

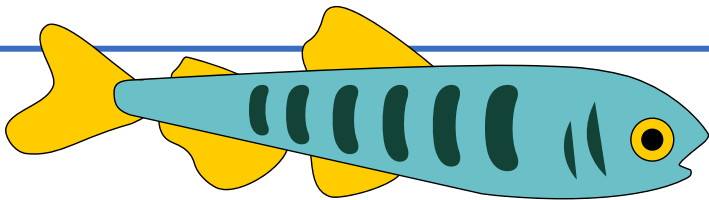
SALMON GENETICS AND RESTORATION HATCHERIES

Salmon have experienced critically low run sizes in the Yukon River for several years. Many factors have led to their decline, and it is possible that Yukon River salmon are headed towards extinction.

Restoration or conservation hatcheries have been suggested as a tool to improve the status of salmon populations. While hatcheries are often dismissed because of the negative impacts they can have on salmon genetics, there are situations where hatcheries can enhance genetic diversity.

Genes are essentially the instructions that determine how living things look and behave. They are made of DNA and passed down from parents to offspring. Having a lot of different genes, or high genetic diversity, in a population is beneficial, especially in a changing climate. Genetic diversity means there is variety in salmon behaviour or traits. Traits that help salmon survive or reproduce are passed down to future generations, leading to a population that is well-suited to its environment over time.

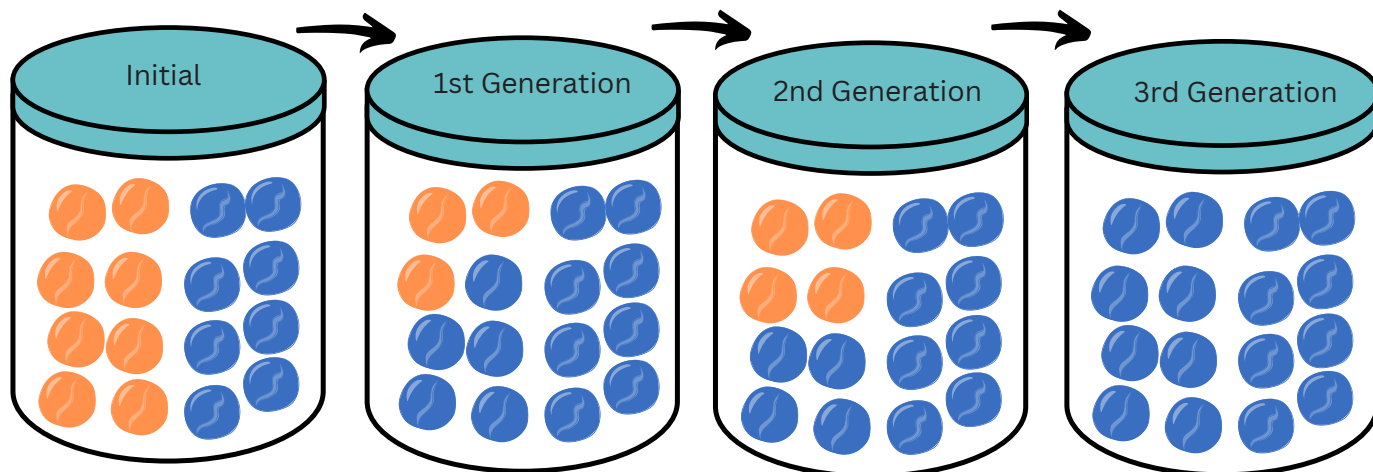
Under normal conditions, natural evolution maintains diversity and the adaptive state of the population so hatcheries are unnecessary and could even be harmful. For example, salmon raised in hatcheries slowly adapt to very different conditions than wild salmon. So, when these hatchery-raised fish are released into the wild, they may struggle to thrive since their behaviors or traits are ill-suited for the natural environment. But when salmon populations drop to critical levels, the main genetic influence on them shifts from adaptation to genetic drift. In such instances, hatcheries become valuable tools.



GENES AND GENETIC DRIFT

Genes are sections of DNA that can code for traits, like eye color or blood type. In a population, there are different versions of genes known as alleles, which lead to different traits (e.g., blue or brown eyes, A+ or O- blood type). When salmon spawn, each parent passes half of their alleles to their offspring which results in a mixing of alleles.

Genetic drift occurs when there are random changes in allele frequencies between generations due to chance events. Genetic drift can be illustrated using a jar of marbles. Let's imagine 16 marbles represent a population of 8 salmon, where each salmon has two alleles. Half of the marbles are orange, and half are blue, symbolizing equal proportions of alleles in the population. To demonstrate genetic drift, we randomly select 2 marbles from the initial jar, and add new marbles of the same colour to the next jar (or generation). We repeat this process until there are 16 marbles in the new jar, representing the genetic makeup of the next generation of salmon. If the new jar doesn't have exactly 8 orange and 8 blue marbles, there's a random shift in allele frequencies. This random change in colours over generations is genetic drift.

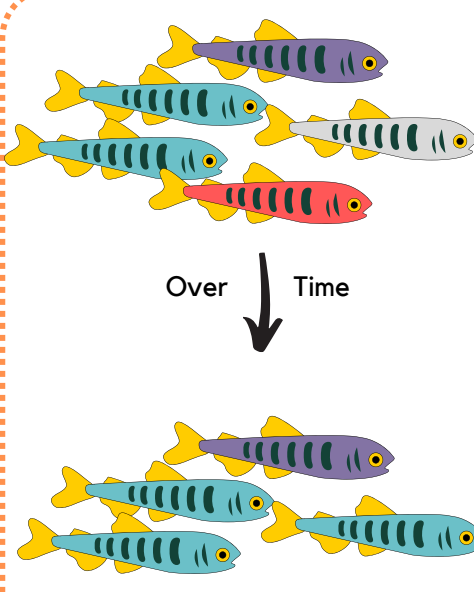


In small populations, like the one represented by 16 marbles, there are fewer alleles initially present, making it easier to lose some due to chance. On the other hand, in larger populations (e.g., +1000 marbles) there are more alleles to start with and we are less likely to lose a particular allele due to chance alone.

To better understand how genetic drift and other genetic processes play out in hatcheries and in the wild, we will explore two different scenarios.


SCENARIO 1: THERE IS A CRITICALLY SMALL SALMON POPULATION IN THE WILD. WHAT COULD HAPPEN FROM A GENETICS PERSPECTIVE IF WE USED A FISH HATCHERY TO REBUILD THE POPULATION?

WILD

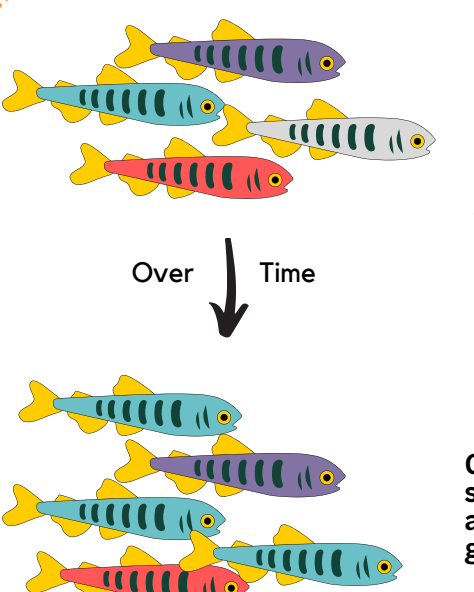


In small wild salmon populations, random chance plays a large role.

Genetic drift leads to genetic diversity loss.


 Genetic drift is the largest driver for genetic diversity loss because there are so few wild salmon.

HATCHERY



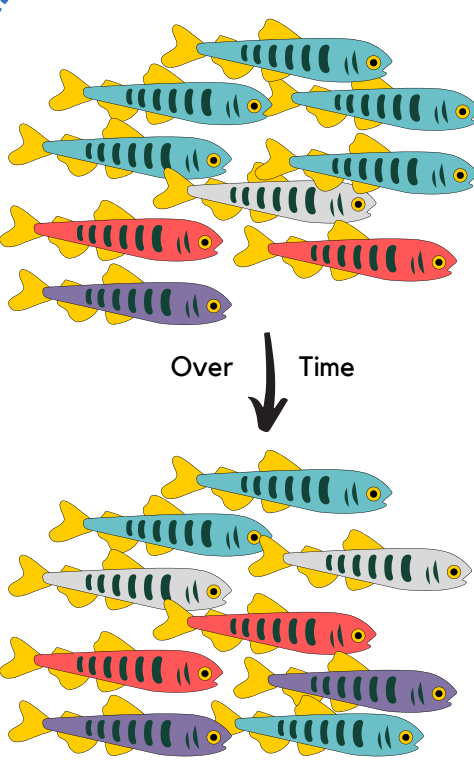
Hatchery enhancement can reduce the impact of random chance among spawners.

Genetic diversity safeguarded against loss from genetic drift.

 Because of human intervention hatchery salmon genetic diversity may exceed wild salmon genetic diversity.


SCENARIO 2: WILD SALMON POPULATIONS ARE STABLE. WHAT COULD HAPPEN FROM A GENETICS PERSPECTIVE IF WE USED A FISH HATCHERY?

WILD

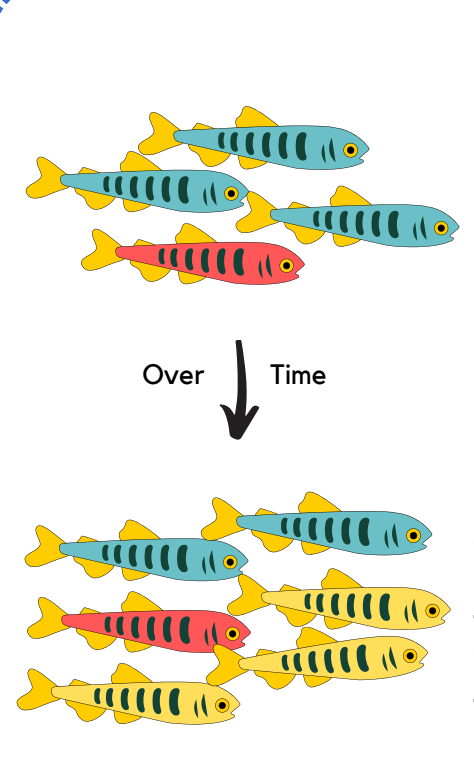


Stable wild salmon population with natural genetic diversity.

Natural evolution maintains diversity and the adaptive state of the population.


 Traits which improve salmon survival in the wild are maintained. Also, many fish = many spawning partners leading to increased genetic diversity.

HATCHERY



Genetic diversity underrepresented because few fish taken from large wild population.

Salmon adapt to hatchery conditions (yellow fish), but adaptations may not be helpful in the wild.

 When hatchery fish spawn with wild fish, they can dilute wild genetics with less favourable hatchery genetics. Traits which improve salmon survival in hatcheries are maintained.

DISCUSSION

Hatcheries can have mixed effects on salmon genetics. When salmon populations are critically low, hatcheries can help maintain genetic diversity until environmental conditions improve. However, when wild salmon are abundant, hatcheries can produce salmon which are less adapted to wild environments.

The influence of hatcheries on salmon conservation extends beyond genetics. Running a hatchery requires reliable electricity; access to a good, abundant, and reliable water source; and constant staff support. Poor management can lead to malfunctions, fish die offs, disease transmission to wild salmon, or displacement of wild fish. Despite these risks, a well-managed hatchery can help the recovery of vulnerable stocks, support rebuilding efforts, and support salmon during major climatic events or habitat loss.

Therefore, hatcheries represent a valuable tool for supporting declining salmon populations. Their application must be carefully weighed against other restoration options, such as habitat restoration work or fishing regulations, to maximize conservation success.



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