Instream Flow Compliance of the Klamath River

By, Sarah Adler

Abstract

For nearly a century, the Iron Gate, Copco 1, Copco 2, and J.C. Boyle Dams have disrupted life in the Klamath River Basin. Altered flows, disconnected habitat, and impaired water quality have dramatically reduced native fish populations sacred for Native American traditions. Removal of the four dams, a priority of Native American tribes and environmental groups for decades, is set to begin in 2023. It will be the largest dam removal project in the country and marks a pivotal moment in the effort to restore the Klamath River. The objective of this paper is to determine whether the Klamath River is meeting instream flow water demand, the flow needed to sustain ecological function, in a pre-dam removal state. Functional flow metric data of the Klamath River above the Iron Gate Dam was obtained from the California Natural Flows Database to calculate the functional flow regime and recommended instream flows of the Klamath River. The instream flow water demands were then compared to observed flow data from the USGS to determine instream flow compliance. The results indicate that the Klamath River is meeting instream flow water demands 77% of the time and is susceptible to large fluctuations in flow. While further research is needed to determine the water quality and cultural impacts of the dams, it can be inferred that the hydroelectric dams do not significantly impair the flow volume of the Klamath River.

Introduction

The Klamath River Basin has a long history of complex water management issues. Flowing from Oregon to the Pacific Ocean, the 263 mile long river is the ancestral home of the Yurok, Karuk, Klamath, Shasta, and Hoopa Tribes. For thousands of years, the tribes lived and fished in the basin, but life for the tribes changed when the federal government claimed the undisturbed land. The basin's hydrology was forever altered when the Klamath Project began in 1906. Wetlands were drained and water was routed from the Upper Klamath Lake to irrigate more than 200,000 acres of farmland (Kirkpatrick et al. 2021). The 1900s also saw the construction of multiple hydroelectric dams including Iron Gate, Copco No. 1, Copco No. 2, and J.C. Boyle that prevent anadromous fish populations such as salmon from over 300 miles of spawning and rearing habitat in the upper basin. Additionally, unrestricted grazing in the upper basin increases nutrient levels and favorable conditions for harmful algal blooms and large fish kills. The dams in addition to agricultural activity contribute to a multitude of ecological and cultural challenges such as the loss of salmon as a sacred resource (Glenwright 2022).

After decades of negotiations, removal of the Iron Gate, Copco 1, Copco 2, and J.C. Boyle dams are expected to begin in 2023. Despite competing interests in the basin, over 40 different water users in the Klamath River Basin including irrigation districts, organizations, and tribes support the decommissioning of the four dams. In 2016, the Klamath River Renewal Corporation was formed to oversee the dam removal process and obtain partial ownership of the dams from PacifiCorp. This dam removal project will be the largest in the country as well as a step closer to restoring the health of the Klamath River and providing social justice to the Yurok, Karuk, Klamath, Shasta, and Hoopa Tribes (Glenwright 2022).

Objectives

The objective of this paper is to determine whether the Klamath River is meeting instream flow water demands with the hydroelectric dams in place. Hydroelectric dams continuously release water downstream and do not store a significant quantity of water, so it is likely that the Klamath River is compliant with instream flow water demand. The final products consist of the functional flow regime graph, recommended instream flows table, and graph of instream flow compliance.

Literature Review

The Klamath River Basin encompasses 12,000 square miles in the northernmost corner of California and extends up into Crater Lake National Park, Oregon. The Upper Klamath Basin, located along the Oregon-California border, is characterized by 4,000 to 6,000 foot high plateaus and lies in the rain shadow of the Cascades making it an arid, high desert area. Despite poor growing conditions and limited water availability, the majority of irrigated lands of the federal Klamath Project is located in this region. The Klamath Project, developed by the United States Bureau of Reclamation, began in the early 1900s to provide farmers with irrigated water primarily from the Upper Klamath Lake and Klamath River (Doremus and Tarlock 2008).

The Klamath Project and the Klamath River Hydroelectric Project have greatly altered life in the Klamath River Basin. The Klamath River Hydroelectric Project consists of multiple hydroelectric dams constructed on the mainstem Klamath River from 1903 to 1962. There are three mainstem dams located in California (Iron Gate, Copco No.1, and Copco No. 2) and two mainstem dams (J.C. Boyle and Keno) located in Oregon as well as two power generation facilities. The dams are owned and operated by the energy company PacifiCorp, and were constructed to supplement the agricultural activity of the Klamath Project. Since their construction, the dams have caused environmental damage that threaten the traditions of the Yurok, Karuk, Klamath, Shasta, and Hoopa Tribes. The dams impair coastal fisheries and historic tribal fisheries by preventing salmon and steelhead from reaching hundreds of miles of habitat in the Upper Basin (Doremus and Tarlock 2008). Reduced flows and agricultural runoff have caused shifts in water temperatures, retention of total phosphorus and nitrogen creating algae blooms, elevated pH, and variable dissolved oxygen levels that do not meet California North Coast Basin Plan water quality objectives and adversely affect beneficial uses (FERC 2022).

Devastating events such as large fish kills have sparked the movement to decommission J.C. Boyle, Copco No. 1, Copco No. 2, and Iron Gate referred to as the Lower Klamath Project. A central component of the decommissioning is the transfer of PacifiCorp's hydropower license to the Klamath River Renewal Corporation (KRRC), State of California, and State of Oregon (FERC 2022). Under the Federal Power Act, the Federal Energy Regulatory Commission (FERC) is required to consider fish and wildlife, recreation, and other environmental concerns equally to power production and development in hydropower relicensing agreements. As a result, fish populations, water quality, tribal water needs, and environmental water needs all have relevance in relicensing decisions (Doremus and Tarlock 2008). FERC approved the transfer of PacifiCorp's federal license of the dams to the KRRC, the State of California, and the State of Oregon in 2021 (FERC 2022).

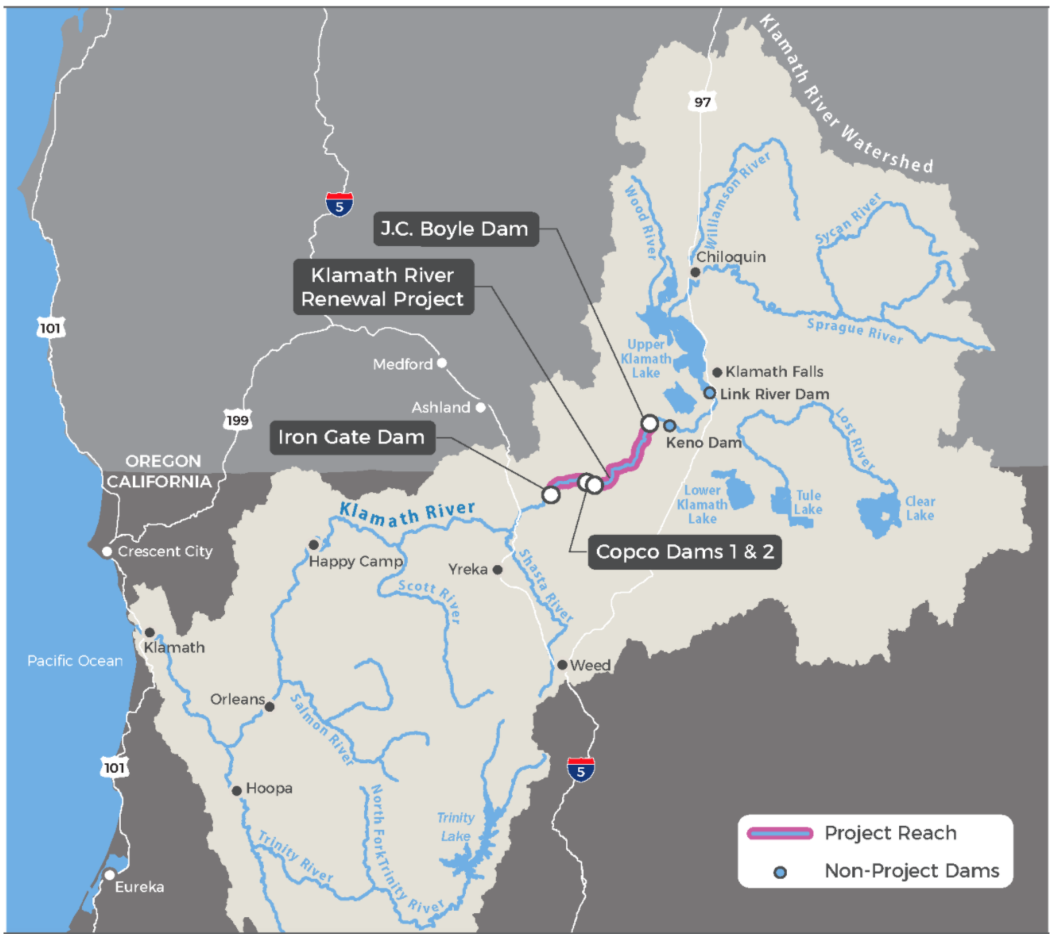

Figure 1: Scope of Dam Removal Project in the Klamath River Watershed (KRRC, 2021)

The KRRC will oversee the dam removal project (see Figure 1) that is set to begin in 2023 pending FERC's approval of the Final Environmental Impact Statement. KRRC, a nonprofit organization, formed in 2016 as part of the amended Klamath Hydroelectric Settlement Agreement (KHSA) to restore the Klamath River and oversee the dam removal project. KRRC was appointed to this role by the State of California, State of Oregon, local governments, Tribal Nations, PacifiCorp, irrigators, and several conservation groups (KRRC 2021).

Decommissioning of the dams and associated power generating facilities will have long term beneficial effects for the Klamath River Basin. It will restore the natural geomorphology and the natural thermal regime of the river. Transforming the river back to free-flowing river conditions will help to restore cultural traditions and improve water quality by reducing conditions that trigger large algal blooms (FERC 2022).

Methods

To begin my analysis, I downloaded functional flow metric data of the Klamath River right above the Iron Gate Dam through the California Natural Flows Database. I then created a reference hydrograph to determine the functional flow regime. Next, I identified and analyzed the functional flow components (i.e., dry-season low flow, wet season base flow, spring recession flow, fall pulse flow, and peak magnitude flows) of the functional flow regime. I created a recommended instream flows table and compared those values to the average annual streamflow to determine how large or small the recommended instream flows are in comparison to the natural flow. At this point, I realized the data was skewed to the right and caused inconsistencies in the recommended instream flows (i.e., recommended instream flows were 141% of the average flows on wet years). Next, I compared the instream flow water demand to observed daily flow data at Iron Gate Dam from the USGS to determine the instream flow compliance of the Klamath River.

Results

The functional flow regime of the Klamath River (see Figure 2) in wet years indicates that the Klamath River is susceptible to large fluctuations in flows. The flow volume jumps significantly to about 5,000 cfs around day 150 to day 250 and peaks at about 32,000 cfs, which skews the distribution of the data to the right. The Klamath River is, thus, a very "flashy" river. Figure 2 also displays the functional flow components essential for maintaining ecosystem function. The functional flows support the ecology, geomorphology, water quality, connectivity, and overall health of the river ecosystem. The dry-season baseflow, for example, occurs approximately from day 250 to day 150 supports native species and reduces competition with invasive species by inhibiting their ability to survive under dry-season conditions. The wet-season baseflow occurs approximately from day 150 to day 250. The spring recession baseflow occurs from day 240 to day 300, the fall pulse flow occurs on day 45, and the peak magnitude flow occurs close to day 190. These functional flow components vary seasonally and are important for maintaining a functioning ecosystem that supports the health of the entire Klamath River ecosystem.

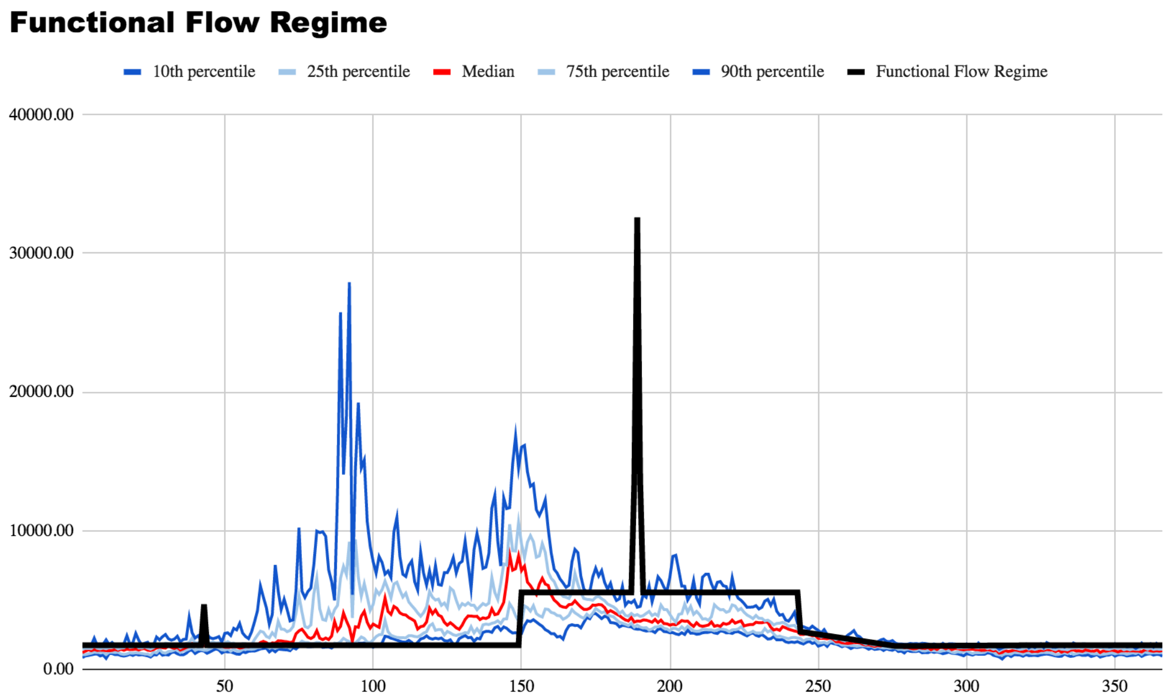

Figure 2: Functional Flow Regime (Wet Year)

The recommended instream flows table (see Figure 3) displays the monthly and annual recommended flows for the Klamath River in all, dry, moderate, and wet years in thousand acre-feet. Comparing the recommended instream flow values to the average flows (reference values) shows the percentage of the average flow the Klamath River needs to sustain aquatic life and ecosystem function. For instance, the Klamath River needs 77% of the average flow conditions in moderate water years to sustain ecosystem function. However, during wet years the table shows that the Klamath River needs 141% of the average flows. This value is a result of the skewed data and does not indicate that the water is not meeting instream flows. Instead, we can infer that the significant variation in flows is altering the instream flow calculation.

	Recommended Instream Flows														
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual	Reference Values	
All	43.1	47.7	43.1	43.1	62.4	164.2	267.0	165.0	135.7	83.2	47.2	41.7	1143.4	1484.8	77%
Dry	27.4	30.1	27.4	27.4	41.3	78.7	195.3	87.4	130.9	80.0	35.2	26.5	787.5	1092.9	53%
Moderate	50.3	42.8	44.3	44.3	63.2	272.3	158.9	166.0	134.5	83.2	47.8	42.8	1150.3	1361.8	77%
Wet	107.0	109.4	107.0	107.0	119.3	426.5	330.2	335.6	132.2	105.0	106.8	103.5	2089.6	1971.9	141%

Figure 3: Recommended Instream Flows

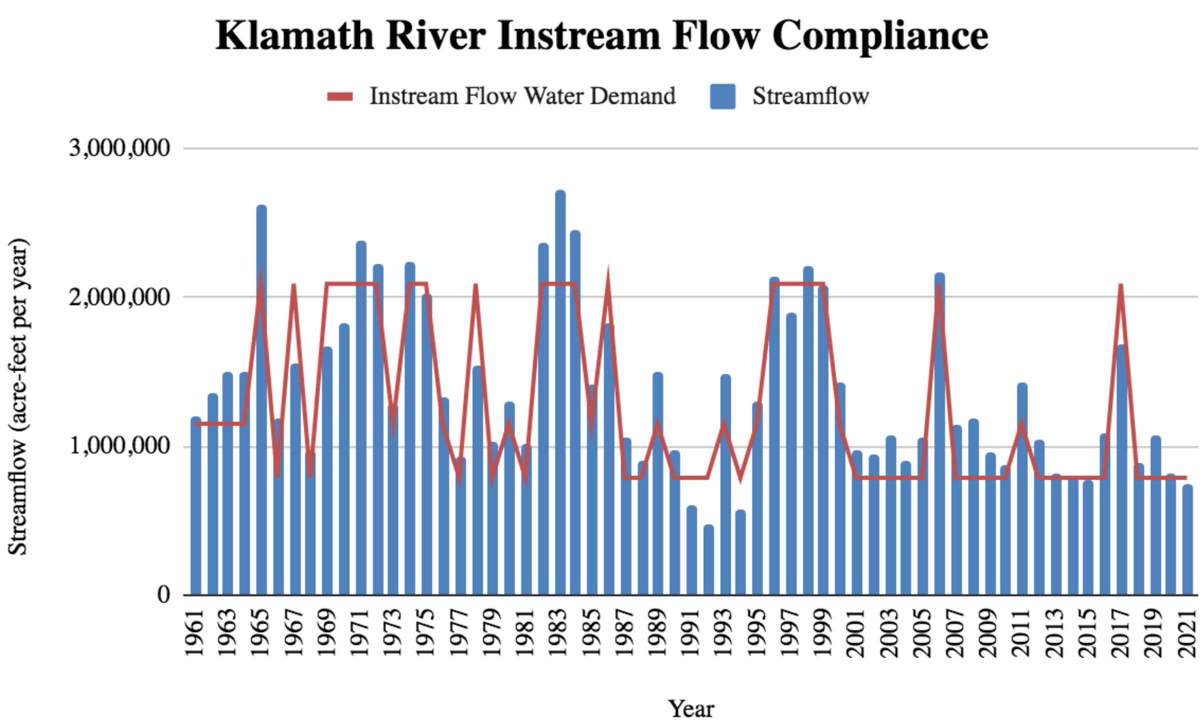

Figure 4: Klamath River Instream Flow Compliance

Next, the annual instream flow water demand was compared to the annual observed streamflow of the Klamath River from 1961 to 2021. If the instream flow water demands were less than or equal to the Klamath River streamflow, then the recommended instream flow requirements were not met. This calculation did not take into account municipal and rural return flow. The results show that the streamflow is meeting recommended instream flows 77% of the time (see Figure 4). However, due to the skewed data, the instream flow of wet years is higher than expected making it likely that the Klamath River is meeting instream flow demand more often. The recommended instream flows and compliance would thus be more accurate by gathering data from other segments of the Klamath River.

Conclusion

This paper quantified the recommended instream flows and determined instream flow compliance of the Klamath River. Despite skewed data that altered the instream flow calculations of the Klamath River in wet years, the Klamath River is meeting instream flow water demand 77% of the time. Thus, it is reasonable to infer that the hydroelectric dams do not significantly impair flow volume. However, instream flow compliance is only one component of the overall health of the Klamath. Restoring the Klamath River to free flowing conditions is expected to improve the connectivity of the river and provide cultural, ecological, and economic benefits to the Klamath River Watershed. Thus, future studies should be done in coordination with Native

American tribes to understand the benefits of the dam removal in restoring the connectivity of the Klamath River and the associated cultural, water quality, and ecological benefits.

References

Doremus, H., & Tarlock, A. D. (2008). Water war in the Klamath Basin: macho law, combat biology, and dirty politics.

Glenwright, K. (2022). *Dams Out Story Map*. California Trout. https://storymaps.arcgis.com/stories/74521a2b427b4578909956a7b14d82cb

Federal Energy Regulatory Commission (FERC). (2022). *Draft Environmental Impact Statement For Hydropower License Surrender and Decommissioning*. https://klamathrenewal.org/wp-content/uploads/2022/02/20220225-3040_P-14803-001-2082-063-Lower-Klamath-Surrender-DEIS.pdf

Klamath River Renewal Corporation (KRRC). (2021). *Klamath River Renewal Project: A Cooperative Effort to Revitalize the Klamath River.* https://klamathrenewal.org/wp-content/uploads/2021/03/Klamath_Brochure_March2021.pdf

Kirkpatrick, K., Karklis, L., Cornsilk, J., Trinca, M., Li, A. (2021). *Climate Change Fuels a Water Rights Conflict Built on Over a Century of Broken Promises*. Washington Post. https://www.washingtonpost.com/nation/interactive/2021/klamath-river-basin-drought/