Catherine Creek Spring Chinook Salmon Hatchery Program Review

Richard W. Carmichael
Tim Hoffnagle
Joseph Feldhaus
Debra Eddy
Nick Albrecht

Oregon Department of Fish and Wildlife
203 Badgley Hall, EOU
One University Blvd
La Grande OR 97850

This program is a cooperative effort of the Oregon Department of Fish and Wildlife, the Confederated Tribes of the Umatilla Indian Reservation and the Nez Perce Tribe. The program is funded by the Bonneville Power Administration and administered by the United States Fish and Wildlife Service under the Lower Snake River Compensation Plan.

Introduction and Background

This paper provides background information, program development history, and an assessment of program performance for the Catherine Creek spring Chinook salmon hatchery program. We cover the time period from initiation of the program in the mid-1990s to present. General background information and pre mid-1990s hatchery program performance were previously presented in Grande Ronde Basin Spring Chinook Salmon Hatchery Review: Introduction and the Early Years.

The Catherine Creek spring Chinook hatchery program was initiated with collection of wild parr for the Captive Broodstock Program in 1995 due to the depressed status of this population (Figure 1). Adult trapping and smolt acclimation facilities were constructed to implement the program and are operated by the Confederated Tribes of the Umatilla Indian Reservation (CTUIR). These facilities function as satellite facilities of Lookingglass Fish Hatchery (Figure 2). Lookingglass Fish Hatchery (LFH) serves as the adult holding, spawning, incubation, and rearing facility for the program. Smolts are transported from LFH to the Catherine Creek acclimation ponds for a short period of acclimation in the spring prior to release. Annual adult mitigation, smolt production, and brood year specific smolt-to-adult return goals were developed for the Catherine Creek program to represent 16.67% of the total Grande Ronde River basin goals (Table 1).

The implementation has been guided by nine priority management objectives: 1) Prevent extinction of the Catherine Creek Chinook salmon population; 2) Establish adequate broodstock to meet annual production needs; 3) Establish an annual return of hatchery fish to the compensation area; 4) Provide a demographic foundation to rebuild from after the key limiting factors and threats are addressed; 5) Maintain and enhance natural production while maintaining long term fitness; 6) Maintain genetic and life history characteristics of the natural population; 7) Operate the hatchery program so that the genetic and life history characteristics of hatchery fish mimic wild fish; 8) Re-establish historical tribal and recreational fisheries; 9) Maintain endemic wild populations of spring Chinook salmon in the Minam and Wenaha rivers – minimize straying.

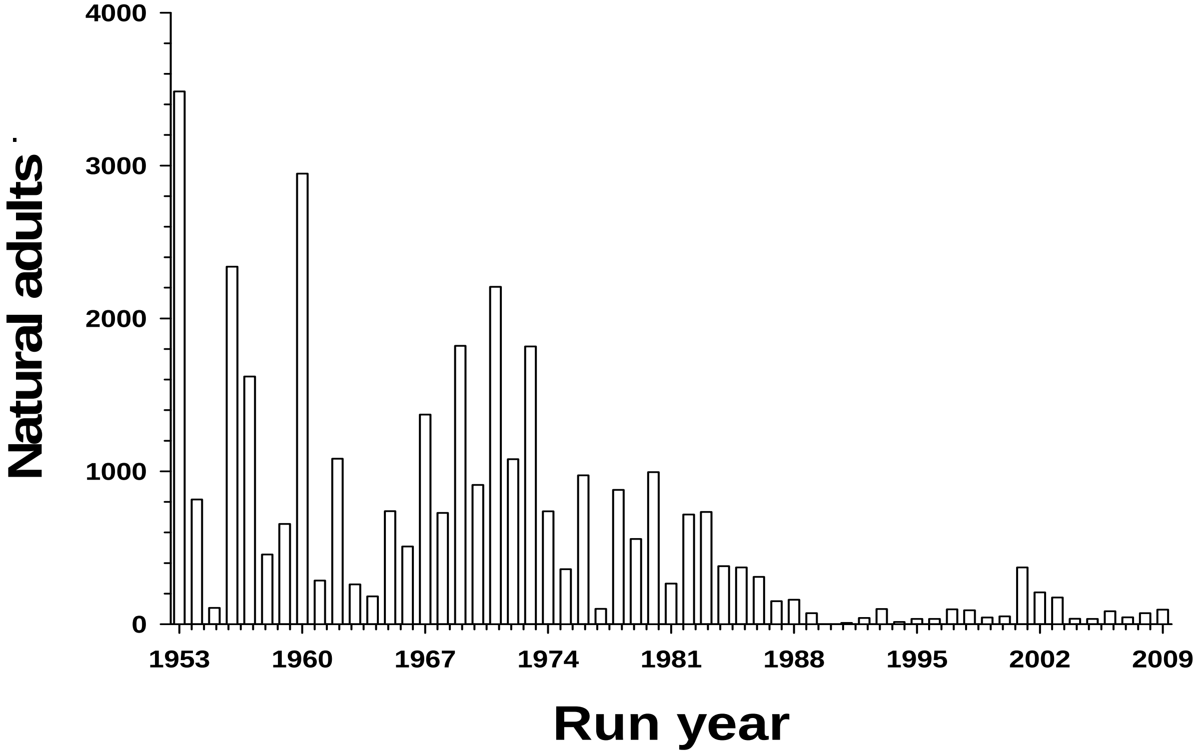

Figure 1. Natural-origin adult spawner abundance in Catherine Creek spring Chinook salmon population.

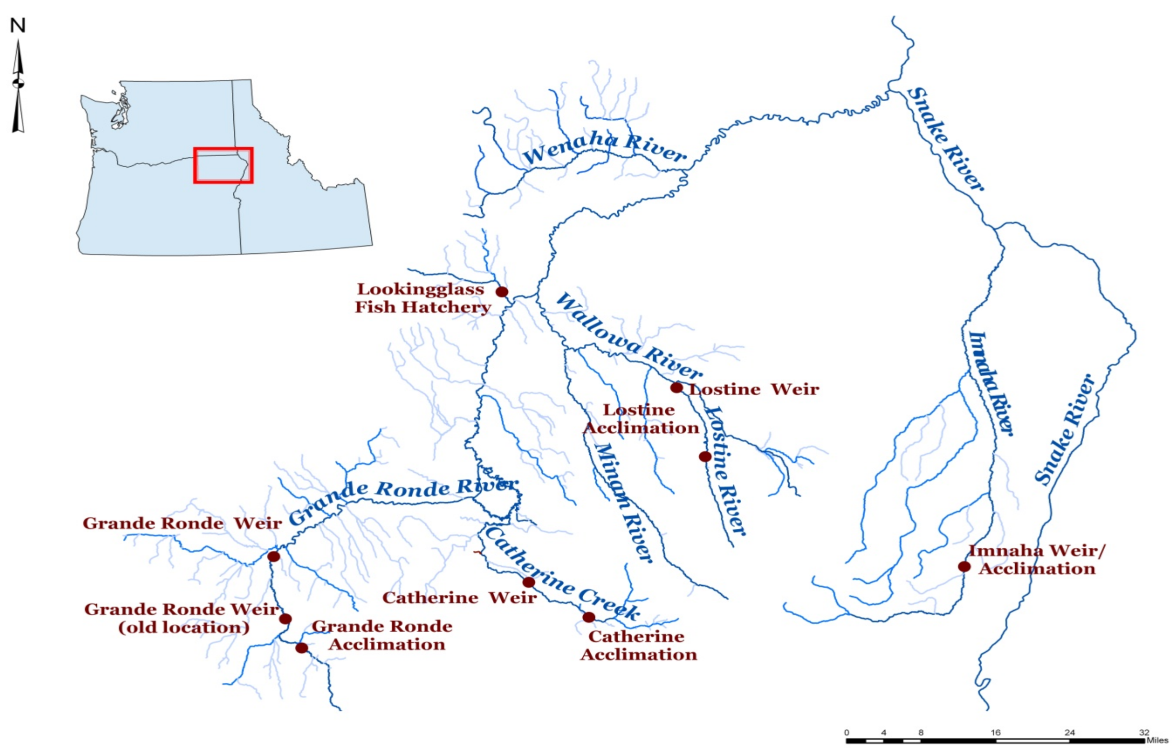

Figure 2. Map of the Catherine Creek Chinook salmon hatchery facilities.

Table 1. Lower Snake River compensation plan mitigation goals for Oregon's Catherine Creek spring Chinook salmon hatchery program. Adult and survival goals are expressed for returns to the compensation area.

Category	Goal
Annual smolt goal	150,000 smolts
Annual adult goal	970 adults
Brood year smolt-to-adult return rate	0.65%

A comprehensive research, monitoring and evaluation program had been underway with the primary objectives to: 1) Document and assess fish culture and hatchery operation practices and performance; 2) Determine optimum rearing and release strategies; 3) Determine total catch and escapement, smolt survival, smolt-to-adult survival, and assess if adult production meets mitigation goals; 4) Compare recruits-per-spawner (R/S) for hatchery and natural origin fish; 5) Assess response in natural population abundance and productivity (adult R/S, smolts-per-spawner) to supplementation; 6) Assess and compare life history characteristics (age structure, run timing, sex ratio, smolt migration, fecundity) of hatchery and natural fish; 7) Determine the success of maintaining genetic integrity of endemic wild spring Chinook salmon in the Minam and Wenaha rivers; 8) Assess success in restoring fisheries.

Program Assessment

When co-managers developed supplementation program strategies for Grande Ronde River basin spring Chinook salmon populations they adopted a spread the risk strategy. The Catherine Creek population was selected to represent a conservative hatchery intervention program. The sliding scale management framework is somewhat simple, with only three escapement management zones. When the predicted escapement of natural and hatchery fish combine exceeds 500, the criteria reaches the most conservative level where no more than 50% of the fish released to spawn naturally can be natural-origin and 30% or more of the broodstock must be natural-origin (Table 2). No returning captive broodstock progeny are retained for hatchery broodstock.

Table 2. Catherine Creek spring Chinook salmon sliding scale broodstock management plan. H = Hatchery and N = Natural.

Escapement level (H & N)	Maximum % natural retained for broodstock	% hatchery above weir	Minimum % of natural-origin broodstock
< 250	40	d	d
251-500	20	≤ 70	≥ 20
> 500	≤ 20	≤ 50	≥ 30

d = No constraint

The captive broodstock program adults served as the only source of broodstock for the 1998-2000 spawn years. From 2001-2004, captive broodstock adults and natural-origin adults collected in Catherine Creek were the broodstock sources. Conventional hatchery produced adults, captive broodstock, and natural-origin adults all contributed to production for 2005-2009. The number of natural-origin females spawned was low in all years (Table 3). Conventional hatchery adults and natural adults are spawned together and captive broodstock adults are always spawned separately. Conventional and captive offspring are reared separately and uniquely marked to allow identification at the adult stage. No Catherine Creek hatchery fish spawned naturally until 2001. Hatchery fish have comprised a high proportion of natural spawners since 2002 (49.7-82.8%). The Proportionate Natural Influence (PNI) has been low the past five years, ranging from 0.183 to 0.328 (Table 4).

During the early years of operation and broodstock collection, a substantial proportion of the run escaped the weir un-trapped (Figure 3). Prespawning mortality of fish collected and held for broodstock at LFH has been at or below 10% for all years (Figure 4). Green egg-to-smolt survival has been consistently high for all brood years except 2001 and 2009. The smolt production goal was originally established at 250,000 and then changed in 2006, when co-managers agreed to reduce the goal to 150,000 and shift production to increase releases into Lookingglass Creek. Smolt production goals have not been met, however production has approached the 150,000 goal in recent years (Figure 5). Hatchery smolt survival to Lower Granite Dam is lower than the survival of natural smolts and it is the lowest of all NE Oregon Chinook hatchery programs (Figure 6). The smolt migration pattern of hatchery smolts at Lower Granite Dam is significantly different than natural smolts. Initial arrival timing is similar, however the hatchery smolts have a compressed distribution with an earlier date of completion, while natural fish have a prolonged migration period (Figure 7).

Table 3. Hatchery broodstock history for the Catherine Creek spring Chinook salmon hatchery program.

Spawn year	Number of females in broodstock		Percent natural origin adults in broodstock	Number of Captive Broodstock females
	Natural	Hatchery		
1998	0	0	0	69
1999	0	0	0	162
2000	0	0	0	177
2001	29	0	100	153
2002	20	0	100	128
2003	28	0	100	160
2004	9	0	100	77
2005	8	9	29.4	44
2006	8	29	30.8	83
2007	14	31	37.3	79
2008	11	21	31.6	81
2009	13	30	35.0	69

Adult returns to the compensation area have been well below the reduced goal of 970 adults (Figure 8). Two factors have resulted in these poor returns: smolt production well below the goal and poor SARs. SARs have been consistently below the goal of 0.65% (Figure 9). Hatchery SARs have been lower than SARs for natural smolts (Figure 10).

Catherine Creek Chinook salmon are exploited at low rates in all fisheries. On average, 78.3% of hatchery adults produced escape to Catherine Creek. The highest exploitation rate occurs in the Lower Columbia River sport fisheries, which has exceeded 14% in recent years (Table 5).

Stray rates are generally low and a majority of the strays return to LFH where the fish were reared. Unlike past years, when large numbers of Carson and Rapid River stock hatchery fish strayed into the Minam and Wenaha rivers, few Catherine Creek strays have been recovered in these populations. Most of the hatchery adults that returned to Catherine Creek have been passed above the weir to spawn naturally, used for broodstock, or outplanted into Lookingglass and Indian creeks for reestablishment of natural production (Figure 11).

Table 4. Vital statistics for natural spawning spring Chinook salmon in Catherine Creek. PNI = Proportionate Natural Influence.

Spawn year	Total Number spawning in nature	Percent hatchery spawning in nature	Percent natural retained for broodstock	PNI
1998	101	0	0	
1999	48	0	0	
2000	58	0	0	
2001	557	22.6	5.5	0.716
2002	457	49.7	14.5	0.420
2003	487	58.7	20.9	0.449
2004	215	82.8	32.7	0.305
2005	152	74.3	20.4	0.183
2006	282	63.1	16.8	0.274
2007	171	71.3	36.3	0.256
2008	216	64.8	19.1	0.227
2009	287	54.0	21.0	0.328

Total adult spawners in nature has varied considerably since supplementation was initiated. When compared with the 1995-2000 time period, we have seen a significant increase in total spawners from 2002-2009. Hatchery fish have comprised over 50% of the natural spawners in each year since 2002 (Figure 12). Natural-origin spawner abundance has remained relatively low in recent years, similar to the low spawner abundance observed in the late 1990s. The adult R/S for conventional hatchery fish has exceeded 1.0 in all four completed brood years. The hatchery R/S for Catherine Creek tends to be the lowest of all NE Oregon spring Chinook hatchery programs. The R/S for natural spawning fish was low for the 2001-2004 brood years, ranging from 0.1-0.4 (Figure 13). The hatchery is providing a significant full life cycle survival advantage due to the extremely low R/S for natural spawning fish.

Natural smolt production was highly variable in both the pre- and post-supplementation periods. We have observed a slight increase in natural smolt abundance since supplementation was initiated (Figure 14). Smolts-per-spawner has decreased since supplementation started in the early 2000s (Figure 15). We found a significant negative relationship between adult spawner abundance and smolts-per-spawner (Figure 16).

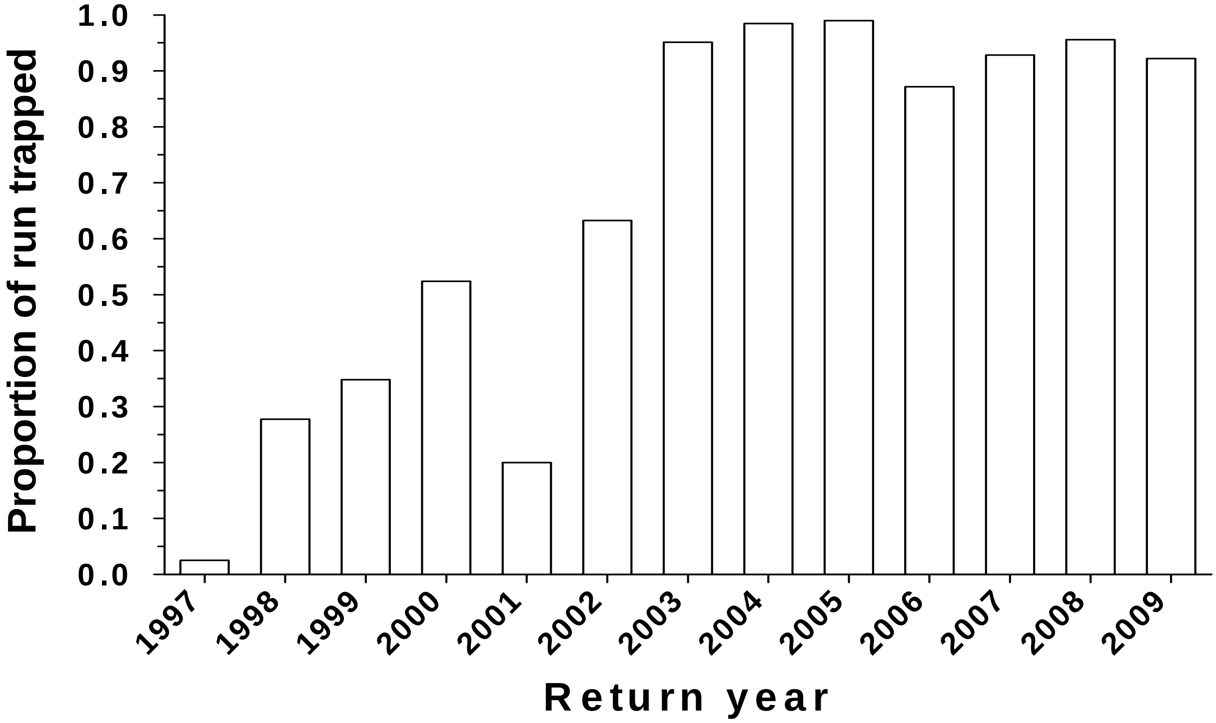

Figure 3. Estimated proportion of Chinook salmon run trapped at the Catherine Creek weir.

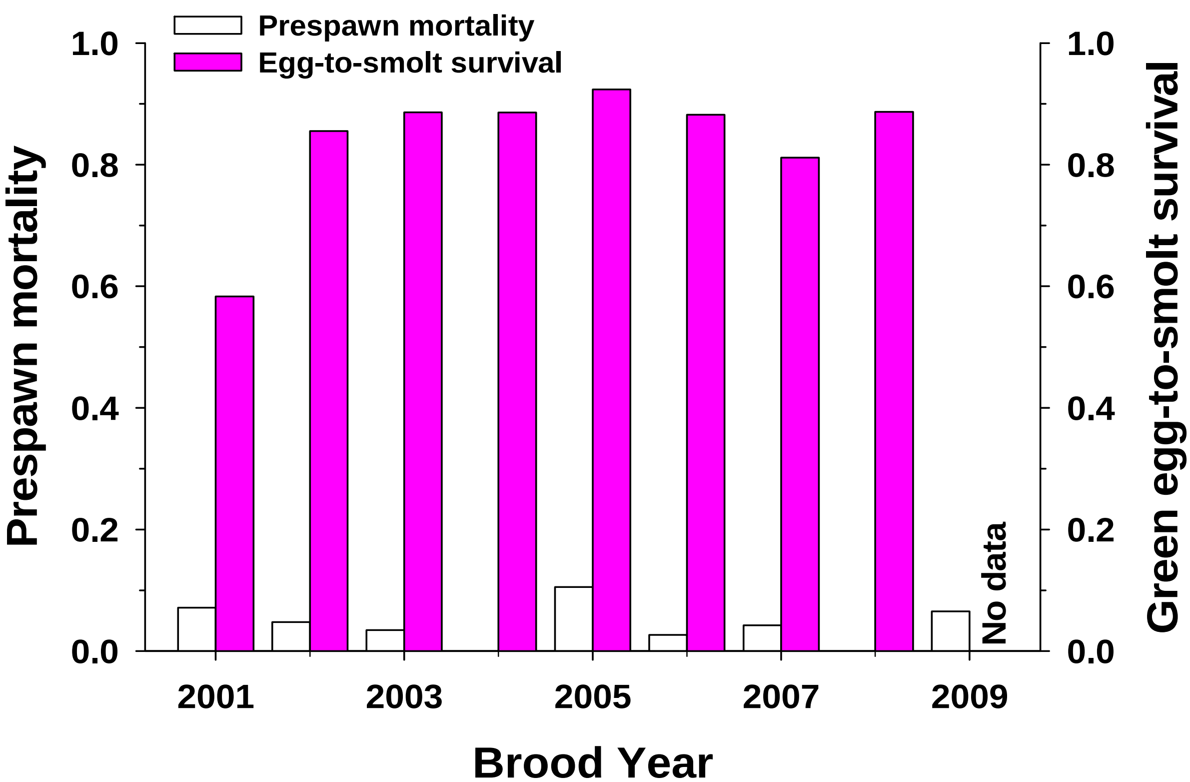

Figure 4. Prespawn mortality of broodstock collected at the Catherine Creek weir and held at Lookingglass Hatchery and green egg-to-smolt survival.

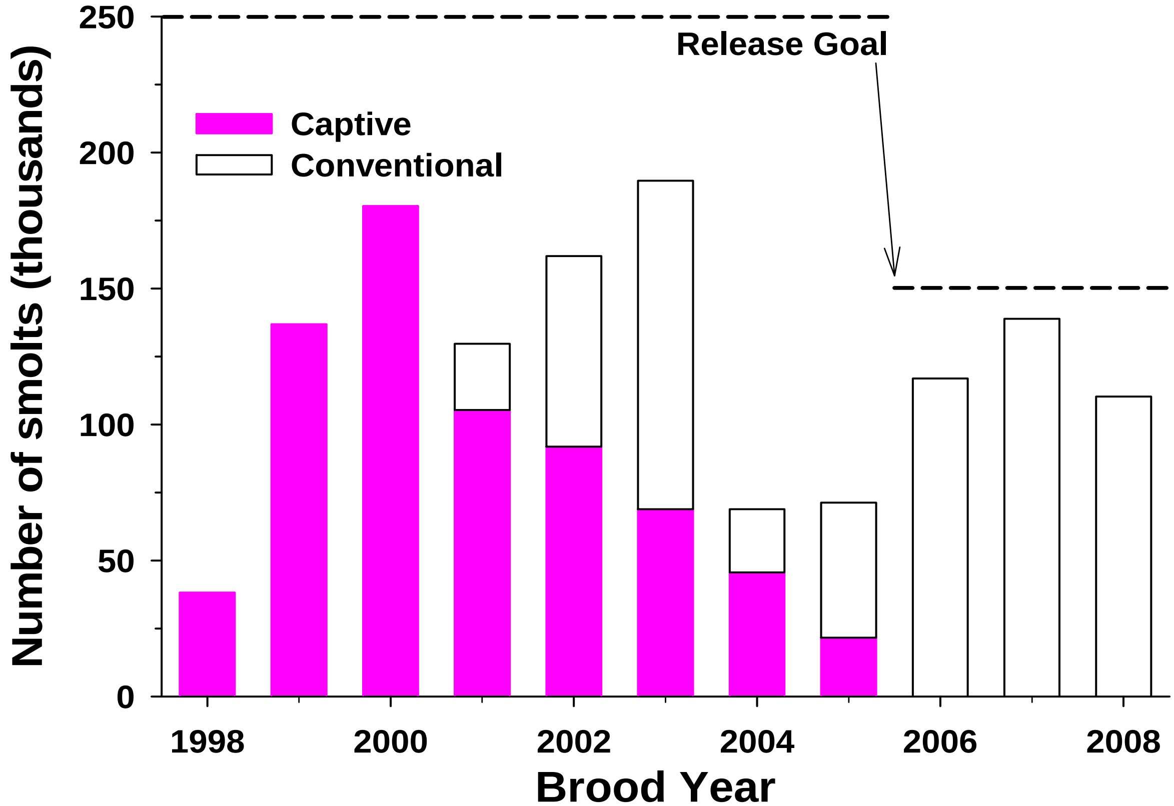

Figure 5. Chinook salmon smolt releases into Catherine Creek, 1998-2008 brood years.

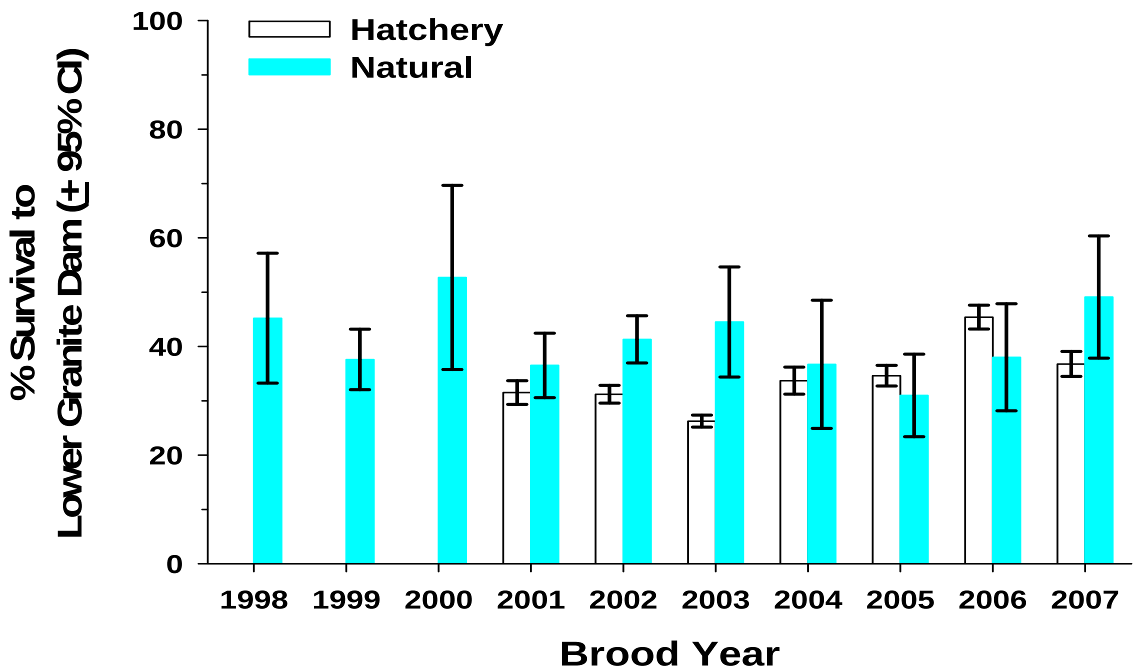

Figure 6. Catherine Creek spring Chinook salmon conventional hatchery- and natural-origin smolt survival to Lower Granite Dam, 1998-2007 brood years.

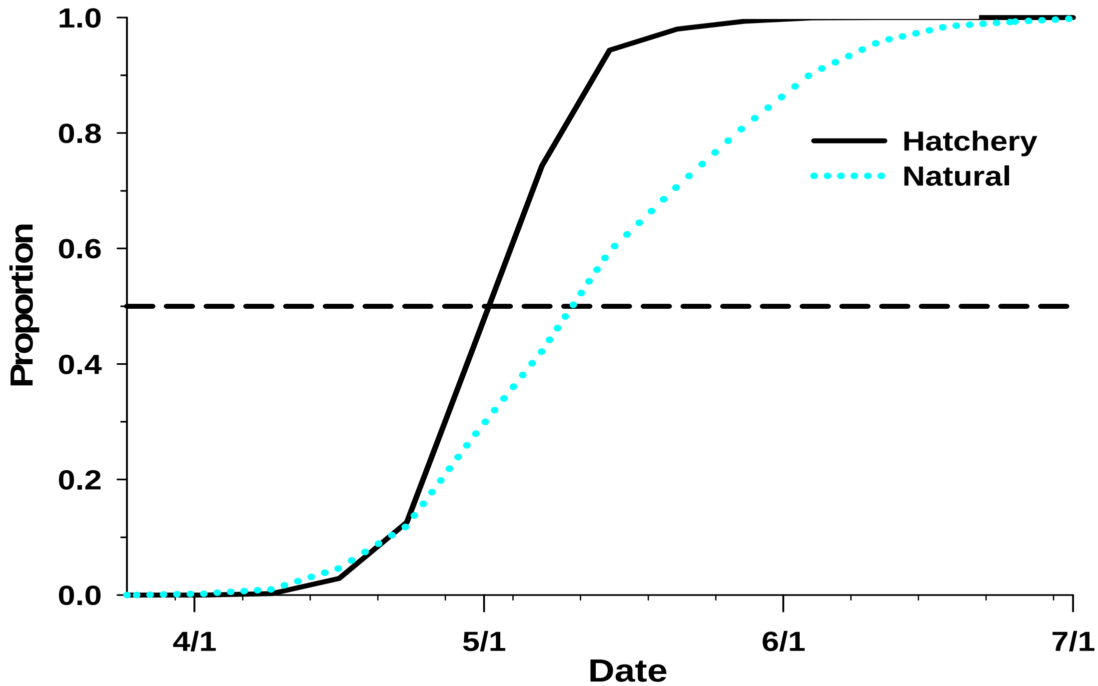

Figure 7. Migration timing at Lower Granite Dam of conventional hatchery and natural-origin Catherine Creek smolts, mean 2003-2009.

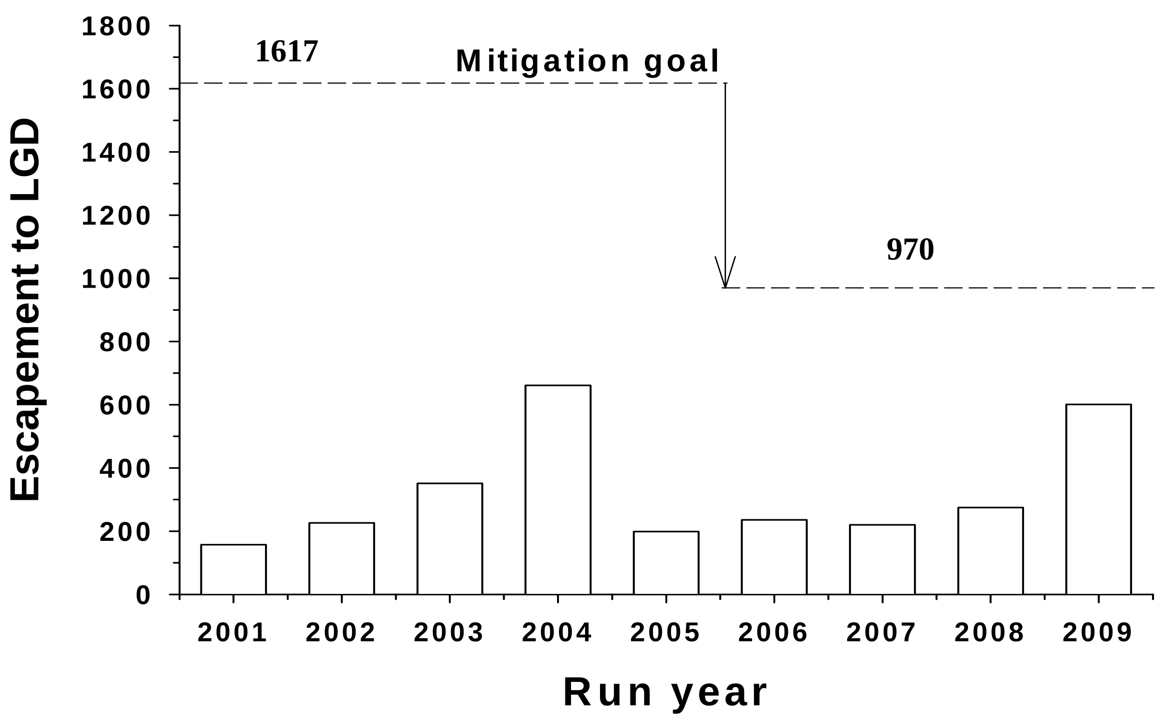

Figure 8. Adult returns to the LSRCP compensation area for Catherine Creek spring Chinook salmon, includes captive broodstock F_1 and conventional returns.

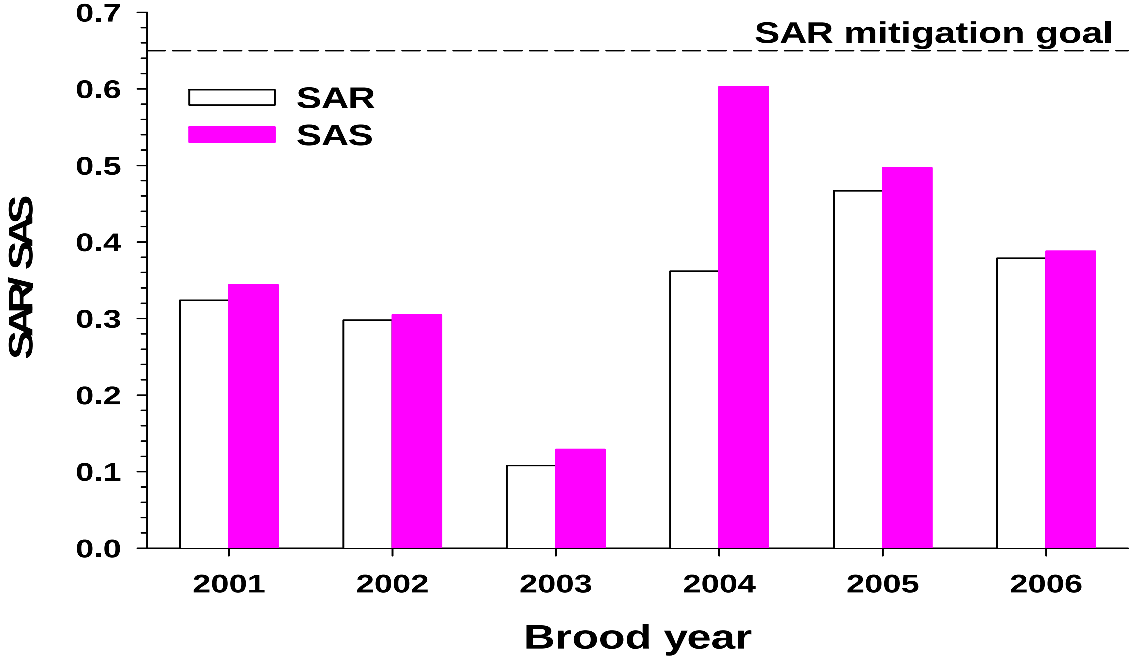

Figure 9. Smolt-to-adult survival (SAS) and return (SAR) rates for conventional hatchery Catherine Creek spring Chinook salmon, 2001-2006 brood years. Note: the 2005 and 2006 brood years include only ages 3 and 4 and age 3 returns, respectively.

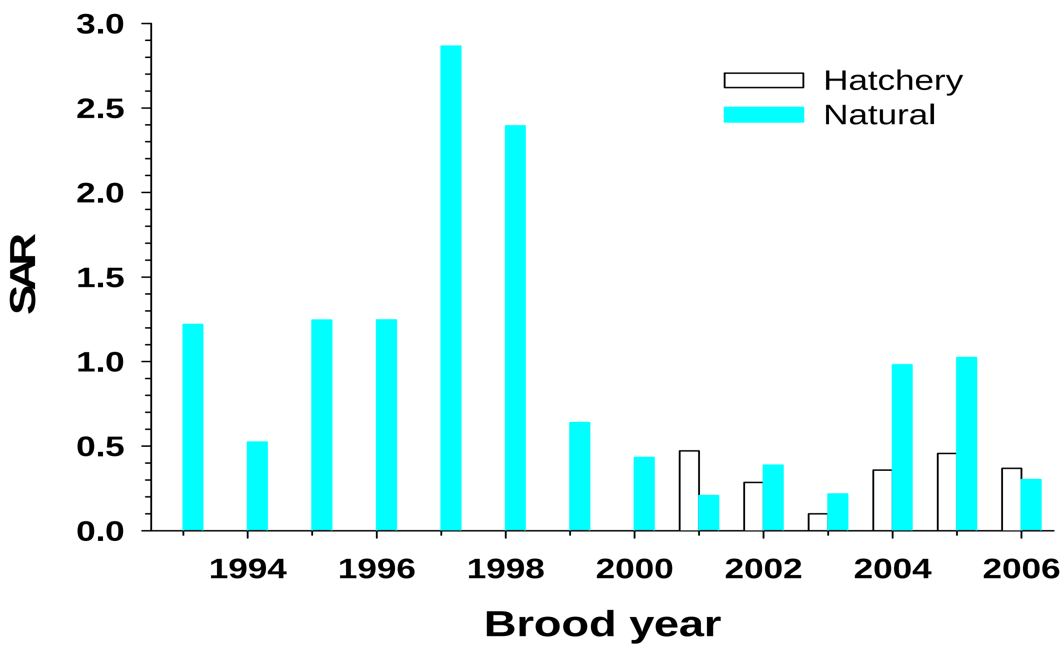

Figure 10. Conventional hatchery- and natural-origin smolt-to-adult return (SAR) for Catherine Creek spring Chinook salmon, 1993-2006 brood years. Note: the 2005 and 2006 brood years include only ages 3 and 4 and age 3 returns, respectively.

Table 5. Catch and escapement distribution (%) for captive F_1 and conventional Catherine Creek spring Chinook salmon.

	Brood Year				
	2001	2002	2003	2004	Mean
Ocean	0.0	1.7	0.0	0.0	0.4
Columbia River Harvest					
Tribal	0.0	0.0	0.0	10.7	2.7
Sport	12.5	0.0	14.3	14.0	10.2
Commercial Net	0.4	0.0	2.4	7.0	2.4
Snake River					
Stray below LGD	0.0	0.0	0.0	2.7	0.7
Stray above LGD	8.3	4.2	6.2	1.7	5.1
Sport above LGD	0.0	0.7	0.0	0.0	0.2
Tribal above LGD	0.0	0.0	0.0	0.0	0.0
Escapement to River	78.8	93.4	77.1	64.0	78.3

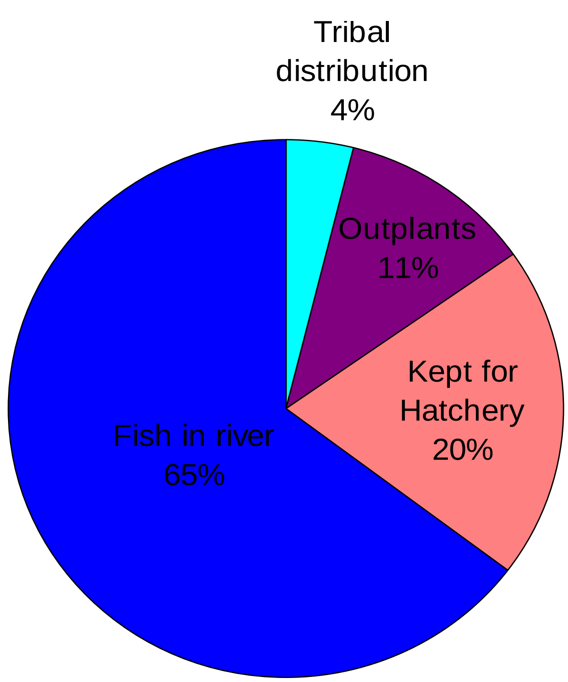

Figure 11. Escapement disposition of Catherine Creek spring Chinook salmon from the 2001-2004 brood years. Data include captive broodstock F_1 and conventional fish.

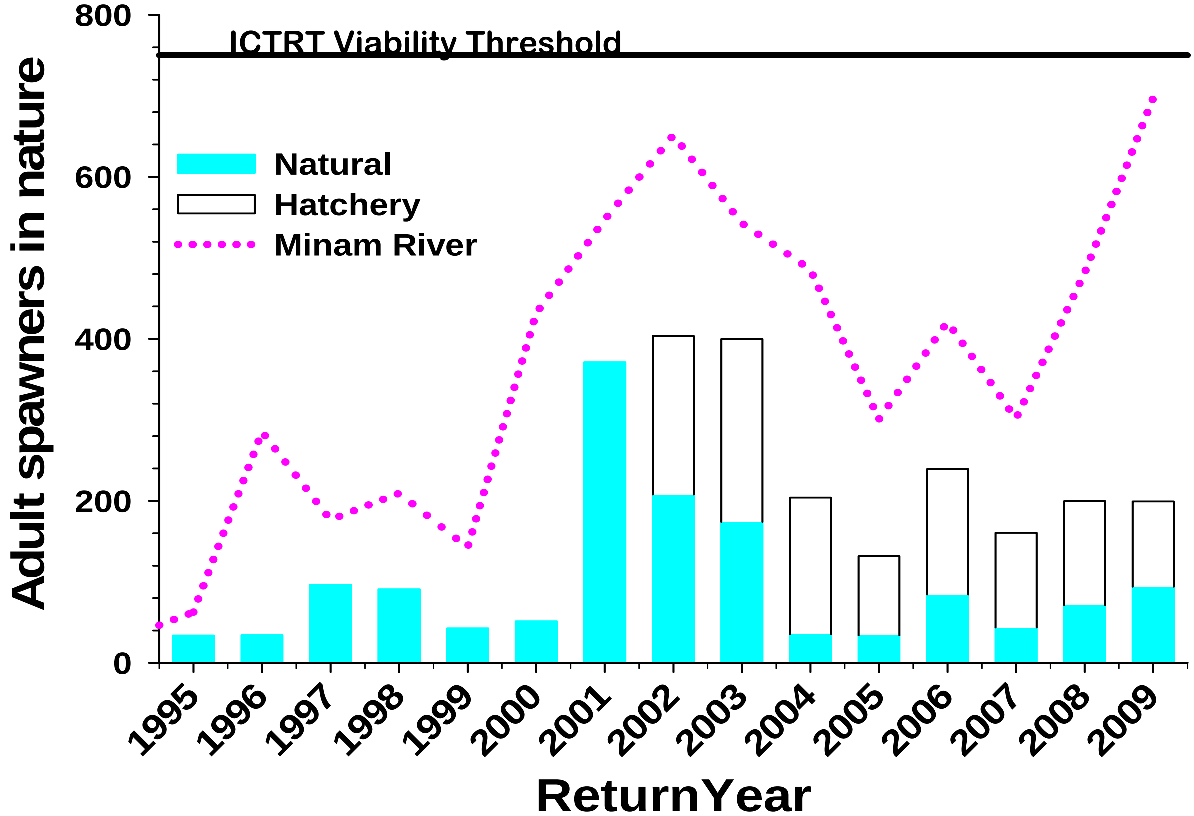

Figure 12. Adult spawner abundance in the Catherine Creek and Minam River populations. Spawners include both natural and hatchery-origin fish.

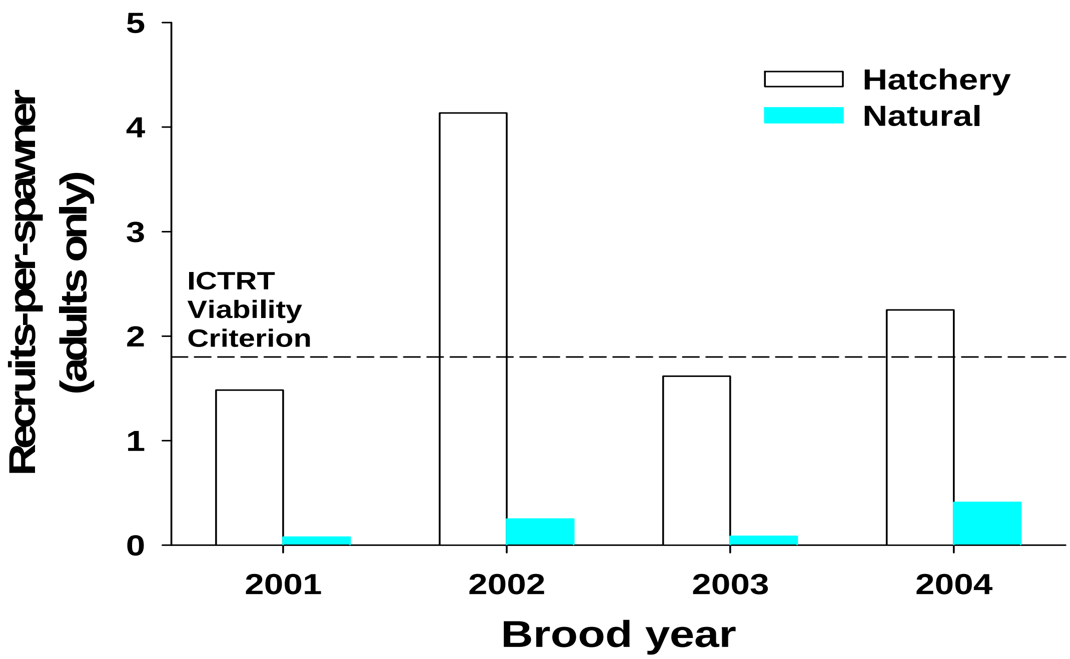

Figure 13. Catherine Creek Chinook recruits-per-spawner (jacks omitted) for hatchery spawned adults and natural spawning hatchery- and natural-origin adults, 2001-2004 brood years.

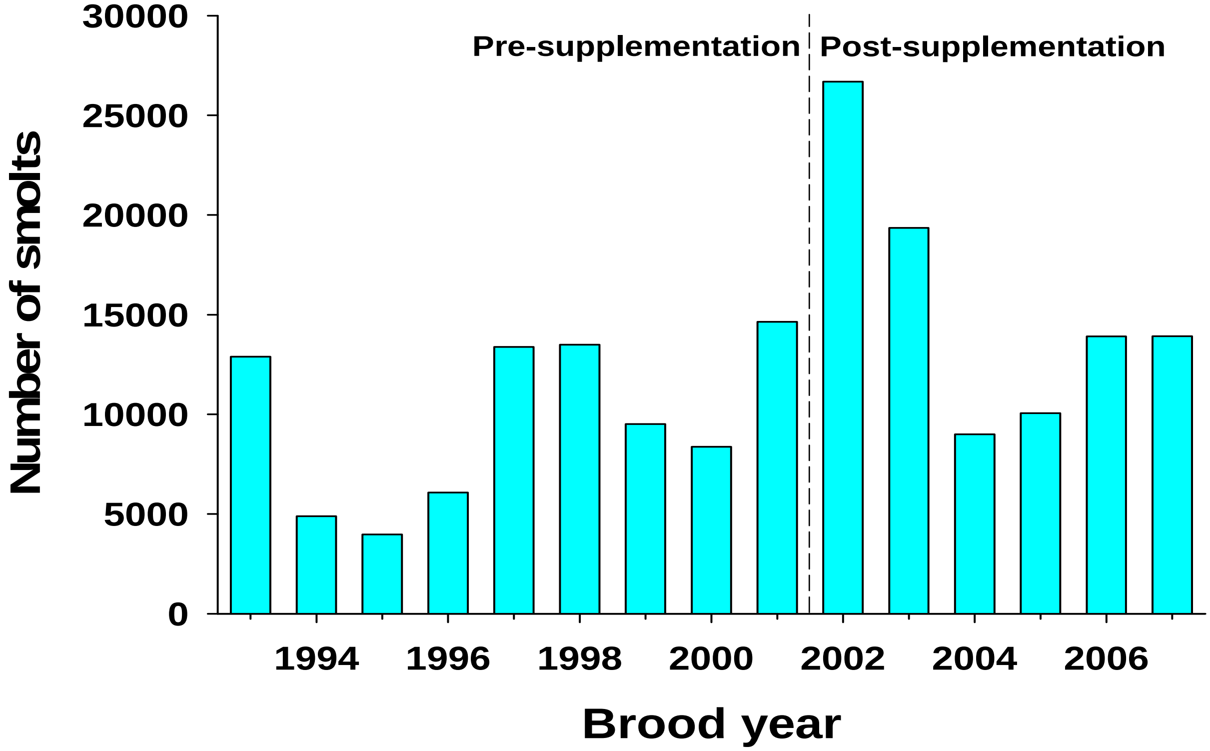

Figure 14. Catherine Creek Chinook salmon natural-origin smolt abundance, 1993-2007 brood years.

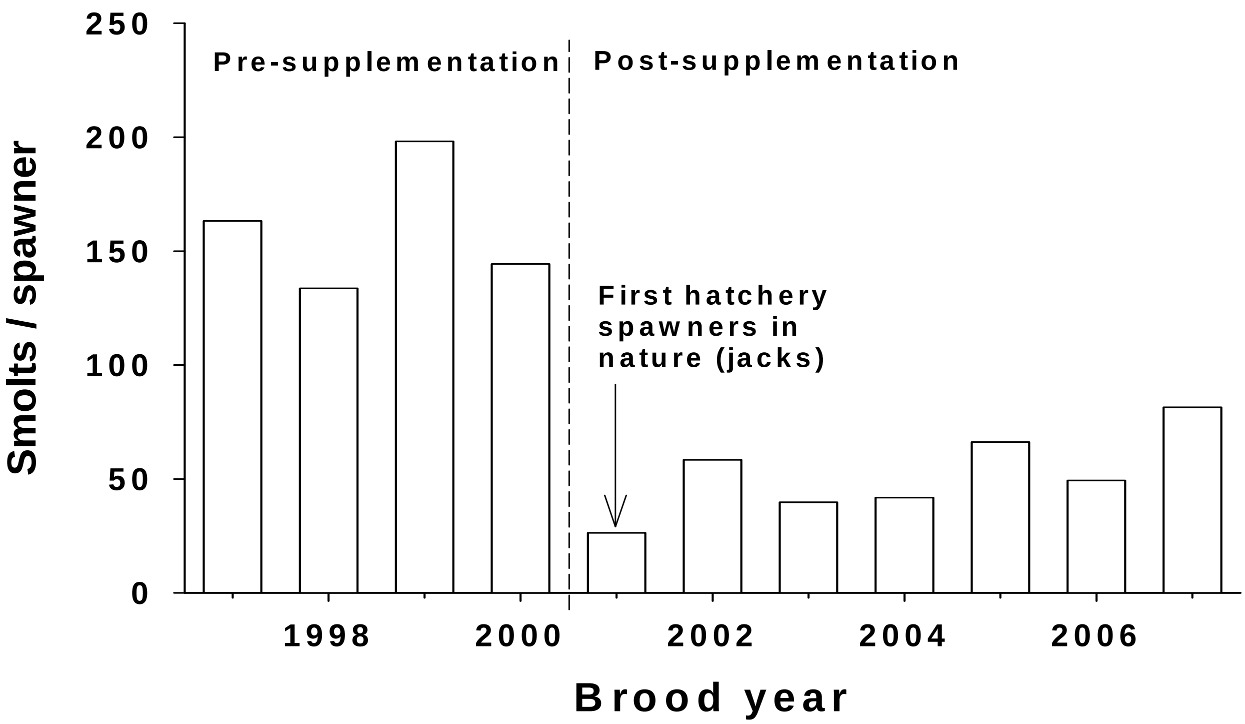

Figure 15. Catherine Creek Chinook salmon naturally produced smolts-per-spawner, 1997-2007 brood years.

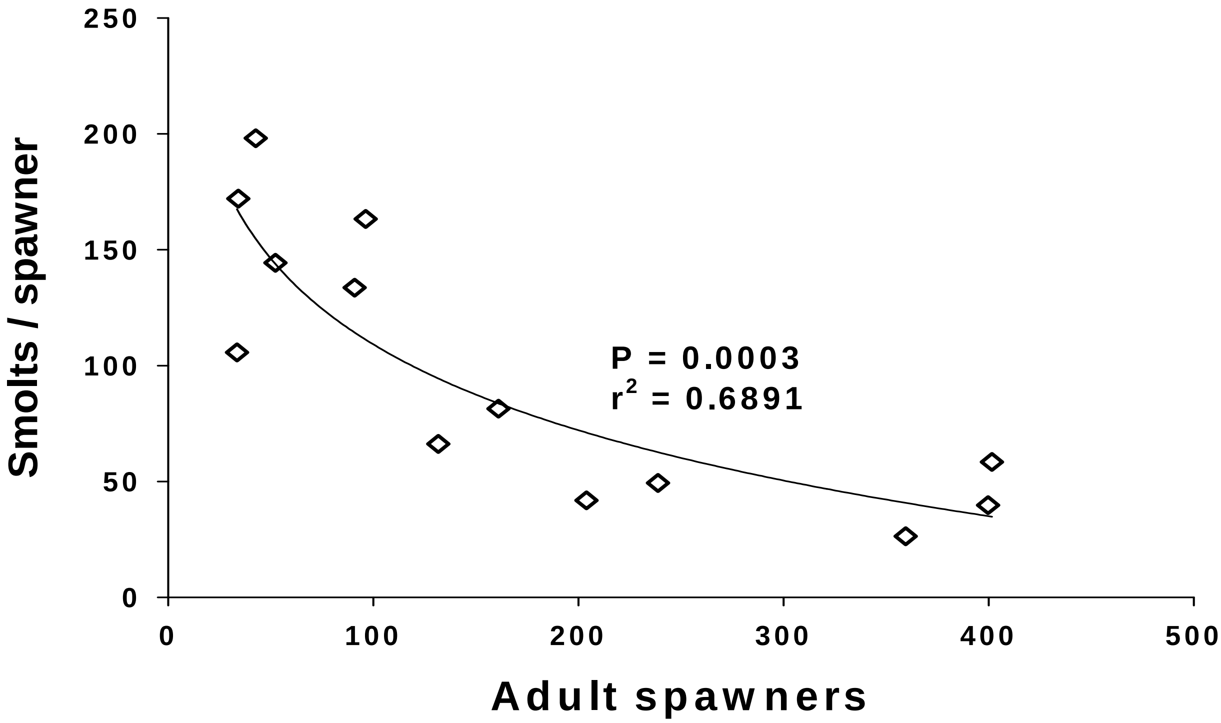

Figure 16. Relationship between adult spawner abundance and smolts-per-spawner for Catherine Creek Chinook salmon, 1995-2007 spawn years.

Similar to what we observed in the Upper Grande Ronde River population, the estimated smolts-per-spawner dropped to low levels at much lower escapement levels than anticipated based on prior Ecosystem Diagnosis Treatment modeling and recent historical escapements. We observed depressed productivity at adult spawner abundance levels of less than 200. We did not find a significant relationship between percent hatchery-origin spawners and smolts-per-spawner. There is high variability in smolts-per-spawner among years when no hatchery fish were present. The smolts-per-spawner values were all low when the percent hatchery spawners was $\geq$ 50%. (Figure 17). From 2005-2009 we observed a similar pattern of early age-at-return of hatchery fish, but differences between hatchery and natural adult age composition are only significant for age 5 due to the small sample size of four brood years (Figure 18). Adult migration timing at the Catherine Creek weir is similar for hatchery and natural fish (Figure 19). There was complete overlap in the range of spawning between natural and hatchery-origin females, however natural females have higher proportions in the lower reaches and hatchery females are concentrated in the reaches near the release location (Figure 20).

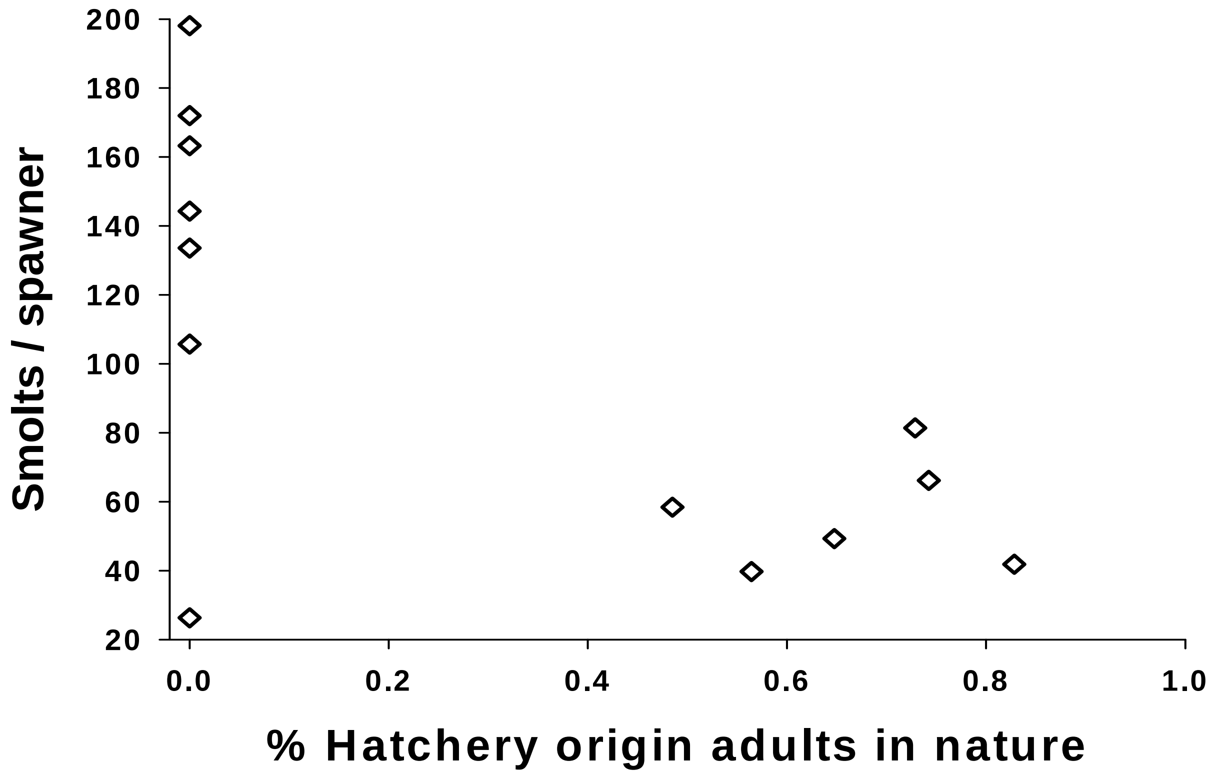

Figure 17. Relationship between percent hatchery-origin adults in nature and smolts-per-spawner for Catherine Creek Chinook salmon, 1995-2007 spawn years.

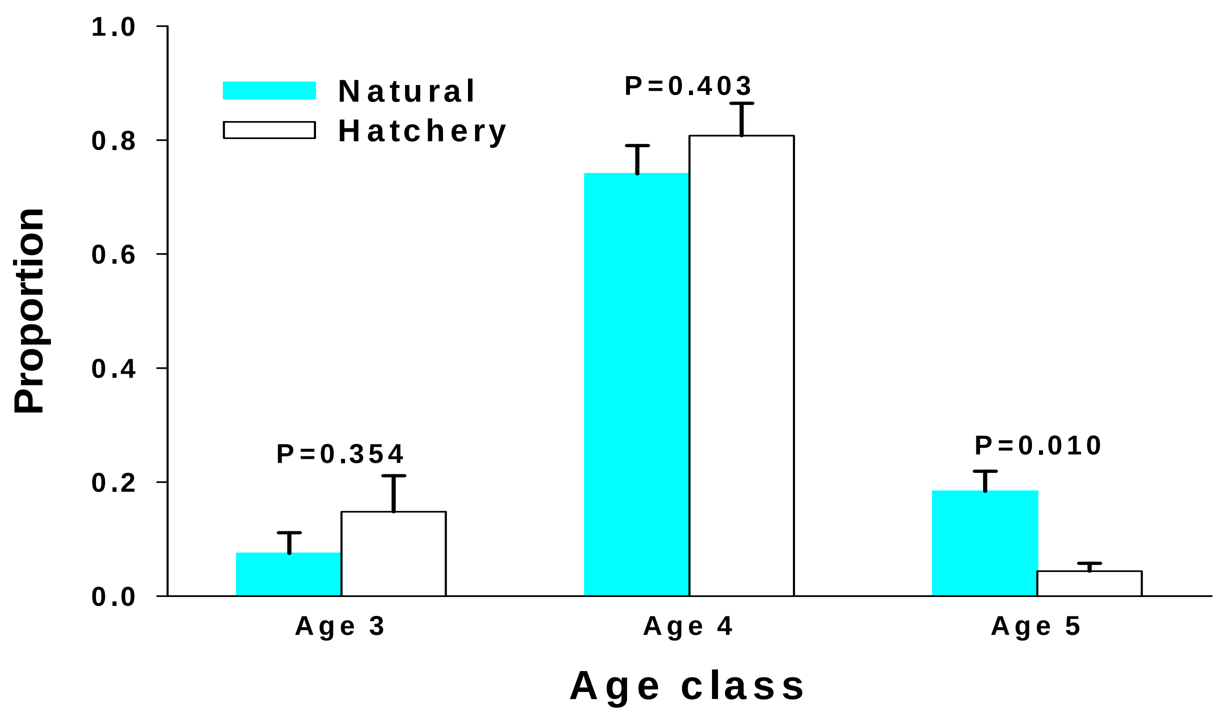

Figure 18. Mean age-at-return distribution for hatchery- and natural-origin Catherine Creek Chinook salmon, 2001-2004 brood years.

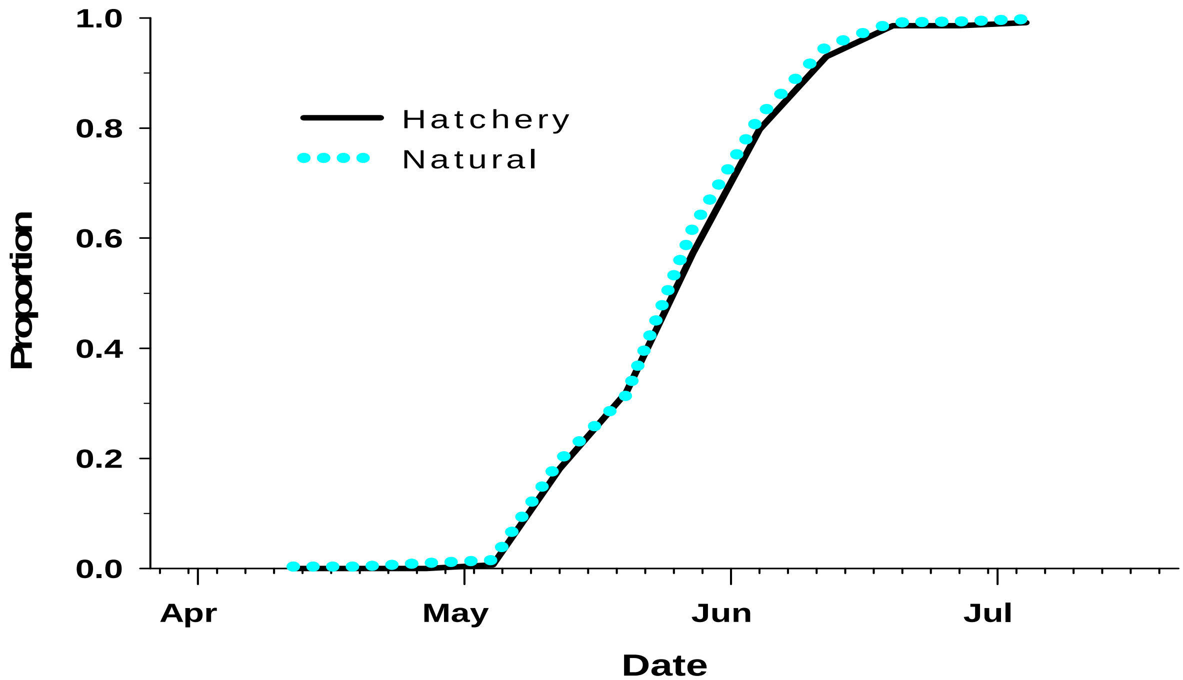

Figure 19. Adult migration timing of hatchery- and natural-origin fish at the Catherine Creek Weir, mean 2005-2009 run years.

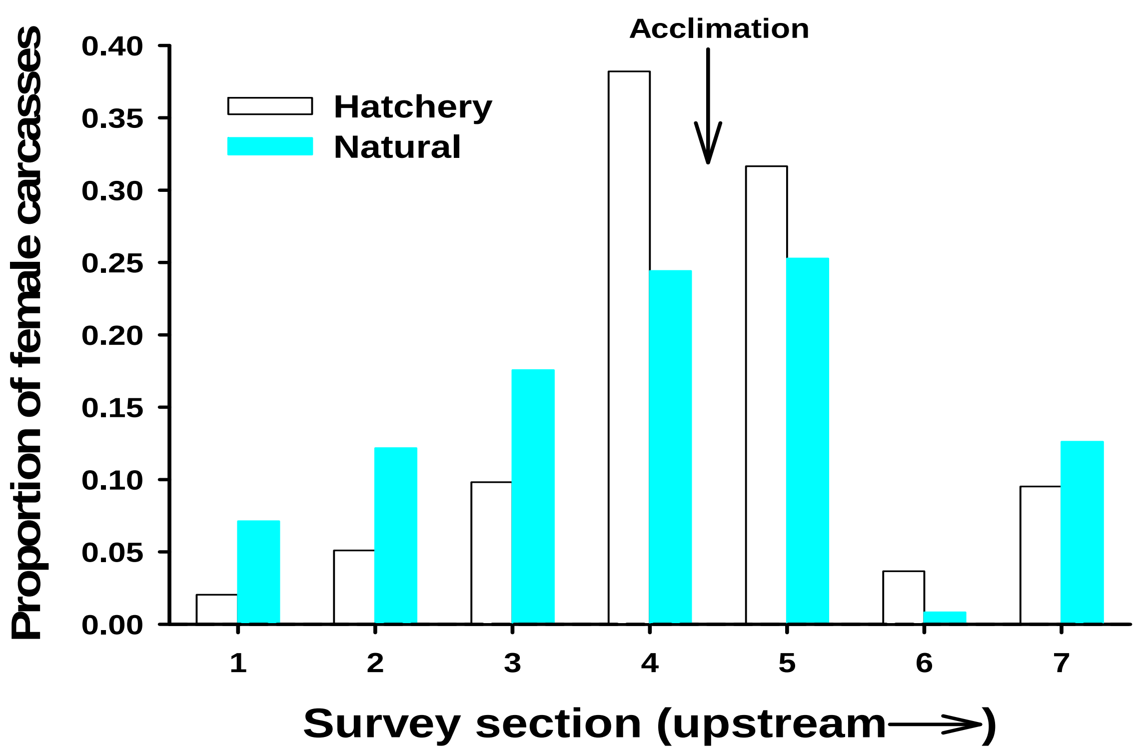

Figure 20. Spawning distribution of hatchery- and natural-origin females in Catherine Creek.

The proportion of natural spawners in the Minam and Wenaha rivers that were hatchery strays has been low since 2002. In the most recent years hatchery strays have comprised less than 5% of the spawners in these two populations (Figure 21). These recent proportions of hatchery strays are much reduced from the high proportions (over 50%) observed from 1986-1994 when Carson and Rapid River hatchery stock were used in the program. The small number of hatchery strays that were recovered in the Minam and Wenaha rivers originated from Lostine River, Catherine Creek and Lookingglass Creek releases (Figure 22).

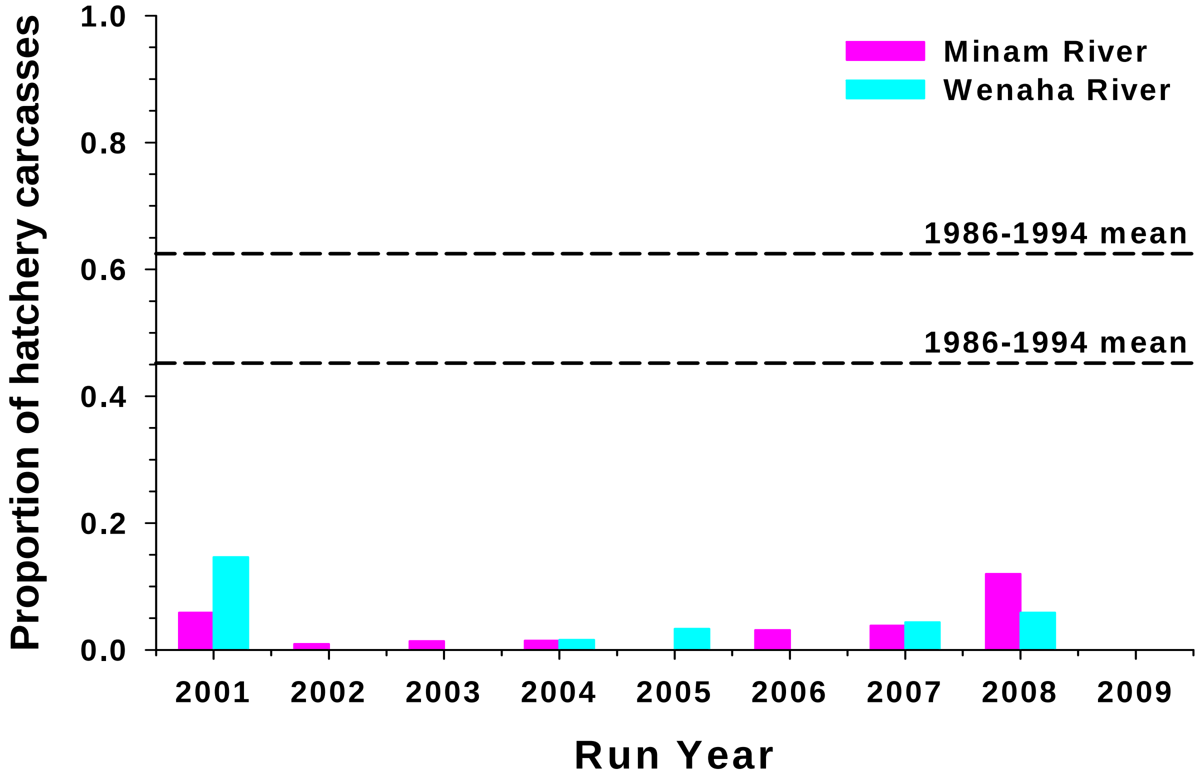

Figure 21. The proportion of total carcasses recovered in the Minam and the rivers that were hatchery-origin strays, 2001-2009.

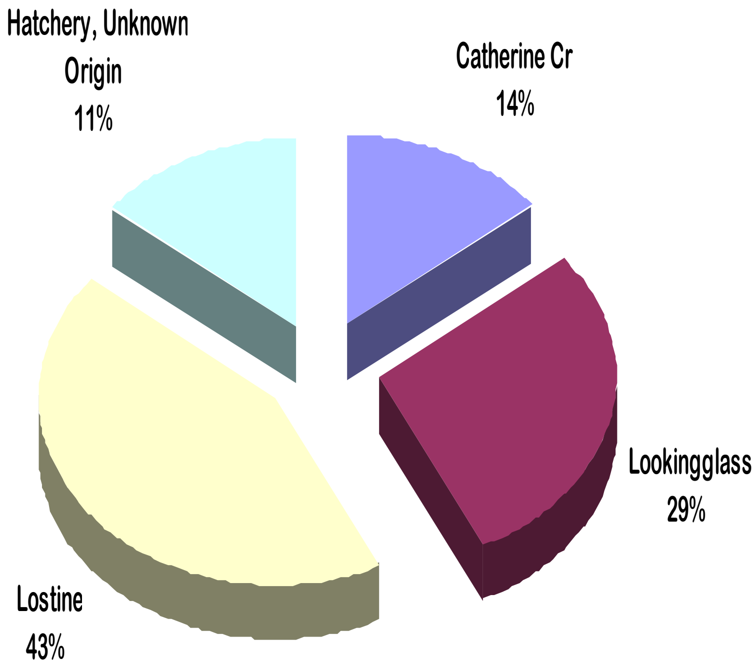

Figure 22. Origin of hatchery strays in the Minam and Wenaha rivers, 2002-2009.

SUMMARY AND CONCLUSIONS

Broodstock Development and Management

We have completed a successful transition from non-local broodstock to local Catherine Creek broodstock, but we have encountered a number of challenges during the transition process. The low abundance of natural-origin returns to Catherine Creek has limited broodstock availably for the conventional program. In addition, low abundance of natural-origin adults results in high proportions of hatchery fish in nature and in broodstock. The high contribution of hatchery spawners produces PNIs that are well below levels considered desirable.

In-Hatchery Performance

Pre-spawning mortality has been low and green egg-to-smolt survival has been high for most years. Although we did not present green egg-to-smolt survival for the 2009 brood year, (migration year 2011) the survival rate for this brood year will be very low due to the catastrophic mortality of parr in the Canadian Troughs on 3, June 2009. The mortality event was attributed to high precipitation that created unseasonably high turbid water, a severed water line, and a clogged drum filter that stopped water flow to the troughs.

Production, Survival, and Adult Production Performance

The smolt production goal has not been reached in any year due to the availability of adults in Catherine Creek and variability in the performance of the captive broodstock program. Smolt survival to Lower Granite Dam is the lowest of all NE Oregon hatchery produced smolts. Adult returns to the compensation area have not shown an increasing trend, which is inconsistent with other NE Oregon Chinook hatchery programs. These low adult returns are a result of poor SARs in all years and low smolt production releases in some years. Few Catherine Creek adults are harvested and the majority of adults produced escape to Catherine Creek. Stray rates of Catherine Creek Chinook salmon are generally low and few have been found in the Minam or Wenaha rivers. We have been unable to open mark-selective sport fisheries targeting Catherine Creek fish because of the depressed status of natural-origin returns. The natural-origin abundance has only exceeded the critical abundance threshold in two of the past fifteen years.

Supplementation: Life History and Spawning Characteristics

We have not observed differences in age-at-return between hatchery natural-origin adults; all other life history characteristics are similar. We have few years of data for comparisons so our conclusions are considered preliminary.

Supplementation: Abundance and Productivity

We have increased the total number of natural spawning fish with the addition of substantial numbers of hatchery returns to the spawning grounds. Natural-origin smolt abundance is higher for the post-supplementation time period. We have not observed an increase in natural-origin adult abundance. The number of smolts-per-spawner declined substantially since supplementation was initiated. Density dependence appears to be a significant factor influencing smolts-per-spawner in the post-supplementation time period. Recruits-per-spawner for natural spawners has been very low since supplementation was initiated with all values below 0.5.

The hatchery program is providing a demographic boost that appears to be critical in preventing the population from going extinct. The very low R/S values for natural spawners in recent years provide no resilience. Significant full life cycle survival improvements, that will allow natural R/S rates to consistently exceed 1.0, are needed in order for this population to persist without continued hatchery intervention.

FUTURE PROGRAM CHALLENGES AND NEEDS

The low productivity of naturally spawning fish and low abundance of natural-origin adults are significant challenges limiting the success of this program. These factors limit smolt production, limit the ability to improve the PNI, and prohibit targeted harvest on hatchery fish. There are no short-term or simple solutions for improving productivity. Productivity can only be enhanced by improving survival across the entire life cycle. These types of improvements in tributary and mainstem migratory habitat will take many salmon generations.

Two significant challenges faced by this program include low smolt-to-adult survival and high smolt morality between the release location and Lower Granite Dam. Work is underway to identify the location and potential causes of mortality that occurs in the Grande Ronde Valley low gradient habitat.

Our lack of understanding about why natural productivity is so low and why supplementation has not produced more natural fish, limits our ability to make adaptive changes. Work is underway to better understand relationships between habitat conditions and Chinook salmon production, relative reproductive success of natural spawning hatchery fish, and density dependent mechanisms. The continuation of these investigations along with supplementation and hatchery effectiveness monitoring will provide essential information needed to better manage the program and understand biological responses in the future.