STEPHAN C. VOLKER (CSB #63093)
ALEXIS E. KRIEG (CSB #254548)
STEPHANIE L. CLARKE (CSB #257961)
DANIEL P. GARRETT-STEINMAN (CSB #269146)
JAMEY M.B. VOLKER (CSB #273544)
LAW OFFICES OF STEPHAN C. VOLKER
1633 University Ave
Berkeley, California 94703
Tel: 510/496-0600
Fax: 510/845-1255

Attorneys for PCFFA and IFR

BEFORE THE

CALIFORNIA STATE WATER RESOURCES CONTROL BOARD

HEARING IN THE MATTER OF THE CALIFORNIA DEPARTMENT OF WATER RESOURCES AND UNITED STATES BUREAU OF RECLAMATION REQUEST FOR A CHANGE IN POINT OF DIVERSION FOR CALIFORNIA WATER FIX	**TESTIMONY OF DR. JOSHUA STRANGE**

I, Joshua Strange, do hereby declare:

I. INTRODUCTION

My name is Joshua Strange. I am presenting this testimony on behalf of the Pacific Coast Federation of Fishermen's Associations (PCFFA) and the Institute for Fisheries Resources (IFR) in this evidentiary hearing before the State Water Resources Control Board (State Water Board) concerning the petition to change the point of diversion for the California WaterFix for the State Water Project (SWP) and federal Central Valley Project (CVP), as specified in the licenses and permits of the U.S. Bureau of Reclamation (USBR) and the California Department of Water Resources (DWR).

I am the Senior Scientist at Sweet River Sciences where I perform a wide-range of duties while providing a variety of water-focused environmental services. We serve a full spectrum of clientele, including a variety of governmental agencies, NGOs, tribes, hydropower companies,

construction firms, and irrigation and water districts. My overall training is in aquatic ecology, which is widely inclusive, and I have specific expertise in fish biology, fish physiology and bioenergetics, fish migration and behavior, fish disease ecology, fish population dynamics, plus instream flows, habitat use, and restoration. My academic degrees include a Bachelor of Science in Fisheries Biology from Humboldt State University, and a Ph.D. in Fisheries Biology from the School of Aquatic and Fisheries Sciences at the University of Washington. I have completed graduate level courses in hydrology and statistics, and taught a comprehensive fish ecology course at Humboldt State University. I have conducted extensive applied research in the Klamath–Trinity basin and have first-hand knowledge of its rivers and fishes, in particular the migration behavior, run-timing, and fish health dynamics of all races of Chinook and coho salmon. I previously worked both part and full time for the Yurok Tribe as a research biologist for ten years, and my Ph.D. dissertation research was funded in part by the National Science Foundation.

My dissertation research focused on adult Chinook salmon migration in the Klamath-Trinity basin and was initiated in 2002 prior to the Klamath River fish kill in September of that year, caused by the fish parasite (*Ichthyophthirius multifiliis* [Ich]). I was on the lower Klamath and Trinity rivers daily tracking adult Chinook salmon by boat, airplane, and road during the summer and fall of 2002 and was one of the initial responders on September, 19th, 2002 to the first reports of salmon mortality from the day before. I have personal, first-hand knowledge of the river conditions, monitoring data, and salmon behavior leading up the 2002 fish kill and in subsequent years thereafter including 2017. The peer-reviewed publications resulting from my dissertation research established the upper thermal limits to upstream migration in adult Chinook salmon, comprised the first large-scale published study of estuarine behavior of adult Chinook salmon, and revealed the migration patterns and migration timing of all major runs of adult Chinook salmon in the Klamath River basin starting from estuary entry until arrival to spawning grounds or hatcheries.

I have designed, led, and assisted with numerous studies of fish health and disease

ecology for juvenile and adult salmonids in the Klamath-Trinity basin, including but not limited to annual monitoring of pathogen levels in adult fall run Chinook salmon in subsequent years after the 2002 Klamath River fish kill. As part of these studies I have conducted extensive work in the field and laboratory and have collaborators with fish pathogen experts and researchers at the U.S. Fish and Wildlife Service (USFWS) CA-NV Fish Health Center and the Department of Microbiology at Oregon State University (OSU) among others. I have participated in the Klamath Fish Health Assessment Team (KFHAT) and have helped provide leadership for the core group of fish disease researchers in the Klamath-Trinity basin that organizes the annual Klamath Fish Health Conference. I have thoroughly researched the various scientific explanations for why and how the 2002 fish kill happened, and for why and how Ich outbreaks occur, including interviewing authors of relevant papers from other Ich fish kills of adult salmonids and controlled experimental studies on Ich. I was the author of the technical memorandum (Strange 2010)[1] that formed the basis of the original fall flow fish health release recommendations to the Trinity River Restoration Program (TRRP) and I have continued to provide updates to disease outbreak risk in subsequent years. The TRRP fall flows subgroup used this report to develop the first comprehensive fall flow release criteria to protect mixed-stock fall run Chinook salmon, and coho, in the lower Klamath River, which was issued in 2010. I have been an active participant in the TRRP's fall flows subgroup and associated coordination and management meetings, including technical discussions with the USBR. In light of my expertise on fish disease ecology and migration behavior, I have provided technical assistance and input on Endangered Species Act (ESA) consultations regarding listed Southern Oregon/Northern California coho Evolutionarily Significant Unit (ESU), Klamath hydro-relicensing, the Trinity Management Council, and the Secretarial Determination process for the Klamath River settlements. I have assisted collaborators at the USFWS, USGS, and OSU in developing fish disease modules and epidemiological models that interface with larger population models.

[1] Exhibit PCFFA-152.

I have experience reviewing, developing, and conducting limiting factors analysis for salmonids using a variety of quantitative life-cycle models in the California Central Valley, California coast, Alaska, and the Klamath-Trinity basin for coho, Chinook salmon, and steelhead/rainbow trout to assess population level effects. These modeling efforts have often included instream flow analysis and water temperature models with a variety of management scenarios including climate change. I have monitored and analyzed water temperature data throughout the Klamath-Trinity basin.

I am actively involved in environmental review and research in the Sacramento-San Joaquin basin for a variety of fish species with an emphasis on the Sacramento-San Joaquin Delta and listed species such as Delta smelt and winter and spring run Chinook salmon. I previously completed comprehensive environmental review of available information, study results, and management actions pertaining to the Delta and its fisheries resources as lead author for that section of the CVP/SWP OCAP Remand EIS.

I am an active member of the American Fisheries Society and have organized conference sessions and been invited as a plenary speaker at other professional conferences. I provide peer-review for submitted manuscript for a variety of fisheries journals. I have published multiple articles in peer-reviewed fisheries journal and authored numerous technical reports and conference presentations. My resume and selected listed of professional papers is attached in Exhibit PCFFA-151.

II. OVERVIEW OF TESTIMONY

My testimony centers on the potential negative impacts to adult and juvenile fish health in the Trinity and lower Klamath rivers that would result if the CA WaterFix deleteriously impacts water level management in Trinity Reservoir, including the volume of cold pool. In particular, salmonid population the Klamath and Trinity rivers systems, including ESA listed coho salmon, are suffering from acute and reoccurring infectious disease problems and associated mortality that requires proactive water releases in order to manage. These water releases rely on adequate water storage in Trinity Reservoir including a sufficient buffer to

protect the cold water pool in the event of sequential years of drought conditions.

III. Adult Fish Health

In September of 2002 an unprecedented fish kill occurred in the lower Klamath River, resulting in the mortality of over 60,000 adult salmonids. The primary pathogen responsible, a motile protozoan parasite commonly called Ich, is one of the most studied fish pathogens in the world and is highly responsive to water flow, water quality, and fish stress. The key to understanding the 2002 fish kill in the lower Klamath River lies primarily in the biology of Ich, which has three primary life-stages: 1) the free-swimming infectious theront; 2) the parasitic and pathogenic trophont; and, 3) the reproductive tomont (Figure 1, below). The free-swimming theront is the most vulnerable life-stage because it is not embedded in a host fish like trophonts, nor eventually encysted and attached to substrates like tomonts, and it also must find a suitable host within 22.5 hours at 20°C or it will perish from starvation (Strange 2010).

In flow-through water systems, such as those often used in hatcheries and in freshwater fish farms, the primary treatment is to increase the amount of water flowing through the system. In addition to dilution of parasites, increasing the flow and turn-over rates in a flow-through system can remove parasites by flushing them out of the system. Also, the high velocities can help disrupt Ich's ability to encounter and attach to the skin or gills of host fish. In sum, such treatments address Ich infections by diluting, disrupting, or removing the infectious Ich theronts. This free-swimming theront is the key, and most vulnerable, life-stage to disrupt in order to reduce the risk of an Ich outbreak. The tiny hairs (cilia) that allows theronts to swim provide weak mobility in relation to swift currents and the swimming ability of fish. According to noted microbiologist, fish immunologist, and Ich expert Dr. Harry Dickerson, the simplest treatment for Ich infections is to break the infectious cycle by "reduction or removal of theronts" (Dickerson 2006; pg. 142), consistent with the positive linear relationship between theront abundance and resulting parasitic trophont infection level absent disruption from swiftly flowing water. Further technical details are provided in Strange (2010) and Strange (2015).[2]

[2] Exhibit PCFFA-153.

Based on these facts, since 2002 USBR has been proactively releasing targeted flows from Trinity dam during the fall salmon migration season if flows become too low in the lower Klamath River in order to disrupt infectious theronts, improve water quality, reduce water temperatures, and assist with upstream migration. This has evolved in the USBR's Long Term Plan to Protect Adult Fish Health in the Lower Klamath River. Implementation of this plan was hindered and jeopardized by the USBR management of the cold water pool in Trinity Reservoir during the multi-year drought from 2013-2015. Aggressive decisions to continue high levels of withdraws from Trinity Reservoir for CVP water deliveries led to incentives to reduce flow releases for adult fish health, increased violation of thermal objectives in the upper Trinity River and likely impacts to ESA listed coho salmon during their spawning season via physiological impacts to thermally sensitive eggs and embryos from excessively warm temperatures. As a result of this, Humboldt County and other stakeholders have been requesting increased carryover storage and more conservative management of the cold water pool in Trinity Reservoir to prevent such problems from occurring again. From a management perspective regarding control of Ich, the key is to prevent outbreak from occurring as opposed to attempting to retard an outbreak once it begins. This requires a sufficient cautionary margin of error to ensure a proactive, preventative approach and this approach is not compatible with aggressive management of the Trinity Reservoir that favors irrigation deliveries at the expense of sufficient freeboard to achieve necessary river releases on a real-time adaptive management basis. To the extent that the CA WaterFix deleteriously impacts already marginally functional carryover storage or the cold water pool management in Trinity Reservoir, corresponding negative impacts to adult fish health management are therefore more likely than not to occur.

IV. Juvenile Fish Health

Cold pool and water level management in Trinity River reservoir also have the potential to impact spring and early summer flow releases to the upper Trinity River, both the flow rate and the temperature of releases. Extensive disease problems have been occurring in the Klamath River system resulting in excessively high mortality rates to outmigrating juvenile salmon from

infections from protozoan-like parasites. Lower temperatures and dilution of infectious spores by higher releases of spore free water such as from Trinity Reservoir are among the primary management tools available to reduce such parasite impacts and related mortality in the lower Klamath River. Flow and water quality conditions in the lower Klamath River (from the confluence of the Trinity River to the Pacific Ocean) are strongly influenced by flow releases from Trinity Reservoir. Importantly, all juvenile salmon from both watersheds must pass through the lower Klamath River as part of their outmigration and the amount of infectious spore exposure in the lower Klamath River can determine whether these fish receive a lethal spore dose or not. Additional technical details are summarized in a Technical Memo by the Klamath Fish Disease Technical Advisory Team (2016),[3] which also references supporting documentation by the US Fish and Wildlife Service.

The flow releases in the spring and resulting temperatures of releases can be impacted by the reservoir management and in particular the end of season cold pool volume and reservoir level, which when coupled with low reservoir inflow, reduces the amount of water available the following year and can result in a drier water year designation and reduced flows to the Trinity River and thereby also the lower Klamath River with its severe juvenile fish disease issues. To the extent that the CA WaterFix results in reduced spring flows to the Trinity River, serious disease impacts could result to juvenile salmonids with the Trinity and Klamath River watersheds.

V. CONCLUSIONS

To the extent that the CA WaterFix depletes cold water storage in Trinity River reservoir and results in reduced reservoir levels, it has the ability to negatively impact fish health for adult and juvenile salmonids, including ESA listed coho salmon, by exacerbating two major disease causing fish parasites and physiologically damaging thermally sensitive reproductive tissues via the physical mechanism of reducing flow volumes and causing degradation to thermal conditions in the Trinity River as well as the lower Klamath River downstream.

[3] Exhibit PCFFA-154

VI. LITERATURE CITED

Dickerson H.W. 2006. *Icthyophthirius multifiliis* and *Cryptocaryon irritans* (Phylum Ciliophora). Pages 116-153 *in* PTK. Woo, editor. Fish Diseases and Disorders, Volume 1: Protozoan and Metazoan Infections, Second Edition. CABI, Cambridge, MA.

Klamath Fish Disease Advisory Team. 2016. Measures to Reduce *Ceratanova shasta* Infection of Klamath River Salmonids: A Guidance Document.

Strange, J.S. 2010. Summary of scientific evidence to guide special flow releases to reduce the risk of adult fall Chinook salmon mass disease mortality in the lower Klamath River. Available from the Trinity River Restoration Program: www.trrp.net.

Strange, J.S. 2015. Declaration of Joshua Strange Case No. 15-cv-1290. 42pp.

VII. FIGURES

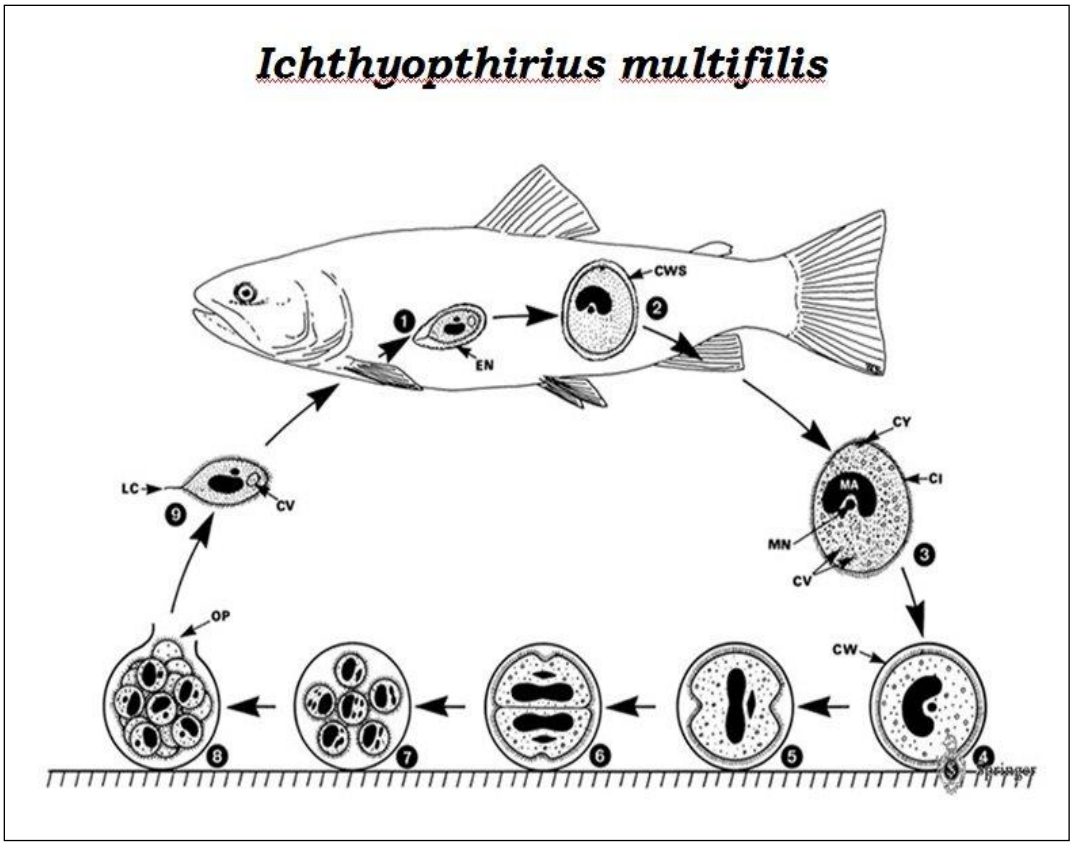

Figure 1. Life cycle of Ich showing the parasitic trophont stage (#1 and 2), the reproductive tomont stage (#3 to 5) that attaches to benthic substrates, encysts, and divides into tomites (#7

and 8), which are then released as the free-swimming infectious theront stage (#9) that must find and successfully attach to fish host within approximately 24 hours at 20°C. Ich cannot tolerant salt or brackish water and its ability to swim and find a suitable host diminishes with increased flow rate.

I declare under penalty of perjury under the laws of the State of California that the foregoing is true and correct, and that I executed this declaration November 28, 2017 in Hoopa, California.

JOSHUA STRANGE, Ph.D.