Big Sheep Creek Spring Chinook Population

The Big Sheep Creek Spring Chinook population (Figure 1) is part of the Snake River Spring/Summer Chinook ESU which has five major population groupings (MPGs): Lower Snake River, Grande Ronde / Imnaha, South Fork Salmon River, Middle Fork Salmon River, and the Upper Salmon River group. The ESU contains spring, spring-summer, and summer run Chinook. The Big Sheep Creek population is a spring run and is one of seven extant populations in the Grande Ronde / Imnaha MPG.

The ICTRT classified the Big Sheep Creek population as a "basic" population (Table 1) based on historical habitat potential (ICTRT 2005). A Chinook population classified as basic has a mean minimum abundance threshold criteria of 500 naturally produced spawners with a sufficient intrinsic productivity (1.9 recruits per spawner at the minimum abundance threshold) to achieve a 5% or less risk of extinction over a 100-year timeframe.

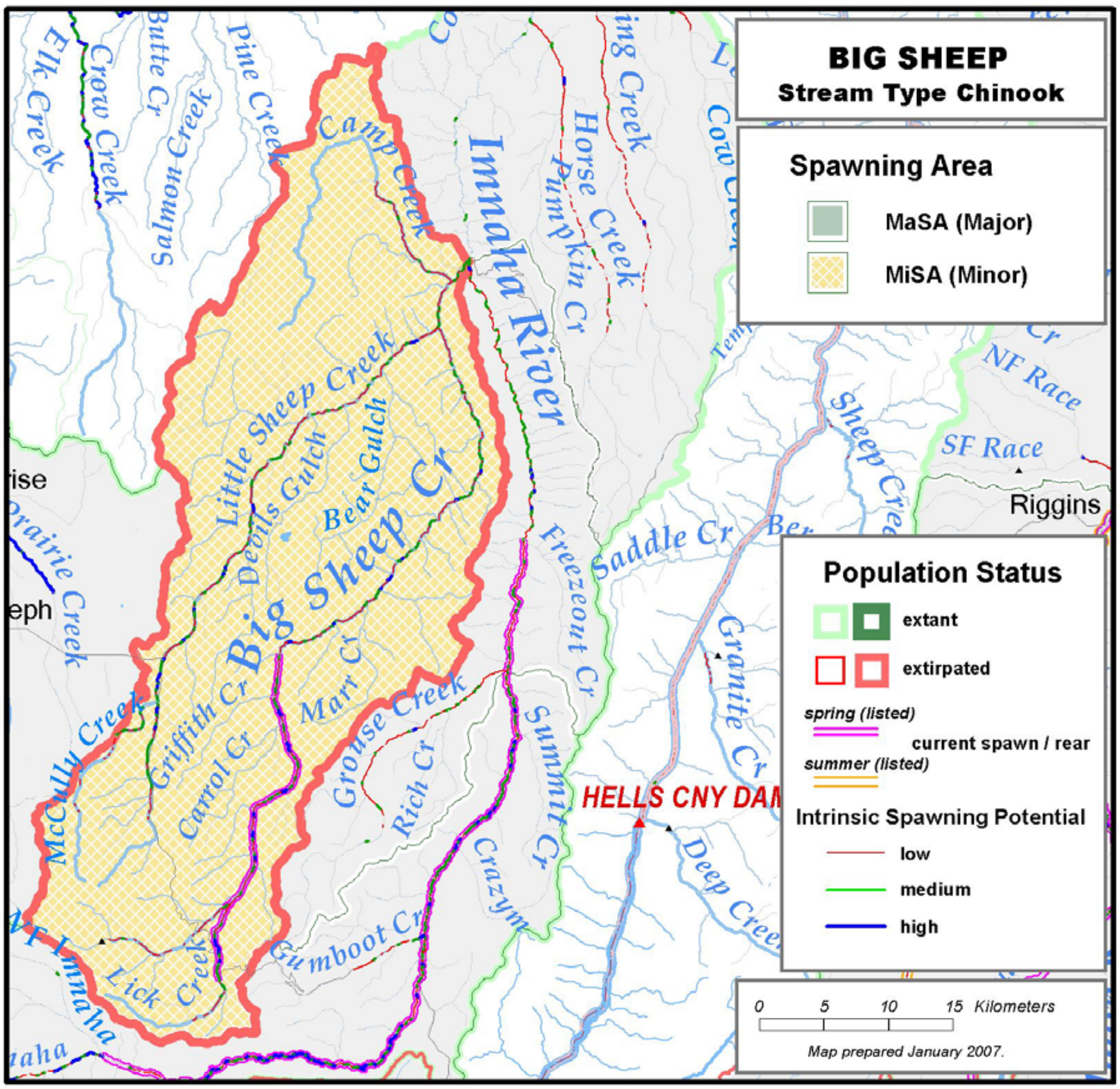

Figure 1. Big Sheep Creek Spring Chinook salmon population boundary and minor spawning area (MiSA).

Table 1. Big Sheep Creek Spring Chinook salmon population basin statistics and intrinsic potential analysis summary.

Drainage Area (km2)	886
Stream lengths km (total)[a]	356
Stream lengths km (below natural barriers)[a]	332
Branched stream area weighted by intrinsic potential (km2)	0.070
Branched stream area km2 (weighted and temp. limited)[b]	0.070
Total stream area weighted by intrinsic potential (km2)	0.261
Total stream area weighted by intrinsic potential (km2) temp limited[b]	0.261
Size / Complexity category	Basic / "A" (simple linear)
Number of Major Spawning Areas	0
Number of Minor Spawning Areas	1

[a]All stream segments greater than or equal to 3.8m bankfull width were included
[b]Temperature limited areas were assessed by subtracting area where the mean weekly modeled water temperature was greater than 22°C.

Current Abundance and Productivity

Current (1964 to 2005) abundance (number of adult spawners in natural production areas) has ranged from 0 (in several years after 1990) to 1,591 in 1966 (Figure 2). Abundance estimates are based on expanded redd counts. Estimates of abundance of adult spring Chinook spawners are based on redds observed during spawning ground surveys conducted annually in Big Sheep Creek and Lick Creek.

Spawning ground surveys have been conducted once annually in standard index survey reaches in Big Sheep and Lick creeks beginning in 1964 (Tranquilly et al. 2004). There were surveys conducted prior to 1964, but they were not temporally and spatially consistent. For this analysis, observations of redds and the locations of surveys are those reported in Tranquilli et al. (2004), updated with annual summaries of spawning ground survey results (personal communications, P. Keniry and F. Monzyk, ODFW NE Fisheries Research Program, La Grande, OR), and cross referenced to Beamesderfer et al. (1997). In Big Sheep Creek from 1964-1985 only the 4.0 mile standardized index survey was conducted. Beginning in 1986 additional reaches have been surveyed annually. From 1986-1989 and 1993-2005 surveys were conducted over a 13.0 mile section from the Highway 40 Bridge to Coyote Creek, the area known to contain most all of the spawners. For the period 1990-1992 a 9.0 mile section from the Highway 40 Bridge downstream was surveyed.

To account for spawning activity in unsurveyed reaches in Big Sheep Creek, we estimate each season's total redds by expanding redd counts in surveyed areas with an average proportion of redds for the unsurveyed reaches. To develop the spatial expansion factor for the 1964-1985 time period, when only index surveys were conducted, we used the average proportion of total redds observed outside the index area from the 1986-1989 and 1993-2005 complete area surveyed data. Supplemental surveys were conducted in 1955-56 and 2004-2005 to assess the extent of spawning that occurs after the standard index survey time. On average 57.8% of total redds are observed at the time of the index survey. To account for spawning activity occurring later than that observed during single pass surveys (all years except 2005-2005), we divide total area redd abundance by the average temporal expansion factor (.578). In Lick Creek from 1964-1997, a standard 4.0 mile index survey was conducted. After 1997 an additional 0.5 mile above the index area was surveyed. The 1964-1997 redd counts were spatially expanded based on the average proportion of total redds outside the index area observed in the 1998-2005 surveys. Supplemental surveys have been conducted after the index surveys in Lick Creek since 1997 to assess the extent of spawning after the index time. On average 45.6% of total redds were observed at the index time. We made a temporal expansion for the1964-1996 index surveys by dividing the counts by .456. Total annual redd estimates for the Big Sheep population were computed as the sum of the annual estimates for Lick Creek and Big Sheep Creek. To convert redds to spawning fish, we assume each redd represents 3.2 fish (including ocean age 1-yr jacks) based on the relationship between the number of fish spawning and redds observed upstream of the weir on the Imnaha River.

To estimate the abundance of natural-origin adult progeny on the spawning grounds each season, we subtract hatchery-origin fish from total spawner abundance. The proportion of adult hatchery origin fish on the spawning grounds is estimated from carcass recoveries and observations of finclips and CWTs. To estimate abundance of progeny for each brood year, we apportion natural-origin adult spawners into brood years using observed age-at-return. Age composition of adults on the spawning grounds is determined from analysis of scales collected from carcasses on the spawning grounds. Scale samples from the Big Sheep Creek population are limited on an annual basis. Therefore, we calculated an average annual age structure from pooled samples across all years. We used an average annual age structure to apply to each return year.

Recent year natural spawners include returns originating from naturally spawning parents and hatchery fish of Imnaha River hatchery stock origin. In most years since 1997 Imnaha hatchery adults that were collected at the Imnaha weir have been planted in Big Sheep Creek and Lick Creek. Hatchery fish have comprised a significant proportion of natural spawners since 1993 in some years. Natural-origin spawners have comprised an average of 82% since 1964, and the recent 10-year proportion of natural-origin spawners is 38% (Table 2).

Abundance in recent years has been highly variable, the most recent 10-year geomean number of natural-origin spawners was 4 (Table 2). During the period 1980-1999, returns per spawner for Chinook in Big Sheep Creek ranged from 0.0 (1993) to 6.77 (1980). The most recent 20 year (1978-1997) SAR adjusted and delimited (at 75% of the abundance threshold, 375 spawners) geometric mean of returns per spawner was 0.29 (Table 2).

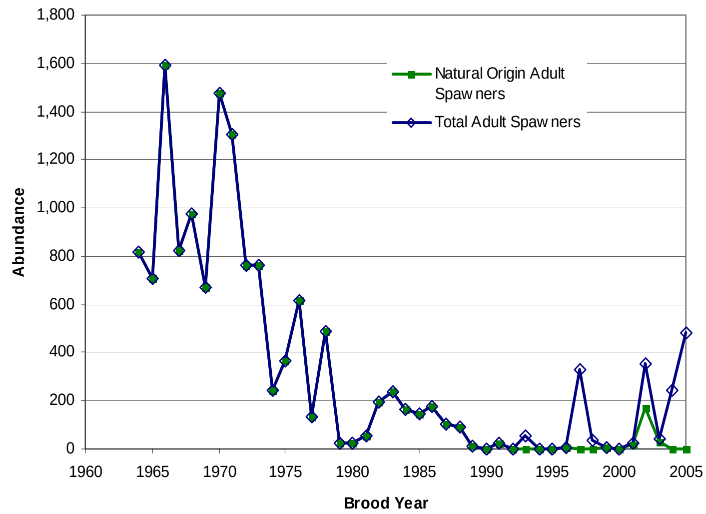

Figure 2. Big Sheep Creek Spring Chinook salmon population spawner abundance estimates (1963-2005).

Table 2. Big Sheep Creek Spring Chinook salmon population abundance and productivity estimates.

10-year geomean natural abundance	4
20-year return/spawner productivity	0.34
20-year return/spawner productivity, SAR adj. and delimited[a]	0.29
20-year Bev-Holt fit productivity, SAR adjusted	1.82
20-year Lambda productivity estimate	n/a
Average proportion natural origin spawners (recent 10 years)	0.38
Reproductive success adj. for hatchery origin spawners	n/a

[a]Delimited productivity excludes any spawner/return pair where the spawner number exceeds 75% of the population size threshold. This approach attempts to remove density dependence effects that may influence the productivity estimate. For this population, no points were excluded, as the parent spawner numbers were all below 375.

Comparison to the Viability Curve

- Abundance: 10-yr geomean natural origin spawners
- Productivity: 20-yr geomean R/S (adjusted for marine survival and delimited at 375 spawners)
- Curve: Hockey-Stick curve
- Conclusion: The Big Sheep Creek population is at **HIGH** risk based on current abundance and productivity. The point estimate resides below the 25% risk curve (Figure 3).

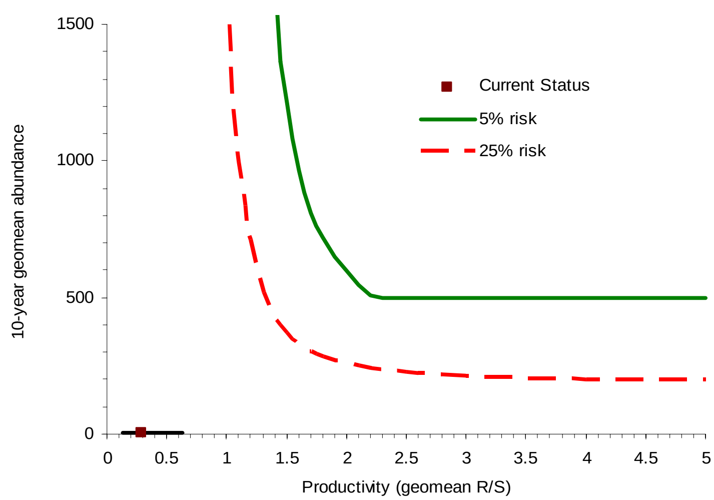

Figure 3. Big Sheep Creek Spring Chinook current estimate of abundance and productivity compared to the viability curve for this ESU. Point estimate includes a 1 SE ellipse and 95% CI (2.02 X SE abundance line, and 1.75 X SE productivity line).

Spatial Structure and Diversity

The ICTRT has identified no major spawning areas (MaSAs) and one minor spawning area (MiSA) within the Big Sheep Creek Spring Chinook population. No modeled temperature limitations exist within the MiSA for this population. Current spawning distribution is believed to be reduced from historic, with loss of spawning in the lower reaches of Big Sheep Creek. Current spawning occurs in Big Sheep Creek from the headwaters downstream to the confluence with Coyote Creek and in Lick Creek in the lower 4.5 miles. No hatchery releases occurred in Big Sheep Creek prior to 1993. Beginning in 1993 in some years Imnaha River hatchery adults have been outplanted into Big Sheep and Lick creeks. In recent years hatchery fish have comprised a significant proportion of natural spawners.

Factors and Metrics

A.1.a. Number and spatial arrangement of spawning areas.

The Big Sheep Creek population has no MaSAs and one MiSA. Currently only the upper portion of the MiSA is occupied. A population that occupies one or less MaSA is considered **high risk**.

A.l.b. Spatial extent or range of population.

The current spawner distribution is reduced relative to historic and the one MiSA is occupied in the upper portion only. There has been some reduction in distribution with no current spawning in the lower reaches of Big Sheep Creek (Figure 4). The population is rated at **moderate risk** for this metric.

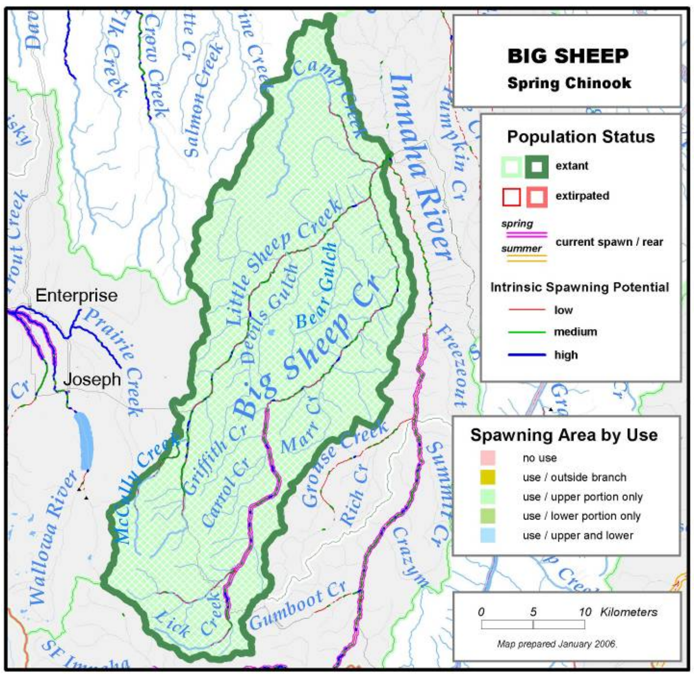

Figure 4. Big Sheep Creek Spring Chinook salmon population current spawning distribution and spawning area occupancy designations.

A.1.c. Increase or decrease in gaps or continuities between spawning areas.

There have been some changes in gaps because current distribution is reduced from historic due to loss of spawning in the lower reaches of Big Sheep Creek. The reduced range has increased the gap significantly between Big Sheep Creek and the Imnaha River population. The population is rated at **moderate risk.**

B.1.a. Major life history strategies.

Limited information exists to evaluate changes in life history pathways. We used habitat changes to infer changes in life history strategies. Habitat changes in Big Sheep Creek have resulted in temperature and hydrograph changes. However, the changes have not been to the extent that they would alter major life history pathways. We have rated this metric as **low risk**.

B.1.b. Phenotypic variation.

Data are not available to assess the degree to which phenotypic traits have been altered or lost. Changes in mainstem Snake River and Columbia River hydrograph and temperatures have altered survival rates and changed relationships of migration timing and survival. We do not believe these changes have been to the extent that any traits have been lost. Outplanting of Imnaha spring-summer Chinook has likely influenced the endemic phenotypic traits of Big Sheep Creek spring Chinook salmon. Imnaha Chinook are a spring-summer type with later migration timing and older average at age return than spring Chinook. The introgression of Imnaha and Big Sheep Creek Chinook will result in significant change in phenotypic variability. We have rated this metric as **moderate risk** because the means of two or more traits have likely changed and variability has been altered.

B.1.c. Genetic variation.

There are no genetic data for Big Sheep Creek, therefore this metric is rated **moderate risk**. With significant outplanting of Imnaha Chinook into the Big Sheep Creek population we expect the population to become identical to the Imnaha River population through time.

B.2.a. Spawner composition.

(1) *Out-of-ESU spawners*. We have not observed any out-of-ESU strays in the Big Sheep Creek population. The metric is rated as **very low risk**.

(2) *Out-of-MPG spawners from within the ESU*. We have not observed any out-of-MPG strays in the Big Sheep Creek population. The metric is rated as **very low risk**.

(3) *Out-of-population within MPG spawners*. The mean percent out-of-population origin fish in the natural spawners in the Big Sheep Creek population for the period 1991-2005 was 46.8. These fish were Imnaha River hatchery origin. With this level of out-of-population spawners the metric is rated as **high risk**.

(4) *Within-population hatchery spawners*. There is no within-population hatchery program, thus the metric is rated as **very low risk**.

The overall rating for spawner composition is **high risk**.

B.3.a. Distribution of population across habitat types.

The intrinsic distribution of the Big Sheep Creek population encompassed three ecoregions, all which accounted for greater than 10% of the distribution (Figure 5). There has been a substantial reduction in the use of the Canyons and Dissected Uplands ecoregion as a result of the reduced spawning distribution in lower Big Sheep Creek (Table 3). With a substantial reduction in one of three ecoregions the population is rated as **low risk** for this metric.

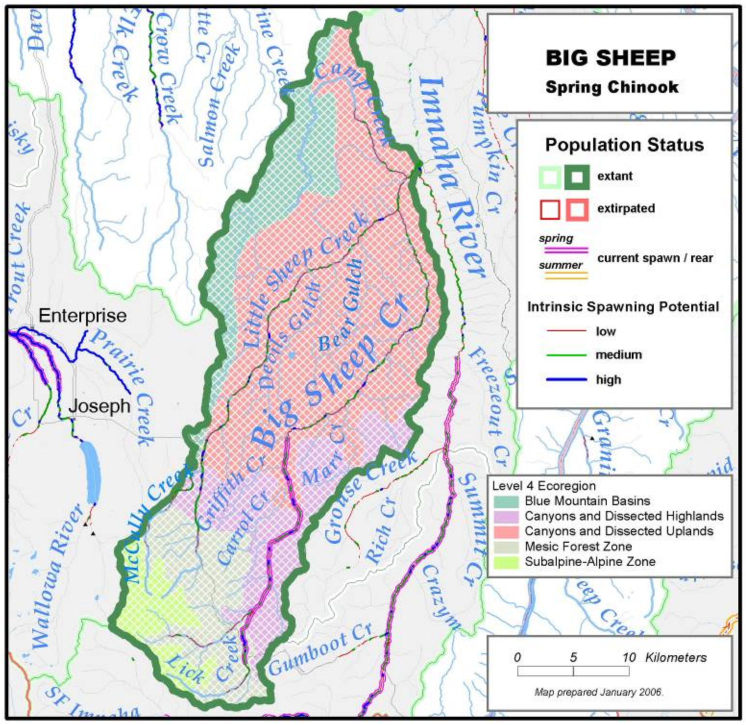

Figure 5. Big Sheep Creek Spring Chinook salmon population spawning distribution across EPA level 4 ecoregions.

Table 3. Big Sheep Creek Spring Chinook salmon population proportion of current spawnin areas across EPA level 4 ecoregions.

Ecoregion	% of historical branch spawning area in this ecoregion (non-temperature limited)	% of historical branch spawning area in this ecoregion (temperature limited)	% of currently occupied spawning area in this ecoregion (non-temperature limited)
Canyons and Dissected Highlands	21.6	21.6	47.7
Canyons and Dissected Uplands	61.1	61.1	33.9
Mesic Forest Zone	17.3	17.3	18.4

B.4.a. Selective change in natural processes or selective impacts.

Hydropower system: The hydropower system and associated reservoirs likely pose some selective mortality on downstream migrating smolts. We do not have quantitative data to assess if the mortality is selective on 25% or more of affected individuals. We hypothesize that the mortality is not 25% or greater consistently for any component, thus we have rated this metric as **low risk**.

Harvest: Current harvest regulations are very restrictive and allow for only a small proportion (5-10%) of Snake River spring/summer Chinook to be harvested annually. The methods of harvest are generally non-selective for adult sized fish. We have rated this metric as **low risk**.

Hatcheries: No hatcheries are operated in the Minam population. The rating is **very low risk**.

Habitat: There does not appear to be any within basin changes that would pose selective mortality on 25% or greater of any component of the population. The rating is **low risk**.

The overall rating for selective changes is **low risk**.

Spatial Structure and Diversity Summary

The combined integrated Spatial Structure/Diversity rating is moderate risk for the Big Sheep Creek population (Table 4). The rating for Goal A "allowing natural rates and levels of spatially mediated processes" was moderate risk. This risk rating is a result of the intrinsic high risk of a small linear population that has little habitat quantity and has only one MiSA. In addition, there has been a reduction in the spawning distribution with loss of utilization in the lower reaches of Big Sheep Creek.

The rating for Goal B "maintaining natural levels of variation" was moderate risk. This overall rating was driven by moderate ratings for phenotypic variation resulting from introgression of Imnaha spring-summer Chinook into the Big Sheep Creek spring Chinook population, absence of genetics data, and a high risk rating for spawner composition due to the high fraction of Imnaha River hatchery Chinook in the Big Sheep Creek population.

Table 4. Big Sheep Creek Spring Chinook salmon population spatial structure and diversity risk rating summary.

Metric	Risk Assessment Scores				
	Metric	Factor	Mechanism	Goal	Population
A.1.a	H (-1)	H (-1)	Mean = (-.33) Moderate	Moderate	Moderate Risk
A.1.b	M (0)	M (0)			
A.1.c	M (0)	M (0)			
B.1.a	L (1)	L (1)	Mean = (.33) Moderate	Moderate	
B.1.b	M (0)	M (0)			
B.1.c	M (0)	M (0)			
B.2.a(1)	VL (2)	H (-1)	High (-1)		
B.2.a(2)	VL (2)				
B.2.a(3)	H (-1)				
B.2.a(4)	VL (2)				
B.3.a	L (1)	L (1)	L (1)		
B.4.a	L (1)	L (1)	L (1)		

Overall Viability Rating:

The overall viability rating for the Big Sheep Creek spring Chinook population does not meet viability criteria and is considered high risk. The 10-year geomean of natural abundance is 4, which is less than 1% of the minimum threshold abundance of 500. The point estimate of productivity is 0.29, which is one of the lowest in the ESU and is very high risk. The overall spatial structure/diversity rating is moderate risk due to ratings for phenotypic changes and spawner composition (Table 5). Given the recent and proposed future outplanting of Imnaha River spring-summer Chinook hatchery fish into this population and the extremely low natural origin abundance, the population may be functionally extinct.

		Spatial Structure/Diversity Risk			
		Very Low	**Low**	**Moderate**	**High**
Abundance/ Productivity Risk	**Very Low** (<1%)	**HV**	**HV**	**V**	M*
	Low (1-5%)	**V**	**V**	**V**	M*
	Moderate (6 – 25%)	M*	M*	M*	
	High (>25%)			**Big Sheep**	

Figure 6. Big Sheep Creek Spring Chinook salmon population risk ratings integrated across the four viable salmonid population (VSP) metrics. *Viability Key: HV – Highly Viable; V – Viable; M* – Candidate for Maintained; Shaded cells-- not meeting viability criteria (darkest cells are at greatest risk).*

Big Sheep Creek Spring Chinook – Data Summary

Data type: Redd count expansions
SAR: Averaged Williams/CSS series

Table 5. Big Sheep Creek Spring Chinook salmon population abundance and productivity data used for curve fits and R/S analysis. Bolded values were used in estimating the current productivity (Table 6).

Brood Year	Spawners	%Wild	Natural Run	Nat. Rtns	R/S	SAR Adj. Factor	Adj. Rtns	Adj. R/S
1980	**23**	**1**	**23**	**157**	**6.77**	**0.58**	**92**	**3.94**
1981	**55**	**1**	**55**	**158**	**2.88**	**0.63**	**99**	**1.81**
1982	**194**	**1**	**194**	**152**	**0.78**	**0.51**	**78**	**0.40**
1983	**238**	**1**	**238**	**102**	**0.43**	**0.58**	**59**	**0.25**
1984	**163**	**1**	**163**	**65**	**0.40**	**1.65**	**107**	**0.66**
1985	**147**	**1**	**147**	**9**	**0.06**	**1.57**	**13**	**0.09**
1986	**178**	**1**	**178**	**10**	**0.06**	**1.41**	**14**	**0.08**
1987	**106**	**1**	**106**	**18**	**0.17**	**1.83**	**32**	**0.30**
1988	**93**	**1**	**93**	**1**	**0.01**	**0.75**	**0**	**0.00**
1989	**13**	**1**	**13**	**1**	**0.07**	**1.79**	**2**	**0.13**
1990	0							
1991	**27**	**1**	**27**	**2**	**0.09**	**3.01**	**7**	**0.26**
1992	0							
1993	53	0.03	1	0				
1994	0							
1995	0							
1996	**7**	**1**	**7**	**6**	**0.87**	**0.54**	**3**	**0.47**
1997	328	**0**	**0**	**71**	**0.22**	**0.30**	**21**	**0.06**
1998	34	**0**	**0**	**119**	**3.48**	**0.30**	**35**	**1.03**
1999	**7**	**1**	**7**	**19**	**2.81**	**0.65**	**12**	**1.82**
2000	0							
2001	25	0.50	16					
2002	356	0.50	170					
2003	44	0.44	29					
2004	247	0.00	0					
2005	480	0.00	0					

Table 6. Big Sheep Creek Spring Chinook salmon population geometric mean abundance and productivity estimates (values used for current productivity and abundance are shown in boxes).

	R/S measures				Lambda measures		Abundance
	Not adjusted		SAR adjusted		Not adjusted		Nat. origin
delimited	median	75% threshold	median	75% threshold	1987-1998	1979-1998	geomean
Point Est.	0.84	0.34	0.70	0.29	n/a	n/a	4
Std. Err.	0.80	0.50	0.52	0.44			0.6
count	6	15	6	15			5

Table 7. Big Sheep Creek Spring Chinook salmon population stock-recruitment curve fit parameter estimates. Biologically unrealistic or highly uncertain values are highlighted in grey.

	Not adjusted for SAR							Adjusted for SAR						
SR Model	a	SE	b	SE	adj. var	auto	AICc	a	SE	b	SE	adj. var	auto	AICc
Rand-Walk	0.34	0.16	n/a	n/a	2.43	0.56	66.6	0.29	0.12	n/a	n/a	2.51	0.24	62.3
Const. Rec	20	10	n/a	n/a	n/a	n/a	66.0	17	7	n/a	n/a	n/a	n/a	61.2
Bev-Holt	1.15	1.38	37	30	1.56	0.71	67.9	0.98	1.02	32	22	1.72	0.45	62.4
Hock-Stk	0.50	0.34	10000	0	2.53	0.56	70.4	0.50	0.42	10000	0	2.80	0.24	67.1
Ricker	0.60	0.42	0.00534	0.00492	1.76	0.68	68.6	0.60	0.35	0.00687	0.00408	1.82	0.44	62.9

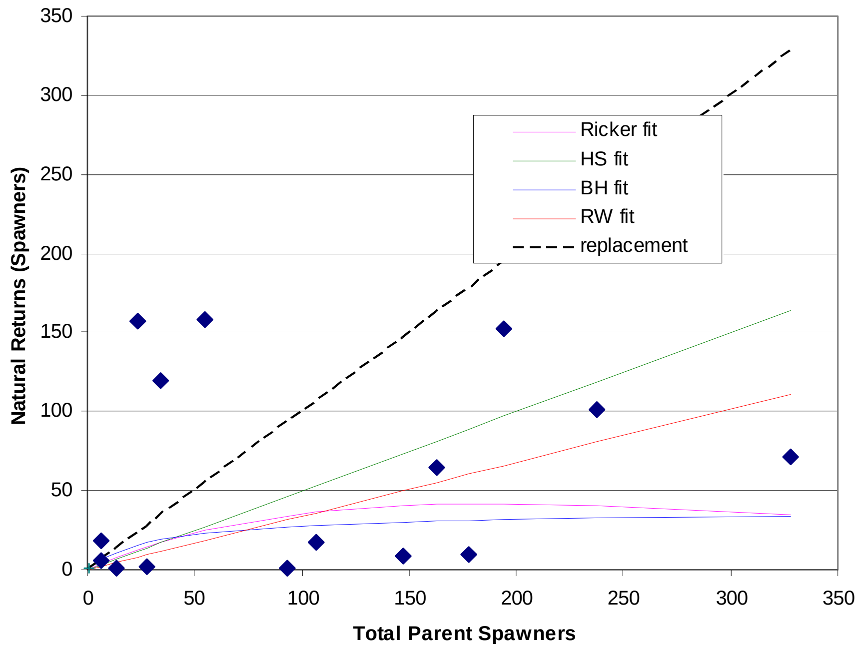

Figure 7. Big Sheep Creek Spring Chinook salmon population stock recruitment curves. All available R/S data were used in estimating the current productivity for this population. Data were not adjusted for marine survival.

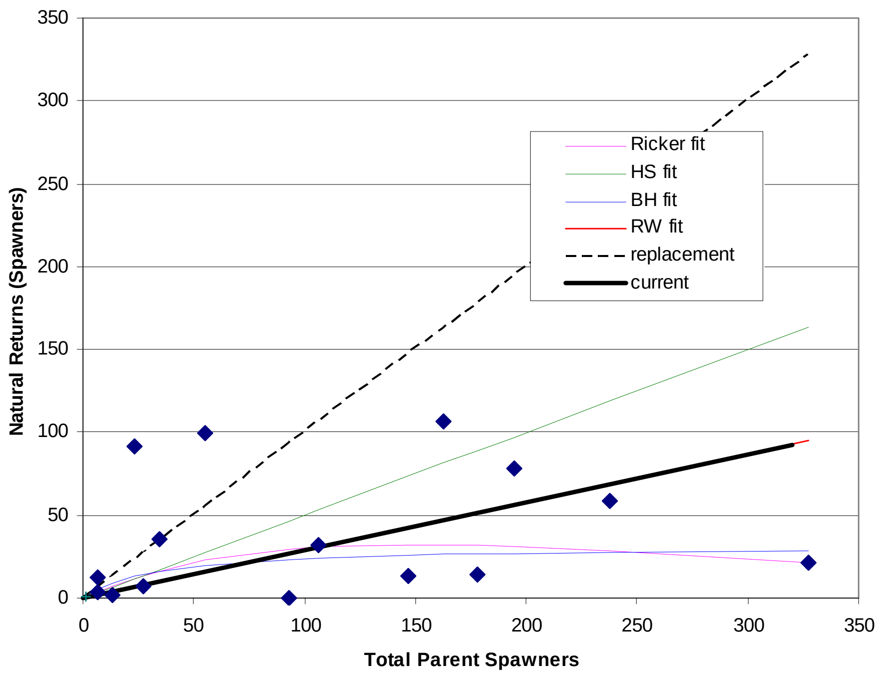

Figure 8. Big Sheep Creek Spring Chinook salmon population stock recruitment curves. All available R/S data were used in estimating the current productivity for this population. Data were adjusted for marine survival.