PERFORMANCE OF A NEW STEELHEAD LINE DERIVED FROM HATCHERY PARENTS COLLECTED IN AUTUMN IN THE GRANDE RONDE RIVER

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INTRODUCTION and BACKGROUND

This paper provides information about the developmental history and performance assessment of a new line of Wallowa stock steelhead created from Wallowa stock hatchery parents that were collected by angling in autumn in the Grande Ronde River of northeastern Oregon. Our performance assessment is not complete because coded-wire tag reporting from adult tag recoveries from the first generation (brood years 2004-2007) of releases is incomplete and adults have yet to return from all of the second generation releases (brood years 2008-2011).

The Grande Ronde steelhead hatchery program was initiated in the late 1970s as part of the Lower Snake River Compensation Plan (LSRCP) to mitigate for Oregon harvest opportunities lost by construction of the four lower Snake River dams. The founding parents for the Wallowa program were endemic to the Snake basin and the resulting stock is a proven, productive hatchery population that has reestablished a fishery with effort, catch rates, and harvest levels similar to historic, pre-dam levels (Flesher et al. 2011). The LSCRP program goal of returning 9,184 adults to the compensation area was met in 1997-98 and in every year since 2001-02 (Warren et al. 2011).

Prior to closure of the native steelhead fishery in 1974, the majority of harvest opportunity occurred in the lower Grande Ronde River during fall (Carmichael et al. 1990), whereas peak harvest of the current Wallowa hatchery stock typically occurs in the spring (Flesher et al. 2011). This apparent shift in timing of harvest opportunities may be associated with selection of the founding parents. The Wallowa stock was sourced from collections of Snake River steelhead during spring at Ice Harbor and Little Goose dams, and incorporated embryos from Pahsimeroi Fish Hatchery, Idaho. Since 1979, Wallowa stock adults returning to Wallowa Hatchery, Big Canyon, and Cottonwood traps (WA) have been utilized as broodstock.

Most Wallowa stock steelhead migrate through the Columbia River corridor in mid-summer, when water temperatures are warmest; a behavior that may encourage migrants to use relatively cooler mid-Columbia tributaries, particularly the Deschutes River, as thermal refuge. Once they enter the mouth of the Deschutes River, Wallowa stock steelhead are apparently more likely to stray far upriver than are other Snake River basin hatchery stocks (Figure 1). Managers hypothesized that the earliest returning portion of the Wallowa stock run—those adults that traveled through the Columbia River mainstem quickly and arrived in the Grande Ronde River in the fall—would produce progeny that would be less likely to stray. Therefore, in response to straying concerns, co-managers agreed to modify the Wallowa program to reduce impacts of hatchery releases on out-of-basin native stocks.

The desire to increase fall harvest opportunities in the lower Grande Ronde River, combined with efforts to reduce straying of Wallowa stock steelhead in the Deschutes basin, provided impetus for the Wallowa autumn line broodstock experiment. By creating an alternate brood line of Wallowa stock steelhead collected from the lower Grande Ronde River by angling in October, the progeny were expected to contribute to the following objectives: 1) modify run-timing to emphasize fall-entry to the Grande Ronde River, 2) reduce straying of Wallowa stock steelhead in the Deschutes River, 3) enhance fishing opportunities in the lower Grande Ronde River in fall, and 4) maintain the successful performance exhibited by the standard Wallowa stock.

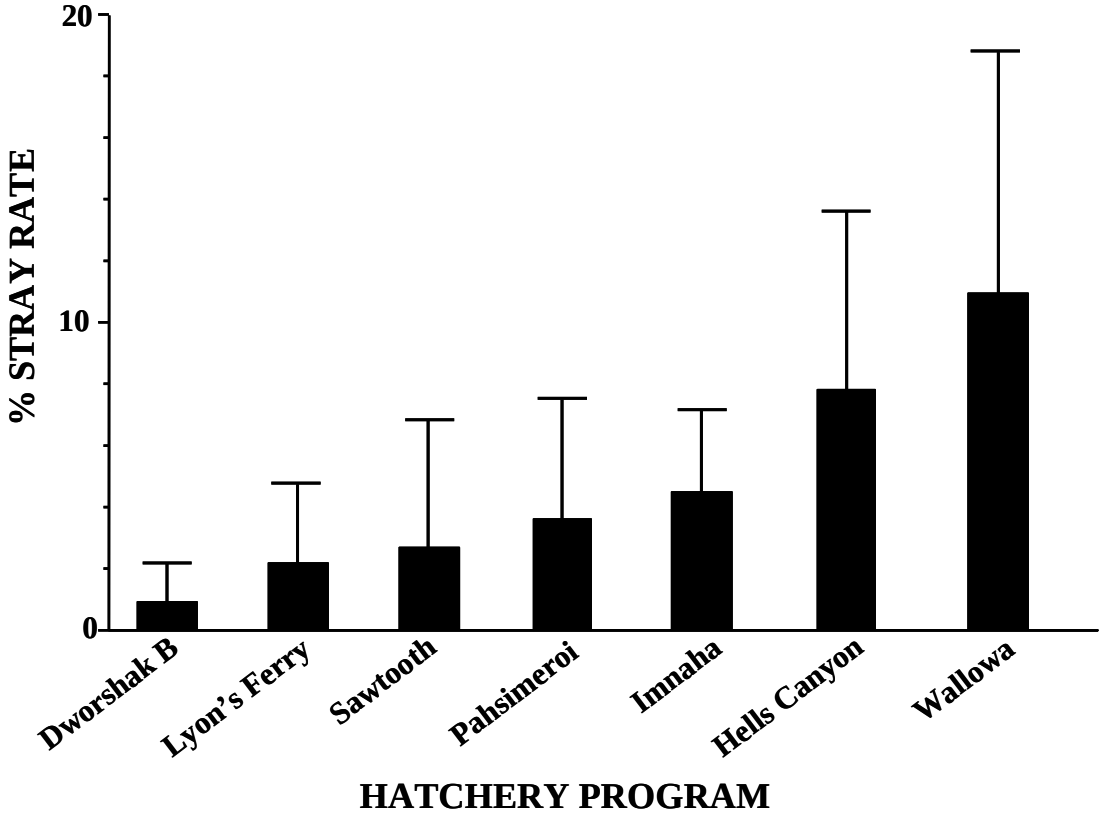

Figure 1. Average (± 1 SE) annual Deschutes River straying rates of hatchery steelhead stocks released into the Snake River. This analysis is based on 11 to 24 years of coded wire tag recovery data (Carmichael and Hoffnagle 2006).

BROODSTOCK COLLECTION and HATCHERY REARING

Broodstock collection for the first generation of the autumn line was by angling in the Grande Ronde River near Troy, Oregon, in October of 2003 through 2006 (for brood years 2004 through 2007; Figure 2). Volunteer anglers from the general public and biologists from ODFW, the Nez Perce Tribe, and the Confederated Tribes of the Umatilla Indian Reservation participated in broodstock collection of between 77 and 115 fish annually. Upon landing a hatchery steelhead, anglers placed the fish in a tube and oriented the tube into the flow where it was held until an ODFW biologist could take possession. Fish were then passive integrated transponder (PIT) tagged for future identification and transferred to the Wallowa Hatchery to be held until spring for spawning. Broodstock from the autumn line and the standard Wallowa stock were spawned separately, eggs were incubated to the eyed stage at the Wallowa Hatchery then transferred

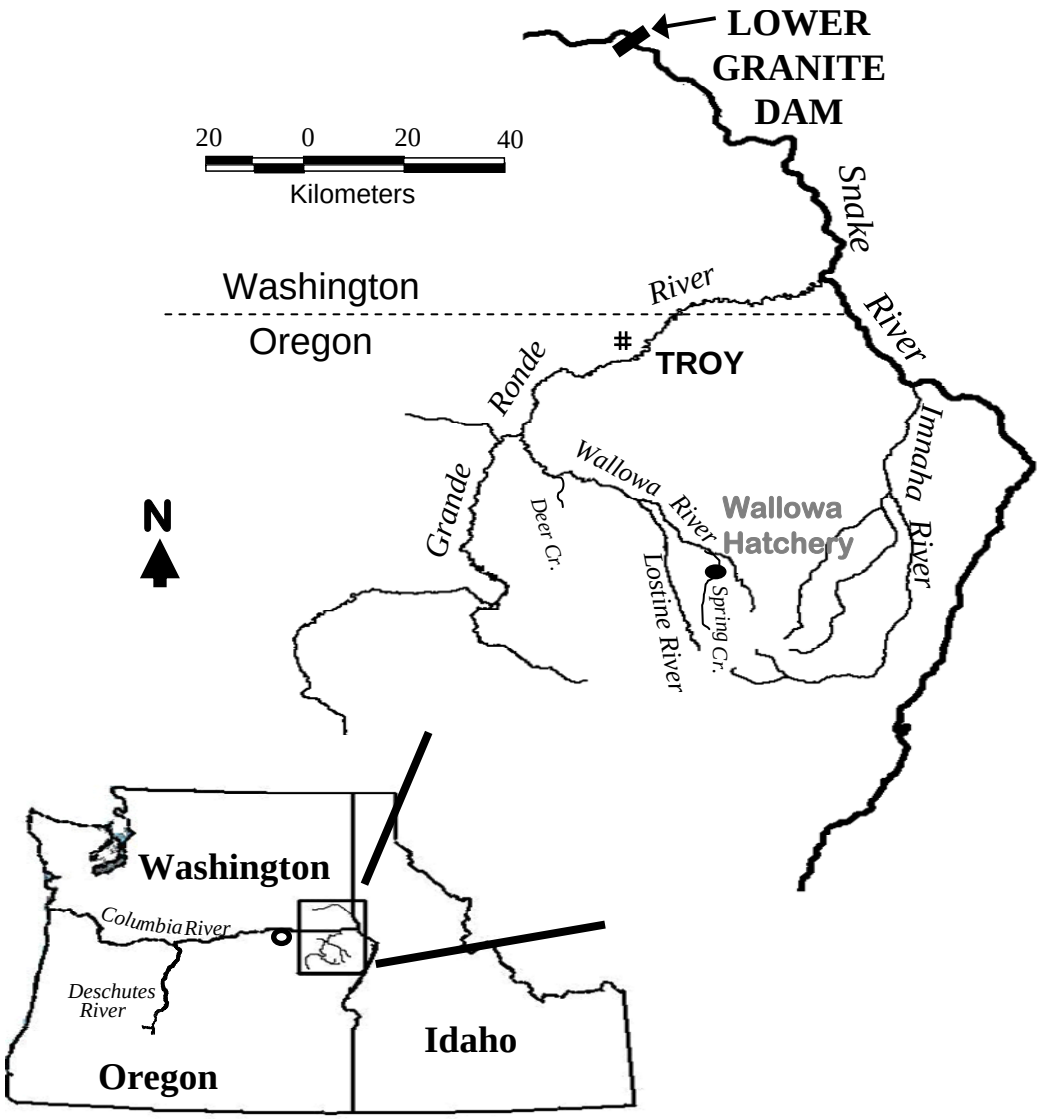

Figure 2. Map of northeast Oregon showing the location of the Wallowa Hatchery on the Wallowa River, and the town of Troy on the lower Grande Ronde River near where autumn line adult broodstock were collected. Inset shows location of study area within a three-state region, with an open circle marking the Irrigon Fish Hatchery's location.

to the Irrigon Hatchery located near the town of Irrigon, Oregon for final incubation and rearing to the yearling smolt stage. While in the hatchery, eggs and fish from the two broodstock lines were kept separate but rearing was the same, except that the standard Wallowa stock was size-graded as fry whereas the small numbers of autumn line fry did not allow for size grading. Number of first generation autumn line reared for release ranged between 114,763 and 221,317, whereas the

number of standard Wallowa stock ranged between 257,806 and 447,755 (Table 1). Second generation autumn line smolts are the progeny of first generation adult broodstock that returned to Wallowa Hatchery and were trapped temporally across the run.

In mid-summer all steelhead were marked with an adipose fin clip and in autumn approximately 100,000 fish each from the autumn line and standard stock groups received a left ventral fin clip and a coded-wire tag (CWT) snout implant that was uniquely coded by release group. To estimate smolt survival and migration timing to Lower Granite Dam, representative samples from each release group were PIT-tagged in November or December. Then in February or early March all fish were transferred to two acclimation ponds at the Wallowa Hatchery, acclimated for no less than 27 d, and released into the river. Prior to release, a representative sample of 50 fish from each acclimation pond were collected for weight (g) and fork length (mm) measurements, from which Fulton's condition factor (K = weight/length^3 x 10^5; Anderson and Neumann 1996) was calculated. To sample fish, water volumes in the ponds were first drawn down, then fish were crowded to one end of the pond using a beach seine, and lastly a large volume dip net was used to collect a sample of fish. Sampled fish were held in a net pen until measurements on anesthetized fish could be made soon thereafter. We used adult PIT tag recoveries at Columbia and Snake River dams to track adult migration timing and to calculate smolt-to-adult survival to Bonneville Dam and smolt-to-adult return to Lower Granite Dam. Coded-wire tag recoveries from out-of-basin locations were used to calculate a stray rate index. We consider our estimate to be an index of straying behavior, rather than a true stray rate, because the intended ultimate destination of steelhead captured in out-of-basin fisheries is unknowable; if un-captured some individuals may have returned to their release location.

Table 1. Numbers of autumn line and standard stock smolt releases by brood year and corresponding numbers of fish that were PIT tagged.

		Number Released		Number PIT tagged	
Brood Year	Generation	Autumn line	Standard stock	Autumn line	Standard stock
2004	F_1	114,763	309,751	3,777	3,769
2005	F_1	138,053	447,755	3,567	3,566
2006	F_1	221,317	257,806	3,567	3,586
2007	F_1	140,082	345,425	3,558	6,914
2008	F_2	241,010	129,447	3,599	5,203
2009	F_2	94,548	230,013	3,425	7,634
2010	F_2	207,535	292,986	5,673	7,773

Irrigon Hatchery personnel were successful at rearing autumn line and standard stock juveniles to a similar size, because the average difference in fork length and condition factor just prior to release was generally small (Figure 3) and judged to be biologically inconsequential.

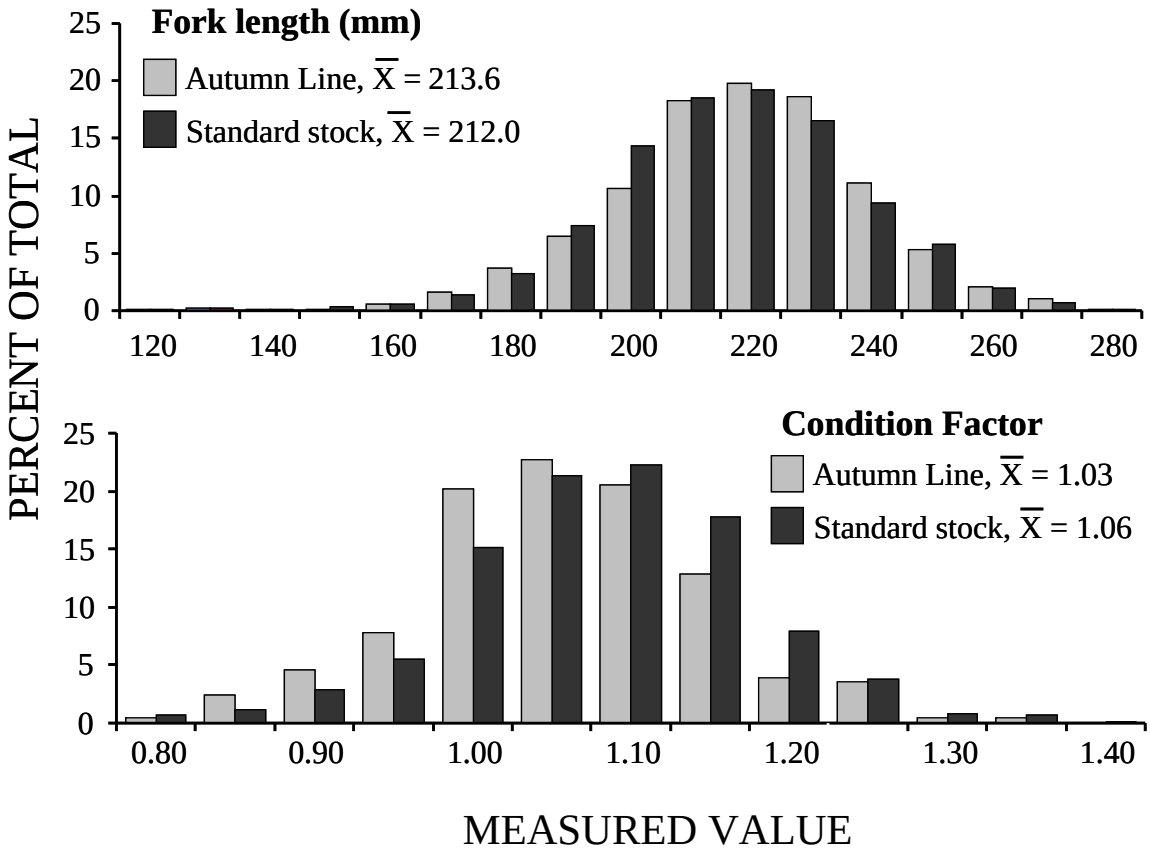

Figure 3. Average fork length (top graph) and condition factor for Wallowa stock autumn line and standard stock for first generation release groups, brood years 2004-2007.

POST RELEASE PERFORMANCE

Following release to the river, smolts took between 17 and 33 days to arrive at Lower Granite Dam (Table 2). In most release years the difference in arrival timing between autumn line and standard stock adults was less than two days. Because arrival timing was similar it is likely that smolts from the two groups were loaded onto barges and shipped to below Bonneville Dam ,or allowed to migrate in-river, at similar rates. Outmigation survival was also similar between the two groups, ranging between 73% and 84%.

Table 2. Annual average travel time and percent outmigration survival to Lower Granite Dam of Wallowa stock autumn line and standard stock smolts, brood years 2004-2010.

	Travel Time (d; ± SD)		Outmigration Survival (± CI)	
Brood Year	Autumn line	Standard stock	Autumn line	Standard stock
2004	23.5 (7.0)	23.8 (7.6)	77 (2.1)	77 (3.0)
2005	21.6 (11.5)	22.4 (10.8)	73 (6.6)	74 (5.3)
2006	30.8 (6.7)	30.1 (8.7)	71 (22.3)	78 (41.0)
2007	31.3 (11.3)	33.1 (12.9)	84 (19.3)	84 (13.5)
2008	18.3 (9.7)	17.3 (11.2)	82 (4.8)	80 (3.9)
2009	27.1 (11.8)	23.8 (11.9)	80 (29.0)	82 (17.0)
2010	21.9 (12.1)	20.1 (12.9)	77 (8.2)	74 (6.0)
Averages	*24.9*	*24.4*	*77.7%*	*78.4%*

Based on PIT tag detections, adult steelhead progeny from the first generation (brood years 2004-2007) of autumn line releases returned to Bonneville Dam an average of about 9 days earlier than their standard stock counterparts (Figure 4). As the run moved upstream to McNary Dam the difference in return timing widened to 24 days, then to 26 days at Lower Granite Dam. However, second generation adult steelhead from the autumn line may not be displaying a similar early return timing behavior. Based on 1 and 2-ocean adults returning from brood year 2008 and 1-ocean adults returning from brood year 2009, average return timing of the second generation autumn line adults to Bonneville Dam was only 5 days earlier than the standard stock, the difference widened to 13 days at NcNary Dam, then it contracted to 9 days at Lower Granite Dam (Figure 5). We will delay making final determinations about the run timing of second generation autumn line adults until several years more data is obtained.

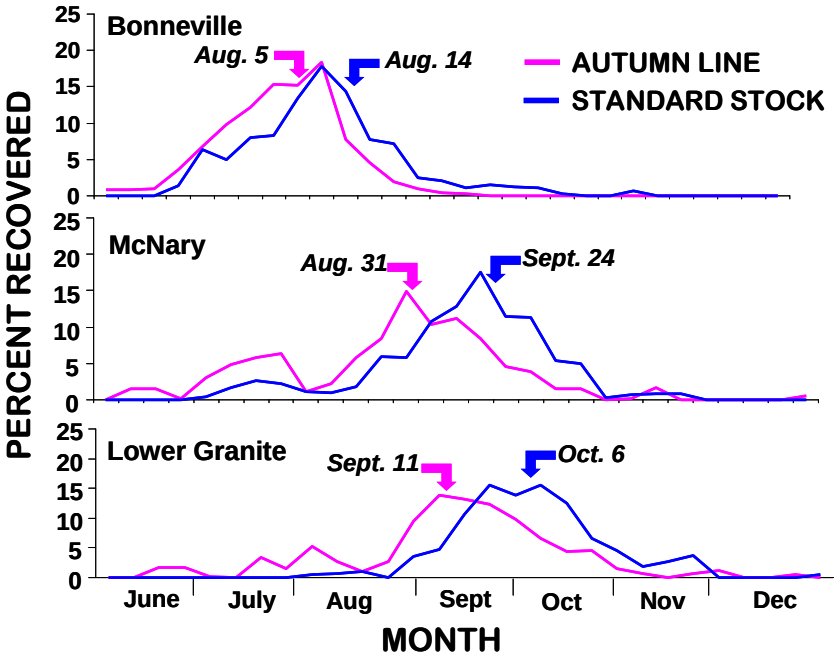

Figure 4. Average adult return timing to Bonneville, McNary, and Lower Granite dams of the first generation (brood years 2004-2007) of the autumn line compared to return timing of the standard Wallowa stock.

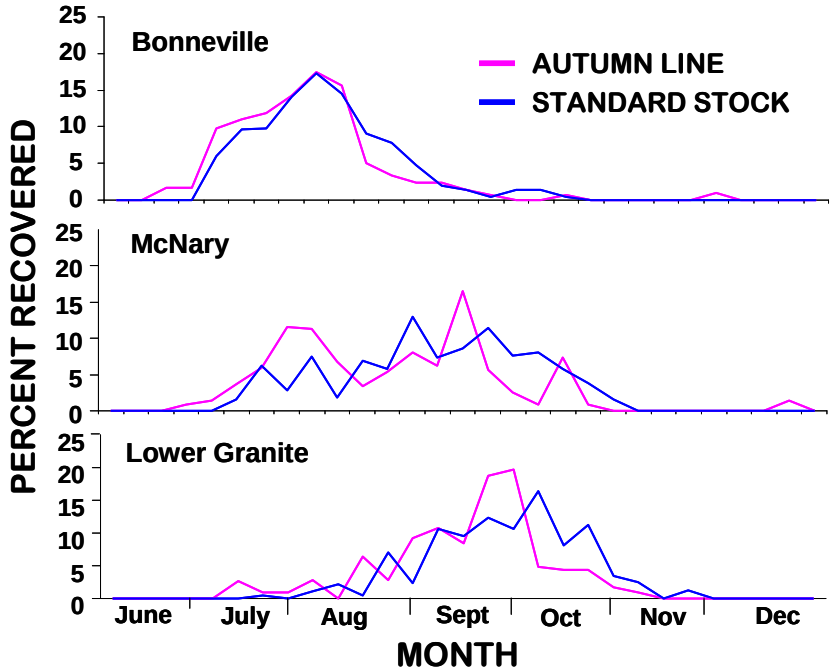

Figure 4. Average adult return timing to Bonneville, McNary, and Lower Granite dams of the second generation of the autumn line compared to return timing of the standard Wallowa stock. This data is only adults from brood year 2008 and 1-ocean adults from brood year 2009.

At the outset of this experiment we did not hypothesize that adults from the autumn line would exhibit higher post-release survival than the standard Wallowa stock; however, smolt-to-adult survival of the first generation of the autumn line to Bonneville Dam was 32% higher than the standard Wallowa stock, a difference that was statistically significant (Paired *t*-test, $P = 0.004$; Figure 5). For brood year 2008, the one complete year of second generation adult returns, the smolt-to-adult survival advantage of the autumn line narrowed to 23.5%. Smolt-to-adult return to Lower Granite Dam was 35% higher for the autumn line (Figure 6), a difference that was also significant ($P = 0.001$). A potential explanation for the stronger survival of the autumn line lies in the adult age at return data (Figure 7), which shows that a higher portion of the autumn line adult run is composed of 1-ocean individuals compared to the standard Wallowa stock. Since the autumn line returns at a younger age they suffer one less year of ocean mortality.

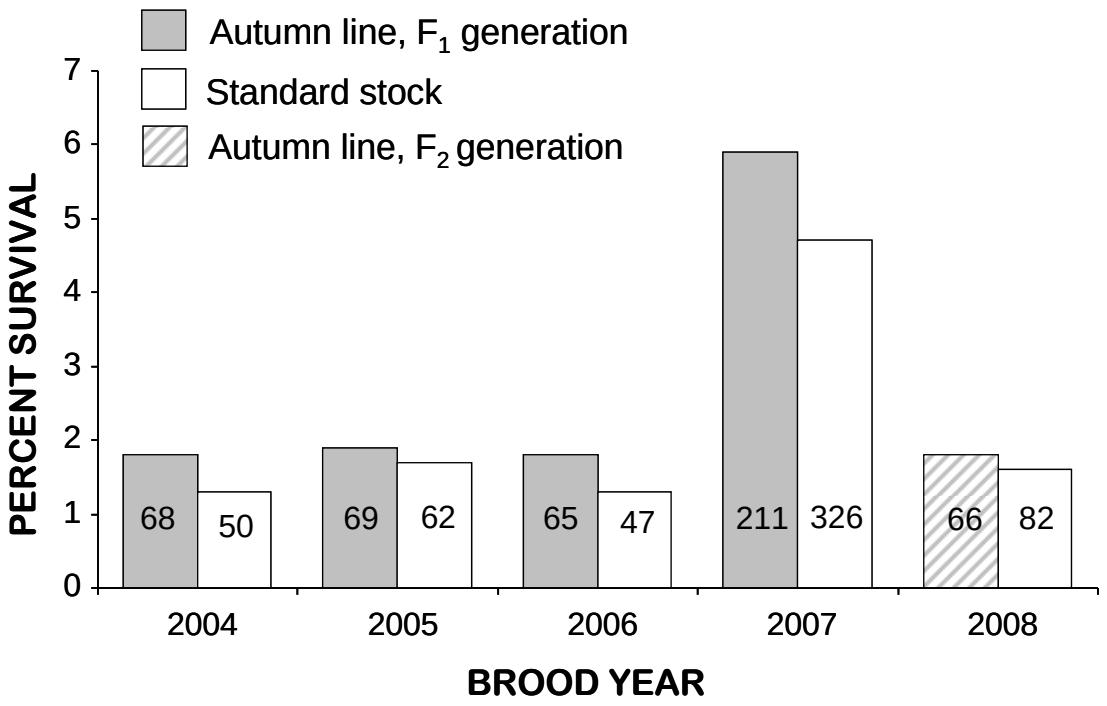

Figure 5. Smolt-to-adult survival to Bonneville Dam based on PIT tag recoveries of autumn line and standard Wallowa stock steelhead. First generation (F_1) autumn line adults are from brood years 2004-2007, whereas 2008 is the only complete brood year in which complete results exist for the second generation. Numbers inside bars are the number of PIT tags detected.

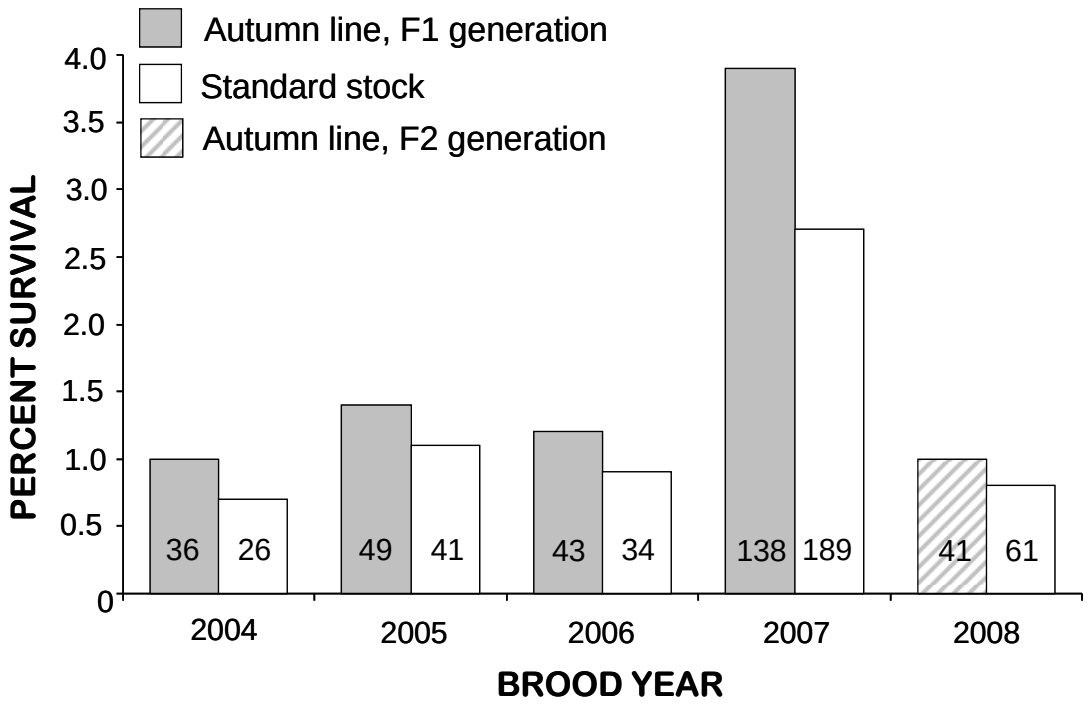

Figure 6. Smolt-to-adult return to Lower Granite Dam based on PIT tag recoveries of autumn line and standard Wallowa stock steelhead. First generation (F_1) autumn line adults are from brood years 2004-2007, whereas 2008 is the only complete brood year in which complete results exist for the second generation. Numbers inside bars are the number of PIT tags detected.

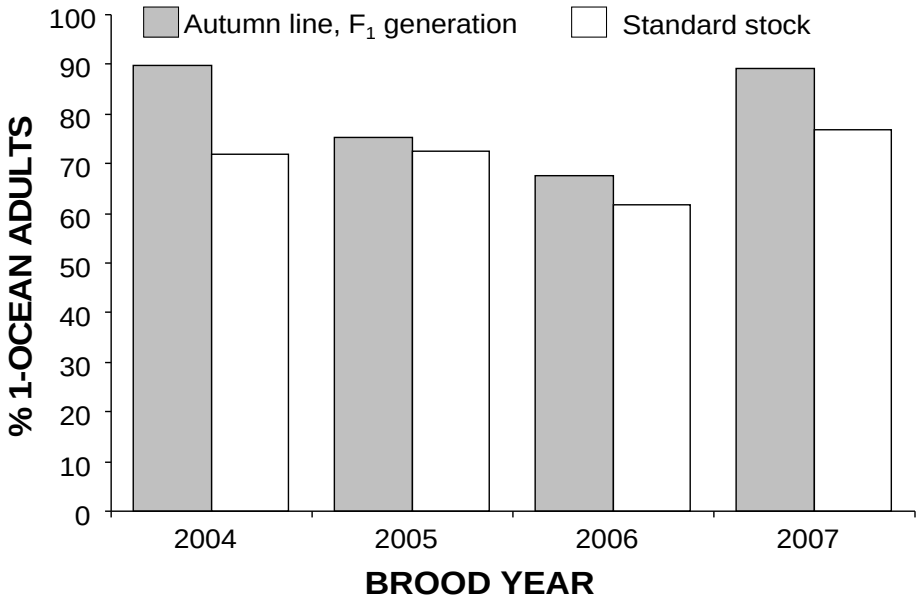

Figure 7. Adult age at return for autumn line and standard Wallowa stock steelhead.

Coded-wire recovery data for the first generation of autumn line releases is not yet complete. Nevertheless, stray rate estimates based on coded-wire recoveries are not encouraging as they suggest that the autumn line is at least as prone to stray as is the standard Wallowa stock (Figure 8). However, we see an interesting pattern in the year-to-year stray rate estimates for both the autumn line and the standard Wallowa stock, which is that stray rates were much higher in 2004 than in subsequent years. This pattern may be attributable to a reduction in the percentage of smolts that were barged, since barged fish are known to stray at higher rates (Fish Passage Center 2007). An estimated 94% of brood year 2004 smolts were barged, but that percentage dropped to 41% for brood year 2007 releases.

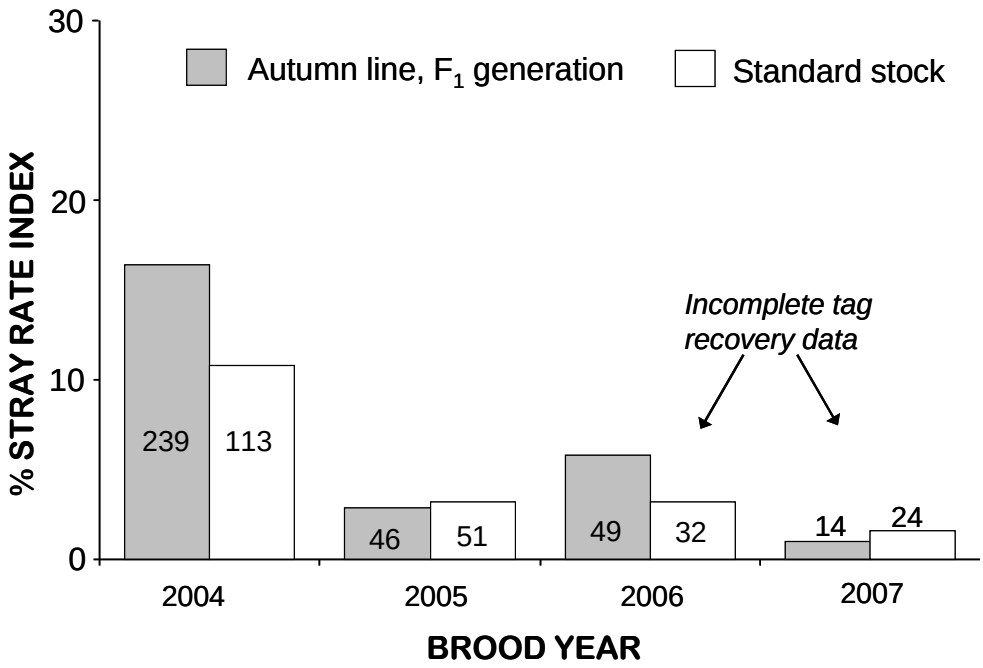

Figure 8. Percent stray rate index for autumn line and standard Wallowa stock steelhead. Coded-wire tag recovery data for brood year 2006 is mostly complete but data for brood year 2007 is mostly incomplete.

In most years over 90% of Wallowa stock stray tag recoveries come from the Deschutes River basin. Therefore, to better understand whether our straying conclusions based on the stray rate index are correct, we also examine tag recovery data in a spatio-temporal context. In the Deschutes basin about 80-85% of tag recoveries for both the autumn line and the standard Wallowa stock are above the lower river fishery, which occurs from the mouth to river kilometer 69 (Figure 9), indicating that the autumn line is just as likely to migrate upstream of the lower river. However, a higher portion of the autumn line adults reach traps located in the upper reaches of the Deschutes basin before 1 February, indicating that autumn line fish stray farther upstream earlier in the season.

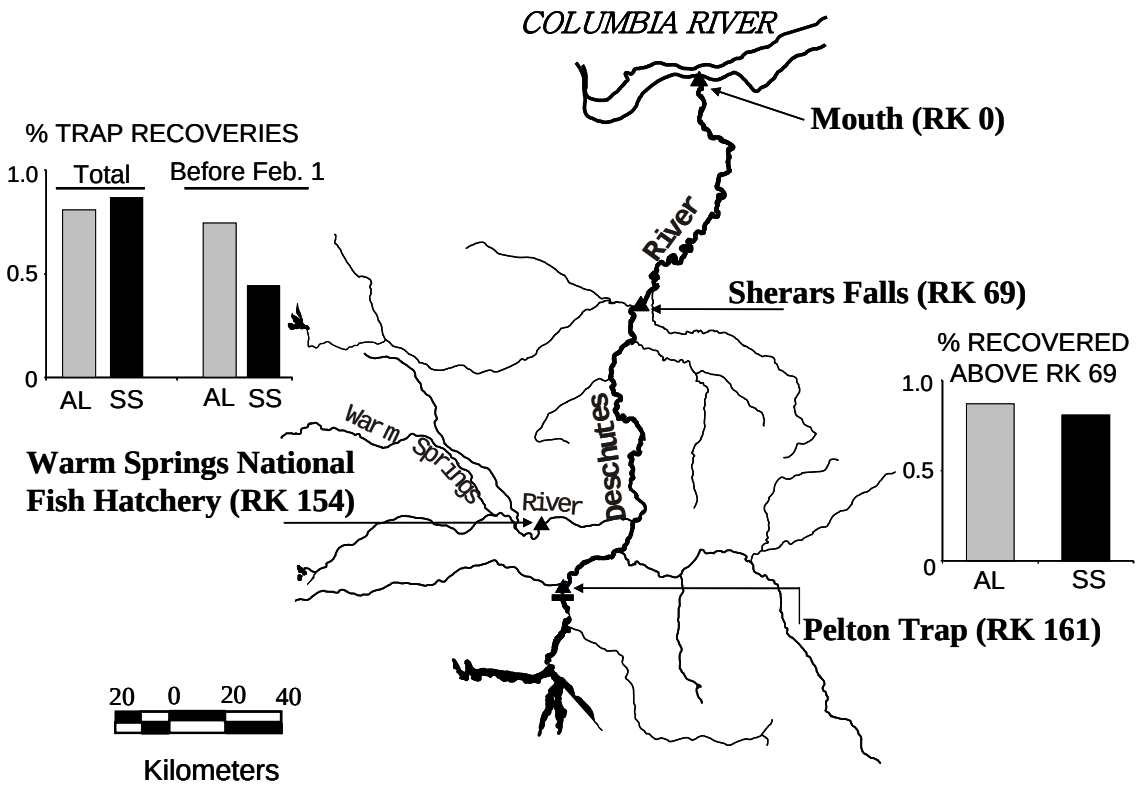

Figure 9. Map of the Deschutes River basin. The lower river fishery takes place from the mouth to Sherars falls, PIT tagged fish are detected at Sherars Falls, and steelhead are trapped at the Pelton Dam trap and at the Warm Springs National Fish Hatchery. Inset graphs show the percentage of autumn line (AL) and standard Wallowa stock (SS) adults recovered above Sherars Falls and the percentage at fish traps. Fish that are trapped after 1 February are believed to be true strays that will not exit the Deschutes River to continue their migration to the Grande Ronde basin.

Studies show that a portion of Snake River basin steelhead that enter the Deschutes River in summer and become vulnerable to capture will ultimately exit to resume their migration up the Columbia River. To investigate the propensity for Wallowa stock steelhead to demonstrate this pattern we gathered PIT tag detection information at Sherars Falls and at McNary Dam (or at dams farther upstream) on the Columbia River upstream from the Deschutes River for four run years (Table 3). The annual number of Wallowa stock PIT tag detections at Sherars Falls is relatively low, in part because the efficiency of the PIT tag antenna is thought to be low. However, the data suggests that about 20% of both the autumn line and the standard Wallowa stock that are detected at Sherars Falls will later be detected at McNary Dam or farther upstream.

Table 3. Detections of PIT-tagged Wallowa stock steelhead at Sherars Falls on the Deschutes River and the percent that subsequently exited the Deschutes and were detected at McNary Dam or sites farther upstream.

Run year	Experimental group	Number detected at Sherars Falls	Number later detected at McNary or upstream	Percent later detected at McNary or upstream
2007-2008	Autumn line	5	0	0
	Standard stock	7	5	71
2008-2009	Autumn line	6	1	17
	Standard stock	3	0	0
2009-2010	Autumn line	19	4	21
	Standard stock	15	2	13
2010-2011	Autumn line	5	2	40
	Standard stock	5	0	0
Total Autumn line		35	7	20
Total Standard stock		30	7	23

We conduct steelhead creel surveys in the Grande Ronde basin from September through mid April; the entire length of the steelhead fishing season. If the creel surveyor encountered an angler that harvested a hatchery steelhead with a ventral fin clip--indicating the presence of a coded-wire tag in the snout—then with permission from the angler the surveyor removed the fish's snout for later processing to determine the numerical tag code, and thus the release group from which the fish originated. Using such fisheries contribution data collected in our creel surveys, as well as data from other creel surveys conducted within the Lower Snake River Compensation Plan area, we can determine if the autumn line has been successful at enhancing autumn fisheries.

Since first generation autumn line adults displayed an earlier average return timing to Lower Granite Dam, we hoped they would contribute more substantially to the autumn fishery. Indeed,

coded-wire tag recovery data in the Grande Ronde basin indicates that a greater proportion of the autumn line are harvested in September and October compared to the standard Wallowa stock (Figure 10). Within the Lower Snake River Compensation Plan area, the estimated number of autumn line adults harvested per 1,000 smolts released also shows that autumn line release groups contribute more fish to the September through November fishery than the standard Wallowa stock (Figure 11). Within the compensation plan, a greater portion of autumn line adults are harvested in Oregon than outside Oregon (Figure 12), whereas that pattern is reversed with the standard Wallowa stock.

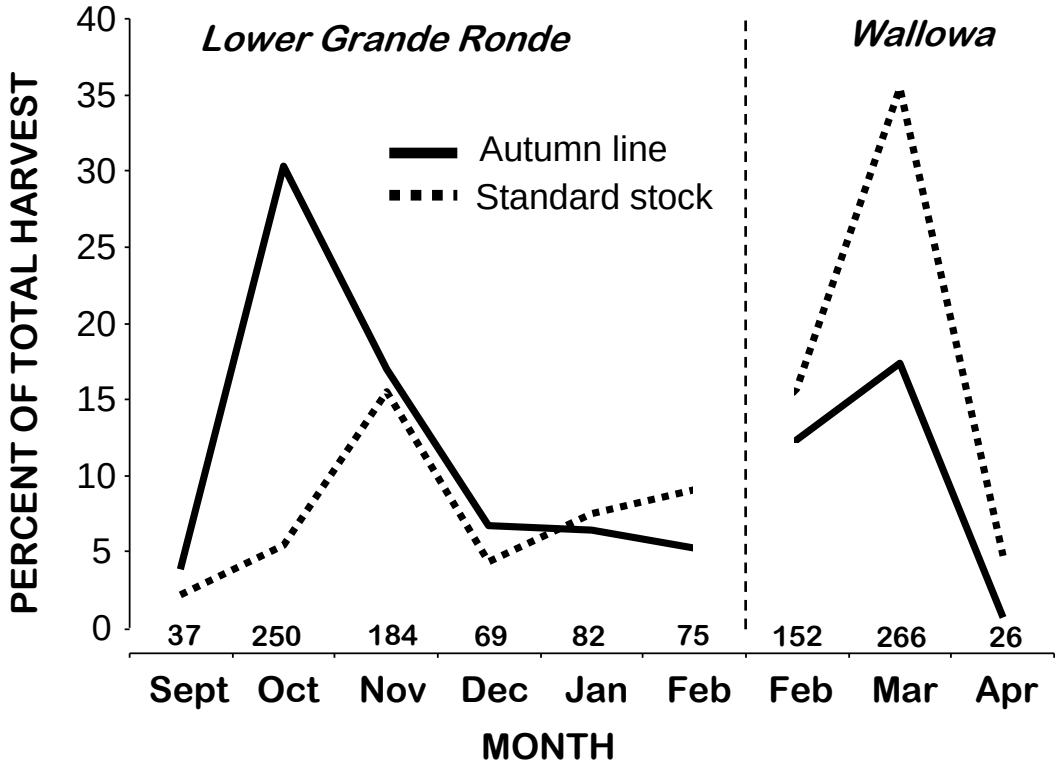

Figure 10. Monthly percent harvest of the total estimated annual harvest of autumn line and standard Wallowa stock in the Grande Ronde River basin, run years 2006-07 to 2008-09. The estimated monthly number of coded-wire tag recoveries on which this analysis is based is shown along the x-axis. Fisheries in the Grande Ronde River occur in the lower river from September through February and from February through April in the Wallowa River, an upstream tributary to the Grande Ronde River.

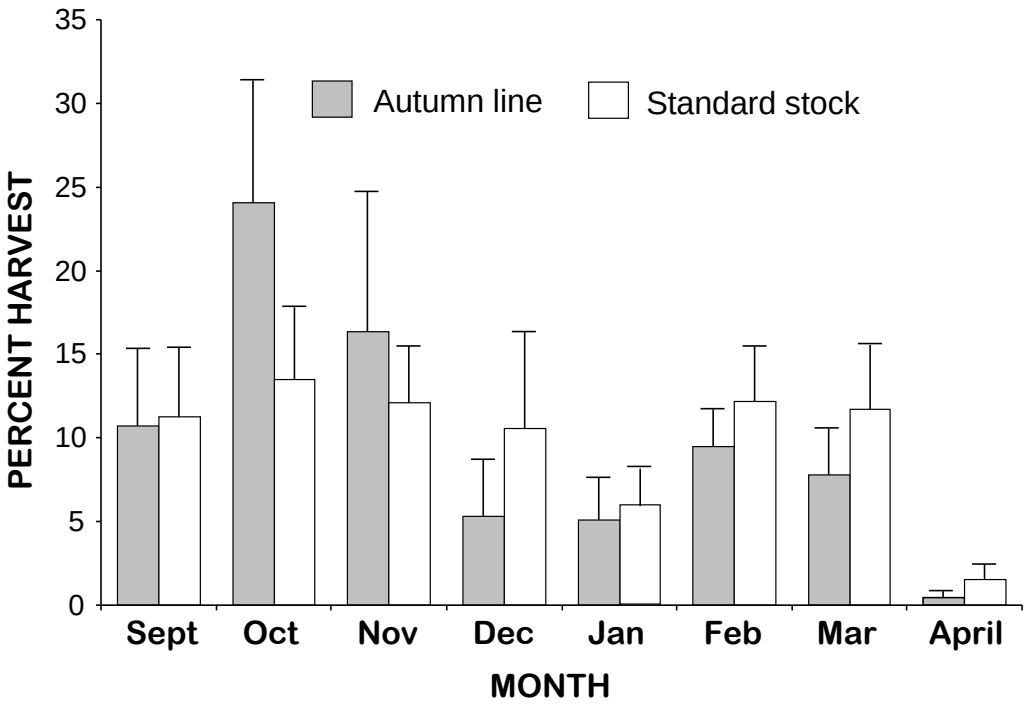

Figure 11. Average monthly autumn line and standard Wallowa stock adults harvested in the Lower Snake River Compensation Plan area per 1,000 smolts released. Data is from run years 2006-07 to 2008-09. Vertical bars = 1 SE.

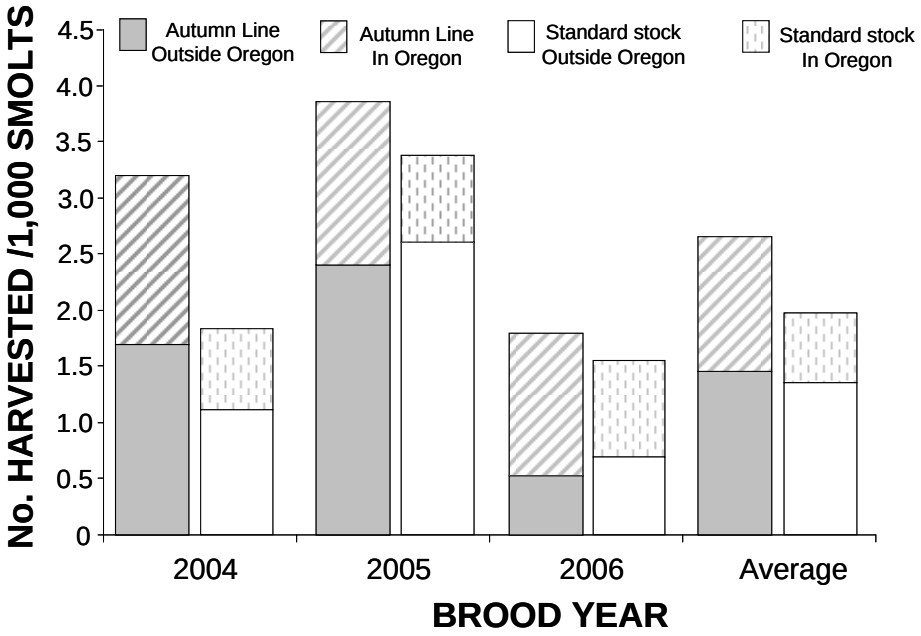

Figure 12. Number of adult autumn line and standard Wallowa stock steelhead harvested in the Lower Snake River Compensation Plan area per 1,000 smolts released. Data is grouped by harvest outside Oregon (solid bars) and harvest in Oregon (diagonal patterned bars).

CONCLUSIONS

The data for adult run timing of the first generation autumn line releases is complete, and it is clear that these individuals met the first objective of this project, that is, to modify run-timing to emphasize fall entry into the Grande Ronde River. However, incomplete data from the second generation leads us to suspect that these groups may not return as comparatively early to the Grande Ronde basin as first generation adults. In return year 2008 a PIT tag antenna array was installed in the adult ladder at Wallowa Fish Hatchery. When we compared tag detection dates from that array to tag detection dates for the same fish detected at Lower Granite Dam, we see a possible trend whereby the earliest returning autumn line adults to Wallowa Fish Hatchery were also the earliest to pass Lower Granite Dam. If this is a consistent year to year trend that continues in later generations of the autumn line, then it may be possible to encourage early return timing by collecting all the earliest returning individuals to the Wallowa Fish Hatchery for broodstock rather than collecting temporally from across the run. Otherwise, managers have discussed maintaining early arrival characteristics of the autumn line by periodically "refreshing" the line with new parents collected in the same manner as the first generation broodstock, i.e., via angling in October.

We did not expect to see an advantage in survival to adulthood for the autumn line. That advantage may be entirely due to an earlier age at return of the autumn line, or perhaps age at return is just one of several factors responsible for the survival advantage. Angling was used to collect first generation autumn line broodstock, and this technique can be selective for older or younger fish depending on the gear that is used (Hayes et al. 1996). Angling is also selective for fish that are more aggressive to a lure or bait, and these fish may have different metabolisms, and thus different survival rates, than fish that are not caught (Lewin et al. 2006). We will be monitoring adult returns of the second generation autumn line to see if the survival advantage continues.

Unfortunately we did not measure an autumn line straying advantage in the incomplete data we have thus far collected. However, the lower staying rates for both autumn line and standard Wallowa stock adults from the brood year 2005 through 2007 releases is encouraging. Straying of Wallowa stock steelhead may be associated with whether or not smolts are barged from Lower Granite Dam; steelhead smolts that are not barged have displayed a lower straying behavior when they return as adults (Comparative Survival Study 2011). Smolts from brood year 2004 were barged at an estimated 94% rate, whereas that rate declined to 76% for brood year 2005, 47% for brood year 2006, and 41% for brood year 2007 (Fish Passage Center 2011). If barging rates remain low it is possible that overall Wallowa stock stray rates will be acceptably low.

FUTURE OF THE AUTUMN LINE

The last year of second generation autumn line adults were spawned in brood year 2011, which

meant that for brood year 2012 a decision had to be made as to how to proceed with the autumn line. This decision was made by ODFW managers and tribal co-managers over the course of several hatchery Annual Operation Plan meetings that occurred in late 2011 and early 2012. The following text is recommendations for the autumn line that appeared as part of Appendix U to the 2012 Annual Operation Plan document.

Recommendations for BY 2012

Brood take / Production: Spawn 72 females to create 240,000 smolts from the fall brood (also known as the autumn line), which is 30% of total Wallowa stock production. Reduce standard Wallowa stock production releases accordingly to maintain total release levels at 800,000 smolts.

Rearing: Continue releasing fall brood production from Wallowa Hatchery to consolidate spawning.

Marking: Maintain current tagging and marking to assess whether the third generation performs similarly to the first generation.

Recommendations for BY 2013 and beyond

Brood take / Production: For brood year 2013, spawn 96 females to create 320,000 smolts from the fall brood line (40% of total production). For brood year 2014, spawn 120 females to produce 400,000 smolts from the fall brood line (50% of total production). Reduce production releases accordingly to maintain total release levels at 800,000 smolts.

Increasing production beyond BY 2014 will depend on our ability to manage the fall brood line in a fashion that: maintains the run timing, stock performance, and harvest benefits consistent with results of the first generation; while offering a size-at-return similar to the production line, and harvest opportunity during both fall and spring periods. In addition, final production goals will need to consider rearing space allocations at both Irrigon Hatchery and acclimation facilities, and feasible broodstock collection protocols for hatchery staff.

Long-term management of the fall brood line will likely include occasional ‘refreshing’ of the broodstock with adults collected via angling in the fall Grande Ronde fishery. We expect refreshing the fall brood line will act to sustain run timing differences observed in the F1 generation, and diversify the genetic makeup of the broodstock. Tentatively, we will plan to refresh the fall brood line during the fall of 2013. Long term strategies may employ a focused one to two-week effort as occurred in 2003-2006, or a dedicated group of volunteer anglers that collect fish throughout the fall period.

Rearing: Long term rearing strategies will ultimately depend on desired production goals for the fall brood line, our ability to differentially mark the fall brood and production lines, and brood take needs.

Marking: Long term tagging and marking strategies will largely be determined when data from the F2 generation is complete. However, to maintain two steelhead lines will require differential marking, which is currently accomplished using left and right ventral clips.

Coordination with Washington: The state of Washington currently uses Wallowa-stock steelhead in the Cottonwood program (lower Grande Ronde River) releases. Currently, Washington is considering utilizing the Wallowa fall brood line for the cottonwood program, depending on results of the current experiment. We will continue to coordinate with the state of Washington, understanding that any desire to use fall brood Wallowa steelhead in Washington programs will affect brood take goals at Wallowa Hatchery.

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