White Paper No. 7[1]

Outplanting and Net Pen Release of Hatchery-Origin Fish

1 Introduction

In general, most salmon and steelhead (*Oncorhynchus* spp) hatcheries in the Columbia River Basin and the Pacific Northwest operate in a similar manner: upstream-migrating adults are trapped for broodstock and spawned when they reach sexual maturity. The fertilized eggs are incubated and hatched and the resulting progeny are reared to the smolt stage prior to release from the facility into a freshwater stream. Age at smoltification varies among species of Pacific salmon and steelhead, ranging from a few weeks after yolk absorption for pink and chum salmon (*O. gorbuscha* and *O. keta*, respectively) to approximately 15–20 months post-fertilization for steelhead (*O. mykiss*), coho salmon (*O. kisutch*), and spring Chinook salmon (*O. tshawytscha*).

The standard method of hatchery propagation is to release juvenile fish into stream areas where returning adults can be recaptured for broodstock. The homing and recapture of returning adults may be maximized if smolt releases occur where adults are trapped for broodstock and where the progeny fish are reared, e.g., at a hatchery. Fish that do not return to a hatchery or release site are commonly called "strays". Recapture and removal of unharvested, hatchery-origin adults at a hatchery (or other release site) reduces the potential for genetic and ecological risks to naturally spawning populations.

However, smolts are often released at sites where adult collection facilities do not exist, but where managers desire fisheries on returning adults to occur. In many situations, smolts are transported by hatchery truck—oftentimes into other watersheds and sometimes over relatively large distances, e.g., more than 100 km—prior to release. In general, adult salmon and steelhead transported to other watersheds return to areas where they were released as smolts. The stray rate for these fish is higher than for those released "on-station" (Quinn 1993).

Releasing smolts into streams geographically removed from a hatchery or adult collection facility is commonly called "outplanting." Steelhead programs in the Pacific Northwest have often used outplanting to support recreational fisheries in a large number of small streams or release locations where adult collection facilities do not exist. The often-stated rationale for such outplanting is to "spread out" the fishing effort of recreational fishers or to respond to specific requests by anglers. More recently, freshwater and saltwater "net pens" have increasingly been used to acclimate and release salmon smolts in areas where a targeted fishery on returning adults is desired. Significant harvests on returning adult fish can then occur in freshwater and marine areas in the general vicinity of the net pens.

[1] White papers were prepared by the HSRG to address topics relevant to hatchery reform. They are intended to stimulate discussion and provide background, documentation and explanations not included in the body of the HSRG's report.

A common feature of outplanting and net pen programs is the release of smolts into areas where no facilities exist to trap returning adults that escape target fisheries. In these situations, non-harvested adults may spawn in streams far-removed from the source hatchery or geographic location where their parents were trapped for broodstock.

Outplanting juvenile and/or adult salmonids also occurs in reintroduction and recovery programs where natural spawning by hatchery-origin adults is explicitly desired. These programs, however, are specifically designed to restore extirpated or imperiled natural populations and are generally not intended to support harvest.

Outplanting and net pen releases can pose significant genetic and ecological risks to natural populations by promoting high stray rates to freshwater areas where interbreeding and competition with naturally spawning populations are undesirable. Among the problems associated with outplanting are delayed downstream migration for smolts, potentially high genetic divergence between hatchery and natural populations, and reduced homing instinct in hatchery fish.

2 Findings and Discussion

Homing to natal streams is an important biological characteristic of salmonid fishes, allowing evolution of local adaptations in life history and other fitness traits (Quinn 1993; Altukhov and Salmenkova 1994; Kinnison et al. 2001; Quinn, Kinnison, and Unwin 2001). Homing precision to a particular stream appears to be under very strong response to stream-specific olfactory cues. Stock-specific, and thus stream-specific, genetically-based adaptations include age and size at sexual maturity, within-season return and spawn timing of adult fish in response to geographic location and water temperatures of the home stream, pre-hatch developmental rates, length of freshwater residence prior to outmigration, and marine migration patterns (Smoker, Garrett, and Stekoll 1998). Despite the biological importance of homing, natural straying of anadromous salmonid fishes plays an important role related to colonization of new habitats and maintaining connectivity between geographically adjacent populations (Shapovalov and Taft 1954; Milner 1997; Quinn 1997).

Many studies have shown that salmon and steelhead seek alternative spawning habitats if no appropriate habitat is immediately available (Pasqual and Quinn 1994). Such behavior is most apparent when natal streams are blocked by catastrophic environmental events. For example, siltation resulting from the 1980 eruption of Mount St. Helens resulted in significant numbers of Chinook salmon and steelhead straying from the Cowlitz River to the Kalama and Lewis rivers (Leider 1989; Quinn, Nemeth, and McIsaac 1991).

Physiological and behavioral studies indicate that environmental cues used by salmon for homing are acquired throughout freshwater life stages, but are particularly sensitive during the smoltification and outmigration period (Brannon 1972; Dittman, Quinn, and Nevitt 1996; Quinn, Stewart, and Boatright 2006). These observations indicate that salmon transported away from their incubation and nursery freshwater environments will have reduced homing fidelity as adults.

Tagging and genetic studies have shown that outplanting and net pen programs promote stray rates that far exceed natural levels (Candy and Beacham 2000; Mackey, McLean, and Quinn 2001). The absence of freshwater imprinting by fish released from saltwater net pens can lead to unpredictable straying by large numbers of unharvested adults to streams where natural spawning is not desired. Similarly, significant numbers of adults

returning to outplanted streams typically escape targeted fisheries and most likely spawn with natural-origin fish in non-target streams.

Outplanted smolts often have delayed downstream migration rates compared to fish released on-station from their culture facilities. This can result in the increased probability of ecological interactions with wild fish (Hawkins and Tipping 1999; Pearsons and Fritts 1999). For example, in separate studies, mean downstream migration rates of outplanted steelhead smolts were 2.9 km/day (Tipping and Byrne 1996) and 1.6 km/day (Tipping et al. 1995), respectively, whereas mean downstream migration rates for smolts released on-station were 33 km/day (Dawley, Sims, and Ledgerwood 1978; Harza 1999).

Outplanting and net pen releases from segregated hatchery programs can be especially problematic because of the potentially high level of genetic divergence between the hatchery stock and natural populations where straying and natural spawning may occur. Although the natural spawning success of hatchery-origin fish is generally less than that of natural-origin fish when they occur in the same stream, those same data indicate that significant numbers of hatchery-origin fish – even those from non-native or long-standing "domesticated" populations - do indeed spawn successfully and can contribute significant numbers of progeny to naturally spawning populations (Chilcote, Leider, and Loch 1986; Campton et al. 1991; Mackey, McLean, and Quinn 2001; Kostow, Marshall, and Phelps 2003; McLean, Bentzen, and Quinn 2003; Araki et al. 2007). Kostow, Marshall, and Phelps (2003) presented data supporting a conclusion that hatchery summer steelhead adults and their offspring may have contributed to wild winter steelhead population declines through competition for spawning and rearing habitats.

Many studies have further indicated a genetic component to homing (Bams 1976; McIsaac and Quinn 1988; Pasqual, Quinn, and Fuss 1995; Candy and Beacham 2000; Stewart, Smith, and Yougson 2002; Dukes et al. 2004), suggesting that native fish have higher genetic sensitivity to detect home stream odors than non-native fish reared and released under identical conditions. These characteristics could further compound the potential genetic risks associated with straying by increasing the stray rates among natural-origin progeny of stray hatchery-origin fish that reproduced successfully in nature.

Based on the scientific information available, the HSRG has concluded that outplanting and net pen releases of hatchery-origin salmon and steelhead smolts pose significant genetic and ecological risks to naturally spawning populations. The simplest way to reduce these risks is to reduce the number and/or size of existing outplanting and net-pen release programs.

However, it is recognized that many of net-pen and outplanting programs support important tribal, commercial and/or recreational fisheries. As a result, significant trade-offs may be needed between the fishery benefits of such programs and the risks they pose to naturally spawning populations. Comprehensive assessments of the benefits and risks of each program, on a case-by-case basis, are necessary to understand the potential trade-offs and make informed decisions.

3 Recommendations

The HSRG has formulated guidelines in an effort to reduce the biological risks of outplanting and saltwater net pen programs. The guidelines encompass program implementation as well as program management and monitoring and evaluation. It is the

HSRG's belief that these guidelines and recommendations should be implemented as soon as possible to reduce the biological risks of outplanting and net pen programs.

- Mark all net pen-released and outplanted fish each year and tag a statistically significant proportion of released fish with coded-wire tags.
- This will allow assessment of the direct contribution of those fish to targeted fisheries and assessment of stray rates and biological risks to natural populations. Systematically tagging a portion of the released fish each year, coupled with marking all outplanted and net pen-released fish, will allow fishery co-managers to assess the degree to which these programs minimize risks to natural populations while meeting harvest goals.
- Conduct intensive harvest of hatchery-origin fish and/or use adult traps to reduce potential natural spawning of unharvested, hatchery-origin fish.
- Restrict releases of hatchery-origin fish to areas where adult collection facilities exist or can be easily developed. In some cases, adult traps can be added to existing smolt release ponds. In other cases, release sites can be restricted to streams with existing adult collection facilities.
- Use locally-adapted and genetically integrated hatchery populations for net pen releases and outplanting wherever possible.
- In other words, minimize or eliminate the use of "out-of-region" populations and fish from genetically segregated hatchery populations in regions supporting natural populations. Fish released for harvest programs should be obtained from genetically integrated hatchery populations and/or populations native to the region or watershed where net pen or outplanting programs occur. One possible exception would be hatchery populations that have been selectively bred, or otherwise genetically or phenotypically manipulated to obtain certain reproductive traits, such as spawn timing, that result in low probabilities of successful natural reproduction in the specific streams or geographic area where smolts are released.
- Monitor and evaluate high-risk hatchery programs annually to ensure that adverse effects to wild populations are minimal, that straying risks are appropriately managed, and that off-station releases are appropriately located so that non-harvested, hatchery-origin adults do not spawn in undesirable locations.
- Develop area-wide risk management guidelines and protocols for outplanting and net pen programs.
- Evaluate fishery benefits and biological risks of each outplanting and net pen program annually or not less than every three years. Programs imposing significant risks relative to benefits should be reduced in size or terminated.

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