This report summarizes how well the combined LSRCP steelhead program has done to meet the mitigation program objectives. It also highlights the achievements and limitations observed over the program history with a brief description of the adaptive management approaches taken by the managers. Information presented in this report represents the combined efforts of many people from several state, tribal, and federal entities.

For most metrics, two figures are presented to show 1) the average or weighted average across all programs in WA, OR, and ID to convey how well LSRCP program is performing relative to the mitigation goals and 2) data series for individual programs to show both the synchrony and variability between programs. Definitions for all of the metrics provided in this summary were agreed upon by the data contributors to ensure the metrics would be comparable across programs. The intent of this report is not to focus on or to address nuances in individual programs but rather to provide an overview of the program relative to the stated mitigation objectives.

LSRCP Mitigation Objectives

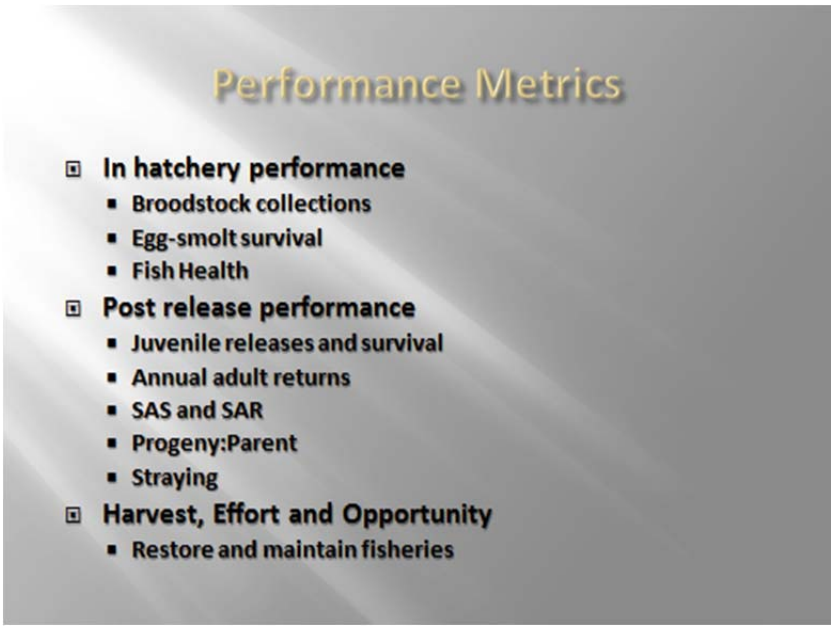
The LSRCP steelhead hatchery mitigation program was established to provide in-kind and in-place mitigation for lost harvest opportunity resulting from the construction and operation of the four lower Snake River hydroelectric dams. Total mitigation expected for the LSRCP is 165,300 adults to be produced annually. This is based on an assumed 2:1 ratio of catch (downstream of project area; Lower Granite Dam) to escapement (upstream of the project area) (Corps of Engineers, 1975). During the program development, it was anticipated that the majority of the harvest mitigation benefits would be distributed downstream of the project area. However, less than expected returns of hatchery fish produced within the program and the depressed status of natural-origin fish influenced Columbia River fisheries management programs. The anticipated 2:1 distribution of harvest benefits downstream:

upstream of Lower Granite Dam has not been realized. It is important to note that while the individual program presentations at this symposium have reported mitigation goals in terms of meeting objectives for "catch below the project area" and "escapement to the project area", this delineation is based more on the historic convention of how the mitigation objectives were originally described and less on actual management goals (Table 1). It may be more appropriate to think in terms of the total mitigation objective (165,300 adults) realizing that, for reasons mentioned above, the observed distribution of harvest benefits is more skewed to the terminal areas.

Table 1. Adult steelhead hatchery mitigation goals for the LSRCP program in Washington, Oregon, and Idaho.

	LSRCP-Adult Mitigation Goal		
	Project Area (Escapement)	**Below Project Area (Catch)**	**Total Mitigation Goal**
Washington	**4,655**	**9,310**	**13,965**
Oregon	**11,185**	**22,370**	**33,555**
Idaho	**39,260**	**78,520**	**117,780**
Total	**55,100**	**110,200**	**165,300**

While some of the LSRCP resources are devoted to support conservation goals and objectives, the majority of resources within the program are focused on harvest mitigation. This roll-up presentation will focus at the programmatic level and not address individual project specific goals and objectives.



Broodstock Collections and In-hatchery Survival

With some exceptions, broodstock collections have not limited that abilty of managers to meet smolt produciotn targets.During the early years of the program, the observed egg to smolt survial rates were generally high but considerable variation was observed between years (Figure 1). Since 1995, in-hatchery survival has remained stable and has averaged 84%. With few expceptions, in-hathcery survival has not limited managers' ability to meet smolt production targets.

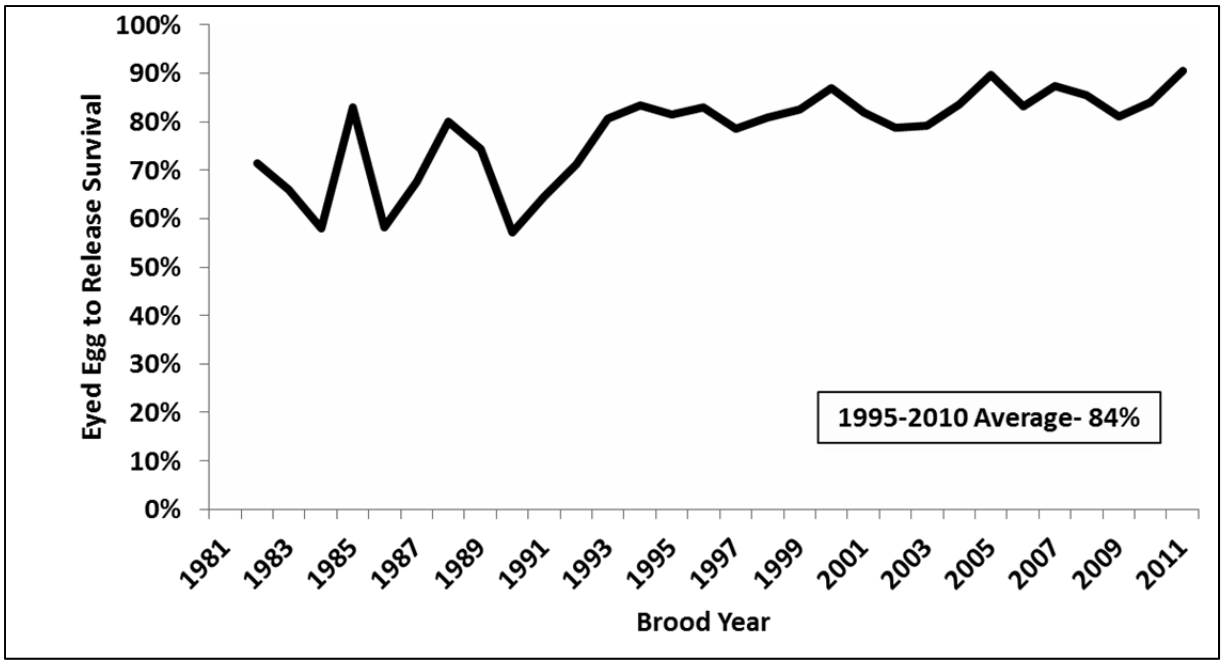


Figure 1. Average eyed-egg to smolt survival rates for all programs within the LSRCP steelhead mitigation program.

Smolt Releases

The original modeled smolt production targets needed to achieve adult mitigation objectives of 165,300 adults were based on releasing 11,020,000 smolts at eight fish per pound with a Smolt to Adult Survival (SAS) of 1.5%. During the 1980s as programs were developing, annual smolt releases across the program were increasing. During the 1990s and 2000s, Oregon and Washington reduced the number of smolts released while releases in Idaho remained stable. Overall, smolt releases for the LSRCP program have declined from approximately 6.25M in 1989 to 5.35M in 2010 (Figure 2).

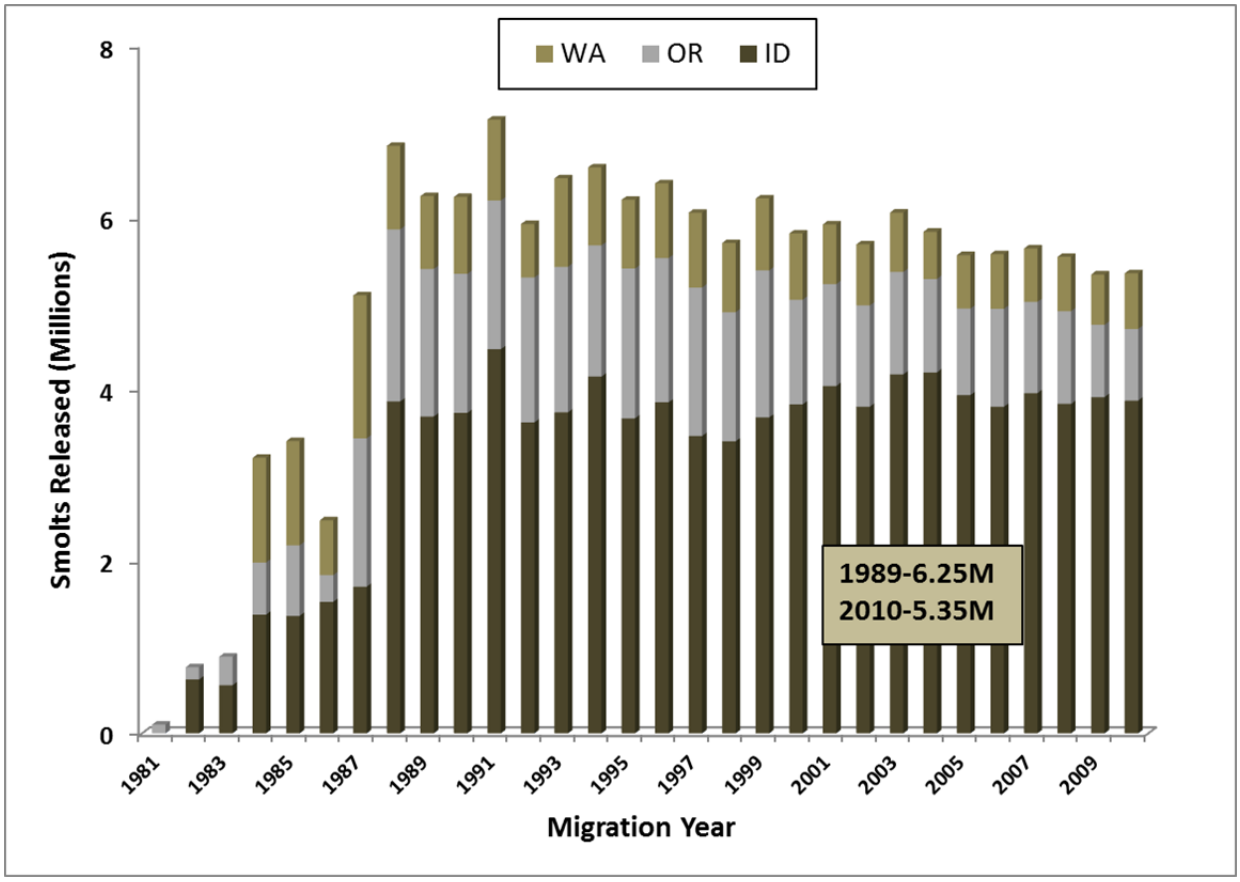


Figure 2. Annual number of steelhead smolts released for the LSRCP programs in Washington, Oregon, and Idaho 1981-2010.

Fish Health

With some exceptions, fish disease has not limited the ability of managers to meet smolt production targets and all programs currently have scheduled fish heath diagnostic screenings.

Post Release Performance

Survival of juveniles from their release site to Lower Granite Dam is estimated using PIT tags. Prior to 1993, other methods such as freeze brands were used and likely not comparable to estimates derived from PIT tags. From 1993-2011, the average survival has been 71% (range: 53-79%) (Figure 3). While managers have not defined a benchmark or goal for this metric, the range of survival rates observed across individual programs is similar. There also appears to be some level of synchrony between programs through time indicating the importance of environmental variables that fish experience after release.

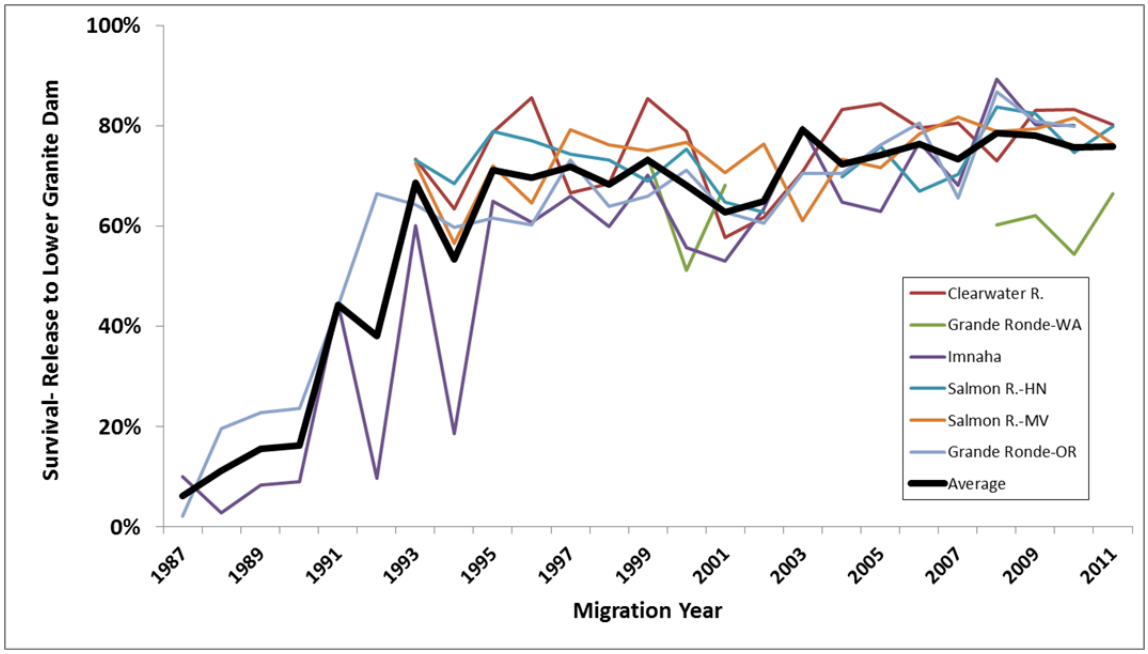


Figure 3. Estimated steelhead smolt survival from release sites to Lower Granite Dam (LGD) 1987-2011. Does not include smolt releases from Washington downstream of LGD (Snake R., Walla Walla R., Touchet R., and Tucannon R.).

Smolt to Adult Survival

Smolt to Adult Survival (SAS) is calculated as the survival rate prior to any human exploitation of adults. Average (weighted) SAS rate for brood years 1980-2005 is 1.14% (Range: 0.26-2.81%) and is highly variable annually (Figure 4). As stated previously, the original modeling indicated the need for a 1.5% SAS to meet the mitigation goal of 165,300 adults produced annual based on 11,020,000 smolts released. Current smolt releases include approximately 5.35M smolts. At this level of smolt production, an SAS of approximately 3.1% is needed to meet the adult mitigation objective. In most years, the observed SAS has been well below this level but for brood year 1999, an SAS of 2.81% was observed resulting in 154,000 adults produced (93% of total mitigation goal).

In addition to the high degree of variability observed temporally, we have observed in excess of a six-fold difference in SAS between programs within the same year (Figure 5). Also notable is the high degree of synchrony between programs indicative of the importance of migration and ocean conditions to the SAS.

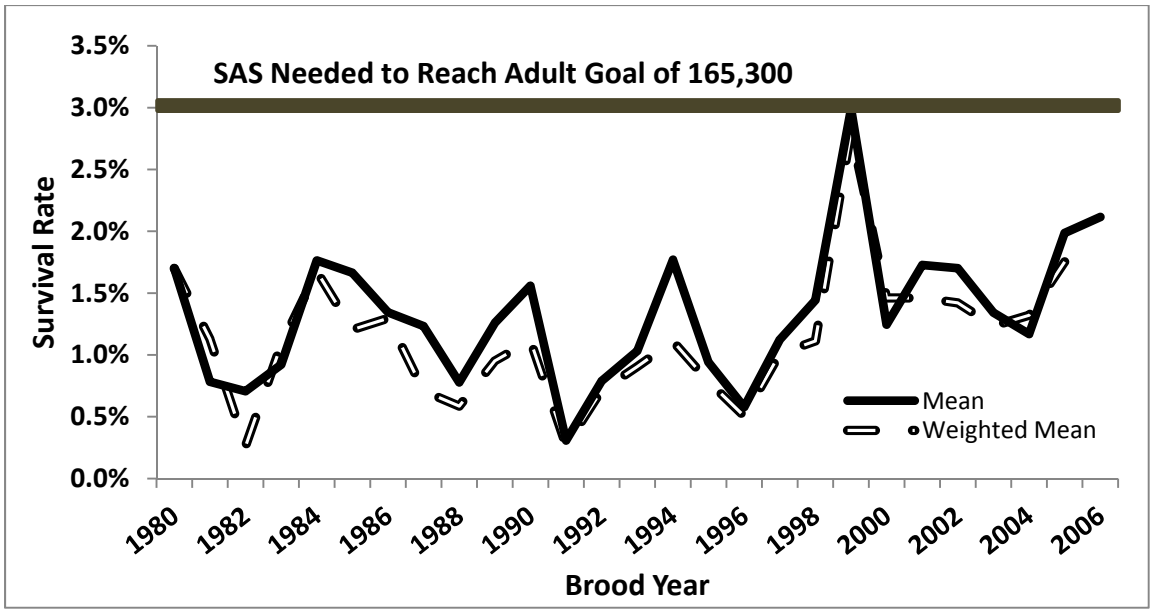


Figure 4. Mean Smolt to Adult Survival (SAS) rates for the combined LSRCP steelhead releases for brood years 1980-2005.

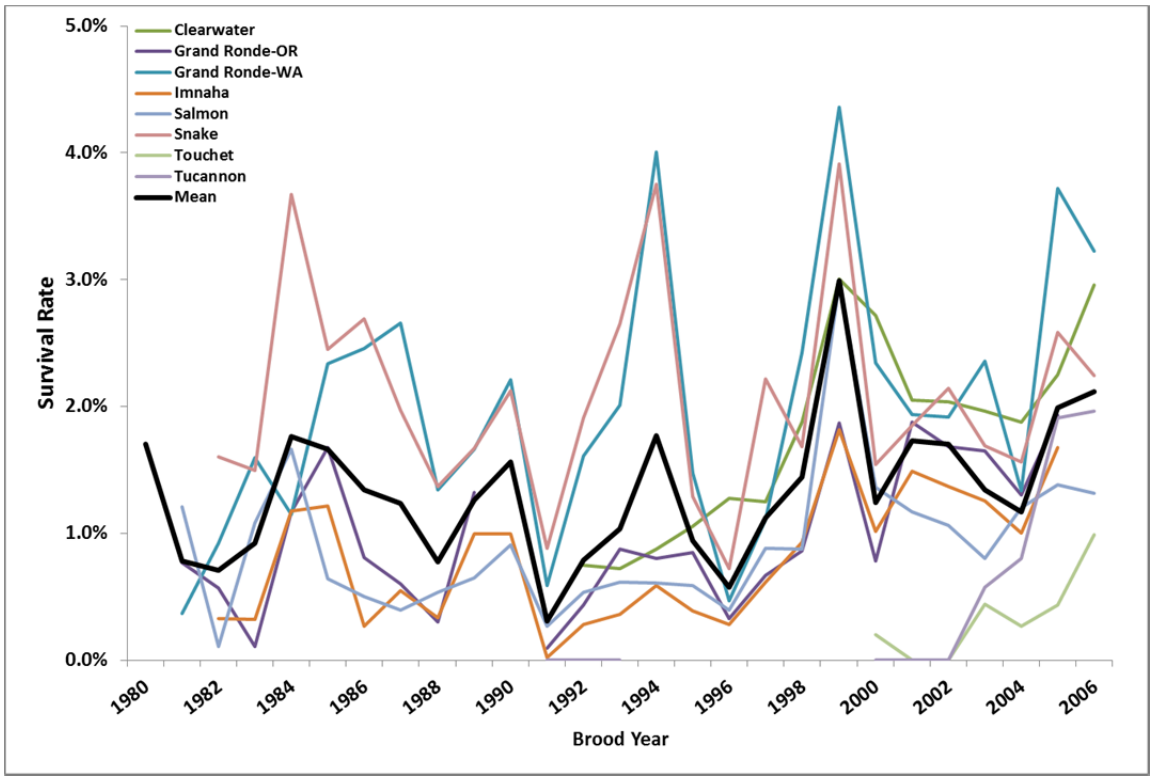


Figure 5. Smolt to Adult Survival (SAS) rates observed for individual LSRCP programs for brood years 1980-2005.

Smolt to Adult Return Rates

The Smolt to Adult Return (SAR) rate is calculated as the survival of smolts from release to return as adults back to the project area. Based on the release of approximately 5.35M smolts, an SAR of 1% is necessary to return 55,100 adults to the project area. Over the history of the program, the weighted SAR has been in excess of 1% in 12 out of 26 years through brood year 2005 (Figure 6). The average SAR observed over the same period is 0.96%. Similar to Figure 5, highly variable SAR rates are observed between programs (Figure 7).

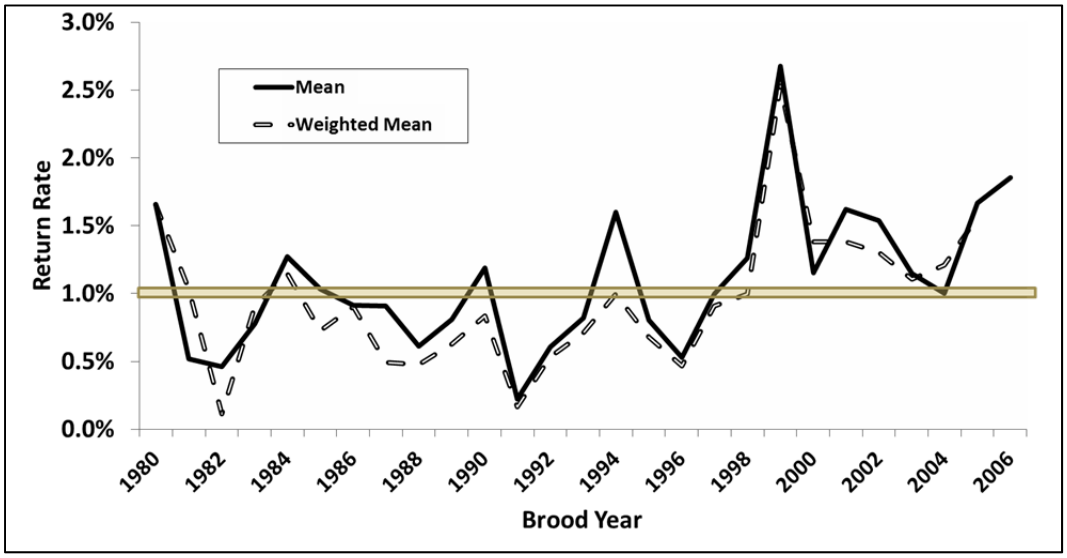


Figure 6. Smolt to Adult Return (SAR) rate of the combined LSRCP steelhead program for brood years 1980-2005.

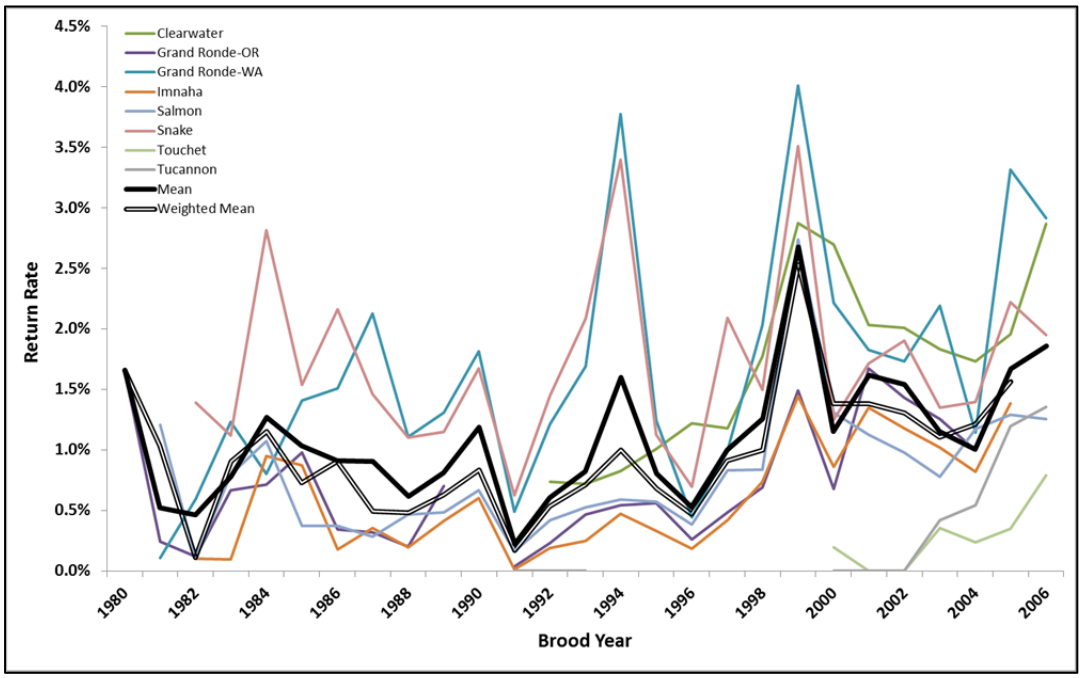


Figure 7. Smolt to Adult Return (SAR) rate of individual steelhead program for brood years 1980-2005.

Annual Adult Returns

The annual escapement of adults to the project area is provided to compare the program performance against the original escapement objective of 55,100 adults to the project area. This adult return objective is after an assumed 2:1 catch (downstream of the project area) to escapement (to the project area). As previously mentioned, this performance metric is based more on a historical convention and not on current fisheries management. During the period 1984-2009, the escapement objective of 55,100 adults was exceeded in nine years. The average annual escapement to the project area since 1984 is 50,292 adults.

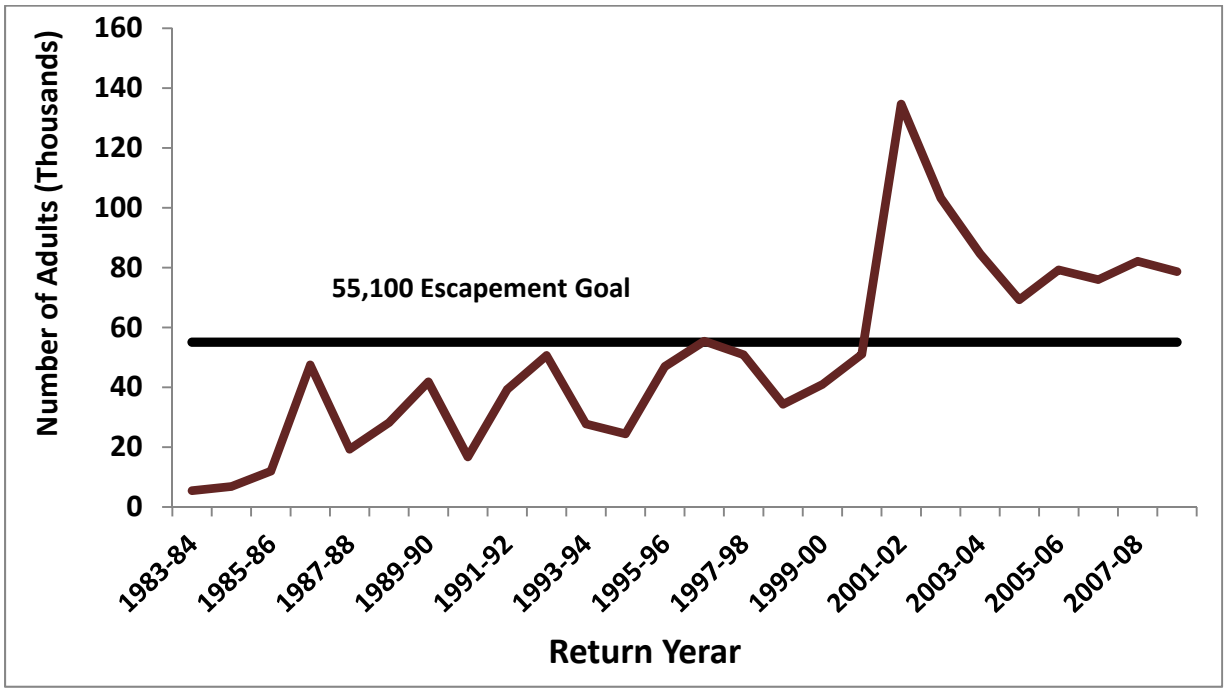


Figure 8. Annual escapement of LSRCP program steelhead to the project area for return years 1984-2009.

Progeny per Parent Ratios (P:P)

The ratio of adult progeny produced per parent (P:P) provides a full lifecycle productivity metric that is useful to assess the relative advantage a hatchery program can provide by significantly increasing the adult-to-smolt survival rate from what is observed in natural spawning populations. For brood years 1981-2005, an average of 17 (range: 2-45) adult progeny were produced for every parent in the broodstock. The P:P ratio was greater than seven for all but two years (1982 and 1991) in the time series. As with other productivity metrics discussed, a significant variation in P:P ratios across programs within the same year was observed (Figure 10)

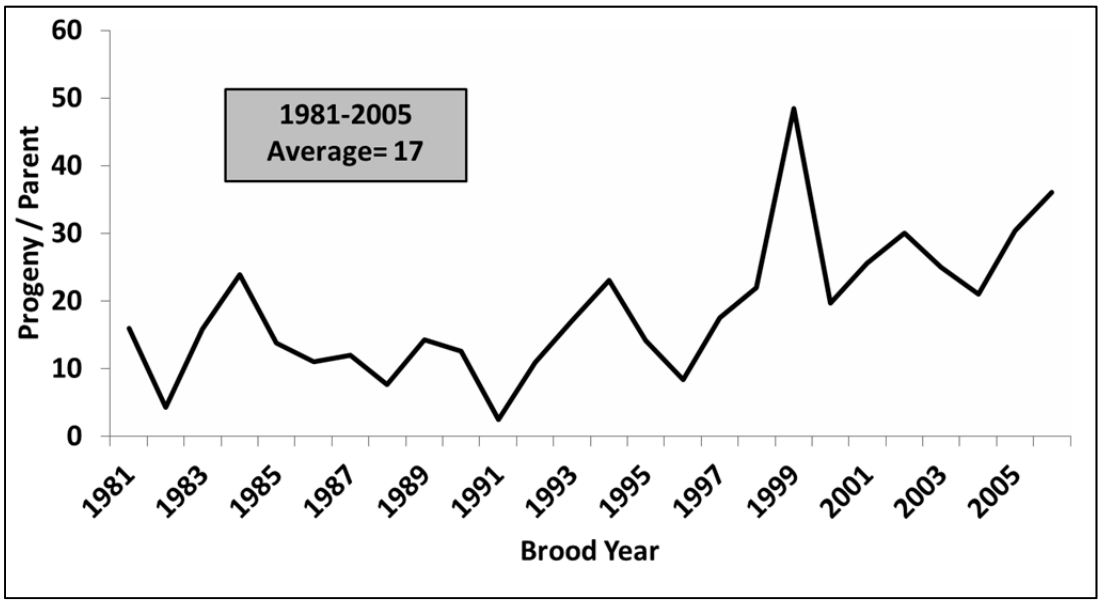


Figure 9. Progeny to parent ratios of LSRCP program steelhead for brood yeas 1981-2005

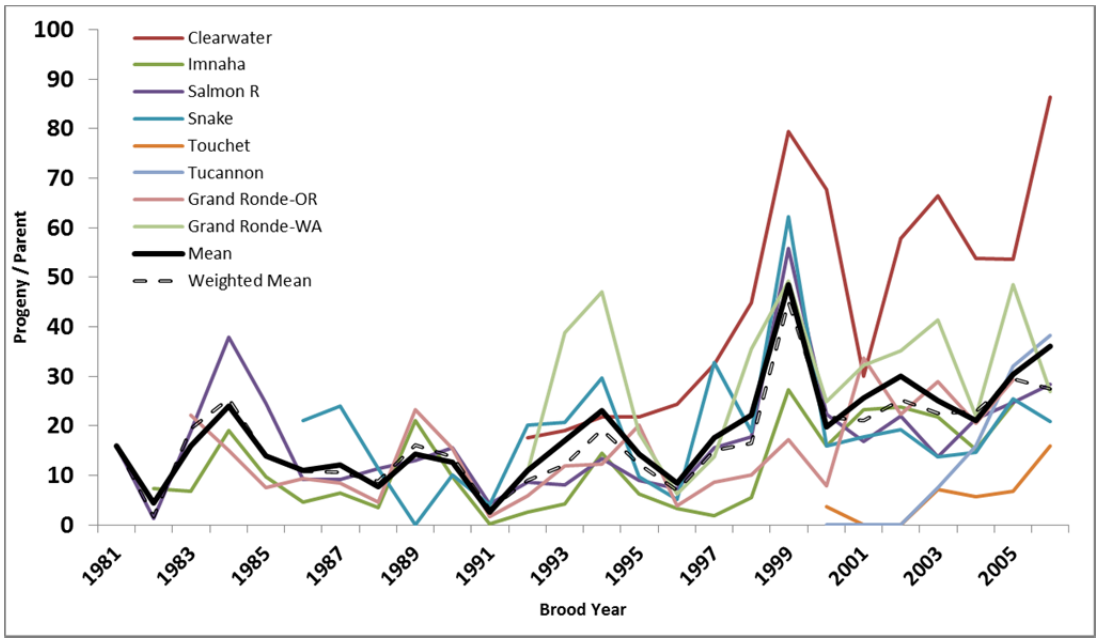


Figure 10. Progeny to parent ratios of individual LSRCP programs for brood yeas 1981-2005

Straying

Adult steelhead recovered (fisheries, hatchery traps, spawning grounds etc.) anywhere outside of the direct path to the release location during any part of the adult migration are considered strays. It is possible that fish harvested outside of the direct path to the release site during the summer and fall months may have ended up back on the direct path had they not been harvested but there is not a good method to estimate this parameter. It should also be noted that the stray rate estimates reported here are based strictly on fish that are recovered as strays in fisheries and natural spawning areas where sampling programs are in place. Because not all fisheries and natural spawning populations are sampled, reported stray rates are most likely underestimated.

The weighted average stray rate across all LSRCP programs for brood years 1982-2005 is 8.7% (Figure 11). Similar to other metrics provided in this report, observed stray rates are variable between programs (Figure 12). While not as obvious as for some of the productivity metrics presented, there does appear to be some level of synchrony with stray rates across many of the programs. This synchrony may be associated with similar juvenile (transportation vs. in-river migration) and adult (e.g. river temperature) migration conditions across programs. Another issue discussed at the symposium that may explain some of the observed straying was the drastic change observed in overwintering habitat for some of the programs after sections of the mainstem Snake River were impounded.

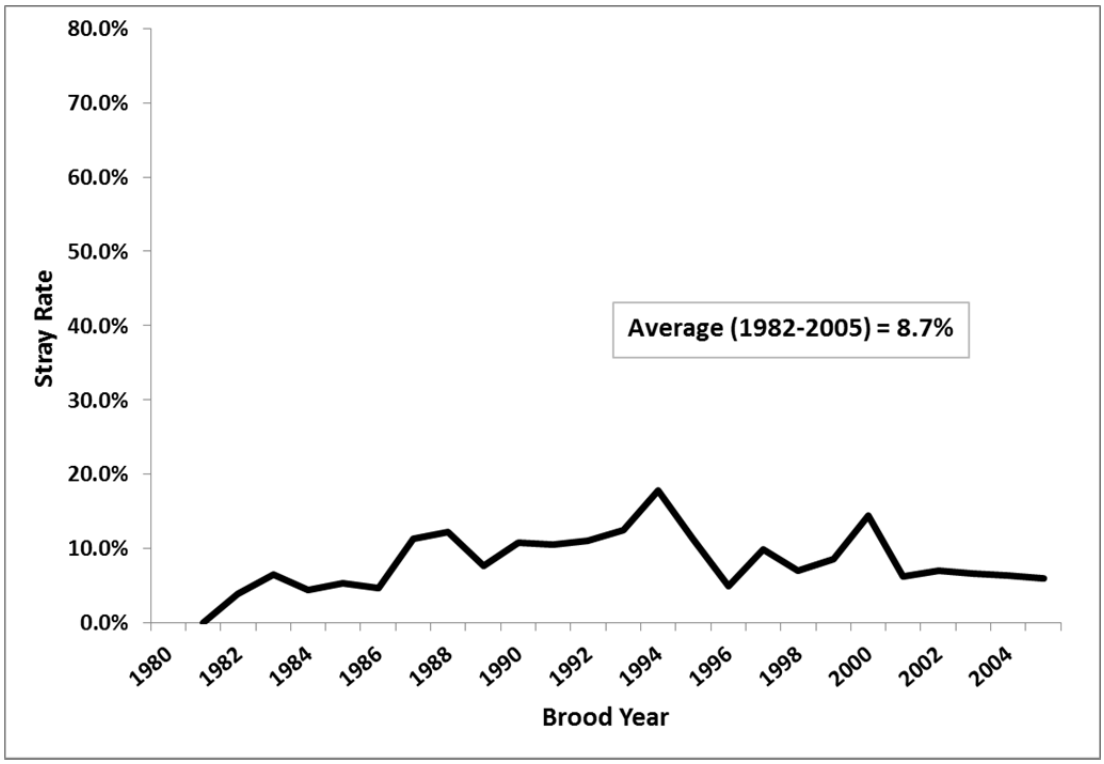


Figure 11. Average (weighted) stray rate for LSRCP steelhead for brood years 1982-2005.

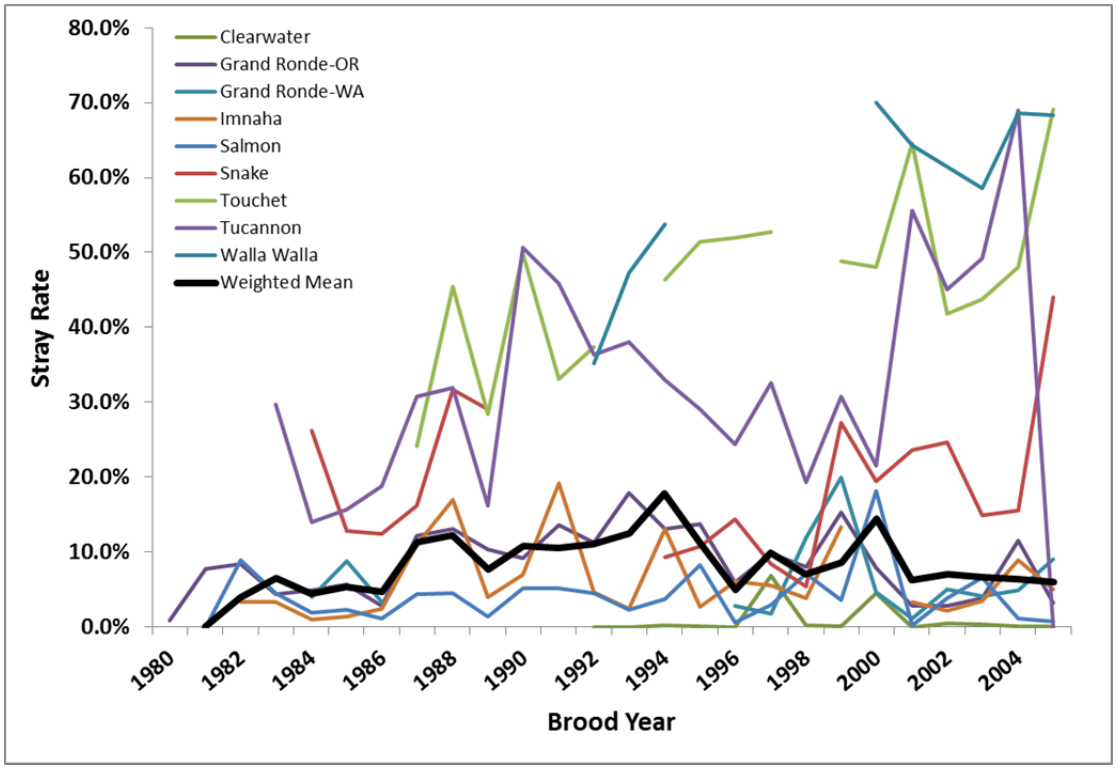


Figure 12. Average (weighted) stray rate for individual LSRCP steelhead programs for brood years 1982-2005.

Contribution to Fisheries Downstream of the Project Area

Within the founding language for the LSRCP program, compensation for the loss of mainstem Columbia River fisheries in kind and in-place was identified. During the program development, a 2:1 catch (downstream of the project area) to escapement (back to the project area) was the anticipated outcome of the LSRCP mitigation program. However, due to declining returns of wild fish and less than anticipated returns of LSRCP program fish, the 2:1 catch to escapement has not been realized. Prior to the min-1990s, harvest rates in the mainstem Columbia River and Snake River below Lower Granite dam were in the 20-50% range (Figure 13). Since them, harvest rates have generally been in the 5-20% range. As noted in the symposium, the individual program harvest rates were compared to the aggregate harvest rates for A-run and B-Run composite index stocks report by the US vs. OR Technical Advisory Committee (TAC) and it appears that the harvest rate for the Idaho stocks are underestimated. Potential explanations for the discrepancies are provided in the Salmon River and Clearwater River program reports in this document.

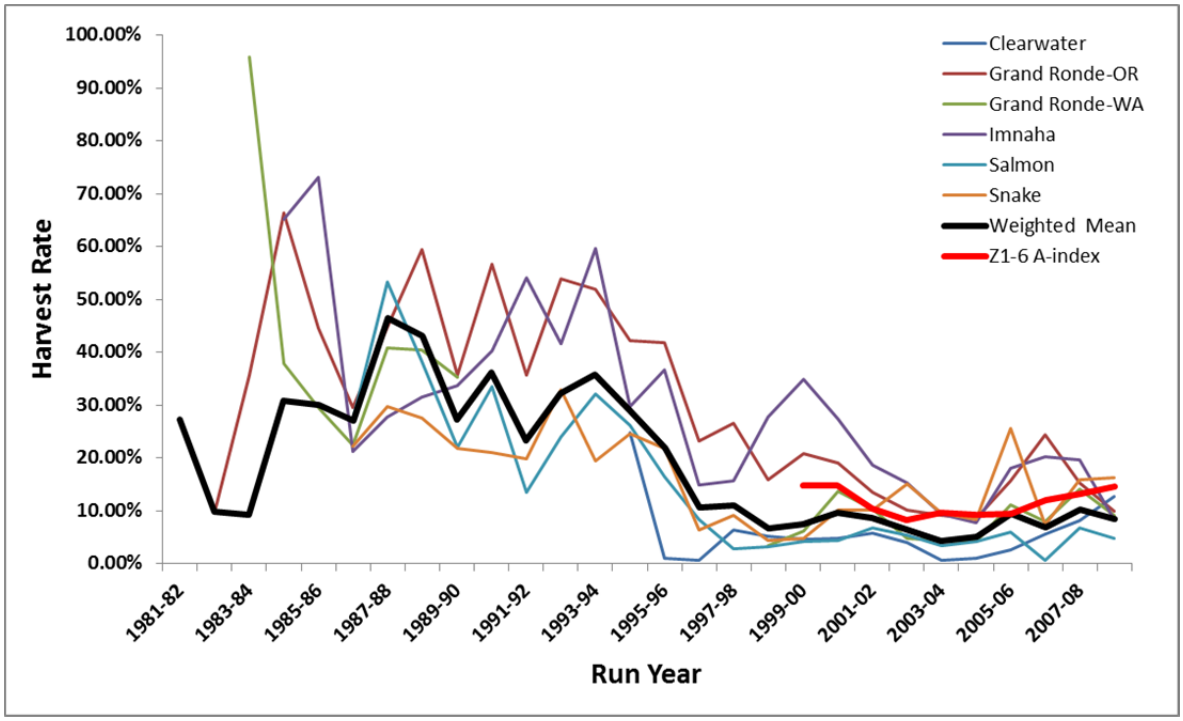


Figure 13. Estimated harvest rates of individual LSRCP programs for fisheries located downstream of the project area, 1982-2009

Restoring and Maintaining Historic Fisheries

One of the primary objectives across all of the programs that have been presented during this symposium is to restore and maintain the historic steelhead fisheries that occurred in the project area. This objective was evaluated both in terms of harvest and opportunity. To evaluate this, we compared the number of fish harvested during the period prior to the development of the LSRCP program to the periods after the LSRCP program was initiated. Prior to the LSRCP program, an average of 26,474 steelhead were harvested annually in the project area recreational fisheries (Figure 14). During the early part of the LSRCP mitigation (1985-1999), the annual harvest of 26,516 was very similar to the pre-program period. In the years since 1999, the average annual harvest has increased to 61,717 (range: 42,697-97,483) which is significantly greater than the harvest observed during the pre-program period. Likewise, we have also observed a significant increase in the angling effort for steelhead (Figure 15). During the pre-program period, the number of angler days averaged 130,000 annually. Since 1999, the number of angler days has increased to 474,500 annually.

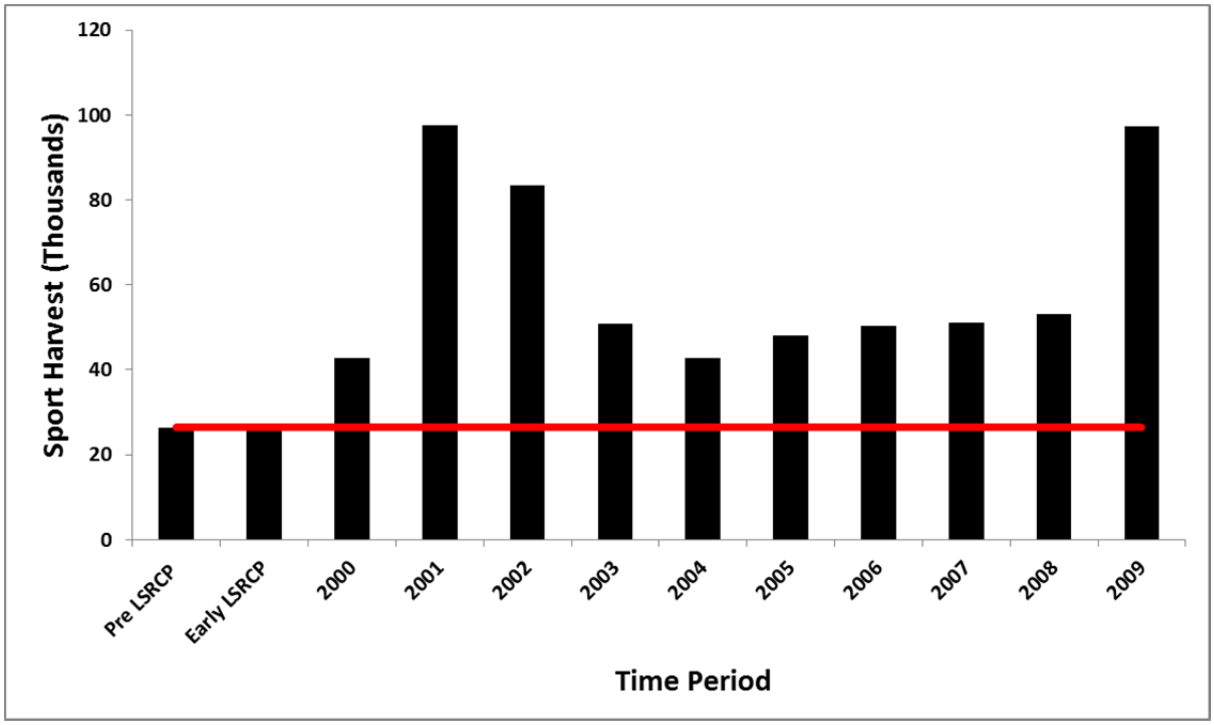


Figure 14. Estimated harvest of steelhead in Snake River project area recreational fisheries prior to and subsequent to the development of the LSRCP mitigation program. The red horizontal line represents the annual harvest observed during the pre-program period.

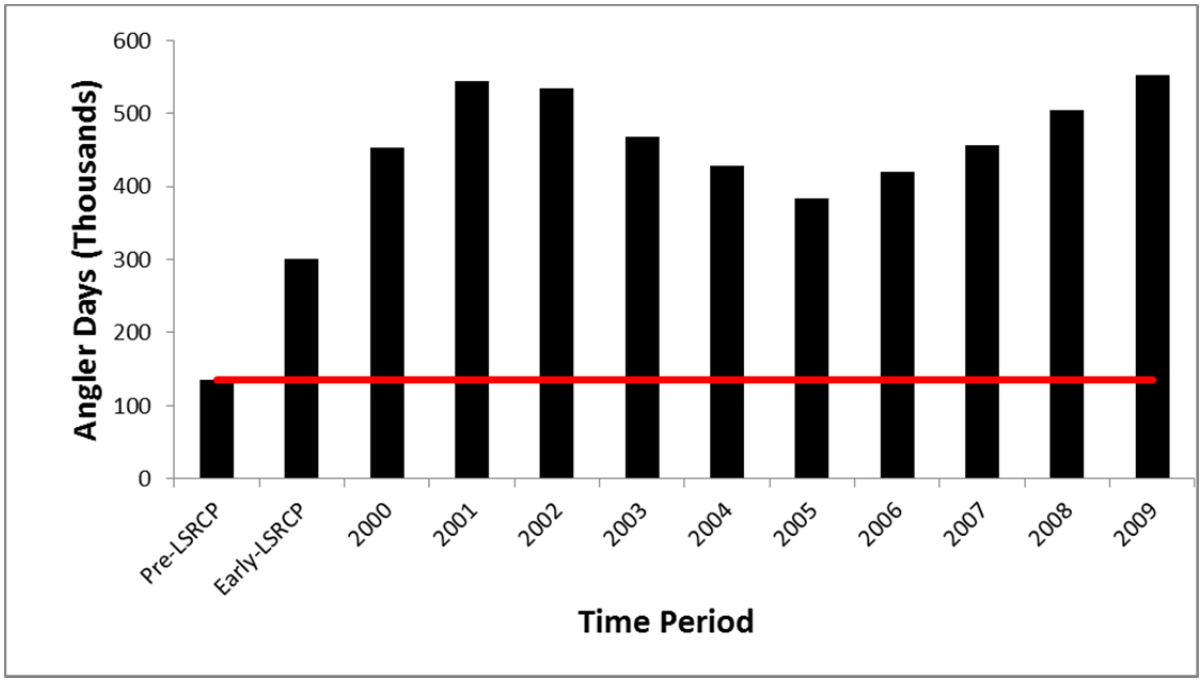


Figure 15. Estimated angler effort (angler days) for steelhead in Snake River project area recreational fisheries prior to and subsequent to the development of the LSRCP mitigation program. The red horizontal line represents the annual angler effort observed during the pre-program period.

The number of days open to steelhead fishing annually has remained similar to the pre-program period. In some areas, the number of river miles open to steelhead fishing has seen some minor changes (plus or minus) and in other areas, there have been significant decreases in the river miles available to fish in order to provide refuge areas for wild stocks of steelhead. In terms of harvest, effort, and opportunity, the program has met the objective of maintaining historic steelhead fisheries in the project area.

Summary and Moving Forward

It was made clear in the individual program presentations that managers have prioritized harvest mitigation as the LSRCP program's primary function. Even so, managers are evaluating the use of hatchery supplementation to increase natural production but at a smaller scale.

Fish culture across the individual programs is generally producing healthy smolts and with a few exceptions, broodstock collection and in-hatchery survival have not limiting the ability of managers to meet smolt production targets.

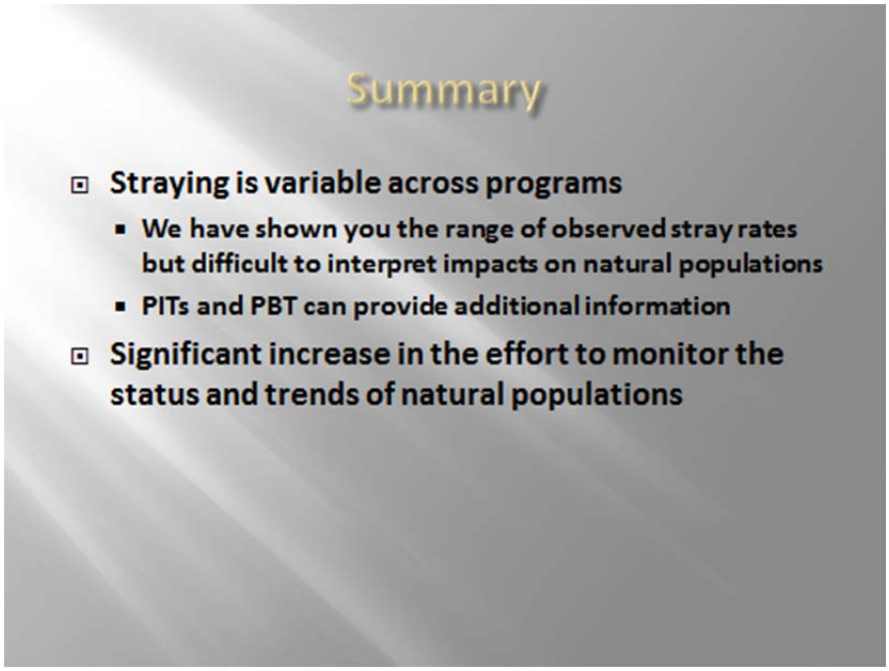
Post-release survival rates have been variable over the program history. While the overall production goal of 165,300 adults has never been reached, for brood years 1983-2005 the program produced an average of 55,960 adults (range: 9,708-154,043). For brood year 1999, 154,043 adults representing 93% of the total mitigation goal were produced.

Adult steelhead produced by the LSRCP program contribute to fisheries in the mainstem Columbia River, Snake River and tributaries of the Snake River. When the LSRCP program was being developed, it was anticipated that the majority (2:1) of the harvest benefits would be distributed downstream of the project area. However, due to declining returns of wild fish and less than anticipated returns of LSRCP

program fish, the 2:1 catch to escapement has not been realized and the majority of harvest benefits are distributed upstream of the project area.

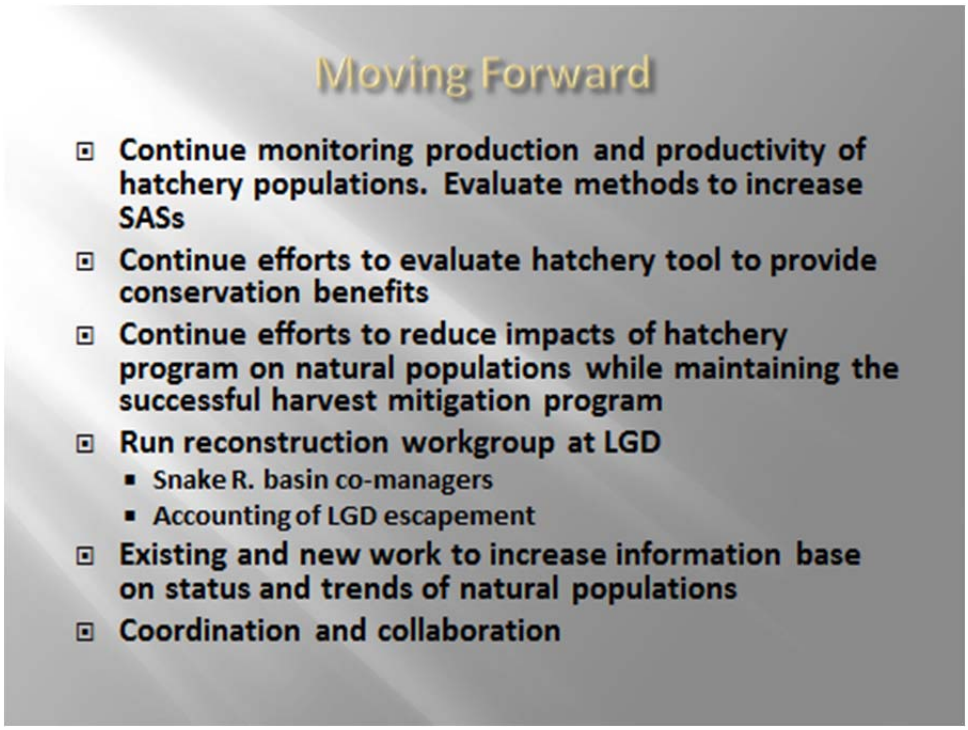
Across all programs, one of the primary goals has been to restore and maintain historic fisheries in the project area. The estimated angler effort and harvest is greater across all programs than it was during the pre-program period. Fisheries in the project area provide a significant opportunity through time and space with fisheries occurring for as many as 304 days over hundreds of river miles and provide a significant economic impact to state and local economies.

Straying of hatchery steelhead and potential impacts to ESA listed natural populations are a concern for the LSRCP the program. The average stray rate observed over the program history is 8.7% (range: 3.9-17.9%) but likely underrepresent the true stray rate because not all stray fish can be recovered. Managers have implemented or are implementing various measures such as development of localized brood stocks, fall brood collections, acclimation, consolidation of release sites and others to reduce the number of hatchery strays. Even with these changes to individual program aimed to reduce stray rates, environmental conditions and smolt transportation also influence stray rates.



Over the program history, managers have been modifying production and management strategies of the program to increase survival, reduce straying, and maximize harvest of program fish. As we move forward, we will continue to monitor the production and productively of the hatchery programs and strive to increase smolt to adult survival while minimizing impacts to natural populations. Managers are also working to increase the information base on the status and trends of natural populations of

steelhead in the Snake River. Collaboration and coordination continue to increase as managers in the Snake River basin work to fill data gaps. An example of this is the new collaborative effort to estimate the escapement and disposition, by stock and origin, of all steelhead upstream of Lower Granite Dam.



Acknowledgements

As evidenced in the title slide at the beginning of this presentation, there are many individuals across several state, tribal, and federal entities that contributed to all of the presentations and to the overall success of this program. We would like to express our sincere appreciation to all of the hatchery staffs for their tireless work to continually improve fish culture protocols and to produce healthy steelhead smolts that ultimately contribute to the successful harvest programs.

References

Corps of Engineers. 1975. Special Report, Lower Snake River Fish and Wildlife Compensation Plan. Lower Snake River Washington and Idaho. U.S. Army Engineer District, Walla Walla Washington. 96 pgs. plus appendices.