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Commentary: Salmon Farms and Hatcheries

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The article by Rosamond Naylor, Josh Eagle, and Whitney Smith entitled "Salmon Aquaculture in the Pacific Northwest: A Global Industry with Local Impacts" (October 2003), provided a thoughtful, thorough discussion of the economic impact and environmental dangers of salmon farming in the Pacific Northwest. However, it was oriented toward concerns about the encroachment of human interventions in the salmon life cycle that are played out in the ocean. As an environmental scientist involved in salmon recovery issues in Oregon 's Columbia River Basin, I can say that much of the potential environmental damage associated with aquaculture in the oceans began to occur more than 100 years ago in Northwestern freshwater habitats due to the operation of salmon hatcheries. Naylor, Eagle, and Smith write, "Many scientists, environmentalists, and fishers worry that the ecological risks of farm fish-such as the spread of disease and parasites , competition among escaped farm fish and endemic species, and pollution from farm effluent-outweigh the potential benefits.'' It is worth examining these same concerns as they apply to salmon hatchery operations, focusing on the Columbia River Basin, which drains British Columbia, Washington, Oregon , much of Idaho , part of Montana, and smaller parts of Nevada, Utah, and Wyoming, as a representative of freshwater impacts of hatcheries.

Salmon hatcheries collectively form an often overlooked industrial giant that is now more than a century old in some parts of the Columbia River Basin. They have had dramatic consequences for the wild salmon of the region. Historically, supplementation hatcheries were built to facilitate excessive rates of salmon harvesting that coincided with the destruction of freshwater spawning habitat by human activities (such as dam construction, mining, and logging). The region now hosts more than 150 industrial hatcheries [1]- mostly state- and federally funded factories for rearing juvenile fish that are released to migrate downstream to the ocean. Hatcheries range geographically from the upper limits of salmon and steelhead distribution in Washington and Idaho to the lower estuary of the river. In areas where large amounts of spawning habitat have been lost to dams, hatcheries have supported the numbers of salmon that return from the ocean in their upstream migration. Hatcheries have also been responsible for many other processes that have modified the salmon populations of the region-in expected and unanticipated ways.

In one sense the augmentation of fish for commercial and recreational fishing is itself the worst aspect of hatcheries, as it obscures the rapid anthropogenic loss of natural spawning habitat for salmon over the last century. The abundance of returning adults of some seasonal runs (such as spring chinook) often provides an illusion that the fish are faring well in the Columbia River Basin, while wild spawners and spawning habitat are actually diminishing. Political pressures associated with large returns of hatchery fish also lead policymakers to inflate harvest quotas being set, which puts further stress on wild fish populations. There is no way to protect returning wild salmon from intensive fishing supposedly focused on returning hatchery fish.

Such fishing is indiscriminate: Wild fish are certainly being caught, and often they are seriously injured or killed.[2]

In addition, the hatcheries of the Columbia River Basin function in a fashion that more often than not threatens the genetic distinctiveness and fitness of the remaining wild salmon population. Hatchery design and operation generally ignores much of the natural life cycle and environment of salmon.[3] Hatchery operations favor the evolution of smaller eggs, which are maladaptive in the wild and undesirable in those circumstances where hatcheries are supposed to be employed to prevent the extirpation of local stocks.[4] Another problem is that hatcheries ignore the maximum number of fish that a particular stream can support. As hatcheries release millions of juvenile salmon for their migration to the sea, hatchery fish compete with the wild fish migrating to the ocean. At times, there simply is not enough food to nourish all of the young fish, producing mortality among both wild and hatchery fish.

To examine the relationship between hatchery and wild salmon, scientists with the National Marine Fisheries Service (NMFS) analyzed chinook population data for the past 25 years for the Snake River, a major tributary of the Columbia.[5] A year and a half after the fall spawning of chinook, their juveniles migrate downstream toward the ocean, where the young fish feed and grow for four or more years. The NMFS scientists related releases of hatchery-reared juveniles with the number of returning wild adults and included data about fluctuations in food available to the juveniles once they reach the ocean. Measures of local oyster growth were used to indicate ocean food conditions. (Work by others previously demonstrated that oysters reflect food availability all the way up the food chain.)[6] Oyster data revealed that in the ocean near the mouth of the Columbia, food availability for each of the past 25 years was categorized as average or poor. Poor years coincided with El Nino events-periods of climatic perturbations fostered by unusual warmth in large areas of the Pacific Ocean. Populations of wild adults that initially migrated to the ocean during periods of low food availability had high rates of mortality. This mortality was increased when large numbers of hatchery juveniles migrated into the ocean with the wild fish.[7] In low food years, the more hatchery chinook released, the higher the mortality of wild fish among that year's juveniles.

El Ninos have been occurring more frequently over the last two decades than previously, and a complex interaction of 20-year ocean cycles, 60-year ocean cycles, and global warming may contribute to a warming of the Pacific. Therefore, poor food availability in areas crucial to juvenile salmon may become periodically more common in future decades, exacerbating the negative effects of hatchery juveniles. In California's Trinity River, similar competition between wild juveniles and hatchery juveniles may be worsened due to anthropogenic sedimentation filling pools and reducing the carrying capacity of the river.[8]

Another problem is that if hatchery fish return as adults and spawn with wild salmon, they produce offspring that are genetically diluted and less suited to the environment of the stream in which they reproduce. Each river has evolved a unique population of fish, whose genotype is well adapted to that specific environment.[9] Wild fish possess resistance to the diseases and parasites of the stream where their population evolved, and in terms of distance, current, water temperature, and other factors, they are physiologically suited to the freshwater migration they face as they leave the ocean.

Hatchery salmon pose a threat to this fine-tuned local evolution. The genetic material of hatchery fish dilutes local populations in at least two ways: Many hatchery fish stray into other streams instead of returning to their release site, and non-native hatchery fish-often originating from populations separated by more than one state-are transplanted by hatchery operators and released by millions into rivers distant from their source of origin.[10] Both processes place native fish at risk through interbreeding and subsequent loss of fitness and evolutionary potential of locally adapted wild populations. For example, in Oregon, nonnative hatchery coho that survived to spawn with native fish lowered the resistance of the Fishhawk Creek coho population to the local parasite *Ceratomyxa shasta.*[11]

Hatcheries not only promote genetic dilution of locally adapted salmon populations, leading to mortality due to abiotic environmental stresses and local diseases, they actually act as sources of disease and water pollution them- selves. Diseases identified among the densely packed juveniles in hatcheries across the United States include the salmon swimbladder sarcoma virus, which has appeared in Atlantic salmon raised at North Attleboro National Fish Hatchery in Massachusetts (where biologists were forced to destroy some of the broodstock to prevent the spread of disease), and the North American strain of viral hemorrhagic septicemia that spread to an Idaho hatchery by an imported Oregon stock (and resulted in the extirpation of over 500,000 coho salmon fry to prevent spread of the disease). Diseases found in trout hatcheries that are capable of infecting salmon include *Nucleospora salmonis*, a parasite found now in Colorado's Rifle State Hatchery and in Ennis National Fish Hatchery in Montana; and the whirling disease parasite (*Myxobolus cerebralis*), recently identified in trout in eight hatcheries in Colorado.

Hatchery operations often involve trucking or barging fish around dams that block migration corridors. The highly compacted and stressed environment during such shipping facilitates the spread of disease among hatchery fish. Water pollutants at very low concentrations reduce the immune system capacities of salmon,[12] which doubtless makes the spread of disease from hatcheries worse for hatchery fish and immune-suppressed wild fish as they migrate together through polluted waters. In Oregon, for instance, state-operated hatcheries have been in noncompliance with their effluent permits so frequently that in 2001 the Oregon Department of Environmental Quality (ODEQ) issued a formal Notice of Noncompliance to the Oregon Department of Fish and Wildlife (ODFW), which operates the state hatcheries. [13] Suspended solids, formalin, and pH, for example, have been detected in effluent water at levels exceeding legal limits.[14] These problems have not been corrected, and additional notices of noncompliance were issued by ODEQ over the last two years. At this time, a number of conservation organizations have sent ODFW formal notice of their intent to file a Clean Water Act citizen suit to remedy these violations. The notice mentions 1,500 separate Clean Water Act violations at Oregon state-run hatcheries in the two years since ODEQ's 2001 Notice of Noncompliance.[15]

A significant source of pollution in hatchery effluent and contamination in hatchery fish is the feed that is used.[16] Commercially sold feeds contain large quantities of fish oil and fish meal. It is unknown what chemicals are used in the feed pellets along with the processed fish products: The exact composition of the feed is considered proprietary by feed producers. Oregon neither tests for nor is given the chemical make- up of the five million pounds of hatchery feed the state facilities use annually.[17] However, Canadian scientists analyzed feed obtained from Bio-Oregon, one of the principal suppliers used by the state of Oregon, and their analysis showed elevated levels of toxic contaminants including polychlorinated biphenyls (PCBs), organochlorine pesticides, polycyclic aromatic hydrocarbons (PAHs), polybrominated diphenylethers (PBDEs), and methyl and inorganic mercury.[18] These contaminants are likely to either become incorporated into the bodies of the hatchery juveniles or else to pass into the environment surrounding the hatcheries in the effluent water.

All of this helps explain why the wild salmon of the Pacific Northwest have been depleted to a threatened remnant of their once diverse and numerous populations. A 1991 report on stocks in California, Oregon, Idaho, and Washington noted that of 214 native, naturally spawning runs of salmon, steelhead, and sea-run cutthroat trout, 101 were in extreme risk of extinction, 58 at moderate risk, and 54 of concern. The report also identified 106 runs that had already become extinct.[19] It was with this background that NMFS, having listed several threatened anadromous fish of the Pacific Northwest, was required by the Endangered Species Act's mandates to develop salmon and steelhead recovery plans. To date, 11 evolutionarily significant units (species of fish definable in location and spawning season) of salmon and steelhead in the Columbia River Basin have been listed as threatened under the Endangered Species Act. Other candidates for listing remain under discussion or review.

Hatcheries, like fish farms, augment the number of salmon available for consumption.[20] Also like fish farms, they have an often-unacknowledged price in terms of genetic dilution of wild populations, effluent release, spread of disease, and competition between hatchery and wild juveniles. Among many biologists there is a growing recognition that the costs of hatcheries may at times outweigh their benefits. NMFS suggests that hatcheries are most likely to have detrimental impacts when the salmon species involved has a longer freshwater residency time and when the freshwater migration route to and from the hatchery is of greater length.[21] NMFS suggests that detrimental effects can be minimized by making hatchery fish as genetically similar to wild fish as is possible and by attending to threats posed by the spread of disease, harvest impacts, and number s of hatchery juvenile that are produced.[22] These are good recommendations, but they do not address the question of whether it is actually beneficial to operate as many hatcheries as we presently do in the Pacific Northwest. The assumption that hatcheries must be a useful enterprise has prevented critical data from being collected to see how hatchery operations actually impact wild fish populations. Unbridled operations of hatcheries and fish farms might result in many salmon in our restaurants-but none that resemble wild populations in our streams or oceans.

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6. Ibid .
7 . Ibid.
8. Action Plan for Restoration of the South Fork Trinity River Watershed and its Fisheries, prepared for the U.S . Bureau of Reclamation and the Trinity River Task Force under contract No . 2 -CS -20-01100 by Pacific Watershed Associates, 1994.
9. Lichatowich and Zuckerman , note 3 above .
I 0 . B . Bakke , " Straying of Hatchery Fish and Fitness of Natural Populations." in Genetic Effects of Straying of Non-Native Hatchery Fish into Natural Populations. National Oceanic and Atmospheric Administration (NOAA) Tech Memo NMFS- NWFSC -30 (Silver Spring, MD: NOAA . I 997) .
11. A. R. Hemmingsen . R. A. Holt. R. D. Ewing , and J. D. McIntyre , '"Susceptibility of Progeny from Crosses among the Three Stocks of Coho Salmon in lnfection by Ceratomyxa shasta·: American Fisheries Society 115 (1986): 492-495; and M. Wade. The Relative Effects of Ceratomyxa shasta on Crosses of Resistant and Susceptible Stocks of Summer Steelhead (Corvallis, OR : Oregon Department of Fish and Wildlife . 1986).
I- A number of papers have now reported immune suppression at contaminant levels that occur in estuaries. See M. R. Arkoosh and T. K. Collie r... Ecological Risk Assessment Paradigm for Salmon : Analyzing Immune Function to Evaluate Risk ." Ecological Risk Assessment 8 (2002): 265-76; M. R. Arkoosh et al.. " Increased Susceptibility of Juvenile Chinook Salmon (Oncorhynchus tshawytscha) to Vibriosis after Exposure to Chlorinated and Aromatic Compounds Found in Contaminated Urban Estuaries:· Journal of Aquatic Animal Health I0 (1998) 182-90; M. R. Arkoosh et al. ·Effect of Pollution on Fish Diseases: Potential Impacts on Salmonid Populations; Journal of Aquatic Animal Health 10 (1998) : 182-90; M. R. Arkoosh et al.. '"Increased Susceptibility of Juvenile Chinook Salmon(Oncorhynchus tshawytscha) from a Contaminated Estuary to the Pathogen Vibrio anguillarum," Transactions of the American Fisheries Society 127 (1998) : 360-74: M. R. Arkoosh . E. Clemons, M. Myer s. and E. Casillas.

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l 3. M. Riskedahl and B . Cook. Oregon Salmon Hatcheries and the Clean Water Act. A Report by the Northwest Environmental Defense Center (Portland . Oregon : Northwest Environmental Defense Center. (2003). www.nedc.org/HatcheryReport.pdf.

14. Ibid.

15. Ibid .

16 Ibid .

17 Ibid.

18 Ibid .

19. W. Nehlsen, J. E. Williams. and J. A. Lichatowich. --Pacific Salmon at the Crossroads: Stocks at Risk from California, Oregon, Idaho, and Washington ,'" Fisheries 16 (1991): 4-21 . Out of the 214 native stocks referred to in this paper. I population of chinook salmon in California had already been listed under the Endangered Species Act.

20. There have actually been very few empirical studies demonstrating an augmentation in overall numbers. but it is a strong presumption that at least where dams have led to extensive spawning habitat loss, the augmentation due to large scale hatchery releases must be considerable.

2 I. J. H. Hard , R. P. Jones. Jr., M. R. Delarm and R. S. Waples, Pacific Salmon and Artificial Propagation under the Endangered Species Act, NOAA Technical Memorandum NMFS - NMFSW-2 (Silver Spring. MD : NOAA 1992)

22. Ibid .