Lower Klamath River
Adult Chinook Salmon Pathology Monitoring, 2008

Final Technical Memorandum
January 2009

Barry W. McCovey Jr.

Klamath River Division
Yurok Tribal Fisheries Program
Hwy. 96, Weitchpec Route, Box 196
Hoopa, CA 95546

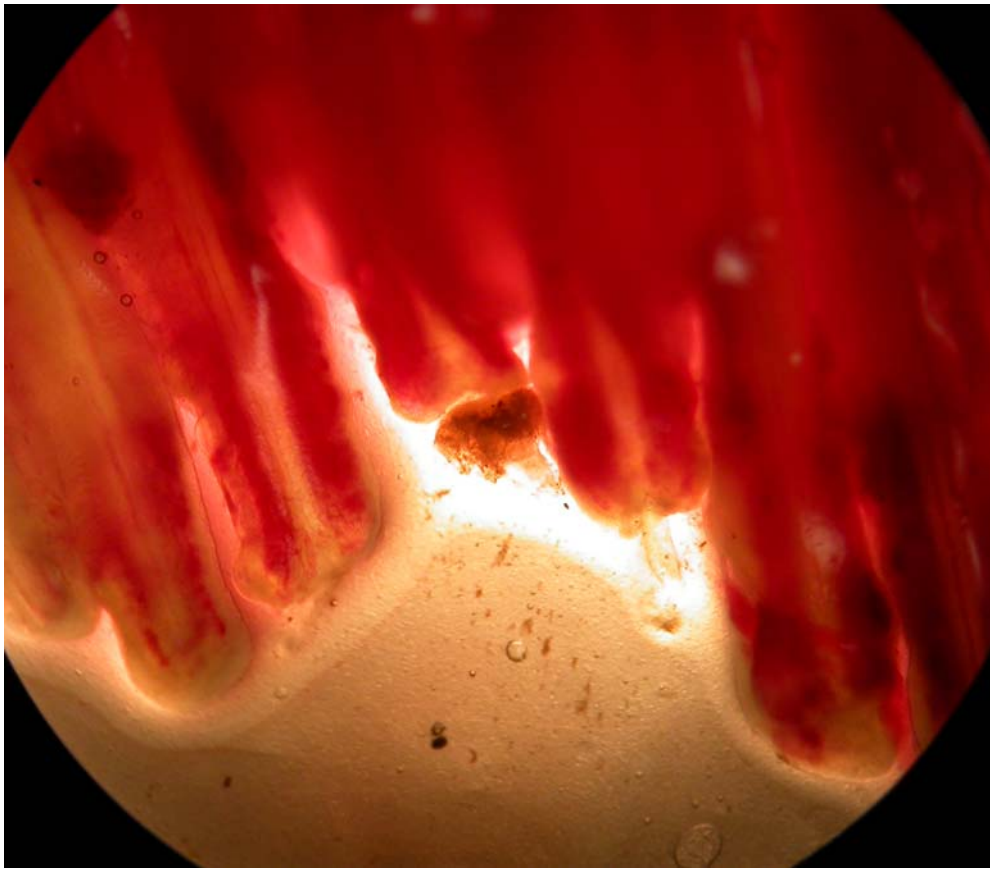


Photo: Erosion of gill filaments in a Klamath River adult Chinook salmon due to columnaris, 2008.

INTRODUCTION

Since the fall of 2003, the Yurok Tribal Fisheries Program (YTFP) 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 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 relatively 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 YTFP 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 occurred in 2002 (Strange 2007).

In 2003 and 2004 the Yurok Tribal Fisheries Program (YTFP), (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 (YTFP 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. No preventative pulse flows were released in subsequent years. 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 low severity (YTFP 2005, 2007; YTFP unpublished data).

Beginning in 2005, the focus of YTFP adult Chinook salmon pathology monitoring effort has been to collect baseline data on background levels of Ich and columnaris (YTFP 2005). An important question is whether Ich occurs at low to moderate levels or if it is largely absent in years with no epizootic outbreak. Ultimately, we intend 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.

This technical memorandum summarizes our findings during the late summer and early fall of 2008 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

Beginning September 2, 2008, field personnel began sampling adult Chinook salmon for pathogens. This survey concluded on October 8, 2008. Sampling was conducted in the mainstem Klamath River, just above the Trinity River confluence pool (Figure 1; rkm 70.5). We set and drifted monofilament gillnets, which were 50’ by 75’, 12’ deep, with 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. All sampling took place between late afternoon and midnight.

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, 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. Ich trophozites are distinguishable from other similar looking benign parasites by their characteristic spinning motion resulting from their cilia. Any gill arches containing Ich trophozites were frozen 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 infection. One was considered minor, two was considered moderate, and three was called severe.

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 Orleans, CA (USGS 11523000), which is approximately 25 river kilometers upstream of our sample location. These records were provisional for 2008 and subject to minor change; however, they provide a reasonable estimate of Klamath River discharge in a timely manner. Klamath River temperatures were measured a short distance (less than 1 km) upstream from our sampling location (Figure 1). River temperature was measured at this site by the YTFP using an Onset Hobo temperature monitor.

RESULTS

From September 2 to October 8, 2008, YTFP personnel sampled a total of 121 set net hours and 123 drifts. A total of 137 adult Chinook salmon were sampled. Weekly sample sizes ranged from 17 to 31 adult Chinook salmon. During this study there were 39 cases of columnaris observed and not a single incidence of Ich (Table 1). Columnaris was observed throughout the study period with a low of 17.6 % infected the first week and a high of 38.7 % infected the second week (Table 1). The severity of most columnaris infections was mild and did not seem to adversely affect overall fish health. Generally, adult Chinook salmon and their gills appeared very healthy.

Klamath River mean daily discharge for the entire sampling period was 1,778 cubic feet per second (cfs) at Orleans, CA (rkm 94). Mean daily discharge on the Klamath River increased at the beginning of 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 22.3˚C on September 8, to a low of 11.8˚C on October 13 (Figure 3).

SUMMARY

Our findings in 2008 were consistent with data collected in previous studies, where 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 trophozites would have been observed in the field.

Columnaris infection levels were higher in 2008 than in previous studies (Figure 4). We believe this is due to columnaris examinations being conducted using a microscope. In past studies, we identified columnaris using only the naked eye; this year we changed our protocol slightly to include a microscope assessment for columnaris. Even the slightest infections are visible through the microscope, these levels of infection would not be observable to the naked eye. These extremely low infection levels do not appear to substantially affect fish health.

During the 2002 fish kill, the incidence and severity of Ich were both extremely high based on sampled fish and the amount of mortality. In 2003 we observed the largest amounts of Ich since 2002; however, the severity was low and the incidence was moderate. 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 FWS CA/NV Fish Health Center. In 2004 there was only one Ich observation, which was confirmed by the Fish Health Center, although there were also a number of false observations caused by field crews mistaking Nanophytes for Ich. Regardless, we can confidently conclude that the incidence and severity of Ich in 2004 was very low. Thus, since 2002 the amount of Ich infections we have observed in adult Chinook salmon in the lower Klamath River has been negligible with the exception of 2003, which had low incidence with moderate severity. The lack of an epizootic outbreak of Ich since 2002 is consistent with the higher flows observed in the lower Klamath River in every year after 2002 (Figure 5).

Overall, the 2008 Lower Klamath River adult Chinook salmon pathology study was a success. We continue to build a reliable long-term data set for future analysis of the relationship between infection levels, environmental conditions, and fish variables.

ACKNOWLEDGEMENTS

The YTFP would like to thank our hard working staff for the long and late hours necessary to make this annual project a success. This study was funded by the Bureau of Reclamation's Trinity River Restoration Program and the Pacific Coastal Salmon Recovery Fund.

Figure 1: Satellite photo of 2008 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).

Table 1: Results of the adult fall-run Chinook salmon pathology monitoring effort on the lower Klamath River, California, in 2008.

Sample Week	Sample Size	Number of Ich	Samples with Columnaris	Effort net hours	drifts	% w/ Ich	% w/ Col.
9-2/9-5	17	0	3	26	13	0.0%	17.6%
9-8/9-12	31	0	12	28	29	0.0%	38.7%
9-15/9-19	18	0	4	13	11	0.0%	22.2%
9-22/9-26	24	0	6	18	21	0.0%	25.0%
9-29/10-3	21	0	8	17	19	0.0%	38.1%
10-6/10-10	26	0	6	19	30	0.0%	23.1%
Totals	137	0	39	121	123	0.0%	28.5%

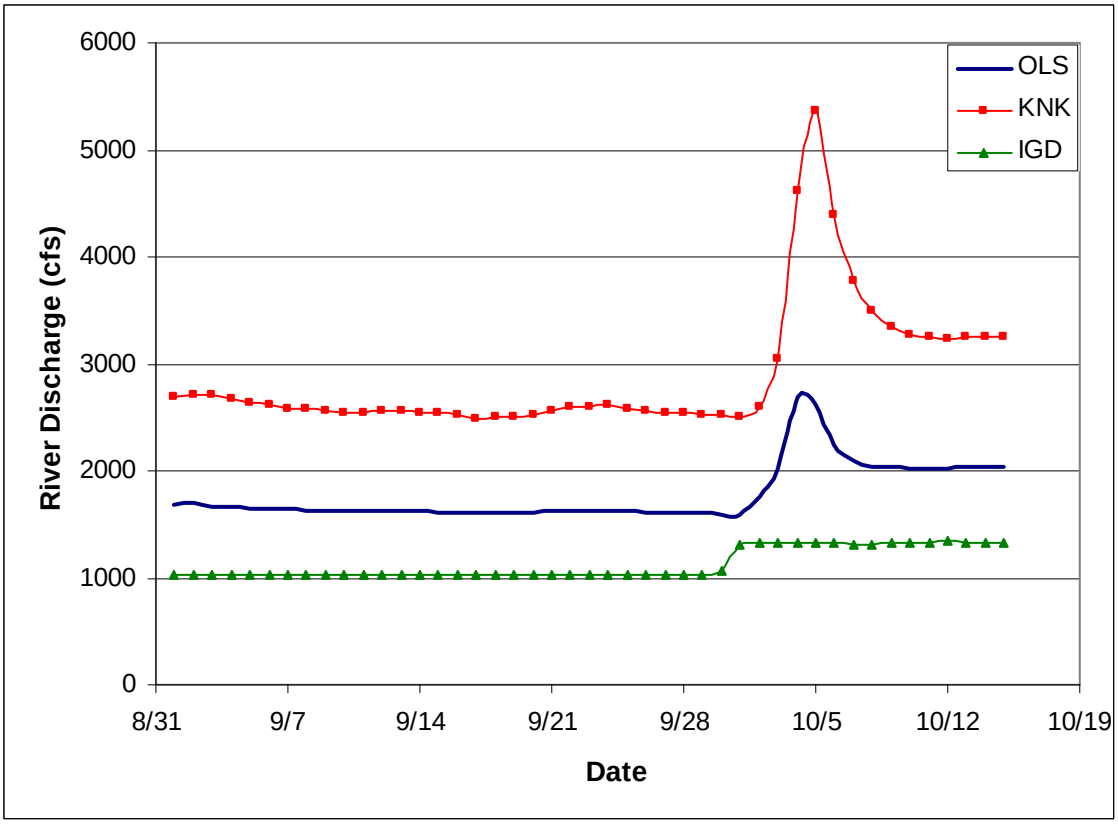


Figure 2. Mean daily discharge measured in cubic feet per second (cfs) of the Klamath River during the adult Chinook salmon pathology monitoring sampling period, September 1 to October 15, 2008. Discharge was estimated on the Klamath River near Klamath (KNK), near Orleans (OLS), and near Iron Gate Dam (IGD).

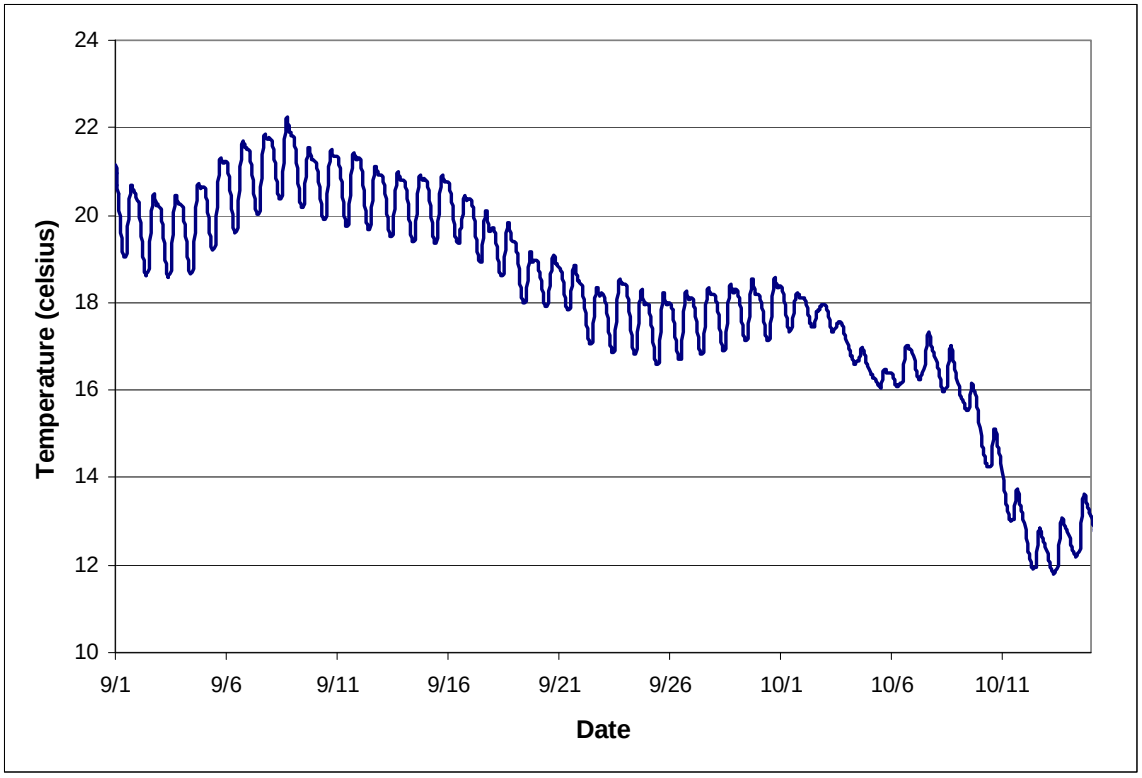
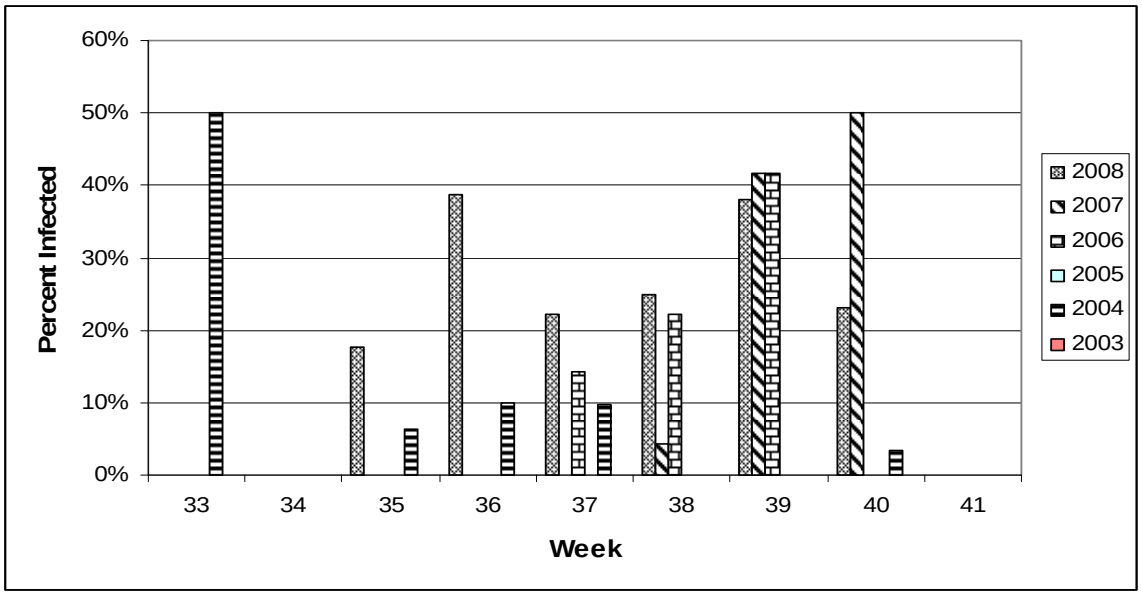


Figure 3. Klamath River and temperatures, which were recorded a short distance upstream from our sampling location. Values are displayed in degrees Celsius (ºC) and as hourly averages. This data was recorded from September 1st, to October 15th, during the 2008 YTFP adult Chinook salmon pathology study.



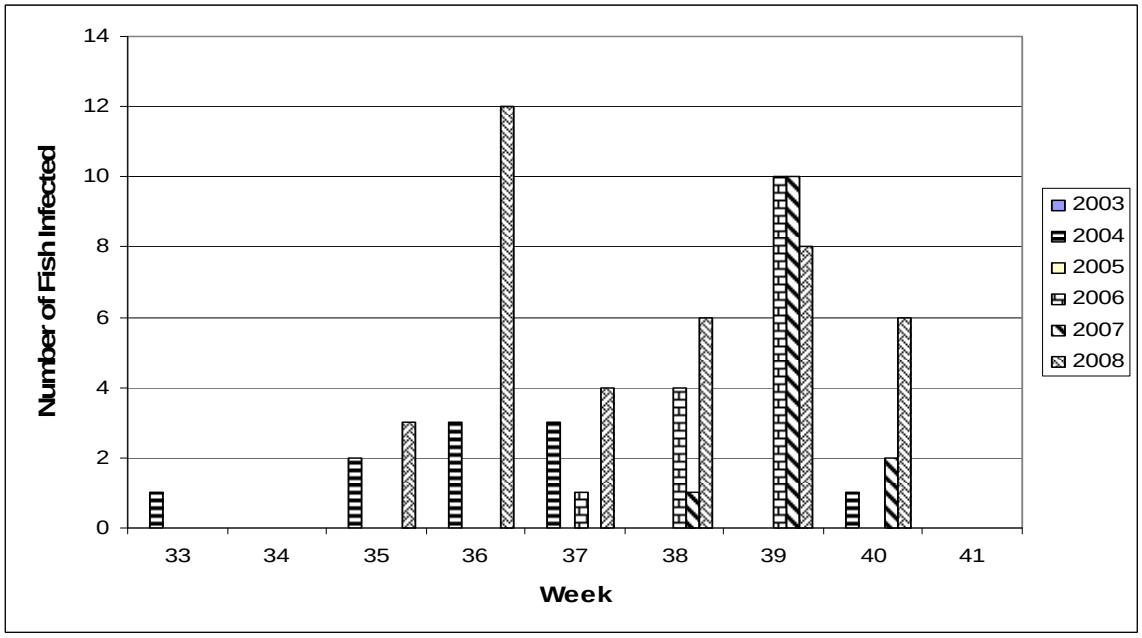


Figure 4. Top: Weekly percent of adult Chinook salmon infected with columnaris during YTFP pathology study from 2003 to 2008. Week refers to the week of the year starting from January 1st. Bottom: Weekly number of adult Chinook salmon infected with columnaris during YTFP pathology study from 2003 to 2008.

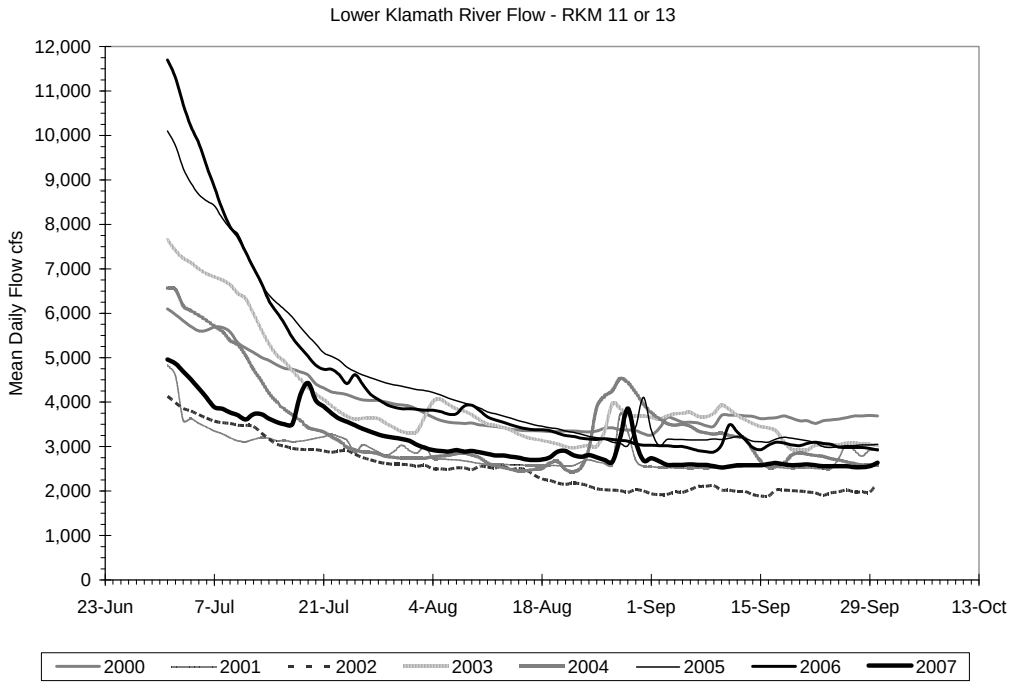


Figure 5. Summer and fall flows for the Klamath River from 2000 to 2007 (USGS).

REFERENCES

Belchik, M., Hillemeier, D., and Pierce, R.M. 2004. The Klamath River Fish Kill of 2002; Analysis of Contributing Factors. Yurok Tribal Fisheries Program. 42pp.

Bodensteiner, L.R., Sheehan, R.J., and Wills, P.S. 2000. Flowing water: an effective treatment for Ichthyophthiriasis. J. Aqua. Animal Health 12: 209-219.

Dickerson, H. W., and D. I. Dawe. 1995. *Icthyophthirius multifiliis* and *Cryptocaryon irritans* (Phylum Ciliophora). Pages 181-227 in P. T. K. Woo, editor. Fish Diseases and Disorders: Protozoan and Metazoan Infections, volume 1. CABI, New York, New York.

Foott, J.S. 2002. Pathology report. FHC Case No. 2002-139. USFWS. Anderson, California.

Guillen, G. 2003. Klamath River Fish Die-off, September 2002: Causative Factors of Mortality. US Fish and Wildlife Service. Report Number AFWOF-02-03. 128pp.

Plumb, J. A. 1999. Health maintenance and principal microbial diseases of cultured

fishes. Iowa State University, Ames, Iowa.

Shotts, E B., Jr; Starliper, C E. Flavobacterial diseases: columnaris disease, cold-water disease and bacterial gill disease. In: Woo P T K, Bruno D W., editors; Woo P T K, Bruno D W., editors. Fish diseases and disorders, vol. 3. Viral, bacterial and fungal infections. I Publishing, New York: CAB; 1999. pp. 559–576. , N.Y.

Strange, J.S. 2003. Adult Chinook Migration in the Klamath River Basin: 2003 Radio Telemetry Study Final Report. Yurok Tribal Fisheries Program; and University of Washington. 73pp.

Strange, J.S. 2006. Adult Chinook Migration in the Klamath River Basin: 2004 Radio Telemetry Study Final Report. Yurok Tribal Fisheries Program; and University of Washington. 180pp.

Strange, J.S. 2007. Adult Chinook Salmon Migration in the Klamath River Basin: 2005 Sonic Telemetry Study Final Report. Yurok Tribal Fisheries Program; and University of Washington. 96pp.

Thune, R. L. 1993. Bacterial diseases of catfish. Pages 511-520 in M. K. Stoskopf, editor. Fish.

Traxler, G.S., Richard, J., and McDonald, T.E. 1998. *Ichthyophthirius multifiliis* (Ich) epizootics in spawning sockeye salmon in British Columbia, Canada. J. Aqua. Animal Health 10: 143-151.

Turek, S., Rode, M., Cox, B., Heise, G., Sinnen, W., Reese, C., Borok, S., Hampton, M., and Chun, C. 2004. September 2002 Klamath River Fish-Kill: Final Analysis of Contributing Factors and Impacts. California Department of Fish and Game. 183pp.

YTFP. 2005. Lower Klamath River Adult Chinook Salmon Pathology Monitoring, 2005. Technical Memorandum KR-05-01. Yurok Tribal Fisheries Program, Klamath River Division. Hoopa, California.

YTFP. 2007. Lower Klamath River Adult Chinook Salmon Pathology Monitoring, 2006. Final Report. Yurok Tribal Fisheries Program, Klamath River Division. Hoopa, California.