Managing Hatchery and Wild Salmonids in Oregon

White Paper from the Oregon Chapter American Fisheries Society
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Background and Purpose

The Oregon Chapter of the American Fisheries Society (ORAFS) is an organization of over 500 scientists whose mission is to improve the conservation and sustainability of Oregon's fishery resources and their aquatic ecosystems for long-term public benefit. Arguably, the most controversial issue facing our organization is that of interaction between hatchery and wild Pacific salmon and steelhead (hereafter "salmonids"). The controversy is due to numerous issues, but it is largely the result of diverse stakeholder values, federal and statutory regulations, treaty obligations, harvest management, uncertain viability of some salmonid populations in the absence of hatcheries, and an evolving suite of scientific research surrounding the issue. In December of 2000, the Executive Committee of ORAFS approved a white paper, Managing Wild and Hatchery Fish in Oregon, which summarized the most up-to-date understanding of the effects of hatchery operations on wild salmon and steelhead. ORAFS concluded that the weight of scientific evidence showed substantial differences exist between hatchery and wild fish of the same species and that these differences could negatively affect wild fish populations. At the time, the paper concluded that hatchery-related risks to wild salmonids did not preclude a useful role for hatcheries in Oregon. However, to minimize risks to wild fish, hatchery practices should be consistent with conserving genetic and life-history diversity and would be most effective when complemented by habitat protection and restoration measures.

Over the past 15 years, scientists have conducted extensive research on the topic of hatchery-wild interactions, and the objective of this paper is to synthesize the most salient findings of this research. The weight of scientific evidence has continued to suggest that hatcheries can have deleterious effects on wild populations of salmonids. These effects include competition with hatchery fish, disease transfer from hatcheries to wild populations, hatchery-induced domestication, loss of genetic diversity, genetic divergence of hatchery fish from wild fish, and declines in reproductive success due to hatchery fish breeding in the wild. Because of these effects, the overall health and viability of many threatened salmonid populations remains uncertain. Although ORAFS maintains that the risks of hatcheries do not preclude their useful role, we support the continued management trajectory towards more permanent, habitat and conservation-based recovery of Oregon's salmonids.

Hatchery and Wild Salmonid Interactions Summary

The three main conclusions from this document are that:

1. Improper use of hatchery fish can have deleterious effects on populations of wild salmonids that have evolved over millennia to their respective habitats.
2. The effects of hatchery fish on wild fish are contingent upon the particular watershed, hatchery program magnitude and practices, ecosystem health, and health of wild populations.
3. Careful, informed, and monitored use of hatchery fish offers a potential way to meet mitigation and harvest expectations without damaging wild populations.

The following information summarizes the three primary conclusions from our review of the scientific literature. The conclusions are also made within the context that wild salmonid populations are valued by society as a human food source; are culturally and spiritually significant to Native American tribes; and are socially, economically, and culturally important to Oregonians. Ecologically, wild salmonids are keystone species which

contribute to other fish and wildlife populations and ecosystem processes in the basins they inhabit. Over the long-term, the sustainability of wild salmonid populations will require access to high quality current and historical salmonid habitat, and comprehensive fisheries management that protects vulnerable stocks from over-exploitation.

1. Improper use of hatchery fish can have deleterious effects on populations of wild salmonids.

Many issues caused by hatcheries are associated with rearing practices that significantly deviate from natural conditions. For example, only a small proportion of adults are spawned in hatcheries and these adults do not "choose" their mates, as occurs in the wild. Offspring are raised in densely populated artificial conditions, juveniles are protected from predators and fed artificial diets, and are often forced to leave the hatchery at a specific time, as opposed to "choosing". Among other consequences, these conditions result in domesticated fish with higher disease loads, reduced life history diversity, lower genetic diversity, and lower reproductive success when they spawn naturally compared to their wild counterparts (Christie et al. 2012; Bingham et al. 2014; Ford et al. 2016). Hatchery practices allow the survival of less genetically-fit individuals through propagation techniques (Araki et al. 2008; Smith et al. 2014), and may affect behaviors including predator avoidance and foraging. Evidence suggests that these domestication effects appear to influence hatchery fish at the earliest stages of development and domestication effects may be difficult to avoid or counteract (Christie et al. 2011; Theriault et al. 2011). Introgression (transfer of genetic material) between domesticated hatchery fish and wild fish on the spawning grounds may pass the hatchery-derived domestication effects to wild fish, leading to less productive wild populations over time (Araki et al. 2007; Berntson et al. 2011; Chilcote et al. 2011). This transfer of heritable traits across generations can lead to the divergence of hatchery populations from wild population over time, such that over generations, hatchery fish genetically differentiate and may also exhibit behavioral differences relative to their wild counterparts (Araki et al. 2008; Christie et al. 2012; Anderson et al. 2013; Waters et al. 2015).

Threats of hatchery fish to wild fish include competition for food and habitats, predator attraction, and transfer of pathogens. Hatchery and wild fish occupy similar habitats throughout their lifecycle, interacting in natal streams, migration corridors, estuaries, and the ocean. Hatchery programs are typically managed independently within river basins, and cumulative effects of hatchery fish releases on wild fish survival in the estuarine and marine environments are poorly known and difficult to quantify. Interactions can lead to density dependent effects (e.g., competition for food and spawning habitat, and disease transmission) and lower productivity of wild populations (Kostow and Zhou 2006; ISAB 2015). Density dependent effects may be most severe during environmentally stressful periods such as drought in natal streams or periods of poor ocean productivity (Kostow 2009). Competition for limited resources during cyclical downturns in the freshwater, estuarine, and marine ecosystems is amplified by consistent hatchery fish releases when wild populations are affected by periods of environmental stress (Kostow and Zhou 2006; ISAB 2015). Releases of hatchery fish or the coordinated timing of their outmigration may attract predators that also prey on wild juvenile fish. Release of diseased fish which benefit from antibiotic treatment in the hatchery environment have the potential to transfer pathogens when interacting with wild fish in natal streams and the migration corridor. Predator attraction and disease transmission effects may also increase when wild populations are stressed by cyclically poor habitat conditions.

2. The effects of hatchery fish on wild fish are contingent upon the particular watershed, hatchery practices, ecosystem health, and health of wild populations.

The effects of hatchery fish on wild populations are influenced by watershed conditions, the health of wild populations, and hatchery practices. Wild salmonid species and populations respond idiosyncratically to

watershed conditions based in part on their evolutionary past and differing life histories. Salmonid survival is influenced by freshwater, estuarine, and marine environmental conditions. Relative to pristine watersheds or watersheds with minimal human alteration, impaired watersheds typically have lower quality habitats and diminished carrying capacity to support wild populations. Degraded watershed conditions may be manifested in elevated water temperatures, altered hydrology, suspended sediment and pollutants, simplified habitat, and fish passage barriers. Wild populations inhabiting impaired watersheds are susceptible to hatchery fish displacement especially during periods of environmental stress. Persistent stocking of hatchery fish in impaired watersheds amplifies resource competition, density dependence effects, predation, reproduction between hatchery and wild fish, and disease transmission between hatchery and wild fish. Restoration of freshwater habitats and improving access to historical habitat are measures that cannot but help improve habitat for wild salmonids, increase riverine carrying capacity, and reduce the potential effects of hatchery and wild fish interactions.

3. Careful, informed, and monitored use of hatchery fish can help bolster wild populations and meet mitigation and harvest needs of the public.

Fish reintroduced into formerly occupied habitats may facilitate recolonization and provide a demographic boost to natural populations. Although studies have shown that hatchery fish reintroduced to historical habitat made inaccessible by dams and other barriers have successfully recolonized those areas, allowing natural recolonization of historical habitat maintains important selection processes (e.g., mate selection, spawn timing) that would be disrupted by transplanting hatchery fish (Anderson et al. 2015). Hatchery programs are also used to supplement wild fish populations functioning below historical levels or the natal watershed's current carrying capacity (Galbreath et al. 2014; Kline and Flagg 2014). However, the long-term effects that most supplementation programs have had on wild populations have not been well studied. The influence of supplementation programs on wild populations appears to be partly dependent on how the supplementation is conducted and on how limiting factors affecting the supplemented population have been addressed by other efforts (Venditti et al. 2015). The type and duration of hatchery supplementation also affect program success.

Hatchery production for terminal fisheries provide cost-effective and high quality fisheries with limited effects to natural production areas (Kostow 2012). Although juvenile hatchery fish interact with wild fish in the estuary and marine environments, adult hatchery fish return to release areas for harvest, minimizing hatchery-wild fish interactions on up-river spawning grounds. An example terminal fishery occurs at the Youngs Bay Select Area Fishery Enhancement Program (SAFE). To minimize hatchery and wild smolt interactions, the program executes strategies to minimize hatchery and wild smolt interactions including net pen rearing low in the watershed, volitional releases from two hatcheries, and night time releases from net pens on the out-going tide (Kostow 2012). Employed practices are intended to minimize hatchery and wild smolt interactions and reduce predation. Fishery managers have successfully employed terminal fisheries, although the fisheries are not without risk to wild populations due to enhanced fishing pressure that may include non-targeted wild fish bycatch (Kostow 2012). However, the fisheries are intensely sampled and monitored for potential impacts to non-local populations.

Hatchery management has been adapting practices to reduce impacts on wild fish and to help recover wild fish populations. Integrated hatchery programs are intended to reduce risks to wild populations when a hatchery program is used to supplement wild spawner abundance (Bowles 1995). Integrated hatchery programs are intended to supplement wild populations over a limited time period using wild broodstock (Hulett et al. 2004; Venditti et al. 2015). Hatchery supplementation should not occur when the genetic and ecological risks of the hatchery program outweigh the potential demographic benefits. Supplementation should be scaled back when

the demographic benefits no longer outweigh the genetic and ecological risks of the hatchery program. Although properly managed supplementation programs may have limited moderate-term effects on wild population productivity (Venditti et al. 2015), avoiding institutionalization of hatchery programs is important for minimizing long-term hatchery effects on wild fish populations.

Fishery management actions have been taken to provide continued harvest opportunities. Fish managers are trying to reduce the risk of hatchery fish interacting with wild fish in spawning areas by segregating adult hatchery and wild fish in watersheds. This management strategy is intended to provide fisheries support and harvest opportunity while reducing the hatchery fish impact on wild fish by limiting spatial interactions that otherwise increase competition, predation, and disease transmission between hatchery and wild fish. Segregating hatchery fish is possible if infrastructure such as adult traps are in place, however, this management approach is generally costly and program effectiveness depends on the maintenance and degree of hatchery fish exclusion from wild fish spawning areas, and the extent and degree of straying by hatchery fish (Bugert 1998). Trapping and sorting operations can also pose problems for wild fish through disease transmission, physical injury, and migration delay. Although behavioral segregation by differentiating spawn timing of hatchery fish relative to wild fish has had limited success, temporal separation through the use of different stocks for supplementation is currently a management tool authorized in the Columbia Basin.

Hatchery Reform Principles

Salmonid hatcheries are being managed as part of a general effort to conserve population structure, reintroduce or reestablish populations, mitigate for lost habitat, and to augment tribal, sport, and commercial fisheries. To accomplish these benefits, hatchery practices need to be congruent with efforts to conserve genetic and life history diversity of wild fish, and should be carried out with complementary measures to protect and restore fish habitat.

The United States Congress authorized the Hatchery Reform Project in 2000 as part of a comprehensive effort to conserve endemic salmonid populations, support recovery of naturally spawning populations, provide fisheries support, and improve the quality and cost effectiveness of hatchery programs (HSRG 2014). The Hatchery Scientific Review Group (HSRG), an independent scientific review panel, was appointed to review state, tribal, and federal hatchery programs in western Washington with the intent to develop strategies to reduce hatchery risks and promote population recovery, while continuing to provide hatchery production to support fisheries (HSRG 2014). The HSRG review methods were replicated by NOAA-Fisheries in the Lower Columbia River Basin and later expanded to the entire Columbia River Basin (HSRG 2009). The HSRG identified three principles to guide hatchery reform (HSRG 2009; HSRG 2014)

1. **Principle 1: Develop clear, specific, quantifiable harvest and conservation goals for natural and hatchery populations within an "All H" context.** Habitat, hatcheries, harvest and hydropower (dams) constitute the "All H." Hatcheries should be considered as part of a comprehensive strategy where habitat, hatchery management, harvest, and hydropower operations are coordinated to best meet resource management goals that are defined for each fish population in the watershed.

2. **Principle 2: Design and operate hatchery programs in a scientifically defensible manner.** The scientific rationale for a hatchery program in terms of benefits and risks must be formulated to explain how the program expects to achieve its goals. The strategy chosen must be consistent with current scientific knowledge.

3. **Principle 3: Monitor, evaluate and adaptively manage hatchery programs.** Ecosystems affected by hatchery programs are dynamic and complex; therefore, uncertainty is unavoidable. New data will change

understanding of the ecological and genetic impacts of hatchery programs. As fisheries managers' understanding of hatchery effects evolves over time, hatchery operations should adapt accordingly.

HSRG recommendations for reducing the effects of hatchery fish on wild fish include:

- Reduce or eliminate hatchery releases where possible, increase the proportion of natural origin broodstock, and/or exclude hatchery fish from natural spawning areas.
- Use selective fisheries to increase or maintain harvest rates on hatchery fish and reduce natural fish harvest.
- Improve habitat to increase natural production.

Federal, state, and tribal hatcheries are increasingly employing these measures to achieve fish conservation and other societal, regulatory, and treaty obligation requirements. However, hatchery programs should be thoroughly monitored to ensure HSRG recommendations are being implemented. Hatchery practices should continue to evolve over time to further minimize impacts to wild populations.

Conclusion

Historically, salmonid hatcheries were established to support fisheries that were diminished by overfishing, habitat degradation or loss, and fish mortality associated with hydropower systems. With time, the fisheries community has studied and fostered an improved understanding of hatchery and wild salmonid interactions. Existing best management practices intended to limit deleterious effects of hatchery fish on wild populations include evaluation of a watershed's limiting factors affecting wild populations, proper design of a hatchery program employing HSRG guidelines, effective implementation of the HSRG informed hatchery program, or elimination of hatchery fish altogether. Program monitoring is essential for limiting effects on wild populations and determining when hatchery operations are not contributing to population goals. Comprehensive management plans that include habitat restoration, responsible harvest management, and appropriate hatchery practices have the greatest potential to achieve the numerous goals presented by the diverse user groups that often compete for limited salmonid resources.

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