THE NEGATIVE EFFECTS OF HYDROPOWER INFRASTRUCTURE AND HATCHERIES IN THE COLUMBIA RIVER BASIN

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Elly Zarzyski
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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

Advisor
Joshua Earle, Department of Engineering and Society

Introduction

As climate change is becoming increasingly destructive and irreversible, the need for energy continues to climb and many have turned towards renewable energy sources as a solution. Located in the Columbia River Basin (CRB) in the Pacific Northwest (PNW), the Grand Coulee Dam is one of the biggest suppliers of renewable energy in the US. The CRB runs through seven states and one Canadian Province, and the dam supplies drinking water and electricity to millions (Columbia River, 2019). The Grand Coulee Dam operations are a positive and clean contributor to the energy grid in the PNW but the dam isn't without its flaws. What is discussed less is the impact added hydropower operations have on the surrounding environment, ecosystem, and communities, especially the effect on salmon populations and other freshwater wildlife. Dams and reservoirs can have a huge impact on the natural flow of rivers, reducing water flow and hindering the migration of fish as well as harming the Columbia River estuary in the case of Grand Coulee. The estuary ecosystem is crucial to lots of wildlife as it is where freshwater meets saltwater tide, creating an area for wildlife to gradually adjust to salt water in the Pacific (Columbia River, 2019). In addition to wildlife and the surrounding ecosystem, communities that rely on the environment remaining consistent are adversely affected by these changes. Specifically, lots of indigenous communities rely on salmon beds for food and as the salmon population declines, so does their livelihood.

There have been multiple projects aimed at mitigating the negative effects of hydropower infrastructure like Grand Coulee, especially the decline in salmon populations. One main example is the startup of hatcheries in the Columbia River. These began as an effort to replenish salmon, and other fish populations in the river, but these projects, like the dam, don't come without their flaws and negative effects on the ecosystem. In this paper I will explore the impacts

of the Grand Coulee Dam operations on the surrounding environment, such as the decline of the ecosystem and how projects like the fish hatcheries added after the dam don't do the good they set out for. Furthermore, these fish hatcheries may have negative consequences for surrounding populations, such as indigenous communities in the PNW and the unethical attributes of hydropower infrastructure. In attempting to develop infrastructure for renewable energy amid climate change, that initial goal of protecting the environment and those living in it must not be forgotten.

My paper will begin with an overview of the background of the Grand Coulee Dam, salmon decline in the CRB, and salmon hatcheries. Then, following the background section I will explain my methodology, followed by my analysis of the research question and conclusion.

Methods

I created this case study to examine the historical and current operations of the Grand Coulee Dam and their impact on the environment and local communities, with a specific focus on the effects on salmon populations. I began research by reviewing articles and research papers pertaining to the history of the Grand Coulee Dam and the wider Columbia River Basin. This provided me with an introduction and background section, which examined the dam, the history of salmon populations in the region, and other dams in the area. Subsequently, I looked at scholarly articles related to the effects of hydropower operations, particularly those of Grand Coulee Dam, on salmon populations through the ProQuest Materials Science database & Engineering Collection database. My research initially focused on the impacts of hydropower operations on salmon populations, but gradually expanded to include an analysis of hatcheries and their advantages and disadvantages. My research also investigated multiple secondary

sources that documented the impact of the Grand Coulee Dam on indigenous communities in the surrounding areas, as well as the relationship between the dam, salmon, and local indigenous communities.

Background

History of the Grand Coulee Dam

Construction for the Grand Coulee Dam began in 1936 and in 1942 it began operations. Adjusted for today's currency, the Dam cost approximately 5 billion dollars to build. Standing 550 feet high and 5,223 feet long, it was an impressive construction project for the mid-1900s, being one of the biggest man-made structures of its time. Additionally, during the Great Depression, its construction created thousands of jobs for a nation in dire need. Construction of the Grand Coulee dam finished just in time for the US to begin involvement in World War II, making its operations pivotal for the electricity needs of war productions (National Parks Service, U.S. Department of the Interior, 2017). The construction of the Grand Coulee Dam and the Hoover Dam around the same time resulted from the New Deal, enacted by President Franklin Roosevelt. By the 1940s hydropower accounted for 40 percent of the country's electricity generation (International Hydropower Association). The Grand Coulee Dam generates approximately 6809 MW of electricity annually, and to put that in perspective, this is sufficient electricity to supply two cities the size of Seattle (Northwest Power and Conservation Council).

The construction of the Grand Coulee Dam has impacted the area around it in many ways since it began in 1933. It took land from indigenous communities like the Spokane and Colville Tribes and its negative impact on their lives didn't stop there. The wildlife that these communities rely on for food and wellbeing were also affected greatly, especially the decline in

salmon population caused by the dam (Office, U.S. Government Accountability, 2003). Since its construction and the beginning of operations, reduced flows in the CRB caused by the dams have harmed the Columbia River estuary by reducing the river's freshwater plume. This area is important for a variety of fish, especially salmon, as it allows gradual adjustment from freshwater to saltwater. Salmon migration has also been blocked by dams in upper parts of the Columbia River (Columbia River, 2019).

History of Salmon Decline

Although it is clear the Grand Coulee Dam has been detrimental to salmon populations in the area, these were already declining prior to its construction. Native Americans caught upwards of 20,000 salmon per year by the 1930s, as they were plentiful, easily caught, cooked, or stored. They were a main part of their diet and livelihood in the CRB. Beginning in 1986, the first Euro-American salmon cannery and following its opening, the salmon decline started due to "overfishing, tributary habitat degradation, blocked access to spawning habitats from dams, and mortality during passage at mainstem dams" (Ferguson, J. W., et al., 2011). The gold rush soon followed, bringing the development of mines along the river, further declining salmon population as they lacked fish passage facilities in this newly added infrastructure (Ferguson, J. W., et al., 2011). Scientists and surveyors suspect salmon populations to be on a decline beginning even as early as the late 1800s, and the construction of the Grand Coulee Dam has pushed populations even closer to extinction.

Because of its effects on the salmon populations, the Grand Coulee Dam had a lot of pushback, especially from indigenous communities that were greatly affected by this decline. When construction began in 1933, 51,879 salmon were counted swimming through the fish

ladders at Rock Island Dam, located south of Grand Coulee. By 1942 the highest count was 35,000, with even less in the years to follow (Northwest Power and Conservation Council). As mentioned, the groups affected the most by this were indigenous communities, for example citizens in Spokane, home to the Spokane Tribe, spoke out about wanting to be provided replacement fish in compensation. This prompted the state of Washington to build two hatcheries as a beginning to compensate for their losses. The hatcheries operated by the Spokane and Colville tribes were built through the Council's Columbia River Basin Fish and Wildlife Program (Northwest Power and Conservation Council). The hatcheries soon began to show ethical issues of their own.

History of Salmon Hatcheries

Salmon hatcheries have a long history in the Columbia River basin. The first hatchery in the Columbia River basin was established in 1877, and by the early 1900s, several state and federal agencies had begun building and operating hatcheries in the region. These hatcheries were primarily focused on producing fish for commercial and sport fishing, as well as for conservation purposes (Northwest Power and Conservation Council). As discussed earlier, the construction of dams on the Columbia River, including Grand Coulee, and its tributaries in the 1900s had a major impact on salmon populations, as it disrupted their natural migratory patterns and made it more difficult for them to spawn. As a result, hatcheries became an increasingly important tool for mitigating the impacts of the dams and maintaining salmon populations. In the mid-20th century, the federal government launched an effort to increase hatchery production of salmon and steelhead in the Columbia River basin, which led to the construction of several new hatcheries. As of 2006, there were about 200 salmon hatchery programs in the Columbia River

Basin. Studies showed that about 80 percent of the salmon and steelhead that returned to the basin as adults were from hatcheries (National Marine Fisheries Service, 2014). These hatcheries aren't cheap. The Bonneville Power Administration (BPA), a federal agency in the PNW that markets electric power, spends nearly half of their annual budget, $60 million, on funding for Columbia Basin hatcheries (National Marine Fisheries Service, 2014).

Analysis

As explained in the background section of this paper, salmon population decline was a problem even before the Grand Coulee Dam was constructed and began operations. Once the Grand Coulee Dam was built, there were multiple negative effects from construction and implementation of the dam, despite plans in place to try to protect salmon and combat population decline. First, the construction of the dam decreased the amount of spawning and rearing habitat available to salmon. As of 1975, it is estimated that water resource development in the CRB such as hydropower infrastructure like the Grand Coulee dam has decreased the number of stream miles from anywhere between 17% to even 100% in some areas (Ferguson, J. W…, 2011). This is detrimental to salmon populations as these miles of stream are potential spawning habitats. In addition to restricting access to adult salmon spawning habitat, hydropower infrastructure contributes to decline in younger salmon during their migration out to the Columbia River estuary (A. L. Van Gaest, et al., 2011). Dangers to salmon during outmigration include hydropower infrastructure affecting the timing and duration of peak flows as well as slowed outmigration caused by the creation of slow-moving reservoirs above each dam (A. L. Van Gaest…, 2011), a major issue with Grand Coulee Dam. This slowed outmigration is also a huge issue because it increases the possibility of predators being able to catch salmon. The extra stress

caused by prolonged migration can also lead to higher mortality rates. The Grand Coulee Dam is the biggest, but along the river young salmon are forced to navigate up to multiple additional dams and reservoirs before they reach the Columbia River estuary (A. L. Van Gaest, et al., 2011).

Environmental Ethics Issues

The Stanford Encyclopedia of Philosophy Ethics describes environmental ethics as: "Environmental ethics is the discipline in philosophy that studies the moral relationship of human beings to, and also the value and moral status of, the environment and its non-human contents" (Brennan, A., & Lo, Y.-J, 2020). The idea of environmental ethics is tricky because it means balancing human innovation and societal advances with our moral duties to the environment and its non-human inhabitants. In the case of the Grand Coulee Dam, its effects on salmon start to cross the moral grounds for social policies as it doesn't protect the earth's environment and even aids in environmental degradation. The issues with the Grand Coulee and its impacts on salmon population is an ethical issue because it harms the livelihood of salmon, even if it's at the expense of human development. The higher mortality rate of salmon, as well as overall decline and endangerment of the species presents this ethical problem, not to mention the wild salmon's quality of life is also decreased due to hydropower infrastructure like the Grand Coulee Dam.

Grand Coulee, as mentioned earlier, has made some advances to try and mitigate its unethical repercussions. The Northwest Power Act, fully developed by 1987, was a series of fish and wildlife programs initiated with the goal of doubling the salmon runs. These programs included various measures that targeted all stages of the salmon life cycle such as the installation of mechanical screens and bypass channels at the dams, flow augmentation, habitat restoration projects, and other similar initiatives. The implementation of these programs followed the

principle of 'adaptive management', which emphasized the need for continuous learning from the implementation of remedial programs and subsequent adjustments to ensure the effectiveness and sustainability of fish and wildlife mitigation. Given concerns over the impacts of hatcheries, adaptive management was particularly crucial when implementing artificial production projects (Volkman, John M.). Hatcheries were a main effort for the Grand Coulee Dam specifically, and posed additional obstacles throughout their efforts to combat salmon population decline and endangerment of the species.

The construction of three hatcheries, Leavenworth, Winthrop, and Entiat, took place in the Columbia River after the Grand Coulee Dam operations began, in an effort to combat decline in fish populations. But since then, several ethical issues also associated with salmon hatcheries have come to light. One of the primary concerns is the impact of hatchery fish on wild salmon populations. Hatchery fish may mate with wild salmon, which can reduce the genetic diversity and fitness of the wild population. Also, studies show that “even hatcheries using local- and predominantly wild-origin broodstocks create fish with lower reproductive success than their wild-born counterparts” (Christie MR, Ford MJ, Blouin MS, 2014). Hatcheries can also create an over-reliance on artificial fish production and reduce the incentive to restore natural salmon habitat. Additionally, hatchery fish may have reduced survival rates in the wild and can be more susceptible to diseases and predators due to their lack of natural selection pressures in the hatchery environment. These ethical issues have been extensively studied and debated in the scientific and management communities.

Hatchery fish in the Columbia River basin make up a huge percent of salmon in the river. Studies looking at specific breeds of the fish show that hatcheries are responsible for 95 percent of the coho, 70-80 percent of the spring and summer chinook, 50 percent of the fall chinook, and

70 percent of the steelhead (Oregon Business Council, 2019). These are high percentages, and as explained earlier, hatchery fish may actually damage the wild populations of salmon they mix with. One large issue with hatchery salmon here is how susceptible they are to parasites/disease. When born in a hatchery there is no presence of disease or parasites, which are plentiful in a watershed. Salmon born in hatcheries are unable to build resistance to these parasites, and it makes them extremely vulnerable compared to wild salmon. In the late 1900s this started presenting as a major problem. A hatchery in Oregon released over a million juvenile fish between 1966-1975. Of all of the groups released only one was marked and evaluated, and of that group not a single fish was observed making it to adulthood. Studies showed that the fish released were highly susceptible to a parasite local to the Columbia River that the wild fish were resistant to (Oregon Business Council, 2019).

Competition is described as a negative ecological interaction between hatchery-raised and wild salmonids in streams. Hatchery fish differ from their wild counterparts in several ways, such as variations in their genetic makeup, which depends on the broodstock utilized by the hatchery, and their rearing environment, which significantly differs from that of natural streams (Edward D. Weber 1 and Kurt D. Fausch, 2003). This competition can include aggression and physical competition between natural fish and the hatchery fish. Because of this, the addition of hatchery salmon in the wild does increase population, but still negatively affects the wild salmon that are native to the river system. In addition to being aggressive, they are also in competition for resources with the naturally born river salmon. Hatchery fish may compete with wild salmon for food and habitat, which can further strain already stressed populations, in similar ways that hydropower infrastructure like the Grand Coulee Dam can impose stress.

Despite its efforts to protect salmon and combat population decline, The Grand Coulee Dam has had numerous negative effects on the species. These effects include decreased access to spawning and rearing habitats, dangerous outmigration processes, and increased predator exposure. The construction of hatcheries was an effort to combat salmon population decline, but ethical concerns surrounding their impact on wild salmon populations have come to light. These concerns include reduced genetic diversity, reduced reproductive success, and an over-reliance on artificial fish production. Hatchery fish now make up a significant portion of salmon in the Columbia River basin, but they may not be positive additions to the salmon population. Ultimately, the ethical issues surrounding the Grand Coulee Dam and hatcheries highlight the need for a balance between human innovation and societal advances with our moral duties to the environment and its non-human inhabitants. As we move forward, it is important to continue to study and debate these ethical issues in order to ensure the long-term sustainability of fish and wildlife mitigation efforts.

Removal of Dams and the Elwha River

The removal of hydroelectric dams is becoming a more popular solution to the ethical problems arising from them. Hatcheries work to try to mitigate the issues caused by dams, but in many places people are becoming more aware that the best solution may be to remove dams altogether. One example is the Elwha River and the Elwha and Glines Canyon dams. The dams were built in the early 1900s generating hydropower to supply electricity for the expanding town of Port Angeles where the lumber industry was rapidly growing. In result, the dams “blocked the migration of salmon upstream, disrupted the flow of sediment downstream, and flooded the historic homelands and cultural sites of the Lower Elwha Klallam Tribe” (National Parks

Services). These effects were detrimental to the area and the river, in similar ways as the Grand Coulee.

In 2011 they decided to remove the Elwha dam in hope that the river would prosper again, and the Glines Canyon dam was removed not long after in 2014. The removal of the dams were mostly an effort to return salmon to the river and help reverse the negative effect the infrastructure had on the population. In actuality it did that and much more. With the barriers removed from the Elwha River, aquatic organisms regained access to the entire river and salmon returned to and prospered in areas that they weren't able to access for a century (National Oceanic and Atmospheric Administration). With the flourishing return of salmon, aquatic food webs also saw major benefits and improvements. Algae as a key source of food for smaller organisms that serve as a critical food source for juvenile salmon in large rivers. Upon returning from the ocean to spawn, adult salmon bring with them marine nutrients that help to support algae growth and keep the cycle prospering. So, their return to the environment in large numbers helped the algae and therefore helped to support the aquatic food web (National Oceanic and Atmospheric Administration).

The land around the river saw vast improvements as well. There were worries soon after the removal of how sediment would be affected. There were 15 sites being monitored before and after dam removal and a few of the sites saw a large amount of sand, around one to three feet, as the river moved sediment from the reservoirs (Shapley, 2019). But, to their surprise and satisfaction it wasn't an ecological disaster, instead a field day for organisms in the ecosystem. Organisms including crabs, shrimp, birds and other marine life went straight for the sandy new environment, making it home. In addition to making land along the river more inhabitable, the removal of the dam helped make the river estuary much bigger and more prosperous. The

removal has “moved the mouth of the river about half a mile further out,” which again, has provided a new habitat for salmon and other estuary wildlife (Shapley, 2019).

The dam removals were overall a huge success, and not only helped the ecosystem, but was deemed beneficial for the communities around the river. The Lower Elwha Klallam Tribe was a huge supporter and advocate of the dam removals and them, along with conservation groups and years of political wrangling and scientific studies, worked hard to push for the removal and rehabilitation of their backyard, the Elwha River. Dam removals like these are an extreme example of one way to combat the negative effects of hydropower infrastructure and help communities adversely affected by it. But this does show proof that the removals have extremely beneficial outcomes for nature and communities reliant on rivers and their ecosystems. It is important we continue to look for sustainable and equitable solutions that support the ecosystem, environment and surrounding communities while also meeting our energy needs.

Conclusion

The Grand Coulee Dam has had a significant impact on the surrounding environment, ecosystem, and communities, especially on the decline of salmon populations and other freshwater wildlife. While the dam has been a clean and reliable source of energy for decades, its negative and unethical consequences cannot be ignored. The decline of salmon populations, in particular, has had a profound effect on indigenous communities in the PNW that rely on these fish for food and livelihood. The hatcheries set up as a solution have also come with their own flaws and negative, unethical impacts on the ecosystem.

As we continue to rely on renewable energy sources to combat climate change, it is essential to consider the ethical implications of hydropower infrastructure like the Grand Coulee

Dam. The negative effects on the environment and communities cannot be ignored, and it is very important to balance our energy needs with the preservation of our natural resources. This should be a focus of projects going forward. Future research should continue to investigate ways to mitigate the negative impacts of hydropower operations on the environment and freshwater wildlife, and to find alternative energy sources that do not have such detrimental effects so they can do the good they are meant to do. We need to work together to find sustainable and equitable solutions to meet our energy needs without sacrificing the well-being of the environment and its inhabitants.

(3762 words)

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