Mitigating Mitigation: A study of the effects of artificial propagation and salmon hatchery management on wild salmon populations in the Pacific Northwest and the Columbia River.

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In 1937, The Pacific Regional Planning Commission published a report entitled "Report on the Problem of Conservation and Development of Scenic and Recreational Resources of the Columbia Gorge in Washington and Oregon". The report was written in response to the reality that, as a result of human activity and industry, the Columbia River and the Columbia River Basin were beginning to undergo irrevocable change. Although the general concern of the document is the aesthetic changes that the gorge would undergo as a result of these human influences, the theme of conservation runs throughout the text. The fact that at a relatively early date people were beginning to understand the impact that human activity has upon the ecology of specific locations like the Columbia River Gorge creates a larger historical context in which we can view the evolution of different types of pollution that have occurred along the Columbia, and better understand the pollution issues that face the Columbia today.

This report also functions as an indicator of the shifting attitudes about the effects of human activity along the Columbia. What is striking about this 1937 document is what issues regarding conservation and mitigation are stressed, and which are not. At one point in the report, the authors express concern over the aesthetic effect that picnic tables and fire pits have along the Columbia (Pacific Northwest Regional Planning Commission, 63-65). Their approach to this problem, and the fact that it warrants even a few pages of discussion, is telling of the journey that conservation and mitigation attitudes have taken since 1937. It is helpful and important to know

that in the same report, I found only one part in the 71-page document that alludes to water pollution, and one sentence that explicitly refers to salmon. Furthermore, this one sentence mentions a decline in fishing, not fish populations (PNRPC, 27). In another part of the document, the issue of dams is discussed. Contrary to current ideas, the report celebrates the introduction of dams into the Columbia, asserting:

> The dam is calculated to serve future as well as present generations. Likewise, the Gorge, if preserved, would be of continuing value. This investment in the dam is being made now. The Gorge, if saved for all time, solely through the medium of public reservations, would also require a present investment (PNRPC, 21).

Reading material such as this is extremely helpful in laying the building blocks for the historical context in which we can view current issues in the Columbia River watershed. It is important to know that the level of concern about the salmon populations in the Columbia River, and in the Pacific Northwest as a whole, has evolved from one sentence in a report in 1937 into a web of interconnected issues that requires pages upon pages of information and study today. The changes in conservation and mitigation methods and viewpoints is, at times, are just as important as the changes themselves. Such is the case with the institution of artificial propagation and the practices of salmon hatcheries along the Columbia River.

In the past, the existence and roles of salmon hatcheries have generally been publicly accepted, and in most cases celebrated as a component for mitigation with regards to the declining salmon populations in the Pacific Northwest. However, as this long-held belief in the inherent benefit of these hatcheries begins to be more closely scrutinized, a more well-rounded view of the benefits, possible benefits, and most importantly, the failings of salmon hatcheries comes in to focus. I feel that it is easy to hear the word mitigation and assume that any program associated with the idea of mitigation is beneficial. What is important to take into consideration is that even the mitigation strategies that are developed need to be questioned, examined, and, at

times, need to be reformed.

In this paper, I examine such an example of a mitigation strategy–the introduction of hatchery raised salmon into the wild– that has in many ways become a source of pollution due to mismanagement, public misconception, a lack of appropriate study before action, and a lack of accountability for action. I approach this topic knowing that both the practice of artificial propagation and the idea of salmon hatcheries, at a basic level, share a common goal of mitigating the declines in salmon populations that have occurred in the past century, however the system they operate through has cracks that need attention. In this paper I examine the ways in which these cracks have been allowed to form.

In order to do this, I first examine the history of artificial propagation and the resulting advent of fish hatcheries in the Pacific Northwest, and the way that the public came to view them. Next I explore the current roles of salmon hatcheries along the Columbia River, and the work that is being done, and needs to be done, to create standards for salmon hatchery operations. Finally, I will discuss the future role of artificial propagation and salmon hatcheries as mitigation tools for the problems facing salmon populations in the Pacific Northwest and the Columbia River. In a 2000 technical report entitled "Salmon Abundances and Effects of Harvest Implications for Rebuilding Stocks of Wild Coho Salmon in Oregon," the Independent Multidisciplinary Science Team (IMST), in connection with the Oregon Plan for Salmon and Watersheds, stressed the need for a historical context in which to view the changes that salmon populations and habitats have undergone in the since the settlement of the western United States. As they authors of the report relate:

> The historic range of ecological conditions and the diversity of salmonid stocks in the Pacific Northwest are important because they provide a framework for developing policy and management plans for the future. The persistence and performance of salmonids under historic ecological conditions is evidence that these habitats were compatible with

salmon reproduction and survival(IMST 2000, ii).

In order to understand the, “historical range of ecological conditions and the diversity of salmonid stocks in the Pacific Northwest,” it is important to establish a basic chronology that outlines the ecological changes in the Pacific Northwest that prompted the initial human interaction with natural salmonid populations.

In his report “Salmon Hatcheries: Past, Present and Future,” Jim Lichatowich explains that the science of artificial propagation is much older than the hatcheries that it has been used in. Lichatowich cites two French fishermen as the innovators of artificial propagation in the year 1841. As he writes, “Messieurs Gehin and Remy observed salmon spawning for several nights, then developed a procedure for stripping eggs from female salmon and fertilizing them. They also devised apparatus for incubating and hatching eggs”(Lichatowich, 3). Although the techniques that Gehin and Remy developed were not used in hatcheries until the late 1800's, the ecological events that prompted their eventual use began to be identified as early as the 1850's.

The first signs of decline in salmon populations in the mid-1800's were the results of over-harvesting, irrigation, and water pollution, which led to losses in salmon habitat. In response to these changes, fishermen and the government turned to artificial propagation in hopes of increasing the harvests of economically viable fishes. The first Pacific salmon hatchery, created by U.S. Fish Commissioner Spencer Baird in 1872, was located in the Sacramento Basin. By 1905 hatcheries had sprung up along the Oregon coast and in many of Oregon’s rivers, and in

that year, 23 million fry and fingerling salmon and steelhead were released into coastal waters. (IMST 1998, 5).

The reliance on hatcheries and artificial propagation was only enhanced with the advent of dams in the early 1930's, as the dams had a direct and drastic effect on salmon populations and harvest. In response to the continually depressed salmon numbers, fishermen and the government looked for what seemed like a quick and easy fix; the introduction of hatchery fish into the rivers and coastal regions. The early rush into the use of artificial propagation and introduction of hatchery fish populations carried with it detrimental effects on natural salmon and salmon habitat, the consequences of which still seriously affect salmon populations. As explained in a 2001 report by IMST, "Initially, the principles of animal husbandry and agricultural production were applied to increase the numbers of fish to compensate for lost habitat and to enhance opportunities for harvest," and furthermore, "In the early years, the belief was that hatcheries could operate independently from the ecosystem of which they were a part"(IMST 2001-1, 7). A large component of the problems that stemmed from the use of hatchery-raised fish was the result of the myopic goal of large fish production, a goal that did not take into account what would happen to the hatchery fish once they were released, or the wild fish inhabiting the rivers, streams, and coastal regions into which the hatchery salmon were released.

The reality that salmon hatcheries were successful in the sense that they put forth large numbers of salmon could not be argued with. However, the idea of success based on the numbers released did not truly reflect the "success" of the entire process because the numbers used did not reflect what happened to the fish outside the hatchery. As the 2001-1 IMST report states, "The early decades of artificial propagation were characterized by claims of success;

however, there were no monitoring or evaluation to document the actual contribution hatcheries made to total production," and, " It is now generally accepted that prior to about 1960, few salmon fry survived after release from hatcheries"(IMST 2001-1, 13).

One of the factors that aided the continued lack of regulation and accountability for salmon hatchery practices relates back to the attitude that was associated with the institution as a whole. As Lichatowich explains in his report, the agriculture-based language in which fish hatcheries are discussed plays a large part in the manner in which they are publicly viewed. As he writes, "Early proponents of artificial propagation of fishes compared hatcheries to farms. The comparison with farms gave hatcheries instant success by analogy. Agriculture had increased the production of important human foods so it was natural to conclude that fish farms (hatcheries) would increase the production of fishes"(Lichatowich, 3). However, as Lichatowich concludes, "this success through association with agriculture was unfortunate because it removed the incentive to actually determine the performance of hatcheries"(Lichatowich, 3). This link between fish hatcheries and farming is key in understanding the public support for artificial propagation and salmon hatcheries, and the enduring belief in the inherent benefits of this practice.

Due to the agriculturally-swayed language, the development and continued use of hatchery fish generally went unquestioned with regards to the effects they had on natural salmon and salmon habitat. In fact, the notion that these hatchery fish could "make-up" for lost habitat, simply based on numbers, allowed for the continuation of unregulated loss of natural habitat and native fish. Current studies are working to invade the rosy-glow that such attitudes surrounded salmon hatcheries with, and explore the actual effects that hatchery-raised fish have had, and presently have, both negatively and positively, on wild salmon and their habitats.

In their 2000 report, “Salmon Abundances and Effects of Harvest: Implications for Rebuilding Stocks of Wild Coho Salmon in Oregon,” the IMST acknowledges that , “Fresh water estuarine salmonid habitat in the Pacific Northwest has been a continuously shifting mosaic of disturbed and undisturbed habitats. One of the legacies of salmonid evolution in a highly fluctuating environment is the ability to colonize and adapt a new or recovered habitat” (IMST 2000-3, ii). With the adaptive qualities of wild fish in mind, it is hard to turn a blind eye to the rapidly declining wild fish populations that are found in the Pacific Northwest, and specifically along the Columbia River. They knowledge that wild fish have been historically durable and adaptive to habitat fluctuations only enhances the degree in which hatchery fish, through their introduction and interaction with wild fish, have affected wild fish populations and their habitats. We cannot place all the blame for salmon depletion and habitat loss on hatcheries–a plethora of pollution sources that affect wild salmon exist and play off of one another–however, the adverse effects that are currently in the wild as a result of hatchery fish are a reality that also cannot be denied.

In order to understand the effects that hatchery fish can have upon wild salmon populations, I move from the broad discussion of all salmon, wild and hatchery-raised, to a more specific discussion of the coho salmon along the Columbia River. The studies of the changes that have occurred within the wild coho salmon that can be traced back to interactions with hatchery fish are helpful in breaking a large issue into smaller parts that can be traced back to general trends on a larger, regional level.

The coho salmon along the Columbia River have gone from one of the strongest natural fish populations in the late 1800's and early 1900's, to bordering on extinction by the late 1990's. As Mark W. Chilcote relates in his study, “Conservation Status of Lower Columbia River Coho

Salmon," "In the last 100 years the estimated abundance of wild coho in the Columbia River basin has declined from an annual average of 618,000 to less than 6,000 adults"(Chilcote, 1). This decline has been linked, on broad levels, to over- harvesting, changing ocean conditions, predation, disease, and most importantly, loss of habitat as a result of human industry and activity. According to IMST's 2000 report, "before 1960, most of the coho harvested along the Oregon coast were of natural origin. Hatchery production was small or non-existent for Columbia River and costal basins"(ISMT 2000-3, A-1). During the 1960's and 1970's hatchery production increased as coho salmon numbers began to fall. By the 1980's, as Chilcote relates, the wild coho populations had reached such depressed levels that the National Marine Fisheries Service came to the conclusion that "the extensive hatchery coho program had genetically overwhelmed the few remaining naturally reproducing populations,"(Chilcote, 1), and essentially wrote off the Columbia wild coho population. A study in 1995 by the Oregon Department of Fish and Wildlife, however, concluded that while wild coho numbers were severely depressed, there were still two surviving, and potentially sustainable coho populations existing near the Clackamas and Sandy Rivers. This discovery prompts the need for a discussion of methods that can be used to protect these numbers of surviving wild coho, and such a discussion begins with the identification of key factors in initial decline.

One of the most significant factors that Chilcote identifies in his study is the influence of hatchery fish on the wild coho salmon populations they came in contact with. As Chilcote writes:

> From 1972 to 1982, the number of late stock hatchery smolts released nearly tripled from 5.2 million to 14.9 million fish. Because the spawn timing of this late hatchery stock is closer to that of the wild coho in lower Columbia basin tributaries, the potential for interbreeding and adverse genetic impact is greater than with the earlier spawning hatchery coho typically produced at hatcheries in Oregon(Chilcote, 25).

This instance highlights one of the main detriments to wild fish populations that hatchery fish can instigate; the erosion of genetic diversity. When hatchery fish are released into the wild, they bring with them the specific genetic traits that are different from those of the wild fish through the process of domestication. As Lichatowich relates, "Domestication is selection for those traits that are beneficial in the hatchery environment. Such selection increases fitness in the hatchery, but it often decreases fitness in the natural environment"(Lichatowich, 6). These traits that are beneficial in the hatchery often lead to weakness in the natural environment, and if wild and hatchery fish breed, the genetics of the wild fish are impacted.

In many cases, the very traits that allowed a specific fish to survive in a specific habitat are diminished through interaction with hatchery fish, and the result is a higher mortality rate for the wild fish. As Lichatowich writes, "Fish native to a watershed where a parasite is present may have developed resistance to the organism whereas fish native to a stream where the same parasite is absent may be vulnerable to it"(Lichatowich, 12). When hatchery fish are introduced into such a watershed, and do not share this same genetic resistance, they interbreed with the native fish, weakening the genetic resistance of the native stock.

An example of this weakening of genetic resistance occurred between the years of 1965 and 1976. As Lichatowich writes:

> The Trask River hatchery stock of coho salmon, which is susceptible to [the parasite] *Ceratomyxa shasta* were planted into the Fishhawk Creek for 12 years. *Ceratomyxa shasta* is found in the Nehalem River and the native stock is resistant to it. Apparently some of the Task River stock of coho survived and returned to Fishhawk Creek where they spawned with wild fish. Research showed that the Fishhawk Creek Coho salmon had reduced resistance to *Ceratomyxa shasta* compared to native coho in other parts of the Nehalem River where Trask River Coho were not stocked(Lichatowich, 12).

The implications of the domestication of hatchery fish, and the erosion of genetic diversity that can result, are not specific to one run of salmon; they effect generations.

Another impact that domestication of hatchery fish can potentially have upon wild salmon populations is the effects it can have on spawning times. The spawning times of salmon are genetically based, and through domestication, many hatchery fish spawn earlier than the wild fish that they interact with in the wild. The hatcheries would collect the eggs from the fish that matured the earliest, in order to reach their numerical goals, and the result was hatchery fish that genetically reached peak spawning time earlier than the natural fish that they would be introduced into the wild with. As Lichatowich relates, "the shift in time of spawning can be lethal to the hatchery fish that spawn in the natural river, because earlier spawning is out of synch with the natural attributes of the watershed. Earlier spawning exposes incubating eggs to fall freshets, bed movement and high mortality"(Lichatowich, 12-13).

Another example of the negative impact that hatchery fish can have upon wild populations comes from hatcheries over-stocking rivers and streams and exceeding the carrying capacity of the stream. The result of such over stocking is increased competition between fish for rearing space and habitat resources, and leads to increased levels of mortality. (Lichatowich, 13).

All of these factors can be traced back, on a basic level, to failures in hatchery management, and failure of hatcheries to take into consideration the ecological repercussions of their work. This being said, use of artificial propagation in salmon hatcheries is a tradition that firmly entrenched in the Pacific Northwest, and one that will continue on into the future. According to Lichatowich, on a yearly basis, Oregon hatcheries release 60.4 million salmon from over 50 hatcheries. As Lichatowich relates, "In the Columbia Basin hatchery fish make up

95 percent of coho, 70 to 80 percent of the spring and summer chinook, 50 percent of the fall chinook , and 70 percent of steelhead"(Lichatowich, 3). The integration of hatchery fish into the entire salmonid life cycle cannot be denied. What needs to be addressed and scrutinized is the hatchery process as a whole that produces these fish. Lichatowich discusses this problem in detail. As he writes:

> Hatcheries were and in many cases continue to be operated as though they were independent of the ecosystems their fish are released into. Carrying capacities of the river and estuary, natural fluctuations in climate and productivity (fluctuating carrying capacities), interactions with wild fish of the same or different species, and the effects of domestication on the ability of hatchery fish to survive in the wild are generally ignored . . . throughout the history of hatcheries, the primary focus of attention has been on the hatchery environment. What happened to the salmon beyond the hatchery fence received little attention (Lichatowich, 11).

Lichatowich describes this failing in the context of the original goal of mitigation that hatcheries operate under. He explains that, since about the 1950's, the mission of hatcheries has had the original two-fold goal of breeding salmon that can survive in the specific conditions of the hatchery, *and* survive in the specific conditions–predators, competition, climate fluctuations, changing habitats -- found in the wild. This goal, rooted in ideas of mitigation, is essentially legitimate; however the failure of salmon hatcheries to properly reach it has resulted in the factors described above that have direct and dire consequences on wild salmon populations.

The reality that there are inherent failings in the institution of fish hatchery management has begun to be appreciated. In their 2001-1 report, the IMST reflected upon the changes that have occurred within hatchery processes in the past and their current practices. As the authors relate,

> Hatchery technology has made dramatic improvements over the last 120 years, but most of these improvements have been in hatchery operations, i.e., activities inside the confines of the hatchery. For example, over the last century, hatchery design improved, nutritional value of feeds increased, better treatments for diseases were developed, geneticists improved animal husbandry practices, and tagging technology has enhanced

monitoring of survival and contribution to fisheries (IMST 2001, 14).

While these changes are a step in the right direction, they all focus on the actions within the hatcheries and involving the hatchery fish before they have been introduced into the wild. The hatcheries have still not moved beyond on of their initial failings; the failure to study the impact that hatchery fish have upon the ecology of the watersheds in which they are introduced. Therefore, we can conclude only that the most fitting form of mitigation that is needed in addressing the failings of salmon hatcheries is further mitigation itself.

The most effective way to go about mitigating the failings of the institution of salmon hatcheries is to reform the system itself. As the authors of the 1998 IMST study conclude, "the continuing degradation of habitat was the primary cause for the declines in abundance of Pacific salmon and that mitigation based solely on hatchery production is not working"(IMST 1998, 24). Furthermore, as Lichatowich writes, "Hatchery operations cannot be treated as though they are independent of the ecosystem. Artificial propagation and natural production must be integrated"(Lichatowich, 14). The first step in this process is through more in-depth and well-rounded research that takes into account the ecological repercussions of hatchery runs. More study needs to be done in order to understand the natural salmon–their genetics, their habitats, and their spawning habits– so that hatcheries can tailor their runs to match and integrate with wild salmon, not compete with them.

Hatcheries need to take responsibility, and be held accountable, for the effects that hatchery populations have upon wild populations and break the mitigation process down to the specific failings of things like domestication, and over-stocking carrying capacities. There need to be standards enacted that outline in a very detailed and specific manner the guidelines for hatchery management. One of the most difficult aspects of creating these standards is that it will

be difficult to establish coherent standards for reform as there are multiple types of hatcheries which affect multiple, intersecting regions that cross state borders.

In Oregon, work is being done to attempt to address this complication. In 1997, the state legislature approved funds for the Oregon Plan, a "bottom-up" plan that established goals to aid the declining salmon populations and jump-start programs designed for habitat restoration. The Plan calls upon the state's different agencies to be a part of the mitigation of these problems through research and examination, and charges them with the task of determining the necessary direction in which mitigation and reform are to travel. It asks them to monitor the status of the Oregon Plan as it grows and expands. One such organization is the Independent Multidiciplinary Science Team whose reports I have cited throughout this paper. This group has put together regular reports detailing aspects of the issues facing salmon populations and watersheds, and worked to create guidelines and standards for evaluating and reforming current salmon hatchery management. (Oregon Forest Resources Institute)

In 1998, the IMST reported in a study that organized research priorities within the Oregon Plan, that, "[determining] the effects of wild-hatchery fish interactions and the impacts of hatchery management,"(IMST 1998, 2) was of "high priority." It called for further study of wild populations, and the result of interactions between wild and hatchery fish, for monitoring measures that would be used to evaluate the effectiveness of hatchery management programs and hatchery performance. In subsequent studies, members of the IMST address specific issues regarding hatchery management, reviewing the science involved, and making recommendations, based on the impact that hatcheries have on natural ecology, for the most appropriate ways of reforming the hatchery system.

This process of reform will be both expensive, time-consuming, and will require steady

evaluation to keep hatcheries accountable for their actions. One way that the authors of the 1998 IMST team suggest will prompt the hatcheries to work with reform programs is through a change in budget allocation. The IMST suggests that, "the budget focus should be on priority ecosystems. A hatchery's funding level should be determined by its role in supporting ecosystem management in a priority watershed"(IMST 1998, 24). Such a change in budgeting practices would be an incentive for hatcheries to truly change the ways in which they approach their work. What is most rewarding about these IMST studies is that they provide evidence that hatchery reform is possible *if* hatchery management complies with the suggested reform. Most of the problems that hatcheries have caused in the past, or are causing, do have solutions in the form of hatchery reform. This does not mean that, even through the best marriage hatchery programs and fish and natural ecology and fish runs, salmon populations will ever truly be restored; the problems stemming from salmon hatcheries are still just a part of a plethora of pollution sources and issues which affect the watershed in the Pacific Northwest, and specifically along the Columbia River. However, if salmon hatcheries, prodded by the standards and recommendations of groups like the IMST, are held accountable for their ecological impact through hatchery reform, one link in a larger chain can be secured.

As the members of the 1998 IMST report concluded, "as a whole, the stocking of hatchery fish has been detrimental to native fishes. However, it is also agreed that technologies and scientific understanding of the problem can, if applied consistently and in support of ecosystem management, provide safe use of artificial propagation in management"(IMST 1998, 25). Furthermore, as the members of the IMST wrote in the their introductory letter of their 2001 report, "We conclude, after nearly three years of study, and four technical reports that

artificial propagation can help accomplish the goals of the Oregon Plan, and we feel that the scientific direction we provide in our reports can help make this a reality." There is still much research, work, and reform that needs to be done, but unlike many of the adverse conditions found in the Pacific Northwest and along the Columbia River, mitigation for the problems caused by salmon hatchery management is possible.

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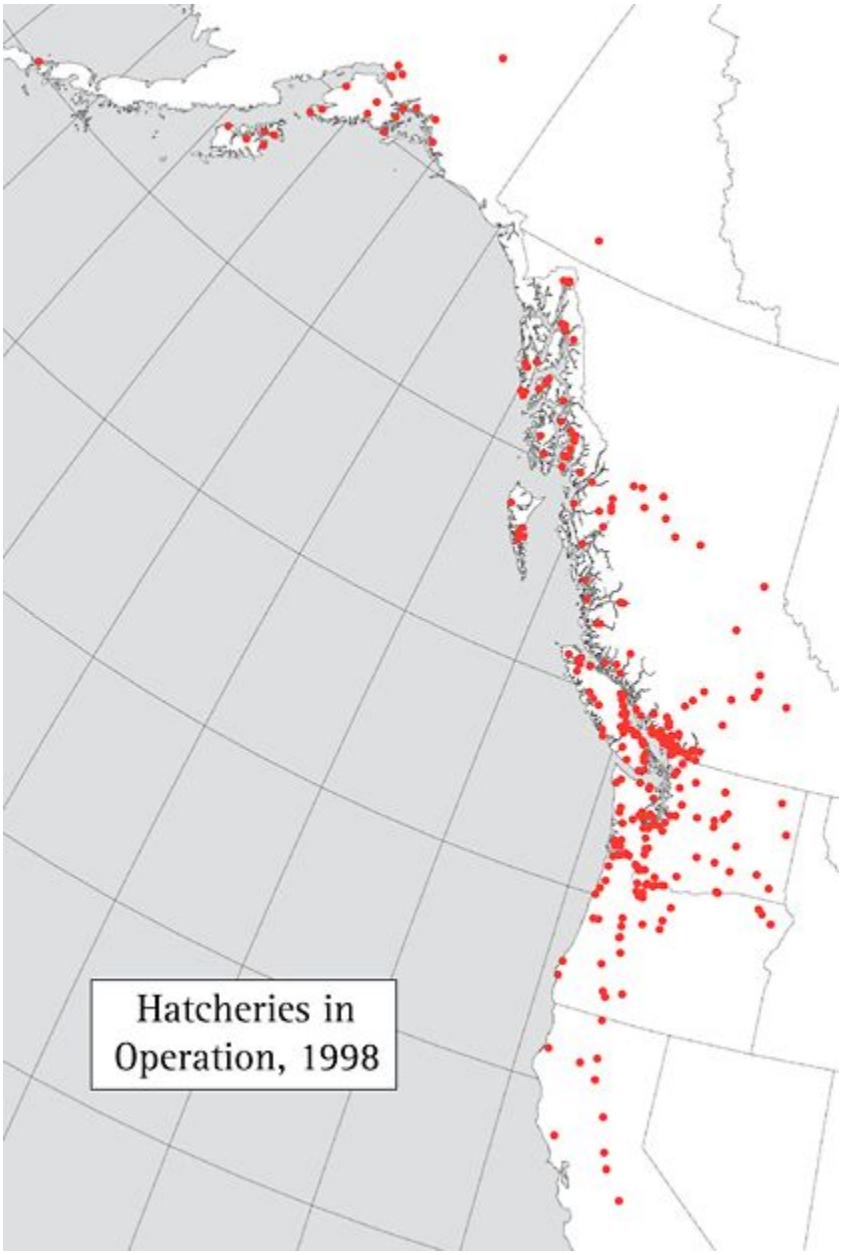

This map, found on organization Inforian's website http://www.inforain.org/maparchive/hatcheries.htm, shows locations of hatcheries throughout the Pacific Northwest as of 1998.

In their website, Inforain describes themselves as " a network of information allowing users to achieve a deeper understanding of their local watersheds, estuaries and forests as well as a broader comprehension of these places within a bioregional context".