NFS Group Comments on Draft Water Quality Certification for Klamath River Renewal Corporation's Lower Klamath Project No. 14803.

July 23, 2018

To: Ms. Michelle Siebal
State Water Resources Control Board
Division of Water Rights – Water Quality Certification Program

From: Jake Crawford, River Steward Program Director, Native Fish Society
Conrad Gowell, Fellowship Program Director, Native Fish Society
Mark Sherwood, Executive Director, Native Fish Society
Kurt Beardslee, Executive Director, Wild Fish Conservancy
Yvon Chouinard, Owner, Patagonia Inc.
Hans Cole, Director of Environmental Campaigns and Advocacy, Patagonia Inc.
Charles Gehr, Northwest and Rockies Sales Manager, Fly Water Travel
Jack Stanford, Professor Emeritus, Flathead Lake Biological Station, University of Montana
Matt Stoecker, Principal Biologist, Stoecker Ecological

Re: NFS Group Comments on Draft Water Quality Certification for Klamath River Renewal Corporation's Lower Klamath Project No. 14803.

Dear Ms. Michelle Siebal,

Thank you for the opportunity to provide comments on the draft Water Quality Certification for the Klamath River Renewal Corporation's Lower Klamath Project – No. 14803 ("The Project"). We support the Project decommissioning that will improve the biological conditions in the Klamath watershed to benefit sensitive and threatened wild, native fish species, and understand that this action is critical to their recovery and long-term protection.

The Native Fish Society (NFS) is a 501(c)3 conservation non-profit, dedicated to utilizing the best available science to advocate for the protection and recovery of wild, native fish and promote the stewardship of the habitats that sustain them. NFS has 3,300 members and supporters and 89 River Stewards that help safeguard wild fish in their homewaters across the Pacific Northwest. NFS has five River Stewards that live, work, and recreate in the Klamath watershed in both California and Oregon. Furthermore, NFS River Stewards, Staff, and Supporters live, work, and recreate in the Klamath basin who are interested in the recovery of threatened and sensitive populations of wild, native fish.

Wild Fish Conservancy is a 501(c)3 non-profit that is dedicated to the recovery and conservation of the region's wild fish ecosystems. Through science, education, and advocacy, WFC promotes technically and socially responsible habitat, hatchery, and harvest management to better sustain the region's wild-fish heritage.

Patagonia is an outdoor clothing and gear company dedicated to using business to inspire and implement solutions to the environmental crisis. This includes a 40-year history supporting grassroots campaigns and local groups working to remove dams, restore habitat and protect wild rivers and wild fish.

Fly Water Travel is a team of fishing and travel experts exclusively dedicated to arranging trips to the world's finest fishing destinations. Fly Water supports fishing businesses in the Klamath basin and clients who travel to the Klamath watershed to experience healthy runs of wild, native fish and the clean water necessary for their survival.

Jack Stanford is a Professor Emeritus at the Flahead Lake Biological Station with the University of Montana, where for over 45 years his research focused on the ecology of Pacific Rim salmon rivers.

Stoecker Ecological is a biological consulting firm that specializes in salmon and steelhead restoration across the West Coast.

We are writing with serious concerns and opposition over components of the draft water quality certification related to "Condition 12. Hatcheries" and the Licensee's plan to "construct, operate, and maintain the Fall Creek and Iron Gate Hatcheries, as presented in the Licensee's June 1, 2018 submittal of updates to Section 7.8 of the *Administrative Draft of the Definite Plan for Decommissioning*".

We are submitting these comments because we have a keen interest in the certification and decommissioning of the Project, and our collective organizations, members, partners, and clients have been deeply involved in past and ongoing wild salmon and watershed restoration projects in California, Oregon, and Washington. We submit the following comments opposing certification and approval for infrastructural investments to Iron Gate Hatchery and Fall Creek Hatchery in order to maintain hatchery salmonid releases in the Klamath, which will undoubtedly compromise and undermine the recolonization and restoration of the river's native fish who would otherwise benefit from decommissioning.

Furthermore, we respectfully request a response to our concerns that address the overwhelming scientific consensus that hatcheries pose significant risks to wild fish. We bring these questions forward now so that together we can take advantage of this unique opportunity to identify an effective path forward to restore wild salmon in the Klamath River. It is imperative that such a plan does not rely on the artificial production of native fish. Time and again, the scientific literature and empirical experience (as documented in this letter) has shown that the use of artificial production in recovery strategies has failed to restore self-sustaining populations. Utilizing such a method on the Klamath will compromise the recolonization of wild anadromous fish with historic habitat following Project decommissioning.

Iron Gate Hatchery was built in 1962 as mitigation for the loss of upstream spawning and rearing habitat for anadromous salmon and steelhead between Iron Gate Dam and Copco 2 Dam. We see no reason for the continuation of a mitigation hatchery program and investment in new hatchery infrastructure, particularly for Chinook salmon, following the removal of the four lower Klamath dams, especially given that anadromous salmonids will now be able to volitionally access this important historically accessible habitat.

The negative effects of salmonid hatcheries on wild fish have been well documented across the Pacific Northwest, and importantly, the negative effects of Iron Gate Hatchery on wild anadromous salmonids in the Klamath basin have been documented in recent peer reviewed scientific literature - See Quiñones et al. (2013)[1]. Given this research and the volumes of peer-reviewed articles documenting issues with the impacts of hatchery production on wild populations, we question the utility of investing in the construction, operation, and maintenance of Iron Gate Hatchery and Fall Creek Hatchery, particularly if after eight years, as stated in the Definite Plan, the hatcheries will be decommissioned. Any hatchery releases following Project decommissioning will further perpetuate ongoing problems identified in the scientific literature, jeopardizing wild fish recolonization into upstream habitat, and leaving populations more vulnerable to human development and climate change in the basin. The extensive scientific literature shows that continued hatchery operations in the Klamath basin will result in a loss in reproductive success and local adaptation by wild fish along with decreases in genetic and phenotypic diversity. These impacts can be expected to have acute effects on wild fish recovery in the basin given the ongoing and projected climatic changes to the area.

Despite a century and a half of use, fish hatcheries remain an unproven method to sustain the viability and biodiversity of native fish populations, preserve the culture of commercial and recreational fishing, and uphold treaty obligations and subsistence fishing for indigenous peoples and sovereign nations. There is an overwhelming scientific consensus that fish hatcheries have a myriad of direct negative consequences for fish including **infrastructural**, **ecological,** and **genetic** impacts, although these categories interact considerably. There is also a growing public awareness of the **indirect** impacts fish hatcheries cause within the socio-ecological interface within watersheds and socio-economic dimensions of fisheries.

In the Klamath River watershed there are three populations of native fish species that are listed under the Endangered Species Act: Southern Oregon Northern California Coast Coho salmon, Lost River sucker, and Shortnose sucker. The Upper Klamath – Trinity River Chinook salmon and Klamath Mountain Province steelhead trout are currently on the Forest Service Sensitive Species list. A petition to list spring Chinook salmon in the Upper Klamath – Trinity River ESU is currently under review.

The negative impacts resulting from fish hatcheries can occur within facilities at the species level, on the natural environment within and beyond the fish hatchery, and to ecosystems far beyond where those hatchery fish are reared and released. The negative effects of hatchery fish are severe enough that courts have recognized “stray [hatchery] fish as low as one or two percent...may pose unacceptable risks to natural populations”[2].

In light of the condition of the Klamath’s threatened and sensitive salmon and steelhead, and the continued impacts fish hatcheries cause, we request that the California State Water Resources Control Board certifies they are following all applicable environmental laws when taking action, including, but not limited to the:

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[1] Quiñones R., M. L. Johnson, and P.B. Moyle 2013. Hatchery practices may result in replacement of wild salmonids: adult trends in the Klamath basin, California. Environmental Biology of Fish. DOI 10.1007/s10641-013-0146-2

[2] Native Fish Soc’y, 992 F. Supp. 2d at 1104 (quoting the administrative record) (internal citations omitted).

- Endangered Species Act,
- National Environmental Policy Act,
- California Environmental Quality Act,
- Administrative Procedure Act,
- Clean Water Act.

Within these policies there is a clear standard to incorporate the best available science and to consider cumulative impacts, socioeconomic, and environmental justice concerns. In light of the following considerations we recommend the California State Water Resources Control Board consider these following comments, which outline the numerous documented negative effects of hatchery operations on wild populations and remove the condition of maintaining hatchery operations as part of the certification.

In particular, the California State Water Resources Control Board must consider the project's potentially significant environmental impacts pursuant to the California Environmental Quality Act ("CEQA"), Cal. Pub. Res. Code § 21000 et seq. and the CEQA Guidelines, 14 Cal. Code Regs. §15000 et seq. We understand that the California State Water Resources Control Board is preparing an Environmental Impact Report ("EIR") for the project. The EIR must include a detailed analysis of the impacts to the environment from the hatchery operations that will occur as part of the project. Additionally, because, as described below, these impacts will be significant, CEQA requires the California State Water Resources Control Board to consider project alternatives and feasible mitigation (such as discontinuing hatchery operations) that will reduce these impacts to less than significant levels. See Pub. Res. Coe § 21002.1.

Further, because Section 9 of the Federal ESA prohibits take of listed species, multiple documents have been submitted by California Fish and Wildlife Department and PacifiCorp to the National Marine Fisheries, including a Habitat Conservation Plan with Incidental Take Permit for Interim Operations for Coho Salmon submitted in March of 2012, and a Hatchery Genetic Management Plan in September 2014, which has not been approved. We question whether authoriziation of a Water Quality Certification for operating Iron Gate Hatchery will contribute to the unlawful take of an Endangered Species Act listed species following the decommissioning of the Project.

In these comments we detail impact/risk categories that have been previously recognized, studied, and reviewed. Within each of these areas, we also detail subcategories and cite specific examples of how those impacts have contributed to increased extinction risk for fish and to impacts on the people who depend heavily on these species.

1. Infrastructural impacts

Infrastructural impacts arise from the captive rearing of fish in a hatchery setting including the (a.) *physical location of the facility*, (b.) *operation and resource consumption of the facility*, (c.) *potential for general facility failure,* and (d.) *demographic and collection impacts*.

> (a.) Often fish hatcheries are located in or adjacent to important floodplain habitat, causing ongoing impacts to fluvial geomorphological processes including preventing active channel

migration. Many fish hatcheries also rely upon weirs, traps, or other infrastructure within the stream channel that negatively impacts downstream habitats, impedes aquatic organism migration and negatively effects spawning and rearing behavior.

(b.) In order to rear fish, hatcheries withdraw water from the stream channel or local groundwater sources to use in the facility. Factors such as flow reductions, displacing other stream-dwelling organisms crucial to the aquatic food web, and dewatering the spawning and rearing areas can all occur from extracting water from the environment surrounding the artificial propagation infrastructure. If water is returned to the stream, effluent discharges consisting of modified water temperature, pH, suspended solids, ammonia, organic nitrogen, total phosphorus, and chemical oxygen demand in the receiving stream's mixing zone can all negatively affect the fish (Kendra 1991)[3]. It is also possible for bacteria, parasites, and viruses to be introduced through this effluent discharge. Fish hatchery operations are required to comply with the Clean Water Act and specifically be covered under a National Pollutant Discharge Elimination permit. The Clean Water Act accomplishes this regulation by requiring a permit for each and every point source discharge, with effluent limits based on the more stringent of technology-based standards and standards necessary to protect water quality and existing water uses. If hatcheries are permitted with an NPDES, their permits are often administratively continued and no longer reflect current federal and state water quality standards as the Clean Water Act requires. Often, it is not known how a fish hatchery impacts water quality, and often the magnitude of impacts depends upon the flow volume of the hatchery effluent relative to the total flow of the stream. In some circumstances, relatively small amounts of toxic discharges from fish hatchery effluent can cause significant harm stemming from residual chemical reagents, salts, and chlorinated water[4]. These water quality permits are intended to protect aquatic life and public health and ensure that all artificial propagation facilities adequately treat their wastewater. Regardless of the cause of water quality impairments, fish hatcheries may not exacerbate water quality problems in impaired watersheds.

(c.) Time and again, fish hatcheries have been subject of artificial propagation failures that cause massive die-offs in captive populations. Risks exist in water intake screens becoming plugged, the facility losing electrical power, or catastrophic loss of fish through environmental disaster such as fire, debris torrent, and flooding. Additionally, poor artificial propagation and facility maintenance is a common reason fish are unintentionally killed in fish hatcheries.

(d.) Injury can be caused to fish populations through the collection of fish for artificial propagation in the hatchery. Usually this impact is imposed on adult fish returning to the stream to spawn, but these impacts can also be imposed through the collection of eggs, emerging fry, and juvenile fish. By taking fish into captivity the phenology of their upstream migration and subsequent life history is disrupted. This disruption in timing occurs primarily through the use of weirs, fish traps, and seines, which contribute to wild fish falling back into less preferable spawning and rearing areas, and fish becoming injured while trying to jump barriers within and

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[3] Kendra, W. 1991. Quality of salmonid hatchery effluents during a summer low-flow season. Transactions of the American Fisheries Society120(10):43-51.

[4] Center for Environmental Law and Policy; and Wild Fish Conservancy Case 2:15-cv-00264-SMJ

> mandated by the artificial propagation facility (Hevlin and Rainey 1993[5], Spence *et al*. 1996[6]). Risk is also posed to wild fish by the need to continually extract natural-origin individuals from the population to counteract domestication effects caused by the fish hatchery. This removal of individuals from the population removes nutrients from upstream reaches (Kapusinski 1997[7]) and contributes to the decline in abundance, productivity, diversity, and spatial distribution of the threatened and endangered populations.

Infrastructural impacts are often assumed to be offset through investments in equipment or changes in artificial propagation procedures. However, the physical existence of the hatchery represents a permanent, negative impact on the surrounding environment and can also pose serious harm to fish populations both in and outside of the facility. In addition, the cost it takes to offset these impacts into the indefinite future is always greater than the cost of restoring watershed function and further delays investment in the root causes of decline for natural fish.

2. Ecological Impacts

Ecological impacts occur on an inter and intraspecies basis both inside and outside the artificial production facility. Ecological interactions occur whether or not inter-breeding occurs and are magnified if resident life histories are being produced. Ecological impacts include: a.) disease, b.) competition, c.) behavioral modification, and d.) marine derived nutrients. Review papers by Pearsons (2008)[8] and Kostow (2009)[9] document numerous, serious, negative ecological consequences as a direct result of the artificial propagation of fish.

> (a.) *Disease:* Common diseases within hatcheries of the Northwest include Furunculosis (*Aeromonas salmonicida), Saprolegnia spp.,* Cold Water Disease *(Flavobacterium psychrophilum), Trichodinids,* bacterial kidney disease (*Renibacterium salmoninarum),* among others. Bartholomew *et al.,* 2013[10] is often cited as a source claiming hatcheries do not pose a risk to surrounding watersheds from artificially amplifying pathogens and parasites. However, through regular monitoring conducted by state and federal agencies, we know that disease is a constant problem when artificially rearing fish in high densities (Saunders 1991[11]). Rearing

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[5] W Hevlin and Rainey S. 1993. Considerations in the Use of Adult Fish Barriers and Traps in Tributaries to Achieve Management Objectives Pages 33-40. Fish passage policy and technology. Bioengineering Section, American Fisheries Society, Bethesda, MD.

[6] Spence, B.C., G.A. Lomnicky, R.M. Hughes, and R. P. Novitzki 1996. An Ecosystem approach to salmonid conservation. TR-4501-96-6057. Mantech Environmental Research Services Corp., Corvallis, OR 356p.

[7] Kapuscinski A.R. (1997) Rehabilitation of Pacific Salmon in Their Ecosystems: What Can Artificial Propagation Contribute?. In: Stouder D.J., Bisson P.A., Naiman R.J. (eds) Pacific Salmon & their Ecosystems. Springer, Boston, MA

[8] Pearsons, T. N. 2008. Misconception, Reality, and Uncertainty about Ecological Interactions and Risks between Hatchery and Wild Salmonids Fisheries 33(6):278-290.

[9] Kostow, K. Rev Fish Biol Fisheries (2009) 19: 9. https://doi.org/10.1007/s11160-008-9087-9

[10] Bartholomew, J. 2013. Disease risks associated with hatcheries in the Willamette River basin. Prepared 11 for the Army Corps of Engineers, Portland District. 26 pages. 12

[11] Saunders, R. L. 1991. "Potential interaction between cultured and wild atlantic salmon." *Aquaculture* 98.1-3 (1991): 51-60.

facilities expose captive fish to increased risk of carrying pathogens because of the increased stresses associated with simplified and crowded environments. It is probable that fish transferred between facilities, adult fish carcasses being outplanted into the watershed, and other fish released from hatcheries, have acted as a disease vectors to wild fish and other aquatic organisms. These diseases, amplified within the hatchery, contribute to the mortality of fish at all life stages and can travel rapidly to areas well beyond where effluent pipes are discharged. The outplanting of juvenile and adult fish can transfer disease upstream of the rearing site, and there is the potential for lateral infection through the travel of avian, mammalian, and other terrestrial predators which overlap with the distribution of artificially propagated fish.

The release of artificially produced hatchery fish into the wild also poses a risk of introducing pathogens and parasites to wild populations that can result in temporary epidemics or permanent reductions in wild populations. While this risk is more difficult to quantify than genetic and competitive effects, they are unlikely to be negligible. Even an individual fish released from a pathogen-laden hatchery environment can transfer the infection to areas where wild fish are susceptible, leading to devastating consequences. This is especially of concern with regard to local wild populations, including the majority of threatened fish populations, that are already at depressed levels of abundance. These dynamics contribute to disease driven mortality at all life stages in wild fish populations.

b.) *Competition:* In watersheds which have a diminished fish population, competition for resources limits the abundance, productivity, diversity, and spatial distribution of wild fish populations. Competition occurs when the demand for a resource for two or more organisms exceeds that which is available. Negative impacts result from direct interactions (i.e. interference of wild fish foraging by artificially propagated fish) and through indirect means (i.e. hatchery fish diminish the availability of aquatic insects available as forage to wild fish). Direct and indirect impacts may arise through competition for: food resources within the stream, juvenile rearing habitat, food resources within the estuary and ocean (Levin et al. 2001[12]) and competition for spawning sites (Buhle *et al*. 2009). These impacts are especially significant between steelhead, chinook, and coho (on an interspecific and intraspecific basis) because of the considerable overlap in habitat and foraging preferences between these species (SWIG 1984). Of great concern are the competitive ecological interactions where wild fish are displaced by artificially propagated and reared fish introduced into the same habitat.

c.) *Behavioral Modification:*

(1) *Predation by other fish & wildlife:* Fish produced in hatcheries also bear maladaptive behaviors due to the strong selection within the artificial production facility. Due to the food distribution and rearing strategies necessary to make artificial production cost effective, hatchery fish become hyper-aggressive and surface oriented, causing them to become more susceptible to predators (Hillman and Mullan 1989). Artificially produced

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[12] Levin, P.S., Zabel, R.W. and Williams, J.G., 2001. The road to extinction is paved with good intentions: negative association of fish hatcheries with threatened salmon. Proceedings of the Royal Society of London B: Biological Sciences 268(1472):1153-1158.

fish also exhibit less diversity in their behaviors and life histories, allowing for predators to key in on migration timing. Especially during *en masse* hatchery smolt releases, wild fish can be preyed upon by pinniped, avian, and other piscivorous predators attracted to the high number of hatchery fish concentrated in a given area. The modification of wild fish behavior can increase vulnerability and susceptibility to predation. This dynamic can occur during juvenile releases in the freshwater environment, during estuary rearing phases, and especially when adult hatchery fish return to spawn and congregate in restricted areas such as below dams and partial migratory barriers.

(2) *Predation by hatchery fish:* Hatchery fish have also been documented directly preying upon smaller wild fish. This direct consumption of fry and fingerlings is highest in areas where artificially produced fish and wild fish commingle. Direct predation of wild fish by hatchery fish is likely highest when artificially produced smolts encounter naturally produced, emerging fry or when they are disproportionately larger than wild fish. Cases of direct predation have been documented where hatchery fish consume wild fish ½ of their total size once they have been released (Pearsons and Fritts 1999). Hawking and Tipping (1998) observed artificially produced age 1 coho salmon and steelhead trout predating on other salmonid fry appearing to be chinook. Seward and Bjornn (1990) have also documented substantial predation impacts by artificially produced chinook preying upon their own species. In instances such as these, hatchery fish preying directly upon wild fish results in the direct take of ESA listed species.

(3) *Residualization:* In steelhead trout, and to a lesser extent within Chinook and coho, modified feeding behavior can affect residualization, meaning that they will not migrate to salt water, but will instead remain in the river as resident fish. Residualization is a common occurrence with artificially produced steelhead (Naman 2008, Hausch and Melnychuk 2012, Melnychuk *et al.* 2014). The addition of these residualized hatchery fish constitutes a significant modification to the habitat of wild salmonids. These residualized hatchery fish will harm, displace, and most likely prey upon other juvenile salmonids . In some areas of the Northwest, residualization rates are as high as 20-80% (Snow and Murdoch 2013, McMichael *et al.* 2014). Residualized hatchery fish are also not limited to the areas surrounding the hatchery, Schuck *et al.* (1998) reported residualized hatchery steelhead approximately 20 kilometers below and 10 kilometers above release sites.

d.) *Marine derived nutrients:* As noted, hatchery Chinook salmon are managed for mitigation of lost spawning and rearing habitat resulting from the construction of Iron Gate Dam and Copco 2 Dam and are not intended to provide direct conservation benefits to natural populations from intentional supplementation or captive breeding. Fisheries, which meet management objectives, will result in the harvest of as many hatchery fish as possible to limit genetic and ecological interactions. If adhering to pHOS performance targets, hatchery fish do not naturally contribute marine derived nutrients. It is estimated that just 6-7% of the marine derived nitrogen and phosphorus once delivered to rivers of the Pacific Northwest currently reach watersheds (Gresh et al. 2006). Artificial propagation has been shown to negatively influence the spatial distribution, productivity, diversity, and abundance of wild fish populations and thus also continues to exacerbate the deficit of marine derived nutrients to watersheds throughout the Northwest. The long term reliance of out-planting post-mortem hatchery fish is expensive, unable to predict and account for how nutrients are naturally distributed throughout the watershed, and constitutes a dangerous vector for hatchery borne diseases to spread. As noted in Kohler *et al.* (2013), nutrient fluxes are not always unidirectional, and especially in cases with poor juvenile survival, nutrient exports through emigration to the ocean can be greater than marine derived nutrients returning through adult anadromous fish migrations.

Overall, the ecological risk of artificial propagation is the replacement of wild fish by hatchery fish (Hilborn & Eggers 2000, Quiñones *et al.* 2013). When fish produced through artificial production interact with wild fish in a limited carrying capacity, hatchery fish may replace rather than augment wild populations (Hilborn 1992).

3. Genetic Impacts

Wild fish throughout the Northwest are defined by their sense of place, or their high fidelity to return to their birthplace. Their ability to migrate to the ocean and return to their natal stream has profound implications on population structure and has encouraged fine scale genetic adaptations to specific habitats used throughout their lifecycle and geographic range. The genetic risks that artificial propagation poses to wild populations can be broken down into: a.) *loss of genetic variability,* b.) *outbreeding and inbreeding effects,* c.) *domestication selection* and e.) *Epigenetic Impacts*. These genetic effects are caused by removing the ability of natural mate selection when gametes are artificially inseminated in the hatchery.

a.) *Loss of genetic variability:* The loss of diversity occurs both within populations and between populations. Within populations, loss of genetic diversity occurs when mass artificial insemination reduces the quantity, variety, and combinations of alleles present (Busack and Currens 1995). Genetic diversity within a wild population changes from random genetic drift and from inbreeding depression. The process of genetic drift is governed by the effective population size, rather than the observed number of breeders. Although many fish might be present on the spawning grounds the effective population size is smaller than the census size. Artificial propagation has been found to reduce genetic diversity and cause higher rates of genetic drift due to small effective population sizes (Waples *et al.* 1990). Negative impacts of artificial propagation on population diversity often manifest as changes in morphology (Bugert *et al.* 1992) and behavior (Berejikian 1995).

b.) *Outbreeding and inbreeding depression:*

(1) Inbreeding depression: the interbreeding of individuals related to one another, occurs in the wild when populations experience significant declines due to habitat destruction, overharvest, or other factors that limit the number of fish. In fish hatcheries, the practice of artificial insemination does not differentiate between related individuals during the

fertilization process, so the likelihood of inbreeding depression is increased regardless of the population size. Inbreeding depression does not directly lead to changes in the quantity and variety of alleles, but instead homogenizes the population which is then acted upon by the environment. The fish hatchery rearing environment, consisting of either concrete raceways or circular tanks, likely contrasts significantly to the natural selection in the stream environment, thus leading to an increase of deleterious alleles and a reduction in the fitness of the population (Waldman and McKinnon 1993). There is substantial data on the effects of inbreeding depression in rainbow trout (Hard and Hershberger 1995, Meyers et al. 1998) and in steelhead trout, this factor alone has been attributed to a 1-4% decline in productivity (Christie *et al*. 2013).

(2) *Outbreeding depression*, or the fitness and/or diversity loss associated with gene flow from other, genetically distinct fish populations, can also pose significant consequences for native fish. Fine-scale local adaptations occur through random genetic drift and natural selection (Taylor 1991, McElhany *et al*. 2000). Even with a high degree of homing behavior, some fish do return to spawn in watersheds other than where they were born. When fish successfully reproduce in watersheds in which they were not born, they are considered to have "strayed." Stray fish result in gene flow between populations. Outbreeding depression impacts natural fish populations when artificially produced fish stray at rates many times higher than natural fish, leading to interbreeding with distant wild population and causing their offsprings to exhibit a lower fitness in the natural environment. Outbreeding depression is exacerbated by the hatchery setting because the artificial infrastructure inhibits olfactory (Dittman et al. 2015) and geomagnetic (Putman *et al* 2014) imprinting on a home stream. Straying in native fish populations is a natural process which counteracts the loss of genetic diversity and helps to recolonize vacant habitat but usually occurs at very low levels (Quinn 2005). Fish artificially raised in hatcheries can create unnatural gene flow in terms of the sources of stray fish and the high proportion of fish that stray. The more outbreeding depression acts, associated with an increase of exogenous spawners, even if immediate consequences are concealed, populations will possess less adaptive capacity to face new environmental challenges (Gharrett *et al*. 1999). It is important to note that effects arising from the interbreeding of artificially and naturally raised individuals from within the same population arise from domestication selection, which impacts act differently than outbreeding depression.

(3) *Domestication Selection* occurs when fitness loss and changes occur due to differences between the hatchery and natural environments. The process of domestication occurs, intentionally or unintentionally, when there are changes in the quantity, variety, and combination of alleles between artificially inseminated fish and naturally produced fish as a consequence of captivity. The National Marine Fisheries Service defines domestication as the selection for traits that favor survival within a [hatchery] environment (Busack and Currens 1995). Domestication selection impacts natural fish when they interbreed with artificially produced fish adapted to the hatchery environment and suffer a reduced fitness (Ford 2002). This can occur in three principle

ways: intentional or artificial selection, biased artificial propagation, and relaxed selection.

A. Intentional or artificial selection is the attempt to change the population to meet management needs, such as spawning time, return time, out outmigration time. Natural populations are impacted when hatchery adults spawn with wild fish and the performance of the population is reduced. This is also a form of outbreeding depression.
B. Biased artificial propagation is caused during the selection and rearing of captive fish. Hatchery operations are always a source of biased sampling when groups of fish are fed, reared, sorted, and treated for disease.
C. Relaxed selection occurs through artificially high juvenile survival rates during early life stages. Hatcheries are a simplified, sheltered environment that is meant to increase survival relative to the natural environment, and allows deleterious genotypes to move into later life history stages and future generations which wouldn't otherwise be expressed.

(4) *Epigenetic change* has also recently been pinpointed as another impact causing the depletion of biological diversity associated with fish hatcheries. Epigenetics is the study of changes in organisms caused by modification of gene expression rather than alteration of the genetic code itself. It is now well-known that the vast share of any organism's DNA remains latent and unexpressed as the organism develops and lives its life. Epigenetics is the means to study which portions of an organism's DNA are in fact expressed, and what environmental, physiological, behavioral, and other factors cause differences in gene expression as organisms develop (Gavery and Roberts 2017). The DNA of the genome confers to an organism its potential capacity to express variation and range of traits; epigenetic study provides us with the tools to understand how environmental influence controls the realized expression of DNA-determined traits, thus determining the actual health, survival and fitness of the organism. Le Luyer at al. (2017) and Gavery and Roberts provided compelling evidence for epigenetic changes in hatchery-reared fish and shellfish compared to their wild counterparts.

Given the overwhelming evidence of genetic impacts hatcheries cause on wild fish, we also cite numerous studies showing the intersection between the four factors outlined above:

Reisenbichler and Rubin (1999) reference five other studies which find that hatchery programs which captively rear fish for over 1 year, (i.e. steelhead, stream-type Chinook, and Coho salmon) genetically change the population and consequently reduce survival for natural rearing. In the study, the authors found substantial genetic change in fitness resulting from traditional artificial propagation when fish were held in captivity for more than 25% of their life span.

Building off of these findings, morphological and behavioral changes were found in artificially produced, adult, spring Chinook including a reduced number of eggs relative to wild fish (Bugert *et al 1992).* (Leider *et al* 1990) reported diminished survival and reproductive success for the progeny of artificially produced steelhead when compared to naturally produced steelhead in the lower Columbia River. The poorer survival observed for the naturally produced offspring of hatchery fish was likely due to the long term artificial and domestication selection in the hatchery produced steelhead population as well as maladaptation of the fish population within the hatchery to the native stream environment. In a paper on the reproductive success of hatchery fish in the wild, it was reported that hatchery fish did not produce fish that could match the survival or reproductive success of wild fish, even with the use of predominantly wild-origin broodstocks (Christie 2014).

These findings were consistent despite differences in geographic location, study species, artificial propagation methods, and artificial rearing practices. Recent research has also documented an epigenetic impact fish hatcheries pose on wild fish through reduced recruitment on populations that consist of artificial production (Christie 2016). Even within a single generation, domestication selection altered the expression of hundreds of genes to rapidly favor the artificial spawning and rearing environment. Moreover, these traits could be passed along to wild populations if hatchery fish spawned with natural fish.

4. Indirect impacts

Because hatchery fish intersect considerably with naturally produced fish, they also pose indirect impacts from activities and decisions stemming from their presence. These impacts include: *Direct and Indirect take through fisheries*, *Monitoring, and Opportunity costs.*

a.) *Direct/Indirect take:* Fisheries directed on artificially produced fish can also harm and/or cause wild fish mortality. Depending on how the fishery is structured, the commercial and recreational pursuit of artificially produced fish can lead to a taking of wild populations in excess of what would be compatible with their minimum viability.
b.) Monitoring: Under the endangered species act, monitoring and evaluation of artificial production is mandated to ensure that activities associated with captive rearing do not limit the recovery of listed populations. Monitoring activities themselves are identified as actions associated with various levels of take on listed species.
c.) *Opportunity costs:* The opportunity costs for funding hatchery programs instead of other fish creating investments like habitat restoration continue with integrated as well as segregated broodstock programs. Ogston et al. 2015 found that habitat restoration opportunity cost in natural fish vs artificial production were comparable on a single brood year basis. However, habitat restoration then continues to naturally produce fish in subsequent generations while artificial rearing practices require indefinite, continued funding to support subsequent brood years.

Conclusion:

Continuing to operate fish hatcheries in the Klamath River adds additional biological impacts and increases risks to the health, life history, and potential recovery of threatened wild Coho salmon and sensitive Chinook salmon. Adding additional risks for these species by bombarding them with artificially mass-produced fish (which carry disease and weakened genetics) detracts from the transition towards a sustainable wild fishery, and exacerbates the ongoing inequity disadvantaged communities experience (as discussed in Phedra, Pezzullo and Sandler 2007). The financial resources fish hatchery facilities require to operate also allocates resources away from solving the root problem of species and ecosystem decline, including but not limited to, habitat restoration and pollution abatement.

Finally, we recognize that there are other diverse communties who value this public resource and the habitats that support them for non-extractive direct use (tourism), indirect values (ecosystem services), and non-use purposes (existence, intrinsic, and bequest values) who have been and continue to be displaced by the public investment in artificial fish production. We hope these issues are carefully considered in future analysis, as significant public financial resources are allocated to artificial hatchery production that only benefits a few.

In conclusion, we believe the best hatchery for wild fish is a healthy river. Mass producing fish in a hatchery setting with the goal of enhancing population health cannot operate indefinitely because of their dependence on naturally produced fish. If continued operation of the Iron Gate Hatchery program is authorized, this investment in an unsustainable, artificial fishery will set a terrible precedent in applying limited dollars towards a project that does not meaningfully benefit wild fish recovery and ecosystem restoration.

The California State Water Resources Control Board should not authorize the water certification for "Condition 12. Hatcheries" and the infrastructural investments to Iron Gate Hatchery and Fall Creek Hatchery because these practices do not meet the definition of "recovery" or "delisting" of "self-sustaining" fish populations within the Endangered Species Act and other federal and state recovery planning documents – an intended outcome of Project decommissioning. Due to the numerous impacts of the artificial production of fish and the communities they support, we encourage the California State Water Resources Control Board to conduct a thorough viability analysis to determine how threatened fish in the Klamath River are affected by the proposed action and make the analysis available to the public. At the very least, the California State Water Resources Control Board must analyze these significant impacts, and consider alternatives and feasible mitigation, in its EIR for the project.

Thank you for the opportunity to voice our concerns about this critically important issue, and this incredible opportunity to restore the Klamath River. We hope that the California State Water Resources Control Board values the comments raised in this letter and heeds our strong recommendation to develop an exit plan for artificial production facilities in the Klamath River with Project decommissioning.

Respectfully,

Jake Crawford, River Steward Program Director, Native Fish Society
Conrad Gowell, Fellowship Program Director, Native Fish Society
Mark Sherwood, Executive Director, Native Fish Society
Kurt Beardslee, Executive Director, Wild Fish Conservancy
Yvon Chouinard, Owner, Patagonia Inc.
Hans Cole, Director of Campaigns and Advocacy, Patagonia Inc.
Charles Gehr, Northwest and Rockies Sales Manager, Fly Water Travel
Jack Stanford, Professor Emeritus, Flathead Lake Biological Station, University of Montana
Matt Stoecker, Principal Biologist, Stoecker Ecological

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