Lower Klamath River
Adult Chinook Salmon Pathology Monitoring, 2022
Technical Memorandum

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Barry W. McCovey Jr
Leanne Knutson

Yurok Tribe Fisheries Department
Klamath River Program
HC 67, Box 196
Hoopa, CA 95546

Photo: Chinook salmon with severe columnaris infection (YTFD photo).

INTRODUCTION

Since the fall of 2003, the Yurok Tribal Fisheries Department (YTFD) has monitored for the prevalence of *Flavobacterium columnare* (columnaris) and *Ichthyophthirius multifiliis* (Ich) in fall-run Chinook salmon in the lower Klamath River. Columnaris is a bacterium that affects the skin and gills of many fishes; it is distributed throughout the world and is believed to be native to the Klamath River (Guillen, 2003). In general, healthy fish are resistant to columnaris (Shotts and Starliper, 1999), however infections can develop due to environmental stress, minor injuries to the skin or gills, or the presence of other pathogens. Environmental stress can include overcrowding, handling stress, low dissolved oxygen, high temperatures, toxins, and high organic loads (Thune, 1993). Columnaris is usually secondary to other pathogens, which can include ich (Plumb, 1999). Ich is a fresh-water ciliated protozoan parasite found throughout the world and is also believed to be native to the Klamath River. Ich infections cause damage to the skin and gills of numerous fish species, including salmonids. Outbreaks of ich occur when conditions are favorable for rapid reproduction of the parasite, which moves horizontally from fish to fish. These conditions arise in rivers with the combination of a suitable environment and susceptible fish. Suitable environmental conditions occur when flows are relatively low (slow velocities and low turnover rates), which is worsened if water temperatures are elevated, and fish become susceptible when they are stressed and congregating in high densities (Dickerson and Dawe, 1995; Bodensteiner, 2000). High water temperatures are not necessary for an Ich outbreak however, as significant ich mortality has occurred in British Columbia in low flow spawning channels at 13 to 15ºC (Traxler et al., 1998). High water temperatures favor outbreaks, but alone do not trigger them. For example, Klamath River water temperatures have been favorable for columnaris and Ich outbreaks in past decades, but the only year an Ich outbreak was observed was in 2002 (Belchik et al., 2004).

The YTFD began monitoring ich and columnaris levels in response to the 2002 Klamath River fish kill, which resulted in the death of 33,000 to 67,000 adult Chinook salmon. The primary cause of the Klamath River fish kill was an epizootic outbreak caused by Ich and columnaris (Foott, 2002; Turek et al., 2004). Factors such as extremely low flows, high fish densities, elevated water temperatures, and long fish residence time are believed to be the main contributing factors to the epizootic outbreak of 2002 (Guillen, 2003; Belchik et al., 2004; Turek et al., 2004). Elevated water temperatures, high fish densities, and long fish residence times occur on an annual basis without producing Ich epizootic outbreaks, thus prudent flow management is of paramount importance in controlling the risk of fish kills such as the one that occurred in 2002 (Strange, 2007, 2010).

In 2003 and 2004 the YTFD, (with additional samples collected by the USFWS Arcata Fish and Wildlife Office and the Karuk Department of Natural Resources in those years only) quantified the incidence and severity of ich and columnaris infections in fall-run Chinook salmon during the late summer and early fall. The purpose was to detect any significant increases in the prevalence or severity of Ich or columnaris infections. If a significant increase was observed, emergency options to prevent or reduce disease

mortality would be discussed by river managers and fish biologists (YTFD, 2004; 2005a). In addition to potential emergency options, a pulse flow was released from Trinity Dam during those years coinciding with peak entry timing of fall-run Chinook salmon in the lower Klamath River in order to reduce the risk of a repeat of the 2002 fish kill. The effects of these pulse flows on migrating adult chinook salmon as determined by biotelemetry is discussed by Strange (2003, 2006, and 2007), including implications for Ich transmission and disease risk. No epizootic fish kills have occurred among fall-run Chinook salmon in the lower Klamath River since 2002, and ich infections have only rarely been documented and at extremely low severity (YTFD, 2005, 2007; YTFD unpublished data).

Beginning in 2005, the focus of YTFD adult Chinook salmon pathology monitoring effort has been to collect baseline data on background levels of ch and columnaris (YTFD, 2005) and to monitor the health of the fall run in real time. Ultimately, we intend to develop a long-term data set, inclusive of a wide variety of water year types, meteorological conditions, and Chinook salmon run sizes, in order to evaluate the relationship between environmental variables, fish variables, and infection levels. Such information would be especially valuable in the unfortunate event of a future epizootic outbreak among adult salmonids in the Klamath River. The real time data collected on fish health is also very important. This information is used by river managers to determine whether actions need to be taken should a fish kill occur or be imminent.

Durig the 2017 sampling year there was no allowable catch for the YTFD to harvest and sample. This was because the predicted returns were at a record low of 11,000 fish. The Pacific Fisheries Management Council set the Yurok Tribes allocation at 650 fish. The lack of numbers closed down the commercial fishery and shut down subsistence fishery and any scientific collection that the YTFD had planned. Because of this, YTFD decided to change the techniques used to collect ich data for the 2017 season. We sampled water for ich DNA at rkm 26 near the Blue Creek confluence. This method has been proven by Oregon State University researchers to be a valid technique to ascertain the amount of Ich DNA in collected water samples (Claire Howell Pers. Comm.). YTFD plans on using this technique as a monitoring tool in the future to develop a baseline of Ich prevalence in the lower Klamath River. In 2018-2021, YTFD was able to resume Ich monitoring due to a significantly larger salmon run compared to the 2017 season.

In 2022, the Chinook salmon run size was large enough to sample fish in the Klamath basin. YTFD was able to collect specimens in real time and examine gills and external body for ich and columnaris prevalence. Additionally, YTFD continued to collect Blue Creek water samples to strengthen the baseline of Ich prevalence in the lower Klamath River.

This technical memorandum summarizes our findings during the late summer and early fall of 2022 in regards to our ongoing ich and columnaris monitoring in adult fall-run Chinook salmon.

Objectives:

1. Quantify the prevalence of columnaris and ich infections among adult fall-run Chinook salmon in the lower Klamath River.
2. Quantify the severity of any Ich infections among adult fall-run Chinook salmon in the lower Klamath River.
3. Develop a long-term data set for future analysis of the relationship between infection levels, environmental conditions, and fish variables.
4. Provide the ability for a real-time, early warning of impending epizootic outbreaks.

METHODS

YTFD field personnel began sampling adult Chinook salmon for pathogens on August 2nd, 2022. This survey concluded on September 29th, 2022. Sampling was conducted in the mainstem Klamath River at four sites: 1) rkm 26, Blue Creek mouth, 2) rkm 38, Tectah Creek 3)rkm 70, below the Yurok Tribal office (Figure 1). YTFD set and drifted monofilament gillnets, which were 40' to 100' in length, 12' deep, and had a 7 ¼" mesh size. Drift sets were conducted by setting a net perpendicular to the thalweg of the river, and allowing it to float downstream with the current. Samplers drifted next to the net in a jet boat to ensure it was positioned correctly or did not get tangled. Nets were drifted downstream in the current for approximately 450'- 500'. Stationary sets were typically deployed in the upstream terminus of eddies. The float line was secured to the bank and the net was stretched at an angle to the flow of the river. Stationary sets were left for two to seven hours per day. Field crews attended nets for the entire duration of the set, checking them every 30 to 60 minutes, or whenever a salmon appeared to be entangled. Sampling took place in the afternoon at Blue Creek and late afternoon through midnight for the other sites.

Upon capture, live or recently expired adult Chinook salmon were examined externally with the unaided eye for evidence of ich or columnaris infection and general body condition. Samplers then removed the outside gill arch from the left and right sides and placed them in clear ziplock plastic bags for examination. Gill arch samples were examined immediately, typically within five minutes of removal. Each gill arch was examined using a 40X dissecting scope and using a consistent search pattern. Any ich trophozites observed on the gill tissue samples were enumerated and recorded. Any gill arches containing Ich trophozites were imprinted on a microscope slide for later examination in the laboratory. Columnaris infections were also noted during the microscope examination. We used a severity index of one through three to document the level of columnaris infection. One was considered minor, two was considered moderate, and three was called severe.

Beginning June 16th, 2022, YTFD field personnel began water sampling at Blue Creek confluence for *Ichthyophthirius multifiliis* environmental DNA. This survey concluded on October 5th, 2022 (Table 1). Once a week, YTFD personnel sampled in the mainstem Klamath River near rkm 26, Blue Creek confluence pool (Figure 3). The two sampling sites included one that was 150 feet upstream of the Blue Creek confluence (B3) and one that was 1000 feet downriver of the Blue Creek confluence (B1). Each site had four 1000ml samples taken. Samples went directly on ice and filtered within 24 hours. Filtering methods included a cleaning run through the filter machine with purified water. Filters used were MF membrane filters 5.0 µm SMWP nitrocellulose membrane from Merck Millipore LTD. Using forceps, filters were removed from their packaging and placed on the Welch Rietschie Thomas filtering machine (model number 2522B-01 115V 3.9A motor number M600108C). Using a laboratory grade graduated cylinder, a 1000 ml sample was measured to the meniscus line. Samples were placed in the filtering cup and vacuumed through the filter, leaving the particles in the water on the filter paper. After folding the filter papers four times using forceps, samples were placed in 2 ml plastic vials. Using ethyl alcohol as a preservative, three drops were added to the sample and placed in the freezer. The water filtering machine was cleaned and flushed after each sample and after filtering samples was completed using 1000 ml of purified water. All parts of the machine were allowed to air dry.

We calculated the mean daily river discharge for the study period based on measurement data records from the U.S. Geological Survey (USGS). Records were obtained from the gauge on the Klamath River near Klamath, CA (USGS 11530500), which is located at rkm 13 (13 river kilometers downstream from our sample locations) (Figure 4). These records were provisional for 2021 and subject to minor change; however, they provide a reasonable estimate of Klamath River discharge in a timely manner.

RESULTS

From August 2022 to September 2022, YTFD personnel sampled on 30 separate occasions for ich and columnaris prevalence in Chinook salmon on the Klamath River. Weekly sample sizes ranged from 1 to 40 adult Chinook salmon. The first fish was collected on August 2nd and the last fish was collected on September 29th, 2022.

One hundred and seventy two fish were collected for the adult salmonid health monitoring study. One hundred and seventy one fish were Chinook and one fish was a coho. Fifty-six Chinook had a mild case of columnaris, nineteen had a moderate case of columnaris, and seven had a severe case of columnaris. One hundred and three fish had a mild ich infection, seventeen had moderate ich infestation (twenty trophonts on a gill arch), and four fish had a moderately severe ich (fifty or more trophonts on a gill arch). Sixty-three Chinook had both a mild case of columnaris as well as a mild case of ich. Six fish had a severe case of columnaris and a mild case of ich. One fish had moderately severe ich and mild columnaris.

YTFD is waiting for the results from the water sampling. Samples will be sent to Oregon State University (OSU) and will be analyzed as funding allows.

Klamath River mean daily discharge for the adult Chinook monitoring sampling period was measured using cubic feet per second (cfs) at Klamath, CA (rkm 13). A low flow of 2320 cfs was recorded on August 27th, 2022 and a high of 3760 cfs was recorded on September 12th, 2022 (Figure 2). Klamath River temperatures during this study averaged 21.40 °C and ranged from a high of 24.3 °C on August 3rd , to a low of 18.5 °C on September 18th, 2022(Figure 2).

Klamath River average discharge during the Blue Creek water sample period was 3815 cfs with a low flow of 2320 cfs on August 27th, and a high flow of 7310 cfs on June 16th, 2022. (Figure 4) referencing USGS site 1150500 on the Klamath River near Terwer.

Table 1: Dates when water samples were collected for the Adult Chinook salmon pathology study 2022. B1 indicates site upstream 100 feet upriver of Blue Creek confluence and B3 is downstream site located 1000 feet downriver.

Date collected and filtered	B1	B3
6/16/2022	X	X
6/23/2022	X	X
6/27/2022*		
7/7/2022	X	X
7/14/2022	X	X
7/21/2022	X	X
7/29/2022	X	X
8/2/2022	X	X
8/8/2022*		
8/17/2022	X	X
8/24/2022	X	X
9/1/2022	X	X
9/7/2022	X	X
9/13/2022	X	X
9/20/2022	X	X
9/30/2022	X	X
10/5/2022	X	X

2022 ICH Water Sampling

B1=Below creek influence

B3=Above creek influence

***Blue creek samples were not collected the week of 6/27 due to technical difficulties and the week of 8/8 due to the influx of sediment from the McKinney fire flash flood event.**

SUMMARY

Due to the conditions of the Klamath River during the 2022 season, YTFD was able to collect ich and columnaris data from freshly harvested salmonids. One hundred and seventy-one Chinook salmon and one coho salmon were collected and examined for Ich number of trophozites on the top gill raker. Thirty-four Chinook collected had no sign of ich or columnaris.

One hundred and thirty-four Chinook had low to moderate infection of either columnaris, ich, or both. Four fish had significantly more ich detections. These four fish were considered to be a moderately severe infection.

Columnaris infection observation levels had a relatively high infection rate but low severity in the 2022 season. Although summer water flow was considered below average, river temperatures stayed moderate during the hottest weeks due to smoke cover from the McKinney fire in the Klamath National Forest. Fires were active for many weeks during a crucial migration time for adult salmon. This assisted with keeping disease infection low even though there was high prevalence observed.

On August 4th, 2022, there was a flash flood event during the McKinney fire in the Klamath National Forest. This created a pulse flow event that introduced a large, currently unknown amount of fine mud sediment into the Klamath River. This caused a drop in dissolved oxygen levels within the fire zone. Due to the dangers from the active fire, Fisheries Biologists were unable to immediately access that section of the river to assess the effects. Observed effects to the Klamath River on the Yurok Reservation consisted of an increase in flow resulting in a rise with cfs and widespread silty mud throughout the lower basin. This created poor visibility and left at least a 5 mm mud film on the bottom of the river. This is still present at the time of this report.

On August 26th, 2022, Lewiston Dam on the Trinity River ordered a pulse flow release that continued until August 29th, 2022. It was a 600 cfs release. Hoopa Tribal Fisheries observed high prevalance of ich and columnaris on Chinook within the Hoopa Valley Reservation prompting action by the Bureau of Reclamation to release additional flows.

September 9th, 2022, there was an additional pulse flow event from Iron Gate Dam. This was prompted by the Yurok Tribe for the boat dance ceremony. This pulse flow reached the mouth on September 11th, 2022. Iron Gate Dam released an additional 2100 cfs during this time.

On September 18th, 2022 through September 20th, 2022, significant rain fell on the region and increased cfs throughout the Klamath and Trinity Rivers.

The 2022 pre-season fall Chinook run was estimated to be 200,100 adults in the Klamath River. The estimated run size for the 2022 season is higher than the 2021 predicted season. Total run size preseason prediction in 2021 was 62,121 Chinook salmon. Based on 2022 preseason estimates, the Yurok Tribe was allocated 7,547 fall-run Chinook

salmon for commercial and subsistence harvest. In addition, smoke from wildfires are thought to have reduced severity of disease by lowering river temperatures during peak migration times.

YTFD continued to collect water samples to show ich environmental DNA for presence of the disease. Sampling was conducted once a week from June 16th, 2022 through October 5th , 2022. Oregon State University will analyze samples as funding allows.

YTFD plans to repeat this study in 2023 and continue to build a reliable long-term data set for future analysis of the relationship between infection levels, environmental conditions, and fish variables.

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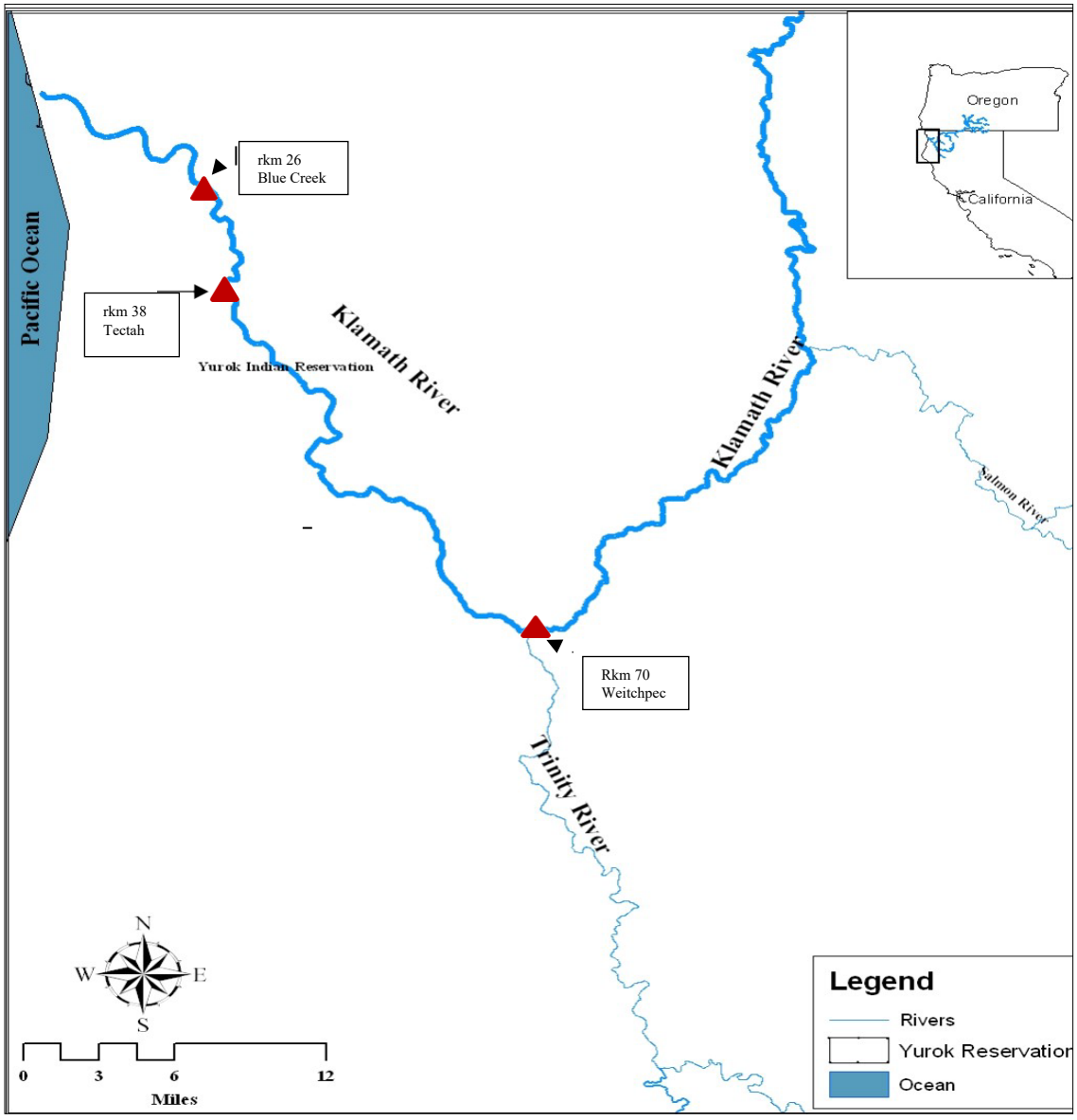

Figure 1
Map showing 2022 YTFD adult Chinook salmon pathology study area and sampling sites for adult salmonids.

Table 1: Results of the adult fall-run adult Chinook salmon pathology monitoring effort on the lower Klamath River, California, in 2022. Ich is *Ichthyophthirius multifiliis* and Col. is *Flavobacterium columnare*

Sample week	Sample Size	Samples infected with Columnaris	Samples infected with Ich	net hours	%w/Col.	%w/Ich
8/1-8/5	1	0	0	4	0.00%	0.00%
8/8-8/12	13	3	1	16	23.08%	7.69%
8/15-8/19	22	2	13	16	9.09%	59.09%
8/22-8/26	40	25	30	20	62.5%	75.0%
8/29-9/2	28	19	24	24	67.86%	85.7%
9/5-9/9	16	10	16	12	62.5%	100%
9/12-9/16	29	12	24	26	41.38%	82.76%
9/19-9/23	7	2	6	24	28.57%	85.71%
9/26-9/30	16	9	10	24	56.25%	62.50%
Totals	172	82	124	166	47.67%	72.09%

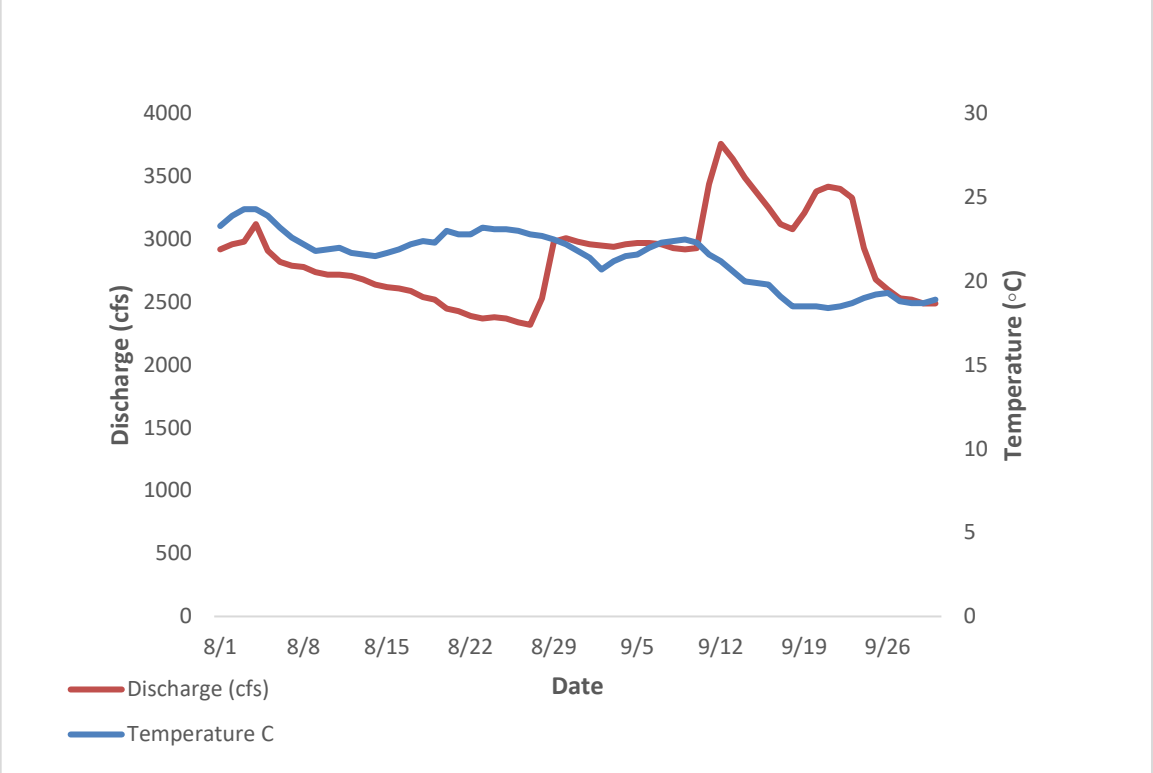

Figure 2: Mean daily discharge, measured in cubic feet per second (cfs), of the Klamath River during the adult Chinook salmon pathology monitoring sampling period, August to October 2022. Discharge was estimated on the Klamath River at rkm 13 near Klamath, CA from a USGS site 11530500 near Terwer. Also shown is mean daily Klamath River temperature was measured at rkm 13. River temperature is shown in degrees Celsius.

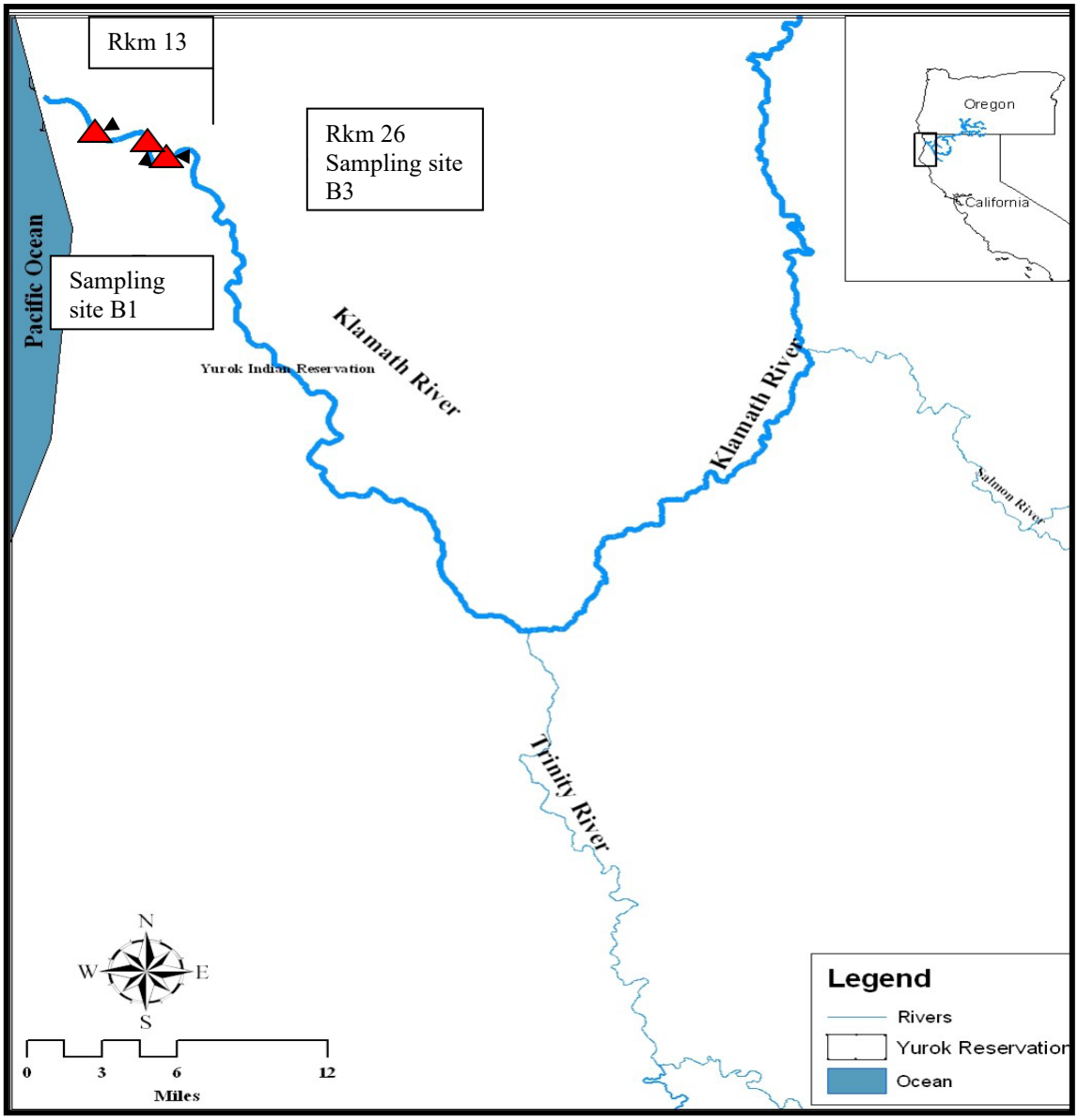

Figure 3: Map showing 2022 YTFD adult Chinook salmon pathology Blue Creek water sampling sites. Water sampling took place 150 feet above rkm's 26 (B3) and 1000 feet downriver (B1). River discharge and temperature was recorded at rkm 13.

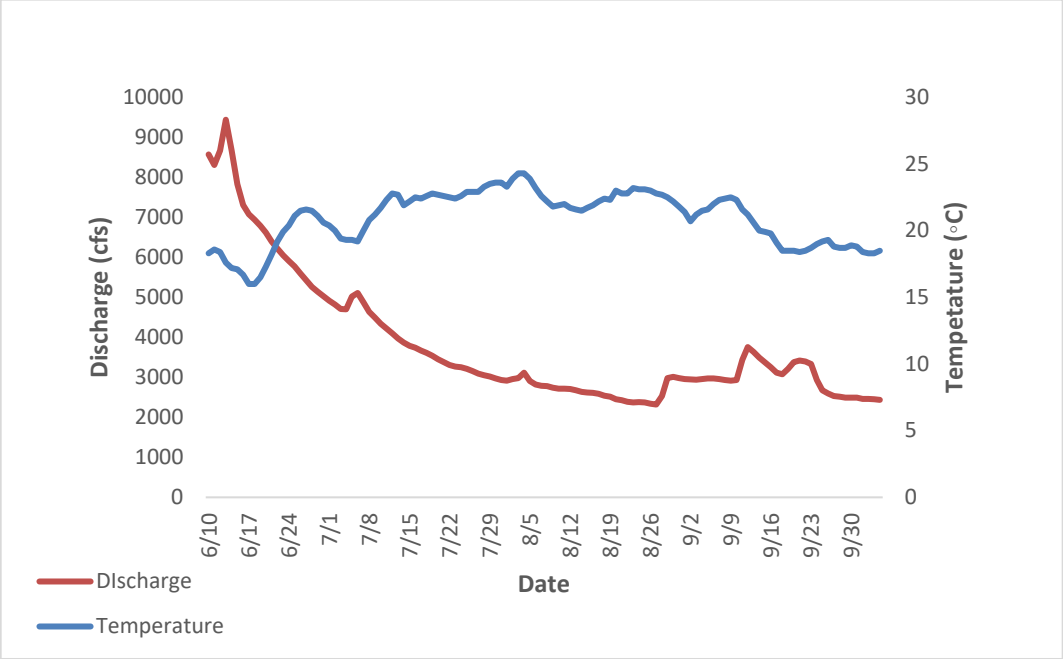

Figure 4: Mean daily discharge, measured in cubic feet per second (cfs), of the Klamath River during the water sampling at Blue Creek for the adult Chinook salmon pathology monitoring sampling period, June 2022 to October 2022. Discharge was estimated on the Klamath River at rkm 13 near Klamath, CA. Also shown is mean daily Klamath River temperature was measured at rkm 13. River temperature is shown in degrees Celsius.

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