Salmon Economics

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**Introduction**

On the west coast of the United, salmon and other fish populations have been decreasing. In Washington and Oregon, most of the salmon populations have been deemed threatened or endangered. In fact, 19 populations have already been deemed extinct. The value of just one population in Washington, the Atlantic salmon, is estimated to have a value of $40 million (Amos). The California Department of Fish and Wildlife believe that salmon fisheries create $900 million in annual income (Cheryl, 2021). It is estimated that 5.5 million salmon would return to the rivers in California. However, since the 1950s it has been counted that only 500,000 fish on average return. This is almost 10% of what it used to be. This decrease is partly due to human involvement, such as urban development or logging practices. Logging can reduce the necessary nutrients which go into the streams, along with introducing pollutants to them (ECONorthwest, 1999). Roads next to streams can cause problems if they clog up the stream or pollute the rivers. In 2015, there were unusually warm waters which ran into the Columbia and Snake Rivers. This warm water killed thousands of the sockeye salmon population. Some groups claim that continued climate change and increase in temperature will result in the melting of glaciers, which provide cold water for the salmon population (Flat, 2021). The introduction of dams in rivers can block the salmon’s migration patterns and prevent them from returning to their streams, even with passages built inside the dam for them to pass. There is also a possibility of the fish getting caught in the turbines in the dam. However, these dams are important to the area as they provide 50-65% of the electricity (Leonard 2015). Man-made fish ladders are designed to aid the fish in going upriver. Other factors which kill salmon can be fishing and the weather, which can decrease the amount of food in the rivers (U.S. Geological Survey).

A study in 1999 surveyed residents of the Pacific Northwest and asked how much they were willing to spend to prevent salmon extinction. The number given was between $30-97 per household. The total including all the households came a value between $102-$330 million. There is an issue of how to value the worth of just having fish alive, but this study can be a start of how to find the intrinsic value of just having the populations. The debate over salmon conservation is that the costs may be too high. Another 1999 article corroborates this by saying that the costs to revise the dams and reduce fisheries could be up to $246 million to $359 million annually. (Huppert,1999) It is also hard to measure the cost of damage the extinction of salmon may bring to the community. There is also the issue of the loss of jobs from fisheries if there is extinction and the damage to the logging industry if there are restrictions in place.

Governments and private markets must work together to find a cost-efficient solution to reduce pollution and over-fishing which will harm the salmon population. Some economists have advised providing subsidies only for roads which will soak up water, and not have the harmful run-off. Other ideas have been to de-incentivize private developers from building things which would harm the salmon population. The problem with these ideas may be that they may not be the most cost-effective option for the private companies constructing the roads or developing the land. These economists believe these policies will not restrict the logging and development industries but will stimulate it by bringing in more higher-skilled laborers.

Salmon may not inherently hold value but, failure to properly evaluate the salmon population and local ecosystem can lead to market inefficiencies and ultimately the extinction of more salmon species in the region. This can further impact the wildlife of the area. Salmon bring necessary nutrients to the forest from the ocean, which are consumed by bears directly to other animals indirectly through them. Salmon may also indirectly affect the logging industry, as trees are also given nutrition though dying salmon.

**Lit Review**

Studies by Dietrich (2016), Kock (2020), and Huusko (2017) used radio telemetry or capture-release models to measure populations in rivers. A study by Clark (2020) used three-pass backpack fishing to measure the fish population. One study showed that rivers with dams had six times less survival rate for the salmon than free-flowing rivers. This was mainly attributed to the dams causing the speed of the rivers to slow down, therefore causing the salmon to do the same. This meant the salmon less likely to escape from predators and therefore had a lower survival rate (Huusko, et al. 2017). A study by Dietrich (2016) also in the northwest placed the survival rate of the salmon in the lower Columbia River as 50-60%. Interesting to note was that in the Roza Dam fish bypass in the Lower Yakima River, it was found that the salmon were slowed, but salmon mortality inside the bypass was low. Also, predators were in and outside the bypass. It was also found that the timing of salmon release was important, as salmon released in May had high mortality rates, but salmon released in April had high survival rates (Kock. 2017).

Over 7,700 river kilometers of salmon habitat were said to be blocked from culverts, structures built within streams to support roads built above. These culverts can block not only wildlife, but also nutrient carrying sediment or organic material and wood as well. Some have been removed as part of an effort to allow for salmon and other fish to pass through, but it was found that in many sites where those barriers were removed, those were unused by the fish regardless (Clark, et al. 2020).

Roy (2018) and Song (2020) considered the cost of having the dams and removing them. These studies were both conducted in the northeastern United States and found that there are trade-offs between running the hydroelectric dams, fish capacity, and cost. Both studies found that it was more effective to use coordinated management efforts between dams in the same system rather than individual dam management or removal. Using the dams in the Penobscot River as a test, Song’s team tested different fish management scenarios. The maximizing point was energy generation at around 60%, with project cost at $17 million while still improving fish capacities. However, the study conceded there are more factors to consider outside of the test such as flood control, water supply, and sediment contamination (Song, et al. 2020). The cost of removing the dams were found to be 50% less than installing fish passages and 82% less than installing new turbines. Downstream dams were found to be more harmful to the fish, and more cost-effective to have few dams upstream with higher capacity to create energy. Roy found that in order to restore biomass to half of maximum capacity, there would have to be $1.6 billion in dam removal and minus 16 megawatts of energy in the northeast. These figures can be used in a benefits transfer model to estimate the cost of removing dams or adjusting the capacity of the dams in the northwest.

It was also found that biodiversity was important to the ecosystem health. An evaluation done with the Ecosystem Service Cascade found that diverse communities helped the salmon industry because diverse communities had key organisms which were linked to productivity. This study was done by finding the indirect use value of freshwater aquatic macroinvertebrate diversity (Daniels, et al. 2018). However, Sanderson (2009) found that new species in rivers can actually harm the salmon, because there is a possibility for them to be eaten. It was found in the Columbia River system that Pacific Salmon will encounter at least 8 non-indigenous predator and competition species. It seemed that biodiversity was beneficial as long as it did not introduce too many new predators.

Studies by Seung (2017) and Brown (1965) try to find the value of fisheries. In Alaska, to combat the decreasing Salmon population, the harvest limit for fishermen was also decreased and federal aid was given. 7.4 million dollars were given to commercial fisheries in the Yukon area alone. It was found that salmon fishery failures in Alaska hurt not only the Alaskan economy but surrounding west coast economies as well. This was because much trade was done between these regions to support the fishing industry. It also found that there could have been commercial fisheries who did not receive aid, and that receiving federal aid did help to alleviate the economic impacts of fishery failures, but only partially (Seung. 2017). This study done by Seung could be used to find the value of the Salmon industry and how salmon fishery failure can impact the economy. Brown used the Clawson method and travel method to find the value of the Salmon-Steelhead sport fishery. This particular study was done in 1962 through mail surveys. It was estimated that salmon-steelhead fishers spent about $18 million in 1962 alone. He suggests that the supply of salmon had to be increased or kept the same, and demand could be decreased through prices so the market could reach equilibrium (Brown, et al. 1965). He also estimated the cost to increase. Since this study is now outdated, another similar study should be done. However, it would be more beneficial to include not only sport fisheries, but also commercial fishing. There is also Salmon stock allocated to Native Americans in the Oregon area, so a more comprehensive valuation of all the different categories would be more accurate. This value may be harder to measure because the salmon is seen as a cultural and religious resource (Lin, et al. 1996).

Leonard (2015) studied the complexities around managing the local fish population and the dams. Leonard states that there are 178 hatcheries for salmon populations and over $88 million was spent on hatcheries by the town of Bonneville alone. Most of these are operated by state, federal, or even tribal agencies. However, it is still inconclusive whether it is beneficial to the salmon populations. The cost different entities spend to keep the ecosystem healthy could also be used as part of the evaluation of the true value of the ecosystem.

**Methodology**

The most straightforward way to evaluate the salmon in the northwestern United States would be to just multiply the population size times the market price of the salmon. However, this would fail to evaluate the effects of the salmon in the local ecosystems. Salmon provide necessary nutrients to the forest and to the wildlife, such as bears. Also, the economic loss from the population decline has to be calculated. Because of this, a blended analysis composed of two parts should be done to evaluate the true value of the salmon and the ecosystem they support. The first analysis should be a travel analysis to analyze the value of the forest and the wildlife they support, and the second could be a cost benefit analysis of the dams. The travel analysis should be done because the parks and wildlife supported by the salmon may not have a market price as the salmon do, so these are not as clear on their value. The second is to find the benefit of the dams compared to the damage done to the ecosystem and see if the benefit is worth the damage.

For the travel analysis, first, the amount of people who visit the fishing spots along the Columbia River could be counted, including the zip code those people reside in. The demographic of what kind of people could also be evaluated. Then, the cost of the trip should be evaluated. This could be the cost per round trip by calculating the cost per mile added to the opportunity cost of traveling to the location. However, there also other costs associated with fishing, such as the cost of rentals or purchasing of equipment and boats, and even if people are not going to fish but to enjoy the wildlife, there are costs such as hiking gear and equipment, as well as park costs. A demand equation can then be formulated using regression analysis for visits per capita to travel costs and other variables gathered from the demographic data, such as age, income level, and education level. The total economic benefit can then be calculated by finding the consumer surplus.

Some difficulties with this method could be that it may be difficult to count the people who visit these locations. Another is since it is easier to count people who do rentals, there may be an over estimation of that population, causing the data to be skewed. The study would also have to be done over at least a year, to fully grasp the range of the salmon and the effects they have to the forest. The weather for that year could also be another unaccounted variable, as if the weather is abnormal for the study year there could be abnormal results as well. The problem with only doing this study would be that it does not include the price of the salmon in the market. It is also difficult to measure the exact impact of the fish on the wildlife population and how much it differs with the amount of salmon. The salmon also indirectly contribute to the growth of trees, which is a product with a market price.

To conduct a cost-benefit analysis of the creation of a dam, the first step would be to list the costs of building the dam. These would include labor, licenses, land, material costs, and environmental damage. Then, the next step would be to find the benefits. These would be electricity created. After finding the cost of the labor, land, licenses, material costs, and environmental damage, these values should be added up. The revenue from the electricity created should also be added up. Then, the two values can be compared and if the benefit is greater than the cost, then the project should be undertaken. The costs of different agencies operating to protect the environment and preserve hatcheries can be added to the environmental damage cost to find the true social cost of the damage from the dams.

The reason for conducting a cost-benefit analysis of the dam is that the benefit of the dam compared to the damage done to the environment is able to be calculated. This would be more beneficial than just calculating the loss of revenue from the declining fish population because it will reveal a more socially optimum solution by including the damage to all the ecosystem rather than just the salmon.

Some difficulties with conducting this would be making sure to account for future value and predicting the environmental damage. This may have to be done by finding a value from another study. One solution may be to find the current ecosystem value minus through the before mentioned means, minus the predicted population loss from each species. These species would have to be given a value through either market price or rated individually.

To find the loss in revenue from the salmon industry, the current market price for each species of salmon times the current population should be calculated. Then, the market price for each species times the population of the fish at that time could be calculated. This would at least show the amount of revenue lost. However, this only finds the revenue lost in the salmon industry, not the damage to the environment. Since it would not be possible to do surveys in the past, a survey could be done now to find the value of the ecosystem, then compared to one in the future, adjusted for inflation. Also, the economic gain from the creation of dams should also be considered to find the social optimum.

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