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Pacific Salmon and Hydroelectric Dams

Hydropower generation is seen as a green source of energy, and compared to many alternatives, it is exactly that. However, many environmental concerns, other than green house gases and climate change, arise when trying to produce hydroelectric power. One serious concern is the survival rate of spawning Pacific salmon passing through the turbines along with the downstream effects of hydropower dams on these fish. As the salmon population continues to decline, with more than 100 stocks extinct and hundreds more endangered in the Pacific Northwest alone [1], the issues relating fish population and electric dams become increasingly apparent. Many large dams were built almost half a century ago, when the only design consideration was maximum power output [,] and since their construction, these considerations have changed significantly [2]. Appropriate upgrades and redesigns that support sustainable salmon habitats are therefore crucial to restoring the reign that spawning Pacific Salmon once had over rivers throughout the Pacific Northwest.

The most significant design flaw in some hydroelectric dams is the absence of fish ladders, lifts, or other methods that provide salmon with a path over the dam. Many dams do include such essential features; however, their absence imposes drastic consequences on the salmon trying to spawn upriver. These consequences can be seen on the Klamath River, which runs through Northern California and Oregon, as in the past, the Klamath River held salmon runs of over 1 million fish;

however, in 2006 a mere 35,000 returned for the annual migration [3]. There are many causes for this drastic decline and among them are four dams which block access to the upstream spawning habitat. Without fish ladders or lifts, the salmon have no way of negotiating past the dams.

The company that owns the four dams along the Klamath, PacifiCorp, eventually came under scrutiny for their harmful dams but instead of agreeing to install fish ladders, they proposed a "trap and truck" program, in which they would aim to capture the salmon and drive them around the dams [3]. This proposal, however, would be damaging to the fish and also be needlessly disruptive. Fish ladders, therefore, remain the most reliable and environmentally friendly solution because without them, spawning Pacific salmon are limited in their ability to reproduce and may suffer drastic population decreases. Regulations must be placed on dams located in salmon spawning rivers to ensure that the salmon are given a path over, or around the dam, and the opportunity to access their historic spawning habitat.

Another problem present in the relationship between the declining salmon population and hydroelectric dams can be found when fish pass directly through the turbines. Due to the complex nature of turbines, it would be nearly impossible to attain a 100% survival rate; however, survival rates of up to 95% for fish passing directly through the turbines have been achieved in some new designs. This is a drastic improvement from the 70% survival rate found in older dams [2]. The survival rate of the salmon becomes a big issue because they must often pass by many dams en route to spawning and to the ocean. For example, on the Snake-

Colombia River systems, salmon must pass up to eight hydroelectric dams on their way to and from the ocean [4], and with each dam, more salmon are killed.

Designing a "fish friendly" turbine, however, is rather difficult due to the many threats to consider. Most obviously, there is the threat of collisions with the blades of the turbine but also water jets. Drastic pressure changes in the turbine, grinding and rubbing of the fish, and many other variables also play a role in fish mortality [2]. New turbine designs improve these areas with smoother blades, larger gaps between the blades to allow fish to swim through the turbine [,] and control systems that sense the presence of fish and proceed to operate the dam using fish friendly modes [5]. Implementing such new features in older, more destructive hydroelectric facilities could also increase electric output by as much as 15% [2]. This improvement would come as a result of fewer spills, which is the act of passing large amounts of water over the dam as opposed to through the turbines. Spills are often used to increase fish passage; therefore less water would be lost due to fewer necessary spills and, as a result, more power would be generated. In sum, upgrades to harmful dams would be both environmentally and economically advantageous.

An area of concern that pertains to Pacific salmon specifically is delays in fish passage, meaning how quickly the fish get upstream and downstream from the dam. It is a significant concern because any interruptions in the migration of the salmon cause increases and decreases in migration time. These interruptions prove to be especially problematic among salmon because for an adult, the delay such interruptions cause could be the difference between reproduction and death. One phenomenon, “fallback”, when an adult fish swimming upstream successfully navigates over the dam, but after having reached the top, becomes ‘sucked down’ through the spillway or the turbine, drastically slows migration time [6]. Evidently, the salmon must once again migrate past the dam, potentially killing the fish.

Juvenile salmon also feel the consequences of delays in migration. For example, the deep waters of the reservoir of dams often cause significant delays of up to several days in their migration. This occurs because of limited flow in the reservoir and, thus, the juvenile salmon are stuck searching for “sensory stimuli” to direct them downstream [6]. Migration time for juveniles is extremely important because salmon are a diadromous species, as the young migrate from fresh to salt water. They must therefore undergo physiological changes before reaching the ocean and, consequently, any delay or acceleration from the natural migration timeline means that the juveniles arrive at the ocean with less energy and become at higher risk of being killed by predators [6].

Since migration time plays such a major role in the survival of salmon, the methods used to allow juvenile salmon to pass by the dams must also be studied extensively. The most efficient and most commonly used method presently for juvenile passage is the spillway because it proves to be effective as it allows a maximum number of fish to pass over the dam. However, as with most methods, it does not come without its drawbacks. Reduced power generation comes as a result of having to pass large amounts of water, along with the fish, over the dam and not through the turbines, but possibilities remain for the fish to become injured or killed by violent turbulent flows and **striking structures.** Predators also tend to group near the spillways [6]. In contrast to the spillway, surface passage is considered the least dangerous and diverts the least amount of water but its downfall remains, however, that too few fish use these routes [6].

Many problems arise with downstream passage, as many salmon choose not to use fish bypass routes. In contrast to the strong adults who are migrating upstream and are easily collected at the base of the damn, the juveniles migrating downstream are minute and much more difficult to collect in the deep reservoir of the dam. For these reasons, downstream passage of juvenile salmon becomes a complex task of engineering and design and must be further researched in order to improve survival of Pacific salmon and increase the ever-diminishing population.

Pacific salmon take over coastal rivers annually to produce offspring; however, fewer have been returning in recent years due to a declining population. Humanity can be attributed as a main cause for this rapid decline and dams in coastal rivers present a large threat to migrating salmon. In order to preserve this fascinating creature, upgrades need to be made to current hydroelectric facilities and regulations must be imposed. By improving fish passage, dams will also benefit from a decrease in necessary spills and, thus, will have a higher power output. Control systems can also be implemented to limit dams to “fish friendly” modes when fish are present in the waters and research can be done in order to discover the most effective way of passing juvenile salmon downstream. By taking these measures, hydro companies can become the cutting edge in environmental sustainability and produce clean, profitable energy. However, if matters are not improved, Pacific salmon will continue their struggle against humanity to survive.

References

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