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Genetic and ecological interactions have been at the center of the debate over benefits and risks of hatchery programs (e.g., NRC 1995; HSRG 2004). The two options for managing these risks are either to minimize interaction through segregation (isolation) of the hatchery population from the natural population or to manage the hatchery population as an integral, benign component of a composite hatchery-natural population. All salmon and steelhead hatchery programs must be classified either as integrated or segregated by intent. These classifications lead directly to a series of genetic and ecological management guidelines for each of the two types of programs. How well programs meet this intent will vary; this variation provides an important measure for evaluating the biological risks posed by hatchery programs on natural populations.

The purpose of this paper is to provide a definition of a segregated hatchery program, describe operational guidelines for implementation, and identify some of the implications and constraints imposed by the guidelines.

Definition of a Segregated Hatchery Program

The terms integrated and segregated describe the intended reproductive relationship of hatchery populations to naturally spawning populations.

Formal Definition: *A hatchery program is a **Segregated Type** if the intent is for the hatchery population to represent a distinct population that is reproductively isolated from naturally-spawning populations.*

Theoretical Premise for Segregated Programs

Hatchery programs are classified as segregated if the hatchery population is propagated as a genetically discrete or segregated population relative to naturally spawning populations. The principal intent of a segregated program is to create a new, hatchery-adapted population to meet goals for harvest or other purposes (research, education, etc.). Hatchery broodstocks (and programs) are considered genetically segregated if the broodstock is maintained primarily or exclusively from adults returning back to the hatchery. As a consequence, little or no gene flow from a natural population to the hatchery broodstock is intended to occur in a segregated program.

Natural spawning of fish from segregated programs may pose genetic and ecological risks to natural-spawning populations. The risks that segregated hatchery programs pose to natural populations depend on the status and goals for the natural populations, the extent to which hatchery-origin fish interact genetically and ecologically with natural-origin fish, and on the amount of genetic and phenotypic divergence between the hatchery and natural populations.

Operating Guidelines for Segregated Programs

1. Each hatchery program should include a detailed genetic management plan for broodstock that outlines protocols, etc.
2. Rear fish in a manner and/or at a location that minimizes potential straying and opportunities for natural spawning.
3. Release fish in areas where opportunities to capture non-harvested adults are maximized, thus minimizing genetic risks to natural populations.
4. Ensure adult production from segregated programs is commensurate with harvest opportunities.
5. Take into consideration the potential selective impacts of harvest (for example, size selectivity) on the long-term viability of segregated programs.
6. Ensure hatchery-origin adults constitute no more than five percent of the naturally-spawning population.
7. Use marks, tags or other methods to distinguish natural- and hatchery-origin fish among natural spawners, in hatchery broodstocks and in harvests.
8. Avoid unintentional inclusion of natural-origin adults in segregated broodstocks.
9. Minimize the effects of predation and competition on naturally-spawning stocks when designing hatchery programs.

Operational Considerations for Segregated Hatchery Programs

Segregated programs, particularly those with only harvest goals, typically have few operational constraints. Segregated hatchery broodstocks may be bred selectively for particular traits (e.g., early run-timing), to facilitate ease of culture and/or to help achieve desired benefits (e.g., harvest). In general, segregated programs are managed in a way that maximizes productivity (i.e., recruits per spawner) or efficiency, irrespective of the ability of returning adults to reproduce naturally or confer any benefits to naturally spawning populations. Indeed, hatchery-origin fish from a genetically segregated program can impose unacceptable genetic and ecological risks to natural populations (Busack and Currens 1995). As a result, segregated programs often represent major trade-offs between minimizing biological risks to naturally spawning populations and maximizing efficiency and harvest benefits of the hatchery program.

Many segregated hatchery programs in Puget Sound and coastal Washington have selectively bred adults, either purposefully or inadvertently, for "early" spawn or run timing, primarily by excluding late-returning adults from broodstocks. Many hatchery stocks of salmon and steelhead now return and spawn several weeks earlier than their natural-origin counterparts. Differences in return timing between natural- and hatchery-origin adults can be used as a management tool to focus fisheries on early-returning hatchery fish, while protecting late-returning natural fish. This approach can facilitate fisheries management from an agency perspective.

Segregated programs can impose significant genetic risks to naturally spawning populations if non-harvested fish spawn naturally. Indeed, any natural spawning by fish from these broodstocks may be considered unacceptable, because of the potential genetic impacts on natural populations. Proponents of such "segregated" programs often argue that early-returning hatchery fish are mis-timed biologically to stream flows and water temperatures and, thus, fail to reproduce successfully even if they do spawn in nature. However, empirical and experimental evidence indicates that such early-returning hatchery fish do indeed reproduce successfully, albeit at a reduced rate relative to natural-origin fish (Chilcote et al. 1986; Campton et al. 1991; Mackey et al. 2001). Although these hatchery-origin fish have a lower reproductive success relative to their natural-origin counterparts, their overall genetic and ecological risks can be substantial if hatchery-origin fish constitute a significant number of natural-origin spawners (Chilcote et al. 1986; Leider et al. 1990; Kostow et al., 2003).

Clearly, the degree to which segregated hatchery programs are successful depends significantly on the degree to which genetic and ecological risks to natural populations can be minimized. Many segregated hatchery broodstocks also represent the genetic products of historical stock transfers among facilities or regions, thus further compounding the genetic and ecological risks that those programs may impose on naturally spawning populations. To minimize these risks, segregated hatchery programs need to be located in areas where virtually all returning adults can be harvested or recaptured, or where natural spawning or ecological interactions with natural-origin fish are considered minimal or inconsequential. Outplanting fish from segregated programs where effective adult recapture does not exist should be discontinued (see HSRG emerging issue paper on this topic).

Implementing a Segregated Hatchery Program:

Scenario 1: New Segregated Program
No hatchery program exists
Status of natural population in terms of past hatchery influence is not important

- Initiate the program with enough fish to provide a minimum effective population size of 500 fish.
- Identify HORs and NORs; avoid unintentional inclusion of NORs in the broodstock
- Operate the program so that it does not create significant genetic or ecological interactions with natural populations (e.g., proper sizing, selective removal to limit strays, adult collection facilities or weir, long-term acclimation at point of release, other measures to control straying)..
- Ensure that the contribution of hatchery-origin fish spawning naturally does not exceed five percent of the natural spawning population.

Scenario 2: Transition from a incompletely segregated or integrated program to a properly segregated program (Most common scenario for both **incompletely** segregated and **incompletely** integrated programs)
Hatchery broodstock has had no systematic gene flow from the natural population
Natural spawning population has had significant influence from hatchery fish

- Identify HORs and NORs; avoid unintentional inclusion of NORs in the broodstock.
- Operate the program so that it does not create significant genetic or ecological interactions with natural populations (e.g., proper sizing, selective removal to limit strays, adult collection facilities or weir, long-term acclimation at point of release, other measures to control straying)..
- Ensure that the contribution of hatchery-origin fish spawning naturally does not exceed five percent of the natural spawning population.

Scenario 3: Transition from a well integrated program to a segregated program
Hatchery broodstock has had systematic gene flow from the natural population
Gene flow from the natural population to the hatchery population has been greater than gene flow from the hatchery to the natural population

- Identify HORs and NORs; avoid unintentional inclusion of NORs in the broodstock.
- Operate the program so that it does not create significant genetic or ecological interactions with natural populations (e.g., proper sizing, selective removal to limit strays, adult collection facilities or weir, long-term acclimation at point of release, other measures to control straying)..
- Ensure that the contribution of hatchery-origin fish spawning naturally does not exceed five percent of the natural spawning population

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