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6/12/07 Workshop
Suction Dredge
Deadline: 6/22/07 Noon

RECEIVED
JUN 22 2007
SWRCB EXECUTIVE

June 19, 2007

State Water Resources Control Board
Division of Water Quality
1001 I Street
P.O. Box 100
Sacramento, California • 95812-0100

Re: Public comments on the effects of suction dredge mining on water quality

We wish to thank the California State Water Board for the opportunity to submit these written comments, in addition to our verbal comments delivered at the June 12, 2007 workshop in Sacramento.

The Karuk Tribe of California is the second largest in the State with over 3,600 members. Our Aboriginal Territory is located within the Mid-Klamath Basin. This area includes the Salmon and Scott River sub-basins. As you are well aware the Klamath River and its attendant fisheries are in jeopardy due to water quality, water quantity and habitat degradation. These rivers and their beneficial uses play an integral part in the social, spiritual and cultural tapestry of the Karuk Tribe. We still rely on a sustainable harvest of the bounty that these waterways have produced since time immemorial. These species include salmon, steelhead trout, sturgeon, Pacific and river lamprey and mollusk harvested in a traditional manner passed on from successive generations.

We feel obligated to address an opening comment made by Board member, Charlie Hoppin, who stated in effect if the miners wish to live like pigs, that is of no concern of the Water Board. We feel this is short-sighted and fails to realize the human waste and other toxic substances left behind by these encampments will eventually through surface runoff enter our waterways, and thus a public health concern. For example, "Both direct and cumulative impacts were identified from poorly designed roads and inappropriate camping locations. Concentrated use of streamside camping sites have deleterious effects which are long lasting, Camp sites tend to persist over long periods of time and lead to increased erosion and stream sedimentation. The lack of proper sanitary facilities (fecal coliform and nitrates) improperly disposed garbage, introduction of soap and detergents and removal of streamside vegetation for firewood have long lasting effects. Road-related runoff and sediment production have had a significant cumulative effect on riparian areas and stream courses." (USDA Forest Service, 2001 Suction Dredging Activities Operating Plan Terms and Conditions for Programmatic Approval of Suction Dredge Plans of Operation. Draft Environmental Impact Statement, Siskiyou National Forest.) While the SWRCB may not be able to regulate these encampments it should be considered as factor in the cumulative effect of this activity.

U.S. Clean Water Act

The Clean Water Act ("CWA" or the "Act") is intended to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters." 33 U.S.C. § 1251(a). To achieve this goal, Section 301 of the Act, 33 U.S.C. § 1311(a), makes "the discharge of any pollutant by any person" unlawful. CWA jurisdiction attaches where there is a "discharge of any pollutant" from a "point source" to "navigable waters." 33 U.S.C. §§ 1311(a), 1362(6), (7), (12), (14). A "point source" is "any discernible, confined and discrete conveyance ... from which pollutants are or may be discharged." 33 U.S.C. § 1362(14). The term pollutant includes dredged spoils, rock, sand, and almost all other forms of waste. 33 U.S.C. § 1362(6).

Small Suction Dredge Activities Are Subject To Regulations

Suction dredges, whether floating or moored, convey water in a discernable, confined, and discrete manner is a point source. Suction dredges discharge waste water effluent containing rock and sand, which are pollutants under the Act. Discharges of such effluent into waters of the United States require regulation.

Suction Dredges as Point Source Polluters

Again, suction dredges, whether floating or moored, convey water in a discernable, confined, and discrete manner. Therefore, suction dredges **are** point sources as defined under the CWA. 33 U.S.C. § 1362(14); see U.S. v. Earth Sciences, Inc., 599 F.2d 368, 37273 (10th Cir. 1978); Trustees for Alaska v. U.S. EPA, 749 F.2d 549, 557-58 (9th 1984); WA Wilderness Coalition v. Hecla Mining Co., 870 F. Supp. 983, 988 (E. D. Wa 1994). Suction dredge operations release stream water and bed material as waste products. The re-introduction of stream water (as turbid water) or total suspended solids into the water column, through the process of suction dredging and sluicing, constitutes a discharge of a pollutant under the CWA. The Ninth Circuit has held that material separated from gold and released into a stream, during placer mining activity, constitutes a pollutant; and even though "the material discharged originally [came] from the streambed itself, [its] resuspension [in the stream] may be interpreted to be an addition of a pollutant under the Act." Rybachek v. U.S. EPA, 904 F.2d 1276, 1282, 1285-86 (9th Cir. 1990).

The mining community suggests that discharges from small suction dredging is insignificant, and therefore, not subject to CWA regulation. However, Section 402 of the CWA, 33 U.S,C. § 1342, does not exempt a discharge from regulation based on its relative significance. Sierra Club v. Union Oil Co., 813 F2d 1480,1490-1491 (9th Cir 1986), rev'd on other grounds, Union Oil Co. v. Sierra Club, 108 S Ct. 1102

(1988); Save our Bays & Beaches v. City and County of Honolulu, 904FSupp1098,1105(D.Hawaii, (1994),

The mining community may also argue that the regulations only apply when a pollutant is added to waters of the United States from the "outside world." Several courts have addressed whether an addition of a pollutant must come from the outside world, See e.g.,Natl.Wildlife Federation v.Gorsuch,693F.2d156,175(D.C.Cir.1982); Natl. Wildlife Fedn. v. Consumers Power Co., 862 F.2d 580, 584 (6th Cir. 1988); Dague v. City of Burlington , 35 F,2d 1343,1346,1354-55 (2d Cir. 1991); Dubois v. U.S. Dept. of Agric., 102 F.3d 1273, 1298 (1 st Cir. 1996); Catskill Mts. Chapter of Trout Unlimited, Inc. v. City of New York, 273 F.3d 481 , 484,491-2 (2d Cir. 2001); Catskill Mts. Chapter of Trout Unlimited, Inc. v. City of New York, 451 F.3d 77, 83 (2d Cir. 2006). Those cases, however, addressed whether the mere transfer of water, without an intervening use, may result in the addition of a pollutant. Unlike mere transfers of water, suction dredges draw stream water and bed material from a water body, retain gold or other precious metals, and then discharge waste materials in the form of turbid water and/or sediment back to the water body.

In summary, the suggestion that small suction dredges do not add a pollutant from the outside world is irrelevant, and contrary to case law on that issue. The intervening use of intake waters in suction dredging adds pollutants to those waters prior to discharge. In this respect, small suction dredging is very similar to most other industrial and municipal discharges subject to regulation.

Suction Dredge Impacts to Fisheries, Water and People

A great deal of literature exists on the effects of suction dredge mining on water quality and stream habitat. While the literature is mixed in terms of the nature and severity of effects from dredge mining operations, serious impacts to water quality and habitat have been documented, depending on the size, location and manner in which dredges are operated. For a recent summary of suction dredge impacts, see Harvey and Lisle (1998).

On March 5, 2005 the Karuk Tribe of California filed a lawsuit against California Department of Fish and Game (CDFG) for the violation of CEQA and the Fish and Game code which mandates that the issuance of suction dredge permits will not be deleterious to fish. In this litigation, Dr. Peter B. Moyle stated. "All anadromous fishes in the Klamath basin should be considered to be in decline and ultimately threatened with extirpation as wild populations because of the long history of decline and the multiple threats to the river system. Suction dredging, through a combination of disturbances of resident fish, alteration of substrates, and indirect effects of heavy human uses of small areas, especially thermal refugia, will further contribute to the decline of the fishes." In addition during the course of the litigation, CDFG stated it is "the Departments current opinion that suction dredge mining under the current regulations in the Klamath, Scott and Salmon watersheds is resulting in deleterious effects on coho salmon" (Neil Manji CDFG Fisheries Program Manager Declaration). While the use of instream suction gold mining techniques is not the root cause of the river's (fisheries) many problems, it is however, a contributing factor that cannot be dismissed nor ignored. Given the current level of existing data about the effects of dredging, where threatened or endangered aquatic species inhabit dredged areas, it would be prudent to suspect that dredging is harmful to aquatic resources (Harvey and Lisle 1998). Considering the uncertainty surrounding dredging effects, declines in many aquatic animal populations, and increasing public scrutiny of management decisions, the cost of assuming that human activities such as dredging cause no harm deserves strong consideration by decision makers (Mapstone 1995). Where threatened or endangered species exist, managers would be prudent to assume activities such as dredging are harmful unless proven otherwise (Dayton 1998). The impacts of suction dredging vary according to size of waterbody, fish species present, season of dredging, frequency and intensity of dredging. Cumulative impacts can result from small-scale mining in the same location for multiple years or from multiple mining operations occurring within an area

(Washington Dept. of Fish and Wildlife Small Scale Mineral Prospecting White Paper Dec. 2006)

In the El Dorado National Forest a study was conducted to determine the effects of suction dredge mining on instream habitats on 7 reaches within 5 watersheds that have relatively high levels of suction dredging (North State Resources 2002). Two watersheds have sampling conducted on a relatively undisturbed reach, as well as a reach located below evidence of suction dredging. The results from the paired studies indicate that the undisturbed reaches are providing optimal macroinvertabrate habitat in the NF Cosumnes and Camp Creek Watersheds, while the disturbed reaches were both rated as sub-optimal. Two reaches are also identified as optimal for macroinvertebrate habitat in Big Canyon Creek and Dogtown Creek. The Steely Fork Cosumnes reach is also rated as sub-optimal. Reaches rated as sub-optimal or marginal were based on the amount of sediment deposition, bank stability issues, and decreases in riparian zone width, and changes in embeddedness. Evidence of degraded habitat conditions are evidenced by fewer invertebrate taxa and lower invertebrate abundance and richness (Eldorado National Forest Monitoring and Evaluation Report FY 2006).

Within the last decade we have seen a dramatic influx of recreational club miners in the Klamath River and its tributaries. These clubs include "The New 49er's, Gold Prospectors Association of America (GPAA) and the Lost Dutchman Mining Association (LDMA). These clubs aggressively advertise and pursue new members, and in our opinion exaggerate the amount of gold to be found. For example currently the New 49er's are attempting to boost associate memberships which allows for a week of access to their claims, by halving the membership price. The primary reason for this action can be best stated in the words of Dave McCracken (General Manager New 49ers) "The more members our lobbyists can say that we have, the more clout we have in being able to maintain our mining rights!" This will only exacerbate the frequency and intensity of localized disturbance. The impacts of instream mining can be categorized as direct effects and critical habitat degradation. These impacts are discussed in the attached Declarations of Dr. Peter Moyle Ph.D and Dr. Walter Duffy Ph.D. and other supporting documents.

An additional water quality impact which must to be addressed is the "flouring" and resuspension of mercury through this activity. A joint study was conducted by State Water Resources Control Board, Dept. of Fish and Game, and United States Forest Service and published May 2005, to investigate this issue.

To summarize the relevant conclusions and recommendations this study found; "Mercury concentrations in the fine and suspended sediment lost from the dredge were more than ten times higher than that needed to classify it as a hazardous waste, and recycled to the environment". We find this to be particularly disturbing due to the historic legacy of mining in our Aboriginal Territory.

Regulation and Enforcement

The Karuk Tribe continues to be deeply concerned over the lack of effective regulation and enforcement of suction dredge mining in general, and its impacts on water quality specifically. The SWRCB must develop strong, effective, and enforceable standards to fulfill its mandates under the CWA. Standards which rely on self-policing must be avoided in any meaningful attempt at regulation. It is painfully clear from monitoring mining related chat forums, that this community will ignore any and all regulations it deems restrictive in the pursuit of gold. Below are some relevant examples;

Wildwes21 01-15-06, 08:20 AM (MDT)

GoldDredger_com Discussion Forum's - WTF, why am I paying for a permit.mht

"Yeah,Once I did get a permit...a long time ago, the first year I ever dredged and on my first day out got check by 2 Cal. State Recreational Officers. I was glad I had it that day. So this dredging with out a permit makes me a "OUTLAW"(one who lives outside of a broken corrupt legel system, like the Men and Weman that stood up to the Tyranny of King George & the British Imperial "Legal" System)in the USA court system...I'm not a criminal (one who steals), nor do I reconize the Court

System here in California as they Fly the USA Military Flag ("Gold Trim" around the Red,White and Blue Stars & Bars) and I am a "Free Man"...a patriot to my country and fellow citizens, but the Government will only get my support when I feel it deserves it and it does not in this case. "

El Dorado 07-09-06, 04:04 PM (MDT)
http://golddredger.com/cgi-bin/dcforum/dcboard.cgi?az=read_count&om=2793&forum=DCForumID2
"Everybody just ignore the supposidly illegal permit crap and dredge away. I do know if I come up to summefest, I will be a renegade!"

Oregon DEQ, Waldo Mining, Sisk NF Dredge Review, 2004. : Notes on DEQ Suction Dredge Demonstration, August 23-24, 2004:
"As written, in most creeks and gulches, the current level of restriction on turbidity is nearly impossible to meet. This presents a dilemma for the miner... exceed turbidity, or quit mining. As most miners will continue to dredge, the current level of restriction forces them to ignore the regulations"

Matt Mattson 12-12-04, 07:48 AM (MDT)
GoldDredger_com Discussion Forum's - From All Directions.mht
Dusty:

"I'm one of the "paranoid" and understand your sentiments. We were all poo-poo'd in the past because there are the "hardcore" miners amongst us that don't think these things affect them, or ever will, as they don't/won't ever plan to get any permits or worry about working within the laws and being above board to begin with . . .

I agree, no regulations will affect the "hardcore" who will continue to (or have to in the future):

A. Hide their dredges way up creeks and canyons, in spots so tough that no one would want to go check them.

B. Work diligently to conceal any and all their activities from rangers and expend as much or more time concealing as working, much like marijuanna growers do.

C. Ignore prime areas to work, simply because they can be spotted from a road or trail or air, and continue searching for those hard to work and access areas that have tree canopy.

D. Live like rats, since being illegal means you necessarilly have to live underground, can't speak openly about what you do, can't show anyone what you do, and can't ask for help for fear of being found out and must live in an underground economy and be continually victimized everytime you sell your gold to a middleman for cash to operate.

E. Live in constant fear of "the man" and being found out. Drug dealers, marijuanna growers, crack addicts all know this fear -- add the "hardcore" dredger to the list as willing to accept living with constant fear of being found out . . .

F. Accept losing all their equipment if it is found, since it certainly can't be claimed or, work with substandard equipment with the attitude that at some point it will be found or simply sacrificed at the end of operations, or is to small for the job but is small enough to be concealed even though you can't make money with substandard equipment or equipment that is to small for the job . . .

But if you're willing to accept the above and be outlaw - hey I agree -- no law or regulation affects your lifestyle at all . . . (of course the "outlaw" will never see any of this discussion as they can't afford a computer and if they can, won't post for fear of the law finding them out through the IP number.) "

In conclusion from the summarized information provided above and attached hereto, it is clear that the impacts of suction dredging can and does have a negative effect on the beneficial uses of our waters. Since the initial influx of Europeans into our aboriginal territory the Karuk Tribe and its resources have suffered greatly due to unmitigated exploitation. At first, the official U.S. Government policy of cultural and physical genocide failed to extirpate the Karuk people. In more recent times, agencies both State and Federal have resorted to passive genocidal policies which allow for user groups such as these to destroy our fisheries and poison our people and water. We thought the ghost and attendant horrors of the gold rush era was a thing of the past. Sadly, with the advent of this new gold rush, the Karuk Tribe believes feel it necessary to engage agencies which have ignored the plight of the Klamath River for too long, and protect and defend ourselves from this renewed threat. The Mission Statement of the SWRCB leaves no room for ambiguity or faintness of heart; *"The State Board's mission is to preserve, enhance and restore the quality of California's water resources, and ensure their proper allocation and efficient use for the benefit of present and future generations."* In this same spirit we now ask you to undertake your obligation to the people of the State of California.

Sincerely,

Leaf G. Hillman
Vice Chairman
Karuk Tribe of California

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SUPERIOR COURT OF CALIFORNIA
COUNTY OF ALAMEDA
HAYWARD DIVISION

Karuk Tribe of California; and Leaf Hillman,	Case No.: RG 05 211597
Plaintiffs,	DECLARATION OF PETER B. MOYLE, PH.D., IN SUPPORT OF ENTRY OF STIPULATED JUDGMENT
vs.	
California Department of Fish and Game; and Ryan Broddrick, Director, California Department of Fish and Game,	DATE: January 26, 2006 TIME: 9:00 a.m. DEPT: 512 (Hayward) JUDGE: Hon. Bonnie Sabraw
Defendants.	

DECLARATION OF PETER B. MOYLE, PH.D., IN SUPPORT OF ENTRY OF STIPULATED JUDGMENT

1. I am a fisheries biologist and professor in the Department of Wildlife, Fish, and Conservation Biology at the University of California at Davis, and Associate Director of its Center for Watershed Science. The Karuk Tribe of California, Plaintiff in this matter has requested that I provide my expert opinion on the potential effects of suction dredging on fishes of the Klamath, Salmon and Scott Rivers and their tributaries. I am not being paid and have not been paid for my work as an expert witness for this legal proceeding. I have personal knowledge of the matters hereinafter set forth, and if called as a witness would be competent to testify thereto.

QUALIFICATIONS AND EXPERIENCE

2. I have been researching freshwater and anadromous fish in California since 1969. I was appointed Professor of Fisheries Biology at the University of California at Davis in 1972, and held the chair of the University's Department of Wildlife, Fish and Conservation Biology from 1982 to 1987. I have served as Associate Director of the Center for Watershed Science since 2002. My curriculum vitae is attached as Exhibit A.

3. The principal area of my research and expertise is the ecology and conservation of freshwater and anadromous fishes, particularly in California. A significant portion of my research has focused on regulated streams and the impacts of dams, diversions, and other factors on fish populations in California, including the Central Valley. I have authored or co-authored more than 160 publications, most of which concern freshwater and anadromous fishes. Among my publications is Inland Fishes of California (Moyle 2002), the standard reference work on California fishes, as well as four other books and monographs on fishes. A list of my publications is attached as Exhibit B.

4. In 1993, I was named a Fellow of the California Academy of Sciences. I serve on the editorial boards of several peer-reviewed journals, including Environmental Biology of Fishes, Biological Conservation, and Biological Invasions. I am a member of the American

Fisheries Society, American Society of Ichthyologists and Herpetologists, Ecological Society of America, Society for Conservation Biology, American Association for the Advancement of Science, and American Institute of Biological Sciences. I also have received an Award of Excellence from the Western Division of the American Fisheries Society (1991); recognition as a Distinguished Fellow of the Gilbert Ichthyological Society (1993); the Outstanding Educator Award from the American Fisheries Society (1995, with J. J. Cech); and recognition as Distinguished Ecologist by Colorado State University (2001). I currently co-hold the President's Chair in Undergraduate Education at UC Davis.

5. In 2003, I was one of the co-authors of the National Research Council's final report on the causes of the decline and strategies for recovery of coho salmon and other fishes in the Klamath River Basin (National Research Council 2003). I also was a member of the Science Board of the CALFED Ecosystem Restoration Program and its predecessor (1998-2005), led the USFWS Delta Native Fishes Recovery Team (1993-1995), and served as a member of the USFS Sierra Nevada Ecosystem Project Team (1994-1996). I currently serve as a member of interagency Fish Screen Evaluation Committee.

6. I have previously served as an expert witness or consultant on salmon and other fishes in California in a number of venues. I was retained as a consultant by the City and County of San Francisco in a re-licensing proceeding before the Federal Energy Regulatory Commission (FERC), and served as an expert witness for the Putah Creek Council, in the Putah Creek Water Cases, Judicial Council Coordination Proceeding Number 2565 (Sacramento Superior Court). I also have testified before the State Water Resources Control Board and a congressional committee. In 2000 I was deposed as an expert witness on coho salmon in the case Environmental Protection & Information Center. Andrea Tuttle, Case No. 00-0713-SC (N.D. Cal). In March, 2004, I was deposed as an expert witness on the 2002 Klamath River salmon kill in the case Pacific Coast Federation of Fisherman's Associations, Yurok Tribe, Hoopa Valley Tribe v. Bureau of Reclamation, Klamath Water Users, No.C 02-020006 SBA (N.D.California). I am currently serving as an expert witness for the Natural Resources Defense Council on NRDC

vs Rodgers (E.D. Cal. No. Civ. 88-1658 LKK) on restoring flows to the San Joaquin River.

7. I have also been called on to provide expertise on salmon and native fish restoration in many other venues and proceedings. For example, I recently presented expert testimony regarding Section 5937 in proceedings before the California State Water Resources Control Board involving the Santa Ynez River (in re Santa Ynez River Public Trust Proceedings on U.S. Bureau of Reclamation Water Rights Permits, Applications 11331 and 11332, 2003).

8. In relation to the suction dredging and fishes of the Klamath, Salmon and Scott Rivers, I have the following background. I have been keeping track of the status of fishes in these rivers ever since I began writing the standard reference work on California fishes, Inland Fishes of California, first published in 1976. In the revised edition, published in 2002, I extensively reviewed the biology and status of fishes of the Klamath Basin. I was responsible for the analyses that led to various species being listed as Species of Special Concern by the California Department of Fish and Game (Moyle et al. 1994) and with two postdoctoral scholars in my laboratory, produced the first major peer-reviewed review of the status of coho salmon in California (Brown et al.1994). As the result of my expertise, I was appointed a member of the National Research Council's committee to review the causes of fish declines in the Klamath Basin (NRC 2003). In the summer of 2002, Dr. Jeffrey Mount and I brought a team of advanced undergraduates and graduate students into the Scott River basin to conduct field investigations on the status of coho salmon in Scott River tributaries. I am aware of the impacts of suction dredging primarily through the work of Dr. Bret Harvey, who conducted his first studies under me while a graduate student in my laboratory. Subsequently, I reviewed several drafts of the best (really only) review paper on suction dredging impacts in California written by Dr. Harvey (Harvey and Lisle 1998). I have also observed suction dredges at work numerous times while conducting field work.

SCOPE OF ASSIGNMENT

9. I was asked by the Plaintiffs to investigate and provide expert opinion, as a fisheries biologist, on the following questions:

(1) What are the likely effects of suction dredging on anadromous fishes, especially coho salmon, in the Klamath, Salmon and Scott Rivers and their tributaries?

(2) What tributaries and thermal refugia contain fish that would be particularly at risk from suction dredging?

10. *In formulating the opinions stated in this declaration*, I have relied on information I accumulated working on salmon and other California fishes since 1969. Much of this material is summarized in my 2002 book, Inland Fishes of California (University of California Press, 502 pp) and in my 160+ peer-reviewed publications. More specifically, I considered each of the publications cited in this report and materials cited in my publications on the Klamath River. Particularly important was the research I conducted on the status of Klamath River fishes on behalf of the NRC. Thus the opinions that I express in this report are based on my 35 years of experience and publications and on periodicals, texts, research, and historical and other materials that other experts in my field would consider reliable. Among the specific references of relevance are the following:

Brown, L. R., P. B. Moyle, and R. M. Yoshiyama. 1994. Status of coho salmon (Oncorhynchus kisutch) in California. North American Journal of Fisheries Management 14: 237-261.

Department of Fish and Game, California. 1994. Final environmental impact report: adoption of regulations for suction dredge mining. DFG, Sacramento. 173 pp.

Harvey, B. C. 1986. Effects of suction gold dredging on fish and invertebrates in two California streams, North American Journal of Fisheries Management 6:401-409.

Harvey, B. C. and T. E. Lisle. 1998. Effects of suction dredging on streams: a review and an evaluation strategy. Fisheries 23(6):8-17.

Moyle, P. B. 2002. Inland Fishes of California. Revised and Expanded. Berkeley: University of California Press. 502 pp.

Moyle, P. B., R. M. Yoshiyama, J. E. Williams, and E. D. Wikramanayake. 1995. Fish species of special concern of California. California Department of Fish and Game, Sacramento, California. 2nd ed. 272 pp.

National Research Council 2003. Endangered and Threatened Fishes in the Klamath River Basin: Causes of Decline and Strategies for Recovery. Committee on Endangered and Threatened Fishes in the Klamath River Basin. Board on Environmental Studies and Toxicology.. National Academy Press.

SUMMARY OF EXPERT OPINIONS

11. Opinion 1: All anadromous fishes in the Klamath basin should be considered to be in decline and ultimately threatened with extirpation as wild populations because of the long history of decline and the multiple threats to river system. Suction dredging through a combination of disturbance of resident fish, alteration of substrates, and indirect effects of heavy human use of small areas, especially thermal refugia, will further contribute to the decline of the fishes. I agree with thrust of Harvey and Lisle (1998), that it should be assumed that dredging is harming declining species unless it can be proven otherwise.

12. Opinion 2. Suction dredging should be banned from following areas, unless it can be proven using peer-reviewed scientific studies that the dredging has no short term or cumulative effects: All tributaries to the Klamath River, 500 m above and below cool-water refuge areas (stream mouths) on the mainstem Klamath River, Klamath River from Trinity River confluence to Green Riffle, Canyon Creek and all other Scott River tributaries, and Salmon River including the north and south forks and all tributaries.

WHAT ARE THE LIKELY EFFECTS OF SUCTION DREDGING ON ANADROMOUS FISHES, ESPECIALLY COHO SALMON, IN THE KLAMATH RIVER AND ITS TRIBUTARIES?

13. The general effects of suction dredging on fish are well described in Harvey (1986) and Harvey and Lisle (1998) and so will be described only briefly here. The effects vary according to a variety of factors including size of stream, fish species present, season of dredging, and frequency and intensity of dredging. The key is that suction dredging represents a chronic unnatural disturbance of natural habitats that are already likely to be stressed by other factors and can therefore have a negative impact on fishes that use the reach being dredged.

Direct effects include entrainment of invertebrates and small fish in the dredges, altering of the habitat that supports the food supply of fishes, and changing channel structure in ways that make it less favorable for fish (usually by making it less stable and complex). An area of particular concern in the Klamath, Salmon and Scott Rivers and their tributaries is the creation of piles of dredge tailings that are attractive for the spawning of salmonids but that are so unstable they are likely to scour under high flows, greatly reducing survival of the embryos placed within the gravel.

14. A more immediate effect is the impact of chronic disturbance of the fishes, which can change their behavior and cause them to move to less favorable conditions. I am particularly concerned in this regard with dredging in or near thermal refugia of juvenile salmonids. As discussed in the NRC (2003) report and references therein, the Klamath River and some of its tributaries can reach temperatures in excess of 65-70°F during the day in late summer. Such temperatures are very stressful or even lethal for many salmonids, so the fish seek out cooler areas, where small tributaries flow into the river or there is upwelling of ground water. Juvenile coho salmon, Chinook salmon, and steelhead will often be packed into these areas during the day. This past August, I spent a day with Dr. Michael Deas, who was documenting the nature of a thermal refuge created by the inflow of single creek into the Klamath River. When I swam through the refuge area with a mask and snorkel I was impressed with the concentrations of fish in the area (and the lack of them in the main river) and how much even a minor disturbance of the habitat would reduce the ability of the area to support fish.

15. Adult salmon and steelhead can also be disturbed by the intense dredging activities. I am particularly concerned with spring-run Chinook salmon, a species with which I have worked closely in the Sacramento River drainage. Adult spring-run Chinook spend the summer in pools in rivers, especially the Salmon River (and its forks) and Wooley Creek. They have to survive the summer without feeding, using reserves of fats and oils they bring up from the ocean. Chronic disturbance of the type created by dredging and dredgers can increase stress on these fish and has the potential to reduce their over-summer survival. An often overlooked

impact of dredging is that the people involved often live on or close to the stream in remote areas for weeks at a time, where they not only dredge, but swim, bathe, and fish (sometimes illegally). Such activity can cause spring-run Chinook to use up precious energy reserves if they have to move to less favorable areas or swim about avoiding people.

16. It is important to note that the Klamath River and its tributaries support the highest diversity of anadromous fishes of any river in California including: coho salmon, chum salmon, multiple runs of Chinook salmon, coastal cutthroat trout, multiple runs of steelhead, eulachon, green sturgeon, white sturgeon, Pacific lamprey, and river lamprey. This is the reason, of course, why the river also supported a rich and diverse fishery by the native peoples who live along the river. Today virtually all the species are in decline or threatened with declines from multiple factors (see NRC 2003). Therefore, in my professional opinion, suction dredging should only be allowed in areas where it can be demonstrated there will no immediate or cumulative impact on the anadromous fishes. *It should be assumed there is harm, unless it can be proven otherwise.* One reason for my taking this conservative position is that we simply do not know the effects of dredging on many species, especially when the intensity of dredging is increasing. For example, the larvae (ammocoetes) of Pacific and river lamprey live in soft materials along the stream edge or in slow-moving sections of stream. Dredging of areas where ammocoetes are abundant will push them into the water column where they can be readily consumed by predators, contributing further to the likely declines of the species. Even for salmonids, information on the effects of dredging, with the exception of a few studies such as that of Harvey (1989), is largely anecdotal or in non-peer reviewed reports (see, for example, the bibliography of DFG 1994). Studies are also largely confined to looking at immediate effects of single dredges and they do not examine the cumulative or long-term effects of multiple dredges and activities associated with the dredges. Indeed little has changed since DFG (1994, p. 71) listed the need for additional studies on practically every important aspect of the environmental impacts of dredging. Harvey and Lisle (1998) present a strategy for acquiring much of the needed information.

WHAT TRIBUTARIES AND THERMAL REFUGIA CONTAIN FISH THAT WOULD BE PARTICULARLY AT RISK FROM SUCTION DREDGING?

17. The NRC (2003) report emphasized two important considerations for the recovery of Klamath basin fishes that are especially relevant here: (1) cold water refuges are key to the persistence of many species, especially coho salmon and (2) the entire array of anadromous fishes (i.e., the Tribal Trust Species) need large scale and pro-active measures to assure recovery. Suction dredging is one more insult to these fishes that is likely to hurt their chances for recovery. In particular, coho salmon, spring-run Chinook salmon, and summer (spring) steelhead are particularly vulnerable to the immediate effects of dredging and have been reduced to low numbers in the Klamath Basin so need special protection.

18. In my professional opinion, the following waters should be Class A (no dredging permitted) waters beyond what is already classified as such:

a. All Klamath River cold-water tributaries, including the Shasta (already class A) River. This is to protect coho salmon in particular.

b. The Klamath River below Iron Gate at the mouths of all tributaries for a minimum of 500 meters (1500 ft) upstream of the mouths and 500 meters downstream of detectable coldwater influence. Most of the smaller tributaries of the Klamath River are substantially colder than the main river and the short sections along the edges that are influenced by the creeks are important summer refuges for juvenile Chinook and coho salmon, as well as steelhead. For example in 2001, USFWS (unpublished data) found juvenile salmonids using refuge areas at the mouths of the following creeks: Aikins, Beaver, Blue, Bluff, Bogus, Boise, Cade, Camp, Cappell, China, Clear, Coon, Dillon, Elk, Elliott, Fort Goff, Grider, Halverson, Hopkins, Horse, Independence, Indian, Irving, Little Grider, McGarvey, Miners, Oak Flat, Pearch, Pecwan, Perch, Pine, Portuguese, Red Cap, Roach, Rock, Rogers, Roseland, Sandy Bar, Seiad, Slate, Stanshaw, Swillup, Thompson, Ti, Tinkman, Tully, Uksnom, Ullthorne, Ukanom, Upsanddown, and Walker. The mouths of the Scott, Shasta, and Salmon rivers should also be protected.

c. Klamath River from Trinity River confluence to Green Riffle, to reduce potential impacts on green sturgeon spawning and rearing.

d. Canyon Creek and all other Scott River tributaries. These streams contain cold water habitats essential for the rearing of juvenile coho salmon.

e. Salmon River including the north and south forks and all tributaries. This designation is to protect the entire suite of Klamath Basin anadromous fishes, especially coho salmon in the tributaries, spring-run Chinook and summer steelhead in the two forks of the Salmon River, and green sturgeon and lamprey in the mainstem Salmon.

19. I have reviewed the proposed Stipulated Judgment that has been submitted to this Court, including Exhibit 1 thereto. The restrictions contained therein on suction dredging do not go as far as what I recommend in my opinions, as stated above. They are, nevertheless, among the most important of the recommendations in my opinions to protect the fish identified above.

I declare under penalty of perjury that the foregoing is true and correct.

Executed at Davis. California on January 14, 2006.

Peter B. Moyle, PH.D.

EXHIBIT A: CURRICULUM VITAE

PETER BRIGGS MOYLE
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And
Center for Integrated Watershed Science and Management
University of California, Davis
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EDUCATION

1964	University of Minnesota	**B.A. -**	**Zoology**
1966	Cornell University	**M.S. -**	**Conservation**
1969	University of Minnesota	**Ph.D. -**	**Zoology**

UNIVERSITY POSITIONS

1969 - 1972	Assistant Professor, Biology, California State University, Fresno, CA
1972 – present	Assistant to Full Professor, University of California, Davis, California
1982 - 1987	Chair, Department of Wildlife & Fisheries Biology, University of California, Davis, California
2002-present	Associate Director, Center for Integrated Watershed Science and Management UCD

PROFESSIONAL SOCIETIES/ORGANIZATIONS

American Fisheries Society (national & local chapters); American Society of Ichthyologists and Herpetologists; Ecological Society of America; Desert Fishes Council; Society for Conservation Biology; AAAS; AIBS

AWARDS

Award of Excellence, Western Division, American Fisheries Society (1991); Haig-Brown Award, California Trout (1993); Distinguished Fellow, Gilbert Ichthyological Society

(1993); Fellow, California Academy of Sciences (1993); Bay Education Award, Bay Institute (1994); Public Service Award, UCD (1995); Outstanding Educator Award, American Fisheries Society (1995, with J. J. Cech); Streamkeeper Award, Putah Creek Council (1997); Distinguished Ecologist, Colorado State University (2001); Outstanding Mentor Award, UCD (2003); President's Chair in Undergraduate Education, UCD (2003-2005, with J. Mount).

OTHER

Editorial Boards, Environmental Biology of Fishes, Biological Conservation, and Biological Invasions. Expert testimony: Bay/Delta Hearings, State Water Resources Control Board; Congressional hearings, Re-authorization of Endangered Species Act, etc. Head, Delta Native Fishes Recovery Team (1993-1995); Member, Sierra Nevada Ecosystem Project Team (1994-1996); Member, Independent Science Board, CALFED Ecosystem Restoration Program; Vice President, The Natural Heritage Institute; Fisheries Consultant, City and County of San Francisco. Member, National Research Council Committee on Endangered Fishes in the Klamath Basin (2002-2003).

TEACHING

Teach basic courses in fish biology, wildlife conservation, fisheries, watershed ecology, and nature/culture. Co-authored (with J. Cech) widely used ichthyology text (5th edition, 2003) and co-edited (with C. Schreck) handbook on techniques for working with fish. Active in Graduate Group in Ecology (currently on Executive Committee). Steering Committee, Nature and Culture Program.

PUBLICATIONS

Author or co-author of over 150 peer-reviewed publications, including five books/monographs.

EXHIBIT B: PEER-REVIEWED PUBLICATIONS
Peter Briggs Moyle

(Does not include ca. 100 non-peer-reviewed publications)

1. Moyle P.B. and J. A. Israel. 2005 Untested assumptions: effectiveness of screening diversions for conservation of fish populations, Fisheries 30 (5):20-28.

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11. Lewis, W. A., R. M. Adams, E.B. Cowling, E. S. Helfman, C.D.D.Howard, R. J, Huggett, N. E. Langston, J. F. Mount, P. B. Moyle, T. J. Newcomb, M. L. Pace, and J. B. Ruhl. 2004. Endangered and threatened fishes of the Klamath River Basin: Causes of decline and strategies for recovery. National Academies Press. 334 pp.

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61. Meng, L., P. B. Moyle , and B. Herbold. 1994. Changes in abundance and distribution of native and introduced fishes of Suisun Marsh. Transactions of the American Fisheries Society 123:498-507.

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65. Brown, L. R., and P. B. Moyle. 1993. Distribution, ecology, and status of the fishes of the San Joaquin River drainage, California. California Fish and Game 79:96-113

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SUPERIOR COURT OF CALIFORNIA
COUNTY OF ALAMEDA
HAYWARD DIVISION

Karuk Tribe of California; and Leaf Hillman, Plaintiffs,	Case No.: RG 05 211597
vs.	DECLARATION OF WALTER G. DUFFY, PH.D., IN SUPPORT OF ENTRY OF STIPULATED JUDGMENT
California Department of Fish and Game; and Ryan Broddrick, Director, California Department of Fish and Game, Defendants.	DATE: January 26, 2006 TIME: 9:00 a.m. DEPT: 512 (Hayward) JUDGE: Hon. Bonnie Sabraw

DECLARATION OF WALTER G. DUFFY, PH.D., IN SUPPORT OF ENTRY OF STIPULATED JUDGMENT

I, Walter G. Duffy, hereby declare:

1. I am an Adjunct Professor of Fisheries Biology at Humboldt State University in Arcata, California, and the Unit Leader of the United States Geological Survey's California Cooperative Fish Research Unit at the University. This declaration is submitted in support of the entry of the Stipulated Judgment presented to the Court by the Plaintiff Karuk Tribe of California ("Karuk Tribe") and the Defendant California Department of Fish and Game ("DF&G"). I have personal knowledge of the matters hereinafter set forth, and if called as a witness would be competent to testify thereto.

2. I was contacted in August of last year by Josh Borger, then one of the attorneys for the Plaintiffs in this action, inquiring whether I would provide technical assistance in this case as a fisheries biologist to the Plaintiffs on the effects of suction dredge mining on certain fish species of concern in the Klamath, Salmon and Scott Rivers and their tributaries. On August 25, 2005, I advised Mr. Borger that I would provide this kind of assistance as a matter of my professional scientific expertise, but that I would not act as an advocate for the Plaintiffs. I have not asked for and have not received any payment for this assistance.

[Qualifications and Experience]

3. I hold Bachelor of Science (1973), Masters of Science (1975) and PhD. (1985) Degrees in Fisheries and Wildlife from Michigan State University. From 1984 to 1988, I held the position of Ecologist at the National Wetlands Research Center in Slidell, Louisiana. From 1988 to 1997, I was the Assistant Leader of the South Dakota Cooperative Fish & Wildlife Research Unit at South Dakota State University in Brookings, South Dakota, and from 1988 to the present have also held the position of Adjunct Associate Professor in Fisheries Science at that University. Since 1997, I have been an Adjunct Professor in Fisheries Biology at Humboldt State University, and the Unit Leader for the United States Geological Survey's California Cooperative Fish Research Unit at that University. I am a member of the American Fisheries

Society, the oldest professional fisheries organization in the world.

4. In my scientific work as a fisheries biologist, I have conducted research on, among other things, the ecology of Pacific salmon and how Pacific salmon respond to processes operating in watersheds and ecosystems. Current research projects include the study of the demographics of coho salmon in northern California coastal streams of varying habitat quality, biological monitoring protocols for watershed restoration in Coastal California, relationships between the growth and survival of coho salmon, and the biological assessment of streams. I have published a number of scientific papers on my research, including the following with respect to the Coho Salmon: Bell, E. and W. G. Duffy, 2006, Individual growth rates and two year residency of juvenile coho salmon, Transactions of the American Fisheries Society (In Review), and Bell, E., W. G. Duffy, and T. D. Roelofs, 2001, Fidelity and survival of juvenile coho salmon in response to a flood, Transactions of the American Fisheries Society 130: 450-458. Among the courses I teach at Humboldt State are Fish Bioenergetics, Restoration Ecology of River Fishes and Biological Assessment of Stream Health. Fish Bioenergetics examines the energy requirements of fish relative to each species physiology and constraints on energy processes imposed by environmental conditions. Restoration Ecology of River Fishes synopsizes the myriad reasons for declining fish populations and reviews ecological concepts applicable to recovering these populations. Biological Assessment of Stream Health reviews the concepts, techniques and problems associated with stream aquatic biological assessment.

5. I have reviewed and I am familiar with the professional literature addressing environmental effects associated with suction dredging. Experience I have relevant to suction dredging in rivers includes research on 1) energy requirements of juvenile Coho Salmon, 2) survival of Coho Salmon eggs and yolk sac fry in different sediments, and 3) the influence of turbidity on feeding by Steelhead and Coastal Cutthroat Trout. Furthermore, earlier in my career I collaborated on research into fish injury and mortality caused by pump entrainment. I have also personally observed suction dredging operations.

[The Effects of Suction Dredge Mining on Special Status Species]

6. Suction dredging is an instream mining technique where pumps driven by gasoline engines are used in effect to "vacuum" up the bottoms of streams, the streambed material is drawn up through a hose and then passed over a sluice to separate out gold. The waste material ("tailings"), consisting of rocks, gravel, silt, and biota, is then discharged back into the stream in a different area from which it was removed.

7. The Proposed Interveners assert that there is no evidence that suction dredging has ever injured a single fish. Presumably, what they mean is that they have no evidence of a sighting of a direct "kill" of a fish by a suction dredging operation. However, even if true, that does not mean that suction dredging has no adverse effects on fish. In my opinion, suction dredge mining in the Klamath, Salmon and Scott Rivers and their tributaries causes serious impacts to special status species such as the Coho, Green Sturgeon, Lamprey and their habitat. These impacts include disturbance of the fish and fish eggs and fry and the invertebrate communities that fish rely upon for food. The dredging also has adverse impacts on other aquatic or riparian dependent plant and animal species; channel morphology which includes the bed, bank, channel and flow of streams and rivers; water quality and quantity; and riparian habitat adjacent to streams and rivers.

8. Suction dredging creates turbidity in the water bodies where it occurs. I have attached hereto as Exhibit 1, a photograph taken by me that shows the extent of the plume of turbidity that can be created by a suction dredging operation. Turbidity is created by the action of the dredge re-suspending fine sediment and organic particles in the water column. The finest particles, such as clay, can stay in suspension for days. Turbidity can have serious impacts on fish species and their habitat. Turbidity can interfere with fish feeding, by reducing their ability to see, smother eggs and yolk sac fry in gravel. By blocking sunlight, turbidity also reduces primary production (e.g., algae and other aquatic plants), which is a basis of the food web. Obviously, the more dredging operations there are in an area, the greater the problem. It has become a particular problem on the Salmon River mainstem because of the increase in such

activities there. The effects of dredging are not individually catastrophic in this regard, but the cumulative effects of the turbidity created by these operations can produce serious impacts on fisheries. The feeding by juveniles in tributaries is a concern, primarily disturbance of that by turbidity.

9. Dredging also often produces deep holes in the streambed and leaves unstable tailing piles. Studies conducted by Harvey and Lisle – "Effects of suction dredging on streams: a review and an evaluation strategy," in Fisheries 23(6):8-17 (1998) – show that fish spawn on these piles. These unstable piles in turn can cause egg and fry mortalities when the piles are dispersed by higher flows.

10. The experience to date indicates that the suction dredgers on the rivers of concern in this action are not willing to take the time to restore the streambed to the pre-dredging condition. The holes and tailings piles created are often left in place. Indeed, the Forest Service's monitoring of suction dredging operations in this area shows extensive abandonment of these holes and tailings piles. Attached hereto as Exhibit 2 is a true and correct copy of a report by LeRoy Cyr (fish biologist for the Orleans Ranger District of the Six Rivers National Forest), dated December 29, 2004, reporting on the results of such monitoring for 2004 for the Salmon River. The report shows that the Salmon River mainstem and its North and South Forks were replete with large pits and islands of spoils left in the river as a result of suction dredging operations. The pits measured up to 88 and 96 feet in length, and at another location 14 pits were found spread over approximately ¼ mile of the river. The tailings piles were similarly large. Mr. Cyr's report expressed his surprise that there was a total of 54 dredging sites found within the Salmon River basin in that year, and that a large proportion of those had large pits and accumulated spoils piles

11. The entrainment of fish eggs and yolk sac fry by suction dredging is another serious impact. Dredging on fish eggs and yolk sac fry can cause up to 100 percent mortality if sucked through a dredge of any size or covered with sediment produced by suction dredge mining equipment. Nearly all eggs and sac fry that survive entrainment would be eaten by fish

and other predators. They would become available prey as a consequence of their being taken out of their protective in-gravel environment by suction dredging. As they are highly desirable food items, it is doubtful that many of them would survive to the swim-up stage. Those that could escape immediate predation might find temporary refuge in substrate interstices. However, it is likely that most would ultimately fall prey to predatory aquatic insects, fish, amphibians and birds as a consequence of being displaced by suction dredging.

12. There is another reason why it is important to protect species during spawning and egg emergence from disturbance by suction dredging operations. Dredging has the effect of compressing their hatching period by interfering with spawning, which not only reduces the numbers of eggs that are hatched but also reduces the genetic variability of the species. The result is increased vulnerability to a variety of insults. This impact affects both the short term population of the species and its long term survival.

[DF&G's 1994 EIR and Suction Dredging Regulations]

13. In the 1994 EIR, Fish and Game adopted as a mitigation measure the Biological Opinion's recommendation that all rivers and other areas where special status species exist be closed to suction dredging. After certifying the 1994 EIR, Fish and Game adopted the proposed regulations, set forth at 14 Cal. Code Regs. § 228 *et seq.* The only exception to the prohibition of suction dredging in these closed areas was the proviso for a special permit if Fish and Game determined (based potentially on a site specific Biological Assessment) that the proposed site specific suction dredging would not result in a "take" of the listed species.

14. Because the Coho salmon was not then listed as a state or federal threatened or endangered species or a species of special concern, the regulations adopted pursuant to the 1994 EIR permitted dredging in the Salmon, Scott, and Klamath Rivers and their tributaries. Similarly, the Pink salmon, Chum salmon, Green sturgeon, Klamath River lamprey, and River lamprey were not listed as species of special concern at that time. As a result, the regulations provided that (a) the Klamath River from the Salmon River upstream to 500 feet downstream of the Scott River is open to dredging all year; (b) the Scott River and its tributaries are open to dredging

from the fourth Saturday in May through September 30; and (c) the main stem North Fork Salmon River from the South Fork Salmon River upstream to the Marble Mountain Wilderness, and the main stem South Fork Salmon River from the North Fork Salmon River upstream to the Trinity Alps Wilderness boundary are open to dredging from July 1 through September 15. The Coho salmon, Pink salmon, Chum salmon, Green sturgeon, Pacific lamprey, Klamath River lamprey, and River lamprey are present in these rivers during these time periods.

[The Special Status Species that are the Subject of this Action]

15. Subsequent to the preparation of the 1994 EIR and the adoption of the above regulations, the Coho Salmon was listed in a variety of contexts as a special status species. These listings included (a) the 1995 listing by DF&G of the Coho salmon as a fish species of special concern in California, (b) the 1997 listing by the National Marine Fisheries Service of the Southern Oregon/Northern California Coast Evolutionarily Significant unit of the Coho salmon as a "threatened" species under the Federal Endangered Species Act, (c) the August 2002 finding by the California Fish and Game Commission ("Commission") that Coho salmon warranted listing as a "threatened" species in the Southern Oregon/Northern California Coast Evolutionarily Significant Unit, and (d) the March 30, 2005 listing by DF&G of the Coho as a "threatened" species under the CESA. All of these listings included the Coho salmon that inhabits the Klamath, Scott and Salmon Rivers and their tributaries. The Green Sturgeon and Lamprey have been identified as species of special concern since 1994.

16. The proposed Complaint in Intervention filed herein alleges that a change in the legal status of fish (e.g., listing as endangered species) does not have anything to do with the effects of suction dredging thereon, and that the effects are independent of the legal status of the fish. ¶ 41. This notion seems to reject the rationale for all of the special protections that are accorded by federal and state law to threatened or endangered species. Because of the significant decline in their populations and their jeopardy of extinction, such species are typically accorded significantly greater protection from the kinds of impacts that would otherwise be considered acceptable. Moreover, there are special considerations relating to some of the species of concern

in the present action that must be taken into account in ensuring that they are adequately protected. They include the following:

a. **Coho Salmon**. The Coho was first listed under the Federal Endangered Species Act because of the significant population decline that has continued for decades. The National Marine Fisheries Service stated in 1997 that "[p]opulations in the California portion of this ESU could be less than 6 percent their abundance during the 1940s." 62 Fed.Reg. 24588 (May 6, 1997) (final rule listing Coho as threatened). The species has continued its decline since then. Coho salmon are susceptible to threats to stream habitats because they deposit their eggs in stream gravel and juvenile Coho salmon remain in streams for one to two years before the ocean.

b. **Green Sturgeon**. This species is present in Klamath River and the Salmon River (Mouth to Forks), and their tributaries. Little is known about Green Sturgeon, particularly the juveniles. What is known about the species is that they spawn in only a few rivers during summer and in the Rogue River, Oregon, make use of deep pools (D. L. Erickson, J. A. North, J. E. Hightower, J. Weber and L. Lauck. 2002. Movement and habitat use by green sturgeon, Acipenser medirostris in the Rogue River, Oregon, USA. Journal of Applied Ichthyology 18:565-569). Furthermore, green sturgeon from the Klamath River have been found to be genetically similar to those found in the Rogue River (J. A. Israel, J. F. Cordes, M. A. Blumberg and B. May. 2004. Geographic patterns of genetic differentiation among collections of green sturgeon. North American Journal Fisheries Management 24:922-931). Green sturgeon are long lived and do not reproduce until about the age of 10 years, making them more susceptible to impacts than many other species. They are also thought to feed primarily on the bottom of rivers and are, therefore, more susceptible to any disturbance of the bottom such as occurs in suction dredging operations (P. B. Adams, C. B. Grimes, J. E. Hightower, S. T. Lindley and M. L. Mosher. 2002. Status review for North American green sturgeon, Acipenser medirostris. National Marine Fisheries Service, Southwest Fisheries Science Center, Santa Cruz, CA). In addition, it is particularly important to ensure that the period of their egg hatching is protected from disruption or interference. For the Green Sturgeon, the first of July is the peak for hatching, with a 7-day window before and after. Thus, after July 1, they are likely to have eggs in the gravel of river bottoms where suction dredging would otherwise be occurring. In addition, the Tribe has provided information indicating that there was an increase in the outmigration of Green Sturgeon during the period when suction dredging was highest on the Salmon River. This is reflected in the 2003 trap report prepared by the Tribe, which I have reviewed. This kind of distinct shift in the migration pattern may indicate stress on the species, and its coincidence with the increased suction dredging activity creates an additional reason for protection of that part of the river from suction dredging.

c. **Lamprey**. In California, Pacific lamprey adults spawn in areas of gravel during April through July and eggs hatch two to three weeks later (P. B. Moyle. 2002. Inland Fishes of California. University of California Press, Berkeley). After hatching, larvae move from gravel to areas of softer sediment where they remain from four to six years before transforming to adults, thus juveniles are present in sediments after July 1st and present for multiple years. Their residence in streams for prolonged periods of time year after year makes them particularly susceptible to the insults of dredging. Juvenile lamprey are also filter feeders so that turbidity created by suction dredging would have a particularly negative impact on this species.

[The Injunction against DF&G's Issuance of Permits in the Proposed Stipulated Judgment]

17. As set forth above, protection for periods of spawning and egg emergence is one of the "driving forces" behind the need to protect these special status species from the effects of suction dredging. Other considerations are also important. The reasons, in my opinion, for the specific injunctions against the issuance of suction dredging permits in the Proposed Stipulated Judgment are set forth in the succeeding paragraphs.

18. **Klamath River.** The main stem of the Klamath River from its confluence with the Trinity River to Iron Gate Dam is habitat for the Green Sturgeon and Lamprey. In my opinion, it is necessary to enjoin the issuance of permits for suction dredging except for the

period July 1 to September 15, as set forth in the Proposed Stipulated Judgment, in order to protect Green Sturgeon spawning and rearing habitat. (Although not addressed in the complaint, this restriction would also serve to protect Fall Chinook holding habitat.)

19. **Tributaries to the Klamath River.** They are habitat for the Coho. In my opinion, the following aspects of the injunction in the Proposed Stipulated Judgment are necessary to provide adequate protection to the Coho.

a. Suction dredge mining should not be allowed on Indian, Elk, Dillon, Independence, Bluff, Red Cap, Camp and Clear Creeks because they are particularly important habitats for juvenile coho salmon. These streams all have cold water and each has reaches of a gradient and gravel sizes preferred by coho salmon.

b. On all other tributaries of the Klamath, permits for suction dredging should be enjoined from allowing such dredging during periods other than July 1 to September 15, as set forth in the Proposed Stipulated Judgment. This is necessary in order to protect Coho spawning and rearing habitat.

c. This injunction would also serve to protect Summer Steelhead spawning, rearing and holding habitat, although this species is not part of the existing complaint.

d. These Klamath River tributaries, where Coho are known to occur based on literature and surveys, amount to 3.02% of the streams in the entire Klamath area or 1.8% of the total stream miles.

20. **Salmon River (Mouth to Forks).** The main stem Salmon River from its confluence on the Klamath River to the Forks of the Salmon River (i.e., the confluence of the North and South Forks of the Salmon River) is habitat for the Coho, Green Sturgeon and Lamprey. Green Sturgeon and Lamprey in particular are present in this area in the summer months when suction dredging activities are heaviest. In my opinion, the injunction in the Proposed Stipulated Judgment against the issuance of suction dredging permits at any time during the year for this segment of the River is necessary to protect the spawning and rearing habitat of the Coho, Green Sturgeon, and Lamprey. (This injunction would also serve to protect

Fall Chinook spawning and holding habitat, and Spring Chinook and Summer Steelhead summer holding habitat, although these species are not part of the existing complaint.) This area deserves to be protected through the injunction because of the combination of species there; and the need in particular to protect the spawning and egg from interference.[1]

21. **Salmon River Tributaries.** The Salmon River tributaries identified in the Proposed Stipulated Judgment are habitat for Coho and Lamprey. In my opinion, the injunction against the issuance of permits for suction dredging at any time during the year for these tributaries is necessary to protect to protect Coho spawning and rearing habitat. (This closure will also protect Spring Chinook and Summer Steelhead spawning and rearing habitat, although these species are not part of the existing complaint.) Rearing habitat is limited due to the mainstem heating up in summer and juveniles migrating out to the cooler tributaries.

22. **Scott River.** The Scott River from its mouth to headwaters is habitat for the Coho Salmon. In my opinion, the injunction against the issuance of permits for suction dredging except for July 1 to September 15, is necessary in order to protect Coho spawning and rearing habitat. Suction dredging should be precluded until July to allow Coho juveniles to either get out of the system or up into the tributaries to avoid the potential for adverse impacts from dredging.

23. **Scott River Tributaries.** The 20 Scott River tributaries identified in the Proposed Stipulated Judgment are habitat for Coho, and their presence here has been documented. In my opinion, the injunction against the issuance of permits for suction dredging in these tributaries is necessary because the main stem becomes disconnected from almost all tributaries by July and dredging could occur under the existing designation where Coho are trapped in reaches and unable to escape, or have limited room to maneuver, in response to dredging. The closure of these tributaries is therefore necessary to protect Coho juvenile rearing in the tributaries.

24. **Thermal Refugia**. The water temperature in the mainstems of the rivers often

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[1] Although the Proposed Stipulated Judgment also enjoins the issuance of suction dredging permits for the North and South Forks of the Salmon River, except from July 1 to September 15, this does not represent a change from the existing regulations.

reaches levels during the summer that can be lethal to fish, but the temperatures in the tributaries are significantly lower than in the mainstem during these months. When the cold water from these tributaries passes into the mainstems, cold water thermal refugia areas are created at the confluence of the tributary and the mainstem of the river. The species of concern in this action often congregate in those areas and hold over in them to seek out temperatures or other habitat conditions more suitable or preferable during the summer months, including the period from July 1 through September 15. The use of these thermal refugia by juvenile and adult salmonids during stressful water quality conditions makes them special habitats that must be protected. In my opinion, the particular areas identified in the Proposed Stipulated Judgment constitute the largest and most consistent refugia from hot mainstem temperatures in the time period from July 1 to September 15. This opinion is based on temperature data showing that these areas provide significantly lower temperatures than the mainstem during this period and upon verified field observations or professional opinion concerning fish presence or value as a fish refugia.

25. The same reasons for enjoining suction dredging permits for certain tributaries listed above apply also to the thermal refugia at the confluence of these tributaries with the mainstems of the three rivers. Thus, in my opinion, the injunction to this effect in the Proposed Stipulated Judgment is necessary for the protection of the special status species identified above. In addition, the Proposed Stipulated Judgment would also enjoin suction dredging permits for the thermal refugia located at the confluence of certain specified tributaries on the Klamath River and the thermal refugia located at the confluence of the North Fork of the Salmon River within certain boundaries and a single creek (Crapo Creek) on the mainstem of the Salmon River below the Forks of the Salmon. In my opinion, the injunction against suction dredging permits for these areas is also necessary to protect the identified species.

[The Proposed Interveners' Declarations]

26. I have reviewed the declarations submitted by the Proposed Interveners in support of their objections to the Proposed Stipulated Judgment. Much of what I have said above contradicts the opinions that they offer, and there is no reason to otherwise address those

differences of opinion. However, I do wish to address a few statements in those declarations.

27. The declaration by Joseph C. Greene implies that the geographic scope of suction dredge gold mining is limited and not large enough to impact fishes. This statement fails to recognize the present abundance and distribution of Coho salmon, spring Chinook salmon, summer steelhead, green sturgeon, and Pacific lamprey in California. The distribution of these species and stocks is now very limited and the Salmon River is the single tributary of the Klamath River that still supports all these species. Furthermore, all these species require cold water such as that found in a only a few tributaries and the confluence of these tributaries with the Klamath River. Thus, while suction dredge mining may not affect large portions of the Klamath River, this mining has been taking place over or in proximity to portions of the river that are the most valuable habitat remaining for threatened fish species.

28. Exhibit #2 of Joseph C. Green's argues that 1) 20-30 year ocean cycles control salmon cycles and 2) freshwater management programs cannot compensate for these ocean cycles. Regarding the former, the Pacific Ocean does change in productivity at 20-30 year intervals. However, coho salmon populations declined from an estimated 5 million fish in the mid-1800's to around 5,000 fish in the 1990's. This period spans almost 150 years or 5-6 changes in ocean productivity. If these changes in ocean productivity were the sole determinant of salmon population abundance one would expect to see periodic increases in salmon population abundance, but salmon abundance has only declined. Regarding the latter point, salmon have evolved to use freshwater rivers and stream to spawn in and rear their young, then move into oceans to feed and grow. Logic dictates that populations cannot survive if they cannot reproduce. Management of rivers and streams is essential to protecting and restoring these threatened fishes to some semblance of their former abundance.

I declare under penalty of perjury that the foregoing is true and correct.

Executed at Arcata, California on January 18, 2006.

Walter G. Duffy, PH.D.

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SUPERIOR COURT OF CALIFORNIA
COUNTY OF ALAMEDA
HAYWARD DIVISION

Karuk Tribe of California; and Leaf Hillman,	Case No.: RG 05 211597
Plaintiffs,	REPLY DECLARATION OF WALTER G. DUFFY, PH.D., IN SUPPORT OF ENTRY OF STIPULATED JUDGMENT
vs.	
California Department of Fish and Game; and Ryan Broddrick, Director, California Department of Fish and Game,	DATE: February 9, 2006 TIME: 9:00 a.m. DEPT: 512 (Hayward) JUDGE: Hon. Bonnie Sabraw
Defendants.	

REPLY DECLARATION OF WALTER G. DUFFY, PH.D., IN SUPPORT OF ENTRY OF STIPULATED JUDGMENT

I, Walter G. Duffy, hereby declare:

1. I am an Adjunct Professor of Fisheries Biology at Humboldt State University in Arcata, California, and the Unit Leader of the United States Geological Survey's California Cooperative Fish Research Unit at the University. I have previously submitted a declaration in support of the entry of the Stipulated Judgment presented to the Court by the Plaintiff Karuk Tribe of California ("Karuk Tribe") and the Defendant California Department of Fish and Game ("DF&G"). This Reply Declaration responds to statements made in the declarations and other papers submitted by the Proposed Interveners on January 26, 2006 by leave of this Court. I have personal knowledge of the matters hereinafter set forth, and if called as a witness would be competent to testify thereto.

Fourth Declaration of David McCracken

2. In his Fourth Declaration, Mr. McCracken states that the Proposed Stipulated Judgment will affect the New 49'ers leases and others' claims on approximately 60 miles of the Klamath and Salmon Rivers and certain of their tributaries. I have no knowledge of the miles of streams under lease to the New 49'ers. However, if the figures set forth in Mr. McCracken's Fourth Declaration are correct, the New 49'ers claim to have leases of 36.5% of the stream miles listed (not including the claims of others on those same streams). In my opinion, this amount of mining activity could have a substantial impact on stream ecology, which would itself be adverse to the special status species inhabiting the rivers and tributaries. In stating my opinions in my prior declaration, I had assumed their activity was much more localized.

3. Mr. McCracken also complains in his Fourth Declaration about the reductions in seasons of dredging from all year to 10 weeks in the summertime on one part of the Klamath and from 16 weeks to 10 weeks in the summertime on another. The 1994 EIR says that dredging occurs mainly in the summer, and my personal observation of suction dredging on these stretches of the Klamath is that dredging activity begins in mid-summer and declines in early fall.

Second Declaration of Dennis Maria

4. In his Second Declaration, Mr. Maria claims that there is no basis for closing to suction dredging the lower reaches of the Scott and Salmon Rivers because they are generally too warm in the summertime to provide habitat for juvenile Coho. ¶ 2. However, he ignores the fact the Stipulated Judgment *would not enjoin the issuance of suction dredging permits* in the Scott River for the "summertime" from July 1 to September 15. Moreover, as I stated in my prior declaration, it is my opinion that suction dredging in this part of the Scott should be precluded until July to allow Coho juveniles to either get out of the system or up into the tributaries to avoid the potential for adverse impacts from dredging.

5. With respect to the lower reach of the Salmon River, Mr. Maria's declaration does not take account of the fact that Green Sturgeon and Lamprey (as well as Spring Chinook and Summer Steelhead) are present there and in jeopardy in the summer months when suction dredging activities are heaviest.

6. Mr. Maria also asserts that there is no reason to close the Klamath River to suction dredging between September 15 and September 30, but this again ignores the presence of juvenile Coho and Lamprey (and possibly Green Sturgeon) who will be adversely affected by disturbance of the river bottom and turbidity from suction dredging during this period.

7. The fact that Mr. Maria is personally "unaware" of any data indicating the presence of adult sturgeon spawners during July or August in the Salmon River (¶¶ 3, 4) does not prove that they are not present or not spawning during that period. Green sturgeon occupy deeper pools, and it is very difficult to see to the bottom of these pools. Their presence in the Salmon River during these months has been documented. Based on my understanding of the period in which they are likely to spawn, I would expect that they do spawn in the Salmon River during the months of July or August.

8. Mr. Maria also repeats a claim made previously by the Proposed Interveners: that he has never seen evidence of a "single fish killed by suction dredge mining." (¶ 5). I briefly addressed that assertion in my prior declaration, but a more complete response is appropriate.

There is ample literature documenting the adverse impacts on fish species from suction dredging. Presumably, what he and others mean by this statement is that they have no evidence of a sighting of a direct "kill" of a fish by a suction dredging operation. In my opinion, this statement proves nothing about the impacts of suction dredging on fisheries. The only way I can conceive there would be a direct sighting of a "fish kill" from a suction dredging operation would be through entrainment in the suction dredge, and the only way "evidence" of this would ever be produced would be if the dredger spotted the dead fish and reported it to DF&G or other responsible agencies, or a third party happened to be present at that exact moment and reported it. The observance and reporting of such an incident, needless to say, is highly unlikely.

9. Certainly, there will be no such *causal sighting* of the fish eggs that are destroyed because they are laid on unstable tailings piles created by dredging and later scoured, or of the fish that experience reduced feeding and survival due to the turbidity created by suction dredging, or those that don't survive because of the stress from dredging activities in cold-water refugia where the fish are holding over – to mention only a few of the different impacts.

10. These impacts are not just "potential," and they certainly are not "speculative." We know that the populations of the Coho, Green Sturgeon and Lamprey and other species in the Klamath River Basin have drastically declined over time. We know that their usable habitat has been greatly reduced – i.e., there is a limited amount of space where these species can survive because of the existing conditions in these rivers. We know what influences are conducive to their survival and reproduction and what influences are harmful. In my opinion, there is no question that suction dredging in the Klamath River Basin is having direct and indirect adverse impacts on these species. While Mr. Maria may be correct that other activities (e.g., swimming) create some stress for fish, it is far different than the dredging that physically alters their habitat and causes direct damage to their eggs or young.

11. It certainly is not the case, as Mr. Maria states, that existing DF&G regulations have restricted suction dredging "in the only period in which such mining is likely to cause actual injury." ¶ 5. As set forth in detail in my prior declaration (¶¶ 16-25), and the Declarations

of Toz Soto (¶ 19) and Dr. Peter Moyle (¶¶ 13-19), the Coho, Green Sturgeon and Lamprey – all listed subsequent to DF&G's regulations – require particularized protection from the impacts of suction dredging. The injunction against the issuance of suction dredging permits would accomplish this. Indeed, I agree with both Mr. Soto and Dr. Moyle that even greater protection than afforded by the Stipulated Judgment would have been justified, but I understand that the Stipulated Judgment is the product of a compromise.

Third Declaration of Greene

12. Mr. Greene's statement of his credentials is in his Third Declaration at ¶¶ 3-5, together with his resume attached as Exhibit 1. None of this contains any reference to any work or publications relating to fish, and his only reference to these rivers is his observation of "mining techniques" on the Klamath River (¶ 4). In my opinion, expert assessments of impacts of suction dredging on particular fish species in particular rivers requires some working knowledge of the life cycle of the particular species and their habitat needs, and the environmental conditions of their habitat. Mr. Greene's declaration does not show any education or work experience in these matters.

13. Mr. Greene touts his 25-30 years experience in toxicity testing – although the impacts of suction dredging are in the main not related to exposure to toxic substances. In the testing techniques he references, the EPA uses a relatively few species to test the toxicity of constituents in water to biota. The standard organisms are water fleas (Daphnia or Ceriodaphnia), scuds (Hyalella) and and fathead minnows. These tests are run for either 24, 48 or 96 hours, after which the concentration at which 50% die is recorded (lethal concentration of 50% or LC50). I do not think that this kind of work in a controlled environment to assess short duration experiments qualifies him to expound on global weather phenomenon or regional fisheries issues.

14. Paragraph 7 of his Third Declaration cites studies he claims show no cumulative effects from dredging. If however, more than one-third of the stream bottom is subject to dredging, as Mr. McCracken claims, I would expect to see cumulative effects.

15. Paragraphs 7-9 say Peter Moyle is reaching his opinion without any scientific data. In challenging Dr. Moyle, Mr. Greene misinterprets Dr. Bayley's report on cumulative impacts of dredging. Mr. Greene states that the report by Bayley confirms "there is no reason to believe that suction dredge mining is deleterious to fish." Dr. Bayley actually states: "The statistical analyses did not indicate that suction dredge mining has no effect on the three responses measured.... (P. B. Bayley, 2002. Response of fish to cumulative effects of suction dredge and hydraulic mining in the Illinois subbasin, Siskiyou National Forest, Oregon. Oregon State University, Corvallis). Ultimately, the study was inconclusive as to cumulative effects. Although I agree that Dr. Moyle's statements can be construed as opinion, I think Dr. Moyle's resume speaks for itself and he is much more qualified to offer an opinion than Mr. Greene.

16. Paragraphs 12-16 respond to the Declaration of Toz Soto regarding Tom Martin creek and lethal temperatures. Mr. Greene's restatement of water temperature influences does not change his original statement that all the temperatures taken exceed 20 ° C, the "incipient lethal temperature." Incipient lethal temperature is a very specific term. Each fish species has a tolerance range of temperature. This tolerance range is influenced by both physiology of the organism and temperature the organism has been acclimated to. Lethal thresholds typically are referred to as incipient lethal temperatures and temperatures beyond these ranges would be considered extreme. At temperatures above the upper incipient lethal temperature, survival depends not only on the temperature but also on the duration of exposure (EPA. 1973. Water Quality Criteria 1972. A report of the Committee on Water Quality Criteria, National Academy of Sciences and National Academy of Engineering (NAS/NAE). U.S. Environmental Protection Agency, EPA-R3-73-033. Washington, D.C. 553 pp). I note that the excerpts from "Pacific Salmon Life Histories" attached to a Request for Judicial Notice identifies 25 degrees Centigrade as the upper incipient lethal temperature for Coho. In the present case, documented temperatures over time and observances of the presence of fish were used to identify the thermal refugia in the Stipulated Judgment.

17. Paragraphs 18-21 of Mr. Greene's Third Declaration challenge my statement

regarding ocean conditions. In my prior declaration, I responded to Mr. Greene's statement in his Second Declaration that ocean conditions were the sole determinant of salmonid populations. I stated that if that were true we could expect to see increases and decreases in population abundance coinciding with Pacific decadal oscillations (ocean conditions) at 25-30 year intervals. In rebuttal, Mr. Greene submits data for the number of Chinook salmon returning to the Klamath and Salmon Rivers from 1978 to 2001.

18. Two points about Mr. Greene's rebuttal are worth stating here. First, I stated that Coho salmon abundance had only declined and not increased during a period from the late 1800's through the present. Mr. Greene's interpretation of my statement reveals his long experience in the laboratory addressing easily controlled short duration phenomenon and his lack of experience analyzing fisheries data. Year to year variation is common in fish populations, as well as other biological populations. Although crude, estimated abundance of Coho salmon in California were placed at 5,000,000 fish in the late 1800's, this number was reduced to 200,000-400,000 in the 1940's, 30,000-40,000 in the 1980's and as few as 5,000 fish in the 1990's. I stand by my statement that since the late 1800's, the trend in Coho salmon abundance has been consistently downward and has not increased appreciably during periods of good ocean conditions.

19. Second, Mr. Greene claims that ocean conditions are more important in determining salmon survival than is freshwater habitat. Data he submits showing the number of Chinook salmon entering the Klamath and Salmon Rivers during the period 1978 – 2001 (exhibits 2 and 3) contradict his statement. Ocean conditions off the California coast were unfavorable for salmon from the early 1970's through 1997 or 1998. The Pacific Ocean off California's coast changed to be favorable to salmon around 1998 or 1999. The data Mr. Greene submits show that numbers of adult and grilse Chinook salmon combined entering in the Klamath and Salmon Rivers actually declined dramatically immediately following the period when ocean conditions changed to favor salmon, and have not recovered to previous numbers he cites. His data does not therefore show that ocean conditions were the predominant factor in the

decline of the Chinook salmon.

I declare under penalty of perjury that the foregoing is true and correct.

Executed at Arcata, California on February 1, 2006.

Walter G. Duffy, PH.D.

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SUPERIOR COURT OF CALIFORNIA

COUNTY OF ALAMEDA

KARUK TRIBE OF CALIFORNIA and LEAF HILLMAN, Plaintiff, **v.** **CALIFORNIA DEPARTMENT OF FISH AND GAME; and RYAN BRODDRICK, Director, California Department of Fish and Game,** Defendants.	Case No. 05211597 **DECLARATION OF NEIL MANJI IN SUPPORT OF OPPOSITION TO THE OBJECTIONS OF THE NEW 49'ERS, INC., AND RAYMOND W. KOONS TO THE PROPOSED STIPULATED JUDGMENT** Date: January 26, 2006 Time: 9:00 a.m. Dept: 512 (Hayward) The Honorable Bonnie Sabraw Trial Date: Action Filed: May 6, 2005

DECLARATION OF NEIL MANJI IN SUPPORT OF ENTRY OF STIPULATED JUDGMENT

I, Neil Manji, declare as follows:

1. I am currently employed by the California Department of Fish and Game ("Department") as a Supervising Biologist and I participated in settlement negotiations in the above captioned matter in that capacity. The matters set forth in this declaration are within my personal knowledge and if called on to testify to these matters I would and could so testify.

2. In my current job at the Department, I serve as the Fisheries Program Manager for the eight counties that comprise the Northern California-North Coast Region ("Region") of the Department. I oversee all fisheries programs within the Region, including programs involving: 1) fisheries habitat restoration; 2) inland and anadromous fisheries resource assessment and monitoring; 3) watershed assessment; and 4) salmon, steelhead and trout hatcheries. I hold a Bachelor of Science (1986) with a major in Fisheries from Humboldt State University and have worked as a fishery biologist since 1989. I worked on the Klamath River specifically in that capacity from 1984-1986, and from 1999 through present. Among other work during that time, I conducted spawning ground surveys and monitored adult and juvenile salmonids on the mainstem and tributaries to the Klamath River. I have also reviewed and edited several manuscripts documenting research and monitoring within the Klamath River Basin. Finally, I am a member of the Klamath Basin Fishery Task Force, Klamath Fishery Management Council and Trinity River Management Council.

3. Based on my experience with the Department, and in my professional opinion as a fishery biologist, the existing regulations governing suction dredging, which are found in sections 228 and 228.5 of Title 14 of the California Code of Regulations, serve to permit suction dredging activities while, at the same time, providing protection for spawning adult salmonids, including chinook salmon, and the developing eggs and larvae of such species, which remain in the gravel following spawning. The existing regulations provide this protection by establishing watercourse-specific closures and seasonal restrictions on suction dredging activities. For example, under the existing regulations, suction dredging on the mainstem of the Klamath River is allowed from the mouth of the mainstem to the Salmon River from the fourth Saturday in May through September 30

(Class G); from the Salmon River upstream to 500 feet downstream of the Scott River throughout the year (Class H); from 500 feet downstream of the Scott River upstream to Iron Gate Dam from the fourth Saturday in May through September 30 (Class G). From Iron Gate Dam to the Oregon Border, no suction dredging is permitted at any time (Class A). (See Cal. Code Regs., tit. 14, § 228.5, subd. (d)(49).)

4. The additional restrictions agreed to by the Department in the Stipulated Judgment at issue in this proceeding are structured in the same manner as the existing regulations. Those restrictions are detailed in Exhibit 1 to the Proposed Stipulated Judgment, and the information document the Department is including with all 2006 suction dredge permit applications. A true and correct copy of that document is attached hereto as Exhibit A.

5. From a biological standpoint, the additional restrictions were designed to substantially lessen the potential for significant impacts on various fish species that suction dredging could cause in the Klamath, Scott, and Salmon River watersheds. In particular, the additional restrictions will protect and benefit coho salmon, steelhead, green sturgeon, and lamprey.

Spawning

6. Chinook and coho salmon and steelhead are anadromous salmonids that spawn in gravel substrates throughout the Klamath Basin at various times of the year. Surveys conducted by the Department and other public agencies indicate that, in the Klamath Basin, chinook salmon spawn from September through December, and coho spawn from November through January. Steelhead can spawn over a longer temporal period from December through June. It is critical during those periods that spawning adults and redds are not disturbed by instream activities, such as suction dredging. Physical disturbance of adults and redds during pre- and post-spawning activities can reduce the spawning success and subsequent survival of progeny.

7. Based on existing evidence regarding the distribution and abundance of coho salmon and steelhead in the Klamath River Basin, the additional restrictions will reduce direct conflict between suction dredging activity and spawning adult coho salmon and steelhead. Further, redds created on dredge tailings have been shown to scour following high flow events moreso than redds created on undisturbed substrates. Redd scouring will negatively affect the survival of incubating

eggs. The additional restrictions are also expected to limit suction dredge-related disturbance to spawning substrates immediately prior to spawning activity. This, the Department expects that the additional restrictions will reduce the potential for such related incidental impacts.

Emergence

8. It can take several months for salmonid eggs to develop and for the sac fry to emerge from the gravel. Emergence of chinook fry occurs from November through March. Coho fry emergence can occur from February through June. Steelhead emergence generally occurs from April through July. As mentioned above, it is critical that the developing eggs and sac fry are not disturbed during those emergence periods. The additional restrictions are intended to reduce those potential impacts.

9. Summer steelhead migrate to freshwater in late spring and oversummer in cool tributaries until they spawn in early to mid-winter. Tributaries important to summer steelhead were identified and prioritized and classified accordingly based on summer steelhead abundance from several years of surveys.

Juvenile Salmonids and Rearing Habitat

10. Unlike chinook salmon, juvenile coho reside in tributaries for a year or more before migrating to the ocean. Due to a flexible life history, steelhead can reside for numerous years without migrating to the ocean. Oversummering habitat is thus critical to the survival of juvenile coho and steelhead. Through reports, survey data, and other information available to Department biologists and other fisheries scientists from other public agencies and Native American tribes, tributaries in which juvenile coho rear were identified. Many of the tributaries in the Klamath basin either run dry by late summer or have temperatures that exceed the lethal threshold for salmonids. Prioritization of tributaries containing critical rearing habitat was based on professional judgment and the presence of juvenile coho or steelhead and the quality of the habitat (e.g., a stream that maintains connectivity with the mainstem is of a higher quality than a stream that loses connectivity or has high temperatures). The Department agreed to close to suction dredging (Class A) high priority tributaries and habitats as part of the Stipulated Judgment to protect those habitats, as well as to eliminate direct conflict between suction dredging activity and juvenile coho or steelhead.

Sturgeon

11. Sturgeon are long-lived anadromous fish that reportedly reach reproductive maturity at approximately 10-15 years of age. Like salmon, sturgeon spawn in fresh water streams and rivers. Green sturgeon have been documented to occur and spawn successfully in the Salmon River, a tributary to the Klamath River. Spawning occurs from April through July while emergence occurs from April through August. Again, it is critical that spawning adults and the developing eggs are not disturbed. The additional closures and seasonal restrictions will protect the peak spawning period of adult sturgeon in areas where spawning activity has been reported by Department biologists and other agency biologists and scientific literature. Recently emerged juveniles are reportedly poor swimmers that remain close to cover while undergoing a downstream migration to rearing habitats. The additional restrictions will reduce direct conflict of the early-emerged juveniles with suction dredging activity and, where tributaries are now closed to suction dredging year round, protect spawning, incubation, early life history stages, and juvenile rearing habitat.

Lamprey

12. Lamprey are also anadromous fish that spawn in the gravel of streams and rivers. Lamprey spawning occurs from April through July. It is critical that spawning adults are not disturbed. The additional restrictions will reduce or eliminate conflict between spawning lamprey and suction dredging activity, as well as provide protection for the developing eggs. The ammocetes (i.e., lamprey larvae) can remain in the gravel for several years which makes them extremely vulnerable to impacts caused by suction dredging. The additional restrictions will provide greater protection for all freshwater life history stages for lamprey.

Thermal Refugia

13. It has been documented that juvenile salmonids use cold water thermal refugia around the mouths of numerous tributaries to the Klamath, Shasta, Scott, and Salmon Rivers from about May 15 through late September. As water temperature in the mainstem of the rivers reaches critically high levels, these cold water refugia become extremely important to salmonid survival. Information from Department biologists identified thermal refugia areas during field investigations that include fish kill investigations and juvenile fish surveys. In addition, there have been several

studies and observations conducted by other state, federal, and tribal biologists that have identified and quantified thermal refugia within the Klamath River Basin. These summer rearing areas were prioritized based on a review of current thermal refugia data and information from other agency biologists, as well as professional judgment from direct observations. Designated thermal refugia are closed to suction dredging year round under the additional restrictions to avoid potential displacement or disturbance of juvenile coho or steelhead that may result from suction dredging activities.

I declare under penalty of perjury that the foregoing is true and correct.

Executed in Redding, California on January 20, 2006.

Neil Manji

studies and observations conducted by other state, federal, and tribal biologists that have identified and quantified thermal refugia within the Klamath River Basin. These summer rearing areas were prioritized based on a review of current thermal refugia data and information from other agency biologists, as well as professional judgment from direct observations. Designated thermal refugia are closed to suction dredging year round under the additional restrictions to avoid potential displacement or disturbance of juvenile coho or steelhead that may result from suction dredging activities.

I declare under penalty of perjury that the foregoing is true and correct.

Executed in Redding, California on January 20, 2006.

Neil Manji

DECLARATION OF SERVICE BY U.S. MAIL and FAX

Case Name: *Karuk Tribe of California and Leaf Hillman v. California Department of Fish and Game, et al.*

No.: 05 211597

I declare:

I am employed in the Office of the Attorney General, which is the office of a member of the California State Bar at which member's direction this service is made. I am 18 years of age or older and not a party to this matter. I am familiar with the business practice at the Office of the Attorney General for collection and processing of correspondence for mailing with the United States Postal Service. In accordance with that practice, correspondence placed in the internal mail collection system at the Office of the Attorney General is deposited with the United States Postal Service that same day in the ordinary course of business.

On January 20, 2006, I served the attached

DECLARATION OF NEIL MANJI IN SUPPORT OF OPPOSITION TO THE OBJECTIONS OF THE NEW 49'ERS, INC., AND RAYMOND W. KOONS TO THE PROPOSED STIPULATED JUDGMENT

by placing a true copy thereof enclosed in a sealed envelope with postage thereon fully prepaid, in the internal mail collection system at the Office of the Attorney General at 455 Golden Gate Avenue, Suite 11000, San Francisco, California 94102-7004, addressed as follows:

Roger Beers
Law Offices of Roger Beers
2930 Lakeshore Ave., Suite 408
Oakland, CA 94610
(510) 835-9849

Neysa A. Fligor
Stein & Lubin LLP
600 Montgomery Street, 14th Floor
San Francisco, CA 94111
(415) 981-4343

James Wheaton
Environmental Law Foundation
1736 Franklin Street, 9th Floor
Oakland, CA 94612
(510) 208-4562

Additionally, I served a true copy by facsimile machine, pursuant to California Rules of Court, rule 2008, in our facsimile machine at (415) 703-5480 and faxed the documents to ((510) 835-9849, (415) 981-4343, and (510) 208-4562. The facsimile machine I used complied with Rule 2008, and no error was reported by the machine. Pursuant to Rule 2008, subdivision (e)(4), I caused the machine to print a record of the transmission, a copy of which is attached to this declaration.

I declare under penalty of perjury under the laws of the State of California the foregoing is true and correct and that this declaration was executed on January 20, 2006, at San Francisco, California.

Elza Moreira
Declarant

[signature]
Signature

EXHIBIT A

State of California – The Resources Agency ARNOLD SCHWARZENEGGER, Governor

DEPARTMENT OF FISH AND GAME

http://www.dfg.ca.gov

TO: All Suction Dredge Permittees

Attached at the end of this document are the Department of Fish and Game's current regulations applicable to suction dredging in rivers, streams, and lakes. To use the regulations, follow the steps below.

Step 1: Review the general regulations on suction dredging (Cal. Code Regs., tit. 14, § 228), especially the sections on "Equipment Requirements" (Cal. Code Regs., tit. 14, § 228(e)) and "Restrictions on Methods of Operation" (Cal. Code Regs., tit. 14, § 228(f)).

Step 2: To determine the season during which suction dredging is allowed and any special restrictions that apply to the stream, river, or lake in which you intend to suction dredge, complete the following steps:

1. Note the classifications (Classes A–G) in section 228.5(a) under "Suction Dredge Use Classifications and Special Regulations." The classifications specify the time period when suction dredging is allowed.

2. Find the name of the river, stream, or lake in which you intend to suction dredge in section 228.5(d). Any special restrictions will be listed. If the stream, river, or lake is not listed by name in section 228.5(d), go to step 3. **If you intend to suction dredge in the Klamath, Scott, and Salmon Rivers, or their tributaries, new restrictions on suction dredging in those waters took effect on November 30, 2005. The new restrictions are discussed in the attached "Additional Information Concerning Suction Dredging."**

3. In section 228.5(b), find the county where the river, stream, or lake you intend to suction dredge is located and note the classification. The classification for that county will govern when you may suction dredge.

Step 3: Carefully read the attached "Additional Information Concerning Suction Dredging" for more information.

If you have any questions regarding suction dredging, contact the Department regional office that serves the county where you intend to suction dredge. The regional offices are listed in the general and special suction dredge applications and at www.dfg.ca.gov/licensing/officelocation.html.

ADDITIONAL INFORMATION CONCERNING SUCTION DREDGING

1. General Information

The regulations in Sections 228 and 228.5 of title 14 in the California Code of Regulations generally govern suction dredging in California. In addition to those regulations, other laws, regulations, and policies may apply, including, but not limited to, the following:

- A suction dredge permit does not allow trespassing. Be sure you have permission from the landowner or the land managing agency before entering private and public lands.
- Substantially altering the flow, or the bed, bank, or channel, of a river, stream, or lake may require a Lake or Streambed Alteration Agreement. Contact your local Department of Fish and Game office for details.
- Waters in National Parks, National Monuments, State Parks, and designated wilderness areas may be closed to suction dredging. Contact the appropriate agency for details.
- Some waters in the San Gabriel Mountains are closed. Contact the Angeles National Forest before suction dredging in those waters.
- Portions of the Sequoia and Sierra National Forests, designated as the Kings River Special Management Area, are closed to suction dredging. Contact the appropriate U.S. Forest Service office for details.
- The Auburn State Recreation Area has special restrictions on suction dredging. Contact the Auburn State Recreation Area office for details.
- Suction dredging may be restricted in waters designated under the state and federal Wild and Scenic Rivers Acts. Waters designated under the acts include portions of the American River (North Fork and Lower American River), Big Sur River, Eel River, Feather River, Kern River, Kings River, Klamath River, Merced River, Sespe Creek, Sisquoc River, Smith River, Trinity River, and the Tuolumne River. Contact the state Resources Agency or federal land managing agency for details.

2. Special Suction Dredge Permits

The Department may not issue special suction dredge permits to suction dredge in closed areas or during closed seasons. The Office of the Attorney General has advised the Department that to the extent the regulations allow the Department to issue such special permits, they are invalid because they exceed the scope of the Department's statutory authority under Fish and Game Code section 5653. As a result, the Department no longer accepts applications for special permits to suction dredge in closed areas or during closed seasons. However, the Department may still issue special permits to suction dredge with an intake nozzle larger than prescribed in the regulations, subject to compliance with the California Environmental Quality Act.

3. New Restrictions on Suction Dredging in the Klamath, Scott, and Salmon Rivers, and Their Tributaries

New restrictions on suction dredging in the Klamath, Scott, and Salmon Rivers, and their tributaries took effect on **November 30, 2005**. The new restrictions (attached) are the result of a lawsuit brought by the Karuk Tribe against the Department of Fish and Game. (*Karuk Tribe, et al. v. California Department of Fish and Game, et al.*, Super. Ct. Alameda County No. RG 05211597.) The Karuk Tribe filed their lawsuit in May 2005, alleging the Department was violating the California Environmental Quality Act and Fish and Game Code section 5653(b) by issuing permits to suction dredge in the Klamath, Scott, and Salmon Rivers, and their tributaries under the Department's existing regulations for suction dredging. (See Cal. Code Regs., tit. 14, §§ 228, 228.5.) The new restrictions on suction dredging in the Klamath, Scott, and Salmon Rivers, and their tributaries will substantially lessen the potential for impacts on coho salmon, a species listed as threatened under the California Endangered Species Act, and other sensitive fish species, including lamprey and green sturgeon.

Most of the new restrictions modify the existing restrictions on suction dredging in the Klamath, Scott, and Salmon Rivers, and their tributaries in the Department's suction dredge regulations. Where the new restrictions conflict with the existing restrictions, the new restrictions apply. **All persons who obtain a suction dredge permit on or after November 30, 2005, will need to comply with the new restrictions.**

NEW RESTRICTIONS ON SUCTION DREDGE MINING

EFFECTIVE NOVEMBER 30, 2005

A. THE KLAMATH RIVER AND ITS TRIBUTARIES

Suction dredge mining is NOT allowed:

1. On the main stem of the Klamath River from its confluence with the Trinity River to Iron Gate Dam *except from July 1 through September 15.*

2. On the following tributaries of the Klamath *at any time of the year*: Indian, Elk, Dillon, Independence, Bluff, Red Cap, Camp and Clear Creeks.

3. On all other Klamath River tributaries, *except from July 1 through September 15.*

B. THE SALMON RIVER AND ITS TRIBUTARIES

Suction dredge mining is NOT allowed:

1. On the main stem Salmon River from its confluence on the Klamath River to the Forks of the Salmon River (i.e., the confluence of the North and South Forks of the Salmon River) *at any time during the year.*

2. On the North and South Forks of the Salmon River, *except from July 1 through September 15.*

3. On the following tributaries of the Salmon River *at any time of the year*: Butler Creek, East Fork Knownothing Creek, Indian Creek, Kelly Gulch, Knownothing Creek, Little North Fork, Methodist Creek, Negro Creek, Nordheimer Creek, and Specimen Creek.

C. THE SCOTT RIVER AND ITS TRIBUTARIES

Suction dredge mining is NOT allowed:

1. On the Scott River from its mouth to Headwaters, *except from July 1 through September 15.*

2. On the following tributaries of the Scott River *at any time of the year*: Big Mill Creek (East Fork), Boulder Creek (South Fork), Canyon Creek, Etna Creek, French Creek, Kangaroo Creek (East Fork), Kelsey Creek, Kidder Creek, McAdam Creek, Mill Creek (Scott Bar), Mill Creek (aka Shackleford/Mill), Miners Creek, Moffett Creek, Patterson Creek, Shackleford Creek, South Fork Scott River, Sugar Creek, Tompkins Creek, Wildcat Creek, and Wooliver Creek.

D. THERMAL REFUGIA

Thermal refugia areas are located at the confluence of the tributary and the main stem of the river. Suction dredge mining is <u>NOT</u> allowed *at any time of the year* at the thermal refugia areas designated below within five hundred (500) feet up the named tributary from the confluence with the main stem and five hundred (500) feet up and downstream on the main stem from the confluence of the tributary with the main stem.

1. The thermal refugia on all direct tributaries on the Klamath, Salmon, and Scott Rivers that are closed to suction dredge mining for the entire year as listed above.

2. The thermal refugia areas at the confluence of the following tributaries with the main stem of the Klamath River: Beaver Creek, Bluff Creek, Bogus Creek, Boise Creek, Camp Creek, Clear Creek, Coon Creek, Elk Creek, Grider Creek, Hopkins Creek, Horse Creek, Hunter Creek, Independence Creek, Indian Creek, Irving Creek, Little Grider Creek, Pearch Creek, Pecwan Creek, Red Cap Creek, Rogers Creek, Salmon River, Salt Creek, Scott River, Slate Creek, Swillup Creek, Thomas Creek, Ti Creek, Tom Marten Creek, Trinity River, and Ukonom Creek.

3. The thermal refugia at the confluence of all tributaries on the North Fork of the Salmon River from Eddie Gulch to the Forks of the Salmon (i.e., the confluence of the North and South Forks of the Salmon River) and Crapo Creek on the main stem below the Forks of the Salmon River.

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SUPERIOR COURT OF THE STATE OF CALIFORNIA
COUNTY OF ALAMEDA
HAYWARD DIVISION

KARUK TRIBE OF CALIFORNIA; AND LEAF HILLMAN, Plaintiffs, v. CALIFORNIA DEPARTMENT OF FISH AND GAME; AND RYAN BRODDRICK, DIRECTOR, CALIFORNIA DEPARTMENT OF FISH AND GAME, Defendants. THE NEW 49'ERS, a California Corporation; AND RAYMOND W. KOONS, an Individual; AND GERALD HOBBS, an Individual, Intervenors.	Case No.: RG 05 211597 **DECLARATION OF NEIL MANJI IN SUPPORT OF DEFENDANTS' CASE MANAGEMENT CONFERENCE STATEMENT** Judge: Honorable Bonnie Sabraw Place: Department 512 Date: October 17, 2006 Time: 9:00 a.m. Action Filed: May 6, 2005 Trial Date: None Set

I, Neil Manji, declare as follows:

1. I am currently employed by the California Department of Fish and Game ("Department") as the Fisheries Branch Chief. The matters set forth in this declaration are within my personal knowledge and if called upon to testify to these matters I could and would so testify.

//

2. This declaration supplements my prior declaration in the present action as executed in Redding, California, on January 20, 2006, and filed with the Alameda County Superior Court on January 23, 2006.

3. In my current position as Fisheries Branch Chief for the Department I am responsible for setting statewide policy relating to the development and implementation of fishing regulations, watershed restoration and protection guidelines. I am also a member of the Klamath Basin Fishery Task Force and Klamath Fishery Management Council.

4. Prior to serving as Fisheries Branch Chief, I worked for the Department as the Fisheries Program Manager for the eight counties that comprise the Department's Northern California-North Coast Regional Office ("Region"). In that capacity I oversaw all fisheries programs in the Region, including programs involving: (1) fisheries habitat restoration; (2) inland and anadromous fisheries resource assessment and monitoring; (3) watershed assessment; and (4) salmon, steelhead, and trout hatcheries. I hold a Bachelor of Science degree with a major in Fisheries that I received from Humboldt State University in 1986, and have worked as a fishery biologist since 1989. My work as a fishery biologist focused on the Klamath River specifically from 1984 through 1986, from 1999 through 2005 until I began my current job as the Fisheries Branch Chief with the Department in April 2006.

5. I make this declaration to provide additional detail to the court regarding the Department's current opinion that suction dredge mining under existing regulations found in Title 14 of the California Code of Regulations in sections 228 and 228.5 (the "existing regulations") in the Klamath, Scott and Salmon River watersheds is resulting in deleterious effects on coho salmon (*Oncorhynchus kisutch*). The Department expressed its current opinion to the court for the first time in a Case Management Conference Statement filed in the present action on September 6, 2006.

6. This declaration and the Department's current opinion are based on existing scientific literature, data available to the Department, and my professional experience as a fishery biologist. With respect to scientific literature, there is now a substantially larger body of published, peer reviewed scientific research regarding fisheries science and suction dredge mining than there was at

the time the Department promulgated the existing regulations in 1994. A list of the scientific literature cited below is attached to this declaration as Exhibit A.

7. With respect to relevant data, the Department also has substantially more information than it did in 1994 regarding the distribution, and presence and absence of coho salmon throughout the species' range. This information and data is the result of work by Department personnel alone or in cooperation with scientists from other public agencies, members of the academic community, and various tribal interests. The information and data is the direct result of, among other things, presence/absence surveys, spawning ground surveys, juvenile out-migrant surveys, fish kill investigations, and thermal refugia surveys.

8. As explained below, based on a review of the scientific literature, data available to the Department, and my experience as a fishery biologist, it is my professional opinion as the Fisheries Branch Chief for the Department that suction dredge mining under the existing regulations in the Klamath, Scott and Salmon River watersheds is having deleterious effects on coho salmon, a species currently protected by the California Endangered Species Act ("CESA") (Fish & G. Code, § 2050 et seq.).

9. In general, the current scientific literature indicates suction dredge mining adversely affects aquatic resources to varying degrees. Poor mining practices have been shown to alter channel configuration, destabilize stream banks, and degrade habitat. (Stern 1988; Harvey *et al.* 1995) Suction dredge mining has also been shown to affect water quality through localized and temporary increased sediment loads. (Harvey *et al.* 1982; Stern 1988; Harvey *et al.* 1995; Prussian *et al.* 1999) Likewise, the scientific literature indicates tailings from suction dredge mining may provide attractive spawning substrate, but the dredge affected substrate is more unstable in higher winter flows than other spawning habitat unaffected by mining activity. (Harvey and Lisle 1998.) Finally, suction dredging has been shown to cause temporary and localized declines in invertebrate populations. (Harvey *et al.* 1982; Thomas 1985; Harvey 1986; Hassler *et al.* 1986; Harvey and Lisle 1998; Prussian *et al.* 1999) As explained below, all of these effects result in deleterious impacts to coho salmon during one or more of the species' life stages, even under the Department's existing regulations.

Spawning

10. The scientific literature, available data and survey information possessed by the Department indicate coho salmon typically spawn in the Klamath Basin from November through January. (Maurer 2002, 2003; Quigley 2005) Spawning has also been documented in the Klamath system (which includes the Scott and Salmon Rivers) as early as late September. ((CDFG 2004), cooperative spawning ground survey data 2005.) Spawning is an extremely high energy activity for all salmon, including coho. According to the scientific literature, Pacific salmon, including coho, that are subjected to added stressors (Berman 1990 as cited in (McCullough 1999)) or migration delays (Andrew and Geen 1960 as cited in (McCullough 1999)) during spawning experience reduced spawning success and pre-spawn mortality. In order to avoid deleterious impacts it is important coho salmon are not delayed or disturbed by instream activities such as suction dredge mining during their upward migration and spawning. Likewise, it is important to avoid instream activities like suction dredge mining once spawning is complete because it can take several months for eggs to develop and coho larvae to emerge from the gravel. Available data and scientific literature indicate coho fry emerge from the gravel from March to June (Hardy 1999; CDFG 2004).

11. Under the Department's existing regulations, suction dredge mining in the Klamath, Scott and Salmon River watersheds is generally governed by the "Class" D, G, and H designations. (See, e.g., Cal. Code Regs., tit. 14, § 228.5, subd. (d)(49), (76), (90).) The Class D designation authorizes suction dredge mining from July 1 through September 15; under the Class G designation suction dredging is authorized from the fourth Saturday in May through September 30; and, under the Class H designation, suction dredging is authorized throughout the year. (*Id.*, subd. (a)(4), (7), (8).) In light of these designations, suction dredge mining is currently authorized under the existing regulations during times of the year when coho are migrating and spawning, as well as when coho eggs and larvae are developing. Suction dredge mining during these times is causing deleterious impacts to coho salmon as a result.

12. Deleterious impacts on coho spawning are of further concern because of scientific literature regarding the use of dredge tailings as spawning substrate. That literature indicates tailings from

suction dredge mining can provide attractive spawning habitat for coho salmon because the tailings are loose and not compacted. (Harvey *et al.* 1995) However, the literature also indicates dredge tailings are often scoured or redistributed during high flows and, therefore, the tailings are not suitable spawning habitat. (Stern 1988; Harvey and Lisle 1998, 1999) Likewise, the scientific literature indicates scour is greater on dredge tailings than on natural substrates. (Harvey and Lisle 1999) The scientific literature indicates as a result that eggs and larvae deposited by fish on dredge tailings are at greater risk of scour than those on naturally deposited gravel. The stability of spawning gravel is critical to reproductive success of salmonids, including coho, because of the long time period that the eggs and embryos remain in the gravel. In short, coho eggs and embryos deposited in dredge tailings likely suffer higher mortality when high winter flows scour the tailings. (Harvey and Lisle 1998)

<u>Eggs and Alevin</u>

13. As described above, suction dredge mining is authorized under the existing regulations in the Klamath River system, including the Scott and Salmon Rivers and their tributaries, from July through the end of September, in some cases in May through September, and in other cases year round. During these times, particularly late September to June, when coho eggs, larvae, and alevin (a pre-emergent life stage where the yolk in a fertilized egg is nearly gone) are in the gravel. The Department is concerned these life stages are particularly vulnerable to deleterious impacts caused by suction dredging because the mining activity causes temporary and localized increases in turbidity.

14. The scientific literature indicates fine sediments suspended from suction dredging while eggs are developing may reduce the oxygen reaching developing eggs and alevins. (Harvey *et al.* 1995) For example, the presence of clay particles can create a thin film across the egg membrane and reduce the consumption of oxygen in developing eggs. (Greig *et al.* 2005) Reduced oxygen has been linked in the scientific literature to reduced survival and greater deformities in some salmonid eggs. (Bisum *et al.* 2002) Because suction dredging is authorized under the existing regulations during times when eggs or alevin may still be in the gravel (CDFG 2004), fine

sediments suspended by suction dredge mining activity is likely causing deleterious localized impacts to coho during this particularly vulnerable life stage.

15. The Department is also particularly concerned about deleterious impacts to coho eggs and alevin resulting from entrainment of the life stage in suction dredge mining equipment. According to the scientific literature, entrainment can cause varying mortality rates to salmonid eggs at differing developmental stages. (Griffith and Andrews 1981 as cited in (CDFG 1994; Harvey and Lisle 1998) The scientific literature also indicates alevin specifically suffer high mortality rates following entrainment. (Griffith and Andrews 1981 as cited in (CDFG 1994; Harvey and Lisle 1998) Because eggs and alevin are still in the gravel when suction dredge mining is authorized under the existing regulations, mining activities are likely causing deleterious localized impacts to coho during this particularly vulnerable life stage.

<u>Juveniles</u>

16. The Department is concerned suction dredge mining during periods of time currently authorized under the existing regulations is having deleterious impacts on juvenile coho salmon. Although juvenile and adult coho are not likely to be entrained in suction dredge mining equipment, several aspects of dredging may affect juvenile coho distribution. Unlike Chinook salmon, juvenile coho reside in tributaries for a year or more before emigrating to the ocean. Over summering habitat is thus critical to the survival of juvenile coho.

17. The scientific literature establishes suction dredge mining can affect stream channel stability and streambed morphology (Harvey *et al.* 1982; Harvey 1986; Hassler *et al.* 1986; Stern 1988; CDFG 1994; Harvey and Lisle 1998, 1999) which can affect salmonid distribution. Dredge tailings can alter habitat depth by filling in pools (Harvey and Lisle 1998) and small streams where coho rear are particularly susceptible to this effect if the tailings span the entire width of the stream. The scientific literature indicates, for example, that a reduction in pool volume from dredging can cause a decline in abundance of rainbow trout in that pool. (Harvey 1986) This illustrates the ability of instream habitat changes to affect salmonid distribution. In addition to changes to stream morphology,

dredging releases prey items for immediate consumption. Yet, in the longer term, dredging causes localized decreases in macroinvertebrate populations that may affect feeding behavior and ultimately growth of juvenile salmonids, including coho. (Harvey *et al.* 1982; Thomas 1985; Harvey 1986; Hassler *et al.* 1986; Harvey and Lisle 1998; Prussian *et al.* 1999).

18. Juvenile and adult fish have been observed holding in dredge holes. (Harvey 1986; Stern 1988). However, the scientific literature indicates filling naturally occurring pools (Harvey 1986) with dredge tailings and creating new holes as a result of suction dredging displaces fish from preferred habitats with cooler water (CDFG 1994). Available data indicates juvenile salmonids use cold water thermal refugia around the mouths of numerous tributaries entering the Klamath, Shasta, Scott and Salmon Rivers (Belchik 1997, 2003; internal CDFG report 2000). Department biologists have documented the location and use of thermal refugia by salmonids, including coho, during field investigations and juvenile fish surveys. In addition, there have been several studies and observations conducted by other state, federal and tribal biologists that identify and quantify thermal refugia in the Klamath River Basin. The importance of cool water habitats/refugia is widely discussed in the literature. (Nielsen *et al.* 1994; Sauter *et al.* 2001; Welsh *et al.* 2001) The combined effects of temperature and potential displacement may be particularly detrimental in the Klamath Basin where water temperatures not only appear to be increasing (Bartholow 2005) but can exceed critical thresholds for coho (internal CDFG report 2000). Under the existing regulations, however, the importance of thermal refugia and disturbance to those habitats are not addressed.

I declare under penalty of perjury that the foregoing is true and correct.

Executed in Sacramento, California on October 2, 2006.

By: ______________________

NEIL MANJI

Exhibit A to Declaration of Neil Manji

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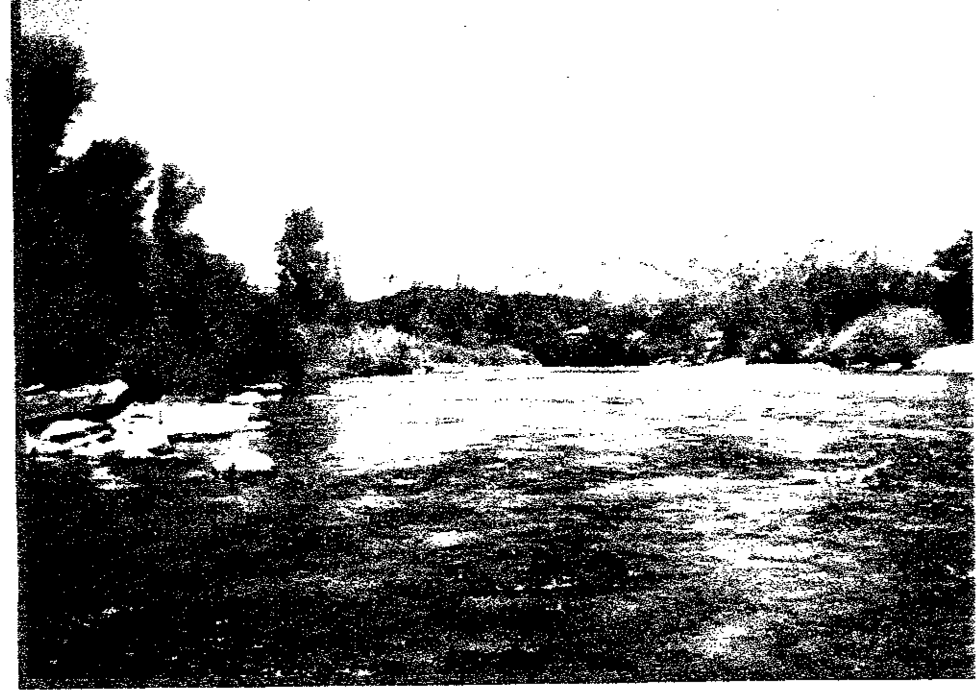
MERCURY

LOSSES AND RECOVERY



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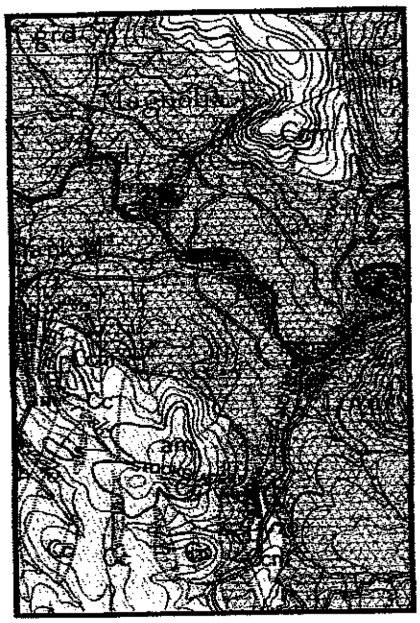

FIGURE 1: *Historical Map of Coloma, California by Waldemar Lindren (1894), United States Geological Survey Folio#3 - Placerville, California, Economic Geology - northwest (Courtesy of: Craig Couch)*

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INTRODUCTION

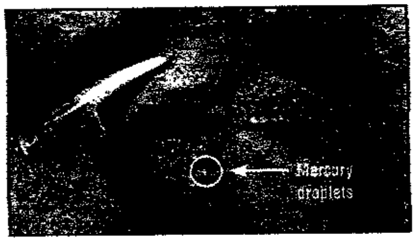

FIGURE 3: Under water photograph showing river sediment, bedrock, and mercury droplets. (Photo by: Rick Humphreys, DWQ)

Mercury has been used widely since the dawn of recorded history for gold mining. During California's gold rush, gold miners used about 6 million kilograms or 6.6 thousand tons of mercury (Churchill, 2000) to recover over 3.6 thousand tons of gold (Bulletin 193). **The weight of mercury used is roughly equal to the total weight of a 9-mile long line of 2,750, full sized pickup trucks (note: the pick up truck line equaling gold recovered would only be 5 miles long). The miners lost about half of the mercury to the environment.**

Using historical records, Churchill (2000) estimated that total mercury losses ranged between 2.3 million and 2.6 million kilograms for placer and lode mining in the Sierra Nevada Geomorphic Province. Consequently, elemental mercury from the gold rush is still found, sometimes in amounts that constitute a local hotspot (i.e., a location where visible elemental mercury is found) in Sierra Nevada watersheds where gold mining occurred. In March 2003, a recreational gold miner reported a mercury hotspot in the South Fork of the American River near Coloma, to State Water Resources Control Board staff. It was the first time a recreational gold miner had revealed a hotspot locations to agency staff. Coloma is California's historic "Gold Discovery" site as James W. Marshall's discovery there in January 1848 initiated the 1849 gold rush. Steve Franklin, the recreational gold miner who reported the hotspot, claimed to have recovered about a kilogram of mercury while gold mining from the hotspot during January and February 2003.

Finding a hotspot near Coloma raised questions about its potential threat to human health, effects on local fish, and threat to water quality. Moreover, its discovery presented an opportunity to test the notion that recreational gold miners effectively *clean up mercury hotspots while suction dredging for gold.* There is no record of any attempts by state or federal agencies to clean up a mercury hotspot in a California river. But State and federal agencies have discussed whether encouraging or even providing support for recreational gold miners to clean up hotspots is viable and wise. The pros are that there is a potentially large, volunteer workforce. The cons are that oversight would be difficult and, up to now, no data supported the notion that suction dredges could recover mercury efficiently.

FIGURE 2: Steve Franklin and SWRCB staff sampled the hotspot on July 8, 2003, and recovered about 125 grams of mercury in about three hours from the river using simple suction recovery tools. Mercury was visible as droplets ranging from one to ten millimeters on bedrock in the river channel. (Photo by: Rick Humphreys, DWQ)

Recreational gold dredging on public and private lands is a moderately popular activity in California. The Department of Fish and Game (DFG) issues several thousand permits annually to recreational gold dredgers. Along with gold, recreational dredgers recover iron (nails bolts, etc.), lead (fishing weights, buckshot, and spent bullets) and mercury (elemental mercury, mercury/gold amalgam, and mercury stained gold). Over the past several years, United States Forest Service (USFS), Bureau of Land Management (BLM) and State agency staff have discussed setting up a mercury recovery program for recreational dredgers. Incentives (e.g., cash for mercury, free dredging permits, new areas opened for dredging) were proposed in exchange for mercury turned in by recreational dredgers. Offering such incentives was and remains controversial for a variety of reasons and a mercury recovery program was not started. ***Moreover, an important drawback* was that the efficiency of a standard suction dredge at recovering mercury was unknown.** Consequently, no one knew if mercury would be lost along with waste sediment from a suction dredge. Clearly, a mercury recovery program that dispersed elemental mercury back into a stream in substantial amounts would be unacceptable. The hotspot presented an opportunity to determine the mercury recovery efficiency of a suction dredge.

Studying the hotspot may also reveal bedrock characteristics and sediment transport conditions that cause hotspots, and the effects that concentrated mercury has on local fish. This report documents the results of a suction dredge test that was completed in September 2003 by State Water Board, USFS, and DFG staff.

Hotspot Setting

The hotspot is located mid-channel in the South Fork of the American River, a few miles downstream from the Marshall Gold Discovery State Park at Coloma. Surface placers and in-river gravel accounted for most gold produced from the area during the gold rush and in-river dredging recovered more gold during the 1930s and 1940s (Bulletin 193). These historic mining operations are the likely mercury source.

The hotspot is located on the downstream side of a low bedrock hump that extends across the river channel perpendicular to its flow. Because the hotspot remains underwater under all observed flow conditions. State Water Board skin divers recorded how the mercury occurred on bedrock and in river sediment visually. The bedrock hump is shaped like a low-pitched roof. River sediment forms wedge-shaped deposits on the up and downstream sides of the hump. Easily visible, small (e.g., 1mm)

FIGURE 4: "The hotspot is located mid-channel in the South Fork of the American River, a few miles downstream from the Marshall Gold Discovery State Park at Coloma." (Photo by: Rick Humphreys, DWQ)

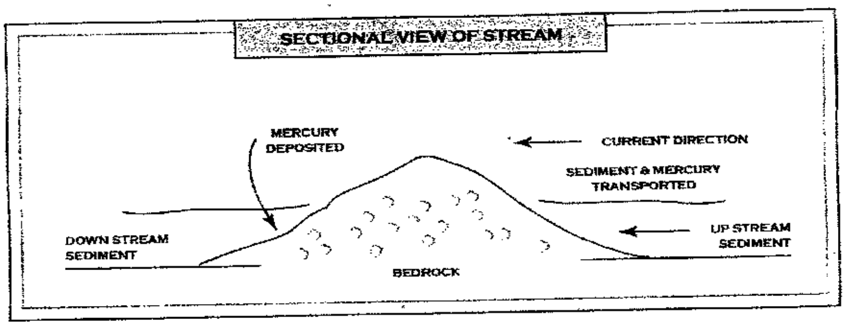

FIGURE 5: Cross-sectional view of stream: graphic showing where mercury deposits on bedrock.

mercury droplets permeate the sediment at the thin upstream edge of the downstream wedge (see fig.2). Hand "fanning" stirs up fine-grained sediment, which is carried away by the river current. Elemental mercury, however, remains on bedrock, and continued fanning causes small mercury droplets to fall into bedrock depressions and fractures. When mercury droplets touch, they fuse into much **large** droplets (up to 25 millimeters). **Hand fanning the upstream sediment wedge also exposes elemental mercury in bedrock depressions and fractures** but in much smaller amounts than on the downstream side.

River flow at the hotspot is uncontrolled during winter and spring runoff but controlled for hydroelectric and recreational rafting purposes for the rest of the year. During controlled flow periods, flows typically range from 200 to 1,200 cubic feet per second (cfs) daily. High runoff coincides with winter storms, and these flows have ranged to 80,000 cfs as recently as 1997. Post dredge test inspections show that during low flow periods (200 cfs), sediment does not travel over the bedrock hump. But post dredge test inspections also showed that mercury had re-deposited on bedrock that had been dredged clean. Higher controlled flows may be moving sediment and mercury over the hump but attempts to observe sediment movement directly at higher flows proved too dangerous.

Mercury may concentrate at the hotspot because after it is carried over the bedrock hump during high flows, it encounters a low flow velocity zone on the downstream side of the bedrock hump. The river current on the downstream side lacks the power to move mercury anymore so it drops out on bedrock on the downstream side. If this scenario is correct, **periodic mercury recovery from this location might be practical.** A mercury removal system's design would depend on the site's the physical characteristics which are unknown. A detailed evaluation of mercury and sediment transport and flow velocity at the hotspot surface would be necessary if periodic mercury removal from this site is considered.

Suction Dredge Test

The USFS volunteered their mineral evaluation team, based in Redding (Rich Teixeiria, Jim DeMaagd, and Tera Curren), to perform the test. According to Rich Teixeiria, the team's dredge is a Keene Engineering floating 4 inch dredge powered by a Honda 5.5 horsepower engine. It is similar to those used by recreational dredgers to recover gold (see fig.3). A single sluice box used carpet and riffles but no "miners" moss (i.e., woven nylon fabric placed between the riffles and carpet for enhanced gold recovery).

The team performed the dredge efficiency test on Sept.15, 2003. The 63.5kg sediment sample used in the test had been collected by State Water Board staff from the hotspot and characterized for grain size and mercury content. State Water Board staff analyzed the sample's grain size at the Cal Trans Laboratory in Sacramento. The sample classifies as a "clean gravel with sand" under Unified Soil Classification System. Visual inspection of size fractions showed that almost all the liquid mercury rested in the fraction that passed a 30-mesh sieve (0.6mm). The mercury content of this fraction served as a surrogate for the mercury content of the entire sample. Chris Foe of the Central Valley Regional Water Quality Control Board had two 30-mesh passing fractions of the sample analyzed for mercury by ALS Chemex Laboratory in Reno, NV. Two suspended sediment samples of the bulk sample (i.e., samples of sediment that settled out of water used for sieving after an hour) were sent to ALS Chemex Laboratory for mercury analysis. A second set of samples from archived material was sent to Frontier Geosciences in Seattle, WA after reliability problems were discovered with analyses performed on standards by ALS Chemex. During the test, the USFS team captured sediment lost off the sluice in a catch basin for later analysis. Small mercury droplets and fine, barely discernable droplets (i.e., floured mercury) were characteristic of these samples. After the test, 30 mesh and finer dredge concentrates and "waste" sediment were sent to ALS Chemex Laboratory. ALS Chemex Laboratory used an analytical method that could not quantify the high mercury concentration in the mercury-rich samples. So a second set of samples was sent to Frontier Geosciences for analyses.

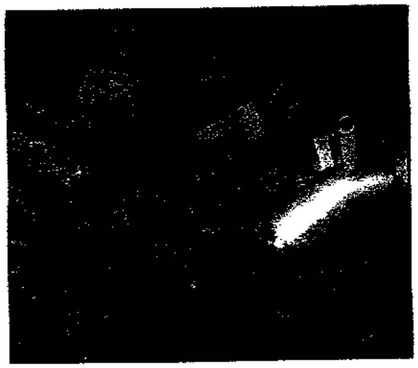

FIGURE 6. Dredging the hotspot. (Photo by: Rick Humphreys, DWQ)

The team (USFS and State Water Board staff) dredged the hotspot the next day on Sept. 16, 2003, and DFG staff recorded the test on video.

Results - Laboratory Data

ALS Chemex reported that the mercury content of the samples received exceeded the upper detection limit of the analysis used and did not reanalyze the samples. As a result, the Frontier Geosciences analyses were used for this report. The bulk sample mercury concentration was 1,170ppm; the mercury concentration of the sediment captured by the dredge was 1,550ppm, and the mercury concentration of the sediment lost by the dredge was 240ppm. The suspended sediment sample mercury concentration was 298ppm. Note that these mercury concentrations are quite high. **Mercury concentrations of the waste and suspended sediment are over an order of magnitude higher than the minimum concentration necessary for classification as a California hazardous waste (20mg/kg).** The suspended sediment's high mercury content is problematic because after re-suspension by dredging, it can be carried long distances by stream current.

RESULTS - SUCTION DREDGE EFFICIENCY

It is necessary to know how elemental mercury, which is a dense liquid, behaves physically when evaluating the laboratory results. During dredging, large mercury droplets were broken up into small droplets by turbulence. The phenomenon is called "flouring" and it is described as a major cause of mercury loss by historic hydraulic gold mining operations. Confounding matters is mercury's ability to form large droplets from small droplets. This causes mercury enrichment of sediment captured on the sluice because small mercury droplets that are caught in the low velocity area behind the sluice riffles fuse into large droplets just as they do on the downstream side of the bedrock hump. Sluice sediment samples had large and small mercury droplets. Such samples are subject to analytical bias from either a single large mercury droplet, or the absence of any mercury droplets.

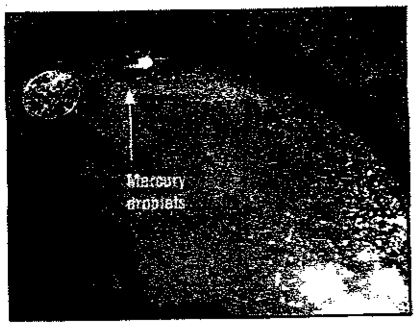

FIGURE 7: Mercury panned from a small creek below the Sailor Flat Hydraulic Mine, Nevada County. (Photo by: Rick Humphreys, DWQ)

Bias probably is affecting the analytical results for the efficiency test. The mercury concentration for the captured sediment is 32 percent higher than that of the parent sample, and that may be because the captured sediment sample analyzed had one or two large mercury droplets. However, in absolute terms, the mercury concentration of both samples agrees fairly well. Mercury concentrations in sediment lost by the dredge was averaged (30-mesh and finer and suspended sediment). The mercury concentration of the lost sediment fractions is about 2 percent that of the test sediment's mercury concentration. Thus, the dredge removed about 98 percent of the mercury from the test sample based on concentration. Unfortunately, a mass balance of sediment captured and lost, as part of the test was not performed because we did not have an accurate total mass for the lost fraction.

The test showed that a typical suction dredge set up to recover gold recovered about 98 percent of the mercury in the high-mercury, test sediment sample. However, the loss was in sediment that had high mercury content and is easily transported away by the river.

RESULTS - IN-RIVER TEST

The team dredged about four yards or about 5,900 kilograms (6.5 tons) of sediment from the hotspot. Team members used special care to find and dredge large liquid mercury droplets as well as mercury-laden sediment from the site. During clean up after the test, team members noted large mercury droplets captured on the sluice. From the 30-mesh passing fraction, SWRCB staff separated about 0.5kg liquid mercury (see fig. 4). The remaining 2.2kg of sediment retained a substantial amount of liquid mercury as small (e.g., 1mm) and fine droplets of floured mercury, which floated on water used to immerse the sediment. Separating residual mercury from the sediment by physical means proved impossible. The mercury content of a 1.1kg sample was determined directly heating the sample and recovering the mercury vapor (i.e., retorting). The retorted sample contained 20gm of mercury or 1.8 percent. The dredge concentrate contained 540gm of mercury (liquid mercury + retorted mercury/ 1.1kg x 2), which accounted for about 20 percent of the sample mass (540gm mercury/2.7kg sieved sample x 100). Note that the mercury concentration of captured sediment from the in river test is about ten times higher than that reported for the efficiency test. The difference likely reflects the success of the dredge team in finding and dredging up mercury droplets during the in river test.

FIGURE 5: Jim DeMaagd and Rich Teixeira setting up the dredge. (Photo by: Rick Humphreys, DWQ)

CONCLUSIONS AND RECOMMENDATIONS

1. A suction dredge set up to recover gold recovered liquid mercury from the mercury hotspot. The dredge recovered about 98 percent of the mercury in a test sediment sample enriched in mercury. Mercury concentrations in the fine and suspended sediment lost from the dredge were more than ten times higher than that needed to classify it as a hazardous waste.

2. Lost sediment with high mercury levels is, in effect, mercury recycled to the environment. Floured mercury in fine sediment and mercury attached to clay particles in suspended sediment may be carried by the river to environments where mercury methylation occurs and where fish have high mercury concentrations. The consequences of having floured mercury added to biologically active areas where mercury methylation already occurs are currently unknown because the methylation potential of floured elemental mercury is unknown. But tests are underway at the DFG laboratory at Moss Landing to determine the methylation potential of floured mercury in sediment samples from this hotspot.

3. It is unacceptable to encourage suction dredgers to "clean up" in stream mercury hotspots because dredges release too much mercury in easily transportable forms. There may be other reasons to discourage suction dredging of mercury hotspots once the bioavailability of floured mercury becomes known. It would be advisable for land management agencies to contact dredgers through their clubs and discourage them from trying to dredge liquid mercury from in-river hotspots on public lands. Removing mercury with hand-operated suction tubes, or better yet, reporting hotspot locations to land management agencies is a better strategy.

4. It might be possible to design a shore-based recovery system for the Coloma hotspot and recover mercury annually. Such a system would need to minimize mercury loss. Recovery equipment would need to be held in storage during nonuse and operated by trained staff. Proper permits (e.g., in stream alteration, and, mercury disposal or recycling) would be needed. Such a project is more complex and costly in time, money, and commitment than previously considered projects. Developing such a system might result in technical advances that could be applied to dredges used by gold dredgers.

5. The sediment transport parameters that cause mercury to concentrate should be characterized. Such a characterization at Coloma might be useful for predicting where other hotspots are located in the South Fork of the American River and other watersheds, and it would provide the data for a recovery project described above.

6. The hotspot's effect on fish and invertebrates in this segment of South Fork of the American River should be determined

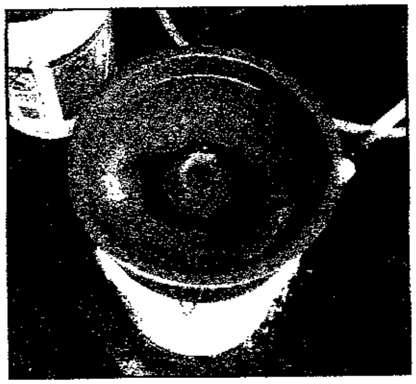

FIGURE 9. Liquid mercury (about 0.5kg) separated from sediment captured by the dredge. (Photo by: Rick Humphreys, DWQ)

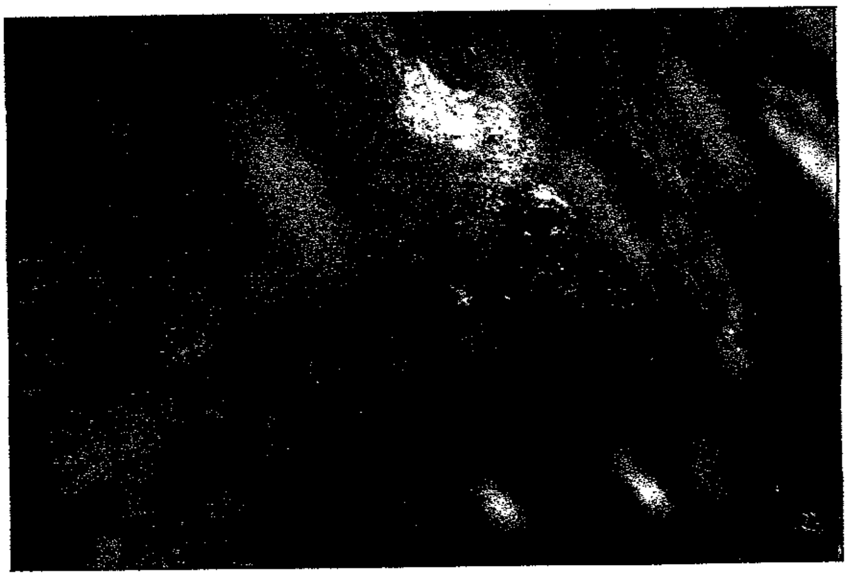

FIGURE 10: Under water diver searches for Mercury. (Photo by: Rick Humphreys, DWQ)

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Effects of Suction Dredging on Streams: a Review and an Evaluation Strategy

By Bret C. Harvey and Thomas E. Lisle

ABSTRACT

Suction dredging for gold in river channels is a small-scale mining practice whereby streambed material is sucked up a pipe, passed over a sluice box to sort out the gold, and discarded as tailings over another area of bed. Natural resource managers should be concerned about suction dredging because it is common in streams in western North America that contain populations of sensitive aquatic species. It also is subject to both state and federal regulations, and has provided the basis for litigation. The scientific literature contains few peer-reviewed studies of the effects of dredging, but knowledge of dredging practices, and the biology and physics of streams suggests a variety of mechanisms linking dredging to aquatic resources. Effects of dredging commonly appear to be minor and local, but natural resource professionals should expect effects to vary widely among stream systems and reaches within systems. Fishery managers should be especially concerned when dredging coincides with the incubation of embryos in stream gravels or precedes spawning runs soon followed by high flows. We recommend that managers carefully analyze each watershed so regulations can be tailored to particular issues and effects. Such analyses are part of a strategy to (1) evaluate interactions between suction dredging and other activities and resources; (2) use this information to regulate dredging and other activities; (3) monitor implementation of regulations and on- and off-site effects of dredging; and (4) adapt management strategies and regulations according to new information. Given the current level of uncertainty about the effects of dredging, where threatened or endangered aquatic species inhabit dredged areas, fisheries managers would be prudent to suspect that dredging is harmful to aquatic resources.

Suction dredging for gold is a small-scale mining practice whereby streambed material is excavated from a wetted portion of a river channel and discarded elsewhere. Suction dredges use high-pressure water pumps driven by gasoline-powered motors to create suction in a flexible intake pipe [commonly 75-300 cm (3 in-12 in) in diameter]. The intake pipe sucks streambed material and water and passes them over a sluice box that is usually mounted on a floating barge. Dense particles (including gold) are trapped in the sluice box. The remainder of the material is discharged into the stream and can form piles of tailings or spoils. Large boulders, stumps, and rootwads may be moved before excavating a site, and rocks too large to enter the intake pipe are piled nearby. Dredging can vary in area from a few small excavations to the entire wetted area in a reach and can exceed several meters in depth. Material is commonly dredged from pools and cast over downstream riffle crests.

Suction dredging is common during the summer in many river systems in western North America. It can affect aquatic and riparian organisms (Griffith and Andrews 1981; Thomas 1985; Harvey 1986), channel stability (T. E. Lisle and B. C. Harvey, personal observation), and the use of river ecosystems for other human activities.

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Suction dredging is regulated by both state and federal agencies, based in part on the U.S. General Mining Law of 1872, Organic Administration Act of 1897, and Clean Water Act of 1972. Suction dredging is an important issue to fisheries professionals because many dredged streams contain threatened or endangered species, and the adequacy of agency management of suction dredging has been legally challenged. Surprisingly, the effects of suction dredging on river ecosystems have not been studied extensively. A literature search yielded only five journal articles that specifically address the effects of suction dredging (Griffith and Andrews 1981; Thomas 1985; Harvey 1986; Hall 1988; Somer and Hassler 1992). However, some impacts of dredging can be predicted from general knowledge of physical and biological processes in streams.

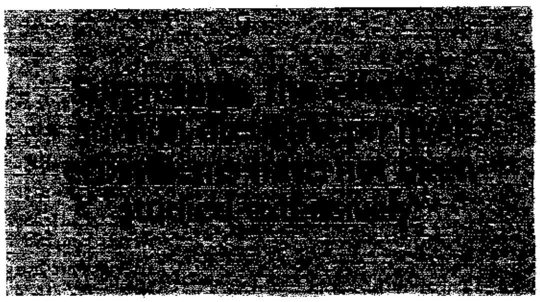
Our goals in this paper are to summarize potential effects of suction dredging on stream biota and physical channel characteristics and to propose a basin-scale strategy for evaluating the effects of suction dredging. We also identify several research areas critical to improving management of suction dredging in streams.

On-site effects of dredging

Entrainment of organisms by suction dredges

State regulations generally limit dredging to summer months, but dredging can still overlap with fish spawning and incubation of embryos. In some streams salmonids do not emerge from the substrate until summer, and many nonsalmonids have protracted spawning periods extending into summer (Moyle 1976).

Griffith and Andrews (1981) observed a range of mortality rates for aquatic organisms entrained into a suction dredge. Mortality among benthic invertebrates in four Idaho streams was generally low (<1% of more than 3,600 individuals) but was highest among an emerging mayfly species. In contrast, entrainment increased mortality of the early life history stages of trout. Mortality was 100% among un-eyed eggs of cutthroat trout (*Oncorhynchus clarki*) from natural redds but decreased to 29%-62% among eyed eggs. Similar tests at a commercial hatchery with eyed eggs of rainbow trout (*O. mykiss*) revealed little difference in mortality after 10 d between a control group (18% mortality) and a group that passed through a dredge along with gravel (19% mortality). Sac fry of hatchery rainbow trout suffered >80%o mortality following entrainment, compared to 9% mortality for a control group. Entrainment in a dredge also would likely kill larvae of other fishes. Sculpins (Cottidae), suckers (Catostomidae), and minnows (Cyprinidae) all produce small larvae (commonly 5 mm-7 mm at hatching) easily damaged by mechanical disturbance. Eggs of nonsalmonid fishes, which often adhere to rocks in the substrate, also are unlikely to survive entrainment. Fish eggs, larvae, and fry removed from the streambed by entrainment that survived passage through a dredge would probably suffer high mortality from subsequent predation and unfavorable physicochemical conditions.



Most juvenile and adult fishes are likely to avoid or survive passage through a suction dredge. All 36 juvenile and adult rainbow and brook trout (*Salvelinus fontinalis*) entrained intentionally by Griffith and Andrews (1981) survived. Adult sculpin also can survive entrainment (B. Harvey, personal observation).

Effects of excavation on habitat

Direct disturbance of streambeds, including dredging, tends to destabilize natural processes that mold stream channels. Channel topography, bed particle size, and hydraulic forces in undisturbed natural channels mutually adjust so variations in stream flow and sediment supply usually create only modest changes from year to year (Dietrich and Smith 1984; Nelson and Smith 1989). These adjustments allow a channel to transport its load of sediment. Excavation by dredging directly causes significant local changes in channel topography and substrate conditions, particularly in small streams. The resulting destabilization may increase local scour or fill in parts of the streambed that were not directly disturbed. Because hydraulic forces and sediment transport rates vary widely among and within channels from year to year, the persistence of dredging-related alterations also can vary widely. For example, dredged channels would be less likely to be remolded annually if they were downstream of impoundments or diversions that decrease peak flows and trap bedload.

Dredging that excavates streambanks may have long-lasting effects because streambanks are commonly slow to rebuild naturally (Wolman and Gerson 1978). Erosion of streambanks is likely to be greater where (1) streambanks and riparian vegetation are directly disturbed by suction dredging and related activities; (2) streambanks are composed of erodible materials such as alluvium; (3) dredging artificially deepens the channel along streambanks; and (4) the roughness of streambanks and the adjacent bed is reduced. Bank roughness in the form of large rocks, roots, and bank projections tends to reduce hydraulic forces on streambanks (Thome and Furbish 1995).

Dredging near riffle crests (the transition between pools and riffles) also can pose special problems for channel stability. If dredging causes riffle crests to erode, spawning sites may be destabilized, and upstream pools may become shallower. Disturbance of riffle crests also can destabilize the reach immediately downstream. Riffle crests are commonly flat, so any imposed topography would tend to deflect the flow to one side of the channel downstream, promoting bank erosion, and scour and fill of the bed (Figure 2). Dredge tailings placed in different locations from year to year would exacerbate these impacts.

In some locations excavations may temporarily improve fish habitat. Pools can be temporarily formed or deepened by dredging. Deep scour may intersect subsurface flow and create pockets of cool water during summer, which can provide important habitat for fish (Nielsen et al. 1994). At low flows, increased water depth can provide a refuge from predation by birds and mammals (Harvey and Stewart 1991). Harvey (1986) observed that all eight fish occupying a riffle during late summer in Butte Creek, California, moved into a dredged excavation nearby. However, dredged excavations are usually short-lived because they tend to be filled with sediment during high flows.

Piling of cobbles

Miners commonly pile rocks too large to pass through their dredges. These piles can persist during high flows and, as imposed topographic high points, may destabilize channels during high flows, as previously described. Piles of cobbles probably have only minor, local effects on the abundance of aquatic organisms. Taxa that strongly select large, unembedded substrate [e.g., speckled dace (*Rhinichthyes osculus*)] might become more abundant where cobbles are piled.

Deposition o f tailings

Sediment mobility

Gravel and coarse sand cast downstream during dredging tend to remain as loose tailings because there is insufficient power to transport them downstream. Fine sediment (clay, silt, and fine sand) will be carried further downstream in suspension, but minor proportions of this material are usually present in gravel streambeds (Lisle 1989). Moreover, a single dredging operation cannot mobilize significant volumes of fine sediment compared with the volume mobilized during high seasonal discharge, when erosional sources deliver fine sediment from the watershed and widespread areas of the streambed are entrained.

Benthic invertebrates

Exposure of new substrate and deposition of tailings locally reduce the abundance of benthic invertebrates. Both Thomas (1985) and Harvey (1986) measured significant reductions in some benthic invertebrate taxa within 10 m of dredges that disturbed the substrate. Harvey (1986) found that large-bodied insect taxa that avoid sand (e.g., hydropsychid caddisflies and perlid stoneflies) were most affected. These results are consistent with reduced benthic invertebrate abundance and species richness after complete embedding of larger substrate by fine sediment (e.g., Brusven and Prather 1974; Bjornn et al. 1977; McClelland and Brusven 1980). Somer and Hassler (1992) measured colonization of artificial substrates upstream and downstream of active dredges and found differences in assemblage composition but not in overall abundance. However, their artificial substrates were initially silt-free, while the surrounding substrate was not.

Bert Harvey

A miner works upstream of these dredges in Butte Creek, California, at a depth of greater than 2 meters.

Bert Harvey

This is the same site in spring of the following year. The log at water's edge in the upper, center-right of this photograph is visible in the upper center of the photo above.

In general, benthic invertebrates (Mackay 1992), hyporheic invertebrates (Boulton et al. 1991), and periphyton (e.g., Stevenson 1991; Stevenson and Peterson 1991) all rapidly recolonize small patches of new or disturbed substrate in streams. Abundance and general taxonomic composition of benthic invertebrates can be restored on dredge tailings four to six weeks after dredging (Griffith and Andrews 1981; Thomas 1985; Harvey 1986). In the three studies cited above, dredging disturbed only a minor proportion of available habitat for benthic invertebrates. Recolonization on tailings would probably be slower if dredging were more extensive because potential colonizers would be less abundant and more remote. However, recovery of benthic invertebrate communities after even large-scale disturbances (e.g., Minshall et al. 1983) suggests that both the total number of individuals and species diversity could recover even in areas of widespread dredging.

However, not all benthic inver-tebrates can be expected to rapidly recolonize disturbed areas. For example, many mollusks have low dispersal rates (Gallardo et al. 1994) and limited distributions in river systems (Green and Young 1993). Many aquatic insects also have limited geographic ranges (e.g., Erman and Nagano 1992). Populations of such species may be influenced strongly by local events such as suction dredging. Unfortunately, only about one-quarter of the freshwater mussels in the United States and Canada have stable abundances (Williams et al. 1993), and little is known about mussels in states where suction dredging is common (California, Idaho, Oregon, Washington). The challenge of evaluating the effects of dredging on aquatic invertebrates is often exacerbated by a lack of taxonomic information.

Stability of spawning gravels

Deposition of dredge tailings also may affect fish reproduction by inducing fish to spawn on unstable material (T. E. Lisle and B. C. Harvey, personal observation). Substrate stability is critical to spawning success of fall-spawning species because the weeks or months of embryo development in the gravel commonly coincide with the season of high flows that mobilize streambeds (Holtby and Healey 1986; Lisle and Lewis 1992). The coarseness of natural armor layers indicates the power of flows to move bed material (Parker and Klingeman 1982; Dietrich et al. 1989), so dredge tailings of fine gravel and sand that are cast over much coarser bed material (cobbles and boulders) have a high potential for scouring. State regulations in Idaho and Washington require dredge operators to backfill holes and level tailings, thereby increasing their stability.

Dredge tailings may be attractive to salmonids as sites for redd (nest) construction because tailings are often located near riffle crests where fish frequently spawn, and they provide relatively loose, appropriately sized substrate. However, dredge tailings may reduce embryo survival because they tend to be less stable than natural spawning gravels. Embryos in tailings may suffer high mortality if high flows scour the tailings, thereby destroying the redds.

The risk depends in part on the timing of spawning and high flows. Tailings are likely to be remolded or removed by high flows, providing greater stability afterwards. For example, fall spawners [chinook salmon (*Oncorhynchus tshawytscha*) and coho salmon (*O. kisutch*)] in northwestern California spawned on fresh tailings that were later completely scoured by seasonal high flows (T. Lisle and B. Harvey, personal observation). In contrast, unstable tailings are likely to be gone or remolded before reproduction by later-spawning species such as steelhead (*O. mykiss*).

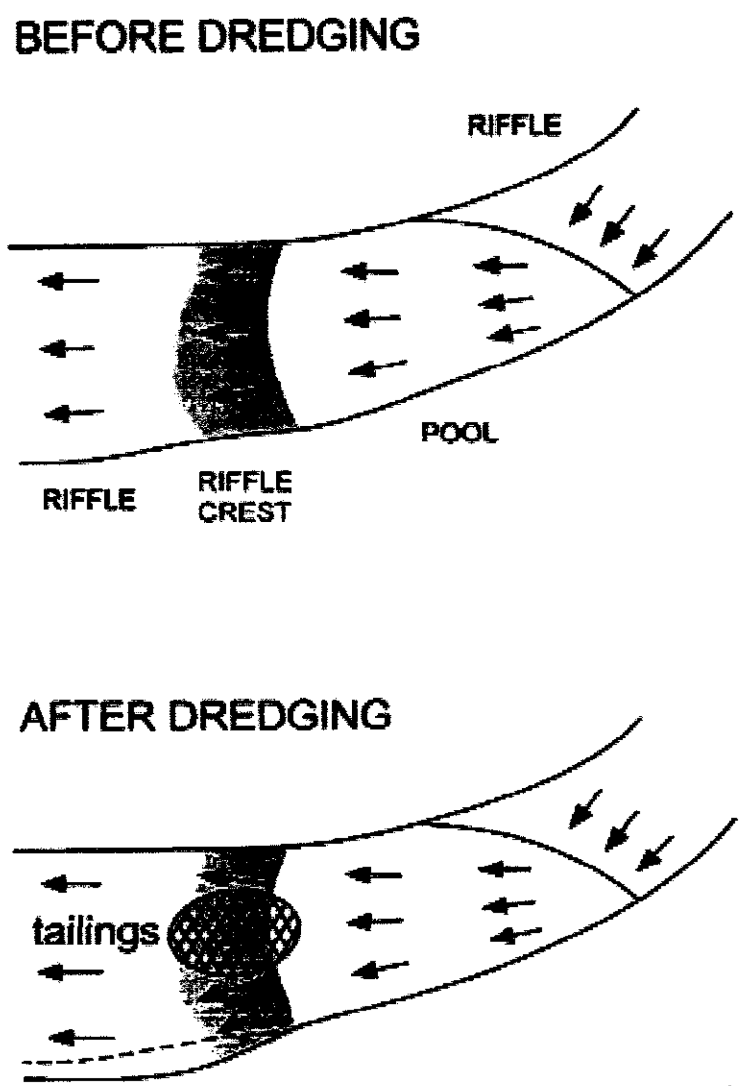


Figure 2. A conceptual planimetric view of a channel before and after dredging shows that diversion of flow around tailings on the riffle crest concentrates flow along the left bank and causes the bank to erode.

Little information exists on the selection of tailings by spawning fish. Hassler et al. (1986) noted that chinook salmon, coho salmon, and steelhead all spawned on dredge tailings in Canyon Creek in northwestern California. Three of eight spring chinook salmon redds, one of one coho redd, and one of eleven steelhead redds were located on dredge tailings. Selection of dredge tailings for spawning cannot be evaluated without knowing the overall availability of spawning gravels. However, spawning gravel was not in short supply in Canyon Creek, suggesting that tailings were not avoided by spawning fish (Hassler et al. 1986).

Tailings may significantly increase the availability of spawning sites for salmonids in channels lacking spawning gravel such as those that are armored with cobbles and boulders too large to be moved by spawning fish (Kondolf et al. 1991). However if such tailings are unstable, the population-level consequences of dredging could be negative. Considering the decline of populations Chinook salmon and coho salmon in western North America (Nehlsen et al. 1991), we think information on the relative stability of tailings and their use for spawning by these species is needed.

The relationship between suction dredging and spawning may require special consideration in regulated rivers. Impoundments commonly reduce sediment supply and peak flows downstream. Dredging may loosen and locally flush fine sediment from static streambeds, with little danger of redds being disturbed during egg incubation. However, we suspect that long-term improvement of spawning habitat by dredging downstream of dams is rare. Annual dredge mining (and renewal of spawning gravels) may not be sustainable because gold-bearing pockets would tend to be mined out without replenishment by new sediments. At the same time, dredge holes and tailings may be more persistent below impoundments, perhaps leaving these areas less suitable for recreation.

Fish habitat

Tailings also may influence juvenile and adult fishes, particularly if habitat depth and volume are altered substantially. Habitat depth is positively related to the abundance and/or size of salmonids (Everest and Chapman 1972) and other stream fishes (Harvey and Stewart 1991). The number of rainbow trout in a small pool in Butte Creek, California, declined by 50% after dredging upstream filled 25% of the pool volume (Harvey 1986). Clearly, small channels are more vulnerable to dredging impacts than large channels. For example, the entire width of small channels may be spanned by dredge tailings, creating shallow riffles that inhibit the longitudinal movement of aquatic organisms.

Some stream fishes can be affected by changes in substrate composition alone. Juveniles and adults of some benthic fish species (e.g., sculpin and dace) often occupy microhabitats beneath unembedded cobbles and boulders (Baltz et al. 1982; Harvey 1986). Harvey (1986) observed significantly reduced densities of juvenile and adult riffle sculpin (*Cottus gulosus*) downstream of a dredge on the North Fork of the American River, California, and attributed the decline in part to burial of cobbles by dredge tailings.

Movement of large roughness elements

Dredge operators may remove coarse woody debris (CWD) and large boulders from stream channels or reduce the stability of these elements by removing surrounding material. (Removing these elements from the stream is prohibited in some states.) Many pools are formed by scour around large roughness elements (Keller and Swanson 1979; Lisle 1986a; Montgomery et al. 1995). Large pieces and conglomerations of CWD are especially important because they cause scour of larger pools and can be more stable than smaller pieces (Bilby 1984). Furthermore, large roughness elements such as CWD can govern the location of scour and deposition at the scale of pools and riffles (Lisle 1986b; Montgomery et al. 1995).

Many studies provide evidence that CWD and other large elements affect various ecological processes and conditions in streams, including the microbial uptake and transfer of organic matter (Tank and Winterbourn 1996), the species composition and productivity of benthic invertebrates (Benke et al. 1984), and the density of fish (e.g., Fausch and Northcote 1992; Crispin et al. 1993). While fish may not always be associated with large substrate elements, these features may be limiting during critical events such as concealment by salmonids in winter (Heggenes et al. 1993; Smith and Griffith 1994) or reproduction by sculpins (Mason and Machidori 1976; Moyle 1976).

Suction dredging is likely to affect large roughness elements only locally, but because CWD has been depleted in many western streams by other human activities (Bilby and Ward 1991; Ralph et al. 1994), resource managers may still need to consider this issue.

Behavioral responses to dredging

Behavioral responses of stream biota to noises and vibrations generated by dredging have not been quantified. This issue appears insignificant for many taxa. Sculpin close to active dredges appear to behave normally (B. Harvey, personal observation), and juvenile salmonids have been observed feeding on entrained organisms at dredge outfalls (Thomas 1985; Hassler et al. 1986). However, Roelofs (1983) expressed concern that dredging could frighten adult summer-run steelhead, based on their response to divers. Spring-run chinook and summer-run steelhead adults held within 50 m of active dredges in Canyon Creek, California, (Hassler et al. 1986) but dredging may have inhibited upstream movement by the fish. Even minor disturbances during the summer may harm adult anadromous salmonids because their energy supply is limited, and the streams they occupy can be near lethal temperatures (Nielsen et al. 1994).

Off-site effects of fine sediment mobilized by dredging

Suspended sediment

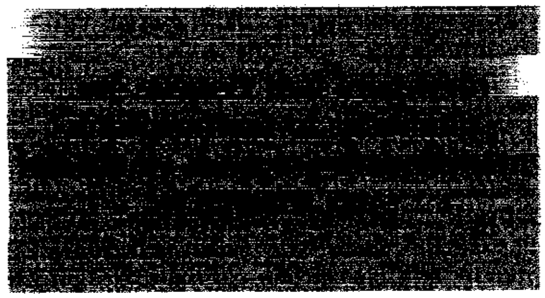
High concentrations of suspended sediment can alter survival, growth, and behavior of stream biota (Newcombe and MacDonald 1991). Impacts of suspended sediment can increase with (1) longer exposure time (Newcombe and MacDonald 1991), (2) smaller sediment particle size (Servizi and Martens 1987), (3) extremes in temperature (Servizi and Martens 1991), and (4) higher organic content of the sediment (McLeay et al. 1987). Extremely high levels of suspended sediment (e.g., >9,000 mg/L) can be lethal to aquatic biota, and lethal thresholds may be lower under natural conditions (Bozek and Young 1994) than in the laboratory (Redding et al. 1987).

Even slightly elevated suspended sediment may reduce reactive distance of salmonids to drifting prey (Barrett et al. 1992) and prey capture success (Berg and Northcote 1985). Growth rates of steelhead and coho salmon in laboratory channels were higher and their emigration rates lower in clear water than in turbid water (22-286 NTU) after 11-21 d (Sigler et al. 1984). In contrast, feeding by sculpin in laboratory channels was not detectably affected by suspended sediment levels of 1,250 mg/L (Brusven and Rose 1981).

Any reduction in feeding efficiency of fish may be offset by reduced risk of predation at moderate levels of suspended sediment. Juvenile chinook salmon spend more time foraging in water of moderate turbidity (20-25 NTU) than in clearer water (Gregory 1993). Similarly, brook trout are more active and spend less time near cover in moderately turbid water than in clear water (Gradall and Swenson 1982). Juvenile estuarine fishes in laboratory channels actively seek moderate turbidity (Cyrus and Blaber 1987). Coho salmon do not avoid turbidities as high as 70 NTU but move into turbid water when frightened (Bisson and Bilby 1982).

One of the most obvious off-site effects of dredging is increased suspended sediment because background concentrations where and when dredging occurs are usually low. However, lethal concentrations of suspended sediment are probably rarely produced by suction dredging. Field measurements of changes in turbidity and suspended sediment below suction dredges indicate minor, localized effects. For example, turbidity was 0.5 NTU upstream, 20.5 NTU 4 m downstream, and 3.4 NTU 49 m downstream of an active dredge on Canyon Creek (Hassler et al. 1986). Suspended sediment concentrations at the same three locations were 0, 244 mg/L, and 11.5 mg/L, respectively. On Butte Creek and the North Fork of the American River where ambient turbidities were <1 NTU, maximum turbidity 5 m downstream of active dredges reached 50 NTU but averaged only 5 NTU (Harvey 1986). In Gold Creek, Montana, suspended sediment was 340 mg/L at the dredge outflow and 1.8 mg/L 31 m downstream of an active dredge (Thomas 1985). Extrapolating results from studies exposing biota to chronic suspended sediments may overestimate the impacts of dredging because dredgers commonly operate for <5 h/d.

Unfortunately, the results cited here do not eliminate the possibility that dredging can affect stream biota via increased suspended sediments. Mobilization of suspended sediment by dredging and resulting effects on biota are site-specific. Production of suspended sediment is no doubt linked to the size and frequency of dredging operations, but such cumulative effects have not been evaluated. Dredging in streambeds in which sand is the dominant interstitial fine sediment is unlikely to yield high suspended sediment concentrations, but excavation of streambanks anywhere is likely to substantially increase suspended sediment because banks commonly contain abundant finer sediments.



Deposition of fine bedload

Neither the extent of off-site deposition and transport of dredging-generated fine sediment (clay, silt, and sand) nor the responses of aquatic biota have been investigated in a variety of streams. These issues deserve consideration because fine sediment can alter a variety of stream processes and conditions, including primary production (e.g., Power 1990), density of aquatic insects (e.g., Hogg and Norris 1991), and fish reproduction (e.g., Phillips et al. 1975; Fudge and Bodaly 1984).

While silt and clay entrained by dredging may remain suspended and travel long distances before being deposited, sand and gravel are usually deposited immediately downstream. At low flows pools tend to accumulate sediment transported as bedload (Keller 1971). Thus, pools can be filled by sediments mobilized by upstream dredging (Thomas 1985; Harvey 1986). While deposition of bedload would be most severe close to dredging sites, disruption of the continuity of bedload transport can have unpredictable consequences downstream, including both erosion and deposition (Womack and Schumm 1977). However, unless significant bank erosion occurs, increased sediment transport is limited by the fact that the sediment load delivered to the channel remains the same, and overall effects downstream are probably minor. Furthermore, lower channel stability by itself may not be important to some aquatic ecosystems.

Deposition of fine sediment downstream of active dredges is unlikely to substantially decrease water depth, but it may increase the embeddedness of cobble and boulder substrates used by many organisms. Complete embedding of substrates (particularly by silt and clay) generally will severely harm assemblages of benthic invertebrate (Hogg and Norris 1991). Slight increases are unlikely to significantly reduce the density of benthic invertebrates. In fact, partially embedded substrate may support a more-dense, diverse invertebrate fauna than unembedded substrate (Bjornn et al. 1977). Neither Thomas (1985) nor Harvey (1986) detected differences in the abundances of invertebrates 10 m or more downstream of dredged areas versus abundances at upstream control sites. However, these studies had low probabilities of detecting differences for several reasons: (1) High spatial variability occurred in the abundances of benthic invertebrates (even under natural conditions); (2) slow-water habitats where silt and clay may have been deposited were not sampled in either study; (3) sand dominated the fine sediments of the streams sampled in both studies; and (4) Harvey (1986) could not sample in the deepest parts of the channel where dredging-generated bedload was concentrated because of limitations of the sampling device.

Downstream transport and deposition of fine sediment also can reduce availability of microhabitats used by benthic fish. Density of sculpin was lower downstream of dredge tailings on the North Fork of the American River, in part because of increased deposition of sand (Harvey 1986). Similar to benthic fishes, amphibian larvae and adults might be harmed by reduced habitat beneath cobbles and boulders. For example, Parker (1991) measured a strong positive response by Pacific giant salamader larvae (*Dicamptodon tenebrosus*) to the addition of cobbles to a stream dominated by smaller substrate.

Deposition and transport of fine sediment by dredging is less likely to affect fish that occupy the water column during summer. Repeated visual censuses and observations of tagged fish revealed no short-term response to dredging by rainbow trout in pools in Butte Creek where substrate embeddedness and the percentage of fine sediment were increased, but habitat depth and volume were not changed substantially (Harvey 1986). Similarly, Bjornn et al. (1977) observed only minor differences in salmonid density in artificial channels with unembedded versus half-embedded gravel, cobble, and boulder substrates. However, if extensive dredging reduced invertebrate production, then salmonids could be affected. For example, Crouse et al. (1981) found a negative relationship between coho salmon production and the amount of fine sediment in the substrate of laboratory streams that lacked allochthonous inputs of invertebrates.

Bedload transport *per se* also may need to be considered when examining off-site effects of dredging on benthic invertebrates and fish. Culp et al. (1986) observed short-term reductions in invertebrate abundance from increased transport of fine bedload in a natural riffle where the composition of the substrate was not altered greatly. In addition, dredging-caused increase in transport of fine sediment may have harmed sculpin at the North Fork of the American River (Harvey 1986): relatively few sculpin occupied microhabitats beneath cobbles and boulders that remained unembedded downstream of the dredge.

Reproduction by spring-spawning animals will not be affected by the deposition of fine bedload where high winter discharge entrains these sediments. However, temporal overlap of dredging and reproduction by species of concern may produce significant off-site effects of dredging. For example, fine sediment deposition over more than 4 km below 4 suction dredges in Piru Creek, California, apparently reduced survival of eggs and larvae of the endangered Arroyo toad (*Bufo microscaphuus californicus*) throughout a significant proportion of the known range of the species (Sweet 1992).

Effects of multiple dredges

Off-site effects of individual dredges may be minor, but downstream impacts may be of concern where dredges are closely spaced, and other human activities and natural conditions increase the potential for cumulative effects. A moderate density of dredges in Butte Creek generated minor increases in sedimentation, and cumulative effects on benthic invertebrates or rainbow trout were not detected (Harvey 1986). However, no research has been dedicated to measuring the cumulative physical or biological effects of many closely spaced dredges. Cumulative effects of dredging and other human activities deserve attention, particularly where reaches are dredged year after year. Experiments will be difficult to conduct because of the length of stream reach that would comprise a reasonable unit of observation and variability among reaches (Carpenter et al. 1995). An experimental approach to management (McAllister and Peterman 1992) that included measurements on streams varying strongly in dredging intensity would help answer questions about cumulative effects.

Activities associated with dredging

Examination of dredging impacts also should include activities commonly associated with dredging such as camping and fishing. Dredge operators often camp in riparian zones that are critical to birds, amphibians, and aquatic insects. Miners' campsites are seldom maintained by resource agencies, so waste disposal and control of site damage is usually left to the miners. Sites are usually occupied for long periods. Some mining claims are used by a series of dredge operators in one season, leading to intense activity in one area. Also, fishing by miners may intensify pressure on local populations.

Analyzing suction dredging in a watershed context

Effects of suction dredging must be analyzed in the context of individual stream systems. The potential for a variety of dredging effects is great, and the distribution of physical and biological attributes and human activities in each stream basin is unique. In many systems, dredging effects may be minor when considered in isolation, yet they may contribute to significant cumulative effects on important resources. A methodology to accurately identify general thresholds of dredging activity leading to unacceptable cumulative effects is not available. A useful strategy is to adapt a watershed-scale approach to identify and evaluate important conflicts between dredging and aquatic organisms. A general strategy for analyzing dredging impacts parallels those outlined in existing management guidelines that include ecosystem analyses at the watershed scale (e.g., FEMAT 1993; Washington Forest Practices Board 1993; Regional Ecosystem Office 1995). Ideally, analysis of suction dredging would be part of a comprehensive examination that addresses all important issues for a particular watershed. The following steps might be included in either a specific analysis of dredging or an overall watershed analysis:

(1) Evaluate interactions between suction dredging and other activities and resources by

A. identifying and prioritizing issues (other activities and resources) that could be affected by dredging and associated activities.

B. identifying and evaluating probable on- and off-site effects of dredging on conditions and processes important to these issues. How strong are these effects? How and when do they occur? How far do they extend? How long do they last? How do they interact with other human disturbances?

C. analyzing how patterns of dredging and disturbances overlay patterns of potentially affected activities and resources.

(2) Use this information to develop guidelines for dredging and other activities. Even an exhaustive analysis is unlikely to reveal an indisputable, definite threshold of acceptable dredging activity. Instead, limits and regulations for each stream system will need to be decided openly in a scientifically informed, political process.

(3) Monitor implementation of regulations, on-site effects of dredging on key physical and biological parameters, and off-site effects of dredging on downstream conditions and processes. Take an experimental approach to monitoring that includes contrasts among different management strategies (McAllister and Peterman 1992).

(4) Alter management strategies and regulations in response to monitoring results, new issues, and changing physical and biological conditions in the watershed.

Examples of the analysis strategy

A. Fish populations

In many western streams where dredging occurs, managers will identify the population viability of one or more fishes as an issue of concern (Step 1.A.). In this case, the following questions might arise (Step 1.B.):

(1) Are fish in early life stages (e.g., eggs, larvae, alevins) present during dredging?

(2) Does dredging increase suspended sediment to levels that could affect fish, and are the likely effects negative or positive?

(3) Do environmental conditions (e.g., high water temperature or fine sediment with high organic content) raise the risk to fish populations of increased suspended sediment?

(4) What is the probability that fish will spawn before dredge spoils are reworked by high flows?

(5) If eggs are deposited in dredge tailings, what is the probability that flows capable of transporting bed material will occur during the incubation period?

(6) What is the stability of dredge spoils relative to natural spawning areas?

(7) To what extent does dredging significantly change the volume of channel geomorphic units or the loss of large substrate elements?

And in analyzing patterns (Step 1.C.):

(1) Does dredging occur in stream reaches that are hotspots of spawning activity?

(2) Are natural spawning gravels in such short supply that a large percentage of spawners might use dredge tailings?

(3) What is the probability that dredging-related mortality will significantly affect fish populations? (Does the area affected comprise a significant or key proportion of a population's range?)

(4) How does the overall impact of dredging on fish populations compare to, or interact with, other possible impacts such as fishing?

Answers to these questions may suggest changes in dredging techniques (Step 2). For example, if dredging occurs where existing fall-spawning chinook salmon are limited by recruitment, then requiring that tailing piles be obliterated could reduce the threat to reproductive success from spawning on unstable tailings.

Issues and impact mechanisms identified in the analysis (Step 1) would logically focus monitoring (Step 3) of the effectiveness of new regulations (Step 2). For example, if destabilization of fall spawning gravels is a problem, managers would want to survey the proportion of redds located on tailings and measure the relative stability of redds on spawning gravels that have and have not undergone post-dredging restoration. This could be done with repeated topographic surveys or scour monitoring devices (Nawa and Frissell 1993).

B. Channel stability

Where channel stability is identified as an issue of concern, a geomorphologist might be enlisted to help answer the following questions (Step 1.B.):

(1) How much will the original bed topography, including the particle size and morphology of pools and riffle crests, be altered by dredging?

(2) Will streambanks be subjected to increased hydraulic forces?

(3) Is the channel likely to reconstruct its original form given typical peak flows?

(4) Will coarse woody debris and other large roughness elements that influence channel morphology be disturbed?

Step 1.C.:

(1) What is the extent of channel morphological effects, and how are dredging sites distributed relative to other disturbances (e.g., fires and roads) and inherently unstable reaches (e.g., those with alluvial streambanks, low gradients, or multiple channels)?

(2) What other factors such as large floods, impoundments, and large sediment inputs affect channel stability, and how does the impact of dredging interact with these factors?

Scoping the problem of channel stability in Step 1 should indicate reaches to monitor because of their inherent instability and proximity to dredging operations. On- and off-site channel changes could be monitored with repeated topographic surveys or aerial photography. At the same time, flood stages and other disturbances (e.g., grazing, landslides, and fires) also would be monitored.

Conclusions

Suction dredging and associated activities have various effects on stream ecosystems, and most are not well undestood. In some situations, the effects of dredging may be local and minor, particularly when compared with the effects of other human activities. In others, dredging may harm the population viability of threatened species. Dredging should be of special concern where it is frequent, persistent, and adds to similar effects caused by other human activities. Fishery managers should be especially concerned when dredging coincides with the incubation of young fish in stream gravels or precedes spawning runs (e.g., fall-run chinook salmon) soon followed by high flows. They also should be concerned about increased fine-sediment deposition in channels that naturally contain abundant fine sediment or receive inputs from other disturbances.

We recommend that basin-scale analyses of dredging and other activities be performed so regulations can be tailored to particular issues and effects in each stream system. Quantitative, uniform guidelines and regulations that are truly applicable and scientifically supportable for a variety of basins probably will never be found. Instead, basin-specific regulations will need to be created in a political but scientifically informed process using information from a basin-scale analysis. Considering the uncertainty surrounding dredging effects, declines in many aquatic animal populations, and increasing public scrutiny of management decisions, the cost of assuming that human activities such as dredging cause no harm deserves strong consideration by decision makers (Mapstone 1995). Where threatened or endangered species exist, managers would be prudent to assume activities such as dredging are harmful unless proven otherwise (Dayton 1998).)

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Scour of Chinook Salmon Redds on Suction Dredge Tailings

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Abstract.-We measured scour of the redds of chinook salmon *Oncorhynchus tshawytscha* on dredge tailings and natural substrates in three tributaries of the Klamath River, California. We measured maximum scour with scour chains and net scour by surveying before and after high winter flows. Scour of chinook salmon redds located on dredge tailings exceeded scour of redds on natural substrates, although the difference varied among streams. Our results show that fisheries managers should consider the potential negative effects of dredge tailings on the spawning success of fall-spawning fishes such as chinook salmon and coho salmon *O. kisutch*.

Suction dredging for gold is common in many streams and rivers in western North America and in gold-bearing lotic habitats worldwide (Hall 1988). Studies of the effects of dredging on fishes have focused on survival following entrainment (Griffith and Andrews 1981) or the immediate responses of fishes to changes in habitat caused by dredging (Harvey 1986). The effect of suction gold dredging on fish spawning has not been studied, in part because dredging rarely overlaps in time with spawning by species of special concern to fisheries managers. Also, in many unregulated streams, most fishes spawn in spring after dredge tailings from the previous summer and fall are redistributed by high winter flows (Thomas 1985; Harvey 1986).

However, dredging during summer may affect the reproductive success of fall-spawning fishes such as chinook salmon *Oncorhynchus tshawytscha*. Because of low streamflow during late summer and early fall, dredge tailings may retain their original form during the spawning period of these species. Tailings often contain substrate appropriate for redd construction and may be used by fall-spawning salmonids. The significance of dredge tailings to fish populations depends in part on the extent dredge tailings are used for spawning, which is itself probably affected by the availability of suitable unaltered substrates and the relative quality of dredge tailings as spawning sites. Because dredge tailings may be more unstable than natural substrates, redds on tailings may be subject to greater scour than those on unaltered substrates. Greater scour of tailings would significantly decrease their quality as spawning sites because mortality of preemergent salmonids can be sensitive to small increases in scour depth (Holtby and Healey 1986; Montgomery et al. 1996). Our objective in this study was to test the null hypothesis that chinook salmon redds on dredge tailings and those on natural substrates are scoured equally.

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Methods

Study sites.-We made scour measurements in three tributaries of the Klamath River in Siskiyou County, northwestern California: Elk Creek, the South Fork Salmon River, and the Scott River (Table 1). Regional streamflow is highly seasonal; most peak flows result from rainfall or rain-on-snow events during wet winters. Suction dredging occurs from June to September. Spawning by chinook salmon occurs most often in October and November, and storm flows capable of mobilizing streambed material typically occur from December to March. All study reaches are single-thread, slightly sinuous alluvial channels with limited floodplains bounded by valley walls. Bed surfaces are predominated by cobbles and boulders. Scour and fill of the streambeds can be expected to vary annually because, although these channels have high sediment supplies typical of the Klamath Mountains, winter streamflow is highly variable. Scour and fill also can be expected to vary spatially because patches of gravel are transported annually whereas boulders move less frequently.

Measurement of scour.-We measured maximum and net scour of redds on dredge tailings and on natural substrate. We directly measured maximum scour at each redd with two scour chains positioned on either side of the redd where bed elevation approximately equaled the surrounding substrate, about midway along the longitudinal axis of the tailspill. We chose these chain locations to avoid damaging embryos and to measure local scour depths presumably equal to those at the bracketed redds. We inserted scour chains in October and November, before large increases in stream discharge obscured the locations of redds

TABLE 1.-Characteristics of the three study sites, including estimated recurrence intervals for peak flows during the study based on nearby gauging stations at Scott River near Ft. Jones, South Fork Salmon River near Somes Bar, and Indian Creek near Happy Camp for Elk Creek (peak flows in Indian Creek from 1955 to 1964 predicted peak flows in Elk Creek with $r^2 = 0.81$).

Stream	Years of study	Drainage area (km^2)	Width (m)	Gradient (%)	Peak-flow recurrence interval (years)
Elk	1993-1994	234	19	1.4	0.3
	1994-1995				2.0
Scott	1995-1996	2,055	29	0.6	1.1
South Fork Salmon	1995-1996	712	22	1.0	1.1

and returned to measure scour in June or July of the following year. Scour chains measure the maximum scour depth that may be followed by some thickness of fill during the measurement period (Leopold et al. 1964; Nawa and Frissell 1993). Net scour is the difference in streambed elevation between the start and end of the measurement period (assuming elevation decreases). We measured net scour by first surveying longitudinal profiles and monumented cross sections over the redds when scour chains were installed in the fall and then resurveying them the following summer when chains were recovered.

Replication ranged from three to seven within a particular combination of stream, year, and substrate (tailings versus natural substrate). In general, replication was limited by the number of redds on tailings. We readily detected redds on natural substrates because less periphyton covered redd materials compared with the surrounding substrate. This difference was less apparent for redds on recently created dredge tailings, and low stability of material in tailings often yielded redds with less strongly mounded tailspills compared with those on natural substrates. For these reasons, redds on tailings were often difficult to identify in the absence of direct observations of spawning fish. After locating as many redds on tailings as possible, we haphazardly selected an equal number of redds on natural substrates by making measurements at the first redds we encountered either upstream or downstream of the redds on dredge tailings.

Analysis.-We analyzed net scour using a two way analysis of variance (ANOVA) with site and substrate (tailings versus natural substrates) as main effects. Our four sets of observations for particular streams in a specific year constituted the sites. Although the site factor contains indistinguishable variation due to annual variation and geographic location, we think analysis of data from three streams collected over 3 years provides a reasonable first assessment of scour on dredge tailings versus natural substrates.

We analyzed the scour-chain data using the same two-way ANOVA approach. However, the data set was reduced for this analysis because scour chains were not recovered at all the redds surveyed. Because we suspected that some unrecovered scour chains were removed by people rather than by scour in excess of the depth of the chains, only redds where at least one scour chain was recovered were included. For 3 of the 26 observations included in this analysis, only one scour chain was recovered. For these observations we averaged the depth of scour at the chain recovered with the burial depth of the lost chain to produce a conservative estimate of maximum scour. Overall, this analysis provides a conservative estimate of differences in scour on dredge tailings versus natural substrates because sites with extreme scour, where scour chains were lost because they were completely exhumed, were excluded from the data set.

Results

Topographic changes at redds following high winter flows ranged from extensive scour and fill to nearly undetectable differences (Figure 1). Net and maximum scour of chinook salmon redds on dredge tailings were significantly greater than

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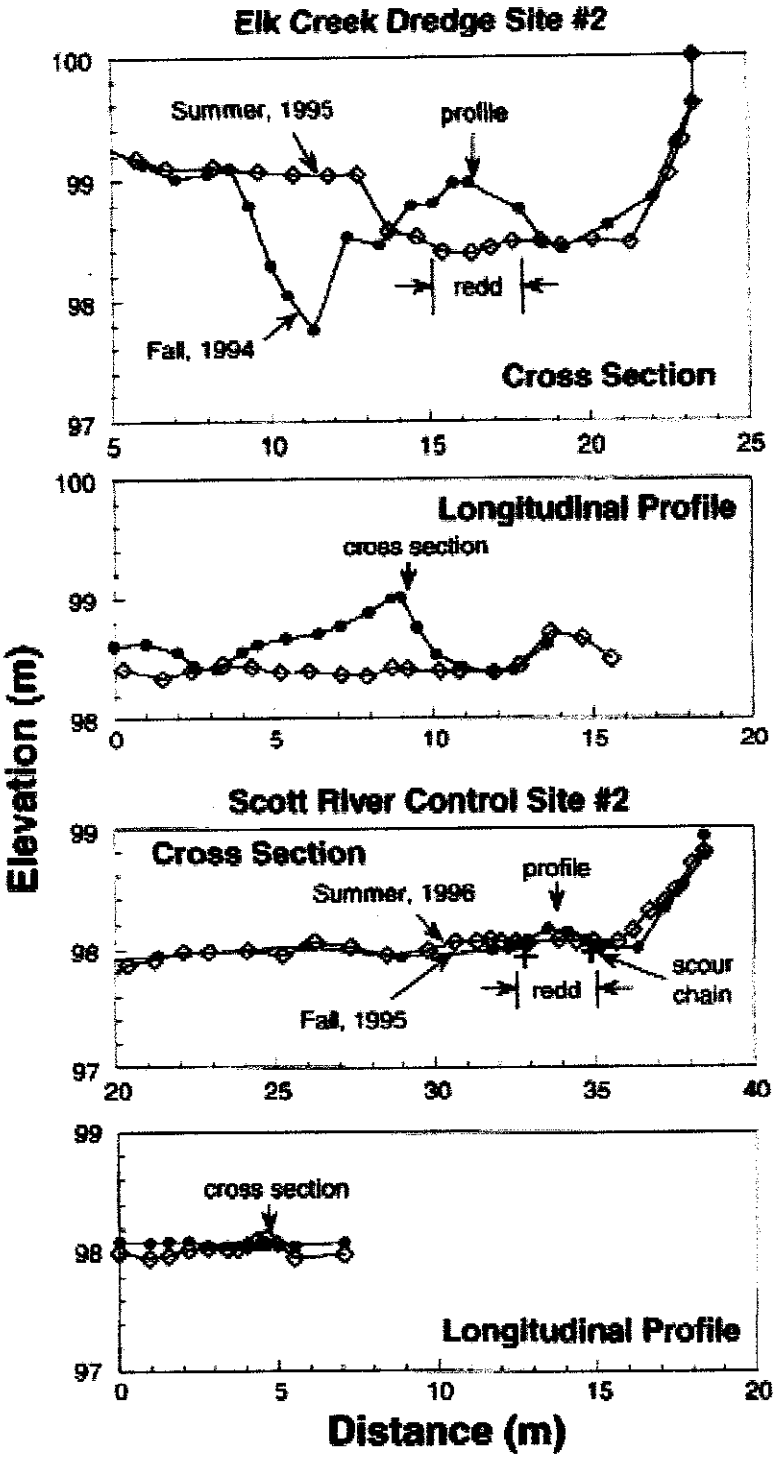
FIGURE 1.-Examples of changes in cross sections and longitudinal profiles at two redd sites. Scour and fill were deep at the Elk Creek site, and the two scour chains (not shown) were lost. Net scour was less at the Scott River site, and scour chains recorded a maximum scour approximately 10 cm below the final bed elevation. Elevations were surveyed relative to an arbitrary data point.


Elk Creek Dredge Site #2
Summer, 1995
profile
Fall, 1994
redd
Cross Section
Longitudinal Profile
cross section
Scott River Control Site #2
Cross Section
Summer, 1996
profile
Fall, 1995
redd
scour chain
Longitudinal Profile
cross section
Elevation (m)
Distance (m)

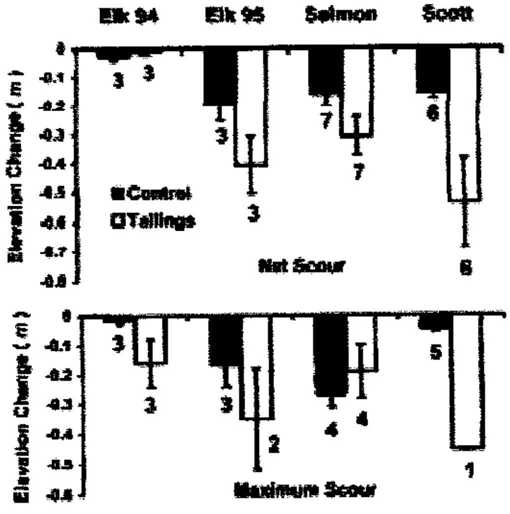


FIGURE 2.-Elevation change over winter at Chinook salmon redds located on dredge tailings and on natural substrates (control) in tributaries of the Klamath River, 1993-1996. Net scour data reflect the elevation change at the middle of the tailspill, whereas maximum scour data indicate the average scour estimated at two scour chains positioned on either side of the longitudinal midpoint of the tailspill at about the elevation of the surrounding natural substrate. Estimates of net scour can exceed maximum scour because scour chains were not recovered at all redds. Error bars = ±SE; numbers below the bars indicate sample size.

scour of redds on natural substrates (for survey data: $F = 7.88$, df = 1, 30, $P < 0.01$; for scour-chain data: $F = 8.85$, df = 1, 17, $P < 0.01$), but differences varied among sites (substrate x site interaction for survey data: $F = 2.60$, df = 3, 30, $P = 0.07$; for scour-chain data: $F = 3.27$, df = 3, 17, $P < 0.05$; Figure 2). Variation among our four sets of observations can be attributed, in part, to annual variation in discharge. For example, in Elk Creek, low winter streamflow in 1993-1994 (Table 1) caused little scour compared with 1994-1995 (Figure 2).

Net and maximum scour were strongly correlated ($r = 0.75$, $P < 0.01$) for the 25 redds where we recovered one or more scour chains. Fill following maximum scour will weaken the correlation between these two measurements; outliers in our data occurred where maximum scour greatly exceeded net scour. In most cases, net and maximum scour were approximately equal, indicating that filling did not occur after scour. This suggests that meaningful measurements of scour of redds in mobile material can be made by surveying only.

Discussion

Previous observations suggest that the greater scour we observed at redds on dredge tailings than on natural substrates had significant consequences for the survival of chinook salmon eggs and embryos. For example, Holtby and Healey (1986) observed a strong correlation between mortality of young-of-the-year coho salmon *O. kisutch* and peak discharge during the incubation period. Montgomery et al. (1996) measured both scour and egg pocket burial depths of chum salmon *O. keta* in a Washington stream and determined that a small increase in scour would affect the integrity of a large proportion of redds. Based on previous studies, DeVries (1997) suggested that loss of eggs from chinook salmon redds will begin when scour reaches 15 cm below the original streambed elevation and scour of 50 cm will cause total loss of eggs. These estimates and the differences in scour we observed suggest that many more preemergent chinook salmon were lost from redds on dredge tailings compared with redds on natural substrates. However, our results also revealed that variability in scour between dredge tailings and natural substrates should be expected among streams and years.

The significance of dredge tailings to salmon populations may vary even among streams with similar patterns of scour. The proportion of Chinook salmon that spawn on dredge tailings would influence the population level effect of tailings and depend, in part, on the availability of spawning sites on natural substrates. If natural spawning sites were relatively abundant and tailings were not strongly selected, a small fraction of redds would be located on tailings. For example, in the lower 11 km of the Scott River in 1995, only 12 of 372 redds were located on tailings (J. Kilgore, U.S. Forest Service, unpublished data) because (1) much more natural substrate than dredge tailings provided spawning habitat (an estimated 3,890 m^2 versus 121 m^2), and (2) the fish exhibited no strong preference for either substrate (0.09 redds/m^2 for natural substrate versus 0.10 redds/m^2 for dredge tailings). However, where natural spawning substrate is in short supply, a large proportion of redds may be located on dredge tailings.

Both the timing of spawning and the body size of spawners will also affect the significance of dredge tailings on spawning success. Because peak seasonal discharge in the streams we studied commonly occurs in December and January, the period of maximum scour usually overlaps with the embryo incubation period of chinook salmon and coho salmon. Steelhead *Oncorhynchus mykiss* are probably less affected by scour because they spawn later, after tailings are likely to be redistributed by high flows and when high flows during incubation are less likely. Fish able to deeply bury eggs should be favored where scour is significant (Holtby and Healey 1986). Both within and among species, larger females usually bury eggs deeper (van den Berghe and Gross 1984; Crisp and Carling 1989).

Applying typical values for depth of scour and egg burial in undisturbed substrates to the dredging situation can be misleading. Miners commonly deposit gravelly material over much coarser armor layers of cobbles and boulders; these areas are often hydraulically suitable for spawning, but do not have appropriate substrate. Thus, unlike redds on undisturbed substrates, redds on dredge tailings are constructed on an anomalously fine bed surface, and fish may be impeded from digging and depositing eggs into the original armor layer because of its coarseness. Therefore, fish may deposit their eggs in the overlying finer gravel that is vulnerable to strong scouring forces. In such cases, scour during a common peak flow would often extend down to the depth of the original armor layer and would include the layer containing incubating embryos.

Our results show that fisheries managers should consider the potential negative effects of dredge tailings on the spawning success of fall-spawning fish, such as chinook salmon and coho salmon. Streams with a shortage of natural substrate appropriate for spawning, a high potential for scour, and a low number of spawners deserve special attention. Where managers determine that unstable dredge tailings may lead to unacceptable effects on spawning success, these effects could be reduced or eliminated through regulations that require that tailings piles be redistributed to restore the original bed topography and particle size distribution.

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