Defining What Constitutes a Wild Salmon[1]

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Abstract

In spite of considerable efforts to restore anadromous salmon in the Pacific Northwest, many runs remain at risk. Along with numerous other factors causing the decline, stocking from hatcheries over a century is often postulated to be a major cause. The listing of over two dozen distinct population segments of salmon under the U.S. Endangered Species Act and one run under the Canadian Species at Risk Act has catalyzed a reassessment of the efficacy of supplemental stocking in restoring (or even maintaining) naturally spawning salmon. Recent policies have generally tended to place greater emphasis on restoring runs of wild salmon rather than maintaining runs through stocking from hatchery production. Except at the most superficial level, there is little consensus about how to define wild. There is a continuum of definitions for wild and each definition subtly supports an implicit policy goal. Given that restoring wild salmon runs is the de facto public policy goal, the definition of "wild salmon" is important. Ultimately, the choice of definition is itself a policy decision that incorporates science as one of several influencing factors. A suite of options for defining what constitutes a wild salmon are available to policy-makers, although the definitions are often poorly articulated.

Introduction

Salmon populations in California, Oregon, Washington, Idaho, and southern British Columbia are much reduced from pre-1850 levels (Lichatowich 1999, Meengs and Lackey 2005). As of 2005, 26 distinct population segments of Pacific salmon and sea-run trout have been identified as endangered or threatened under the U.S. Endangered Species Act (ESA) and one under the Canadian Species at Risk Act (SARA) (Irvine et al. 2005). Further, Oregon, Washington, Idaho, and California state laws require conservation, protection, and restoration of state-listed salmon populations.

The debate about how to identify and protect "at-risk" salmon has been confounded by extensive releases of young salmon from numerous hatcheries for more than 125 years. From southern British Columbia southward, natural production was usually insufficient to sustain desired harvest levels. Construction of dams and loss of habitat further exacerbated salmon's inability to cope with high levels of fishing. As an alternative to reduced fishing, fisheries managers have made extensive use of artificial propagation.

The indirect or secondary economic benefits of sport and commercial fishing are considerable and there continues to be enduring public support for continued supplemental stocking. Commercial, sport, and tribal salmon fishing in California, Oregon, Washington, and Idaho remains largely dependent on artificial propagation. Thus, unlike any other ESA- or SARA-listed species, free-living salmon are regularly and legally harvested at relatively high levels. Further, fresh salmon in the retail market are also widely available year round and are relatively inexpensive due mainly to aquaculture production in Chile, Scotland, Norway, and Canada. The enforcement of ESA, SARA, and other environmental statutes relative to the status of wild salmon has, however, forced fisheries managers to reevaluate the role of salmon hatcheries or any type of artificial propagation to sustain or enhance runs.

For the past 150 years and especially since the 1991 listing of the first group of "at risk" salmon in the U.S. and in 2004 in Canada, the policy debate over salmon recovery has been befuddled with various conceptions or definitions of what is a wild salmon in contrast to a hatchery salmon. ESA and SARA are remarkably ambiguous about defining "recovery" and leave considerable discretion to the government agency designated to implement each act. Further, policy choices are usually offered as a legal or court-mandated bureaucratic process or set of administrative steps to follow. A clear biological end-point or goal is rarely articulated. The policy choices in salmon recovery are not simple dichotomies, but involve a nuanced view of both scientific information and societal values and preferences. Further complicating any discussion is the fact that some of the words used, although common, everyday words, are defined in confusing or misleading ways, or are not defined at all.

One of the most confusing terms used in the public dialog surrounding salmon policy is the word wild. “Wild” carries varying connotations, but which specific connotation is being used is often a reflection of an implied policy preference. The root of this confusion is grounded in the reality that biologists, policy makers, and lay citizens are rarely talking about the same thing when they use “wild.”

Nature of the Controversy

Assuming that the public policy goal is to restore self-sustaining, naturally spawning salmon populations (Irvine 2005), the widespread, long-term use of stocking from hatcheries to increase salmon runs in the Pacific Northwest has raised a number of well-known concerns (NRC 1996). Hatchery operations have evolved substantially since the late 1800s, but genetic and behavioral differences between natural and hatchery salmon raise a fundamental question: is current stocking from salmon hatcheries helping or hurting recovery of naturally spawned salmon stocks? Similarly, can stocking from hatcheries be used successfully to help rebuild naturally spawning populations in the future?

Opinions differ dramatically on whether hatcheries should continue to be used as part of our salmon recovery efforts. The Native Fish Society (U.S.), for example, is an advocacy group for the conservation, protection, and restoration of native fishes in the Pacific Northwest, and its policy position vehemently opposes the use of hatcheries to restore declining runs of salmon.

A very different policy preference is argued by the U.S. Pacific Fisheries Resource Conservation Council (PFRCC 2003), which noted that hatcheries:

> *“ . . . are widely supported institutions that have been intended to supplement natural production of salmon, replace production where wild stocks have declined, and serve as an educational tool to increase public awareness of fish and their significance.”*

A key scientific element of the debate is whether hatchery strays (artificially propagated salmon that do not return to their hatchery of origin, but spawn with the natural population in natural habitat) alter the genetic characteristics of naturally spawning populations, and whether such alterations have any ecological or policy significance.

Some scientists have hypothesized that hatchery-bred salmon that spawn naturally with non-hatchery-bred fish cause an overall reduction in fitness (defined as the ability of a salmon to produce offspring that survive and reproduce) of native populations:

> *" . . . the declining productivity of both hatchery and wild populations is attributable, at least in part, to destruction of adaptive gene pools that has occurred already through processes other than the overfishing and habitat loss envisioned by Congress when it designed the ESA's listing mechanism."*
> (Goodman 1990)

Others, however, conclude that processes of natural selection, or management strategies, could (given enough time without the influence of hatchery fish) prevent hatchery genes from permanently affecting the population. Nickelson (2003) found that hatchery strays in 14 populations of coho from the Columbia River to Cape Blanco, Oregon, did not affect the overall productivity of the natural coho populations. It was noted that the differences in spawning timing between the hatchery and the naturally spawning coho may have reduced genetic overlap in some populations.

Although the long-term effect of hatchery strays on naturally spawning populations remains uncertain, evidence of breeding between naturally spawned salmon and hatchery strays is not. The Oregon Department of Fish and Wildlife estimated that hatchery strays represented 33% of the spawning population of coho on the Oregon Coast in 1990, but since 1990, this percentage steadily declined to 1.8% by 2004 (ODFW 2005).

The addition of millions of hatchery fish annually into streams containing many fewer naturally spawned salmon may cause effects such as increased predation due to the abnormally high concentrations of fish, intense competition for food, spread of disease between hatchery and naturally spawned salmon, and "mixed stock" fishing that kills the less abundant (and perhaps ESA or SARA listed) naturally spawned salmon along with the hatchery-produced salmon.

Although there is persistent criticism based on scientific concern, stocking programs have maintained public and political support because of its ability to sustain large salmon runs that support commercial, sport, and tribal fishing. Without stocking, salmon fishing in the Pacific Northwest and California would decrease substantially.

Biological Differences

There are many assertions about the biological differences between hatchery and naturally spawned salmon. To some it is an article of faith that hatchery fish are less fit (referring to their ability to survive and reproduce) than wild fish and therefore the use of hatchery-bred salmon is inappropriate. To some, it may seem intuitive that hatchery salmon must be less fit because they were spawned in captivity and some studies support this. Other studies, however, report that the fecundity of adult hatchery salmon is equal to that of naturally spawned adult salmon, indicating that hatchery salmon fitness may not be different at least with respect to reproductive ability (Lannan 2002; Nickelson 2003). The only uncontested difference between hatchery and naturally spawned salmon is that hatchery salmon are artificially spawned in a hatchery while naturally spawning salmon reproduce without direct human intervention.

There is confusion between problems caused by artificial propagation and problems caused by specific, undesired management practices (Brannon et al. 2004). Asynchronous spawning timing is a good example. A hatchery fish returning to spawn earlier than the natural population is usually the result of a choice made by hatchery managers to select early returning fish as their brood stock. Over time, as is the case for Washougal River (Washington) hatchery fish, early selection of brood stock can change spawning timing by as much as three months (Brannon et al. 2004). Early selection was a choice based on the salmon management priorities in place to support a particular management goal. Managers could have selected brood stock to maintain synchronous run timing with the naturally spawning population. Such examples are often inappropriately cited as evidence that early spawning problems were caused by poor adaptability and genetic inferiority of hatchery fish. According to Brannon et al. (2004), there is general agreement that the indiscriminant use of hatchery fish has contributed to the decline of native fish in the Pacific Northwest, but there is no evidence that such decreases were the result of artificial propagation. For that reason it is important to differentiate between the effect of management decisions involving the use of cultured fish, and the effect of artificially propagated fish on the corresponding natural population.

Laboratory studies to compare the fitness of wild and hatchery salmon have proven inconclusive because results are difficult to relate to natural populations where so many other confounding factors affect salmon survival and reproduction. In addition, field studies have often used non-native hatchery stocks when comparing hatchery with naturally spawning fish (Reisenbichler et al. 2004). Instances of both laboratory and field studies have shown conflicting results concerning the differences in fitness between hatchery and naturally spawning salmon (Brannon et al. 2004).

In our view, the primary driving force behind this debate has less to do with science than personal values, competing economic interests and policy preferences. If hatchery managers could produce salmon that were identical in every way to naturally spawned salmon, and if salmon runs could be sustained in perpetuity using artificial propagation, there probably would still be opposition to the use of hatcheries to supplement runs. Conversely, if biologists were able to prove convincingly that hatchery operations alter the natural stocks, it is likely there still would be many who support supplemental stocking to maintain large, fishable runs.

Science vs. Values

Using a value-laden term like wild to describe a controversial concept can exacerbate policy controversy and ambiguity. In the 1800s, wild carried a negative connotation. Wild was used to describe things that were unknown, dangerous, or that needed to be controlled or conquered. By the 1960s, evolving societal priorities (at least in North America) transformed wild into a word with more positive connotations such as pristine, untouched, beautiful, and desirable. Earlier connotations however, had not been lost entirely. Wild has since evolved into a term whose connotation depends on the worldview of the user and the listener. As a value-driven term rather than a scientifically derived one, wild may carry either a negative or a positive connotation. Still, the answer to the question, "what is a wild salmon?" is critical to the restoration and sustainability of salmon in the Pacific Northwest and California. In policy and science debates, the term wild is rarely precisely defined.

It is not uncommon for scientific reports and assessments to implicitly support particular definitions of wild for policy purposes. Unbiased, either in reality or perception, comparative analysis of biological information about naturally-spawned and hatchery-spawned salmon is sparse. However, a wealth of anti- and pro-hatchery salmon literature appears in the media and even scientific publications.

Policy advocacy masquerading as science is not surprising. Interest groups and policy advocates tend to express their beliefs about the role of hatcheries and thus often present only one side of the relevant scientific information. Pro-hatchery and anti-hatchery interest groups have created a “dueling science” policy dialog with each side attempting to overwhelm policy-makers and the public with biased information.

In our opinion, the debate over what is wild does not swing on the balance of genetics or ecology (although such information is one element of the debate), but on societal preferences. The goal for salmon recovery is ultimately dictated by the whole of society rather than the more vocal, energetic, or powerful advocates, whether the advocates be fisheries biologists or agriculturists. Science's role in establishing this goal is theoretically to state the relevant facts and assess to the extent feasible the viability of each policy goal (Lackey et al 2006).

At some level, most people in the Pacific Northwest would like to see salmon thrive through the next century, but at what cost? Would those passionate about the conservation of natural salmon populations may be willing to accept a relatively large change to their lifestyles for the benefit of salmon populations? Others may not consider salmon a high priority given the competing demands on public resources by education, health care, national defense, roads, etc. The crux of developing salmon policy is that policy-makers must consider more than science or narrow policy goals. As with all ecological policy, salmon policy must be a balance of competing priorities that reflect society's values and goals within the range of what is ecologically possible.

As in most policy issues, most of the debate takes place between those who have the most at stake, a situation that may explain why so few efforts have been made to seriously alter (much less actually eliminate) hatchery operations. There are those who are apprehensive about changing hatchery practices in ways that reduce run sizes, and those who would like to see hatchery operations stopped altogether. It is not the hatcheries themselves that are the issue, but how they are used to implement a specific salmon policy.

Salmon Continuum

Assuming that maintaining runs of wild salmon is the desired public policy objective, a variety of advocacy groups aggressively push to have their notion of “wild” adopted. At one extreme, wild is purely a question of heredity: was the salmon spawned in the wild from adults who were also spawned naturally? At the other extreme, those whose main concern is the availability of salmon for harvest by sport or commercial fishing may prefer to define wild as any free-living salmon. In the latter view, a salmon released from a hatchery and living unconfined by cages or pens would be wild. There are many intermediate definitions as well (Figure 1).

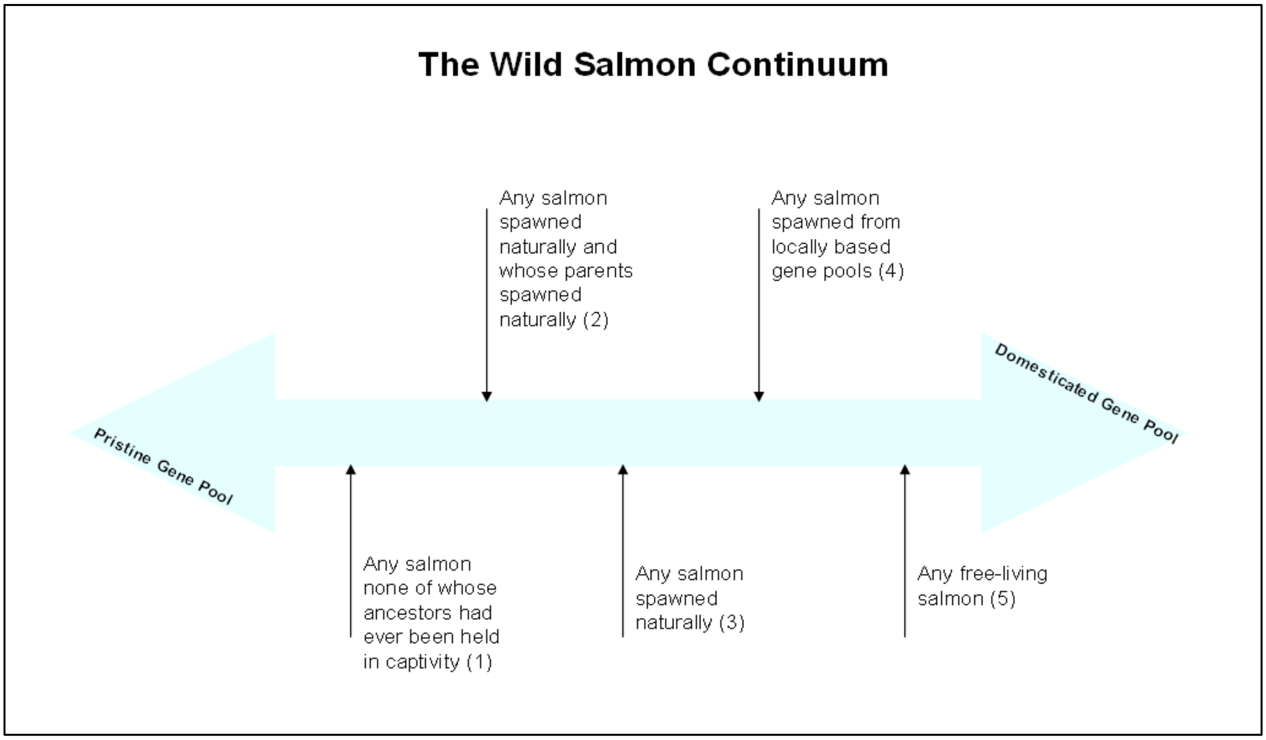


Figure 1. The continuum of definitions of "wild" correlated with the continuum of possible policy objectives.

The argument about an explicit definition of wild is not a debate over semantic nuances, it has profound policy implications. Applying either the genetic or the free-living definitions would mean that salmon recovery strategies would differ greatly. The choice of definition and implicit recovery goal may vary depending on one's policy objective. A river used heavily for commercial fishing may be managed by implicitly defining wild as free-living. Such management practices would require hatchery supplementation of the naturally-produced salmon run or replacing the natural population so that fish yields could remain high in spite of habitat alteration. A different scenario involves managers of a stream running through a national park. They might opt for a more genetically sustainable management strategy since the purpose of the park's establishment may have been to preserve sustainable ecosystems. Any risk of genetic or behavioral effects from hatchery fish might not be acceptable.

Of the many potential definitions of wild, we propose 5 as being representative of the range of the continuum. They also tend to be the most often used by policy-makers, advocates, and scientists:

Any salmon, none of whose ancestors had ever been held in captivity. (Type 1)

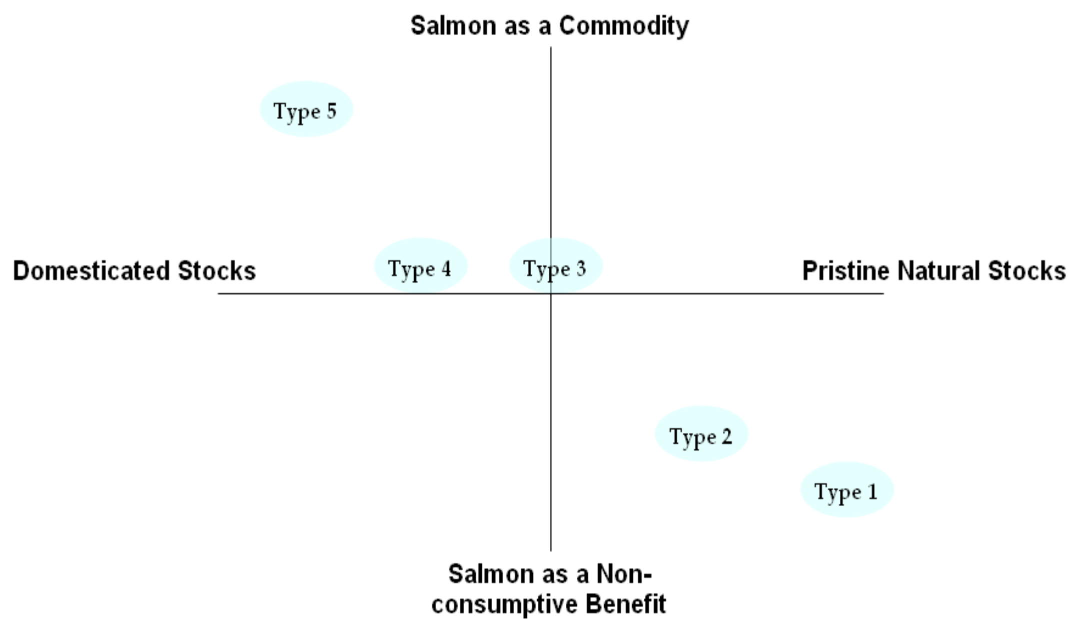
Any salmon spawned naturally and whose parents spawned naturally. (Type 2)

Any salmon spawned naturally. (Type 3)

Any salmon spawned from locally-based gene pools. (Type 4)

Any free-living salmon. (Type 5)

The first definition (Type 1) is at the most restrictive extreme of the continuum (Figure 2). In this case, none of the salmon's previous generations have ever been reared in a hatchery. For populations that have been supplemented by hatcheries for over a century, whether or not there are any salmon in California, Oregon, Washington, or Idaho that could be classified this way is problematic.



Type 1: Any salmon none of whose ancestors had ever been held in captivity

Type 2: Any salmon spawned naturally and whose parents spawned naturally

Type 3: Any salmon spawned naturally

Type 4: Any salmon spawned from locally based gene pools

Type 5: Any free-living salmon

Figure 2. Wild types 1 through 5 and their approximate position within the range of potential policy objectives.

The second definition (Type 2) would include second generation naturally spawned salmon. Many fisheries management agencies tend to use this definition.

The third definition (Type 3) appears to be a common way of defining wild among the interested public. This notion of wild does not include hatchery fish that have recently been released as juveniles (through supplementation or augmentation programs), but it does include the offspring of strays that will hatch and rear naturally as the first generation hatchery and wild crossed salmon.

The fourth definition (Type 4) includes salmon spawned from locally based gene pools. Most population segments of salmon, even though they are of the same species, represent distinctly different genetic pools of variation and have characteristics specific to the habitat of a particular environment. Some would argue that as long as the spawning adults are from the same local population, their free-living offspring should be considered wild. Thus, the type 4 definition includes hatchery-derived salmon when the brood-stock is obtained from the resident population.

The fifth definition (Type 5) is the least constraining. Any salmon, regardless of genetic stock or where and how it was raised, once in the water and unconstrained by human barriers, is wild. Released hatchery and escaped aquacultural pen-raised salmon would be classified as Type 5 fish. Using this definition, all free-living salmon would be included in an analysis of population size or recovery options.

An implicit assumption underlying the continuum concept of wild is the degree that the genetic pool is altered by introducing artificially propagated fish. When considering pre-1850s gene pools (prior to any additions from hatcheries), though difficult to prove scientifically, many assume that as the percentage of the run supported by hatchery releases increases, the gene pool will be increasingly altered (Figure 3).

An option for policy-makers who wish to move away from the use of the traditional, bimodal concept of wild is to organize salmon with different lineages into categories (Types 1 through 5). From these clearly defined categories, policy-makers can select the types that are appropriate for specific management goals and adjust hatchery practices and regulations accordingly (Figure 2). By categorizing salmon by types along a continuum, it is no longer necessary to provide a new definition for wild each time it is used, reducing further the confusion caused by using controversial and semantically nuanced terms such as wild.

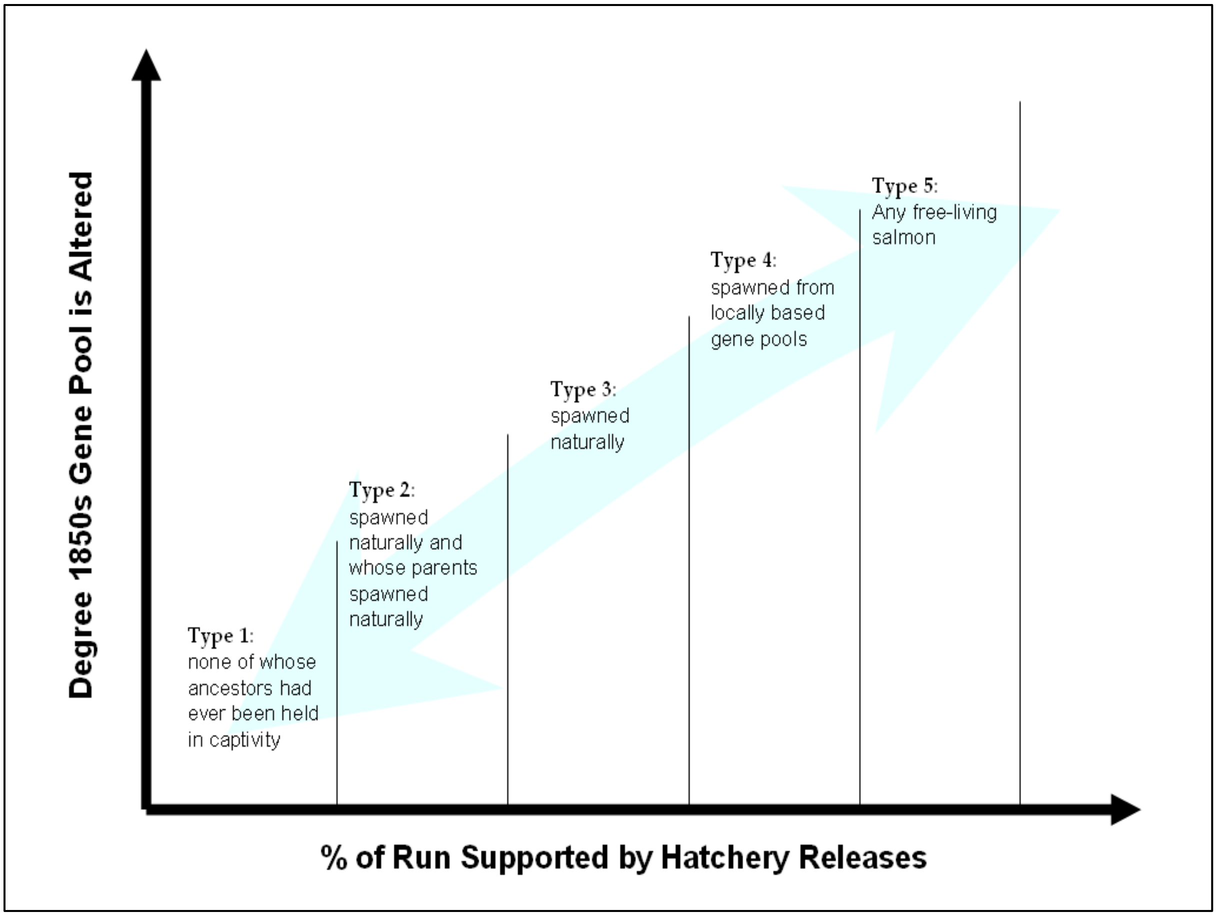


Figure 3. Hypothesized effects of supplementation on pre-1850s gene pools along the "wild" salmon continuum.

Conclusion

In spite of considerable efforts to restore natural runs of anadromous salmonids in the Pacific Northwest and California, over the long-term, they remain at risk. Recent policies have placed a much greater emphasis on restoring runs of wild salmon rather than maintaining runs through stocking from hatchery production. Except at the most superficial level, there is little consensus about how to define wild. There are a number of competing definitions each lending support for an implicit policy goal.

The choices of definitions and management goals are policy decisions that incorporate science as one of several factors. The continuum of definitions we propose correlates with a continuum of potential and plausible policy goals. By clearly and explicitly defining wild as steps along a continuum, the debate over salmon management goals can more readily focus on the competing societal values and preferences that are at the core of the policy and management choices.

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