UPPER SALMON RIVER- SPRING CHINOOK SALMON HATCHERY PROGRAM REVIEW

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Introduction and background

The upper Salmon River (USR) spring Chinook Salmon program funded though the Lower Snake River Compensation Plan (LSRCP) was established to provide in-place and in-kind mitigation for losses of spring run Chinook Salmon associated with the construction and operation of the four lower Snake River hydroelectric dams (Lower Granite, Little Goose, Lower Monumental, and Ice Harbor). Sawtooth Fish Hatchery is located on the Salmon River approximately seven miles upstream from the town of Stanley, Idaho (Figure 1). All adult trapping, spawning, incubation and rearing occurs at this facility. Construction of the hatchery was completed in 1985. The LSRCP adult mitigation goal for the USR spring Chinook Salmon hatchery program is 19,445 adult Chinook Salmon above the Project Area (Lower Granite Dam) and 77,780 adults available for downriver (Columbia River and lower Snake Rivers) harvest (Table 1). The original release target of 2.3 million yearling smolts was based on an assumed smolt-to-adult survival rate of 0.87% that would meet the LGD mitigation objective. The current production target at Sawtooth Fish hatchery is 2.0M yearling smolts.

Table 1. Adult return goals for LSRCP funded Chinook Salmon reared at Sawtooth Fish Hatchery.

Project Area Goal	Downstream of Project Area Goal	Total Adult Goal
19,445	77,780	97,225

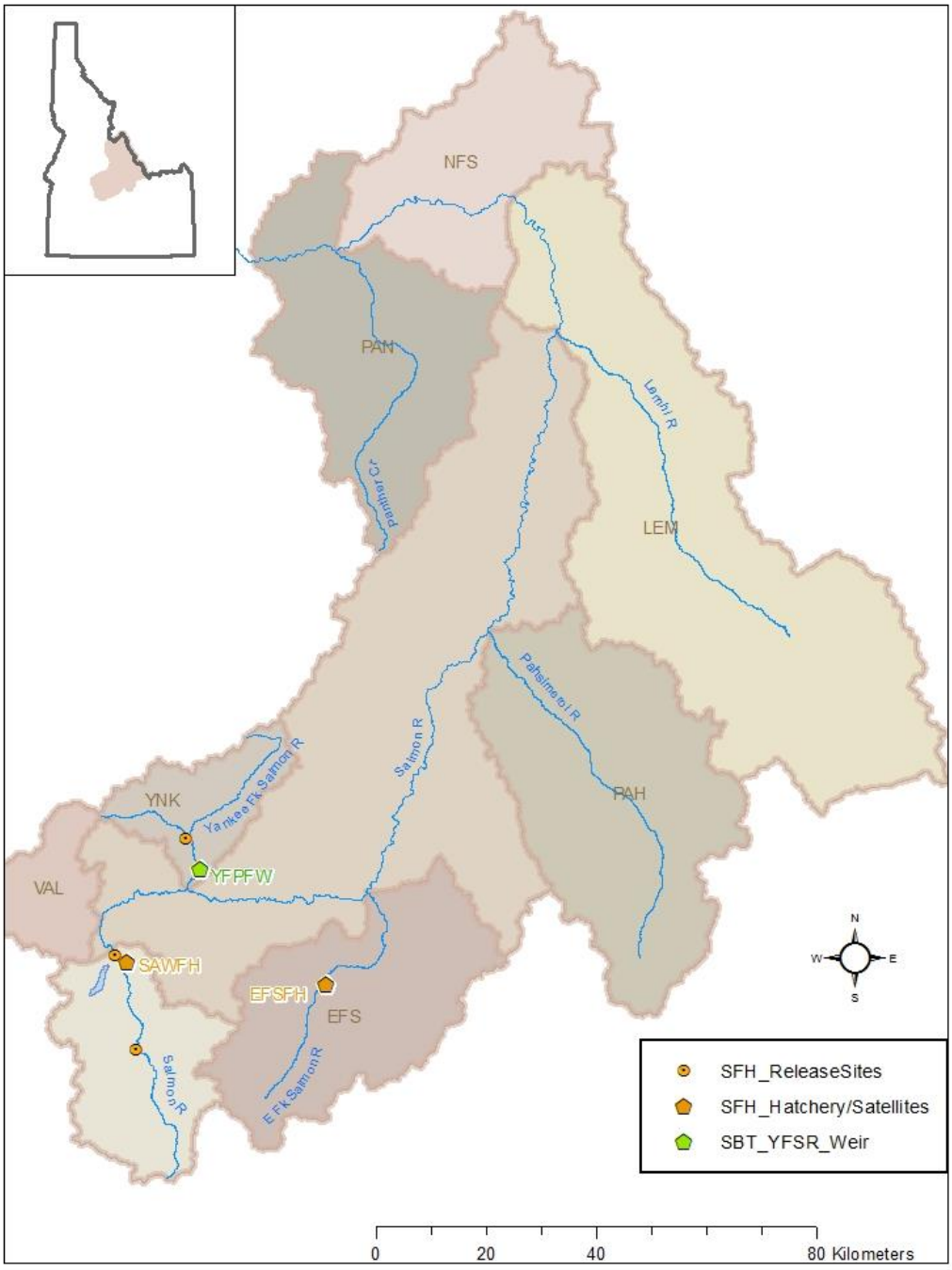

Figure 1. Map of the Upper Salmon River Major Population Group (MPG) and locations of hatchery facilities and juvenile release sites associated with hatchery production at Sawtooth Fish Hatchery.

Production **and management changes since the last ISRP review**

Since the last Independent Scientific Review Panel (ISRP) review in 2010, the production target at Sawtooth Fish Hatchery has increased from 1.7M to 2.0M yearling smolts. As part of the 2.0M smolt production, up to 300,000 yearling smolts are released in the Yankee Fork Salmon River as part of the Shoshone-Bannock Tribe's hatchery program. The remaining 1.7M yearling smolts are released on-site, or just upstream of Sawtooth Fish Hatchery. This report will focus on the performance of the fish released on-site at Sawtooth Fish hatchery but will also include estimates from the Yankee Fork releases for some survival metrics.

Historically, the Sawtooth Fish Hatchery program has been managed as a segregated broodstock. Beginning in 2010, mangers changed it to a stepping-stone integrated broodstock consistent with programmatic recommendations from the Hatchery Scientific Review Group (HSRG) in 2009.

The change to managing with an integrated broodstock was chosen for two primary reasons. 1) An integrated broodstock maintains genetic continuity with the natural population and guards against risk associated with the unintentional spawning of hatchery fish with the natural population downstream of the weir. 2) Managers have chosen to supplement the natural population upstream of the hatchery weir with hatchery adults to increase the abundance of natural fish in the population. The integrated broodstock minimizes domestication selection and results in hatchery fish that are more similar to the natural population as compared to a segregated broodstock. The stepping-stone approach was chosen because the number of natural-origin adults returning to Sawtooth Fish Hatchery has been insufficient to fully integrate a hatchery program with at 2.0M smolt production target. As such, when natural-origin adult returns are less than 1,000 adults, the integrated component of the broodstock is comprised of 250,000 smolts. Adult returns from these smolts are used to supplement the natural spawning population upstream of the weir. Additionally, a portion of these adults are incorporated into the broodstock that is used to produce the remaining 1.75M smolts thereby maintaining a genetic linkage between the natural and hatchery fish. As the abundance of natural origin adults increases through time, the proportion of the program that is integrated with natural adults will also increase with the goal to fully integrate the entire program.

Due to uncertainties associated with the effectiveness of supplementation, a project (BPA project 2010-031-00) was initiated in 2010 to assess the effectiveness of supplementation associated with the programs at Sawtooth, Pahsimeroi, and McCall fish hatcheries (Venditti et al, 2022).

Objectives for the integrated program include targeting a Proportionate Nature Influence (PNI) of 0.5-0.67. To achieve this high PNI, we target using 100% natural origin fish in the broodstock. The first Integrated adults ruturned in 2014 and since then, returns of both integrated and natural adults have been very low. These lowe returns are consistent with other populations in the Snake River basin. As a result, the PNI target has only been met in three of eight years during the period 2014-2021.

ESA status and consultation history

The Sawtooth Fish Hatchery spring Chinook Salmon program is contained within the Salmon River Upper Mainstem population that is part of the Upper Salmon River Major Population Group (MPG) and Snake River ESU (Figure 1). The upper Salmon MPG contains eight extant populations and one extirpated population (Panther Creek). All natural populations of spring Chinook Salmon in the Upper Salmon River MPG are part of the Snake River ESU. The hatchery-origin Chinook Salmon from Sawtooth Fish hatchery are also part of the ESU and are included in the listing.

The Snake River spring/summer Chinook Salmon ESU was listed as threatened in 1992. In the recent 5-

year status review by the National Marine Fisheries Service (NMFS), it was determined that there was no new information that would warrant a change in the listing status (NMFS 2022). None of the populations in the Upper Salmon River MPG currently meet viability criteria and the Salmon River Upper Mainstem population is rated at high risk for abundance and productivity and low risk for spatial structure and diversity.

Through consultation with NMFS and the USFWS, two Biological Opinions (WCR-2017-7042 and 01-EIFW00-2017-1079) were completed in 2017 that established take limitations for ESA listed species including spring/summer Chinook Salmon, Fall Chinook Salmon, steelhead, and Bull Trout that are impacted by operation of the spring/summer Chinook Salmon hatcheries in the upper Salmon River MPG. The non-tribal fishery is operated in accordance with IDFG's Fishery Management and Evaluation Plan (IDFG 2011).

Broodstock history

Initial broodstock for the USR program was collected at a temporary weir in the USR from 1981 to 1984 at the site of the current Sawtooth Fish Hatchery. It was estimated that approximately 50% of the two-ocean broodstock collected in 1981 were from the release of Rapid River hatchery smolts in 1979. A similar proportion of the three-ocean returns in 1982 are assumed to be from the same hatchery release. Since 1983, all broodstock have been locally returning adults to the upper Salmon River at Sawtooth Fish Hatchery.

Broodstock **goals**

Broodstock collection targets are established annually through the AOP process. A "Broodstock Calculator" is used to calculate the number of adults to be trapped and spawned based on a five-year running average of survival metrics (i.e. adult pre-spawn mortality, fecundity, disease culling rate, eye-up rate, and eye-release survival). Current broodstock targets for the Sawtooth Fish Hatchery include trapping and holding 1,200 adults. The number of natural adults collected and incorporated into the brood varies annually and is based on a sliding-scale of abundance for the number of natural fish that arrive at the trap.

Management **and M&E objectives**

Management Objectives for the Upper Salmon River hatchery program are to meet the LSRCP adult mitigation objectives, restore and maintain tribal and non-tribal fisheries in the Salmon River basin and minimize the impact of the hatchery program on the natural Chinook Salmon populations in the upper Salmon River consistent with objectives outlined in IDFG's Fisheries Management Plan (IDFG, 2009)**.** Monitoring and evaluation (M&E) objectives for the Upper Salmon River program include monitoring production, productivity, and life history characteristics of hatchery and natural populations and to evaluate broodstock and rearing strategies to increase and maximize adult returns. The monitoring and evaluation of the natural population consists of a comprehensive fish-in, fish-out monitoring program that follows fish from the cradle to the grave via sampling at screw traps, snorkel surveys, and spawning ground surveys in addition to juvenile and adult sampling at Lower Granite Dam. For IDFG, monitoring of natural populations in the Salmon R basin is funded through the BPA Fish and Wildlife program under project 1990-055-00.

In-Hatchery and Post-Release Performance

Adult pre-spawning mortality

Average pre-spawn mortality rates for male and female spring Chinook at Sawtooth Fish Hatchery are generally low, with most years recorded at <10% and since 2007 has averaged 2% (Figure 2). The exception was for brood year 2006, when 64% of adults died due to an outbreak of *Ichthyophthirius multifiliis* (Ich).

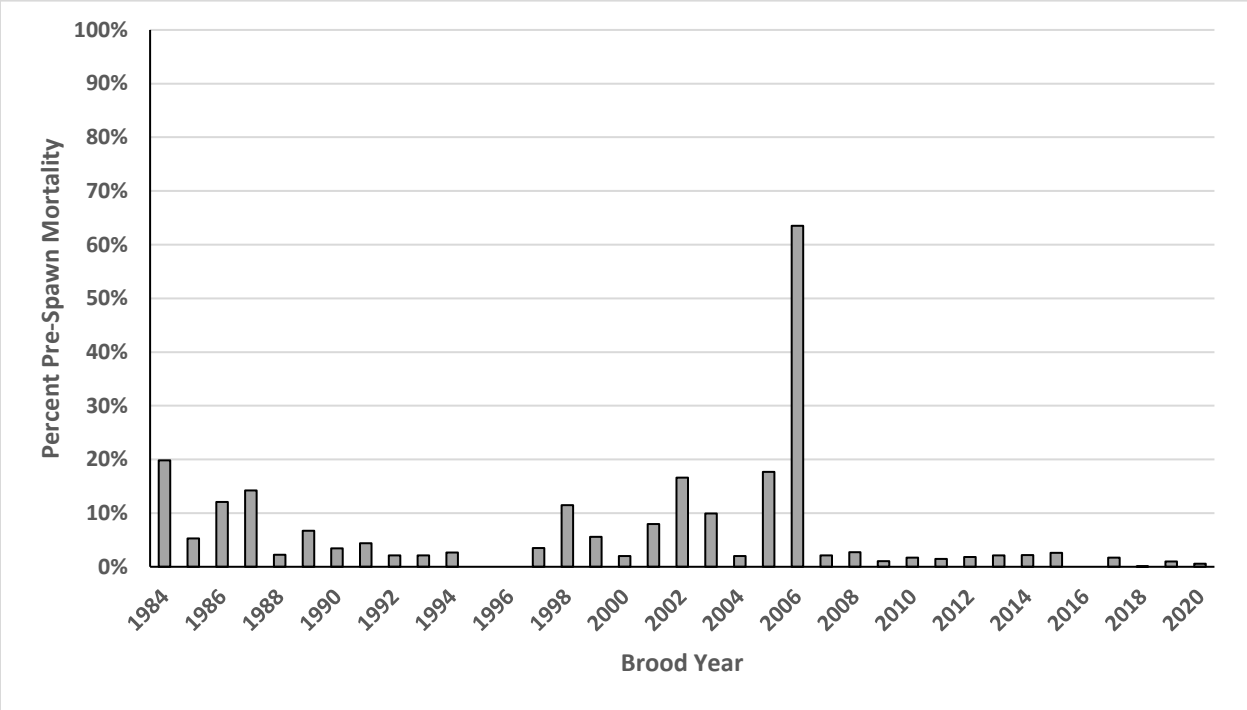

Figure 2. Pre-spawn mortality rates of spring Chinook Salmon at Sawtooth Fish Hatchery, 1984-2020.

Egg to smolt survival

Average survival from eyed-egg to release at Sawtooth Fish Hatchery for spring Chinook Salmon is 88% over the entire time series and 83% for the most recent 10 years (Figure 3).

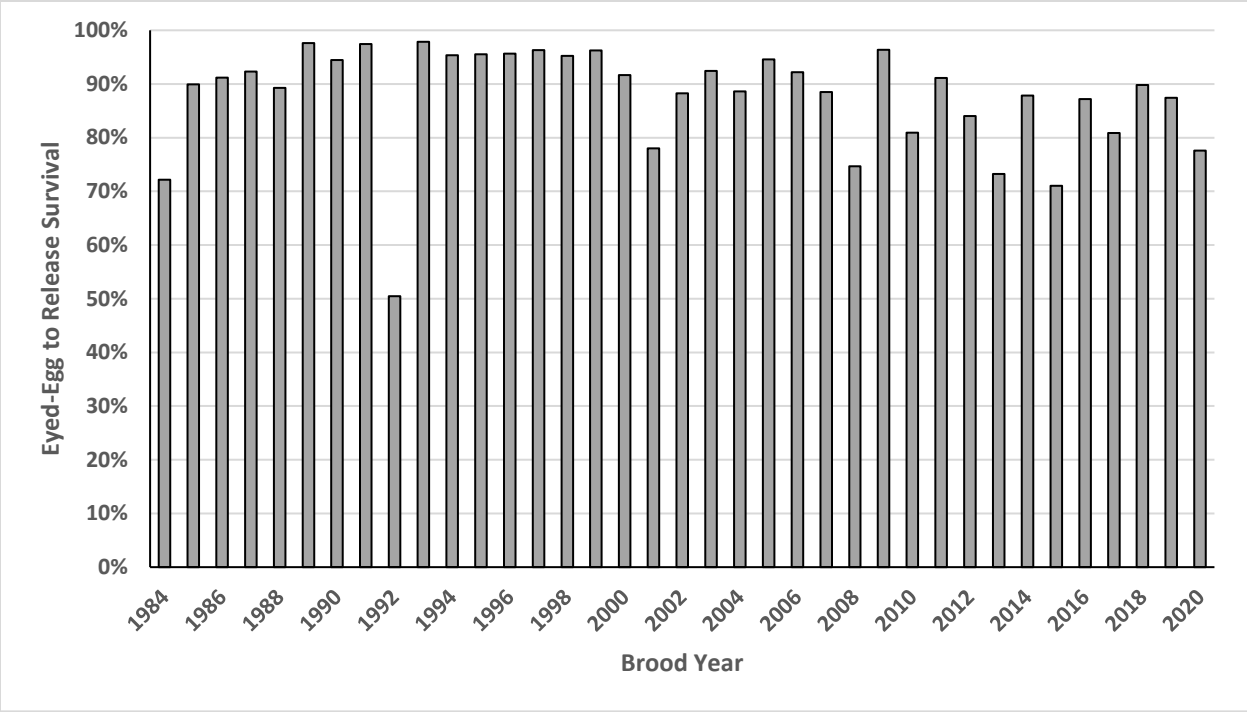

Figure 3. Eyed egg to release survival of Sawtooth Fish Hatchery spring Chinook Salmon smolts, 1984-2020.

Juvenile releases

Production targets for juvenile releases of spring Chinook Salmon increased incrementally since 2002 in an effort to achieve the adult mitigation goals (Figure 4). Likewise, due to the relatively poor post-release performance of sub-yearling releases, all sub-yearling releases were phased out and since brood year 1993, all production at Sawtooth Fish Hatchery has been composed of yearling smolt releases (Figure 5). Early in the Sawtooth Fish Hatchery program, release targets were routinely underachieved due to low adult returns. Since brood year 2007, juvenile releases have been more consistent from year to year but production targets are still not achieved every year. Annually, up to 300,000 yearling smolts are released into the Yankee Fork Salmon R. as part to the Shoshone-Bannock Tribe hatchery program.

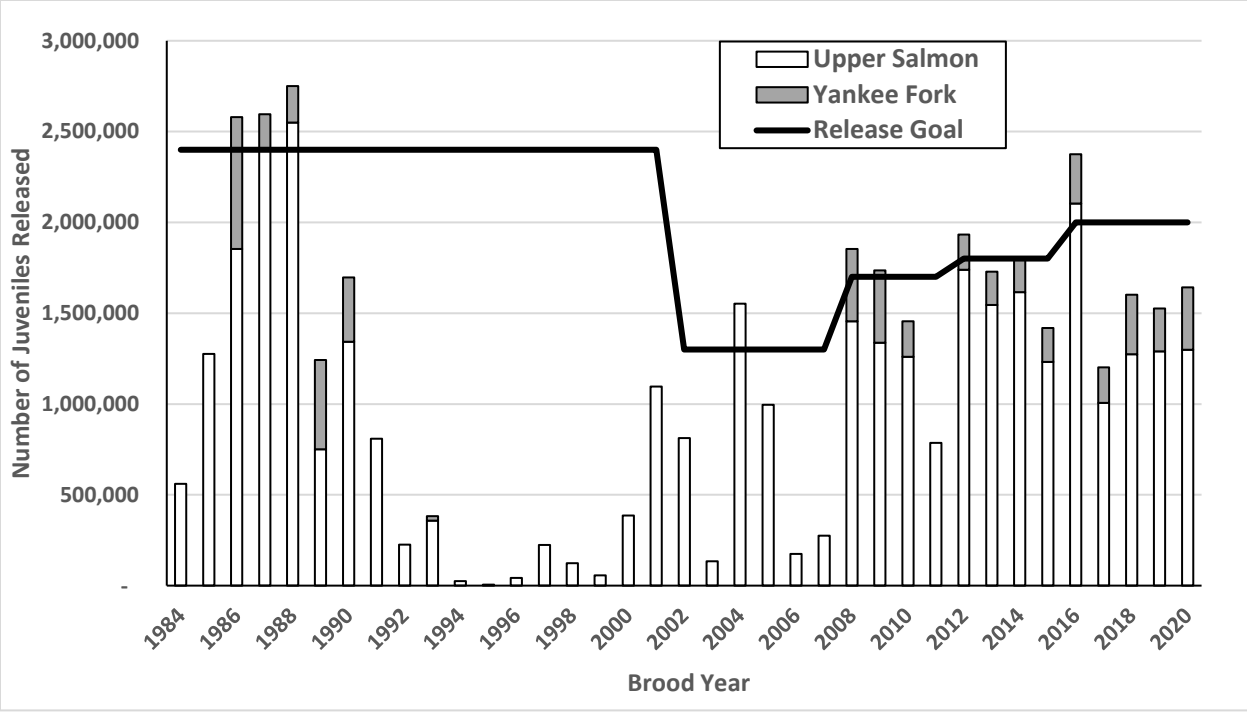

Figure 4. Release target and actual number of juvenile spring Chinook Salmon released from Sawtooth Fish Hatchery, 1984-2020.

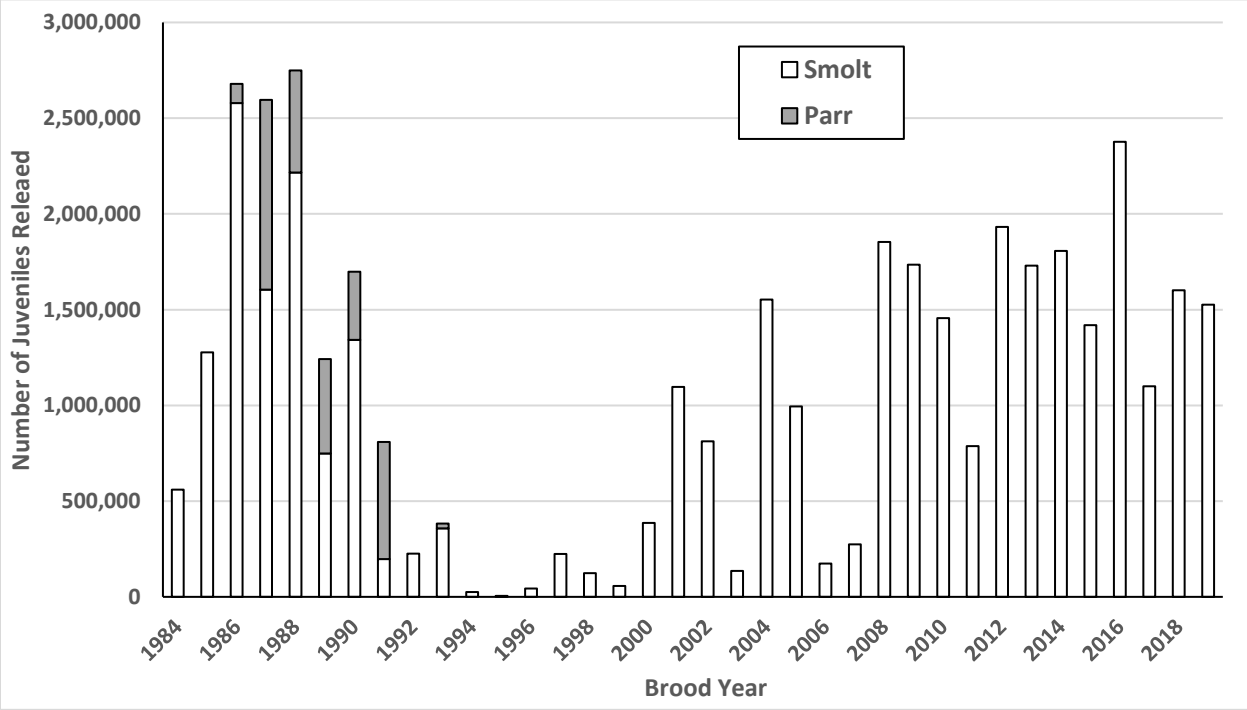

Figure 5. Number of sub-yearling and yearling spring Chinook Salmon released from Sawtooth Fish Hatchery, 1984-2020.

Juvenile survival from release to Lower Granite Dam

Juvenile release groups of spring Chinook Salmon have been representatively tagged with Passive Integrated Transponders (PIT) tags since 1995 and are used to estimate juvenile survival from release to Lower Granite Dam. Since 2008, PIT tagging efforts increased (number tagged per release group) as part of a cooperative effort with the Comparative Survival Study (McCann et al., 2021) and to provide estimates of adult returns for survival analysis and for in-season fisheries management.

Estimated survival of juvenile spring Chinook Salmon from release to Lower Granite Dam has increased in more recent years with an average survival of 62% in the last 10 years compared to 50% for the previous 16 years. During the years (2008-2020) when both Sawtooth and Yankee Fork releases were PIT tagged, the average survival of the Sawtooth release is 59% and the average survival of the Yankee Fork release is 42%.

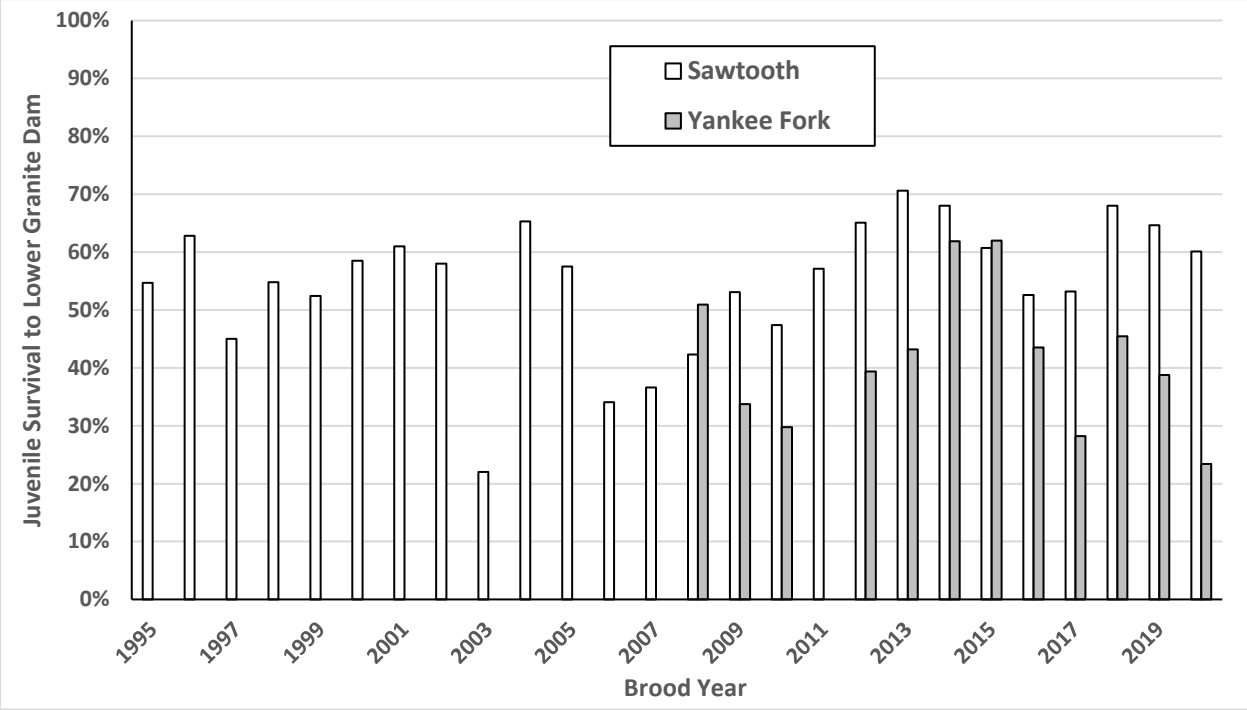

Figure 6. Estimated survival, from release to Lower Granite Dam, of juvenile spring Chinook Salmon from released from Sawtooth Fish Hatchery for brood years 1995-2020.

Adult returns to the Project Area (mitigation goal)

The LSRCP adult mitigation goal for programs in Idaho are measured as adult returns above the Project Area and is defined as returns to Lower Granite Dam. For Sawtooth Fish Hatchery, the goal is to return 19,445 adults annually to Lower Granite Dam.

Prior to return year 2012, adult returns to Lower Granite were estimated indirectly from a traditional run reconstruction. Adults were accounted for on the spawning grounds, returns to the trapping facilities, and estimates of harvest in the tribal and non-tribal fisheries upstream of Lower Granite Dam. All of these components were summed to estimate the return to Lower Granite Dam. Beginning in 2012, adult returns to Lower Granite Dam have been estimated directly from a systematic sampling program and use of Parental Based Tagging (PBT) to assign sampled fish to their hatchery, stock, and cohort of origin (Belnap et al., 2021).

Over the history of the Sawtooth Fish Hatchery program, the Project Area goal has never been achieved. However, we have seen an overall improvement in returns since return year 2007. In the most recent 10 years (2012-2021) the average return to Lower Granite Dam is 4,084 compared to 1,274 from the previous 26 years. (Figure 7). Arguably, some of the apparent improvement is a result of the more thorough accounting that has resulted from the adult sampling program at Lower Granite Dam and the incorporation of the PBT tagging program. Similar to other wild and hatchery populations, adult returns from Sawtooth Fish Hatchery at Lower Granite Dam have decreased significantly since 2015 (Figure 8).

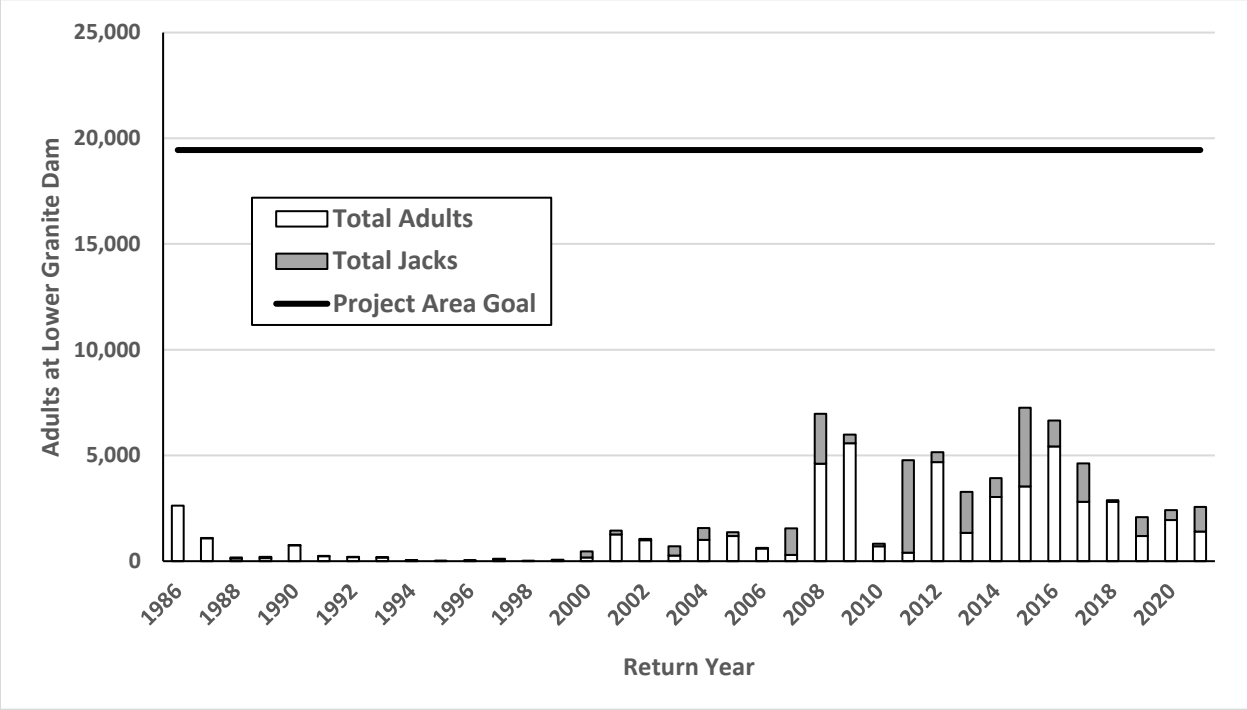

Figure 7. Number of adult Chinook Salmon from Sawtooth Fish Hatchery estimated at Lower Granite Dam 1986-2021. The black horizontal line represents the Project Area goal for Sawtooth Fish Hatchery.

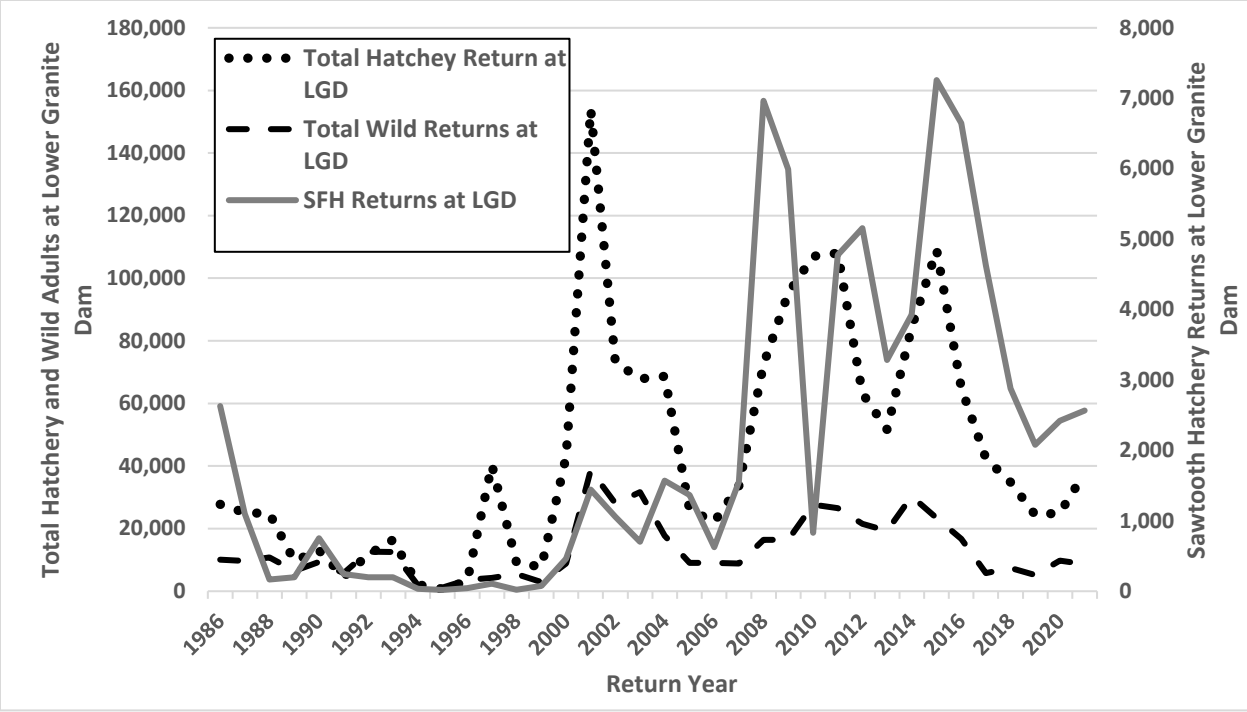

Figure 8. Estimated number of hatchery-origin adults from Sawtooth Fish Hatchery (SFH) and the total hatchery and wild return of spring/summer Chinook Salmon at Lower Granite Dam (LGD), 1986-2021.

Smolt-to-adult return (SAR)

The smolt-to-adult return rate (SAR) in this report is defined as the fraction of juveniles released that return to Lower Granite Dam as adults. Adults from a single cohort return over three years as one-, two-, and three-ocean adults. Stock and cohort specific estimates at Lower Granite Dam are determined based on PBT analysis described in the "Adult Returns to Project Area" section above. Based on the current smolt production target of 2.0M yearling smolts at Sawtooth Fish Hatchery, an SAR of 0.97% is necessary to achieve the adult mitigation goal to the Project Area (19,445 adults).

Smolt-to-adult return rate (SAR) for spring Chinook Salmon released from Sawtooth Fish Hatchery has varied significantly over the program history (Figure 9). The mean SAR since the inception of the program is 0.28%. In the most recent 10 brood years (2007-2016) the average SAR is 0.30% which is still less than one third of what is needed to meet the Project Area goal.

Since 2012, we have been able to directly compare the SAR for the release at Sawtooth Fish Hatchery with the release in the Yankee Fork. Similar to what has been observed for the smolt survival estimates to Lower Granit Dam, SAR for the Yankee Fork Release is consistently lower than that observed for the release at Sawtooth Fish Hatchery (Figure 10). Lytle Denny from the Shoshone-Bannock Tribe will be discussing the Yankee Fork program in more detail in his report and presentation.

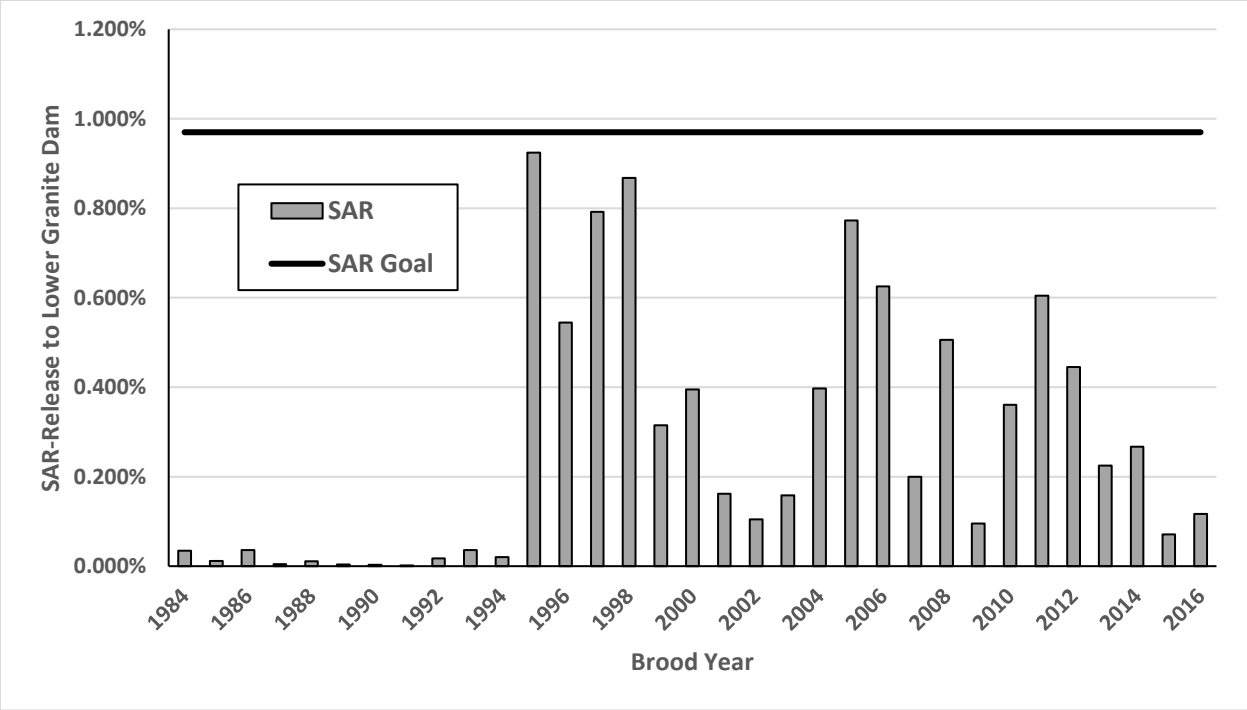

Figure 9. Smolt-to-adult return rate (SAR) of spring Chinook Salmon reared at Sawtooth Fish Hatchery for brood years 1984-2016.

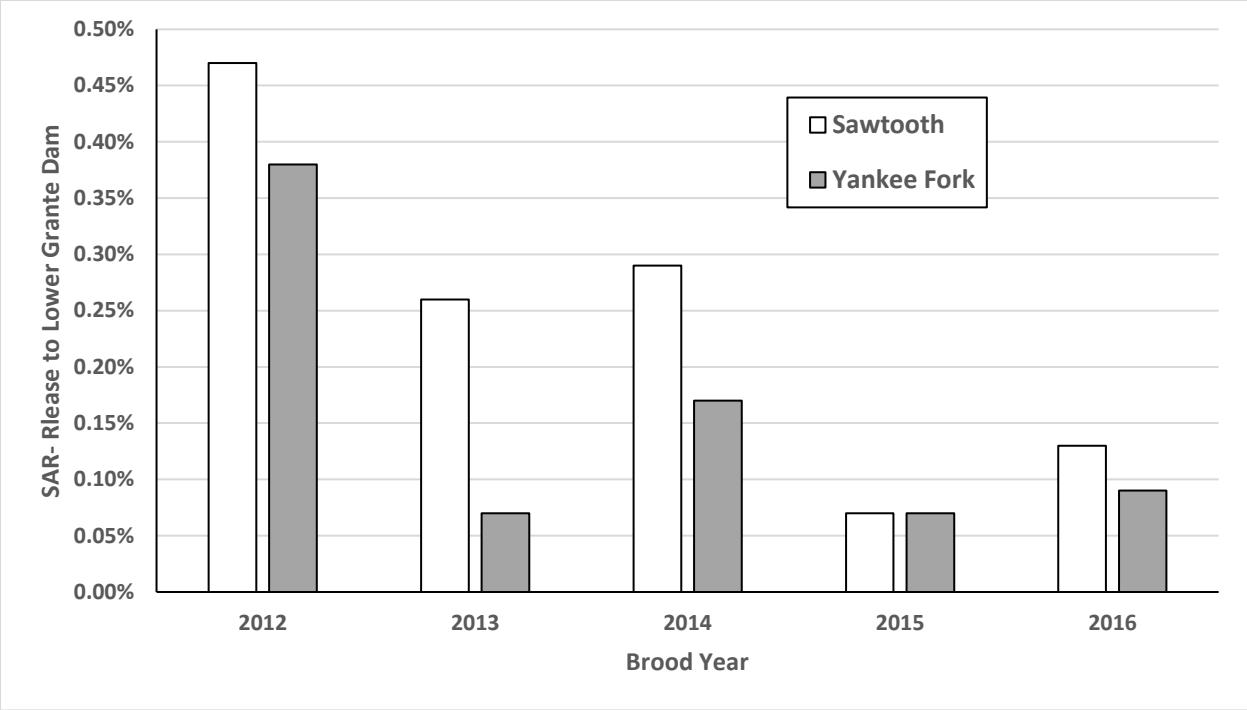

Figure 10. Smolt-to-adult return rate (SAR) of spring Chinook Salmon reared at Sawtooth Fish Hatchery and released on-site at Sawtooth Fish Hatchery and in the Yankee Fork Salmon R. for brood years 2012-2016.

Smolt-to-adult survival **(SAS)**

Smolt-to-adult survival rate (SAS) in this report is defined as the fraction of juveniles released that survive to adulthood back to the Columbia River mouth. Due to minimal harvest of spring/summer Chinook in the Pacific Ocean, returns to the Columbia River mouth represent the survival rates prior to human exploitation. Estimates to the Columbia River mouth are derived by backing down the Lower Granite estimates (described above) to Bonneville Dam using the stock and cohort specific PIT tag conversion rates between Bonneville and Lower Granite dams. The Bonneville estimates are then backed down to the Columbia River mouth based on coded wire tag recoveries from fisheries sampled in the Columbia River downstream of Bonneville Dam. When the LSRCP program was developed, it was assumed that the catch to escapement ratio of fish harvested downstream of the project area was 4:1. As such, based on the smolt release target of 2.0M, an SAS of 4.85% is required to meet the total adult escapement goal of 97,000 to the Columbia River mouth.

The SAS for spring Chinook Salmon released from Sawtooth Fish Hatchery has averaged 0.32% over the history of the program. During the most recent 10 brood years (2007-2016) the average SAS is 0.40% indicating that on average, only 8% of the total adult return goal would be achieved under the current smolt release target (Figure 11).

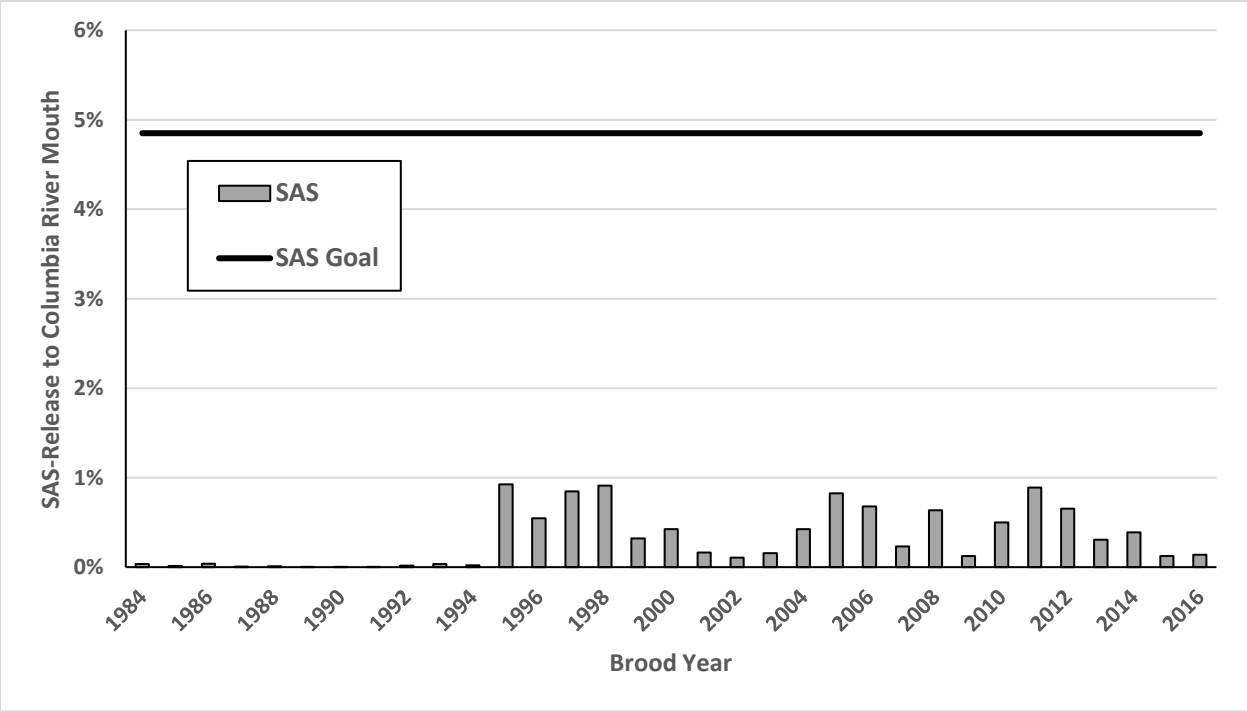

Figure 11. Smolt to adult survival rate (SAS) of spring Chinook Salmon reared at Sawtooth Fish Hatchery for brood years 1984-2016.

Recruits per spawner

The number of returning hatchery origin adults produced per adult spawned is a useful metric that captures survival over the entire lifecycle and highlights the survival advantage that occurs during the hatchery rearing phase of the lifecycle. In this report we provide the number of adult recruits produced per spawner that is calculated as the number of returning adults estimated at the Columbia R. mouth divided by the number of parents that were spawned for that cohort. The number of parents spawned includes those spawned, the number of adults that died prior to spawning, and parents whose eggs were culled at the hatchery for disease management purposes.

The average number of recruits per spawner for the spring Chinook reared at Sawtooth Fish hatchery over the history of the program is 5.5 (Figure 12). The average for the most recent 10 years (BY2007-2016) is 7.4.

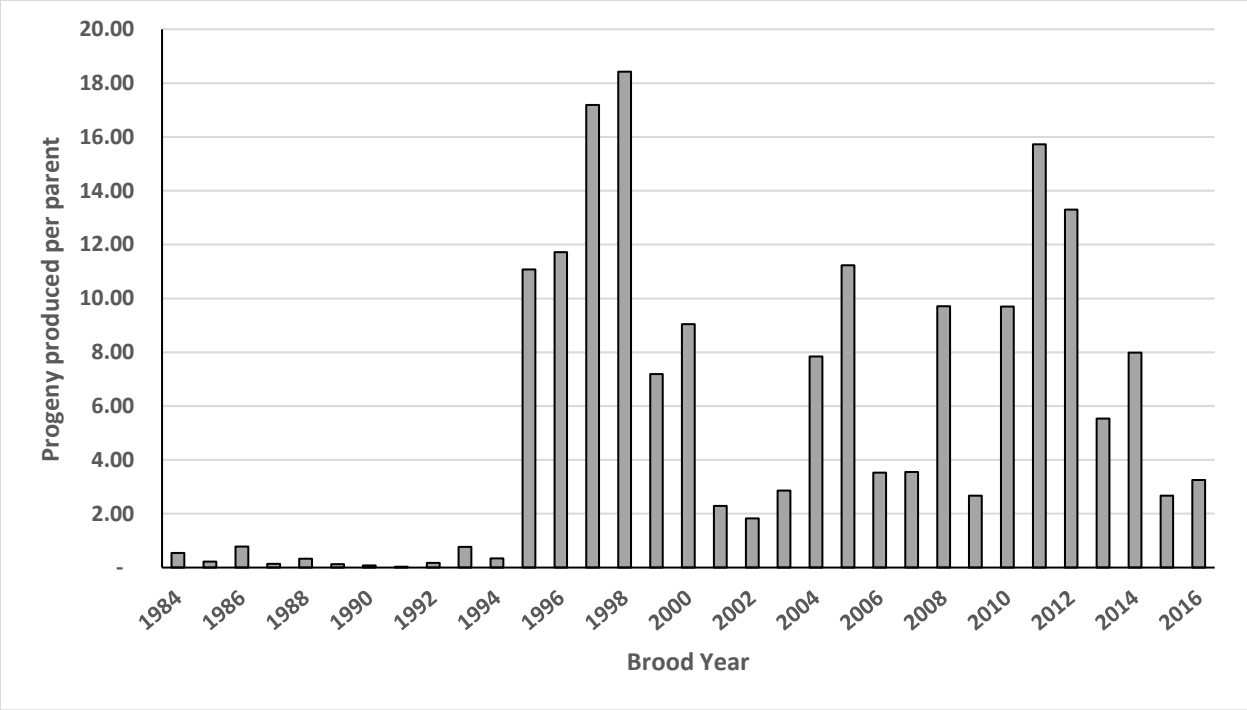

Figure 12. Adult progeny produced per parent for spring Chinook Salmon released from Sawtooth Fish Hatchery for brood years 1984-2016.

Harvest contributions

The primary objective for the LSRCP-funded fish produced at Sawtooth Fish Hatchery is to provide for lost harvest opportunity associated with the construction and operation of the four lower Snake River hydroelectric dams.

Fisheries in Idaho

Annually, fisheries in Idaho are initially established based on pre-season forecasts of Chinook Salmon destined for return to the upper Salmon River from Sawtooth Fish Hatchery. In-season, the forecasted numbers are updated based on PIT tag detections at the Columbia River and Snake River dams. Harvest shares for fisheries are based on the anticipated return to Sawtooth Fish Hatchery and the number of broodstock needed to meet juvenile production targets. Fish returning that are in excess to brood needs are split evenly between the tribal and non-tribal fisheries. Weekly conference calls conducted during the fisheries are used to update the projected returns and numbers of fish harvested to date.

The first non-tribal fishery targeting adults returning to Sawtooth Fish hatchery occurred in 2008. Since then, fisheries have occurred in 10 of the last 14 years. The number of fish harvested, and the amount of angler effort has varied over that timeframe with an average annual harvest of 723 (range: 9-1,515) and an average of 17,900 (range: 1,749-36,650) hours of angler effort for years when fisheries occurred. (Figure 13). Although fisheries have occurred frequently in recent years, the number of fish available for

harvest has been low. If the mitigation goal for Sawtooth Hatchery was being met, the number of fish available for harvest would be approximately 9,000 fish each for both the tribal and non-tribal fisheries.

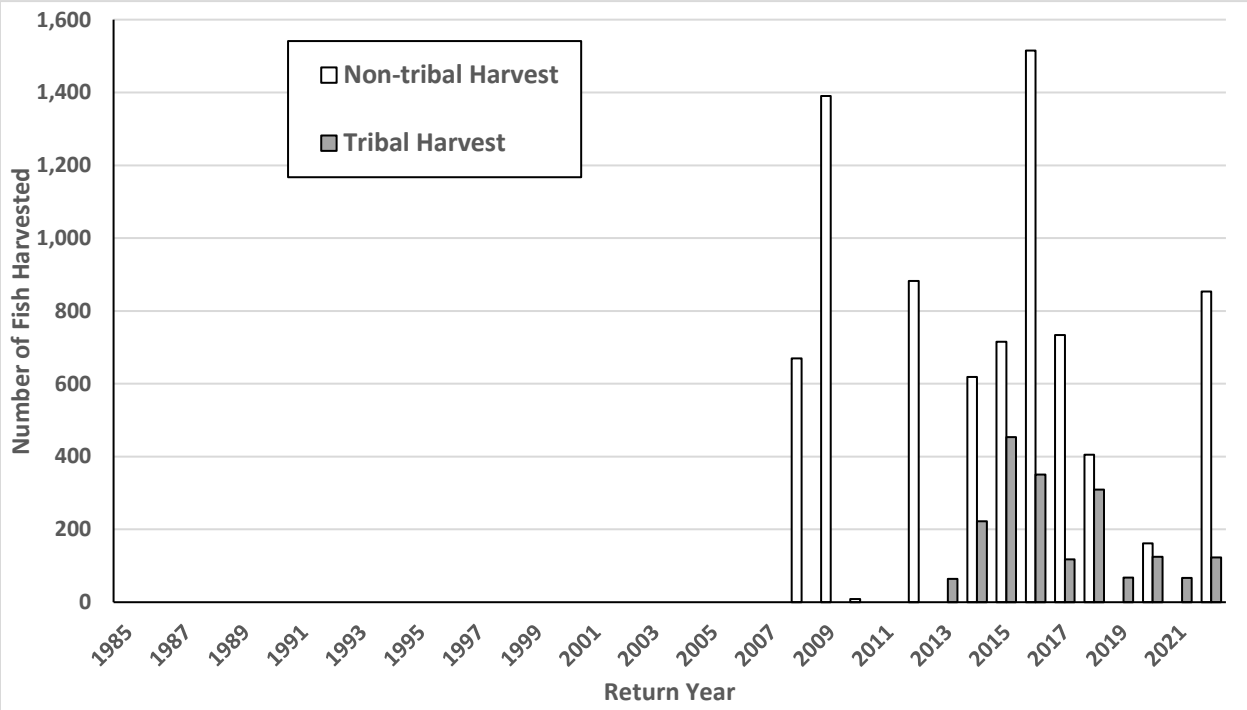

Figure 13. Estimated harvest of spring Chinook Salmon from the tribal and non-tribal fisheries targeting spring Chinook Salmon from Sawtooth Fish Hatchery in the upper Salmon River, 1985-2022. Estimated tribal harvest prior to 2013 was unavailable at the time this report was written.

Harvest downstream of Idaho

Between 1987 and 2019, harvest of spring Chinook produced by Sawtooth Fish Hatchery occurred in fisheries downstream of Idaho in all but 11 years (Figure 14). During this time, an average of 211 (range: 0-1,869) fish were harvested annually. In the most recent 10 years (2010-2019), the average is 560.

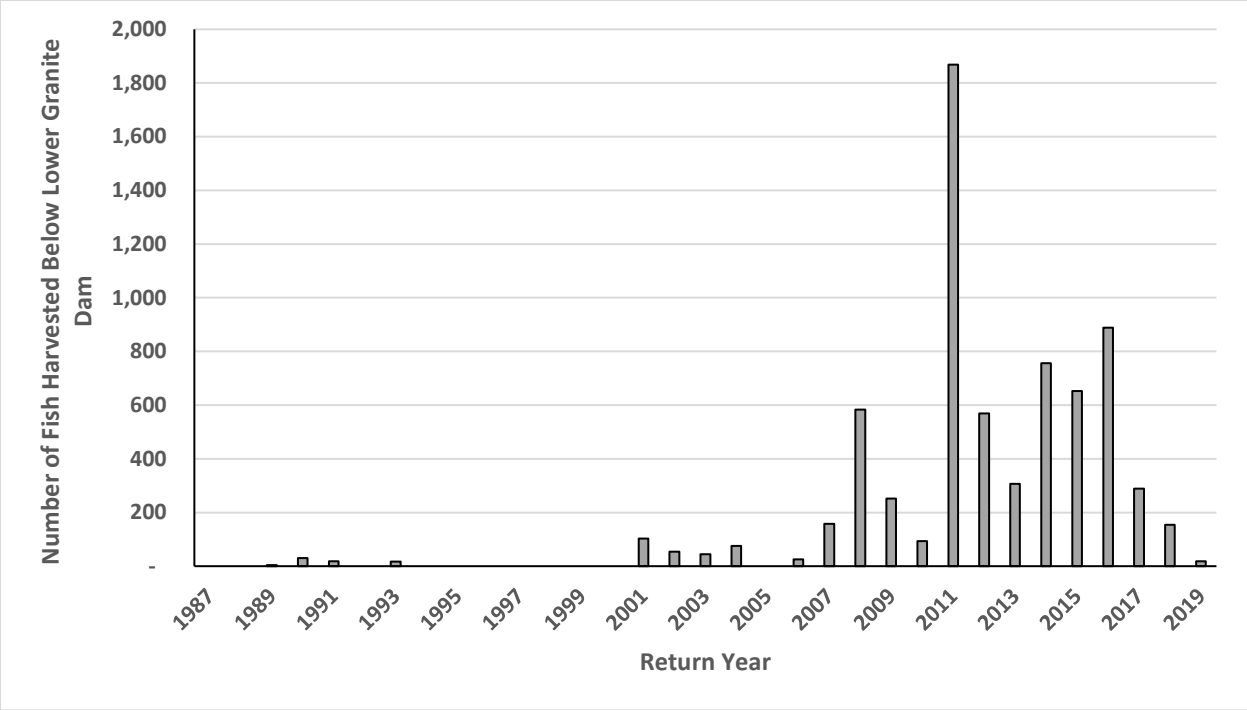

Figure 14. Number of spring Chinook Salmon produced at Sawtooth Fish Hatchery harvested in fisheries downstream of Idaho, 1987-2019.

Results to date for the integrated broodstock and supplementation efforts

Objectives for the integrated broodstock include targeting a Proportionate Natural Influence (PNI) of 0.50-0.67 for the population upstream of the weir at Sawtooth Fish Hatchery. To achieve this high PNI, we target using 100% natural-origin fish in the broodstock (pNOB). The first integrated adults returned in 2014 and since then, returns of both integrated and natural adults have been very low, which is consistent with other populations in the Snake River basin. As a result, the pNOB target has not been met and the PNI target has only been met in three of eight years during the period 2014-2021 (Table 2).

Table 2. Proportion of the integrated broodstock at Sawtooth Fish Hatchery that is composed of natural-origin adults (pNOB) and proportion of spawners upstream of the Sawtooth Hatchery weir that are hatchery-orign (pHOS) for spawn years 2014-2021. PNI = Proportionate Natural Influence (pNOB/(pNOB+pHOS)).

Spawn Year	Observed pNOB	Observed pHOS	PNI
2014	0.28	0.43	0.39
2015	0.6	0.69	0.47
2016	0.53	0.8	0.4
2017	0.2	0.91	0.18
2018	0.26	0.81	0.25
2019	0.33	0.13	0.72

2020	0.71	0.15	0.83
2021	0.55	0.24	0.7

When comparing the mean number of recruits per female spawner from the first generation in brood years 2010-2015, females spawned in the hatchery produced on average 11 times more recruits than natural females that spawned in nature upstream of the weir (Vendittl et al., 2021). This is typical of the amplification that occurrs in the hatchery resulting in a much large number of smolts produced per female compared to naturally spawning females.

Venditti et al. (2021) also evaluated the adults produced per female in nature for both integrated and natural-origin females that were passed upstream of the weir for brood years 2014 and 2015. For both years, the number of recruits per spawner for natural-origin females was higher than for hatchery-origin females but productivity for both groups was extremely low and the number of F_2 recruits was less than 10 individuals for some groups (Table 3).

Table 3. Number of F_1 females by origin passed above the Sawtooth weir for natural spawning in 2014 and 2015 and the total number of their F_2 progeny (includes age-3, 4, and 5 offspring) that subsequently returned to the weir. Origins include natural (NP), integrated (IB), and segregated (SS).

	F_1 Female		F_2 Recruits			Recruits per Female (F_2/F_1)
Spawn Year	Origin	N	Male	Female	Total	
2014	NP	42	6	5	11	0.262
2014	IB	66	2	1	3	0.045
2014	SS	61	3	3	6	0.098
2015	NP	20	13	2	15	0.750
2015	IB	32	2	3	5	0.156
2015	SS	57	12	8	20	0.351

Summary and outlook for the Future

While the adult mitigation goal for Sawtooth Fish Hatchery is far from being achieved, we have observed more consistent adult returns and harvest opportunity in recent years. Looking forward, managers will continue to look for opportunities to refine rearing methods and production strategies with the goal of increasing post release performance of hatchery reared fish and/or increasing smolt production at Sawtooth Hatchery with the goal of providing annual Tribal and non-Tribal fisheries with increased adult Chinook Salmon available for harvest.

Since the last ISRP review in 2010, we have continued to observe a consistent and high survival during the hatchery phase of the lifecycle and a highly variable post release survival rate. One notable improvement has been the ability to more consistently meet the juvenile production targets in the last

ten years, enabling the hatchery population to better take advantage of years when post-release survival is improved.

The change in broodstock management from segregated to integrated has significantly changed weir and broodstock management for this program. Monitoring and evaluation staff work closely with the hatchery staff during the adult return to manage the broodstock composition and escapement of hatchery and natural fish upstream of the weir to meet the sliding scale guidelines. Due to the low abundance of natural fish, the PNI target for the population upstream of the weir has only been met in three of eight years during the period 2014-2021 but the PNI values are consistent with how the sliding scale was developed for years of low natural origin returns. We are relatively early in the evaluation phase of this supplementation effort and future returns will help to guide an adaptive management approach for supplementation efforts in the upper Salmon R. Regardless, as the abundance of natural adults allows, managers will move towards fully integrating the production at Sawtooth Fish Hatchery to reduce risks associated unintentional spawning of hatchery fish downstream of the weir.

The adult mitigation goal to the project area (19,445) for Sawtooth Fish Hatchery has never been met and over the history of the program the average annual return to the Project Area has been 10% of the goal. Among the LSRCP spring/summer Chinook programs, the Sawtooth program remains the furthest from meeting its project area mitigation goal and major changes are needed to close the gap. There has been a significant improvement in adult returns in more recent years with more than a three-fold increase in the most recent 10 years compared to the previous 26 years. However, regardless of the recent increases in adult returns, it is unlikely that Sawtooth Hatchery will meet its mitigation goal on a consistent basis without increasing the number of smolts released.

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