APPENDIX A: TRENDS IN SPAWNING ESCAPEMENT

Spawning escapement of Skagit summer and fall Chinook has been fairly stable since escapement estimates were first made in 1952. Escapements were relatively low in the mid-1950' and the early 1990s, while escapements were higher in the 1970', and there has been an increasing trend since 1996 (Table 1; Fig. 1). There are, however, differences in trends between populations. Since about 1984, Upper Skagit summer Chinook have made up an increasing percentage of the total escapement. Prior to 1984, approximately 60% of the summer and fall production unit escapement was comprised of Upper Skagit summer Chinook, yet, since that time, Upper Skagit summer Chinook have averaged about 75% of the total summer and fall production unit escapement. Side by side to this change in escapement composition, a complementary decrease in the percentage comprised of Lower Skagit falls and Lower Sauk summers has also been observed (Table 1; Fig. 2).

Escapement estimates of Skagit spring Chinook have been generated back to 1952 (Table 1). However, because a change in estimation methods from peak live and dead counts, multiplied by a length factor, to the current redd count method, the numbers are reliably comparable only since 1994. Since 1994, the escapement trend of Skagit springs has been fairly flat with a slight increasing trend (Fig. 3). Each of the three spring populations has contributed approximately equal percentages of the escapement, and since 1994 there has been no noticeable change in the percentage contributed by each population (Fig. 4).

By examining correlations in escapement trends between populations, it may be possible to determine which populations are limited by common limiting factors, as well as hypothesize where those constraints might occur. Correlations in spawning escapement can be examined for summer and fall populations back to 1973, for spring populations, and among spring and summer and fall populations, back to 1994. Because redd counts started in 1992 in the Upper Cascade River, correlations between Upper Cascade spring Chinook and the summer and fall Chinook populations can be examined back to 1992.

The spawning escapement trends for the Lower Skagit fall Chinook, over the 1973–2004 time period, are significantly correlated to those of both the Lower Sauk and Upper Skagit summer Chinook populations, with a higher correlation to those of the Lower Sauk summer Chinook population; however, there was a non-significant correlation between the Lower Sauk summer Chinook and the Upper Skagit summer Chinook escapements (Table 2). This may indicate that factors that affected the escapement of Lower Skagit fall Chinook may also have affected the escapements of Lower Sauk and Upper Skagit summer Chinook. However, there may also have been additional factors that affected escapement of either Lower Sauk or Upper Skagit summer Chinook that were not shared by the other population. In addition, since 1994, the correlation between Lower Skagit fall Chinook and Lower Sauk summer chinook escapements has been non-significant. This indicates that, whatever factors that caused the correlation between Lower Skagit fall Chinook and Lower Sauk summer Chinook escapements between 1973 and 1993, they have not had the same effect on each population since 1994. In fact, since 1994, escapement trends for Lower Sauk summer Chinook have not been significantly correlated to

any other Skagit River population (Table 2), which indicates that escapement of Lower Sauk summers may be limited by factors that are confined to the Lower Sauk River spawning area.

For Skagit River springs, escapements of Upper Sauk spring Chinook are significantly correlated to those of every Skagit River Chinook population except Lower Sauk summers and Suiattle springs (although the correlation with Suiattle springs is just slightly non-significant), which is somewhat unexpected, given that the Lower Sauk summer and Suiattle spring populations are geographically the closest spawning populations to the Upper Sauk spring population. This would indicate that the factors that affect escapement of Upper Sauk springs occur primarily outside of the Sauk River System, in areas shared with the Lower Skagit fall, Upper Skagit summer, and Upper Cascade spring populations. Escapement trends since 1994 for Suiattle springs are significantly correlated only to those of Upper Cascade springs (Table 2). Yet, there is no known place in the river where both Suiattle and Upper Cascade spring Chinook juveniles coexist, and the other four populations do not. Such correlations imply that the factors with the most effect on abundance of Suiattle spring Chinook are speculative. One factor may affect mainly the spawning grounds of these two populations, with less effect on the spawning grounds of the other populations—possibly due to the fact that the Upper Cascade and the Suiattle Rivers are in the same hydro-region, experiencing similar rainfall patterns for both populations' spawning areas. Another factor that may affect the yet-unknown habitats where yearling chinook rear, which may be more accessible to yearling Suiattle and Upper Cascade spring Chinook, than they are to Upper Sauk spring Chinook. Still, another factor affecting the abundance of Upper Cascade and Suiattle spring Chinook may occur in marine areas where these two populations are more likely to occur than are the other four Skagit River Chinook populations.

In summary, if the correlations between escapement trends are valid indicators, it would appear that the factors that affect escapement of Lower Sauk summers probably occur primarily on the Lower Sauk summer spawning grounds. Additionally, the factors that affect Upper Sauk spring escapement probably occur primarily outside the Sauk River System. However, it is unclear where the factors that affect the other four Chinook populations primarily occur.

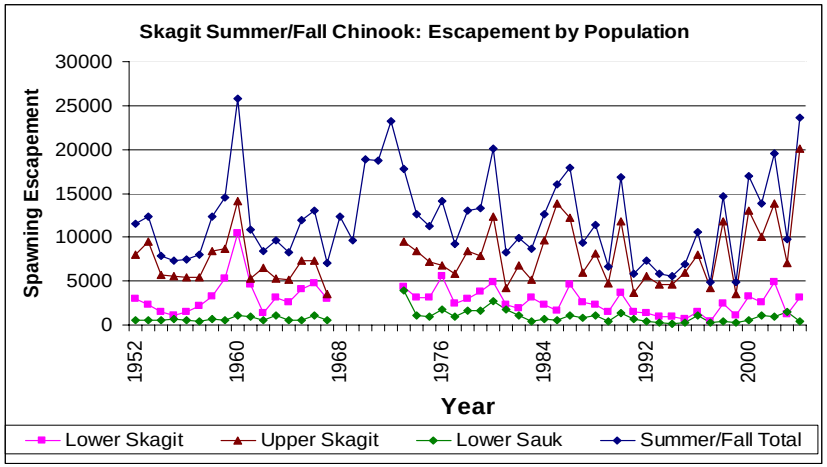

Figure 1. Spawning escapements of Skagit summer/fall Chinook since 1952.

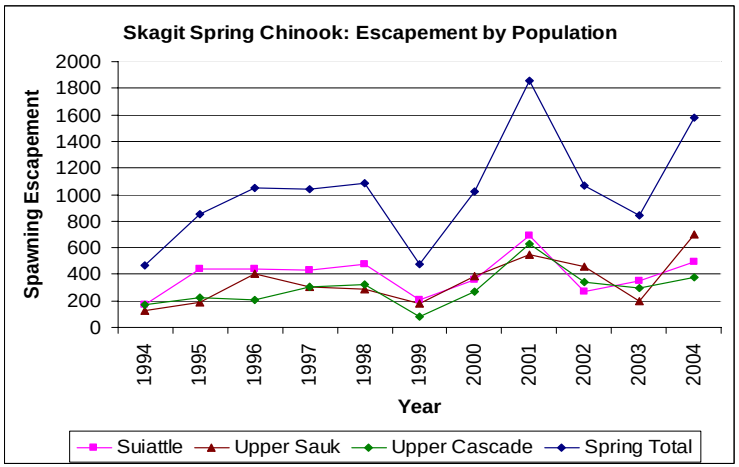

Figure 3. Spawning escapements of Skagit Spring Chinook since 1994.

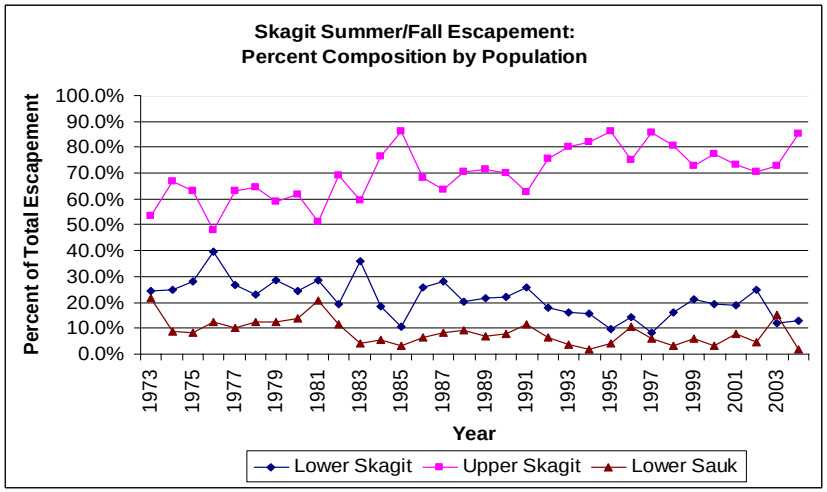

Figure 2. The percentage of the spawning escapement of each Skagit summer/fall chinook population that is composed of each population, since 1973.

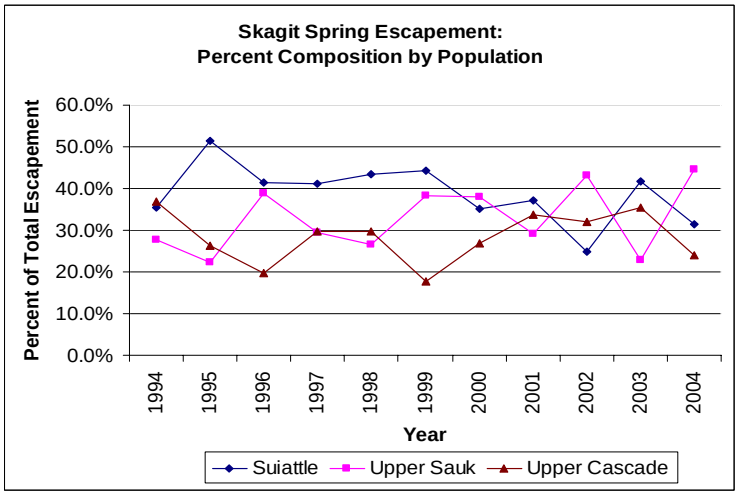

Figure 4. The percentage of the spawning escapement of each Skagit spring Chinook population that is composed of each population, since 1994.

Table 1. Population-specific escapements of Chinook salmon in the Skagit System since 1952, and percentage of the summer and fall population escapement composed of each summer or fall population since 1973. Percentages are not shown for years prior to 1973, because in many of those years, data from the Upper Skagit River were used to calculate escapements in the Lower Skagit or Lower Sauk Rivers (SSC 1997).

								Percentage of Summer/Fall Total		
Year	Lower Skagit	Upper Skagit	Lower Sauk	Suiattle Springs	Upper Sauk Springs	Upper Cascade Springs	Sum/Fall Total	Lower Skagit	Upper Skagit	Lower Sauk
1952	3000	8058	547	289	1894		11605	25.9%	69.4%	4.7%
1953	2263	9524	564	505	789		12351	18.3%	77.1%	4.6%
1954	1507	5753	565	415	649		7826	19.3%	73.5%	7.2%
1955	1081	5633	631	540	844		7345	14.7%	76.7%	8.6%
1956	1490	5467	544	1206	1884		7501	19.9%	72.9%	7.2%
1957	2141	5420	397	901	2523		7958	26.9%	68.1%	5.0%
1958	3228	8436	676	453	636		12340	26.2%	68.4%	5.5%
1959	5319	8690	509	1034	740		14518	36.6%	59.9%	3.5%
1960	10486	14150	1142	618	3345		25778	40.7%	54.9%	4.4%
1961	4565	5306	1007	924	3302		10878	42.0%	48.8%	9.3%
1962	1402	6487	534	1290	1643		8423	16.6%	77.0%	6.3%
1963	3168	5326	1140	693	1249		9634	32.9%	55.3%	11.8%
1964	2623	5115	486	479	681		8224	31.9%	62.2%	5.9%
1965	4042	7387	525	1053	2018		11954	33.8%	61.8%	4.4%
1966	4701	7313	1056	948	1366		13070	36.0%	56.0%	8.1%
1967	2957	3511	563	818	336		7032	42.1%	49.9%	8.0%
1968				761	147		12330			
1969				830	978		9613			
1970				1020	1066		18872			
1971				1468	610		18760			
1972				1804	150		23234			
1973	4388	9526	3896	577	1255		17809	24.6%	53.5%	21.9%
1974	3116	8389	1082	355	108		12587	24.8%	66.6%	8.6%
1975	3185	7171	964	327	300		11320	28.1%	63.3%	8.5%
1976	5590	6760	1770	460	173		14120	39.6%	47.9%	12.5%
1977	2485	5807	926	407	113		9218	27.0%	63.0%	10.0%
1978	2987	8448	1640	528	404		13075	22.8%	64.6%	12.5%
1979	3829	7841	1636	407	411		13306	28.8%	58.9%	12.3%
1980	4921	12399	2738	818	590		20058	24.5%	61.8%	13.7%
1981	2348	4233	1702	652	393		8283	28.3%	51.1%	20.5%
1982	1932	6845	1133	476	277		9910	19.5%	69.1%	11.4%
1983	3151	5197	375	352	202		8723	36.1%	59.6%	4.3%
1984	2306	9642	680	345	238		12628	18.3%	76.4%	5.4%
1985	1686	13801	515	715	1819		16002	10.5%	86.2%	3.2%
1986	4584	12181	1143	806	736		17908	25.6%	68.0%	6.4%
1987	2635	5982	792	730	815		9409	28.0%	63.6%	8.4%
1988	2339	8077	1052	740	870		11468	20.4%	70.4%	9.2%
1989	1454	4781	449	514	668		6684	21.8%	71.5%	6.7%
1990	3705	11793	1294	685	557		16792	22.1%	70.2%	7.7%
1991	1510	3656	658	354	747		5824	25.9%	62.8%	11.3%
1992	1331	5548	469	201	580	205	7348	18.1%	75.5%	6.4%
1993	942	4654	205	291	323	168	5801	16.2%	80.2%	3.5%
1994	884	4565	112	167	130	173	5561	15.9%	82.1%	2.0%
1995	666	5948	278	440	190	225	6892	9.7%	86.3%	4.0%
1996	1521	7989	1103	435	408	208	10613	14.3%	75.3%	10.4%
1997	409	4168	295	428	305	308	4872	8.4%	85.6%	6.1%
1998	2388	11761	460	473	290	323	14609	16.3%	80.5%	3.1%
1999	1043	3586	295	208	180	83	4924	21.2%	72.8%	6.0%
2000	3262	13092	576	360	388	273	16930	19.3%	77.3%	3.4%
2001	2606	10084	1103	688	543	625	13793	18.9%	73.1%	8.0%
2002	4866	13815	910	265	460	340	19591	24.8%	70.5%	4.6%
2003	1161	7123	1493	353	193	298	9777	11.9%	72.9%	15.3%
2004	3070	20040	443	495	700	380	23553	13.0%	85.1%	1.9%

Table 2. Correlations (r) in escapement trends between Skagit River chinook populations from 1973–2004, and from 1994–2004. Years earlier than 1973 were not used because, in many of those years, data for one population were used to calculate escapements for a different population (Skagit System Cooperative 1997). The 1973 – 2004 correlations are applicable only to the summer and fall populations, because the method for estimating spring Chinook escapements changed in 1994; the Upper Cascade spring Chinook data go back only to 1992. Correlation coefficients that are significant at the 5% probability level (2-tailed test) are shown in **bold**.

Correlation Matrix 1973–2004.

	Lower Skagit Fall	Upper Skagit Summer	Lower Sauk Summer	Suiattle Spring	Upper Sauk Spring	Upper Cascade Spring
Lower Skagit Fall	1.000					
Upper Skagit Summer	**0.512**	1.000				
Lower Sauk Summer	**0.617**	0.166	1.000			
Suiattle Spring	**0.371**	**0.365**	**0.440**	1.000		
Upper Sauk Spring	**0.125**	**0.388**	0.258	**0.567**	1.000	
Upper Cascade Spring	0.491	0.540	0.483	**0.812**	0.538	1.000

For 30 degrees of freedom, correlation coefficient significance levels are (significance level = correlation): 0.05 = 0.349; 0.02 = 0.409; 0.01 = 0.449; 0.005 = 0.484; 0.001 = 0.554.
For 11 degrees of freedom (Upper Cascade spring correlations), correlation coefficient significance levels are (significance level = correlation): 0.05 = 0.553; 0.02 = 0.634; 0.01 = 0.684; 0.005 = 0.726; 0.001 = 0.801.

Correlation Matrix 1994–2004 (since redd count escapement methodology for spring chinook).

	Lower Skagit Fall	Upper Skagit Summer	Lower Sauk Summer	Suiattle Spring	Upper Sauk Spring	Upper Cascade Spring
Lower Skagit Fall	1.000					
Upper Skagit Summer	**0.813**	1.000				
Lower Sauk Summer	0.281	0.169	1.000			
Suiattle Spring	0.117	0.358	0.324	1.000		
Upper Sauk Spring	**0.674**	**0.837**	0.257	0.596	1.000	
Upper Cascade Spring	0.449	0.489	0.443	**0.808**	**0.672**	1.000

For 9 degrees of freedom, correlation coefficient significance levels are (significance level = correlation): 0.05 = 0.602; 0.02 = 0.685; 0.01 = 0.735; 0.005 = 0.776; 0.001 = 0.847.