HATCHERY CONTRIBUTION TO A NATURAL POPULATION OF CHINOOK IN THE HANFORD REACH OF THE COLUMBIA RIVER, WASHINGTON

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Abstract

This paper is an attempt to quantify the contribution of Priest Rapids Hatchery to the productivity of Upriver Bright stocks in the Hanford Reach natural production area. Analysis of coded-wire tag recoveries from approximately 200,000 Upriver Bright fall chinook reared at Priest Rapids Hatchery (*Oncorhynchus tshawytscha),* marked annually since 1973, indicates a significant contribution to the natural spawning on the Hanford Reach. The population structure of returning runs, escapement estimates, number of hatchery smolts released, number of hatchery smolts marked with coded-wire tags, returning hatchery fish, and coded-wire tag (CWT) recoveries were evaluated to estimate natural production of smolts and the proportion of natural production attributable to hatchery progeny. It was found that on average 29.83% of the Priest Rapids Hatchery returns spawn on the Hanford Reach, and that hatchery-reared fish contribute up to 33.05% of adult returns to the Hanford Reach spawning grounds in any one year, averaging 8.63% over the 20 years surveyed. Our results show that fisheries managers should consider the potential for hatchery-reared fish to contribute to the productivity of natural stocks in the

development of recovery goals and management practices, and that the fraction of the returning population from the hatchery must be considered when estimating natural population parameters.

Introduction

Definition of the Problem Statement

Although artificial propagation has been used to augment Pacific salmon populations for over a century, the performance of hatchery-reared salmonids and their progeny in the wild is poorly understood. Based on observations of hatchery-reared fish in natural production areas, it seems likely that some hatchery fish are spawning in the wild. However, many studies suggest that hatchery-reared or hatchery-bred fish are unable to reproduce naturally or have reduced fitness compared to wild fish (Fleming and Petersson 2001). Other studies support that hatchery-bred fish are capable of spawning in natural settings (Cuenco *et al.* 1993, Phillips *et al*. 2000). There are several critical issues that stem from this controversy that affect stock management. These include the distribution of hatchery-bred adults in natural systems, the reproductive value of hatchery fish when compared to natural counterparts, and their contribution to the combined productivity of the stock. If the contribution of the hatchery releases is providing successful mitigation, the potential to use supplementation as a tool for salmon restoration will be substantiated.

Failure to account for hatchery fish in these calculations can lead to incorrect perceptions of natural stock performance. Spawner abundance, recruit per spawner and smolt to adult survival rates are common measures used to characterize the status of a population. These indices of population health are often calculated from data on returning run size and age composition, the number of redds, and the number of smolts produced. For example, in recruit per spawner calculations, not counting naturally spawning hatchery fish can inflate the estimated number of smolts produced per spawning adult, suggesting that a population is above replacement (>1:1 recruit per spawner ratio) and thus incorrectly indicate that the population is doing well when it is not (Talbot 2001). The intent of this paper is to quantify the proportion of natural production of Upriver Bright fall chinook in the Hanford Reach that is attributable to Priest Rapids Hatchery. We will employ a 20-year time series of coded-wire tag (CWT) groups and analysis of escapement estimates, number of hatchery-reared smolts released, number of hatchery-reared smolts released with coded-wire tags and age composition of returning runs.

Salmon Stock Background

Columbia River Upriver Bright (URB) stock are defined as wild and hatchery fall chinook originating upstream of McNary Dam (All-Species Review 1996). The URBs are major contributors to Pacific Fishery Management Council (PFMC) and Pacific Salmon Commission (PSC) fisheries, and are an escapement indicator stock/ model stock to the Chinook Technical Committee (CTC) of the PSC. Despite the high degree of mortality that occurs during both upstream and downstream migration through the hydropower system, Hanford Reach URBs are one of few Columbia River salmon stocks that are not currently declining; they are classified as strong by Nehlsen et al. (1991) and healthy by Huntington et al. (1996) and WDFW (1993).

The Hanford Reach is a 90-km segment of the Columbia River located between the upstream end of McNary Dam reservoir (rkm 549) and Priest Rapids Dam (rkm 639). It is the only sizeable free-flowing reach of the mainstem Columbia River upstream of Bonneville Dam, and subsequently encompasses the largest tract of remaining lotic habitat. Fall chinook salmon have successfully made use of Hanford Reach spawning and rearing habitat as other production areas became inundated by reservoirs (Dauble and Watson 1997). The Hanford Reach contains the most significant area of URB fall chinook production in the mainstem Columbia River. Spawning primarily occurs in discontinuous segments between rkm 558 and 630 (Dauble 2000).

Smolt to adult survival rates are greatly reduced from pre-development conditions primarily due to flow regulation (i.e. power ramping) and losses during upstream and downstream migrations through four mainstem dams (Wagner et al. 1999). Furthermore, less than 20% of historic production areas are accessible, connectivity between spawning areas is reduced, and spawning ground habitat is controlled by highly variable flow management (Dauble 2000).

Priest Rapids Hatchery (rkm 639) was built in 1963 and is managed to mitigate for fishery impacts caused by Priest Rapids, Wanapum, and John Day dams (Allen and Meekin 1973, Chapman 1994). The hatchery's operation goal is to annually produce 100,000 lb of subyearling URB fall chinook for Priest Rapids and Wanapum dams mitigation, and 1.7 million subyearling URB fall chinook as part of the mitigation for John Day Dam (Montgomery Watson 1997). This generally results in the release of five to seven million subyearling smolts into the Hanford Reach. Approximately 200,000 hatchery fish and 200,000 wild fish are coded-wire tagged annually for monitoring of ocean distribution and harvest rates. Priest Rapids Hatchery has provided additional harvest opportunities for URB fall chinook runs since 1973, however it has not yet been determined whether it has contributed to natural recruitment.

Methods

The physical attributes of the Columbia River at this location, primarily large width and depth, can present difficulties for sampling, thereby limiting the scope of research and data collection and creating complications for study design. One method of quantifying hatchery contributions to productivity in a site that is difficult to sample directly is to estimate the number of adult hatchery-bred fish in natural production areas by coded-wire tag expansion from tagged carcasses recovered on the spawning ground. This technique involves the compilation and analysis of data on escapement, age composition of returning hatchery runs, hatchery releases, catch, sampling effort, and CWT rates and recovery distributions.

Estimates of escapement to the Hanford Reach as calculated by McClure (2002) were used as baseline spawner abundance by year. They are given by:

$$E_{HR} = E_{McN} - E_{ICH} - E_{PRD} - BS_{PRH} - BS_{RGH} - Catch$$

where E_{McN}, E_{ICH}, and E_{PRH} are counts of adult escapement over McNary, Ice Harbor, and Priest Rapids dams; BS_{PRH} and BS_{RGH} are the amount of broodstock collected for the Priest Rapids and Ringold hatchery programs, and catch reflects the number of fish harvested in the Columbia River.

Coded-wire tag data is available for hatchery origin smolts since brood year 1975 and natural origin smolts since brood year 1986. The CWT recovery data can also be used to partition the composition of the URB escapement to the Hanford Reach between fish of natural origin that homed to their natal river location, Priest Rapids Hatchery origin, and other origins (strays). Data on PRH release numbers by brood year, PRH CWT release groups by brood year, and CWT recoveries on the spawning grounds of PRH fish were used to make these estimates. Coded-wire tags recovered from carcasses on the spawning grounds were partitioned across age-classes. Priest Rapids Hatchery CWT recoveries from the spawning grounds were expanded by the tagging rate:

$$T = \frac{\#released}{\#tagged}$$

and multiplied by age-class composition to estimate abundance of each age-class.

The estimate of abundance of (A) of Priest Rapids Hatchery fish spawning on the Hanford Reach for each return year was calculated as the sum of the estimated abundances for each age-class (excluding jacks):

$$A = T_{BY4}(S_4) + T_{BY5}(S_5) + T_{BY6}(S_6)$$

where S is the number of age 4, 5, and 6 spawners returning in a given calendar year and T_{BY} is tagging rate of the corresponding brood year for the age-class of spawners. Next, the proportion contribution of PRH to the spawning population in Hanford Reach was calculated by dividing estimated abundance of PRH fish on spawning grounds by estimated escapement.

The proportion of PRH returns that spawned in the Hanford Reach was estimated by simply dividing the PRH natural spawning contribution by the sum of PRH natural spawning contribution and PRH hatchery returns.

Results

Table 1 is a compilation of the data used to estimate the contribution of PRH fish to Hanford Reach natural production and the calculation of that contribution. The proportion of Hanford Reach escapement attributable to PRH ranged from 1.33% to 33.05% with an average of 8.63%. Although the percent contribution oscillates from year to year, there is no discernible trend (Figure 1).

The number of coded-wire tags recovered in each return year was highly variable, ranging from 0-856 recoveries (expanded). No coded-wire tags were recovered for return years 1992 and 1993; therefore, we were unable to calculate a PRH contribution to the spawning grounds for those years.

Priest Rapids Hatchery returns to the hatchery, natural spawning, and percent of fish returns spawning in the wild are listed in Table 2. The proportion of Priest Rapids Hatchery fish returning to the Hanford natural production area ranged from 4.64% to 60.57% with an average of 29.83% (Table 2). The proportions of the hatchery returns that are recovered on the spawning grounds (expanded) are illustrated in Figure 2.

Table 1. Components of total production in the Hanford Reach and Priest Rapids Hatchery and calculations of the contribution of Priest Rapids Hatchery to Hanford Reach natural production (1979-2001).

Brood year	Priest Rapids Hatchery # released	Priest Rapids Hatchery # CWT	Expanded # tags recov. on spawn ground	Return year	Hanford Escapement	Hanford Escapement less PRH contrib.	PRH contrib to Hanford (excl jacks)	% PRH contrib. (excl jacks)
1975	1,340,735	284,416	341	1979	22,600	22,289	311	1.38%
1976	759,146	147,338	221	1980	20,500	18,687	1,813	8.84%
1977	538,015	152,532	51	1981	13,544	12,499	1,045	7.71%
1978	1,197,297	153,156	172	1982	16,926	14,564	2,362	13.95%
1979	3,004,934	147,145	184	1983	32,681	30,629	2,052	6.28%
1980	4,817,750	236,738	120	1984	36,252	33,571	2,681	7.39%
1981	5,507,574	310,876	114	1985	59,579	58,184	1,395	2.34%
1982	10,296,700	406,529	920	1986	69,087	46,256	22,831	33.05%
1983	9,742,700	222,732	527	1987	81,046	66,843	14,203	17.52%
1984	2,954,000	202,244	67	1988	72,096	62,991	9,105	12.63%
1985	6,559,000	310,494	134	1989	64,333	63,477	856	1.33%
1986	6,048,000	201,843	42	1990	39,847	38,178	1,669	4.19%
1987	7,709,000	207,422	21	1991	31,298	29,888	1,410	4.50%
1988	5,404,550	204,470		1992	30,711	30,711		
1989	6,431,100	194,530	44	1993	32,577	32,577		
1990	6,386,000	199,469	100	1994	53,133	50,622	2,511	4.73%
1991	6,844,700	201,647	37	1995	38,074	35,189	2,885	7.58%
1992	6,386,000	194,622	28	1996	36,321	33,985	2,336	6.43%
1993	6,705,836	183,874	135	1997	35,645	32,281	3,364	9.44%
1994	6,702,000	178,496	8	1998	27,449	26,715	734	2.67%
1995	6,700,000	196,086	208	1999	27,720	24,371	3,349	12.08%
1996	6,644,100	193,203		2000	38,576	35,296	3,280	8.50%
1997	6,737,600	204,251		2001	45,999			
average	5,394,506	214,994	174	1,990	40,000		4,009	8.63%

Table 2. Priest Rapids Hatchery returns to the hatchery, natural spawning, and percent of fish returns spawning in the wild (1980-2000).

Return year	Adult PRH contribution to Hanford Reach	Adult PRH returns to hatchery	Adult PRH returns to hatchery + wild	% PRH returns spawning in Hanford Reach
1980	1,813	2,192	4,005	45.27%
1981	1,045	1,594	2,639	39.59%
1982	2,362	2,613	4,975	47.48%
1983	2,052	3,014	5,066	40.51%
1984	2,681	6,387	9,068	29.56%
1985	1,395	11,956	13,351	10.45%
1986	22,831	14,865	37,696	60.57%
1987	14,203	18,171	32,374	43.87%
1988	9,105	9,966	19,071	47.74%
1989	856	6,496	7,352	11.64%
1990	1,669	3,479	5,148	32.42%
1991	1,410	2,636	4,046	34.84%
1992				
1993				
1994	2,511	13,819	16,330	15.38%
1995	2,885	10,740	13,625	21.17%
1996	2,336	14,280	16,616	14.06%
1997	3,364	10,836	14,200	23.69%
1998	734	15,074	15,808	4.64%
1999	3,349	23,101	26,450	12.66%
2000	3,280	7,235	10,515	31.19%
average	3,645	9,392	13,596	29.83%

Discussion

On average, about 25% of the Priest Rapids Hatchery returns are recovered on the Hanford Reach spawning ground (range: 4.6 - 60.6%, Table 2). We feel that this calculation is more appropriate than to look simply at total contributions of hatchery fish to the natural spawning aggregate that averaged 8.63%, because of the management goals of the hatchery. The goal of Priest Rapids Hatchery is to mitigate for fishery losses due to the Priest Rapids, Wanapum, and John Day

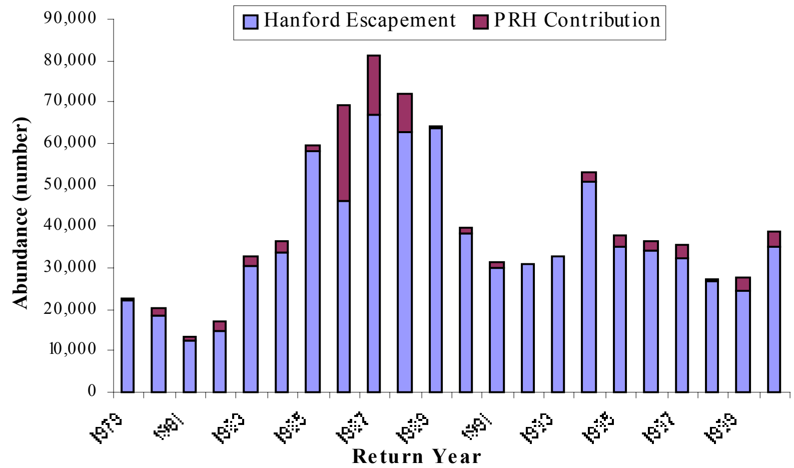

Figure 1. Estimated Hanford Reach spawning escapement with the estimated contribution of Priest Rapids Hatchery returns.

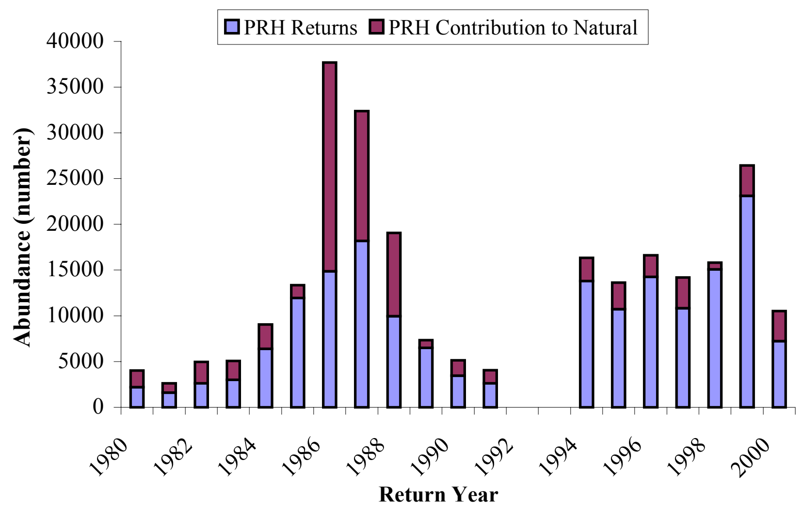

Figure 2. Proportion of Priest Rapids Hatchery returns contributing to the Hanford Reach spawning population.

dams. The hatchery is not managed as a supplementation facility; therefore the contribution to the natural spawning population has not been optimized.

Jacks are underrepresented in carcass sampling surveys, are not included in estimates of escapement, and therefore we excluded them from analysis. The Priest Rapids Hatchery contribution rate is therefore reduced. It would be advantageous to find a way to include jacks in future analyses.

Although there are several data compiling entities in the Pacific Northwest, many discrepancies exist among datasets. Data reporting was inconsistent among and within sources, as evidenced by the mixing of brood year, release year, recovery year, and age-class designations. Furthermore, calculations to estimate escapement and abundance are not well documented, standardized, or consistent. These challenges make analysis of URB data difficult.

The level of sampling effort for carcass recovery surveys was highly variable. Since no coded-wire tags were recovered in return years 1992 and 1993, we were unable to calculate a PRH contribution rate for those years. This is apparent in the 1992-1993 gaps in Figures 1 and 2. These data gaps also affect the estimated PRH contribution for brood years 1986-1989, resulting in underestimates of the actual contribution.

Conclusion

It is evident that chinook salmon reared at Priest Rapids Hatchery are contributing to the natural productivity of the Hanford Reach spawning grounds. The URB population could benefit by managing the Priest Rapids Hatchery as a supplementation program for naturally spawning fall chinook salmon in the upper Columbia River system.

The region should strive to improve data reporting methodologies and standards.

Finally, a better understanding of the contribution of hatchery fish to productivity of wild stocks is needed to evaluate stock performance, refine escapement goals, direct artificial production and guide management practices.

References

Allen, R.L., and T.K. Meekin. 1973. An evaluation of the Priest Rapids chinook salmon spawning channel, 1963-1971. Washington Department of Fisheries Technical Report Number 11, Olympia, Washington, 46 p.

Beaty, R.E. 1996. Changes in size and age at maturity of Columbia River upriver bright fall chinook salmon (*Oncorhynchus tshawytscha*): implications for stock fitness, commercial value, and management. Technical Report 96-7. Columbia River Inter-Tribal Fish Commission. Portland, Oregon.

Chapman, D.W., A. Giorgi, T. Hillman, D. Deppert, M. Erho, S. Hays, C. Peven, B. Suzumoto, and R. Klinge. 1994. Status of summer/fall chinook salmon in the Mid-Columbia Region. Don Chapman Consultants Inc., Boise, Idaho, 412 p.

Dauble, D.D. 2000. Assessment of The Impacts of Development and Operation of the Columbia River Hydroelectric System on Mainstem Riverine Processes and Salmon Habitats, Report to Bonneville Power Administration, Battelle's Pacific Northwest Division, Richland, Washington.

Dauble, D.D. and D.G. Watson. 1990. Spawning and Abundance of Fall Chinook Salmon (*Oncorhynchus tshawytscha*) in the Hanford Reach of the Columbia River, 1948-1988. PNL-7289, Pacific Northwest Laboratory, Richland, Washington.

Dauble, D.D., and D.G. Watson. 1997. Status of fall chinook salmon populations in the mid-Columbia River, 1948-1992. North American Journal of Fisheries Management. 17:283-300.

Fish, F.F. and M.G. Hanavan. 1948. A report upon the Grand Coulee Fish-Maintenance Project 1937-1947. U.S. Department of the Interior, Fish and Wildlife Service, Special Scientific Report 55, Washington, D.C. 62 p.

Fleming, I.A. and E. Petersson. 2001. The ability of released, hatchery salmonids to breed and contribute to the natural productivity of wild populations. Nordic Journal of Freshwater Research. 75: 71-98.

Fulton, L.A. 1968. Spawning areas and abundance of chinook salmon (*Oncorhynchus tshawytscha*) in the Columbia River basin—past and present. Unites States Fish and Wildlife Service Special Scientific report—Fisheries No. 571. 26 p.

Huntington, C., W. Nehlsen, and J. Bowers. 1996. A survey of healthy native stocks of anadromous salmonids in the Pacific Northwest and California. Fisheries 21(3): 6-14.

Independent Science Advisory Board. 2001. Letter of hatchery surplus review. ISAB 2001-3 prepared for the Northwest Power Planning Council and the National Marine Fisheries Service, Portland, OR.

Montgomery Watson. 1997. Hatchery evaluation report: Priest Rapids Fish Hatchery Upriver Bright fall chinook. Prepared for the United States Department of Energy, Bonneville Power Administration. Portland, OR.

Nehlsen, W., J.E. Williams, and J.A. Lichatowich. 1991. Pacific salmon at the crossroads: stocks at risk from California, Oregon, Idaho, and Washington. Fisheries 16(2):4-21.

Phillips, J.L., J. Ory, and A.J. Talbot. 2000. Anadromous salmonid recovery in the Umatilla River Basin, Oregon: a case study. Joournal of the American Water Resources Association 36(6): 1287-1308.

Roler, R. 1987. Age composition and mark and no-tag rates of the escapement of Upriver Bright stock fall Chinook salmon, 1986. Washington Department of Fisheries, Battle Ground, WA.

Roler, R. 1988. Age composition and mark and no-tag rates of the escapement of Upriver Bright stock fall Chinook salmon, 1987. Washington Department of Fisheries, Battle Ground, WA.

Roler, R. 1989. Summary of Upriver Bright returns above McNary Dam and the Deschutes River, 1988. Washington Department of Fisheries, Battle Ground, WA.

Roler, R. 1990. Summary of Upriver Bright returns above McNary Dam and the Deschutes River, 1989. Washington Department of Fisheries, Battle Ground, WA.

Roler, R. 1991. Summary of Upriver Bright returns above McNary Dam and the Deschutes River, 1990. Washington Department of Fisheries, Battle Ground, WA.

Roler, R. 1992. Summary of Upriver Bright returns above McNary Dam and the Deschutes River, 1991. Washington Department of Fisheries, Battle Ground, WA.

Roler, R. 1995. Summary of Upriver Bright returns above McNary Dam and the Deschutes River, 1992. Washington Department of Fisheries, Battle Ground, WA.

Roler, R. 1995. Summary of Upriver Bright returns above McNary Dam and the Deschutes River, 1993. Washington Department of Fisheries, Battle Ground, WA.

Talbot 2001. Quantitative methods of developing escapement goals in the Columbia River Basin: a scientific perspective. Columbia River Inter-Tribal Fish Commission, white paper. Portland, OR, 15 p

United States versus Oregon Technical Advisory Committee. 1997. 1996 All-species review summer chinook, Columbia River Fish Management Plan, 15p.

Wagner, P., J. Nugent, W. Price, R. Tudor, P. Hoffarth. 1999. 1997-99 Evaluation of juvenile fall chinook stranding on the Hanford Reach, Washington Department Department of Fish and Wildlife 1997 interim report to the Bonneville Power Administration, project number: 97-104.

Washington Department of Fisheries (WDF), Washington Department of Wildlife (WDW), and Western Washington Treaty Indian Tribes (WWTIT). 1993. 1992 Washington State salmon and steelhead stock inventory (SASSI). Olympia, 212 p.