

**Lower Klamath River
Adult Chinook Salmon Pathology Monitoring, 2007**

Final Technical Memorandum
October, 2008

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Photo credit: Michael Belchik, dead coho salmon during the 2002 fish kill.

INTRODUCTION

The Yurok Tribal Fisheries Program (YTFP) began monitoring pathogens in adult Chinook salmon in response to the September 2002 Klamath River fish kill, which resulted in the death of more than 33,000 adult Chinook salmon. Mortality of fish was caused by an epizootic outbreak of two pathogens that target gill tissue, *Ichthyophthirius multifiliis* (ich) and *Flavobacterium columnare* (columnaris), and caused death from suffocation (Foott 2002; Turek et al. 2004). Factors such as extremely low river flow, high fish densities, elevated water temperatures, and long fish residence times are believed to be the main contributing factors that led to the epizootic outbreak of 2002 (Guillen 2003; Belchik et al. 2004; Turek et al. 2004). However, elevated water temperatures, high fish densities, and long fish residence times occur on an annual basis without producing epizootic outbreaks, in particular for ich. Therefore ensuring adequate summer flow releases from upstream dams is of paramount importance in controlling the risk of fish kills such as occurred in 2002 (Strange 2007).

Since the fall of 2003, the YTFP has monitored for the prevalence of pathogens among fall-run Chinook salmon in the lower Klamath River with an emphasis on ich and columnaris. Columnaris is a widely distributed bacterium that affects the skin and gills of many fishes 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). Columnaris is observed among adult Chinook salmon in the Klamath River every year to some extent; where as the outbreak of ich in the lower Klamath River during 2002 was unprecedented. Ich is a freshwater ciliated protozoan parasite also found throughout the world and 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 with the combination of a suitable environment and susceptible fish. Suitable environmental conditions occur when flows are low and water temperatures are relatively elevated, and fish become susceptible when they are stressed and congregated in high densities (Dickerson and Dawe 1995). 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 15°C (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 ich outbreaks in past decades, but the only year an ich outbreak was observed was in 2002 (Belchik et al. 2004). In addition, research using controlled aquaculture experiments led to the conclusion that increasing turnover rates and water velocities are the most effective measures to prevent and stop ich outbreaks (Bodensteiner et al. 2000).

An important question relevant to the Klamath River is whether ich occurs at low to moderate levels frequently without producing mortality or if it is generally absent in years with no epizootic outbreaks. This study is helping to answer that question. Ultimately, our goal is to develop a long-term data set, inclusive of different 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.

In addition to monitoring for ich and columnaris in 2007, we also sampled gastrointestinal tissues for two myxozoan parasites, *Ceratomyxa shasta* and *Parvicapsula minibicornis*. These samples were collected as part of a collaborative, basin-wide disease study being led by Scott Foott of the USFWS CA/NV Fish Health Center (Fish Health Center) to quantify myxospore production by adult salmonids. Myxospores are the life stage of these myxozoan parasites that are released from infected fish. This technical memorandum summarizes our findings during the late summer and early fall of 2007 in regards to our ongoing ich and columnaris monitoring but does not include any results pertaining to *C. shasta* or *P. minibicornis*.

The objectives of this study were to:

1. Quantify the prevalence of ich and columnaris 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

Beginning September 4, 2007, field personnel began sampling adult Chinook salmon for pathogens. Sampling was conducted in the mainstem Klamath River at the Trinity River confluence pool (Figure 1; rkm 69.5). We set and drifted monofilament gillnets, which were 50' by 75', 12' deep, with 7 1/4" mesh size. Drift sets were conducted by setting a net perpendicular to the thalweg of the river that was allowed 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 in the current for 450' - 500' in length. 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. For the first two weeks of sampling, stationary sets were deployed at dusk and removed early in the morning with frequent net checks during the

duration of the set to remove any captured fish. Later stationary sets were initiated in the early morning hours, which seemed to result in a higher catch per unit effort.

Upon capture, live or recently expired adult Chinook salmon were examined externally with the unaided eye for evidence of 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 or stored on ice for examination within one hour of removal. Each gill arch was examined using a 40X dissecting scope with a consistent search pattern. Any ich trophozoites observed on the gill tissue samples were enumerated and recorded. Ich trophozoites are distinguishable from other similar looking benign parasites by their characteristic spinning motion resulting from their cilia.

Mean daily river discharge data for the study period was obtained from the U.S. Geological Survey (USGS). Data records were obtained from gauges on the Klamath River near Klamath, CA (USGS 11530500), below Iron Gate Dam (USGS 11516530), and on the Trinity River just below Lewiston Dam (USGS 11525500). Klamath and Trinity River temperatures were measured a short distance (less than 1 km) upstream from their confluence (Figure 1). River temperatures were measured at these sites by the YTFP.

RESULTS

From September 4 to October 12, 2007, YTFP personnel sampled 70 set net hours and 8 drifts. A total of 98 adult Chinook salmon were sampled, all of which were captured in set nets. Weekly sample sizes ranged from 4 to 24 adult Chinook salmon. During this study there were 13 cases of columnaris observed and not a single incidence of ich (Table 1). The first appearance of columnaris occurred during the third week of the study (Sept 16 – 22). The incidence of columnaris increased up to the fifth week of the study but was absent by the end of the study period (Table 1). Generally, adult Chinook salmon and their gills appeared very healthy.

Klamath River mean daily discharge for the entire sampling period was 1,127 cubic feet per second (cfs) below Iron Gate Dam and 2,895 cfs near Klamath (rkm 13) (Figure 2). Mean daily discharge for the Trinity River below Lewiston Dam was 466 cfs during the study period. Mean daily discharge on the Klamath River increased in mid-October due to the first storm event of the season (Figure 2). Klamath River temperatures during this study averaged 18.1°C and ranged from a high of 23.0°C on August 15, to a low of 13.9°C on October 12 (Figure 3). Trinity River temperatures averaged 17.5°C during this study and ranged from a high of 22.7°C on September 6, to a low of 12.8°C on October 7 (Figure 3).

SUMMARY

Our findings in 2007 were consistent with data collected in 2005 and 2006 (YTFP 2005, 2007), wherein we found no ich and moderate amounts of columnaris in the field (Figure 4). There were no secondary laboratory observations made on gill imprints, so we cannot rule out the possibility that there could have been very minor amounts of ich present during these years. However, if any ich were present, the incidence and severity were extremely low or at least some would have been observed in the field. Columnaris is readily apparent to the naked eye and easily verifiable. Columnaris infection levels have varied from year to year but generally display a pattern of maximum infections during the peak of the salmon run (Figure 4) and during periods of especially high water temperatures.

During the 2002 fish kill, the incidence and severity of ich were both extremely high based on a limited number of fish sampled by the Fish Health Center and the high amount of mortality. In 2003 we observed some ich; however, the severity was low and the incidence was moderate (YTFP unpublished data). During 2003, we also observed a slight increase in the amount of ich we encountered as the season progressed. The findings from 2003 are based on our field observations and gill imprints analyzed by the Fish Health Center. In 2004 there was only one incidence of ich observed, which was confirmed by the Fish Health Center, although there were also a number of false observations caused by field crews mistaking benign *Nanophytes* for ich. Regardless, we can confidently conclude that the incidence and severity of ich in 2004 was negligible.

In conclusion, since 2002 the amount of ich infections we have observed in adult fall-run Chinook salmon in the lower Klamath River has been negligible with the exception of 2003, which had low incidence with moderate severity and may have been due to a residual increase in ich abundance leftover from the 2002 epizootic outbreak. Summer and fall flows have also been higher in the lower Klamath River since 2002 (Figure 5). This is important because it suggests that ich among Klamath River fall-run Chinook salmon is generally absent in years with no epizootic outbreaks, which supports the conclusion of a threshold effect of river discharge with exceptionally low flows being the trigger for an epizootic fish kill such as occurred in 2002.

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TABLES AND FIGURES

Table 1. Results of the adult fall-run Chinook salmon pathology monitoring effort on the lower Klamath River, California, in 2007.

Sample Week	Sample Size	Number of Ich	Samples with Columnaris	Effort net hours	drifts
2 Sept - 8 Sept	21	0	0	18	0
9 Sept - 15 Sept	8	0	0	13	0
16 Sept - 22 Sept	23	0	1	13	2
23 Sept - 29 Sept	24	0	10	12	2
30 Sept - 6 Oct	4	0	2	3	4
7 Oct - 13 Oct	18	0	0	11	0



Figure 1. Satellite photo of 2007 YTFP adult Chinook salmon pathology study area. This photo shows the confluence of the Klamath and Trinity Rivers in Northern California (photo from Google Earth 2007).

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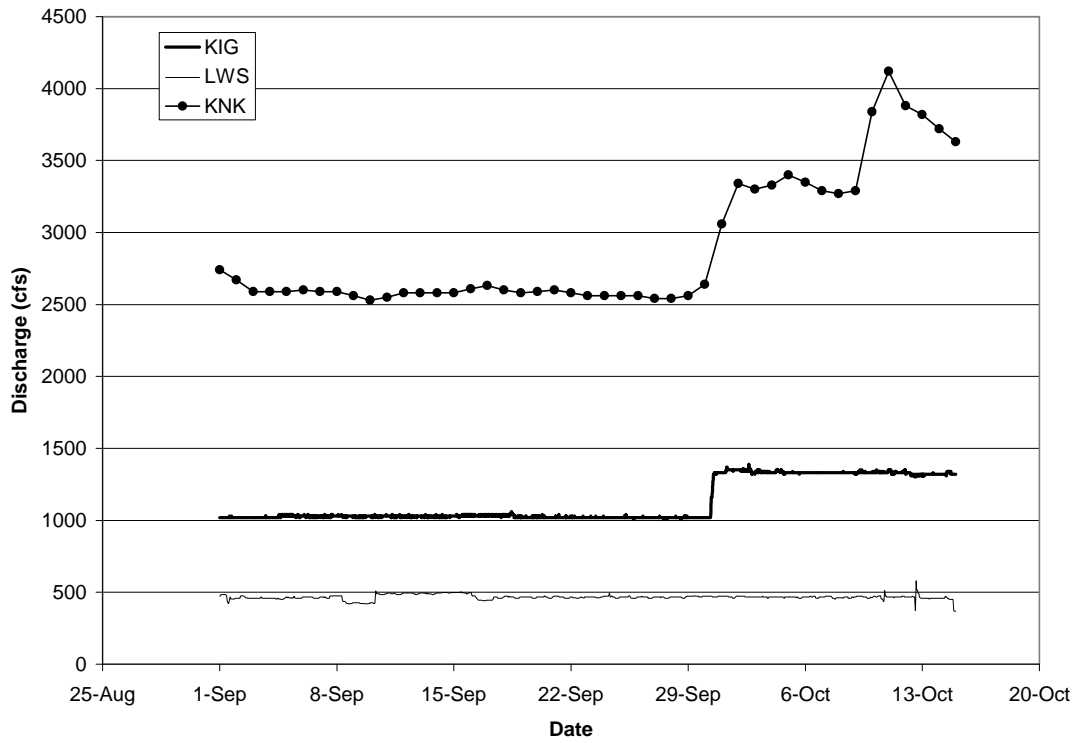


Figure 2. Mean daily discharge measured in cubic feet per second (cfs) of the Klamath and Trinity rivers during the adult Chinook salmon pathology monitoring sampling period, September to October, 2007. Discharge was estimated on the Klamath River near Iron Gate Dam (KIG), near Klamath (KNK), and on the Trinity River near Lewiston (LWS).

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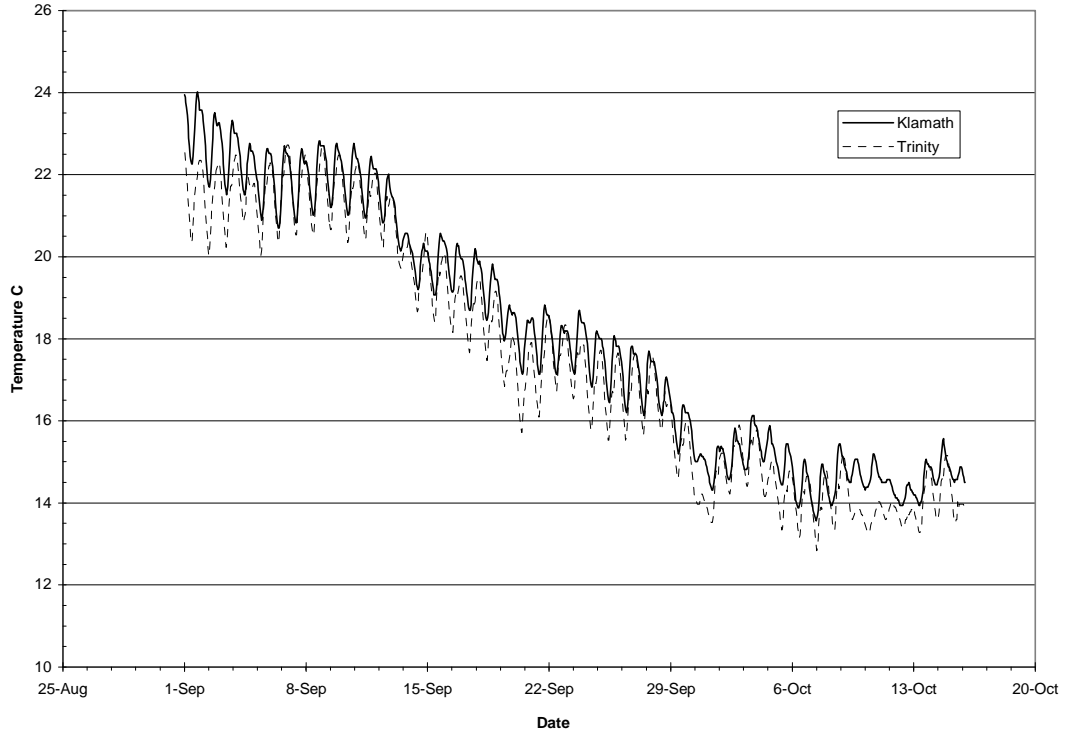


Figure 3. Klamath and Trinity River temperatures, which were recorded a short distance upstream from their confluence. These sites are within one rkm of our sampling location. Values are displayed in degrees Celsius (C) and as hourly averages. This data was recorded from September 1st, to October 15th, during the 2007 YTFP adult Chinook salmon pathology study.

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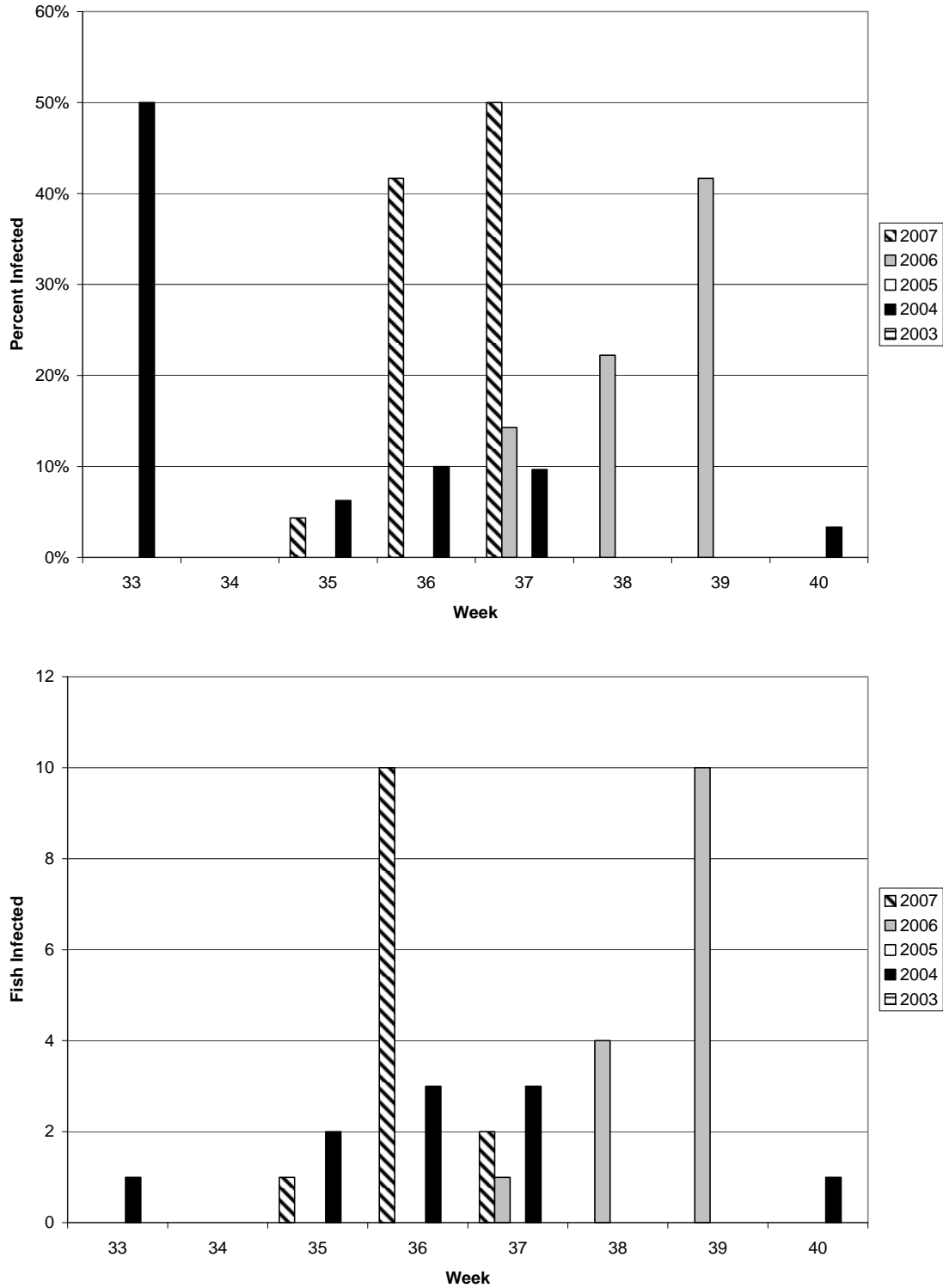


Figure 4. Top: Weekly percent of adult Chinook salmon infected with columnaris during YTFP pathology study from 2003 to 2007. Week refers to the week of the year starting from January 1st. Bottom: Weekly number of adult Chinook salmon infected with columnaris during YTFP pathology study from 2003 to 2007.

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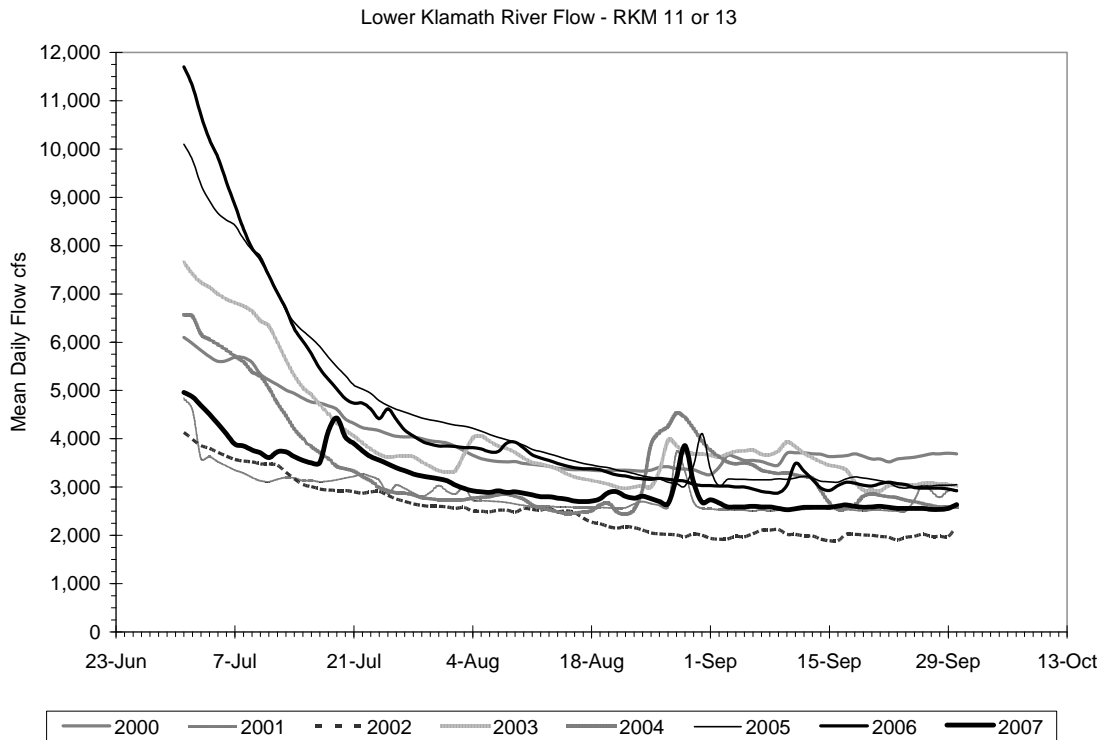


Figure 5. Summer and fall flows for the Klamath River from 2000 to 2007 (USGS).

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