Steelhead Streamside Incubation Program

LSRCP Steelhead Program Review Presentation
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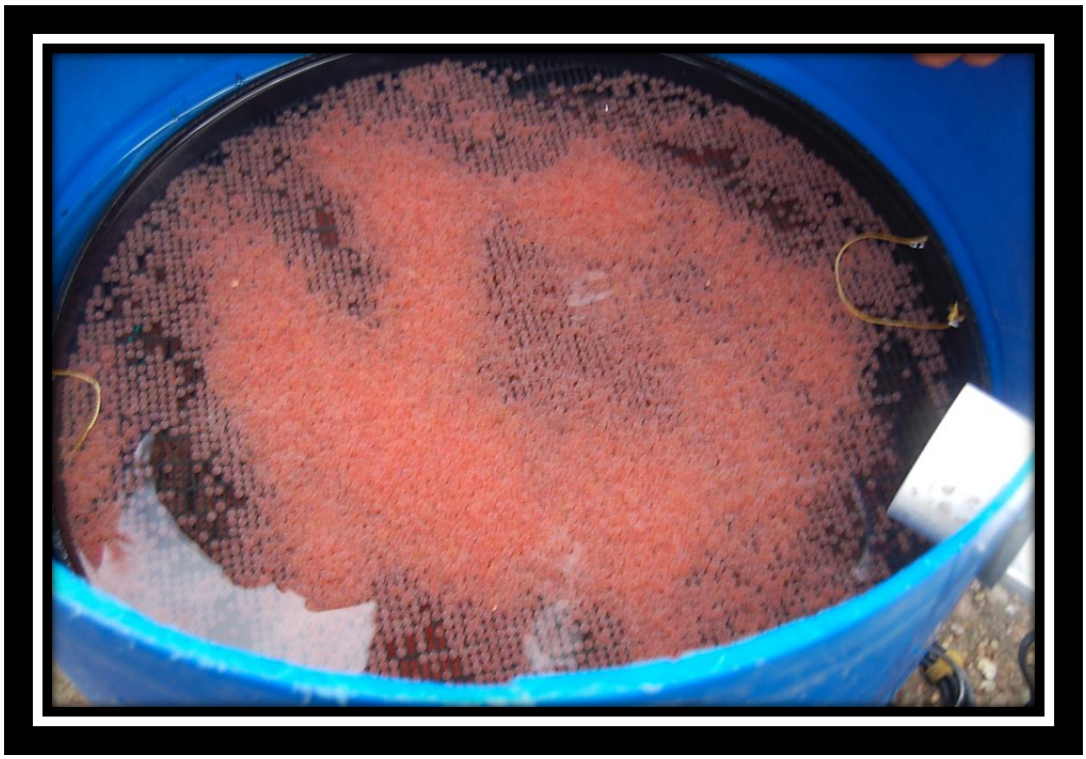

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Introduction

The Shoshone-Bannock Tribes (SBT) initiated a Steelhead Streamside Incubation (SSI) Program in 1995 to maintain, rehabilitate, and enhance steelhead populations in the upper Salmon River basin. The SSI Program was developed to preserve cultural, traditional, and subsistence-based linkages to anadromous fish.

A research, monitoring, and evaluation (RM&E) strategy was developed in 2005 to guide and inform the SSI Program enhancement efforts. In 2009, a parental exclusion/pedigree analysis was conducted on the adult steelhead (broodstock) used to produce gametes that were outplanted in remote site incubators (RSI) from 2006 – 2008, and compared to juvenile steelhead sampled in tributary habitats of Yankee Fork from 2006 - 2009. The objective of the study was to determine whether the SSI Program produces juveniles, as this was never documented and a much needed step before investing in infrastructure to evaluate whether adults are produced. Parental genotypes of broodstock fish were compared to unknown origin juvenile steelhead sampled in the Yankee Fork to determine relative abundance of SSI progeny. Comprehensive results indicate that from brood years 2006 – 2008, 13.8% of the juvenile steelhead population, encountered in Yankee Fork was of SSI origin (range 11.4% - 16.1%).

The SBT plans to expand upon existing RM&E efforts in Yankee Fork, based upon results from the genetic parentage analysis, while developing new RM&E efforts in Panther and Indian creeks. Future work includes genetic sampling parental broodstock, outplanting genetically marked gametes in RSIs and quantifying the number of juveniles emigrating and ultimately the number of adults that return that are SSI origin. A detailed study design will be included in the SBT RM&E Plan, which is currently being developed.

Background

Prior to 1970, anadromous fish were an abundant and sustainable natural resource that provided ample subsistence opportunities for the indigenous peoples of the Salmon River basin. Since the development of the Federal Columbia River Power System (FCRPS), anadromous fish abundance has been greatly diminished and this has resulted in policy direction changes within the SBT.

Beginning in the 1970's, anadromous fisheries plummeted to levels that could no longer support subsistence-based harvest. By 1972, the Shoshone-Bannock Tribes Fort Bridger Treaty Rights were challenged over a Chinook salmon fishing incident in the Yankee Fork. The State vs. Tinno (1972) decision, favored the SBTs right to harvest anadromous fish and remain sovereign from state and federal jurisdiction.

The SBT recognized the need for internal regulation of Tribal harvest of both fish and wildlife; therefore, the Shoshone-Bannock Tribal Game Code was established in 1975. Regulations included in the Tribal Game Code limited the amount of harvest of Chinook salmon and steelhead to "the reasonable need of his immediate family." At the time of the implementation of the Tribes Natural Resource Ordinance and Policies, "reasonable need" was defined as no more than four salmon per family, per year.

During the 1980's, in response to the precipitous decline of anadromous fisheries in the Salmon River basin, the SBT increased efforts to preserve native fish populations by designating certain areas for harvest (e.g., Yankee Fork), and curtailing other areas (i.e., Bear Valley Creek); however, designated harvest areas were nearly vacant of fish and Tribal interest in traditional fishing practices waned. Despite an occasional "bathtub fishery", Tribal harvest opportunities became more and more limited and cultural values of the SBT were at risk of not being embraced by the younger generations. During this period of time, the SBT maintained a strong policy direction to rebuild natural fish populations and the use of artificial propagation was not a supported enhancement strategy.

In the 1990s, the SBT began to recognize the benefits that hatchery produced Chinook salmon were providing to the South Fork Salmon River fishery (Figure 1). Decent numbers of hatchery fish for harvest were rejuvenating interest in fishing, thus, saving cultural, traditional, and subsistence-based linkages to anadromous fish. In turn, policy makers began to consider making a shift to supporting artificial production as a tool to provide harvest opportunities. Ultimately, the least intrusive artificial propagation techniques (somewhere between gravel and concrete) were pursued by the SBT and a Chinook salmon egg incubation program was proposed to state and federal agencies.

Figure 1. Shoshone-Bannock Tribal youth spearfishing in the South Fork Salmon River, Idaho (photo courtesy of Enrique Patino, NOAA Fisheries).

The Chinook salmon egg incubation proposal did not receive the necessary support from the state and federal agencies, in part, due to a lack of available Chinook salmon broodstock. Intent on initiating a low cost artificial propagation technique that honored the SBT policy of minimally intrusive native fish population management, the SBT proposed using RSIs with steelhead broodstock instead of Chinook salmon. In 1995, the SBT Steelhead Streamside Incubation Program was initiated.

The SSI Program has been in operation since 1995, results indicate the technology can produce juvenile fish. However, the SBT has not been able to determine whether the SSI Program has produced adult fish, which is the primary goal. This report documents the RM&E work that was completed as part of funding received by the Lower Snake River Compensation Plan (LSRCP) to document whether juvenile fish are produced by the SSI Program.

Vision Statement

The decision to implement the SSI Program was a major policy shift for the SBT. A tribe that had been extremely focused on natural production policies was forced to accept artificial propagation or risk losing a lifelong connection to a resource that is inherent in every aspect of the culture that still survives today. Ultimately, the SSI Program fell directly under the "Vision Statement" of the SBT. The Vision Statement is a written expression of the SBT cultural and natural resource values, and pronounces the intention to protect, preserve, and enhance rights reserved by the Fort Bridger Treaty of 1868. This statement reflects the three goals envisioned by Tribal policy makers, and the management objectives by which these goals will be accomplished.

"The Tribes will pursue, promote, and where necessary, initiate efforts to restore the Snake River systems and affected unoccupied lands to a natural condition. This includes the restoration of component resources to conditions which most closely represents the ecological features associated with a natural riverine ecosystem. In addition, the Tribes will work to ensure the protection, preservation, and where appropriate-the enhancement of Rights reserved by the Tribes under the Fort Bridger Treaty of 1868 and any inherent aboriginal rights."

Goals

The SBT initiated the SSI Program in 1995 to help maintain, rehabilitate, and enhance steelhead populations in the upper Salmon River. The clear imbalance of hatchery fish and depleted natural-origin summer steelhead in the Salmon River led the SBT to seek alternative management options for increasing abundance of naturally spawning fish. The primary goal of the SSI Program is to increase adult abundance and provide harvest opportunities for Tribal members. Although the primary goal is to increase harvest opportunities, it is equally important to provide connection with cultural and social values.

The SSI Program was designed primarily to utilize eggs that are considered excess or surplus to those required to meet summer steelhead production goals at nearby local hatcheries. The SBT believe that rather than discard these surplus eggs, they could be used to augment production in Salmon River tributaries where summer steelhead historically spawned and/or are absent.

Management Objectives

Objective 1. *Provide traditional harvest opportunities for steelhead in historical fishery areas in the Salmon River basin.*

Steelhead numbers in traditional Tribal fishing areas of the Salmon River basin have been eliminated or severely reduced by local habitat degradation and mainstem Snake and Columbia river hydropower development. The entire upper Salmon River basin is currently being managed primarily for hatchery-driven fishery mitigation purposes. Hatchery steelhead smolt releases in Salmon River basin provide some opportunity for tribal anglers but most of these fish are intercepted by fisheries downstream from traditional Tribal fish hunting areas. SSI production increases steelhead returns into upper basin tributaries to provide tribal fishery opportunity.

Production Targets

The fish production objectives for the SSI Program, consistent with the *US v Oregon* Agreement, are to incubate and release one million eyed eggs annually. The production targets are as follows: 1) incubate 500,000 eyed-eggs in the Yankee Fork; 2) incubate 400,000 eyed-eggs in Panther Creek; and 3) incubate 100,000 eyed-eggs in Indian Creek.

Operational and Maintenance Objectives

The operational and maintenance objectives include: 1) testing the streamside incubator technology for successful hatching; 2) increasing egg to fry survival; 3) determining optimum RSI densities and configurations; 4) providing incentives for habitat improvements; 5) minimizing cost; 6) minimizing process; 7) minimizing fish handling; 8) increasing community education, involvement, and caring; 9) fulfilling the requirements of *US v Oregon*; 10) fulfilling the requirements of the LSRCP; and 11) fulfilling the requirements of Idaho Power Company mitigation (Kutchins 1995).

Methods

Broodstock Collection and Spawning

Hatchery broodstock for the SSI Program are collected from hatchery adult summer steelhead returning to Sawtooth and Pahsimeroi fish hatcheries, located in the upper Salmon River. Hatchery adult summer steelhead are trapped at weirs from early March through mid-May and held until spawning. Eyed-eggs obtained from Pahsimeroi Fish Hatchery are transferred to RSIs in Panther and Indian creeks, while eyed-eggs obtained from Sawtooth Fish Hatchery are transported to Yankee Fork.

Spawning generally occurs over the same time period of adult trapping. Adult fish are spawned following IDFG spawning protocols. Adults are spawned on a one by one basis and the following information is collected: tissue sample and fork length. Green eggs are water hardened and incubated on well water, and held separately from general production gametes. Upon eye-up, dead eggs are removed and eyed-eggs are prepared for transfer to RSIs.

Remote Site Incubator Configurations and Egg Outplanting

RSIs are constructed in Panther Creek, Indian Creek, and Yankee Fork (Figure 2) from April through May to incubate eyed-eggs. Four RSIs are located in Beaver Creek a tributary of Panther Creek, a single RSI is located in Indian Creek, and five RSIs are installed in Yankee Fork.

All RSIs are standardized to optimum configurations. Each RSI consists of a 189.3 L polyurethane cylinder with an inflow pipe, stand pipe, water diffuser, and outflow pipe (Figure 3a). The RSI contains pea gravel, bio-saddles, and several egg trays (Figure 3b). Gravity flow is achieved using standardized 5.1 cm polyvinyl chloride (PVC) pipe plumbed into the RSI, leading to a 7.6 cm head collection pipe, located 10 – 70 m upstream. The inflow pipe also contains a regulator to adjust flow to the desired gallons/minute setting. Each head pipe is fitted with 0.6 cm mesh screen to minimize sediment and debris collection. A catch tank consisting of a 113.6 L Rubbermaid polyurethane tub with a custom fit cover is attached to the outflow pipe, where volitionally migrating juveniles can transition from the RSI to the natural stream environment.

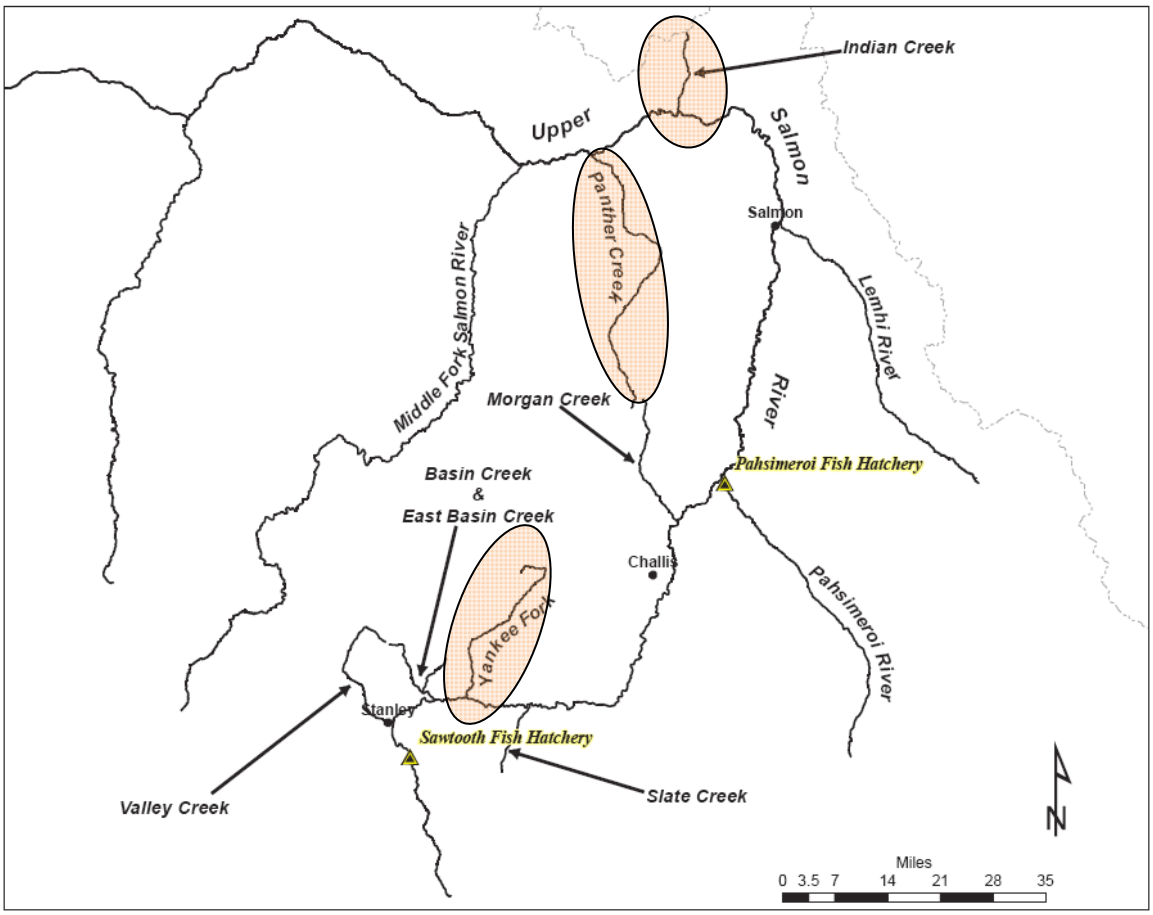

Figure 2. Map of the Salmon River basin and SSI Program tributaries.

Figure 3. Typical RSI set-up (a) with a cross-sectional view (b).

Eyed-eggs are obtained from the hatchery at least one week prior to the anticipated hatch date. Eggs are loaded into plastic bags filled with river water and O_2, stored in a cooler with ice, and transported to the RSI within a few hours. Using the standpipe and flow regulator, water level is lowered to the height of the desired tray being loaded. The eyed-eggs are gently poured over the tray and then flow is raised to the next tray. This process is continued until the RSI is loaded with the desired egg quota, which is generally about 100,000 eggs or 20,000 – 25,000 eggs per tray. Once all of the eggs are loaded, the standpipe is raised and flow is adjusted. Flow is monitored regularly through the incubation process.

Incubation and Hatching Success

RSIs are monitored and maintained at least one a week after installation from April until removal in July or August. Chemical monitoring includes recording flow, water height, and temperature. Biological monitoring includes recording embryo stage development and ultimately hatch success. Upon full volitional fry emigration, fry production is estimated by enumerating dead eggs and dead fry remaining in the RSI or catch tank.

Program Accomplishments

Several types of incubation units have been used and evaluated, including RSIs constructed from discarded refrigerators, commercial upwelling incubators of various sizes, and in-stream incubation systems (e.g., wooden boxes, Jordan-Scotty, and Haddix boxes) (Haddix 2000). RSIs that are upwelling units have become the sole unit used to incubate eyed-eggs in the SSI Program since 2007. A properly functioning RSI unit typically exceeds 95% hatch success.

From 1995 – 2010, the SSI Program outplanted 14,903,040 eyed eggs and seeded 12,321,905 fry in twenty eight different locations (Table 1). The number of eggs incubated in a given year ranges from 201,600 in 1995 to 1,135,510 in 2008. Over this period, survival from eyed-egg to hatching averaged 81.9% (range 56.8% in 2004 to 99.3% in 2005). The number of individual RSI sites has decreased from 23 in 2003 to 10 in 2012.

Table 1. Number of eyed-eggs planted and hatched as part of the SSI Program from 1995 – 2010.

Year	Eggs Planted	Eggs Hatched	% Hatch
1995	201,600	149,570	74.2%
1996	646,000	510,000	78.9%
1997	1,000,000	755,000	75.5%
1998	1,050,210	856,751	81.6%
1999	836,960	632,388	75.6%
2000	874,181	722,948	82.7%
2001	976,297	880,641	90.2%
2002	845,585	815,379	96.4%
2003	1,085,431	1,053,509	97.1%
2004	1,004,939	570,333	56.8%
2005	1,109,730	1,101,941	99.3%
2006	989,608	606,792	61.3%
2007	1,070,051	896,278	83.8%
2008	1,135,510	1,044,319	92.0%
2009	1,010,461	900,217	89.1%
2010	1,066,477	825,839	76.8%
Total	14,903,040	12,321,905	81.9%

Research, Monitoring, and Evaluation

Since its initiation in 1995, the SBT have demonstrated a strong ability to hatch eyed-eggs in almost any setting. Production targets for hatching have been achieved and public outreach objectives have been met both on and off of the reservation. In fact, the Shoshone-Bannock High School has been involved in the project through the "Dance of the Salmon" program and numerous adolescents have been taught the value of protecting natural resources. In addition, private landowners have and continue to participate in the SSI Program by allowing us to place the RSIs on their land and/or use their water. We've also completed some preliminary monitoring and evaluation studies using DNA parentage analysis, and recently, secured funding to fully implement a long-term RM&E Plan.

The Tribes RM&E approach in the Yankee Fork was: 1) spawn and genotype hatchery adult steelhead; 2) collect and incubate fertilized eggs; 3) incubate eyed-eggs in RSIs; 4) release fry volitionally from RSIs; 5) collect age 0+ parr during first fall; 6) collect age 1+ parr during second fall (Figure 6). Upon collection of tissue from age 0+ and 1+ parr, samples were analyzed to genotype fish back to either streamside incubator or natural origin.

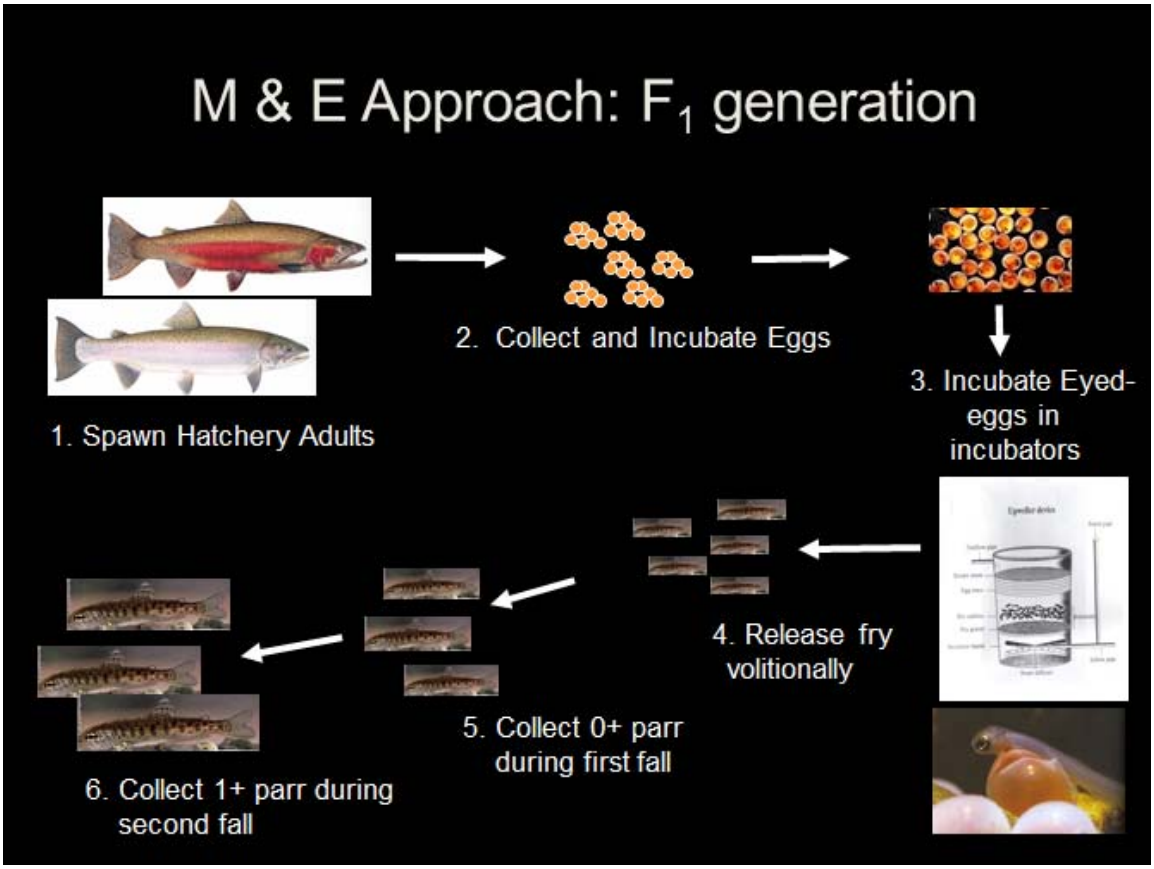

Figure 4. Monitoring and Evaluation approach through F_1 generation.

Parental based tagging is an approach that uses inherent genetic differences among individual fish to use parentage assignment of stocked offspring as an internal, non-destructive, tag to identify released animals and evaluate their growth, movement, and/or survival rates (Lethcher and King, 2001). Pairs of hatchery adults (P1) are spawned then genotyped using 14 microsatellite DNA loci. Gametes produced from the P1 adults are incubated in assigned trays at local hatcheries until they reach the eyed-egg stage of development. Once the eyed-eggs are water hardened and ready to be placed in the RSIs, each family is tracked and placed in pre-assigned RSI trays. Hatch success is monitored for each tray/family, and the resulting fry (F1) are volitionally released into the river. During the first and second fall following release, tissue from age 0+ and age 1+ parr are collected, respectively. A parental exclusion/pedigree analysis is used to differentiate juvenile steelhead produced by the SBT streamside incubator project from all other steelhead produced naturally or planted artificially in the study watershed.

Juvenile sampling was conducted in the Yankee Fork drainage during September of 2006, 2007, 2008, and 2009 to determine whether SSI progeny were surviving. Following Konopacky et al. (1985, 1986), the Yankee Fork drainage was divided into seven distinct strata; three reaches were selected within each stratum including Pond Series 1 and 3 except for stratum five which contained four reaches (Figure 5). The 25 total sites were selected for a variety of habitats (pools, glides, riffles) and ease of accessibility for an upper, middle, and lower location within each stratum. Sites were generally rectangular in shape, aligned with the shoreline, and divided into transects for habitat measurements.

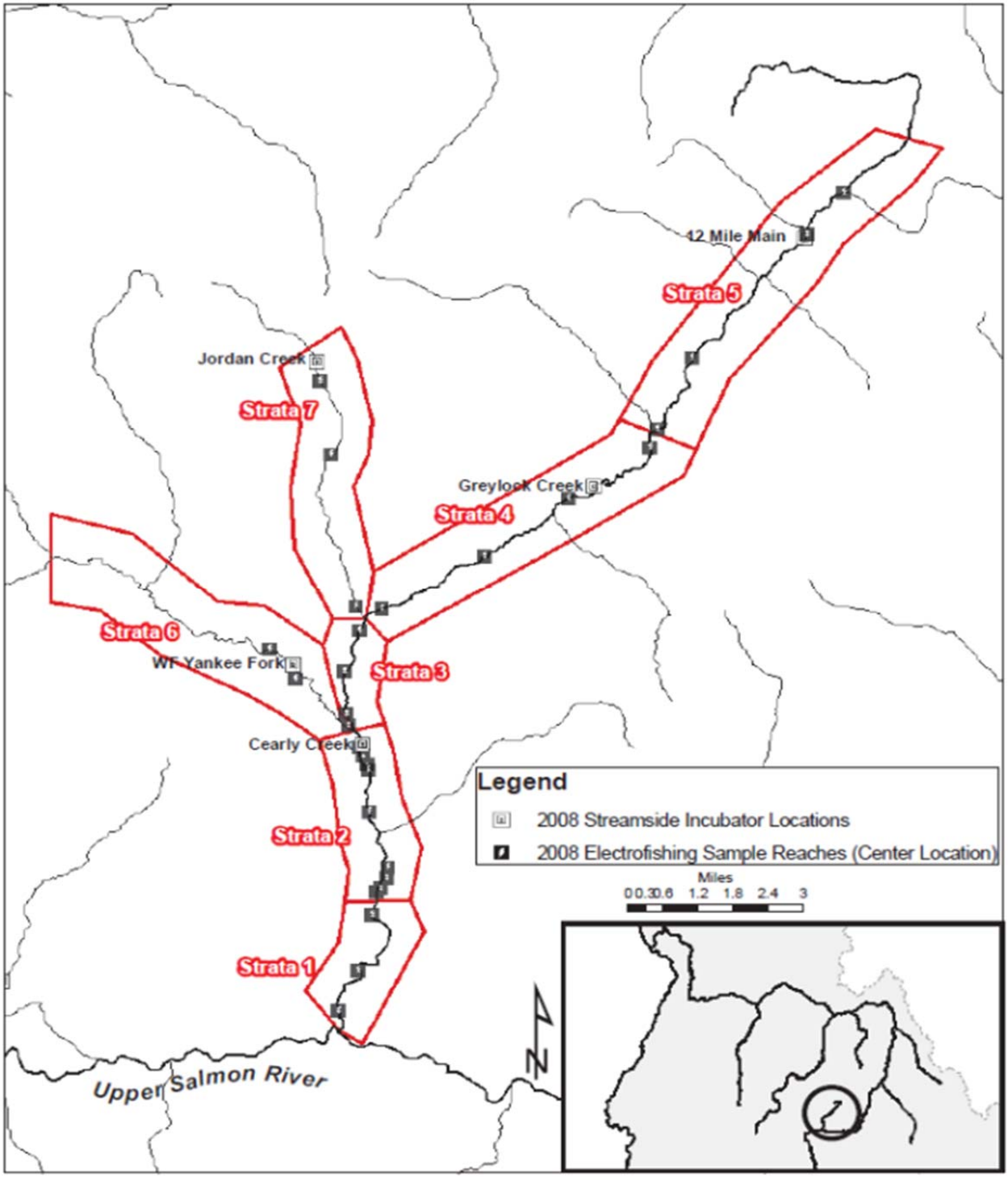

Figure 5. RSI incubator and juvenile sampling locations in the Yankee Fork Salmon River, Idaho, 2008

Multiple-pass electrofishing requires closed populations to minimize emigration and immigration; hence the use of block nets. Sites were predominately 100 m in length, but did reach above 100 m due to habitat inclusion and accessibility for block net placement. Upstream and downstream ends of the sampling reach were blocked using 7-mm-mesh nets secured to the streambed with tri-pods and rebar, generally at habitat unit separations. Sites were electrofished

in an upstream direction between 20 – 30 minutes with one crew member electroshocking (Smith-Root, Inc. Pulsed DC LR-24 Backpack Electrofisher) and two to three others utilizing dip nets to capture fish drifting downstream under electronarcosis. Voltage and frequency were adjusted and monitored to maximize capture, but limit fish injury (voltage: 350-450, frequency: 30-50 Hz, duty cycle: 10-12%). Fish were transferred immediately to a bucket and then to a holding tub for further analysis.

Population estimates and probability of capture was calculated using model $M_{(b)}$ (Zippen removal population estimator, Zippen 1956) by the program CAPTURE. CAPTURE computes estimates of capture probability and population size for all electrofishing passes based on a stationary population, equal probability of capture for each animal, and constant probability of capture.

Adult steelheed were spawned by the SBT at Sawtooth Fish Hatchery in 2006-2008. During this period, tissue samples were taken from 1194 age 0+ and 243 age 1+ juvenile steelhead collected from electrofishing efforts (Table 2). In addition, approximately 295 age 1+ steelhead were collected in the rotary screw trap. Comprehensive analysis of the number of assignments showed an overall RSI contribution to the Yankee Fork steelhead population of 0.140, 0.161, and 0.114 in 2006, 2007, and 2008, respectively (Table 2).

Table 2. Comparison of the number of parent pair/offspring assignments detected by either single year parentage analyses (i.e., assignment of juveniles collected during 2007 electrofishing and 2008 screw trap sampling to 2007 brood stock), or comprehensive parentage analysis (i.e., assignment of all juveniles collected between 2006-2009 to combined 2006-2008 brood stock).

	No. of steelhead genotyped				Single year analysis			Comprehensive analysis			
		Electrofishing		Trap	No. of ssignments			No. of assignments			
Year	Brood stock	Age-0$^+$ Juveniles	Age-1$^+$ Smolts	Age-1$^+$ Smolts	Age-0$^+$ Juveniles	Age-1$^+$ Smolts	Overall HAT	Age-0$^+$ Juveniles	Age-1$^+$ Smolts	Age-2$^+$ Smolts	Overall HAT
2006	104	349	123	--	57	5	0.131	57	5	4	0.140
2007	174	459	120	67	72	15	0.135	72	20	12	0.161
2008	213[a]	386[b]	0	228	64	6	0.114	64	6	--	0.114
totals:	491	1194	243	295	193	26		193	31	16	

[a] One duplicate individual detected in 2008 brood stock was excluded from parentage analyses.

[b] Includes four age-0$^+$ steelhead sampled at the West Fork Yankee Fork screw trap in 2008.

Genetic Parentage Analysis

Parentage assignment with real data

Parentage assignments observed in the brood year 2006 (Matala and Ardren 2008), 2007 (Williamson and Matala 2009), and 2008 Yankee Fork pedigree analyses provide evidence that juvenile steelhead trout produced by the SSI Program successfully emerge and survive in-stream through the first year of life (Table 2). The 2008 parentage assignment identified 64 age-0$^+$ and 6 age-1$^+$ juveniles produced from RSIs, with an overall assignment proportion of 0.114 RSI juveniles produced from the 2008 spawning efforts among all steelhead juveniles genotyped (N = 614). The overall proportion of RSI assigned juveniles in the 2008 analysis was similar to that

observed in the brood year 2006 (0.131; Matala and Ardren 2008) and 2007 (0.135; Williamson and Matala 2009) analyses. Not surprisingly, the comprehensive parentage analysis that utilized the combined 2006 to 2008 datasets detected additional age-1^+ and age-2^+ RSI assigned steelhead in Yankee Fork. The brood year 2007 age-2^+ individuals were primarily detected at the rotary screw trap as they emigrated from Yankee Fork in 2009. Detection of these age-2^+ smolts provides evidence that juvenile steelhead trout produced by the SSI Program continue to survive in-stream through the second year of life and that the age of seaward migration may vary for juvenile steelhead produced from the streamside upweller program. Comparison of the proportions of RSI and natural-origin age-2^+ steelhead smolts that emigrate from Yankee Fork could not be performed since age-specific data (i.e. scale or otolith samples) were not taken from migrating natural-origin steelhead smolts. The estimated abundance of age-0^+ *O. mykiss* in Yankee Fork for 2008 was 36,647 juveniles, with an estimated 7,786 individuals produced by the streamside incubators.

Progeny distribution and movement

Similar to the brood year 2007 analysis (Williamson and Matala 2009), brood year 2008 RSI juvenile steelhead were not evenly distributed throughout the Yankee Fork drainage system (Table 3). The majority of the brood year 2008 age-0^+ and age-1^+ RSI assigned offspring were encountered in stratum #4 and one of the dredge ponds in stratum #2 (Figure 5; Table 3). In contrast, the majority of brood year 2007 RSI assigned juveniles offspring were encountered in stratum #7 (Williamson and Matala 2009). Comparison between the brood year 2007 and 2008 age-0^+ RSI progeny distributions may be made for only strata #2, #3, #4, #6, #7. Between 2007 and 2008, no significant differences were observed in the percentage of age-0^+ RSI assigned juveniles encountered in the five strata compared (data not shown). Many (83%) of the age-0+ steelhead encountered within dredge pond (series #3; located in stratum #2) were RSI assigned individuals. None of the brood year 2008 RSI steelhead were detected elsewhere in stratum #2. Interestingly, all juveniles sampled in stratum #2, site-2 in previous parentage analyses of brood year 2006 (Matala and Ardren 2008) and 2007 (Williamson and Matala 2009) were RSI assigned. Since RSI progeny have been consistently encountered from year to year within stratum #2, this region of Yankee Fork may represent favorable or preferred rearing habitat for RSI juvenile steelhead produced by the streamside upweller program in Yankee Fork. Brood year 2008 age-1^+ RSI assigned offspring were encountered only at the rotary screw trap on the mainstem Yankee Fork. Since age-1^+ steelhead were not captured in the Yankee Fork tributaries during the fall 2008 electrofishing surveys, comparison of the distributions of brood year 2007 and 2008 RSI age-1^+ steelhead within Yankee Fork could not be performed.

Table 3. Parentage assignment results from the progeny perspective. The numbers of parent-progeny matches are reported for each juvenile collection location (e.g., stratum and site).

		Age-0+ juveniles			Age-1+ juveniles		
Location		**n sampled**	**# HAT assigned**	**% HAT assigned**	**n sampled**	**# HAT assigned**	**% HAT assigned**
Stratum 1	Site 1	14	0	0	0	0	0
	Site 2	14	0	0	0	0	0
	Site 3	13	0	0	0	0	0
Stratum 2	Site 1	24	0	0	0	0	0
	Site 2	9	0	0	0	0	0
	Site 3	21	0	0	0	0	0
Stratum 3	Site 1	23	0	0	0	0	0
	Site 2	28	0	0	0	0	0
	Site 3	24	1	4	0	0	0
Stratum 4	Site 1	26	0	0	0	0	0
	Site 2	25	22	88	0	0	0
	Site 3	--	--	--	0	0	0
	Site 4	25	10	40	0	0	0
Stratum 5	Site 1	--	--	--	--	--	--
	Site 12M	--	--	--	--	--	--
Stratum 6	Site 1	25	1	4	0	0	0
	Site 2	25	2	8	0	0	0
	Site 3	25	0	0	0	0	0
Stratum 7	Site 1	4	1	25	0	0	0
	Site 2	--	--	--	--	--	--
	Site 3	14	7	50	0	0	0
Pond	Series 1	19	0	0	0	0	0
Pond	Series 3	24	20	83	0	0	0
Screw Trap		4[a]	0	0	228	6	3
Overall by age-class		386	64	17[b]	228	6	3[b]

[a] Age-0+ steelhead sampled at the West Fork Yankee Fork screw trap in 2008.

[b] These values are the % HAT assigned by age-class.

Since family identity was preserved during egg outplant and the identity of the 2008 brood stock pairs represented in each RSI was recorded, data describing the migratory behavior, habitat preference, and successful RSI site selection for all RSI assigned juvenile steelhead trout during their first year of life in the Yankee Fork watershed may be documented. Comparison of the locations where brood year 2008 age-0+ RSI juvenile steelhead had been outplanted into an RSI and where they were subsequently captured indicated that juveniles are often not encountered in

the same stratum into which they had been outplanted. In fact, 25 of the brood year 2008 RSI assigned steelhead initially placed into and incubated in the streamside upweller on Jordan Creek (stratum #7) were subsequently encountered downstream within stratum #4. Likewise, temporally replicate field sampling of a brood year 2007 putative natual-origin juvenile was observed, first as an age-0^+ individual in stratum #7 and subsequently as an age-1^+ individual in stratum #1 (Williamson and Matala 2009). These observations coincide with those of other studies showing that movement of juvenile Chinook salmon and steelhead trout during the first year of life will be relatively small, and in a predominantly downstream direction (Richards and Cernera 1989; Close and Anderson 1992; Peery and Bjornn 2000).

The comprehensive parentage analysis permitted an expanded assessment of RSI production in Yankee Fork for brood years 2006 and 2007 and provided evidence that at least some RSI juveniles migrate seaward as age-2^+ individuals. Interpretation of the results and inferences about changes in the overall distribution of RSI steelhead in Yankee Fork as well as the age of seaward migration of RSI progeny requires a cautious approach. First, the Yankee Fork sub-basin experiences periods of high water flow (K. Tardy, personal communication) which may create a dynamic environment wherein the accessibility, location, and quality of suitable rearing habitat may change from year to year. Second, the Sawtooth Hatchery also has a program to release age-1^+ juveniles into the Yankee Fork (Denny and Tardy 2008). Migratory behaviors perpetuated and inherited through a history of domestication selection (Lynch and O'Hely 2001; Ford 2002) in the hatchery may be conveyed to RSI progeny outplanted into RSIs. For instance, RSI origin trout may have a tendency to migrate at a younger age relative to their natural-origin counterparts, thus fewer age-1^+ RSI steelhead were detected, compared to age-0^+ RSI and age-1^+ natural-origin steelhead, throughout Yankee Fork. Alternative explanations may be that age-0^+ juveniles migrate to more hospitable over-wintering habitat in the mainstem Salmon River, and/or RSI juvenile steelhead have lower survival relative to natural-origin juveniles.

Descriptive statistics

Patterns of observed allelic diversity or the brood year 2008 genetic analysis were similar to those observed during the previous analysis for 2007 (Williamson and Matala 2009). Similar to previous analyses of genetic diversity of brood year 2006 (Matala and Ardren 2008) and 2007 (Williamson and Matala 2009) Yankee Fork steelhead, departures from HWE expectations primarily occurred at *Omy77* and *Ots1*. The observed number of private alleles was higher (10 over all 17 loci) in the 2008 brood stock compared to all putative natural-origin and the RSI assigned collections (range: 0-4 over all 17 loci). A similar pattern was observed in the 2007 brood year analysis (Williamson and Matala 2009). Likewise, higher linkage disequilibrium, was detected in both the brood year 2007 (Williamson and Matala 2009) and 2008 brood stocks compared to all putative natural-origin and the RSI assigned collections. This evidence suggests that steelhead obtained from the Sawtooth Fish Hatchery and used as brood stock in the 2007 and 2008 Yankee Fork SSI program may represent admixed samples, or have family structure owing to the brood stock collections containing a higher proportion of RSI individuals. However, unlike the brood year 2007 analysis, moderate levels of LD were also detected in multiple 2008 natural-origin juvenile collections (strata #3, #4, and #6). Linkage disequilibrium observed for putative natural-origin juvenile collections may indicate sample admixture between the offspring of recognized resident rainbow trout and naturally spawning RSI steelhead.

Population differentiation

Clear differences exist between the 2008 RSI collections (brood stock and assigned juveniles) and the remaining putative natural-origin collections. This pattern is similar to that observed for earlier analyses [brood year 2006 (Matala and Ardren 2008); brood year 2007 (Williamson and Matala 2009)], and is illustrated in Figure 5. Each of the RSI groups are dispersed (rather than all RSI collections being clustered together) in the topology of the phenogram (Figure 6). This arrangement indicates that year to year variation in allele frequencies occurs within the brood stock collections taken for the Yankee Fork SSI Program. Two possible explanations follow. First, logistical limits on the numbers of adults selected as brood stock for the Yankee Fork SSI program may preclude a representative sample being taken each year from the Sawtooth Fish Hatchery. Numbers of brood stock for 2007 and 2008 were 174 and 213 individuals, respectively. Given these numbers of adults, it seems unlikely that the broodstock collections do not constitute representative samples on the sole basis of low numbers. Second, adult steelhead taken at the Sawtooth Fish Hatchery may represent either an admixed sample, or contain family structure. It is conceivable that yearly differences in the degree of sample admixture and/or family structure may lead to significant allele frequency differences in the collections of adults taken as brood stock for the SSI Program from year to year. Elevated linkage disequilibrium and higher numbers of private alleles observed in the 2007 and 2008 brood stock collections suggest that family structure may be a more plausible explanation. In addition, a limited number (3-4) of artificial spawning events were performed over a fairly short period (2-3 weeks) for brood years 2007 and 2008. It is possible that the limited number of spawning events performed over a relatively short period do not necessarily capture a representative sample of the genetic diversity of steelhead that return to Sawtooth Fish Hatchery. Comparison of a collection of Sawtooth Fish Hatchery steelhead that were sampled over the entire duration of the Sawtooth Fish Hatchery spawning run with the 2007 and 2008 collections of adults selected as brood stock for the Yankee Fork SSI Program would provide a way to resolve the explanations (i.e. admixture or family structure) of the observed genetic signals (i.e. higher LD detected and number of private alleles observed) in the brood stock used to seed the RSIs.

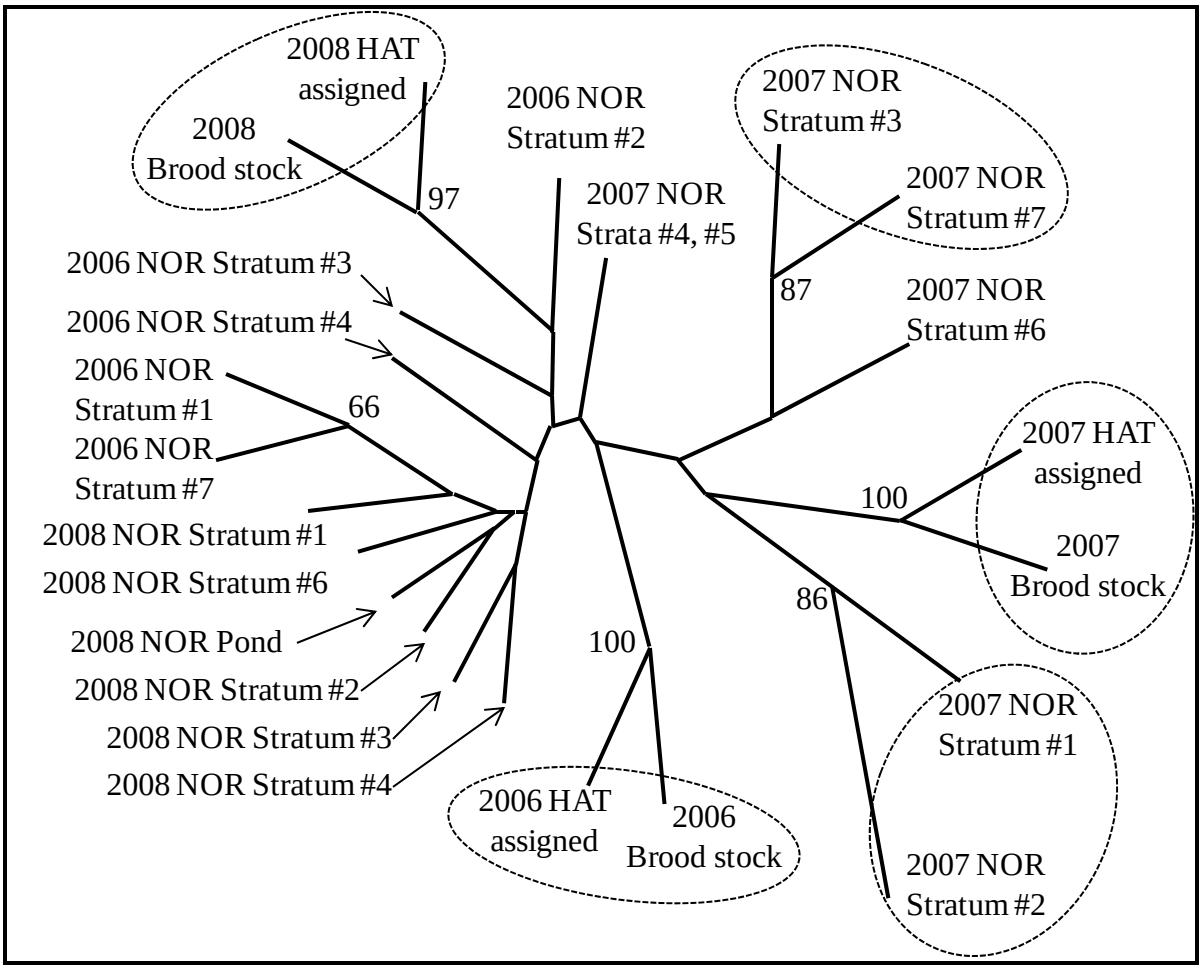

Figure 6. Unrooted Neighbor-joining phenogram based on Cavalli-Sforza and Edwards (1967) chord distance units among the 2006 to 2008 Yankee Fork age-0^{+} steelhead trout juveniles grouped by stratum where they were sampled. The phenogram was constructed with PHYLIP (Felsenstein 1989) using data from 14 microsatellite loci. For 1000 boot-strap replicates, node values of 50% and greater are given. Clusters of samples for which there is strong bootstrap support are circled. Based on parentage assignment to adults used to supply streamside upwellers from 2006 to 2008, juvenile fish were classified as hatchery origin (HAT). Remaining putative natural origin (NOR) individuals were grouped according to year and sampling strata within Yankee Fork.

Future Work

A comprehensive RM&E Plan is currently being drafted by the Shoshone-Bannock Tribes Fish and Wildlife Department that will serve as a guide for future work in the Salmon River basin, and a reference for all co-managers on the policy and direction of our growing program.

Future monitoring will track the number of parent fish (P_1) spawned, and subsequent F_1 juveniles that survive and migrate out of the treated watershed and return as F_1 adults to spawn. A similar approach will be used to track the productivity of F_1 adults that produce F_2 juveniles that survive and migrate out of the watershed and return as F_2 adults to spawn. Research, monitoring, and evaluation is planned to determine the overall contributions of fish resulting from the SSI Program. RM&E components include: 1) operating rotary screw traps; 2) operating weirs; 3) conducting creel surveys; 4) conducting electrofishing surveys; and 5) operating PIT tag arrays.

Overall, the Tribes will determine the number of adults that return from SSI Program activities.

Continued genetic evaluation is critical to determine the long-term efficacy of steelhead streamside supplementation activities. Limited information on numbers of returning adults, redd counts, size of the natural origin population, and migration timing restricts our ability to fully estimate the relative productivity of upweller supplementation. The SBT propose that the addition of a weir and continued screw trap operation would greatly increase the ability to document the natural spawning population and estimate the efficacy of RSIs at increasing population abundance in Yankee Fork.

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