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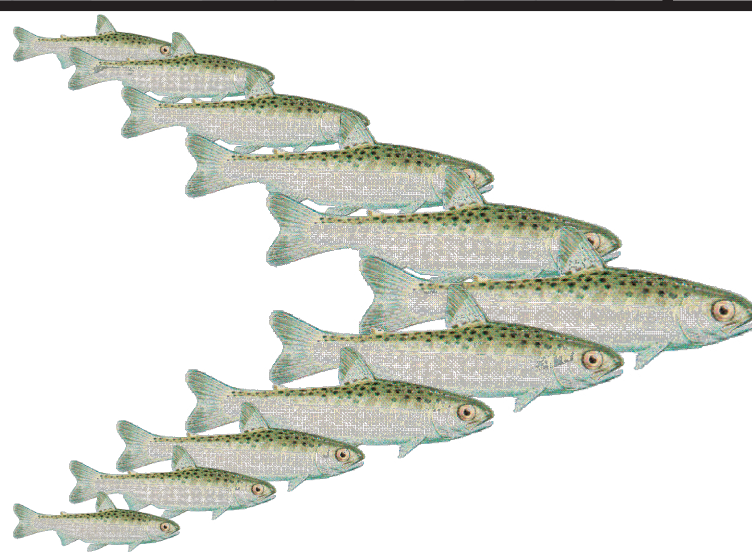
Ringold Springs Hatchery Test Facility



by Joseph D. Bumgarner

Washington Department of
FISH AND WILDLIFE
Fish Program
Science Division

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Ringold Springs Hatchery Test Facility

Final Report

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Abstract

A multi-year evaluation was conducted at Ringold Springs Hatchery (RSH) to determine if the U. S. Army Corps of Engineers (COE) should build additional rearing vessels at the hatchery as part of the required John Day mitigation. The fall Chinook salmon used in this study were initially reared at the Oregon Department of Fish and Wildlife's (ODFW) Bonneville Hatchery, then transported to RSH, and reared in either raceways (treatments) or a large earthen pond (control) for several weeks before being released in the Columbia River at RSH in June. Phase 1 of the project utilized passive integrated transponder (PIT) tags in juvenile fall Chinook salmon released from the control or treatment groups at RSH to compare migration speed and detection rates at one or more of the downstream dams. Phase 2 compared smolt-to-adult returns (SARs) of control and treatment groups as determined by total estimated recoveries of coded-wire tags (CWTs) from all recovery locations. This report covers the tenth and final year of the study, and the final analyses of Phase 2 (adult recoveries and return rates).

Results from weekly juvenile growth monitoring and documentation of release size, and downstream migration tracking (survival and timing) through the use of PIT tags were previously presented in annual progress reports. In summary, smolts released from the rearing pond generally had higher downstream migrant survival rates, had shorter migration times, and smolts generally appeared more "smolted" (i.e. more silvery in color) than smolts reared in the raceways.

In 2006, staff hired temporary workers and security guards for the capture, processing, and security of returning fall Chinook salmon to RSH. A total of 117 adults and 1 jack fall Chinook salmon were captured in the trap facility. Four adults were recovered with CWTs but none of the snouts recovered in 2006 were from the study groups.

The regional CWT database was queried, and all recoveries of study fish were tallied. Significantly more adult fall Chinook salmon returned from the rearing pond group in three of the five brood years of the study as compared to the treatment raceways. Overall, about 35% more adult fall Chinook salmon returned from the rearing pond group over the course of the study. In addition, significantly fewer ($P = 0.025$) age 3 adult fall Chinook salmon, and significantly more age 5 ($P = 0.005$) adult fall Chinook salmon returned from the control group as compared to the treatment groups. Mean length at return between the groups was not significantly different.

In conclusion, fall Chinook salmon reared and released from the rearing pond had higher overall survival rates than those reared in concrete raceways. However, bird predation in the rearing pond can be significant (believed by RSH hatchery staff to be as high as 30% in one year) and should be considered as part of a cost-benefit analysis to determine which rearing method is better for the program. Based on this study, I would recommend construction of 1-2 additional rearing ponds with avian predator netting at RSH. This would provide the greatest number of adult returns back to the Columbia River system to support the mitigation fishery. Further, predator control netting should also be installed on the existing rearing pond to maximize fall Chinook salmon survival to release.

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Introduction

In 1997, the Washington Department of Fish and Wildlife (WDFW) and the U. S. Army Corps of Engineers (COE) initiated a multi-year study at Ringold Springs Hatchery (RSH). The COE was being tasked to increase production of upriver-bright (URB) fall Chinook salmon (*Oncorhynchus tshawytscha)* as part of the John Day hydroelectric facility mitigation. The proposal by the COE was to increase the rearing capacity of RSH by constructing 20 standard concrete raceways. Concurrent research at other WDFW facilities was suggesting that fish reared in semi-natural hatchery ponds had greater survival than those reared in standard concrete raceways. As such, an agreement was reached between the parties involved to construct only two raceways, and then conduct a study to test the survival differences between fall Chinook salmon reared in the two new concrete raceways or a large earthen rearing pond at RSH. Passive integrated transponder (PIT) tags in juvenile fall Chinook salmon were to be used to compare migration speed and detection rates at one or more of the downstream dams on the Columbia River between the two rearing types. The second phase of the study was to compare smolt-to-adult returns (SARs) between the two rearing types as determined by total estimated recoveries of coded-wire tags (CWTs) from all recovery locations.

Background

The COE funds production of juvenile URB fall Chinook salmon fingerlings at Bonneville Hatchery (operated by Oregon Department of Fish and Wildlife - ODFW) as part of its mitigation for the The Dalles / John Day Dam hydroelectric facilities authorized under the Flood Control Act of 1950. When this project was initially proposed (1995), the program strategy was to release about 3.5 million smolts (smolt releases size was 50-60 smolts/lb) on-site at Ringold Springs Hatchery (RSH), combined with additional releases of subyearling smolts at Bonneville Hatchery, other hatcheries, and direct stream release sites within Columbia River Zone 6 (Bonneville, The Dalles, and John Day pools) to support Tribal treaty fisheries.

Also in 1995, a new mitigation goal of 107,000 fall Chinook salmon adults was being proposed by fishery managers in the Columbia River Basin. Based on SARs from the 1978-1989 brood years it was estimated that approximately 7.5 million smolts would be needed to meet the proposed goal. However, low survivals due to poor ocean conditions in some years may require an increase in smolt production to 11-14 million to reach the adult goal. The cost of trucking these additional smolts might be higher than the cost of locating permanent acclimation sites in the Columbia River upstream of Zone 6 (e.g. RSH). In addition, there was and perhaps still is, a concern that unacclimated smolts survive at lower rates than acclimated smolts due to the trauma and stress incurred during transport. To fulfill their mitigation responsibilities, the COE and other fishery managers within the Columbia River Basin were seeking additional rearing capabilities in the mid-Columbia River to meet the proposed obligation of between 7.5-14 million smolts annually. The range in smolt production would be dependent on the size that fall Chinook salmon are released, which likely effect post-release survival rates. Other studies have shown larger size steelhead smolts generally returned adult fish at a higher rate (Tipping 1996, 1997).

From 1993-1995, the COE agreed to provide funds to ODFW to truck approximately 0.5 and 4.25 million URB fall Chinook salmon smolts each year to the Hanford K Basin Ponds and RSH, respectively. These releases were evaluated and results showed that RSH could successfully rear URB fall Chinook salmon smolts for the John Day mitigation. The calculated capacity of RSH at the beginning of this study ranged from 3.5 to 5.5 million fall Chinook salmon smolts (depending on release size). However, changes to the current configuration of the hatchery could increase the capacity, and could provide a substantial part of the John Day mitigation. In 1997, a cooperative agreement was reached between the COE, the WDFW, the National Oceanographic and Atmospheric Administration Fisheries Division (NOAA Fisheries, previously known as National Marine Fisheries Service), and the Bureau of Reclamation (BOR) to share the facilities at WDFW's RSH to benefit and/or increase the upriver fall Chinook salmon runs in the Columbia River.

Fall Chinook salmon smolt production at RSH in the past ranged from 3-4 million subyearlings (smolts were reared and released from the rearing pond). The COE goal was to increase the fall Chinook salmon production at RSH by about 2 million smolts annually. The COE proposed to increase the production through the use of standard concrete raceways (20) that could rear about 100,000 smolts each. However, managers questioned if the SARs of smolts reared in concrete raceways would equal those of smolts reared in the large earthen rearing pond. If survival were less, it would be more beneficial in the long-term to construct another earthen rearing pond for the additional two million smolts. As such, the COE agreed to fund a study to determine whether standard concrete raceways or earthen rearing ponds were the most effective way to increase adult fall Chinook salmon production at RSH. With that agreement in place, the first phase of the expansion project was to build two standard concrete raceways to test if survival to adulthood (ages 3-6) of fall Chinook salmon smolts reared in these raceways equaled the survival of fall Chinook salmon reared in the existing earthen rearing pond.

Also in 1997, WDFW and ODFW agreed to transfer about 3.7 million URB fall Chinook salmon from the Bonneville Hatchery to RSH. It was also agreed to CWT the treatment (2 groups of 100,000 smolts each) and control (1 group of 200,000 smolts) groups while they were at Bonneville Hatchery. However, the two test raceways were not completed until 1998, thus 1998 marked the beginning of the study to determine if the capacity to rear URB fall Chinook salmon at RSH could be increased above current levels with the addition of concrete raceways.

Phase 1 of the study included intensive monitoring of the juvenile fall Chinook salmon reared and released at RSH before and after release between 1998 and 2002 (Ross et al. 2002). Juvenile monitoring activities at RSH included: 1) monitor weekly growth rates (length and weight) and accurately determine final release size, and 2) describe downstream migration success and timing between the study groups using PIT tags. Part of the weekly monitoring was to assist the hatchery staff in determining appropriate feed rations to ensure the treatment and control groups were of equal size upon release.

Phase 2 of the study, and the focus of this final report was to assess the project based on adult returns though CWT recoveries at RSH, in other fisheries throughout the Columbia River Basin, and in the ocean. The intent was that returning adults were to be sampled for CWTs at RSH through the fall of 2006, which would represent age 5 returns to the hatchery from the 2002 release year. While age 6 adults have been recovered from the program, their frequency was low enough that it was determined to not have any significant effects on the results. The Regional

Mark Processing Center (RMPC) CWT database would be queried, and CWT recoveries from all downstream fisheries and all other recovery locations would be summarized.

This report summarizes activities for the Ringold Springs Test Facility study from October 1, 2006 to September 30, 2007. Expenditures during the funding period defined above were used to compile and analyze the fall Chinook salmon return data queried from the RMPC database, and producing this final report of the study. Funding was also used for tracking budgets for the project, general coordination between the hatchery and evaluation staff, and coordination with COE. Expenditures were also used to operate the adult trapping facility at RSH and recover CWTs from the returning adult fall Chinook salmon and for recycling captured steelhead to the Ringold Area fishery.

This final report summarizes the results of Phase 2 of the evaluation study, which includes the accounting of all adult returns reported to the Regional CWT database, using those data to compare SARs between fall Chinook salmon reared in the large earthen rearing pond or concrete raceways, and providing recommendations on which rearing method should be considered for future use at RSH to increase fall Chinook salmon returns to the Columbia River, and in particular for the John Day mitigation program.

Facilities

The RSH is located at river kilometer 567 on the Columbia River (Figure 1). The treatment raceways (3 m x 30.5 m) are located on the grounds of the RSH, which includes the existing nine-acre earthen rearing pond (control). Each raceway has an approximate volume of 97.6 m^3 and a mean flow of about 47 L/s. The nine-acre rearing pond has an approximate volume of 82,128 m^3, and mean flow of about 252 L/s. Standard rearing protocols were followed to produce about 100,000 fall Chinook salmon smolts per raceway, and about 3.4 million fall Chinook salmon smolts in the rearing pond to a release size of at least 50 smolts/lb (9 g/smolt).

The RSH also has an adult trapping facility. Returning adult salmon enter the trapping facility from late August through early December of each year. Depending on run size and timing, the trap was generally sorted on a weekly basis. Security guards were posted during the time when adult fall Chinook salmon were present due to problems with poaching from the adult trapping area.

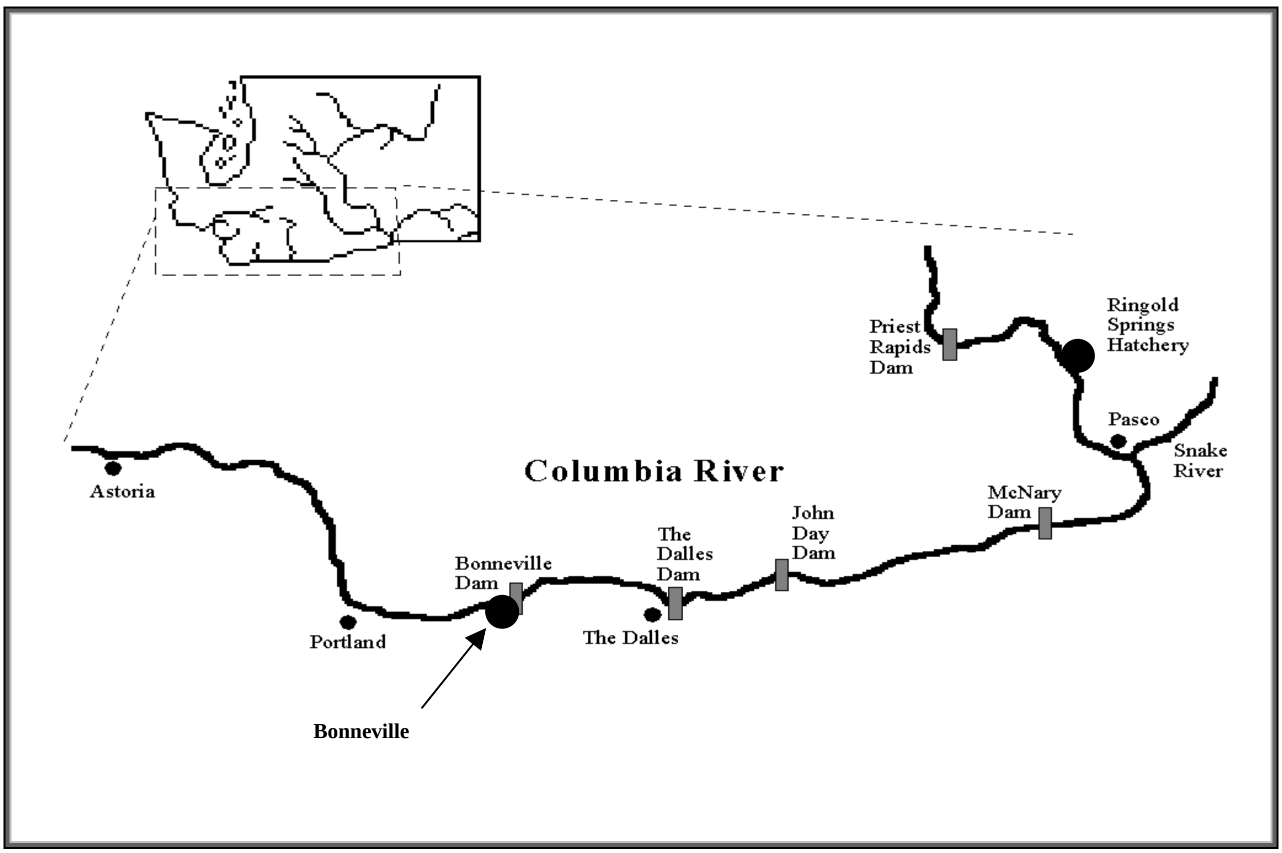

Figure 1. Map of the lower and mid-Columbia River and location of Ringold Springs Hatchery.

Study Design

It was considered critical that the juveniles within the concrete raceways be assessed because differences in outmigration behavior (degree of smoltification, migration speed (travel days) and timing, and increased residualism) have been noted between juvenile smolts reared in natural ponds and concrete raceways (Fuss et al. 1995; Tipping 1996). These potential differences may be vital for the program to be in compliance with hatchery operations under Section 7 consultation. Further, it was noted that feed conversions rates in the rearing pond were low compared to the raceway-reared smolts due to the presence of natural feed (insects). Also, rearing density between the groups was very different (rearing pond: 43 fish/m^3; raceways: 1,024 fish/m^3). The presence of natural feed and the lower rearing densities of fall Chinook salmon in the rearing pond may have been enough of a difference to invalidate this entire study, as each of these factors likely play role in determining adult returns to the program. Unfortunately, to determine the effect for all of the above factors would have required a large number of replicate groups and/or PIT tags, which were not included in the original study design. As such, all I can do is acknowledge to the reader that these differences exist between the groups. Should the rearing pond fish outperform the raceway fish in overall survival, determining which factor(s) is most beneficial is a mute point considering the overall question (i.e. which rearing method will return the most fall Chinook salmon back to satisfy mitigation goals) and should not have a great effect the end decisions made.

Juvenile Rearing

During rearing at the RSH test facility, subyearling fall Chinook salmon were sampled at weekly intervals to verify that growth rates, size at release, health, and general condition of fall Chinook salmon smolts in the control and treatment vessels were similar. Each year, smolts in the rearing pond and raceways were released at approximately the same size (approximately 50 smolts/lb). A single, non-replicated tag code was used for each raceway (about 100,000 CWTs in each) and a single tag code was used for the control group (about 200,000 CWT). While there was two unique CWT codes for the concrete raceways groups, there were not treated as unique study groups, rather they were treated as pseudo-replicates of the same treatment. In the end, the pseudo-replicates were not helpful in determining the overall question of which rearing method was most beneficial. As such, for the data analysis on the adult returns, the two-raceway CWT groups were combined into a single group. Fish in the rearing pond and raceways at RSH were released on approximately the same date within the same year. However, because of structural differences in removing smolts from the pond or the raceways, it was not always possible to release the smolts on the same day. It takes about three days to release the smolts from the rearing pond, but it takes less than one day to release smolts from the two concrete raceways.

For the juvenile evaluations, two-sample t-tests were used to determine if significant differences in migration rates to hydroelectric projects downstream of RSH were present between the rearing pond and raceway smolts. These results have been previously reported (Ross et al, 2002) for 2002 only. For this report, an additional analysis on downstream survival (based on the Survival under Proportional Hazards (SURPH) model) to McNary Dam (over all five brood years) and mean travel days to McNary, John Day, and Bonneville dams (over all five brood years) will be examined.

Adult Evaluation

Survival and contribution to the adult stage of the control and treatment group were evaluated by using CWT recoveries from fisheries and at RSH. The objective was to test the null hypothesis that the SARs of fall Chinook salmon released from the raceways was no different than fall Chinook salmon smolts released from the nine-acre rearing pond. I utilized two separate statistical tests (G-test, Ratio Test) to test the null hypothesis. The G-test was used to compare SARs between the groups within each year, while the Ratio Test was used for all years combined. In both tests, I used calculated SARs based on total recoveries (Ocean, Columbia River and it's tributaries, and RSH) and recoveries from just the Columbia River basin only. Since I was limited in the number of available data points, if similar results were obtained from the two separate tests, I felt the conclusions would be more readily accepted. Each of these separate tests is described in the following paragraphs. Survival rates (total recoveries / number of smolts released) were calculated, arcsine transformed and tested for normality following D'Agostino's test as described in Zar (1996). Results of the normality testing are presented in Table 1.

Table 1. D'Agostino's test results for normality on SAR's or proportional return data sets for total recoveries or Columbia River Basin only recoveries for fall Chinook salmon released from RSH (1997-2001 brood years). Critical value $D_{0.05, 10}$ = >0.251 and <0.285.

Data	Total Recoveries	Columbia River Basin
SARs	0.276 (NS)	0.273 (NS)

The G-test statistic (Fowler et al. 2005) was used to test for significant differences in SAR's within each brood year. Power of this test was estimated using simulation methods using 1,000 replicates for differences in survival between the two groups of 50-90%, assuming an average survival of 0.89% with a standard deviation of 0.72 based on 15 years of data from Priest Rapids

Hatchery. Under this simulation model, if 100,000 smolts were tagged in each raceway and had rate survival rates between 0% and 60% of the smolts in the control group, the power of detecting a true difference between control and treatment will be sufficient over 75% of the time. If survival of control and treatments were similar (≤ 25% different) then it is unlikely that any statistically significant difference can be determined.

For a second data analysis on the SARs, I used a ratio test as described in Harmon et al. 1993. This method removes the inter-annual variation in survival rates, and has more statistical power than a standard ANOVA. For this test I calculated the ratios of the SARs (rearing pond : raceway). The null hypothesis for this analysis is the ratio of SARs from the rearing pond and raceways equals one (i.e., equal survival). The 95% confidence interval (CI) for all years ($N = 5$) was calculated using the natural log (ln) of the ratios. The 95% CI was retransformed to test the null hypothesis that the overall ratio is equal to one. The null hypothesis will be rejected if the 95% CI did not contain one. For this test, a CI bound greater than one would indicate that rearing pond fall Chinook salmon survived at higher rates compared to those fall Chinook salmon in the raceways.

In addition to the tests on survival rates, I noticed that returning adult age composition was different between the groups, with fewer age 3 and more age 5 fish in the rearing pond group compared to the raceway groups. While not part of the original hypothesis, I was curious, so I tested the adult age composition and length at age composition between the rearing pond and raceway groups using the G-test statistic (Fowler et al. 2005).

Results

Juvenile Rearing

Results from weekly growth monitoring and documentation of release size, and downstream migration tracking (survival and timing) through the use of PIT tags have been previously summarized in annual progress reports (Fuss et al. 1998, 1999; Bumgarner et al. 2000; Ross et al. 2001, 2002). The following is a summary of those earlier reports.

1). Smolts released from the rearing pond generally had higher downstream migrant survival rates to McNary Dam as compared to the raceway groups (4 of 5 years). Comparisons of pooled survival rates between the rearing pond and raceway #1 were not significantly different ($F = 0.36$, $P = 0.53$), but were significantly different between the rearing pond and raceway #2 ($F = 5.39$, $P = 0.048$).

2). Smolts released from the rearing pond had shorter migration times to McNary Dam ($F = 17.1$, $P = 0.003$) as compared to the raceway groups (5 of 5 years), but travel time to John Day or Bonneville dam between the groups were not significantly different, despite rearing pond smolts overall took fewer days.

3). Observations from biological staff indicated that rearing pond smolts generally appeared more "smolted" than raceway smolts, they were eating natural feed (insects) in the pond, and it was kept in mind that the rearing densities were a lot less in the rearing pond compared to the raceways. All of these factors were considered important in determining overall survival.

2006 Returns

In October 2006, RSH staff hired temporary workers and security guards for the capture, processing, and security of returning fall Chinook salmon to the hatchery. Between 1 October and 31 December, RSH staff captured 117 adults and 1 jack fall Chinook salmon in the trap facility. All fall Chinook salmon were checked for tags, with four males and zero females with CWTs recovered for the season. All adult fall Chinook salmon with CWTs had their snouts removed with individual labels placed with each snout. All snouts were gathered at the end of the season, shipped to the head lab in Olympia, and processed in the off-season. At the time of completion of this report, data collected from the CWT adults had yet to be posted on the RMPC database. However, the data was obtained from WDFW headquarters in Olympia. None of the snouts recovered from RSH in 2006 were from our study groups.

Adult Evaluation

Staff queried and summarized the PSMFC RMPC database for CWT recoveries from fall Chinook salmon released from RSH during the study years. The estimated number of adult fall Chinook salmon by recovery locations and total recoveries are presented in Appendix A. The SARs for fall Chinook salmon reared in the rearing pond or in the concrete raceways based on total recoveries (Ocean, Columbia River and tributaries, and RSH) and recoveries within the Columbia River Basin only are presented in Figure 2 and Figure 3, respectively.

Under either recovery scenario, significant survival differences between the rearing pond and raceway-reared groups were detected in three of the five brood years (Table 2). Figures 2 and 3 show that fall Chinook salmon reared in an earthen pond had equal or higher survival rates than those reared in the raceways for every year of the study. For two of the five brood years, survival differences in the treatment groups were around 90% of the rearing pond group (Table 2). Two other years were about 60% of the rearing pond group, and one year had returns of about 40% of the rearing pond group. Based on the result of the power analysis, raceway reared groups that survived at >75% of the rearing pond groups were not statistically significant, while years where survival was <75% were significant.

Table 2. Statistical tests of smolt-to-adult survivals on fall Chinook salmon between treatment and control groups based on two recovery scenarios.

Brood Year	Control (SAR %)	Treatment (SAR %)	Treatment SAR (% of Control)	Significant Test	G-test Statistic (*P-Value*)
SARs Based on Total Recoveries (Ocean, Columbia River and tributaries and RSH)					
1997	0.122	0.106	86.9%	No	5.4 (*0.10>P>0.05*)
1998	0.564	0.371	65.8%	Yes	38.5 (*P<0.001*)
1999	0.289	0.119	41.2%	Yes	38.0 (*P<0.001*)
2000	0.138	0.088	63.8%	Yes	15.8 (*P<0.001*)
2001	0.397	0.373	94.0%	No	5.4 (*0.10>P>0.05*)
SARs Based on Columbia River Recoveries Only					
1997	0.088	0.085	96.6%	No	1.2 (*P>0.50*)
1998	0.395	0.277	70.1%	Yes	25.6 (*P<0.001*)
1999	0.215	0.076	35.3%	Yes	34.0 (*P<0.001*)
2000	0.088	0.060	68.2%	Yes	11.1 (*0.005>P>0.001*)
2001	0.227	0.211	93.0%	No	4.2 (*P>0.10*)

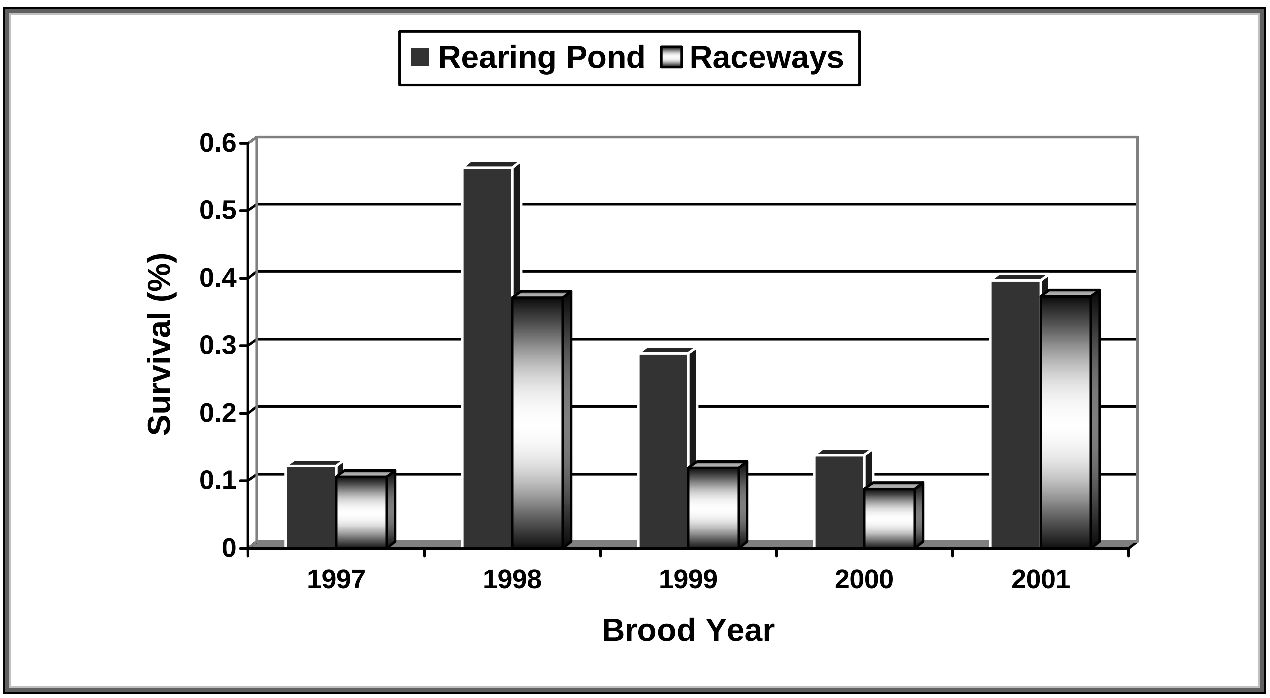

Figure 2. Estimated total smolt-to-adult survival of URB fall Chinook salmon from treatment and control groups released at RSH test facility for the 1997-2001 brood years.

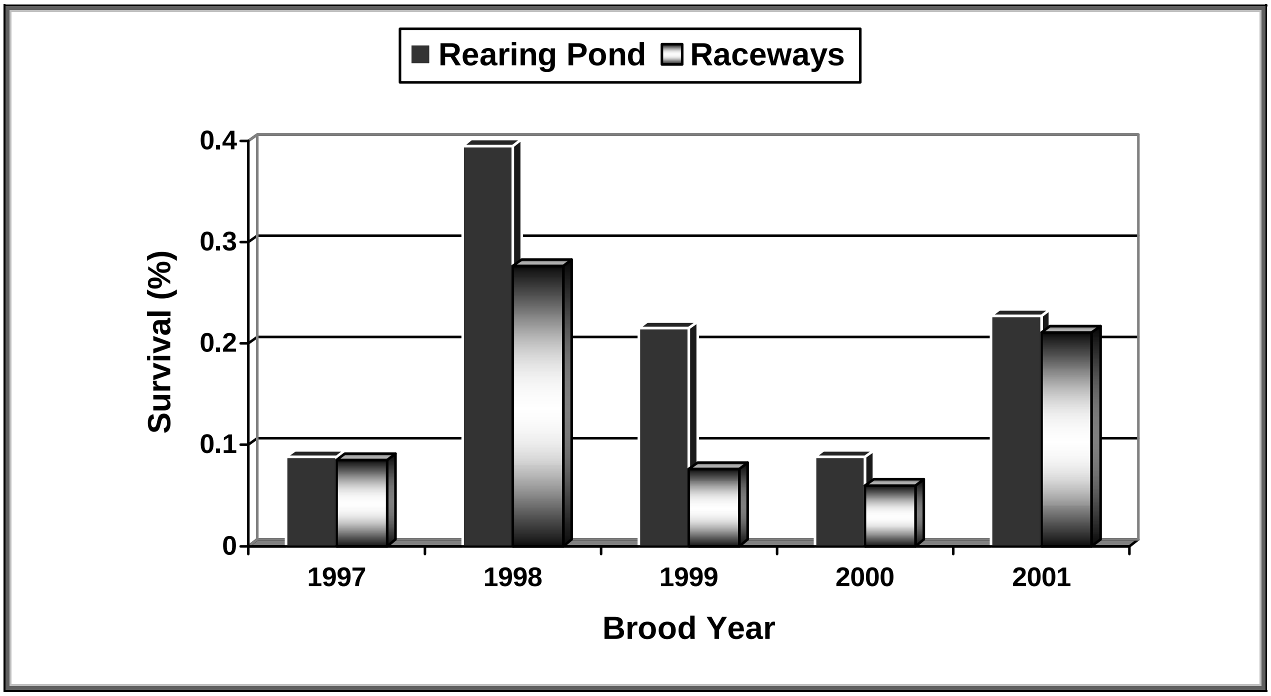

Figure 3. Estimated smolt-to-adult survival of URB fall Chinook salmon to the Columbia River Basin only from treatment and control groups released at RSH test facility for the 1997-2001 brood years.

For the second data analysis of the SARs, I calculated the ratio of Rearing Pond:Raceway group for all adult recoveries (Ocean, Columbia River and tributaries, and RSH), and for recoveries within the Columbia River Basin only. Based on the range of the 95% confidence intervals, a significant difference was found for the Columbia River recoveries only (95% CI = 1.02-1.52). There was no significant difference in the total recoveries scenario (95% CI = 0.96-1.60), though the result was skewed in the same direction, indicating more fish returned from the rearing pond group. These results support the previous analyses and find that the fall Chinook salmon in the rearing pond survived at a significantly greater rate compared to the raceway-reared fall Chinook salmon over the course of the study.

In addition to summarizing the adult return data for SARs, I also analyzed the data for differences in age composition and mean length at age between the treatment and control groups. While mean release size was not significantly different between the treatment and control groups in any of the years, returning age composition was significantly different. Fewer age 3 (G-test = 5.3, P = 0.025) and a greater number of age 5 adult fall Chinook salmon (G-test = 7.0, P = 0.005) returned from the rearing pond group compared to the treatment raceways (Figure 4). There was also fewer age 2 fish in the rearing pond group compared to the raceways, but it was not significant. Mean length of adult fall Chinook salmon by age class was not significantly different (using the same statistical test as the age composition) among the groups (Figure 5).

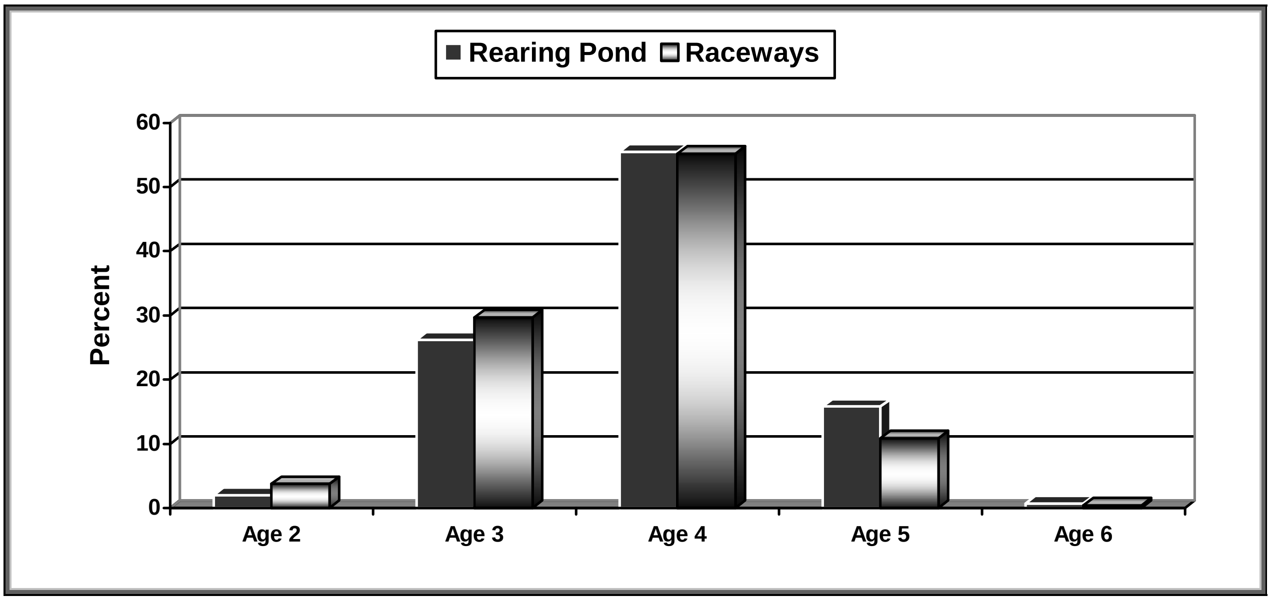

Figure 4. Mean age composition of adult returns from subyearling fall Chinook salmon released from RSH Test Facility rearing pond or raceways from 1997-2001 brood years.

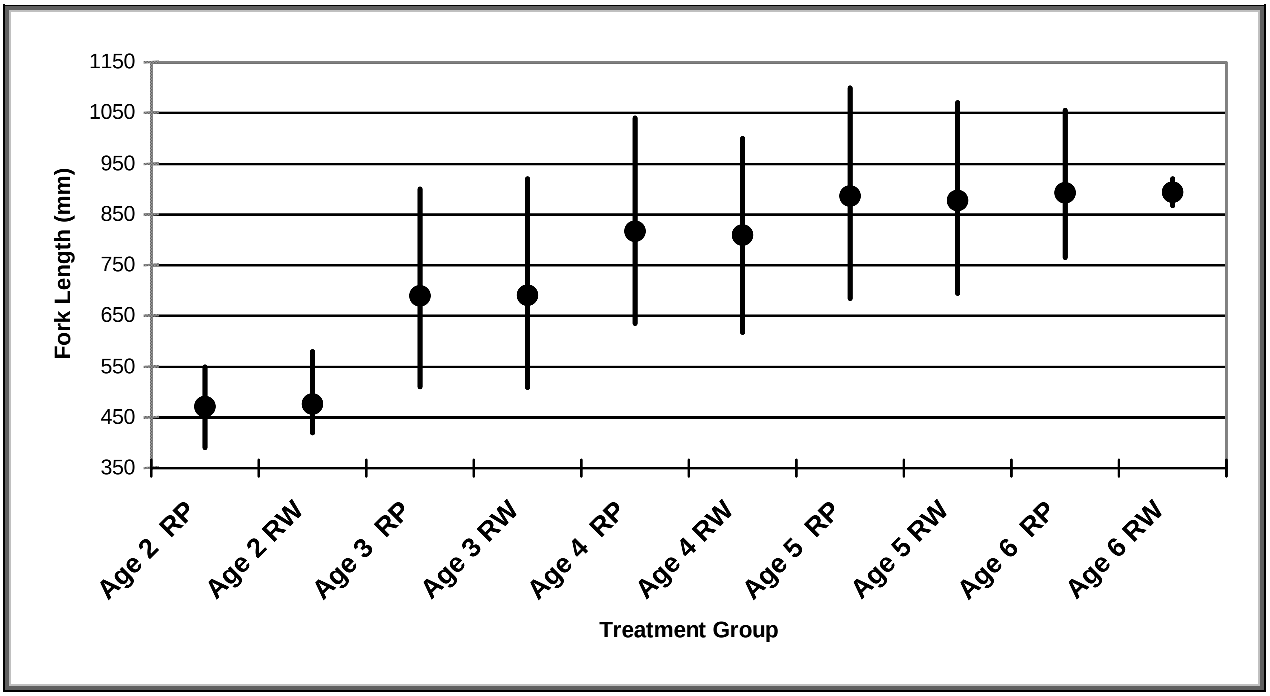

Figure 5. Minimum, maximum and mean length at age of adults returning from subyearling fall Chinook salmon released from RSH Test Facility rearing pond or raceways from 1997-2001 brood years.

Final Discussion & Recommendations

Data obtained from the juvenile rearing/release portion (phase 1) of the study showed that fall Chinook salmon in the rearing pond appeared more smolted, had faster migration, and had greater downstream survival than those reared in the concrete raceways. These results are supported by the adult return data, where raceway reared smolts had ≤65% overall the survival rates when compared to smolts reared in earthen ponds. Two separate data analyses on the adult survival data showed that fall Chinook salmon in the rearing pond returned at greater rates that those reared and released from the concrete raceways. Adult fall Chinook salmon age composition was also different with more age 5 adults retuning in the rearing pond group, and more age 3 adults in raceway groups. Although, returning adult size by age class was not significantly different between the groups. Managers will need to evaluate whether these are significant factors that could affect downstream fisheries (i.e. size of gillnets used in fisheries). I conclude that the most effective approach to increase URB fall Chinook salmon production at RSH would be construction of an additional rearing pond(s) that could rear about 1-2 million smolts annually.

Avian predators are a major problem at RSH. During the 2002 release year, it was estimated that herons and gulls consumed about 1.25 million smolts from the rearing pond. Continued losses of this magnitude on an annual basis would greatly affect adult returns and make it difficult to achieve the required proportion of the John Day mitigation goal at this facility. While concrete raceways would be more easily covered with bird netting than the large earthen rearing pond at RSH, the data suggests it to be more beneficial to construct additional rearing ponds. Other large rearing ponds (WDFW's Lyons Ferry Hatchery) are shaped differently and have been successfully covered with bird netting. Examples of covered rearing ponds at other hatchery facilities should be examined prior to any construction at RSH. Before any final decisions are made based on the results presented here, a cost-benefit analysis needs to be performed to determine which rearing method would provide the most adult fall Chinook salmon for the dollars spent (rearing pond, release structures, avian predator netting, hatchery water infrastructure).

Citations

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Appendix A

Fisheries and hatchery recoveries of subyearling URB fall Chinook salmon released from RSH 1997-2001 brood years

Appendix A: Table 1. Fisheries and hatchery recoveries of subyearling URB fall Chinook salmon released from RSH 1997-2001 brood years.

						Ocean Fisheries					Columbia River Basin									
Release Location	Brood year	# Fish / pound	CWT fish released	Total number released	% of Total Release	High Seas	AK	CAN	WA	OR	Lower Columbia River Sport	Lower Columbia River Net	Bonneville Hatchery	Upper Columbia River Sport	Upper Columbia River Hatchery / Trap	Snake River Hatchery / Trap	Ringold Springs Hatchery	Total Recoveries	Columbia Basin SAR	Total SAR
Rearing Pond	1997	57	217,216	3,192,170	6.80	4	46	19	0	4	3	68	0	74	9	0	38	265	0.088	0.122
	1998	41	201,533	3,276,160	6.15	0	217	92	25	6	61	267	0	353	25	2	89	1,137	0.395	0.564
	1999	47	210,392	3,223,221	6.53	2	87	58	8	0	30	127	0	230	12	1	53	608	0.215	0.289
	2000	43	184,665	2,793,183	6.61	0	34	50	7	2	8	51	1	68	4	0	30	255	0.088	0.138
	2001	50	132,039	2,063,589	6.40	0	85	117	11	11	43	76	0	85	11	0	85	524	0.227	0.397
	Total		***945,845***	***14,548,323***	***6.50***	***6***	***469***	***336***	***51***	***23***	***145***	***589***	***1***	***810***	***61***	***3***	***295***	***2,789***	***0.201***	***0.295***
Raceway 1	1997	53	113,528	149,482	75.95	0	26	6	2	0	7	36	0	48	5	0	11	141	0.094	0.124
	1998	46	105,066	105,338	99.74	0	61	10	3	3	0	92	1	101	15	1	55	342	0.252	0.326
	1999	46	106,981	108,028	99.03	0	27	13	7	0	2	18	0	17	3	0	15	102	0.051	0.095
	2000	40	89,706	89,706	100.00	0	19	17	5	0	0	19	1	4	2	0	12	79	0.042	0.088
	2001	51	109,640	109,640	100.00	0	81	88	9	0	8	70	0	72	6	0	69	403	0.205	0.368
	Total		***524,921***	***562,194***	***93.37***	***0***	***214***	***134***	***26***	***3***	***17***	***235***	***2***	***242***	***31***	***1***	***162***	***1,067***	***0.131***	***0.203***
Raceway 2	1997	63	114,498	149555	76.56	0	13	0	1	0	8	31	0	31	4	0	13	101	0.076	0.088
	1998	48	102,418	102502	99.92	0	77	23	12	7	13	99	0	137	18	0	41	427	0.301	0.417
	1999	47	101,900	105348	96.73	0	20	22	0	1	0	27	0	48	5	0	23	146	0.101	0.143
	2000	38	92,016	92,016	100.00	0	3	5	2	0	12	26	0	20	0	0	13	81	0.077	0.088
	2001	50	109,791	109,791	100.00	0	79	86	11	2	21	57	0	57	4	0	98	415	0.216	0.378
	Total		***520,623***	***559,212***	***93.10***	***0***	***192***	***136***	***26***	***10***	***54***	***240***	***0***	***293***	***31***	***0***	***188***	***1,170***	***0.155***	***0.225***