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Migration of Hatchery and Wild Steelhead Smolts from the Kalama River from 1999 through 2005

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Introduction

Genetic and ecological interactions between hatchery and wild salmonids have been widely debated and studies are numerous (Leider et al. 1984, Chilcote et al. 1986, Leider et al. 1986, Leider et al. 1990, McMichael et al. 1997, Kostow et al. 2003, Kostow and Zhou 2006, Sharpe et al. 2007). A long-term investigation of steelhead interactions on the Kalama River was initiated in 1975 by the Washington Department of Fish and Wildlife (then Department of Game: Chilcote et al. 1980).

A juvenile outmigrant monitoring component of those investigations in the Kalama River basin began in 1978 as part of a seven-year study by Loch et al. (1985). Use of the traversing fyke net methods developed by Loch et al. outmigrant studies resumed from 1992 to 1994 (Hulett et al. 1995). Juvenile outmigrant trapping was again resumed in the Kalama River in 1998, this time using rotary screw trap gear. This document describes and summarizes the results of rotary screw trapping operations conducted from 1999 through 2005. These traps provide important baseline data on wild steelhead production and hatchery steelhead outmigration for ongoing studies. The freshwater productivity data will also be used, along with adult return data, to assess steelhead population status and trends in the Lower Columbia ESU. Further, wild-broodstock hatchery programs in the Kalama release winter-and summer-run steelhead and smolt trap operation was a critical tool for evaluation of success of those programs. Specifically the objective of this study was to monitor hatchery and wild juvenile steelhead outmigrants and to document any other juvenile salmonid outmigrants in the Kalama River above Kalama Falls Hatchery (KFH).

Methods

Study Site

The Kalama River, situated in southwest Washington, flows westerly from its headwaters at Kalama Springs, located on the flanks of Mount St. Helens, to its confluence with the Columbia River at river kilometer (rkm) 117. The Kalama is a moderate-sized drainage approximately 113 km in length draining approximately 531 km^2. A fishway and trapping facility at KFH (rkm 17) is adjacent to a falls (Figure 1) that restricts salmon and steelhead passage at some flows Bradford et al. (1996).

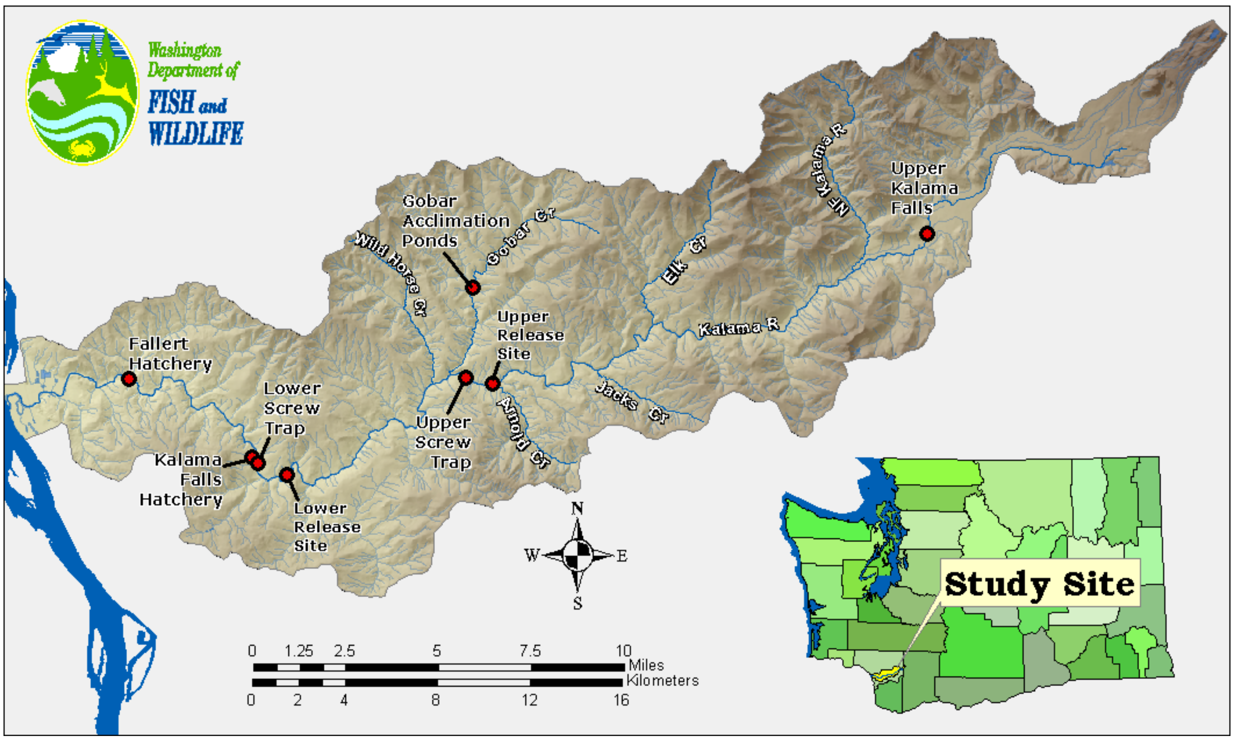

Figure 1. Location of the Kalama River basin with the lower and upper trap and release sites, Gobar Pond, and the Kalama Falls -Hatchery.

Smolt Trap Operation

The size, number, and precise location of the rotary screw traps used in the Kalama varied across years depending the flow regime, changes in channel morphology and availability of equipment and funding (Table 1). In all years, an 8 ft rotary screw trap was operated adjacent to KFH at rkm 17. In most years, a second 5 ft rotary screw trap was operated in the upper watershed at rkm 32. This provided supplemental marked fish for estimating trap efficiency of the lower trap (described below) and allowed an estimate of productivity of the upper basin in waters closed to fishing and most public access. In all cases, the traps were installed in areas where the river was constricted with a defined thalweg to increase trapping efficiencies. The traps were anchored to large trees with 3/8” steel cable at opposite stream banks and positioned parallel to the stream bank so that flow entered the cone in a straight line. Water velocity at the Upper Trap site produced between 10 and 16 cone revolutions per minute (CRPM) while water velocities at the Lower Trap site produced between 6 and 10 CRPM. Trap position was adjusted as needed to accommodate varying flows to maximize capture probability without unnecessarily risking loss of the equipment and safety of personnel.

When used, the upper trap was operated 24 hours per day. The lower trap was originally operated 24 hours per day (1999-2002), but was fished only during nighttime hours beginning in 2003 because of safety concerns for recreationalrafters passing the trap location. Historic data convincingly demonstrated that outmigrant movement during daylight hours is negligible and any outmigrants missed during the day will be accounted for with decreased capture probabilities (Loch 1985). Across all years trap operation was interrupted for brief intervals because of equipment failure, debris loading, or dangerously high flows. In most cases migrant estimates should not be affected by the interruptions because, again, capture probabilities during those intervals will decrease. In some cases when, by chance, the interruption occurred when no marked fish were available for recapture, our final estimates may be biased low.

Table 1. Summary of Kalama smolt trap operations from 1999 through 2005.

TRAPPING	LOWER TRAP			UPPER TRAP		
YEAR	BEGIN	END	LOCATION (rkm)	BEGIN	END	LOCATION (rkm)
1999	3/21/99	6/30/99	17.2	na	na	32.2
2000	3/24/00	6/28/00	17.7	4/10/00	6/17/00	32.2
2001	3/22/01	8/1/01	17.7	4/24/01	6/27/01	32.2
2002	3/23/02	6/26/02	17.7	3/24/02	6/20/02	32.2
2003	3/26/03	6/16/03	17.7	4/10/03	4/17/03[a]	32.2
2004	3/22/04	6/18/04	17.7	4/21/04	6/7/04	32.2
2005	3/16/05	6/19/05	17.7	4/10/05	6/13/05	32.2

[a] Upper trap broken early in 2003 season and funds were not available for repair.

Fish Handling

Each trap was checked and emptied of fish at least once daily in the morning. Initially, fish removed from the livebox onboard the trap were placed in 19 L buckets and anaesthetized approximately 20 at a time in MS-222 solution (~ 60 mg/l). For each specimen, we noted species, presence or absence of fin clips and other marks (described below), and recorded the fork length (FL) to the nearest mm from a subset of the migrants. Steelhead and cutthroat juveniles were classified as parr, pre-smolts, or smolts (Rawding et al. 1999). The criteria for steelhead parr included well-developed parr marks and heavy spotting across the dorsal surface; pre-smolts were those fish that measured greater than 120mm FL, had faint parr marks, less prominent dorsal spotting, silvery appearance, and no dark caudal fin margin; smolts measured greater than 120mm FL, had deciduous scales, silver appearance, and a dark pigmentation on the outer margin of the caudal fin. Since smoltification is a process that salmon, steelhead, and cutthroat undergo along their downstream migration, and these salmonids are more than 120 km from the ocean, captures of smolts and presmolts were pooled for the outmigration analysis. Parr captures were excluded from the analyses.

Fish were sampled as quickly as possible and were allowed to recover fully before being either released back into the river downstream of the trap in rapidly flowing water or marked and transported upstream of the trapping location for use in estimating trap efficiency (described below).

In most years scale samples were collected systematically from every 10th maiden fish handled (wild fish only). Ages determined from the scale samples were used to determine age composition of each emigrant cohort. Starting in 2005 genetic samples (caudal fin tissue stored in 100% ethanol) were collected and archived with the intent of eventually using them for DNA pedigree analysis and determination of race (i.e. summer-run or winter-run) and origin (i.e. hatchery or wild) composition as part of an ongoing long-term research project in the Kalama watershed (Sharpe et al. 2000, Hulett et al. 2004).

Fish Marking

In all years most marks were administered with a MICRO-Ject portable jet injector (NewWest Technologies, Santa Rosa, CA, USA) and colored ("photonic") marking formulation injected into various fins (but usually the anal fin). Occasionally, partial fin (caudal) clips were administered instead of or in combination with photonic marks to increase numbers of unique marks available to identify specific release groups.

In all cases hatchery fish were marked prior to release from the hatcheries with a variety of marks to allow assignment to the different release groups upon capture as downstream migrants and as adults upon return to the hatchery. In most years the marks used were a combination of an adipose fin clip and a coded wire tag (CWT) injected into either the snout or the left or right cheek musculature. In 2000 and 2001, we also applied liquid nitrogen cold brands to the dorsal anterior of fish as an identifying mark in addition to adipose clips and CWT placement.

The release location of smolts captured at the upper trap and then marked was 2.1 rkm upstream of the trap. The release location of fish captured and marked at the lower trap varied from year to year, due primarily to predation concerns, ranging from 1 rkm to 1.6 rkm upstream. All marked fish were allowed to recover fully from anesthesia prior to release.

Abundance Estimation

We generally used a 2-trap stratified design for our outmigrant mark-recapture abundance estimations where migrants were captured and marked at the upper trap and recaptured at the lower trap to estimate capture probabilities across weekly strata. In addition, we attempted to use a 1-trap design at the lower trap, but we were generally unsuccessful at generating reliable capture probabilities (details are provided below).

Mark-recapture estimates and standard deviations (SD) for steelhead outmigrants (wild and hatchery) were generated using the software program DARR (Darroch Analysis with Rank Reduction; Bjorkstedt 2005). DARR calculates a Petersen maximum likelihood estimate for stratified populations as described by Darroch (1961) and illustrated in Seber (1982). We stratified mark-recapture sample periods into seven-day intervals. DARR aggregated the data as needed to prevent estimator failure due to small sample size, while still maintaining as much of the original structure as possible (Bjorkstedt 2005).

Murphy et al. (1994) listed the standard assumptions of the Petersen method that apply in trap efficiency experiments: (1) the population is closed; (2) all fish have the same probability of capture in the first sample; (3) the second sample is either a simple random sample, or if the second sample is systematic, marked and unmarked fish mix randomly; (4) marking does not affect catchability; (5) fish do not lose their marks; and (6) all recaptured marks are recognized. During the smolt trapping season, we took steps to reduce the possibility that these assumptions were violated. Assumption 1 is that of closure, which assumes that no fish leave or enter between sampling occasions. Since smolts are actively emigrating this assumption cannot be met. However, the Petersen estimate is still consistent if the loss rate of tagged and untagged smolts is the same (Arnason et al. 1996). Therefore, the closure assumption is treated as if it were met in this study.

We tested for bias caused by violations of the remaining principle assumptions. We reasoned that the most likely violations of assumptions 2 and 3 would be because of a relationship between trap avoidance and size of the juveniles, especially with steelhead, where large steelhead might avoid the trap more readily. We addressed this issue by testing for differences in recovery rates by length. Although Seber (1982) recommends a comparison of recaptured fish with those not seen again, this is not possible with the batch mark we used for smolt trapping. For batch marked fish, we followed the recommendation of Thedinga et al. (1994) and compared recaptured fish with all marked fish. Assumptions 4, 5, and 6 were tested by holding marked fish to assess tag loss, tag readability, and handling mortality. Properly applied MICRO-Ject marks were easily identified and retention consistently exceeded 99% (Sharpe and Glaser 2007). Field staff were trained to properly apply marks and identify marked fish. Also, we intentionally marked only those fish that were not obviously injured or descaled during trapping or handling. Taken together, by marking only healthy fish and testing for delayed negative effects of handling and marking, we increased the likelihood that we were releasing groups of marked fish that were representative of the populations we were assessing.

Results

Trapping Model Selection: 1-trap vs. 2-trap

Whenever possible we used the stratified 2-trap model for estimating abundance of hatchery and wild steelhead migrants (Table 2). In all years when we could make a comparison between results obtained from 1-trap and 2-trap designs the capture probabilities for the 2-trap design were consistently higher than capture probabilities for fish marked at the lower trap, trucked upstream, and then recaptured in the same trap (Table 3 and Figure 2). Because we were unable to derive any reasonable explanation why fish that had to migrate more than 19 km downstream before recapture were entrained in the trap at a higher rate, it seems much more plausible that the capture probabilities of fish released a shorter distance upstream from the lower trap were biased low. We concluded that use of a 1-trap design would consistently generate abundance estimates that were biased high. However, an important implication of that conclusion is that in years when only one trap was operated (1999 and 2003) our estimates are probably biased high.

We compared abundance estimates derived from capture probabilities of marked wild fish to those in which marked wild and hatchery fish were combined. As noted above, we were limited to using only fish marked at the upper trap. Because a relatively small number of fish were marked at that site (and consequently a small number of marked fish were recaptured at the lower trap), to increase our mark group we thought pooling wild and hatchery fish, if appropriate, would increase precision of our abundance estimates. Abundance estimates derived using capture probabilities from marked wild fish did not differ significantly from estimates derived from capture probabilities of pooled wild and hatchery fish (Figure 3). The estimates were highly correlated ($R^2 = 0.959$). Further, the estimate for the slope coefficient was not significantly different from one (Slope $\pm$ SE = 1.076 $\pm$ 0.0474, $P > 0.05$) and the estimate for the y-intercept did not differ significantly from zero (Intercept $\pm$ SE = -2376 $\pm$ 1473, $P = 0.121$). Therefore, we concluded that the pooling of marks from hatchery and wild fish was appropriate.

Tests for Size Selectivity

In K-S tests for bias due to size selectivity of the trapping operation we found no statistically significant differences in the size of either hatchery or wild steelhead marked at the upper trap and recaptured at the lower trap (Table 4). We conclude that our estimates were not biased due to size selectivity.

Abundance Estimates

Estimates for combined annual production of naturally produced summer- and winter-run steelhead smolts from the Kalama River are provided in Table 2 with additional details (weekly capture and recapture summaries) provided in Appendix Table 1. Production estimates varied widely from a low in 2000 of 20,301 ± 2,858 (Estimate ± SD) to a high in 2001 of 41,508 ± 6,676, excluding what is very likely an incorrect (biased high) estimate of 52,175 ± 7,156 fish in 2003 when only the lower trap was operating.

We attempted to derive an adjusted abundance estimate for migrants in 2003 to correct for what appeared to be a very large bias. We thought that if there was a constant, predictable relationship between estimates of capture probabilities from the one-trap and two-trap designs we could multiply the one-trap estimate by a correction factor to obtain a more reliable migrant estimate. We were not successful because while the two-trap estimates of capture probabilities were always higher that those of the one-trap design, the differences were not proportionately constant. Using linear regression there was no evidence for a statistically significant relationship between the seasonal capture probabilities ($R^2 = 0.188$, $F = 0.696$, $P = 0.465$).

Emigrant estimates for hatchery fish also varied widely from year to year and from stock to stock but in general the proportion of hatchery fish planted that successfully emigrated from the system was high in the early years of each program and decreased thereafter. Abundance estimates, variability around those estimates, numbers of fish planted and the proportion of those fish emigrating are provided in Table 2.

Table 2. Steelhead emigration estimates from 1999 through 2005. "Wild" refers to naturally- produced summer- and winter-run steelhead combined. WBWR, WBSR, and HWR indicate wild brood winter-run, wild brood summer-run, and domesticated hatchery (Chambers Creek Stock) winter-run smolts and presmolts, respectively. KFH and OTHER refer to Chambers Creek stock HWR reared at the Kalama Falls Hatchery (KFH) and Lewis or Elochoman Hatcheries (OTHER), respectively. The estimates are derived from the 2-trap design (except for 1999 and 2003) with capture probabilities obtained from recapture of marked wild and hatchery steelhead migrants combined (see text). For hatchery fish, the number of fish of each type that were planted and our estimates of the 95% confidence intervals for the percent successfully migrating are provided.

YEAR		WILD	WBWR	WBSR	HWR KFH	HWR OTHER
1999[1]	Estimate	26,543	34,565	--	30,035	35,730
	SD	7,025	10,872	--	8,740	9,512
	# Planted	--	34,364	--	24,074	29,121
	% Migrating	--	39%-163%	--	54%-196%	59%-187%
2000	Estimate	20,301	42,147	85,179	37,506	33,715
	SD	2,858	8,197	13,464	7,708	7,322
	# Planted	--	42,246	70,227	33,528	30,569
	% Migrating	--	62%-138%	84%-159%	67%-157%	63%-157%
2001	Estimate	41,508	6,077	46,876	6,736	16,490
	SD	6,676	1,531	8,784	1,358	3,504
	# Planted	--	11,012	39,274	27,264	41,400
	% Migrating	--	28%-82%	76%-163%	15%-34%	23%-56%
2002	Estimate	25,726	9,640	29,933	6,507	20,363
	SD	3,888	777	3,090	509	1,767
	# Planted	--	22,180	38,226	16,978	44,224
	% Migrating	--	37%-50%	62%-94%	32%-44%	38%-54%
2003[1]	Estimate	52,175	37,279	45,443	28,597	--
	SD	7,156	7,619	7,275	5,761	--
	# Planted	--	13,603	36,104	61,532	--
	% Migrating	--	164%-384%	86%-165%	28%-65%	--
2004	Estimate	23,885	14,384	24,962	7,660	--
	SD	6,377	1,487	4,441	763	--
	# Planted	--	38,077	47,612	41,320	--
	% Migrating	--	30%-45%	34%-71%	15%-22%	--
2005	Estimate	20,532	3,241	4,053	5,155	--
	SD	3,535	204	217	234	--
	# Planted	--	31,916	24,471	41,436	--
	% Migrating	--	9%-11%	15%-18%	11%-14%	--

[1] Estimates may be biased high because only one trap was operated in these years (see text).

Table 3. Marked steelhead from upper trap (UT) or lower trap (LT) with recaptures at lower trap, with z-statistics (z) and significance levels (*P*) for differences in recapture proportions of fish marked and released from the upper or lower trap .

Year	UT Marks	Recaptures of UT marks at LT	LT marks	Recaptures of LT marks at LT	z	*P*
2000	262	39	1757	102	5.379	<0.0002
2001	558	59	3290	262	2.062	0.0392
2002	491	66	2455	136	6.325	<0.0002
2004	542	43	1427	60	3.319	0.0009
2005	698	107	2029	158	5.803	<0.0002

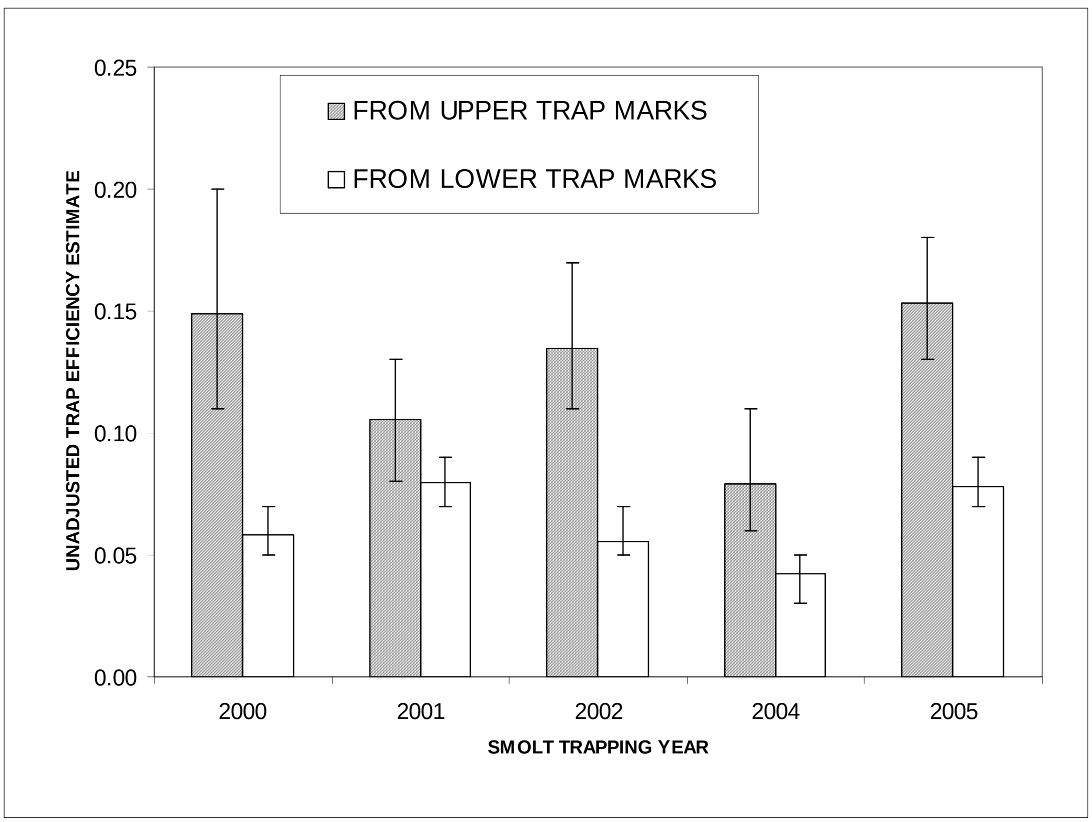

Figure 2. Seasonal trap efficiencies (fish marked/fish recaptured; ± 95% CI) for steelhead smolts marked at the upper trap (shaded) or lower trap (clear) and recaptured at the lower trap.

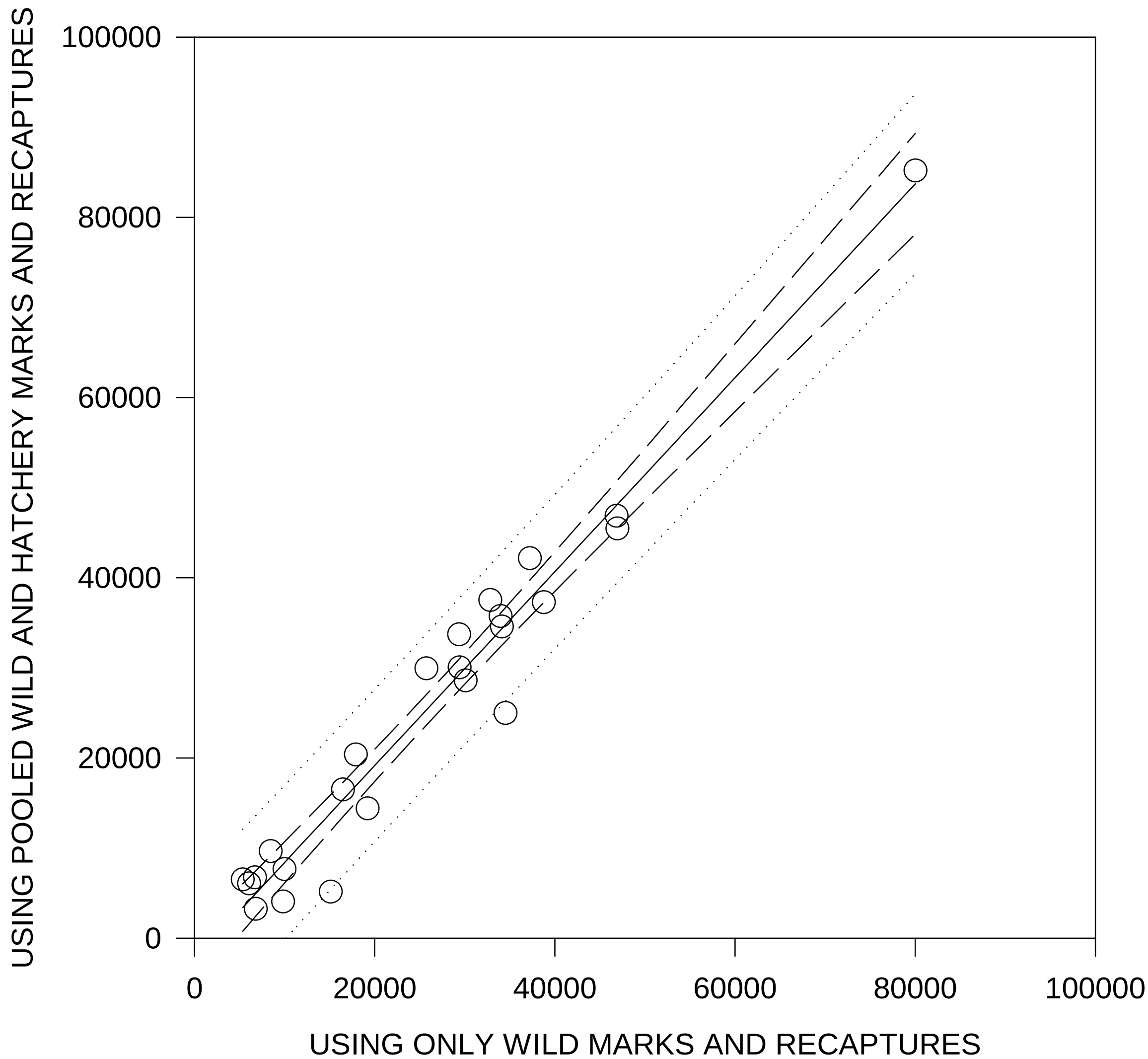

Figure 3. Relationship between migrant estimates using only wild marked fish and pooled wild and hatchery marked fish to determine trap efficiency.

Table 4. Kolmogorov-Smirnov test results comparing size of steelhead marked and released (M) from the Upper Trap and recaptured (R) at the Lower Trap. Lengths were not obtained from enough hatchery steelhead in 2001 to perform the test. Only one trap was operating in 1999 and 2003.

Year	Origin of Fish	Sample Size		Mean FL (mm)		SD		KS Test Results	
		M	R	M	R	M	R	*D*	*P*
2000	Hatchery	129	13	205	196	18	14	0.299	0.201
	Wild	262	39	181	181	18	19	0.139	0.5
2001	Hatchery	NA	NA	NA	NA	NA	NA	NA	NA
	Wild	554	60	171	173	17	17	0.127	0.322
2002	Hatchery	125	66	195	195	17	15	0.078	0.949
	Wild	491	66	171	170	18	16	0.099	0.599
2004	Hatchery	316	54	195	194	14	20	0.156	0.195
	Wild	542	43	173	171	16	15	0.098	0.819
2005	Hatchery	160	102	190	189	16	14	0.141	0.157
	Wild	698	107	173	170	19	14	0.108	0.215

Discussion

Model Selection

The original intent of operating two traps in the Kalama was to both increase the number of marked fish available for recapture in the lower trap and to permit an estimate of smolt production from the upper watershed within the portion of the river that is considered a wild steelhead sanctuary. The finding that we should rely exclusively on upper-trapped fish as a source of marked fish for estimating capture probabilities in the lower trap is problematic. The total number of usable marked fish was less than ideal for robust estimates and the marking regimen at the upper trap generally did not allow testing for delayed migration of marked fish.

Several explanations for the differences in estimates of capture probabilities seem plausible. First, differential loss to predation of marked and unmarked fish might explain low estimates of capture probability if release sites and methods for lower trap marked fish compromised the short-term survival of the marked fish. All marking and transport protocols are thought to be physiologically stressful events for fish (Sharpe et al. 1998, Sharpe 2007) and can reasonably be assumed to compromise the well being of fish including, for example, reducing the ability to avoid predators. Further, lower trap release sites were generally lower gradient shallow glides where predators might have been able to more easily obtain their prey. We did observe numerous avian predators including great blue herons and, especially, common mergansers in and near the lower trap release sites. Fewer predators, in some years none, were observed in or near the upper trap release location.

Also, because the fish marked at the lower trap were generally released during daylight hours a relatively short distance above the trap, it may be that they left the release site during daylight hours and were able to see and thus avoid the trap more easily. Support for this possibility includes the observation by Klungle et al. (2006) where they released marked fish after dark and found that capture probabilities for lower trap marked fish were the same or slightly higher than upper trap marked fish. However, release after dark of marked fish might also reduce susceptibility to predation.

While we accept that the fish marked at the upper trap were more suitable for estimating capture probabilities than the fish marked at the lower trap, it is not clear that estimates derived from upper trap-marked fish were not themselves biased. Upper trap-marked fish had to migrate approximately 19 km before encountering the lower trap. They would have been subjected to some level of mortality during that migration. This would include potential predation in the same reaches immediately above the lower trap that might have compromised the lower trap-marked fish that we failed to recapture. However, the upper trap-marked fish would likely travel those reaches during darkness and might also have achieved some degree of recovery from handling stress, so their vulnerability to predation could be reduced.

Collectively, these results suggest that future smolt trapping in Kalama should use the 2-trap design or, alternatively, further explore the benefits of night release in avoiding survival or migration issues with marked release groups. These results also emphasize the importance of having some means to assess capture probability and survival assumptions associated with mark-recapture population methodologies frequently used to estimate smolt production.

Wild Migrants

The observed range in Kalama wild steelhead smolt production reported here (20,301-41,508, excluding 1-trap design years) is within the range reported for estimates using traversing fyke net methodology on the Kalama (8,558-43,336) in years 1978-1984 (Loch et al. 1985) and 1992-1994 (Hulett et al. 1993, 1994, 1995). The corresponding mean production estimate for this study (26,390) is very close to the mean from all the fyke net years (25,635). There were three years of estimates from the fyke net studies that were well below the range reported here: 10,953 in 1982, 12,113 in 1984, and 8,558 in 1993. It is unclear whether that actually reflects lower smolt production in those years or reflects measurement error using the fyke net methodology. As detailed in Loch et al. (1995) and Hulett et al. (1993), the fyke net catches were expanded using gear efficiency estimates based on captures of known numbers of hatchery steelhead released upstream of the trap, regressing gear efficiencies observed for individual smolt releases to mean flow over the capture intervals for those releases, and using the derived regression equation to estimate gear efficiencies for wild fish over the range of flows observed during their capture.

Obtaining an understanding of natural production by steelhead in the Kalama is complex because of the diversity of steelhead types spawning in any year. Spawners can include winter- and summer-run fish that were themselves naturally produced, hatchery summer-run steelhead passed upstream as part of an ongoing reproductive success study in the watershed (Hulett et al. 2004; Sharpe et al. 2000), other hatchery steelhead evading our adult trap in the lower watershed, and residual hatchery or resident wild fish. The relative abundance of spawner types will vary year to year and it is unclear how the ability to produce smolts varies among different spawner types. Mixed stock analyses based on DNA profiles could be used to partition smolts to stock origins, similar to the approach used by Sharpe et al. (2000) based on allozyme genetics data. The value of obtaining stock specific production estimates would have to be weighed against the cost of obtaining the required DNA profiles of the adult parents and smolt offspring. Summer-run DNA data will be available for adults that spawned in 2003, 2004, and 2005 from the summer-run reproductive success study being completed on the Kalama. Tissue samples are available for the corresponding adult winter-run and for their smolt offspring captured in 2005, 2006, and 2007.

Hatchery Migrants

A large proportion of the hatchery fish, of all types in most years, failed to successfully migrate from the watershed, becoming either residuals or perishing. It appears that the tendency for non-migration increased over the years of monitoring (Figure 4). The observation that the majority of hatchery steelhead didn't actually migrate is troubling because the likelihood of negative ecological interactions with native conspecifics and other fish with overlapping ecological requirements is high (McMichael et al. 1997, Sharpe et al. 2007, Viola and Schuck 1995).

We did expect to find relatively lower emigration rates for our wild broodstock hatchery stocks because spawning of our wild broodstocks is later and it is difficult to get the juveniles to smolt size in one year. The magnitude of failure to emigrate in most years was not expected. In one year (2005) more than 80% of the wild broodstock hatchery fish did not appear to migrate past the trap. Also surprising was the observation that the "traditional" winter-run stocks (HWR-HFH and HWR-OTHER) failed to emigrate at a high rate. In surveys of Gobar Creek (below the location where most hatchery winter-run fish were released) we routinely encountered large numbers of residuals from our wild broods and low numbers of residuals from the traditional stocks (Sharpe et al. 2007). In fact, all of the hatchery winter-run releases after 2000 showed lower than expected emigration rates, regardless of stock origin.

Future analyses of these data are warranted. For example, as time and funding become available it might be useful to relate outmigration rates of the hatchery fish to variables such as size of the fish at release, growth trajectories of the fish exhibited during rearing or disease incidence within particular stocks. Such *a posteriori* analyses might prove fruitful because we noted a great deal of variability both within and between years in these parameters and, especially, a tendency for higher survival and larger smolt sizes in earlier years and higher mortality and smaller more variable smolt sizes in later years.

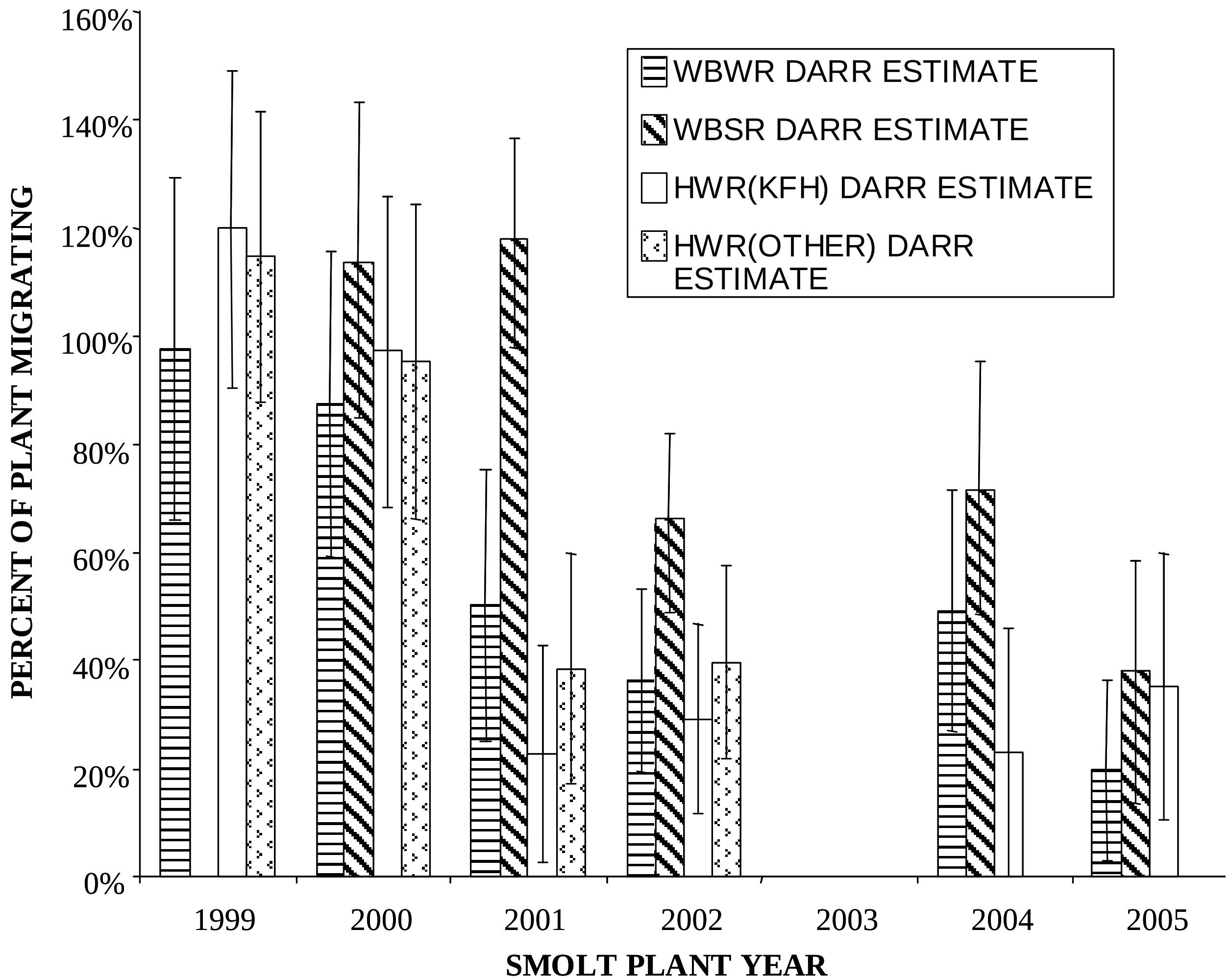

Figure 4. Percent of hatchery steelhead accounted for as migrating ± 95% confidence intervals. Abbreviations are as in Table 2. Data for 2003 are not included here because only a single trap was operating that year (but see Table 2). Data for 1999 (another one-trap year) is included because it appears to be consistent with data for 2000, but should be used with caution.

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APPENDIX

Appendix Table 1. Hatchery and wild steelhead mark, recapture, and catch data from Kalama smolt trapping operations from 1999 through 2005. "WILD MARKS" refers to fish marked and released for recapture (from the upper trap in 2000, 2001, 2002, 2004 and 2005; from the lower trap in 1999 and 2003). "UT" and "LT" refer to upper trap and lower trap, respectively. "WILD" refers to naturally produced summer- and winter-run steelhead combined. WBWR, WBSR, and HWR indicate wild brood winter-run, wild brood summer-run, and domesticated hatchery (Chambers Creek Stock) winter-run stocks, respectively. KFH and OTHER refer to Chambers Creek stock HWR reared at the Kalama Falls Hatchery (KFH) and Lewis or Elochoman Hatcheries (OTHER), respectively.

WEEK	MIDWEEK DATE	WILD MARKS	UT HATCHERY MARKS	LT WILD RECAPS	LT HATCHERY RECAPS	WILD LT CATCH	WBWR LT CATCH	WBSR LT CATCH	HWR/KFH LT CATCH	HWR(OTHER) LT CATCH
1999 SMOLT TRAPPING (ONE TRAP ONLY)										
16	4/21/99	25				31				
17	4/28/99	23				25				
18	5/5/99	32		2		32			1	2
19	5/12/99	41		1		41	50		65	105
20	5/19/99	165		5		165	119		153	278
21	5/26/99	95		2		95	229		228	296
22	6/2/99	121		3		121	181		153	125
23	6/9/99	50		1		50	107		51	32
24	6/16/99	58		1		58	62		23	6
25	6/23/99						13		8	
26	6/30/99	11				11	4		1	
1999 TOTALS		621	0	15	0	629	765	0	683	844
2000 SMOLT TRAPPING (TWO TRAPS OPERATING)										
13	3/29/00					2				
14	4/5/00					11				
15	4/12/00					20				
16	4/19/00	5				52	8	3	8	
17	4/26/00	9	1	2		92	8	2	10	

WEEK	MIDWEEK DATE	WILD MARKS	UT HATCHERY MARKS	LT WILD RECAPS	LT HATCHERY RECAPS	WILD LT CATCH	WBWR LT CATCH	WBSR LT CATCH	HWR/KFH LT CATCH	HWR(OTHER) LT CATCH
18	5/3/00	13		4	1	266	101	27	79	40
19	5/10/00	42	168	3	10	365	286	1367	189	107
20	5/17/00	67	119	3	8	220	401	1932	306	196
21	5/24/00	23	124	2	4	191	745	693	711	674
22	5/31/00	36	37	3	4	210	754	766	730	774
23	6/7/00	33	23	10	3	173	661	677	656	662
24	6/14/00	32	57	11	22	168	190	523	87	109
25	6/21/00	2	1	1	2	21	13	94	7	2
26	6/28/00	0				6	1	16		
27	7/5/00	0				3	1	3		
2000 TOTALS		262	530	39	54	1800	3169	6103	2783	2564
2001 SMOLT TRAPPING (TWO TRAPS OPERATING)										
12	3/21/01					70				
13	3/28/01					104				
14	4/4/01					142				
15	4/11/01					184				
16	4/18/01					595				
17	4/25/01	259		19		713	0	1304		1
18	5/2/01	98		4		255	3	504	7	17
19	5/9/01	59		8		456	22	193	20	31
20	5/16/01	68		5		353	256	847	214	551
21	5/23/01	42		12		383	308	723	316	881

WEEK	MIDWEEK DATE	WILD MARKS	UT HATCHERY MARKS	LT WILD RECAPS	LT HATCHERY RECAPS	WILD LT CATCH	WBWR LT CATCH	WBSR LT CATCH	HWR/KFH LT CATCH	HWR(OTHER) LT CATCH
22	5/30/01	20		8		109	216	138	537	1421
23	6/6/01	6		2		29	39	65	109	261
24	6/13/01	4				13	6	29	14	20
25	6/20/01	1		1		5			1	1
26	6/27/01	1				11				
27	7/4/01					2			1	1
28	7/11/01					0				
29	7/18/01					5				2
30	7/25/01					5	1			1
31	8/1/01					1				
2001 TOTALS		558	0	59	0	3435	851	3803	1220	3188
2002 SMOLT TRAPPING (TWO TRAPS OPERATING)										
12	3/20/02					3				
13	3/27/02					9				
14	4/3/02	18				23				
15	4/10/02	26		1		39				
16	4/17/02	3				60				
17	4/24/02	26		1		102				
18	5/1/02	91	7	7		355	6	1	2	15
19	5/8/02	58	95	9	6	411	26	969	32	99
20	5/15/02	114	166	20	17	531	462	1467	299	1094
21	5/22/02	62	108	20	16	392	722	827	484	1565
22	5/29/02	49	44	3	11	263	135	317	91	307

WEEK	MIDWEEK DATE	WILD MARKS	UT HATCHERY MARKS	LT WILD RECAPS	LT HATCHERY RECAPS	WILD LT CATCH	WBWR LT CATCH	WBSR LT CATCH	HWR/KFH LT CATCH	HWR(OTHER) LT CATCH
23	6/5/02	23	26	3	5	193	62	208	2	55
24	6/12/02	15	27	1	8	81	19	102		8
25	6/19/02	6	8	1	1	22	2	28	1	2
26	6/26/02					2		2		
2002 TOTALS		491	481	66	64	2486	1434	3921	911	3145
2003 SMOLT TRAPPING (ONE TRAP ONLY)										
13	3/26/03	6				7				
14	4/2/03	27				29				
15	4/9/03	15				17				
16	4/16/03	22				26				
17	4/23/03	173		7		173				
18	4/30/03	214		7		214	3	438	42	
19	5/7/03	202		7		202	237	331	113	
20	5/14/03	285		7		286	454	210	346	
21	5/21/03	454		17		455	263	288	302	
22	5/28/03	288		17		290	177	213	74	
23	6/4/03	44				45	42	68	17	
24	6/11/03	25		1		25	19	26	3	
25	6/18/03	3				3	4	6	1	
2003 TOTALS		1758	0	63	0	1772	1199	1579	899	0
2004 SMOLT TRAPPING (TWO TRAPS OPERATING)										
13	3/31/04					19				
14	4/7/04					21				

WEEK	MIDWEEK DATE	WILD MARKS	UT HATCHERY MARKS	LT WILD RECAPS	LT HATCHERY RECAPS	WILD LT CATCH	WBWR LT CATCH	WBSR LT CATCH	HWR/KFH LT CATCH	HWR(OTHER) LT CATCH
15	4/14/04					23				
16	4/21/04					93				
17	4/28/04	48		2		130				
18	5/5/04	61	2	2		172	12	1	4	
19	5/12/04	89	75	6	6	294	18	1130	24	
20	5/19/04	80	138	6	20	373	775	700	423	
21	5/26/04	152	81	18	14	258	628	189	301	
22	6/2/04	104	39	7	8	128	191	140	62	
23	6/9/04	3	6	1	4	13	8	11	3	
24	6/16/04	5	3	1	2	8	5	2		
25	6/23/04					2				
2004 TOTALS		542	344	43	54	1534	1637	2173	817	0
2005 SMOLT TRAPPING (TWO TRAPS OPERATING)										
12	3/16/05					2				
13	3/23/05					5				
14	3/30/05					13				
15	4/6/05					65				
16	4/13/05	72	2	1		71				
17	4/20/05	89	4	2		67				
18	4/27/05	156		13		503	2	2	12	
19	5/4/05	192	2	44		801	35	35	211	
20	5/11/05	145	91	35	44	583	203	1042	709	
21	5/18/05	9	2	6	32	125	377	300	528	

WEEK	MIDWEEK DATE	WILD MARKS	UT HATCHERY MARKS	LT WILD RECAPS	LT HATCHERY RECAPS	WILD LT CATCH	WBWR LT CATCH	WBSR LT CATCH	HWR/KFH LT CATCH	HWR(OTHER) LT CATCH
22	5/25/05	4	4	1		49	133	35	65	
23	6/1/05	19	30	2	16	45	115	37	57	
24	6/8/05	11	20	2	10	26	43	20	20	
25	6/15/05	1	5	1	2	7	7	4	4	
26	6/22/05					1				
2005 TOTALS		698	160	107	104	2363	915	1475	1606	0