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# PACIFIC COAST FEDERATION of FISHERMEN'S ASSOCIATIONS

Noah Oppenheim
*Executive Director*
Glen H. Spain
*Northwest Regional Director*
Vivian Helliwell
*Watershed Conservation Director*
***In Memoriam:***
Nathaniel S. Bingham
Harold C. Christensen
William F. "Zeke" Grader, Jr.

**Please Respond to:**

☐ **Southwest Office**
P.O. Box 29370
San Francisco, CA 94129-0370
Tel: (415) 561-5080
Fax: (415) 561-5464

www.pcffa.org
Email: fish1ifr@aol.com

[X] **Northwest Office**
P.O. Box 11170
Eugene, OR 97440-3370
Tel: (541) 689-2000
Fax: (541) 689-2500

## STATEMENT BY NW REGIONAL DIRECTOR GLEN SPAIN ON BEHALF OF THE PACIFIC COAST FEDERATION OF FISHERMEN'S ASSOCIATIONS (PCFFA)

## TO THE

## OREGON HOUSE COMMITTEE ON ENERGY AND ENVIRONMENT

## (Support for SB-3A – Regulation of Motorized Instream Mining) Hearing on 3 May 2017

The Pacific Coast Federation of Fishermen's Associations (PCFFA) is the West Coast's largest commercial fishing industry trade association, representing the interests of family-owned, commercial seafood harvest operations coastwide. We are organized as a federation of 15 different coastal fishing port associations, vessel owners' associations and port-based seafood marketing associations. The collective membership of all these PCFFA-affiliated member groups is about 1,000 commercial fishing family businesses working in every U.S. West Coast port, and in every commercial fishery. Our members' collective net business investment in those fisheries is well over $200 million, employing thousands of people.

We want to go on record as supporting the compromise bill of SB-3A, (originally introduced as SB-3 in the Senate, of which SB-3A is the engrossed version as amended in the Senate) being debated in this Committee today, as the preferred pathway to resolving the long-festering issues related to in-river motorized mining (particularly what is called "suction dredge mining") in the State of Oregon.

Although it is clearly a compromise, *and certainly not as strong on certain suction dredge protections as we might have liked*, it does nevertheless provide several valuable protections for instream aquatic life that we sought both in the previous Legislatures and through the Governor's SB 838 Stakeholder Task Force, on which PCFFA was represented.

In particular, SB-3A does protect valuable salmon runs from which our people harvest salmon for their livelihoods. But as one compromise, SB-3A still allows suction dredges to proceed in those many other areas in Oregon in which there are no over-riding state interests for the protection of valuable salmon runs. These protections in SB-3A are absolutely essential to protect Oregon's salmon fisheries. The majority of our West Coast commercial fishing industry fleet still participates in its once abundant ocean commercial salmon fisheries.

Oregon's salmon runs, in turn, depend upon maintaining healthy and biologically productive river systems for their existence. Salmon hatch from eggs laid in freshwater streams, and are thus *at their most vulnerable life stage* within Oregon's small inland streams. Unfortunately, those are in many cases precisely the same streams most heavily targeted in Oregon by suction dredge miners.

In recent years – due in large part to the ongoing suction dredge moratorium in California, but also to the recent high price of gold – until the recent SB 838-required moratorium, there have been nearly twice as many suction dredge miners working in Oregon (about 1,700) than typically occurred in the past. These suctions dredge operations were also highly concentrated in coastal salmon-bearing streams. This means proportionally greater impacts on fragile coastal streams which are the nursery beds for the very salmon that our industry depends upon for its livelihoods. Many of those salmon runs are also protected by other state and federal laws, while at the same time being jeopardized by suction dredging!

Anything that jeopardizes the regions' valuable salmon runs, or decreases salmon survival rates generally within their native rivers, *ultimately costs our industry jobs and dollars* by depleting our allowable harvest. Suction dredging is clearly one of those negative impacts.

**Adverse Impacts of Suction Dredging Are Well-Documented and Can Cumulatively Be Extensive**

It is an article of faith among suction dredgers that their operations, as they often repeat: "do not harm fish in any way," and sometimes they even claim that suctioning up and disturbing large portions of riverbeds "benefits stream ecosystems." Frankly, this myth is a fabrication. It has no scientific support.

Indeed, the science is clear that suction dredge operations can and do interfere with, and in some cases destroy, salmon egg nests ("redds"). Suction dredges can disrupt river ecosystems in multiple ways, as noted in a recent report (*Suction Dredge Mining Impacts on Oregon Fishes, Aquatic Habitat, and Human Health*) to the Oregon Legislature by the Oregon Chapter of the American Fisheries Society (AFS), dated January, 2017, specifically prepared the inform the Legislative Hearings on this issue. **That AFS Report is attached for the record.**

Of particular concern is the fact that suction dredges frequently exhume elemental mercury now safely trapped under many feet of clay-based river sediments, and which is then released back into the environment in the form of small mercury droplets where it can easily oxidize to become methylmercury, a potent (and cumulative) neurotoxin that affects both fish as well as human health.

Even if a large portion of this elemental mercury is then collected by the operator (as many claim), such collections are *never 100% efficient*. The remainder is then dispersed back into the river where it is once again exposed to chemical processes that can "methylate" mercury to convert it into the most toxic family of mercury compounds known. These methylmercury compounds are water soluble, enter urban water systems, bio-accumulate in fish that are part of the human food chain, and are also *deadly human neurotoxins*. Unborn and small children are at particular risk of neurological damage from *even very small amounts* of these virulent mercury-based toxins.

While one dredge operation may have small individual impacts on aquatic life, also of particular concern is the cumulative impact of the heavy concentration of multiple suction dredge operations in fragile coastal salmon spawning areas that we have been repeatedly seeing. Many of those regions also contain mercury and other toxic metal compounds currently entombed in the clay sediment bottoms of rivers, which are then disturbed and redistributed by the dredgers. These negative impacts are both cumulative as well as synergistic.

## Fragile Coastal Watersheds Should be Off Limits

Many of Oregon's once-abundant salmon runs are now just beginning to recover from near extinction due to widespread instream habitat losses and past habitat damage. Several of these coastal salmon runs (such as the Oregon coastal coho) are now federally listed as either endangered or threatened species under the Federal Endangered Species Act (ESA).

*Tens of millions of dollars* in taxpayer and landowner money and years of effort has already gone into repairing Oregon's many damaged coastal salmon watersheds, through such programs as the *Oregon Plan for Salmon and Watersheds* and through the Oregon Watershed Enhancement Board (OWEB).

It makes no policy sense, and worse economics, for the State of Oregon to still allow widespread and highly invasive suction dredge operations in coastal rivers that are simultaneously being rehabilitated at great public and private expense. At best, this amounts to the government working at cross-purposes with itself, essentially undoing the work it has already done toward river restoration. Worse, under prior laws and regulations the Oregon suction dredge permit program was running at a *total net loss to the State*, and could not pay even a substantial fraction of the law enforcement costs of the program, much less to undo any of the damages it creates.

In other words, under prior laws and regulations, the destruction of Oregon's key salmon streams caused by suction dredge mining was actually being *heavily subsidized* by the very same Oregon taxpayers who were also paying to clean up the damages that such suction dredge operations cause!

## LEGISLATIVE SOLUTIONS PRESENTED BY SB-3A

Under SB-3A, suction dredge mining would not be allowed in the habitat that is most important for native salmonids, nor in streams already too polluted by turbidity, sediments or toxic metals like mercury. This is only common sense!

Furthermore, suction dredges would be subject to reasonable inspection (just as most other boats already are) to prevent the accidental transport of aquatic invasive species from one stream to another or across state lines. And the cost of the program would be reset so that it does not burden Oregon taxpayers, but rather pays for its own enforcement and implementation costs, as also makes good policy and economic sense.

To that end, PCFFA supports efforts by the Legislature which would help remedy and prevent some of those past resource use conflicts between suction dredge miners and the fishing industry, and which would limit the adverse impacts of suction dredging generally on our salmon runs, our salmon-dependent coastal communities, and the state's economically important fishing industry jobs.

**Specifically, PCFFA supports SB-3A as a compromise solution to most of these problems.**

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**ATTACHMENT:** Report to the 2017 Oregon Legislature by the Oregon Chapter of the American Fisheries Society (AFS), *Suction Dredge Mining Impacts on Oregon Fishes, Aquatic Habitats, and Human Health*, (January, 2017).

**SUCTION DREDGE MINING IMPACTS ON OREGON FISHES, AQUATIC HABITATS, AND HUMAN HEALTH**

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OREGON CHAPTER AMERICAN FISHERIES SOCIETY

JANUARY 2017

## EXECUTIVE SUMMARY

The Oregon Chapter of the American Fisheries Society (ORAFS) authored a primary (2013) and a supplemental (2015) white paper on the "Effects of Suction Dredge Mining on Oregon Fishes and Aquatic Habitats" to provide legislators with a scientific review of recreational suction dredge mining effects on streams and aquatic organisms in Oregon. In anticipation of suction dredge mining legislation during the 2017 legislative session, ORAFS completed a more comprehensive review of literature pertaining to suction dredge mining impacts. This review focuses on effects of suction dredge mining on stream geomorphology and habitat, aquatic organisms, mercury redistribution, methylation, and bioaccumulation of toxins.

**Geomorphic Effects**

- Fluvial geomorphology is the study of stream channel forms (e.g., pools and riffles) and the processes that create them. Understanding potential geomorphic effects of suction dredging is essential for understanding impacts to aquatic species habitat. Suction dredge mining can alter stream channel forms and disrupt channel-forming processes. Suction dredge mining activity directly alters the streambed by removing or displacing cobbles, boulders, and logs. These actions destabilize the streambed and increase channel erosion, including the erosion of habitats necessary for fish reproduction and juvenile rearing.

**General Habitat Effects**

- Suction dredge mining alters aquatic habitats by affecting the streambed and streambanks. Suction dredge mining is directed at depositional areas of the stream channel where gold is most likely to settle, including the downstream-end of pools, riffles, and channel margins. These same areas are the main habitats that produce aquatic insects (which are a primary food source for juvenile fishes) and are important habitats for fish spawning and juvenile rearing. Damage to these habitats negatively impacts fish development and survival.

**Anadromous and Freshwater Fish General Effects**

- Suction dredge mining impacts habitats used by Oregon's salmon and steelhead populations, many of which are listed as threatened or endangered under the Endangered Species Act (ESA). Rivers and streams are essential year-round nursery habitats for salmon and steelhead populations. Suction dredge mining alters habitats used by anadromous fish for reproduction and juvenile rearing habitat by increasing streambed erosion, smothering of spawning gravels with silt and sand, and displacing or removing cobble, boulders, and logs used for cover by juvenile salmon and steelhead.

**Bull Trout Effects**

- Suction dredge mining impacts habitat for Bull Trout (*Salvelinus confluentus*), a threatened species listed under the ESA. Bull trout are genetically distinct from Dolly Varden (*Salvelinus malma*), which are not found in Oregon. Bull Trout currently occupy only a small portion of their historical range in Oregon and are impacted by habitat loss, habitat degradation, and fishing harvest. Bull Trout populations are often small, and are susceptible to suction dredge activities that focus on low gradient, gravel streambed stream reaches that are used by Bull Trout for migration, holding, spawning and egg incubation, and juvenile rearing.

- Due to their fall spawning, long egg incubation period, and propensity for juveniles to reside within the interstitial spaces of streambed substrate, Bull Trout are susceptible to being directly entrained in suction dredge equipment. Suction dredge mining affects fish development, survival, and recruitment into the population, potentially threatening Bull Trout population persistence.

**Effects on Lampreys**

- Suction dredge mining can impact lamprey habitat. At least ten species of lampreys are found in Oregon, making the state a "hot spot" for lamprey diversity. The anadromous Pacific Lamprey is the largest and most studied species. Pacific Lamprey is culturally important to Native Americans for food, medicine, ceremony, and many other uses.
- Juvenile lamprey rear in depositional areas where silt and sand can settle. Larval lamprey can reside in freshwater systems for up to seven years. Suction dredge mining has the potential to directly affect lampreys through entrainment of larvae, and indirectly through habitat alteration and simplification, fine sediment burial, and redistribution of heavy metals (e.g., mercury) to habitats used by larvae. Mercury methylation and uptake of methylmercury by larval lamprey may lead to bioaccumulation of the toxin in fish that consume larval lamprey.

**Freshwater Mussel Effects**

- Suction dredge operation entrains freshwater mussels leading to physical injury or mortality. Dredges may also interfere with reproduction and feeding and bury mussels in mine tailings. Mussels are also harmed from mining activities through habitat loss and the redistribution and methylation of mercury from historical mining practices. Mussels are important in stream ecosystems as they improve water quality by filtering particulates from the water column and are a food source for birds and wildlife. Methylmercury-contaminated mussels are a potential health hazard for birds, wildlife, and humans.

**Mercury Contamination Effects**

- Suction dredge mining in historically-mined streams can mobilize mercury that resides deep in the stream bed. Although suction dredge miners remove mercury from the streambed, not all of the mobilized mercury is captured in the dredge sluice. The discharged sediment plume may have mercury concentrations that substantially exceed water quality standards, creating a health hazard for fish, wildlife, and humans.
- In low oxygen aquatic environments, mercury is converted into its most hazardous form: methylmercury. Methylmercury is a neurotoxin. Methylmercury bioaccumulates in the food web, potentially impacting fish, wildlife and ultimately humans through consumption of contaminated fish.

**Conclusions:** Scientific studies document the adverse biological and physical effects suction dredge mining can have on stream geomorphology, habitats, and aquatic organisms. Suction dredge mining operations in historically-mined waterways also have the potential to mobilize legacy mercury leading to bioaccumulation of methylmercury in fishes and mussels that are consumed by humans. Methylmercury is a neurotoxin that is a human health hazard and is of particular concern for pregnant women and children. The level of potential adverse effects related to suction dredge mining, particularly in historically-mined systems, strongly suggests the need for state policy to further regulate suction dredge mining and grant comprehensive protection of rivers and stream.

SUCTION DREDGE MINING IMPACTS ON OREGON FISHES, AQUATIC HABITATS, AND HUMAN HEALTH

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OREGON CHAPTER AMERICAN FISHERIES SOCIETY
JANUARY 2017

## 1. Introduction

In 2013, the Oregon Chapter of the American Fisheries Society (ORAFS) authored a white paper entitled, "Effects of Suction Dredge Mining on Oregon Fishes and Aquatic Habitats." In a 2015 supplementary white paper, ORAFS reviewed the effects of mercury, risks to channel geomorphology, impacts to lampreys and mollusks, and made some recommendations for regulating and monitoring suction dredge mining in Oregon. Both papers are publicly available at www.orafs.org.

In 2014, in accordance with Senate Bill 838 (passed in 2013), the Governor convened a study group to develop recommendations for a regulatory framework for suction dredge mining in Oregon. SB 838 imposed a five-year moratorium on suction dredge mining which began in January 2016. Legislation to establish state policy on suction dredge mining is expected to be under review during Oregon's 2017 legislative session.

This paper provides a more thorough analysis of the topics covered in the preceding ORAFS white papers and is based on an updated and comprehensive literature review including studies published after the earlier white papers were completed. Topics covered in this document include suction dredge effects on stream geomorphology and habitat, aquatic organisms, and mercury redistribution, methylation, and bioaccumulation. The information is presented in a step-wise fashion with subsequent information building on the previous.

Although many of the studies on suction dredge mining dating to the later part of the twentieth century remain the foundation of the literature on suction dredge effects on stream environments, more current work has highlighted contaminant impacts related to the practice. Recent literature reviews (R2 Resource Consultants 2006; HWE 2009) and suction dredge regulatory planning documents (HWE 2011; CNF 2013; USFS 2015) summarize the earlier work and expand on contemporary investigations into how suction dredge operations may imperil aquatic organisms and human users who interact with mined environments. The expanding body of scientific knowledge on stream ecology provides the scientific community with a better understanding of aquatic organisms' habitat requirements. Additionally, the realization of the prevalence of mercury in streams that were historically mined creates a human health concern (Humphreys 2005; Fleck et al. 2011; Marvin-DiPasquale et al. 2011). As scientists develop a better understanding of mercury uptake and bioaccumulation through food webs, the risks of reintroducing previously buried mercury is becoming better understood.

In sum, suction dredge mining may affect populations of salmon (*Oncorhynchus* spp.), steelhead (*O. mykiss*), lamprey, other fishes, and stream invertebrates; simplify aquatic habitats such that they have less capacity to support aquatic life; and increase fish, wildlife, and human exposure to toxic heavy metals.

## 2. Suction Dredge Operation

**Suction dredge mining for gold is a small-scale mining activity that removes streambed sediments from the active channel**. Suction dredges come in many configurations, but are typically comprised of a floating system that includes a high-pressure pump driven by a gasoline-powered engine, flexible intake hose, header box, and sluice secured to a framework that is supported by pontoons. The pump creates suction in the flexible intake hose that vacuums up streambed sediment and water through the header box and into the sluice. Heavy particles are trapped in the sluice riffles (grooved board) which may be augmented with carpet or other material that traps denser materials including gold (USFS 2015). Lighter sediments not trapped in the sluice are discharged in a turbid plume back to the stream (USFS 2015). Dredges are typically tethered to streamside trees, boulders, or other anchoring structures to maintain dredge position.

The dredge operator completes a reconnaissance of a potential work area to identify low velocity areas where gold may settle (McCracken 2013; USFS 2015). Due to the high density of gold, this metal will settle where velocities rapidly decrease such as in pools, eddies, and downstream from channel obstructions. Following initial testing of the potential mining area by systematically dredging small sampling holes (process referred to as "sniping"), the operator will remove streambed surface sediment to access the underlying deeper sediments where sufficient concentrations of gold may be located (McCracken 2013). Although gold may be found near the streambed surface, the most productive gold-producing sediments are located deeper in the channel bed. These deeper sediments are not typically mobilized during average flood events that transport streambed surface sediments (McCracken 2013; USFS 2015). The operator will then dredge to bedrock or a "hard-packed", cemented layer indicative of a flood deposit or remnant hydraulic mining debris in areas that were historically mined prior to the mid-20$^{th}$ century (Marvin-DiPasquale et al. 2011; McCracken 2013). The hard-packed layer slows or blocks further deeper movement of gold (and mercury where present) through the streambed sediments (Marvin-DiPasquale et al. 2011; CNF 2013; USFS 2015). In addition to hard-packed layers, gold particles are often found in bedrock fissures, between discreet sediment layers, or at the interface of a streambed sediment layer and bedrock (McCracken 2013; USFS 2015).

The dredge operator will typically establish a pit (production area) that extends down to bedrock or the hard-packed layer (McCracken 2013; USFS 2015). Stream bed materials that exceed the intake pipe diameter of the suction dredge are piled by hand downstream or to the side of the production area. The operator then works the dredge in an upstream direction, mining material from the front wall of the production area (USFS 2015). Processed coarse sediments are discharged by the dredge a short distance into the downstream pit and finer particles are discharged in a turbid plume a longer distance downstream of the work area. Suction dredge processing rates are limited by the size of the streambed material, the engine that drives the pump, and the diameter of the intake hose. Small scale suction dredges have intake pipe diameters ranging from 2 to 5 inches and up to 15 hp engines. The larger the pump and suction hose, the greater the dredge capacity to process streambed sediment (McCracken 2013). With each one inch increase in the intake hose diameter, the suction volume doubles and the potential excavation depth increases by a foot (McCracken 2013).

## 3. Geomorphic Effects

**Suction dredge operators have direct and indirect effects on the integrity of the streambed and habitat quality.** Fluvial geomorphology is the study of stream channel forms (e.g., pools and riffles) and the processes that create them. Understanding potential geomorphic effects of suction dredging is essential for understanding impacts to aquatic species habitat. Direct suction dredge mining effects include removal and piling of larger cobbles and boulders that exceed dredge capacity, displacement of streambed materials during dredging, and the discharge of finer substrates onto the stream bed surface. Although individual dredge tailing pile effects may be short term in nature and are typically not visible the next year as a result of peak flows following the summer dredging season (Prussian et al. 1999), summer-time dredging in Oregon rivers and tributaries affects spawning habitat for fall-spawning Chinook Salmon (*O. tshawytscha)*, Coho Salmon (*O. kisutch*) (Harvey and Lisle 1999), and Bull Trout (*Salvelinus confluentus*). Dredging of a broader area or cumulative impacts of multiple dredges working in the same stream, results in expanded stream bed disturbance that may persist for longer periods. Additionally, dredge sites not near the thalweg (i.e., deepest part of the channel), and where cobbles and boulders are piled, may affect the streambed for longer periods (Harvey et al. 1982, Thomas 1985, Stern 1988, Prussian et al. 1999).

Dredge operations can affect pool habitats through streambed erosion and pool filling. Dredging near riffle crests can degrade the streambed feature, or hydraulic control, that is responsible for maintaining water surface elevations in upstream pools, reducing pool volume and habitat value (Harvey and Lisle 1998). Finer gravels that pass through the dredge form tailing piles that can redistribute downstream from the original location and fill downstream pool habitat within a year (Thomas 1985). Suction dredge operators who remove streambed-anchoring boulders and large wood, destabilize the channel and simplify stream habitats that are important for fish rearing. Example impacted habitats include undercut banks, water velocity breaks created by boulders and large wood, and riffle-pool features that provide substrate for aquatic insect food sources and fish resting areas.

Dredging indirectly affects channel bed stability by disrupting natural streambed surface armoring that forms over time as finer sands and gravels are transported by flowing water from the streambed surface, leaving behind coarser substrates that are more resistant to scour (Parker and Klingeman 1982; Wilcock and DeTemple 2005). Streambed surface armoring provides streambed stability and interstitial spaces that provide habitat for aquatic organisms including aquatic insects, fish, and mussels. Removal of overburden sediment to access finer underlying gold-producing sediments, and mixing of coarser and finer substrates disrupts streambed surface armoring and increases the potential for streambed erosion and habitat impairment (e.g., loss of pool volume, filling of interstitial spaces, destabilized spawning gravels).

In sum, suction dredge mining affects channel morphology by destabilizing the streambed surface through direct removal of coarse sediment, mixing of coarse and fine sediments, and removal of streambed anchoring features such as boulders and large wood. Streambed destabilization simplifies aquatic habitat and results in a streambed less resilient to flood events. These effects may be exacerbated in a stream reach by the operation of multiple dredges or a single dredge operated over a large area. Cumulatively, multiple dredges potentially impact the stream over a greater space and time, diminishing the stream's capacity to support aquatic organisms.

## 4. General Habitat Effects

**Suction dredge mining alters aquatic habitats through stream bed alteration and large wood removal.** Dredges operate most efficiently in depositional areas that accumulate placer gold. Pool tailouts or riffle crests, channel margin eddies, and other slack water features created by channel obstructions, are focal areas for suction dredge mining. These slow water features provide spawning and rearing habitat used by salmonids, lampreys, and other native fishes. Disruption of the streambed surface, tailing piles, and redistribution of finer sediments decrease habitat quality. Loose and unconsolidated tailings piles may be used by salmonids (particularly Coho Salmon, Chinook Salmon, and Bull Trout, to construct spawning redds. When fish deposit eggs on these finer dredge tailings, eggs and subsequent developing larval fish can be lost as tailings are more easily displaced than natural streambed materials during annual high flow events (Harvey and Lisle 1999).

**Disruption of the streambed has a short-term effect on aquatic macroinvertebrate and long-term effect on freshwater mussel habitats.** Suction dredge processing of stream bed materials displaces aquatic macroinvertebrates, such as stonefly, mayfly, and caddisfly larvae residing in the streambed. These insects are the prey base for juvenile salmonids rearing in the affected streams. In addition, alteration of the streambed surface sediments may create adverse conditions for aquatic insect recolonization. Impacts to aquatic macroinvertebrates are typically limited to the mined area (Prussian et al. 1999) and are relatively short-term in nature, with recolonization of dredged sites ranging from several weeks to up to a year (Griffith and Andrews 1981; Prussian et al. 1999). Streams that are mined annually or have a long-term history of mining, may experience a more chronic impact to aquatic macroinvertebrate populations (Prussian et al. 1999).

Discharge of dredged sediments onto the undisturbed streambed downstream of the dredged location results in aquatic organism burial (Somer and Hassler 1992; Krueger et al. 2007). Aquatic macroinvertebrates and less mobile freshwater mussels may not be able to move at a sufficient rate to avoid burial. Once buried by mine tailings, some mussels are unable to reorient themselves and perish, although mortality rates are related to burial depth, substrate caliber, and mussel species and size (Krueger et al. 2007). In contrast to short-term recovery of aquatic macroinvertebrates, recolonization of mussel beds may require years to decades depending on the location of source populations and recolonization processes (see Section 8 Freshwater Mussel Effects).

**Suction dredge operations mobilize fine sediment creating sediment plumes that may influence streambed embeddedness and heavy metals distribution.** Dredging operations occur during the summer when low flows enable dredge operators to safely access streams and regulatory permits authorize suction dredge mining. Suspended sediments discharged from dredges eventually settle out of the water column, with heavier particles settling out first. Sediment plume persistence depends on the characteristics of the mined sediments, stream flow, and how the suction dredge is operated. Sediment plumes may affect water quality over 500 ft downstream from the dredge site (Prussian et al. 1999). Sediments with a high clay content will have more persistent sediment plumes due to the low density particles. High clay content in historically mined streams may also have high mercury concentrations as mercury adsorbs to high surface area-low volume clay particles (Marvin-DiPasquale et al. 2011; Fleck et al. 2011). Therefore, sediment plume persistence and potential effect distance are influenced by mined sediment composition.

Spawning gravels downstream from dredge activities are affected by fine sediments that settle from the dredge plume on to the streambed (USFS 2015). Fine sediments deposit on the streambed, filling the interstitial spaces in gravels subsequently clogging the pathways that are necessary for removing metabolic wastes of fish eggs and fish larvae. Similarly, the filling of interstitial spaces reduces hiding cover availability, increasing habitat competition for both juvenile fish and aquatic macroinvertebrates (USFS 2015). In short, fine sediment burial of the streambed surface impacts developing fish eggs, diminishes hiding cover, and makes juvenile fish and macroinvertebrates more vulnerable to predation.

The redistribution of mercury used in historical mining practices from deeper sediment strata by suction dredge mining contaminates surface sediments and introduces toxic heavy metals into depositional areas which affect juvenile fishes and aquatic macroinvertebrates (Fleck et al. 2011). For example, lamprey larvae (ammocoetes) sampled from depositional habitats in the Klickitat River, accumulated methylmercury in their tissue at concentrations that were approximately 14 times greater than the total mercury concentrations in the nearby sediments (Linley et al. 2016). Similarly, ammocoetes rearing in fine sediments in the Trinity River, a historically mined drainage in Northern California, had mercury concentrations 12 to 25 times greater than concentrations in mussels inhabiting the streambed surface (Bettaso and Goodman 2010).

**Suction dredge operations may disturb a small portion of the entire stream, but a large portion of critical habitats.** If suction dredge mining occurs in habitats with high value for fish production, regardless of stream size, suction dredge operations may have disproportionately increased effects on resident and migratory fish populations. Removal of high quality habitat components including large wood, boulders, and streamside vegetation, or destabilizing the streambed, could substantially affect important habitat features in a stream.

## 5. Anadromous and Freshwater Fish General Effects

**Suction dredging affects all life stages of anadromous fish that use mainstem and tributary streams to complete their life history strategies.** Anadromous fish species including Pacific salmon and steelhead species are born in freshwater, rear in both fresh and saltwater, and then return to freshwater to spawn. Life cycle characteristics vary by geography, migration timing, and genetic integrity of the population.

Spring and fall runs of Chinook Salmon inhabit coastal and inland basins throughout Oregon, and overlap with the primary suction dredge mining regions in the state. Adult spring Chinook Salmon enter mainstem rivers between March and June and mature in the river until spawning in August and September. Fall-run fish which reach sexual maturity in the ocean and enter freshwater between August and December, spawn shortly after their freshwater migration. Chinook Salmon eggs incubate through the winter and fry typically emerge from the spawning gravels in January and February. Smolts outmigrate between March and May, although alternative rearing pathways also include juvenile rearing in natal streams and outmigrating the spring one year after leaving the spawning gravels. Most Chinook Salmon will reside in the ocean for two or three years and return to fresh water as age 3 or 4 year old fish. Age 5 and age 6 Chinook Salmon also occur, but are more rare.

Coho Salmon generally exhibit a relatively simple 3-year life cycle with adults beginning their spawning migration in the late summer and fall and spawning by mid-winter. Coho Salmon in the Rogue River basin migrate to spawning tributaries from October through February with the majority of the spawning occurring in November and December. Eggs and fry remain within the spawning gravels for 1.5 to 4 months depending on water temperatures, before emerging from the spawning gravels as fry by about mid-June. Juvenile fish rear in freshwater for up to 15 months before migrating to the ocean as smolts in the spring of their second year. Adults typically spend 2 years in the ocean before returning to spawn as 3-year olds.

Summer-run and winter-run steelhead are found in coastal and inland river basins in Oregon. Winter-run Steelhead enter freshwater between November and April and spawn shortly thereafter. Most inland runs are summer-run Steelhead which enter Columbia River tributary rivers from August through May with peak migration between March and April. Spawning occurs from mid-February through May and eggs and fry remain in the gravel from April through July. Juvenile Steelhead can remain in natal streams and mainstem rivers for one to two years before migrating to the ocean as smolts. Adults typically remain in the ocean for 2-3 years before returning to natal streams to spawn. Steelhead generally have more diverse life history strategies than both Chinook Salmon and Coho Salmon.

Anadromous juvenile fish rear in their natal streams before redistributing to downstream reaches to capitalize on more productive habitats or to migrate to the ocean. Suction dredge operations on mainstem rivers affect Chinook Salmon adult migration, holding and spawning habitats, egg and larval development habitat, and juvenile rearing habitat by increasing turbidity and gravel embeddedness, destabilizing the streambed, and simplifying stream habitat. Suction dredge operations in tributaries similarly affect all life stages of Coho Salmon and steelhead. Mainstem operations also impact the adult and juvenile migratory corridors for Coho Salmon and steelhead as these species migrate through mainstem habitats to reach their respective destinations. Life stage impacts would be caused by geomorphic and general habitat effects and direct entrainment through dredges.

Depending on the overlap of suction dredge mining and juvenile salmonid rearing and out-migration, juvenile salmonids may be present when suction dredges operate. In-water work windows when suction dredges operate overlap with salmon and steelhead freshwater presence.

**Suction dredging affects all life stages of freshwater fish that use mainstem and tributary streams to complete their life history strategies.** Freshwater fish complete their lifecycle entirely in freshwater. Although freshwater species have a simpler life pathway relative to anadromous species, freshwater fish also exhibit diverse life history strategies that include resident, fluvial, and adfluvial strategies. Resident fish typically remain in natal streams for life and have limited migrations. Fish exhibiting a migratory strategy, migrate among habitats to complete their lifecycle. The fluvial strategy includes seasonal migrations among natal stream and riverine habitats; the adfluvial strategy includes seasonal migrations among natal, riverine, and lake habitats. Similar to anadromous species life stages, suction dredge operations affect habitats used by all freshwater fish life stages. Small stream dredging would impact all resident fish life stages, and juvenile fluvial and adfluvial fish. Mainstem dredging affects adult and juvenile rearing habitat and migratory corridor conditions for fluvial and adfluvial fish. Life stage impacts would be caused by geomorphic and general habitat effects and direct entrainment through the dredge (Griffith and Andrews 1981).

In sum, Oregon's salmon and steelhead populations have evolved to use freshwater resources nearly year-round. While some life stages, such as the egg and larval fish, are more susceptible to suction dredge mining than others, there is the potential for mining operations to conflict with salmon and steelhead even during the regulatory in-water work windows. Suction dredging may affect all salmonid life stages as well as the habitats salmonids rely on. Although juvenile fishes will use artificial mining pits and consume insect larvae discharged by dredges, there are no scientific studies that report net benefits from dredging to salmonids or their habitat.

## 6. Bull Trout Effects

**Suction dredge mining activities may directly affect Bull Trout through entrainment of eggs, fry and juvenile fish.** Bull Trout are a federally-listed threatened species under the Endangered Species Act (USFWS 1999). This species of char native to Oregon and other states in the western United States, has been impacted throughout its range by habitat loss and impairment, overfishing, and interaction with non-native fish species. Bull Trout in Oregon were previously considered Dolly Varden (*S. malma*) until Cavender (1978) first described the taxonomic characteristics of Bull Trout and separated Bull Trout from Dolly Varden. Substantial genetic work over the past 30 years has discretely separated the distribution of Bull Trout and Dolly Varden (Dunham et al. 1998), and the two distinct species only co-occur in a few areas in northern Washington and into Canada. All known Bull Trout populations in Oregon have been genetically characterized and no Dolly Varden have been documented in Oregon (Sankovich et al. 2003).

Bull Trout are distributed throughout Oregon, often in isolated populations inhabiting streams characterized by abundant cold, clear water, and complex habitat. Specific habitat associations vary depending on life stage and life history strategy which include resident or migratory (moving to larger rivers, lakes, or the marine environment in some populations; Rieman and McIntyre 1993) life forms. Resident and migratory Bull Trout spawn in headwater streams with cold water temperatures, less than about 9°C (48°F) generally in September and October (McPhail and Baxter 1996). Resident adult Bull Trout spawners may be as small 6 inches in length (Fraley and Shepard 1989; Whitesel et al.1999), while migratory adult Bull Trout may be longer than 28 inches (Fraley and Shepard 1989; McPhail and Baxter 1996). Resident Bull Trout spawn in small gravel and redds may be the size of a dinner plate, while large migratory spawners may build redds of 2 square yards or more (Hemmingsen et al. 1997). Eggs must remain within the gravel nest (i.e., redd) in which they were laid to hatch, and take a relatively long time to hatch. Fry emergence from the gravel may take more than 220 days (Fraley and Shepard 1989). Based on fall spawning, emergence would be expected from April to June (McPhail and Murray 1979, Fraley and Shepard 1989, Allan 1990, Ratliff 1992). After emergence, fry almost exclusively occupy the streambed and are generally concealed within the streambed substrate void spaces during the day time and emerge during the night to feed for their first year of life (McPhail and Murray 1979; Fraley and Shepard 1989; Brown 1992; Rieman and Mcintyre 1993; Baxter 1995; Saffel and Scarnecchia 1995; Polacek and James 2003). For migratory Bull Trout, juveniles generally stay within the headwater stream where they were spawned until about age 2 or 3 before making downstream migrations (Pratt 1992; Mogen and Kaeding 2005), however migrations of age-1 juveniles have also been observed (Bowerman and Budy 2012). Juvenile and subadult Bull Trout may migrate throughout the year, but most migration occurs between June and December, with a peak in August (Homel and Budy 2008).

Researchers have observed Bull Trout fry burrowing into the river bed substrate when disturbed by human presence (Goetz 1994; Thurow 1997; Polacek and James 2003). Therefore, as dredge miners enter the stream, fry and juvenile fish would naturally burrow into the substrate. Even larger juveniles of 2 to 3 years of age may conceal themselves within the substrate during the daytime (Thurow 1997; Bonneau and Scarnecchia 1998).

In summary, Bull Trout eggs are within spawning gravel for over half the year and juveniles are present in natal streams year-long. Eggs are buried in the gravel and juveniles use interstitial spaces within gravel and cobble substrate to hide. Therefore, suction dredge mining in Bull Trout spawning and rearing streams has the potential to entrain eggs, fry and juvenile fish causing mortality.

**Bull Trout populations occupy a small portion of their historical range and populations in northeastern Oregon are susceptible to displacement due to suction dredge activities that focus on low gradient, gravel streambed reaches of the river corridor.** Bull Trout use these areas for adult migration corridors, spawning habitat, and rearing habitats. Suction dredge activities destabilize the channel and simplify habitat by altering the streambed surface (e.g., embedment with fine sediment, mixing of coarser and finer sediment), removing streambed-anchoring materials such as boulders and large wood, and eroding undercut banks. Bull Trout populations in northeastern Oregon are generally small and spawning and rearing habitat is limited in some streams to less than 1-mile of summer rearing habitat.

Spawning and early life stage rearing is generally confined to higher elevation streams with cold water temperatures or lower elevation streams with substantial spring inputs. Particularly in northeastern Oregon, suction dredge activities within headwater streams threaten small resident Bull Trout populations. Populations at risk in part due to suction dredge mining are located in the upper North Fork John Day River, Middle Fork John Day River, upper Powder River, and upper Pine Creek watersheds (Buchanan et al. 1997).

## 7. Effects on Lampreys

**Suction dredge mining activities have the potential to directly affect lampreys through entrainment of larval life stages (ammocoetes), and indirectly through habitat alteration and simplification, and redistribution of heavy metals to depositional habitats used by ammocoetes.** Two common lamprey species in Oregon include the large-bodied, anadromous Pacific Lamprey (*Entosphenus tridentatus*; status: federal species of concern, “sensitive” species in Oregon), and Western Brook Lamprey (*Lampetra richardsoni*; status: “sensitive” species in Oregon), a small-bodied, freshwater-resident lamprey. These two lampreys occur throughout much of the Snake and Columbia river basins, and coastal Oregon. Other lamprey species are less common and/or less fully understood. These lesser known lamprey, include the Western River Lamprey (*L. ayresii*; status: federal species of concern, “sensitive” species in Oregon), largely an estuarine, nearshore ocean species that is closely related to the Western Brook Lamprey. Another resident lamprey, the Pacific Brook Lamprey (*L. pacifica*) exists in the Clackamas River Basin, and potentially in certain areas on the Oregon Coast. In addition, several resident, small-to-medium bodied lampreys are also found in central and southwest Oregon, in the Great Basin and Upper Klamath Lake Basin. These lampreys include the Northern California Brook Lamprey (*E. folletti*), Miller Lake Lamprey (*E. minimus*; status: “sensitive” species in Oregon), Pit-Klamath Lamprey (*E. lethophagus*), the Klamath River Lamprey (*E. similis*), the Klamath Lake Lamprey (*Entosphenus* sp.), and the Goose Lake Lamprey (*Entosphenus* sp.). This makes Oregon a “hot spot” of lamprey diversity (Potter et al. 2015; Markle 2016). The following narrative is focused on the Pacific Lamprey as scientists know more about this species than other lampreys, and the species is culturally important to Native Americans. Pacific Lamprey habitat overlaps with streams that experience suction dredge mining.

After spending up to four years in the ocean as an ectoparasite on adult fish and marine mammals, maturing adults of Pacific Lamprey (35-90 cm) cease feeding and return to streams to spawn. The estimated year-long adult freshwater phase consists of an initial migration (March-September), a holding period (July-April), and final migration to spawning habitat (March-June; Clemens et al. 2010). Unlike salmon and steelhead, Pacific Lamprey do not home to natal streams to spawn (Goodman et al. 2008; Spice et al. 2012). Instead, adult lampreys are attracted to bile acids emitted by lamprey larvae (migration attraction) and the sex hormones of other adults (spawning attraction). Adult Pacific Lamprey die after spawning.

Pacific Lampreys spawn in habitats similar to salmonids: upstream of riffle crests in gravel bottomed streams (Stone 2006). The larvae (~1.5 cm) hatch from eggs after ~3 weeks and disperse downstream until suitable burrowing habitat (typically silt) is found, or spring flows subside (Dawson et al. 2015). Larvae spend 3-7 years burrowed mainly in silt, sand, and organic matter, but also gravel/cobble, typically < 20 cm deep, filter-feeding on microscopic organisms and algae (Dawson et al. 2015). Several biological and environmental factors stimulate an extensive physiological and morphological transformation, from eye-less, brown, funnel-shaped filter feeders into eyed fish with silver coloration and toothed mouths for parasitic feeding in the ocean. After transformation, smolts outmigrate during high water events from September-June (Dawson et al. 2015).

Western Brook Lamprey and other freshwater-resident lampreys have much shorter adult migrations limited to freshwater waterbodies, and no parasitic phase. Adults (13-16 cm long) do not feed between transformation (transition from ammocoete to adult) and reproduction. Larvae use similar burrowing habitat and have filter feeding diets similar to larval Pacific Lamprey.

Populations of Pacific Lamprey have been ranked by the U.S. Fish and Wildlife Service as being at various states of imperilment, if not already extinct in areas of Oregon (Wang and Schaller 2015). Factors impacting Pacific Lamprey include fish passage barriers (e.g., dams and poorly designed road culverts), de-watering of rivers and reservoirs, unscreened surface water diversion, dredging, streambed scouring (e.g., by logging splash dams), channelization, loss of stream-side vegetation, removal of large woody debris, introduced predatory fishes (Luzier et al. 2009; CRITFC 2011), and various toxic contaminants, including mercury (Bettaso and Goodman 2010; Nilsen et al. 2015; Linley et al. 2016). Western Brook Lamprey is thought to be less susceptible to artificial barriers, but shares other limiting factors listed for Pacific Lamprey.

**Suction dredge mining effects on lampreys are similar to effects outlined for anadromous and freshwater-resident salmonids.** Lampreys are susceptible to water quality impairment and instability of stream beds during adult upstream migration, and as larvae downstream migration. Streambed instability, habitat simplification, and gravel embeddedness caused by gravel removal and fine sediment discharge, can affect adult holding and spawning habitats. Larval rearing habitat in channel margins is susceptible to streambed disturbance, sedimentation related to dredge sediment plumes, and the redistribution and deposition of contaminants like mercury that can be taken up by larval lamprey (e.g., see Bettaso and Goodman 2010). Larval lamprey sampled from the Klickitat River accumulated methylmercury in their tissue at concentrations that were approximately 14 times greater than the total mercury concentrations in the nearby sediments (Linley et al. 2016). Similarly, larval rearing in fine sediments in the Trinity River, a historically mined drainage in Northern California, had mercury concentrations 12 – 25 times greater than mercury concentrations in Western Pearlshell mussels (*Margaritifera falcata*) inhabiting the streambed surface (Bettaso and Goodman 2010). Tissue concentrations of methylmercury in larval lamprey are hypothesized to negatively affect larval lamprey development. As a prey item for fishes, birds, and mammals, high levels of methylmercury in larval lamprey may bioaccumulate into higher concentrations in their predators, lowering fitness and survival for animals at the top of the food web (Linley et al. 2016). Mercury concentrations in adult lamprey, an historically important food source for Native Americans, is less well known.

## 8. Freshwater Mussel Effects

**Suction dredge mining activities can directly and indirectly affect all life stages of freshwater mussels.** Mussels are harmed directly through physical injury or mortality, interference with reproduction and feeding, and burial; and indirectly through habitat loss and water quality degradation. The damage to substrate used by mussels can last more than one season. These direct and indirect effects are likely to reduce the size and resiliency of freshwater mussel populations. The Pacific Northwest is home to freshwater mussels in three genera: Western Pearlshell Mussel, Western Ridged Mussel *(Gonidea angulata*), and several related groups of Floaters (*Anodonta* spp.; Nedeau et al. 2009). No western species are federally protected, but populations have declined or been lost from multiple watersheds throughout the West (Hovingh 2004; Strayer et al. 2004; Howard et al. 2015; IUCN Red List, 2016) due to habitat degradation, water withdrawals, impaired water quality, loss of native host fish, and competition from invasive bivalves. Adult mussels inhabit the substrate, where they can move vertically and laterally in response to season, breeding status, and flow conditions (Amyot and Downing 1997; DiMaio and Corkum 1997; O'Dee and Chordas 2001).

Gametes and larval mussels (glochidia) are present in the water column at different times of the year, depending on species. Male mussels broadcast sperm into the water column, where it is picked up by females via their filter feeding apparatus and used to fertilize their eggs. When embryonic development is complete, larval mussels are released into the water column, where they must find a suitable fish host in order to survive, develop, and disperse. Because they are long-lived, with lifespans ranging from 10-15 years (*Anodonta*), 20-30 years (*G. angulata*), and 80-100 years (*M. falcata*), they require several years to reach reproductive maturity, and local populations are slow to recover after declines.

**Mussels are vulnerable to short- and long-term habitat disturbance, mortality, and pollution caused by suction dredge mining.** Western mussel species are relatively thin-shelled, especially juveniles, and vulnerable to being crushed or damaged by suction equipment. Physical disturbance can reduce breeding success and may lead to early release of juvenile mussels (Hastie and Young, 2003), and habitat instability can impact juvenile settlement and survival (Österling et al., 2010). Increased substrate disturbance and suspended particle concentrations can lead to longer periods of valve closure, less filtration (i.e., decreased rate of ingestion), and the gills may become clogged (Kat 1982; Aldridge et al. 1987; Brim-Box and Mossa 1999). Excessive sedimentation can interfere with reproduction (Gascho Landis et al. 2013; Gascho Landis and Stoeckel 2016) and larval mussel interactions with host fish (Brim-Box and Mossa 1999). Mussels that are disturbed or covered in sediment may be unable to excavate themselves or regain their proper orientation in the substrate, leading to lethal and sub-lethal impacts (Marking and Bills 1979; Krueger et al. 2007), and different species may differ in their ability to right themselves after disturbance (Waller et al. 1999). Changes in stream bed structure following suction dredge mining may also alter species abundance and distributions (Vannote and Minshall 1982). Freshwater mussels have a patchy distribution in streams and are associated with protected areas that experience low shear stress and scour during high flows (Strayer 1999). Removal of rocks, stones, or wood debris that exceed suction dredge capacity, as well as dislodging sediment during the dredging process, can destabilize the substrate and potentially alter flow refuges within the stream channel. This can result in localized habitat loss for freshwater mussels.

## 9. Mercury Contamination Effects

**Although mercury is a naturally occurring element that enters the environment through geochemical processes, historical mining practices used a large volume of mercury to recover gold and in so doing, contaminated stream corridors.** During the California Gold Rush, millions of pounds of liquid mercury were added to sluice boxes to recover gold. Mercury-gold amalgamation sequestered gold in the bottom of the sluice, making it easier to recover fine gold from sluices (USGS 2005). An estimated 10-30 percent of the total volume of mercury used to recover gold (Bowie 1905 *cited in* USGS 2005) was lost to aquatic environments during the operation of the thousands of sluices that separated gold from streambed sediments. Turbulent sediment-laden water entering a typical sluice dislocated mercury or broke the mercury into smaller particles (flouring) that were then discharged from the sluice into the receiving waterway (USGS 2005). Based on sluice dimensions and liquid mercury use, typical sluices likely lost several hundred pounds of mercury during the 6-8 month operating season. The total amount of mercury lost to the environment from placer mining operations in California during the Gold Rush period, has been estimated at 10 million pounds (Churchill 1999). Although historical mercury losses in Oregon were likely less than those in California's Sierra Nevada mining region due to the smaller scale mining that occurred in Oregon, watersheds in southwestern and northeastern Oregon that were targeted by miners from the mid-1800s to the mid-1900s have similar mercury contamination concerns (ODEQ 2017). Mercury contamination in Oregon has been linked to historical placer and lode (hard rock) mining practices that also used mercury to amalgamate gold (ODEQ 2017). In comparison to atmospheric mercury associated with industrialization (e.g., fossil fuel burning) that is deposited on the landscape through precipitation, historical mining-related mercury is the dominant mercury source in smaller watersheds where gold mining took place (Domagalski et al. 2016).

**Suction dredge mining re-suspends legacy mercury located deep in streambed sediment.** Like gold, mercury migrates down through the sediment to depths that are not typically disturbed during floods (USFS 2015). Suction dredge activities mobilize mercury from deeper sediments (USFS 2015), liberating mercury that would otherwise remain sequestered in the channel bed (Fleck et al. 2011; Marvin-DiPasquale et al. 2011). While suction dredge miners remove mercury from streambeds, not all mercury is captured in the dredge sluice. Droplets of mercury and mercury adsorbed to fine sediments are also discharged by the dredge in the sediment plume (Humphreys 2005; Fleck et al. 2011; Marvin-DiPasquale et al. 2011). In two studies from the California Sierra Nevada, sediment plume mercury concentrations were over 10-20x higher than the hazardous waste threshold of 20 ppm (Humphreys 2005; Fleck et al. 2011). Mercury concentrations in the sediment plume were greater than mercury concentrations in the coarser substrates trapped in and discharged from the sluice.

Fine droplets of floured mercury or mercury adsorbed to clay particles, discharged by the sluice are easily transported by the stream away from the dredge location (Humphreys 2005; Fleck et al. 2011; Marvin-DiPasquale et al. 2011). These fine grained sediments remain in suspension longer than heavier sediments (Fleck et al. 2011), and the adsorbed mercury is more readily converted to methylmercury via microbial processes (Marvin-DiPasquale et al. 2011). In sum, the turbid water discharged from a sluice working in mercury-contaminated sediment, has the potential to negatively affect a broader area of the stream corridor, relative to the dredge's physical disturbance footprint, due to the transport and deposition of fine particle mercury that may be readily converted to methylmercury if favorable conditions for methylation exist downstream.

**The methylated form of mercury has the greatest potential to negatively impact fish, wildlife, and humans through fish consumption**. Methylmercury is a neurotoxin and the most hazardous form of mercury (Ullrich et al. 2001). It can adversely affect fish, wildlife, and humans (Ackerman et al. 2016; Lepak et al. 2016). Humans are most frequently exposed to methylmercury through consumption of certain fish and shellfish species that are high in methylmercury concentrations. Gender and age influence how methylmercury affects the health of individuals, with methylmercury exposure to children and pregnant women of greatest concern (WHO 1990). Methylmercury can impair neurologic, cardiovascular, endocrine, and immune system function in humans who regularly consume contaminated fish (ODEQ 2013).

Mercury is converted to methylmercury through microbial processes typically associated with low oxygen aquatic environments like wetlands (Brigham et al. 2009). However, mercury methylation in aquatic systems has also been shown to increase with increasing availability of elemental mercury and dissolved organic carbon, and in the presence of sulfate-reducing bacteria, low pH, and increased water temperatures (Ullrich et al. 2001). Additionally, water source, turbidity, and the frequency of riparian inundation can affect methylation (Henery et al. 2010; USEPA 1997; ODEQ 2013; Singer et al. 2016). Methylmercury is more reactive and bioavailable relative to elemental mercury (Fleck et al. 2011). Methylmercury enters the food chain through adsorption by plankton and then bioaccumulates in the tissues of organisms in higher concentrations at each successive trophic level (Ackerman et al. 2016; Donovan et al. 2016). The majority of mercury found in fish is methylmercury (SWRCB 2017) and those fish species that are piscivorous or top-level predators (e.g., bass) generally have the highest mercury concentrations because of the bioaccumulating properties of methylmercury. Once mercury is methylated, it can follow one of several pathways including demethylation (return to inorganic mercury), sequestration in sediments, transport in the water column, percolation into the streambed-water table interface (i.e., hyporheic zone), or uptake into the food web (Singer et al. 2016).

## 10. Conclusion

Suction dredge mining adversely alters channel morphology and aquatic habitat for native aquatic organisms in Oregon's rivers. Aquatic organisms including anadromous and freshwater-resident fish, Bull Trout, lamprey, and mussels are adversely effected directly and indirectly by suction dredge operations. Entrainment through the dredge may result in mortality of eggs and larval fishes (direct effects); streambed destabilization reduces egg-to-fry survival. Fine sediment deposition on spawning and rearing habitats, and habitat simplification may reduce juvenile fish production.

Recent studies investigating mercury effects on stream environments are exposing the regional contamination caused by historical mining practices that relied on mercury to recover placer gold. Mercury contamination from placer mining and lode mining, in addition to contamination from mercury mines, has resulted in toxic stream corridors. Suction dredge mining practices expose and redistribute formerly sequestered mercury, increasing methylmercury production potential, and mercury bioaccumulation through the food web. The level of potential effects related to suction dredge mining, particularly in historically-mined systems, strongly suggests the need for state policy to further regulate suction dredge mining and grant comprehensive protection of rivers and stream.

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