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Salmonids in the Nooksack and Skagit Rivers

Pacific Salmon and their genetic family members populate the west coast of North America's rivers; to look at these populations as a whole to assess their current success and well-being would prove an incredibly extensive task, but by focusing on the populations originating from the Nooksack and Skagit Rivers and tributaries, we can thoroughly investigate the species health. Since Europeans arrived in the Pacific Northwest and began significantly altering the ecosystems and environment and putting heavy fishing pressure on the local wild Pacific Salmon, the population has dropped drastically.[1] The threat against Pacific Salmonids (members of the same Salmonidae family as Pacific Salmon) has become so serious that three of the species are now considered endangered.[2] This endangerment of the Pacific Salmonids, while due in part to climate change, habitat destruction, and the pressure of overfishing, has largely been aggravated by attempts to restore salmon populations through the use of hatcheries.[3] By looking at the various factors which are endangering Pacific Salmon and their family members we can hopefully not only learn how we have arrived in this critical situation, but also what the future may look like for these majestic fish and what steps could be taken to restore their population. When faced with the daunting realities of climate change and the human-caused degradation of the natural world, it is easy to lose hope, accepting the problems we face as too great to be prevented or even understood, but by considering one piece of the puzzle we can address the issue in a more approachable manner.

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[1] Oliver Grah and Jezra Beaulieu, "The Effect of Climate Change on Glacier Ablation and Baseflow Support in the Nooksack River Basin and Implications on Pacific Salmonid Species Protection and Recovery," *Climatic Change* 120, no. 3 (October 1, 2013): 657–70, https://doi.org/10.1007/s10584-013-0747-y.
[2] Grah and Beaulieu. "Glacier Ablation," 658.
[3] Maureen P. Small et al., "Have Native Coho Salmon (Oncorhynchus Kisutch) Persisted in the Nooksack and Samish Rivers Despite Continuous Hatchery Production Throughout the Past Century?," *Conservation Genetics* 5, no. 3 (June 1, 2004): 367–79, https://doi.org/10.1023/B:COGE.0000031136.35472.af.

Studying the environmental threats against members of the Salmonidae family is particularly important due to the characteristics of these fish which make them uniquely crucial, especially to the Pacific Northwest ecosystems. Firstly, many members of this fish family, and all five types of Pacific salmon are anadromous, or migrate from freshwater rivers into the ocean and then back into rivers to spawn and then die. Because these fish travel back and forth between these ecosystems, they are able to transport nutrients from the ocean far upstream into tributaries where these nutrients would otherwise never reach, and then their offspring carry back other vital nutrients into the ocean.[4] Thus studying salmonid's well-being, or lack thereof, is incredibly informative because it can indicate the health of multiple different ecosystems. Another aspect of Pacific Salmon which makes them so significant to the Pacific Northwest region is their crucial importance to the people of the area, not only as a critical source of sustenance and income, but also as aspects of culture and heritage.[5] Unfortunately, many do not see these intrinsic values embodied by salmonids, and rather seek to preserve them only as a means to the end of the industrial fishing industry, notedly the very same system which is heavily responsible for the decline of Pacific Salmon.[6] These combination of factors are not unique to only these two rivers and these issues facing the Salmonidae of the Nooksack and Skagit river can, with discretion, be applied to all Pacific Salmonids as they face similar threats regardless of the exact locality.

We will begin this investigation in the Nooksack river looking at a comparison between native Coho Salmon and Coho Salmon originating from hatcheries. As Scheurell et. all explain, there has been significant concern for the negative effect hatchery-raised salmon can have on the genetics

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[4] Mark Scheuerell et al., "A New Perspective on the Importance of Marine-Derived Nutrients to Threatened Stocks of Pacific Salmon (Oncorhynchus Spp.)," *Canadian Journal of Fisheries and Aquatic Sciences* 62 (April 12, 2011): 961–64, https://doi.org/10.1139/f05-113.

[5] Grah and Beaulieu, "Glacier Ablation," 657-58.

[6] Small et al., "Native Coho," 367.

of native, wild spawning salmon. Hatchery salmon are raised in environments which do not prepare them well to deal with the dangers and challenges of the ecosystems into which they are released, thus they grow smaller and less well adapted than the native salmon. When these two groups spawn together, the hatchery salmon's weaker genetics taint those of the native salmon, essentially "de-evolving" the species.[7] In this study, the authors used genetic testing of Coho Salmon throughout the Nooksack and adjacent but smaller Samish rivers to see how closely they resemble the DNA of hatchery salmon in order to deduce whether any native Coho populations had been able to survive untainted.[8] Concluding the study the authors state, "...wild-spawning Coho Salmon in the upper NF Nooksack River were genetically distinct from hatchery Coho Salmon in the Nooksack River and from wild-spawning Coho Salmon in the lower NF Nooksack River, and that wild spawners collected below the hatchery in the lower NF Nooksack River were indistinguishable from hatchery fish".[9] The results of this study describes two phenomena occurring in the Nooksack salmon population, one encouraging, the other disheartening. Firstly, some Native Coho Salmon, due to their significantly different run time (about one month earlier than the hatchery fish) and a diverse and extensive habitat within the Nooksack river have allowed a population of native Coho to survive on the North Fork.[10] Despite this, in the rest of the Nooksack river area represented by this study hatchery fish have predominated over native populations, which have essentially lost their genetic individuality, weakening the traits crucial for survival.[11]

Another key problem facing the Salmonidae in the Nooksack River is the detrimental effects of global warming, not only on water temperature, but also on glacial ablation and the slow recess of snowpack, this is specifically applicable to the Nooksack river as these are key water sources for it.

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[7] Small et al., "Native Coho," 367-70.
[8] Small et al., "Native Coho," 370-72.
[9] Small et al., "Native Coho," 374.
[10] Small et al., "Native Coho," 376.
[11] Small et al., "Native Coho," 374-77.

Grah and Beaulieu begin their article on this issue with a warning for the future for the Nooksack "There are at least eight source glaciers within the Nooksack River watershed on Mt. Baker... if glacial recession continues at its present rate, many of these glaciers may disappear entirely and their contribution to streamflow could be lost."[12] Grah and Beaulieu also address the impact of increased rain precipitation and subsequent loss of snowfall and snowpack in this study.[13] Upon considering these combined effects of climate change on the ecosystem the authors conclude, "The warm season (April to September) runoff is projected to decrease by 16–19 % by the 2020s, 22–28 % by the 2040s and 34–43 % by the 2080s. This will result in depleted Pacific salmonid summer and fall habitat due to reduced quality and quantity of flow, which limits spawning and rearing habitats and overall ecosystem health."[14] Not only will these changes in precipitation affect the river flow, but also, in combination with air temperature, they will have a significant impact on water temperature, heating the river waters far beyond optimal conditions for salmonid species. "Stream temperatures in the Nooksack River watershed that are favorable for salmon under the current condition will transition to stressful habitat; and areas that were stressful for salmon will transition to fatal areas."[15] These results all demonstrate that the impact of climate change on precipitation and glacial recession severely threatens the future of salmonids within the Nooksack.

As one of the members of Salmonidae on the endanger species list, Chinook Salmon are impacted by the issues facing the entire family more acutely. Though the Skagit River once held a healthy population of native, wild Chinook Salmon, damming and harmful agricultural practices have drastically changed the river.[16] These issues can be seen and addressed by considering the

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[12] Small et al., "Native Coho," 658.
[13] Grah and Beaulieu, "Glacier Ablation," 658-59.
[14] Grah and Beaulieu, "Glacier Ablation," 664.
[15] Grah and Beaulieu, "Glacier Ablation," 667.
[16] T. Beechie, E. Beamer, and L. Wasserman, "Estimating Coho Salmon Rearing Habitat and Smolt Production Losses in a Large River Basin, and Implications for Habitat Restoration," *North American Journal of Fisheries Management* 14, no. 4 (November 1, 1994): 797, https://doi.org/10.1577/1548-8675(1994)014<0797:ECSRHA>2.3.CO;2.

success of young out-migrant Chinooks, in what density and age they begin to leave the river, how this correlates to the success of the returning spawning populations, and what connection this could have with the degradation of the ecosystem.[17] However, salmonids unique life history, occurring across both salt and freshwater ecosystems, can make assessing this data much more difficult and complex as the factors influencing their populations' health can be diverse and convoluted.[18] As Chinook Salmon should spawn, hatch, and migrate in great numbers, the density of the hatches and migration can have a significant effect on the success of the salmon.[19] Yet despite the importance of density, hatching and young salmon are also critically affected by factors such as the flow of the river, as high flows can prove detrimental disturbances to hatching salmon.[20] Management of water release critically impacts the survival of hatching Chinook, and since regulations were put in place during the 1980's in an attempt to curb harmful high-flow periods, Chinook Salmon have appeared to survive better independent of the density of hatch populations.[21] Assessing this situation becomes even more complex when considering that overall discharge throughout the Skagit has been lower since the creation of the dam, before which Chinook were thriving.[22] Though these variables affect all Chinook populations on the Skagit river, the Chinook present there have six different populations, migrating at different times of the year and influenced differently by population density and river flow, helping to somewhat mitigate the situation.[23] Attempting to draw a concise conclusion regarding the Skagit's Chinook Salmon proves incredibly convoluted in light of these

[17] Mara S. Zimmerman et al., "Abundance, Survival, and Life History Strategies of Juvenile Chinook Salmon in the Skagit River, Washington," *Transactions of the American Fisheries Society* 144, no. 3 (2015): 627–28, https://doi.org/10.1080/00028487.2015.1017658.
[18] Zimmerman et al, "Juvenile Chinook," 628.
[19] Zimmerman et al, "Juvenile Chinook," 627-28.
[20] Zimmerman et al, "Juvenile Chinook," 627-28.
[21] Zimmerman et al, "Juvenile Chinook," 638-39.
[22] Zimmerman et al, "Juvenile Chinook," 638-39.
[23] Zimmerman et al, "Juvenile Chinook," 638-39.

varying factors, we can see from this example how threats to the species intertwine to make solving the issue of endangerment extremely complex.

Though obvious that current salmon runs are a mere fraction of the magnitude they once were, attempting to understand exactly the depletion of the population is a challenge. Thankfully, a key hint to unravelling this question lies in the interaction between spawning salmon carcasses and the ecosystems which are fed by the nutrients they transport inland. By looking at how these ecosystems are struggling with the salmon decline on the Skagit river, we can make an estimate of what numbers of salmon would be required to support an ecosystem in a healthy state. Although not limited to these, some of the key members of an ecosystem which rely on a healthy salmon runs along the Skagit river include salmonid smolts, insectivorous birds (nutrients from salmon carcasses are redirected through insects to benefit these organisms), and bald eagles.[24] After considering these categories, calculating the mass of salmon carcasses required to sustain them, and comparing these numbers to the current number of salmon carcasses, we see that these populations would need at least twice the salmon run size than the current hatchery spawner escapement goals.[25] Yet, it is important to note that these current spawner escapement goals are rarely met, especially for more threatened salmon, Chinook and Coho, and that this estimate only accounts for the bare minimum nutrients for a component of the entire ecosystem.[26] Furthermore, looking at the human caused damage to these ecosystems which rely on the nutrients provided by salmon carcasses shows that they may no longer be able to support the sizes of runs necessary for their own health.[27] Considering the variety in salmon run time and location needed to feed all the ecosystems up and down the

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[24] John-H. Michael, "Pacific Salmon Spawner Escapement Goals for the Skagit River Watershed as Determined by Nutrient Cycling Considerations," *Northwest Science*, Vol. 72, No. 4, (1998): 239, https://research.libraries.wsu.edu:8443/xmlui/handle/2376/1203.
[25] Michael, "Spawner Escapement," 243-47.
[26] Michael, "Spawner Escapement," 243-47.
[27] Michael, "Spawner Escapement," 243-47.

Skagit shows that these increases in numbers cannot be made only in the salmon species which are less consumed by the industrial fisheries (Chum and Pinks) but that Chinook and Coho must also increase their run numbers.[28] The clear conclusion being that industrial fishing must lighten the load it places on these fish. Though these considerations paint a fairly bleak picture for salmon on the Skagit, it is important to note that the increases in salmon necessary to revitalize the river are not unprecedented in other coastal river ecosystems. While these goals may be lofty, we can certainly do better than the current management plan.

One of the main concerns surrounding salmon restoration is that, like the populations decline, it can be hard to estimate how depleted their ecosystem has become from human-caused infostructure and pollution. However, by looking at the rearing habitat for salmon smolt along the Skagit river, estimating its capacity, and then comparing that to historical data, we can get some impression of the current situation. The data shows that the production capacity for Coho Salmon smolts in summer habitat has decreased by 24% and for winter habitat by 34%, with the largest portion of these losses occurring in side channel sloughs.[29] Although forestry and the blocking of culverts on smaller tributaries account for some of these losses, the vast majority is due to agriculture, which is attributed with 73% of summer and 91% of winter habitat losses.[30] Though these numbers are discouraging as they illustrate the stresses place on the river by industrialization and unsustainable farming practices, it is interesting and encouraging to compare with the previous information concerning the decrease in salmon carcasses. By comparing the two we can see that while ecosystems have been harmed and will affect the health of salmon population, there is still room from growth and hopefully a chance to move closer to a sustainable population. This reality further emphasizes the need to reduce fishing stress on the population, the rivers need more fish,

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[28] Michael, "Spawner Escapement," 243-47.
[29] Beechie, Beamer, and Wasserman, "Estimating Coho," 797.
[30] Beechie, Beamer, and Wasserman, "Estimating Coho," 797.

there is still some habitat for their population to increase, and thus more fish must be able to complete their life cycle.

By looking at these studies, we begin to grasp the complexity of the salmonids struggle to survive in this harsh post-industrial environment dominated by mismanagement and lack of respect for these incredible fish. By investigating the threats facing salmonids in the Nooksack river we can see the issues which will decide their future, understand what's causing them, and despite seeing some hope, acknowledge the severity of the situation. Though it is obvious from the state of Coho Salmon in the Nooksack and Samish rivers that hatchery-breed fish are having a tremendously negative effect on the genetics of the wild populations, its inspiring and comforting to see that a wild population has been able to survive through resilience and diversity.[31] In addition to the hatcheries, it is clear that climate change is having a directly negative effect for the salmonids in the Nooksack.[32] By looking at the example of the Skagit river we see some different problems facing the salmonids, specifically as it is a dam-controlled river which runs through an area dominated by agriculture, the destruction of the river's ecosystem is an incredible threat to its fish species.[33] This issue is also aggravated and worsened by industrial fisheries which so drain the salmon populations, that there are not enough fish to populate what ecosystem they still have to spawn and hatch in.[34] This operates as a destructive cycle, as humans continue to destroy the ecosystems and populations of the salmon, they are unable to provide the river with the nutrients it needs to maintain said ecosystem and provide for the next generation of smolts.[35] From the examples of these two rivers, I think we can draw a list of priorities for what needs to change to give wild salmonids a fighting chance in the

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[31] Small et al., "Native Coho," 374-77.
[32] Grah and Beaulieu, "Glacier Ablation," 666-68.
[33] Beechie, Beamer, and Wasserman, "Estimating Coho," 797.
[34] Michael, "Spawner Escapement," 243-47.
[35] Michael, "Spawner Escapement," 243-47.

Pacific Northwest and beyond. Firstly, the stress of fisheries has to be reduced, without this there will never be enough fish to repopulate and restore the rivers. Secondly, the rivers need to be restored to provide fish with the ecosystems they need to reproduce and survive and to provide the river environment with the key nutrients it needs. Although these two rise to the top of the priority list, it is crucial to realize the negative effect hatcheries are having on wild salmon and that the issues caused by climate change also trickle down onto these fish species. Pacific Salmonids are an incredibly unique and resilient family, and it is amazing to see them fight for survival, yet if humanity continues on our current path, their chances will grow bleaker still. We must seek to understand these environmental issues in our local communities where the affects will undoubtedly touch us, realize the importance of them in the big picture, and fight to change what we can.

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