Hatchery Scientific Review Group
Pacific Salmon Hatchery Reform

To: The Columbia River Hatchery Reform Steering Committee
From: The Hatchery Scientific Review Group
Subject: Preview of Key Findings for Lower Columbia River Steelhead Hatchery Programs
Date: March 10, 2008

The Congressionally-established Hatchery Scientific Review Group (HSRG) has provided a foundation for hatchery reform principles that should aid salmon hatcheries in the Pacific Northwest in meeting conservation and sustainable harvest goals in the 21st century. The HSRG process has established principles based on goal setting, scientific defensibility, and adaptive management of hatchery programs. Tools to determine outcomes of proposed actions were developed and include a scientific framework for artificial propagation of salmon and steelhead, a benefit/risk assessment tool, hatchery operational guidelines, and monitoring and evaluation criteria. This report represents preliminary findings for lower Columbia River steelhead populations. Final recommendations will be published once the HSRG has completed its review of all Columbia Basin regions.

In order for steelhead hatcheries to contribute to harvest on a sustainable basis, they must be operated in a manner that is compatible with conservation goals at the local and regional levels. This means that they must be managed consistent with basic biological principles and viewed as integral components of the ecosystems they affect.

Hatchery programs need to be genetically managed either as segregated from or integrated with natural populations[1]. The HSRG has developed guidelines for minimal conditions that must be met for each type of program as a function of the biological significance of the natural populations they affect. For Primary populations the proportion of effective hatchery-origin spawners (pHOS) should be less than 5% of the naturally spawning population, unless the hatchery population is integrated with the natural population. For integrated populations the proportion of natural-origin adults in the broodstock should exceed pHOS by at least a factor of two, corresponding to a PNI (proportionate natural influence) value of 0.67 or greater. For Contributing populations, the corresponding guidelines are: pHOS less than 10% or PNI greater than 0.5 (Table 1). *It is important to note that these represent minimal conditions not targets*. For example, the potential for fitness loss when pHOS is 5% is significantly greater than it would be at 3%.

[1] A natural population is genetically segregated from all hatchery programs with which it is not specifically integrated.

Table 1. HSRG standards for broodstock management and abundance by designation. The abundance criteria for Primary populations are based on HSRG Technical Publication No. 3. Abundance standards for Contributing populations were defined as 50% of Primary values.

Criteria	Designation Status Met
PNI > 0.67, NOS > 500	**Primary**
pHOS < 5%, NOS > 500	**Primary**
PNI > 0.5, NOS > 250	**Contributing**
PHOS < 10%, NOS > 250	**Contributing**
Current conditions	Stabilizing

The HSRG analyzed a range of hatchery management options for the lower Columbia and upper Willamette steelhead Distinct Population Segments (DPS), and arrived at a proposed solution intended to address the manager's goals consistent with the HSRG guidelines for Primary and Contributing populations (Figure 1). In order to highlight the importance of the environmental context, two habitat scenarios were considered: current conditions and a hypothetical 10% habitat quality improvement. Under the HSRG broodstock solution, 12 of 21 of the natural populations reviewed met the guidelines for a Primary population, versus 6 for current hatchery programs (Table 2). When genetics guidelines are met population are afforded a better opportunity to adapt to local conditions, resulting in increased viability (Figures 2 and 3).

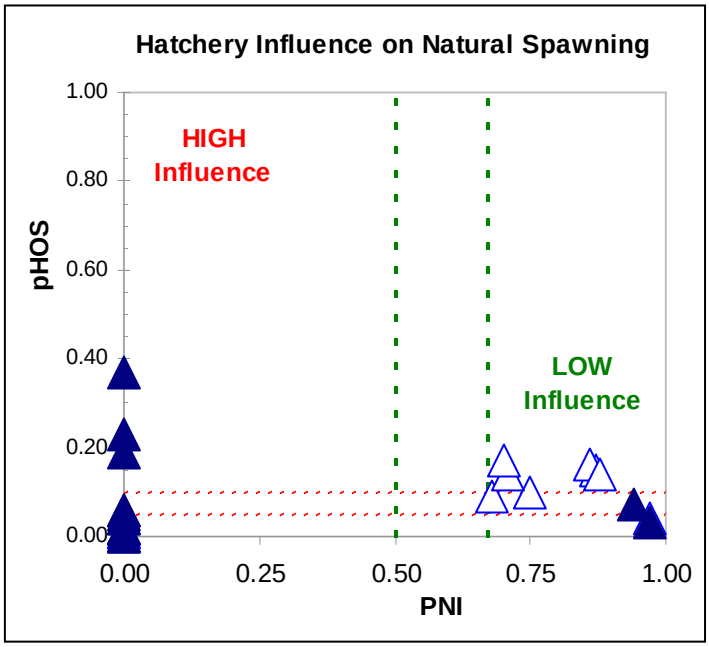


Figure 1. Relationship of the proportion of fish on the spawning grounds that are of hatchery-origin (pHOS) and the proportionate natural influence index (PNI) for Primary steelhead populations in the lower Columbia and upper Willamette DPS. Only populations designated as Primary by the managers are shown. Solid triangles represent values for current programs and open ones represent values for the HSRG solution.

Table 2. The effect of the HSRG hatchery solution and habitat improvement on population status. In this illustration, the HSRG standards for a Primary status are met when NOS is greater than 500 and either PNI is greater than 0.67, or pHOS is less than 5%. Standards for Contributing status are met when NOS is greater than 250 and either PNI is greater than 0.5 or pHOS is less than 10%.

Population	Population Designations	HSRG Standards met		
		Current	HSRG Solution	HSRG Solution + 10% Habitat Improvement
Coweeman Winter Steelhead	Primary	Contributing	Primary	Primary
Cowlitz-NF Toutle Winter Steelhead	Primary	Contributing	Primary	Primary
Cowlitz-SF Toutle Winter Steelhead	Primary	Primary	Primary	Primary
Kalama Summer Steelhead	Primary	Contributing	Primary	Primary
Kalama Winter Steelhead (Late)	Primary	Contributing	Contributing	Contributing
EF Lewis Summer Steelhead	Primary	Contributing	Primary	Primary
EF Lewis Winter Steelhead	Primary	Stabilizing	Contributing	Primary
Sandy Winter Steelhead	Primary	Primary	Primary	Primary
Washougal Summer Steelhead	Primary	Contributing	Contributing	Contributing
Molalla Winter Steelhead	Primary	Stabilizing	Primary	Primary
North Santiam Winter Steelhead	Primary	Stabilizing	Primary	Primary
South Santiam Winter Steelhead	Primary	Primary	Primary	Primary
Clackamas Winter Steelhead	Primary	Primary	Primary	Primary
Lower Cowlitz Winter Steelhead	Contributing	Stabilizing	Contributing	Contributing
Upper Cowlitz Winter Steelhead	Contributing	Primary	Primary	Primary
NF Lewis Winter Steelhead	Contributing	Stabilizing	Stabilizing	Stabilizing
Washougal Winter Steelhead	Contributing	Contributing	Contributing	Contributing
Calapooia Winter Steelhead	Contributing	Primary	Primary	Primary
NF Lewis Summer Steelhead	Stabilizing	Stabilizing	Stabilizing	Stabilizing
Salmon Creek Winter Steelhead	Stabilizing	Stabilizing	Stabilizing	Stabilizing
Willamette West Side Tribs Winter Steelhead	Stabilizing	Stabilizing	Stabilizing	Stabilizing

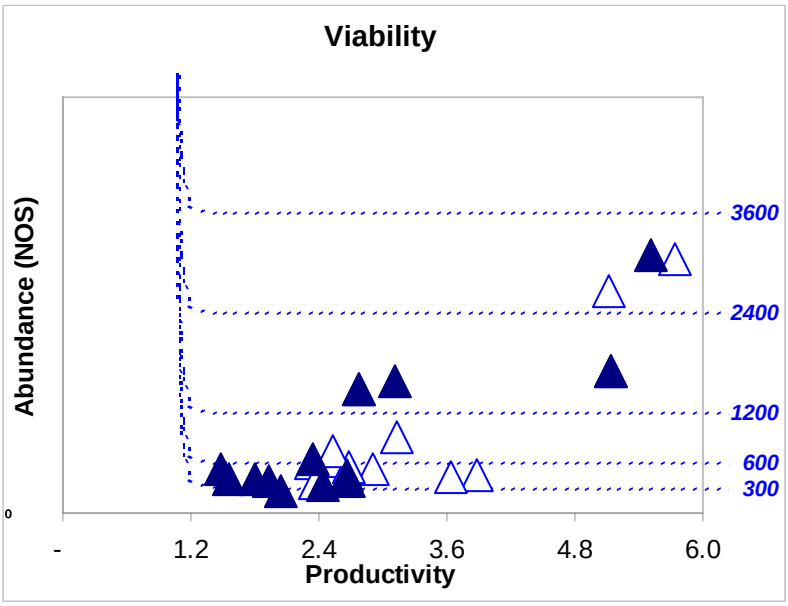


Figure 2. The average expected number of natural-origin spawners (NOS abundance) is plotted against population productivity. The productivity value represents the rate of population growth at low densities after fitness loss and harvest are accounted for. Solid triangles represent the current hatchery programs, the open triangles the HSRG solution.

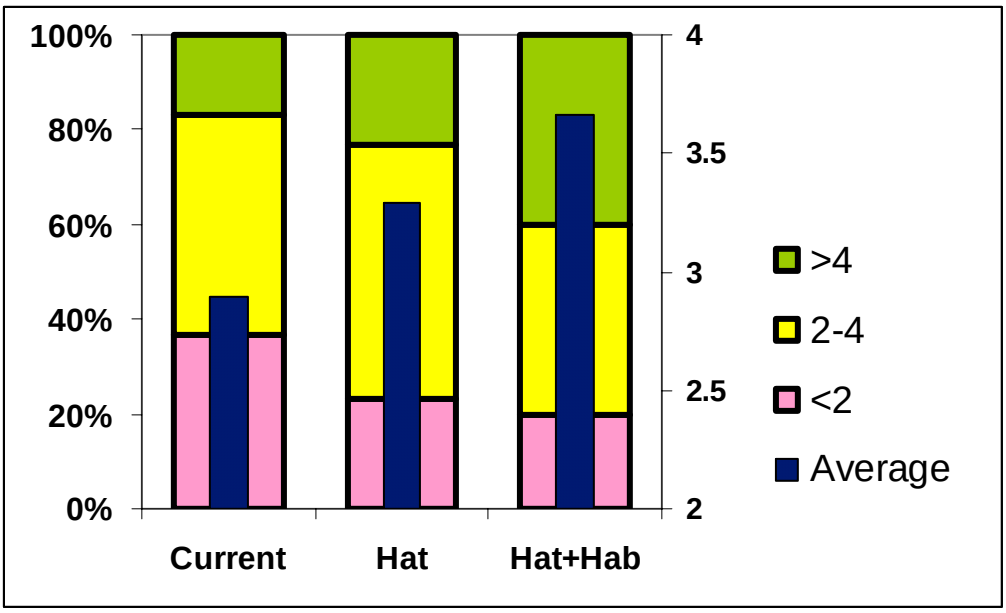
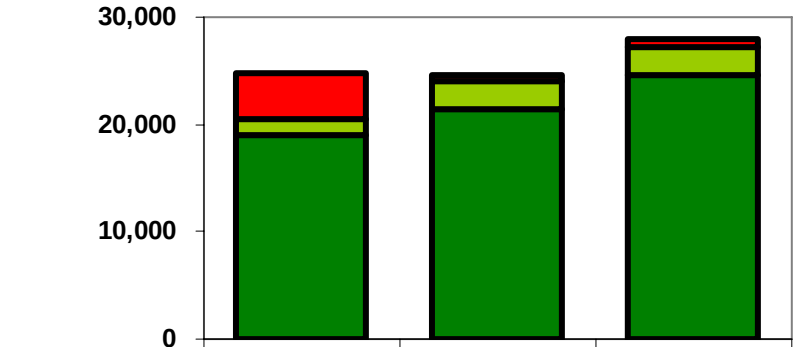


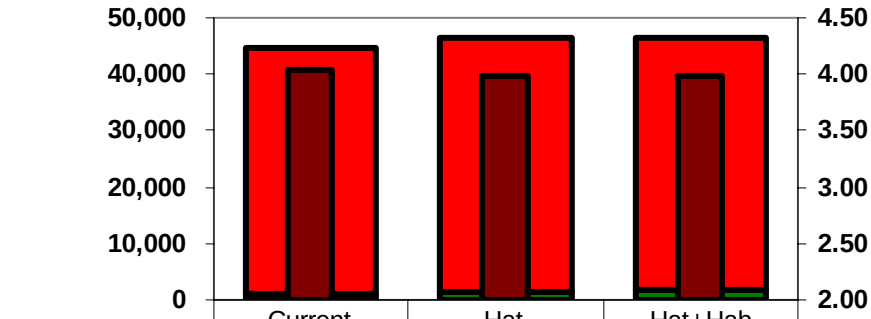
Figure 3. Productivity (adult recruits per spawner) adjusted for harvest and fitness loss for three scenarios. The left axis (wide bars) shows the proportion of steelhead populations in the lower Columbia and upper Willamette DPS with productivity in the indicated range. The right axis (narrow blue bars) shows the average productivity of Primary populations. "Hat" refers to the HSRG solution under current habitat conditions. "Hat+Hab" refers to the HSRG hatchery solution combined with a 10% habitat productivity improvement.

Under the HSRG solution, natural-origin spawning escapement was estimated to increase by 10% as the proportion of hatchery fish on the spawning grounds decreased (Figure 4). When combined with the HSRG solution, a 10% habitat productivity improvement resulted in an approximate 30% increase in natural origin spawner abundance (Figure 4). The HSRG solution retained harvest benefits, or even increased them slightly, while hatchery smolt production was slightly reduced (Figure 5).



	Current	Hat	Hat+Hab
HOS (PNI<.5)	4,324	714	714
HOS (PNI>.5)	1,348	2,580	2,580
NOS	19,077	21,369	24,623

Figure 4. Spawning escapement abundance and composition by scenario. "Hat" refers to the HSRG solution under current habitat conditions. "Hat+Hab" refers to the HSRG hatchery solution combined with a 10% habitat productivity improvement. HOS (PNI < 0.5) refers to hatchery-origin spawners where PNI is <0.5 or where PHOS is >0.1. HOS (PNI > 0.5) refers to hatchery-origin spawners where PNI is >0.5 or where PHOS is <0.1. NOS refers to natural-origin spawners.



	Current	Hat	Hat+Hab
HOR	43,677	44,965	44,965
NOR	1,140	1,393	1,607
Smolt Release	4.04	3.98	3.98

Figure 5. Expected total harvest for the three scenarios analyzed (left axis). "Hat" refers to the HSRG solution under current habitat conditions. "Hat+Hab" refers to the HSRG hatchery solution combined with a 10% habitat productivity improvement. The inserted narrow, brown bars show the total hatchery smolt release in millions (right axis). HOR represents hatchery-origin spawners and NOR represents natural-origin spawners.

The main purpose of most steelhead hatchery programs within the Lower Columbia and Upper Willamette River DPS is to provide harvest. Many of these are outplant programs based on domesticated hatchery stocks (e.g., early winter-run, and Skamania summer-run). Hatchery fish from these programs make a relatively small direct genetic contribution to the naturally spawning populations because of differences in spawn timing and behavior (Table 3). However, concerns have been raised about ecological interactions associated with these programs. While the number of hatchery fish that "effectively" interbreed may be low, the census number of fish present may be very large (Table 4). The HSRG has not developed guidelines for managing ecological risks. However, when the HSRG genetic guidelines are applied, the census proportion of hatchery fish on the spawning grounds is also reduced (Figure 6). The survival benefits to the naturally spawning populations from reduced hatchery strays could be very significant (Kostow and Zhou 2006).

Table 3. Relative reproductive success of hatchery steelhead, based on estimated, per capita, genetic contribution of hatchery fish on the spawning grounds relative to natural-origin spawners.

	Affected Population	
Hatchery Population	**Natural Summer Steelhead**	**Natural Winter Steelhead**
Domesticated Summer Steelhead[2]	0.11	0.11
Domesticated Winter Steelhead[3]	0.18	0.17
Integrated Steelhead	0.8	0.8

Source: Leider, Chilcote and Loch 1984.

[2] e.g. Skamania-origin summer steelhead, Santiam
[3] e.g. Chambers-origin early winters, and Big Creek early winters, Washougal

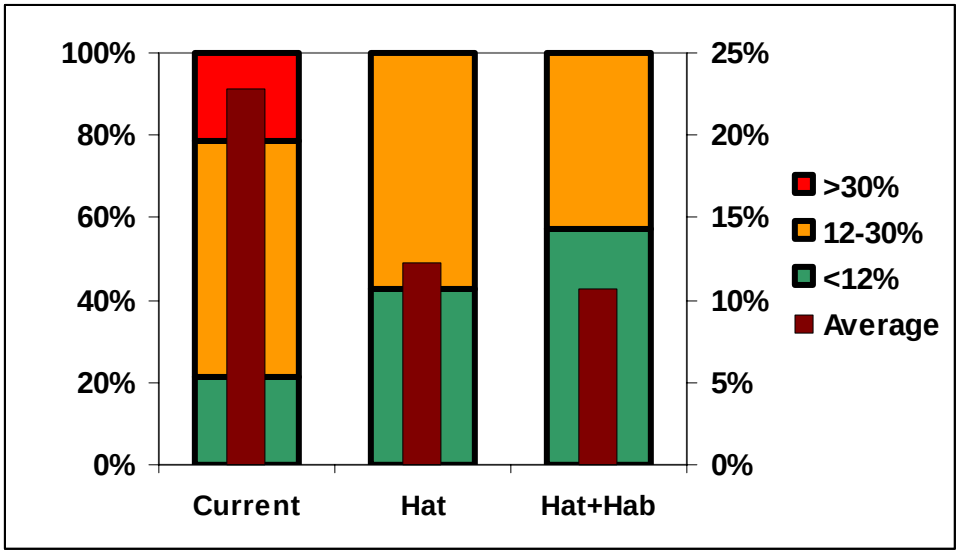
Table 4. Comparison between effective pHOS and Census pHOS. Census values shown in blue for each population and for three scenarios.

Population Name	Population Designation	Current		HSRG		HSRG +10% Habitat	
		Effective pHOS	Census pHOS	Effective pHOS	Census pHOS	Effective pHOS	Census pHOS
Coweeman Winter Steelhead	**Primary**	2%	**15%**	1%	**8%**	1%	**7%**
Cowlitz-NF Toutle Winter Steelhead	**Primary**	6%	**28%**	10%	**16%**	9%	**14%**
Cowlitz-SF Toutle Winter Steelhead	**Primary**	4%	**19%**	1%	**5%**	1%	**4%**
Kalama Summer Steelhead	**Primary**	6%	**13%**	9%	**12%**	8%	**10%**
Kalama Winter Steelhead	**Primary**	7%	**14%**	14%	**17%**	12%	**15%**
EF Lewis Summer Steelhead	**Primary**	4%	**20%**	15%	**19%**	13%	**17%**
EF Lewis Winter Steelhead	**Primary**	23%	**64%**	16%	**21%**	14%	**18%**
Sandy Winter Steelhead	**Primary**	3%	**5%**	4%	**5%**	3%	**4%**
Washougal Summer Steelhead	**Primary**	5%	**25%**	14%	**19%**	12%	**17%**
Molalla Winter Steelhead	**Primary**	37%	**46%**	17%	**26%**	15%	**23%**
North Santiam Winter Steelhead	**Primary**	19%	**58%**	2%	**12%**	2%	**11%**
South Santiam Winter Steelhead	**Primary**	2%	**13%**	2%	**11%**	2%	**9%**
Clackamas Winter Steelhead	**Primary**	0%	**0%**	0%	**0%**	0%	**0%**
Lower Cowlitz Winter Steelhead	**Contributing**	18%	**55%**	36%	**57%**	31%	**52%**
Upper Cowlitz Winter Steelhead	**Contributing**	0%	**0%**	1%	**8%**	1%	**7%**
NF Lewis Winter Steelhead	**Contributing**	29%	**70%**	29%	**70%**	26%	**66%**
Washougal Winter Steelhead	**Contributing**	0%	**1%**	1%	**5%**	1%	**4%**
Calapooia Winter Steelhead	**Contributing**	2%	**12%**	2%	**10%**	2%	**9%**
NF Lewis Summer Steelhead	Stabilizing	16%	**52%**	17%	**51%**	15%	**48%**
Salmon Creek Winter Steelhead	Stabilizing	29%	**69%**	32%	**69%**	29%	**65%**
Willamette West Side Tribs Winter Steelhead	Stabilizing	5%	**20%**	3%	**16%**	2%	**9%**

Developing integrated hatchery programs for steelhead involves unique challenges and requires extra caution. The diverse life history patterns expressed by natural steelhead populations are difficult to replicate in the hatchery. The practice of rearing and releasing 1-year smolts results in life histories that differ from those of natural populations and, thus, increases ecological risks (e.g., residualism of released smolts in freshwater). Genetic risks may also increase due to potential domestication selection effects. Where conservation is the purpose, integrated programs that capture the life history attributes of the population are the most appropriate. Such programs need to be carefully developed with consideration of increased genetic and ecological risks, including added culture difficulties.

In addition, monitoring the composition of hatchery and natural-origin fish on the spawning grounds is difficult because (a) steelhead spawn at a time of the year when water levels are high, thus precluding direct observation of spawning fish, and (b) adults survive spawning; therefore, recovery of carcasses cannot occur. These factors also make it difficult to operate temporary weirs effectively.

Figure 6. The percent of Primary steelhead populations in the lower Columbia and upper Willamette DPS with greater than 30% (red), 12-30% (yellow), and less than 12% (green) hatchery-origin fish on the spawning grounds is represented by the stacked bars and the left axis in the chart[4]. The brown bars indicate the proportion of hatchery fish on the spawning grounds averaged over all Primary populations in this region (right axis). The proportion of hatchery fish on the spawning grounds is an indicator of potential ecological intra-species interaction.



[4] The breakpoints (12% and 30%) are based on ranges used by Kostow and Zhou (2006).

Conclusions

If managers' harvest and conservation goals are to be met on a sustainable basis, they should:

1. Implement effective integrated or segregated broodstock management practices to achieve HSRG broodstock standards by a) limiting the number of hatchery-origin fish spawning naturally, b) reducing the number of hatchery fish released, and/or c) including appropriate numbers of natural-origin fish in integrated hatchery broodstocks. To this end, the following are recommended:
    - Fully harvest hatchery fish in excess of spawning and broodstock needs. This includes developing additional methods and gear (including weirs) that enable harvest of hatchery fish with low mortality of natural fish.
    - Avoid "recycling" of adults
    - Release smolts in locations where returning adults may be recaptured.
    - Discontinue the practice of "out-planting"
    - Rear and release fish in ways that improve homing and reduce straying. For example, use local broodstock to the extent possible, use acclimation facilities for releasing smolts, and recapture returning adults.
    - Use volitional release to reduce ecological impacts by dispersing smolts temporally during the outmigration period, and to potentially reduce residualism and improve homing fidelity.
    - Modify infrastructure so that facilities are capable of meeting natural and hatchery broodstock management goals.
    - Mark all hatchery fish. Population goals can be accomplished only if hatchery fish can be reliably distinguished from natural-origin fish.
    - Reduce the size of on-station releases from programs that result in large surpluses of returning adults and stray rates that exceed HSRG guidelines.
2. Designate some watersheds as "wild steelhead management zones" where no hatchery steelhead are released.
3. Assure that ecological impacts of hatchery structures and operations are minimized and at least meet all regulatory requirements (i.e. water withdrawal and discharge, fish passage and screening).

The HSRG also concluded that hatchery reforms alone will not achieve recovery of listed populations. Habitat improvements and harvest reforms are also necessary. It is also clear that the effectiveness of habitat actions will be greatly increased if they are combined with hatchery and harvest reforms. For example, a 10% increase in habitat productivity could produce a 30% increase in natural origin spawner abundance if combined with hatchery reforms**. Unless hatchery and harvest reforms are implemented, the potential benefits of current or improved habitat cannot be fully realized. The HSRG has concluded that a holistic strategy that combines reforms and improvements in all three "H's" will be necessary to meet the managers' conservation and harvest goals for steelhead salmon in the lower Columbia and upper Willamette DPS.**