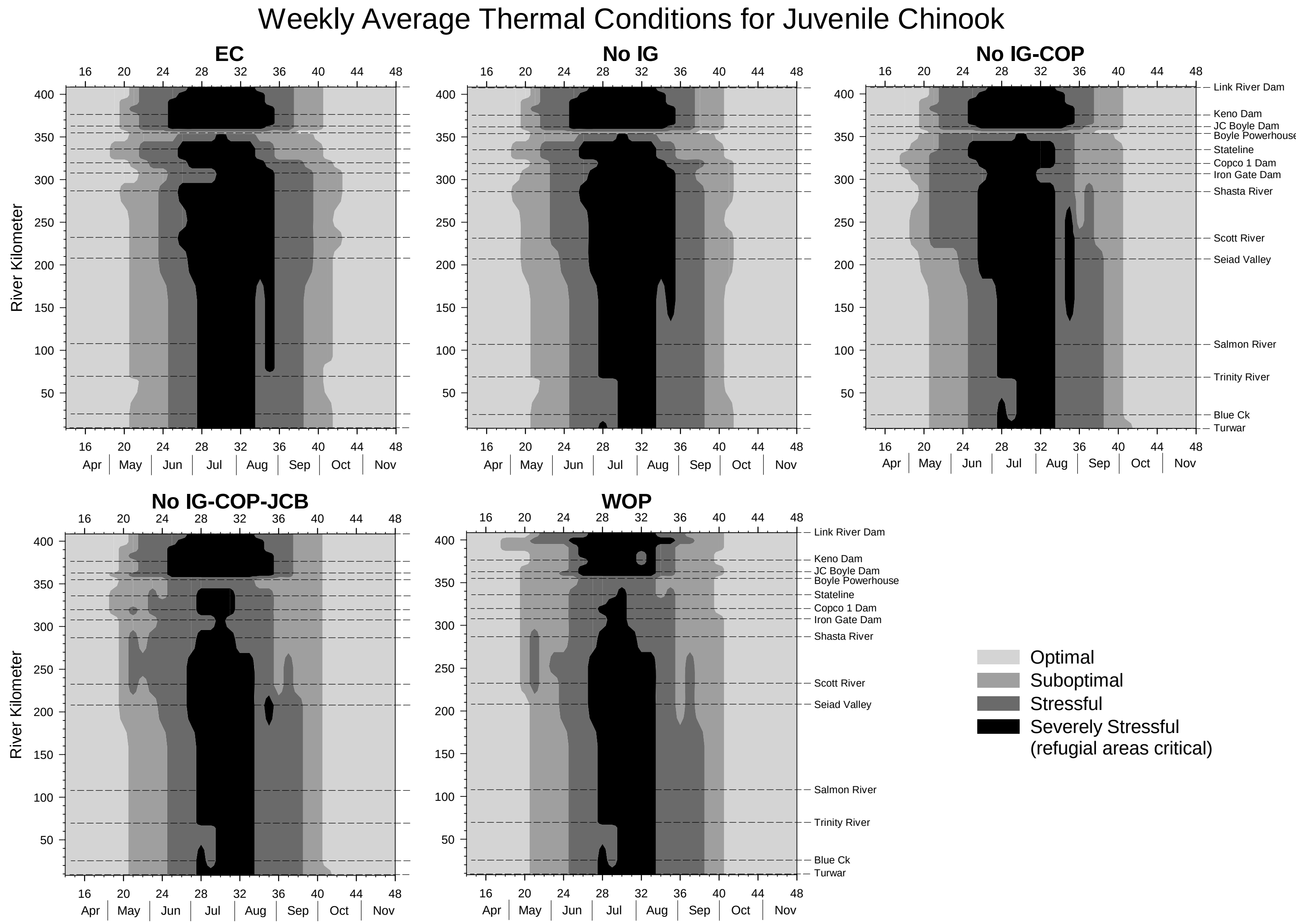

Figure B7. Average weekly thermal conditions for juvenile chinook within and below the KHP. Water temperatures predicted by the KRWQM were categorized by level of stress, and then averaged by week across years (2000-2004). Only data from riverine sites and Keno Reservoir are included; other mainstem reservoirs and Upper Klamath Lake are represented solely by outflow from the dams.

Table B5. Thermal conditions predicted by the Klamath River water quality model April - July for juvenile chinook between Keno and Copco 2 dams under various Project configurations. Thermal stress categories are: OPT (optimal), SUB (suboptimal), STR (stressful), and SEV (severely stressful). For each scenario and site, entries are the percentage of days falling within stress categories in each two week period over 2000-2004 (total of 70 days per period). Project configurations are: EC = existing condition; No IG = Iron Gate Dam removed; No IG-COP = Iron Gate, and Copco 1 and 2 dams removed; No IG-COP-JCB = Iron Gate, and Copco 1 and 2, and JC Boyle dams removed; WOP = Iron Gate, and Copco 1 and 2, JC Boyle, and Keno dams removed.

Biweekly Period	Scenario	At Keno Dam RM 232.86				Abv JC Boyle reservoir RM 227.57				At JC Boyle Dam RM 224.32				Abv JCB Powerhouse RM 220.20				Blw JCB Powerhouse RM 219.40				At State Line RM 209.16				Abv Copco Reservoir RM 203.61				At Copco Dam RM 198.57			
		OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV
Apr 23 - May 6	EC	90	10			80	20			91	9			100				97	3			80	20			77	23			100			
	No IG	90	10			80	20			91	9			100				97	3			80	20			77	23			100			
	No IG-COP	90	10			80	20			93	7			100				96	4			76	24			70	30			71	29		
	No IG-COP-JCB	90	10			80	20			77	23			87	13			87	13			87	13			87	13			90	10		
	WOP	96	4			89	11			86	14			89	11			89	11			83	17			83	17			84	16		
May 7 - 20	EC	56	44			44	56			57	43			90	10			77	23			39	61			33	67			63	37		
	No IG	56	44			44	56			57	43			90	10			77	23			39	61			33	67			67	33		
	No IG-COP	56	44			44	56			60	40			91	9			50	50			26	74			17	83			26	74		
	No IG-COP-JCB	56	44			43	57			33	67			49	51			47	53			29	71			29	71			30	70		
	WOP	80	20			70	30			61	39			66	34			66	34			60	40			53	47			53	47		
May 21 - Jun 3	EC	3	53	33	11		57	33	10	6	53	31	10	36	64			23	61	16			67	33			59	41		20	66	14	
	No IG	3	53	33	11		57	33	10	6	53	31	10	36	64			23	61	16			67	33			59	41		23	63	14	
	No IG-COP	3	53	33	11		57	33	10	9	50	30	11	41	59			13	51	36			60	39	1		54	36	10		56	39	6
	No IG-COP-JCB	3	53	33	11		59	31	10		53	37	10		77	23			77	23			67	33			61	39			59	41	
	WOP	19	43	39		10	50	40			60	36	4	7	76	17		4	79	17			74	26		1	69	30		4	63	33	
Jun 4 - 17	EC			76	24		1	76	23			79	21		100				71	29			36	46	19		37	43	20		40	60	
	No IG			76	24		1	76	23			79	21		100				71	29			36	46	19		37	43	20		40	60	
	No IG-COP			76	24		1	76	23		10	70	20		100				23	64	13		19	60	21		23	57	20		37	43	20
	No IG-COP-JCB			76	24			74	26		3	66	31		60	33	7		60	33	7		56	30	14		59	27	14		57	31	11
	WOP		69	30	1		61	36	3		57	39	4		77	23			77	23			79	21			77	23			73	27	
Jun 18 - Jul 1	EC			31	69			33	67			44	56		100				51	46	3		7	41	51		4	61	34		6	93	1
	No IG			31	69			33	67			44	56		100				51	46	3		7	41	51		4	61	34		13	87	
	No IG-COP			31	69			33	67		1	56	43		100				14	57	29		1	41	57		1	49	50		4	61	34
	No IG-COP-JCB			31	69			29	71			27	73		33	51	16		33	49	19		16	53	31		14	53	33		13	60	27
	WOP		31	43	26		29	27	44		27	19	54		51	40	9		51	40	9		40	47	13		36	41	23		31	46	23
Jul 2 - 15	EC			14	86			4	96			14	86		100				16	70	14			17	83			19	81			41	59
	No IG			14	86			4	96			14	86		100				16	70	14			17	83			19	81			51	49
	No IG-COP			14	86			4	96			13	87		100					70	30			3	97			4	96			20	80
	No IG-COP-JCB			14	86			3	97			1	99		9	67	24		9	66	26			34	66			33	67			56	44
	WOP		1	17	81			10	90			10	90		16	56	29		16	56	29		10	67	23		7	67	26		4	66	30
Jul 16 - 29	EC				100				100			1	99		100				1	56	43			10	90			13	87			9	91
	No IG				100				100			1	99		100				1	56	43			10	90			13	87	1		14	84
	No IG-COP				100				100			1	99		100					53	47			4	96			7	93			16	84
	No IG-COP-JCB				100				100				100		9	57	34		9	54	37			24	76			20	80			30	70
	WOP			20	80			4	96			4	96		19	43	39		19	43	39		3	60	37			40	60			29	71

Table B6. Thermal conditions predicted by the Klamath River water quality model August - October for juvenile chinook between Keno and Copco 2 dams under various Project configurations. Thermal stress categories are: OPT (optimal), SUB (suboptimal), STR (stressful), and SEV (severely stressful). For each scenario and site, entries are the percentage of days falling within stress categories in each two week period over 2000-2004 (total of 70 days per period). Project configurations are: EC = existing condition; No IG = Iron Gate Dam removed; No IG-COP = Iron Gate, and Copco 1 and 2 dams removed; No IG-COP-JCB = Iron Gate, and Copco 1 and 2, and JC Boyle dams removed; WOP = Iron Gate, and Copco 1 and 2, JC Boyle, and Keno dams removed.

		At Keno Dam RM 232.86				Abv JC Boyle reservoir RM 227.57				At JC Boyle Dam RM 224.32				Abv JCB Powerhouse RM 220.20				Blw JCB Powerhouse RM 219.40				At State Line RM 209.16				Abv Copco Reservoir RM 203.61				At Copco Dam RM 198.57			
Biweekly Period	Scenario	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV
Jul 30 - Aug 12	EC				100				100			3	97		100				17	49	34			27	73			30	70			7	93
	No IG				100				100			3	97		100				17	49	34			27	73			30	70	1		20	79
	No IG-COP				100				100			6	94		100				9	41	50			16	84			21	79			37	63
	No IG-COP-JCB				100				100				100		26	40	34		26	40	34		4	39	57		4	39	57		4	43	53
	WOP		4	29	67			24	76			20	80		20	56	24		20	56	24		14	53	33		7	56	37		6	46	49
Aug 13-26	EC				100				100			10	90		100				23	70	7			19	81			49	51			9	91
	No IG				100				100			10	90		100				23	70	7			19	81			49	51			20	80
	No IG-COP				100				100			11	89		100					67	33			11	89			23	77			56	44
	No IG-COP-JCB				100				100				100		27	67	6		26	69	6		3	71	26		4	73	23			77	23
	WOP		6	43	51			26	74			21	79		30	60	10		30	61	9		21	76	3		17	76	7		7	80	13
Aug 27 - Sep 9	EC		3	31	66		4	23	73		4	57	39	6	94				71	29			17	54	29		19	63	19			50	50
	No IG		3	31	66		4	23	73		4	57	39	6	94				71	29			17	54	29		19	63	19			43	57
	No IG-COP		3	31	66		4	23	73		4	61	34	6	94				16	77	7		19	40	41		21	46	33		21	71	7
	No IG-COP-JCB		3	31	66		4	16	80		6	11	83		60	40			60	40			37	63			36	64			30	70	
	WOP		37	63			36	46	19		29	44	27		81	19			80	20			64	36			49	51			41	59	
Sep 10-23	EC		37	63			46	54			41	59		27	73			1	99				99	1			90	10			4	96	
	No IG		37	63			46	54			41	59		27	73			1	99				99	1			90	10			10	90	
	No IG-COP		37	63			46	54			56	44		37	63			3	89	9			89	11			90	10		3	86	11	
	No IG-COP-JCB		37	63			40	57	3		31	60	9		100				100			1	99			3	93	4		6	84	10	
	WOP	11	80	9		6	70	24		4	67	29		10	90			10	90			7	93			7	93			10	83	7	
Sep 24 - Oct 7	EC	3	91	6			99	1		6	91	3		84	16			31	69			9	91			9	91				74	26	
	No IG	3	91	6			99	1		6	91	3		84	16			31	69			9	91			9	91				73	27	
	No IG-COP	3	91	6			99	1		14	83	3		96	4			33	66	1		6	94			6	94			11	89		
	No IG-COP-JCB	3	91	6			91	9			90	10		9	91			10	90			11	89			11	89			14	86		
	WOP	19	81			14	86			14	86			30	70			30	70			30	70			23	77			21	79		
Oct 8-21	EC	71	29			60	40			80	20			100				96	4			76	24			77	23			34	66		
	No IG	71	29			60	40			80	20			100				96	4			76	24			77	23			39	61		
	No IG-COP	71	29			60	40			83	17			100				94	6			69	31			73	27			80	20		
	No IG-COP-JCB	71	29			59	40	1		56	44			89	11			89	11			84	16			83	17			83	17		
	WOP	91	9			89	11			86	14			94	6			94	6			96	4			93	7			93	7		
Oct 22 - Nov 4	EC	100				100				100				100				100				100				100				100			
	No IG	100				100				100				100				100				100				100				100			
	No IG-COP	100				100				100				100				100				100				100				100			
	No IG-COP-JCB	100				100				100				100				100				100				100				100			
	WOP	100				100				100				100				100				100				100				100			

Table B7. Thermal conditions predicted by the Klamath River water quality model April - July for juvenile chinook between Iron Gate Dam and the Salmon River confluence under various Project configurations. Thermal stress categories are: OPT (optimal), SUB (suboptimal), STR (stressful), and SEV (severely stressful). For each scenario and site, entries are the percentage of days falling within stress categories in each two week period over 2000-2004 (total of 70 days per period). Project configurations are: EC = existing condition; No IG = Iron Gate Dam removed; No IG-COP = Iron Gate, and Copco 1 and 2 dams removed; No IG-COP-JCB = Iron Gate, and Copco 1 and 2, and JC Boyle dams removed; WOP = Iron Gate, and Copco 1 and 2, JC Boyle, and Keno dams removed.

Biweekly Period	Scenario	At Iron Gate Dam RM 190.54				Above Shasta River RM 177.52				At Walker Bridge RM 156.79				Above Scott River RM 143.86				At Seiad Valley RM 129.04				Above Clear Creek RM 99.04				Above Salmon River RM 66.91			
		OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV
Apr 23 - May 6	EC	100				100				100				100				97	3			100				100			
	No IG	99	1			96	4			100				96	4			90	10			94	6			100			
	No IG-COP	84	16			91	9			84	16			89	11			89	11			94	6			100			
	No IG-COP-JCB	94	6			91	9			91	9			91	9			89	11			94	6			100			
	WOP	91	9			87	13			87	13			89	11			91	9			94	6			100			
May 7 - 20	EC	100				44	56			64	36			59	41			76	24			83	17			90	10		
	No IG	47	53			33	67			56	44			46	54			73	26	1		80	20			87	13		
	No IG-COP	29	71			34	64	1		39	57	4		39	57	4		74	20	6		81	19			83	17		
	No IG-COP-JCB	49	51			41	59			46	54			46	54			77	17	6		81	19			83	17		
	WOP	60	40			60	40			53	47			51	46	3		79	16	6		81	19			87	13		
May 21 - Jun 3	EC	61	37	1		9	87	4		14	69	17		11	66	23		14	69	17		34	51	14		41	54	4	
	No IG	9	73	19		4	66	30		10	53	37		9	56	36		17	64	19		31	53	16		40	54	6	
	No IG-COP		56	43	1	3	51	41	4	1	50	43	6	3	51	40	6	9	66	21	4	26	59	16		34	56	10	
	No IG-COP-JCB	1	60	39		1	56	43		3	53	43	1	3	53	43	1	9	69	20	3	27	57	16		36	56	9	
	WOP	10	56	34		9	51	40		4	51	41	3	9	49	40	3	13	64	19	4	30	54	16		37	56	7	
Jun 4 - 17	EC		64	36			50	50			47	53			50	50			74	26			89	11			90	10	
	No IG		44	56			46	54			44	56			44	56			63	37			80	20			90	10	
	No IG-COP		36	53	11		33	57	10		31	59	10		36	56	9		57	43			76	24			86	14	
	No IG-COP-JCB		70	30			60	34	6		43	50	7		49	49	3		66	34			86	14			90	10	
	WOP		74	26			73	27			66	31	3		63	37			73	27			87	13			91	9	
Jun 18 - Jul 1	EC		30	70			3	74	23			90	10			81	19			86	14		24	63	13		24	60	16
	No IG		3	83	14		1	79	20			86	14		1	77	21		1	83	16		21	63	16		34	50	16
	No IG-COP		4	71	24		1	73	26			73	27		1	71	27		1	73	26		16	66	19		29	54	17
	No IG-COP-JCB		21	59	20		7	71	21		4	73	23		4	76	20		3	76	21		24	61	14		31	53	16
	WOP		30	47	23		21	57	21		9	70	21		7	73	20		3	77	20		14	70	16		27	59	14
Jul 2 - 15	EC			100				1	99			34	66			26	74			53	47			67	33			67	33
	No IG			16	84			24	76			23	77			34	66			54	46			67	33			67	33
	No IG-COP			43	57			19	81			21	79			30	70			47	53			67	33			67	33
	No IG-COP-JCB		1	89	10			56	44			46	54			49	51			59	41			67	33			67	33
	WOP		1	67	31			56	44			46	54			50	50			56	44			66	34			67	33
Jul 16 - 29	EC			59	41				100			6	94			3	97			4	96			17	83			24	76
	No IG				100			7	93			10	90			9	91			9	91			23	77			27	73
	No IG-COP			21	79			9	91			10	90			9	91			9	91			21	79			27	73
	No IG-COP-JCB		4	49	47			20	80			14	86			10	90			9	91			27	73			29	71
	WOP			34	66			26	74			14	86			14	86			10	90			24	76			29	71

Table B8. Thermal conditions predicted by the Klamath River water quality model August - October for juvenile chinook between Iron Gate Dam and the Salmon River confluence under various Project configurations. Thermal stress categories are: OPT (optimal), SUB (suboptimal), STR (stressful), and SEV (severely stressful). For each scenario and site, entries are the percentage of days falling within stress categories in each two week period over 2000-2004 (total of 70 days per period). Project configurations are: EC = existing condition; No IG = Iron Gate Dam removed; No IG-COP = Iron Gate, and Copco 1 and 2 dams removed; No IG-COP-JCB = Iron Gate, and Copco 1 and 2, and JC Boyle dams removed; WOP = Iron Gate, and Copco 1 and 2, JC Boyle, and Keno dams removed.

Biweekly Period	Scenario	At Iron Gate Dam RM 190.54				Above Shasta River RM 177.52				At Walker Bridge RM 156.79				Above Scott River RM 143.86				At Seiad Valley RM 129.04				Above Clear Creek RM 99.04				Above Salmon River RM 66.91			
		OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV
Jul 30 - Aug 12	EC			23	77				100			10	90			9	91			11	89			24	76			26	74
	No IG				100			13	87			16	84			16	84			14	86			29	71			31	69
	No IG-COP			41	59			23	77			23	77			21	79			20	80			29	71			31	69
	No IG-COP-JCB		10	47	43			36	64			27	73			24	76			23	77			30	70			31	69
	WOP		7	49	44		3	33	64			27	73			26	74			26	74			26	74			31	69
Aug 13-26	EC			20	80				100			6	94			7	93			14	86			29	71			40	60
	No IG				100			24	76			19	81			14	86			14	86			44	56			56	44
	No IG-COP			64	36			44	56			33	67			23	77			16	84			47	53			57	43
	No IG-COP-JCB			91	9			64	36			50	50			39	61			33	67			49	51			60	40
	WOP		3	81	16			71	29			53	47			47	53			43	57			47	53			60	40
Aug 27 - Sep 9	EC			43	57			33	67		1	44	54		3	44	53		3	43	54		4	56	40		4	60	36
	No IG			47	53		1	44	54		7	40	53		9	39	53		11	37	51		9	50	41		10	54	36
	No IG-COP		21	77	1		17	46	37		16	43	41		16	41	43		14	40	46		13	49	39		13	51	36
	No IG-COP-JCB		43	57			26	63	11		19	47	34		17	43	40		16	47	37		13	51	36		13	51	36
	WOP		44	56			34	57	9		20	51	29		19	43	39		16	46	39		14	50	36		13	51	36
Sep 10-23	EC			97	3		6	77	17		10	90			11	79	10		13	79	9		23	59	19		34	46	20
	No IG		11	89			13	87			17	83			20	80			24	67	9		33	51	16		36	44	20
	No IG-COP	6	77	17		3	57	40		3	50	47			50	50			40	56	4		40	46	14		46	36	19
	No IG-COP-JCB	6	86	9		4	70	26		4	51	44		1	51	47			44	54	1		41	46	13		47	34	19
	WOP	10	81	9		6	67	27		6	54	40		3	54	43		3	51	41	4		49	37	14		49	33	19
Sep 24 - Oct 7	EC		34	66			36	64			41	59			41	59			40	60		4	40	56		7	40	53	
	No IG		81	19			66	34			57	43			54	46			49	51		6	40	54		7	39	54	
	No IG-COP	14	86			11	80	9		13	60	27		9	59	33		7	51	41		7	43	50		7	41	51	
	No IG-COP-JCB	14	86			14	86			13	69	19		11	60	29		9	59	33		7	50	43		7	46	47	
	WOP	19	81			17	83			16	69	16		14	63	23		13	60	27		9	50	41		7	44	49	
Oct 8-21	EC		100				99	1		23	76	1		13	84	3		27	70	3		30	67	3		40	57	3	
	No IG	34	66			34	66			51	47	1		40	59	1		43	54	3		41	56	3		50	47	3	
	No IG-COP	84	16			76	24			76	23	1		70	29	1		61	37	1		57	40	3		59	39	3	
	No IG-COP-JCB	90	10			81	19			80	20			74	24	1		71	27	1		64	33	3		61	36	3	
	WOP	91	9			87	13			83	17			79	20	1		74	24	1		70	27	3		64	33	3	
Oct 22 - Nov 4	EC	90	10			79	21			94	6			90	10			93	7			93	7			96	4		
	No IG	100				100				100				97	3			96	4			96	4			99	1		
	No IG-COP	100				100				100				100				100				100				100			
	No IG-COP-JCB	100				100				100				100				100				100				100			
	WOP	100				100				100				100				100				100				100			

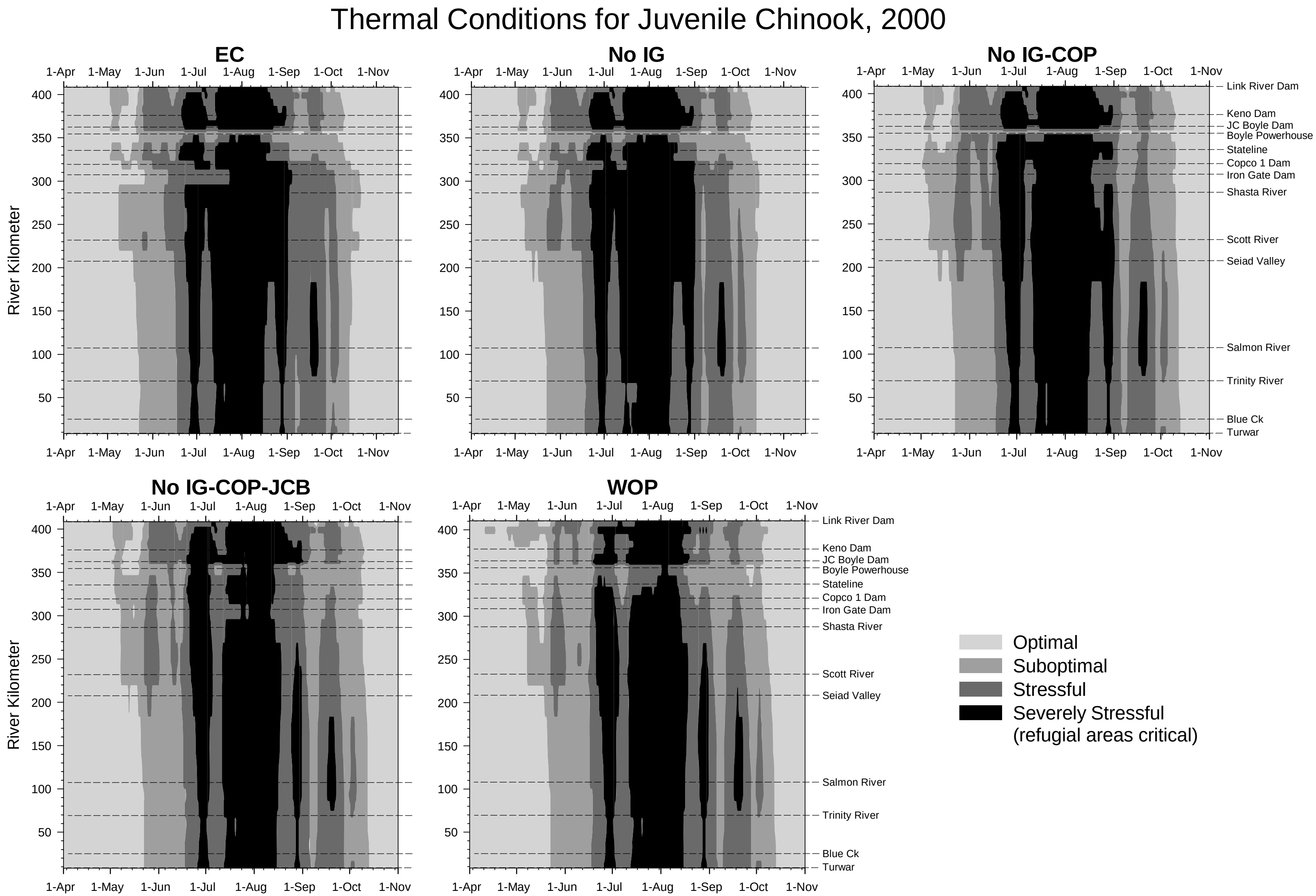

Figure B8. Conditions during spring, summer, and fall of 2000 for juvenile chinook within and below the KHP, based on water temperatures predicted by the KRWQM. Only data from riverine sites and Keno Reservoir are included; other mainstem reservoirs and Upper Klamath Lake are represented solely by outflow from the dams.

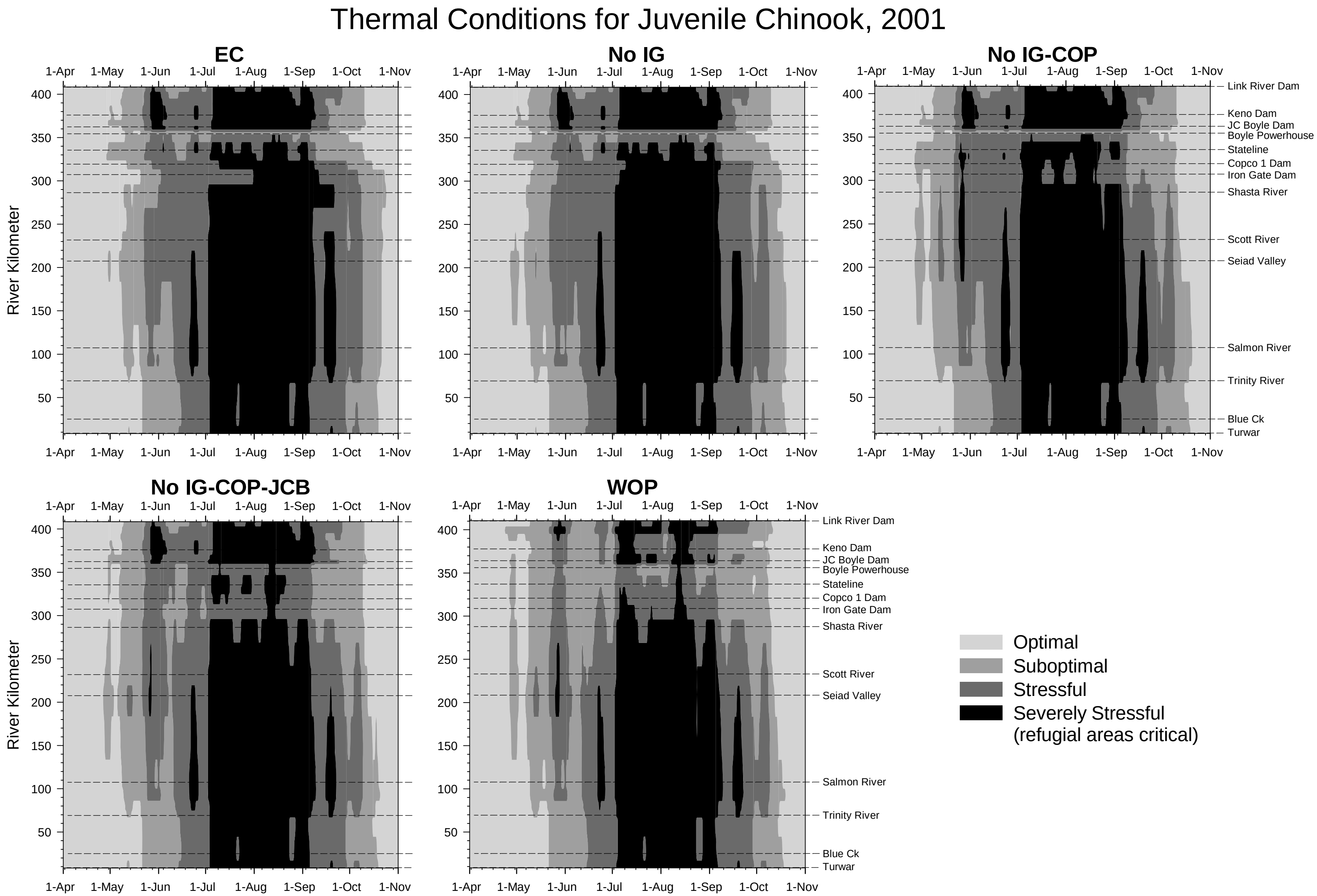

Figure B9. Conditions during spring, summer, and fall of 2001 for juvenile chinook within and below the KHP, based on water temperatures predicted by the KRWQM. Only data from riverine sites and Keno Reservoir are included; other mainstem reservoirs and Upper Klamath Lake are represented solely by outflow from the dams.

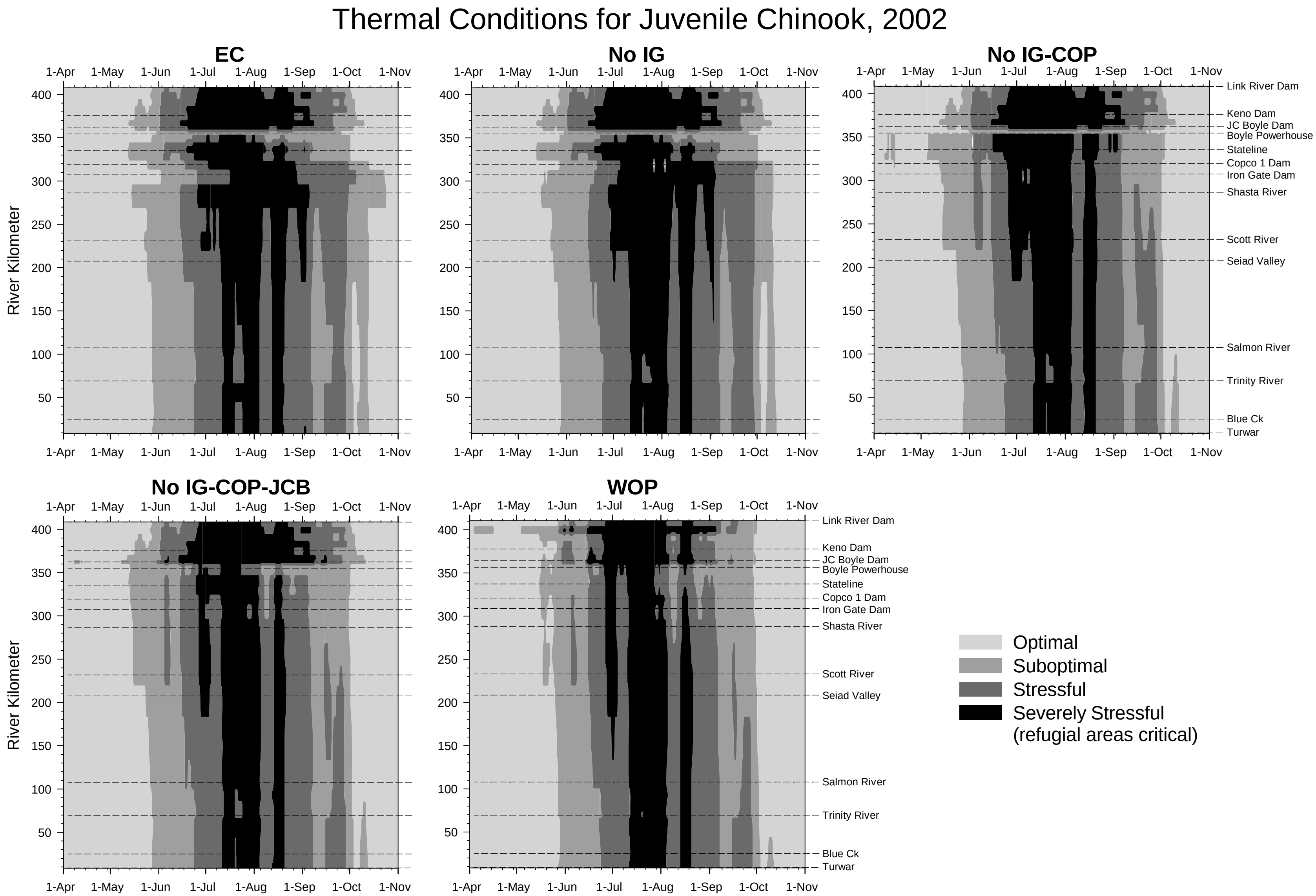

Figure B10. Conditions during spring, summer, and fall of 2002 for juvenile chinook within and below the KHP, based on water temperatures predicted by the KRWQM. Only data from riverine sites and Keno Reservoir are included; other mainstem reservoirs and Upper Klamath Lake are represented solely by outflow from the dams.

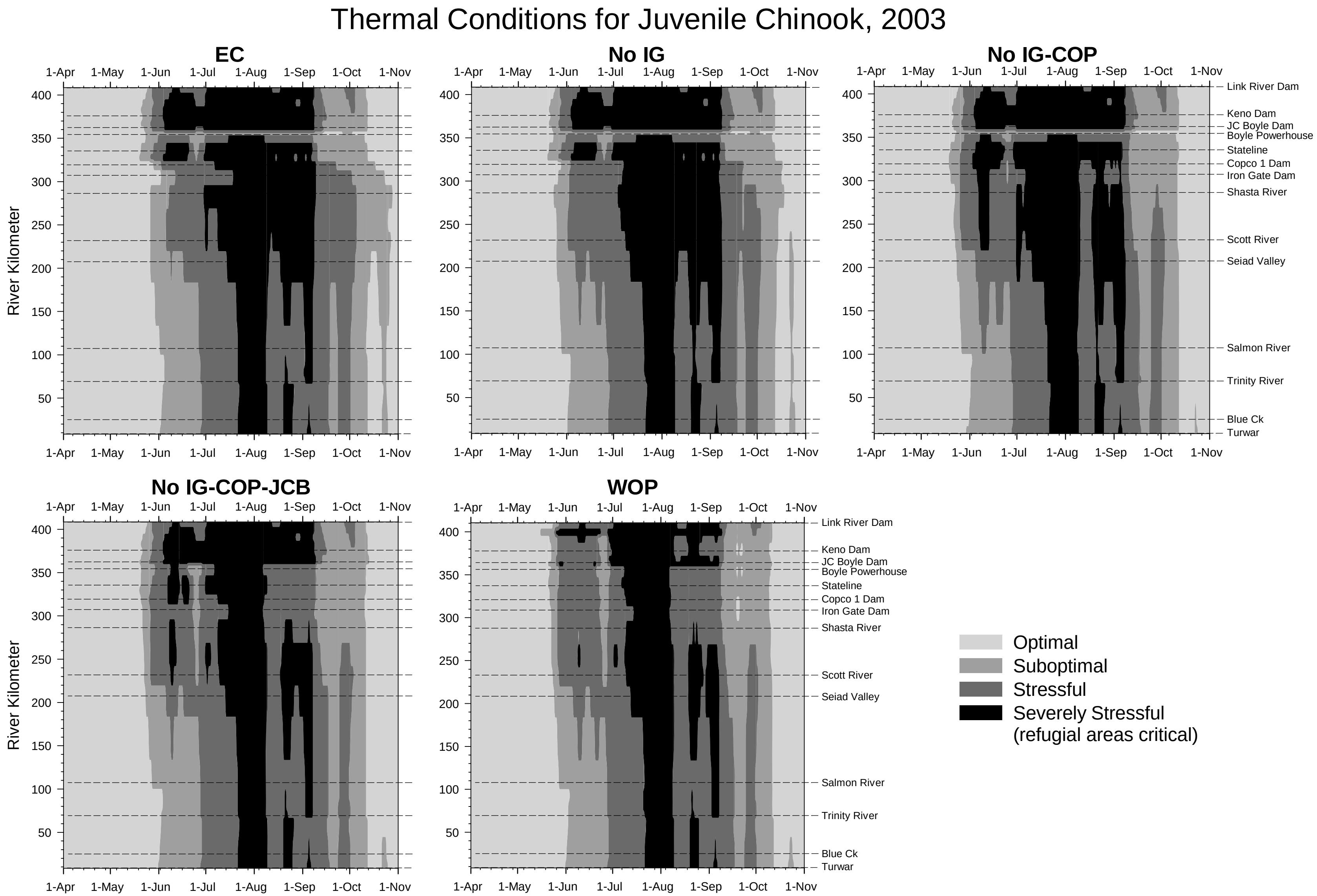

Figure B11. Conditions during spring, summer, and fall of 2003 for juvenile chinook within and below the KHP, based on water temperatures predicted by the KRWQM. Only data from riverine sites and Keno Reservoir are included; other mainstem reservoirs and Upper Klamath Lake are represented solely by outflow from the dams.

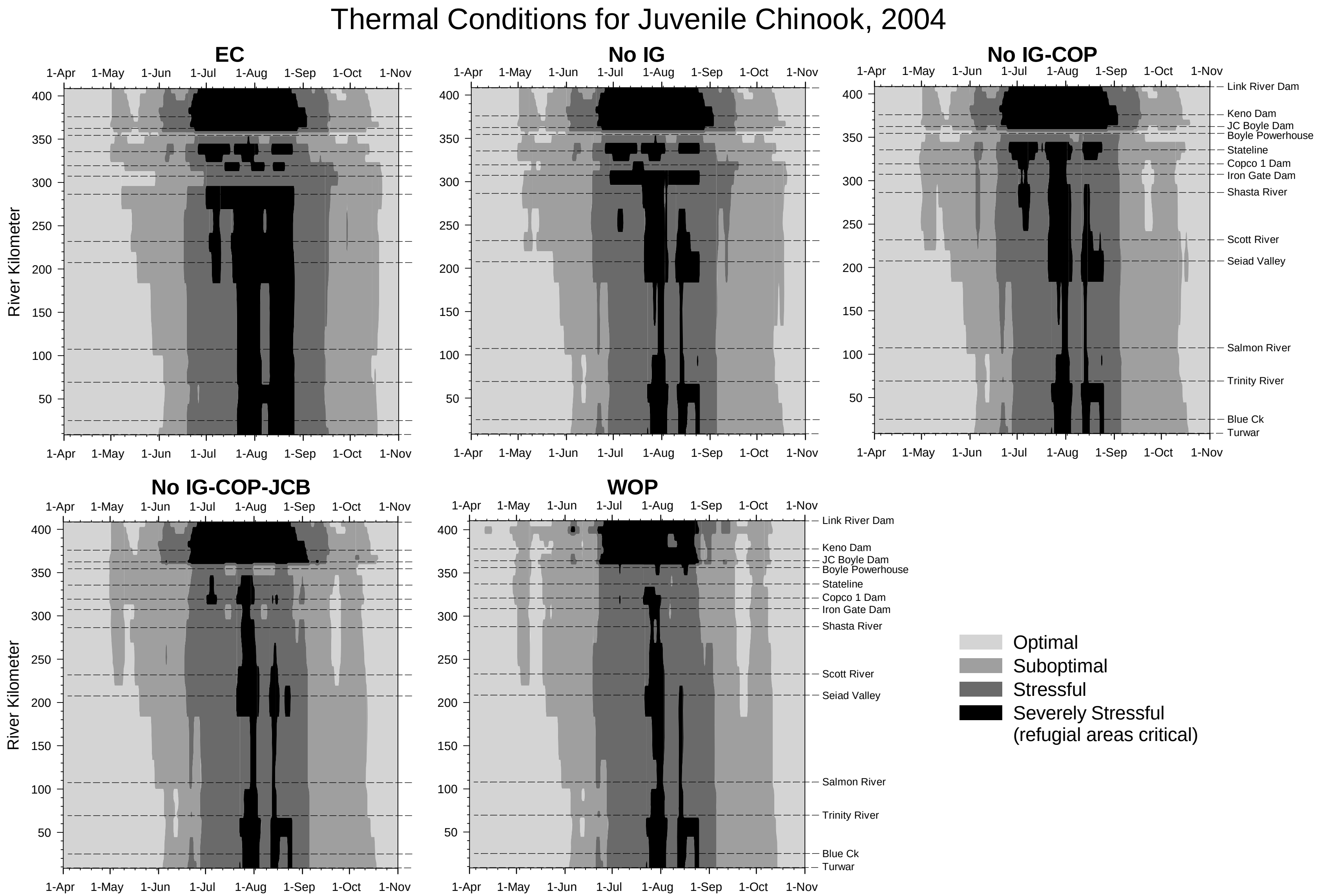

Figure B12. Conditions during spring, summer, and fall of 2004 for juvenile chinook within and below the KHP, based on water temperatures predicted by the KRWQM. Only data from riverine sites and Keno Reservoir are included; other mainstem reservoirs and Upper Klamath Lake are represented solely by outflow from the dams.

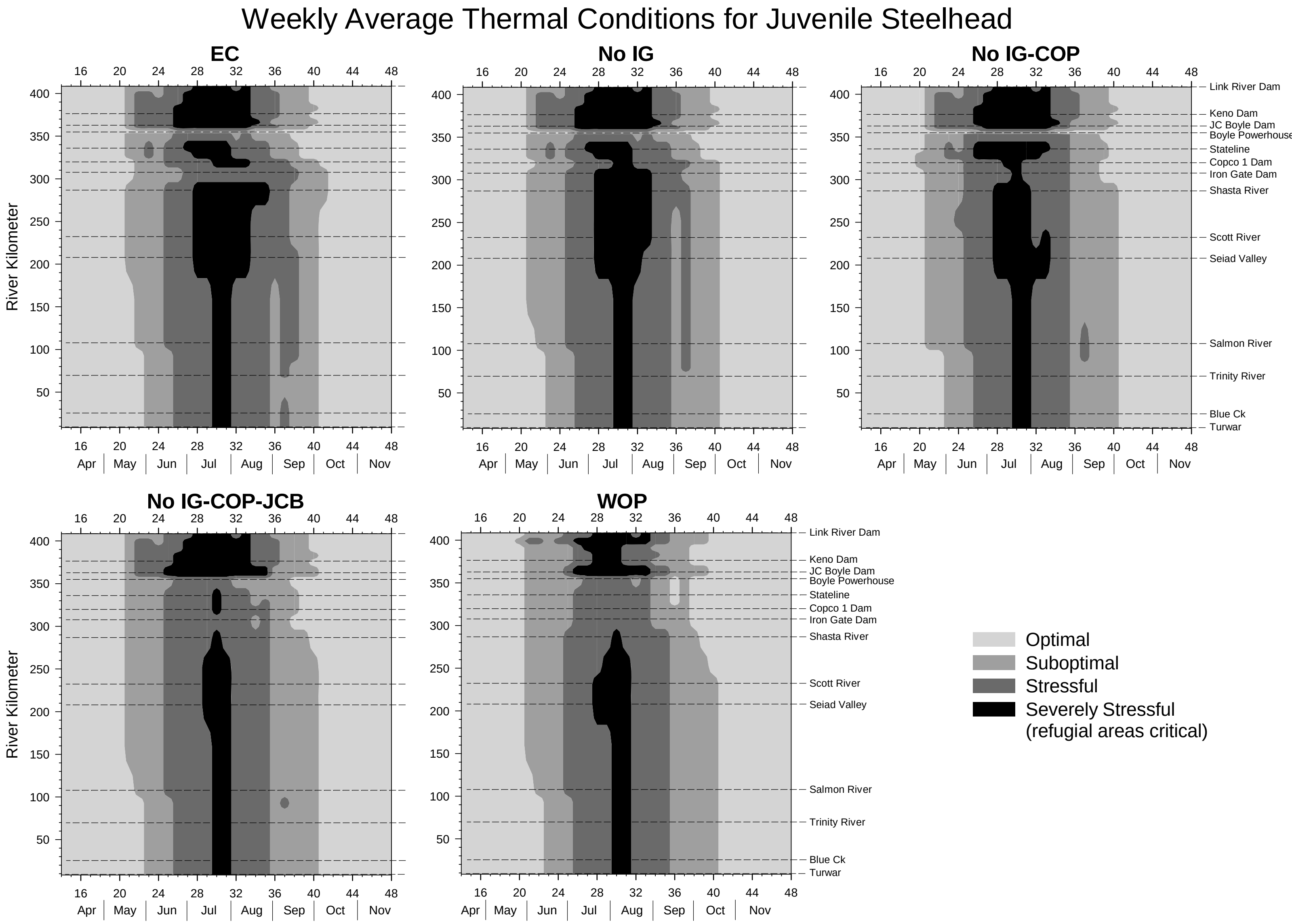

Figure B13. Average weekly thermal conditions for juvenile steelhead within and below the KHP. Water temperatures predicted by the KRWQM were categorized by level of stress, and then averaged by week across years (2000-2004). Only data from riverine sites and Keno Reservoir are included; other mainstem reservoirs and Upper Klamath Lake are represented solely by outflow from the dams.

Table B9. Thermal conditions predicted by the Klamath River water quality model April - July for juvenile steelhead between Keno and Copco 2 Dams under various Project configurations. Thermal stress categories are: OPT (optimal), SUB (suboptimal), STR (stressful), and SEV (severely stressful). For each scenario and site, entries are the percentage of days falling within stress categories in each two week period over 2000-2004 (total of 70 days per period). Project configurations are: EC = existing condition; No IG = Iron Gate Dam removed; No IG-COP = Iron Gate, and Copco 1 and 2 dams removed; No IG-COP-JCB = Iron Gate, and Copco 1 and 2, and JC Boyle dams removed; WOP = Iron Gate, and Copco 1 and 2, JC Boyle, and Keno dams removed.

Biweekly Period	Scenario	At Keno Dam RM 232.86				Abv JC Boyle reservoir RM 227.57				At JC Boyle Dam RM 224.32				Abv JCB Powerhouse RM 220.20				Blw JCB Powerhouse RM 219.40				At State Line RM 209.16				Abv Copco Reservoir RM 203.61				At Copco Dam RM 198.57			
		OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV
Apr 23 - May 6	EC	97	3			99	1			99	1			100				100				97	3			97	3			100			
	No IG	97	3			99	1			99	1			100				100				97	3			97	3			100			
	No IG-COP	97	3			99	1			99	1			100				100				97	3			96	4			99	1		
	No IG-COP-JCB	97	3			97	3			96	4			99	1			99	1			99	1			99	1			99	1		
	WOP	100				100				97	3			100				100				99	1			100				100			
May 7 - 20	EC	76	24			79	21			77	23			100				90	10			79	21			74	26			93	7		
	No IG	76	24			79	21			77	23			100				90	10			79	21			74	26			93	7		
	No IG-COP	76	24			79	21			76	24			100				74	26			67	33			64	36			71	29		
	No IG-COP-JCB	76	24			79	21			69	31			81	19			81	19			81	19			81	19			83	17		
	WOP	87	13			87	13			84	16			99	1			99	1			93	7			91	9			90	10		
May 21 - Jun 3	EC	27	40	29	4	23	50	27		27	44	29		100				53	37	10		20	64	16		13	59	29		54	40	6	
	No IG	27	40	29	4	23	50	27		27	44	29		100				53	37	10		20	64	16		13	59	29		60	34	6	
	No IG-COP	27	40	29	4	23	50	27		31	39	30		96	4			27	54	19		4	73	23		1	63	36		3	66	31	
	No IG-COP-JCB	27	40	29	4	14	56	30		7	64	29		29	56	16		29	56	16		17	64	19		14	67	19		21	54	24	
	WOP	41	40	19		24	56	20		21	56	23		43	51	6		43	51	6		37	51	11		37	49	14		40	39	21	
Jun 4 - 17	EC		21	63	16		34	49	17		24	61	14	83	17			3	77	20			70	16	14		73	13	14		76	24	
	No IG		21	63	16		34	49	17		24	61	14	83	17			3	77	20			70	16	14		73	13	14	1	76	23	
	No IG-COP		21	63	16		34	49	17		39	51	10	86	14				59	41			63	27	10		64	23	13		76	16	9
	No IG-COP-JCB		21	63	16		29	53	19		30	50	20		76	24			76	24			77	23			80	20			77	23	
	WOP	17	60	23		4	71	23	1	4	69	24	3	29	56	16		27	57	16		24	56	20		20	60	20		20	59	21	
Jun 18 - Jul 1	EC		3	60	37		7	41	51		4	70	26	63	37				79	21			27	51	21		29	49	23		34	66	
	No IG		3	60	37		7	41	51		4	70	26	63	37				79	21			27	51	21		29	49	23		41	59	
	No IG-COP		3	60	37		7	41	51		6	76	19	69	31				37	51	11		16	54	30		19	49	33		26	51	23
	No IG-COP-JCB		3	60	37		4	33	63		4	30	66		67	33			67	33			47	31	21		49	30	21		37	49	14
	WOP	1	46	46	7	1	39	24	36	1	36	24	39	6	70	20	4	7	67	21	4	1	60	37	1	1	54	43	1		51	44	4
Jul 2 - 15	EC			19	81			14	86			21	79	21	79				26	73	1		3	34	63		4	34	61		3	96	1
	No IG			19	81			14	86			21	79	21	79				26	73	1		3	34	63		4	34	61		3	97	
	No IG-COP			19	81			14	86			21	79	20	80				3	70	27			21	79			29	71		1	64	34
	No IG-COP-JCB			19	81			11	89			3	97		39	60	1		39	59	3		19	69	13		13	73	14		10	83	7
	WOP		11	37	51		3	17	80		3	11	86		26	66	9		27	64	9		19	77	4		14	81	4		11	84	4
Jul 16 - 29	EC			3	97				100			16	84	11	89				30	49	21			39	61		6	31	63			59	41
	No IG			3	97				100			16	84	11	89				30	49	21			39	61		6	31	63	1		60	39
	No IG-COP			3	97				100			16	84	11	89				10	54	36			21	79			23	77		6	31	63
	No IG-COP-JCB			3	97				100				100		20	69	11		20	67	13		7	51	41		4	54	41		4	54	41
	WOP		10	10	80			17	83			19	81		31	34	34		31	34	34		20	50	30		13	56	31		10	61	29

Table B10. Thermal conditions predicted by the Klamath River water quality model August - October for juvenile steelhead between Keno and Copco 2 Dams under various Project configurations. Thermal stress categories are: OPT (optimal), SUB (suboptimal), STR (stressful), and SEV (severely stressful). For each scenario and site, entries are the percentage of days falling within stress categories in each two week period over 2000-2004 (total of 70 days per period). Project configurations are: EC = existing condition; No IG = Iron Gate Dam removed; No IG-COP = Iron Gate, and Copco 1 and 2 dams removed; No IG-COP-JCB = Iron Gate, and Copco 1 and 2, and JC Boyle dams removed; WOP = Iron Gate, and Copco 1 and 2, JC Boyle, and Keno dams removed.

Biweekly Period	Scenario	At Keno Dam RM 232.86				Abv JC Boyle reservoir RM 227.57				At JC Boyle Dam RM 224.32				Abv JCB Powerhouse RM 220.20				Blw JCB Powerhouse RM 219.40				At State Line RM 209.16				Abv Copco Reservoir RM 203.61				At Copco Dam RM 198.57			
		OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV
Jul 30 - Aug 12	EC			6	94				100			16	84	27	73				36	53	11		6	40	54		13	37	50			39	61
	No IG			6	94				100			16	84	27	73				36	53	11		6	40	54		13	37	50	1		41	57
	No IG-COP			6	94				100			20	80	27	73				14	47	39			40	60		3	39	59		14	39	47
	No IG-COP-JCB			6	94				100				100		43	49	9		43	49	9		24	34	41		19	43	39		14	44	41
	WOP		17	31	51		14	16	70		10	17	73		41	49	10		41	49	10		36	51	13		31	47	21		27	47	26
Aug 13-26	EC			23	77			7	93			43	57	53	47				60	40			1	71	27		4	81	14			51	49
	No IG			23	77			7	93			43	57	53	47				60	40			1	71	27		4	81	14			67	33
	No IG-COP			23	77			7	93			53	47	57	43				4	79	17			66	34		3	67	30		4	87	9
	No IG-COP-JCB			23	77			4	96			6	94		66	34			66	34			31	66	3		21	76	3		16	80	4
	WOP		20	51	29		9	41	50		3	36	61		56	44			56	44			44	56			39	61			30	70	
Aug 27 - Sep 9	EC		6	90	4		7	63	30		7	91	1	99	1			4	96			1	36	63		3	43	54				99	1
	No IG		6	90	4		7	63	30		7	91	1	99	1			4	96			1	36	63		3	43	54			1	99	
	No IG-COP		6	90	4		7	63	30		9	91		97	3			1	37	61			40	60			41	59			44	56	
	No IG-COP-JCB		6	90	4		7	41	51		9	33	59	6	94			6	94			4	63	33		6	59	36		6	44	50	
	WOP	6	67	27			53	47		1	43	54	1	14	81	4		14	81	4		16	69	16		16	61	23		13	57	30	
Sep 10-23	EC		71	29			74	26		6	74	20		100				47	53			13	87			19	81					46	54
	No IG		71	29			74	26		6	74	20		100				47	53			13	87			19	81					46	54
	No IG-COP		71	29			74	26		7	86	7		100				20	80			4	96			6	94			11	89		
	No IG-COP-JCB		71	29			69	31			60	40		31	69			31	69			19	81			20	80			23	77		
	WOP	33	67			23	77			19	81			53	47			53	47			51	49			49	51			39	61		
Sep 24 - Oct 7	EC	30	67	3		13	87			41	59			100				97	3			63	37			53	47				97	3	
	No IG	30	67	3		13	87			41	59			100				97	3			63	37			53	47			1	96	3	
	No IG-COP	30	67	3		13	87			49	51			100				67	33			23	77			29	71			49	51		
	No IG-COP-JCB	30	67	3		11	89			10	90			79	21			80	20			59	41			54	46			54	46		
	WOP	67	33			30	70			33	67			87	13			87	13			84	16			79	21			69	31		
Oct 8-21	EC	93	7			87	13			96	4			100				100				97	3			99	1			66	34		
	No IG	93	7			87	13			96	4			100				100				97	3			99	1			67	33		
	No IG-COP	93	7			87	13			96	4			100				100				96	4			97	3			97	3		
	No IG-COP-JCB	93	7			79	21			84	16			100				100				100				99	1			99	1		
	WOP	99	1			97	3			97	3			100				100				100				100				99	1		
Oct 22 - Nov 4	EC	100				100				100				100				100				100				100				100			
	No IG	100				100				100				100				100				100				100				100			
	No IG-COP	100				100				100				100				100				100				100				100			
	No IG-COP-JCB	100				100				100				100				100				100				100				100			
	WOP	100				100				100				100				100				100				100				100			

Table B11. Thermal conditions predicted by the Klamath River water quality model April - July for juvenile steelhead between Iron Gate Dam and the Salmon River confluence under various Project configurations. Thermal stress categories are: OPT (optimal), SUB (suboptimal), STR (stressful), and SEV (severely stressful). For each scenario and site, entries are the percentage of days falling within stress categories in each two week period over 2000-2004 (total of 70 days per period). Project configurations are: EC = existing condition; No IG = Iron Gate Dam removed; No IG-COP = Iron Gate, and Copco 1 and 2 dams removed; No IG-COP-JCB = Iron Gate, and Copco 1 and 2, and JC Boyle dams removed; WOP = Iron Gate, and Copco 1 and 2, JC Boyle, and Keno dams removed.

Biweekly Period	Scenario	At Iron Gate Dam RM 190.54				Above Shasta River RM 177.52				At Walker Bridge RM 156.79				Above Scott River RM 143.86				At Seiad Valley RM 129.04				Above Clear Creek RM 99.04				Above Salmon River RM 66.91			
		OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV
Apr 23 - May 6	EC	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0
	No IG	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0
	No IG-COP	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	97	3	0	0	100	0	0	0	100	0	0	0
	No IG-COP-JCB	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0
	WOP	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	97	3	0	0	100	0	0	0	100	0	0	0
May 7 - 20	EC	100	0	0	0	100	0	0	0	99	1	0	0	97	3	0	0	84	16	0	0	96	4	0	0	100	0	0	0
	No IG	91	9	0	0	86	14	0	0	77	23	0	0	80	20	0	0	83	17	0	0	93	7	0	0	100	0	0	0
	No IG-COP	80	20	0	0	80	20	0	0	71	29	0	0	77	23	0	0	83	17	0	0	89	11	0	0	99	1	0	0
	No IG-COP-JCB	87	13	0	0	86	14	0	0	80	20	0	0	81	19	0	0	83	17	0	0	90	10	0	0	99	1	0	0
	WOP	87	13	0	0	86	14	0	0	84	16	0	0	84	16	0	0	83	17	0	0	91	9	0	0	99	1	0	0
May 21 - Jun 3	EC	80	20	0	0	41	59	0	0	34	63	3	0	33	60	7	0	59	27	14	0	64	36	0	0	66	34	0	0
	No IG	36	59	6	0	27	60	13	0	20	56	24	0	27	50	23	0	51	31	17	0	56	41	3	0	64	36	0	0
	No IG-COP	21	46	33	0	14	47	39	0	10	51	39	0	16	47	37	0	37	46	17	0	47	47	6	0	57	43	0	0
	No IG-COP-JCB	33	47	20	0	26	46	29	0	10	56	34	0	21	49	30	0	37	46	17	0	53	43	4	0	64	36	0	0
	WOP	40	40	20	0	37	33	30	0	24	41	34	0	29	39	33	0	41	43	16	0	53	43	4	0	63	37	0	0
Jun 4 - 17	EC	23	76	1	0	0	97	3	0	0	86	14	0	0	90	10	0	1	90	9	0	14	81	4	0	14	81	4	0
	No IG	0	81	19	0	0	80	20	0	0	73	27	0	0	73	27	0	6	81	13	0	16	77	7	0	21	73	6	0
	No IG-COP	0	74	26	0	0	74	23	3	0	74	23	3	0	74	26	0	4	79	17	0	14	79	7	0	21	74	4	0
	No IG-COP-JCB	4	74	21	0	1	76	23	0	0	77	23	0	0	79	21	0	6	94	0	0	14	84	1	0	21	76	3	0
	WOP	21	60	19	0	6	73	21	0	3	76	21	0	3	76	21	0	7	93	0	0	16	83	1	0	21	76	3	0
Jun 18 - Jul 1	EC	0	63	37	0	0	33	61	6	0	20	77	3	0	17	76	7	0	27	67	6	0	47	50	3	0	50	47	3
	No IG	0	39	57	4	0	21	69	10	0	9	84	7	0	14	76	10	0	29	64	7	0	49	47	4	0	50	47	3
	No IG-COP	0	24	61	14	0	20	64	16	0	16	69	16	0	14	74	11	0	21	70	9	0	49	46	6	0	50	46	4
	No IG-COP-JCB	0	54	41	4	0	29	61	10	0	23	66	11	0	21	69	10	0	33	59	9	0	50	44	6	0	50	46	4
	WOP	0	60	27	13	0	41	47	11	0	29	60	11	0	27	63	10	0	37	54	9	0	49	47	4	0	50	47	3
Jul 2 - 15	EC	0	13	87	0	0	0	54	46	0	0	71	29	0	0	64	36	0	0	73	27	0	0	77	23	0	4	74	21
	No IG	0	0	66	34	0	0	57	43	0	0	64	36	0	0	67	33	0	0	70	30	0	4	71	24	0	4	73	23
	No IG-COP	0	0	90	10	0	0	66	34	0	0	64	36	0	0	67	33	0	0	70	30	0	4	71	24	0	4	73	23
	No IG-COP-JCB	0	16	77	7	0	4	77	19	0	0	73	27	0	0	70	30	0	0	73	27	0	1	76	23	0	7	70	23
	WOP	0	14	80	6	0	4	73	23	0	0	71	29	0	0	73	27	0	0	71	29	0	0	77	23	0	6	73	21
Jul 16 - 29	EC	0	0	93	7	0	0	6	94	0	0	26	74	0	0	10	90	0	0	26	74	0	0	54	46	0	0	66	34
	No IG	0	0	23	77	0	0	24	76	0	0	23	77	0	0	21	79	0	0	20	80	0	3	51	46	0	3	63	34
	No IG-COP	0	6	43	51	0	0	19	81	0	0	26	74	0	0	20	80	0	0	20	80	0	3	50	47	0	3	61	36
	No IG-COP-JCB	0	9	73	19	0	6	46	49	0	0	31	69	0	0	27	73	0	0	30	70	0	3	54	43	0	3	63	34
	WOP	0	7	67	26	0	4	40	56	0	0	31	69	0	0	29	71	0	0	29	71	0	1	53	46	0	3	63	34

Table B12. Thermal conditions predicted by the Klamath River water quality model August - October for juvenile steelhead between Iron Gate Dam and the Salmon River confluence under various Project configurations. Thermal stress categories are: OPT (optimal), SUB (suboptimal), STR (stressful), and SEV (severely stressful). For each scenario and site, entries are the percentage of days falling within stress categories in each two week period over 2000-2004 (total of 70 days per period). Project configurations are: EC = existing condition; No IG = Iron Gate Dam removed; No IG-COP = Iron Gate, and Copco 1 and 2 dams removed; No IG-COP-JCB = Iron Gate, and Copco 1 and 2, and JC Boyle dams removed; WOP = Iron Gate, and Copco 1 and 2, JC Boyle, and Keno dams removed.

Biweekly Period	Scenario	At Iron Gate Dam RM 190.54				Above Shasta River RM 177.52				At Walker Bridge RM 156.79				Above Scott River RM 143.86				At Seiad Valley RM 129.04				Above Clear Creek RM 99.04				Above Salmon River RM 66.91			
		OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV
Jul 30 - Aug 12	EC	0	0	61	39	0	0	4	96	0	0	26	74	0	0	26	74	0	0	26	74	0	4	33	63	0	4	34	61
	No IG	0	0	14	86	0	0	33	67	0	0	33	67	0	0	34	66	0	0	31	69	0	0	41	59	0	4	40	56
	No IG-COP	0	10	46	44	0	3	34	63	0	3	37	60	0	1	33	66	0	1	29	70	0	3	39	59	0	4	40	56
	No IG-COP-JCB	0	23	59	19	0	11	46	43	0	6	40	54	0	3	36	61	0	3	31	66	0	3	40	57	0	4	40	56
	WOP	0	24	50	26	0	13	44	43	0	6	41	53	0	6	34	60	0	6	34	60	0	3	40	57	0	3	41	56
Aug 13-26	EC	0	0	70	30	0	0	9	91	0	0	46	54	0	0	39	61	0	0	49	51	0	4	66	30	0	4	69	27
	No IG	0	0	47	53	0	0	57	43	0	0	54	46	0	0	54	46	0	0	64	36	0	3	70	27	0	4	73	23
	No IG-COP	0	3	89	9	0	0	74	26	0	0	69	31	0	0	63	37	0	0	66	34	0	3	71	26	0	4	73	23
	No IG-COP-JCB	0	27	73	0	0	4	83	13	0	0	76	24	0	0	71	29	0	0	74	26	0	3	71	26	0	4	74	21
	WOP	0	33	67	0	0	6	81	13	0	3	74	23	0	1	74	24	0	1	73	26	0	3	71	26	0	3	74	23
Aug 27 - Sep 9	EC	0	0	100	0	0	1	47	51	0	10	60	30	0	13	54	33	0	14	61	24	0	17	70	13	0	19	69	13
	No IG	0	7	89	4	0	16	70	14	0	19	66	16	0	20	57	23	0	19	59	23	0	19	67	14	0	21	66	13
	No IG-COP	4	40	56	0	1	33	56	10	0	24	66	10	0	21	63	16	0	21	61	17	0	23	64	13	0	21	66	13
	No IG-COP-JCB	9	50	41	0	6	39	56	0	0	34	59	7	0	31	57	11	0	21	64	14	0	23	64	13	0	23	64	13
	WOP	11	56	33	0	9	37	54	0	3	34	56	7	0	33	56	11	0	30	59	11	0	23	64	13	0	24	63	13
Sep 10-23	EC	0	10	90	0	0	19	81	0	0	34	66	0	0	41	59	0	0	44	56	0	1	50	49	0	1	59	37	3
	No IG	0	60	40	0	3	51	46	0	4	44	51	0	4	46	50	0	3	51	46	0	1	56	43	0	1	60	37	1
	No IG-COP	16	80	4	0	7	74	19	0	6	64	30	0	6	60	34	0	4	59	37	0	3	59	39	0	3	59	39	0
	No IG-COP-JCB	26	74	0	0	17	76	7	0	9	67	24	0	9	61	30	0	7	57	36	0	4	60	36	0	3	60	37	0
	WOP	37	63	0	0	24	66	10	0	17	57	26	0	11	59	30	0	9	56	36	0	7	57	36	0	4	59	37	0
Sep 24 - Oct 7	EC	0	87	13	0	0	84	16	0	6	73	21	0	7	67	26	0	9	64	27	0	9	69	23	0	9	70	21	0
	No IG	1	99	0	0	7	91	1	0	10	87	3	0	11	79	10	0	11	70	19	0	14	66	20	0	16	69	16	0
	No IG-COP	47	53	0	0	19	81	0	0	16	83	1	0	16	80	4	0	16	73	11	0	16	70	14	0	17	67	16	0
	No IG-COP-JCB	60	40	0	0	41	59	0	0	17	83	0	0	17	79	4	0	17	76	7	0	16	73	11	0	17	69	14	0
	WOP	63	37	0	0	49	51	0	0	23	77	0	0	20	77	3	0	19	73	9	0	19	70	11	0	19	67	14	0
Oct 8-21	EC	30	70	0	0	41	59	0	0	66	34	0	0	67	33	0	0	69	31	0	0	71	27	1	0	73	26	1	0
	No IG	74	26	0	0	77	23	0	0	79	21	0	0	77	23	0	0	76	24	0	0	77	23	0	0	77	21	1	0
	No IG-COP	96	4	0	0	91	9	0	0	86	14	0	0	84	16	0	0	80	20	0	0	81	19	0	0	79	21	0	0
	No IG-COP-JCB	99	1	0	0	96	4	0	0	89	11	0	0	86	14	0	0	84	16	0	0	81	19	0	0	80	20	0	0
	WOP	99	1	0	0	96	4	0	0	93	7	0	0	87	13	0	0	84	16	0	0	81	19	0	0	81	19	0	0
Oct 22 - Nov 4	EC	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0
	No IG	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0
	No IG-COP	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0
	No IG-COP-JCB	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0
	WOP	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0

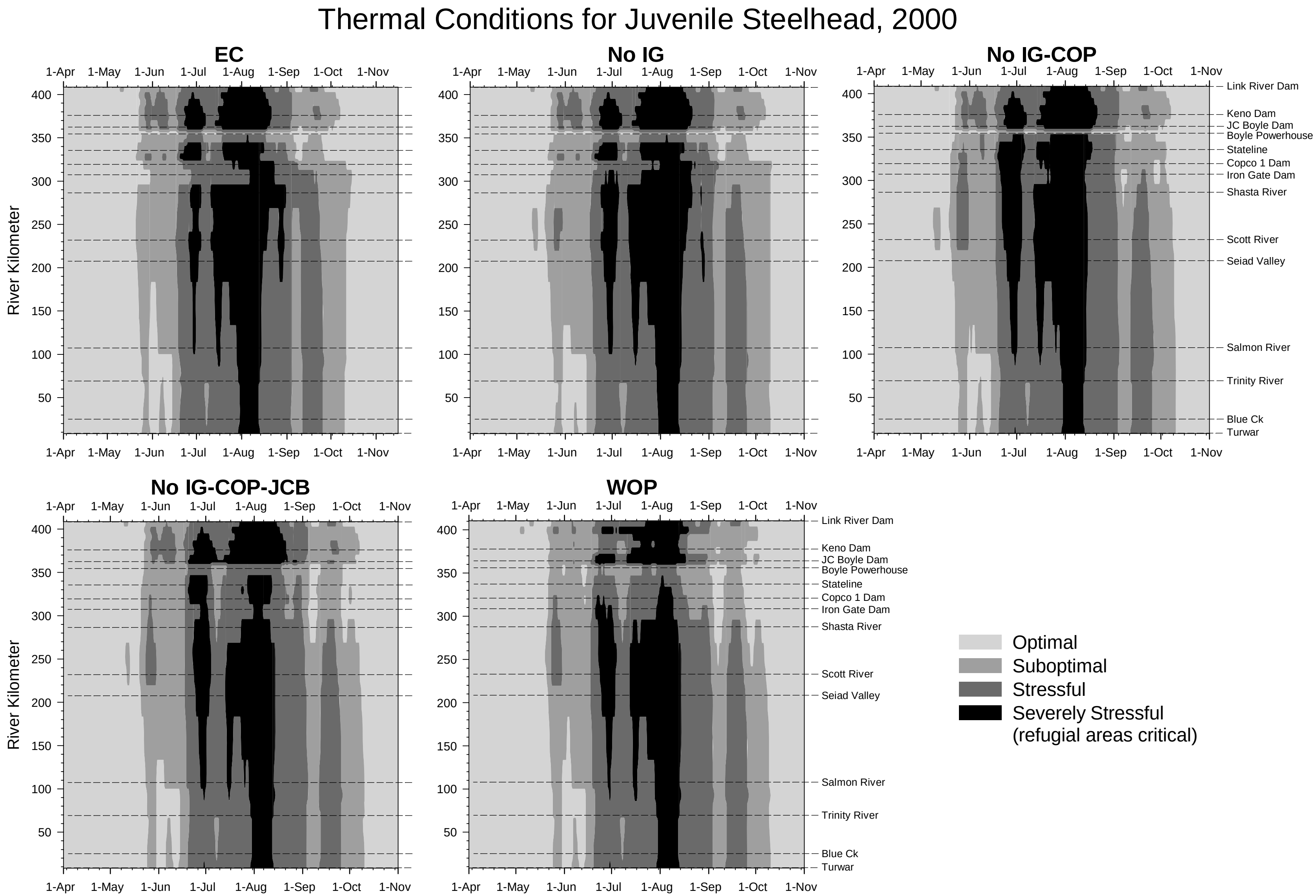

Figure B14. Conditions during spring, summer, and fall of 2000 for juvenile steelhead within and below the KHP, based on water temperatures predicted by the KRWQM. Only data from riverine sites and Keno Reservoir are included; other mainstem reservoirs and Upper Klamath Lake are represented solely by outflow from the dams.

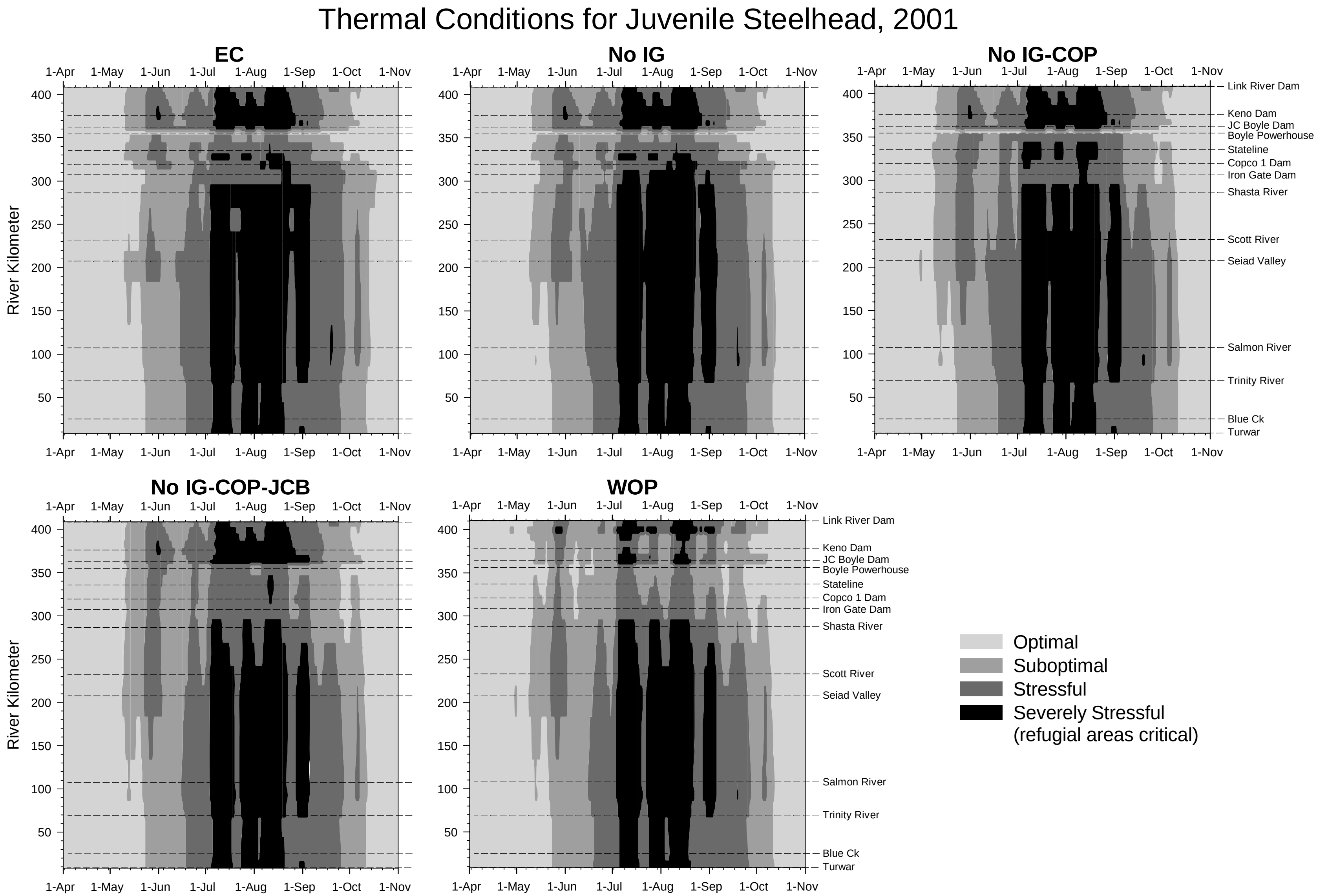

Figure B15. Conditions during spring, summer, and fall of 2001 for juvenile steelhead within and below the KHP, based on water temperatures predicted by the KRWQM. Only data from riverine sites and Keno Reservoir are included; other mainstem reservoirs and Upper Klamath Lake are represented solely by outflow from the dams.

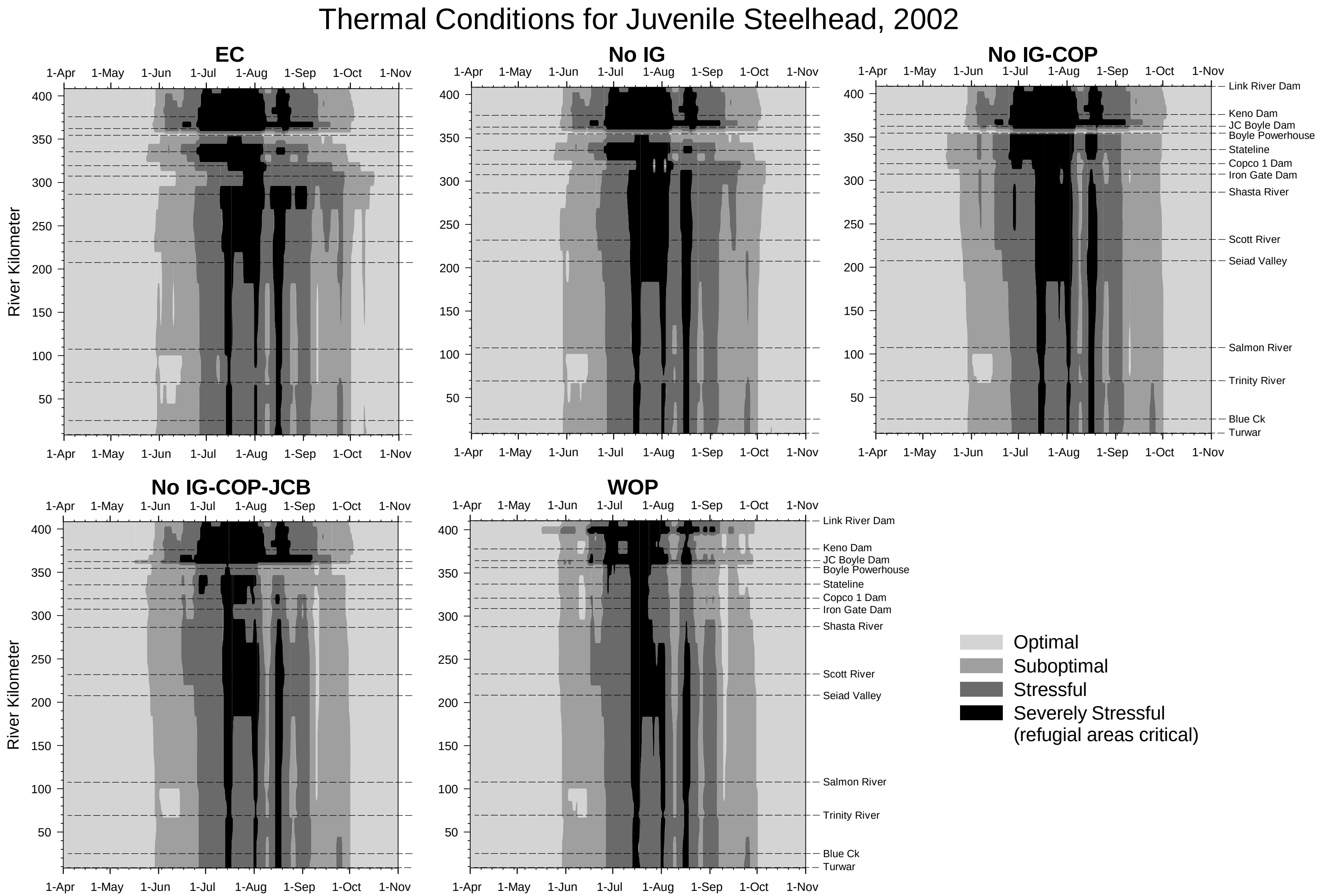

Figure B16. Conditions during spring, summer, and fall of 2002 for juvenile steelhead within and below the KHP, based on water temperatures predicted by the KRWQM. Only data from riverine sites and Keno Reservoir are included; other mainstem reservoirs and Upper Klamath Lake are represented solely by outflow from the dams.

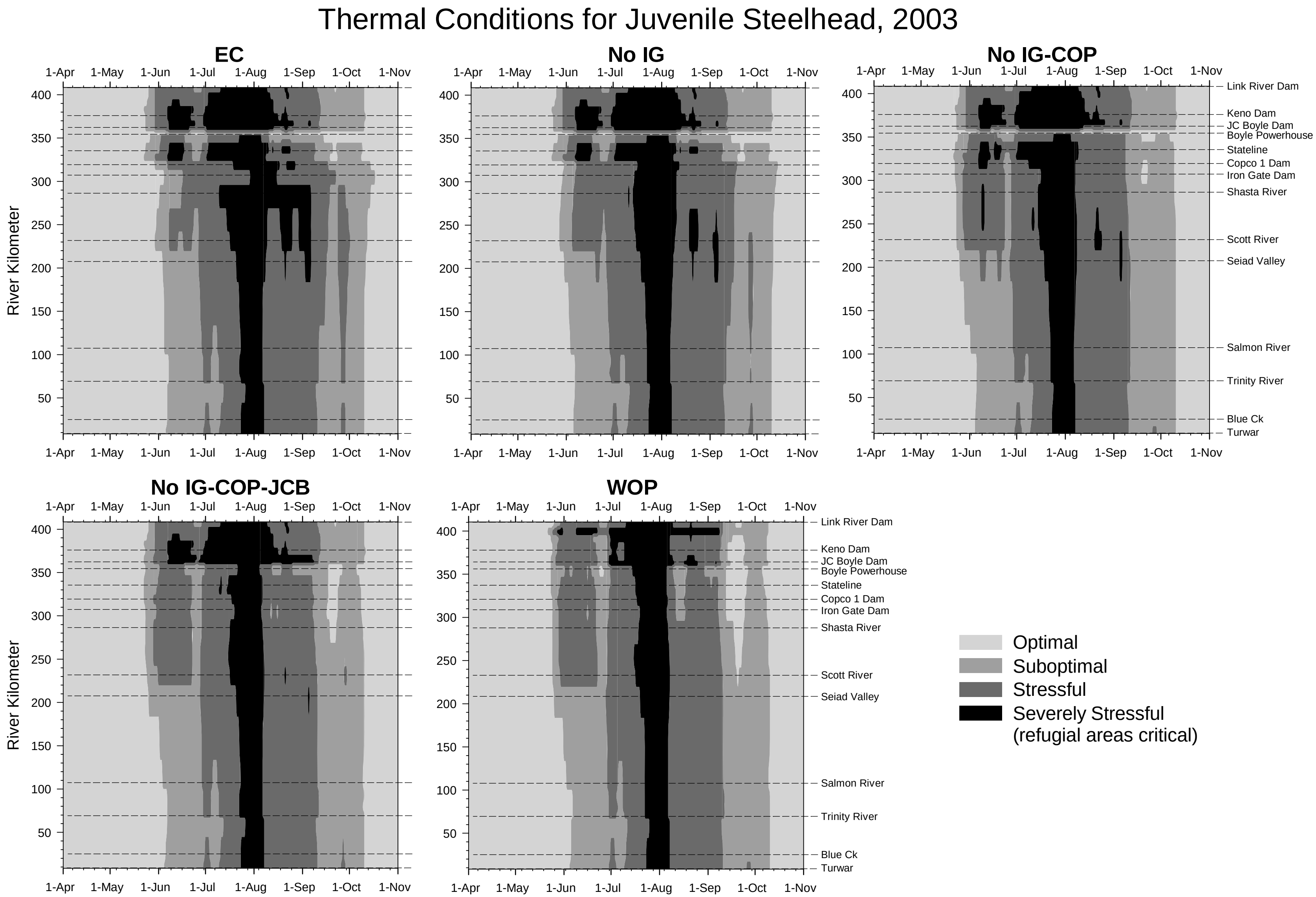

Figure B17. Conditions during spring, summer, and fall of 2003 for juvenile steelhead within and below the KHP, based on water temperatures predicted by the KRWQM. Only data from riverine sites and Keno Reservoir are included; other mainstem reservoirs and Upper Klamath Lake are represented solely by outflow from the dams.

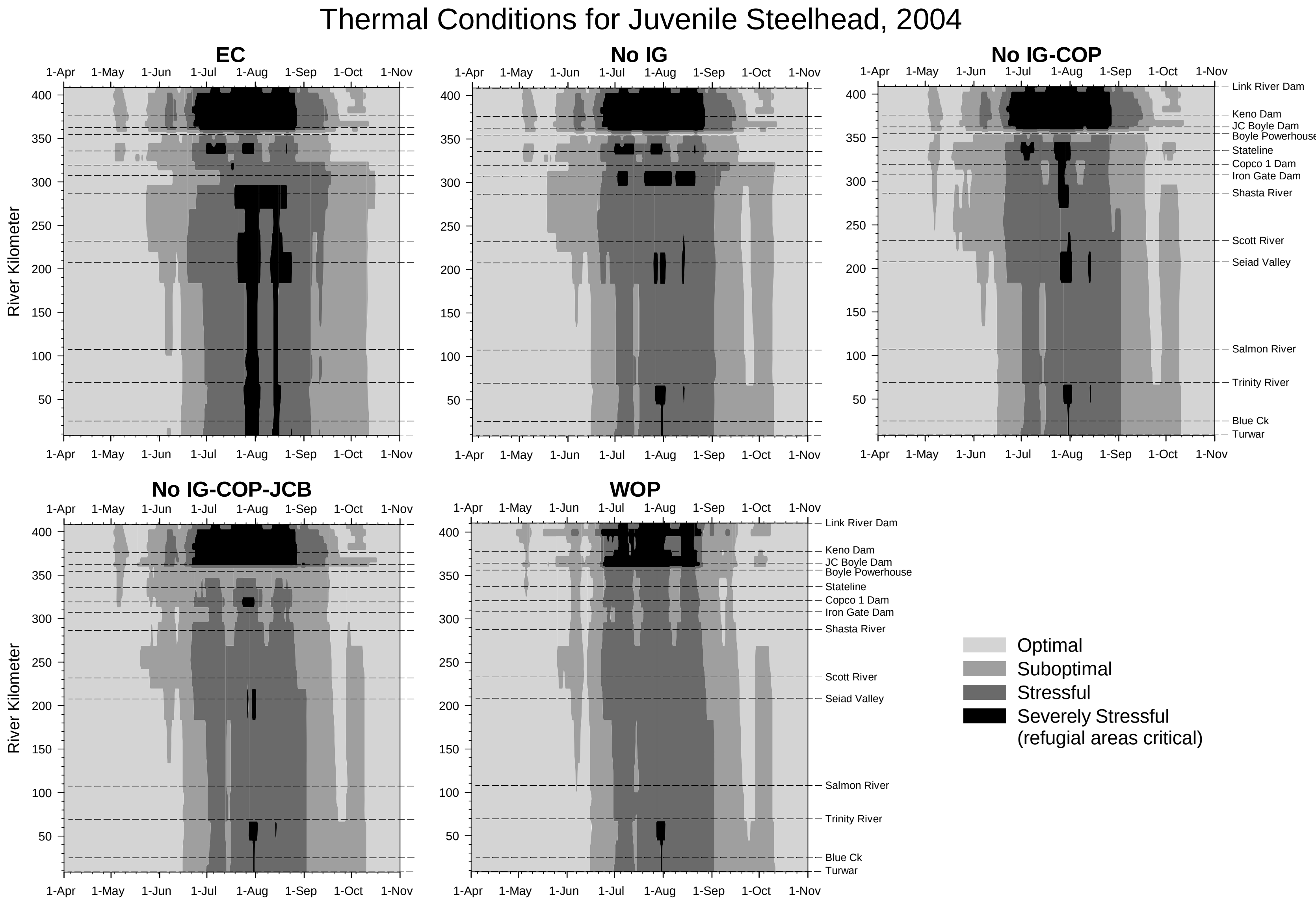

Figure B18. Conditions during spring, summer, and fall of 2004 for juvenile steelhead within and below the KHP, based on water temperatures predicted by the KRWQM. Only data from riverine sites and Keno Reservoir are included; other mainstem reservoirs and Upper Klamath Lake are represented solely by outflow from the dams.

Table B13. Frequency with which thermal refugia would be occupied, and the average daily minimum river temperature for periods when refugia would be occupied, under various KHP configurations. The threshold for thermal refugia occupancy (maximum daily temperature >22°C) is from Belchik (2003).

		Assume occupancy of thermal refugia when maximum daily temperature >22ºC														
		Number of days (2000-2004) when refugia are occupied					Average number of days per year when refugia are occupied					Average minimum daily temperature of river when refugia are occupied				
Site	River kilometer	EC	No IG	No IG-COP	No IG-COP-JCB	WOP	EC	No IG	No IG-COP	No IG-COP-JCB	WOP	EC	No IG	No IG-COP	No IG-COP-JCB	WOP
Keno Dam outflow	374.7	347	347	347	347	261	69	69	69	69	52	22.7	22.7	22.7	22.7	20.0
Klamath River above JC Boyle Reservoir	366.2	450	450	450	464	360	90	90	90	93	72	19.2	19.2	19.2	19.1	18.2
JC Boyle Reservoir outflow	360.9	297	297	269	477	388	59	59	54	95	78	22.7	22.7	22.7	18.1	17.7
Klamath River Bypass above powerhouse	354.3	0	0	0	197	208	0	0	0	39	42				17.2	17.4
Klamath River below powerhouse	353.0	209	209	174	199	206	42	42	35	40	41	14.1	14.1	18.9	17.2	17.4
Klamath River at Stateline	336.5	393	393	417	310	193	79	79	83	62	39	16.3	16.3	17.5	17.2	18.3
Klamath River above Copco	327.6	363	363	412	308	219	73	73	82	62	44	18.6	18.6	17.2	18.0	18.8
Copco Dam outflow	319.5	164	136	366	288	226	33	27	73	58	45	21.8	21.5	18.2	18.6	19.2
Iron Gate Dam outflow	306.6	77	372	283	194	195	15	74	57	39	39	21.9	19.3	20.1	19.5	19.6
Klamath River above Shasta River	285.6	417	382	333	278	248	83	76	67	56	50	18.5	18.8	20.2	19.7	20.0
Klamath River at Walker Bridge	252.3	285	307	319	282	258	57	61	64	56	52	21.6	21.2	21.1	21.1	21.3
Klamath River above Scott River	231.5	380	363	335	314	292	76	73	67	63	58	19.9	20.1	20.7	20.4	20.7
Klamath River at Seiad Valley	207.6	345	331	337	313	302	69	66	67	63	60	20.3	20.4	20.3	20.3	20.4
Klamath River above Clear Creek	159.4	298	289	282	275	270	60	58	56	55	54	20.1	20.2	20.3	20.3	20.4
Klamath River above Salmon River	107.7	278	262	263	258	255	56	52	53	52	51	20.4	20.5	20.5	20.5	20.6
Klamath River at Orleans	92.6	274	261	263	261	253	55	52	53	52	51	20.7	20.7	20.7	20.7	20.8
Klamath River above Bluff Creek	78.9	263	247	247	244	231	53	49	49	49	46	20.5	20.5	20.5	20.5	20.7
Klamath River above Trinity River	69.7	263	243	246	241	225	53	49	49	48	45	20.3	20.3	20.3	20.3	20.7
Klamath River at Martins Ferry	63.5	220	226	213	209	193	44	45	43	42	39	20.6	20.0	20.6	20.7	20.9
Klamath River at Blue Creek	25.7	268	257	255	255	241	54	51	51	51	48	20.0	19.8	20.0	20.0	20.3
Klamath River at Turwar	8.5	281	268	270	268	262	56	54	54	54	52	20.1	20.0	20.1	20.1	20.3

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Technical Memorandum

To: Larry Dunsmoor, Biologist, Klamath Tribes
From: C.W. Huntington, Aquatic Biologist
Subject: Klamath R. flows within the JC Boyle Bypass and below the JC Boyle Powerhouse
Date: 15 April 2004

The following memorandum summarizes the methods and results of multiple analyses completed in response to questions you asked about the degree to which PacifiCorp's (PC's) hydropower operations alter streamflows within specific reaches of the Klamath River considered to be among those most dramatically altered by PC. The questions addressed by the analyses are as follows:

- What can an Indicators of Hydrologic Alteration (IHA) type of assessment (Richter et al. 1996), based on recent model-generated hourly flow data, tell us about PC-related flow changes in the JC Boyle bypass reach (km 354.6-360.9)?
- What can an IHA-type assessment of similar data tell us about PC-related flow changes in the upper-most "full flow" (power-peaking) reach of the Klamath River below the JC Boyle Powerhouse (at km 354.6)?
- What do available river stage data for the USGS gauge site on the Klamath River below JC Boyle Powerhouse (No. 11510700; km 353.5) tell us about maximal rates of change (i.e., up and down-ramp rates) in that area?

Initially, you also indicated an interest in having an IHA-type assessment conducted on flow data for the bypassed reach of the river channel below Copco II Dam (at km 319.1). We agreed that the value of such an analysis would be low because hydropower operations reduce flow through that portion of the river channel to only about 5 cfs unless high runoff forces spill or there is some sort of project maintenance event (PacifiCorp 2000a). This modified flow pattern is clearly not one to which the river's native assemblage of aquatic biota is well adapted.

Indicators of Hydrologic Alteration (IHA) Analyses

Originally described by Richter et al. (1996), an IHA analysis consists of a paired comparison between the unaltered and modified flow regimes of a riverine site affected by one or more forms of development. The analysis examines the central tendency and dispersion patterns of dozens of hydrologic parameters within each of five distinct groups: (1) the magnitude of monthly water conditions, (2) the magnitude and duration of annual extreme water conditions, (3) the timing of annual extreme water conditions, (4) the frequency and duration of high and low flow pulses, and (5) the rate and frequency of water condition changes. The intent of an IHA analysis is to clearly define the nature of hydrologic change because of the recognized influence of flow regimes on the biotic composition, structure, and function of riverine/riparian systems.

The specific hydrologic parameters examined within each IHA group, and some of the methods used in their calculation, have changed over time. However, the basic analytical approach remains unchanged and has been incorporated into user-friendly software that automates IHA analyses of gauge records of (mean) daily flows (TNC & SSS 2003). Richter et al. (1996) suggested that shorter-than-daily time steps could be appropriate when assessing hydrologic alterations from power peaking operations, but there are no standardized calculation algorithms nor software for such analyses at present (C. Smythe, Smythe Scientific Software, pers comm.).

IHA-type Assessments for Specific Klamath River Reaches

Consultants to PC have developed year 2000 and 2001 hourly flow data for a multitude of locations along the Klamath River and two scenarios: Existing Condition (EC; with the Klamath Hydroelectric Project [KHP] functioning as it did during these two years) and Without Project (WOP; with river flows unmodified by the presence of the KHP). These data, based on simulations made using an RMA2 hydrodynamic flow-routing model, provide the best information available at present on how the KHP modifies river discharge and were used by PacifiCorp (2004b) in their recent graphical comparisons of WOP and EC river flows. The RMA2-simulated hourly river flows formed the basis for the IHA-type assessments I completed to answer the first two of your three questions.

In order to conduct IHA-type assessments on model-generated hourly flow data for the two Klamath River reaches identified as being of particular interest, I refined a set of 35 hydrologic parameters very similar to those outlined by Richter et al. (1996). These parameters, and how they were calculated from hourly data in my assessments, are given in Table 1.

Table 1. Summary of 35 hydrologic parameters used in the Index of Hydrologic Alteration (IHA; Richter et al. 1996) assessment and how they were calculated from modeled hourly flow data for each location and condition (Without Project or Existing Condition) on the Klamath River.

IHA statistics group/parameters	How the parameters were calculated
Group 1: Monthly magnitude Median flows per each of 12 months (all in cubic feet per second [cfs])	Median flow values for each calendar month were calculated after all hourly data for all years included in an analysis were stratified by month. Minimum, 25th-percentile, 75th-percentile, and maximum hourly values for flows occurring within each month were calculated after similar stratification of the data, to characterize the pattern of dispersion.
Group 2: Magnitude and duration (recurrence) of annual extremes 1-day minimum and maximum flows 3-day minimum and maximum flows 7-day minimum and maximum flows 30-day minimum and maximum flows 90-day minimum and maximum flows number of zero flow days per year baseflow (7-day minimum/median)	Annual 1, 3, 7, 30, and 90-day minimum flows were calculated as the lowest hourly flow matched or exceeded (in a downward direction) each day for the given number of consecutive days. Annual 1, 3, 7, 30, and 90-day maximum flows were calculated in a similar fashion, using the highest hourly flow matched or exceeded (in an upward direction) each day for the given number of consecutive days. The mid-range of two annual values was taken as equivalent to the median as a measure of central tendency for each of the 10 parameters in Group 2. The pattern of dispersion for each parameter was characterized simply by the range between a minimum and maximum value because the number of years (two) included in the baseflow analysis precluded calculations of percentile values.
Group 3: Timing of annual extremes Julian date of 99th percentile flow Julian date of 1st percentile flow	Julian dates of first occurrence for the annual 99th percentile (high) flow and the annual 1st percentile (low) flow were calculated from hourly data, with low flows tallied only if preceded in the year by at least one hourly occurrence of the year's 99th percentile flow. Mid-ranges of annual values were substituted for medians for each of these two parameters, while minimum and maximum values were used to characterize dispersion. The limited number of years included in the analysis precluded calculations of median and percentile values for the annual timing of extreme flows.
Group 4: Frequency and duration of high and low pulses Low pulse count (#/yr) High pulse count (#/yr) Low pulse duration (hrs) High pulse duration (hrs)	Each hourly or longer pulse of low or high flow was tallied and its duration determined. Such pulses were defined as being continuous periods where flows were less than the 25th-percentile (low) value or greater than the 75th percentile (high) value within the 1960-2002 (period-of-record) daily flow dataset for the USGS gauge on the Klamath River immediately downstream of the JC Boyle powerhouse (No. 11510700). Measures of central tendency and dispersion for annual counts of flow pulses were calculated in the same way as those for Group 3 hydrologic parameters. Measures of central tendency and dispersion for the duration of flow pulses were calculated in the same way as those for Group 1 parameters, and were calculated from data pooled across years.
Group 5: Rate and frequency of change in conditions Daily range (cfs) Fall count (#/yr) Rise count (#/yr) Fall rate (cfs/hr) Rise rate (cfs/hr)	Changes and rates of change in flow between consecutive hourly discharge data were identified and recorded, with changes of less than 10 cfs ignored in an effort to screen out what appeared to be modeling anomalies. The difference between each day's maximum and minimum hourly flow was also recorded. Measures of central tendency and dispersion for annual counts of positive and negative changes (rises and falls) in hourly flows were calculated in the same fashion as were those for Group 3 parameters. Measures of central tendency and dispersion for the rates of flow change reflected in these hourly rises or falls, and for the daily range in flow, were the same as those for Group 1 parameters, and were calculated from data pooled across years.

Although similar, my assessments of WOP versus EC flows in the JC Boyle bypass and peaking reaches during the 2000-2001 period should not be viewed as classic IHA analyses for four reasons. First, the use of hourly rather than daily flows meant that the calculation algorithms and resultant values for several of the hydrologic parameters used were slightly different than those of Richter et al. (1996) or TNC & SSS (2003). Second, the assessments are based on data for only two years, one of "average" runoff and the other "dry". The simulated flow record was less than needed to fully characterize the long-term influence of the KHP. Third, the WOP scenario that was modeled does not reflect a "natural" hydrograph but is simply a simulation of what river flows would have been in the absence of the KHP. Finally, relatively small oscillations in hourly WOP and EC flows appear to have been an artifact of the hydrodynamic modeling (M. Deas, Watercourse Engineering, pers comm.), at least for the two river segments of interest. I attempted to screen out some of these oscillations when analyzing the frequency and rate of hourly flow changes (see Table 1), but to the degree I was unable to remove them they tended to add variability to the modeled flows.

When examining the results of my IHA-type assessments, their dependence on simulated hourly flow data should be kept clearly in mind. The data used were not from stream gauges and their utility in the type of assessments I have performed is derived from viewing quantitative differences between WOP and EC flows as indicators of the types and relative degrees of project-induced changes in Klamath River hydrographs. The general nature of hydrodynamic modeling and specific details on how the WOP and EC scenarios were simulated by PC's consultants (EC runs had higher spatial and temporal resolution to allow simulation of KHP power-peaking operations) make it a certainty that my estimates of KHP effects contain smallish errors that would be difficult to eliminate (M. Deas, Watercourse Engineering, pers comm.). Nevertheless, using the model results to identify the general patterns, timing, frequency, and relative magnitude of the effects identified appears to be reasonable at present, since this is the best data available upon which to base such an analysis and I am not aware of any major flaws in the model application. PacifiCorp (2004) provided graphical summaries comparing the WOP and EC simulations of hourly river flows, suggesting that they drew a similar conclusion about the reasonableness of comparisons between the two.

JC Boyle Bypass Reach. The IHA-type assessment of KHP effects on flows in the Boyle bypass reach during 2001 and 2002 was based on RMA2-simulated flows adjusted to the Klamath River at km 357. This point on the river is downstream of springs that add approximately 225 cfs to water released or spilled from JC Boyle Dam (M. Deas, Watercourse

Engineering, pers comm.) and upstream of areas backwatered by power-peaking operations at the Boyle powerhouse. EC data on hourly flows in the river at km 357 were RMA2 output for a site immediately below JC Boyle Dam plus discharge from the aforementioned springs. WOP flows used for km 357 were RMA2 output for km 355.6, a modeled site a short distance downstream that is unaffected by additional significant inputs.

Results of the assessment are summarized in Table 2, with greater detail provided in Attachment A. The assessment suggests multiple KHP-induced changes in flow, including those outlined below and visually apparent in Figure 1.

- *Monthly magnitude* -- The KHP reduced the magnitude and variability of monthly flows. Median monthly flows were reduced by an average of about 75%, while the coefficient of dispersion (variability) was reduced substantially for flows during each month but February. Monthly 25th to 75th-percentile ranges of flow were extremely narrow for the EC, and fell consistently outside and below those for the WOP condition.

- *Magnitude and duration of annual extremes* -- The magnitudes of maximum and minimum flows occurring on specified numbers of consecutive days were consistently and dramatically reduced by the KHP. Under existing conditions, between-year variation in minimum flows was virtually eliminated as flow releases from JC Boyle Dam were held at very low, constant levels unless high runoff exceeded powerhouse capacity and caused spill into the bypass reach.

- *Timing of annual extremes* -- Annual extreme flows, both high (99th-percentile) and low (1st-percentile), occurred substantially earlier in the year due to operations of the KHP. High flows first occurred about two months earlier, and low flows about five to six months earlier, under EC than they did for the WOP condition.

- *Frequency and duration of high and low pulses* – High flow pulses of magnitudes approaching those that would occur without the KHP were eliminated, while the duration of low flow pulses was dramatically extended.

- *Rate and frequency of change in conditions* – The KHP dramatically decreased the frequency of flow changes occurring in the bypass reach, a frequency that was likely elevated under the WOP condition by upstream irrigation projects. Although the KHP's effect on median or "typical" rates of flow change was negligible (when changes did occur), maximal rates of change were clearly reduced by the project (see Attachment A, Tables A1 and A2).

Table 2. IHA-type comparison of Without Project (WOP) and Existing (Exist.) streamflow conditions in the JC Boyle bypass reach of the Klamath River, based on modeled hourly flows PacifiCorp (2004b) reported for 2000 and 2001. Source data: RMA2 model simulations described in PacifiCorp (2004b).

	Medians				*Coefficient of dispersion* [a]			
			Deviation [b]				*Deviation* [b]	
IHA Group	*WOP*	*Exist.*	*Magnitude*	*Percentage*	*WOP*	*Exist.*	*Magnitude*	*Percentage*
Group 1: Monthly magnitude								
October (cfs)	1197	325	-872	-73%	0.21	0.00	-0.21	-100%
November (cfs)	1126	325	-801	-71%	0.15	0.00	-0.15	-100%
December (cfs)	1038	325	-713	-69%	0.20	0.00	-0.20	-100%
January (cfs)	1552	325	-1227	-79%	0.91	0.00	-0.91	-100%
February (cfs)	2716	325	-2391	-88%	0.82	1.24	0.42	51%
March (cfs)	1946	325	-1621	-83%	1.18	0.33	-0.85	-72%
April (cfs)	1762	325	-1437	-82%	0.37	0.00	-0.37	-100%
May (cfs)	1737	325	-1412	-81%	0.30	0.00	-0.30	-100%
June (cfs)	1541	325	-1216	-79%	0.46	0.00	-0.46	-100%
July (cfs)	918	325	-593	-65%	0.24	0.00	-0.24	-100%
August (cfs)	890	325	-565	-63%	0.22	0.00	-0.22	-100%
September (cfs)	961	325	-636	-66%	0.19	0.00	-0.19	-100%
Group averages [c]				*75%*				*94%*
Group 2: Magnitude and duration (recurrence) of annual extremes								
1-day minimum (cfs)	548	325	-223	-41%	0.06	0.00	-0.06	-100%
3-day minimum (cfs)	707	325	-382	-54%	0.03	0.00	-0.03	-100%
7-day minimum (cfs)	835	325	-510	-61%	0.13	0.00	-0.13	-100%
30-day minimum (cfs)	993	325	-668	-67%	0.11	0.00	-0.11	-100%
90-day minimum (cfs)	1212	325	-887	-73%	0.30	0.00	-0.30	-100%
1-day maximum (cfs)	3445	1100	-2345	-68%	0.76	1.41	0.65	86%
3-day maximum (cfs)	3408	1052	-2356	-69%	0.77	1.38	0.61	79%
7-day maximum (cfs)	3284	1000	-2284	-70%	0.79	1.35	0.56	72%
30-day maximum (cfs)	2527	505	-2022	-80%	0.78	0.71	-0.07	-9%
90-day maximum (cfs)	1586	325	-1261	-80%	0.55	0.00	-0.55	-100%
Number of zero days per year	0	0	0	0%	---	---	0.00	0%
Baseflow	0.58	1.00	0.42	72%	0.05	0.00	-0.05	-100%
Group averages [c]				*61%*				*79%*
Group 3: Timing of annual extremes								
Julian date of 99th percentile flow	100	35	-65	-65%	0.34	0.37	0.03	7%
Julian date of 1st percentile flow	197	38	-159	-81%	0.10	0.42	0.32	305%
Group averages [c]				*73%*				*156%*
Group 4: Frequency and duration of high and low pulses								
Low pulse count (#/yr)	27.5	2	-25.5	-93%	0.33	1.50	1.17	358%
High pulse count (#/yr)	5	0	-5	-100%	2.00	0.00	-2.00	-100%
Low pulse duration (hrs)	27	983	956	3541%	1.11	0.08	-1.03	-93%
High pulse duration (hrs)	31	0	-31	-100%	2.97	0.00	-2.97	-100%
Group averages [c]				*959%*				*163%*
Group 5: Rate and frequency of change in conditions								
Daily range (cfs)	124	0	-124	-100%	1.07	0.00	-1.07	-100%
Fall count (#/yr)	1623	101	-1522	-94%	0.20	2.00	1.80	884%
Rise count (#/yr)	1585	112.5	-1472.5	-93%	0.12	2.00	1.88	1542%
Fall rate (cfs/hr)	14	14	0	0%	0.50	0.71	0.21	42%
Rise rate (cfs/hr)	14	14	0	0%	0.50	0.50	0.00	0%
Group averages [c]				*57%*				*514%*

[a] *When data were pooled across years, the coefficient used was the difference between the 75th and 25th-percentile values, divided by the median. If the parameter was calculated annually (i.e., twice), the coefficient of dispersion was the maximum minus the minimum, divided by the midrange.*

[b] *The deviations represent the Indicators of Hydrologic Alteration.*

[c] *Group averages were computed as the mean of all deviations (in absolute values) within the group.*

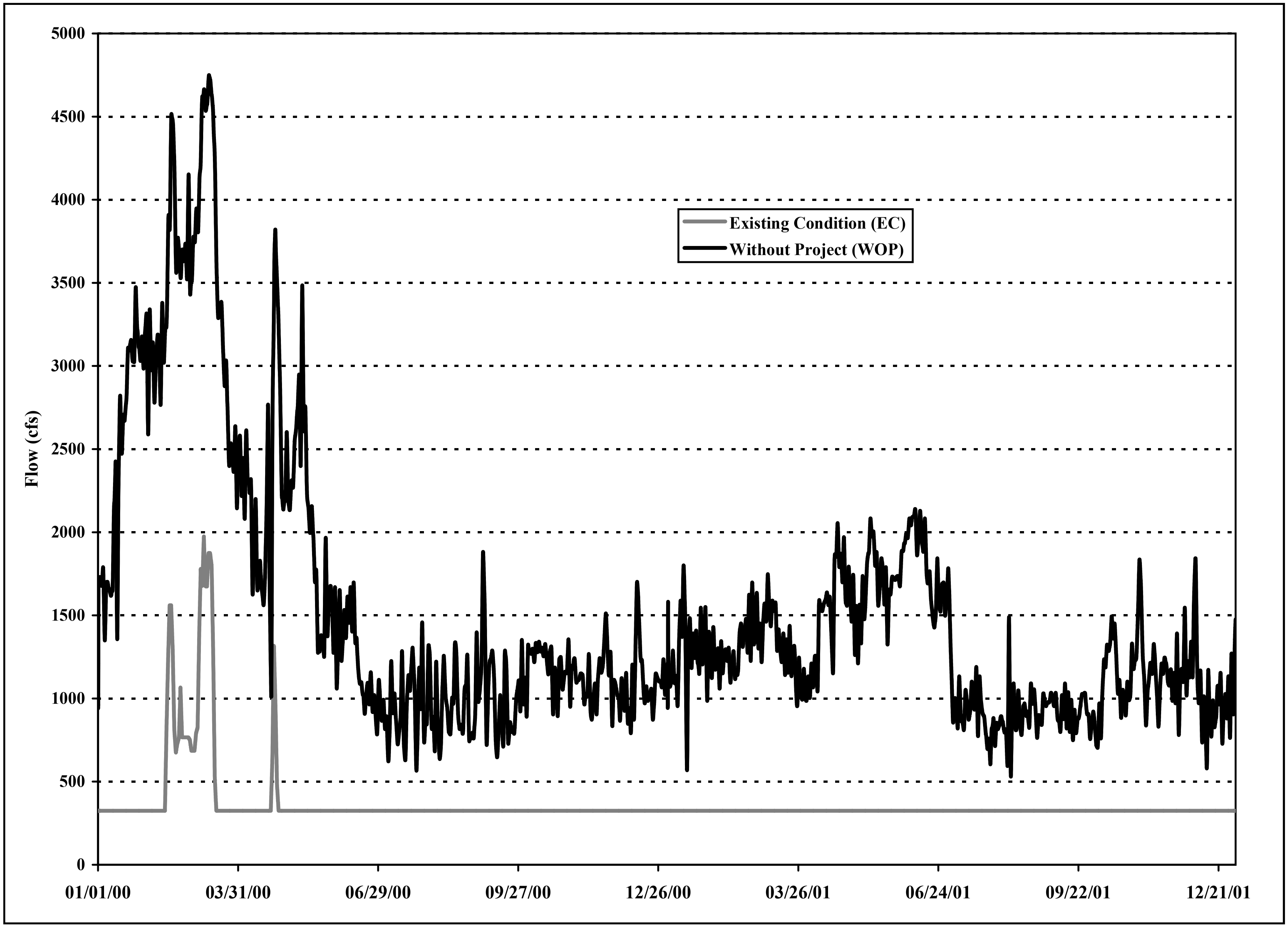


Figure 1. Simulated hourly flows for the Klamath River at km 357, in the JC Boyle bypass reach, during 2000 and 2001. Data source: RMA2 model output described by PacifiCorp (2004b).

JC Boyle Peaking Reach. Results of the IHA-type assessment of KHP effects on the flow regime in the JC Boyle peaking reach during 2000 and 2001 are given in Table 3. The assessment was based on RMA2 simulated hourly flow data for the Klamath River at km 354.0, about 0.6 km below the JC Boyle powerhouse, and suggests the following KHP-induced changes in flow:

- *Monthly magnitude* – The KHP reduced median flows, and increased flow variability substantially, during most months of the year. Increases in flow variability were greatest for those months with the lowest median flows and smallest for those with the highest median flows.

- *Magnitude and duration of annual extremes* -- The magnitudes of minimum flows occurring on specified numbers of consecutive days were consistently and sometimes dramatically reduced by the KHP, while those of maximum flows were consistently increased.

- *Timing of annual extremes* -- Annual extreme flows, both high (99^{th}-percentile) and low (1^{st}-percentile), occurred substantially earlier in the year due to operations of the KHP. High flows first occurred from two to three months earlier, and low flows four to six months earlier, when the EC flows were compared to WOP flows.

- *Frequency and duration of extended high and low pulses* – Power peaking by the KHP caused dramatic increases in the frequency of high and low flow pulses within the reach, and substantial decreases in the duration of these pulses. The frequency of high flow pulses was increased by more than 3000% and that of low flow pulses by more than 850%. Overall, these pulses appear to have become the dominant feature of the river's hydrograph in this area, diminishing (but not eliminating) monthly and seasonal patterns of variation in flow (Figure 2).

- *Rate and frequency of change in conditions* – The KHP caused dramatic increases in median daily flow ranges (>1000%) and in the frequency and rates of flow change below the JC Boyle powerhouse. Median hourly rates of rise and fall in flow for the site analyzed were each increased more than 500%. Maximum rates of rise and fall in flow were increased by more than 300%. All of these changes were to a WOP condition that was itself affected by upstream disturbances, including irrigation projects.

Table 3. IHA-type comparison of Without Project (WOP) and Existing (Exist.) streamflow conditions in the Klamath River below JC Boyle Powerhouse, based on modeled hourly flows PacifiCorp (2004b) reported for 2000 and 2001. Source data: RMA2 model simulations described in PacifiCorp (2004b).

	Medians				*Coefficient of dispersion* [a]			
			Deviation [b]				*Deviation* [b]	
IHA Group	*WOP*	*Exist.*	*Magnitude*	*Percentage*	*WOP*	*Exist.*	*Magnitude*	*Percentage*
Group 1: Monthly magnitude								
October (cfs)	1169	770	-399	-34%	0.21	2.11	1.89	882%
November (cfs)	1102	705	-397	-36%	0.15	1.82	1.67	1103%
December (cfs)	1013	703	-310	-31%	0.20	1.39	1.19	592%
January (cfs)	1518	1753	235	15%	0.92	1.25	0.33	36%
February (cfs)	2668	2677	9	0%	0.83	1.00	0.18	21%
March (cfs)	1905	1780	-125	-7%	1.19	1.27	0.07	6%
April (cfs)	1727	1755	28	2%	0.37	0.72	0.35	95%
May (cfs)	1699	1720	21	1%	0.30	1.01	0.71	235%
June (cfs)	1508	1462	-46	-3%	0.46	1.56	1.10	238%
July (cfs)	897	537	-360	-40%	0.24	2.30	2.06	860%
August (cfs)	869	489	-380	-44%	0.22	2.50	2.28	1037%
September (cfs)	939	795	-144	-15%	0.19	1.55	1.36	732%
Group averages [c]				*19%*				*486%*
Group 2: Magnitude and duration (recurrence) of annual extremes								
1-day minimum (cfs)	535	328	-207	-39%	0.07	0.00	-0.07	-100%
3-day minimum (cfs)	691	328	-363	-53%	0.04	0.00	-0.04	-100%
7-day minimum (cfs)	816	328	-488	-60%	0.13	0.00	-0.13	-100%
30-day minimum (cfs)	975	328	-647	-66%	0.11	0.00	-0.11	-100%
90-day minimum (cfs)	1185	488	-697	-59%	0.31	0.64	0.33	107%
1-day maximum (cfs)	3396	4005	609	18%	0.76	0.47	-0.30	-39%
3-day maximum (cfs)	3360	3915	555	17%	0.78	0.46	-0.31	-40%
7-day maximum (cfs)	3237	3821	584	18%	0.79	0.43	-0.36	-45%
30-day maximum (cfs)	2484	2713	229	9%	0.79	0.70	-0.09	-12%
90-day maximum (cfs)	1551	1920	369	24%	0.55	0.33	-0.22	-40%
Number of zero days per year	0	0	0	0%	---	---	0%	0%
Baseflow	0.66	0.24	-0.42	-64%	0.55	0.25	-0.30	-55%
Group averages [c]				*36%*				*62%*
Group 3: Timing of annual extremes								
Julian date of 99th percentile flow	99	24	-75	-76%	0.65	0.35	-0.30	-46%
Julian date of 1st percentile flow	197	54	-143	-73%	0.10	0.10	0.00	0%
Group averages [c]				*74%*				*23%*
Group 4: Frequency and duration of high and low pulses								
Low pulse count (#/yr)	29.5	290.5	261	885%	0.31	0.29	-0.02	-6%
High pulse count (#/yr)	5.5	175.5	170	3091%	2.00	0.26	-1.74	-87%
Low pulse duration (hrs)	31	13	-18	-58%	1.13	0.31	-0.82	-73%
High pulse duration (hrs)	41	6	-35	-85%	1.68	1.00	-0.68	-41%
Group averages [c]				*1030%*				*52%*
Group 5: Rate and frequency of change in conditions								
Daily range (cfs)	124	1451	1327	1070%	1.02	0.78	-0.24	-23%
Fall count (#/yr)	1595	2945	1350	85%	0.21	0.03	-0.18	-86%
Rise count (#/yr)	1554	3190.5	1637	105%	0.13	0.01	-0.12	-92%
Fall rate (cfs/hr)	11	74	63	573%	0.50	5.30	4.80	960%
Rise rate (cfs/hr)	14	85	71	507%	0.71	3.99	3.28	462%
Group averages [c]				*468%*				*325%*

[a] *When data were pooled across years, the coefficient used was the difference between the 75th and 25th-percentile values, divided by the median. If the parameter was calculated annually (i.e., twice), the coefficient of dispersion was the maximum minus the minimum, divided by the midrange.*

[b] *The deviations represent the Indicators of Hydrologic Alteration.*

[c] *Group averages were computed as the mean of all deviations (in absolute values) within the group.*

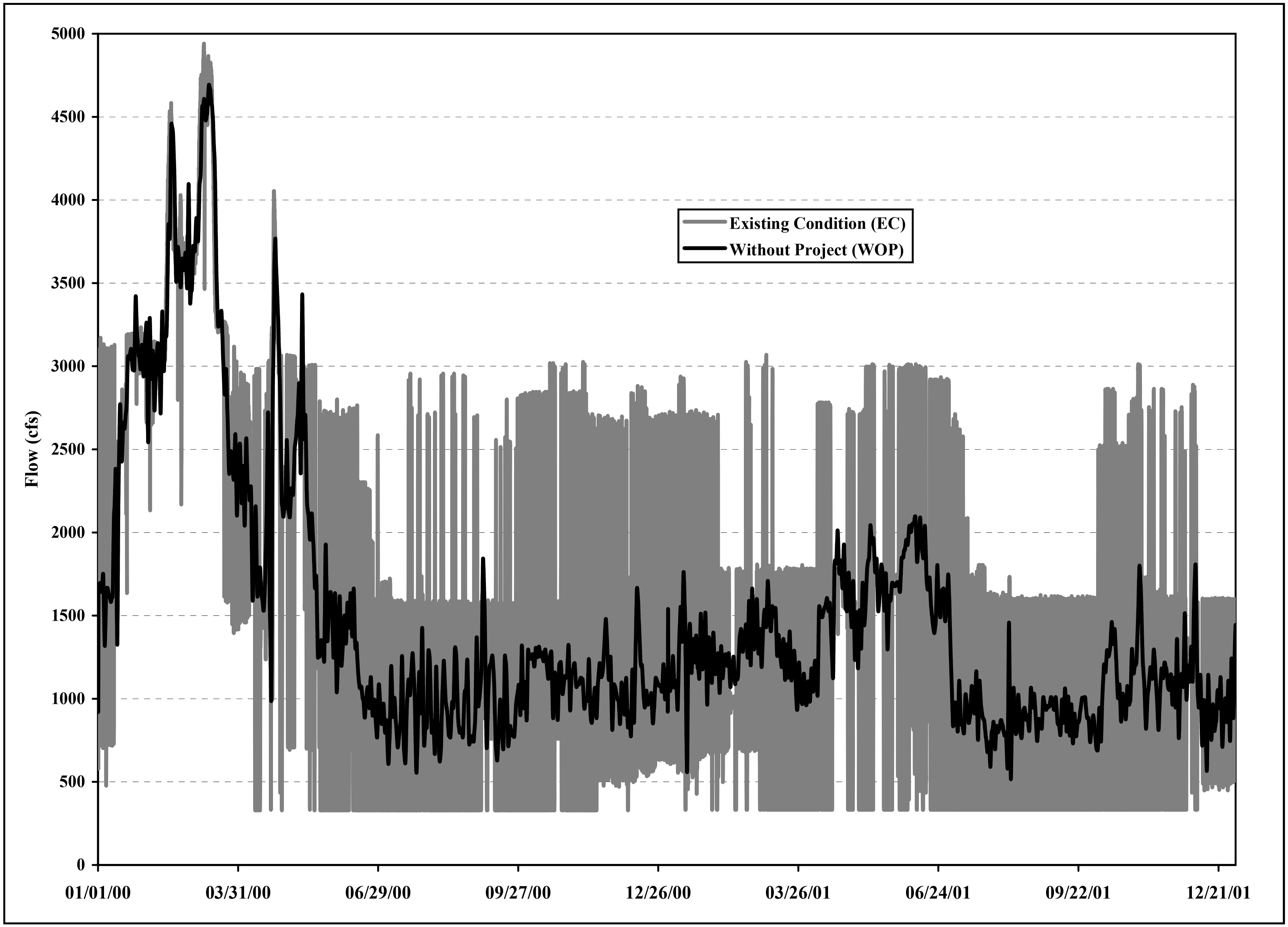


Figure 2. Simulated hourly flows for the Klamath River at km 354.0, below the JC Boyle powerhouse, during 2000 and 2001. Data source: RMA2 model output described in PacifiCorp (2004b).

Maximal Rates of Change in River Stage Below JC Boyle Powerhouse

I acquired all of the half-hourly stage data that the USGS collected at their gage site on the Klamath River below JC Boyle powerhouse (No. 11510700; km 353.5) during water years 1994 (a "dry", <5th-percentile year), 1995 (an "average", ~60th-percentile year), and 1999 (a "wet", ~85th-percentile year). The data for these three years, which included a broad range of streamflow conditions, were then used to calculate both the maximum positive and maximum negative change in stage occurring at the site *over any full one-hour period* within each day within each year. Daily maximum rates of increase in stage (up-ramp) and of decrease in stage (down-ramp) were subsequently used to determine for each year the percentages of days on which a given hourly up or down-ramp rate was exceeded.

Results of my analysis of the USGS stage data for the gauge site below JC Boyle powerhouse are summarized in Table 4 and Figure 3. Daily maximum up- and down-ramp rates at the USGS gauge site below the powerhouse ranged from zero to well over 1.2 feet per hour, with the higher rates within this range experienced most frequently during 1994 (the dry year) and least frequently during 1999 (the wet year). Daily maximum down-ramp rates at the site also ranged from zero to substantially above 1.2 feet per hour, and followed a pattern similar to that seen in the up-ramp rates. The relatively higher daily maximum down-ramp rates occurred more frequently during years when water was less abundant.

Table 4. Exceedance values for daily maximum rates of up- and down-ramping (ft/hr) at the Klamath River gauge site below JC Boyle Powerhouse (USGS #11510700) during 1994, 1995, and 1999.

Condition/	Percent of days on which a given absolute rate of stage change was met or exceeded							
year	0.15 ft/hr	0.30 ft/hr	0.45 ft/hr	0.60 ft/hr	0.75 ft/hr	0.90 ft/hr	1.05 ft/hr	1.20 ft/hr
Upramping								
1994	90%	89%	88%	88%	85%	40%	32%	7%
1995	77%	69%	68%	67%	59%	4%	2%	1%
1999	50%	40%	37%	35%	26%	14%	7%	3%
Down-ramping								
1994	90%	89%	88%	88%	87%	83%	42%	25%
1995	80%	70%	67%	66%	65%	62%	20%	3%
1999	52%	40%	37%	34%	30%	19%	12%	6%

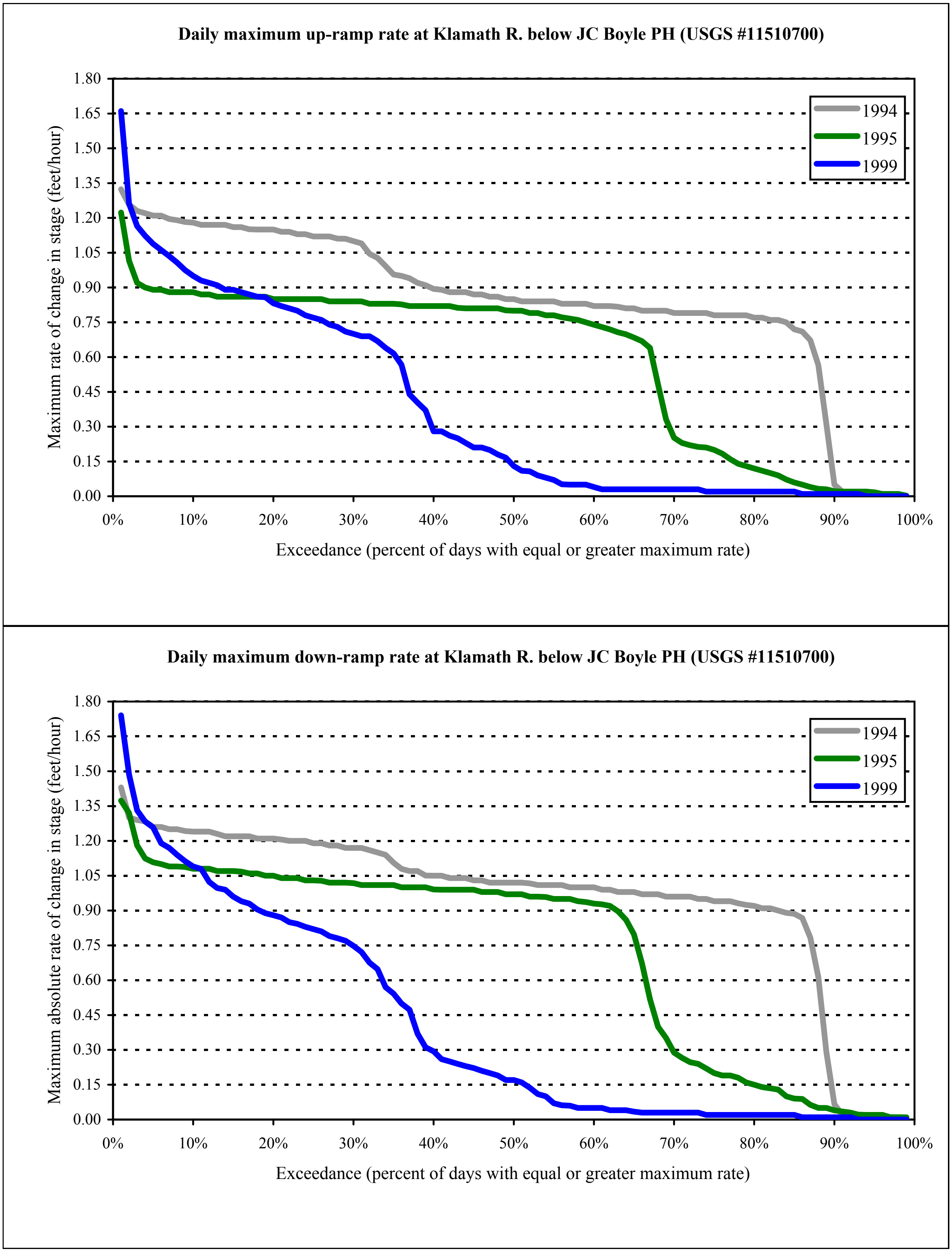


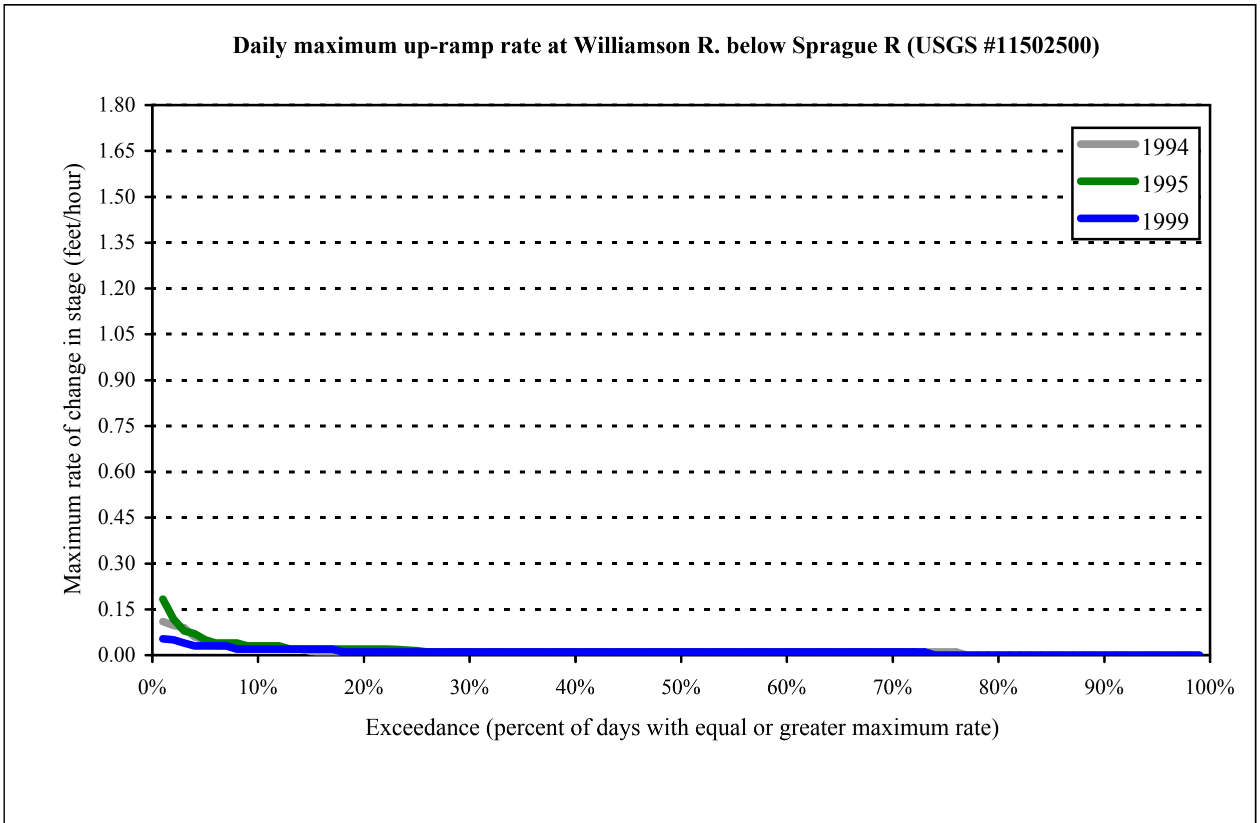
Figure 3. Exceedance values for daily maximum rates of rise (up-ramp) and decline in stage (down-ramp) at Klamath River R. below JC Boyle Powerhouse (USGS Gage #11510700) during 1994, 1995, and 1999.

Given the high rates of stage change recorded at the gauge below the JC Boyle powerhouse, I conducted an identical analysis for the USGS gauge site at km 16.6 on the Williamson River below the Sprague River confluence (No. 11502500). This second site has a hydrograph influenced by the presence of upstream springs, by upstream irrigation diversions, and by limited log pond storage in the Sprague River system. Flows at the Williamson River gauge account for about three-quarters of the Klamath River's drainage area above the gauge near JC Boyle powerhouse, are passing through a relatively low-gradient channel, and are dampened downstream by the presence of Klamath Lake before being influenced by Bureau of Reclamation irrigation projects and the KHP. The Williamson gauge is thus a clearly imperfect, but likely best-available, source of information on the approximate levels of up- and down-ramping that might be seen at the gauge site below the JC Boyle powerhouse under natural conditions.

Results of my stage-change analysis for the Williamson River gauge site below Sprague River are given in Figure 4. Daily maximum rates of increase or decrease in stage at the Williamson River site during 1994, 1995, and 1999, were generally well over an order of magnitude (and sometimes about two orders of magnitude) lower than those seen at the USGS gauge below JC Boyle powerhouse during the same years.

After examining the differences between the daily maximum rates of stage change recorded at the two gauges during 1994, 1995, and 1999, I became concerned that annual peak runoff might be naturally and disproportionately higher at the Boyle powerhouse site versus the Williamson River site, potentially biasing the full-year comparisons of stage-change rates between the two. This concern was strengthened when a review of USGS flow records showed that annual peak daily flows at the powerhouse site were two to three times those at the Williamson site during 1994, 1995, and 1999. In an effort to account for this source of potential bias, I performed a comparative analysis of daily maximum rates of stage change at the sites that was limited to days from May through September of these three years. This was a period after peak runoff had occurred at both sites and also a period during which small juvenile fish in the river system would have been relatively vulnerable to stranding or trapping by rapid flow reductions (PacifiCorp 2004c).

Results of my analysis of daily maximum rates of stage change at the two gauge sites during May through September of 1994, 1995, and 1999, are given in Figures 5 and 6. The dramatic between-site differences in daily maximum rates appear to have been unrelated to differences in their respective magnitudes of annual peak runoff. In fact, the differences in daily maximum rates of change in stage were a bit greater between the JC Boyle powerhouse and Williamson River sites during a portion of the year unaffected by annual peaks in runoff than they were when considered across the entire year as a whole.



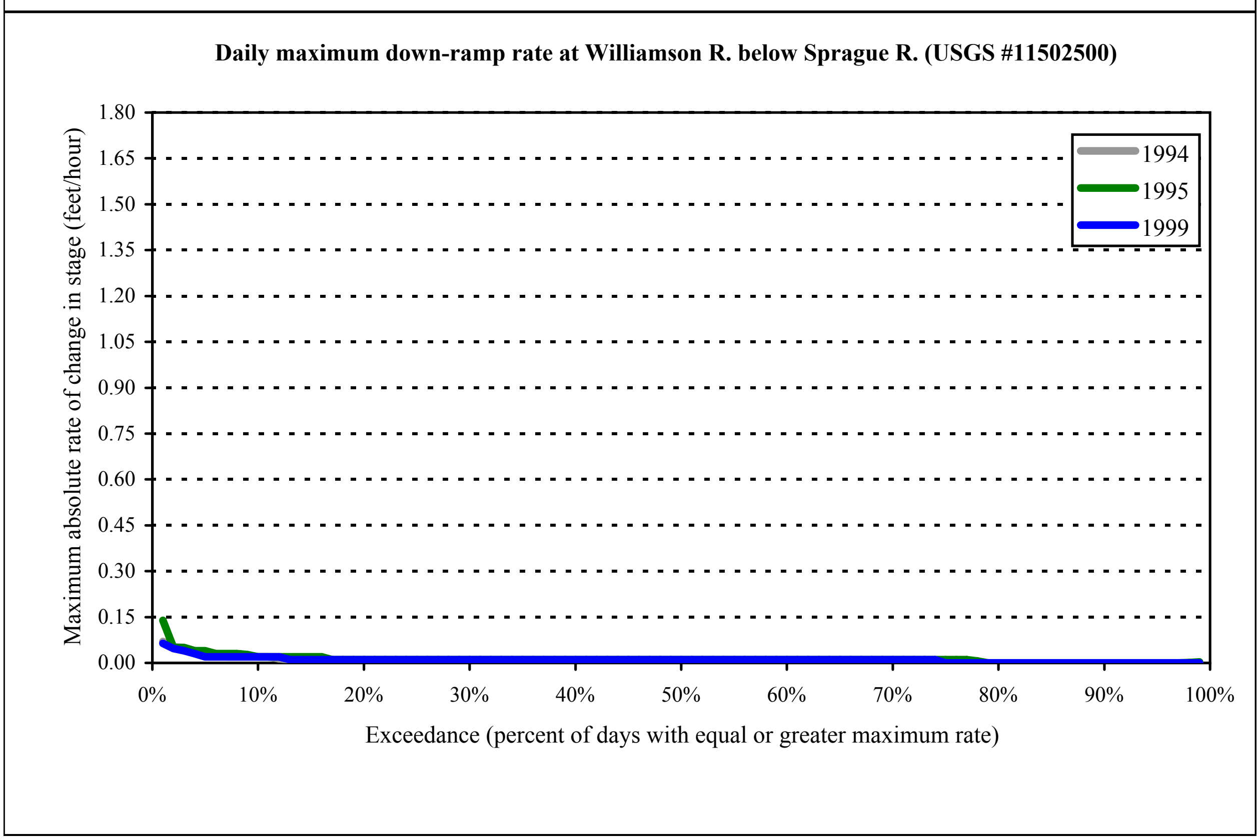
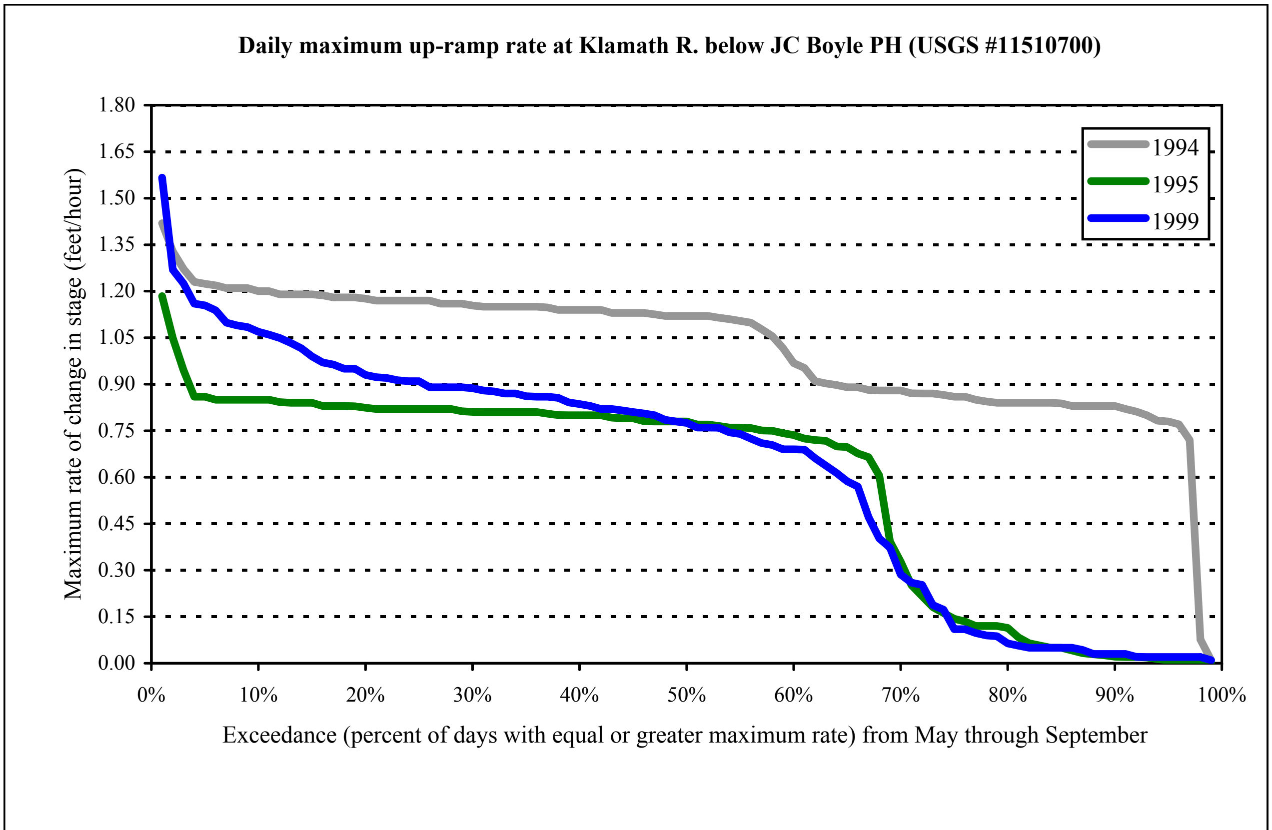


Figure 4. Exceedance values for daily maximum rates of rise (up-ramp) and decline in stage (down-ramp) at Williamson R. below Sprague R. (USGS Gage # 11502500) during 1994, 1995, and 1999.



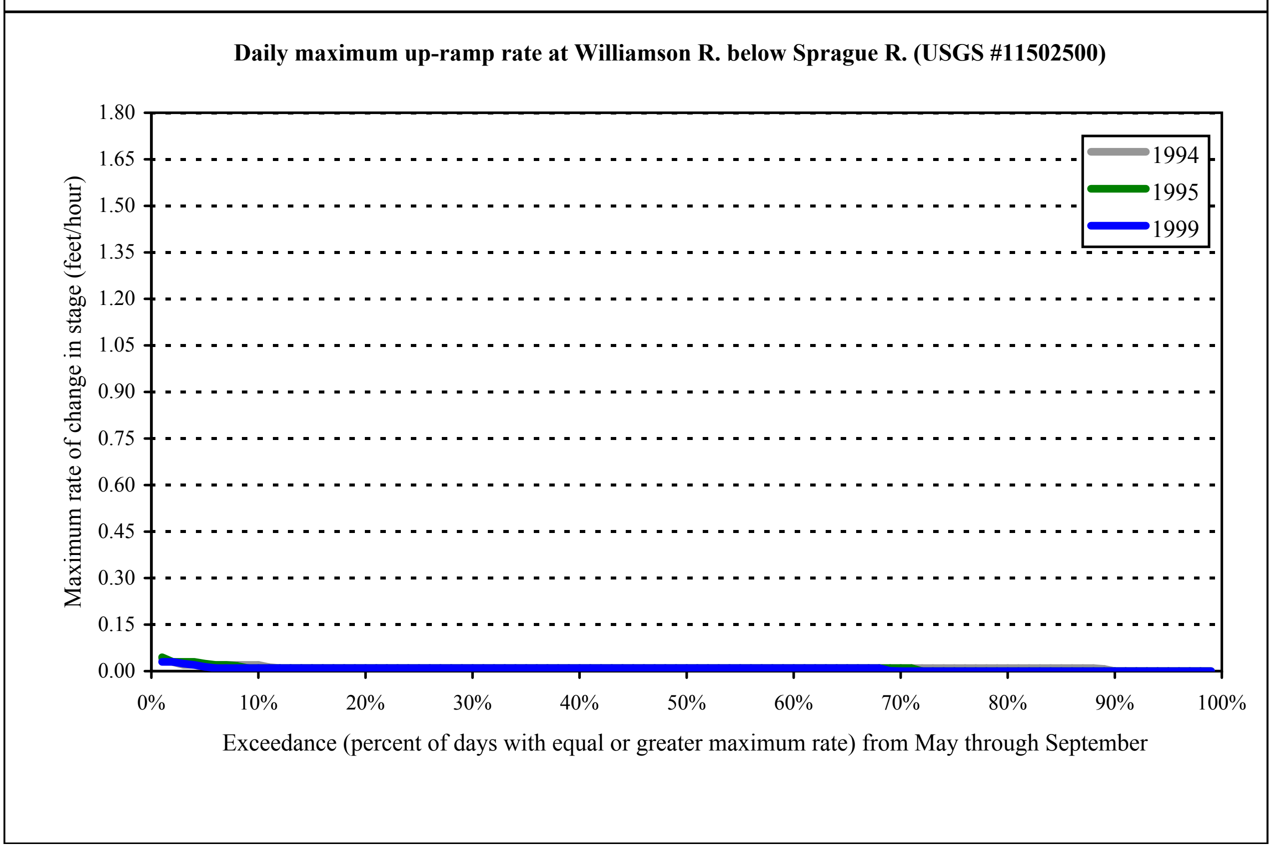
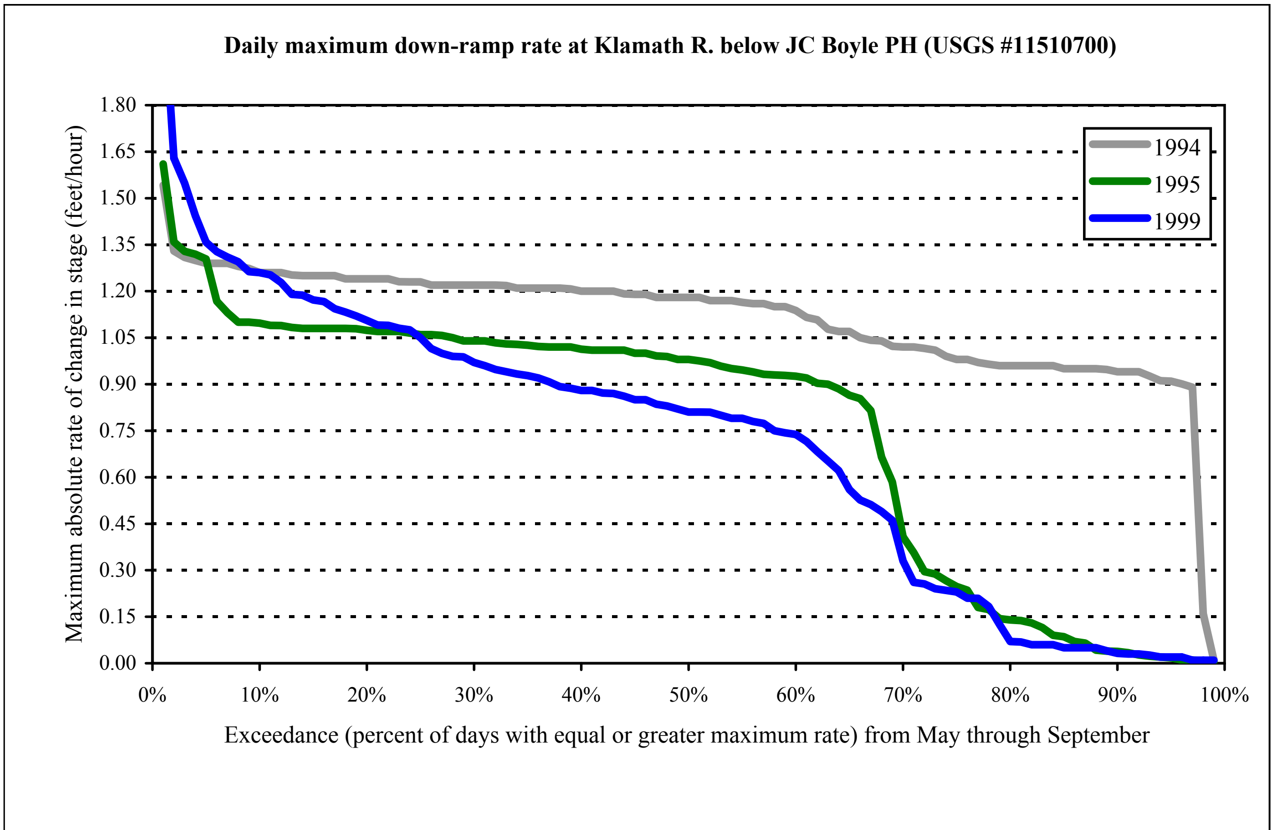


Figure 5. Exceedance values for daily maximum rates of rise in stage (feet/hour) for the Klamath R. below JC Boyle Powerhouse and for the Williamson R. below Sprague R., May - September, 1994, 1995, and 1999.



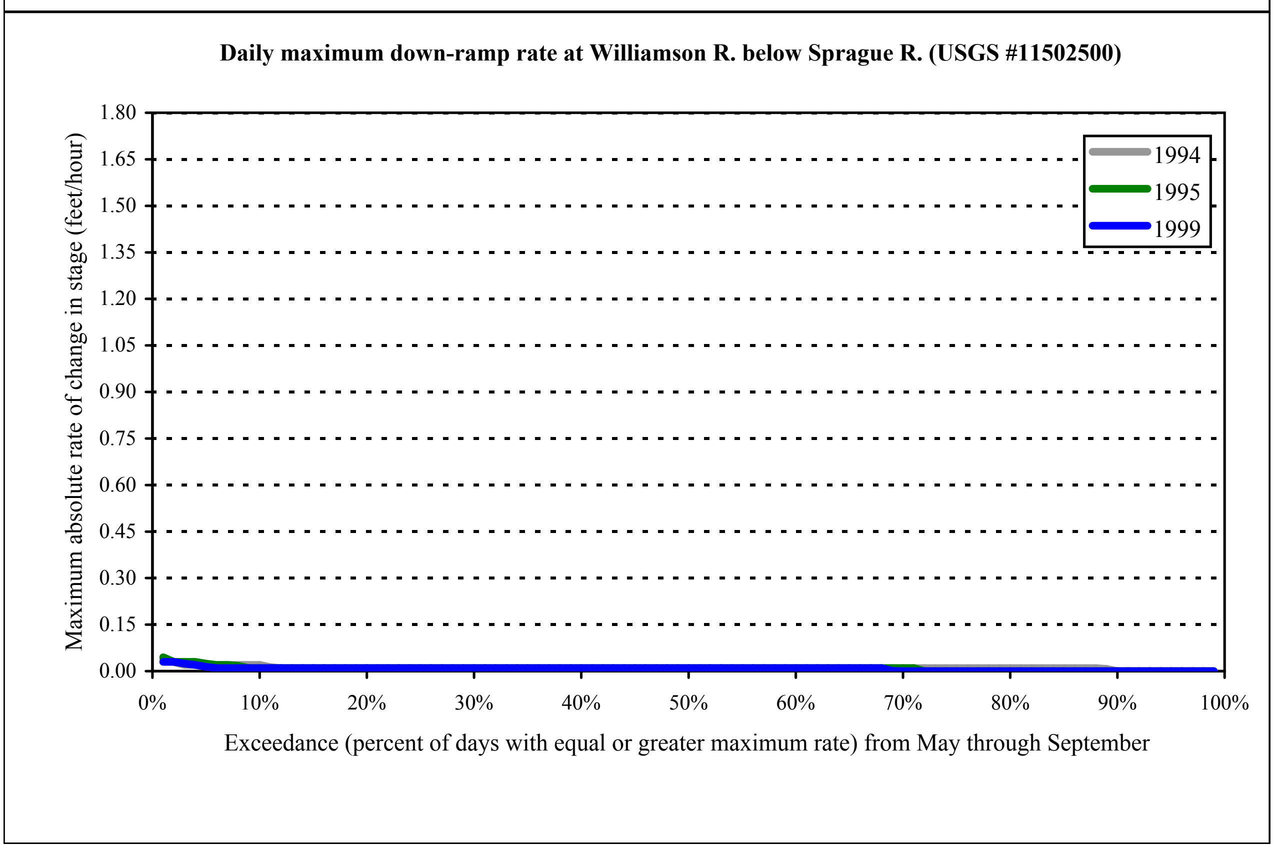


Figure 6. Exceedance values for daily maximum rates of decline in stage (feet/hour) for the Klamath R. below JC Boyle Powerhouse and for the Williamson R. below Sprague R., May - September, 1994, 1995, and 1999.

Citations

PacificCorp. 2004a. Final License Application for the Klamath Hydroelectric Project, FERC No. 2082. Exhibit A – Project Description. PacifiCorp, Portland, Oregon. February 2004.

PacifiCorp. 2004b. Water Resources Final Technical Report. Klamath Hydroelectric Project, FERC No. 2082. PacifiCorp, Portland, Oregon. February 2004.

PacifiCorp. 2004c. Fish Resources Final Technical Report. Klamath Hydroelectric Project, FERC No. 2082. PacifiCorp, Portland, Oregon. February 2004.

Richter, B.D., J.V. Baumgartner, J. Powell, and D.P. Braun. 1996. A method for assessing hydrologic alteration within ecosystems. Conservation Biology 10:1163-1174.

The Nature Conservancy and Smythe Scientific Software (TNC & SSS). 2003. Indicators of Hydrologic Alteration. User's Manual. August 2003.

Attachment A

Table A1. IHA-type assessment of modeled hourly "Without Project" (WOP) streamflow conditions for the JC Boyle bypass reach of the Klamath River, 2000-2001.

IHA Group	Median value	Percentile values 25th	Percentile values 75th	Coeff. dispersion	Range of values Minimum	Range of values Maximum
Group 1: Monthly magnitude						
October	1197	1038	1292	0.21	703	1836
November	1126	1031	1201	0.15	780	1709
December	1038	939	1144	0.20	579	1843
January	1552	1268	2674	0.91	569	3475
February	2716	1296	3525	0.82	1059	4517
March	1946	1300	3598	1.18	953	4750
April	1762	1561	2209	0.37	1003	3821
May	1737	1564	2088	0.30	1211	3485
June	1541	1151	1861	0.46	784	2140
July	918	826	1049	0.24	565	1621
August	890	816	1013	0.22	530	1490
September	961	851	1031	0.19	646	1882
Group 2: Magnitude and duration (recurrence) of annual extremes						
1-day minimum	548	---	---	0.06	530	565
3-day minimum	707	---	---	0.03	696	717
7-day minimum	835	---	---	0.13	780	890
30-day minimum	993	---	---	0.11	936	1049
90-day minimum	1212	---	---	0.30	1028	1395
1-day maximum	3445	---	---	0.76	2140	4750
3-day maximum	3408	---	---	0.77	2094	4721
7-day maximum	3284	---	---	0.79	1995	4573
30-day maximum	2527	---	---	0.78	1540	3514
90-day maximum	1586	---	---	0.55	1151	2020
Number of zero days per year	0	---	---	---	0	0
Baseflow	0.58	---	---	0.05	0.56	0.59
Group 3: Timing of annual extremes						
Julian date of 99th percentile flow	100	---	---	0.34	68	131
Julian date of 1st percentile flow	197	---	---	0.10	187	206
Group 4: Frequency and duration of high and low pulses						
Low pulse count (#/yr)	27.5	---	---	0.33	23	32
High pulse count (#/yr)	5	---	---	2.00	0	10
Low pulse duration (hr)	27	17	47	1.11	1	132
High pulse duration (hr)	31	24	116	2.97	7	1764
Group 5: Rate and frequency of change in conditions						
Daily range	124	74	207	1.07	4	1448
Fall count (#/yr)	1623	---	---	0.20	1458	1788
Rise count (#/yr)	1585	---	---	0.12	1488	1681
Fall rate (cfs/hr)	14	11	18	0.50	11	268
Rise rate (cfs/hr)	14	11	18	0.50	11	279

Table A2. IHA-type assessment of modeled hourly "Existing" (Exist.) streamflow conditions for the JC Boyle bypass reach of the Klamath River, 2000-2001.

IHA Group	Median value	Percentile values 25th	Percentile values 75th	Coeff. dispersion	Range of values Minimum	Range of values Maximum
Group 1: Monthly magnitude						
October	325	325	325	0.00	325	325
November	325	325	325	0.00	325	325
December	325	325	325	0.00	325	325
January	325	325	325	0.00	325	325
February	325	325	727	1.24	325	1561
March	325	325	433	0.33	325	1974
April	325	325	325	0.00	325	1317
May	325	325	325	0.00	325	325
June	325	325	325	0.00	325	325
July	325	325	325	0.00	325	325
August	325	325	325	0.00	325	325
September	325	325	325	0.00	325	325
Group 2: Magnitude and duration (recurrence) of annual extremes						
1-day minimum	325	---	---	0.00	325	325
3-day minimum	325	---	---	0.00	325	325
7-day minimum	325	---	---	0.00	325	325
30-day minimum	325	---	---	0.00	325	325
90-day minimum	325	---	---	0.00	325	325
1-day maximum	1100	---	---	1.41	325	1875
3-day maximum	1052	---	---	1.38	325	1778
7-day maximum	1000	---	---	1.35	325	1675
30-day maximum	505	---	---	0.71	325	685
90-day maximum	325	---	---	0.00	325	325
Number of zero days per year	0	---	---	---	0	0
Baseflow	1.00	---	---	0.00	1.00	1.00
Group 3: Timing of annual extremes						
Julian date of 99th percentile flow	35	---	---	0.37	1	68
Julian date of 1st percentile flow	38	---	---	0.42	1	77
Group 4: Frequency and duration of high and low pulses						
Low pulse count (#/yr)	2	---	---	2.00	0	4
High pulse count (#/yr)	0	---	---	---	0	0
Low pulse duration (hrs)	983	414	4796	4.46	83	8761
High pulse duration (hrs)	0	0	0	---	0	0
Group 5: Rate and frequency of change in conditions						
Daily range	0	0	0	---	0	710
Fall count (#/yr)	101	---	---	2.00	0	202
Rise count (#/yr)	112.5	---	---	2.00	0	225
Fall rate (cfs/hr)	14	11	21	0.71	11	32
Rise rate (cfs/hr)	14	14	21	0.50	11	32

Table A3. IHA-type assessment of modeled hourly "Without Project"(WOP) streamflow conditions for the Klamath River below the JC Boyle Powerhouse, 2000-2001.

IHA Group	Median value	Percentile values 25th	Percentile values 75th	Coeff. dispersion	Range of values Minimum	Range of values Maximum
Group 1: Monthly magnitude						
October	1169	1013	1264	0.21	689	1801
November	1102	1006	1173	0.15	763	1674
December	1013	915	1119	0.20	565	1808
January	1518	1239	2631	0.92	558	3422
February	2668	1267	3472	0.83	1035	4460
March	1905	1271	3545	1.19	932	4693
April	1727	1529	2169	0.37	982	3768
May	1699	1533	2046	0.30	1183	3432
June	1508	1126	1823	0.46	766	2098
July	897	809	1024	0.24	554	1589
August	869	798	989	0.22	516	1458
September	939	835	1010	0.19	629	1843
Group 2: Magnitude and duration (recurrence) of annual extremes						
1-day minimum	535	---	---	0.07	516	554
3-day minimum	691	---	---	0.04	678	703
7-day minimum	816	---	---	0.13	763	869
30-day minimum	975	---	---	0.11	922	1028
90-day minimum	1185	---	---	0.31	1003	1367
1-day maximum	3396	---	---	0.76	2098	4693
3-day maximum	3360	---	---	0.78	2055	4665
7-day maximum	3237	---	---	0.79	1956	4517
30-day maximum	2484	---	---	0.79	1504	3464
90-day maximum	1551	---	---	0.55	1123	1978
Number of zero days per year	0	---	---	---	0	0
Baseflow	1551	---	---	0.55	1123	1978
Group 3: Timing of annual extremes						
Julian date of 99th percentile flow	99	---	---	0.35	67	131
Julian date of 1st percentile flow	197	---	---	0.10	187	206
Group 4: Frequency and duration of high and low pulses						
Low pulse count (#/yr)	29.5	---	---	0.31	25	34
High pulse count (#/yr)	5.5	---	---	2.00	0	11
Low pulse duration (hr)	31	17	52	1.13	3	254
High pulse duration (hr)	41	23	92	1.68	5	1697
Group 5: Rate and frequency of change in conditions						
Daily range	124	74	201	1.02	4	1420
Fall count (#/yr)	1595	---	---	0.21	1428	1762
Rise count (#/yr)	1553.5	---	---	0.13	1449	1658
Fall rate (cfs/hr)	14	11	18	0.50	11	261
Rise rate (cfs/hr)	14	11	21	0.71	11	268

Table A4. IHA-type assessment of modeled hourly "Existing"(Exist.) streamflow conditions for the Klamath River below the JC Boyle Powerhouse, 2000-2001.

IHA Group	Median value	Percentile values 25th	Percentile values 75th	Coeff. dispersion	Range of values Minimum	Range of values Maximum
Group 1: Monthly magnitude						
October	770	332	1956	2.11	328	3019
November	705	332	1617	1.82	328	3026
December	703	571	1551	1.39	328	2889
January	1753	710	2896	1.25	332	3235
February	2677	954	3637	1.00	332	4584
March	1780	1119	3371	1.27	332	4941
April	1755	1441	2709	0.72	328	4054
May	1720	1058	2800	1.01	328	3069
June	1462	392	2673	1.56	328	3012
July	537	332	1568	2.30	328	2956
August	489	332	1554	2.50	328	2956
September	795	332	1564	1.55	328	2829
Group 2: Magnitude and duration (recurrence) of annual extremes						
1-day minimum	328	---	---	0.00	328	328
3-day minimum	328	---	---	0.00	328	328
7-day minimum	328	---	---	0.00	328	328
30-day minimum	328	---	---	0.00	328	328
90-day minimum	488	---	---	0.64	332	643
1-day maximum	4005	---	---	0.47	3069	4941
3-day maximum	3915	---	---	0.46	3005	4824
7-day maximum	3821	---	---	0.43	2991	4651
30-day maximum	2713	---	---	0.70	1766	3659
90-day maximum	1920	---	---	0.33	1600	2239
Number of zero days per year	0	---	---	---	0	0
Baseflow	0.24	---	---	0.25	0.21	0.27
Group 3: Timing of annual extremes						
Julian date of 99th percentile flow	24	---	---	0.25	1	47
Julian date of 1st percentile flow	54	---	---	0.51	7	101
Group 4: Frequency and duration of high and low pulses						
Low pulse count (#/yr)	290.5	---	---	0.29	249	332
High pulse count (#/yr)	175.5	---	---	0.26	153	198
Low pulse duration (hr)	13	10	14	0.31	1	38
High pulse duration (hr)	6	4	10	1.00	1	656
Group 5: Rate and frequency of change in conditions						
Daily range	1451	1243	2380	0.78	32	3019
Fall count (#/yr)	2945	---	---	0.03	2899	2991
Rise count (#/yr)	3190.5	---	---	0.01	3179	3202
Fall rate (cfs/hr)	74	25	417	5.30	11	1056
Rise rate (cfs/hr)	85	28	367	3.99	11	1102

May 2, 2011

Klamath River Expert Panel
Scientific Assessment of Two Dam Removal Alternatives on Chinook Salmon
Comments on the Draft Report dated May 2, 2011

The Klamath Tribes were unable to adequately comment on this panel report, because the comment period was much too short during a period of intense activity on multiple fronts. Therefore, we reserve the right to make further comments in the future. Citations herein refer to the same citation list as in the report. All comments were authored by Larry Dunsmoor, Senior Aquatics Biologist for the Klamath Tribes.

Comment Number	Comment Author	Page, Paragraph	Comment	Panel Response
1	L. Dunsmoor	General	Perhaps the most important part of the Proposed Action is the least tangible in some ways. We have moved from intensely antagonistic, conflict-based management to one of collaborative management. The changes that we have experienced in recent years are not complete, but they are still progressing, and they are profound. Coupled with the extensive monitoring programs in the Proposed Action, the stage is set to proceed with what we know, and adapt to what we learn. The Panel's report fails to assign significance to this dynamic, which is not surprising since there was insufficient time for the Panel to understand and appreciate the extent to which this transformation sets the stage for success.	
2	L. Dunsmoor	11, 1st ¶ in 2.1	The Panel identifies reduced nutrient loading and "thermal inputs into UKL" as likely effects of the Proposed Action. While thermal loading to the UKL tributaries is indeed a significant issue, I do not believe that a similar case can be made for thermal loading to UKL. The lake is large and shallow, has a large surface area to volume ratio - it will equilibrate to air temperature, regardless of the thermal inputs received from tributaries or other extant sources. As ODEQ (2010) puts it on pg	

Comment Number	Comment Author	Page, Paragraph	Comment	Panel Response
			2-28: "Upper Klamath Lake is not considered a source to thermal impairment because the temperature of water discharged from Upper Klamath Lake likely follow the natural thermal regime. The naturally wide and shallow bathymetry and long residence time of Upper Klamath Lake would have allowed water temperature to reach equilibrium with heat fluxes." Insofar as UKL is concerned, nutrient loading (both internal and external) is the central issue.	
3	L. Dunsmoor	11, footnote 3	While I understand the Panel's desire to somehow gauge the significance of the Chinook response to the alternatives, I suggest that some additional concepts are important considerations beyond some expectation that overall Chinook populations will increase. First, the Klamath Tribes live above these dams, and reserved their rights to the upper basin's anadromous fish resources when they entered into a treaty with the US. Copco 1 Dam was built without fish passage despite the Tribes' protests, and their access to anadromous fish was suddenly lost. It would be enormously significant to the Klamath Tribes if re-established Chinook runs were much lower than 10,000 (although the more the better). Second, do the alternatives not differ in terms of the likelihood of persistence of Chinook? I find the Panel's views to be remarkably pessimistic in regard to rehabilitating water quality and habitats under the Proposed Action; indeed, it seems that uncertainty is consistently translated into pessimism in this report. While I disagree with the Panel on many important points, the pessimism expressed in regard to the Proposed Action should be accompanied by an analysis that is absent from	

Comment Number	Comment Author	Page, Paragraph	Comment	Panel Response
			the report. Namely, an analysis of the likelihood of persistence of various stocks under the two alternatives. If the Panel really believes that the monumental rehabilitation program under the KBRA and KHSA is unlikely to substantially increase abundance, what does the Panel think will happen if we don't implement the settlement agreements?	
4	L. Dunsmoor	12, 1st ¶	The Panel interprets the KBRA measures for reducing external loading to UKL to be primarily wetland rehabilitation and riparian re-vegetation, and concludes that these are unlikely to produce substantial improvements in water quality to UKL. In fact, the scope of the Proposed Action is much broader, and while the Panel is correct to be concerned about water quality conditions, their skepticism regarding the proposed rehabilitation measures goes too far, and is based in a failure to appreciate the magnitude of what is indeed being proposed. Section 2.5.3 of ODEQ (2002) quantifies external sources of nutrients to UKL. KBRA actions that will reduce external loading match up pretty well, as follows (Barry et al. 2010): a. re-connect about 12,700 acres of re-claimed wetlands to Agency Lake, ceasing P-laden ag return flows from former wetlands; b. rehabilitate riparian plant communities throughout most of the valley-floor tributary systems above UKL, with emphasis on the Sprague, which is the largest external source; c. rehabilitate floodplain function through breaching/removal of levees, emphasis on the Sprague; d. reduce consumptive use (and associated return flows) sufficient to increase inflow to UKL by 30,000 acre ft on an average annual basis, emphasis on the Sprague and Wood; e. establish a General Conservation Plan (similar to HCP) above UKL to incentivize landowners to carefully manage their	

Comment Number	Comment Author	Page, Paragraph	Comment	Panel Response
			riparian corridors; f. rehabilitate upland dryland pasture to reduce reliance on irrigation and facilitate access to non-floodplain grazing; g. provide ranch management planning assistance, which will enhance riparian communities at the least, and may result in altered irrigation practices as well; g. rehabilitate the channelized South Fork Sprague, which is a major source of suspended sediment to the main stem Sprague (Matthews 2007), and a major source of nutrients as well; h. rehabilitate Seven Mile Creek, a major nutrient source. The Klamath Tribes, and many other parties to the KBRA, are confident that these actions will significanlty reduce the external load to UKL. There are uncertainties in regard to what the ultimate results will be, but they are less severe than those the Panel expresses.	
5	L. Dunsmoor	12, last ¶	The UKL TMDL calls for a 40% reduction in external P loading, not 47%. It also provides analysis that concludes attaining this reduction (with no commensurate reduction in the internal load) would indeed significantly reduce algal biomass and activity (e.g. pgs 63-64 in ODEQ (2002), and Fig 2-17 in ODEQ (2010).	
6	L. Dunsmoor	13, last ¶	Here the analysis contemplates removing the entire external P load. The system is naturally eutrophic, how is it appropriate to use complete removal of the external P load as a metric for the feasibility of the KBRA? Further, the KBRA contemplates many more actions than just wetland sequestration (see comment 4) that are likely to moderate the external load.	
7	L. Dunsmoor	14, 2nd ¶	"Control of high temperatures in UKL…": first, see comment 2, there is no way to "control" temperature in UKL, and no TMDL targets such a thing. Much concern about temperatures in UKL and KR is expressed here, based on an apparent perception that	

Comment Number	Comment Author	Page, Paragraph	Comment	Panel Response
			temperatures will remain warm with June-September temperatures >20 °C. A series of annual plots of water temperatures in and between UKL and the KR below Iron Gate Dam during Aug-Oct relative to fall Chinook run timing to Iron Gate Hatchery is presented in Figure 1 (appended to comment table). A few things are apparent. First, temperatures below Iron Gate are almost always higher and less variable than at the sites upstream, including UKL. This is clearly a result of the thermal inertia imposed on the system by the hydro project reservoirs (Dunsmoor and Huntington 2006 and citations therein). Second, run timing to the hatchery is an expression of what fall Chinook can and are doing in the system under present conditions. If these fish were encountering water temperatures in UKL instead of those below Iron Gate, they would be better off. Conclusions in the panel's report expressing doubt about future performance due to continued high temperatures cannot be reconciled with current conditions in UKL, or with the likely effects of dam removal on the thermal regime, which were evaluated by Dunsmoor and Huntington (2006) and are not addressed in the Panel's report.	
8	L. Dunsmoor	14, top ¶, last sentence	The decades-long lag assumes no in-lake efforts to remediate the internal load. Nutrient reduction efforts in the KBRA are intended for UKL and Keno Reservoir. We intend an integrated approach that treats both the internal and external loads. And yes, it will take time.	
9	L. Dunsmoor	15, 1st ¶	Keno Dam does not create a fish passage barrier. Seasonal passage difficulties arise from seasonal nutrient and organic matter loading from UKL.	
10	L. Dunsmoor	15, 2nd ¶	This paragraph displays poor understanding of the Proposed Action. KBRA reduces and caps Project water diversions. Wetland treatment of Project return flows may be a viable approach to reducing loading, and will be evaluated. Refuge	

Comment Number	Comment Author	Page, Paragraph	Comment	Panel Response
			management is simply not pertinent to the charge of this Panel – it will have no effect on Chinook. Nonetheless, the Panel should be aware that the KBRA increases and firms up the water supply for the refuges, and adds fish and wildlife management to the purposes of the Reclamation Project. These, in conjunction with walking wetlands, represent great improvements in the refuges.	
11	L. Dunsmoor	15, last ¶, last sentence	Here the ramifications to life cycle timing of the dam-removal-induced increase in spring-time water temperatures are discussed as a negative. A necessary assumption would be that spawning timing would not shift. In fact, spawning timing will likely be earlier (Dunsmoor and Huntington 2006) and more successful (lower pre-spawn stress and mortality, more benevolent spawning temperatures). Reversion of the system to a more naturally variable thermal regime (as opposed to the monotonic dynamics and minimal diel variance under Current Conditions) is likely to be ecologically beneficial in many complex ways during much of the year.	
12	L. Dunsmoor	19, plot	Low DO in Keno Reservoir is a significant problem. One idea that will be evaluated is the mechanical removal of particulates at or near the UKL outlet as a way to reduce nutrients in all downstream waters, and to improve DO (and other constituents) conditions in Keno Reservoir. The excerpt below summarizes the thinking on why such an approach is worth evaluating. From page 2-27 in ODEQ (2010): "Sullivan et al. (2009) reported a mean 5-day BOD of 12.6 mg/L and a 30-day BOD of 28.6 mg/L in Link River. In Keno impoundment, most forms of BOD were significantly and positively correlated with particulate carbon, suggesting an important link between algae and BOD. They conclude that a reduction of the load of particulate algal material from the Upper Klamath Lake could limit the magnitude of low DO periods in the Keno impoundment. The organic load	

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			from Upper Klamath Lake causes significant BOD load with subsequent settling of particulate matter to sediments in Keno impoundment contributing to internal nutrient loads and increased sediment oxygen demand (discussed below as internal sources). Warm water leaving Upper Klamath Lake is presumed to be natural due to the natural wide and shallow morphology."	
13	L. Dunsmoor	19, 1st ¶, second sentence	This statement is not well supported. It says that, despite the major efforts envisioned under the KBRA, it is unlikely to improve – that is, it will not change from the current condition. The conclusion is at odds with the TMDL analyses. DO dynamics will closely follow algal dynamics, and the TMDL analyses conclude large changes in algal dynamics. Efforts to sequester P in UKL sediments are of great interest to the parties. For example, strategic application of treatments to discrete areas of UKL with high P flux from the sediments may interact with the in-lake circulation patterns and disrupt algal dynamics in both the treated areas and areas "downstream".	
14	L. Dunsmoor	19, 3rd ¶	Active reintroduction is planned for both fall and spring Chinook above Upper Klamath Lake.	
15	L. Dunsmoor	Pg 19, 2nd ¶, and pg 27, last ¶	We expect spring Chinook to move through UKL in the spring, and hold in cold areas like the Williamson and Wood rivers and their tributaries, and perhaps in Pelican Bay and its associated springs (where adult redbands summer). Seasonal DO barriers would not be an issue for fish employing such a strategy. Such a strategy is not mentioned by the Panel. Neither is any life history strategy other than an ocean type.	
16	L. Dunsmoor	20, 1st ¶	Trap and haul is to be a seasonal phenomenon, and phased out once nutrient reduction measures effect a reduction in algal dynamics sufficient to allow passage.	
17	L. Dunsmoor	20, 2nd ¶	UKL is food rich. While it will indeed be important to select stocks whose early life stages effectively move through UKL, it is likely that those fish will experience high growth rates while in	

Comment Number	Comment Author	Page, Paragraph	Comment	Panel Response
			the lake. Larger downstream migrants can be expected to have higher survival rates, generally speaking. There are potential positives as well as negatives.	
18	L. Dunsmoor	20, 3rd ¶	This strategy does not allow for adaptation to upper basin consitions. We lost our upper basin stocks when Copco 1 Dam cut them off. Now, we need to reconstruct upper basin stocks. It will take time. We do not expect instant success. Early returns are likely to be small, and it may take multiple years of working with different sources stocks to find the right approach. Coupling pre-adaptation return rates with historical SARs which are affected by the present limiting factors (hydro dams, nutrients, etc.), which in turn are targeted for improvement by the KHSA and KBRA, is likely to produce a worst-case view of the potential for Chinook re-establishment. Page 21, 1st paragraph under 2.6 makes several of the same points as I make above. The two sections seem to be incompatible.	
19	L. Dunsmoor	21, 2.5	This seems to attribute no lower basin benefits to habitat rehabilitation or to dam removal. What are current trajectories of populations under Current Conditions? It is true that some curtailment of harvest may be required, it just seems once again that pessimism rules the day, and too little (or no) benefit is ascribed to restorative measures.	
20	L. Dunsmoor	24, 1st ¶	Consumptive use by agriculture is reduced under the KBRA, especially during dryer years when Project use of surface water is reduced by up to about 100,000 acre ft. Above UKL, inflows are to be increased by 30,000 acre ft through retirement of water uses.	
21	L. Dunsmoor	24, 2nd ¶	"Nonetheless, Current Conditions offers less potential than the Proposed Action to _____.". Could fill in the blank here with almost anything. This structure should appear throughout this	

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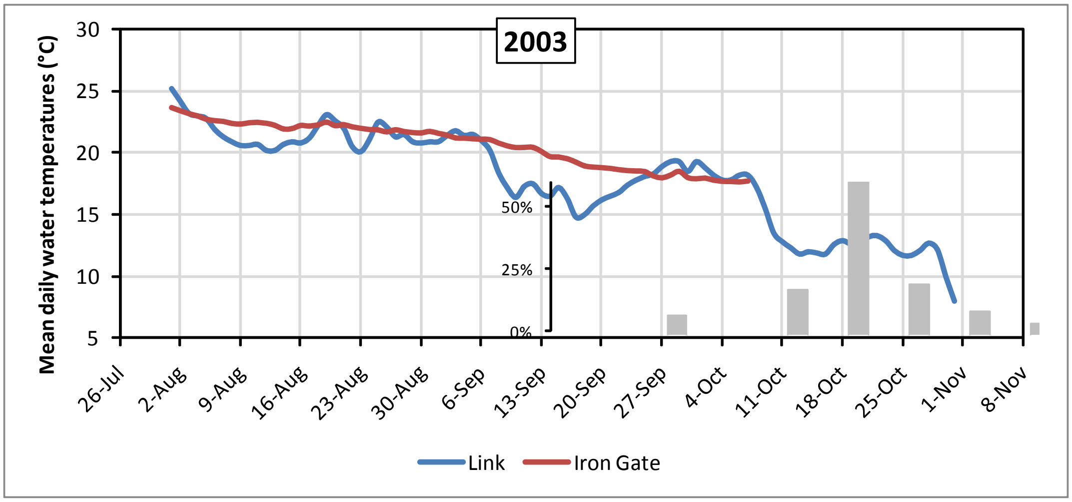
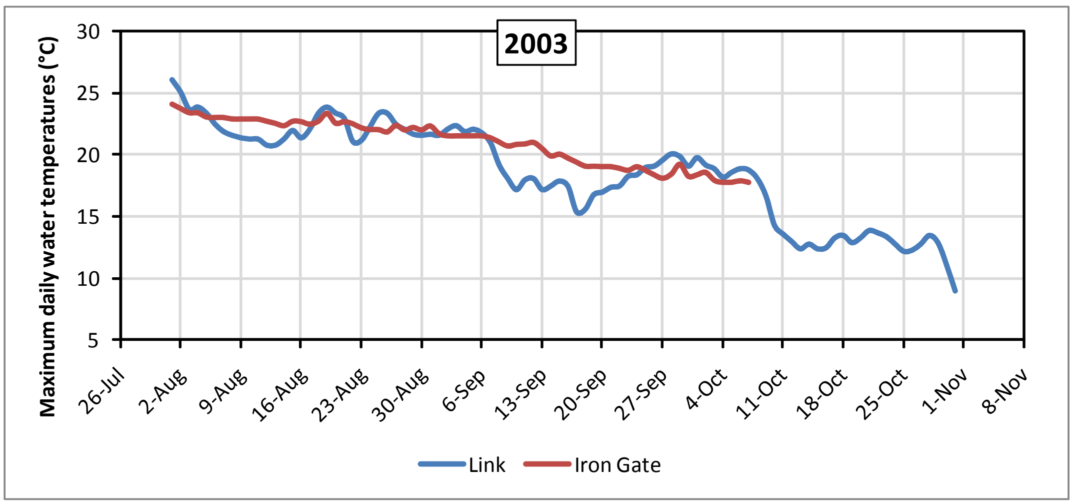
			report on every topic. How does one alternative perform relative to the other?	
22	L. Dunsmoor	28, sections 3.4 and 3.6	Here I find a conundrum. 3.4 says the KBRA is likely to fall short. 3.6 says managers should attempt to mitigate basin-wide limiting factors. The reasoning here is circular and negative. We are told that we cannot successfully implement our basin-wide plan to rehabilitate limiting factors, and then told that we should try to rehabilitate basin-wide limiting factors. If the intent is to say that the KBRA does not target the right restorative actions, then I would ask, how certain is the Panel on this point? Did the Panel's brief exposure to the Klamath enable such a sweeping declaration? The Panel's list of basin-wide limiting factors is not compelling. For example, activities on the refuges are a non-issue in terms of basin-wide limiting factors. Diversions are not an issue on the Salmon. Groundwater pumping proposed under the KBRA is carefully constrained, developed in close consultation with USGS groundwater hydrologists, and will cease upon cresting the threshold of adverse effects; it cannot be credibly cited as a basin-wide limiting factor. No mention is made of the hydro project blocking all fish passage into the upper basin, or its negative effects downstream. Nutrients, the associated trophic state of UKL and the KR, and the hydro project dams are the primary limiting factors. Water and habitat management, and disease, are important as well. The KBRA addresses these areas and more.	





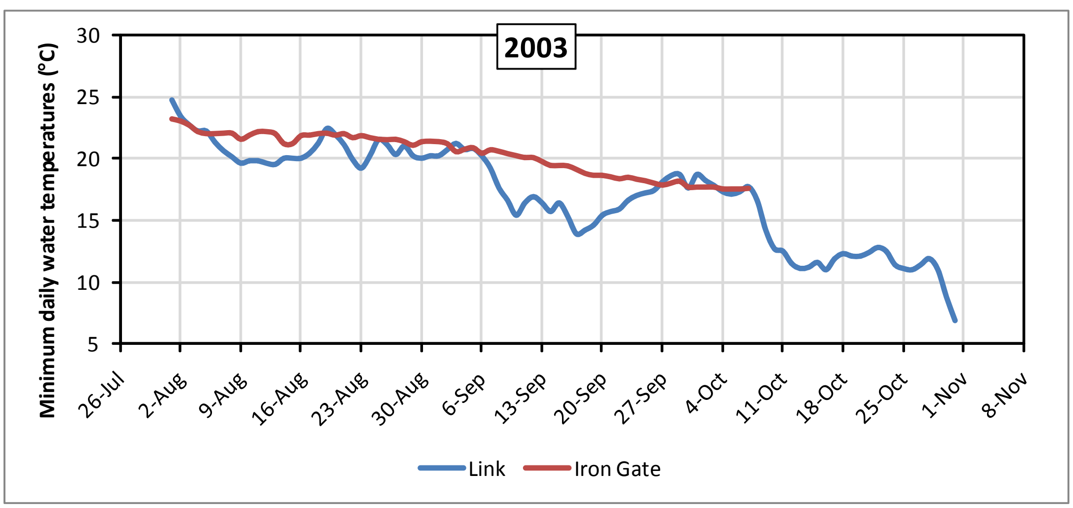
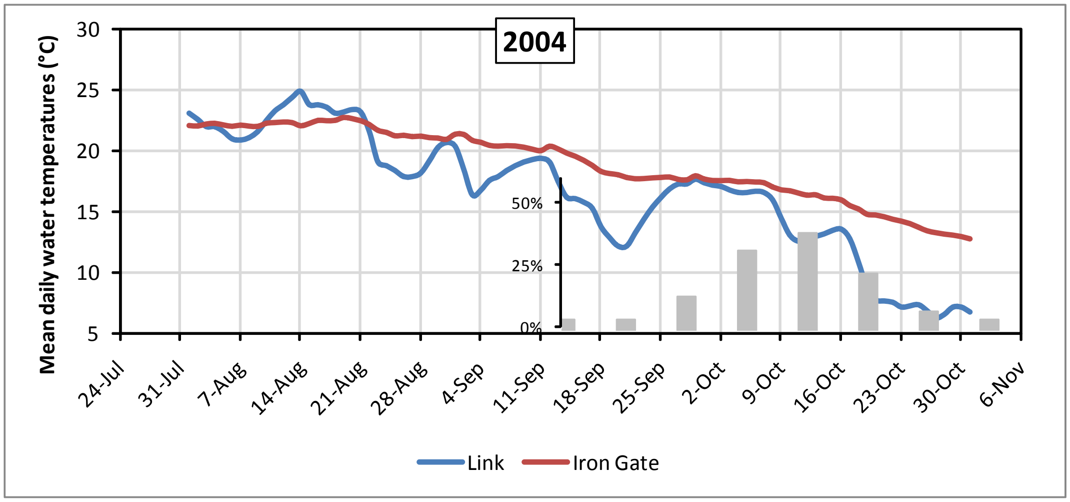
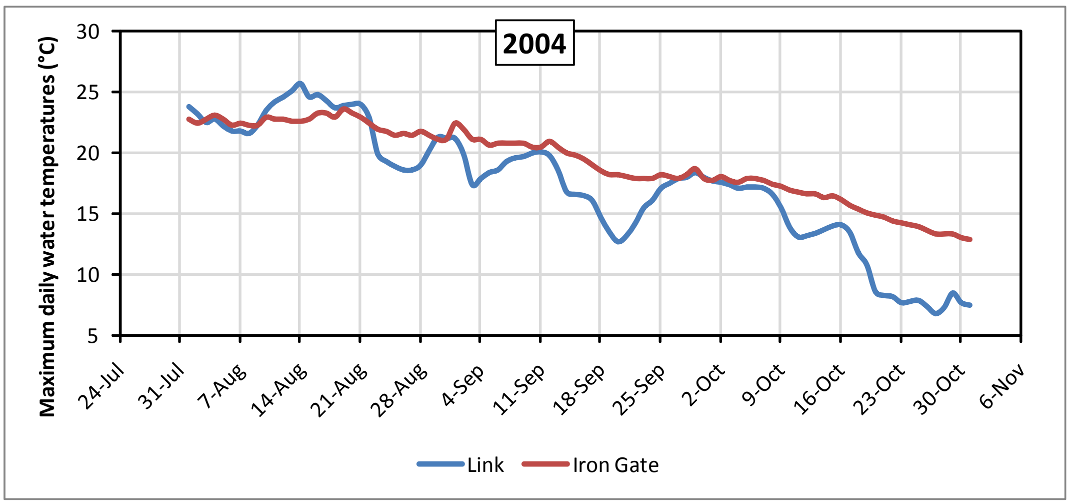
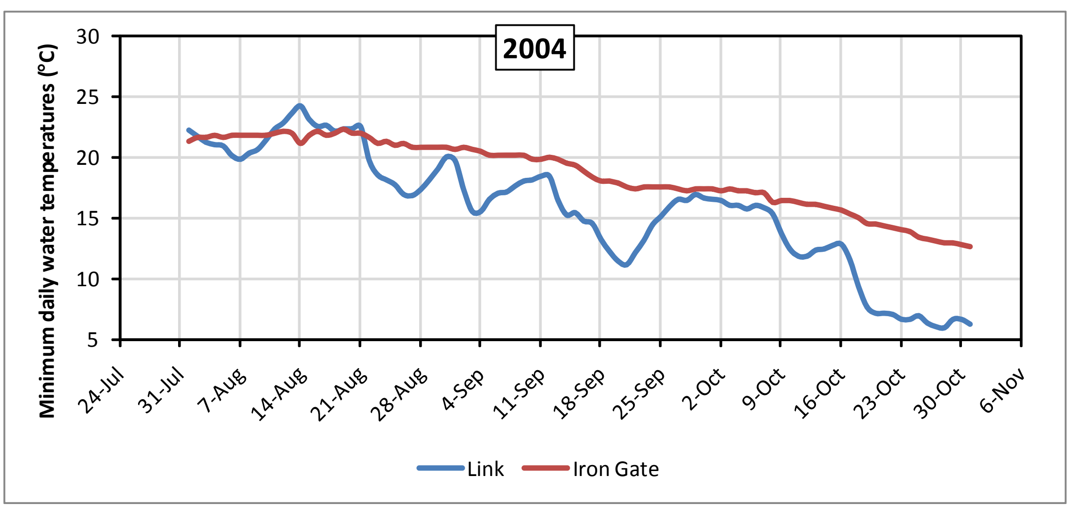


Figure 1. Mean, maximum, and minimum daily water temperatures during August-October for selected sites in the upper Klamath River system. All data are from continuously recording thermographs operated by either the USGS or USFWS. The UKL site is immediately north of Buck Island (USGS); the Link and Keno sites are at USGS gauge sites that are short distances downstream of their respective dams; and the Iron Gate site is at the Iron Gate Hatchery Bridge downstream of the dam (USFWS). Weekly returns (as percent of annual total) of fall Chinook to the Iron Gate Hatchery are represented by the histogram.







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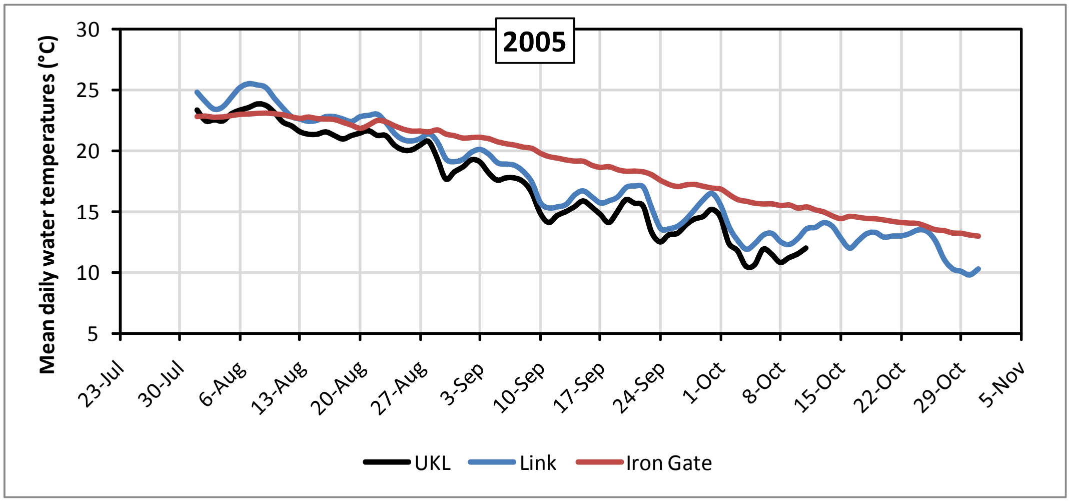

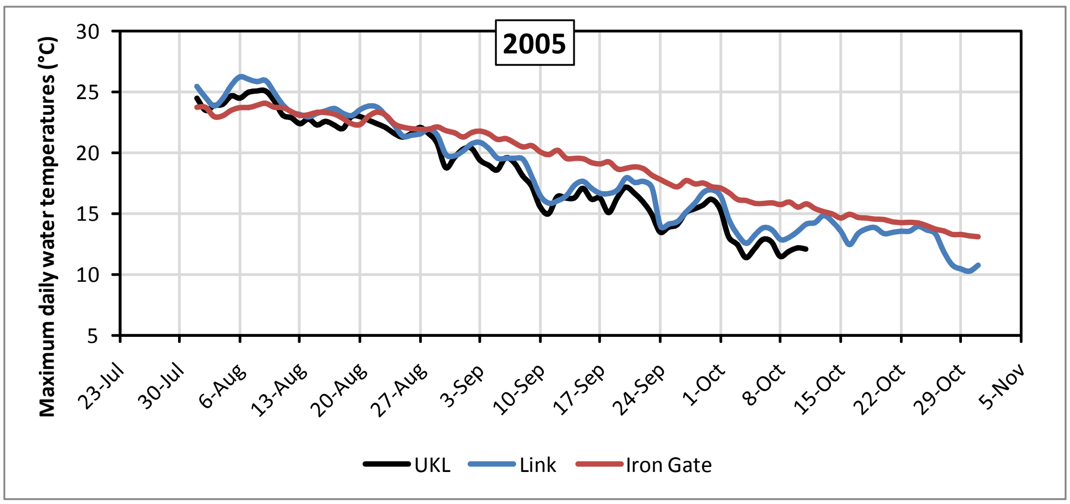

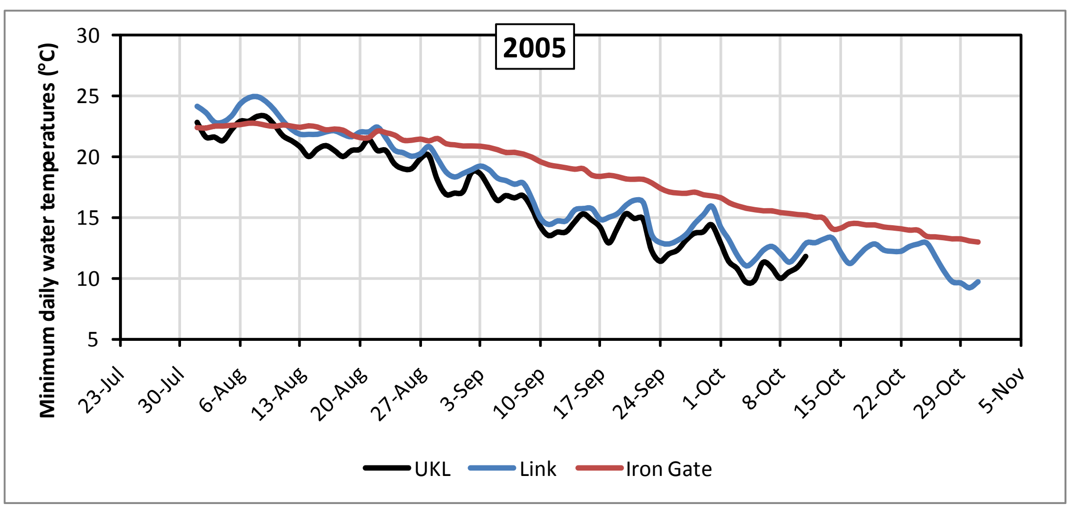

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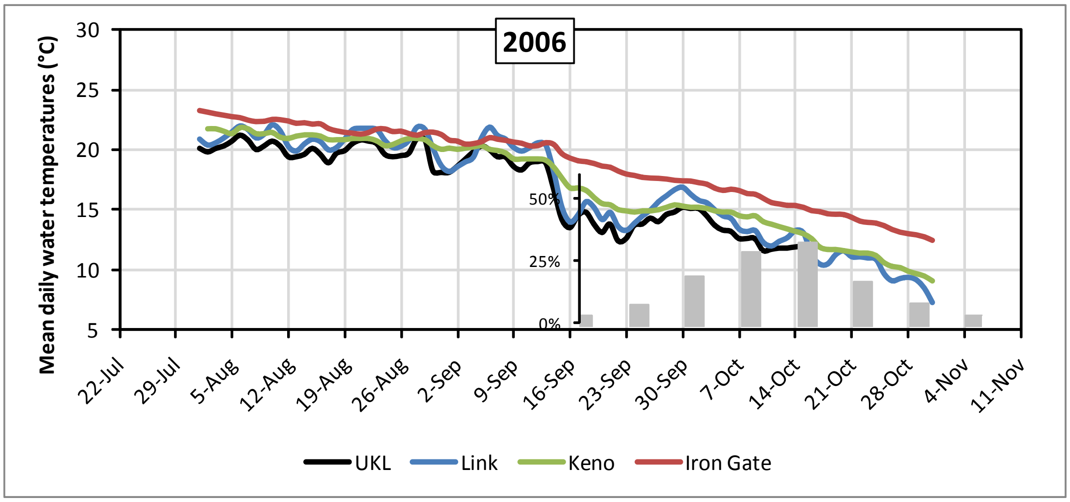

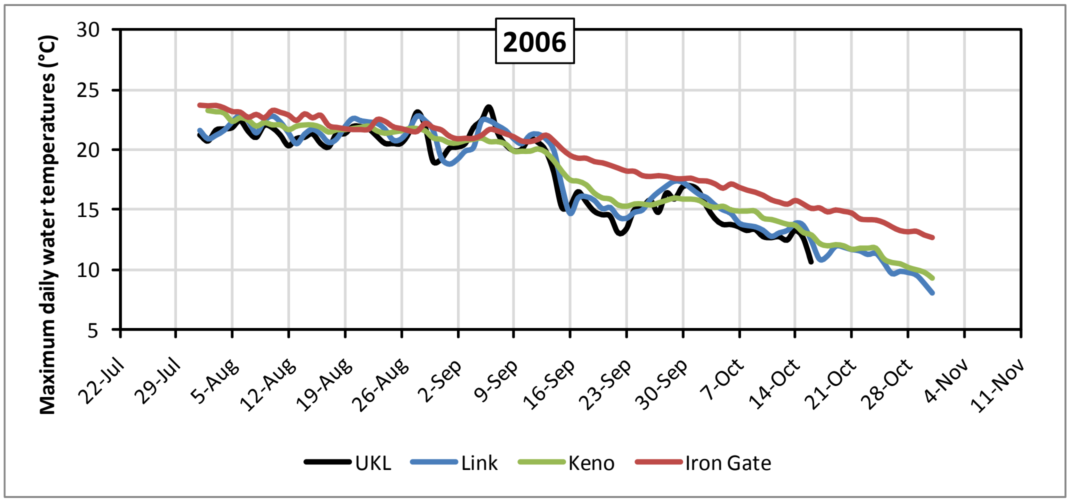

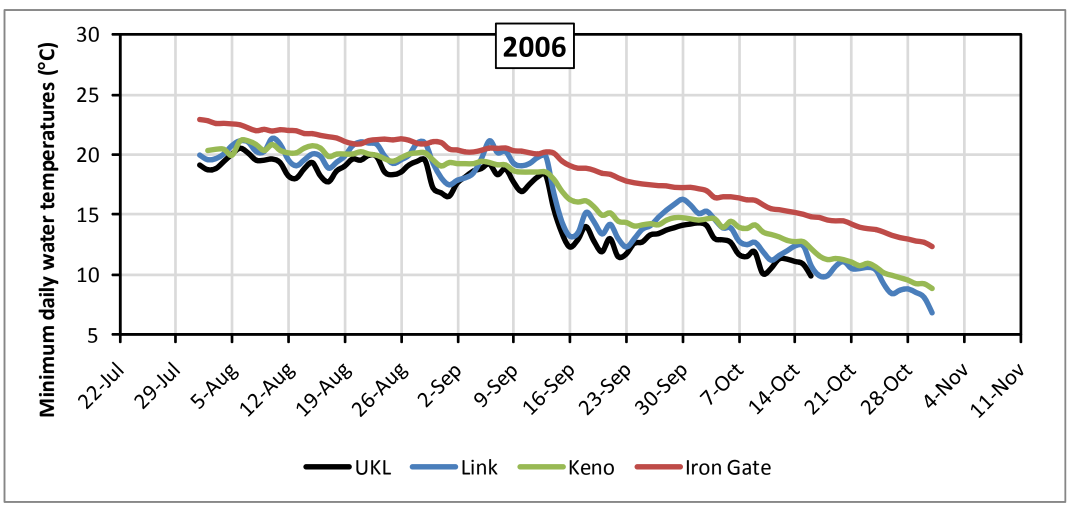

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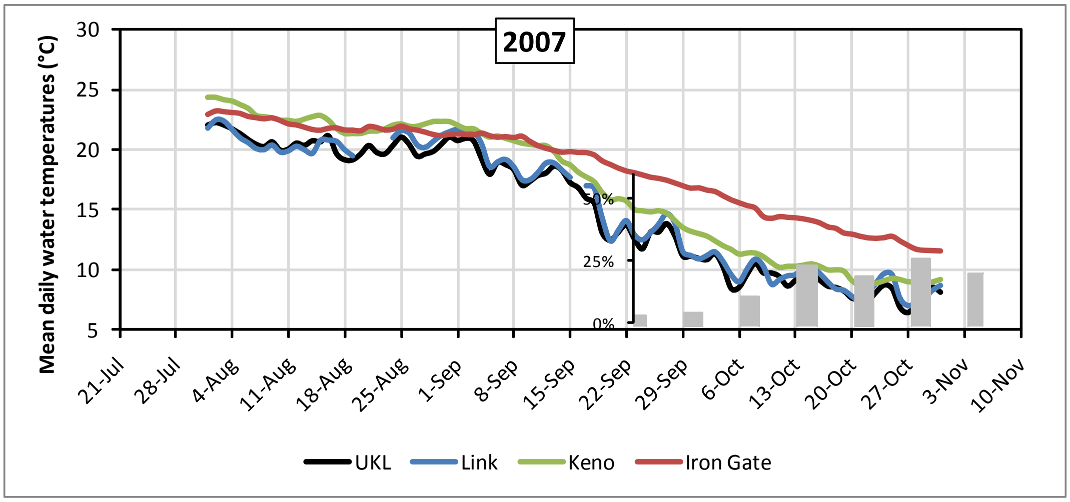

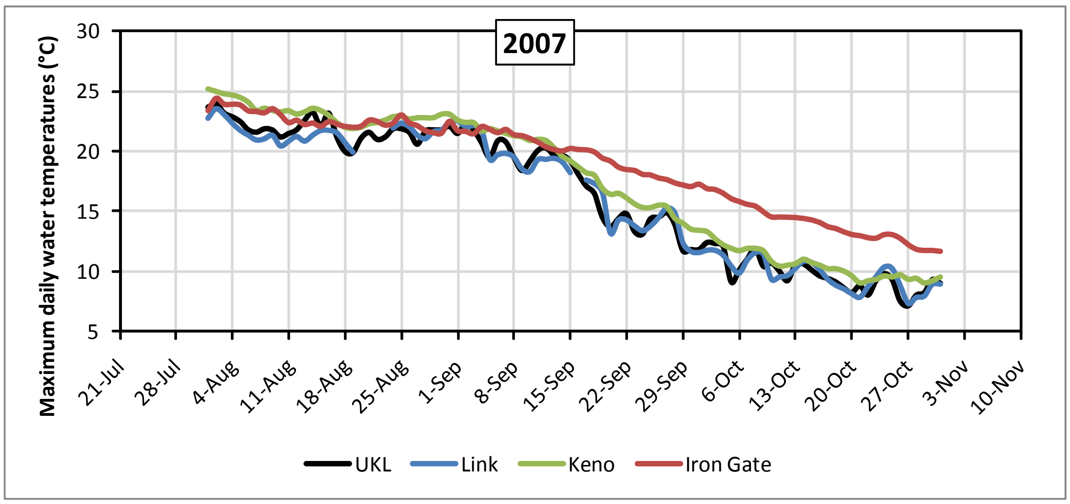

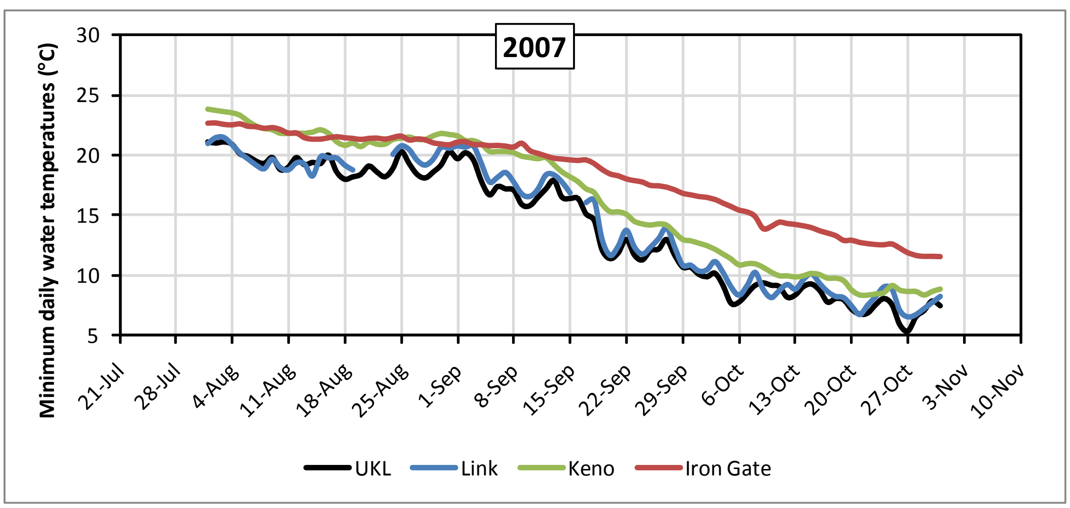

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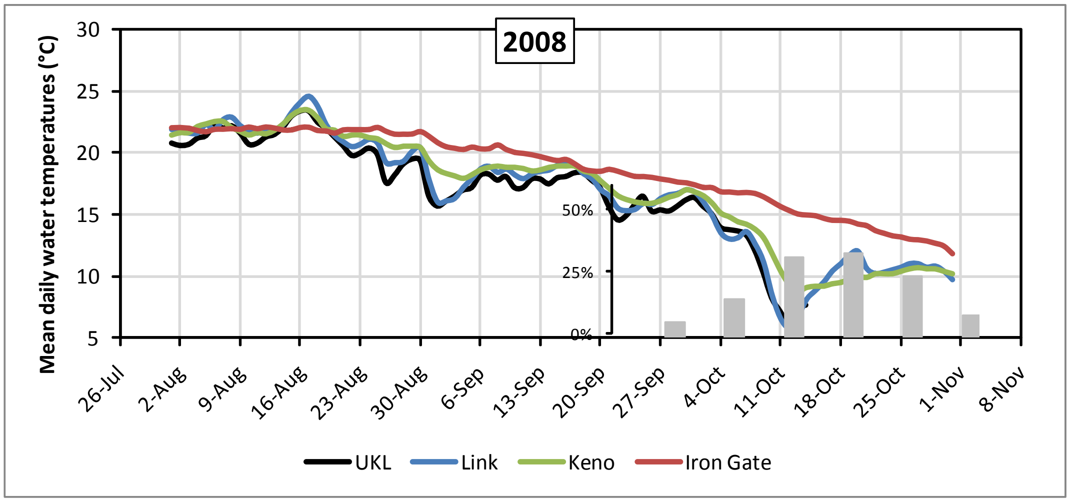

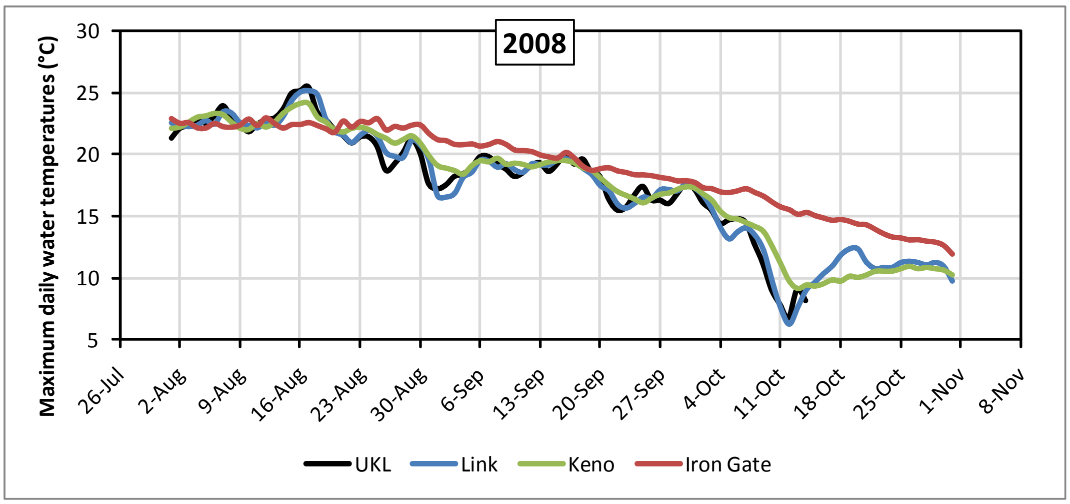

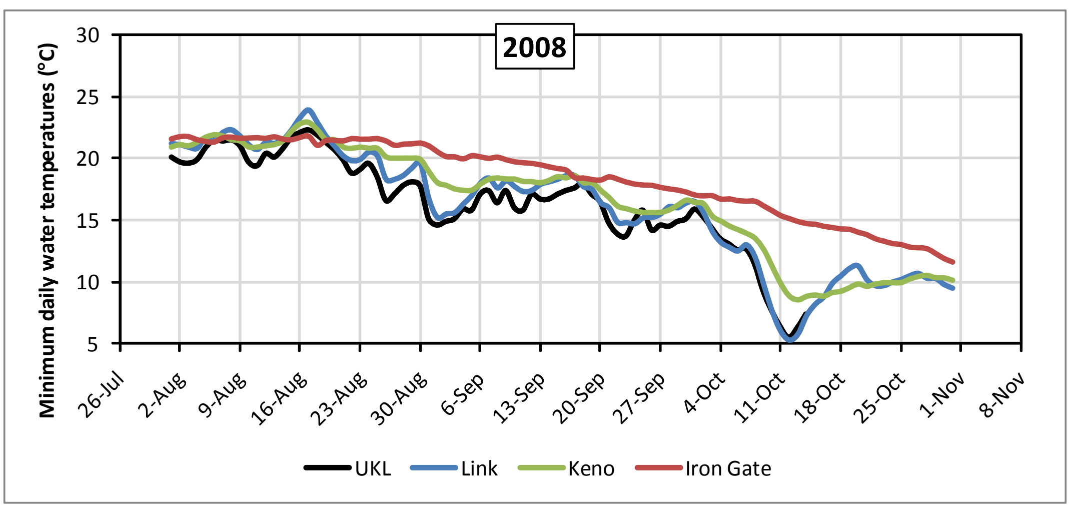

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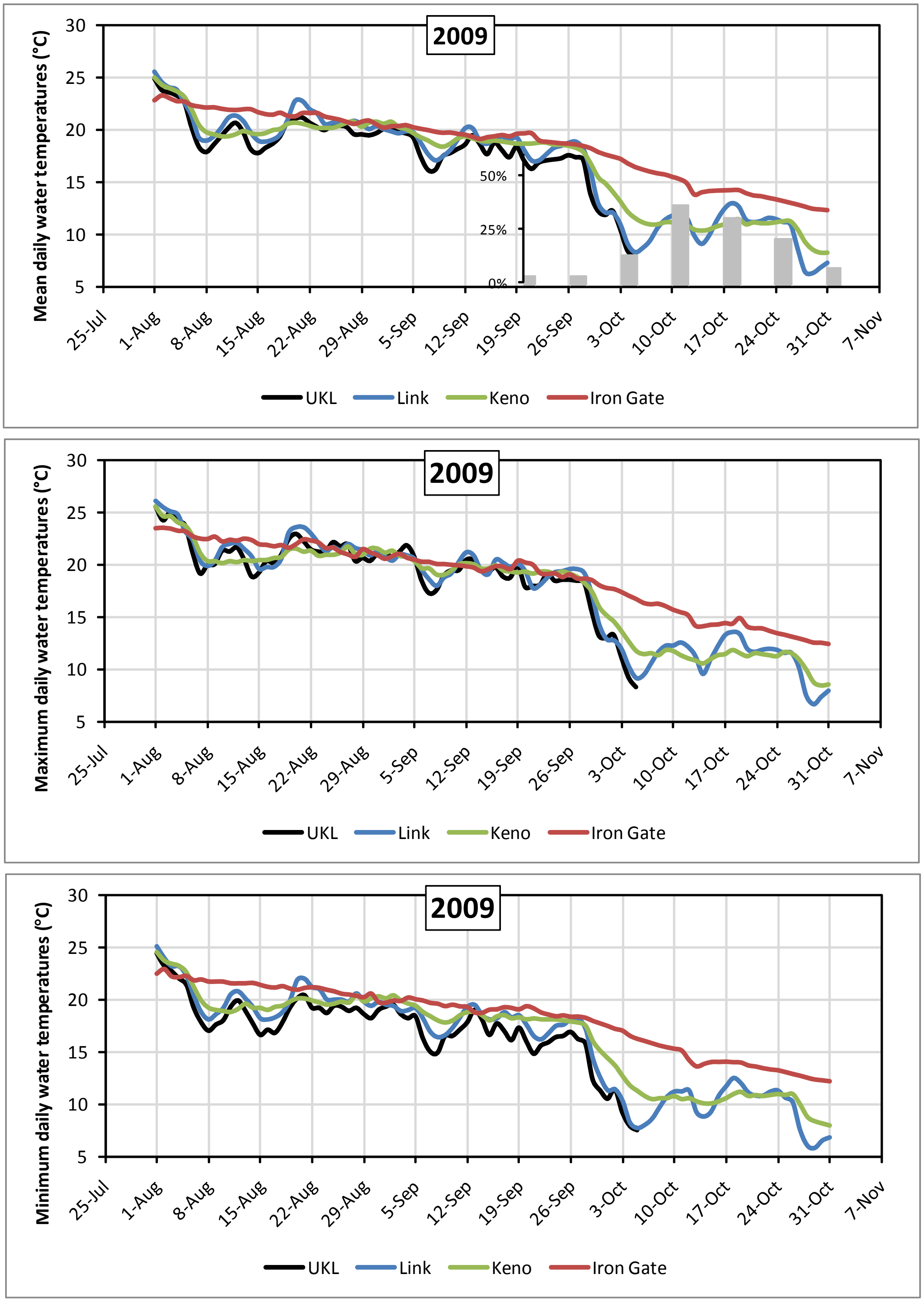

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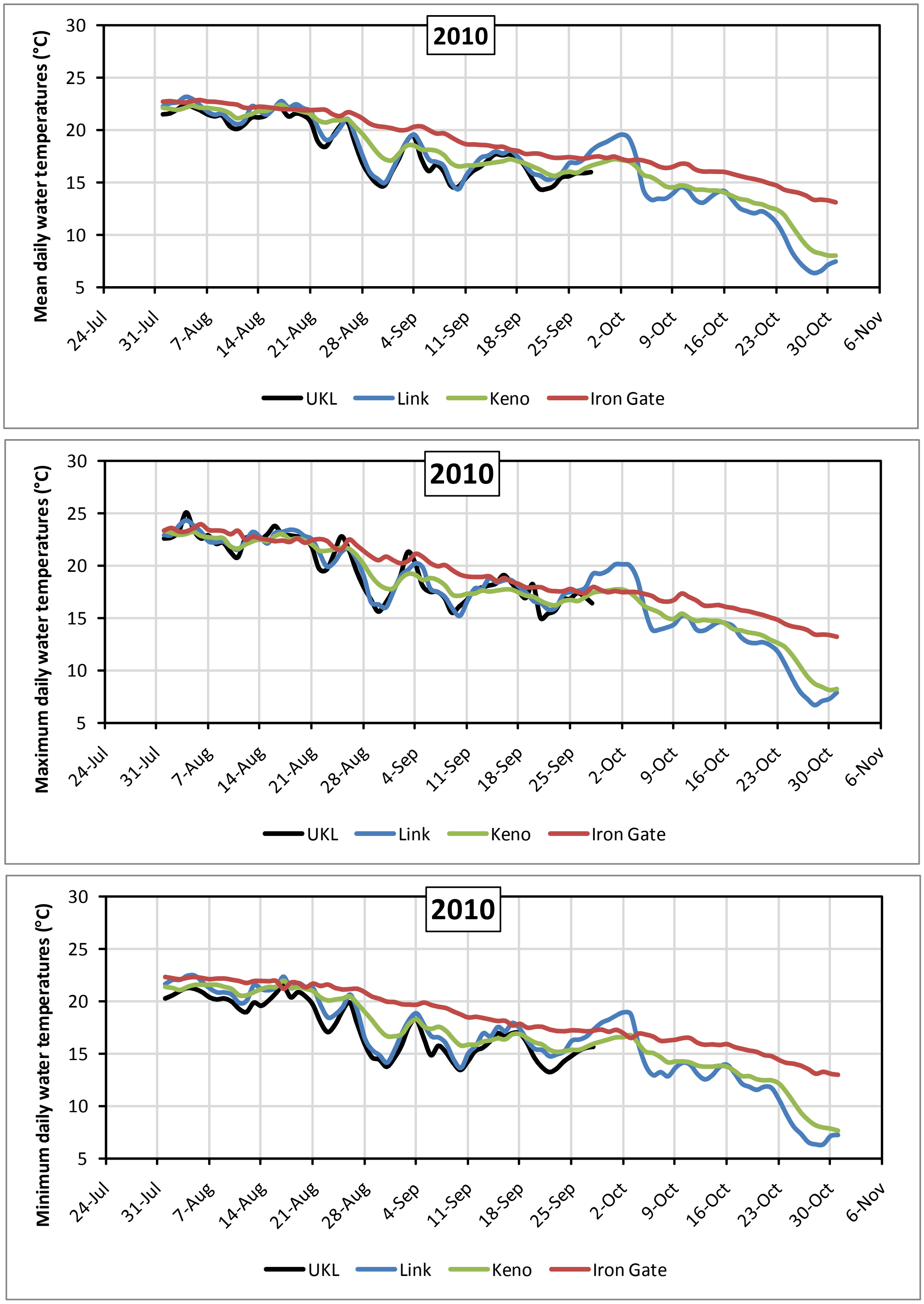

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THE COPCO DAMS AND THE FISHERIES OF THE KLAMATH TRIBE

Prepared by
Lane & Lane Associates

For

The Bureau of Indian Affairs
U.S. Department of the Interior
Portland, Oregon

December 1981

THE COPCO DAMS AND THE FISHERIES OF THE KLAMATH TRIBE

APPENDICES

MAPS

TABLES

FIGURES

THE COPCO DAMS AND THE FISHERIES OF THE KLAMATH TRIBE

INTRODUCTION

The anadromous fisheries of the Klamath Tribe were located on the streams and lakes forming the headwaters of the Klamath River. These headwaters were in the Klamath Basin in southern Oregon and northwestern California at the eastern edge of the Cascade Range and just north of the California border. (Map I)

The COPCO Dams which block the passage of anadromous fish into the waterways of the territory of the Klamath Tribe are located on the Klamath River between Beswick and Hornbrook in Siskiyou County California just south of the Oregon border. (Map I)

The first dam was built in the years between 1911 and 1918. By the time that it was completed, anadromous fish were no longer able to pass into the upper Klamath river or into the headwater spawning streams of the Klamath Basin. Although the builders of the dam promised to provide fish passage facilities, none were built.

Instead, in accordance with provisions in California law, a fish hatchery was built downstream from the dam. There was purportedly an agreement between the departments of fish and game of California and Oregon for this hatchery to provide trout and salmon to Oregon to compensate for the fish loss suffered by Oregon.

There is no evidence that any consideration was given to the fish loss suffered by the Indians of the Klamath Indian Reservation despite continued protests by the Indians and by officials of the Bureau of Indian Affairs on behalf of the Indians.

The COPCO dams on the Klamath River in California were the first in what ultimately became an integrated development of all available hydroelectric power sites in the Klamath Basin from the COPCO dams to Upper Klamath Lake. The original developer was the California-Oregon Power Company. After several corporate restructurings, the enterprise was absorbed by the present owner, Pacific Power and Light.

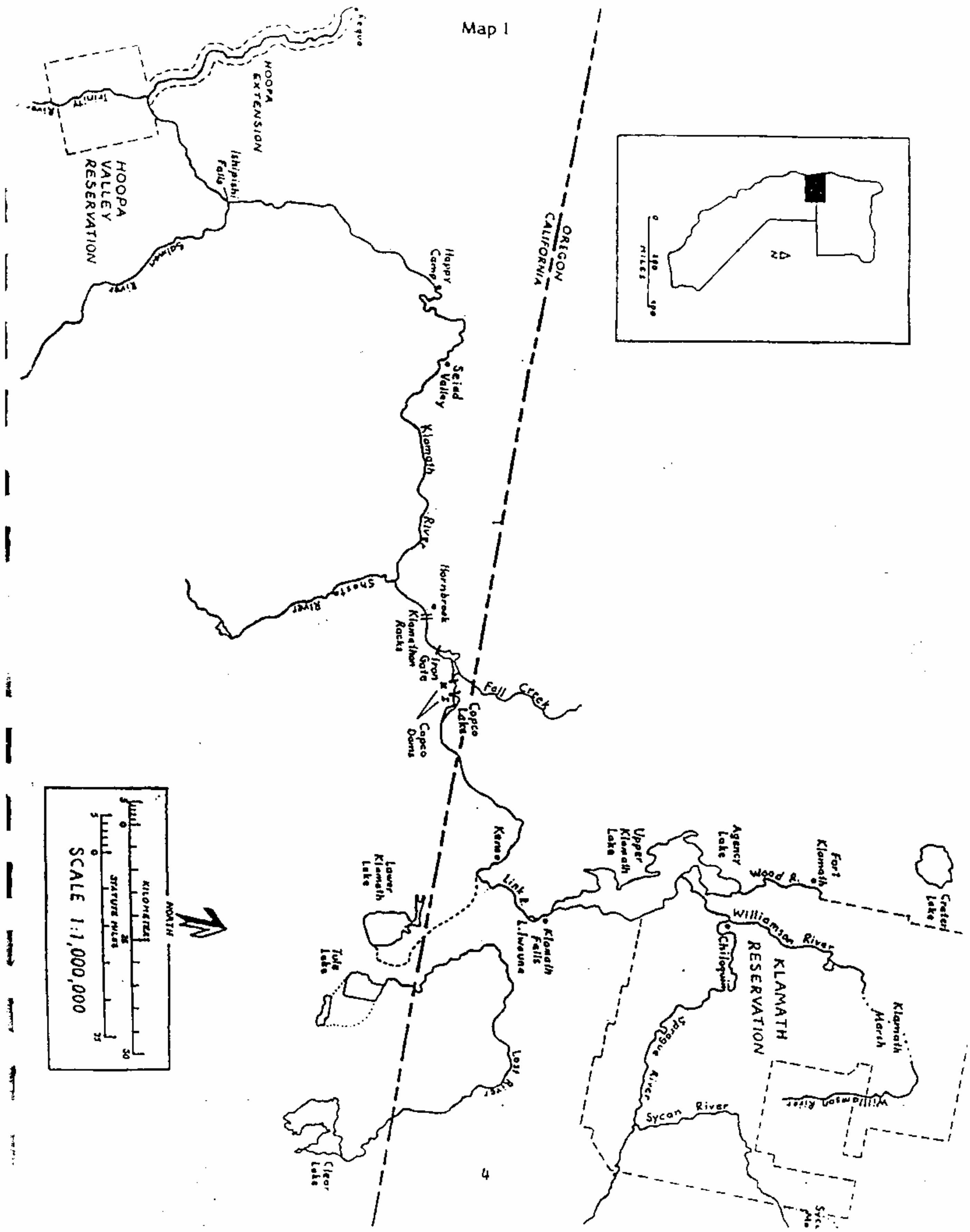
This has resulted in a series of dams and diversions which interlock with the first COPCO dam which blocked the anadromous fish runs to the upper Klamath system. The situation is further complicated by massive reclamation and irrigation works in the Klamath Basin.

Ultimately, the building of the dams and the blocking of the anadromous fish involves two states, California and Oregon, as well as the U.S. Bureau of Reclamation, the Bureau of Indian Affairs, and Pacific Power and Light (formerly COPCO).

In 1940 the Bureau of Indian Affairs began an investigation of the impact of the COPCO dams on the treaty protected Indian fisheries of the Klamath Reservation and took initial steps toward developing litigation for damages on behalf of the Indians. B.G. Courtright, then Superintendent of the Klamath Agency, Kenneth R.L. Simmons and Howard M. Gullickson, attorneys with the Bureau of Indian Affairs, and William Veeder, attorney with the Department of Justice assembled documents related to the events and issues and wrote briefs and memoranda. The preparations lapsed and resumed several times during the 1940s and 1950s during the latter stages of which the firm of Wilkinson, Cragun and Barker was involved in negotiations and investigations on behalf of the Klamath Indians.

This report incorporates and relies upon materials developed in these earlier efforts. In addition, we have included material relating to the Indian users of the affected fisheries and information relating to the Indian fisheries based primarily on ethnographic and historic sources.

Map 1


OREGON
CALIFORNIA
HOOPA VALLEY RESERVATION
HOOPA EXTENSION
Ishipishi Falls
Happy Camp
Seiad Valley
Klamath River
Shasta River
Hornbrook
Klamathon Racks
Iron Gate
Copco Lake
Copco Dams
Fall Creek
Keno
Link R.
Klamath Falls
Lower Klamath Lake
Upper Klamath Lake
Agency Lake
Fort Klamath
Wood R.
Crater Lake
Williamson River
Chiloquin
KLAMATH RESERVATION
Klamath Marsh
Sprague River
Sycan River
Lost River
Tule Lake
Clear Lake
NORTH
KILOMETERS
STATUTE MILES
SCALE 1:1,000,000

THE KLAMATH RIVER SYSTEM AND THE KLAMATH BASIN ENVIRONMENT

The Klamath River system is one of the major river systems of northern California and south-central Oregon. Its watershed is approximately 15,640 square miles. Environmentally, the drainage consists of two contrasting parts. The downstream section flows through a narrow winding valley, extending from Keno, near the Oregon border to the river outlet near the small town of Requa on the northern California coast. The upstream portion of the Klamath River system consists of a complex system of streams and lakes flowing through the Klamath Basin. The Basin includes about 3,740 square miles but not all of it is drained by the Klamath River. There are a number of smaller drainage systems without outlets to the sea. Some of these are now interconnected with the Klamath system. The Upper Klamath Basin drainage area was about 716 square miles. (Area figures adapted from Cal DWR 1960:6) The only portion of these latter waterways designated as the Klamath River is the section flowing from Ewauna Lake southward across the California border. It is 263 miles in length. The Klamath has a number of major tributaries in California. The main ones are the Shasta, Scott, Salmon, and Trinity Rivers. The upper area of the river and the drainage system above it is the area cut off from the sea by the COPCO Dam.

The Klamath Basin headwaters consist of three rivers, the Williamson, its tributary the Sprague, and the Wood. These rise in the northern and eastern part of the Basin and flow into Upper Klamath Lake. This lake consists of two parts, the upper and northern portion of which is sometimes called Agency Lake. It is the largest lake in Oregon.

One characteristic of the Basin is worthy of note:

> Draining to Klamath Lake is a broad basin of nearly 4,000 square miles, which, because of the gentle topography, light rainfall, volcanic soils,

> and extensive marsh areas is not productive of very large run-off. However, these same factors are conducive to regularity of discharge, and, therefore, with the additional regulating effect of Upper Klamath Lake the flow in the upper section of the river is markedly uniform.
>
> . . .
>
> Due to the regulating effect of the upper basin the summer flow of the Klamath is better sustained than any of the other major streams, except the Pit and McCloud Rivers. (Bonner 1928:35,36)

A uniform sustained flow would be beneficial to anadromous fish migration and spawning.

Klamath Lake flows into a short connecting stream, the Link River, a little more than a mile long, which in turn becomes a small marshy lake, Ewauna. The out-flow from this lake is the Klamath River.

In the southeastern portion of the Basin is another water system. This consisted (it is now altered) of the Lost River, draining country to the east including Clear Lake, and flowing into Tule (Modoc) Lake.

In aboriginal and early historical times, the Lost River system was independent of the Klamath system, having no exterior surface drainage.

Predevelopment Environment

Albert Gatschet, a linguist attached to the U.S. Geographical and Geological survey of the Rocky Mountains visited the area in 1873 and provided a good description of this complex environment. His description is particularly useful since it describes the environment in the period before radical changes were made to it for agricultural and industrial purposes:

> The home of the Klamath tribe of southwestern Oregon lies upon the eastern slope of the southern extremity of the Cascade Range, and very nearly coincides with what we may call the headwaters of the Klamath River, the main course of which lies in Northern California. Its limits are outlined in a general manner in the first paragraph of the treaty concluded between the Federal Government and the Indians, dated October 14, 1864, which runs as follows: "The Indians cede all

the country included between the water-shed of the Cascade Mountains to the mountains dividing Pit and McCloud Rivers from the waters on the north; thence along this water-shed eastwards to the southern end of Goose Lake; thence northeast to the southern end of Harney Lake; thence due north to the forty-fourth degree of latitude; thence west along this same degree to Cascade Range." It must be remarked that the homes and hunting-grounds of two "bands" of the Snake Indians were included within these limits, for these people were also made participants to the treaty.

Here, as with all other Indian tribes, the territory claimed must be divided into two parts, the districts inclosing their habitual dwelling-places and those embodying their hunting and fishing grounds, the latter being of course much larger than the former and inclosing them. The habitual haunts and dwelling-places of the tribes were on the two Klamath Lakes, on Klamath Marsh, on Tule Lake, and on Lost River. Some of these localities are inclosed within the Klamath Reservation, of which we will speak below.

The Cascade Range is a high mountain ridge following a general direction from north to south, with some deflections of its main axis. The line of perpetual snow is at least 10,000 feet above the sea-level, (8,000 plus or minus RBL), and the altitude of the highest peaks about 12,000 to 14,000 feet (6,000 to 9,000 feet RBL). On the west side the sloping is more gradual than on the east side, where abrupt precipices and steep slopes border the Klamath highlands and the valley of Des Chutes River. The range is the result of upheaval and enormous volcanic eruption, the series of the principal peaks, as the Three Sisters, Mount Jefferson, and Mount Hood, marking the general direction of the ridge.

. . .

The most prominent object of nature visible from the level parts of the Klamath Reservation is the Cascade Range with its lofty peaks. Seen from the east shore of Upper Klamath Lake, it occupies nearly one hundred and fifty degrees of the horizon. Though Shasta Butte, visible on the far south, does not properly belong to it, the ridge rises to high altitudes not very far from there, reaching its maximum height in the regular pyramid forming Mount Pitt. This pyramid is wooded on its slopes, and hides several mountain lakes - Lake of the Woods, Buck Lake, and Aspen Lake - on its southeastern base. Following in a northern direction are Union Peak, Mount Scott, and Mount Thielsen, with many elevations of minor size. At the southwestern foot of Mount Scott lies a considerable lake basin about twenty miles in circumference, and at some places two thousand feet below its rim. The water being of the same depth, this "Crater Lake" has been pointed out as probably the deepest lake basin in the world (1,996 feet by one sounding), and it also fills the largest volcanic crater known. At its southwestern end a conical island emerges from its brackish waters, which is formed of scoriae - proof that it was once an eruption crater.

. . .

On the west side of Mount Scott and Crater Lake rise the headwaters of the North Fork of Rogue River, which run down the western slope, and a narrow trail crosses the ridge south of the elevation. Northeast of it and west of Walker's Range lies a vast level plain strewed with pulverized pumice-stone, and forming the watershed between the affluents of the Klamath and those of Des Chutes River, a large tributary of the Columbia.

Upper Klamath Lake, with its beautiful and varied Alpine scenery, verdant slopes, blue waters, and winding shores, is one of the most attractive sights upon the reservation. Its principal feeder is Williamson River, a water-course rising about thirty miles northeast of its mouth. After passing through Klamath Marsh it pursues its winding course south through a canon of precipitous hills, six miles in length; then reaches a wide, fertile valley, joins Sprague River coming from Yaneks and the east, and after a course of about sixty miles empties its volume of water into Upper Klamath Lake near its northern end. The elevation of this lake was found to be about eighty feet higher than that of Little Klamath Lake, which is 4,175 feet. Wood River, with its affluent, Crooked River, is another noteworthy feeder of the lake, whose shores are partly marshy, partly bordered by prairies and mountains. The lake is embellished by a number of pretty little islands, is twenty-five miles long in an air-line, and varies between three and seven miles in width. On the eastern shores the waters are more shallow than on the western.

The waters of the lake first empty themselves through Link River, and after a mile's course fall over a rocky ledge at the town of Linkville. From there onward the stream takes the name of Klamath River. Passing through a marsh, it receives the waters of Little Klamath Lake, then winds its circuitous way towards the Pacific Ocean through a hilly and wooded country, canons, and rapids, innavigable for craft of any considerable size. Hot springs of sulphuric taste flow westward east of Linkville, one of them showing a temperature of 190° Fahr.

The Klamath Reservation is studded with a large number of isolated and short volcanic hill ridges, with a general direction from northwest to southeast. South of Klamath Marsh there are elevations culminating at 5,650 and 6,000 feet, and in Fuego Mountain 7,020 feet are attained. Yamsi Peak, between Klamath Marsh and Sykan Marsh (5,170 feet) reaches an altitude of not less than 8,242 feet, thus rivaling many peaks of the Cascade Range. The Black Hills, south of Sykan Marsh, rise to 6,410 feet, but are surpassed by several elevations south of Sprague River, near the middle course of which the Yaneks Agency (4,450 feet) is situated. Sprague River, the most considerable tributary of Williamson River, drains a valley rich in productive bottoms and in timber.

The basaltic ridge, which forms a spur of the Cascade Range and passes east of Fort Klamath, slopes down very abruptly toward the Quaternary lake basin, now forming a low marshy prairie and watered by Wood River, which enters upper Klamath Lake near Kohashti and by Seven Mile Creek, nearer the Cascade Range. This basaltic spur, called Yanalti by the Indians, represents the eastern side of a huge fault-fissure. Its altitude constantly decreases until it is crossed by a rivulet one-eighth of a mile long, called Beetle's Rest, which issues from a pond, drives a mill, and then joins Crooked River. This beautiful spring and stream were selected by the Government as the site for the Klamath Agency buildings. The old agency at Kohashti on the lake, three miles south, was abandoned, and a subagency established at Yaneks. The agency buildings are hidden in a grove of lofty pine trees. South of these the ridge rises again and culminates in a elevation, called Pitsua (4,680 feet). The junction of Sprague and Williamson Rivers is marked by a rock called Ktai-Tupakshi, and described in Dictionary, page 149 as of mythic fame. South of Sprague River the ledge rises again, and, approaching close to the lake shore, forms Modoc Point, a bold headland, which culminates in an elevation east of it, measuring 6,650 feet, in Nilaks Mountain, on the lake shore, and in Swan Lake Point (7,200 feet), about eight miles from Klamath Lake. A deep depression south of this height is Swan Lake Valley (4,270 feet), and a high hill north of the two, near Sprague River, is called Saddle Mountain (6,976 feet). Yaneks Butte, with a summit of 7,277 feet, lies midway between the headwaters of Sprague River and the Lost River Valley. A long and steep ridge, called the Plum Hills, rises between Nilaks and the town of Linkville.

We now arrive at what is called the "Old Modoc Country". The main seat of the Modoc people was the valley of Lost River, the shores of Tule and of Little Klamath Lake. Lost River follows a winding course about as long as that of Williamson River, but lies in a more genial climate. The soil is formed of sandstone interstratified with infusorial marls. Nushaltkaga is one of its northern side valleys. At the Natural Bridge these strata have been upheaved by a fault, so that Lost River passes underneath. The sandstone is of volcanic origin, and contains pumice and black scoria in rounded masses, often of the size of an egg. The largest part of Tule Lake, also called Rhett Lake and Modoc Lake, lies within the boundaries of California. It is drained by evaporation only, has extinct craters on its shores, and the celebrated Lava Beds, long inhabited by the Kombatwash Indians, lie on its southern end.

Clear Lake, also called Wright Lake, is a crater basin, with the water surface lying considerably below the surrounding country. Its outlet is a tributary of Lost River, but is filled with water in the cooler season only. Little or Lower Klamath Lake is fed by Cottonwood Creek, and on its southern side had several Indian settlements like Agawesh. It has an altitude of 4,175 feet, and belongs to the drainage basin of Klamath River. South of these lakes there are considerable volcanic formations, which however, lie beyond the pale of our descriptive sketch.

Peculiar to this volcanic tract is the frequent phenomenon of the pond sources. These sources are voluminous springs of limpid water, which issue from the ground at the border of the ponds with a strong bubbling motion, without any indication of other springs in the vicinity. They are met with in soil formed of volcanic sands and detritus, have a rounded shape with steep borders, and form the principal feeders of the streams into which they empty. Ponds like these mainly occur in wooded spots. Some of them have a diameter of one hundred feet and more, and are populated by fish and amphibians of all kinds.

The lake region east of the Reservation was often visited in the hunting and fishing season by the Klamath Lake, Modoc, and especially by the Snake Indians. Goose Lake was one of the principal resorts of the Snake and the Pit River Indians; and even now the numerous rivulets flowing into it make its shores desirable to American stockmen and settlers. Warner (or Christmas) Lake fully thirty-five miles in length, was once enlivened by the troops camping at Fort Warner, on its eastern side. Chewaukan Marsh has its name from the tchua or "water potato", the fruit of Sagittaria, and is by its outlet connected with Abert Lake.

The Indians of the Reservation annually repair about the month of June to Klamath Marsh to fish, hunt, and gather berries and wokash or pond-lily seed, which is one of their staple foods. Its surface is somewhat less than that of Upper Klamath Lake. Its shores are high on the southeastern, low and marshy on the northwestern side. Water appears at single places only, insufficient to warrant the marsh being called, as it often is, a lake. (Gatschet 1890:xvi-xxii Linguistic terms deleted)

Map II is a copy of the map accompanying Gatschet's paper.

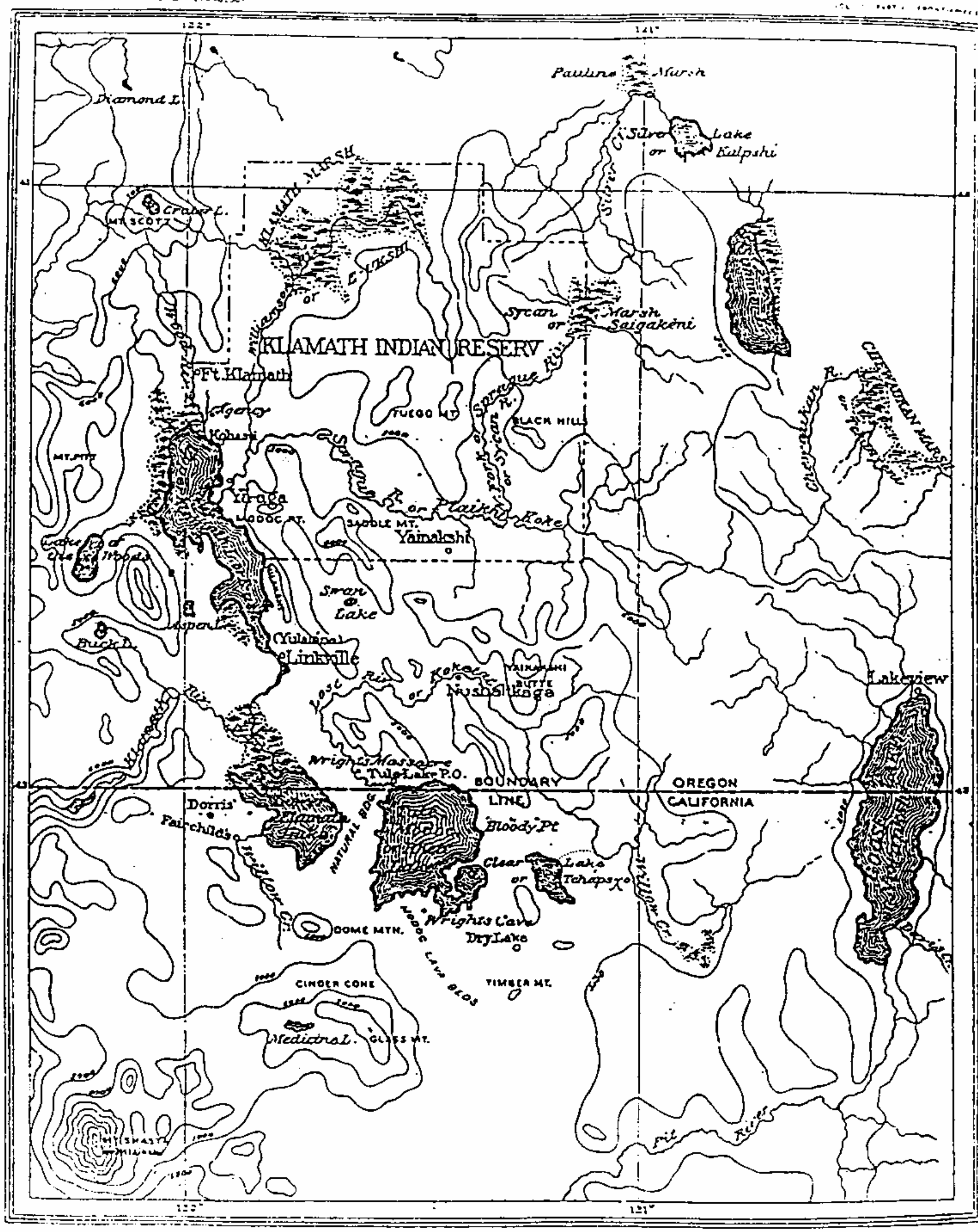
Development and Change

Today, the Klamath Basin is radically altered. The changes, most of which relate to alterations in the waterways, are exceedingly complex. Our aim here is not to unravel the details of these changes but simply to give a rough indication of what has happened.

The manipulations of waters in this area (southern Oregon-northern California) began with placer mining for gold in tributaries of the Klamath and other rivers in California downstream from the Klamath Basin as early as 1848. This mining continued over the years. By the end of the 19th century it had turned into hydraulic mining which damaged so many of the streams of the region.

Damage to fish runs resulted from the physical distruction of some spawning areas and heavy siltation of others. Mining did not effect Klamath waters in Oregon.

Map II



Scale 15 miles to 1 inch

MAP OF THE HEADWATERS OF THE KLAMATH RIVER

By the latter half of the 19th century, some of the ditches that had originally been dug to provide water for mining, had been converted to irrigation canals. None of these activities directly influenced the Klamath Basin but some small scale irrigation had been undertaken, including some at Klamath Agency. By the 1890s schemes were being put together to develop agriculture in the Basin through massive hydraulic projects. For example, one proposal was being planned in 1892 to reclaim 70,000 acres of land on Upper Klamath Lake by lowering the water level and thus drying out some of the adjacent marsh lands. This scheme did not mature but at least 2,000 acres were being irrigated by the turn of the century. However, the water management necessary to alter the Klamath Basin lands for irrigation was of such a large scale that extensive development only took place after the U.S. Reclamation Service was brought into existence by the Newlands Act in 1902 and the Klamath Basin was chosen as a major project area.

The first hydroelectric power dams in the Klamath region were built in the 1890s:

> Yreka, California, saw its first electric lights in 1891. James Quinn built a 36-kilowatt plant on the Shasta River three miles north of town. . . .
>
> Utilization of water in Klamath Falls, for example, began in 1882 when a canal was constructed along Link River to operate a flour mill located near the site of the West Side hydroelectric plant. It was 1896, however, before electric service was established from a small plant built on the east side of Link River, under a franchise granted in 1895 to H. V. Gates, founder of the Klamath Falls Light and Water Company. (Dierdorff 1971:270)

Shortly thereafter a number of other small dams were built in the Klamath Basin. These will be noted in the section on "Barriers". Here we will confine ourselves to noting some of the reclamation activities in the Basin which so altered the physical nature of the total environment. The Reclamation Act of June 17, 1902 was the starting point for Bureau of Reclamation activity in the Klamath Basin.

The draining of Lower Klamath Lake evidently started with the dredging of its outlet to the Klamath River before the turn of the century. It was accelerated after 1905:

> . . .Most of the irrigated agricultural development in the Klamath River Basin has occurred in the valley portions of this plateau region. Much of this development is on land reclaimed by drainage of shallow lakes and swamps. (Cal DWR 1960:5)
>
> In 1905, the United States Reclamation Service, now the Bureau of Reclamation, began to reclaim and develop for irrigation the lands of the upper Klamath Basin now included in the Klamath Project. Construction of such works as Clear Lake Dam, Gerber Dam, Link River Dam, and many miles of canals, together with drainage of Tule Lake, has provided for the irrigation of the largest, and one of the most fertile, agricultural areas in the basin. (Cal DWR 1960:8)
>
> The Klamath River heads in Upper Klamath Lake, controlled at its outlet by Link River Dam. Under natural conditions this lake, and the now reclaimed area of Lower Klamath Lake, had considerable regulatory effect on the Klamath River. During flood stages the natural flows would leave the stream channels, flood the adjoining flat lands and lake bottom, fill the sump areas, and later return at reduced rates of flow to the main channel. Upper Klamath Lake continues to regulate high flows in the river, but reclamation of the Lower Klamath Lake area now prevents flood waters from entering.
>
> To the east and south of Lower Klamath Lake are the Lost River watershed, the lava bed areas tributary to Tule Lake Sump and Lower Klamath Lake, and the closed basin to Butte Valley. Under natural conditions this extensive area of approximately 3,000 square miles contributed no surface flow to the Klamath River. Under present conditions the drainage water from irrigation and flood flows return to the Klamath River. (Cal DWR 1960:18)
>
> Lost River had its terminus in Tule Lake, a natural sump without outlet. Presently, however, a portion of the flood flow of Lost River is diverted by gravity into the Klamath River in Oregon. The flows which reach Tule Lake are controlled within leveed areas and finally diverted into the Klamath River by pumping. (Cal DWR 1960:5)

Boyle provides additional details:

> In 1890, a dike was built to prevent overflow of Klamath River with Lost River and on into Tule Lake. This dike was cut by the Lost River diversion canal when built in 1911-1912 thus eliminating a relief of Klamath River water during floods. Also Tule Lake area was dried up for reclamation by diverting Lost River into Klamath River. These two changes modified the flow of Klamath River at Keno and below.

In 1906 and 1907, the Southern Pacific Railroad was required to install headgates at Ady so flow of water to and from Lower Klamath Lake could be regulated or shut off entirely. On October 12, 1917 the headgates were closed to accomplish drying up the Lower Klamath Lake. Here again the natural process of lake regulation of Klamath River was lost and the flows of water below Keno materially changed. (Boyle 1976:51)

Most of these changes related to agricultural development. Some of them would have been more extensive and thus even more damaging to the fauna and flora if parts of the water ways had not been protected by being set aside as wildlife refuges. The Basin and its lakes and streams are a major North American wintering ground for waterfowl. All of the major lakes (Upper Klamath, Lower Klamath, Tule, and Clear) have refuge areas set aside which are administered by the U.S. Fish and Wildlife Service.

When Lower Klamath Lake was drained, before irrigation facilities developed, an ecological disaster ensued which was mitigated only by the fact of the bird refuge:

> To the (L) of the highway, at the southern end of the dry bed of Lower Klamath Lake is the KLAMATH LAKE BIRD RESERVE. This reservation in Klamath County, Oregon, and Siskiyou County, California, was set aside as a refuge in 1908, subject to the primary use of the lands by the Bureau of Reclamation. It contains 81,619 acres, 61,139 of which are in Oregon.
>
> Lower Klamath Lake, once a singularly beautiful expanse of water bounded by tules, and the home of myriads of breeding waterfowl, has been almost completely dry for many years as a result of an attempt to convert it into agricultural land. The conditions that obtained before its drainage were described by Mr. William L. Finley: "Here are numerous ducks, including mallards, canvasbacks, pintails, gadwalls, mergansers, cinnamon teal, and ruddy ducks. The marshes are also the homes of Canada geese, sandhill cranes, bitterns, coots, and rails. Along the mud flats are avocets, stilts, phalaropes, snipe, killdeers, and other waders. On the lakes are colonies of numberless gulls, night herons and great blue herons, cormorants, grebes, terns, and pelicans. I have seen the marshes white with the nesting multitudes."
>
> After 1917, when control gates were closed and the waters of the Klamath River prevented from entering into the lake, its destruction was rapid. Water remaining was soon lost through evaporation, and tule

and peat fires continued the destruction until there remained only a desert. A large portion of the land thus uncovered was useful for no other purpose than a bird refuge and the remainder was burdened with mandatory reservations that discouraged any attempts at agriculture.

Since this drainage, sportsmen and conservationists have agitated for the restoration of Lower Klamath, and government engineers have recently reported a plan and it is expected that the work of returning Lower Klamath Lake to its one-time ideal condition for birds will be begun soon.

In its present condition, a few birds still use the Lower Klamath Refuge, but in nothing like their former numbers. Killdeers still nest around the few lakes remaining on the refuge, and small numbers of ducks and geese still stop in migration. (Oregon Writers Project 1940:400-401)

Since that description was written, the area has been irrigated and agricultural development has been more successful. Today, the changes in the waterways and in the Basin are even more extensive and complicated. The basic changes impacting fisheries are:

1. The cutting off, draining and redirecting of the flow of lakes such as Lower Klamath and Tule.
2. The damming and altering of the level of Upper Klamath Lake.
3. The ditching and draining of Marshes. For example, only 10% of Klamath Marsh is now open water whereas, 75 years ago, about 50% of it was open water. (U.S. v Adair 6 ILR F-150)

Other activities than the manipulation of waterways have also affected fish life in the Basin. Most of the forests of the Basin have been logged with attendant degrading of water courses. Agriculture with chemicals draining into the waters and with stream banks damaged by live stock has created inevitable problems.

These various alterations in the environment must have had a detrimental impact on the non-anadromous fish of the area. They may also have affected the anadromous fish. Until the first COPCO dam was built, there is no reason to believe that anadromous fish were seriously reduced in numbers by events in the Klamath Basin. However, Boyle, in his description of the building of COPCO I, noted:

> In May 1910, river gauging was begun at the Ward's bridge and records of river discharges were kept daily. A study of the records over a period of five years indicated a change from a uniform flowing stream to one with lower water in summer and higher water in early spring. Answer to the change was readily found in the development of the reclamation and irrigation project being constructed by the U. S. Reclamation Service in the Upper Klamath Basin.
>
> While the change in river flows were not too serious at the time, they were destined to get worse as the Reclamation Service projects progressed. (Boyle 1976:14)

INDIAN OWNERS AND USERS

Upstream Users

Klamath Tribe

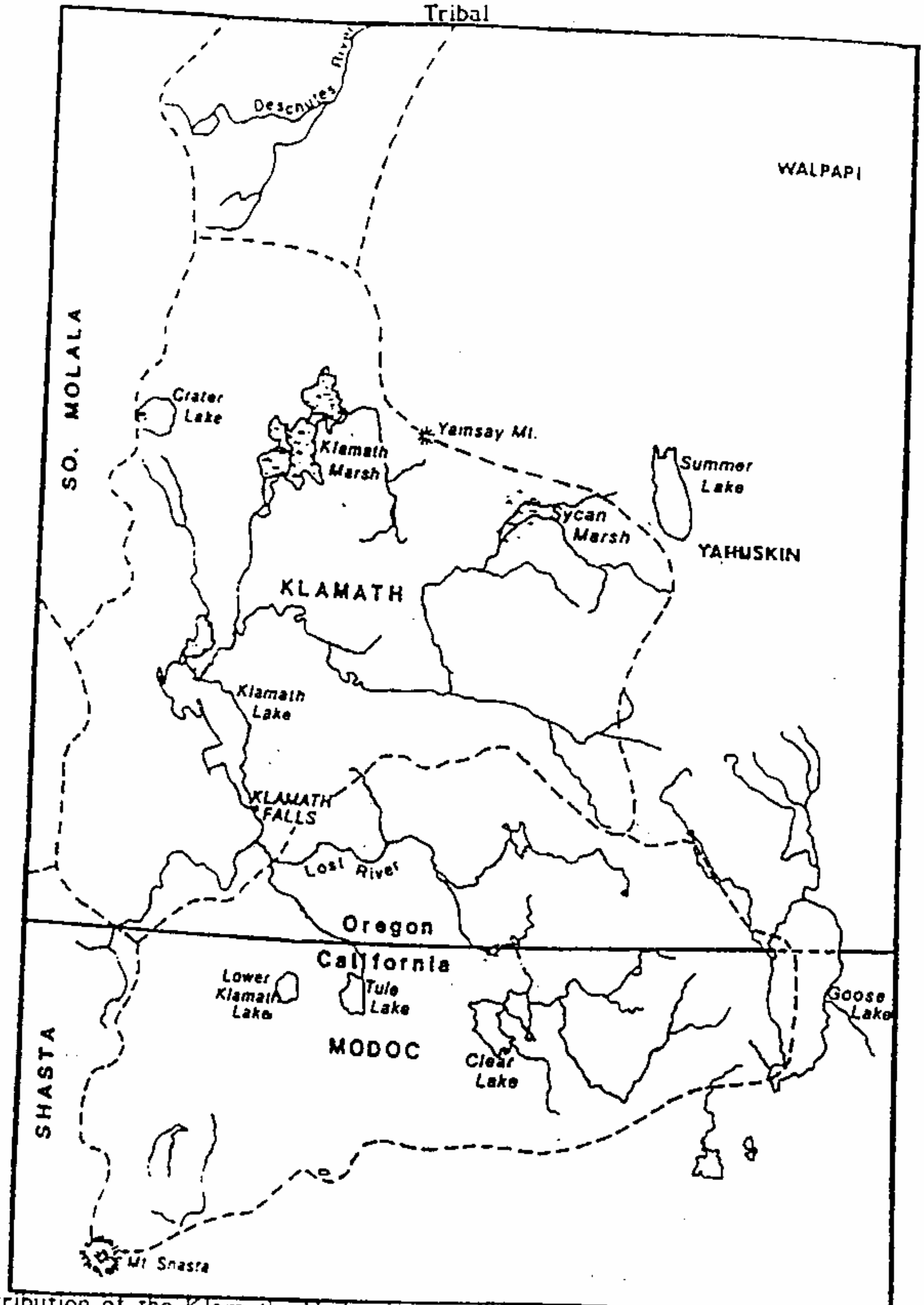
The Klamath Tribe consists of descendants of people who lived in or east of the Klamath Basin when the Klamath Treaty of 1864 and the Walpapi (Snake) Treaty of 1865 were signed. The major components of this population were people identified by non-Indians as Klamath, Modoc, Yahuskin, and Walpapi Snakes (Paiute).

Klamath - Modoc

The Klamath and the Modoc were two groups of peoples loosely organized into autonomous local bands. They spoke closely related dialects of a language called Lutuamian by linguists. Lutuamian may be related to Sahaptin, the language family in which Walla Walla, Umatilla, Tenino, Nez Perce, and other Southern Plateau languages are grouped. It is definitely connected with the California Penutian languages such as Wintu, Maidu and Yokut. (Shipley 1978:80ff)

Although they were closely related, there were cultural differences between the Klamath and the Modoc. Some of the differences related to the different geographic environments in which they lived. (See Appendices A and B.) Both the Klamath and the Modoc are today often classified by ethnologists as belonging to the Plateau culture area. However, their location on the cultural border between the Plateau, California, the Basin, and the southern extension of the Northwest Coast influenced their cultures and set them somewhat apart from other Plateau peoples to the northeast. Appendix A provides a synopsis of aboriginal Klamath life and culture.

Map III
Tribal



Distribution of the Klamath, Modoc, Yahuskin, and Walpapi (adapted from Stern 1966:280)

The Klamath occupied most of the Klamath River drainage Basin down to the vicinity of the present Oregon-California border. The Modoc lived to the southeast of the Klamath in a territory centering about Tule and Clear Lakes and encompassing Lower Klamath Lake. Their southern boundary extended from Mount Shasta, in what is now Northern California, northeastward to Goose Lake on the Oregon-California border. (Map III)

Yahuskin

There has been considerable confusion about the identity of this small group. They have usually been assumed to have been a Northern Paiute people who lived eastward of the Klamath. According to Gatschet:

> A body of Snake Indians, numbering one hundred and forty-five individuals in 1888, is the only important fraction of native population foreign to the Maklaks which now exists upon the reservation. They belong to the extensive racial and linguistic family of the Shoshoni, and in 1864, when the treaty was made, belonged to two chieftaincies, called, respectively, the Yahooshkin and the Walpapi, intermingled with a few Payute Indians. They have been in some manner associated with the Maklaks for ages, though a real friendship never existed, and they are always referred to by these with a sort of contempt, and regarded as cruel, heartless, and filthy. This aversion probably results from the difference of language and the conflicting interests resulting from both bodies having recourse to the same hunting grounds. They are at present settled in the upper part of Sprague River Valley above Yaneks. They cultivate the ground, live in willow lodges or log houses, and are gradually abandoning their roaming proclivities. Before 1864 they were haunting the shores of Goose Lake, Silver Lake, Warner Lake, Lake Harney, and temporarily stayed in Surprise Valley, on Chewaukan and Saikan Marshes, and gathered wokash on Klamath Marsh. They now intermarry with the Klamath Indians. As to their customs, they do not flatten their infants' heads, do not pierce their noses; they wear the hair long, and prefer the use of English to that of Chinook jargon. Before settling on the reservation they did not subsist on roots and bulbs, but lived almost entirely from the products of the chase. (Gatschet 1890:xxxv Linguistic terms deleted)

In a paper growing out of U.S. Indian Claims Commission research, Voegelin suggests that the problem of identification of the Yahuskin is more complicated. She suggests that leaders of a small group of Paiute of uncertain identity and residence signed the treaty of 1864 but never took up permanent residence on the reservation when it was established:

> The treaty-signing Yahuskin of 1864 consisted of a score or so of Great Basin Northern Paiute, deriving at that specific date from the Surprise Valley-Warner Valley region in northeastern California and south-central Oregon. They did not derive, at the time they signed the treaty, from the Silver-Summer-Abert lakes region of central Oregon, although this latter region is the one they presumably ceded, and the one customarily assigned to them by ethnographers. (Voegelin 1955:95,97)

According to Voegelin, the post treaty people identified as Yahuskin were a Klamath subgroup:

> The post-treaty, Klamath Reservation Yahuskin of Klamath Agency records were not Great Basin Paiute, but a small Klamath-speaking group which has been virtually unnoticed up to now, but which, in pre- and post-treaty times, occupied a strategic borderline position in upper Sprague River Valley between the Klamath Marsh-Upper Klamath Lake Klamath Indians to the west and the Great Basin Northern Paiute-speaking peoples to the east. (Voegelin 1955:97)

Stern disagrees with Voegelin:

> An able exposition by Erminie Wheeler-Voegelin (1955) holds that the Yahuskin Snakes of the treaty were a pick-up band of Indians from the Surprise-Warner valleys area, with whom Colonel Drew had made contact, and that the group subsequently designated by that name were the Upland Klamath. The latter view accords with that previously advanced by Nash (1937), p. 386. There are, however, grounds for maintaining the view that they comprised a small band of Paiute, drawn chiefly from the Silver-Summer-Abert Lake region, living together with the Upland Klamath. (Stern 1965:288)

That the post-treaty Yahuskin were at least in part Klamath seems very likely. Voegelin's other contention, that the pre-treaty Yahuskin were not related to the post-treaty Yahuskin does not seem to be convincingly demonstrated. We suspect that an early source quoted by Voegelin comes very close to reflecting reality:

> The Indians occupying and claiming Sprague's River valley, are a small band of Klamaths, having among them a few of the Snake tribe,

who border them on the north and east, and having a Snake-Klamath -- Moshun-kosk-kit -- for their chief. (Drew 1865:5)

In other words, the Yahuskin may have been a Klamath group of mixed ancestry with continuing contacts with various Paiute groups from the lands to the east.

Walpapi Paiute

Voegelin makes a similar argument regarding this small group. She says that one somewhat indefinite group of Paiute signed the treaty but that another actually joined the reservation community:

> The treaty-signing Walpapi of 1865 were a mounted, predatory, fluctuating group of Great Basin Northern Paiute and other Indians who ranged throughout central Oregon from ca. 1859 to 1867 under Panaiha (vars., Paulina, Pahnine, Polini, etc), an extremely able Northern Paiute post-White war leader. The Walpapi were not localized in a large, heart-shaped area extending from Burns, Ore., to some forty miles north of Canyon City, Ore., although this is the area they ceded. The post-treaty, Klamath Reservation Walpapi of Klamath Agency records consisted of something over a hundred Northern Paiute Indians who, in 1867 and 1868 moved or were removed from the Silver-Summer lakes region at the western edge of the Great Basin to upper Sprague River Valley on the Klamath Reservation; their removal to the Reservation occurred some three years after the Walpapi treaty of 1865 had been negotiated. (Voegelin 1955:97)

In the confusions of this early period and, given the unsatisfactory records of the period, we are not convinced that Voegelin definitely proves that the pre- and post-treaty Walpapi were separate. However, this issue is not critical for present purposes. Leaders of a small group of Northern Paiutes signed the treaty of 1865 and, when the reservation was actually established a few years later, a small group of Northern Paiute settled within it. Today, the people of the Klamath tribe are much intermingled. Many, if not most tribal members, are aware to some degree of the affiliations of their ancestors.

Treaty Fishing Rights

Klamath fishing rights were reserved by the Treaty with the Klamath, Modocs, and Yahooskin band of Snakes, in 1864 (16 Stat. 707). (See Appendix C.) The treaty provided that:

> . . .the exclusive right of taking fish in the streams and lakes, included in said reservation, and of gathering edible roots, seeds, and berries within its limits, is hereby secured to the Indians. . .

The reservation was defined in the Treaty as:

> Beginning upon the eastern shore of the middle Klamath Lake, at the Point of Rocks, about twelve miles below the mouth of Williamson's River; thence following up said eastern shore to the mouth of Wood River; thence up Wood River to a point one mile north of the bridge at Fort Klamath; thence due east to the summit of the ridge which divides the upper and middle Klamath Lakes; thence along said ridge to a point due east of the north end of the upper lake; thence due east, passing the said north end of the upper lake, to the summit of the mountains on the east side of the lake; thence along said mountain to the point where Sprague's River is intersected by the Ish-tish-ea-wax Creek; thence in a southerly direction to the summit of the mountain, the extremity of which forms the Point of Rocks; thence along said mountain to the place of beginning.

The treaty also provided that additional groups might be settled on the reservation.

> ARTICLE 11. It is agreed between the contracting parties that if the United States, at any future time, may desire to locate other tribes upon the reservation provided for in this treaty, no objection shall be made thereto: but the tribes, parties to this treaty, shall not, by such location of other tribes, forfeit any of their rights or privileges guaranteed to them by this treaty. (16 Stat. 707)

In 1865 a treaty was made with the Woll-pah-pe tribe of Snake Indians (14 Stat. 683). (See Appendix D.) This treaty provided that the people move to the Klamath Reservation. These people had not previously lived on the lands incorporated into the Klamath Reservation although they may at times have lived in parts of the country ceded in the Klamath treaty. Their descendants are members of the Klamath Tribe.

Simmons, an attorney for the Bureau of Indian Affairs, concluded:

> The right of exclusive fishing in reservation waters, guaranteed by the Treaty of October 14, 1864 (16 Stat. 707; II Kappler Indian Laws and Treaties, 865) was a tribal right, the benefits of which were equally enjoyed by all members of the Klamath Tribe. (Simmons 1942:5)

The provision in the Klamath Treaty regarding "the exclusive right of taking fish in the streams and lakes, included in said reservation" contrasts with that in other northwestern treaties where off-reservation fishing rights are secured by language referring to "usual and accustomed fishing places". When the Klamath Reservation fisheries were destroyed by dam development and water diversions, the Klamath did not have off-reservation treaty protected fisheries which they could utilize.

Prior to the federal treaties with the Indians, Indian fishing rights had been protected by Oregon Territorial law. The legislative committee of Oregon in 1844 passed the following act:

> Be it enacted by the legislative committee of Oregon, as follows:
>
> Section 1. That the Indians shall be protected in the free use of such pieces of vacant land as they occupy with their villages or other improvements, and such fisheries as they have heretofore used.
>
> Sec. 2. That the executive power be required to see that the laws in regard to Indians be faithfully executed; and that whenever the laws shall be violated, the said Executive shall be empowered to bring suit in the name of Oregon against such wrong-doer in the courts of the country. (Burnett 1904:166)

User Numbers

It is not possible to document the exact number of individuals and families who used the Klamath Basin anadromous fisheries. The number of people on the tribal rolls and other census rolls are presented in Table A. We were requested to provide such figures for ten year intervals. However, in some instances, the only available figures are from intervening years. In such cases, we have provided figures from those years.

TABLE A

Klamath Population Figures

1864	1,071+	710 or more Klamath, 339 Modoc, 22 Yahuskin. Supposedly a count of those present at the treaty grounds. (Huntington and Logan in Gatschet 1890:lxiii)
	772+	633 Klamath, 117+ Modoc, 22 Snake. 40 Modoc and their families not present. (Kelly in Stern 1965:40)
1865	1,900	1,200 Klamath, 700 Modoc. (Huntington in Voegelin 1955 a:106; ARCIA 1865:655)
1867	100+	Walpapi. (Voegelin 1955a:97)
	2,000+	(1865 Klamath-Modoc + 1867 Walpapi)
1875	747	543 Klamath, 103 Modoc, 101 Walpapi (ARCIA 1875:618)
1876-77	896+	565 Klamath, 194 Modoc, 137 Yahuskin. The total includes only those present on the reservation when the count was made. (Gatschet 1890:lxxvi-lxxvii)
1877	908	677 Klamath, 93 Modoc, 148 Walpapi. (ARCIA 1877:300)
1878	782	681 Klamath, 101 Modoc. (ARCIA 1878:788)
1880-81	1,023+	"Unreliable". (ARCIA in Gatschet 1890:lxxvi)
1881	1,018	676 Klamath, 122 Modoc, 165 Yahuskin, 55 Molale. The Molale, not mentioned in any other census, would have been remnants of a people who once occupied territory south and east of the Willamette Valley. (U.S. Census in Gatschet 1890:lxxvi)
1886	972	806 Klamath-Modoc, 166 Snake. (USNA BIA Census Rolls)
1888	933	788 Klamath-Modoc, 145 Yahuskin identified as Snake. (Emory, Indian Agent, in Gatschet 1890:lxxvi)
1890	835	Agency. (USNA BIA Census Rolls)
1897	1,020	Agency enrollment figure. (US-SFA RG 75 Box 220)
1899	1,126	Agency enrollment figure. (US-SFA RG 75 Box 220)
1899	51	Modoc in Oklahoma (BIA compilation 1950:167)
	1,177	Klamath Agency plus Oklahoma Modoc.

1900	1,131	1,050 Klamath, Modoc, Piute, Pit River plus 81 off reservation. (US-SFA RG 75 Box 220)
1900	1,148	Agency enrollment figure. (BIA 10 March 1942)
1901	1,160	Agency enrollment figure. (US-SFA RG 75 Box 220)
1902	1,141	Agency enrollment figure. (US-SFA RG 75 Box 220)
1903	1,166	Agency enrollment figure. (US-SFA RG 75 Box 220)
1904	1,171	Agency enrollment figure. (US-SFA RG 75 Box 220)
1905	1,152	Agency enrollment figure. (US-SFA RG 75 Box 220)
1905-06	1,147	755 Klamath, 279 Modoc, 113 Walpapi. 56 of the Modoc were in Oklahoma. (Hodge 1907:1:7:12; 1910:2:901)
1906	1,160	Agency enrollment figure. (US-SFA RG 75 Box 220)
1907	936+	655 Klamath, 271 Modoc. (Mooney 1928:18)
1907	1,051	Agency enrollment figure. (US-SFA RG 75 Box 220)
1908	1,038	Agency enrollment figure. (US-SFA RG 75 Box 220)
1909	1,100	Agency enrollment figure. (US-SFA RG 75 Box 220)
1910	1,126	Agency enrollment figure. (US-SFA RG 75 Box 220)
1909-10	1,044+	696 Klamath, 256 Modoc, 103 Walpapi. (Hodge 1910:2:901, Swanton 1952:465) Kroeber gives 300 Modoc. (Kroeber 1925:320) Swanton gives 382 of whom 212 were in Oregon, 33 were in Oklahoma, 20 were in California, and the rest were scattered in 5 other states. (Swanton 1952:465)
1915	978+	696 Klamath, 282 Modoc. (U.S. Census 1915)
1920	1,130	Agency enrollment (USNA BIA Census Rolls)
1930	888+	802 Klamath on Klamath Reservation, 55+ at Siletz, 31 Modoc in Oklahoma. (Swanton 1952:465)
1930	1,284	Klamath Reservation (USNA BIA Census Rolls)
1933	1,349	Klamath Reservation (USNA BIA Census Rolls)
1935	1,194+	802 Klamath, 392 Modoc (U.S. Census Report 1935)
1937	1,412	Klamath Reservation (USNA BIA Census Rolls)
1940	1,357	862 Klamath on the Klamath Reservation, 338 Modoc, 157 Walpapi (ARCIA 1940)

1945	1,330	937 Klamath on reservation, 64 at Siletz, 329 Modoc. (BIA compilation 1950)
1954	2,133	Final Klamath roll. (BIA 12957
1955	2,118	Provisional enrollment of Klamath Tribal members. (Federal Register 13 May 1955, cited in Stern 1965:316)
1958	2,133	Klamath adults eligible to vote regarding tribal status. (Hood 1972:383)

According to Simmons:

> General members of the Klamath Tribe claim there were approximately 1500 Indians residing on the Klamath Reservation from 1897 to 1910, which may be true in spite of the following table showing the official census on file at the Klamath Agency. Many of the children and wives or husbands of tribal members may not have been included: (Simmons n.d.:10)

He noted that Clayton Kirk, a member of the Tribal Business Committee questioned the Agency enrollment figures, claiming that there were up to 2,000 Indians on the reservation at different periods prior to 1908 and that, following 1908, illness seriously reduced the population. The official Agency census figures have been incorporated in our table as "Agency enrollment figures".

Downstream Users

The Klamath, Modoc, Yahuskin, and Walpapi occupied the headwater regions of the Klamath River and adjacent areas. Representatives of all three groups plus those of some Northern Paiute signed the treaties of October 14, 1864 and August 12, 1865 and all four groups were assigned to the Klamath Reservation.

Three other peoples lived downstream on the Klamath River. From the boundary of Klamath territory to the mouth of the river, these were the Shasta, the Karok, and the Yurok.

Shasta

The Shasta and the Karok spoke related languages of the Hokan stock, a language stock widespread in California. The former occupied territories along the Klamath River and its tributaries southwest of Klamath territory and west of Modoc territory. They lived on both sides of the Oregon-California border, roughly from just upstream from Beswick, California down to Seiad Valley. (Map IV) The COPCO dams are in what was originally Shasta territory. The Shasta had a wide variety of food resources, but salmon and other fish from the Klamath and its tributaries were among their most important food resources.

In pre-European times, there may have been over 1,000 Shasta in the groups living along the Klamath River. By the 20th century, there were only a few hundred survivors scattered about in northern California and in Oregon. (See Swanton 1952:514; Silver 1978: 211-223.)

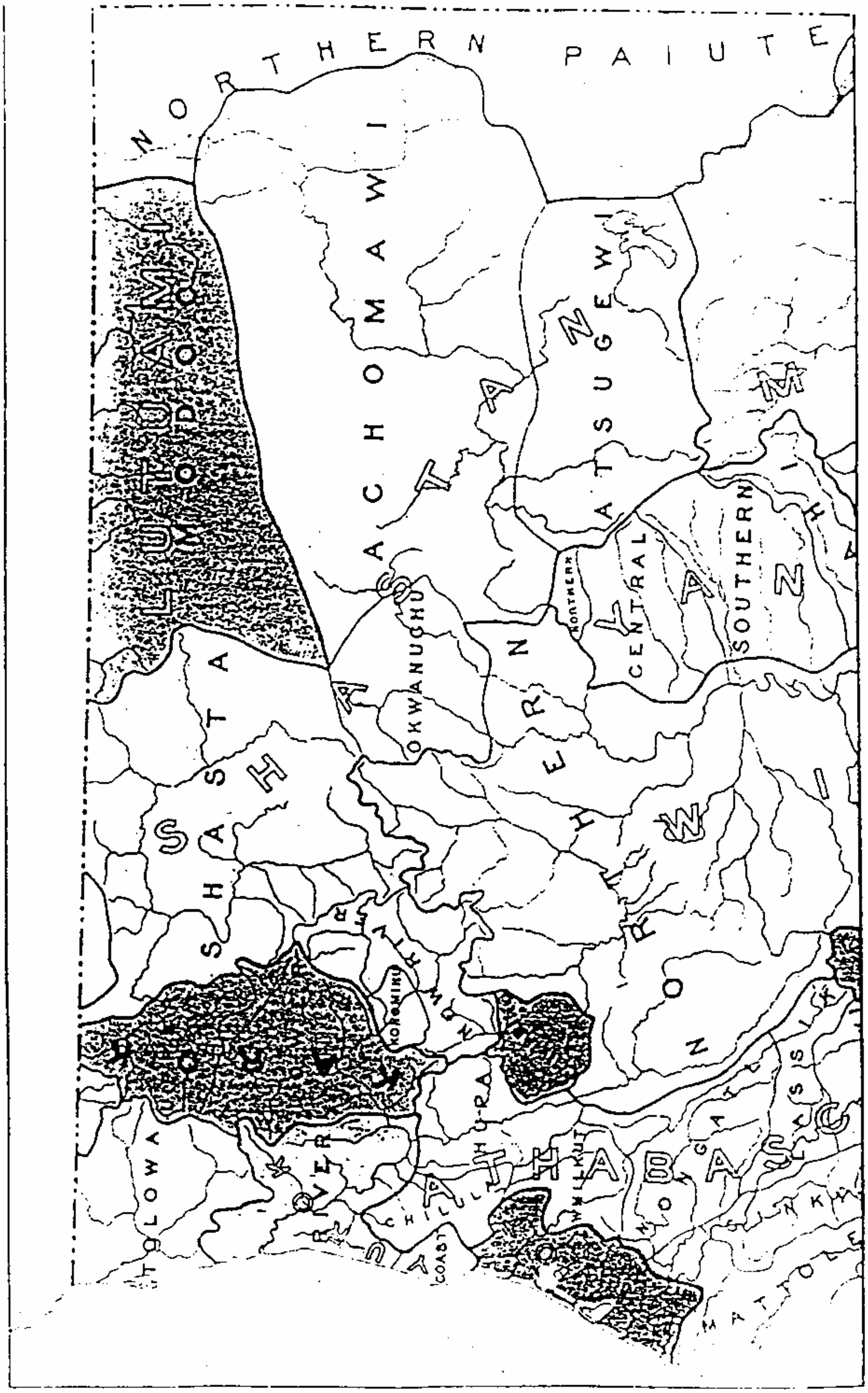
Karok

The Karok occupied the valley of the Klamath from their boundary with the Shasta near Seiad, California downstream to Weitchpee. Probably even more than the Shasta peoples, the Karok depended upon the salmon runs of the Klamath River for their sustenance. There were an estimated 2,700 Karok in 1848. In 1880, the population was about 1,000. In 1930, according to the U.S. census, there were 755 persons identified as Karok. Bright states that in 1972 the Sacramento Office of the BIA believed that there were 3,781 known individuals with Karok ancestry. (See Swanton 1952: 495-496; Bright 1978:180-189.)

Yurok

The Yurok occupied the Klamath valley along the lower 45 miles of the river. Like the Karok, they were salmon fishermen. In the 1850s there were reported to be around 3,100 Yurok. There are evidently no population figures for the Yurok for the late 19th or early 20th century. Pilling estimates that in 1970, there were between 3,000 and 4,500 persons claiming some Yurok ancestry. (See Swanton 1952:528-529; Pilling 1978:137-154.) In <u>Short v the United States</u> -- 3,323 Yurok are mentioned as plaintiffs -- (<u>Short v U.S.</u> 486 F.2d 561)

Map IV
Downstream Users



Treaty Status

The status of California treaties is succinctly explained by Stewart:

> At about the time that the U.S. Congress admitted California into the Union, another act of Congress (September 30, 1850) authorized the president to negotiate treaties with the Indians of California to cede and relinquish to the United States their title and interest to all lands in California. Commissioners were appointed to negotiate the treaties and 18 treaties were signed by representatives of 139 different Indian groups or tribelets between March 19, 1851, and January 7, 1852. Under the treaties 18 reservations were to be established for the Indians on which they would receive some clothing and food as well as education in the "art of civilization." The area to be reserved for Indians amounted to 8,619,000 acres (fig. 1).
>
> As soon as the provisions of the treaties became known the legislature of California adopted resolutions opposing the ratification of the treaties; consequently, when the treaties were submitted by President Millard Fillmore to the Senate for ratification on June 1, 1852, the Senate rejected the treaties and took the unusual step of placing them in secret files of the Senate. There they remained until January 18, 1905, when the Senate voted to remove the injunction of secrecy. The failure to ratify the treaties left the federal government without explicit legal obligation toward the Indians of California.
>
> Even without the treaties, the U.S. government recognized that it was morally and legally bound to protect the Indians of California and to compensate them for their land in which they had original Indian titles as a result of use and occupancy from time immemorial. The Supreme Court of the United States had ruled as early as 1823 (Johnson v. M'Intosh, 8 Wheat 543) that American Indians had rights of occupancy and ownership equal to the fee simple absolute title of the Whites; however, California White citizens of the nineteenth century almost completely frustrated the feeble attempts of the federal government to treat the Indians of California fairly.
>
> Federal efforts to protect California Indians took the form of establishing executive order reservations. The first was Hoopa Valley, in Humboldt County, consisting of 116,572 acres set apart in 1864 (see table 1). Three other reservations were authorized but local opposition either delayed or blocked them. In 1873 Tule River Reservation in Tulare County (49,074 acres, later enlarged) and Round Valley Reservation in Mendocino County were established with the hope that individuals of many tribelets would move to these reservations, yet many stayed away. Some other reservations established early were Cahuilla in 1875 in the desert and Palm Springs (Agua Caliente) in 1896, both in Riverside County. In 1891 an extension to the Hoopa Reservation, designated as the Klamath Strip, was added on both sides of Klamath River from the original reservation toward the ocean.
>
> The publication of Century of Dishonor (1881) and the novel Ramona (1884) by Helen Hunt Jackson, dealing with the plight of

> California Indians, pricked the conscience of America and stimulated more federal help for California Indians. Small reservations, often called rancherias, were purchased in southern California beginning with Rincon and La Jolla in 1892, Ramona and 10 others in 1893. The procedure continued and was extended throughout California until 1940 when XL Ranch was purchased for the Achumawi in Modoc County, and in 1942 Chico Colony of 25 acres for any Indians who wished to settle there. In all, 117 California Indian communities were established by the federal government on land set aside from the public domain or purchased with federal funds. Sizes varied from the 116,572 Hoopa Reservation to a one-acre plot in Strawberry Valley, Yuba County, made available in 1914. The area of land under some federal restriction as of 1950 was 632,599.58 acres. That year a total of 10,000 Indians listed the federal reservations and rancherias as their homes. There were 14,100 California Indians not attached to reservations (U.S. Congress. House Committee on Interior and Insular Affairs 1953). (Stewart 1978:705-706)

The executive order reservations included several for the Yurok and other California Indian groups, one of which, the Hoopa Extension of 17,299 acres, included a section of the Lower Klamath River. The Shasta had two reservations further upstream which were terminated in 1958. (Stewart 1978:705-712)

The Hoopa Extension is explained and discussed in <u>Short v the United States</u>:

> In 1876, a 12-mile square tract of land in Northern California, on the last reach of the Trinity River before it joins the Klamath River, was set aside by order of President Grant as the Hoopa Valley Indian Reservation. Most but not all of the Indians of the tract, called the Square, were and have been Hoopa Indians. In 1891 President Harrison made an order extending the boundaries of the reservation to include an adjoining 1-mile wide strip of land on each side of the Klamath River, from the confluence of the two rivers to the ocean about 45 miles away (in consequence of which the reservation took on the shape of a square skillet with an extraordinarily long handle). Most of the Indians of the added tract, called the Addition, were and have been Yurok Indians, also known as Klamaths. (<u>Short v U.S.</u> 486 F.2d 561)

Although the Yurok and other Indians of the Hoopa Extension Reservation are not treaty Indians, they have had federally and state recognized special salmon fishing rights. The creation of the Hoopa Extension itself was a federal recognition of Yurok fishing rights. The state of California has acknowledged

Yurok fishing rights in its Fish and Game Code. We have not checked the present status of this recognition but it remained the same at least until 1973:

> 429.8. Notwithstanding any other provision of this code, California Indians who are bona fide registered members of the Yurok Indian Tribe may take fish, for subsistence purposes only, from the Klamath River between the mouth of said river and the junction of Tectah Creek with said river, exclusive of tributaries, without regard to seasons, under the following conditions:
>
> (a) Upon application therefor, the department shall issue to any Yurok Indian who is listed on the register of the Yurok Tribal Organization, as furnished to the department, a renewable, nontransferable permit to take fish pursuant to this section for a period of one calendar year. Any Indian of the Yurok tribe while taking fish pursuant to this section shall have upon his person such valid permit and shall display it upon the request of any duly authorized officer.
>
> (b) Hand dip nets, and hook and line only may be used for taking fish pursuant to this section.
>
> (c) Pursuant to this section not more than three trout or salmon or combination thereof, or more than one sturgeon, may be taken in any one day. There is no bag limit on any other fish.
>
> (d) No Yurok Indian while fishing pursuant to this section may be accompanied by any person who does not possess a valid permit as prescribed by this section. It shall be unlawful for any person who does not hold such permit to accompany any Yurok Indian who is taking fish pursuant to this section.
>
> (e) The sale of any fish taken under the provisions or this section shall constitute cause for permanent revocation by the commission of the permit held by the sale. (California 1951-53:93-94)

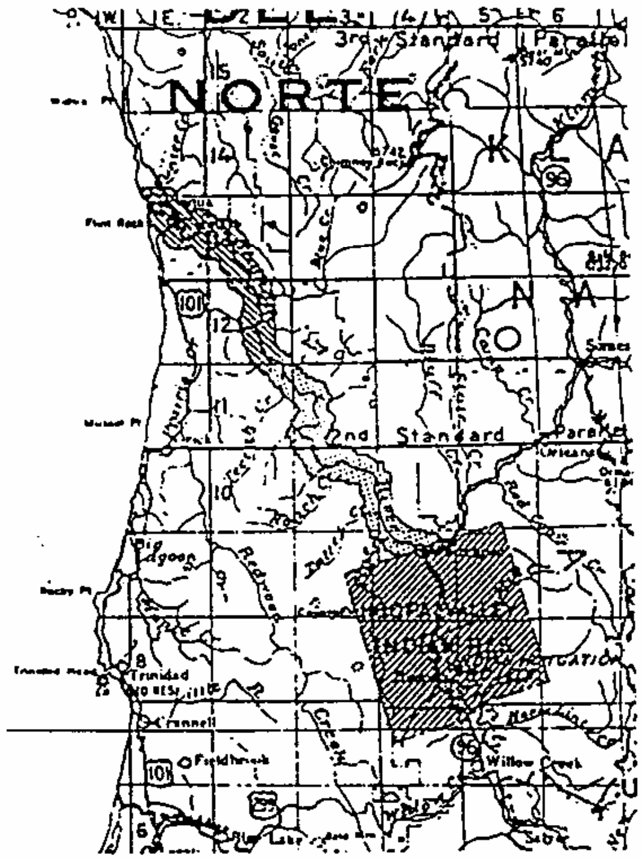
In 1966, in Elser et al v Gill Net No. 1, a California District Court of Appeal ruled that registered members of the Yurok Tribe still had a "limited right" to fish for subsistence purposes in the Klamath River. (Elser et al v Gill Net No. 1, 54 Cal. Rptr. 568) In Donahue v California, in 1971, the right was still recognized by a decision of a California District Court and the point was made that the term "legal Yurok fisherman" would include Indian guests. (Donahue v California App.

93 Cal. Rptr. 310) Mattz v Arnett, in 1973, in the California Court of Appeal reinforced the position of the Yurok. (Mattz v Arnett 93 S. Ct. 2245)

Map V

Map of Hoopa Valley Indian Reservation, California*

Scale: 1 inch = 12 miles



LEGEND: Old Klamath River Reservation.
Connecting Strip.
Original Hoopa Valley Reservation.

*United States Department of Interior, General Land Office 1944.

If Yurok and or the people of the Hoopa Extension were involved in a claim regarding damage to salmon runs on the Klamath River, presumably the people of the Hoopa Reservation on the Trinity River might claim an interest for the judgment in Short v the United States in effect said that the two reservations constituted a single reservation and that all of the Indian people having rights on either section shared in the rights on both sections:

> As already noted, the plain and natural consequence of the order was the creation of an enlarged, single reservation incorporating without distinction its added and original tracts upon which the Indians populating the newly-added lands should reside on an equal footing with the Indians theretofore resident upon it. This the President was as free to do under the reserved powers granted him by the act of 1864 as he had been free in the early years, without enlarging the reservation, to settle Redwoods, Saiaz and others and as he would have been free in 1869 to settle upon the reservation the Yuroks of the Klamath River Reservation. In introducing the Yuroks of the Addition into the enlarged reservation in 1891, on a basis of equality with their kinsmen and the several other tribes already there, the President was merely continuing to accommodate the tribes of the area in the Indian reservation in Northern California he had established under the act of 1864. Compare Halbert v. United States, 283 U.S. 753, 51 S.Ct. 615, 75 L.Ed. 1389 (1931) and Quinaielt Tribe v. United States, 102 Ct. Cl. 822 (1945), on the President's power to enlarge a treaty reservation for the common benefit of the tribe originally settled there and tribes "in that locality". . .
>
> Administrative opinions, in the years following the executive order of 1891, recognized both that a number of tribes including Klamaths, Hoopas and other tribes were entitled to rights on the reservation and, with pointed relevance to the instant case, that the Indians of the Addition and the Square were equal in respect to rights in the lands of the Square. These opinions are described in the accompanying findings. In one of them, in 1916, it was ruled that the Hoopas, Klamaths and several other tribes were entitled to rights on the reservation. In another, in 1933, it was determined that allotments of land on the Square should cease, and assignments of land contingent on cultivation be substituted, because, it was held, the Indians of the Addition and the Square were equally entitled to allotment of lands and there was insufficient land for all those entitled. (Short v U.S. 486 F.2d 561)

In 1913, in Donnelly v United States, the U.S. Supreme Court decided that the Hoopa Extension was an Indian Reservation and Indian Country. (Donnelly v U.S. 228 U.S. 243)

Karok fishing rights are presently recognized by the State of California:

> Members of the Karok Indian Tribe listed on the current Karok Tribal Roll are allowed to take fish at Ishi Pishi Falls using hand held dip nets. Fish taken may not be sold. (California Dept. Fish & Game 1981:10)

ETHNOHISTORICAL BACKGROUND

Prehistory

The prehistory of this region is reasonably well known in general terms. Swartz indicates sources and the state of knowledge up to the 1960s. (Swartz 1967) Bryant, Bisler, and Nelson provide a brief but more current survey of research and conclusions regarding Klamath Basin prehistory. (Bryant et al 1978)

In briefest terms, the evidence available today suggests that the Klamath Basin has been occupied at least 9,000 years. In the earliest occupation, hunting was much more important than it has been in recent times and fishing technology was relatively undeveloped. Over a long period of time, hunting became less important as local plant and fish resources came to be used more intensively. By about 1,300 years ago, a culture basically like that existing when Whites first entered the area was in existence. It was heavily oriented to waterways and was fairly highly specialized in terms of the use of fish and plants. (Bryant et al 1978:41-47)

Cressman, the senior archeological researcher for the region, summarizes:

> The midden provides a record of the change from a very widespread subsistence pattern, using about everything the habitat provided as food animals, to one in which the range is restricted and the dominant article is fish. By Level III the occupants were learning to exploit the runs of salmon from the sea, the trout and the suckers in the rivers, as well as continuing the very heavy use of mussels which was a pattern of the previous Level. With the increased use of fish and waterfowl there went a reduction in the amount of less desirable animals such as rodents and carnivores, while game never was really important after Level IV. In the economy heavy reliance was placed on roots and seeds and with the abandonment of the midden changes occurred in the tools for exploiting the Wocas which produced a series of tools at least one of which is distinctive for the Klamath Lake area. However, this change had not taken place during the use of the midden. . .
>
> Scrapers are almost uniformly small, reflecting the subsistence pattern of dependence on small animals, fish, and mussels. In this there

> is a striking difference from their Great Basin neighbors who relied heavily but not exclusively on large game animals. . .
>
> The subsistence pattern was next discussed on the basis of both direct and indirect evidence. It has been referred to immediately above and needs no further elaboration here except to point out that it reflects a gradual development of a type from a wide range of use of animals, roots and seeds, mussels and some fish to one based on fish as the main article of protein diet and Wocas as the dominant seed food. The food economy illustrates the gradual but finally completely successful adaptation to the riverine and marsh resources. (Cressman 1956:468-469)

Some of the evidence used by Cressman came from Kawumkan Springs. He estimated the date of the site which he excavated there as extending from at least 7,500 years ago to perhaps 1,700 years ago. The site was divided into four arbitrary (forty centimeter) levels labeled, bottom to top, IV, III, II, I. He says: "By Level III the occupants were learning to exploit the runs of salmon from the sea. . ." (Cressman 1956:468) This locality was one of the important salmon fisheries of the Klamath in 1910.

Minor, Beckham, and Toepel confirm and update Cressman's conclusions:

> The subsistence pattern observed in the archaeological record at Kawumkan Springs was shown by Cressman (1956:453 and Table 10) to compare very closely to that of the ethnographic Klamath culture. The relative proportions of manos to metates and mortars to pestles remained approximately equivalent throughout the occupation, documenting the age and importance of seed and root-processing activities at the site. The bones of large mammals and birds together made up about one-fourth of the faunal collections, with rodent and fish bones comprising the remaining three-fourths of the assemblage. River mussel shells were abundant throughout the deposits. The only noteworthy change observed in the distribution of faunal remains was an increase in the proportion of fish bones in comparison to rodent bones in the upper levels of the midden.
>
> The first occupation of Kawumkan Springs Midden was originally estimated by Cressman (1956) to have begun by at least 7500 years ago, and possibly as early as 10,000 years ago. This interpretation was based primarily on the occurrence there of several leaf-shaped projectile points similar to specimens found under a layer of Mazama pumice at Odell Lake (Cressman 1948) in the Cascade Range to the north. As

previously mentioned, the eruption of Mount Mazama is now known to have taken place around 7000 years ago (Kittleman 1973). A subsequent obsidian hydration analysis of projectile points from the site has revised downward the original age estimate for Kawumkan Springs Midden, showing that significant occupation of the excavated portions probably began about 5000 years ago (Aikens and Minor 1978). The results of the obsidian hydration study suggest that the occupation began late in the temporal spans of the earlier projectile point types, rather than early as previously assumed. A long, relatively continuous occupation beginning around 5000 BP and continuing to historic times was indicated for the site. (Minor et al 1979:64-65)

Contact Period

The facts for this summary are drawn from a number of specific sources but are available in most standard sources. We have used Stern 1956, Bryant et al 1978, and Minor et al 1979. The first Whites known to have entered the Klamath Basin were members of the McDonald expedition of the Hudson Bay Company in 1825. They were followed by Ogden in 1826. After Ogden others ventured into Klamath Country, but the next explorer of record is Fremont who visited the Klamath Basin in 1843 and again in 1846.

Until Fremont's second visit, there was little violent confrontation between people of the Klamath Basin and White visitors. On Fremont's second visit, there was violence and some of Fremont's men and some Klamath were killed. In the following years there was some trouble, but generally speaking the Klamath Basin peoples escaped many of the tragedies that affected most of their neighbors.

By the 1860s there was increasing trouble. Part of the problem was increasing violence. This was associated with population loss, cultural disintegation and general unrest. By the end of the 1850s, there were numbers of Klamath, Modoc, Paiute, and other Indians wandering about in Oregon and northern California as refugees, or seeking opportunities for a better existence.

Gold mining had begun in the late 1840s and 1850s in northern California and, shortly thereafter, in southwestern Oregon. This brought thousands of Whites to the area. Among other things, this influx created a demand for food. Cattle raising started in California and spread into Oregon. Soon after, the raising of grain and other farm crops began in northern California and in the Willamette Valley to the north. Pressures for White settlement commenced in the intervening area. Whites desired a treaty to confine the Indians of the Basin to a reservation in order to free the bulk of the land for settlement and exploitation. Some Indians, at least, were anxious to regain a more stable existence and the security of a reserved homeland. The Klamath in particular were amenable to the idea, for the reserve encompassed most of their traditional fishing grounds. This meant that they would have in theory relatively little need or stimulus to venture beyond their homeland. The security was not in the large area of land reserved but in the fisheries that were adequate to support the population in existence at that time.

A treaty was signed October 14, 1864 with the Klamath, Modoc, and Yahuskin. A treaty with the Walpapi Paiute was signed August 12, 1865. The reservation was established immediately but all of the intended residents did not settle upon it. The Modoc, none of whose territory was included in the reservation, moved only reluctantly in 1869. Many returned to their home territory in 1870. This move precipitated the Modoc "war" of 1872-1873. At the end of these troubles, most of the Modoc were back on the reservation but one contingent of dissidents was shipped to the Quapaw Reservation in Oklahoma.

It was the policy of the federal government that the members of the Klamath Tribe should become farmers. Although many members of the tribe attempted to become farmers, the lands of the reservation were relatively unsuitable for the small scale agriculture possible at that time. Many Klamath attempted to advance their well being in other ways. It has been noted by several students that the Klamath have used considerable initiative and drive in pursuit of material development:

> In subsequent years, native premium upon wealth and industry led to many new ventures: farming--until it proved ecologically infeasible--then stockraising, freighting, wage labor, and fur-trapping; and these in combination with fishing, hunting, and the gathering of favorite roots and berries provided ample subsistence and a standard of living little, if at all, inferior to that of many a pioneer white. Although Agents were not to overstress the enthusiasm with which their charges had embraced the aims of civilization, the application of at least some Klamath is indelibly attested in the attention given in official reports to a thriving, clandestine, and illegal traffic in timber felled on the reservation, rafted out, and sold to neighboring settlers. (Stern 1962:172)

Some tribal members were quite successful in agricultural and other ventures. Others combined small scale ranching with traditional subsistence activities. Most labored on ranches and in the expanding timber industry.

> At the end of the 19th century, although life was radically altered, many traditional patterns of life survived. In 1884, one-half to two-thirds of the reservation families were away from home for months at a time. Some of them were fishing, hunting and gathering vegetable foods. (Stern 1965:102)

Allotment of land in severalty under the Dawes Act was attempted between 1895 and 1910. However, because much of the land of the Reservation was unsuitable for farming and in timber suitable for logging, the bulk of the land remained tribal property and this in turn helped to preserve the traditional subsistence resources. (Stern 1962:173)

In the period from the late nineteenth century to the 1950s, the Klamath had to cope with numerous problems. Some of these were characteristic of most reservation societies while others were relatively unique to the Klamath. Among the problems which made it difficult for the Klamath to effectively control and defend resources such as their anadromous fisheries were: relatively weak tribal government, internal schisms and a large off-reservation population. By 1955 the off-reservation membership amounted to 40 per cent. (Stern 1965:185)

As logging on the reservation became important, considerable payments were disbursed to tribal members. This was a mixed blessing. Among other things, it created the illusion that the Klamath were successful and well-to-do individual entrepreneurs. The obvious wealth of timber resources also attracted the attention of non-Klamath entrepreneurs. These and other factors made the Klamath Reservation a prime target for termination during the period of that federal policy in the 1950s.

On August 13, 1954, President Eisenhower signed the Klamath Termination Act (Public Law 587). The termination became effective August 12, 1961 after an extension delay. This law did not terminate the tribe although it did necessitate reorganization. It removed federal supervision over the trust and restricted property of the Klamath Tribe and of individual tribal members. It also led to the termination of some services that the Tribe had previously received.

From the beginning, termination was viewed with very mixed feelings by Klamath officials and by experts. In retrospect, from the point of view of the Klamath Tribe it was probably an unfortunate and undesirable move. It led to the loss of ownership of valuable resources and has certainly weakened the tribe and put it in a difficult position with regard to the protection of remaining rights.

RESOURCES OF THE KLAMATH BASIN WATERS

General

Most of the peoples of the Northwest depended heavily upon fish and other water related resources of their environments but it is doubtful that many used their resources more intensively than did the Klamath. The accounts of first non-Indians to visit the region give a sense of this integration between the Klamath and their environment:

> (November 30, 1826) Course south to Clammitt River 25 miles from River of the Falls. Mr. McKay proceeded ahead to an Indian village distant 3 miles. It was composed of 20 tents built on the water surrounded by water approachable only by canoes, the tents built of large logs shaped like block houses the foundation stone or gravel made solide by piles sunk 6 ft. deep. (Ogden 1910:210)

> (1843) December 11th.--No Indians made their appearance, and I determined to pay them a visit. Accordingly, the people were gathered together, and we rode out toward the village in the middle of the lake, which one of our guides had previously visited. It could not be directly approached, as a large part of the lake appeared a marsh; and there were sheets of ice among the grass, on which our horses could not keep their footing. We therefore followed the guide for a considerable distance along the forest; and then turned off toward the village, which we soon began to see was a few large huts, on the top of which were collected the Indians. . .
>
> The huts were grouped together on the bank of the river, which from being spread out in a shallow marsh at the upper end of the lake, was collected here into a single stream. They were large round huts, perhaps twenty feet in diameter, with rounded tops, on which was the door by which they descended into the interior. Within, they were supported by posts and beams.
>
> Almost like plants, these people seem to have adapted themselves to the soil, and to be growing on what the immediate locality afforded. Their only subsistence at this time appeared to be a small fish, great quantities of which, had been smoked and dried, were suspended on strings about the lodge. Heaps of straw were lying around; and their residence in the midst of grass and rushes had taught them a peculiar skill in converting this material to useful purposes. Their shoes were made of straw or grass, which seemed well adapted for a snowy country; and the women wore on their head a closely-woven basket, which made a very good cap. Among other things, were parti-colored mats about four feet square, which we purchased to lay on the snow under our blankets, and to use for table-cloths. (Fremont 1887:297 The lake was Klamath Marsh.)

Gatschet, referring to the 1870s, gives a summary of the resources of the Klamath:

> The lake shores and river banks produce more edible fruits and berries than the marshy tracts; and it is the shores of Klamath and Tule Lakes which mainly supply the Indian with the tule reed and scirpus, from which the women manufacture mats, lodge-roofs, and basketry. The largest tule species grows in the water to a height of ten feet and over, and in the lower end of its cane furnishes a juicy and delicate bit of food. Woods, river sides, and such marshes as Klamath Marsh, are skirted by various kinds of bushes, supplying berries in large quantities. The edible bulbs, as camass, ko'l, l'ba, ipo, and others; are found in the prairies adjacent. Pond-lilies grow in profusion on lake shores and in the larger marshes, especially on the Wokash Marsh west of Linkville, and on Klamath Marsh, as previously mentioned. The Lost River Valley is more productive in many of these spontaneous growths than the tracts within the Reservation.
>
> . . .
>
> . . .Beavers, otters, minks, and woodchucks are trapped by expert Indians on the rivers, ponds, and brooklets of the interior.
>
> The shores of the water-basins are enlivened by innumerable swarms of water-fowls, as ducks, geese, herons, and cranes. Some can be seen day by day swimming about gracefully or fishing at Modoc Point and other promontories, while others venture up the river courses and fly over swampy tracts extending far inland. Among the ducks the more common are the mallard, the long-necked Kilidshiks; among the geese, the brant and the white goose. Other water-birds are the white swan, the coot or mudhen, the loon, the pelican, and the penguin. Fish-hawks and bald-headed eagles are circling about in the air to catch the fish which are aproaching the water's surface unaware of danger. Marsh-hawks and other raptores infest the marshes and are lurking there for small game, as field-mice, or for sedge-hens and smaller birds. The largest bird of the country, the golden eagle, or Californian condor, has become scarce. Blackbirds exist in large numbers, and are very destructive to the crops throughout Oregon. Other birds existing in several species are the owl, lark, woodpecker, and the pigeon. Migratory birds, as the humming-birds and mocking-birds, visit the Klamath uplands, especially the Lost River Valley, and stop there till winter.
>
> The species of fish found in the country are the mountain trout, the salmon, and several species of suckers. (Gatschet 1890:xxiii-xxv)

Spier, who did ethnographic research in the area, comments:

> Fish, the primary food stuff, can be taken almost anywhere in Klamath territory, but the supply is more plentiful in some sections than in others. Williamson river is one: fish can be caught there the

> year round, but in many other streams they run only in the spring. For this reason, the greatest number of settlements cluster on that river. The runs of fish there begin in the early spring, are at their height in March and April, and continue, one variety following another, into the fall. According to Coley Ball seven kinds of fish run in the spring, followed in the fall by the larger varieties. Mid September marks the end of the sucker run. The time of the salmon run is not clear. Gatschet's statement is that salmon ascend the Klamath river twice a year, in June and again in the autumn. This is in agreement with my information, that the run comes in the middlefinger month, May-June, and that the large fish run in the fall. Pat Kane did not know whether there is more than one variety of salmon, which he called tcia lEs. They ascend all the rivers leading from Klamath lake (save Wood river, according to Ball), going as far up Sprague river as Yainax, but are stopped by the falls below the outlet of Klamath marsh. Other fish live in the marsh, however. (Spier 1930:147-148)

Among their food sources, fish were of the greatest importance. The annual reports of the Commissioner of Indian Affairs make reference to the fishery resources of the Klamath Basin. Unfortunately, they do not always distinguish between various species of fish:

> Klamath Agency, Lake County, Oregon
> August 20, 1878
>
> "Early in the spring and depending somewhat, as to time, upon the mildness of the weather and rains, fish in great abundance run up the little streams and are taken out by nets, spears, and even by the hands. These are used fresh for present food and dried for future supplies. The fishing season lasts from four to six weeks."
>
> July 7, 1879
>
> "Rivers and lakes upon the reservation swarm with fish. After the spring fishing during which time immense quantities of fish are gathered, there follows a succession of root, seed and berry gathering. . . .
>
> August 1, 1881
>
> "All these streams are abundantly supplied with the finest species of trout that the country affords. The lakes are also well stocked with a variety of excellent fish suitable for food for the Indians."
>
> 1886
>
> "The streams abound with fish, mainly different varieties of the trout; also the sucker. When all other sources of subsistence fail, the Indians turn to this unfailing source, sure to find food to stay their hunger and that of their famishing children."

August 15, 1888

"In its lakes and streams there seems to be an inexhaustible supply of all kinds and the finest variety of fish, especially the trout species, which for size, numbers, and excellence is not surpassed on the continent. These can be caught at all seasons of the year and afford one and a never failing source of subsistence to the Indians."

August 10, 1889

"Fish in great variety and of the finest quality abound in all the lakes and streams of the reservation. These can be caught at all seasons of the year and form a never failing source of supply to the Indians."

August 21, 1894

"Mountain trout abound in the streams and form a large proportion of the Indians' food."

September 25, 1896

"Its streams are full of fish, mostly the rainbow trout. These can be caught at all seasons of the year. Within the bounds of this reservation are found the finest fishing grounds on the globe."

September 24, 1900

"The clear, cold streams still abound in trout of several varieties, although the great fame of Spring Creek, Williamson River, and other streams have attracted many anglers from afar whose skill has perceptibly reduced the number of fish which these beautiful streams afford. The fish afforded by these streams is a valuable resource to the Indians, and as the reservation furnishes some rare localities for the purpose the Government would confer a great favor upon our people, not only upon the Indians who reside upon the reservation, but to the numerous white settlers of southern Oregon and northern California upon the Klamath River, by establishing fish hatcheries upon the sources of that great stream upon this reservation." (Annual Reports Commissioner of Indian Affairs for years indicated 1878, 1879, 1881, 1886, 1888, 1889, 1894, 1896, 1900.)

The following passage describes the amount of fish that was available in the Klamath Basin in the period just before water management began on the Klamath system:

"Those who like to see fish, immense congregations of them, all alive and running, and most of them weighing from 2 to 6 pounds apiece, ought to be here now. Five minutes walk from Main street brings one to the shores of the Klamath rapids, where every little nook, bay and tributary creek is so crowded with mullets that their backs stick out of the water. Ordinary fishing with hooks and spears or even nets is too slow to think of. With a pitchfork or with naked hands a backload may be thrown out in five minutes. These enormous droves of

fish can now be seen not alone here, but in the rivers and creeks generally throughout the county. Mullets, rainbow trout and salmon -- splendid fish, giants of their size and apparently anxious to be caught. This phenomenon will last a month, and until their egg-laying camp meeting is over with. After that, the herd of fish will be distributed over a wider space and will be in plenty the year through."
(Klamath Republican, March 21, 1901 Reprinted in Klamath Echoes 1965:1:2:21.)

If this article can be taken at face value, it would appear that the salmon referred to were spring chinook.

Non-Anadromous Fish

The people of the Klamath Tribe had access to and utilized a remarkable variety and quantity of fish. A large and important part of these were non-anadromous species.

Table B lists fresh water fish used aboriginally by the people of the Klamath Basin. The list does not not necessarily include all non-anadromous varieties or species of the region. Anthropological and fisheries sources note the importance of the various species to the Indians of the region. The shortnosed sucker was: "a food-fish of some value to the Indians who know it as the 'Yen'". (Spier 1930:151) The Klamath Lake small scale sucker: "is of great value to the Indians, by whom it is known as 'kahptu'". (Spier 1930:151) The Klamath Lake large scale sucker, tswan, was: "used as food. . ." (Jordan and Evermann 1923:54-56) The Lost River sucker was:

> the most important food-fish of the Klamath Lakes region. It is apparently resident during most of the year in the deeper waters of Upper Klamath and Tule lakes, running up the rivers in March and April in incredible numbers, the height of the run varying from year to year according to the condition of the streams. The Lost River fish are the most highly prized, and are said to be much fatter and of finer flavour than those ascending the tributaries of Upper Klamath Lake.
>
> This species reaches the largest size of any of the Klamath Lake suckers, examples over 3 feet in length and weighing several pounds

having been examined. It is of vast importance to the Klamath Indians, who, during the spring run, catch it in immense numbers and cure it for winter use. (Jordan and Evermann 1923:54-56)

Spier notes among minnows, k!o'toks; a blue minnow, k!aam; a large minnow, Endils; and a thick skinned minnow, t!ea bE, found in the marshes. (Spier 1930:154,153) Jordan and Evermann note chub, Rutilus, for which they claim three species. (Jordan and Evermann 1923:71) It is beyond our competence to equate Spier's minnows with Jordan and Evermann chub or with the chub noted by Mack in Table B.

In his Klamath dictionary Barker includes names for fifteen kinds of fish. He cautions that these were not checked for biological identification and that his list may require modification. (Barker 1963:496)

TABLE B

Non-Anadromous Fish

Common Name	Scientific Name	Source
Shortnosed Sucker	Chasmistes brevirostris	(Jordan and Evermann 1953:55; Mack 1979:422)
Small Scale Sucker	Chasmistes stomias	(Jordan and Evermann 1923:56; Mack 1979:422)
Large Scale Sucker	Chasmistes copei	(Jordan and Evermann 1923:56; Mack 1979:422)
Lost River Sucker	Catostomus luxatus	(Jordan and Evermann 1923:57; Mack 1979:422)
Brook Lamprey	Lampetra lethophaga	(Mack 1979:422)
Tui chub	Gila bicolor	(Mack 1979:422)
Blue chub	Gila coerulea	(Mack 1979:422)
Speckled Dace	Rhinichthys osculus	(Mack 1979:422)
Cut-throat trout	Salmo clarki	(Spier 1930:151; Mack 1979:422)
Rainbow trout	Salmo gairdneri	(Jordan and Evermann 1923:195; Mack 1979:422)

In addition to fish, crawfish and fresh water mussels were eaten:

> Crawfish are taken from the streams. These are simply boiled and are soft enough to eat in this fashion. To judge by the quantities of fresh-water clamshells at the old house sites, clams are also an article of diet. (Spier 1930:154-155)

Anadromous Fish

Non-anadromous fish were important in the Klamath Basin but so also were anadromous fish. Table C indicates those known to have been available in the Klamath Basin. The Klamath River and its headwaters was one of the major anadromous fish sources between the Columbia and the Sacramento Rivers. It supported considerable populations of both spring and fall chinook and steelhead. The presence of salmon in the waters of the Klamath Basin is noted from records of the mid-nineteenth century. On May 6th, 1846 Fremont, the second known White visitor to the Klamath noted:

> In the forenoon of the sixth we reached the Tlamath Lake at its outlet, which is by a fine, broad stream, not fordable. This is a great fishing station for the Indians, and we met here the first we had seen since leaving the lower valley. They have fixed habitations around the shores of the lake, particularly at the outlet and inlet, and along the inlet up to the swamp meadow, where I met the Tlamaths in the winter of '43-'44, and where we narrowly escaped disaster.
>
> Our arrival took them by surprise, and though they received us with apparent friendship, there was no warmth in it, but a shyness which came naturally from their habit of hostility.
>
> At the outlet here were some of their permanent huts. From the lake to the sea I judged the river to be about two hundred miles long; it breaks its way south of the huge bulk of Shastl Peak between the points of the Cascade and Nevada ranges to the sea. Up this river the salmon crowd in great numbers to the lake, which is more than four thousand feet above the sea. It was a bright spring morning, and the lake and its surrounding scenery looked charming. (Fremont 1887:483)

In 1852 Gibbs wrote of the Klamath salmon:

TABLE C

Anadromous Fish

Common Name	Scientific Name	Source
Chinook Salmon	Oncorhynchus tschawytsca	
Coho Salmon	Oncorhynchus kisutch	(Snyder 1931:16)
Steelhead	Salmo gairdneri	
Pacific Lamprey	Entosphenus tridentus	(Kroeber & Barrett 1960:5)

The spring salmon enter but few of the rivers on the coast, and only those either of considerable size, or coming from snow mountains. Both the spring and winter kinds run up the Klamath and Sacramento rivers in vast numbers." (Gibbs in Suckley 1860 12:2:310)

In the 20th century Cobb also noted the Klamath runs:

> Klamath River.--This is the most important river in California north of the Sacramento. It issues from the Lower Klamath Lake in Klamath County, Oreg., and runs southwesterly across Siskiyou County, passes through the southeastern section of Del Norte County, keeping its southerly course into Humboldt County, where it forms a junction with the Trinity River, and thence its course is directed to the northwest until it reaches the Pacific Ocean.
>
> The Klamath River is important as a salmon stream because it has both a spring and fall run of salmon. In 1888 a cannery was established at Requa, at the mouth, and this has been operated occasionally over since. The pickling of salmon has been done here for a number of years. Some years part of the catch has been shipped fresh to the cannery on Smith River or to the Rogue River (Oreg.) cannery. Since 1909 the cannery has been operated continuously by the Klamath River Packers Association. (Cobb 1930:437-438)

Gatschet, who visited the Klamath to investigate their language and culture in 1875 mentioned salmon as one of their important fish. (Gatschet 1890:xxv) He noted the spring and fall runs. (Gatschet cited in Spier 1930:148)

In 1907 Barrett, an anthropologist, studied the material culture of the Klamath and the Modoc. He wrote: "Fish were abundant in the lakes, salmon and salmon trout being especially esteemed by the Indians." (Barrett 1910:243)

Fisheries

In interviews with Klamath Tribal members, Courtright and Simmons identified specific salmon fishing locations on lakes and streams of the Klamath Basin. The major fisheries indicated were at: Sprague River, Baking Powder Grade, west Chiloquin; Sprague-Williamson River confluence; Williamson River just southwest of Chiloquin; Sprague River, Corum Can, Tom or Spring Can, halfway between Chiloquin and Sprague River (town); Sprague River-Sycan River confluence;

Sprague River-Whiskey Creek confluence, approximately five miles west of Beatty; Sprague River, Cottonwood Springs, two and one half miles east of Beatty; Sprague River, Chalk Bluff, seven miles north of Yainax; Barclay Springs, two miles due north of Elgoma Mill on Klamath Falls highway; Upper Klamath Lake, Pelican Bay; Spencer Creek. (Courtright to Simmons 13 August 1941)

There was a map upon which these fishing places were located. (Courtright to Simmons 13 August 1941) We have not found this map.

Klamath Falls was also a major fishery and salmon spearing location. (Spier 1930:153)

Spier gave a general description of the distribution of salmon in the Basin:

> They ascend all the rivers leading from Klamath lake (save Wood river, according to Ball), going as far up Sprague river as Yainax, but are stopped by the falls below the outlet of Klamath marsh. Other fish live in the marsh, however. (Spier 1930:148)

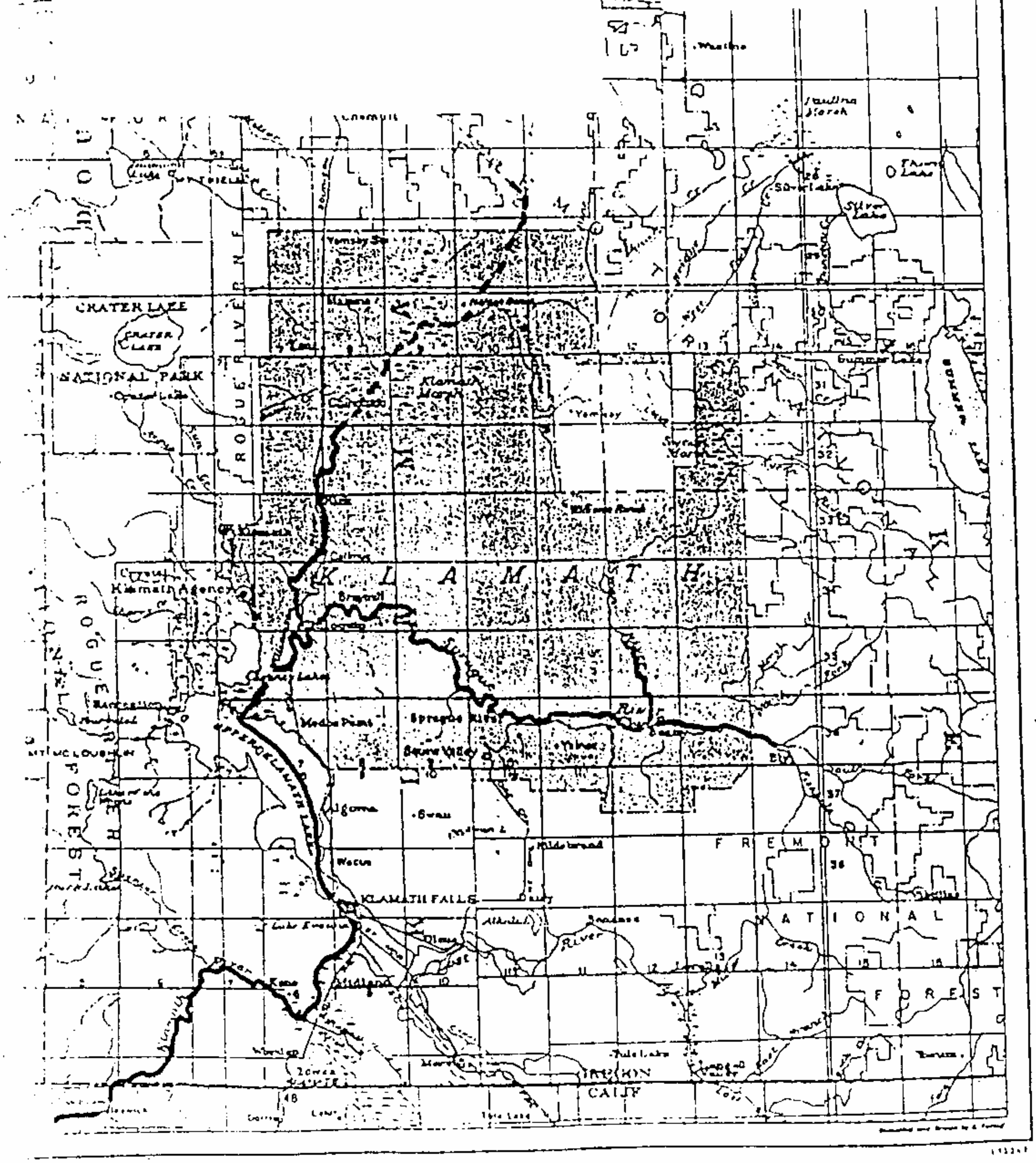
George Duvall, a tribal elder in the 1940s, asserted that salmon went up the Sprague as far as Bly, just beyond the eastern boundary of the reservation. (Map VI)

Map VI

DISTRIBUTION OF ANADROMOUS FISH

Heavy line indicates known distribution of anadromous fish.

Dotted line indicates possible extension of distribution of anadromous fish.



According to Mr. Tuba Lang, Klamath Wildlife Technician, tribal member John Copland claimed that salmon got to Jack Creek above Klamath Marsh. (Lang 1981:personal communication) This is the only suggestion that we have that salmon might have been able to get up the falls below the marsh.

Athough Gatschet, Barrett, and Spier are unequivocal in their references to salmon, there is some confusion in the anthropological literature regarding whether or not salmon reached the Klamath Basin. A.L. Kroeber, a respected expert on California Indians, wrote in about 1919: "The salmon are said not to run into the Klamath Lakes or above. . ." (Kroeber 1925:325) Hewes, in a survey of Indian fishing in western North America, wrote: "Salmon were not present in the Klamath Lakes and adjacent districts, . . ." and ". . . but salmon were available only in the Klamath River and its tributaries below Copco Marsh, to which a few ascended." (Hewes 1947:96) Both Kroeber and Hewes were writing after the first Copco Dam had blocked the salmon from the upper parts of the river and from the Klamath Basin. They appear to have been unaware of the impact of the dam on the fisheries. In a more recent study Kroeber's error is corrected. (Kroeber and Barrett 1960:5)

It would hardly be necessary to mention this error except that officials of COPCO also tried to assert that salmon did not enter the Klamath Basin. According to Simmons, referring to a meeting in or before 1941:

> You will recall officials of the Power Company stating to us in San Francisco, California that they were of the opinion the salmon had never gone up as far as the Sprague River because of the growth of fungus near the outlet of Klamath Lake. (Simmons to Ryckman 28 July 1941)

Craig Bienz, the Klamath Tribal biologist believes that they must have been referring to a bloom of algae that developed in Lake Ewauna when it was used for log storage. He believes that the algae bloom was due to this industrial activity and was not a natural condition. (Craig Bienz 1981:personal communication)

Snyder, a biologist who made a study of Klamath River salmon, was uncertain as to the exact limits of salmon distribution in the Basin, but he was convinced that salmon had formerly passed beyond the location of the first Copco Dam.

> During the summer of 1918, the writer, acting under the authority of the United States Bureau of Fisheries, interviewed many fishermen and old residents of the Klamath Lake region in an effort to learn something of the migration of salmon. Testimony was conflicting and the lack of ability on the part of those offering information, to distinguish between even trout and salmon was so evident that no satisfactory opinion could be formed as to whether king salmon ever entered Williamson River and the smaller tributaries of the lake. However this may be large numbers of salmon annually passed the point where the Copco Dam is now located. (Snyder 1931:22)

In the 1940s, preparing for legal action against COPCO for the blocking of the anadromous fish runs, Superintendent Courtright interviewed 50 members of the Klamath tribe and a number older non-Indian settlers in the region regarding salmon fishing in the Klamath Basin streams. Excerpts from or summaries of some of these statements assembled by Simmons and Courtright follow. We have not seen the original affidavits:

Testimony of Klamath Tribal Members

Cole, John: born 1885, member of Klamath Tribe--

"Frequently during the fishing season when several hundred salmon had been speared and removed from the water we would load them in a wagon and we would take them in a wagon to different localities where the Indians were living in communities and distribute them. We would give each Indian family enough fish to last them for some time. They would dry them and use them as part of their food supply for the coming months. I would personally salt down 400 or 500 pounds of fish following each salmon run while I was here on the reservation." . . ."After 1902 I fished every year during each salmon run until the spring of 1909 when I left the reservation and returned to my father's ranch near Keno, Oregon. I did not return to the reservation until 1918. During each of these years following 1902 the salmon runs were about the same. There were sufficient salmon running in the streams for all of the Indians to obtain the salmon they needed in sufficient quantity." . . ."The fish I am speaking of were all King salmon. Some of the Indians called them dog salmon. I know the difference between a steelhead and a King salmon. There were very few steelhead. These fish I caught were King salmon and were the same type of salmon I caught with my father in the Klamath River when I was a young boy about 12 years of age."

Nelson, Victor: Member of Klamath Tribe--

"The Indians obtained a large part of their livelihood from the salmon fish they caught. I would say that all of the Indians on the reservation participated in the benefits derived from the fish taken out of the Sprague River. The fish were pretty well distributed to all Indian families." . . ."At the Baking Powder Grade in the Sprague River, 20 men on an average, would fish daily throughout the summer months. They would spear and take out of the river approximately 100 fish a day, averaging 30 pounds a fish. I would say that approximately 3,000 pounds of salmon fish were taken out at the Baking Powder Grade each day for 90 days. . ."

Lotches, Bertha: born 1889, member of Klamath Tribe--

"My husband fished salmon in all of the fishing spots at Sprague River. He particularly fished at the fishing holes where Spring Creek empties into Sprague River two miles north of Beatty. This was the best fishing hole in Sprague River. He speared salmon during the runs each year from 1901 until the runs stopped. I would help him rack and dry the fish and prepare them for winter use. He would take out between 300 and 400 salmon a year. They would average in weight between 30 and 60 pounds. We would use whatever salmon we needed and would put up an ample supply of dried salmon for the winter months. We always had salmon on hand for our consumption and our friends' use."

Skeen, David: born 1881, member of Klamath Tribe--

"The Indians during those years lived in communities. They all helped one another. The Indians like to eat fish and meat. Most of their meals are composed of fish and a little bread and coffee. They will take a large fish and boil it in a pot and serve it with bread and coffee as a meal. Their habits and especially the fact that they like salmon fish so well accounts for salmon being the principal part of their diet. I would say that the salmon fish obtained by these Indians during those years provided one-half of the food consumed by them."

Lang, Delford: member of Klamath Tribe--

Lived on Klamath Reservation 1910 until right after World War I. Speared salmon at riffles near Lone Pine when 11 or 12 years old. Salmon ran up Sprague as far as Bly. Salmon averaged 18 to 20 lbs. Probably fall chinook. Speared salmon by torch-light at Baking Powder Grade. Salmon trolled for also. Fishing site on Williamson River below junction with Sprague. No salmon runs after 1910. Salmon were not dog salmon (chum). Dried salmon ground into meal. Never saw chum or sockeye there.

"I know of my own knowledge that one-half of the total food supply of my family was supplied by the salmon taken out by other members of my family and me and I also know of my own knowledge that the salmon taken out by Indian members of the Klamath Tribe of Indians provided approximately one-half of the food that all of the Klamath Indians used from 1898 to the time the fish were stopped by the dam of the California Oregon Power Company in 1910."

David, Robert: member of Klamath Tribe--

"During the early days on the reservation up to 1910 the salmon secured from the reservation rivers furnished a large part of the food supply of the Indians. There was very little farming during those years and very little hunting was done by the Klamath Indians. No rations were received from the Agency. There were no per capita payments received. We Indians depended to a great extent on the salmon for our food supply. I would state that about one-third to a half of our food supply was provided for by the salmon."

Chocktoot, David: member of Klamath Tribe--

"It was very important to the Indians to have these salmon. The salmon provided the Indians with about one-third of their food supply each year. During those years from 1895 to 1910 the Indians received no rations from the Government and very little help. No per capita payments had been made. The Indian had to make his own living. There wasn't much money in the country at the time and very little work. The Indians in the Beatty locality did some farming. They raised principally wild hay, some little grain, but scarcely any vegetables."
. . ."I know that these fish were salmon. Many of the Indians called them dog salmon. They were not trout. I know the difference between salmon and trout. They were the large chinook or pink salmon."

Kirk, Clayton: member of Klamath Tribe--

"In trying to arrive at the quantity of fish caught annually on an average from 1890 to 1909 you might compute it in this way: There are 1,000 Indians, we will say, on the average, including the total population of those Indians that ate fish, with on the average of two fish a day, weighing about 20 pounds. If they ate two fish during the time of the two salmon runs, they would consume 40,000 pounds annually. That is the nearest we can come to computing this. Those fish were salmon. In addition each Indian dried at least 4 salmon each year weighing on the average of 20 lbs. for winter consumption which would last until the next salmon run. I would say all of the Indians each year would dry 80,000 pounds annually. We would dry some and had some fresh fish. I estimate that 1/6 of the sustenance of all of the Indians residing on the Klamath River between the years 1890 and 1909 was provided by the salmon fish caught in the reservation streams. . . .

Johnson, James: born 1887, member of the Klamath Tribe--

"I am a member of the Klamath Tribe of the age of 59 years. I was born in the Sycan Valley on the Klamath Indian Reservation. I have lived on the reservation all of my life. During the time the salmon runs occurred in the reservation waters I lived at Chiloquin, Oregon.

"From the time I was a very small boy of the age of seven years, I speared salmon in most of the fishing holes on the reservation. I remember distinctly spearing salmon when I was seven years old and having them drag me in the water.

I speared salmon at Baking Power Grade near Chiloquin, Oregon and at the junction of the Williamson and Sprague Rivers. I remember seeing many of the old Indians getting salmon at the junction of the Williamson and Sprague Rivers with willow net which they prepared and dragged across the stream, stopping the salmon from going up the stream until they had secured all of the salmon they needed for their own use and the use of their friends. Then these old people would remove the willow nets and allow the salmon to go up the Sprague River. I also speared salmon in the Sprague River at several of the popular fishing holes near Beatty, Oregon. I speared salmon at what was known as the Cottonwood Springs fishing hole and at the Cowum Can fishing hole. I also caught salmon in the Sprague River with a spoon.

"I was very fond of salmon fishing. I like it very much. At the time the salmon runs occurred in the river I was living with my father and mother. There were about ten of us in the family and I supplied the salmon for the use of my family. What salmon I caught I did not need my family would give to their friends. I would take between 300 and 400 salmon out of the reservation streams each and every fall during the salmon runs. These salmon would weigh between 30 and 80 pounds. The runs would generally last between 60 and 90 days, starting toward the end of August and lasting sometimes into October. I would always catch the salmon before they spawned later on at the end of the run. Sprague River is one of the fine spawning streams of the reservation. Around Baking Powder Grade it was especially easy to spear salmon as the river widens out and is shallow and there are a lot of sandbars on which we could stand to spear the salmon.

"These spears were sapling poles about an inch in diameter, from 6 to 8 feet long. Sticks were attached to each side of the sapling pole. Holes were put in the ends of the stick fastened to the end of the sapling pole. In these holes were put pieces of steel or bone. When the salmon was speared the bone or steel would go through the salmon which was attached to a string, thus securing the salmon.

"I could hit a salmon 9 times out of 10 at a distance of at least 30 feet with these spears. All of the able-bodied Indians would take out during each salmon run in the fall more than enough fish for their present needs and their needs during the winter until the next salmon run. We dry about half of the fish we took out. They would keep well during the cool fall months and during the winter. The Indians would keep the dried fish in a deep pit they would dig in the woods. They would cover the pit well with grass and bark and they would put grass and bark on top and cover it with dirt. These fish would then keep fresh all winter. These salmon provided a large part of the food supply consumed by the Indians during the years the salmon ran up the streams. I would say that the salmon provided half of the food supply. One of the principal meals of the Indians during those years was boiled or dried salmon, bread and coffee. There was no farming around the Chiloquin area. Some wild hay was raised but very little grain. Some of the Indians hunted but the principal food was salmon. We got very few rations from the Agency during those years. They would give us a little rice and sugar enough to last us a week or so. We received no money from the Agency and no per capita payments. It was up to the Indians during those years to live the best they could on salmon and what Nature had provided on the reservation."

. . .

"I know the difference between steelhead and salmon. The steelhead and the salmon were about equally divided, probably there were more steelhead than salmon. The steelhead were much smaller. As I have stated, I fished all over the reservation and every Indian during those years of the salmon runs participated in the benefits received from the salmon taken from the streams. All of the able-bodied Indians fished and they divided the catch with the old Indians and with other Indians who could not fish which was caused by old age, etc. But every Indian family at the end of the salmon run had enough fish to carry them through until the next salmon runs." (Simmons n.d.:4ff.)

Summaries of Statements of Klamath Tribal Members

Duvall, George: member of Klamath Tribe, born 1872, on Klamath Reservation 1910-1920, 28 years old in 1900. Used to be lots of salmon. Went up Sprague River as far as Bly (see Map). Fishery locations at Baking Powder Grade, Spencer Creek, upper end of Link River.

Wright, Harry: member of Klamath Tribe, born 1872, on Klamath Reservation 1910-1920, 28 years old in 1900. Salmon ran to head of Sprague River. Fished every fall at Baking Powder Grade near Chiloquin. Salmon ran at end of August and in September. On trip, would get 10 to 12 salmon weighing 12 to 14 pounds each. Would make 2 or 3 fishing trips during a run. ". . .the salmon run was so heavy they could run between your legs and almost knock you down." Fished by torch-light. "Salmon were dog salmon (?)

Mose, Eva: member of Klamath Tribe, born 1874, on Klamath Reservation 1910-1920, 26 years old in 1900. Fall Salmon run on the north fork of the Sprague River.

Mose, Ike: member of Klamath Tribe, born 1881, on Klamath Reservation 1910-1920, 19 years old in 1900. Speared salmon, lots of salmon dried.

Crane, Dice: member of Klamath Tribe, born 1882, on Klamath Reservation 1910-1920, 18 years old in 1900. Asserts that the Salmon were "dog salmon", not coho or chinook. Fish weighed about 25 pounds. Fished below Cottonwood Springs.

Duffy, Matson: born 1876, on Klamath Reservation 1910-1920, 24 years old in 1900. Spear-fished for Salmon every year during September and October at Cottonwood Springs. Salmon averaged 25 to 30 pounds with some up to 40 pounds.

Beal, Erskine: member of Klamath Tribe, lived on reservation. . . ."This was the run of the chinook salmon. Once in awhile some steelhead would appear but the run was composed almost entirely of chinook salmon. . ."

Anderson, Elva: member of the Klamath Tribe, lived on reservation. In Elva Anderson's affidavit, the following statement is made: "Affiant knows these fish were salmon. She has seen dogs on the place eat these fish and die. She knows the difference between salmon and steelhead and rainbow trout."

Jackson, John: Tribal member, lived near Chiloquin. "The big salmon runs usually occurred in the fall of the year. I know salmon from steelhead and these fish were the large King or Chinook salmon. Some of the Indians called these dog salmon."

Nelson, Herbert: Tribal member, lived at Chiloquin. "I know that these fish were salmon. In the Indian language it is call g'otch. These fish weighed between 30 and 60 pounds. Some of them were steelhead salmon."

(USFA-Seattle RG 75 Box 220)

Courtright also interviewed non-Indian residents:

Testimony of Non-Indian Klamath Basin Residents

Anderson, O.T.: Born 1879, 21 years old in 1900, lived in Klamath County 1914-1920. Fished for fall run salmon with spear in north fork of Sprague River. Fish averaged 20 pounds. Believed that runs stopped in 1910.

Smith, John A.: Born 1875, 25 years old in 1900, lived on Klamath Reservation 1912-1920. Caught salmon in 1912 and for 2 to 3 years after that. Fish averaged more than 20 pounds.

Schmitz, Carrie V.: lived in Klamath County from 1897 on. Saw salmon runs in north fork of Sprague River in late September and early October. Recalled fish camps at Cottonwood Springs.

Ogle, H.H.: Born 1892 at Klamath Agency and lived there until 1905. Recalled salmon in Spencer Creek, 20 miles below Klamath Falls, so thick that they frightened horses fording the creek.

Obenchain, Frank: born 1877, 23 years old in 1900, lived just east of Klamath Reservation from 1881 through 1920. Recalled spearing salmon in north fork of Sprague River. Believed they were "dog salmon". Also fished with spoon near Cottonwood Springs. Saw Indians fishing at Cottonwood Springs with spears.

Wolford, Benjamin E.: Yainax Oregon merchant. "That affiant knows the difference between King and Chinook Salmon and steelhead. That these fish being taken out there by the Indians were Chinook Salmon and King Salmon. Many of the Indians would give affiant salmon and leave them at his store at Yainax. Affiant remembers distinctly one Indian fisherman named Bidwell Riddle giving him a salmon weighing 35 pounds during the fall of 1910. Many of the Indians left salmon fish at the store for the consumption of affiant."

(USFA-Seattle RG 75 Box 220)

In a memorandum written in 1941, Klamath Agent Courtright summed up the information regarding salmon in the Sprague River of the Klamath Basin:

> The older Indians tell me that Sprague River was "full of salmon". There were several holes along the river and fishing was had at these places all day long and most of the night when torches were used. Fish were taken out by the wagonload. (Courtright 16 January 1941)

Identity of Anadromous Species

Snyder, in his study of the salmon of the Klamath River, states that chinook and the pink salmon spawned in the Klamath River. The chum and the pink were rare and seldom seen.

> Silver salmon (coho) are said to migrate to the headwaters of the Klamath to spawn. Nothing definite was learned about them from inquiry because most people are unable to distinguish them. In 1925, 295 silver salmon appeared at the Klamathon racks (see p. 127), of which 269 were males and 26 were females. (Snyder 1931:16)

Reporting on the situation in the lower river well after the Klamath Basin was cut off, the 1960 California Department of Water Resources Klamath Basin Report said:

> Very little is known concerning the size of silver salmon runs in the Klamath River. Recently, however, the Department of Fish and Game has accumulated considerable evidence which shows that silver salmon are more abundant than has been generally supposed. Silvers spawn in most tributaries to the Klamath, from those near the mouth, such as High Prairie, Hunter, Turwar, and Blue Creeks, to Fall and Bogus Creeks just below Copco Dam. They utilize many smaller streams not used by king salmon. Two or three hundred silvers are counted through the Klamathon Racks each year. No attempt has been made to get a complete count of silver salmon at Klamathon, but those that pass through the gates during the king salmon run are counted. (Cal DWR 1960:152)

Snyder notes that Jordan and Evermann recorded that sockeye were found in the Klamath River but that he could not substantiate that claim. (Snyder 1931:16) Cobb reported that 20 sockeye were taken in the Klamath River in the autumn of 1915. (Cobb 1931:413)

As indicated previously, early observers noted two chinook runs in the Klamath River, a spring and a fall run. Stern mentions Klamath fishing a spring run of salmon. (Stern 1965:12) However, the statements of witnesses from the Klamath Basin appear to refer primarily to a run in the fall. Snyder discusses the problem of the spring run:

> Although king salmon in small numbers at least, appear to enter the Klamath at all seasons, there are apparently two more or less definite periods of migration, one occurring in the spring and the other in midsummer and early fall. Some doubt appears as to the distinctness of these migrations, the first possibly being little more than a long continued and varying start of the summer influx. However, G.R. Field and W.H. Baily, and the fishermen as well, speak of two distinct runs. Field wrote: "As the run of winter steelheads ceases, about March 30, spring Salmon begin to come. A few enter the Klamath in the latter part of February, but the run really starts in March and slackens or almost entirely passes by the last of May. These fish average about 11 pounds in weight and are indistinguishable from those which come later, except that the eggs are always immature. These spring salmon may be caught in the smaller streams fed by melting snow at the headwaters of Salmon River during the month of June."
>
> The spring migration, granting that it was once very pronounced, has now come to be limited as to the number of individuals, and is of relatively little economic importance. The fish of this run begin to

materially increase in numbers in the latter part of March or early in April and the migration has reached its maximum, and waned before the middle of June. The river at the time of the spring migration is apt to be in a condition of maximum flood as indicated in figure 3, the water bearing quantities of yellow silt and having a very low temperature. A huge yellow fan extends from the mouth outward over the surface of the ocean, occasionally reaching a width of three or more miles. Its shape and extent seemingly influenced by wind and tide, varies from day to day, now shifting far to the north or south and extending a greater or lesser distance out to sea. The line between fresh and salt water is often sharply defined by a narrow band of foam. From some distance to the north and south of the river the shore fauna shows the influence of fresh water.

The number as well as the destination of the fish which enter the river at this time is unknown. It is certain that the number is small or insignificant when compared with that of the summer run, yet many fish might easily escape notice in the silt-laden torrent with which the channel is filled. Possibly the migrating fish slowly make their way to the most distant headwaters or they may spread out over a considerable area of the basin and reach maturity at the same time as those of the summer migration.

. . .

R.D. Hume in a paper without date, and presumably published by himself in Stanford University Library ---) says of the Klamath River: "In 1850 in this river during the running season, salmon were so plentiful, according to the reports of the early settlers, that in fording the stream it was with difficulty that they could induce their horses to make the attempt, on account of the river being alive with the finny tribe. At the present time the main run, which were the spring salmon, is practically extinct, not enough being taken to warrant the prosecution of business in any form. The river has remained in a primitive state, with the exception of the influence which mining has had, no salmon of the spring run having been taken except a few by Indians, as a reservation by the government has been maintained there within a few years, and no fishing has been allowed on the lower river by white men; and yet the spring run has almost disappeared, and the fall run reduced to very small proportions, the pack never exceeding 6000 cases, and in 1892 the river producing only 1047 cases."

The impounding of flood waters above dams may now control in a measure the influence of spring freshets, and the gradual release of this water may contribute somewhat to the minimum flow of summer. (Snyder 1930:18-22)

In the statements summarized earlier, a number of Klamath Tribal members identified some of the salmon of the Basin as dog salmon. Evidently the term "dog salmon" was used loosely by local people. A few chum did spawn in the lower Klamath River but it is not known that they got up to the Klamath Basin. Snyder interviewed residents of the Basin in 1918 and remarks upon the inability of the people with whom he talked to distinguish between various species of trout and salmon. (Snyder 1930:17) He does not indicate whether he was talking to Indians or non-Indians.

The Klamath River was noted for steelhead as well as salmon. Steelhead entered the river in great numbers. In this region, according to Snyder, both sea run rainbow and sea run cut-throat are called steelhead. (Snyder 1940:101) According to Snyder, commercial fishermen in an unspecified year once took 14,578 steelhead from the lower river between August 5th and September 6th. (Snyder 1940:98) It will be recalled that James Johnson suggested that there may have been more steelhead than salmon. (See page 60 of this report.)

The 1960 California Klamath River report discussed the anadromous fish of the Klamath which, at that time of course, would have been restricted to waters below Iron Gate Dam:

> . . .During spring and early summer, fishing is carried on for young steelhead and to some extent for young silver salmon. Then during the summer and autumn there is considerable angling in the Klamath Estuary and lower reaches for both species of adult salmon and for adult steelhead.
>
> Adult king salmon enter the Klamath River from the ocean in two well defined runs, one in spring and another in fall. The spring run begins in late March, reaches a peak in May, and diminishes to the vanishing point by end of June. At present this run is small. The summer (fall) run usually begins entering the Klamath Estuary about the first of July. It increases gradually throughout that month, reaches a peak in August, declines steadily through September, and practically disappears by the beginning of winter. The spawning runs of salmon and steelhead proceed up the Klamath River and branch out into its tributaries. . .
>
> Steelhead utilize practically all tributaries of the Klamath and are without doubt the most widespread of the anadromous fishes in the

drainage. The major portion of the steelhead run at Klamathon comes after November 15 and usually after the counting racks have been removed for the season, so no complete accounts are available. (Cal DWR 1960:151,152)

Mr. Drew of the Klamath County Museum has drawn our attention to a phenomenon that may have affected anadromous fish runs passing through Upper Klamath Lake. He said that in certain years, when the water level in the lake was low and a strong southerly wind was blowing, the water would be literally be blown back from the lakes outlet and the Link River below would cease to flow. On several such occasions salmon and other fish were trapped in the pools left in the river bed. If this was a natural phenomenon predating water management in the area, it could certainly have affected fish runs. (Drew 1981:personal communication)

Modoc Fisheries

Prior to their removal to the Klamath Reservation in 1869 the Modoc seem to have had no salmon in their own territory unless salmon came up the stream joining Lower Klamath Lake to the Klamath River. The ethnographer, Verne F. Ray, places the lake and the stream in Modoc territory, but specifically states that the Modoc had no salmon in their own territory.

> "Fishing was a well-developed economic pursuit among the Modoc but it did not compare in importance to hunting. In this respect the Modoc contrasted greatly with the adjacent Klamath. It is true that salmon were absent in Modoc territory whereas they were available in the lands of the Klamath. However, there were numerous species of food fish in the streams and lakes of the Modoc and the quantities available were considerable, especially during the runs. Also, the Modoc traded with the Klamath for salmon and obtained some without payment when they visited their neighbors during the salmon runs in Sprague River. However, the quantities involved were of little significance in the over-all Modoc economy." (Ray 1963:192-193)

After 1864, the Modoc were assigned to the Klamath Reservation and shared in the fisheries of the reservation.

The Anadromous and the Non-Anadromous Fisheries

The fisheries of the Basin were rich for several particular reasons beyond the fact of the presence of suitable waterways. Although the Basin is east of the Cascades and parts of it are extremely arid, the region benefited from extremely heavy runoff from the Cascade slopes which formed its western border. In addition, at least the upper (more northerly) portions of the Basin, while warm and dry in the summer time, were subject to extremely heavy winter snow falls. The annual runoff, despite the contrast between the warm dry summers and the cool wet winters was normally fairly constant:

> The structure of the various watersheds affect the pattern and regimen of runoff. In the extreme northern portions of the basin the Williamson and Wood Rivers, two of the principal streams, draining 3,800 square miles of high plateau whatershed, discharge directly into upper Klamath Lake. Although precipitation occurs principally in the winter months, the resulting water supply percolates into the volcanic substructure of the area, moves through the permeable pumice deposits of the Klamath Marsh, and finally is discharged by the two rivers in almost constant monthly amounts. The Sprague River drains the eastern portion of the watershed area and maintains a high base flow, characteristic of volcanic terrain, yet this stream is subject to high runoff in the spring months. (Cal DWR 1960:18)

This means that although spring freshets might sometimes damage alevins in the spawning beds, water conditions were usually satisfactory for spawning and hatchings.

Just before and at the turn of the century, the fishery resources of the Klamath Basin were very rich. In pre-White times, although anadromous fish were important, non-anadromous fish were probably more important. Two things happened early in the 20th century which may have reduced the importance of non-anadromous fish to the Indians of the Klamath Basin and, consequently, increased the importance of anadromous fish.

The Klamath Lakes and streams became famous as a sports fishery. As the 1898 annual report of the Commissioner of Indian Affairs notes, even before the turn of the century pressures on the fresh water game fish of the area were heavy:

> August 30, 1898
>
> "Tourists have often been permitted to camp for some weeks at a time on these streams for recreation and the pleasure of angling. . . .No such persons during the past year have abused the privileges extended to them by imposing upon Indians in any way. . . .No angling is permitted except with a hook, baited with insects, real or artificial, and no nets, spoons, or explosives are allowed to be used by fisherman. It is true, however, that fish are less abundant than formerly in our trout streams and that an important resource of the country is not what it once was, either as a source of food or pleasure. The establishment of a fish hatchery on Spring Creek or some other stream in the Klamath region would be worth considering by the proper authorities." (US CIA-AR 1898)

Even more important were the effects agricultural enterprises in the Basin. In the 20th century large scale reclamation projects were developed which resulted in radical alterations to the aquatic environment of the Basin. Lakes and marshes were drained and water was diverted for irrigation purposes.

These various alterations in the environment must have had a detrimental impact on the non-anadromous fish of the area. They may also have affected the anadromous fish. However, these spent the greatest part of their lives in the ocean. If just before and after the turn of the century, the non-anadromous fish were suffering depletion and destruction, the anadromous species may have increased in importance. We cannot prove that this was the case. We note however, that the ethnographic literature, early accounts and the early reports of the Commissioner of Indian Affairs often seem to suggest a greater importance of fresh water fish than of anadromous fish. Later reports hardly mention fresh water fish other than trout, but emphasize salmon.

USE AND IMPORTANCE OF FISH TO THE KLAMATH BASIN PEOPLES

Fish were basic in the life and culture of the Klamath and slightly lesse important in the life and culture of their neighbors. The importance of fish to the Indians of the Klamath region can be documented in many ways.

We first note the evidence of archeology.It is often difficult or impossible to link archaeological data with historic inhabitants of a given area for specific ethnohistorical purposes such as those which concern us here. In the case of the Klamath region, the continuity of the prehistoric and historic cultural record seems to be well established. Luther Cressman, after years of intensive research in the prehistory of the Klamath region concluded that: (1) The culture of the Klamath was unusually and uniquely adapted to the utilization of the water resources of the region, and (2) That there was direct continuity between the recent Klamath people and the prehistoric occupants of the area extending back over a remarkably long period.

Spencer sums up recent knowledge of Klamath Basin prehistory:

> Prehistoric investigations point generally to a development over an extremely long period of time of an ecological adaptation of both hunting and gathering. It is evident that the Klamath achieved an efficient and stable mode of life in a rich and rather specialized environment. In their traditions, they combined cultural practices both of the Plateau and the Great Basin.
>
> Thanks to the research of Cressman (1956), the long prehistoric sequence of the Klamath area is understood; archeological work has been carried out in both historic and prehistoric Klamath sites. The very special adaptation of the modern Klamath can be seen as the end product of about 10,000 years of occupancy of the region. Cultural changes through time are well charted; the Klamath tradition is one of some antiquity. . .
>
> It is estimated that Kawumkan Springs was abandoned as a dwelling site by A.D. 200. Cressman suggests that the special historic subsistence dependence on fish and Wocas or water lily seeds may have begun at that time, although to the special two-horned mano or grinding tool, he assigns a late prehistoric development. If he is correct, then a

1500-year depth for the modern Klamath adaptation to the special environment can be claimed. . .

> Cressman is clearly a proponent of long Klamath occupancy of their historic territory. We can agree that the fishing industry --argued by the abundant fish-bone scrap and the gorges and harpoons --is of considerable age and importance. It can also be agreed that Klamath territory has been occupied for thousands of years. Whether the prehistoric continuum is the history of the Klamath cannot be determined, but it seems safe to ascribe perhaps the last 1000 to 1200 years of material to Klamath forebears because it was during this period that permanent housing, the evolution of the two-horned mano, and the present emphasis on fishing developed. We can assume that the Klamath adaptation was a stable, well-established lifeway. (Spencer 1977:177-178)

Another evaluation is that of Aikens and Minor:

> Cressman's basic perception of an internal development from lesser to greater utilization of river and marsh resources, with no fundamental changes in the overall economic system, does not seem seriously threatened. (Aikens and Minor 1978:14)

Fishing Technology

An examination of Klamath fishing technology points in the same direction. Appendix E is an excerpt of information on aboriginal Klamath and Modoc fishing traits from Voegelin's culture element survey of northeastern California. It provides, in concise tabular form, an overview of the basic beliefs and practices connected with fishing. Much of the fishing gear of the Klamath-Modoc was similar to that used by other peoples of the Pacific Northwest. However, other items and fishing methods are uniquely adapted to local conditions.

An example is the rock "dams" which were found in a number of different streams in Klamath territory. These were lineal piles of rocks laid in shallow parts of streams and rivers to channel fish runs to make them accessible or to create eddies to attract fish:

> These are quite common in the rivers wherever a shelf of rock in the stream bed favors their construction. Their purpose is to create an eddy of still water in which the fish can be netted when they take

> refuge from the swift current. Most of these have been destroyed by the loggers who have cleared the channels of obstructions to float their logs. Gatschet seems to doubt that these are artificial constructions, but it is clear that only the foundation is a natural configuration. These are short dams (sa'mkauus) or wings of rocks extending out from one bank. One such in the low falls of middle Williamson river at takalma'keda takes advantage of a bend in the river bank to enclose a pool thirty-five feet across. Weirs are not used in connection with dams; in fact they are unknown to the Klamath. (Spier 1930:149)

> "On Link River the several dams are placed at intervals. . . (and) are laid out in round and oblong formations, built with river rock, three to four feet above the river beds. Those who piled the rocks constructed each dam with narrow neck, to be closed apparently by some sort of net, probably made of willows." (King 1959:1)

Sometimes a paving of lighter colored rocks were placed on the stream bottom so that fish would be highlighted as they passed over. (Voegelin 1942:55)

We tend to appreciate material things to the extent that they are complicated and separated from the environment. It is sometimes difficult for us to recognize the ingenuity and efficiency of devices which are physically unseparated from the environment and/or which appear simple and uncomplicated. The rock structures were fishing machines in which the environment was restructured to make it more efficient. They were used in conjunction with nets, dip nets, or harpoons. Often helpers waded in the stream and drove the fish into reach of the fishermen. (Voegelin 1942:55,173)

Many of the fishing methods were cooperative. For example, a number of fishermen might use a purse bag net 9' long with a 5' wide and 2' mouth. The mesh at each side of the mouth was threaded onto a separate pole. Two fishermen stood in the water, each holding a pole vertically with the mouth between them. Others drove the fish towards the mouth of the net. When the net was full, the poles were shifted to a horizontal position. As the fishermen dragged the net through the water towards the shore, the weight of the fish slid the net sides back along the poles thus closing the mouth. This gear was "much used, especially in rivers". (Spier 1930:151)

Another much used fishing method involved another specialized net. It consisted of a framework of two long poles spread to form an angle held open by a crosspiece fastened between the side poles near the apex. A line joined the extended tips of the poles. The net was slipped over the extended poles and fastened to the crosspiece. The gear was worked from a canoe with the fisherman in the bow and the paddler in the stern. The fisherman, holding the joined poles and the crosspiece, dipped the extended poles and the wider part of the net into the water in front of the canoe as the paddler made noise with his paddle or with a stick against the side of the canoe to scare the fish towards the net. Sometimes fishermen in other canoes also assisted in driving fish towards the net. When the net was full, the apex of the joined poles was slipped under the bow and the crosspiece was rested over the bow. This fixed the net up and out of the water. The net was then pulled back along the poles into the canoe and the fish emptied into baskets. (Barrett 1910:249)

The triangular dip net was unusual in form and is seemingly unique in its use. Kroeber says that it was somewhat like the surf fishing net of the Yurok who lived at the mouth of the Klamath River. (Kroeber 1925:325) The triangular shape occurs in a dip net used by the Karok and other nearby Californian peoples but the construction and use is quite different. (Kroeber 1925:816; Dubois 1935:127)

Spier quotes Meachem, describing another unique adaptation of a trap to Klamath conditions:

> The Klamath mode of taking fish is peculiar to the Indians of this lake country. A canoe-shaped basket is made, with covering of willow work at each end, leaving a space of four feet in the middle top of the basket. This basket is carried out into the tules that adjoin the lakes,

and sunk to the depth of two or three feet. The fishermen chew dried fish eggs and spit them in the water over the basket, until it is covered with the eggs, and then retire a short distance, waiting until the whitefish come in large numbers over the basket, when the fishermen cautiously approach the covered ends, and raise it suddenly, until the upper edge is above the water, and thus entrap hundreds of fish, that are about eight inches in length. These are transferred to the hands of the squaws, and by them are strung on ropes or sticks and placed over fires until cured, without salt, after which they are stored for winter use. (Meachem in Spier 1930:152)

A final example involves a method for spearing bottom fish:

A second type of spear, called Ka"lEks, is used for suckers and other fish whose habit it is to swim near the lake bottom. This is a long pole having a conical bundle of hard wood prongs (eighteen inches long) bound to one end. Their points are spread to a circle of five inches by a wooden hoop thrust down and bound among them. There are said to be twenty such prongs in a bundle; Barrett however notes half a dozen to fifteen; and a spear with iron points which I saw had none. This spear is used in dark, still waters. Poised above the spot where bubbles rise and jabbed down into the mud at a venture, it may pin a fish among the prongs. Another spear provided with a single barbed point is thrust into the fish to haul it up. (Spier 1930:153)

Other examples could be given but we believe that these are sufficient. None of the devices described here are totally unique. All have parallels elsewhere. The multipronged spear and its use was also unusual if not unique. The canoe-shaped trap used in the marshes is some what analagous to "box shaped" traps used by various groups in the Northwest but it is used in quite different ways. Over time, living in intimate association with their waterways and depending upon them for the major portion of their subsistence, the Klamath Basin peoples have selected, refined, and adapted fishing technology to make it pre-eminently suitable for their particular environment to the point that almost every observant person who visited them and observed their culture has commented upon this adaptation. We may turn to Barrett, who made a study of their material culture, for a summary statement:

On the whole, however, the Lutuanmi must be placed in a class by themselves, at least as regards their material culture, with their specialized tule and stone objects, and implements for use on the water, and their characteristic foods. In large part this specialization is the outcome of habitat in a restricted and unusual environment of large, shallow, inland lakes. (Barrett 1910:260)

Beliefs

Despite the importance of fish for the people of the Klamath Basin, they are supposed to have had remarkably few ritual ceremonials related to fish or fishing:

> There are not many special attitudes toward fish nor restrictions on their use. The principal restriction is that one bereaved of a spouse or child may not fish nor even cross a river for fear the fish will flee. This must have been a serious curtailment of the mourner's activities, considering the high infant mortality which must have existed. At the expiration of a year, the mourner must use a special sweat-lodge a second time before he can resume his occupation. Throughout this period he may not eat fish for fear of sickness.
>
> Respecting any fish that is caught with difficulty, for instance those speared through the ice, its gall (bis) must be thrown back into the water else others will cease to come. The fish are thought to turn away if this rule is neglected as children turn aside from a morsel of fish they think too small. The practice is called notowa'ble a'mbotot, to throw back into the water.
>
> In place of the first salmon ceremony common among the Northwest Coast tribes, the Klamath have an observance over the first sucker. The locale is wo'kstat on the bank of Sprague river near the settlement koma'eksi, south of Braymill. Above this spot is a cave styled the home of KEmu'kumps, the culture hero. The first sucker is roasted and allowed to burn to ashes. Those that follow must not be taken home but roasted there, else no more will come. If the rite is observed, suckers will be plentiful. Wo'kstat is the only place where the rite is held, the only place "where KEmu'kumps made this law".
>
> > KEmu'kumps was living at koma'cski. He made a dome-shaped mat lodge (the cave) using steholas mats to cover it (the poorest mats). That is why it leaks. Right at his home he killed fish. The fish had great difficulty in swimming up there, so KEmu'kumps killed the first he saw. He roasted it right at the river bank. He did not take it; let it burn to ashes. He said, "This is the way the pEsa'odiwas (humans, in mythical terminology) will do." After he did this, fish came in great numbers. . .
>
> There is no first salmon ceremony, no prayers for salmon, no salmon heart magic like that of the Yurok, no prohibitions against

> speaking of the salmon, as among the Wishram, and no special relations or taboos connecting twins with the salmon. (Spier 1930:148-149)

Gatschet, visiting the Klamath in 1877, was told that the spirits of some of the dead reside in the bodies of living fish. He suspected that his informant may have learned this belief while visiting Columbia River people. (Gatschet 1890:xcvii) Spier's comment is:

> Gatschet records an obscure statement which he interprets: "The Maklaks (Klamath) believe that the souls or spirits of the deceased pass into the bodies of living fish; they become inseparably connected with the fish's body and therefore cannot be perceived by Indians under usual circumstances" (1:130). The word used is however skuks, ghost. I received no information of this sort. (Spier 1930:101)

Zakoji, working with Klamath more recently, adds a bit more information from an interview with a tribal member. This person explained that the first fish that he caught was a trout. The event was celebrated by a family feast using this fish. He should have made an (unspecified) sacrifice at the time but he did not and therefore his father did. "I was told about Kamu'kampeh and sacrifice then." "I just don't dare eat the first fish or other animal. Earth of God (Kamukampeh) will help you if you are careful of this." (Zakoji 1953:195,196)

This fits a pattern described by Spier although Spier does not stress fish:

> The first fruits of a young hunter or root gatherer are looked upon as something altogether special. They must be abandoned if future success is to be assured. While I received conflicting versions of the young deerslayer's procedure, they agree that he cannot eat his kill. One informant had it that the first deer is abandoned by the hunter and never eaten. If he has companions, he does not even show it to them and must present the second one slain to one of them. Another informant agreed that he cannot partake of the flesh of the first deer, but his parents make a feast of it, giving away articles in honor of the occasion. Similarly a young woman destroys by burning the first roots she gathers alone, and does not exhibit her success to anyone. The second basketful is distributed among her companions, and only after this may she keep what she gathers. Analogously a man leaves the first fish or game he takes after the loss of a close relative, and a gambler

gives away his first gains after reacquiring power following the death of a relative. The practice of abandoning such fruits is called sapu'tsa. Unlike the comparable case of the novice deer hunter, no celebration is held for a little girl who gathers roots under her elders' tutelage. (Spier 1930:158)

It is almost certain that there were more beliefs and practices of this nature than have been recorded.

Ethnographic Data

When we turn to ethnographic data, descriptions of life and activities, the same picture of the importance of fish is evident. According to Spier, fish were "the staple" and "the primary food stuff" of the Klamath. (Spier 1930:145,147) He described the Klamath as having "a river and marsh culture". (Spier 1930:145) Their territory was large but their winter homes or settlements were invariably clustered along their waterways and were often located where winter fishing was possible. (Spier 1930:10-21)

> Fish, the primary food stuff, can be taken almost anywhere in Klamath territory, but the supply is more plentiful in some sections than in others. Williamson river is one; fish can be caught there the year round, but in many other streams they run only in the spring. For this reason, the greatest number of settlements cluster on that river. The runs of fish there begin in the early spring, are at their height in March and April, and continue, one variety following another, into the fall. According to Coley Ball seven kinds of fish run in the spring, followed in the fall by the larger varieties. Mid-September marks the end of the sucker run. (Spier 1930:147-148)

> The towns for the most part lie along Williamson river, on the southern side of Klamath marsh, and along the eastern shore of Klamath lake. As these are winter settlements, the open lake is avoided, and occupied only where warm springs outweigh its disadvantages. They cluster along Williamson river whose sheltered valley is distinctly warmer than the lake front a few miles distant and where the running stream contains fish most of the year. (Spier 1930:11)

Maps VII and VIII, from Spier, and the fishing locations from Spier make this clear.

Map VII

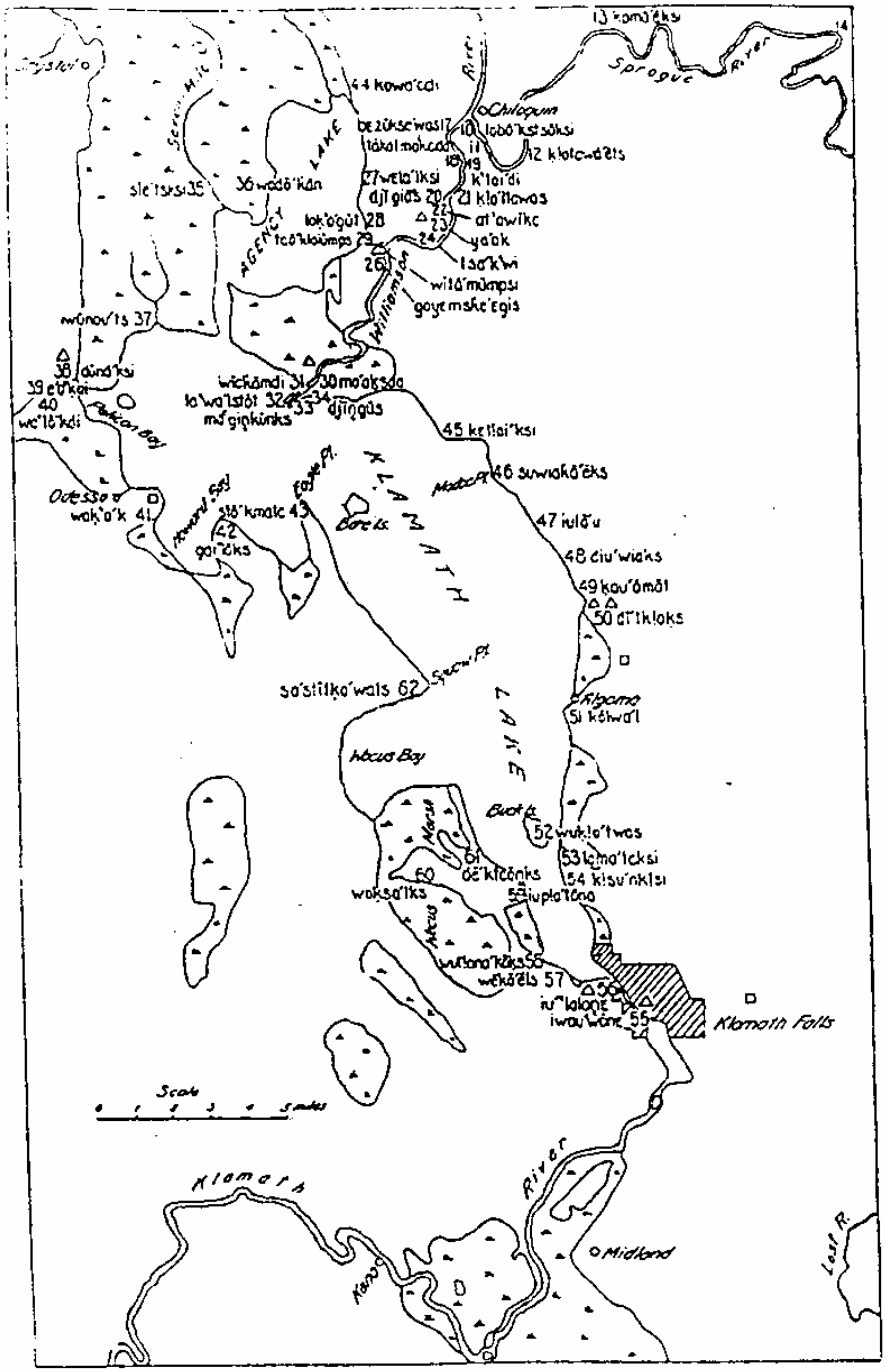


Fig. 3. Settlements in southern Klamath territory. Triangles represent cremation piles; rectangles, mourners' sweat-lodges.

Map VIII

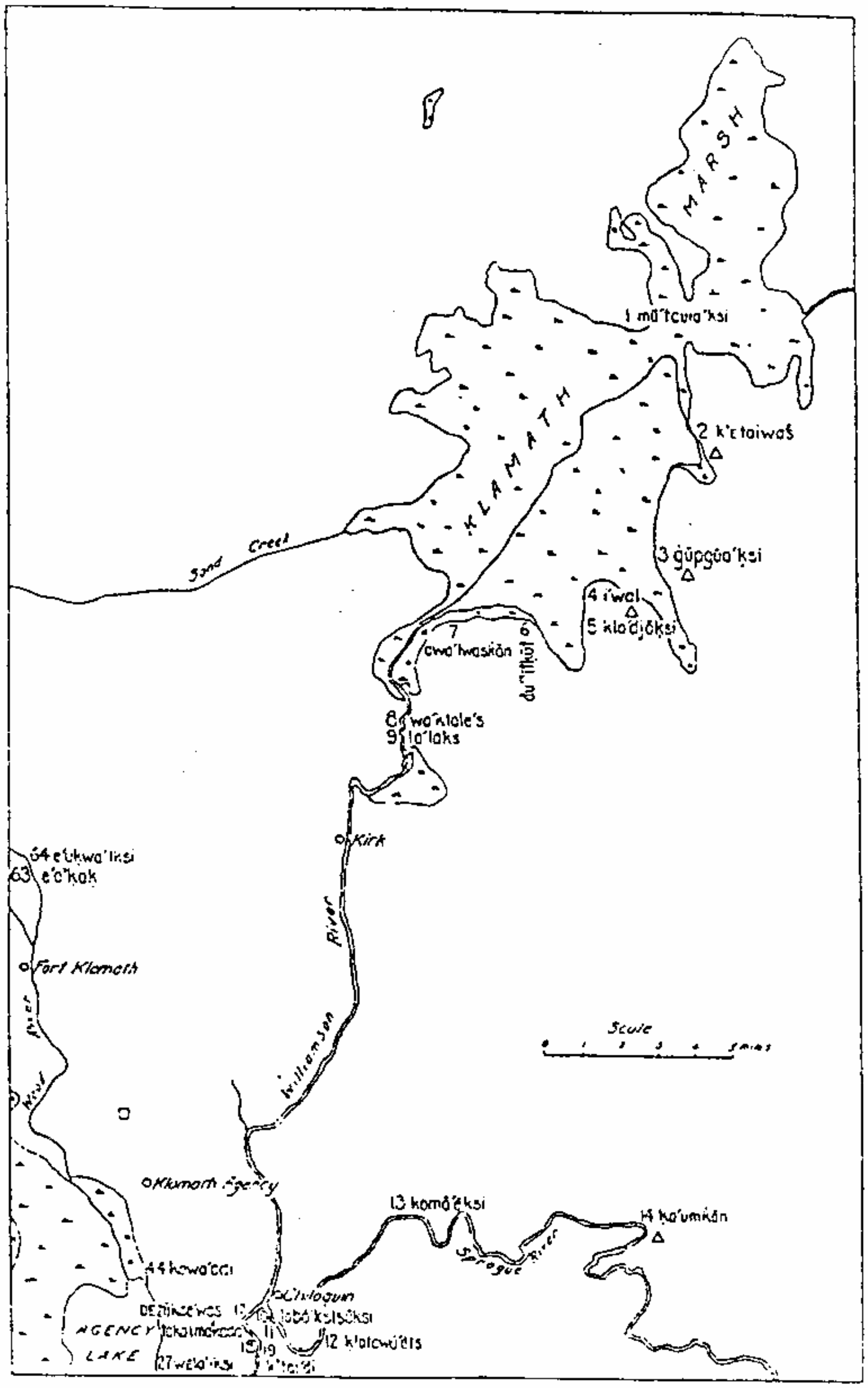


Fig. 2. Settlements in northern Klamath territory. Triangles represent cremation piles; rectangles mourners' sweat lodges.

Zakoji, reveiwing and rechecking Klamath ethnography in 1953 reconfirms the pattern:

> These winter lodges, or <u>loltmalaks</u>, were carefully located adjacent to those waters accessible to fishing during the freezing months of winter. Throughout the winter months, approximately from November to February, the Klamath remained relatively fixed to their settlements, fishing in neighboring unfrozen waters and occasionally engaging in hunting expeditions. (Zakoji 1953:6)

All recent archeological surveys confirm this ethnographically determined occupation pattern. For example:

> Virtually all of the prehistoric sites we encountered are located on the periphery of the Klamath Marsh or the Williamson River. Ethnographic reports indicate that the major Klamath villages were located along the marsh shore or river banks and a high occurrence of sites was expected in these areas (zones A1, A2, A3). The steep slopes (zone B1) and the upland forest areas (zone B3, B4) were expected to contain fewer sites. Both expectations were validated by our field surveys. (Bryant et al 1978:88)
>
> The Klamath fully exploited runs of chub, salmon, suckers, and all year availability of trout minnows, crayfish, and clams. They possessed a complex technology of net designs for different areas and for different types of fish. . ." (Bryant et al 63)

The annual round of the Klamath reflected the importance of fish to them. In the spring people left their winter homes to visit fisheries such as those at lower Lost River (Klamath and Modoc), at Barclay Springs and Modoc Point on Upper Klamath Lake, and along the upper Sprague River (Klamath, Modoc, and Paunte). At these places, fresh fish would be added to the immediate diet and other fish would be dried for future use. In the summer, fishing continued while the collecting and processing of vegetable foods became more important. Again, much of the activity involved the preparation and storage of food for winter use.

In the fall, people moved to locations where fruits and nuts could be gathered and game hunted. Late in the fall, people returned to their wintering locations where they rebuilt their houses and settled in until the next spring. In the winter people seem to have stayed closed to home living upon stored food, although where conditions permitted, local fishing, including ice fishing took place. (See Spier, 1930:10-11; Bryant et al 1978, etc.)

Use of Fish

The majority of non-anadromous fish runs occurred in the spring and early summer when there was fresh fish in great abundance. Some of those fish were dried. However, many of them were small and somewhat less suitable for curing for storage. Furthermore, with dried fish, there is always a "shelf life" problem. Fish dried and stored in the spring would suffer more spoilage than those dried in the fall. The point is that there may have been an abundance of fish available in the spring, and early summer which, for various reasons, would not have contributed as much as one might imagine to the winter food supplies.

There was a second problem. The Klamath Basin peoples could not survive on fish alone. A part of their production time had to go into the harvesting and preparation of other foods, including vegetable foods. Ray gives a sense of the time and energy demands for the Modoc:

> The search for vegetal foods occupied a large part of the Modoc woman's days, spring through autumn. Many of the movements of families and groups during the growing and ripening seasons were dictated by the succession of crops and the wide geographic spread of the many plants which had to be gathered of economic necessity. The total number of species utilized was impressively large but the physical character of the Modoc habitat was such that many kinds of plants were found only in limited numbers and in widely distributed patches. This was true even of the staples, epos and camas.
>
> Epos was the most important plant food of the Modoc. . . It was the tuberous root of the plant that was used by the Modoc. It was gathered before blooming, usually in May, when the roots were soft and milky. The plants were found in elevations from 4,000 to 7,000 feet, in open places in the pine forests and in meadows and on rocky slopes. The season was very short, only three or four weeks. Modoc women were forced to work at top speed to harvest a sufficient quantity for

current use and storage for the winter. Large groups of women went together early each morning to one and then another of the patches within working distance of the village. When these fields were exhausted the village moved to a new site, and so on, until the season was over. The productive days of the season amounted to only ten or fifteen because of time lost in traveling and in cleaning the plants. The cleaning had to be done while the roots were fresh, that is, every three or four days. The tubers were collected in conical, openwork burden baskets or in the same baskets as those used for cleaning the husks from the roots: round, openwork containers, large but shallow, of juniper withes. A successful day of digging netted one basketful. Each woman kept the product of her labors for the use of her family.

Camas was the root of second importance in the Modoc dietary. The bulbs were dug in June or July, depending upon the advancement of the season. The plants were found in moist meadows, scattered in the montane coniferous forests at elevations from 4,000 to 7,000 feet. The pattern of digging was much the same as for epos and the travel and logistics problems were similar. Most of the camas was kept for winter use. Toward this end the bulbs were partially dried and cleaned at the site of digging. This preliminary drying required several days or a week. As a consequence the women sometimes had to travel considerable distances from the village or the root-digging camp on the last days of a stay, the nearby fields having been exhausted meanwhile. The season lasted for about a month, at the end of which time the roots accumulated by each woman were carried to her winter home and cooked in an earth oven. After removal they were dried on tule mats, then placed in bags and stored in pits.

The roots of desert parsley were available in April and May —even earlier than epos. This parsley, a perennial plant with a turniplike tuber of large size, was found in the sagebrush scrub country; Tule Lake was a productive area. The early appearance and relative abundance of the plant gave it a prominent place in the Modoc dietary. The tubers were cooked and eaten fresh, also dried for winter.

Another plant extensively utilized by the Modoc is of especial interest because it is poisonous in the raw state. This is the so-called white camas, also known as death camas or deadly zygadene. A leaching process known by the Modoc rendered the bulbs edible. They were ready for harvesting soon after the camas season, in late July, thus prolonging the root-digging season, a significant economic advantage. The bulbs were gathered from moist, grassy places in the montane coniferous forests, carried to the village, and cleaned of their tunicate coverings. They were then dried and placed in tule sacks. Leaching was accomplished by immersing the sacks in a steadily flowing stream for three days, after which they were again dried and placed in storage.

The Modoc exploited seed-bearing plants of many species as a food resource. Their pattern contrasted greatly with the Klamath, however, whose major dependence was upon seeds of the water lily. The Modoc gathered water-lily seeds, too, but of more importance were

> the tiny seeds of a multitude of plants, in the typical manner of northern California Indians generally. . . Among the more important seed plants were the sunflower, buckwheat, willow dock, rye grass, plains mustard, lambs' quarters, manna grass, blazing star, tarweed, balsam root, and water lily. (Ray 1963:198-199)

As Ray notes, the demands of this sort upon the Klamath were not so great but they were nevertheless considerable.

> The spring and early summer are spent on the marshes and prairies, gathering roots such as camas and ipos. When the camas has been dried and stored, they move to the marshes, especially to Klamath marsh, to harvest pond-lily seeds from mid-August to the end of September. While the women are busy with this harvest, men hunt mule deer, antelope, and other animals whose habitat is in eastern Klamath territory. Late summer and autumn, seeds, berries, and nuts are gathered, the Indians congregating where these are plentiful. Many of those at Klamath marsh, for example, move directly to Huckleberry mountain, southwest of Crater lake, to garner these berries. Summer and autumn are the seasons for journeying to visit and trade, for raiding, and <u>especially for laying up a store of fish against the coming winter</u>. It must be understood that the winter locations are not completely abandoned during this season, for many of them are favorably situated for these very activities. But it is customary for such a group as the aukekni division, whose winter residences cluster thickly along the middle Williamson river, to scatter and meet again at Klamath marsh for the pond-lily harvest in August and September. (Underlining added. Spier 1930:146)

We have emphasized the comment about summer and autumn being especially the time for preparing a supply of fish for winter use. An important part of that supply was almost certainly salmon. Being relatively large fish and, being "dry", having lost fat in their journey far up the river from the sea, they were efficiently prepared and not being fat, they kept well. By efficiently prepared, we mean that more food could be prepared for storage for the amount of time expended than would be the case with smaller fish.

There is a final element to be considered. The Klamath Basin was a region of warm dry summers but it is also characterized by heavy and long lasting snowfall in the winter:

> Winters are exceptionally severe at this altitude (4000 feet), with deep snow and lakes, marshes, and even streams solidly frozen. Movement is stopped and unless a winter residence has been chosen which gives some possibility of fishing, starvation may be faced before spring. (Spier 1930:11)

He notes elsewhere:

> When one considers that the countryside teems with a wide variety of animal life in summer, and the seeming abundance of seeds, roots, and fish, it is difficult to comprehend the change that winter brings. Yet outright starvation in winter must have been frequent. The constant refrain of Ogden, who visited the country in the winter of 1826, bears on the scarcity of game, the near approach to starvation, throughout the months his party was there. Yet it is not incredible in view of the deep snows that cover the land, the thick ice on lake and marsh, when travel is at a minimum and fish can no longer be taken. Snow falls early, in November, and lies on the ground in exceptional years well into May. The early spring, when winter stores have run low, is the critical period. When the lake remains frozen unduly long and snow still falls, starvation sets in. Then horses are killed, and finally the hides or even dressed elk skins are roasted in their extremity. Nothing will induce them to turn to dog flesh. When the snow leaves the prairies, they hasten to glean whatever roots have escaped the previous season's harvest. Then too a few trout may be had to eke out their subsistence. (Spier 1930:147)

It may seem odd that people with the range and quantity of resources that were available to the Klamath would have had a problem of periods of hunger. The ultimate survival of people living under such conditions depends not on what is available in normal productive seasons or under the best of circumstances but upon what is available in unproductive seasons and unusual circumstances. The heavy snows made winter a difficult time for hunting. The Klamath did some ice fishing and open stream fishing in the winter, but for the most part their well-being in winter depended upon preserved and stored vegetable products and fish. It is in this context that the value of fall salmon runs must be evaluated.

Fish were eaten fresh or cured for storage. All species of fish were preserved including suckers. (Erwin Weiser, Tribal member in Jackson and Lee 1981:78) According to Spier:

All varieties of fish are dried in the sun, not smoked. The fish is slit down the back, entrails and backbone removed, the head cut off, and the flanks opened. Of the drying of salmon, Coville observes "it was their custom, after a fish was split open, to lay in the body cavity a yarrow stem (lal-wal'-sam, Achillea millefolium L.) with its leaves and flowers still attached. This treatment, by holding the fish open, hastens the drying process and prevents the decomposition that would be likely to follow if the walls were allowed to collapse. My informant knew of no special significance attached to the use of this particular plant and of no special adaptability it had for this purpose, except that it did not give the dried fish such a bad taste as some other plants." (Meacham refers to drying whitefish over fires.) A hole is cut through the fish so that they can be strung on poles, which are placed in rows on a high scaffold or set across branches of a tree. Sometimes the head is left on and the poles passed through a hole near the tail. The cache is covered with bits of board and bark. Dry fish are pounded up to make kamalsh.

Parties returning from fishing excursions to Lost river in Modoc country sometimes cook their catch in a hot spring east of the railway station in the present town of Klamath Falls. (Spier 1930:155)

Fire drying is reported in Voegelin's trait list. (Voegelin 1942:60)

Continued Use and Importance of Fish

When the reservation was established, one of the intentions was to convert Indians of the Klamath Basin to agriculture. Payments were to be made for five years: ". . .the design of the expenditure, (it) being to promote the well-being of the Indians, advance them in civilization, and especially agriculture. . ." (Keppler 1972:866) Efforts were made and there were small successes. Generally speaking the country was unsuitable for the agriculture possible at the time. In 1875, Agent Dyar wrote:

> "Were this a good agricultural country," he remarked, "they would soon become self-supporting and could they be induced to go to the Indian Territory it would be far better for them. As it is they must rely on stock and their old native food for subsistence." (Dyar to Smith, October 30, 1895 in Stern 1965:59)

The need for continued subsistence fishing was reflected in supplies ordered by the Agency. For 1872-1873, for the Yainox substation, one gross each of fish hooks and lines were ordered. Two gross of fish hooks and 12 dozen seines (seine nets) were ordered for the Klamath Agency in 1876-1877. (Johnson 1947:160, 165)

Stern discusses in some detail the continued importance of native foods:

> In the original designs of the government, farming and other "civilized" enterprises were supposed to supplant such aboriginal pursuits as fishing, hunting, and gathering. From the Agent's viewpoint, the retention of native subsistence methods presented two major disadvantages. Not only did the traditional occupations coincide in season with farming, but they drew the Indians from under the direct surveillance of the Agency, and even off the reservation. The issuance of rations, though designed to provide a substitute during the transitional period, was restricted as much as possible, in order to allow more funds for other purposes.
>
> It is clear from the graphic descriptions of the early Agents that they were well aware of the Indians' strong reliance upon native foods. The fish in Lost River, observed Dyar, ran from two to four weeks earlier than in the streams within the reserve. By late winter even the supplies of rations had been exhausted, and the Klamath eagerly awaited the news from the south. "If the Indians are not allowed to go to Lost River in the Spring," O. C. Applegate had pointed out, "then they will have to be subsisted during the month of March. The Lost River fishery continued to be exploited for fifty years, until the owners of the abutting land put an end to it. On the reservation, the Sprague and Williamson continue to supply a catch, although the drying of fish for the winter, common enough on the Lower End until about thirty years ago, has now passed into disuse. (Stern 1965:65-66)

It is not completely clear to us what time frame is being used here although we assume that the thirty years are some time in the past from the 1950s. That is to say, drying fish for the winter may have ceased to be important between 1920 and 1930. By this period, the Copco dams had cut off the supply of anadromous fish. This did not mean the end of the utilization of fish and other native foods:

> In their continued loyalty to traditional foods, the Klamath were responsive to several advantages beyond--but including--appeal to the palate. The techniques involved in securing them were relatively simple and familiar, imposing few demands upon the individual for capital investment in tools and labor, required little in regularity of

routine, and involved the cooperation of only small groups. Participation was direct, self-controlled, and provided an immediate reward.

Consequently, the issues of beef and flour were assimilated in use to native staple foods, rather than replacing them entirely. . .

Through it all, native foods continued to be favored, and the observation that "the Indian (school) children are very fond of fish" is nearly as true today as it was in 1893.

An analysis of the statistical and narrative reports of the Agents shows that they consistently tended to undervalue the contribution made by native foods to the Klamath economy. From the first statistical entry in 1882, when they are estimated to contribute forty per cent of the food supply, native foods steadily decline in the records, leveling off from 1888 to 1893 at approximately twenty per cent, and, after a spirited fluctuation from then to 1901, rising slowly to ten per cent in 1904. That dependency upon these foods declined from total to partial reliance is admissible. O. C. Applegate, while Superintendent, reported that by the turn of the century some of the food resources had begun to dwindle under intensive use. He found the fish less abundant than in the halcyon days of the first Agent, and observed that both water fowl and prairie chickens had been overhunted.

While conceding the decline, a critic may well find fault with the bland assessment of Elisha Applegate a decade earlier (1891) that native food quests were then "indulged in more as incidents and to add variety of life than as occupations to be seriously depended upon." The year after Applegate made his report, one graduate of the Indian school, upon returning home, saw things in a different light. "Whenever I got job, I pitched hay. I did fishing and hunting, and I had plenty to eat all the time. . .lots of deer meat, and I used to pick wokas too. If this was an indulgence, it was in sheer survival.

The sources of error are not hard to find. Administrators could form only the most general opinion of the contributions made by native foods, and must have tended to judge from the examples provided by Indian employees immediately at hand and from the more acculturated Indians. Moreover, their reports were in part designed to illustrate the progress which their charges had made away from their former customs. Accordingly, they understated the degree to which native economic activities conditioned the acceptance of new modes of earning a livelihood and supplemented those which had been taken up. (Stern 1965:67-68)

Writing of conditions circa 1950, Stern continued:

Whether dwelling in town or on a ranch, tribal members continued to seek native foods; but these activities had come to occupy a different place in their lives. Men of all ages still fished and hunted; many families still gathered huckleberries; and elderly women at least continued to dig for the succulent roots of ipos and camas and to gather wokas. The latter foods, however, were sought as cherished delicacies, now rare; while journeys to the berry fields assumed the character of an outing. Much of the fishing had acquired a strongly sportive aspect and was carried on by angling. Only the spearing of mullet during the spring runs and the hunting of deer and waterfowl seriously served food demands. (Stern 1965:192)

Fish, game, and even local vegetable foods were particularly important to many Klamath during the depression of the 1930s. (Mrs. A. Summers, Klamath Tribal member, and A.B. Wampler, long time Klamath Basin resident. In Jackson and Lee 1981:55, 257.)

One of the points made by those advocating termination for the Klamath Reservation in the 1950s was that the Klamath were living a life essentially like that of their neighbors:

> It is our belief that the Klamath Tribe and the individual members thereof have in general attained sufficient skill and ability to manage their own affairs without special federal assistance. Through intermarriage with non-Indians and cooperative work and association with their non-Indian neighbors. These people have been largely integrated into all phases of the economic and social life of the area. The standard of living of the Klamath Indians compares favorably with that of their non-Indian neighbors. Their dress is modern, and there remains little vestige of religious or their traditional Indian customs. Most of them live in modern homes, many of which are equipped with electricity, water and sewage disposal. . . The Klamath Tribe has been considered one of the most advanced Indian groups in the United States. (U.S. Congress 1954a:203-204. Quoted in Hood 1972:381)

It was intended to give the impression that the Klamath were economically independent of subsistence activities and that they had obtained a high standard of living based on agriculture, industry, and business. It is now recognized that this was incorrect. (See Hood 1972)

In 1953, according to evidence presented in U.S. v Adair only one third of 668 Klamath families supported themselves through agriculture. (U.S. v Adair 6 ILR F-150) If the figure is correct, it means that 333 families in this totally rural area were not involved in agriculture. Some part of these were supported through the timber industry but it is probable that a significant part the non-agriculturalists depended on subsistence activities for some part of their food. In addition, we consider it very probable that in a "frontier" rural area, most agriculturalists would also fish and hunt for subsistence purposes. Klamath Tribal members assert this and we know of no similar area where this is not the case.

Hood cites information provided to the Committee on Indian Affairs to the effect that, in this period:

> It appears that more than 2/3 of the 270 able-bodied male Klamath on the Reservation between the ages of 13 and 63, either do not work at all or work only off and on. . . (Hood 1972:382)

This may be another version of the previously noted quantitative claim. Whether or not, we draw the same conclusion. A lot of Klamath must have subsisted in part on fishing and hunting.

The U.S. District Court in Oregon reached the same conclusion in 1956:

> Finding of Fact 9. Hunting and trapping on the reservation is still practiced by the tribe and its members and affords a substantial part of the subsistence and livelihood of the Klamath people. Many would be inadequately fed were they deprived of the right to hunt on their reservation as their needs for food require. (Klamath et al v Maison 139 F. Supp. 634)

Sharing

The testimony collected by Courtright on salmon fishing and the testimony of contemporary Klamath stress the sharing of native foods. Spier and Stern both note that sharing of food with guests constituted good manners. (Spier 1930:91; Stern 1965:8) Several texts collected by Barker exemplify this ideal:

> If anyone had gotten a little, (fish), then they gave him some. Thus were people long ago, not stingy. They gave to each other, if someone were poor. Then they gave (to him). . .
>
> AC: People were good, we Indians a long time ago. We were good people. And I have told my--we were good people long ago. We

took even a little bit of food (i.e., all we had) for (someone). And, even though there was no food here, then we took for (somebody), something. And it was this. And doing it thus it is called "They even divide up a flea." Thus was the Indians' way. Thus they used to call it. To someone, even a little bit of food they took there. Yes, for another, and they gave some food, even (though it was) from a small amount, even if there was no food, just being very sympathetic at that time. (Barker 1963:135,163)

No doubt this ideal, like most ideals, was a goal rather than an inevitable reality. Stern and others also describs the concealing of food and reluctance to share in hard times. (Stern 1965:11) However, whether or not sharing always took place, the fact is that it was considered to be good and desirable behavior. It is further evidence that resources such as fish were not restricted in use to fishermen but were shared throughout the community.

This sharing fits with the patterns of relationship to resources:

> There is no individual ownership of fishing places, as with dams. Nor, for that matter, are there proprietary rights to hunting territories, berry or seed patches. A chief has no control, no ownership of fishing rights. Even those whose permanent dwellings are near the dams have no particular claim to them. To be sure, one might ask those who live near-by to fish in the spot for him, but solely because they know best how to use the nets there. (Spier 1930:149)

Trade and Commercial Fishing

By "commercial fishing" we refer to the harvesting of fish in order to exchange these for other products. Commerce is "The exchange of goods, productions, or property of any kind". (Black's Law Dictionary 1968:336) Although the scale was smaller in prehistoric times than at present, Klamath trade in fish preceded European entry in the region and expanded to include trade with non-Indians after their arrival.

Aboriginally, most Klamath fishing was for personal use and for trade. Spier writes as follows:

> Trade is probably of no great consequence within the tribe although it figures intertribally. Contacts were few and frequently unfriendly until after the coming of the whites. The exception is the neighboring Modoc groups; others are too distant. Winters are too severe for travel and trade, but summers find the Warm Springs people in residence with the Klamath. These similarly set out for Warm Springs and the Dalles when the grass begins to grow, camping there in the open during the summer, and building mat-covered structures of earth-lodge shape (wake'ploks) if they stay through the winter. Slaves, Pit River bows, and beads are taken there to trade for horses, blankets, buffalo skins, parfleches, beads (probably dentalium shells), dried salmon, and lampreys. (Spier 1930:41)

There was some trade among people within the Basin. The Modoc, who originally had less access to salmon, sometimes obtained them from the Klamath in trade. (Ray 1963:192) Such trade among Indian groups continued into the historical period. Klamath Tribal members Mr. Tuba Lang and Mr. LeRoy Hicks report hearing older tribal members, such as Harold Wright, tell of taking wagon loads of (dried?) salmon up to Huckleberry Mountain in August in the early 20th century. There, tribal members encountered Indians from other places and the salmon was traded for other products. (Personal communication 19 October 1981)

When Whites entered the Klamath Basin, they purchased salmon and other fish from the Klamath Basin peoples. Ogden obtained fish during his visit in 1826. (Minor et al 1979:140) At Klamath Lake, in May in 1846, Fremont traded for salmon with the Klamath:

> All here was in the true aboriginal condition, but I had no time now for idling days, and I had to lose the pleasure to which the view before me invited. Mr. Kern made the picture of it while we were trading with the Indians for dried fish and salmon, and ferrying the camp equipage across the outlet in their canoes.
>
> . . .I thought that until the snow should go off the lower part of the mountains I might occupy what remained of the spring by a survey of the Tlamath River to its heads, and make a good map of the country along the base of the mountains. And if we should not find game enough to live upon, we could employ the Indians to get supplies of salmon and other fish. (Underlining added. Fremont 1887:484,486)

By the end of the 19th century, members of the Klamath Tribe, while continuing to catch salmon for family consumption and for trade to other Indians were also selling salmon to local settlers.

Bertha Lotches reported:

> "Many of the salmon my husband speared and caught out of Srague River we traded to farmers and merchants in Lake View and Pine Creek, Oregon. For the salmon we would get horse feed from the whites, a little money, vegetables and fruits. This was the practice of numerous Indian salmon fishermen in the Beatty area. They would trade a large portion of their salmon for money and for food commodities to the whites in these places and the whites farming and working in that locality."

According to David C. Skeen, he knew that the Indians would catch all of the salmon they would need for their own use and that of their friends in the particular area. He said in his affidavit:

> "I often times bought fresh salmon from the Indian fishermen and paid them $1.00 a fish at different times." (USFA-Seattle RG 75 Box 220)

This was commercial fishing on a small scale. The market was limited because the purchasers were local people. There was no fish processing plant in or near the Klamath Basin.

The only large scale commercial fish processing plants on the Klamath River were at Requa at the mouth of the river. The first cannery there was established in 1888. (Cobb 1930:438) The fishery was a gill net fishery from dug out canoes conducted by Yurok Indians on their reservation in the estuary of the river:

> In the early 1900's there were three salmon canneries and a cheese factory at this site. The first salmon cannery was built in 1888. Fishing was done by Requa Indians gill netting from dugout canoes. By 1918 all but one cannery were abandoned but this one (the Fields Cannery) continued to operate until January 1, 1934, when state law closed commercial fishing in the river. In order that all the Indians would have an equal chance at the fish, no nets were permitted out of a canoe until an evening bell at the cannery was rung. The fishermen were on location and when the bell rang there was a clatter of wooden floats on the gunwales as the nets were shot.

The little town, mostly Indians, was known to sportsmen before the turn of the century. The Requa Hotel was well filled by sportsmen seeking salmon at the lagoon or steelhead up the river. Stages from Eureka ferried across the river to make their night stop at Requa. After the bridge in 1925 replaced the ferry much of the sport fishing moved up river to the new town of Klamath but Requa still has a host of fishermen during the season. (Scofield 1954:29)

The peak years for salmon canning at the mouth of the Klamath were 1912 and 1915 with most of the fish coming from the river. (Fry 1949:45) We say that most of the salmon came from the river, -- the lower portion and the estuary, because ocean trolling for salmon did not commence on the northern California coast until after 1916. (Scofield 1954:43) Available data are not adequate to relate the decline in the Lower Klamath commercial salmon fishery to the blocking of the river by the first COPCO dam but the general coincidence of the two events is suggestive.

By 1918, only one of the three canneries was left. (Scofield 1954:29) This plant was closed when the Klamath River was closed to commercial fishing in 1933, which reinforces the idea that the canneries at Requa depended almost entirely upon Klamath River salmon. (Fry 1949:46) With the closing off of the Upper Klamath River and the Klamath Basin, a significant source of salmon was gone.

We have given some evidence for and some reasons why salmon were important in aboriginal Klamath life. The statements by elders taken in the 1940s provide abundant data regarding the use and importance of salmon from the late nineteenth century until the runs were blocked and destroyed by the first COPCO dam in the period around 1911. With respect to this, we cannot improve on the statement of Simmons. There follow some excerpts from his statement:

Almost every affidavit obtained from these Indian members of the Klamath Tribe contains statements to the effect that every Indian male or female, minor or adult, on the Klamath Indian Reservation, participated in the benefits received from the salmon fishing activities of members of the tribe. It was the custom of Indian fishermen with their families and friends, to come to the banks of the river and there camp during the salmon fishing season. Practically every able-bodied male member of the tribe would spear fish, during this time, taking enough salmon from the river to care for their families' needs and those of relatives and friends. The Indian custom of helping their neighbors was strictly maintained and a superabundance of fish were caught yearly. Approximately one-half of the fish caught were dried and kept for winter consumption and one-half eaten fresh.

Again quoting from Bertha Lotches statement:

> "The salmon caught each year out of the Sprague River provided more than one-half of the food supply for the Indians living there. The Indians in those years had no per capita payments. The only food rations given at the Agency were to the sick and people in dire distress. The Indians had to shift for themselves and live as best they could. The loss of salmon was very serious. Salmon to the Indian is like bread and butter to the white man. To many Indian families the salmon fish provided the entire meal. The Indians did but little farming and then only raised wild hay in the Beatty locality. They had not been trained to raise vegetables, fruit or grain to any extent."

The popular fishing stream of the Indians was the Sprague River, which is an ideal salmon stream, due to the swift current always prevalent in the river. Williamson River was a very poor fishing stream because of the tranquillity of the water. The favorite fishing spots of the Indians were the Baking Powder Grade and Cottonwood Springs fishing places, located on the Sprague River. These fishing locations of the Indians are shown on the large map (Exhibit I). Pictures of the spots were taken by B. G. Courtright, Superintendent, of the Klamath Indian Agency, during the latter part of July, 1941. They were pointed out to him by Indians who actually fished there and from whom affidavit were secured. (Exhibit II--pictures of fishing locations along the Sprague and Williamson Rivers).

Tom Lang, speaking of the numbers of Indians fishing for salmon, states:

> "As I stated these runs occurred during September and October of every year and lasted about sixty days. This did not include the spawning period for the Indians never caught salmon during that time. I remember each and every year the Sprague River at the fishing hole known as the Baking Powder Grade would be filled with fish. I speared fish there with other Indians each and every one of these years. It was the custom of the Indians to migrate to this fishing hole and to the fishing holes on Sprague River in large numbers. Practically all of the able-bodied

members of the Tribe and their families would come each year during the fishing season to these fishing holes and establish camps there and drying racks. We would fish day and night, large bonfires would be built at night which would burn continuously allowing the fishing to continue throughout the night. The fishing there was all done with spears, no nets were used or tackle of any description.

"During those years about one-third of all of the Indians of the Klamath Indian Reservation who lived along the Williamson and Sprague Rivers would migrate to these fishing spots and establish camps there and remain in there during the entire fishing period of 60 days during September and October of each year. The families would return home when they had secured sufficient fish to last them until the next fishing season. Many of the Indians who were particularly fond of fishing and expert at spearing the salmon would remain during the entire season. Off and on during the season I would estimate that approximately 1500 Indians came in to fish. This was especially true during the early years when there were many more Indians on the reservation."

And Bertha Lotches places the Indian population at about 1200 exclusive of women and children:

"From 1901 to 1910 there were about 600 adult Indians living in and around Beatty. About half of the Indians on the reservation were located in the Beatty, Oregon, area, and half in and around Chiloquin, Oregon. This estimate of adults living around Beatty does not include women and children. About 200 adults would actually spear and catch salmon out of the fishing holes of the Sprague River each year. Their families would, of course, aid them in drying the fish and in making camps near the fishing holes during the salmon runs. The salmon runs as I recall occurred late in August and lasted until early in October. Every Indian fisherman had the opportunity of participating in spearing salmon during these runs. . . .It would generally take fishermen about a week to get all of the salmon necessary for their family supply for the year although it is true that some fishermen who were particularly expert and loved the sport would fish almost constantly during the runs. I mean by that day and part of the night. They would fish by torch light at night."

It is somewhat difficult to estimate the number of pounds of salmon taken from reservation streams and consumed by members of the Klamath Tribe of Indians annually. A close approximation can be made.

According to Tom Lang:

"On the average each and every year from 1898 to 1910, with my family, I would take out of the reservation waters 50 or 60 salmon between 40 and 50 pounds in weight. This amount would provide for our family which usually numbered between 12 and 14 persons until the next fishing season the following fall. . . . ."

"The average adult Indian would consume three and four salmon, weighing approximately 40 pounds each year. . . ."

Each Indian would, on the average, consume 200 pounds of salmon annually. Assuming there were 1500 Indians on the reservation, which is a conservative estimate, the annual average consumption of salmon would approximate 300,000 pounds.

When you consider the facts that the Indians liked salmon, that they did very little if any farming, had no money and small per capita payments in supplies mainly, and were dependent almost entirely on salmon for their main source of food supply, this estimate is most conservative.

However, using the same, Bertha Lotches would cut the annual consumption of salmon down to 150,000 pounds of salmon, making no deductions for consumption by children:

"Each adult Indian in the Beatty locality would, on the average, consume about 100 pounds of salmon annually. A child living there would consume on the average about 25 lbs. of salmon annually."

There was always more than sufficient salmon to supply the needs of all Indians in the reservation.

Quoting from Bertha Lotches statement:

"I can truthfully state that there would be ample salmon taken out of the river to provide sufficient salmon for each Indian family on the reservation each year. There was always a surplus of salmon available to be caught."

Clayton Kirk reduces the annual consumption to 120,000 pounds.

"In trying to arrive at the quantity of fish caught annually on an average from 1890 to 1909 you might compute it in this way: There are 1,000 Indians, we will say, on the average, including the total population of those Indians that ate fish, with on the average of two fish a day, weighing about 20 pounds. If they ate two fish during the time of the two salmon runs, they would consume 40,000 pounds annually. That is the nearest we can come to computing this. Those fish were salmon. In addition each Indian dried at least 4 salmon each year weighing on the average 20 lbs. for winter consumption which would last until the next salmon run. I would say all of the Indians each year would dry 80,000 pounds annually. We would dry some and had some fresh fish. I estimate that 1/6 of the sustenance of all of the Indians residing on the Klamath River between the years 1890 and 1909 was provided by the salmon fish caught in the reservation streams. I base this conclusion on the following facts:

"During this period from 1890 to 1909 there were very few places that the Indians could secure other food from mercantile establishments, the largest one being in Klamath Falls, known as Linkville at that time, a small town of about 1,000 people, in 1890. The other place was Fort Klamath, the store being built about 1890. The third place was at Bly, ten miles east of Beatty near the southeast corner of the reservation. The next place was at Bonanza, Oregon, 20 miles southwest of Beatty. The three stores or mercantile establishments were very small. Also the Indians at this time didn't have very much money. While they sold approximately 18,000,000 acres of land in their Treaty with the United States Government, negotiated October 14, 1864, these were paid for by the Government in largely maintaining the reservation, providing schools, manual training and a portion of it was prorated by giving each Indian Blankets, fish hooks, building materials and other equipment for husbandry for a period of 25 years. There were no per capita payments during those years. Under this treaty the Indians were also given a few head of stock for heads of families and the only way at that time that the Indians could get any cash was on the sale of stock and what they could earn by hard labor in making rails, putting up hay, farming, whatever employment they could get was from the few settlers that surrounded the reservation in the localities of Bly, Bonanza, Klamath Falls and Fort Klamath. While it is true that game was plentiful on the reservation very few members of the tribe participated in hunting. All of the members of the tribe participated in the fishing benefits and in addition all of the Indians liked salmon fish. It was the principal subsistence food, from what all the Indians told me, since time immemorial."

It is amazing to read the statements taken from many of the Klamath Indians in regard to amounts of salmon taken out of the reservation streams at various intervals.

Erskine Beal, in his affidavit, states:

"I remember distinctly during 1904 on several occasions I would drive a spring wagon to the fishing holes and fish all night with the Indians getting sufficient salmon to load this wagon full of salmon fish. The wagon would hold approximately 35 to 40 salmon, the salmon varying in weight between 10 and 40 pounds. . . .There would sometimes be between 100 and 125 Indian fishermen spearing fish during these runs. Thousands of pounds of salmon would be taken out during the heavy runs. . . .

". . . .This was the run of the chinook salmon. Once in awhile some steelhead would appear but the run was composed almost entirely of chinook salmon. This run would last a little longer than a month. I have caught many 40 pound salmon at the fishing holes on Sprague River near Beatty, Oregon. . . ."

John Cole made the following statements:

"50 or 60 Indians would be fishing during the time that I was there. I have frequently participated in taking between 1200 and 1300 pounds of fish from the Sprague River at Baking Powder Grade fishing hole in three or four hours. Three of us would very frequently remove betwen 1200 and 1300 pounds of fish in that period of time. . . ."

Mrs. Eliza Crawford recalls that each year from 1893 to 1909 her husband would bring in several hundred salmon fish, 50 of which would be dried, 50 would be salted in brine and 100 would be eaten. Also many fish were given to friends. She says:

"None of these salmon caught by my husband weighed under ten pounds. One of the salmon caught I remember distinctly which we happened to place on the scales weighed 22½ pounds."

In John Jackson's affidavit, it is stated:

". . . .I would usually take out between 300 and 400 pounds of the salmon each year. We would dry half of the salmon and use them during the winter. The salmon furnished us with a large part of our food. We would eat salmon almost every day unless we had a supply of fresh fish, trout or mullets available.

". . . .There would be from 75 to 100 adult Indians spearing salmon in the stream and probably 100 or so Indians with their families camped there. . . . Groups of Indians would remain camped there from about one to two weeks until they had secured sufficient salmon for their present needs and for winter consumption. Then they would leave and other Indians move in. This occurred constantly during the entire period of the salmon runs in the fall of the year. These runs would last about 60 days. There would probably be several hundred Indians fishing there at different intervals during the salmon runs." (USFA-Seattle RG 75 Box 220)

Although salmon spawned in a number of streams in the Klamath Basin, tribal members state that the major salmon stream in the late nineteenth and early twentieth century was the Sprague River. Salmon ran up the Sprague to the vicinity of Bly, which is only a few miles beyond the eastern boundary of the reservation. "They went up the Sprague almost to its source and were plentiful at

Beatty, Oregon, located on the Reservation. (Courtright 16 January 1941) This means that almost all of the fisheries on this major salmon stream were within the boundary of the Klamath Reservation. (Map VI)

The bulk of the salmon in the Basin were a Klamath Tribal resource for:

> "the exclusive right of taking fish in the streams and lakes, included in said reservation, and of gathering edible roots, seeds, and berries within its limits is hereby secured to the Indians aforesaid." (16 stat. 707)

KLAMATH DAMS

Copco I

The original dam which blocked the movement of anadromous fish up the Klamath River into the Klamath Basin in southwestern Oregon was COPCO I (S29 T48N R4W, upstream from adjacent COPCO II) in Siskiyou County, California. (Map IX) This is a power dam which was built by the Siskiyou Electric Power and Light Company for the California-Oregon Power Company (COPCO). One of the founders of this latter company was Joseph D. Grant. The following comments taken from his memoirs dramatically detail the circumstances leading to the construction of the barriers:

> I rushed, like John Gilpin (being also a simple draper) into this big power business, as gaily as John mounted his steed.
>
> Why?
>
> I had money to invest. A friend had told me of a dam site on the Upper Klamath River adapted to the production of power on an immense scale. I looked at that site. What I saw took my breath away: a vision of tremendous possibilities. Perhaps I had a touch of mountain fever. Anyway, I persuaded some friends of mine to join me; we got control of the power-site; we went joyously to work; and we wallowed for a season in a fool's paradise.
>
> In 1911, we incorporated as the California-Oregon Power Company, absorbing the Siskiyou company. I found myself president of the consolidated corporation.
>
> Our field of enterprise, which went on swelling "wisibly", like the fat boy in Pickwick, covered an area of 16,000 square miles -- a territory larger than Switzerland and almost as mountainous. Mount Shasta, in its majestic isolation the grandest peak in California, reminded me of the emblem of our clan. To the north are the Siskiyous and the Cascades, down whose sides boil the waters of three magnificent rivers, the Klamath, the Rogue and the Umpqua. We picked up power sites on all these.
>
> Within this region are the chain of Klamath Lakes; the weird lava beds where Captain Jack and his Modoc braves fought our soldiers in 1873; and that world-wonder, Crater Lake, held within the chalice of an extinct volcano. How tonic to gaze at such scenery, and what a sportsman's paradise! My canny Scots instinct told me that these

amenities would attract many visitors to our highlands and enhance the prosperity of the whole territory. But I confess that now and again my extremities were chilled. In our own racy slang, had we bitten off more than we could chew? In economic development, this region was a last frontier.

Whereas Switzerland supports some 4,000,000 inhabitants, our territory had hardly 100,000 people, despite the promise of its fertile acres in the Rogue, Shasta, and Umpqua valleys. Manifestly, much pioneering remained to be done. Upon this task our power company entered with brisk enthusiasm, playing nurse to agriculture in the valleys, and to lumbering and mining in the mountains.

In 1911 we began the dam in a narrowing of the Klamath River canyon nine miles downstream from the point where the river enters California, a spectacular location, in lava rock-formations, wild and rugged, and the scene of Indian warfare. Hard by the dam, old flintlocks and other relics were turned up by our workers.

We named our dam Copco One -- "Copco" signifying California-Oregon Power Company. Above the dam was created a man-made lake, a silver sheet of water six miles long and a mile wide. Geologists reminded us that this was not the first time the valley had been submerged; they pointed out that ages ago a natural obstruction blocked the river-channel, just as the steel-and-cement wall does today.

Meanwhile, our business barometer, apparently at "set fair," began almost imperceptibly to indicate a change in financial conditions. We hadn't money enough. The will to win through, animating all of us, outstripped performance. We had acquired control of other properties, but we lacked cold cash to develop them as adequately as our engineers, the best men in the state insisted that they must be developed. Finally, I went to New York to interest if I could, certain bankers who "specialized" in hydroelectric development. I failed to interest these gentlemen. My fault, no doubt. I was a novice high finance, and they had not seen our properties. They said -- a statement which I salted away -- that for the moment no capital was available. Somehow I felt that I might be pretty smart in the drygoods business but I was a qualified fool as a "promoter."

To make matters worse for me and my loyal friends, we had come within an ace of getting active support from one of our big railroad men. From the inception of our enterprise, we had had in mind that the great railroads would electrify their mountain lines.

I met E.H. Harriman in San Francisco. He asked me what I intended to do with our power site. I said that my associates and I were planning to develop it, "Go ahead," enjoined Harriman, "and if you need money, I'll advance it." We had no written understanding with the colossus, and when he died we could not approach his heirs, as his offer had been informal. Had he carried out the electrification of the Siskiyou division of the Southern Pacific he would have been the first in the United States to electrify a trunk-line railroad. A few years later the Chicago, Milwaukee and St. Paul won this distinction with the electrification of its Rocky Mountain division.

> In our power development I had worn out my jeans reaching for more money. And my own friends, whom I had lured into this thing, had worn out shoe leather in the same quest. Our dam, the pride of our hearts, had cost three million dollars instead of two.
>
> Returning to San Francisco, our little group met, faced the facts, and we practically agreed to pool all our available resources. Salvation might yet come from within; it couldn't come from without. We were risking all we had, we were imperiling the comfort of our wives and families, we were gambling with life and happiness. It was, as we all agreed, Death or Victory.
>
> I pause for a moment to consider what might have been the attitude of the Man in the Street towards us, not as we were, but as we appeared to be (carrying on outwardly as usual) -- bloated capitalists. Such a man might have exclaimed: "They were out for big money, having more already than they deserved to have: I don't pity them!" But we were not out for money in that material sense. We were not out for "power" (no pun intended); we were, to a man, almost crazy mad to <u>do</u> a big thing for California and Oregon, whereby conditions might be enormously bettered. We wanted, if you like to exclaim with the architect, Christopher Wren: "This is our monument."
>
> To emphasize our financial position, one cheery soul on our board, when we met after my return from New York, said to me: "Joe, don't you know we're already bankrupt?" Well, we weren't; I knew it; so did he; but we were sailing perilously close to the wind.
>
> Meanwhile we tried to get control of other properties. There were only three of us. When we attempted to negotiate, the vendors told us that they would sell provided we put up a large deposit in cash. We couldn't do it. Others bought the properties. We had coveted them not out of avarice but because we saw so clearly that a whole could be worked infinitely more cheaply and efficiently than a part. (Grant 1951:339-342)

Boyle, the engineer involved in the construction of Copco 1 and other Copco dams provides more details of construction and of Copco affairs in the region in the ensuing period:

> During the period of 1908 through 1911, the Siskiyou Electric Power and Light Company had extended its holdings by acquisition of several smaller power properties in Southern Oregon and Northern California. Also it had expanded its transmission system to include line 1 to Yreka, line 2 to Dunsmuir, line 3 to Medford, and line 4 to Klamath Falls. All of these lines were connected to the Fall Creek generation station, the center of production. Two proposed plants in Ward's

Canyon would be easily connected by short lines to this load distribution center.

In early May 1910 the Siskiyou Electric Power and Light Company started surveys of Ward's Canyon on the Klamath River and the reservoir area above for the purpose of purchasing land and building a hydroelectric power plant.

. . .

The river bottomlands were covered with beautiful farms used mostly for cattle raising. The homes and buildings were old but generally well kept.

The river meandered throughout the area, slow flowing and deep until it reached the canyon, where it became very rapid.

The soil was river silt, some subirrigated and some irrigated from numerous springs, dip wheels and inflow creeks.

It would be necessary if a dam was built at the head of Ward's Canyon to flood practically all of those good farm lands.

The people who lived on their farms were very reluctant to sell even though the prices offered were somewhat high, but they realized that power development was progress and use of electricity was rapidly becoming a public necessity.

The principal owners affected were:

William Lennox	Mary Ward	George L. Chase
Henry Keaton	William Raymundo	D. D. Hahn
Maureza Aquada	Stone and Edwards	Erkine Parks
Kitty Ward	Henry and Herman Spannons	Manuel Crovelle

. . .

The first location selected for a dam was at the head of Ward's Canyon where the river broke over into swift water. It was also the place where Indian Jake (of the Shasta Indians) used to sit by the hour to spear fish.

The south abutment for a proposed dam looked perfect, but the north abutment looked questionable. Drifts were run with shafts and open cuts as far as 130 feet under ground and perpendicular to the river. The andesite from the south abutment ran nearly across the river then started down at 20 degrees and 40 degrees deeper and deeper. The material on top was talus of cinder, loose volcanic fragments and boulders of basalt. The answer was clear. Any dam at this proposed site for creating a reservoir would be questionable.

Work was discontinued on July 25, 1911 on this canyon entrance site.

By moving downstream about 1000 feet the andesite formation was exposed on both sides of the river up to about 130 feet above water level. This new site however would require a dam about 28 feet higher due to drop in the river. Savings could be made however by moving the powerhouse across the river and thus eliminating about 1000 feet of 16-foot diameter concrete-lined tunnel.

Because of proposed project was so close to Fall Creek it was decided to proceed with investigations, layout and design of the project. All this work was done on the job.

Foundation investigation and river diversion were started on "Klamath River Dam No. 1" in July 1911, and prospecting work on another plant below of about the same capacity was started on "Klamath River Dam No. 2" at the same time.

. . .

The area surrounding the project was a happy hunting ground for the Indians, plenty of fish in the river and bountiful wildlife in the lava canyon, especially in wintertime. Cats and birds of all kinds native to the country were in abundance on the sunny slopes between the rim rocks.

Indian "Tom" (a Modoc), and Indian "Jake" (a Shasta) did the fishing and most of the hunting. They lived with their squaws on Deer Creek just upstream from the Lennox ranch on public land. Tom was reportedly hiding so he would not have to go to the Oklahoma reservation.

. . .

Most of the other Indians in the neighborhood were mixed bloods, such as the Keatons, Griffiths, Raymonds, Frains, and others.

Kitty Ward, a full-blood Indian, lived in a tall log cabin which she and her white husband Tim built for a home. It was beautifully located on the lower end of the proposed reservoir beside flowing springs ample to irrigate some of the lands.

The cabin was below the flow line so when time to fill the reservoir came, Kitty was told it was necessary for her to move. She certainly knew how to put the white man in his place. Between sobs and tears, she refused again and again to leave her home saying "I no move, let water come, I die here." Tim had been dead for several years, but Andy Marlow, as a ranch foreman and keeper of her wampum cooperated in getting Kitty to visit in Hornbrook, a visit from which she never returned.

The area involved is shown on the outline map, Sheet H-53. It was contemplated at the time that the Copco No. 1 dam would be constructed to create a reservoir, and that the powerhouse would be located at the present Copco No. 2 site.

As a result of surveys, it was concluded that development of this project would produce more power (50,000 KW) than could be absorbed for a long period of time on the Company's system. Therefore the development was split into Copco No. 1 and Copco No. 2.

The plan adopted for the development of Copco No. 1 is shown on the following drawings: Sheets H-54, H-18 and H-91. Foundation investigations, consisting of tunnels, open cuts and diamond drill borings, were started in the fall of 1911 and completed in the spring of 1912. The project is described in an article written by J.C. Boyle for the Journal of Electricity, Power and Gas under date of February 22, 1913: Volume XXV, No. 8; and in the Yreka Journal, July 9, 1913.

Although the country surrounding the construction site is principally basalt, and the walls of the canyon themselves vary to 250 feet in height in lava, the river in its erosion had exposed a reef across the canyon at the location of the dam, approximately 130 feet high. This reef of andesite was apparently continuous for considerable distance on both sides of the canyon and considered to be the oldest exposed formation in the Siskiyou Mountains.

. . .

Two of the most interesting construction features of this installation were the diversion of the river from its channel, and the excavation in the river channel for the foundation of the dam.

The width of the canyon at the base of the dam was 70 feet, all of which was taken up by the water of the river. For 150 feet above the dam and for 350 feet below the dam, the river channel had a grade of 2 feet per hundred, producing a velocity in the water of about 20 feet per second. The erosion produced by such a current would not permit winging the river from side to side, neither would blasting in the river bottom permit fluming the river, so a wing dam of rock-filled cribs, 30 feet high, was made 100 feet upstream from the main dam.

This wing dam diverted the river from its original channel through an unlined tunnel around the east end of the dam. This tunnel is 356 feet long with a cross section of 16 feet by 18 feet and a grade of 2 feet per hundred.

The dam to be built was of the arch-gravity type, 130 feet in height above the bed of the river, 90 feet thick at the base and 13 feet thick at the top. The length of the crest would be 400 feet, curved on the arc of a circle of 356 feet radius, curvature upstream. The center 200 feet of the crest to be an overflow section capable of discharging the highest flood waters. At the upper toe there was a cutoff wall 10 feet thick extending below the foundation of the dam at least 10 feet, and at the lower toe there was provided an apron which would discharge the overflow water in a horizontal direction.

Owing to the position of the canyon walls at the dam site, it was found impossible to place the structure perpendicular to the river bed, the west abutment being further downstream than the east abutment. However, by making the dam curved with a 356-foot radius the ends were found to strike the canyon walls nearly perpendicularly. . .

In October 1912 excavation was started in the river bottom.

Practically all the work done during the two years from June 1913 to June 1915 was in the foundation of the dam. While the work progressed very satisfactorily, it was slow on account of the reduced force of men. The average number of men working during the two-year period was 27. . .

On March 1, 1913 the crew was reduced to 10 men and work was confined to maintenance of property, unloading powerhouse machinery and excavation on the dam foundations.

The California-Oregon Power Company was incorporated December 15, 1911 to acquire and consolidate with other properties of the Siskiyou Electric Power and Light Company which was then doing the construction work on the Klamath River Dam No. 1. (Boyle 1976:8-13)

We are uncertain as to the legal relationships between Siskiyou Electric Power and Light Company and California-Oregon Power Company for, further along, Boyle writes:

Copco Nos. 1 and 1-A were constructed by the Company's own forces and under the name of Siskiyou Electric Power and Light Company, was a construction company. (Boyle 1976:21)

Grant claimed to have gained control in 1911 but, Boyle quotes from the Yreka Journal passages which suggest that the take over occurred later:

However, a contract provided that the S.E.P.L. Co. should continue to completion the work in progress. Bonds and preferred and common stocks were sold by Copco to provide construction money.

On February 2, 1916 the Yreka Journal said: "In order to secure funds for needed construction work, the completion of the great power project at Copco, on the Klamath River, . . . the stockholders of the California-Oregon Power Company have assessed themselves $3.30 on bonds outstanding for five years. This method of financing construction work was deemed preferable to a new bond issue, which would increase interest charges on the company.

"A committee of bondholders has the power to make a settlement with the company, either for cash or stock covering interest in default. In addition to bonds deposited to secure borrowed money, there are $3,200,000.00 first and refunding bonds outstanding.

"The company is paying interest on $1,200,000.00 underlying bonds and on its floating debt and is earning enough to pay upon the first and refunding bonds, but necessary construction is underway for which the money is needed.

"These financial arrangements have been accompanied by a reorganization of the company, with some of the strongest financiers in California as executives. J. D. Grant of San Francisco, the new president; John D. McKee, vice-president, J. P. Churchill of Yreka, former president, is now a vice-president and Alex Rosborough, former secretary, is also a vice-president in charge of operations."

This marked the passing of control from Churchill to the McKee interests. The Churchills, Siskiyou County people, had pioneered and consolidated into an integrated company practically all of the power generating and distribution agencies in Northern California and Southern Oregon and therein invested much of their money.

. . .

In May 1910, river gauging was begun at the Ward's bridge and records of river discharges were kept daily. A study of the records over a period of five years indicated a change from a uniform flowing stream to one with lower water in summer and higher water in early spring. Answer to the change was readily found in the development of the reclamation and irrigation project being constructed by the U.S. Reclamation Service in the Upper Klamath basin.

While the change in river flows were not too serious at the time, they were destined to get worse as the Reclamation Service projects progressed.

The Company had already invested large sums of money on Klamath River Dam No. 1 and No. 2, so it was faced with either bringing suit involving interstate water rights or making some arrangement wherein it could get some measure of control of water in the Upper Klamath Basin.

During the Fall of 1915, a delegation of financial men and engineers from San Francisco made an inspection trip to appraise the work which had been completed, and to see what work remained to be done.

The appraisal showed about $1,000,000 had been spent and about $2,000,000 would be needed to complete the project. However, by leaving about 13 feet off the top of the dam and installing only one unit in the powerhouse the remaining cost might be reduced to about $1,000,000.

. . .

- The river had been diverted through the tunnel.
- The excavation completed on the abutment cuts of the dam.
- All explorations for foundations were finished.
- The layout for Copco No. 2 had been completed.
- The excavation for powerhouse No. 1 was completed to water level.
- The construction plant, crushers, sand machines, mixers and conveying equipment for concrete were ready.
- The two units for the powerhouse with transformers and associated equipment were delivered.
- The upstream cut-off wall for the dam foundation was finished to 30 feet above water level, and work was progressing on the downstream cut-off wall.

- The railroad had been made operational, and a one-mile spur had been built to camp and on down the canyon to the powerhouse.

All the difficult foundation work was done. What was needed now was cement, forms, reinforcing steel, labor, supplies and money.

The original plans were changed in the following respects. The original four-unit plant was reduced to two units. And instead of developing a peaking plant of 40,000 KW, it was reduced to a system load factor plant of 20,000 KW. Provision, however, was made on the downstream end of the powerhouse for expansion and installation of two additional units if warranted in the future. The forebay was eliminated. The original 17-foot diameter penstock was replaced by two 10-foot diameter penstocks connected directly from the dam to the twin turbine wheels of Unit No. 1. A bulkhead at the west end of the dam provided space for the second unit.

. . .

Then came a variety of jobs to be done. These were to:

Build the new fish traps at Klamathon and survey and build a fish hatchery, with attendant cottages, for the California Fish Commission at Fall Creek.

Copco had worked out a plan with the Pacific Gas and Electric Company, and the Northern California Power Company to build an interconnection of the three systems. "The arrangement was accomplished by a tri-party contract" which enabled Copco to dispose of a large amount of surplus power when Copco No. 1 plant was put in operation and thereby substantially add to its revenues. (Boyle 1976:13-15)

The building of COPCO I began in May, 1911 and was completed in 1918. (Courtright to Simmons 24 June 1942) Snyder states that it was "operative as a barrier October 25, 1917, according to H.A. Frazer of the California-Oregon Power Company." (Snyder 1931:22) This dam was 110 feet high. The water backed up behind it formed formed COPCO Lake.

Copco II

COPCO II was built about ½ mile downstream from COPCO I (SW¼ S29 T48N R4W). (see Map IX) Construction began in 1916 and was completed in 1925. (Simmons to Chapell 5 August 1940) Again, Boyle provides detail:

Location survey work, prospect work, foundation investigations and general layout of the Copco No. 2 project were made during the time Copco No. 1 was being built.

As originally planned in 1911 and 1912, this plant consisted of a dam, spillway, open canal and tunnel to a four 10,000 KW unit power plant.

Before construction was started, the development was changed to a two-unit plant to handle the streamflows through the Copco No. 1 powerhouse. The dam, waterways and powerhouse were changed to generate 30,000 KW under a static head of 157 feet, net operating head of 140 feet, and a water capacity of 2600 to 3000 second feet.

Before construction was started, economic studies were made of the development, the result of which provided for the following:

(1) A diversion dam about 50 feet high located about 1300 feet downstream from Copco No. 1 dam, together with a concrete intake structure, spillway gates and accessories.
(2) A 16-foot diameter horseshoe-shape concrete-lined tunnel (No. 1) connecting the intake at the dam with a woodstave pipe.
(3) A 16-foot diameter creosoted Douglas fir woodstave pipeline to Tunnel No. 2.
(4) A 16-foot diameter horseshoe-shape concrete-lined tunnel with an underground pipeline to Tunnel No. 2.
(5) Two 13½-foot diameter steel penstocks about 400 feet long.
(6) Reinforced concrete and structural steel powerhouse containing two 15,000 KW units with accessory equipment.
(7) Power to be generated at 6600 volts and stepped up to 130,000 volts to make deliveries to Pacific Gas and Electric Company over Line 14.

Construction of the Copco No. 2 dam was involved with the difficult problem of dewatering the foundation because of the loose material encountered in the river bottom at the dam site. It was necessary to build a diversion flume over the dam site from a cofferdam upstream. While this cofferdam and flume were well constructed, there was leakage of about 30 second feet which had to be accumulated in an auxiliary flume while excavation of the dam was in progress. It was also necessary to construct a cofferdam downstream from the dam to prevent backwater entering the excavation.

. . .

Tunnel No. 1 is approximately 2400 feet long with one adit about midway between the upper end and the lower end, making four headings with one ventilating shaft.

. . .

The connecting link between Tunnel No. 1 and Tunnel No. 2 consisted of 1313 lineal feet of 16-foot inside diameter creosoted fir woodstave pipe under contract with Continental Pipe Manufacturing Company.

. . .

Tunnel No. 2, about 5000 feet long, connected the 16-foot diameter woodstave pipe to the two 13½-foot steel penstocks. It was driven from two headings. The excavated section was sufficient to obtain a 16-foot inside diameter horseshoe section with 9-inch concrete lining in rock and 21-inch concrete lining where timbered.

The surge chamber, constructed in rock above the tunnel, was unusual as to size and design. It had a vertical vent from the top of the surge chamber and an overflow spillway which carried any surplus waters back to the river channel above the powerhouse. The tapering portion of the chamber was concreted; the lower portion was gunited.

The penstocks were connected directly to the outlet of Tunnel No. 2, and each penstock was connected directly to the turbines in the powerhouse. Anchor blocks included both penstocks, and the sections between anchor blocks were backfilled to the springline with loose rock.

. . .

Copco No. 2 plant was put into commercial operation in July 1925. Capacity 30,000 KW. (Boyle 1976:16-17)

Iron Gate

A third dam, Iron Gate, was begun in 1960 and completed in 1962. The state application for a permit to appropriate water for this development was filed April 16, 1956. (Boyle 1976:55) It is about eight stream miles downstream from COPCO II (SW¼ S9 T47N R5W). (Map II) This dam was built both for power and to regulate water fluctuations attendant upon the operation of COPCO II and to add to power production. This dam had a long and complicated preliminary history relating not only to COPCO I and II but also to water management upstream in the Klamath Basin:

Copco's plan followed very closely the requirements of the Federal Power Commission, namely that an application must include a proposal to develop and utilize all the power resources of the area.

On May 9, 1921, application was made to the Federal Power Commission for permission to investigate a stretch of river about 10 miles in length lying in Oregon immediately above the state line, for the purpose of the ultimate development of about 320,000 KW between Keno and Iron Gate. The Federal Power Commission issued a permit No. 215 on November 27, 1922 under which engineering studies could be made.

On May 12, 1921, application was made to the State Engineer of Oregon to appropriate 1500 second feet of water for the development of 70,000 THP (theoretical horsepower), application No. 7894, on this same stretch of river. Permit was not issued by the State Engineer for the reason that the Attorney General of Oregon had rendered an opinion that those waters were not subject to appropriation having been transferred to the United States for irrigation purposes under Oregon Legislative Act of 1905.

As time passed, engineering studies were completed and the preliminary layout of projects submitted and revised applications to the Federal Power Commission and the State Engineer of Oregon.

The original state filing No. 7894 was changed and new filings made as follows:

Canyon Project	No. 13603 - 28,295 THP)
	original No. 7894
Big Bend	No. 13604 - 65,455 THP)
Grant No. 2	No. 13605 - 36,477 THP
Grant No. 3	No. 13606 - 17,045 THP
Grant No. 4	No. 13607 - 34,091 THP
	181,363

These applications were before the State Engineer for approval and Copco asked that the Canyon Project be approved for construction. The Company had appropriated $4,000,000.00 and had received a preliminary license from the Federal Power Commission. This preliminary license was recalled when the FPC was advised that Copco had not been granted a permit for use of the water from the state.

Legal questions arose as to whether or not the state "could issue any permits for appropriation of any of the waters within the Klamath River or the Klamath Lake basins." The State Engineer advised that permits pending would not be approved by the State Reclamation Commission until a license was obtained from the Federal Power Commission. A hearing was held before the State Reclamation Commission on October 10th, 1930 in Salem, Oregon. Protests were filed for and against issuing a permit. The Commission sought to determine whether or not water appropriated would impair or be detrimental to the public interest. Eighty-seven pages of testimony were taken. Finally, it was proposed that a bill (S-315) be introduced in the January 1931 session of the Oregon Legislature for the purpose of clarifying the matter of water rights below Keno. State authorities, lawyers, and public officials prepared the bill. It passed both houses but was vetoed by the governor.

> The governor and his staff delayed further action until the act creating the Hydroelectric Commission of Oregon had become effective.
>
> The Hydroelectric Act of January 22, 1931 provided for a commission within the State of Oregon similar to the Federal Power Commission. It had jurisdiction over the water power resources of the state and required that all pending applications for the development of power be referred to the Commission within 60 days. The State officials were contemplating going into the development and marketing of power.
>
> Copco did not transfer its applications on the Klamath River to the new commission because there still remained considerable uncertainty about water rights. So the State Engineer canceled the pending applications and advised that if renewed, they would have to come under the new Hydroelectric Commission of Oregon, stating that Copco had lost their priority and that the only way they could regain that priority would be through litigation.
>
> The Company then transferred its activities to the Iron Gate site in California on the Klamath River and decided to use the $4,000,000.00 approved for the Canyon Project on Iron Gate development.
>
> The applications to develop the Iron Gate site filed with the Federal Power Commission and the State of California again brought up the old problems of water rights. Legal and legislative procedures involved not only the waivers in favor of irrigation in Oregon but extended them also to California. These waivers plus the question of interstate rights plus the question of prior rights to use of water at Copco No. 1 and Copco No. 2 in California were discussed in several conferences but no satisfactory agreement was reached, so the Iron Gate project was indefinitely postponed early in 1932. (Boyle 1976:50-51)

In 1924, the Klamath River downstream from Iron Gate had been set aside as a fish and game district by a legislative act. Further dam building in this area was forbidden:

> The main Klamath River, from its confluence with the Shasta River to its mouth, is presently closed to any development by a "person, firm, corporation, or company," which would necessitate the construction of a dam or obstruction to the flow of the stream. This portion of the river was set aside by an initiative act, approved by the electorate of the State of California in 1924, which established the Klamath River Fish and Game District. (Cal DWR 1960:71-72)

However, the COPCO dams, by virtue of their design, had created downstream problems. Simmons explained the problems created by COPCO II (although he confused II with I):

The California Oregon Power Company made extensive surveys of the Klamath River for power possibilities from 1904 to 1907. Sites for two dams in the Klamath River in the State of California were located through these surveys. The largest of these dams, to which the Indians constantly refer, an enormous concrete structure, 110 feet in height, without fishways or ladders of any kind, is located near Copco, California, and was completed in the year 1925. The first dam in the Klamath River, located about three miles below this large dam, was commenced about the year 1905. This is a diversion dam and carries water through a tunnel built in a mountain. On the other side of the mountain, the water is taken out and due to a considerable drop, power is developed. The diversion dam was complete between the years 1909 and 1912. No fish ladders of any kind were installed in this dam, although some of the fish did manage to make their way up over the dam.

After the diversion dam went in operation there was very little water in Klamath River during the salmon runs, as it was all being diverted through the tunnel in the mountain to develop power. Consequently, the salmon could not even get as far as the diversion dam after its completion between the years 1909 and 1912. This is apparent from a picture taken of this dam, which is in the District Counsel's file. However, the majority of the salmon did not proceed up the river any farther than this site of the large Copco dam, where construction work was being done. (Simmons n.d.:18)

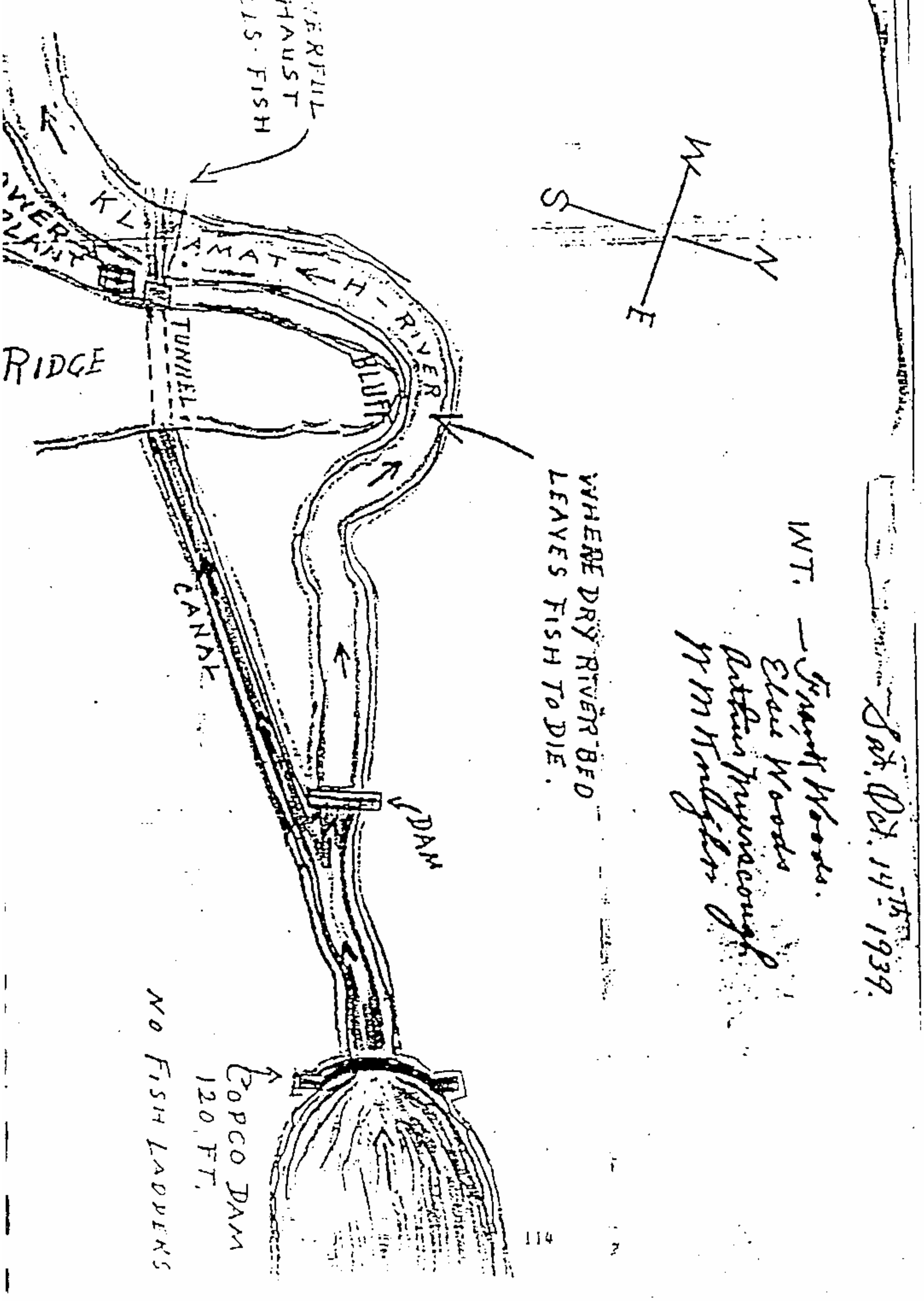
A sketch, Figure 1, made by W.M. Knight for Superintendent Courtright helps to explain the situation created by COPCO II.

By the 1950s, it was clear that variations in flow caused by the operation of the COPCO dams were causing serious damage to fish in the Klamath below the dams.

Present dams and power plants on the Klamath River proper have created fluctuating flows detrimental to fish life as well as a threat to human life, a situation which requires remedial action in the near future. (Cal DWR 1960:150)

In 1957, the Federal Power Commission ordered the California Oregon Power Company to take steps to solve this problem. The 1960 annual report of the FPC discusses the problems and the proposed dam for which it gave approval:

Figure 1


POWERFUL EXHAUST KILLS FISH
KLAMATH RIVER
POWER PLANT
RIDGE
TUNNEL
BLUFF
CANAL
DAM
WHERE DRY RIVER BED LEAVES FISH TO DIE.
COPCO DAM 120 FT.
NO FISH LADDERS
W
S
N
E
Sat. Oct. 14th 1939.
WT. — Frank Woods.
Elsie Woods

Evidence adduced at the hearing by the California Department of Fish and Game was to the effect that the Klamath Basin contributes a major share of California's sport and commercial salmonoid fisheries. King (Chinook) salmon, silver salmon and steelhead trout are the principal species. All three species were taken commercially in (some parts of) the river until 1934 when legislation prohibited the activity. It appears that below the Copco plant there are sizeable numbers of rainbow trout. However, the method of operating this and upstream plants has caused the river level downstream to fluctuate severely. Under normal operations there are changes in elevation of the river level of two feet or more one-half mile below the Copco plant when flows therefrom range between 3,200 cubic feet per second to less than 200 cubic feet per second. The evidence shows that fluctuating water levels such as this have a decidedly detrimental effect on fish and aquatic life.

In 1958 the Department studied the effect of fluctuations under a proposal by Copco to limit them to nine inches per hour with a minimum flow of 500 cubic feet per second. The proposed schedule was rejected by the Department "because it did not solve the stranding problem and also because the fluctuations under the proposed schedule still appeared too hazardous to anglers fishing the river below the Copco plant."

. . .

A reinforced concrete arch dam in the SW¼ section 9, T. 47 N., R. 5 W., Mt. Diablo meridian, constructed initially to elevation 2,225 feet (U.S.G.S. datum) with valve controlled discharge and creating a reservoir for regulation of the river below the dam, and associated fish-trapping facilities described in the drawing designated as Exhibit 62-A in the record of the hearing on the application. Ultimately, the development would be completed by increasing the height of the dam and incorporating therein a gated spillway section to create a reservoir with normal water surface at elevation 2,328 feet (U.S.G.S. datum) and extending upstream about 7 miles to Applicant's existing Copco No. 2 development.

. . .

Article 40. Except for conditions beyond the control of the Licensee, the initial stage of Iron Gate Development shall be so operated that the rate of fluctuation of flows in the river below the dam shall not exceed 250 cubic feet per second of water per hour and that the change in river stage or elevation shall not exceed three (3) inches per hour as measured at a gage located not more than one-half (½) mile downstream from the dam, whichever produces the least amount of fluctuation; and Licensee shall release over, around or through said Iron Gate Development a minimum flow of not less than 710 cubic feet per second of water into the natural channel of Klamath River, for the protection and preservation of fish and wildlife;

Article 41. After completion of the ultimate stage of Iron Gate Development and except for conditions beyond the control of the

Licensee, licensee shall release over, around or through Iron Gate Development a flow of not less than 710 cubic feet per second of water into the natural channel of Klamath River and shall not fluctuate the flow of said river below the Iron Gate Development in any manner or at all. (FPC AR 1960:66,69,72)

Klamath Development Downstream

The California-Oregon Power Company and other groups explored the possibilities of downstream development:

> Lower Klamath River Basin. The Lower Klamath River Basin included the Klamath River and all its tributaries between Iron Gate and its confluence with the Pacific Ocean. This part of the basin included Shasta Valley and Scott Valley as the areas most likely to be developed by irrigation. The balance of the area needed very little water for the lands which may be irrigated and, because of its canyon walls and rough terrain, it had been established as a fish and game district by legislative act of California, December 17, 1924. This act also prohibited the construction of any dam or other artificial obstruction below the confluence of the Klamath River and the Shasta River.
>
> There are at least ten dam sites along the Klamath River between Iron Gate and the mouth of the river, none of which were developed. They were chosen by different engineers at different times and made the subject of exhaustive reports.
>
> On a 1910 reconnaissance by Copco, only two of these were mentioned as desirable--No. 1 at Big Bend, four miles upstream from Happy Camp, and No. 2 at Ishi Pishi Falls, just above the mouth of the Salmon River.
>
> The No. 1 site could be developed to produce about 30,000 KW under a 100 foot head and about 45,000 KW under a 150 foot head, with a tunnel length of about 3500 feet through the ridge which forms the big bend. The river grade resulted in a fall of about 55 feet around Big Bend. A small dam diverting the river to utilize only the 55 foot drop could develop about 15,000 KW.
>
> . . .
>
> A low level tunnel was proposed during the gold mining days to unwater this five or six miles of river to placer mining but was never developed because high head diversions from Thompson Creek and Indian Creek were better used for hydraulic mining.
>
> The flexibility offered in this project fit well into Copco's plans to develop units of production which would serve the need of the surrounding area. The transmission lines of the company were extended down the Klamath River from Yreka to Grey Eagle mine and from Cave Junction in Illinois Valley to Happy Camp having in mind that a power

plant at Big Bend, in addition to serving the surrounding area, would feed back to the company's transmission system any surplus generation.

> The site at Ishi Pishi Falls was probably the lowest cost per KW of any of the proposed developments on the Klamath River below Iron Gate. The foresight of Frank Langford and his associates is commendable. He initiated water rights in 1908, obtained rights of way and started extensive construction work. The amount of power he expected to develop was flexible, starting with about 25,000 KW and ultimately developing perhaps 200,000 KW, including waters from the Salmon River.
>
> His problem was finding a market for his power.
>
> The territory immediately adjacent was sparsely settled so he envisioned transmitting power to Trinidad harbor for the production of aluminum, copper and other electro-metals.
>
> Application No. 74 before the Federal Power Commission by the Electro-Metals claimed rights from filings made in 1905.
>
> The development of irrigation in Scott Valley, like Shasta Valley and others, was on a partial basis wherein certain areas were irrigated by gravity or by pumping depending on the justified costs. Copco was interested in the pumping developments as an outlet for sale of power. Therefore activity engaged in studies and estimates for the benefit of those who requested such service.
>
> A review of many studies for irrigating Shasta Valley was made beginning with the James M. Davidson survey in 1892 and ending with the California Department of Water Resources studies in 1963. There were found to be 37 engineering reports (see appendix B) together with comments, most of which related to water for additional irrigation in Shasta Valley from Klamath River as an outside source. (Boyle 1976:2-3)

Perhaps Electro-Metals had a problem of obtaining financing because there was no forseeable use for the power that they hoped to produce. They also had a problem of strong resistance from those concerned with the preservation of Klamath River fisheries. In granting the permit, the Federal Power Commission commented as follows:

> ...that objections to the issuance of a preliminary permit have been submitted by the California Fish and Game Commission and others, based on the ground that the proposed development will interfere with the migration and spawning of the salmon and would, therefore, prove destructive to the fish industry of the Klamath River; that on the other hand the chamber of commerce, county board of supervisors and other civic organizations are practically unanimous in favoring the

development; that after extended hearings the division of water rights, department of public works, California, has granted the water rights necessary to the issuance of the Federal permit; and that in so doing it may be presumed that the State has placed itself on record as favoring the use of this stream for power development in the face of any damage that may necessarily result to the fishing industry or fish culture. He recommended, therefore, that the Electro Metals Co. be granted a preliminary permit, subject to the special condition that the license, if issued, shall provide that the licensee shall, when required, without cost to the United States, construct such fishways or take such other steps in the interest of maintaining existing conditions of fish migration or fish culture in the Klamath River as the Secretary of Commerce may approve.

> The commission thereupon took action as follows:
>
> In the matter of the application of the Electro Metals Co. of San Francisco Calif. (project No. 74), for a preliminary permit and license for a power project on the Klamath River, on lands of the United States partly within the Klamath National Forest, in Humboldt and Siskiyou Counties, Calif.,. . .it was voted that preliminary permit be issued for a period of two years, subject to the provisions of said act, to the rules and regulations of the commission pursuant thereto, and the license, if issued, to be subject to such special conditions as the Secretary of Agriculture shall deem necessary for the adequate protection and utilization of said Klamath National Forest, and to the following special condition:
>
> The licensee shall, when required, without cost to the United States, construct such fishways or take such other steps in the interest of maintaining existing conditions of fish migration or fish culture in the Klamath River as the Secretary of Commerce may approve. (underlining added, FPC AR 1925:50-51)

Electro-Metals received its permit in August 1924. In November 1924 an initiative was passed in California banning the building of any more dams on the Klamath downstream from COPCO II. A California Fish and Game Department official reported upon this at a fisheries meeting:

> Mr. SCOFIELD: We have been having trouble for sometime. The Electro-Metals Company proposed to build a 250-foot dam in the lower end of the Klamath River, and after fighting them off for some three years the Fish and Game Commission started in on an initiative measure to amend the constitution to set aside the Klamath River to prevent dams being built in there. That measure passed, and unless this company or other companies can defeat that in the courts, they are barred from that river for the present. . .

Mr. SCOFIELD: I might state that while this initiative campaign was on the Federal Power Commission sent, I think, it was, their engineer, Mr. Kelly, out to the State to find out how that was progressing, and he went to the power companies and to the Forestry Board for his information, and then the Federal Power Commission issued a provisional permit, which stated that they would have to demonstrate to the United States Bureau of Fisheries that the salmon could pass over the dam before the final permit would be given. It came right in the heat of the campaign and it gave the Electro-Metals Company a very good argument to defeat this measure. They immediately started the slogan that under the United States government permit the fishing could not be injured. (WSFB 1925:124)

Despite Electro-Metals ingenuous argument, the campaign was successful:

The people of California are well aware of the importance of the Klamath River as a recreational area, and in 1924, by an initiative measure adopted by an overwhelming majority of the ballots cast, voted to create a special fish and game district of this river from its confluence with the Shasta River to the sea. The provisions of this law prohibit construction of dams on this section of the Klamath River proper. (Fish and Game Code Section 11036.) Commercial fishing for salmon and steelhead was halted in the Klamath River by the State Legislature at the end of 1933. (Fish and Game Code Section 8434.) This river has thus been set aside for the recreational enjoyment of all the people. (Cal DWR 1960:149)

The text of the act is as follows:

"Section 1. The Klamath River Fish and Game District is hereby created and shall consist of the Klamath River and the waters thereof, following its meanderings from the confluence of the Klamath River and the Shasta River in the County of Siskiyou to the mouth of the Klamath River in Del Norte County.

"Section 2. Every person, firm, corporation, or company who constructs or maintains any dam or other artificial obstruction in any of the waters of the said Klamath River Fish and Game District is guilty of a misdemeanor and upon conviction must be fined not less than five hundred dollars ($500) or be imprisoned in the county jail of the county in which the conviction shall be had not less than one hundred days, or both such fine and imprisonment, and any artificial obstruction constructed, placed or maintained in said district is hereby declared to be a public nuisance." (Cal DWR 1960:150)

There were evidently differences of opinion between the California Department of Fish and Game and the Department of Public Works for, in approving another downstream application, the Power Commission commented:

. . .that objections had been submitted by the California Fish and Game Commission and other organizations and individuals covering both projects; that these objections were based on the claim that the construction of the proposed project would interfere with the migration and the spawning of the salmon and would, therefore, prove harmful to the fish industry; and that after extended hearings on the matter the division of water rights, department of public works, California, had decided in favor of the water-power interests and had granted the necessary water rights. He recommended that the application of Mr. Seybold be granted, subject to the special condition that the license, if issued, shall provide that the licensee shall, when required without cost to the United States, construct such fishways or take such other steps in the interest of maintaining existing considitions of fish migration or fish culture in the Klamath River as the Secretary of Commerce may approve. (FPC AR 1925:49)

The approval of this project and that of Electro-Metals conformed to FPC policy spelled out in 1923:

Section 18 of the Federal water power and provides that "The operation of any navigation facilities * * * in connection with any dam * * * shall at all times be controlled by such reasonable rules and regulations * * * as may be made from time to time by the Secretary of War," and that "such rules and regulations may include the maintenance and operation by such licensee at its own expense of * * * such fishways as may be prescribed by the Secretary of Commerce." The War Department has not yet issued any rules and regulations under the authority quoted. The Federal Power Commission, nevertheless, has on its own motion and under the general authority granted by the act required the installation of fishways in instances designated by the Secretary of Commerce on recommendation of the Bureau of Fisheries. In certain instances also the commission has declined to permit the construction of high dams when it was advised by the Department of Commerce that the losses which might be occasioned by the prevention of the passage of migratory fish were likely to be greater than the value of the power proposed to be developed.

The instances of importance where possible conflict between fishing interests and power development has arisen are on the Columbia and the Klamath Rivers. In the former case it is proposed to construct a dam some 90 feet in height across the river. To determine what steps should be taken to provide for the passage of migratory fish past this dam a committee representing the local fishing and power interests, and including representatives of the State Fish Commissions of Oregon and Washington, has been constituted under the chairmanship of Professor Cobb, of the school of fisheries of the University of Washington. This committee is carrying on experiments and it is expected that it will be able at an early date to devise means for satisfactorily handling the problem. While definite conclusions can not be stated, it seems probable that whether migratory fish will or will not pass over a dam is not so much a question of height of dam as of the character of the facilities provided: that is, a question of cost.

In the second case, affecting the Klamath River in northern California, applications were filed with the commission in October, 1920, for power developments involving dams some 200 feet in height. Extended hearings were held at Yreka and Requa by the commission and several later hearings were held by State officials. At these hearings the main questions at issue were those relating to the height of dam over which salmon could be taken and to the relative value of power and fishing interests on the river if these interests were mutually exclusive.

The development of water power on the lands of the United States requires the approval of both the State and Federal Governments, the former granting the right to use the water, the latter the right to use the land. Under the Federal water power act a license may not be issued until an applicant has secured its water rights from the appropriate State authority. Under such circumstances it is apparent that development can proceed only when the State and the Federal Governments take corresponding action. Two questions were, therefore, presented to the commission: First, whether the erection of high dams in a stream frequented by migratory fish is a necessary bar to their passage, and second, to what extent, if any, should the commission assume the responsibility of deciding questions of local policy when State laws and State agencies for determining these policies already exist.

From the beginning of its administration the commission has followed the practice of working in close cooperation with those State authorities upon whom has been placed by law the responsibility respecting power development within their States. The commission has held that in matters which primarily concern an individual State the decision, whenever practicable, should be left to State authorities. In this connection it said in its latest annual report:

> It is too thoroughly convinced of the desirability of the maintenance of State sovereignty within its legitimate sphere and of the exercise of individual State responsibility to have any intention of dictating a domestic policy for any State.

The laws of California provide that the State department of public works shall allow, under the provisions of the water commission act, the appropriation for beneficial purposes of unappropriated water under such terms and conditions as in the judgment of the commission will best develop, conserve, and utilize in the public interest the water sought to be appropriated. The laws of the State further provide that any person, firm, or corporation proposing to construct a dam in any of the waters in the State in which fish have been planted or may exist shall, before the commencement of the construction of the dam, file with the State fish and game commission a notice of intention, and if the proposed construction will when finished prevent the free passage of such fish as naturally frequent the waters it shall be the duty of the State board of fish and game commissioners to require, and of the person, firm, or corporation to construct, a durable and efficient fishway of such form and capacity, in such location, and at such time as may be fixed by the fish and game commission. The law further provides that whenever in the opinion of the State fish and game commission it shall be impracticable because of the height of any dam or other conditions to construct a fishway over or around the dam that commission may order in lieu of such fishway the construction and equipment within a specified time on a site to be selected by it of a fish hatchery according to specifications which it may determine. The authority to determine whether a dam shall or shall not be constructed rests with the State department of public works.

It was in view of this situation that the department of public works and the State fish and game commission were advised in September, 1922, that the question of the relative value of Klamath River as a source of water power and as a spawning ground for salmon appeared to be of interest primarily to the State of California; that the constituted authorities of the State conversant with their respective powers and duties should be able to determine which use of the stream was for the best interest of the State; and that it was not deemed to be the function of the Federal Power Commission to sit in judgment upon their findings or to act as arbiter between them. When, therefore, the State department of public works after four years of consideration finally granted on behalf of the state the right to use the waters of the river to develop power the commission in its turn gave a preliminary permit authorizing the use of the public land. The commission was urged to veto the action of the State department of public works. It had the legal authority to do so by refusing to issue permits. It did not believe, however, that a course of independent action was one calculated to lead to that degree of State and Federal cooperation which it is endeavoring to effect. Neverthless, in issuing preliminary permits it prescribed as a condition of any license issued that "the licensee shall, whenever so required, without cost to the United States, construct such fishways or take such other steps in the interest of maintaining existing conditions of fish migration and fish culture in the Klamath River as the Secretary of Commerce may approve."

Whether fish ladders or other devices will enable fish to pass or be taken over dams of the height proposed has not yet been determined. The experiments being conducted in the State of Washington should throw light on this question. The two years' period of the preliminary permit will afford time for the applicants to present their plans, on the approval of which the issuance of license and the authorization to construct will depend. In the meantime no construction can be carried on and no rights acquired which are not subject to the condition cited. (FPC AR 1924:9-12)

Although no major dams have yet been built on the Klamath below Iron Gate, the area continues to rank high as a future source of power and water in California:

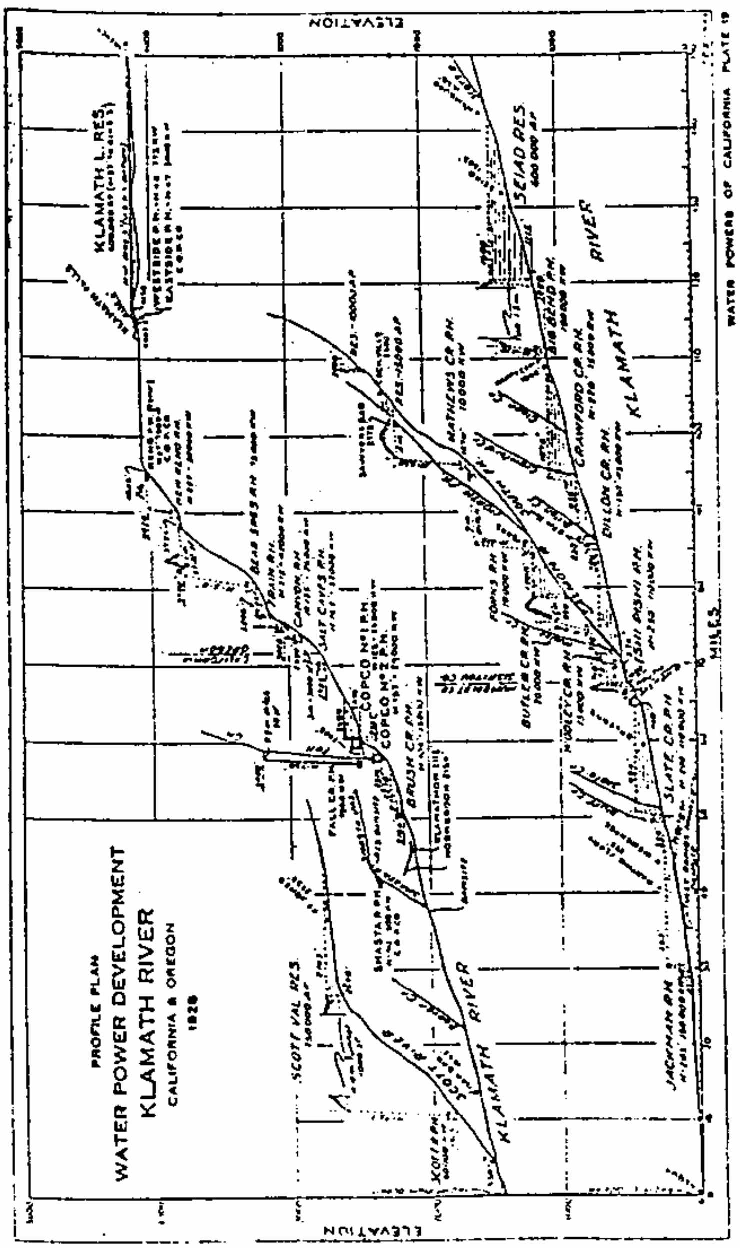
> The North Coastal area has the most abundant water supplies of any of the State's hydrologic study areas. The long-term mean annual runoff of all streams in the area totals 29.7 million acre-feet. This is more than 40 percent of the total for the State.
>
> Despite its copious water supplies, the North Coastal area will have to depend on water development facilities for its in-area water requirements because of the maldistribution of runoff within the season. Some of the great rivers which account for much of the area's winter runoff are little more than small creeks during the summer and fall.
>
> . . .
>
> The lower Klamath River development would include the 15-million acre-foot Humboldt Reservoir on the lower Klamath River, Ironside Reservoir on the Trinity River, three pumping plants to lift the water up the Trinity River, into Helena Reservoir, and a second tunnel between Helena Reservoir and the Sacramento Valley. It could develop an annual yield of approximately six million acre-feet, at a cost of about 1.6 billion dollars. Mitigation of damages to the Klamath River fisheries would be a serious problem in this plan. There are alternative plans with a lesser impact on the fisheries, which would yield smaller quantities of water. (Cal DWR 1966:72,113)

The 1966 California water study identifies five proposed dam sites below Iron Gate. Working downstream they are: Hamburg, Happy Camp, Red Gap, Weitchpec, and Humboldt. (Cal DWR 1966 fig. 8) A 1974 report envisions a single major dam, Humboldt, backing water up to Dillon Creek. (Cal DWR 1974:80) Figure II from Bonner, 1928, gives some indication of dam planning on the Klamath, both below and above the COPCO dams from a 1928 perspective.

Seckler, in a study of California water management, takes a dim view of the sort of development of the Klamath proposed in most of the long range plans:

> With continued withdrawals of water from the Delta, additional sources of water will have to be found. This means that the dam builders will turn their attention to the rivers of the north coastal area, specifically the Eel, the Klamath, and the Trinity. These rivers and their valleys constitute one of the last refuges of nature in California.

Figure II


PROFILE PLAN
WATER POWER DEVELOPMENT
KLAMATH RIVER
CALIFORNIA & OREGON
ELEVATION
MILES
KLAMATH RIVER
KLAMATH L. RES.
SCIAD RES.
WATER POWERS OF CALIFORNIA PLATE 19

In addition to destroying the region's natural amenities and its economic base in the recreational use of its resources, these dams will destroy the periodic flushing action of floods through the river systems. The deep pools in the rivers will thus silt full, destroying breeding grounds and therefore the valuable fishery resources of the area. Weeds and brush will encroach onto the banks of the rivers, supplying a base for further silt accumulation and destroying the accessibility and beauty of the rivers. Because the silt will accumulate in the river beds and reservoirs, the ocean beaches will lose their source of replenishment and decay back into the sea. These effects are already observable from existing water "development" projects in the region; further development will generate an ecological disaster. (Seckler 1971:26)

Upper Klamath River

As we have suggested in the section on environment, upstream (Klamath Basin) water use and management is extremely complicated. It involves Oregon and California, the U.S. Bureau of Reclamation, the National Forest Service, the Bureau of Indian Affairs, and, after 1920, the Federal Power Commission.

"The California Oregon Power Company expected to develop all the power resources of the Upper Klamath River Basin to and including Iron Gate, so they determined the boundaries of the Upper Klamath River Basin as all the drainage area above Iron Gate." (Boyle 1976:1)

In a somewhat disjointed fashion, Boyle notes power sites and competitions in the Basin:

Keno was the control point in the Upper Klamath Basin where the Klamath River left the agricultural land and regulating lakes and started down the canyon through the Cascade Mountains on its course to the Pacific Ocean. Keno has also been marked as the point of division between irrigation and power, however diversions for irrigation were proposed to points below Keno.

McCormick Site. On February 20, 1906 an agreement was made by the Reclamation Service with Thomas McCormick for purchase of water rights and rights of way for building a cut in the Keno reef for lowering the Klamath River, possibly lowering Lower Klamath Lake and providing a better discharge channel for waters from the proposed Lost

River diversion canal. The McCormick site was a strip 400 feet wide, 9000 feet long on the mouth and west bank of the Klamath River, including power development possibilities in this strip of 68 feet fall. . . .

. . .

Bureau of Reclamation. During March and April 1906, the Reclamation Service made preliminary surveys of the power possibilities below Keno (McCormick Site) to Beswick, California. In the distance of about 28 miles it recorded an average drop of 51 feet per mile and in some places 100 feet per mile. All public lands between Keno and Klamathon, California, bordering the river, were then withdrawn from public entry and reserved for power development. No water filings were made by the Reclamation Service at that time.

Southern Pacific Power Site. The property acquired by the Southern Pacific Railroad Co. was purchased from it by Copco in 1921. It had a possible diversion dam site at the old crib dam and bridge on the Klamath River six miles below Keno. The Southern Pacific had made preliminary investigations and had excavated a bench along the north side of the river about three quarters of a mile long which could be used in connection with any power development planned by that company.

. . .

Southern Oregon Water Company. A proposed development was that of the Southern Oregon Water Company who owned considerable of the riparian lands between Keno and the California-Oregon state line, about 1300 acres.

The incorporators of the Southern Oregon Water Company were mostly men connected with the Long-Bell Lumber Company. The lands were subsequently transferred to Weyerhaeuser. No developments of power were made although the lands controlled some of the important power sites.

Long-Bell Lumber Company was asked whether or not it intended to develop power on its holdings. It had thought at one time that it might be economical for Long-Bell and Weyerhaeuser jointly to develop power and use it in their mills and manufacturing plants when they built them in Klamath Falls, but were since convinced that they could buy power cheaper than they could develop it. Negotiations resulted in the purchase of all these holdings by Copco.

State of Oregon. On August 28, 1913 a withdrawal of 1000 second feet from appropriation of the waters of the Klamath River was made on behalf of the State of Oregon to be used for power development. Chapter 87, Laws of Oregon, 1913. Legal opinion pointed out that:

"In view of Chapter 228, General Laws of Oregon 1905, and the action taken by the United States in pursuance thereto, it was questionable whether or not the state could issue any permits for the appropriation of any of the waters within the Klamath River and Lake Basins.

"If the state may issue permits, there is a legal question as to the effect of the state's withdrawal."

Keno Power Company. The Keno Power Company's first plant was put into operation in 1912.

On April 4, 1917 the Keno Power Company asked the city of Klamath Falls for a franchise and grant for 25 years to supply for all purposes, electricity within the city limits as then established and within any future extended boundaries.

Copco asked for and obtained an injunction against granting such a franchise.

Keno Power's power plant was being used to supply power and lights to a few farmers in the neighborhood of Keno, but it had no lines within the town of Klamath Falls and no line leading to it.

Copco brought suit in the Federal court on the basis that for a long time it had been serving Klamath Falls and was under Public Service Commission of Oregon, which had power to determine the convenience and necessity of allowing a second utility to invade the field of one already in an area.

Under date of June 15, 1917, Keno Power Company gave the Oregon Klamath Record a story of its activities:

". . .we have made extensions totaling about ten miles of transmission lines serving new pumping station. . .100 H.P. The Pine Grove extension will serve a 75 HP plant and intend to serve all farmers above the reclamation canal. . . . We have recently ordered a new turbine that will take care of all needs of Klamath county for several years to come."

The result of all the argument between Keno Power Company and Copco was confusion among the citizens of the community and the development of personal bitterness among the officers of both companies which nearly developed into physical violence.

During August 1919 Copco made a study of the Klamath River canyon between Keno and the mouth of Spencer Creek including the power plant of the Keno Power Company. A fall of about 260 feet could be developed to produce about 48,000 KW.

Some riparian lands had already been acquired by Copco. All property ownerships were determined and other needed riparian lands surveyed.

The power plants and distribution lines of Keno Power Company were acquired by Copco on April 1, 1920. They were operated as a separate utility until January 1, 1927 when they were merged into the Copco system.

. . .

The Klamath Irrigation District on August 8, 1929 filed an application with the State Engineer to appropriate 2000 second feet of water from Klamath River to develop 22,600 horsepower (McCormick power site). Upon receipt of the application, the Attorney General issued an opinion dated September 3, 1929 that unless it was determined by the State Engineer that there was no conflict with the water rights of the United States, that the application might be approved, but whatever rights might be allowed the district, such would be junior to those of the government. No further action was taken by the State Engineer. The application was authorized to be canceled by the District.

When this decision was known, Copco presented its claim for water rights and the State Engineer, on advice of the Attorney General, held that the power company had the same rights to appropriate water as the Irrigation District, providing that a waiver of power rights be made in favor of irrigation use. Such a waiver was executed by Copco and filed with the State Engineer's office. No approval was received.

U.S. Senate Bill S-3556, introduced at the request of the Klamath Irrigation District, was discussed on December 16, 1930 and January 19, 1931 before the Committee on Public Lands and Survey. This bill "authorized the sale of a certain tract of land in the state of Oregon to the Klamath Irrigation District." This McCormick site bill was never passed.

The Bureau of Reclamation advertised the McCormick site for sale on January 18, 1927. Many protests were filed against the sale, so on the date of sale Copco made public a statement ". . .that it was not interested in making a bid for purchase of the McCormick power site as it was not an economical site on which to build compared to some of the lower sites." However, if any bids were received Copco would withdraw this statement.

. . .

City of Klamath Falls. The City of Klamath Falls made application July 24, 1933, by Mayor Willis E. Mahoney to appropriate water to develop power for a municipal plant in the NE¼ of Sec. 31, T39S R7E WM. The amount of power was not stated but 1500 second feet of water was specified. As Mahoney was advised that he would have to bring a suit against the State of Oregon to get a permit to use water, the application was withdrawn. (Boyle 1976:3-7)

Over time, Copco managed to achieve most of its major objectives in its goal of developing a unified and integrated power system on the Upper Klamath. A first step was to reach an accommodation with the Bureau of Reclamation which was planning massive irrigation projects in the Basin and which had first right to the waters:

Under the terms of the contract dated February 24, 1917, between the United States and the California-Oregon Power Co., the power company was given the right to regulate the outflow of Upper Klamath Lake, subject to existing rights and the prior rights of the Klamath project for water for irrigation. To regulate the outflow, the company, in 1921, constructed the Link River Dam at a cost of about $310,000. (U.S. Bureau of Reclamation 1936:12)

It appears that on February 24, 1917, a contract was made between Copco's predecessor corporation, California Oregon Power Company and the United States, for the purpose of adjusting the water rights in the Lake and Klamath River between power and irrigation use. Under the provisions of the contract, Copco constructed the Link River dam and conveyed the dam and the land upon which it is situated to the United States, in consideration for which Copco agrees to regulate the lake between certain specified elevations, to furnish water to the irrigators for irrigation purposes, and to supply energy at low rates for pumping purposes in connection with irrigation and drainage during the entire 50-year period of the contract. The contract expires in 1967 and, unless its terms are extended by contract or otherwise, upon its expiration the parties including Copco, the United States, and the irrigators will be returned to the same positions with respect to power and water rights as they were prior to the execution of the contract. (FPC AR 1954:3)

Link Dam

This dam is the farthest upstream dam in the Klamath River system:

The dam at the outlet of upper Klamath Lake is known as the Link River Dam. It is a power and irrigation dam, constructed and operated by the California-Oregon Power Company under the terms of a contract entered into between the United States and the Power Company, on February 24, 1917. The Reclamation Service uses this dam for the diversion of certain waters for the irrigation of lands in its immediate vicinity. (Simmons to Gardiner 1 February 1943)

This dam was completed on November 1, 1921. At the time of completion, the California-Oregon Power Company deeded the property to the U.S. Government, Bureau of Reclamation. At this time the dam is owned by the U.S. Bureau of Reclamation and is operated by the California-Oregon Power Company, with headquarters at Medford, Oregon. At the time this was contracted for, provision was made for the installation of an approved fishway. However, this was not installed until 1926. This fishway is of concrete and runs to a height of 18 feet in the Link River and over the Link Dam. (Courtright to Simmons 29 January 1943)

The Link River Dam was built for the purpose of regulating the level of upper Klamath Lake to the end that the waters thereof might be conserved for irrigation purposes and for the generation of power below the Keno project. This dam was completed in 1921 and has been operated for the purposes intended since then, initially under an agreement between the United States and a predecessor of Copco and recently under a similar contract between the United States and the Applicant in this proceeding. Under the latter agreement, Copco may regulate the level of upper Klamath Lake between elevations 4143.3 and 4137.0, Reclamation Service datum. The operation of the Link River Dam conserves water in periods of heavy run-off so that it can be used by power plants below for peaking purposes. Through this scheme of releases the plants below are operated as an integrated unit. (FPC AR 1960:63)

The "predecessor" mentioned above was presumably the California Oregon Power Company which, later, evolved into Copco. This dam was a matter of some concern to the Klamath Tribe and the BIA in terms of fisheries and fish passage and it was investigated by Simmons:

I am advised by the Superintendent of the Klamath Indian Agency, Klamath Agency, Oregon, that the plans of the dam provided for the installation of an approved fishway. The fishway was not installed until 1926. It is built of concrete and runs to a height of 18 feet, in Link River and over the dam.

Two provisions of the contract of February 24, 1917 amply protect the Klamath Tribe of Indians from any and all damage the tribe may suffer by reason of the construction, maintenance, or operation of the dam. Parragraphs 5 and 7 of the contract provide:

"Contract between United States and
California-Oregon Power Company,
February 24, 1917.

"5. The lowering and raising of the waters of the lake below or above the normal fluctuations while in a state of nature shall be undertaken by the Company only after making satisfactory adjustments at its own expense in regard to all interests which may be affected thereby, whether of the State for navigation or other purposes, or of any private individuals, or Indians.

"7. The Company assumes any and all liability for damage to the property or rights of the State of Oregon or of the Indians due to the operation of said dam by said Company or to the regulation and control of the levels of said lake by said Company and hereby undertakes to hold the United States harmless from any and all liability for damage due to such regulation and control." (Simmons to Gardiner 1 February 1943)

In the 1950s, when Copco was preparing for its last large Klamath River developments, it is reported to have purchased considerable amounts of land around the mouth of the Williamson River and at Modoc Point from Indian owners. The company evidently used a tribal member as a go-between to approach tribal land owners. It is alleged that it was explained that the area was going to be flooded or would become more liable to flooding and that the threat of this was used to encourage owners to sell. All did except Mr. Ellsworth Lang. The land was not flooded and, some years later, it was transferred to an agribusiness, Tulena Farms. Tribal members are still angry about these matters.

The raising of the level of Upper Klamath Lake by means of the Link dam engendered some ill feeling among Indians and non-Indians around the lake. Since this is beyond the bounds of immediate interests, we have not investigated this or checked the facts. We note it simply in the event that it be relevant to Klamath treaty fish rights.

> Agnes M. Oliver, a long time Klamath Basin resident was interviewed regarding the history of the area.
>
> What did you do for recreation?
>
> Work. We went swimming in the lake (Klamath Lake). It was clean in those days. It's pretty much of an algae lake now. They'll get it killed in a few years.
>
> Who's they?
>
> The people, the government. COPCO blew the original rock dam down here at the head of Link River, and put the other dam in and started raising the water too high, and spread it over all the marshes of the north end. Then they started getting algae.
>
> What do you think they should have done instead?
>
> Well, they should have used a little more thought and consideration for the people that lived here instead of just giving everything to COPCO. P P and L took over from COPCO.
>
> I can see it affects you.
>
> It does everybody actually. We didn't have electricity, but then they could have done it just a little bit more (pause) honest. (Jackson and Lee 1981:286-287)

Following the completion of the Link Dam, Copco gradually expanded and consolidated its developments, but on the Upper Klamath, there were no major developments until the 1950s:

> ...Copco began in 1951 initial steps toward obtaining licenses to construct another hydro plant on the Klamath River at Big Bend, between Keno and the California state line. A Federal Power Commission license for the plant was granted January 28, 1954, on condition that the company secure an extension of its 1917 agreement with the Bureau of Reclamation relating to the regulation of Upper Klamath Lake and operation of Link River dam. On January 31, 1956, the company and the USBR executed the required new agreement running to the year 2006, the life of the FPC license. Construction was started in July, 1956, and the plant and related transmission facilities went into service on October 1, 1958.
>
> Capacity of the plant is 88,000 kilowatts, making it the largest of the Klamath River developments. Name of the installation was changed from Big Bend to the John C. Boyle Hydroelectric Project in a ceremony held June 25, 1962. A plaque unveiled at that time describes Boyle as "a distinguished engineer, who designed the project and supervised its construction and whose talents since graduation from the University of California in 1910 have been devoted to the advancement of electric service throughout the system of The California Oregon Power Company and its successor company, Pacific Power & Light." (Dierdorff 1971:277)

A part of the period of reduced activity in the Klamath Basin probably relates to the skirmishes between Copco and Oregon reflected, somewhat vaguely, in Grant's reminiscences:

> And all this in the face of official stupidity. A monumental instance: the California-Oregon Power Company recently had planned to build an additional dam on the Klamath River near Klamath Falls, at Grant Site. Political meddling, and the vetoing of an "enabling act" by the governor of Oregon, caused a change of plan, and the dam is to be built instead at a site lower down the river, in California. Thus southern Oregon has lost a $4,000,000 development, and another striking demonstration has been given of the mobility of capital. If ill-treated in one locality, straightway it will seek another. (Grant 1951:343)

The Grant site project involved a series of dams and diversions between Keno Oregon and Beswick California, -- from the Big Bend down into the Klamath Canyon. It was the to consist of five units of dams, diversions, and power plants.

A preliminary FPC permit was issued in 1922 and the project received FPC approval in 1930 under project number 215. (FPC AR 1931:56-58)

We have not investigated the disagreements between Copco and Oregon in the late 1920s regarding Klamath River development.

Big Bend Dam

This hydroelectric power dam is on the Klamath River west of Keno Oregon (T41S R7E) and above Copco I. Boyle describes the dam and some of the background events in his somewhat disjointed fashion. In saying that his fashion is "disjointed", we do not mean to disparage a valuable and authoritative source of information. His publication is clearly a fairly unedited collection of notes and diary observations assembled over the years. Part of its authority lies in the fact that it is probably "out of the files as is":

> Copco made no power developments in the Klamath Basin after 1924 on Link River, and 1925 on Klamath River at Copco No. 2.
>
> . . .
>
> . . .In the early '20s Copco system load increased at about 4,000 to 5,000 KW per year. By 1957 this increase jumped to about 10,000 and 15,000 KW per year.
>
> So filings were made on the McCloud River on January 9, 1952 with the Federal Power Commission for development of about 250,000 KW there.
>
> However, Klamath Canyon was most attractive, being near the Copco load center where construction cost and transmission lines would be minimum. It was therefore decided to make another attempt to secure necessary water rights in Oregon sufficient to justify construction.
>
> The creation of the Hydroelectric Commission of Oregon in 1931 with amendments of the Legislative Act made it possible for a power company to obtain a license similar to a Federal Power Commission license for use of water in Oregon, for power purposes. Such a license could be obtained for use of water in the Klamath River without conflicting with the water rights of the U.S. Government and other irrigationists.

In 1951, the Klamath community was advised that a power plant would be built on the Klamath River below Keno if it was unanimously approved by all interested parties of the Klamath basin.

On February 15, 1951, Copco authorized applications to the Federal Power Commission and the Hydroelectric Commission of Oregon to construct the Big Bend Plant on Klamath River 6 miles below Keno.

Because of the need to construct larger power developments adequate to meet the system demands, the plans were changed to combine two of the original projects with one of 88,000 KW capacity.

The purpose of applications at this time, perhaps four or five years in advance of need, was to determine what if any legal complications would arise which would delay the development or make it impossible to construct the plant. Based upon the experiences during 1925 to 1930 in Klamath regarding water rights, the outlook was not optimistic.

A plan was submitted covering development of the remaining undeveloped projects between Keno and Iron Gate and it incorporated additional storage at Aspen Lake. Applications to the Federal and State Commissions were mailed on April 16, 1951.

Practically all the irrigation districts in the Klamath Reclamation Project joined in filing protests. The Secretary of Interior filed a protest as did the Bureau of Reclamation and many individuals.

During the following months some resolutions favoring the project were filed. The Oregon State Federation of Labor at Convention in Klamath Falls June 29, 1951 was an important one.

The deadline date for filing protest with the Federal Power Commission was July 19, 1951. Some extension of time was given by the Hydroelectric Commission of Oregon.

On Friday, September 7, 1951, the State Hydroelectric Commission stated that no further hearings would be held and it was satisfied that if Copco could work out an agreement with the Bureau of Reclamation for an extension of the contract to regulate the Upper Klamath Lake and presented it to the State Commission, no further questions would be raised over issuance of a state license to use the water.

Hearings were held before the Federal Power Commission on June 3 and 4, 1952 and June 30, 1952. Fifty-seven exhibits were filed and oral testimony was taken. Another hearing was held in Yreka on September 5, 1952. Progress seemed slow and time was running out.

So on May 18, 1953, Copco asked the Secretary of Interior and the Bureau of Reclamation to withdraw their protests and consider extending the Upper Klamath Lake contract for the license period established by the Federal and State Commissions.

. . .

On January 7, 1955 the Secretary of Interior authorized negotiations on an extension to the contract of February 24, 1917.

On August 5, 1955, the draft of a contract between the Department of Interior and Copco covering regulation of Upper Klamath Lake, pumping rights for the Klamath Project, water uses and other associated provisions were submitted to all interested parties and comments requested by September 1, 1955. If a contract was signed, copies were to be filed with the Federal Power Commission, Hydroelectric Commission of Oregon and the Public Utility Commissions of Oregon and California. Approval of these four commissions and the Bureau of Reclamation must be obtained before construction work could be started. Copco's revised plans provided for additional power developments to those proposed in the original filings. Total estimated cost, about $70,000,000.00. (See article in Electrical West May 1960.)

In a meeting in Sacramento September 28, 1955, a letter from Copco to the Oregon and California River Compact Commissions stated in part "that no Klamath water shall be used by Copco when it may be needed or required for use for domestic, municipal, or irrigation purposes within the Upper Klamath River Basin as defined in the compact; Provided nothing shall curtail or interfere with the water rights of Copco having a priority earlier than May 19, 1905; Provided further that all drainage and return flows shall be at a point above Keno."

The new agreement between Copco and the Bureau of Reclamation was completed January 31, 1956. Work was authorized to start in June 1956 and Copco had obtained the unanimous support originally requested in 1951.

The Big Bend project was rushed to completion and 88,000 KW were added to the Copco system by October 1, 1958. (Boyle 1976:52-55)

After Big Bend was completed in 1959, Copco made application to bring all of its Klamath River and Basin plants together as an operating unit under the single license for Big Bend, Project No. 2082. This was desirable from their point of view and in conformity with FPC policy:

As we have noted before, the concept of considering a particular watershed as a whole is the backbone of the licensing provisions of the Act. (FPC 23:1960:61)

The existing unlicensed developments consisted of:

East Side Development on Link River consisting of a canal and penstock extending from Link River Dam to the powerhouse containing a 4,250-horse-power turbine driving a 3,200-kilowatt generator; West

Side Development on Link River consisting of a canal and penstock extending from Link River Dam to the Powerhouse containing a 1,040-horsepower turbine driving a 600-kilowatt generator; Keno Regulating Dam on Klamath River consisting of a wood-bent structure with earthen abutments and control works for maintaining the level of Ewauna Lake and Klamath River between Keno and Klamath Falls; Copco No. 1 Development on Klamath River about 31 miles below Keno consisting of a concrete gravity arch dam with tainter gates creating a reservoir about 4½ miles long; penstocks, a powerhouse containing two 18,600-horsepower turbines each driving a 10,000-kilowatt generator, and a substation; Copco No. 2 Development on Klamath River about ¼ mile below the Copco No. 1 Development consisting of a concrete and earth diversion dam, a conduit composed of two tunnels, a wood-stave pipe and penstocks leading to the powerhouse containing two 20,000-horsepower turbines each driving a13,500-kilowatt generator, and a substation; and appurtenant facilities; the location, nature and character of which project works are more specifically shown and described by certain exhibits hereinbefore cited and by certain other exhibits which also formed part of the amended application for license or application for amendment of license. (FPC AR 1960:69)

COPCO I was not licensed by the FPC because it was built before 1920, the year in which FPC licensing began. The Link River dam was also unlicensed as it was built before 1920. However, in later FPC hearings, it was pointed out that Link was owned by the federal government and did not require a license. (FPC 23 AR 1960:66) For whatever reasons, none of the other Copco dams in existence on the Klamath prior to the 1950s were licensed. (FPC AR 1960:69)

IMPACT

The Loss

The impact of the first COPCO dam can be briefly stated. Its construction reduced, if it did not destroy all anadromous fish runs above its location. Its completion permanently blocked all further anadromous fish passage.

We cannot say how much was lost in the complete destruction of all anadromous fish runs above the COPCO dams. So far as we know, no counts of anadromous fish were ever made in the Klamath Basin. The U.S. Bureau of Fisheries placed fish racks in the Klamath River at Klamathon, below the sites of the COPCO dams, one or several years before construction on the dams started. A record of the counts of fish stopped at the Klamathon racks would have given some indication of the number of fish that had been trying to move above that point. However, it appears that no count was made or kept. Snyder claims that no records of numbers for the Klamathon racks are available before 1925. (Snyder 1931:117) By that time, the runs were already reduced. (Snyder 1931:91)

There is disagreement as to when anadromous fish were blocked from the Upper Klamath and the Klamath Basin. Simmons states that the blocking occurred after 1908. (Simmons 15 August 1942) This would have been at least two years before construction of the COPCO dam is reported to have begun. Snyder states that the dam "became operative as a barrier" on October 25, 1917. (Snyder 1931:22) Another source seems to suggest that the blocking did not occur until 1918. This source is a copy of a Klamath Falls Evening Herald newspaper article of 7 March 1918 incorporated into a letter from Boyle of the California-Oregon Power Company to Simmons. Klamath Agency Superintendent Courtright asserts that there was no passage beyond the COPCO I dam site in 1911. (Courtright to

Simmons 24 June 1942) V.D. Evans, principal clerk at the Klamath Agency in 1941 said that steelhead stopped running in 1914 and salmon stopped in 1915. (Evans July 1941)

The following information is from the Simmons Statement of Facts prepared in or before 1942:

> Most of the Indians claim the salmon stopped frequenting reservation waters during the year 1909, which was a severe blow to the members of the Klamath Tribe.
>
> . . .
>
> Clayton Kirk states that he is certain the salmon stopped coming to the reservation waters in the year 1909 for that was the year he was married and he expected to secure a large part of his family's food from the salmon in the Sprague River. The disappointment of not finding any salmon running in the river that year, he states, defintely impresses the date upon his mind.
>
> Benjamin E. Wolford, who came to the Klamath Reservation in April, 1910, to take charge of a store at Kainax, Oregon, and to act as the Indian post trader there, states:
>
> "That the salmon runs stopped completely in 1912 as a result of the construction work being done by the California Oregon Power Company on a power dam located in the Klamath River in the State of California; that he frequently during the salmon runs in the fall of 1910 and 1911 visited the locations along Sprague River where the Indians were fishing and observed them taking out many salmon."
>
> Various Indians give the year the salmon stopped running in reservation waters as follows:

Name	Year Salmon Stopped Running
David Skeen	1908
Tom Lang	1910
Edward F. Ball	1909
Herbert Nelson	1910
Carlos Blair	1911
Mrs. Elizabeth Crawford	1909
Robert David	1910
Erskine Beal	1909
John Jackson	1909
Victor Nelson	1907
Mary Chiloquin	1909
Clayton Kirk	1909
B. E. Wolford (white merchant)	1912

(Simmons n.d.:16-17)

The confusion evidently relates to the intertwining of three events. The construction work began in 1911. The dam was completed in 1918. In or before 1910, the U.S. Fish Commission set up a fish rack at Klamathon, below the dam site, which blocked or could have blocked anadromous fish runs beyond that point.

Klamathon Fish Racks

In 1910, the year before construction of COPCO I began, the U.S. Bureau of Fisheries placed racks in the Klamath River at Klamathon below the dam site. In this period, until the 1920s, there was a belief held by most fisheries managers although not by all fisheries experts, that it was possible to maintain, enhance, or create fish runs by capturing the fish, fertilizing the eggs, and planting the eggs in what were supposed to be suitable waters. Little awareness was shown of survival problems. It was assumed that one fertilized egg or fingerling equaled one adult fish.

This was the context of the Bureau of Fisheries racks. Once it was known that the construction of COPCO I was to commence in 1911, the fish racks in the river in 1910 made sense. They would capture and thus preserve the fish of the last run. If the racks had not been put in, fish managers of the time would very likely have expected the run to have been in danger of being wiped out at the construction site.

In 1915, the Superintendent of the Klamath Agency saw the fish rack at Klamathon and wrote a letter to the Commissioner of Indian Affairs describing it:

> The train upon which I am traveling has just crossed the Klamath River in California, - the river that drains the upper Klamath Lake, into which flow the Sprague and Williamson rivers on the Klamath Indian Reservation. As one looks up the River as the train crosses the railway bridge, one sees a dam built across the River which does not wholly

> obstruct the flow of the River but which, I am told, does prevent the salmon from going any further up stream. My information is that this dam was built and is used by the California Fish Commission for the purpose of taking salmon eggs for the propagation of salmon. Whether this be true, I can not say. But it is true that on the Klamath Reservation, where formerly salmon were abundant and furnished much food for the Indians, there are now no salmon to be found. (Agent to Commissioner of Indian Affairs 2 January 1915)

In a letter to K.R.L. Simmons in 1940, J.C. Boyle, Vice President in charge of operation for COPCO wrote:

> In answer to the questions in your letter of August 5, 1940, I wish to advise that the construction of the fish hatchery at Fall Creek, the construction of the fish racks at Klamathon and the construction of operators cottages, etc., incidental to the operation of these, was carried on during the last six months of 1918. This work was under my direction and I was assisted by Mr. Bert Doney of the California Fish and Game Commission. The real estate upon which these structures were built was deeded to the California Fish and Game Commission on March 27, 1919. (Boyle to Simmons 14 August 1940)

Given the Agent's letter of 1915, Boyle's recollection most likely relates to later racks. This is possible if the racks were temporary ones removed from the river when fish were not running. The Agent may have seen Klamathon racks in 1915 and Boyle may have built racks at Klamathon in 1918. Snyder states that the racks were placed in the river in late July and kept there until late November the implication is that they were removed from the river at other times. (Snyder 1930:31) This leaves a discrepancy for the Agent describes the racks as being in the river on January 2nd.

The structure that the Agent saw consisted of two barriers across the river which prevented fish from passing up stream and held the fish between the barriers for collection for artificial spawning:

> Upon the closure of the upper reaches of the Klamath by the great dam at Copco, a hatchery was established at Fall Creek (Fig. 26) and a particularly efficient trap, placed in the river near Hornbrook. This trap is sometimes spoken of as the "Klamathon Racks." Its function is to stop all migrating salmon and retain them until they are ripe enough for artifical spawning. (Snyder 1931:111)

Evidently racks were first placed at Klamathon in 1910:

> "The Federal Bureau of Fisheries has operated a salmon egg-collecting station on the river below the dam and have for the last eight years prevented the salmon from ascending the river above the racks at Hornbrook." (25th Biennial Report of the California Fish and Game Commission for the years 1916-1918 quoted in Gullickson to Commissioner of Indian Affairs 7 August 1946).
>
> "I would further call your attention to the fact that prior to the completion of the dam and the construction of the hatchery, the United States Bureau of Fisheries had for eight years stopped all of the salmon at the Klamathon racks near Hornbrook, California, and had planted the resulting fish in the Klamath River and other streams in California." (Taft to Simmons 22 August 1940 quoted in Gullickson to Commissioner of Indian Affairs 7 August 1946)

Gullickson, District Counsel for the Bureau of Indian Affairs assumed, although he did not have specific evidence, that the Bureau of Fisheries racks and the building of COPCO I were connected. (Gullickson to Commissioner of Indian Affairs 7 August 1946) The assumption appears to be warranted. We cannot imagine why the Bureau of Fisheries and later, the California Fish and Game Commission would have prevented salmon runs from going upstream to spawn except in anticipation of the impending permanent blocking of the stream by COPCO I.

Dam Construction

COPCO I blocked all passage of anadromous fish upstream from its location. In a response to queries from K.R.L. Simmons in 1942, Klamath Agency Superintendent B.G. Courtright provided specific information on the date and way in which anadromous fish were blocked from the Upper Klamath:

> The letter from the Attorney General's Office and about which you wrote me, and a copy of which was sent me direct from the Indian Office, asks eleven questions and I am answering them to the best of my ability as follows:
>
> 1. Date of first construction work which obstructed passage of salmon?

Answer: 1911.

2. Nature of this obstruction or work?

Answer: Foundation for dam. The wing dam which diverted the channel permitted salmon to go upstream. However, when the foundation was further along, a diversion tunnel was constructed opposite from the wing dam.

3. Date of construction which obstructed and cut off the salmon completely - nature of this work?

Answer: 1911. The nature of the work which obstructed the salmon consisted of foundation and a wing dam and a diversion tunnel. Inquiry shows that the current was too swift to permit the salmon to go through the tunnel so, after the diversion tunnel was installed, the salmon ceased to go up the Klamath River.

4. Date construction diversion tunnel? Date completion? Nature of purpose or use?

Answer: The diversion tunnel was built in 1911. The date of completion of the tunnel was 1911. The nature or purpose of the tunnel was to by-pass the water while the main dam was being constructed.

5. Date construction of by-pass? Nature of this by-pass?

Answer: Date of construction of the by-pass (tunnel), 1911. The nature of this by-pass was a tunnel bored through the side of the hill to permit the water to pass around the site of the construction of the dam.

6. Whether or not California Fish & G. Com. approved this by-pass? Nature of approval?

Answer: The California Fish & Game Commission did not approve nor was it necessary for them to pass upon the by-pass.

7. Were salmon able to swim up by-pass? Or able to get by the dams in any other manner?

Answer: No, the salmon were unable to proceed against the swift current coming through the tunnel or by-pass. The salmon were unable to get by the dam in any other manner as no fish ladders or other arrangements were made for this purpose.

8. Were there other growths or obstructions which might have contributed to stopping salmon?

Answer: There were no other growths or obstructions stopping salmon from coming up the Klamath River below this Copco Dam.

9. Are there other dams in the Klamath River? If so, are they equipped with fishways or ladders?

Answer: There are no other dams below the Copco Dams No. 1 and No. 2.

10. Could the Indians who fished for salmon have engaged in other work, minimizing the damage suffered by the loss of the salmon.

Answer: Yes, the Indians could have caught other kinds of fish than salmon, thus minimizing the damage suffered by the loss of the salmon.

11. Can other estimates of value of salmon to Indians be obtained to supplement those submitted January 6, 1942?

Answer: I am unable to find any other methods of estimating the value of salmon to Indians to supplement those already submitted with your report of January 6, 1942.

The survey work on the Copco No. 1 Dam was started during the summer of 1910 and the foundation was started in the spring of 1911. The dam was completed and put into operation during the spring of 1918 but, of course, the salmon had been stopped at the beginning of the work. The second unit was added to this No. 1 dam by increasing the height 13 feet and this was done in 1922.

I am enclosing herewith a map of the territory in question in this case, which shows the Klamath River from its source to the point where it empties into the Pacific Ocean. It also shows the location of No. 1 and 2 plants and towns along the route. It also shows the Copco plant at the fish hatchery on Fall Creek. It will be noted on this map that there are no dams or obstructions extending in the Klamath River below these dams. The map shows the Oregon and California sides of the territory and shows the Sprague River and the Williamson River, up which streams salmon used to come. I thought this map might be of use, or of interest, at least. (Courtright 24 June 1942)

Courtright is quite specific in setting the year of blocking by the dam as 1911. As we noted previously, a letter including a newspaper clipping sent by Boyle seems to imply a later date:

Since your visit to Medford on July 29, 1940, at which time we discussed the construction and operation of fish ladders and fish hatcheries on the Klamath River, I have had a further search made of our files and records. I have also communicated with men who were associated with our Company during 1918 and 1919 and who were familiar with the Klamath River problems.

Very little information is available from these sources because agreements covering these problems were made over twenty years ago and records have either been destroyed or misplaced.

I have found a clipping of an article which appeared in the Evening Herald, Klamath Falls, Oregon, on March 7, 1918, which I think confirms generally the information which I gave you on your visit here and also confirms the information given you by Mr. Ryckman of the Oregon State Game Commission. This article reads as follows:

"HATCHERY FOR STREAMS OF KLAMATH"

"Fishway Over Copco Dam Found To Be Impracticable.
New Hatchery In California Will Supply Stock For Streams Here.

"Sportsmen of Klamath County and the whole Coast will be delighted to learn that a plan has been worked out whereby thousands of fish of different varieties will be planted in the streams adjacent to the Klamath Lakes, which will make this section an angler's paradise.

"For the past three or four years the federal bureau of fisheries has maintained fish racks at Klamathon in California, on the Klamath River, and local sportsmen claim that this has seriously interfered with the run of fish up the Klamath.

"With the completion of the big dam at Copco any run of fish up the river beyond that point has been cut off, and discussion between the federal bureau of fisheries and the fish commissions of California and Oregon has been in progress for some time past as to the best means of solving this problem in a fair way and satisfactory to all parties concerned, and especially the protection of one of the world's greatest fisherman's resorts, viz.: the Klamath Lake region.

"The idea of a fish ladder over the Copco dam was first taken up and considered in detail, but as a height of some 130 feet would have to be overcome, it was decided from statistics and the opinion of experts, that the installation would not give satisfactory results.

"Finally the California-Oregon Power Company was taken into the discussion of general plans, and as all the members composing the board of directors of that company are enthusiastic fishermen, there was soon arrived at a plan whereby the federal bureau of fisheries has relinquished all its control of the Klamath River in California to the California State Fish Commission, and has turned over to it the buildings, racks and spawn taking apparatus. California-Oregon Power

Company has agreed to the erection of a hatchery on its property on Fall Creek, which, on account of the clear and even temperature of the water, a perfect condition is found for hatching and caring for the little fish, and the California Fish Commission agrees to take spawn and hatch various varieties of fish native to the coast streams, and to deliver to the Oregon Fish Commission and the game wardens of Klamath County all the little fish necessary to stock abundantly the numerous lakes, rivers and creeks in the vicinity.

"The Oregon Fish and Game Commission is particularly pleased, as a much felt want is being supplied without cost, other than transportation, to the people of Oregon and this locality.

"The commission was represented by the project Engineer H. W. Hincks of the Modoc Point project in this matter."

In answer to the questions in your letter of August 5, 1940, I wish to advise that the construction of the fish hatchery at Fall Creek, the construction of the fish racks at Klamathon and the construction of operators cottages, etc., incidental to the operation of these, was carried on during the last six months of 1918. This work was under my direction and I was assisted by Mr. Bert Doney of the California Fish and Game Commission. The real estate upon which these structures were built was deeded to the California Fish and Game Commission on March 27, 1919. (Boyle 14 August 1940)

This source seems to suggest that the blocking occurred only with the completion of COPCO I in 1918. However, the date assigned to the article may be wrong. If it was printed in 1918, it is stating that the racks were put in place in 1914 or 1915. If the placing of the racks referred to is that of 1910, the article might be from 1914.

Another clipping reproduced in Boyles' book may support the suspicion that the clipping in his letter to Simmons is misdated:

Evening Herald, Klamath Falls, Oregon, October 30, 1914

NO SALMON BELOW DAM

Hatchery Responsible For Shortage Felt Here

The question of why the annual run of salmon has not made it appearance in the Klamath River as usual has been investigated and the causes determined beyond any question of doubt. There has been discussion as to the cause of a lack of salmon run into the headwaters for the purpose of reproduction; and as a result the California-Oregon Power company was insistent on an investigation to determine if the cause lay in any way at the Klamath River dam under construction in California.

At the request of this company, and in the interests of the fishing industry in Southern Oregon, a most thorough investigation was made. No salmon were found below the dam.

This led to further investigation being made, and the cause was located at Klamathon, where the United States bureau of fisheries has established racks, traps and field stations for the taking of salmon eggs.

We found that there are two separate racks extending entirely across the river from bank to bank, thus effectively cutting off the entire run of salmon.

In justice to the power company we can say that they are in no way responsible for no salmon being in the river.

C.M. RAMSBY,
A.J. SPRAGUE.
(Boyle 1976:23)

Testimony of persons, Indian and non-Indian, who were fishing for salmon in the streams of the Klamath Basin or who were knowledgeable about the area almost all recollected 1910 as the year the salmon stopped coming. One person thought that he had taken salmon in 1915 or 1916.

H.W. Hincks, the project engineer on the Klamath Irrigation Project between 1912 and 1917 stated, if we interpret correctly, that in that period, he did not see chinook salmon in any numbers although large steelhead runs came up the Williamson and Sprague Rivers:

> Mr. H.W. Hincks, City Engineer of Pasadena, California, was Project Engineer of the Klamath Irrigation Project from the fall of 1912 to 1917. He constructed the fish ladder in the dam in Sprague River. Mr. Fortier and I recently talked with Mr. Hincks in his offices at Pasadena, California. He advises that he does not remember any run of king salmon in that river nor had he ever observed king salmon in any numbers in Klamath Lake or in the Williamson or Sprague Rivers. He, however, advises that steelhead came up the Williamson and Sprague Rivers in great numbers, as well as rainbow trout and white fish and suckers. He does remember seeing an occasional king salmon in the Sprague River. Mr. Hincks' observations would only be important as to the year 1913, as according to your report, the salmon stopped running in 1914, immediately after construction work was begun on the Copco Dam. It may be that the construction work on the Copco Dam commenced in 1913 and this accounts for the absence of the king salmon in the reservation streams. Mr. Hincks is positive, though, that he did see steelhead in great numbers, which, undoubtedly, came from

> the Ocean up the Klamath River into Klamath Lake and then into the Sprague and Williamson Rivers. (Simmons to Courtright 5 November 1940)

Another explanation that was considered by Simmons was the possibility of a landlocked "steelhead" population:

> Many of the old Indian fishermen who participated in spearing and taking salmon from the Williamson and Sprague Rivers advised me these runs stopped in about the year 1910. Some of these Indians said the runs continued until 1917 or 1918. I am reasonably certain the construction of the main Copco Dam at Copco, California prevented any fish from coming up the river after the year 1910. Would it be possible for many steelhead to become landlocked in Klamath Lake after 1910 and still migrate up the Williamson and Sprague Rivers during the spawning period? Would this condition allow a number of landlocked steelhead to exist in these reservation waters for several years after the construction work on the Copco Dam had stopped the fish from entering the former spawning grounds? (Simmons to Ryckman 28 July 1941)

Some people in the Klamath Basin today are still convinced that there are strange "salmon like" trout in Upper Klamath Lake.

We cannot certainly resolve the issue of when anadromous fish were blocked from running to Klamath Basin. Mr. McKee's letter does not make total sense in that the California Fish and Game Commission was supposed to have blocked all of the salmon at Klamathon at and before the time that McKee wrote his letter. However, some fish may have been getting through the racks or some may have been getting through before or after the racks were in the river. If some chinook salmon and some steelhead were getting past Klamathon, the steelhead rather than the chinook might have been more successful in getting through the tunnel and flumes. Somewhere in such conjecture may be the explanation of what Mr. Hincks recollected. However, the skills needed to unravel the mystery are those of fishway experts.

It seems fairly clear that the bulk of the Klamath Basin chinook salmon runs were not getting to their spawning grounds after 1910. A few chinook and perhaps more steelhead may have been getting into the Basin as late as 1916 or later but certainly not after 1918.

This means that anadromous fish since have been restricted to the Klamath River and its tributaries below the Copco dams in California after 1918.

The principal salmon spawning beds in the Klamath River proper are located from the mouth of the Shasta River to the upstream limit of migration at Copco Dam, a distance of approximately 22 miles (Plate 1). Spawning on the main stem of the Klamath River, downstream from its confluence with the Shasta River, is scattered and does not involve large numbers of fish. Larger tributaries, including the Trinity, Salmon, Scott, and Shasta Rivers, as well as a host of excellent smaller tributaries, such as Blue, Clear, Elk, Indian, Beaver, Bogus, and Fall Creeks, contain important spawning beds utilized by salmon and steelhead. Some of these streams have annual spawning runs of both king and silver salmon as well as steelhead. Spring salmon migration in the Klamath River system was once very great, but it has now become reduced and is of considerably less economic importance. As the streams came to be used more and more by man, summer conditions were often made intolerable to the spring run. So even though conditions have remained suitable for fall run fish, spring runs have vanished from some streams and have been greatly diminished in others.

Studies during the 1920's indicated that salmon runs of the Klamath River system as a whole were diminishing, and that further investigation should be made to find means of remedying this condition. Counts of upstream migrant king salmon began in 1925 at Klamathon Racks on the Klamath River, 14 miles below Copco Dam. Five years later a counting rack was installed on Shasta River, near its confluence with the Klamath River, and counts were obtained there also.

The average annual number of king salmon reaching Klamathon Racks during the 22 years in which counts were made is about 12,000. No counts were made during the war years. The bulk of the king salmon utilizing areas upstream from Klamathon usually spawn from October 1 through the early part of November, and the seaward migration of young salmon commences in the latter part of December and continues into early April. Table D-2 gives the counts of adult king salmon at Klamathon Racks from 1925 through 1955.

Very little is known concerning the size of silver salmon runs in the Klamath River. Recently, however, the Department of Fish and Game has accumulated considerable evidence which shows that silver salmon are more abundant than has been generally supposed. Silvers spawn in most tributaries to the Klamath, from those near the mouth, such as High Prairie, Hunter, Turwar, and Blue Creeks, to Fall and Bogus Creeks just below Copco Dam. They utilize many smaller streams not used by king salmon. Two or three hundred silvers are counted through the Klamathon Racks each year. No attempt has been made to get a complete count of silver salmon at Klamathon, but those that pass through the gates during the king salmon run are counted.

Steelhead utilize practically all tributaries of the Klamath and are without doubt the most widespread of the anadromous fishes in the drainage. The major portion of the steelhead run at Klamathon comes after November 15 and usually after the counting racks have been removed for the season, so no complete accounts are available. (Cal DWR 1960:151-152)

MITIGATION EFFORTS

Fish Passage

The Klamathon racks were constructed in an attempt to mitigate the damaging effects of the dam. They reflected the practices of fishery management at the time. Fish were trapped the eggs stripped, fertilized and hatched in a hatchery on Fall Creek. Whether or not this did any good at all in maintaining fish runs in the Klamath River below COPCO I (and the two later dams, COPCO II and Iron Gate), the Klamathon racks had no bearing on Klamath Tribal fishing rights. The treaty protected fisheries were above the dam rather than below it. Had fingerlings been transferred above the dam and been able to get back down through and over the dam, they still would not have been able to get back to the Basin as mature fish. The practise of physically carrying fish in containers of some sort past dams had not yet been developed. The only means of getting mature fish up the river past the dam and into the Basin would have been by means of a fish ladder.

In August, 1916, McKee of COPCO assured the Commissioner of Indian Affairs that a fish ladder would be built or was being built:

> "We note that complaints have reached your office through the Klamath Indian Reservation that the run of salmon in the Klamath River has been interfered with by a dam which our company has under construction upon the Klamath River.
>
> "In reply we beg to say that we expect that the said dam will be completed by the end of the present year, 1916. Ample provision has been made in the plans for the dam for a fish ladder which will permit unobstructed passage of fish up the Klamath River. In the meantime, and during the period of construction, the waters of the river are being carried in part through a tunnel around the dam and in flumes through the base of the dam. There is no difficulty about fish making their way upstream under present conditions.
>
> "When the tunnel and flumes through the dam which now permit the run of fish to pass are closed up, the fish ladder will be in operation.

"We are sending copies of this correspondence to our engineer in charge of the work at the dam, requesting him to reexamine the situation and if it appears that anything further can be done to facilitate the passage of fish upstream during the construction of the dam, to do whatever is necessary to bring this about at once. Yours very truly, (signed) J. McKee, Vice President, California-Oregon Power Company." (McKee to Merritt 23 August 1916 in Simmons n.d.:22)

In August, 1918, the Assistant Commissioner of Indian Affairs was still making inquiries regarding the fishway:

> This will refer further to the Copco dam being constructed on the Klamath River by the California-Oregon Power Company and the desirability of having installed in connection therewith a fishway to permit salmon to reach the upper waters of the river.
>
> The California-Oregon Power Company has previously expressed a willingness to cooperate in the matter of providing a proper type of fishway over the dam and the Office understands that your Commission delegated Mr. W. H. Hincks, former Irrigation Engineer of the Indian Service, to represent it in a conference with engineers of the power company and a representative of the California Fish Commission relative to the matter. This conference of engineers it is understood has not been held and the Office learns that the power company has concluded or is about to conclude arrangements with your Commission whereby the company shall be released from building the proposed fishway in consideration of the Company's undertaking to place a given number of salmon spawn above the dam. Whether this is in the nature of a tentative arrangement only we are not advised.
>
> As the Office understands it this arrangement would not meet the situation, inasmuch as it appears that salmon are spawned and live in fresh water for their first year and go to sea when they remain in the salt water for three years more, returning at the end of the fourth year of their lives to their home waters for spawning, after which they die. It is also learned that salmon placed above the dam never mature, salmon weighing more than one pound, and that few reach a weight of four pounds.
>
> The Indians of the Klamath Reservation have, from time immemorial, depended upon the supply of fish for a large percentage of their food and it is highly, desirable that proper provision be made by the power company for the passage of salmon over its dam.
>
> This Office will be pleased to be advised concerning the nature of the reported arrangements made by your Commission with the power company in this matter. (Meritt to Oregon State Fish and Game 14 August 1918)

By December of that year, Meritt was aware that no fishway was going to be built.

The Office is in receipt of your letter of November 16 inclosing a copy of one addressed to you by Mr. C. F. Stone of Klamath Falls, Oregon, concerning arrangements made by your Commission with the California-Oregon Power Company whereby the latter is to place three million trout fry in Klamath River, above the Copco Dam, each season, by way of compensation for the hindrance of the spring run of rainbow on account of the obstruction of the river by the company's dam.

While the arrangement referred to will perhaps solve the trout question, in the Klamath River above the aforesaid company's dam, no provision apparently has yet been made for the restoration of the salmon run in the river. It appears from the record in the case that a great many salmon were taken from the river by the Indians for personal consumption prior to the construction of the Copco dam, but that since that time no salmon have been caught.

. . .

This office will be pleased to be advised whether the arrangement made by your Commission with the California-Oregon Power Company for the placing of trout fry is tentative only or is in the nature of a release of the company by the Oregon Fish Commission from building a suitable fishway, and if the latter, whether it was made with reference to the run of trout only.

The Office feels that the shutting off of the salmon run in the Klamath River was a result of the construction of the dam in question, is an imposition on the Indians who depended upon it in the past, and would like to have your cooperation in the matter of requiring the company to build a proper fishway as originally contemplated. (Meritt to Shoemaker 11 December 1918)

The Klamath Falls Evening Herald article of March, 1918 summarized the events and indicated that the idea of a fishway had been abandoned as impractical and that an in lieu fish hatchery was being planned instead. (Boyle to Simmons 14 August 1940) (See p. 147.)

Simmons, in his brief, interpreted these events as follows:

"Further protests were made by the Commissioner of Indian Affairs but without results. The dams were constructed; no fishways were installed. According to our engineers there could never have been any intention on the part of the California Oregon Power Company to construct fishways in the dam for the reason that the cost would have been prohibitive and that a suitable fishway, if constructed in the dam, would have required so much water for its successful operation that the main purpose of the dam, for generating power, would have been defeated or curtailed to such an extent that serious financial loss would have resulted to the California Oregon Power Company." (Simmons n.d.:22)

Simmons, probably using information that we have not recovered, summed up and interpreted these events as follows:

> Some attempts were made by the California Oregon Power Company although they do not appear to be sincere attempts on their part, to allow the salmon to proceed up Klamath River to Klamath Lake and the Reservation streams, from 1910 to 1916. The company was required, due to pressure brought upon it by the Fish and Game Commission of California to maintain a by-pass for water to allow the fish to go up the river into Klamath Lake and into the Klamath Reservation waters. The by-pass did not prove to be very successful for the reason that the flow of water through the tunnel was too great.
>
> The State of California became very interested in these dams, and insisted that suitable fishways be installed. In the 25th Biennial Report, 1916-1918, of the California Fish and Game Commission, it is stated:
>
> "In January, 1913, the California and Oregon Power Company began the construction of a concrete dam in the Klamath River two and a half miles above the mouth of Fall Creek in Siskiyou County. This dam, 110 feet high, has required a great deal of study on the part of this department. The great problem involved was whether an efficient fishway could be constructed on such a dam, and if such a fishway was constructed, what would be the benefit derived from such an undertaking. The principal run of fish on the Klamath River in the region of Copco dam is trout and salmon. The Federal Bureau of Fisheries has operated a salmon egg-collecting station on the river below the dam and have for the last eight years prevented the salmon from ascending the river above the racks at Hornbrook. This is necessary that the supply of salmon may be maintained in the Klamath River. If the racks were removed and the salmon allowed to ascend the river and a fishway constructed that would allow the passage of the breeding salmon above the dam, the resulting fry would have to return to the ocean and on their downward journey would be destroyed by the power wheels of the hydroelectric plant that takes the water from the dam, for in our opinion it is impossible to successfully screen a pipe that has such a suction as the tubes that feed the turbines at this plant. Therefore, in our judgment it would be a waste of time to construct a fishway for the passage of salmon above the Copco dam. . . .
>
> "Under the provisions of the law passed by the last legislature, (Fish and Game Code of California, 1939-1941, Art. 2, Division 4, Section 526) whenever a dam or other obstruction is placed in a river or stream that, in the judgment of the Fish and Game Commission, is too high for the successful operation of a fishway, or for other reasons it is deemed best to establish a hatchery below the dam for the propagation of any species of

fish that may be interfered with by the construction of the dam, the owners of the dam must construct and equip a hatchery for the purpose of propagating fish for the river and turn it over to the state for operation. This is the policy that the Federal Government is taking in Alaska, and it is the law in the State of Washington. Last year five hatcheries were built and equipped in Washington by the owners of large dams and turned over to the state. Our commission is trying to follow the same course on the Klamath River, as it is the only practical way of insuring a good supply of trout in the upper reaches of the Klamath River. . . .

"All arrangements are now complete for the construction of a large, modern hatchery on Fall Creek this summer. This hatchery will be used to propagate salmon as well as supply the upper reaches of the Klamath River with an ample number of trout fry to insure a good, if not better, fishing in that section than was had before the dam was built. The California and Oregon Power Company, complying with the provisions of the law, will establish this hatchery free of all expense to the state, turning it over to the commission for operation."

Then in the California Fish and Game Biennial Report, Volume 4, for 1918, the following article appears:

"A New Hatchery on Klamath River is Planned.

"A law recently passed by the legislature provides that when it is proved unfeasible to install a fish ladder over a dam, a power company will be required to install a fish hatchery several years. The first hatchery to be erected under this law will probably be placed on the Klamath River near Copco, where the California-Oregon Power Company has a 130-foot dam. Experts have proved that a fish ladder over this dam would be impracticable. The California-Oregon Power Company has therefore agreed to the erection of a hatchery on its property on Fall Creek. The United States Bureau of Fisheries which has operated a spawning station lower down the Klamath River has given up its work at this location and relinquished control to the California Fish and Game Commission.

"The solution of the problem arising from the Copco dam has thus been solved and improved fishing conditions on the Upper Klamath River are to be expected."

Thus the California Oregon Power Company settled with the State of California and through this hatchery allowed Klamath River in the State of California to continue as one of the great salmon streams of this country, but the State of Oregon and the Klamath Tribe of Indians were forgotten by the California Oregon Power Company, insofar as the destruction of the salmon runs in Klamath River, in the State of Oregon, Klamath Lake and the Williamson and Sprague Rivers on the Klamath Indian Reservation were concerned. (Simmons nd. 19-20)

Appendix F is a copy of the full text of the section on obstructions in streams from the California Fish and Game Code.

There is no reason to believe that the Klamath Tribe was forgotten, but it is clear that their interests in the fisheries were ignored. Boyle, in charge of construction at COPCO I says that discussions were held with representatives of the Bureau of Indian Affairs and that they visited the site during construction to inquire about fish passage:

> At the time of starting construction of Copco No. 1 dam, the question of constructing a fish ladder was discussed with interested parties. During the initial construction period, representatives of the Klamath Sportsmen's Association, the U.S. Bureau of Indian Affairs, and the California Fish and Game Commission frequented the job and made inquiries as to construction of a fish ladder.
>
> The Company was willing to construct a fish ladder over Copco No. 1 dam, under the laws existing at the time, providing proper plans and specifications were submitted by the California Fish and Game Commission which would adequately take care of the fish migrations. The Company took the position that it was not willing to construct more than one fishway.
>
> The Company agreed with the California Fish and Game Commission, after considerable study, that in lieu of constructing a fish ladder it would build a fish hatchery at Fall Creek, costing approximately the same amount of money as a fish ladder, and deed the land on which the hatchery was located to the State. Also, the Company would rebuild the dams at Klamathon used by the Federal Bureau of Fisheries as an egg-taking station.
>
> Investigations were made from time to time by members of the Klamath Indian Reservation and the Klamath Sportsmen's Association and, finally the matter was referred to the District Counsel of the Department of the Interior, Office of Indian Affairs, Billings, Montana. (Boyle 1976:21. Underlining added. The end of the last sentence refers to the Indian Affairs investigation which began in 1940.)

In his recollections, Boyle includes two other clippings which are interesting for the light that they throw upon the hatchery versus fish passage issue:

Evening Herald, Klamath Falls, Oregon, January 3, 1919

BIG HATCHERY COMPLETED BY C. O. POWER CO.

Work Will Be Finished This Week

KLAMATH COMES FIRST

Building of Fish Wheel Over the Big Copco Dam Is Found to Be Impracticable—Hatchery Is Built by the California-Oregon Power Company Instead of Fishway

---

As the result of a controversy of the advisability of the construction of a Fish Ladder over the big Copco Dam, the California Oregon Power Company is just completing a large Fish Hatchery at Fall Creek a short distance below Copco, from which it is understood that all the eggs and fry, needed for this district, will be finished this week.

The construction of a fish ladder to take care of the fish coming up the Klamath River was at first discussed, but found to be impracticable. The hatchery built by the Company is about 125 feet long and about half of that in width. Whether it will be operated by the California and Oregon State Officials or by the Federal government, is still uncertain.

Evening Herald, Klamath Falls, Oregon, February 16, 1921

SAYS FISHWAY OVER DAM IS IMPRACTICAL

In answer to a letter from William W. McNealey, written in the interest of local sportsmen, W. H. Shelbley, in charge of fish culture at Sacramento, the latter writes comprehensively regarding the proposed construction of a fishway over the Copco dam for the purpose of giving salmon a chance to ascend the river.

Mr. Shebley's letter states in part, "...The matter of a fishway over Copco dam was gone into thoroughly by our experts and engineers before we decided to compel the California Oregon Power Company to build a hatchery, in lieu of a fishway, as provided in our fishway law. The problem involved was whether an efficient fishway could be constructed over a dam that is 100 feet in height, and with plans for construction that would raise the dam ten or fifteen feet higher, and what would be the benefit of such undertaking.

"The principal run of fish in the Klamath River at Copco is trout and salmon. The federal bureau of fisheries was operating a salmon egg collecting station in the river below the dam; and had for eight years prior to our surveys prevented salmon from ascending the river above their racks at Klamathon. This was in accordance with the law, and was necessary in order that the supply of salmon may be maintained in Klamath River. Since that time the California fish and game commission has taken the egg collecting station over, and the power company has established a hatchery at Fall Creek, where salmon and trout eggs are hatched for the Klamath river."

Mr. Shebley in his letter states further that if the racks were removed at Klamathon and the salmon allowed to ascend the river, and if it were possible to build a fishway over the dam, the resultant fry would have to return to the ocean, and on their journey oceanward would be destroyed in the power wheel of the hydroelectric plant. Therefore it would be a waste of time and money to build a fishway over Copco dam. The supply of trout, says Mr. Shebley, above the dam, can be increased by distributing several hundred thousand fry each season above the dam. In 1920, 250,000 fry were planted above the dam.

There is a plan continued the letter ". . .for two more large dams on the Lower Klamath River and if they are allowed to be constructed they will exterminate all the salmon in the Klamath, as there are no spawning grounds below the proposed dam sites.

"Kindly explain to the persons who are agitating the construction of a fishway over Copco dam that it is impractical, and if built the salmon would be taken below the dam sites.

"The California Fish and Game Commission at considerable expense is maintaining this hatchery, and the people of Oregon are getting as much if not more benefit from our efforts than the people of California. We are now making a determined fight against the construction of any more dams on the Klamath River, but have a hard fight against two powerful corporations, who have made application to the federal power commission in Washington for permits to construct two very high dams on the lower reaches of the river.

"We hope that the citizens of Klamath Falls will appreciate the difficulties under which we are working."

W.H. SHEBLEY
(Boyle 1976:23,24)

The Fall Creek hatchery operated until 1948:

Following the construction of Copco No. 1 Dam, the company constructed on Fall Creek, a stream about one-half mile below the plant, a hatchery and egg taking station and deeded them to the Fish and Game Commission. These facilities were operated until 1948 when "operations were discontinued due to the high cost of maintaining the installation and high operational cost of raising fish. Since 1948 salmon eggs have been taken at Fall Creek but raised at the Mt. Shasta hatchery. (FPC AR 1960:66)

Iron Gate Mitigation

Iron Gate dam was constructed in part to mitigate the effects (downstream) of COPCO I and II. However, its construction also destroyed more salmon and trout habitat:

> The testimony is that the Iron Gate Development would prevent access by salmon and steelhead trout to about 16 miles of spawning gravel and would also destroy one of the most popular stream fishing areas in the upper Klamath River. It is the position of the Department that in order to maintain the runs of salmon and steelhead which now utilize the area above the Iron Gate site, fish trapping, egg taking and hatchery facilities will be required. (FPC AR 1960:66-67)

This fact was protested at the Federal Power Commission licensing hearing:

> Following publication of notice of application for amendment of the license, which notice provided for the filing of protests or petitions to intervene, the State of California acting by and through its Department of Fish and Game filed an "informal protest" to the issuance of the amendment requested relating to the construction of the reregulating dam unless and until such license as might be granted contain certain conditions enumerated in such "protest." Thereafter, the Commission set the matter down for public hearing, and it was heard on August 4, 1959, in the City of Klamath Falls, Oregon with the undersigned hearing examiner presiding. In addition to the Applicant, there appeared at the hearing representatives of the State of California and the Oregon State Game Commission as parties to the proceeding, and the Staff of the Commission. There were also present or represented at the hearing the State Engineer of Oregon, the Oregon Fish Commission, the President of the Klamath River Sportsmen Association, the United States Bureau of Reclamation, the Klamath Basin Water Users Protective Association, the Honorable Randolph Collier, member of the California State Senate, the California Wildlife Federation, the Department of Water Resources of the State of California and the Klamath Indian Executive Committee. Following the hearing, briefs were filed by the Applicant, the State of California and the Staff of this Commission. (FPC AR 1960:61-62)
>
> At the hearing held in Klamath Falls, Oregon on August 4, 1959, the representative of the Oregon State Game Commission requested that adequate provision be made in the license for the protection of fish and wildlife.
>
> Honorable Randolph Collier, State Senator from the Siskiyou-Del Norte counties, California, favored the agreement between the State of

> California and the Applicant described above, but felt that the second state of construction of the Iron Gate project should be undertaken within five years from the completion of the first stage. He felt also that the waters of the river should not be allowed to go beyond 1,740 cubic feet per second during the months of May and September, inclusive, each year.
>
> The representative of the California Wildlife Federation stated that his organization supported the recommendations of the California Department of Fish and Game. However, he and the representative of the Klamath River Sportsmen Association questioned whether a 65 foot dam would adequately reregulate the flow of the stream. They also requested that provision be made to assure a relatively low temperature of the water. The Sportsmen Association's representative requested, in addition, that there be reasonable access to the impounded waters.
>
> A member of the Executive Committee of the Klamath Indians requested an express reservation in the license that such license is subject to any and all rights of the Klamath Indians. (FPC AR 1960:67-68)

It should be noted that three things were being considered at the hearings: 1. Iron Gate Dam; 2. Big Bend (Upper Klamath) dams; 3. the inclusion of all Copco dams on the Klamath River under a single license (Project No. 2082). Therefore, these events were of direct as well as indirect concern to the Klamath Tribe.

With respect to Iron Gate negotiations, the California State Department of Fish and Game and Copco agreed on a service of mitigation measures:

> With full awareness of stream conditions affecting fish and game which now exist and which may hereafter exist after the construction of the Iron Gate Dam, the State of California through its Department of Fish and Game and its Fish and Game Commission, entered into, on July 27, 1959, an agreement with The California Oregon Power Company and that agreement was made a part of the record in this proceeding. The contract of July 27, 1959, recites, among other things, that the State of California is satisfied that the construction, maintenance and operation of the Iron Gate Development as proposed by the Applicant will reregulate the flow of Klamath River in a manner satisfactory to the State of California. The agreement provides that upon receipt of a license from the Federal Power Commission and necessary state authority, Copco will immediately commence the

construction of, diligently prosecute to completion, and thereafter maintain and operate, the first stage of reregulating facilities near or at the site of its proposed Iron Gate Development. It provides further that Copco shall release over, around or through said Iron Gate Development a continuous flow of not less than 710 cubic feet per second of water into the natural channel of the river for the protection and preservation of fish and wildlife; that the rate of fluctuation of flows of Klamath River below the Iron Gate Development shall not exceed 250 cubic feet per second per hour and that the change in river state or elevation shall not exceed three inches per hour.

In addition to the reregulation of the stream as above described, Copco agreed that concurrently with the construction of the first stage of the development it will construct permanent fish trapping and egg collecting facilities at or near and downstream from such development, to consist of structure, equipment and water supply for trapping and holding upstream anadromous migrants in accordance with plans and specifications seasonably to be furnished by the Department of Fish and Game. Copco further agreed that subject to certain limitations all project waters were to be opened to free access and use for the purposes of hunting and fishing.

It should here be pointed out that Copco did not agree to construct fish hatchery facilities but the contract provides that the right is reserved to all parties to the agreement to be heard in any future proceedings in regard to fishery facilities other than the fish trapping and egg collecting facilities referred to above. In keeping with the agreement of July 27, 1959, and predicated upon the proviso that the right is reserved to all parties thereto to be heard in any future proceeding in regard to fish hatchery facilities, the Department of Game withdrew the informal protest which it had previously filed. (FPC AR 1960:62)

The order issued by the FPC laid out the required mitigative measures:

Article 42. The Licensee shall, concurrently with the construction of the first stage of Iron Gate Development, construct permanent fish trapping and egg collecting facilities at or near and downstream from Iron Gate Development, the type of such facilities to be generally in accordance with plans approved by the Commission upon recommendations of the Secretary of the Interior and the Department of Fish and Game of the State of California.

Article 43. The Licensee shall construct, maintain and operate, or shall arrange for the construction, maintenance and operation of such fish ladders, fish traps or other fish handling facilities, or fish protective devices, for the purpose of preserving the fishery resources at the Iron Gate Development, and comply with such reasonable modifications of the project construction and operation in the interest of fish life as may be prescribed, after notice and opportunity for hearing, by the Commission upon its own motion, or upon the recommendations of the Secretary of the Interior and the Department of Fish and Game of the State of California.

Article 44. Prior to the construction and operation of the first stage of the Iron Gate Development, the Licensee shall, to the extent of conditions within its control, operate its existing Copco No. 1 and Copco No. 2 plants so as to limit fluctuation of the surface of the Klamath River at a recording station located one-half (½) mile below the lower of said plants. . . .(FPC AR 1960:72)

PROTEST

Officials of the Bureau of Indian Affairs protested the damage to Klamath Indian fishing rights due to the building of COPCO I. In 1915 the Superintendent of the Klamath Agency wrote to the Commissioner of Indian Affairs.

> The train upon which I am traveling has just crossed the Klamath River in California, -- the river that drains the upper Klamath Lake, into which flow the Sprague and Williamson rivers on the Klamath Indian Reservation. As one looks up the River as the train crosses the railway bridge, one sees a dam built across the River which does not wholly obstruct the flow of the River but which, I am told, does prevent the salmon from going any further up stream. My information is that this dam was built and is used by the California Fish Commission for the purpose of taking salmon eggs for the propagation of salmon. Whether this be true, I can not say. But it is true that on the Klamath Reservation, where formerly salmon were abundant and furnished much food for the Indians, there are now no salmon to be found.
>
> Complaint has been made by the Indians that by some means they are being deprived of the salmon which formerly ran in their rivers, and I have intended to bring the matter to your attention before this time, but I have been prevented by the stress of work. I avail myself of the present opportunity, hoping that means may be found to restore the salmon to the Indians. I shall be pleased to receive any instructions which the Office may have for me in the matter. (Superintendent -- Commissioner of Indian Affairs 2 January 1915)

The "dam" to which the superintendent was referring to was in fact the fish rack installed by the U.S. Bureau of Fisheries around 1912 and taken over by the California Fish Commission in 1919. The rack was installed, once the go ahead on the COPCO dam was given, in order to try to salvage the upriver anadromous fish runs.

Members of the Klamath Tribe had been complaining about the blocking of the salmon runs. According to James Johnson:

> "It was about 30 years ago the salmon stopped running up the river. This was caused by the power dam then being constructed in the

Klamath River above Hornbrook, California by the California Oregon Power Company. I remember very well when that construction work was going on while I was hauling freight at Agar, California, near Hornbrook, California, and went over on occasions and watched them build the dam.

"When the dam stopped the salmon from coming up the river in Klamath Lake and into the Williamson and Sprague Rivers all of the Indians complained bitterly to the Superintendent then in charge. The Superintendent kept assuring us and promised us repeatedly that he would see that fish ladders were put in the dam so that the fish could come up the river but nothing was ever done. We Indians have continued complaining through the years and it was not until last year when Superintendent Courtright wrote into Washington that anything was done." (Simmons n.d.:17)

Tribal member, Erskine Beal had actually fished at the fishing site where COPCO I was built:

"The salmon stopped running about 1909 when the power dams were under construction in the Klamath River in the State of California. I know the places where the power dams were constructed as I fished there and caught salmon before the California Oregon Power Company started putting in these dams. After 1909 when work was started on these dams, the salmon ceased coming up the river. There were no more salmon. This also damaged considerably the trout fishing and reduced the number of trout available in the streams. The trout would always come up the river to eat the spawn of the salmon. I noticed and still notice that the trout fishing in all of these reservation streams has materially fallen off. This was caused, I am certain, by the construction of the power dams of the California Oregon Power Company in the Klamath River. I have been down to Copco, California, and have seen the power dams. There are no fish ladders installed there and no way for the salmon fish to get up the Klamath River into Klamath Lake and into the Williamson and Sprague Rivers on the reservation. I understand repeated efforts have been made by the Indians and the Government to remedy this situation but without results up to the present." (Simmons n.d.:18)

On August 15th, 1916, the Commissioner of Indian Affairs wrote to the California Oregon Power Company to advise the company of Klamath Indian protests regarding the blocking of salmon by the dam. The response was reassuring:

"Your favor of the 15th instant, addressed to Mr. C. G. Steele, Division Manager of the California Oregon Power Company at Yreka, California. has been forwarded to this office for attention.

"We note that complaints have reached your office through the Klamath Indian Reservation that the run of salmon in the Klamath River has been interfered with by a dam which our Company has under construction upon the Klamath River.

"In reply we beg to say that we expect that the said dam will be completed by the end of the present year, 1916. Ample provision has been made in the plans for the dam for a fish ladder which will permit unobstructed passage of fish up the Klamath River. In the meantime, and during the period of construction, the waters of the river are being carried in part through a tunnel around the dam and in flumes through the base of the dam. There is no difficulty about fish making their way upstream under present conditions.

"When the tunnel and flumes through the dam which now permit the run of fish to pass are closed up, the fish ladder will be in operation.

"We are sending copies of this correspondence to our engineer in charge of the work at the dam, requesting him to reexamine the situation and if it appears that anything further can be done to facilitate the passage of fish upstream during the construction of the dam, to do whatever is necessary to bring this about at once. Yours very truly, (signed) J. McKee, Vice President, California-Oregon Power Company." (In Simmons n.d.:22)

In August, 1918, the Assistant Commissioner wrote to the Oregon State Fish and Game Commission seeking information and objecting to the arrangements being made:

This will refer further to the Copco dam being constructed on the Klamath River by the California-Oregon Power Company and the desirability of having installed in connection therewith a fishway to permit salmon to reach the upper waters of the river.

The California-Oregon Power Company has previously expressed a willingness to cooperate in the matter of providing a proper type of fishway over the dam and the Office understands that your Commission delegated Mr. W.H. Hincks, former Irrigation Engineer of the Indian Service, to represent it in a conference with engineers of the power company and a representative of the California Fish Commission relative to the matter. This conference of engineers it is understood has not been held and the Office learns that the power company has concluded or is about to conclude arrangements with your Commission whereby the company shall be released from building the proposed fishway in consideration of the company's undertaking to place a given number of salmon spawn above the dam. Whether this is the nature of a tentative arrangement only we are not advised.

As the Office understands it this arrangement would not meet the situation, inasmuch as it appears that salmon are spawned and live in

> fresh water for their first year and go to sea when they remain in the salt water for three years more, returning at the fourth year of their lives to their waters for spawning, after which they die. It is also learned that salmon placed above the dam never mature, seldom weighing more than one pound, and that few reach a weight of four pounds.
>
> The Indians of the Klamath Reservation have, from time immemorial, depended upon the supply of fish for a large percentage of their food and it is highly, desirable that proper provision be made by the power company for the passage of salmon over its dam.
>
> This office will be pleased to be advised concerning the nature of the reported arrangements made by your Commission with the power company in the matter. (Meritt to State Fish & Game 26 August 1918)

Evidently no reply was forthcoming for on October 11th the Assistant Commissioner wrote a polite follow-up note requesting a reply to the letter of August 26th. (Meritt to State Fish & Game 11 October 1918). A response was finally made on November 16th. We have not seen a copy of this reply but evidently it explained an arrangement for a seasonal transfer of trout fry from the Fall Creek hatchery to the upper Klamath River. This did nothing to solve the problem of the loss of salmon to the Klamath Tribe and in December Meritt wrote to the Oregon State Game Warden as follows:

> The Office is in receipt of your letter of November 16 inclosing a copy of one addressed to you by Mr. C. F. Stone of Klamath Falls, Oregon, concerning arrangements made by your commission with the California-Oregon Power Company whereby the latter is to place three million trout fry in Klamath River, above the Copco Dam, each season, by way of compensation for the hindrance of the spring run of rainbow on account of the obstruction of the river by the company's dam.
>
> While the arrangement referred to will perhaps solve the trout question, in the Klamath River above the aforesaid company's dam, no provision apparently has yet been made for the restoration of the salmon run in the river. It appears from the record in the case that a great many salmon were taken from the river by the Indians for personal consumption prior to the construction of the Copco dam, but that since that time no salmon have been caught.
>
> . . .
>
> This Office will be pleased to be advised whether the arrangement made by your Commission with the California-Oregon Power Company

for the placing of trout fry is tentative only or is in the nature of a release of the company by the Oregon Fish Commission from building a suitable fishway, and if the latter, whether it was with reference to the run of trout only.

> The Office feels that the shutting off of the salmon run in the Klamath was a result of the construction of the dam in question, is an imposition on the Indians who depended upon it in the past, and would like to have your cooperation in the matter of requiring the company to build a proper fishway as originally contemplated. (Meritt to Shoemaker 11 December 1918)

Evidently sometime in 1918 a meeting had been held between H.W. Hincks acting for the Oregon Fish Commission and COPCO officials regarding a fishway around the COPCO dam. Hincks had been Project Engineer of the Klamath Irrigation Project from 1912 until 1917 and had constructed a fish ladder over a dam in the Sprague River. As the following excerpt from the December letter from Meritt to Shoemaker suggests, an agreement was reached between Hincks and COPCO for a fishway. This was to be approved by the Fish Commission of California at a later conference. According to this letter, that meeting did not take place:

> Former Engineer Hincks of the irrigation branch of the Service advised in the early part of the year that he had been in conference with representatives of the California-Oregon Power Company and the Oregon Fish Commission regarding the construction of a proper fishway over the Copco dam and that your Commission had, by resolution, directed him to represent it in a conference with the California Commission and the Engineers of the California-Oregon Power Company, to be held later, in designing a suitable fishway. Mr. Hincks further reported that your Commission was satisfied with the plans suggested by our Service as to the type of fishway that should be constructed and that it remained for the California-Oregon Power Company to agree to the plans or submit others satisfactory to all concerned. Mr. Hubbell was later named to act in Mr. Hincks' place at the proposed conference. This conference, it appears, has never been held, though the Power Company has previously expressed a willingness to co-operate in the matter of restoring the run of salmon to the Klamath River by constructing a proper fishway over the Copco dam. (Meritt to Shoemaker 11 December 1918)

In 1918 Hincks was in the Irrigation Branch of the Bureau of Indian Affairs and on loan to the Oregon Fish Commission. He was replaced by Hubbell and, whether or not a meeting was held, the fishway idea was abandoned and an "in lieu" hatchery was built which seems to have operated from 1919 until 1949 and provided Oregon with trout fingerlings for the Klamath Basin. We do not know whether there were ever any salmon transferred above the dam. We do not know if salmon fingerlings from above the dam could have passed successfully back by the COPCO dam in sufficient numbers to warrant the effort.

Simmons seems to have believed that some salmon fingerlings were raised at the Fall Creek hatchery and transplanted to Klamath Lake:

> My office has under investigation the effect on the salmon run in the Klamath River of two dams constructed by the California Oregon Power Company in the State of California in the years 1910 to 1912 and 1916 to 1925. At the time these dams were being constructed your Bureau was advised by the Commissioner of Indian Affairs that the Indians of the Klamath Indian Reservation would expect fish-ways to be constructed in such dams so that their salmon fishing in Klamath Lake and in the Sprague and Williamson Rivers would not be destroyed. The California Oregon Power Company gave assurance to the Commissioner of Indian Affairs that fish-ways would be installed. However, due to either a misunderstanding or lack of plans, no fish-ways were ever constructed. In place of these fish-ways the California Oregon Power Company spent some $22,000 in building a fish hatchery on Fall Creek, a tributary to Klamath River, in the State of California, which fish hatchery was subsequently granted by the California Oregon Power Company to the State of California.
>
> I have been reliably advised that at the time this fish hatchery was granted to the State of California an agreement was consummated between the Bureaus of Fish and Game of the States of Oregon and California, providing for an equitable division between the States of Oregon and California of the salmon fingerlings raised in the fish hatchery on Fall Creek after the salmon fish were trapped and their eggs stripped and hatched. This arrangement to plant half of the salmon fingerlings in the Klamath River in the State of California and transport the other half to Klamath Lake in the State of Oregon continued for some years after the construction of this fish hatchery. Then the arrangement ceased for no apparent reason.
>
> For many years no salmon have entered any Oregon waters either by transportation or otherwise due, of course, to the power dams of the California Oregon Power Company, located above the fish hatchery on Fall Creek.
>
> Can you advise me fully of the details of this transaction, of the date the State of California accepted this fish hatchery as its property, the

> gift of California Oregon Power Company and of what arrangement, if any, then existed between the states of Oregon and California, relative to the division of the salmon fingerlings and other conditions of the grant? Do you have available printed reports showing the number of salmon fingerlings raised at this fish hatchery on Fall Creek since the State of California operated and maintained the hatchery? If so, I would appreciate having such information furnished me. (Simmons to Chappell 5 August 1940)

Oregon may not have been much concerned with the problem of Klamath Basin salmon. The major known commercial fishery for Klamath salmon in the early 20th century was in the Klamath River estuary in California where there was no obvious benefit accruing to Oregon. At that time, it was thought that the Klamath salmon did not travel in the ocean far from the mouth of the Klamath River. (Snyder 1930:92ff.) Concern on the part of the Oregon Fish Commission for Klamath salmon may have been minimal. On the other hand, they were interested in trout as a part of the interest in the Klamath Basin as a sport fishing center.

To the degree that COPCO officials were coperative in the matter of fish blockage and passage at COPCO I, it may have been that their primary concern was not with salmon but with trout, for sport fishing. If one reflects back upon the Klamath Falls Evening Herald of March 7th, 1918 given here on page 147, it will be noticed in the article that:

1. Sportsmen will be delighted to learn that thousands of fish will be planted in the streams adjacent to Klamath Lakes, which will lmake this section an angler's paradise.
2. The special concern is protection of one of the world's greatest fisherman's resorts.
3. The members of the COPCO board of directors are enthusiastic fishermen.

Clearly the concern was with regard to recreational fishing for trout.

EFFECTS OF STATE REGULATION ON KLAMATH FISHING

As noted previously, the Klamath Treaty guaranteed exclusive fishing rights on the reservation. The reservation did not include all of the original fisheries of the Klamath and it included none of those of the Modoc or the Paiute except for some locations where these people had customarily joined with the Klamath in fishing.

However, the reservation evidently contained a sufficient number of valuable and productive fisheries that Klamath tribal members were able to do most of their fishing within its boundaries. The State of Oregon had no jurisdiction over hunting or fishing on the reservation. The on-reservation fishing of tribal members was free of state regulation.

Part of the western boundary of the reservation consists of the Wood River, Agency Lake, and Upper Klamath Lake. There has been a potential for differing interpretations of where the boundary is for fishing purposes (east shore? west shore? mid stream? etc.). Our understanding is that this question has never been clearly resolved. In earlier years it seems not to have created any major problems between Tribal members and State fisheries people.

We have found no evidence that the State of Oregon interfered with fishing by Klamath Tribal members in the early part of the present century. It is possible that, in this somewhat remote area, the concern with regulation was not so great as in more "visible" areas. There is in particular no evidence of which we are aware that Indian fishing on or adjacent to the reservation for salmon or steelhead were interfered with before 1910-1914. After this period, there were no further anadromous runs. The Klamath Tribe did not suffer the frustration of having their fishing interfered with while the fish were being allotted to other users.

There is little evidence that the state of Oregon made serious efforts to interfere with or to control fishing on the Klamath Reservation until after the passage of Public Law 280 in 1953:

> The state officials who are defendants never asserted any right to limit the hunting exercised by the tribesmen on the reservation until after the enactment of Public Law 280, 83d Cong., 67 Stat. 588, August 15, 1953. Following its adoption, they have threatened repeatedly to arrest members of the tribe and confiscate their guns, sights, traps and other equipment because such members hunt out of season or possess out-of-season game killed within season and held on the reservation, or fail in other respects to conform with the Oregon laws respecting season, species, bag limits or sex. (Klamath v Maison 139F. Supp. 634)

The Klamath v Maison 1956 decision denied the claim that Public Law 280 had adversely affected Klamath hunting and fishing rights. This conclusion, that 280 did not give the state of Oregon the right to control hunting and fishing on what had been the Klamath Reservation was reaffirmed by the 9th Circuit Court in 1974. (Kimball v Callahan 9th CCA)

Following the passage of the termination law in 1954, Oregon, making the assumption that hunting and fishing rights of the Tribe had also been terminated, began to pressure tribal members to obey state fish and game laws on the lands that had been part of the reservation. Tribal members were cited for illegal fishing. The Tribe brought suit against the State in the U.S. District Court of Oregon. In 1956, the court held that hunting and trapping laws of the State were inapplicable to Klamath Indians hunting or trapping on the reservation. (Klamath et al v Maison 139F. Supp. 634) This decision was appealed to the 9th Circuit Court where it was overturned. However, in deciding Kimball v Callahan, after the U.S. Supreme Court had decided that the Menominee retained their hunting and fishing rights after termination, the 9th Circuit Court reversed itself:

> One final consideration this court must make concerns the extent of plaintiffs' rights, that we here hold survive the Termination Act.

> Plaintiffs seek no rights against private landowners, acknowledging that those persons might properly exclude Klamaths and anyone else from hunting and fishing if they so desire. Plaintiffs do, however, seek a declaration, and we so hold, that they may exercise their treaty hunting, trapping, and fishing rights free of state fish and game regulations on the lands constituting their ancestral Klamath Indian Reservation, including that land now constituting United States national forest land and that privately owned land on which hunting, trapping, or fishing is permitted. (Kimball v Callahan 9th CCA)

The survival of the fishing rights was, in turn, linked to continuing water rights by the U.S. District Court of Oregon:

> The Tribe, when it possessed land, possessed hunting and fishing rights and also water rights. Now the Tribe no longer possesses land within the former Reservation.
>
> The defendants contend that water rights are always appurtenant to land; when the Tribe disposed of its land, the Tribe also relinquished all its water rights.
>
> This contention overlooks the nature of the connection between Indian water rights and Indian hunting and fishing rights. The Indians obtained their reserved right to the water they need to cultivate their land from Article II of the Treaty. Their other rights to water come from the hunting and fishing rights reserved to them in Article I. Without sufficient water to preserve fish and wildlife on the Reservation lands, Indian hunting and fishing rights would be worthless. (U.S. v Adair 6 ILR F-150)

In May 1981, a consent decree was agreed upon and issued to settle the disputes reflected in Kimball v Callahan. This decree was an agreement between the Klamath Tribe, Oregon, and the United States, in the light of continuing legal confirmations that Klamath hunting and fishing rights continued in existence, at least within the boundaries of the Klamath Reservation as it existed in 1954. Besides providing for cooperation in the preservation and management of wildlife in the area, the decree documents the three parties' recognition and acceptance of the fact that Klamath hunting, fishing, and trapping rights continue to exist:

> This Agreement is necessitated by the rulings of the United States District Court of the District of Oregon and those of the Ninth Circuit Court of Appeals in the above-entitled action, wherein the treaty rights of the Klamath Indian Tribe and its members to hunt, trap and fish free

of regulation by the State of Oregon other than for conservation purposes were confirmed, as was the sovereign authority of the Tribe to regulate the exercise of those rights by its members. (Kimball v Callahan Settlement Agreement 29 April 1981)

However, whereas, in Kimball I, the right was held to be exclusive, in Kimball II, it was taken as non-exclusive. Since 1975, the Klamath Tribe has had a Game Commission which administers a tribal wildlife management code within the former Klamath Reservation boundaries.

Appendix A.

Excerpts from "The Klamath of Southern Oregon" by Robert F. Spencer

The Klamath live today, as in the past, on the 4000-foot-high plateau of central and southern Oregon. Their land verges to higher ground in the west, toward the spectacular geologic formation of Crater Lake. Klamath habitat involved a chain of lakes, headwaters of the Klamath River, located in a shallow depression on the high plateau. In aboriginal times, the Klamath settled on the lake shores (selecting higher ground for their hamlets) and on the main streams connecting lake and marsh. It is this lake-marsh pattern which lends a certain distinctiveness to the Klamath. The tribe, if such it can be called considering the lack of any centralization, drew its sense of identity from language--although this was shared with the Modoc, a Californian type group--and from common ecology and ideology. It placed its small settlements on lake, river, and marsh. These were largely winter settlements; people moved over the territory in summers, hunting, gathering, and for war, returning to the winter hamlet with the onset of cold weather.

It is evident that the Klamath were split into four or perhaps five subdivisions, depending essentially on proximity. These tribelets, while they might feud with each other, as was sometimes the case, permitted some intermarriage. Small groups of men from different tribelets might occasionally go out as a war party, raiding non-Klamath for booty and slaves. Within each section or tribelet were the permanent winter settlements. Spier (1930:13-21) lists 62 such towns, applying the apt term "hamlet" to them. They were not in any sense centralized communities. Unlike the Sanpoil, and certainly unlike the Wishram and others to the north of the Plateau, the Klamath made little of chiefs. There were such, rich men, leaders in war, but they were speakers only, offering an example to the group by their success in wealth. The hamlets consisted of semisubterranean earth lodges, with roof entrances, spread out over some distance, although occasionally clustered at random. A single earth lodge could accommodate several related nuclear families. A hamlet could thus consist of just one such or several. Not too large a population is suggested. A century ago when the culture was still in effective operation the Klamath probably were somewhat less than 1000, this contrasting with the more numerous and denser populations both to the north and in California (Kroeber, 1939:137).

A quite different tone prevailed in Klamath culture than in the Sanpoil. The latter, with their emphasis on harmony, on the worth of the individual developed patterns of visiting hospitality, and generosity. There was a structure to Sanpoil society which made for an essentially predictable and serene world. Although the Klamath were not lacking in the same ideals, they phrased them differently with the result that certain tensions arose in the society and a quite different set of values emerged. Harmony was stressed both with the supernatural and with others, but for the latter especially, there were no enforcing mechanisms. A basic goal was wealth and the prestige derived from it, but unlike the peoples of the northern coasts or even the Yurok and Hupa further down the Klamath River, the Klamath had only the vaguest kind of wealth notion. They collected, amassing a surplus of goods of any kind--skins, food, shells, weapons--in short, any item which could be collected in quantity. It may be suggested that the Klamath offer a marginal phrasing of the strong wealth complex of peoples further to the north.

Unlike the Hupa, they had never developed the idea of a unit of wealth. Possessions indeed were valued throughout the whole Plateau, the Sanpoil, as has been seen, had some notions of wealth and possessions, their shamans being reputedly wealthy. But the Klamath stressed the wealth complex rather out of proportion to their material inventory. It was the acquisition of property which colored the life of the individual.

The concept of wealth also led to the place and activity of the individual. Klamath morality called for activity on the part of each member of the group. He was expected to work, to produce, to amass a surplus, this being a moral goal and one reflecting "good" behavior. Something of this moral tone appears as well in native California, an ideal which tended to enforce the separatism so characteristic of this area. People were expected to remain at home, at least in the local community, and to devote themselves to the demands of the local scene. In the Klamath case, the individual was judged on the basis of his application and industry, as a hunter and fisherman, if a man, or as a gatherer, skin-dresser, or cook, if a woman. The word for "chief" in the Klamath language was synonymous with "rich man". There is the distinct impression that the chief used his wealth to dominate social situations. He urged his people to "be good" in formalized harangues and thereby, in a less formal way, succeeded in achieving a position of dominance.

The wealth quest was individual. Persons of "good" reputation worked to produce and to enhance their social status. People were free to do as they wished, finding the economic activity which best suited them. They suffered in reputation only if they were seen as "lazy". Laziness, equated with poverty, created disharmony in the society. The chief gave of his goods to the "poor", albeit grudgingly, nor were the "poor" grateful. Individual achievement was thus a keynote in Klamath society, but there was little room for the somewhat more benign relations which were true of the Sanpoil. There was little hospitality, little sharing of food, and gifts were given reluctantly.

Klamath material culture, like that of the general Plateau and the West exclusive of the Northwest Coast, was uncomplicated. Basketry was well developed, becoming in fact, the highest artistic achievement. It was made by women and consisted of storage baskets, general containers, cooking baskets, and round basketry hats. Mats were also made, the Klamath employing a mat-covered lodge for summer use. This was a round dwelling, however, suggesting the earth lodge but lacking the excavation and the roof entrance. Clothing was simple, not unlike that of the Sanpoil; moccasins, replacing the footgear of tules, and buckskin appear to have come in with recent trade as Plains traits. Bodily adornment involved tattooing, cuts into which charcoal was rubbed. Head flattening was also practiced; a child's head had the frontal bone depressed while the child was bound in the cradle board, the universal feature of Plateau infancy. "Bows" were both simple and sinew backed, the latter especially for war, while arrows were both of reed and stone tipped. Armor was both of elkhide and made of slats, the latter suggesting the rod and slat cuirasses of the north. Clubs and a short spear were also in the weapon assemblage. Canoes and snowshoes provided means of transport. The former were simple dugouts, used largely for fish spearing. Work in stone and wood was limited and did not achieve any heights of artistry. Adzes were made of antler rather than stone (cf. Barrett, 1910). Sewing was done with awl and sinew.

Socially, the Klamath had a simple bilateral family, with some suggestion of patrilocal and virilocal residence, although this was not enforced. As among the Sanpoil, polygyny was permitted, although rare, and a bride price legitimized marriages. The marriage price was paid in the form of pelts, skins, fathoms of shell beads, mats, and other property. Bride service was also known, a factor creating temporary uxorilocal residence. Divorce, mere separation, was not uncommon. It was rendered complex, however, by the property involvements at marriage.

The Klamath, with their particular brand of individualism, lacked any elaboration of ceremonial activities. They lacked the First Fruits Rites of some neighboring peoples, even mourning rites being largely individualized. There were social dances, but they were simple and nonceremonial. The institution which brought men from different hamlets and tribal sections together was war. Any man could organize a war party, a group consisting of a few men. A chief was known for his success in war as well as his wealth. Men joined a war party voluntarily, choosing usually to link themselves with a successful strategist. This need not have been a chief, but rather a leader appointed by him. In the event of a large war party, 20 or 30 men, several leaders might be chosen. The basic notion in war was revenge, retaliation for a slain kinsman or an abducted child. Klamath sections could and did feud with each other on this basis. Concerted warfare was directed against neighboring peoples. The Klamath war party, going out ostensibly for revenge, was as much concerned with booty and, especially after new and desired elements such as the horse began to be introduced, with slaves. The war party depended on surprise tactics. They rushed into the enemy settlement, whooping clubbing, and shooting arrows. Women sometimes went along to add to the din. After the first surprise, the warriors took cover, picking off the enemy with arrows. Booty and slaves were taken and scalps from the enemy warriors. Actually, the dead frequently were dismembered, and following an orgy of killing the severed parts were brought back as trophies. Scalps, in keeping with western Amerind practice, included the brows and the whole scalp above the ears. The scalp dance, perhaps the only group activity in which the Klamath engaged, was held to rejoice over vengeance taken. The dance lasted over several nights and was marked by frenzied behavior.

Klamath religion was again a variation on the theme of the guardian-spirit guest and on shamanism. The Klamath were fairly heavily drawn to a complex mythology as well, more so than was true of the Sanpoil. Guardian spirits, however, were not so well defined. The concept existed of power, forces which came from animals, it is true, but there was not the same precise relationship to a specific guardian spirit as was true further to the north. Power and songs were linked in the native view; spirits, zoomorphic and anthropomorphic, gave success in various ventures, hunting, gambling, becoming wealthy. They appeared in dreams and visions, conferring songs. Sweating and fasting were part of the spirit-seeking experience, as was lonely vigil. In keeping with the vague character of the guardian spirit, there was no tendency for those with the same guardian to form associations.

Shamanism had many of the elements which appear in the general area. The shaman was one who had secured more spirit power and was able to use it for curing. Both men and women could be shamans, the vision experience generally being by no means barred to women. Some shamans were reputedly homosexuals, engaging in the wearing of the clothing and the behavior of the opposite sex. Such transvestitism, while by no means unknown among the American Indians generally, was, among the Klamath, allowed only the shaman. Shamans cured and were always summoned by the sick person and his family. The cause of disease was the familiar intruded object, causing illness and sent by an enemy, a malignant shaman, or as a result of breaking a prohibition, such as eating too soon after dreaming. The shaman "doctored," that is, singing his songs, noting the cause of the illness and its location with his "spirit eyes." He then sucked the object out, a dramatic and stirring activity, what with the shaman fighting the "pain," vomiting blood, and struggling with his power. Shamans had apprentices who assisted them, taking the "pain" from the shaman into their own bodies as the curing was done. A shaman was paid for his services. While he may have been wealthy, it was the office itself which called for great respect and fear.

Beside curing, shamans controlled weather, accompanied a war party, made game return, and found lost articles with their power. The most stirring activity of the shaman, however, was the winter seance, held to initiate novice shamans, to demonstrate power, and to prove the strength of one's power. Before an audience of families from his own and adjacent communities, the shaman sang, performed such feats as swallowing fire and arrows, and hurled his power at rival shamans. Winter was not a sacred season since power could be sought at any time, but the shaman employed the time when people were present in the home hamlet to show his might. Chiefs, as has been seen, had little power as such. In Klamath life, it was the shaman who emerged as the feared and respected figure.

Klamath mythology was well developed. It involved not only the various spirits of the animal world, but included anthropomorphic beings as well, such as a quasi-human creator. All the natural features of the Klamath landscape were tied up with tales of how a river, a rock, a cliff, came to be. This is turn was tied up with the sense of power emanating from such natural features. Mountains, lakes, the forest, all were sources of songs of power. The Klamath lived closely in rapport with the natural terrain and found a close mystic bond with it.

Looking back over the Plateau, considering such groups as the Sanpoil-Nespelem and the Klamath, differences in the phrasing of culture traits may be noted. Northwest Coast and Plains influences both made their mark, especially in political and territorial organizations. Chieftainship was a prominent feature, even if among the Klamath it came to have somewhat less meaning. There is the contrast between war and pacifism, between groups which had a strong sense of tribal consciousness as against those which stressed the local autonomy of hamlet or village. In general, however, as the array of cultural elements presented by the Plateau is reviewed, some precisely definable underlying patterns are discernible. Root gathering, fishing, earth lodges and mat lodges, girls' rites, a concept of the guardian spirit in religion, as well as political organization suggest a common cultural base, raw materials worked on by each Plateau group and given in each instance a distinctive slant. (Spencer 1977:179-183)

Appendix B

Introduction to "Primitive Pragmatists" by Verne F. Ray

The Modoc Indians lived on both sides of what is now the California-Oregon boundary, immediately east of the Cascade Range of mountains. Their world was one of extravagant geographic diversity. Even within the bounds of their small tribal territory they looked upon perpetually snow-covered peaks and active volcanoes on the west, vast forests of Ponderosa pine on the north, barren alkali flats on the east, and near-virgin lava fields on the south. Numerous large lakes and thousands of acres of marshland were scattered over the plains of sagebrush and juniper. Isolated hills and minor mountain ranges created numerous drainage systems but all of the streams were relatively small. The greatest of these, the Klamath River, traversed only the northwestern portion of Modoc territory. Lost River was the stream of second order--"lost" because it rises in Clear Lake and flows into Tule Lake, which has no known outlet.

Along the banks of Lost River and most of the other streams were pleasant meadows blanketed with the green grasses which made these courses the favored grounds for villages and camps. Clear, cold springs provided drinking water, the alkaline properties of the streams rendering their waters scarcely potable. Bunch grass grew sparsely among the sagebrush in the adjoining hills and supplemented the grasses of the meadows as forage for Modoc horses. South of Clear Lake the bunch grass grew more prolifically and served as a significant resource, especially in winter, when other forage was scarce.

The watercourses belied their size by the abundance of fish—trout, perch, suckers—which they supplied to the Modoc larder. The lakes and marshlands swarmed with ducks, geese, and swans in winter; and pelicans, loons, and gulls remained throughout the year. The former were of great importance in the Modoc economy and the latter were valued as supplementary resources during the lean months. The plains and hills provided rabbits, woodchucks and squirrels, the sage hen, prairie chicken and curlew; also the all-important antelope and deer. Mule deer also roamed the mountains, as did brown, black, and grizzly bears, elk, and mountain sheep.

Fields of camas flourished in the bottom lands. The Modoc dug the nutritious bulb in considerable quantities, supplementing the supply with many other tuberous roots which their lands provided, especially epos (Carum sp.). The lakes gave up a wealth of food in the form of water-lily seeds, an important item in the Modoc diet. Hills and mountains provided other seeds and nuts, notably the pine nut, but the Modoc depended far less upon seed for food than did most of the Indians of northern California.

The tribal territory of the Modoc was roughly four-sided, permitting the boundaries to be described in terms of the cardinal directions. The western line was that of the Cascade Divide, extending from the summit of Mt. Shasta northward to within two or three miles of the present California-Oregon border. The northern boundary ran from this point northeasterly to the region of Hildebrand and Yainax Butte, continued easterly to the region of small lakes south of Quartz Mountain, and southeasterly to Goose Lake, again at the Oregon-California border. The boundary emerged from the lake at its southern extremity, then followed a southeasterly direction to Mt. Shasta. Goose Lake was shared with the Yahuskin Paiute and the Achomawi. Only a part of the western shore was the territory of the Modoc.

This proximity did not mean that the three tribes were in close relationship, either socially or otherwise. The Modoc looked upon the Paiute as a inferior people whose personal characteristics and ways of life made social or commercial intercourse with them inappropriate and distateful. With the Achomawi the Modoc were perpetually at war and from them they took a great many slaves. The Shasta they feared and hated. Only with their northern neighbors, the Klamath, was their relationship reasonably close and free. This relationship could not, however, be called friendly.

The Modoc shared fewer culturally diagnostic traits with the Klamath than they did with the Achomawi. However, borrowings resulting from proximity, similarities consequent upon occupancy of the same environmental province, and the sharing of traits common to all of western America made for a considerable degree of resemblance, and have led numerous observers to the erroneous conclusion that the Modoc and Klamath were culturally one. Both tribes depended partially upon water-lily seeds for subsistence, a trait not found elsewhere in the West. This was an ingenious utilization of a specialized environment which embraced many thousands of acres of marshland. These waters likewise produced tule and swamp grass in profusion, and the clothing of the two tribes was characterized by the use of these fibrous materials; also sagebrush bark from the desert areas they both possessed.

Cremation was the sole mode of disposal of the dead in both tribes. Neighbors all around them practiced burial exclusively. Cremation, however, was widespread in California even though absent immediately to the south of the Modoc. This is one of many bits of evidence which favors a central rather than northern California basic affinity for Modoc culture. Cremation is found archeologically far to the north in the central Plateau but this was not the source of Modoc-Klamath cremation, with its elaborate character and close resemblance to the central-Californian pattern. This is the principal Californian trait imbedded in Klamath culture.

A predilection for making artificial rock piles for religious or commemorative purposes and for attributing mythological significance to rock piles of unknown origin is characteristic of the two tribes, but not exclusive to them. More modest examples of lthis trait are found in various parts of the Plateau. The Klamath-Modoc practice appears to be an elaboration of the Plateau pattern.

Both tribes--at least in recent times--were vitally concerned with slavery. This was in no sense a simple sharing of a practice. The Modoc conducted slave raids and held slaves in a typical Californian way. The Klamath, on the other hand, bought slaves from the Modoc, and did some raiding on their own, so that they might engage in a slave commerce with the people of the Dalles on the Columbia River. They held and utilized very few slaves if any. In this they conform to a dominant Plateau ideal.

Another significant contrast was present in religion. Modoc beliefs and practices were Californian; the Klamath were typical of the Plateau. The acquisition and utilization of guardian spirits constituted a strict prerogative of shamans among the Modoc, a sharp contrast with Paiute and Klamath practice. The source of power was the dream, a Californian trait shared by the Basin. Most impressive was the congregation of spirits at a curing seance, a locally elaborated Californian concept. The initiation for the shaman was the announcement of professional practice accompanied by demonstrations of power, also Californian. The Modoc world view was dominated by the concept of an anthropomorphic bisexual culture hero. Warfare was well developed in the California style. Marriage patterns, birth practices, and adolescent ceremonies integrated with other northern and central Californian examples. These contrasted markedly with the Basin but not with the Plateau, except for details. The Modoc sweat lodge and sweating habits were a compromise between California and Plateau-Basin-Plains practices. The men's clubhouse was present but the heat was provided by heated rocks and steam rather than by fires.

Until recently clothing was typically Californian. Men wore little or nothing except a front apron in mild weather. The standard garment for women was the double apron or "skirt."

Houses were of the Californian earth-covered type with local elaborations. Canoes did not resemble the fine specialized forms of nearby northwestern California, but were typical of northern California generally.

Linguistically the Modoc and Klamath were an isolated unit. Their language was unintelligible to their neighbors in any direction. Formerly interpreted as a separate stock, called Lutuamian, it is now known to be a divergent brand of Sahaptin.

It was stated above that the Modoc looked upon themselves as ethnically unique and prided themselves on making their own decisions in all matters of cultural principle and behavior. This freedom extended to the individual, to the degree that cultural limitations permitted, which was considerable. Patterning was more prominent and distinctive than in most Californian societies, but orderliness, arrangement, and specificity of detail were not characteristic. For nearly any specific question about the cultural norms for economic activities, religious behavior, personal relationships, and the like, considerably varying answers were possible. In this the Modoc were consistent with many other Californian tribes, but the variability was not nearly as great as in the Basin. Compared to the Plateau, however, the looseness was extreme.

So much for the minutiae of culture, and interpersonal behavior. In tribal and intertribal matters there was much more formalization. Attitudes, policies, prerogatives, enemies, revenge, and such were so conceived and structured that response was consistent and uniform and the decisiveness of action by the tribe as a whole was impressive.

Modoc life was not, however, ruled by any dominant patterns, drives, or trends that might make for over-all cultural consistency or make available philosophic principles on which abstract judgments might be based. Unless pragmatism be such! The invariable test of the appropriateness and value of behavior-individual, family, or tribal--was the degree to which desired ends were achieved. The ends always justified the means, a conviction which made for intrigue, deception, and violence. This is sufficient answer, in itself, for the relatively low value which the Modoc placed upon affective relationships between individuals, for their social isolation in the intertribal community, and for their conviction that their ways of life were freely chosen or of their own invention. (Ray 1963:xi-xv)

Appendix C

Treaty with the Klamath, Etc., 1864

reproduced from 1972 reprint edition of Kappler's Laws and Treaties, vol. II.

TREATY WITH THE KLAMATH, ETC., 1864.

Articles of agreement and convention made and concluded at Klamath Lake, Oregon, on the fourteenth day of October, A. D. one thousand eight hundred and sixty-four, by J. W. Perit Huntington, superintendent of Indian affairs in Oregon, and William Logan, United States Indian agent for Oregon, on the part of the United States, and the chiefs and head-men of the Klamath and Moadoc tribes, and Yahooskin band of Snake Indians, hereinafter named, to wit, La-Lake, Chil-o-que-nas, Kelloque, Mo-ghen-kas-kit, Blow, Le-lu, Palmer, Jack, Que-as, Poo-sak-sult, Che-mult, No-ak-sum, Mooch-kat-allick, Toon-tuck-tee, Boos-ki-you, Ski-a-tic, Shol-las-loos, Ta-tet-pas, Muk-has, Herman-koos-mam, chiefs and head-men of the Klamaths; Schon-chin, Stat-it-ut, Keint-poos, Chuck-e-i-ox, chiefs and head-men of the Moadocs, and Kile-to-ak and Sky-te-ock-et, chiefs of the Yahooskin band of Snakes.

Oct. 14, 1864. 16 Stats., 707. Ratified, July 2, 1866. Proclaimed Feb. 17, 1870.

Cession of lands to the United States.

Boundaries.

ARTICLE 1. The tribes of Indians aforesaid cede to the United States all their right, title, and claim to all the country claimed by them, the same being determined by the following boundaries, to wit: Beginning at the point where the forty fourth parallel of north latitude crosses the summit of the Cascade Mountains; thence following the main dividing-ridge of said mountains in a southerly direction to the ridge which separates the waters of Pitt and McCloud Rivers from the waters on the north; thence along said dividing-ridge in an easterly direction to the southern end of Goose Lake; thence northeasterly to the north-

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ern end of Harney Lake; thence due north to the forty-fourth parallel of north latitude; thence west to the place of beginning: *Provided*, That the following-described tract, within the country ceded by this treaty, shall, until otherwise directed by the President of the United States, be set apart as a residence for said Indians, [and] held and regarded as an Indian reservation, to wit: Beginning upon the eastern shore of the middle Klamath Lake, at the Point of Rocks, about twelve miles below the mouth of Williamson's River; thence following up said eastern shore to the mouth of Wood River; thence up Wood River to a point one mile north of the bridge at Fort Klamath; thence due east to the summit of the ridge which divides the upper and middle Klamath Lakes; thence along said ridge to a point due east of the north end of the upper lake; thence due east, passing the said north end of the upper lake, to the summit of the mountains on the east side of the lake; thence along said mountain to the point where Sprague's River is intersected by the Ish-tish-ea-wax Creek; thence in a southerly direction to the summit of the mountain, the extremity of which forms the Point of Rocks; thence along said mountain to the place of beginning. And the tribes aforesaid agree and bind themselves that, immediately after the ratification of this treaty, they will remove to said reservation and remain thereon, unless temporary leave of absence be granted to them by the superintendent or agent having charge of the tribes.

Reservation.

Boundaries.

Indians to remove to and live upon the reservation.

It is further stipulated and agreed that no white person shall be permitted to locate or remain upon the reservation, except the Indian superintendent and agent, employés of the Indian department, and officers of the Army of the United States, and that in case persons other than those specified are found upon the reservation, they shall be immediately expelled therefrom; and the exclusive right of taking fish in the streams and lakes, included in said reservation, and of gathering edible roots, seeds, and berries within its limits, is hereby secured to the Indians aforesaid: *Provided, also*, That the right of way for public roads and railroads across said reservation is reserved to citizens of the United States.

White persons not to remain on reservation.

Right of way for railroads.

ARTICLE 2. In consideration of, and in payment for the country ceded by this treaty, the United States agree to pay to the tribes conveying the same the several sums of money hereinafter enumerated, to wit: Eight thousand dollars per annum for a period of five years, commencing on the first day of October, eighteen hundred and sixty-five, or as soon thereafter as this treaty may be ratified; five thousand dollars per annum for the term of five years next succeeding the first period of five years; and three thousand dollars per annum for the term of five years next succeeding the second period; all of which several sums shall be applied to the use and benefit of said Indians by the superintendent or agent having charge of the tribes, under the direction of the President of the United States, who shall, from time to time, in his discretion, determine for what objects the same shall be expended, so as to carry out the design of the expenditure, [it] being to promote the well-being of the Indians, advance them in civilization, and especially agriculture, and to secure their moral improvement and education.

Payments by the United States.

How to be expended.

ARTICLE 3. The United States agree to pay said Indians the additional sum of thirty-five thousand dollars, a portion whereof shall be used to pay for such articles as may be advanced to them at the time of signing this treaty, and the remainder shall be applied to subsisting the Indians during the first year after their removal to the reservation, the purchase of teams, farming implements, tools, seeds, clothing, and provisions, and for the payment of the necessary employés.

Additional payment for certain purposes.

ARTICLE 4. The United States further agree that there shall be erected at suitable points on the reservation, as soon as practicable after the

[illegible] shops to

ratification of this treaty, one saw-mill, one flouring-mill, suitable buildings for the use of the blacksmith, carpenter, and wagon and plough maker, the necessary buildings for one manual-labor school, and such hospital buildings as may be necessary, which buildings shall be kept in repair at the expense of the United States for the term of twenty years; and it is further stipulated that the necessary tools and material for the saw-mill, flour-mill, carpenter, blacksmith, and wagon and plough maker's shops, and books and stationery for the manual-labor school, shall be furnished by the United States for the period of twenty years.

Tools, books, and stationery.

ARTICLE 5. The United States further engage to furnish and pay for the services and subsistence, for the term of fifteen years, of one superintendent of farming operations, one farmer, one blacksmith, one sawyer, one carpenter, and one wagon and plough maker, and for the term of twenty years of one physician, one miller, and two school-teachers.

Farmer, mechanics, and teachers.

ARTICLE 6. The United States may, in their discretion, cause a part or the whole of the reservation provided for in Article 1 to be surveyed into tracts and assigned to members of the tribes of Indians, parties to this treaty, or such of them as may appear likely to be benefited by the same, under the following restrictions and limitations, to wit: To each head of a family shall be assigned and granted a tract of not less than forty nor more than one hundred and twenty acres, according to the number of persons in such family; and to each single man above the age of twenty-one years a tract not exceeding forty acres. The Indians to whom these tracts are granted are guaranteed the perpetual possession and use of the tracts thus granted and of the improvements which may be placed thereon; but no Indian shall have the right to alienate or convey any such tract to any person whatsoever, and the same shall be forever exempt from levy, sale, or forfeiture: *Provided*, That the Congress of the United States may hereafter abolish these restrictions and permit the sale of the lands so assigned, if the prosperity of the Indians will be advanced thereby: *And provided further*, If any Indian, to whom an assignment of land has been made, shall refuse to reside upon the tract so assigned for a period of two years, his right to the same shall be deemed forfeited.

Reservation may be surveyed into tracts and assigned to heads of families and single persons.

Not to be alienated nor subject to levy, etc.

Restrictions may be removed.

Forfeiture.

ARTICLE 7. The President of the United States is empowered to declare such rules and regulations as will secure to the family, in case of the death of the head thereof, the use and possession of the tract assigned to him, with the improvements thereon.

ARTICLE 8. The annuities of the tribes mentioned in this treaty shall not be held liable or taken to pay the debts of individuals.

Annuities not liable for debts.

ARTICLE 9. The several tribes of Indians, parties to this treaty, acknowledge their dependence upon the Government of the United States, and agree to be friendly with all citizens thereof, and to commit no depredations upon the person or property of said citizens, and to refrain from carrying on any war upon other Indian tribes; and they further agree that they will not communicate with or assist any persons or nation hostile to the United States, and, further, that they will submit to and obey all laws and regulations which the United States may prescribe for their government and conduct.

Peace and friendship.

ARTICLE 10. It is hereby provided that if any member of these tribes shall drink any spirituous liquor, or bring any such liquor upon the reservation, his or her proportion of the benefits of this treaty may be withheld for such time as the President of the United States may direct.

ARTICLE 11. It is agreed between the contracting parties that if the United States, at any future time, may desire to locate other tribes upon the reservation provided for in this treaty, no objection shall be made thereto; but the tribes, parties to this treaty, shall not, by such

Other tribes may be located on reservation.

Proviso.

location of other tribes, forfeit any of their rights or privileges guaranteed to them by this treaty.

Treaty, when to take effect.

ARTICLE 12. This treaty shall bind the contracting parties whenever the same is ratified by the Senate and President of the United States.

Execution.

In witness of which, the several parties named in the foregoing treaty have hereunto set their hands and seals at the place and date above written.

J. W. Perit Huntington, [SEAL.]
Superintendent Indian Affairs.
William Logan, [SEAL.]
United States Indian Agent.

La-lake, his x mark. [SEAL.]
Chil-o-que-nas, his x mark. [SEAL.]
Kellogue, his x mark. [SEAL.]
Mo-ghen-kas-kit, his x mark. [SEAL.]
Blow, his x mark. [SEAL.]
Le-lu, his x mark. [SEAL.]
Palmer, his x mark. [SEAL.]
Jack, his x mark. [SEAL.]
Que-ass, his x mark [SEAL.]
Poo-sak-sult, his x mark. [SEAL.]
Che-mult, his x mark. [SEAL.]
No-ak-sum, his x mark. [SEAL.]
Mooch-kat-allick, his x mark. [SEAL.]
Toon-tuc-tee, his x mark. [SEAL.]
Boss-ki-you, his x mark. [SEAL.]
Ski-at-tic, his x mark. [SEAL.]
Shol-lal-loos, his x mark. [SEAL.]
Tat-tet-pas, his x mark. [SEAL.]
Muk-has, his x mark. [SEAL.]
Herman-kus-mam, his x mark. [SEAL.]
Jackson, his x mark. [SEAL.]
Schon-chin, his x mark. [SEAL.]
Stak-it-ut, his x mark. [SEAL.]
Keint-poos, his x mark. [SEAL.]
Chuck-e-i-ox, his x mark. [SEAL.]
Kile-to-ak, his x mark. [SEAL.]
Sky-te-ock-et, his x mark. [SEAL.]

Signed in the presence of—

R. P. Earhart, secretary.
Wm. Kelly, captain First Cavalry, Oregon Volunteers.
James Halloran, second lieutenant First Infantry, W. T. Volunteers
William C. McKay, M. D.
Robert (his x mark) Biddle.

Appendix D

Treaty with the Snake, 1865

reproduced from 1972 reprint edition of Kappler's Laws and Treaties, vol. II.

TREATY WITH THE SNAKE, 1865.

Aug. 12, 1865.
14 Stat., 683.
Ratified July 5, 1866.
Proclaimed July 10, 1866.

Articles of agreement and convention made and concluded at Sprague River Valley, on this twelfth day of August, in the year one thousand eight hundred and sixty-five, by J. W. Perit Huntington, superintendent of Indian affairs in Oregon, on the part of the United States, and the undersigned chiefs and head-men of the Woll-pah-pe tribe of Snake Indians, acting in behalf of said tribe, being duly authorized so to do.

Peace.

Prisoners and slaves.

ARTICLE 1. Peace is declared henceforth between the United States and the Woll-pah-pe tribe of Snake Indians, and also between said tribe and all other tribes in amity with the United States. All prisoners and slaves held by the Woll-pah-pe tribe, whether the same are white persons or members of Indian tribes in amity with the United States, shall be released; and all persons belonging to the said Woll-pah-pe tribe now held as prisoners by whites, or as slaves by other Indian tribes, shall be given up.

Cession of lands to the United States.

Boundaries.

ARTICLE 2. The said tribe hereby cedes and relinquishes to the United States all their right, title, and interest to the country occupied by them, described as follows, to wit: Beginning at the Snow Peak in the summit of the Blue Mountain range, near the heads of the Grande Ronde River and the north fork of John Day's River; thence down said north fork of John Day's River to its junction with the south fork; thence due south to Crooked River; thence up Crooked River and the south fork thereof to its source; thence southeasterly to Harney Lake; thence northerly to the heads of Malheur and Burnt Rivers; thence continuing northerly to the place of beginning.

Indians to remove to reservation.

ARTICLE 3. The said tribe agree to remove forthwith to the reservation designated by the treaty concluded on the *14th* [15th] of October, 1864, with the Klamath, Moadoc, and Yahooskin Snake Indians, there to remain under the authority and protection of such Indian agent, or other officer, as the Government of the United States may assign to such duty, and no member of said tribe shall leave said reservation for any purpose without the written consent of the agent or superintendent having jurisdiction over said tribe.

To submit to the United States and not depredate.

Offenders to be given up.

ARTICLE 4. The said Woll-pah-pe tribe promise to be friendly with the people of the United States, to submit to the authority thereof, and to commit no depredations upon the persons or property of citizens thereof, or of other Indian tribes; and should any member of said tribe commit any such depredations, he shall be delivered up to the agent for punishment, and the property restored. If after due notice the tribe neglect or refuse to make restitution, or the property is injured or destroyed, compensation may be made by the Government out of the annuities hereinafter provided. In case of any depredation being committed upon the person or property of any member of the aforesaid Woll-pah-pe tribe, it is stipulated that no attempt at revenge, retaliation, or reclamation shall be made by said tribe; but the case shall be reported to the agent or superintendent in charge, and the United States guarantee that such depredation shall be punished in the same manner as if committed against white persons, and that the property shall be restored to the owner.

Wrongs upon Indians how redressed.

ARTICLE 5. The said tribe promise to endeavor to induce the Hoo-ne-boo-ey and Wa-tat-kah tribes of Snake Indians to cease hostilities against the whites; and they also agree that they will, in no case, sell any arms or ammunition to them nor to any other tribe hostile to the United States.

Hostile tribes; sale of arms, etc.

ARTICLE 6. The United States agree to expend, for the use and benefit of said tribe, the sum of five thousand dollars to enable the Indians to fence, break up, and cultivate a sufficient quantity of land for their use, to supply them with seeds, farming-implements, domestic animals, and such subsistence as may be necessary during the first year of their residence upon the reservation.

Fencing and cultivating lands.

Seeds, tools, etc.

ARTICLE 7. The United States also agree to expend, for the use and benefit of said tribe, the sum of two thousand dollars per annum for five years next succeeding the ratification of this treaty, and twelve hundred dollars per annum for the next ten years following, the same to be expended under the direction of the President of the United States for such objects as, in his judgment, will be beneficial to the Indians, and advance them in morals and knowledge of civilization.

Beneficial expenditures.

ARTICLE 8. The said tribe, after their removal to the reservation, are to have the benefit of the services of the physician, mechanics, farmers, teachers, and other employés provided for in the treaty of the 15th October, 1864, in common with the Klamaths, Moadocs, and Yahooskin Snakes, and are also to have the use of the mills and school-houses provided for in said treaty, so far as may be necessary to them, and not to the disadvantage of the other tribes; and, in addition, an interpreter who understands the Snake language shall be provided by the Government. Whenever, in the judgment of the President, the proper time shall have arrived for an allotment of land in severalty to the Indians upon the said reservation, a suitable tract shall be set apart for each family of the said Woll-pah-pe tribe, and peaceable possession of the same is guaranteed to them.

Physician, mechanics, etc.

Mill and school houses.

Interpreter.

ARTICLE 9. The tribe are desirous of preventing the use of ardent spirits among themselves, and it is therefore provided that any Indian who brings liquor on to the reservation, or who has it in his possession, may in addition to the penalties affixed by law, have his or her proportion of the annuities withheld for such time as the President may determine.

Possession of ardent spirits on reservation, how punished.

ARTICLE 10. This treaty shall be obligatory upon the contracting parties as soon as the same shall be ratified by the Senate of the United States.

Treaty, when to be obligatory.

In testimony whereof, the said J. W. Perit Huntington, superintendent of Indian affairs, and the undersigned chiefs and headmen of the tribe aforesaid, have hereunto set their signatures and seals, at the place and on the day and year above written.

J. W. Perit Huntington, Superintendent Indian Affairs in Oregon.		[SEAL.]
Pah-ni-ne,	his x mark.	[SEAL.]
Hau-ni-noo-ey,	his x mark.	[SEAL.]
Ki-nau-ney,	his x mark.	[SEAL.]
Wa-ak-chau,	his x mark.	[SEAL.]

Chok-ko-si,	his x mark.	[SEAL.]
She-zhe,	his x mark.	[SEAL.]
Che-em-ma,	his x mark.	[SEAL.]
Now-hoop-a-cow-.c...	his x mark.	[SEAL.]
Ki-po-weet-ka,	his x mark.	[SEAL.]
Hau-ne, or Shas-took,	his x mark.	[SEAL.]
Sab-too-too-we,	his x mark.	[SEAL.]

Executed in our presence—

W. V. Rinehart, major First Oregon Infantry.
Wm. Kelly, captain First Cavalry, Oregon Volunteers.
Lindsay Applegate.
Wm. C. McKay, M. D., acting interpreter.
Albert Applegate, second lieutenant, First Oregon Infantry, commanding escort.
F. B. Chase.

Appendix E

CULTURE ELEMENT DISTRIBUTIONS: XX
NORTHEAST CALIFORNIA

BY

ERMINIE W. VOEGELIN

ANTHROPOLOGICAL RECORDS

Vol. 7, No. 2

CULTURE ELEMENT DISTRIBUTIONS LIST

SYMBOLS USED IN THE ELEMENT LIST

+	Element affirmed by informant.
-	Element denied by informant.
(+)	Element affirmed, but some doubt concerning it on part of informant or ethnographer.
(-)	Element denied, but with qualifications as in the preceding.
.	Element enquired about, but informant uncertain regarding it.
o	Absent because lacking or impossible in the environment. (Not to be confused with the symbol o preceding an element number, and which is explained below.)
R	Element said to be of comparatively recent introduction.
*	Further information concerning item is contained in the section "Ethnographic Notes on the Element List."
Blank	Element not enquired for by ethnographer.

The following symbols precede element numbers:

†	For statistical computations, the number or letter entries under this element have been read as plus.
‡	For statistical computations, the element has been broken into two or more (e.g., 1 foot or less; more than 1 foot).
o	For statistical computations, the element has been eliminated.

	Kl	Mo
282. 1st salmon	•–	•o
283. 1st sucker	•+	–
284. 1st steelhead trout	–	–
285. Taboo to catch salmon before rite	–	o
286. Steelhead	–	–
287. Suckers	+	–
288. Taboo to eat salmon before rite	–	o
289. Steelhead	–	–
290. Suckers	+	–
291. Spring of year	+	–
292. Priest prepares for rite	–	–
293. Neighboring tribe holds (salmon) rite	–	–
294. Old man catches 1st fish	•+	–
295. Anyone may catch 1st fish for rite	–	–
296. Anyone may eat 1st fish	–	+
297. First (2) suckers burned	+	–
298. All of 1st catch eaten immediately	+	–
299. Punishment for removal of portion	•+	–
300. Taboo against leaving in basket overnight	–	
Gathering		
Gathering Techniques and Observances		
*300a. Poles, staves for gathering acorns, pine cones	–	+
*300b. Shepherd's crook stave	–	–
*301. Forked stick grapple	–	–
*302. Straight pole	–	+
303. Straight pole with cross bar	–	–
304. Also used for wood gathering	–	–
305. Limbs shaken with hands, feet	–	–
*306. Sapling as ladder for climbing trees	–	–
307. Double-pole ladder, buckskin rungs	–	–
308. Digging stick	•+	–
309. Plain, pointed at one end	–	–
310. Plain, bipointed	–	–
311. Crutch handled	+	+
312. Seed plants sometimes broken by hand		•+
313. 1st-fruits rite	+	+
314. Observed for: acorns	o	–
315. Pine nuts	–	–
316. Wokus (water lily seeds)	•+	+
317. Ipos bulbs (Calochortus sp.)		+
318. Manzanita berries		
319. Annual; observed in	+	+
320. Springtime	–	+
321. Midsummer	+	+
322. Fall of year	–	
†323. Number of days	10	–
324. Dancing	–	–
325. Praying	+	–
326. Singing	+	–
326a. Feasting on 1st fruit	+	–
327. 1st fruit gathered thrown away	–	•+
Preagriculture (Other than Tobacco)		
328. Burning for better wild-seed crops	+	+

	Kl	Mo
Angling		
235. Acute-angled hook, 1 barb	•-	+
236. Acute-angled hook, 2 barbs, bilateral	-	(+)
237. Gorge	•+	-
238. Meat, grasshopper on line; no hook	-	
239. Several hooks on line	•+	+
Harpoons, Spears		
240. Harpoon, detachable point(s)	+	-
241. Single toggle	-	-
242. Two toggles	+	-
243. Toggle of bone	+	-
244. Barbed toggle, three-piece	-	-
245. Simple toggle, one-piece	+	-
246. Harpoon used infrequently		
247. Fish spear, fixed point(s)	+	+
248. One point	-	-
249. Two points	+	-
250. More than two points	+	+
251. Circular arrangement of points	+	+
252. Points spread by ring	+	+
253. Wooden point(s)	•+	-
254. Bone point(s)	-	+
255. Flaked stone point(s)	+	-
256. Fish "spear," 1 point fixed, 1 detachable	-	-
257. Landing gaff	R	R
258. Hooked at end	R	R
259. Straight stick, pointed end	-	-
Other Fishing Techniques		
260. Fish shot with bow and arrow	-	-
261. Infrequently	-	-
262. Fish poisoning with plant substance	-	-
263. Fish caught with bare hands	•+	•+
264. Flares at night for fish	+	+
265. Harpooning, dipping fish through ice	•+	+
266. Fish killed	+	+
267. Manufactured club	-	+
268. Natural stone	+	+
269. Piece of stick	+	+
270. Biting neck of fish	-	-
271. Breaking neck or back	-	-
272. Striking head on ground, rock	-	+
273. Fish creel of basketry	•+	•+
274. Fish carried on forked stick through gills or jaw	+	-
275. On string or withe	+	+
276. Fish carried in fish net, over shoulder		
277. Fish laid head to tail, tied and packed on back	-	-
Fishing Observances		
278. Continence before fishing	+	+
279. 1st salmon, other fish taboo to youth	-	•+
280. 1st trout	+	+
281. 1st-fish rite or observance	+	-

	Kl	Mo
188. Deer bones, remains hidden in woods	-	+
189. Thrown away in woods	+	-
Fishing		
Nets		
190. Long flat nets	+	+
191. Gill net	+	+
192. Seine net	-	-
193. Perforated stone sinkers	-	+
194. Grooved stone sinkers	+	+
195. Wooden floats	-	-
196. Tule floats	+	+
197. Bag net, not dipped or scooped	-	+
198. Set	-	+
199. On A-frame	-	+
200. Tule floats	-	+
201. Small, dived with	-	-
202. Dip or scoop net	+	+
203. On A-frame	•+	•+
204. Kite-shaped frame	-	-
205. Circular mouth, 1 handle	•+	+
•206. Bow and arrow type	-	-
207. Circular mouth, 2 handles	-	-
208. On semicircular pole, no other handle	-	-
•209. Rectangular pouch net	+	+
210. For lampreys also	o	-
211. Roots put on set lines	-	-
Weirs, Scaffolds, Pens		
212. Straight across stream	•(+)	+
213. Converging	-	-
214. Diagonal or semicircular	•+	-
†215. Openings in weir	(3)	1
216. Pen with each door	-	+
217. Door closed by hand	-	(+)
218. Net in opening	-	-
219. Trap in opening	-	-
220. Movable weir of willow, etc., woven, dragged	-	+
221. Men form line across stream	-	+
•222. Fish driven into weir, net, or trap	(+)	+
223. Platform on weir	•(+)	-
224. Dipod supports for weir	(+)	+
225. Single-post supports for weir	-	+
226. Scaffold without weir	+	+
227. Floor or booth on scaffold for harpooning	+	-
•228. White rocks on bottom to increase visibility	+	-
•229. Stone pens or dams	•+	•+
Traps		
230. Long basketry trap, cylindrical	•+	+
231. Conical basketry trap, inner cone	-	-
232. Conical, opening at apex	-	-
•233. Flat, rectangular base trap, open top	-	-
234. Fish scooped up in basket	+	•+

Fishing

Nets; weirs, scaffolds, pens; traps.--Tule-wrapped clay ball sinkers. Bag net dragged. Shell rattle on net. Stick pens, not associated with weirs. Basketry or pole trough. Angling; other techniques.--Feather "fly." Hair "fly." Hair string or ball. Knot or block on end of line. Shooting fish taboo. Lamprey gaff. Buckeye used for poisoning fish. Fishing observances.--Special disposal of salmon or other fishbones. First-fish rite: priest or chief catches first fish; only priest or chief eats first fish; similar rite for lampreys.

trout); see note 284. At: Not many salmon in Hat Creek; occasionally a good run. AW: Salmon ascend Pit River as far as falls at site of Pit 1 power house, in Achomawi area (see Kniffen, Achomawi, map 1). Trout, suckers, catfish, bass also found within area. AE: No salmon; very few streams, creeks; fish scarce. WT: Salmon in area. When salmon begin running, if couple have pubescent daughter following rite held so couple can eat salmon. Young men catch salmon; take it to home of old man "who uses cane"; this old man may be adolescent girl's grandfather. Old man's wife cooks the first fish, then old man prays over it for short time, facing sun and leaning on his cane; after this everyone present, except girl(s) nearing puberty, eats this first fish. For other salmon caught after first run, no prayers of this sort. Rite restricted to parents of girls entering puberty, not general practice. WM: Salmon plentiful in area. If leave first salmon in basket overnight, will not catch any more. WS: Salmon in area. No rites over first salmon, but in middle of summer, during July, people start fishing at nodalčobipom (Castle Crag depot, 5 mi. S of Dunsmuir) and fish up Sacramento River to Shasta Retreat across river from Dunsmuir. At every village on the way they dance; stay 3-5 days at each place; young people dance, "just for a good time at night as they make this trip; old people sleep. It takes them 2-3 weeks to make this trip; there may be 200-300 people on it. Camp at 3-5 different locations on way." MM: Few salmon in area; other varieties fish more abundant. MF: Salmon in area, more abundant. NF: No salmon nearer than Yuba River; sometimes go there to spear, net salmon. First salmon cooked, eaten at "dinner" by all. Salmon plentiful in Feather River, but NF group never went there to fish as this was in "another country." NM: No salmon or suckers in area; never go to Yuba River or Sacramento Valley to fish. Small fish, only, found in creeks in area; no large rivers in area; little emphasis on fishing, which is pursued in main with small flat gill net. NS: Salmon obtainable within area, in American River. No salmon caught until certain time in summer; first fish cooked, divided and eaten by all members of community, "for good luck." No comparable rite for any other variety of fish. MV: Salmon plentiful; first-salmon rite similar to first-acorn rite (see note 313).

283. Kl: In spring old man (not shaman) catches first 2 suckers with nets at certain spot on Williamson River and throws them, alive, into fire which has been built on flat surface of deeply embedded rock near river. Fish burnt to foretell season's luck; "if they roll around when thrown in the fire, the people will have lots of fish; if they die quickly, quietly, there won't be many fish." Men, women, children gather at rock where rite held (only 1 place where this is done in whole of Kl area) and eat first catch of suckers on spot. "If they don't eat it all up there, people won't catch any more suckers." After these observances, all suckers caught can be transported home to be eaten, dried.

284. SW: Wait until Karuk give White Deerskin dance at end of July before eating steelhead (rainbow trout); if any steelheads caught in salmon net before Karuk dance given, they must be thrown back into river. Fishermen who disregard this rule are in danger of being killed.

292. NF: "Dreamer" or singing shaman.

294. Kl: First 2 suckers.

296. SW: First run taboo to adolescent girls.

299. Kl: Old man in charge of rite tells youth, "Don't you pack those fish home on the first day; eat well; don't carry them around, or break their backbones." If youth disobeys, sticks bound from wrist to shoulder on boy's arms, and then bent upward and broken, thus breaking boy's arms at elbow; boy sometimes died. Any of old men present administer this punishment.

300. WM: See note 282.

Gathering

Gathering techniques and observances.--

300a. See note 357. AW: Pick up acorns from ground by hand; do not beat trees.

300b. Used to bend down limbs within hand's reach. NV: Obtained pine nuts at Lookout (in MF area); man intending to go for such, continent night before he starts. To obtain pine cones, he climbs tree, hooks branches with staff, cuts off cones.

301. Used to bend down limbs.

302. Used for whipping, knocking acorns and pine cones off limbs.

306. Branches left on pole, to serve as footholds. SW: Wrap grapevine around fir pole, or leave limbs on pole for footholds. AW: Native twine wrapped around sapling for foothold; limb left on sapling at upper end to serve as hook; pole hooked onto upper branches of tree, as climber progresses upward.

308. Kl, SW: Made of mountain mahogany.

311. SW: Iron bar across top end. AE: Use crutch-handled type mostly, but sometimes plain bipointed one as well.

312. Mo: Break or pull up entire plant of lamb's-quarters, pile plants on bare hard ground, and beat out seeds with long straight stick.

313. NS: Prepare meal for group, when first batch of any wild fruit gathered. Example, for manzanita berries, make large quantity of cider with first gathered berries, all drink. MV: Headman goes out and tests acorns for ripeness; tells people when they are ripe. His wife then goes out, secures 1 pack-basketful of acorns; dries them, and in about 6 days she is able to make 2 baskets of acorn mush from them. These she takes into assembly house; there members of secret society pray over mush and eat it; then everyone can go out and gather acorns.

double-barbed bone hooks used; several tied on long string; 1 end of string tied to bush, other end which had hooks on it, tied around rock; rock thrown far out into stream. Indian Valley NM informant knew nothing of this.

237. Slender piece of bone, 2-3 in. long, ends pointed. Kl: Made of deer bone: baited with minnow; used at night.

238. SW: Meat tied on end of string for crawfish and catfish; line with fish on it drawn up slowly and flat basket shoved underneath fish when they get near surface of water. AW: Same technique used for crawfish. Fishlines dyed red with bark of tree (alder ?), so that fish cannot see line in water.

239. Kl: As many as 10 gorges fastened to line of native twine.

Harpoons, spears.--

241. SW: Rarely used.

246. At: Harpoon used for salmon, but due to scarcity of salmon in streams in area, harpoon used infrequently. AW, WS, NF: Harpoon used for salmon (see notes 219, 282). WS: Harpoon used in connection with scaffold (see note 226).

250. At: 4 points; used to spear trout, mainly, from boats.

253. Kl: Mountain mahogany wood.

258. Kl: Grapple or gaff recent; formerly raised end of spear slowly upward; impaled fish "sometimes came off" and escaped.

Other fishing techniques.--

260. SW: In still water of Modoc County; also in Klamath River; boys.

262. AE: Most of fish obtained, secured by this method. Women churn up water in stream after putting plants in it. NF, NS, MV: Soaproot used. AE, WT, MM, NM: Use of soaproot denied. MV: Also use horehound as fish poison. Data on use of turkey mullein (dove weed), manroot, ginsing too unreliable to include, as informants did not know common English names for plants used. WM: Soaproot used in Stillwater area as fish poison, but not in McCloud area, where "river runs too swiftly" to use fish poisons. WS: Soaproot obtained from vicinity of Redding, where plentiful; absent in Upper Sacramento region; not used for fish poison in latter area, although streams not so large as in McCloud area.

263. Kl: In spring only, when many fish running. Mo: By women. AW: Done frequently during salmon run at falls on Pit River at site of present Pit 1 power house; not done in any other streams within Achomawi area.

264. SW: Fires built alongside dams; pitchpine torches used as flares also.

265. Kl: Round-mouthed net (see element 205) "just like a dipper" used in winter, only, to dip up fish through hole in ice. Men pound with poles on top of ice, dance, to frighten the fish. AE: Fish dipped up through hole in ice.

267. WS, MM, NF, MV: Club cut from limb of tree.

271. SE: When catching salmon in net, only.

273. Kl: Twined tule basket, 14 in. high, 24 in. wide at top. Packed on back with pack strap; made, used expressly for carrying fish. Mo: Openwork twined conical willow pack basket used. WT: Willow basket, with small opening at top; widens out at bottom; bottom lined with leaves. Imitation of modern creel? MM, MF: "Use any sort of basket to pack home fish." NS: Pack basket.

Fishing observances.--

278. SE: When catching salmon in net, only. SW: See note 144. AW: Have "medicine" which counteracts any baneful effect. MV: When trapping salmon, do not eat any meat.

279. Mo: First of any species of fish or game youth secures taboo to him; if he ate it he would be "no account, have no luck in future." For salmon specifically, see note 282. At: First fish, game of any species taboo to youth and his parents. For salmon specifically, see note 282. AW: First deer, duck, fish boy kills taboo; also first deer, duck, fish youth catches after he has been sent out on vision quest and obtained vision should not be eaten by him. For salmon specifically, see note 282. At: See note 282. MV: First fish of any variety secured by youth treated same as first game (see note 137).

280. MM, NM, NS, MV: First sucker caught by youth taboo to him also; denied by MF, NF.

282. Kl: No salmon in Klamath Marsh, but abundant elsewhere in area; run in spring. Suckers, etc., abundant in marsh area. Mo: Mullet, trout chiefly, available in Tule Lake; no salmon. SE: Salmon plentiful in area; first salmon caught with line, after which salmon can be speared. SW: Salmon abundant in area. Shasta do nothing with first salmon they catch, but before they begin fishing, first salmon is caught down-river from them, by "a man who was raised at Hamburg [i.e., who belonged to Kammatwa group, a small buffer group between the Shasta proper and the Karuk, on the Klamath River; see Dixon, Shasta, p. 388, and Kroeber, Karok Towns, pp. 36-37]. Formerly he [Kammatwa man] caught this salmon in spring, at beginning of 'summer salmon' run; he used certain plants available at this season for rite. Perhaps he ate head, only, of this first salmon. Now, however, summer salmon run in September, and plants needed for rite are dried up by then." After this rite had been performed at Hamburg, the Shasta can catch summer salmon, dry and store them, but cannot eat them. Before they can eat fresh salmon, the Karuk down-river have to have given the White Deerskin dance (kuwarik - Shasta name). Shasta attend this dance as spectators; Shasta men avoid hunting at this time, so they will not see smoke from fire on mountains, which is built at beginning of dance. Previous to White Deerskin dance, the Shasta cannot catch or eat steelhead (rainbow

Fishing

Nets.--

190. AE: Streams small, consequently nets used not large. WT: 1 or 2 men, only, made fish nets: not everyone. WM: Du Bois, Wintu, p. 15, mentions use of net stretched across McCloud River, at Baird, for communal fish drive; my informant denied this; probably mistaken. NP: Except for Yuba River, streams in area small; high water in winter only. NM: See note 282. NS: A few of old men, only, make nets.

192. AE: Mentioned in myth, only; Owl had seine, but Weasel ran up and rolled log into it, tearing it up. NS: Net (bin), composed of several small flat nets fastened together for purpose, placed on and behind barrier of rocks, 2-3 ft. high, erected across stream at base of falls. As salmon attempt to leap barrier, fall into net; men stationed at each end of net lift it and fish taken out.

194. AW: Use natural stone for net sinker; no groove or perforation.

203. Kl: Used in springtime; dragged by 2 men, in river. Mo: 2 men to operate. AW: Not used; Hadesi group on Pit River use it. WT, WM, WS: 1 man to operate. (For sketch see Du Bois, Wintu, p. 127, fig. 5.) WT: Used under falls.

205. Kl: See note 265. At: Not used much.

206. See Dixon, Maidu, p. 142, fig. 13; Du Bois, Wintu, p. 127. AW: For trout and suckers. AE: 4-5 grooved stone sinkers attached to bottom of net.

209. See Spier, Klamath, p. 151.

Weirs, scaffolds, pens.--

212. Kl: Spier, Klamath, p. 149, says "weirs . . . are unknown to the Klamath"; possibly my informant misunderstood my repeated questioning on this point, but his account of weir with 3 openings, from top of which men speared fish, is too circumstantial to be overlooked. AW: Weirs built across stream on Pit River, below falls at Pit 1 power house; nowhere else in area.

213. AW: Circular "corral" built of rocks, with single opening in center on downstream side.

214. Kl: See note 229.

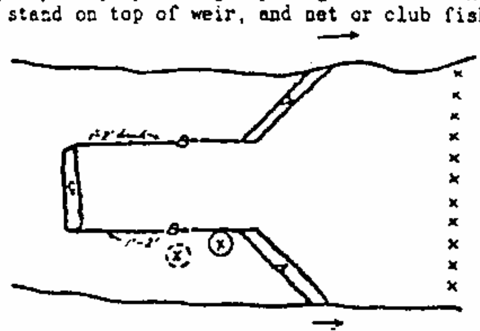
215. SW: 2-3 openings. AW: Refers to corral-shaped weir; see note 213.

219. WT, WM, WS: See Du Bois, Wintu, p. 128, on fishtrap. WT: Willows, as well as rocks, used for converging sides of weir. Trap walls 3 ft. high; back end 3 ft. high and elevated above water ca. 3 ft. WS: Trap of this sort used during midsummer salmon run (see fig., this page; note 282): "as salmon tired and went down-river, caught in this trap." Such trap might be made at Shasta Retreat; men would then proceed up-river to Mossbrae Falls [illegible] near Shasta Springs and sometimes put a lot of green leaves in water, to frighten salmon down-river into trap.

221. SW: In Rogue River, but not in Klamath River.

222. By men, women wading, beating water with long poles.

223. Kl: At night men sit on top of weir, with circular nets (see element 205); net salmon as they try to jump through openings in weir. MV: Men stand on top of weir, and net or club fish.



..., people frightening salmon downstream, spearing them; arrows point upstream; A, rock and brush dam; B, fir branches intertwined; C, brush piled up; (X), man clubbing fish; (X) man to string up fish.

226. WT, WS: Salmon house (buki) lacking. WM have salmon house. For description see Du Bois, Wintu, p. 123. WS: Set 2 poles, in form of dipod, in river; rest 1 end of log in fork of dipod, other end on river bank; man stands on this log near dipod end and spears salmon; informant remembered 1 man "who could spear 2 salmon at a time; other men couldn't spear any." This type of scaffold referred to as tokamas.

228. Chalk, generally.

229. Kl: Stone dams attributed to mythical being. Consist of semicircle of rocks, curving out from bank, then in again toward bank, with opening on downstream end. 2 such semicircles, on opposite sides of Williamson River, W of Chiloquin (not in Klamath Marsh area proper). Men stand inside enclosure, netting fish, which other men frighten into nets. See Spier, Klamath, p. 149. Mo, AW, WT: Made by human beings.

Traps.--

230. Kl: Weighted with stone at each end. AE: 6-7 ft. long.

231. AW: Narrow end untied, to take out fish. Catch otters and minnows with this trap, also.

233. See note 219.

234. Mo: Willow pack basket used. NS: Seed beater (patai) used.

Angling.--

235. Kl: Hooks made of sucker's tailbone or of bone shank and 2 bone points (see Spier, Klamath, fig. 10, p. 154) denied by informant. [illegible]: Sing while angling, to make fish swallow hook and keep on line. AW: Before fishing, men swallows food without chewing it, in imitation of fish swallowing hook and line. NM: Quincy NM informant (Marie Hedricks) stated bilateral

	Kl	Mo
424. On coals, in ashes	+	+
425. In pit oven	-	-
*426. Stone boiled	-	-
427. Meat boiled	*-	+
428. Rarely	-	
429. Blood boiled	-	+
430. Mammal meat dried	+	+
431. Fish dried	+	+
432. Salted for drying	-	-
433. Drying frame	+	+
434. Four-post frame	*+	+
435. Outdoors	+	+
436. Indoors	-	-
*437. Fish slit, strung on pole to dry	+	+
438. Smoke (fire) drying	+	+
439. Sun drying	-	+
440. Dried meat or fish ground	+	+
440a. Meat	+	+
440b. Immediately before eating, cooking only	+	+
441. Salmon, or other fish	-	-
441a. Made into meal, stored	-	-
442. Salmon eggs added	-	-
443. Seeds added	-	-
444. Fat added	-	-
445. Bone awl for splitting fish	+	+
446. Special drying house	-	-
447. Thatch	-	-
448. Bark	-	-
449. Poles, conical	-	-
450. Double lean-to	-	-

Appendix F

COPCO-PPL Merger

We have not investigated the corporate history of the California Oregon Power Company. A Pacific Power and Light official, Dierdorff, gives some background information on Copco and its eventual incorporation into Pacific Power and Light:

> "Copco's most directly related predecessor company, Siskiyou Electric Power Company, was incorporated August 15, 1902. Its corporate successor in 1908 was Siskiyou Electric Power & Light.
>
> . . .
>
> Initial activity of the Siskiyou company in the fall of 1902 was to start work on a high-head hydro plant on Fall Creek, a tributary of the Klamath River flowing into that stream from the north near the head of the present Iron Gate reservoir. Still in use, the site is occupied by a hydro plant of 2,300-kilowatt capactiy.
>
> . . .
>
> In the Klamath Falls community, a second electric company, Klamath Light and Power, completed a hydro plant on the west side of Link River in 1908 and began competing with Klamath Falls Light and Water Company. The new company extended lines to Merrill and Bonanza. Two years later it bought out its older competitor and sold the combined properties to Siskiyou Electric.
>
> Service in the Phoenix-Talent area was established in 1909 by the Jackson County Light & Power Company, which bought its power supply from Rogue River Electric.
>
> In 1910 an application for water rights on the Klamath River near Keno was filed by B. E. and J. W. Kerns and a diversion dam and power plant installed a short distance downstream from the site of the present Keno regulating dam. An important purpose of this plant was to provide power for irrigation and drainage of extensive lands brought into agricultural production on the Keno flat. It also supplied power to residents of the Keno area and a line was extended to Klamath Falls. The plant went into operation in 1912. It was acquired by Copco in 1920.
>
> . . .
>
> On December 15, 1911, California-Oregon Power Company was incorporated by the Siskiyou group to acquire the stock and consolidate the properties of Siskiyou Electric, Rogue River Electric, Prospect Construction, Klamath Power Company and Klamath Falls Light and Water Company. This was accomplished as of January 1, 1912. However, the Siskiyou, Rogue River and Prospect companies remained active for several years in order to complete or acquire certain properties.

A project carried forward by the Siskiyou company was construction of the Copco One hydroelectric plant on the Klamath River above Fall Creek. Preliminary work on the project began in 1912 and the first 10,000-kw unit went into service in 1918. . . .

Control of the California-Oregon company passed to San Francisco interests during the period Copco One was under construction. When that plant came into operation the transmission line from Fall Creek to Dunsmuir and Castella was extended south to a point known as Delta where it connected with a line built northward from Kennett by Pacific Gas and Electric Company. The interconnection was made at government request to augment power supply in the San Francisco area at a time when World War I was imposing heavy load on existing facilities.

. . .

The California-Oregon ("hyphen") company was reorganized into The California Oregon Power Company, incorporated October 16, 1920, with headquarters in San Francisco. The new corporation took over the assets of its predeccessor January 1, 1921.

In December of that year the head office of the firm was moved from San Francisco to Medford. About the same time, work was started on raising the dam and installing a second unit at the Copco One plant on the Klamath River, and arrangements were made with Mountain States Power for construction of a transmission line from Prospect to Springfield to supplement the supply of power in the Willamette valley. This line was completed and went into service November 1, 1922, and the added Copco One generating unit was in operation within the month.

Properties of the Douglas County Light and Water Company in the Roseburg area were acquired July 1, 1923, and in 1924 the new East Side plant at Klamath Falls was completed to replace the one built in 1906. Work was started in 1924 on Copco Two at a site just below Copco One and a 110,000-volt line was built from that point to Delta to increase capacity of the PG&E tie.

In October, 1925, the stockholders owning all of the common stock and part of the preferred stock of California Oregon Power exchanged their stocks for securities of California Power Corporation, a subsidiary of Standard Gas & Electric Company, which in turn was controlled by H. M. Byllesby Company of Chicago. (Dierdorff 1971:271-275)

Grant provides a brief personal perspective on the initial years:

After years of hard work we found ourselves in fairly smooth water, making money as a comparatively small concern, but with our future, as we envisaged it, hopelessly "cribbed, cabined and confined."

We decided to sell -- at a profit, yes, but with big ambitions thwarted.

> Why?
>
> Because capital is concentrated in the east. It is not concentrated in the west; it is not fluid. A banker reading this might say: "We can't go into these promotion schemes." But in California -- and I'm speaking as a banker -- we have promoted such enterprises; we have backed intelligence and honesty; and it is greatly to our credit that we have done this again and again. There was plenty of money in San Francisco to finance our power company. But it is not the policy of our bankers to work together. If you do business with one bank, other banks regard you with indifference.
>
> Well, perhaps that type of banking is all right -- for some. But bankers who want to make money must be connected with active enterprises, with energetic men who are alive to the needs and to the swiftly-shifting currents of the times. Otherwise, bankers who control the money of a community are likely to become little more than barnacles impeding its full speed ahead.
>
> In 1926 we sold out to the Byllesby interests, operating on a national scale. They linked up up with their vast holdings to the north. It was a logical step in the integration of power companies into stronger combinations. (Grant 1951:342)

Under Byllesby control, the California Oregon Power Company continued to operate although it did not expand much during the rest of the 1920s:

> During the depression years and throughout World War II the company's construction activities were necessarily limited. It did, however, effect a recapitalization in 1942, made possible by a capital contribution by Standard Gas & Electric of approximately $4,500,000 worth of debentures, preferred and common stock. This enabled Copco to meet requirements of the Federal Power Commission with respect to restating plant accounts on the "original cost" basis. (Dierdorff 1971:275)

By 1960, the California Oregon Power Company controlled power distribution in the Klamath Basin, in Siskiyou, Modoc, and Del Norte counties in California, and in adjacent areas in northern California and in southwestern Oregon. (Cal DWR 1960:274) In that year COPCO was taken over by Pacific Power and Light:

> CLIMACTIC event of 1960--the Company's 50th anniversary year--made the news on December 30, when it was announced that the Boards of Directors of Pacific Power and The California Oregon Power Company had reached general agreement of the terms of a proposed merger of Copco into Pacific.
>
> Pacific's January 10, 1961, letter to stockholders said in part: "subject to approvals by stockholders and by the regulatory commissions having jurisdiction, the merger would be effected by an exchange of stock in the ratio of 1.2 shares of Pacific common stock for each share

of Copco common. Details of the proposed consolidation, including provisions for the exchange of Copco's preferred stocks, are being worked out by a joint committee of officers and directors for submission to stockholders of each company. It is hoped that the proposal may be acted upon at special meetings of the stockholders tentatively scheduled for early March."

On January 30, 1961, the Company sent its stockholders a copy of the merger agreement dated January 18 and notice of a special meeting of stockholders on March 14 to act on the proposal. The letter of transmittal included the following:

"The California Oregon Power Company is an electric utility serving 93,000 electric customers in important areas of southern Oregon and adjoining portions of northern California. It has annual revenues of $25,000,000 and a gross utility plant account of $179,000,000. The company was established in 1911 and has played a progressive part in the extension of electric service and the development of hydroelectric resources in its operating territory, which has a population of 254,000. Copco's service area in Oregon adjoins that of your Company and the two systems are interconnected.

. . .

"Your Company has annual revenues of $63,000,000 and a gross utility plant account of $398,000,000. Merger of the two companies would result in a broad-based utility operation with annual revenues of $88,000,000 and a gross plant account of $577,000,000. The merged company would serve 243,000 electric customers in Oregon and have a total of approximately 411,000 utility customers. . . .

. . .

Copco's management similarly addressed the stockholders of that company, recommending a favorable vote at its special meeting on March 14. Stockholders of each company voted almost unanimously in favor of the merger. More than 90% of the shares of each were represented at the meetings.

All regulatory approvals were obtained and the merger was completed on June 21, 1961. . . .

For Paul McKee the consolidation of Copco with Pacific was tinged with sentiment. He had begun his business career with Copco in 1914 after graduation from Stanford, and served as assistant to the president from 1914 to 1920 and as vice president and general manager from 1920 to 1926.

The merger agreement provided that the initial Board of Directors of the surviving Pacific Company should consist of 15 of the 21 prior members of that Board and eight of the nine prior directors of Copco.

McKee continued as chairman of the board of Pacific and Don McClung as president. Two of Copco's senior officers were named vice chairmen. One was A. S. Cummins, president of Copco since 1941.

> Prior to taking that post, he had been vice president and secretary of Standard Gas & Electric Company.
>
> Glenn L. Jackson, a vice president of Copco, also was named a vice chairman. Jackson started in the utility business in 1925 upon graduation from Oregon State University. He was a salesman for Mountain States Power from 1925 to 1927, sales manager from 1927 to 1929 and vice president from 1929 to 1938. In 1933 he became director and in 1935 a vice president of Copco, then an affiliated company. His service with Copco was interrupted only by a military leave during World War II, when he became a colonel in the U. S. Air Force.
>
> John C. Boyle, vice president and general manager and a director of Copco, became a vice president and director of Pacific. He began his utility career with Copco following graduation from the University of California in 1910, and his accomplishments over many years of service to the company included the planning and execution of major development programs.
>
> Frank C. Bash, vice president and treasurer of Copco, became a vice president of Pacific and later was appointed manager of the Copco division.
>
> H. P. Bosworth, Jr., Copco vice president who came to the company in 1923 as a graduate engineer from Cornell, became a vice president of Pacific and served until his retirement in 1966.
>
> Copco directors who went on Pacific's Board were Messrs. Boyle, Cummins and Jackson, of the company's staff; Alfred S. V. Carpenter, Medford; Gregory A. Harrison, San Francisco; Henry H. Pringle, Medford; George M. Roberts, Medford; and Eugene Thorndike, Medford. E. B. Hall, Klamath Falls, was named a director emeritus of Pacific and served in that capacity until his death in 1965 at the age of 93. (Dierdorff 1971:267-268)

As indicated there were connections between the staff of California Oregon and Pacific Power and Light:

> Talbot said it had been his hope and that of other directors that John A. Laing, vice president and general counsel for many years, might accept the presidency in the event of his retirement. Laing, however, had expressed the desire to remain as counsel and adviser "and at the same time maintain a substantial contact with the general practice of law, rather than to become completely involved in executive responsibilities."
>
> The letter of resignation related that "subsequent inquiries and consultations among our directors and advisers have disclosed the opportunity to secure for the presidency of our Company the services of Mr. Paul B. McKee, formerly vice president and general manager of The California Oregon Power Company, and for the past seven years president of Empresas Electricas Brasileiras (Brazilian Electric Company). Those of us who are acquainted with Mr. McKee and his

record as a utility executive believe him to be exceptionally well equipped to act as president of this Company, and it is a great pleasure to me to recommend him unqualifiedly to the Board for election as my successor."

Talbot's resignation was accepted by the Board "reluctantly and with deep regret" and with "the grateful thanks and appreciation of the Company for his twenty-three years of outstanding and successful leadership."

On Talbot's motion, McKee was elected a director of the Company and thereupon named president. The minutes then recited that McKee "entered the meeting at this point at the request of the Board and was cordially greeted by the directors."

McKee likewise was named president of Northwestern Electric and Portland Gas & Coke companies.

Born in San Francisco on October 11, 1891, McKee was graduated from Stanford in 1914 with a degree in electrical engineering. . . .

He went to work for The California Oregon Power Company in 1914 and in 1920 was made vice president and general manager of that company, a post he held until 1927. In that year he was chosen by Sidney Z. Mitchell to go to Brazil on behalf of American & Foreign Power Company, an Electric Bond & Share subsidiary, to serve as president of Empresas Electricas Brasileiras, with headquarters in Rio de Janeiro.

McKee spent six busy years traveling throughout Brazil and acquiring for operation and development a group of utility properties in that nation. It was an assignment demanding resourceful leadership and a talent for building and maintaining good public relations, qualifications which were obviously in demand for the challenging new task in the Pacific Northwest. (Dierdorff 1971:120-121)

Appendix G

Excerpts from State of California Fish and Game Code
Thirty-Seventh Edition, 1951-1953

Article 2. Obstructions and Fish Screens

520. As used in this article:

(a) "Dam" includes all artificial obstructions;

(b) "Conduit" includes pipe, mill race, ditch, flume, siphon, tunnel, canal, and any other conduit or diversion used for the purpose of taking or receiving water from any river, creek, stream, or lake;

(c) "Owner" includes the United States (except that for the purpose of Sections 520.5, 522, 526 and 534 "owner" does not include the United States as to any dam in the condition the dam exists on the effective date of the amendment to this section), a person, political subdivision, and a district (other than a fish and game district), owning, controlling or operating a dam or pipe;

(d) "United States" means the United States of American, and in relation to any particular matter includes the officers, agents, employees, agencies, or instrumentalities authorized to act in relation thereto.

(Amended by Ch. 1101, Stats. 1945.)

520.2. The United States shall file with the commission pursuant to this article a separate application for each dam it proposes to construct or enlarge if an owner other than the United States would be required to file an application pursuant to Division 3 of the Water Code in order to construct or enlarge the same dam. The application shall be on forms provided by the commission.

(Added by Ch. 1101, Stats. 1945.)

520.3. The application of the United States shall give the following information:

(a) The name and address of the owner.

(b) The location, type, size, and height of the proposed dam and appurtenant works.

(c) The storage capacity of the reservoir.

(d) Such other pertinent information as the commission requires.

(e) As accurately as may be readily obtained, the area of the drainage basin, rainfall and stream flow records and flood flow records and estimates.

(f) The purpose for which the impounded or diverted water is to be used.

(g) Such other appropriate information as may be necessary in a given instance.

In instances wherein the physical conditions involved and the size of the dam are such as to render the above requirements as to drainage areas, rainfall, stream flow, and flood flow unnecessary, the commission may waive the requirements.

(Added by Ch. 1101, Stats. 1945.)

520.5. Whenever an application for approval of plans and specifications for a new dam in any stream in this State, or for the enlargement of any dam in any such stream, is filed with the Department of Public Works, pursuant to the provisions of Chapter 766, Statutes of 1929, a copy of such application shall be filed by the applicant with the commission. When the commission deems that the construction of a fishway over such a dam is necessary for the preservation and protection of fish, and that construction and operation of such fishway is practicable, it shall set a date for a hearing, which hearing shall be held within 10 days after filing of such application with the commission. At such hearing the applicant shall be entitled to introduce evidence to show that construction of such fishway is not necessary or is not practicable, taking into consideration the height of the dam and the amount of water available. If, after such hearing, the commission finds that the construction of such fishway is necessary and practicable it shall, within five days after such hearing, notify the applicant to that effect. After notice from the commission that a fishway is required, it shall be unlawful to commence the construction of any new dam or the enlargement of any dam without first obtaining the written approval by the commission of the design for such a fishway.

(Added by Ch. 721, Stats. 1933.)

521. The commission shall examine from time to time, all dams in all rivers and streams in this State naturally frequented by salmon, trout, shad, or other fish.

522. If, in the opinion of the commission, there is not free passage for fish over or around any dam, the commission shall cause plans to be furnished for a suitable fishway, and order in writing the owner of the dam to provide the dam, within a specified time, with a durable and efficient fishway, of such form and capacity and in such location as shall be determined by the commission. Such fishway must be completed by the owners of the dam to the satisfaction of the commission within the time specified.

(Amended by Ch. 1323, Stats. 1951.)

522.5 When all of the provisions of this article have been complied with, if in the opinion of the commission changed conditions make additional structures desirable for the free passage of fish, the department may make such additional structures and may expend such sums of money as it deems necessary for such additional construction, including the cost of insurance against any liability which the department may incur in connection with such structures.

(Amended by Ch. 1323, Stats. 1951.)

523. The owner of any dam upon which a fishway has been provided must keep the fishway in repair and open and free from obstructions to the passage of fish at all times.

524. It is unlawful to wilfully destroy, injure, or obstruct any fishway.

525. The owner of any dam shall allow sufficient water at all times to pass through a fishway, or in the absence of a fishway, allow sufficient water to pass over, around or through the dam, to keep in good condition any fish that may be planted or exist below the dam. During the minimum flow of water in any river or stream, permission may be granted by the commission to the owner of any dam to allow sufficient water to pass through a culvert, waste gate, or over or around the dam, to keep in good condition any fish that may be planted or exist below the dam when, in the judgment of the commission, it is impracticable or detrimental to the owner to pass the water through the fishway.

(Amended by Ch. 456, Stats. 1937.)

526. Whenever in the opinion of the commission it is impracticable, because of the height of any dam, or other conditions, to construct a fishway over or around the dam, the commission may order, in lieu of the fishway, the owner of the dam completely to equip, within a specified time, on a site to be selected by the commission, a hatchery, together with dwellings for help, traps for the taking of fish, and all other equipment necessary to operate a hatchery station, according to plans and specifications furnished by the commission. After such hatchery has been constructed, the department shall operate it without further expense to the owner of the dam.

(Amended by Ch. 1323, Stats. 1951.)

527. The hatchery, traps and other equipment necessary to operate a hatchery station shall not be of a size greater than necessary to supply the stream or river with a reasonable number of fish. The owner of the dam shall permit the commission to locate the hatchery, dwellings, traps and other equipment upon any of the land of the owner of the dam upon a site or sites to bemutually agreed upon by the commission and the owner of the dam.

528. If the owner of the dam generates electricity at the place of the dam, the owner shall furnish sufficient light, without, expense, for the use of the hatchery.

529. The owner shall permit the use of water, without expense, to operate the hatchery.

530. The commission may, in lieu of a fishway, hatchery, dwelling, traps or other equipment necessary to operate a hatchery station, order the owner of the dam to plant, under the supervision of the department, the young of such fish as naturally frequent the waters of the stream or river, at such times, in such places, and in such numbers as the commission may order.

(Amended by Ch. 1323, Stats. 1951.)

531. The owner of a dam shall accord to the public for the purpose of fishing, the right of access to the waters impounded by the dam during the open season for the taking of fish in such stream or river, subject to the rules and regulations of the commission.

532. The owner of a dam is not liable in damages to any person exercising the right to fish, who suffers any injury through coming in contact with, or tampering with, any of the property of the owner of the dam.

533. The commission may sell, at cost, to the owner of a dam, young fish ordered to be planted.

534. Except as otherwise provided in this code, it is unlawful to construct or maintain in any stream in Districts 1, 1 1/2, 2, 2 1/2, 2 3/4, 3, 4, 4 1/2, 5, 23 and 25, any device or contrivance which prevents, impedes, or tends to prevent or impede the passing of fish up and down stream.

(Amended by Ch. 791, Stats. 1939.)

Appendix H

California-Oregon Interstate Water Compact

By 1953 it had become apparent to both Oregon and Calfornia that future demands for Klamath River water, both within the interstate basin and in other areas to which Klamath River water might be exported, would eventually force a determination of the proper distribution and use of Klamath River water to the mutual advantage of each state. Rather than leave this determination unsolved until the time when critical water needs might force a hasty and possibly unsatisfactory settlement of the problems the two states wisely agreed to face the issues which would inevitably rise, and through mutual agreement determine how these interstate waters should be used for the fullest benefit of all parties concerned. To accomplish this purpose, bills were passed in each State Legislature in 1953, which established compact commissions within each state. The function of these commissions was to cooperate in formulating and submitting to their respective legislatures an interstate compact relative to the distribution and use of the waters of the Klamath River. The consent of the Congress of the United States to the negotiation of an interstate compact was given by Public Law 316, 4th Congress, approved August 9, 1955.

The commissions of both states spent considerable time in becoming better acquainted with the water problems of the Klamath River Basin. Subsequently a compact, mutually agreeable to both commissions, was formulated and approved on November 17, 1956. This compact was ratified by the Legislatures of Oregon (Chapter 142, Oregon Laws 1957) and California (Chapter 142, Oregon Laws 1957) and California (Water Code, Division 2, Part 6) on April 17, 1957. The compact was consented to by Act of Congress (71 Stat. 497) on August 30, 1957, and became effective on September 11, 1957.

The major purposes of this agreement, with respect to the water resources of the Klamath River Basin, are set forth in Article I of the compact:

> "A. To facilitate and promote the orderly, integrated and comprehensive development, use, conservation and control thereof for various purposes, including, among others: the use of water for domestic purposes; the development of lands by irrigation and other means; the protection and enhancement of fish, wildlife, and recreational resources; the use of water for industrial purposes and hydroelectric power production; and the use and control of water for navigation and flood prevention.
>
> "B. To further intergovernmental cooperation and comity with respect to these resources and programs for their use and development and to remove causes of present and future controversies by providing (1) for equitable distribution and use of water among the two States and the Federal Government, (2) for preferential rights to the use of water after the effective date of this Compact for the anticipated ultimate requirements for domestic and irrigation purposes in the Upper Klamath River Basin in Oregon and California, and (3) for prescribed relationships between beneficial uses of water as a practicable means of accomplishing such distribution and use." (Cal DWR 1960:8-9)

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Observations and Significance of Fish and Invertebrate Stranding During the First Few Major Peaking Cycles in 2006 Downstream of the J. C. Boyle Hydroelectric Project

Technical Memo to the Klamath Tribes
by
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July 28, 2006
Revised September 19, 2006

In order to investigate the impacts of the first few major peaking cycles of the year, I visited two sites in the JCB peaking reach July 4-8, 2006 (Figure 1). Below I document observations from these site visits, and discuss the effects of peaking flows on the fish community in the Klamath River.

Flow Regime

The first peaking cycles occurred July 3-4, with flows fluctuating between about 1700-3000 cfs (Figure 2). However, peaking did not begin in earnest until the morning of July 5, when flows descended from 3370 to 375 cfs for the first time following spring run-off. Daily minimum flows descended to 375 cfs every day in July thereafter, with daily maxima of 1850 cfs (single turbine) to 2900 cfs (double turbine).

July 4-5, Frain Ranch

When I arrived at 1930 hours, flow was high (2810 cfs at the USGS gauge below the JCB powerhouse, Figure 2), and the vegetated near-shore areas were inundated. Reed-canary grass dominated the riparian vegetation in the area, and there were very small, vegetated side channels in some locations. After a brief search in a side channel, I observed several groups of larval fish among the vegetation. Both sucker and minnow larvae were present, and were in early stages of larval development, in that their bodies very small (suckers about 15 mm long, minnows about 8 mm long) and their fins were only beginning to form. Early larval fish have limited swimming capabilities, which is one reason they are found in vegetated shoreline areas in this riverine environment.

During the early morning hours of July 5, river flow was ramped down to 375 cfs (Figure 2). From 0500 - 0800 hours on July 5 I carefully inspected an exposed shelf comprised of gravel and small cobble that was approximately 180 ft long by 20 ft wide (Figure 3). The shelf was completely inundated well into the vegetated margin a few hours earlier. I visually inspected the exposed surfaces on the shelf, under rocks, in puddles, and among the reed-canary grass stems.

Dead fish were scattered throughout the area, with a tendency towards greater concentrations in areas still holding some water, generally in the form of small to tiny puddles. Mouths of most of the dead fish in puddles were at full gape, indicating that they died from hypoxia. The oxygen demand in the puddles apparently rendered them incapable of sustaining the trapped fish until flows ramped up again. Many dead fish were found under and between rocks in completely dewatered areas as well. None were found in the reed-canary grass stands, probably because the organic substrate in such areas was relatively smooth and sloped towards the river.

Dead juvenile sculpin (Figure 4) were most common, ranging in length from about 22-33 mm. Perhaps 10% of the sculpin were still alive despite being dewatered, though many were near death. Apparently, sculpin can survive for some period out of water under cool, moist conditions. I estimated that the shelf held several hundred dead and dieing sculpin.

Suckers and minnows were also trapped. Dead juvenile suckers (Figure 5) ranging in length from about 21-30 mm were distributed similarly to the sculpin, but were much less common. Live sucker and minnow larvae were found in a tiny (perhaps 4 square inches surface area) puddle (Figure 6). No other larvae were found, but they would be extremely difficult to find if dead and dewatered. I found the living larvae because of their swimming movements.

In addition to the large numbers of dead fish, there were enormous numbers of dead aquatic insects (Figure 7) and large numbers of trapped crayfish (Figure 8). As with the fish, puddles tended to have higher concentrations of dead insects and crayfish (in places >100 dead insects/ft^2 based on the photo in Figure 7), but they were ubiquitous throughout the shelf. Large, adult crayfish were almost always dead, but many of the early instars (about 20-40 mm long) were still alive in moist interstices and puddles (Figure 8).

July 6, Below Shovel Creek

On July 6, 2006, I inspected two exposed gravel bars in the Klamath River downstream of the Shovel Creek confluence, at the lower end of the JCB peaking reach. River flow was low during my inspection (0630-0800 hrs) – flow below the JCB powerhouse at the low end of the peaking cycle (0130-0630 hrs) was 371 cfs (down from about 2800 cfs at the onset of the down-ramp; Figure 2), and by 0800 there was no increase in flow at the site.

The first bar I inspected extended downstream from an island. Because of the morphology of the channel and bar at this location, it was obvious that the bar would experience relatively high water velocities when inundated, and therefore would not be ideal habitat for young fish. I found no dead or stranded fish, and saw no young fish in the shallows.

The second bar had a wide, well developed side channel with ideal habitat for young fish. Much of the bar was dewatered, though there was one large, residual pool (about 1 ft deep) and many small puddles still holding water. Thousands of stranded larval and juvenile fish were alive in the large pool. Many more larval and juvenile fish were present in the shallow water at the margin of the river where water would flow into the side channel at higher river flows.

On the other side of the island, a large, flat gravel bar was dewatered, and again I could find no dead fish. Many thousands of larval and juvenile fish were present (not stranded) in the shallow water along the edge of the bar.

July 7, Frain Ranch

On July 7, flow below the JCB powerhouse was ramped down to 371 cfs by 0200 hrs (Figure 9). From 0300-0700 hrs, I intensively sampled the same shelf near Frain Ranch where I observed extensive fish and invertebrate mortality on July 5 (Figure 10). Once the shelf was completely exposed, I measured its length by pacing (90 paces x 2.5 ft/pace = 225 ft) and approximate average width (10 paces x 2.5 ft/pace = 25 ft), yielding an approximate shelf area of 5,625 ft^2. I then laid out 10 transects perpendicular to the channel following a systematic random protocol (e.g. random transect location selected in the first $1/10^{th}$ of the bar's length, then additional transects were spaced at intervals of $1/10^{th}$ bar length thereafter). Along each transect, I started at the water's edge, randomly selected an initial sample location in the first $2/10^{ths}$ of the average width of the bar, then sampled each $2/10^{ths}$ of the bar width thereafter along the transect up to the water's edge at high flow. Each individual sample consisted of a careful search within a 1 ft^2 area, removing and inspecting each rock (using a powerful halogen flashlight) until encountering substrates lacking interstices capable of concealing fish. In this manner, 46 plots were searched, and the presence of stranded fish or crayfish recorded.

No dead fish were observed in sample plots, or anywhere else on the shelf. One freshwater clam was encountered (0.02 clams per ft^2). A total of 17 stranded crayfish were encountered in 9 plots, which translates to a density of 0.37 ± 0.25 crayfish/ft^2 (mean ± 95% CI). Expanding this density to the total area of the shelf results in an estimate of 2,081 (645 – 3,487 95% CI) stranded crayfish. Not all crayfish were dead, and most were early instars.

One plot was on the edge of a residual pool (about 6 ft x 6 ft x 0.3 ft), in which 50-100 larvae were stranded but still living. No stranded fish were visible in any of the smaller puddles that were searched. Numerous adult sculpin were visible in extremely shallow water in the river margin along the edge of the shelf.

I collected no quantitative data regarding densities of dead aquatic insects. Subjectively, however, the density of dead aquatic insects was an order of magnitude higher on July 5 than on July 7. The same is true for the densities of dead fish and crayfish, which were much higher on July 5. Comparison of photographs taken July 7 (Figure 11) to those from July 5 (Figure 7) illustrates the difference.

July 8, Frain Ranch

I returned again to the Frain Ranch site during the trough of the peaking cycle early in the morning of July 8. The shelf was again completely dewatered, no dead fish were visible, and the density of dead aquatic insects was low.

Discussion

In the Frain Ranch reach of the Klamath River, the first large peaking cycle of the year (July 5) caused enormous stranding mortalities of larval and juvenile fish, adult and juvenile crayfish, and aquatic insects. The measured density of stranded crayfish during the third major peaking cycle (July 7) was large, indicating a biologically significant level of stranding (and associated mortality).

Densities of dead and stranded fish and crayfish were not systematically quantified on July 5 during the first major peaking cycle. However, based upon my careful inspection of the site on July 5, I can confidently assert that densities of stranded and dead fish and crayfish were much higher on July 5 than the measured density of crayfish (0.37 crayfish/ft^2) on July 7. Conservatively, I estimate that the density of dead fish on July 5 was at least one third again as large as the measured density of crayfish from July 7. The resulting density of 0.49 fish/ft^2 would translate to approximately 2,700 dead fish on the single shelf sampled. Assuming that the dewatered shelf on the other side of the river experienced similar mortality, then approximately 5,000 fish were killed in this 225 ft long reach of the Klamath River in a single peaking cycle. Further, at least as many crayfish were stranded, many of which died, and orders of magnitude more aquatic insects perished as well. The foregoing expansions are not precise estimates of stranding and mortality, and are not intended to be used as such. Nonetheless, it is certain that very large, biologically significant numbers of fish and invertebrates perished in the July 5 peaking cycle.

Much lower incidence of stranding and mortality on the third and fourth major peaking cycles strongly implies that most mortality associated with the peaking operation resulted from the first (and possibly the second) peaking cycle. Therefore, appropriate design of studies to detect and quantify the occurrence and biological significance of stranding mortality would require sampling during the first few major peaking cycles of the year. The field effort documented here indicates that even a well designed, intensive study, if conducted on July 7, would severely underestimate both the extent and biological significance of the effects of peaking, which were exerted primarily on July 5.

PacifiCorp's studies to evaluate stranding consisted in part of looking for stranded fish one day per site on May 31, July 11, and August 8/9, 2002, and June 10/11, July 14, and August 19/20, 2003 (PacifiCorp 2004, pgs 6-44 to 6-45). Sites selected for sampling included one site at Frain Ranch (a short distance downstream from the site I sampled) and at three sites in California deemed to have a high potential for stranding due to their low beach gradient. No sites further upstream than the lower Frain Ranch reach were evaluated. However, peaking cycles in which Klamath River flows descended below 500 cfs took place most days in April and May, and every day in June during 2002 (Figure 12), so as young-of-the-year fish either entered or were produced within the peaking reach prior to the onset of the PacifiCorp studies, they were immediately subjected to extreme flow fluctuations, and faced the threat of stranding on a near daily basis. Flows did not descend below 500 cfs (an arbitrary threshold selected to identify periods when peaking took flows to very low levels) as frequently during April and early May in 2003, but did every day of the last week or so in May. Therefore, the kind of mortality I observed in 2006 would have gone unnoticed in the PacifiCorp studies.

In years like 1996, 1998-99, 2003, and 2006 (Figure 12), spring-time flow conditions were probably more conducive for reproduction than during years like 2001-2, and 2004-5, when peaking regularly took Klamath River flows well below 500 cfs. Therefore, the kind of severe mortality event I observed on July 5, 2006, was probably more likely to occur in the years when extreme peaking did not occur until late spring or early summer, because young fish would accumulate as spring-time reproduction proceeded. Then, when peaking began in earnest, this accumulation of young would be available for the kind of event I witnessed. During years when peaking conditions were severe throughout the spring and early summer, reproductive success was probably severely curtailed, and progeny faced immediate high mortality rates associated with peaking. Under such conditions, few young fish would be available for stranding at any instant in time, and studies designed to detect stranding as PacifiCorp's were could easily result in a false conclusion that few young fish were stranded, when in fact the severe, chronic effects of peaking prior to the studies have already killed the fish.

It appears that in the river near Copco Reservoir, the ramp rate is attenuated to the extent that stranding is much less severe than at Frain Ranch. Otherwise, there would have been massive mortalities at the site I examined below Shovel Creek, because there were large numbers of young and vulnerable fish present. PacifiCorp (2004, at pg 6-47) quantified dominant ramp rates (for single turbine down-ramps to low flows near 350 cfs) of 9.36 in/hour over 3.5 hrs at the USGS gage below the JCB powerhouse, 5.22 in/hr over 4.25 hrs at their Frain Ranch site a short distance downstream from my site, and 2.90 in/hr over 6.0 hrs at sites downstream from Shovel Creek. My study documented severe mortality at Frain Ranch during a two-turbine down-ramp, which occurred at a ramp rate of 7.25 in/hr over 4.5 hrs at the USGS gage below the powerhouse (USGS gage data at: http://nwis.waterdata.usgs.gov/nwis/uv?cb_00060=on&cb_00065=on&format=gif&period=31&site_no=11510700). Therefore, while I cannot be certain of the ramp rate on July 5, 2006 at Frain Ranch (because the stage-discharge relation for the cross section there is unknown), it is certain that the down-ramp experienced on that date was less than it is at other times (e.g. the July 14, 2003 data presented in PacifiCorp 2004 at pg 6-47).

I encountered no redband trout in the very limited effort I was able to put into this study. I agree with PacifiCorp (2004, at pg 6-46) that a likely reason for this is the low density of trout fry in the peaking reach. PacifiCorp (2004, at pg 6-44) did observe some trapped trout fry at sites downstream from Shovel Creek, but none at the lower end of the Frain Ranch reach. However, the question remains as to whether there would be more trout fry in the peaking reach in the absence of peaking, if more spawning gravels were available, and if effective fish passage reconnected fish in the peaking reach to spawning habitat in Spencer Creek.

Addley et al. (2005, pg 36) concluded that food availability was more important than temperature for redband trout growth rates in the peaking reach. Results of the bioenergetics modeling in the Keno reach indicate that as the fish grow larger they either switch to more abundant or higher energy prey (such as forage fish) or migrate to modify their thermal regime (Addley et al. 2005, pg 34). There appears to be little opportunity for fish in the Keno reach to moderate their thermal regime via migration; fish would have to either move into Spencer Creek, or move to the JC Boyle bypass reach (an option limited by the poorly functioning ladder at Boyle Dam). The more likely explanation is that the fish switch to forage fish. Redbands do not appear to get as old (PacifiCorp 2004, pg 6-56) or grow as large (pg 6-52) in the peaking reach as in the Keno reach. Substantially more forage fish were collected from the Keno reach than the peaking reach (PacifiCorp 2004, pgs 6-50 to 6-51). The simplest and most logical explanation for the observed differences between the Keno and peaking reaches reflects the nomenclature used to distinguish them: ***peaking***. The extreme peaking regime kills large numbers of forage species (insects, crayfish, and fish), which fits neatly with the results of both the bioenergetics model as well as with the limited fisheries information that was acquired on the redband trout.

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Addley, R. C., B. Bradford, and J. Ludlow. 2005. Klamath River bioenergetics report. Prepared for PacifiCorp by the Institute for Natural Systems Engineering, Utah Water Research Lab, Utah State University, Logan.

PacifiCorp. 2004. Ramping and flow fluctuation evaluations. Section 6 of the Fish Resources Final Technical Report, Klamath Hydroelectric Project, FERC No. 2082. Portland, Oregon.

PacifiCorp. 2005. Evaluation of effects of flow fluctuation on aquatic resources within the J. C. Boyle peaking reach. Response to FERC AIR GN-2, Klamath Hydroelectric Project, FERC No. 2082, Portland, Oregon.

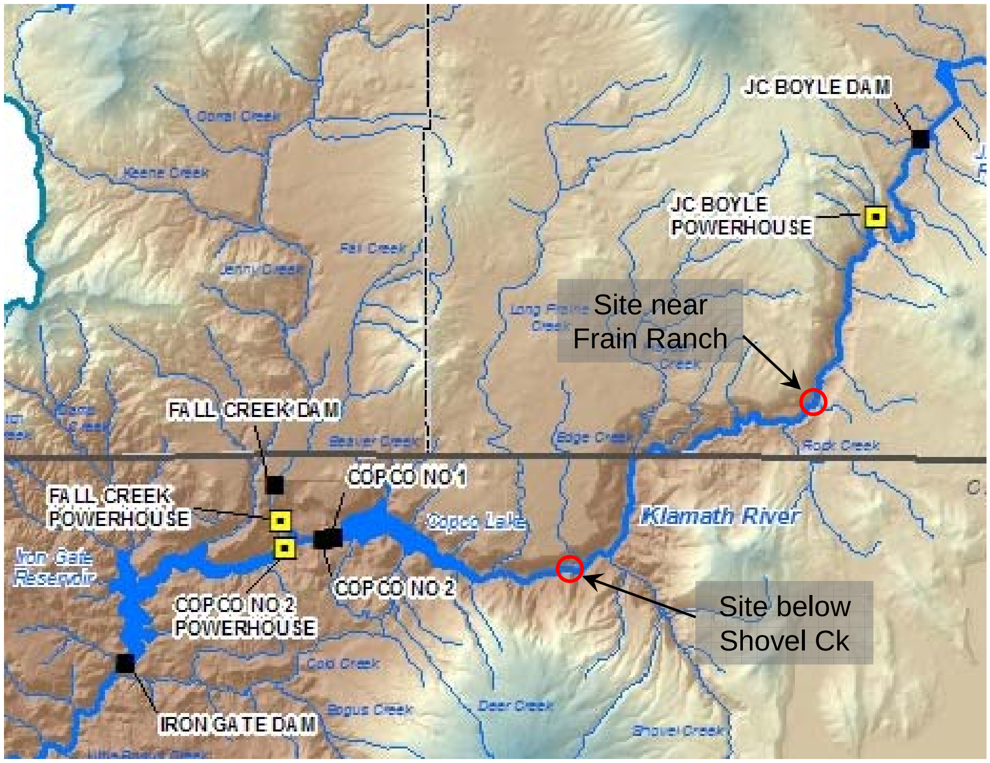

Figure 1. Location of sites visited in July 2006. Map modified from USFWS map created by B. J. Brush.

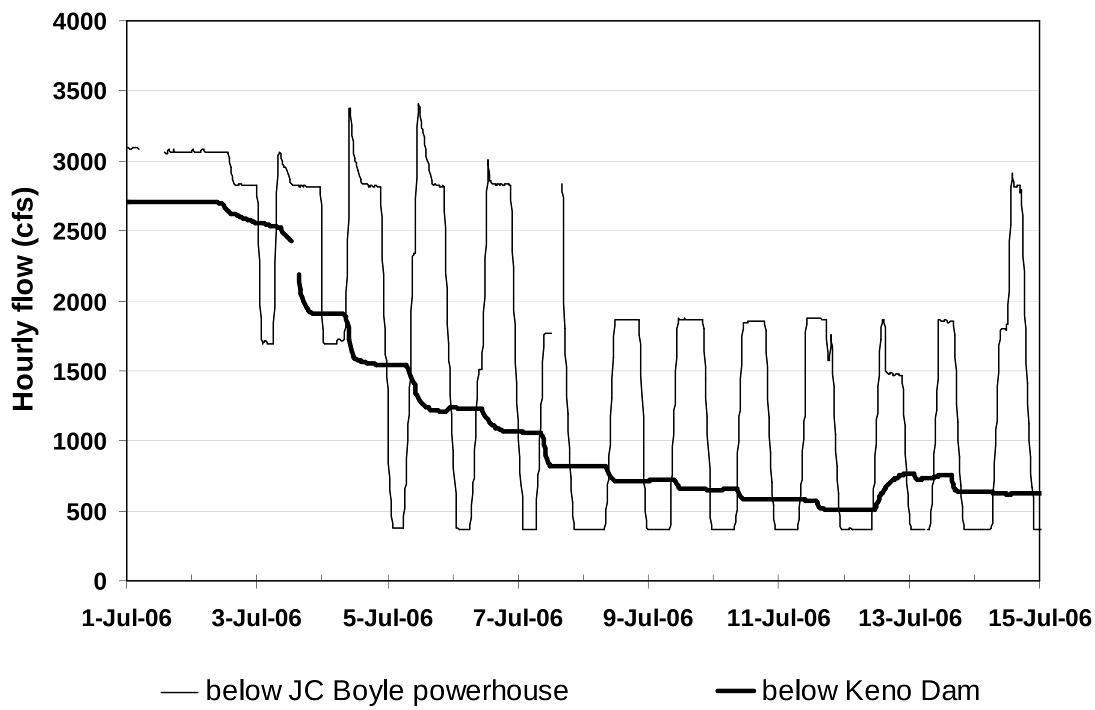

Figure 2. Hourly flows at the USGS gauge (#11510700) below the J. C. Boyle powerhouse and at gauge #11509500 below Keno Dam during the first half of July, 2006.

Figure 3. The site on the Klamath River near Frain Ranch where stranding was observed on July 5 and 7, 2006. Klamath River flow was 375 cfs below the JCB powerhouse (several miles upstream from this site) when this picture was taken.

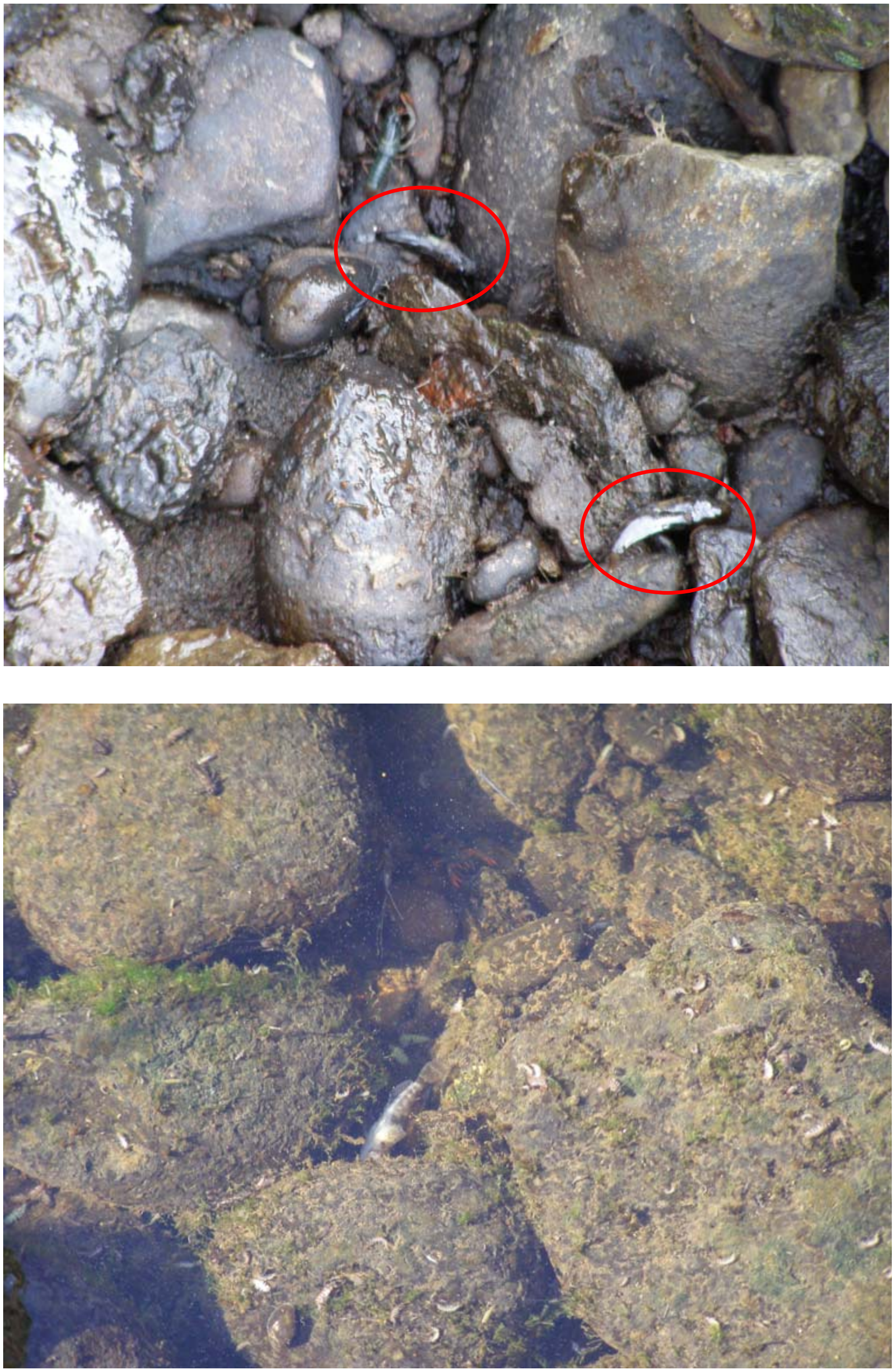

Figure 4. Dead sculpins at the Frain Ranch site on the Klamath River, July 5, 2006.

Figure 5. Dead suckers at the Frain Ranch site on the Klamath River, July 5, 2006.

Figure 6. Live larval suckers and minnows stranded in a puddle (about 4 in^2 surface area) at the Frain Ranch site on the Klamath River, July 5, 2006.

Figure 7. Dead fish and aquatic insects at the Frain Ranch site on the Klamath River, July 5, 2006. Hydropsychid caddisfly larvae were most common, though many stoneflies and mayflies were present as well. An area about 3 ft^2 is in view in the lower photo (scaled by assuming the hydropsychids to be about 0.5 in long), and more than 300 dead insects are clearly in view, so there were in excess of 100 dead insects per ft^2 at this location.

Figure 8. Dead and stranded crayfish and aquatic insects at the Frain Ranch site on the Klamath River, July 5, 2006. Adult crayfish in the top photo are dead, as is the juvenile crayfish centered in the bottom photo, but the other juvenile crayfish was still living.

Figure 9. The Frain Ranch site on the Klamath River at the top of a two-turbine peaking cycle (top photo), with a flow of about 2,840 cfs at 1800 hrs on July 6, 2006, contrasted with about 370 cfs the next morning at 0700 hrs (bottom photo).

Figure 10. The exposed shelf at the Frain Ranch site on the Klamath River as it looked at dawn on July 7, 2006.

Figure 11. The Frain Ranch site on the Klamath River on the morning of July 7, 2006. Dead insects were much less common than on July 5.

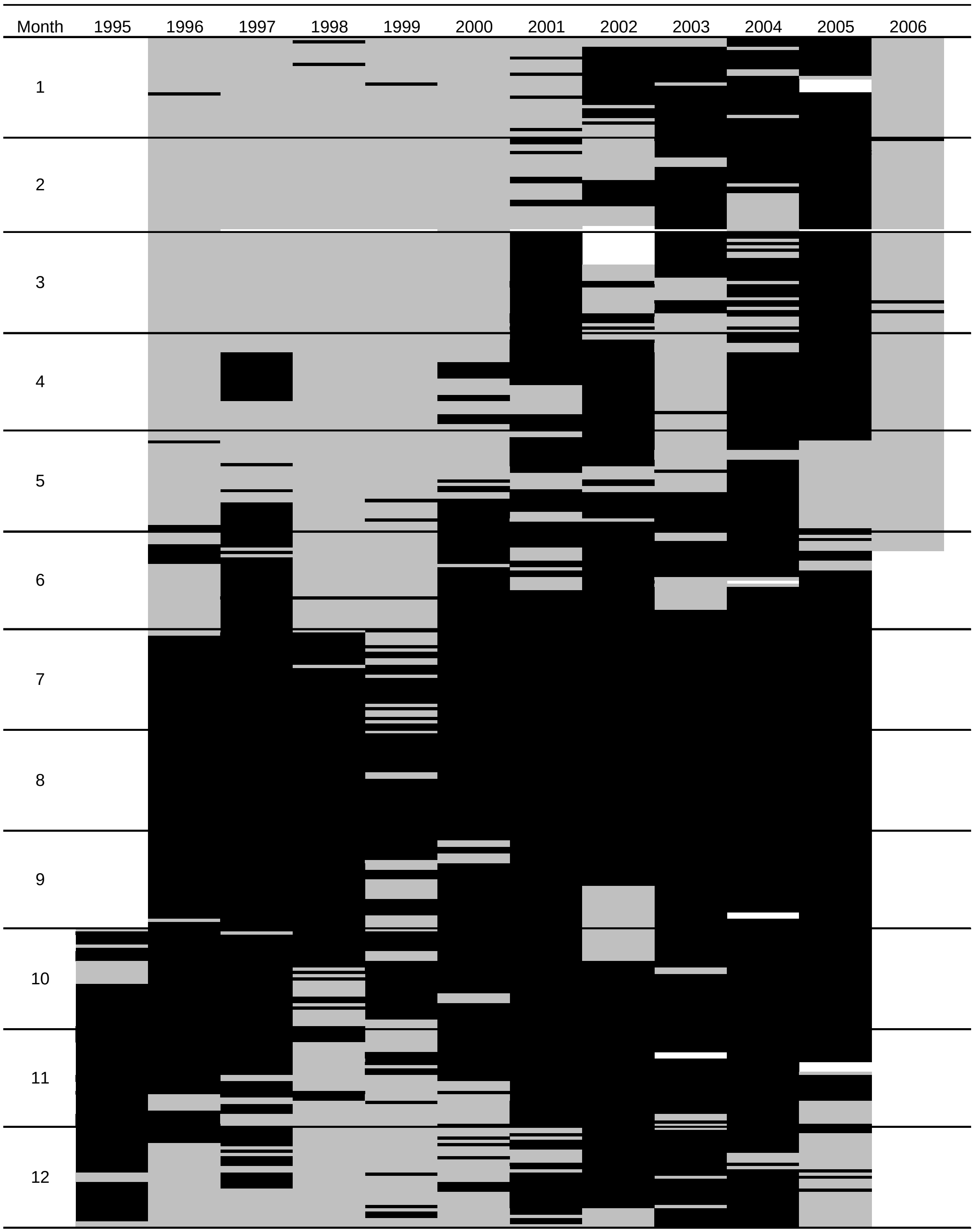

Figure 12. Frequency of two turbine peaking below the JC Boyle powerhouse. Each day in a year is colored white (no data), grey (minimum daily flow ≥500 cfs), or black (minimum daily flow <500 cfs). Two turbine peaking cycles generally reduce river flows to less than 500 cfs, so the black shaded areas approximate the incidence of two turbine peaking cycles. Grey areas denote either single turbine peaking cycles, steady flow through the turbines, or periods of spill.