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Effects of Hatchery-Raised Salmonids on Wild Salmonid Populations

Salmonids: Their History and Decline

Human beings have relied on fish as a source of food for millennia. For a very long time, the natural bounty of the world's oceans, lakes, and rivers was both stable as a resource and sufficient for human needs. But as more advanced fishing technology and techniques were developed, it became possible for people to catch far more fish than the waters could reasonably supply. Because of this, fish populations plummeted, even as rising human populations meant that the demand for fish increased. This stress on the world's waters depleted many of the most popularly fished species (U.S. Fish & Wildlife Service 2008).

Due to their global availability and large size, salmonids – that is, fish belonging to the family Salmonidae – were among the most profoundly affected species. Salmonids are ray-finned fish, and many species are anadromous, which means that they live in salt water but migrate into fresh water to breed. Salmonid species affected by overfishing include: the North Pacific's sockeye salmon (*Oncorhynchus nerka*), Chinook salmon (*Oncorhynchus tshawytscha*), pink salmon (*Oncorhynchus gorbuscha*), coho salmon (*Oncorhynchus kisutch*), chum salmon (*Oncorhynchus keta*), and steelhead trout (*Oncorhynchus mykiss*), collectively called Pacific salmon; and the Atlantic salmon (*Salmo salar*) of the North Atlantic (Government of Canada 2006).

At the beginning of the 20^{th} century, the single most significant threat to wild salmonid populations was commercial fishing. Seines, gillnets, and fish wheels were all used to catch staggering amounts of fish, and even regulations on these methods could not repair or control the damage. As many commercial fishing techniques were regulated and outlawed, other threats emerged; for example, dam building and habitat destruction (U.S. Fish & Wildlife Service 2008). As the 20th century began, salmonid populations were suffering so badly that something needed to be done if they were to survive (Ford and Myers 2008).

Hatcheries

The proposed solution to the salmonid population crisis was the introduction of fish hatcheries. A hatchery is a controlled facility where fish are bred and raised for at least part of their life cycle. These protected environments improve the survival rates of vulnerable young fish from the egg stage to the juvenile stage, because they provide a constant environment with abundant food and refuge from predators. Once the fish reach a certain size, they are released into the wild (NOAA 2006).

The first salmon hatchery was established for Chinook salmon on the Columbia River in 1877 with the intended purpose of supplementing commercial fishery harvests (Fifer 2008). But as wild salmonid populations began to plummet, people turned to hatcheries as a conservation aid with the understanding that they could be beneficial to populations that were significantly below carrying capacity or that would otherwise become extinct within a few generations (Reisenbichler and Rubin 1999). Hatchery-based management has the potential to be extremely effective for salmon. Salmonids are relatively easy to hatch and raise in captivity, and farm-raised fish can easily be used to supplement wild populations that are suffering. This practice has been in use from the late 1800s through today; however, it is not without negative retributions (NOAA 2006).

Genetic Hazards

While the introduction of hatchery-raised fish into natural environments seems like a good way to supplement wild populations and thereby prevent total depletion, it is a strategy with many negative consequences. The main problem with hatcheries is genetic risk.

There is strong evidence that released hatchery fish can reduce the fitness and spawning efficiency of the natural population (Reisenbichler and Rubin 1999). Genetic diversity is essential to the survival and fitness of any species because it protects the species from being decimated by a single environmental change, such as severe fluctuations in water temperature. If all members of a population were genetically identical, there would be no possibility for adaptation to changing environments. Also, genetic diversity prevents inbreeding, which often leads to disease and deformity. When fish are raised in a hatchery, they generally represent only a small sample of the wild genetic distribution; as such, when they are released into the wild, there is an overabundance of those genotypes and overall genetic diversity is greatly reduced (NOAA 2006).

Another genetic problem with hatcheries is artificial selection. Hatcheries keep young fish in tanks, where selection pressures are quite different from those that occur in the wild. Hatchery tanks tend to be constant and relatively calm, with a much higher density of fish than would occur in the wild. These artificial pressures influence the development of the fish in such a way that the adults are often better suited to life in hatchery tanks than in natural habitats. This genetic tendency is obviously quite harmful to fish living in the wild (NOAA 2006).

Eventual breeding between wild and hatchery salmon is an intended result of salmon farming. However, if the farmed salmon are genetically less fit or differently equipped than the wild salmon they breed with, the whole population is liable to suffer (Reisenbichler and Rubin

1999).

Parasites, Diseases, and Contaminants

Fish hatcheries are also a potential source of disease pathogens. Although the problem is difficult to study because it is so widespread in both wild and farmed salmonids as well as non-salmonid hosts, research suggests that farmed salmon are a likely source of diseases and parasites that have broken out among wild salmon populations (Noakes *et al.* 2000).

One such parasite is the sea louse (*Lepeophtheirus salmonis* and *Caligus clemensi*), which primarily feeds on salmon. A study in British Columbia in 2005 investigated the transmission of sea lice to juvenile pink and chum salmon as the fish passed a salmon farm during their migration to the ocean. The results showed that the infection pressure within 30 kilometers of the farm was 73 times greater than infection pressure elsewhere, suggesting that hatchery-raised salmon are capable of transmitting parasites to wild salmon (Krkosek *et al.* 2005).

Another serious health problem among hatchery salmon is kidney disease caused by bacteria. Such diseases are responsible for high mortality rates among farmed salmon, and they have been known to spread rapidly into wild salmon populations with devastating effects (Rucker *et al.* 1954).

Contaminants are yet another concern. Analyses of worldwide harvests of both farmed and wild salmon in 2004 show that concentrations of contaminants such as organochlorides are significantly higher in farmed salmon than in wild salmon. These contaminants may potentially be passed on to human beings who consume the fish – and since salmon are fished primarily for human consumption, this is a major concern (Hites *et al.* 2004).

Ecological Hazards

Whenever hatchery fish are introduced into the wild alongside native populations, of course there will be various interactions between the farmed and wild fish. In the case of salmonids in particular, this can be problematic because of the specific characteristics of farm-raised salmon as opposed to wild salmon (NOAA 2006).

Because they are so heavily protected as juveniles, adult hatchery salmon tend to be larger than adult wild salmon. Salmonids are primarily piscivorous (they feed on other fish), so large, farm-raised salmon have a distinct opportunity to prey upon smaller, wild salmon, thereby further depleting the wild population (NOAA 2006).

Hatchery fish of a given species also have the same habitat and dietary requirements as their wild conspecifics. This means that hatchery salmon constitute an additional source of competition for wild salmon. While coexistence is possible, hatchery salmon are often larger and sturdier than their wild counterparts, and therefore wild salmon are the first to suffer from the competitive pressure (NOAA 2006).

Salmon are territorial about their foraging areas. Juvenile salmon have aggressive competitions to determine and defend these territories. Since hatchery fish populations are much denser than wild ones, hatchery fish are well accustomed to competition by the time they are released into the wild. Since natural salmon densities are much lower than those of artificial populations, there is not as much of a need for aggressive territory defense in the wild, yet farm-raised salmon continue to display very aggressive behavior. This disruption of natural social interactions can potentially reduce wild salmon populations (NOAA 2006).

All of these ecological concerns, combined with a general decline in habitat quality, contribute to reduce the carrying capacity for natural, wild salmon populations (NOAA 2006).

Behavioral Problems

Artificial hatchery environments are much different than natural stream, river, and ocean environments. As a result, fish raised in these unnatural environments are not given the opportunity (as juveniles) to develop natural behaviors. Hatchery tanks and production areas are devoid of natural components such as rocks, gravel, leaf litter, coarse woody debris, strong currents, vegetation, and overhead cover. In addition, the food supply in hatcheries is constant, predictable, and often not the type of food which is available in nature. As a result of being raised in such a sterile environment, farm-raised salmon do not develop natural behaviors related to foraging, predator avoidance, social interactions, and migration. This causes problems when the hatchery fish are released into the wild and faced for the first time with a natural environment; it is often difficult for them to successfully integrate their hatchery-learned survival mechanisms with the existing wild populations' survival techniques (NOAA 2006).

Hatchery Success

The risks and drawbacks of salmon hatcheries as a means of supplementing wild salmon populations are numerous and serious. However, this technique has been used successfully in several instances. For example, the pink salmon hatchery in Kodiak Island, Alaska has increased the annual catch from 3 million to 20 million fish per year since 1980 (Hilborn and Eggers 2000). Overall, stocked fish from Alaska's salmon hatcheries account for 14-37% of annual statewide commercial harvest (Heard 2000). Maine's Atlantic salmon hatcheries have also been largely successful; most wild populations are heavily dependent on farm-raised supplements (NOAA 2006). In many cases, hatcheries have kept the commercial salmon fishing industry alive.

The Future

Despite these success stories, salmon hatcheries have a long way to go before they can be considered the ideal solution to wild salmon population deficits. Several new production and release techniques that will help increase natural behaviors in hatchery fish are currently in development. These methods include pre-release training for fish so that their transition into the wild will not be so abrupt; this training could include the naturalization of hatchery environments or the introduction of natural food at the hatchery level (Brown and Laland 2005). Perhaps these changes will increase the adaptability of hatchery salmon and decrease mortality in both wild and farmed populations.

Conclusion

Commercial salmon farming is important to human beings nutritionally, culturally, and economically. However, as wild salmon populations are overfished, the need to supplement them becomes more and more necessary if total depletion is to be avoided. Hatcheries are certainly a practical solution, but not a perfect one. Genetic risks, ecological hazards, fish behavioral problems, and risks associated with disease and contaminants all contribute to the overall dangers of total reliance on hatcheries. But, as evidenced by the success and innovation of thriving salmon hatcheries, it is clear that there is room for salmon farming in the future.

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