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Supplement A: Chinook Salmon Run Reconstructions for the East Fork Andreafsky River (Brood Years 1990–2005) and the Kogrukluk River (Brood Years 1977–2006)

This document is drawn from the Appendix of Siegel (2017).

Methods are provided for run reconstructions of the Chinook Salmon populations in the East Fork Andreafsky River (brood years 1990–2005) and the Kogrukluk River (brood years 1981–2006), tributaries of the Yukon and Kuskokwim rivers, respectively. These time series include years with unreliable/missing weir data and age/sex sampling. This Appendix describes methods used to fill in data gaps to create a continuous time series for each population. When analyzed in conjunction, correlation of life history characteristics between the two populations (and possibly others in the future) could demonstrate representation of western Alaskan Chinook Salmon as opposed to being unique to each population. Thus, these run reconstructions will provide another tool to complement the combined population run reconstructions to investigate population dynamics of western Alaskan Chinook Salmon.

METHODS

Data Sources

The majority of data used for these analyses came from the escapement weir monitoring projects on the East Fork Andreafsky and Kogrukluk rivers and were gathered from published reports summarizing results from these projects. The East Fork Andreafsky River weir is run by the U.S. Fish and Wildlife Service (USFWS), and the Kogrukluk River weir is run by the Alaska Department of Fish and Game (ADFG). Weir operations are designed to produce unbiased escapement estimates as well as age, sex, and length distributions of the escapement estimates. Scales are collected and used to estimate age distributions. Sex is determined visually by weir crews on both rivers through secondary characteristics, including snout prominence in males and roundness of the belly and extension of the genital opening in females. For a more detailed description of weir sampling methods, refer to Mears (2015) for the East Fork Andreafsky River and Williams and Shelden (2011) for the Kogrukluk River.

Escapement estimates produced for the East Fork Andreafsky and Kogrukluk River populations by using a Bayesian approach to estimate missed migration were acquired from ADFG and USFWS, respectively. These estimates are considered the best available for both systems (superior to published estimates), although substantial uncertainty remains for a few years when the weirs were largely not operational as a result of high water (Z. Liller, ADFG, personal communication; J. Mears, USFWS, personal communication).

Harvest data from the commercial, subsistence, and sport fisheries on the Yukon and Kuskokwim rivers were collected and reported by ADFG. Harvest data were apportioned by age-classes in both the Yukon and Kuskokwim rivers. These data were primarily gathered from published ADFG documents. Some harvest data were acquired as unpublished data from ADFG via communication with agency biologists.

Terminology

Brood year: the year in which spawning took place to produce a cohort of fish of the same age.

Return year: the year in which a mature fish returns to spawn.

Escapement: fish that make it back to the spawning beds within a return year. In this case, it is defined as those individuals that make it past the escapement monitoring weirs.

Returns: mature fish in a return year that return to the river to spawn. The term includes those individuals that survive to escapement plus those that are harvested in the terminal fisheries within a single return year.

Brood recruits: all returns from a single brood year that survive to return to their respective river system. The term includes the escapement plus those fish that are harvested in the terminal fishery. Brood recruits mature and return at different ages over multiple return years.

East Fork Andreafsky River Run Reconstruction (Brood Years 1990–2005)

Escapement.—Escapement estimates are provided for return years 1994–2012. For all return years except 2001, total escapement estimates were produced from weir data by using a stratified sampling method with a Bayesian approach to estimate missed sampling (J. Mears, USFWS, unpublished data). During these years, sampling was considered sufficient to characterize the run. During 2001, the weir was not running long enough to produce representative data. Thus, an escapement estimate from ADFG aerial survey conversions was used instead (Volk et al. 2009).

Weir age–sex–length (ASL) sampling was used by USFWS to produce estimates of the distribution of the escapement by age at maturity and sex. For all years except 2001, ASL sampling was considered sufficient to produce unbiased estimates of age and sex proportions. Accordingly, estimates from a stratified sampling approach published in the annual weir reports were used (USFWS 1995–1999 and 2003–2013). Although weir reports for return years 1999 and 2000 were not obtained, the data for those years were acquired directly from the agency (J. Mears, USFWS, unpublished data). The weir was largely nonoperational during the run in 2001, and thus the average age and sex proportions from the years with quality weir data (1994–2000, 2002–2012) were used to estimate the age and sex distribution for that year. East Fork Andreafsky River escapement numbers by age and sex combinations (Table S.A.1) were calculated by multiplying estimated age and sex proportions by total escapement estimates.

Harvest and exploitation.—To estimate harvest, it was assumed that all populations in the lower stock group of the Yukon River were exploited proportionally in the fisheries below the confluence with the Andreafsky River. Harvest estimates for Yukon River stock groups in each fishing district were retrieved from the annual ADFG "Origin of Chinook Salmon in the Yukon fisheries" reports (ADFG 1996–2015). The published harvest data are apportioned by age-class (but not by sex within ages). Accordingly, we estimated annual harvest for each age-class separately (Table S.A.2) by using the following equation:

$$Ha_{y,a} = \frac{Ea_y}{(El_y + Hu_y)} \times (H1_{y,a} + H2_{y,a} \times P_y),$$

where $Ha_{y,a}$ is the estimated harvest of the East Fork Andreafsky River stock in year y for fish of age-class a; Ea_y is the estimated East Fork Andreafsky River escapement; El_y is the estimated escapement of the lower stock group in the Yukon River (Hamazaki, in review); Hu_y is the estimated harvest of the lower stock group above the confluence with the Andreafsky River; $H1_{y,a}$ is the estimated harvest of the lower stock group in district 1; $H2_{y,a}$ is the estimated harvest of the lower stock group in district 2; and P_y is an annual estimate of the proportion of the district 2 harvest taken below the confluence with the Andreafsky River (L. Dubois, ADFG, unpublished data). Lower stock group harvest upstream of the confluence with the Andreafsky River (Hu) is estimated for each return year by subtracting the estimated lower stock group harvest below the confluence from the estimated total lower stock group harvest via the equation

$$Hu_y = Hl_y - \left(H1_y + H2_y \times P_y\right),$$

where Hl is the total estimated harvest for the total lower river stock group. Exploitation rate by age-class (Table S.A.3) was calculated by dividing age-specific harvest estimates by the estimates of age-specific returns (the sum of age-specific harvest and escapement estimates).

Returns.—Annual East Fork Andreafsky River returns by age-class and sex (Table S.A.4) were estimated as the sum of annual harvest estimates and annual escapement estimates. Each sex was assumed to be harvested at the same rate within an age-class. Thus, harvest estimates for each age-class were apportioned to each sex proportional to the estimated escapement. Brood year was calculated by subtracting the age at maturity from the return year. The data were reorganized and presented by brood year returns (Table S.A.5).

Average age and productivity.—The average age of the escapement by return year and the average age of recruits by brood year (Table S.A.6) were estimated using the following equation:

$$A = \frac{\sum n_a \times a}{N},$$

where A is the average age; n is the number of fish of age a; and N is the total number of fish of all ages. Productivity (Table S.A.6) was calculated as the number of returns from a brood year cohort divided by the escapement during the corresponding brood year. Productivity was found to peak in year 2000 while being below replacement levels during brood years in the mid-1990s, 2002, and 2004 (Figure S.A.1).

Changes in the average age of brood recruits and of the escapement over time were analyzed using ordinary least-squares linear regression for the total population and for males and females separately (Figure S.A.2). Although none of the Andreafsky River brood recruit models was significant ($P < 0.05$), all demonstrated trends toward a younger age of maturity. The average age of all brood recruits was estimated to have declined from 5.17 to 5.06 over brood years 1990–2005 ($F = 0.7036$; df = 1, 14; $P = 0.42$). The average age of male brood recruits was estimated to have declined from 4.92 to 4.72 ($F = 1.257$; df = 1, 14; $P = 0.28$). Average age of female brood recruits was estimated to have declined from 5.61 to 5.51 ($F = 0.521$; df = 1, 14; $P = 0.48$).

Changes in the average age of the escapement were minimal and nonsignificant. Smaller changes in the average age of the escapement in comparison to returns were a consequence of a decline in age-selective harvests during the time period of analysis, allowing a higher proportion of older fish to survive to escapement (Table S.A.3). Average age of the total escapement was estimated to have decreased from 5.08 to 5.00 between return years 1994 and 2012 ($F = 0.4503$; df = 1, 17; $P = 0.51$). The average age of the male escapement was estimated to have decreased from 4.84 to 4.71 ($F = 0.6357$; df = 1, 17; $P = 0.44$). The average age of the female escapement was estimated to have stayed relatively constant, moving from 5.53 to 5.54 during the time series ($F = 0.0003$, df = 1, 17; $P = 0.99$).

Kogrukluk River Run Reconstruction (Brood Years 1977–2006)

Escapement.—Escapement data for return years 1981–2013 were taken from ADFG estimates from the Kogrukluk River weir data produced using a stratified Bayesian approach to fill in for missed sampling when the weir was not operational (Z. Liller, ADFG, unpublished data). In the majority of years, less than 20% of the escapement was estimated, allowing for relatively precise estimates. In a few years (1982, 1987, 1989, 2007, and 2012), more than 50% of the escapement was estimated, and thus escapement estimates for those years have a high degree of uncertainty.

For all years in the time series (with the exception of 2012), age and sex proportions of the escapement were estimated from weir ASL sampling (Molyneaux et al. 2009; Williams and Shelden 2010, 2011; Brodersen et al. 2013; Hansen and Blain 2013; Liller et al. 2015). For the majority of years, samples were considered sufficient to produce unbiased estimates for the entire escapement by using a stratified sampling approach. For seven return years (1987, 1989, 1992, 1993, 1994, 1998, and 2013), age and sex sampling was limited; thus, estimates may be inaccurate but were used due to the lack of a superior alternative. No stratified estimate was produced for 2013; therefore, the proportions utilized were straight sample proportions. Samples for 2012 were considered too inaccurate to use for age and sex proportions due to collection being limited to the very beginning and end of the run. Average age proportions estimated for the entire Kuskokwim River escapement were used for the 2012 Kogrukluk River age distribution estimates (Z. Liller, ADFG, unpublished data). These data did not have age-classes separated out by sex; thus, for 2012, escapement for each age at maturity was distributed by sex using the average proportion of each sex by age at maturity in the escapement calculated from years with quality age or sex distribution data (1981–1986, 1988, 1990–1991, 1995–1997, and 1999–2011). For all other years, Kogrukluk River escapement numbers by age and sex (Table S.A.7) were calculated by multiplying the estimated age and sex proportions by the total escapement estimates.

Exploitation by age-class.—Harvest in the Kogrukluk River was assumed to be proportional to harvest in the entire Kuskokwim River. Exploitation by age-class in the Kuskokwim River returns (Table S.A.8) was estimated by dividing estimates of harvest for each age-class in the Kuskokwim River terminal fisheries by estimates of the total return (Z. Liller, ADFG, unpublished data). Harvest estimates by age-class and sex (Table S.A.9) were calculated using the following equation:

$$H_{y,a} = X_{y,a} \times \frac{E_{y,a}}{(1 - X_{y,a})},$$

where $H_{y,a}$ is the harvest in year y for fish of age-class a; $E_{y,a}$ is the estimated escapement; and $X_{y,a}$ is the respective estimated exploitation rate. The published harvest data are apportioned by age-classes (but not by sex within age-classes); therefore, the above equation was applied within each age-class to produce individual age-class harvest estimates.

Returns.—Each sex within the same age-class was assumed to be harvested at the same rate. Returns by return year (Table S.A.10) were estimated by adding harvest and escapement together. Brood year was calculated by subtracting the age at maturity of individual spawners from the return year. The data were reorganized by brood year returns (Table S.A.11).

Average age and productivity.—Average age of the escapement for each return year and returns for each brood year (Table S.A.12) were estimated using the following equation:

$$A = \frac{\sum n_a \times a}{N},$$

where A is the average age; n_a is the number of fish of age a; and N is the total number of fish in the return. Productivity (Table S.A.12) was calculated as the number of returns from a brood year cohort divided by the escapement during the corresponding brood year. Productivity was found to peak in brood years 1983 and 2000 while being below replacement levels during brood years in the early 1980s, early 1990s, and mid-2000s (Figure S.A.3).

Changes in the average age of brood recruits and of the escapement over time were analyzed using ordinary least-squares linear regression for the total population and for males and females separately (Figure S.A.4). The average age of all brood recruits was estimated to have declined from 5.37 to 5.12 over brood years 1977–2006 (F = 3.97; df = 1, 28; P = 0.057). The average age of male brood recruits was estimated to have declined from 5.07 to 4.82 (F = 3.54; df = 1, 28; P = 0.070). The average age of female brood recruits was estimated to have declined from 6.00 to 5.74 (F = 7.81; df = 1, 28; P = 0.012).

Declines in the average age of the escapement were steeper than those of brood recruits. This is a result of age selectivity in the Kuskokwim River harvest becoming stronger after the year 2000 in our estimates (Table S.A.8). Average age of the total escapement was estimated to have decreased from 5.46 to 4.94 between return years 1981 and 2013 (F = 20.3; df = 1, 31; P < 0.001). Average age of males in the escapement was estimated to have decreased from 5.18 to 4.64 between return years 1981 and 2013 (F = 24.77; df = 1, 31; P < 0.001). The average age of females in the escapement was estimated to have decreased from 6.02 to 5.69 between return years 1981 and 2013 (F = 15.22; df = 1, 31; P < 0.001).

Supplementary Table S.A.1. Escapement estimates by sex and age-class for the East Fork Andreafsky River Chinook Salmon population. The first number in each age (e.g., 2.3) represents the number of winters spent in freshwater, and the second number (i.e., after the decimal) denotes the number of winters spent in salt water. Age-1.2 females may be misidentified males.

	Male age									Female age									
Year	1.1	1.2	1.3	2.2	1.4	2.3	1.5	2.4	Males	1.1	1.2	1.3	2.2	1.4	2.3	1.5	2.4	Females	Escapement
1994[a]	0	627	4,293	11	717	0	0	0	5,649	0	0	518	0	1,562	0	226	0	2,306	7,956[e]
1995[a]	0	1,989	681	0	691	0	27	0	3,389	0	177	309	0	1,889	0	79	0	2,454	5,844[e]
1996[a]	22	107	1,522	0	123	0	7	31	1,812	8	94	770	0	242	0	56	0	1,170	2,982[e]
1997[a]	0	1,339	421	0	236	0	0	0	1,996	0	217	134	0	842	0	0	0	1,192	3,188[e]
1998[a]	0	723	2,196	0	203	6	0	0	3,128	0	49	673	0	258	0	36	0	1,015	4,143[e]
1999[b]	13	1,100	1,007	0	380	0	8	0	2,508	0	77	151	0	717	0	6	0	952	3,459[e]
2000[b]	0	128	647	0	231	0	2	0	1,008	0	107	291	0	418	0	0	0	816	1,824[e]
2001[c]	3	534	798	2	183	1	3	2	1,525	0	51	314	1	472	1	18	0	856	2,381[d]
2002[a]	0	1,240	1,531	0	386	0	6	0	3,163	0	18	277	0	619	0	47	0	961	4,124[e]
2003[a]	23	586	1,477	0	258	0	0	0	2,345	0	140	719	0	1,099	0	40	0	1,997	4,342[e]
2004[a]	0	2,668	2,559	0	218	0	0	0	5,445	0	610	727	0	1,542	0	53	0	2,932	8,377[e]
2005[a]	0	286	750	0	155	0	0	0	1,191	0	73	779	0	338	0	1	0	1,191	2,382[e]
2006[a]	0	1,138	2,756	0	481	0	0	0	4,375	0	241	1,547	0	1,650	0	0	0	3,438	7,813[e]
2007[a]	0	2,114	831	0	486	0	17	0	3,449	0	0	520	0	1,335	0	2	0	1,857	5306[e]
2008[a]	0	108	2,354	0	217	0	27	3	2,709	0	0	827	0	700	16	48	0	1,591	4,270[e]
2009[a]	2	995	529	2	663	2	2	0	2,196	0	0	90	0	1,689	0	18	0	1,797	3,992[e]
2010[a]	2	1,354	566	42	22	20	0	0	2,007	0	0	892	14	286	14	25	1	1,231	3,237[e]
2011[a]	0	2,209	1,830	0	177	0	0	0	4,216	0	42	390	0	611	0	11	0	1,054	5,271[e]
2012[a]	18	445	2,286	0	319	0	0	0	3,068	0	0	448	0	837	0	5	0	1,290	4,359[e]

[a] Age/sex distribution from weir data (Andreafsky River weir reports).

[b] Age/sex distribution from weir data (data provided by J. Mears, U.S. Fish and Wildlife Service).

[c] No reliable age/sex data. Estimated as average of weir-monitored years.

[d] Escapement from aerial conversions.

[e] Escapement from weir data.

Supplementary Table S.A.2. Harvest estimates by age-class and return year for the East Fork Andreafsky River Chinook Salmon population. Age notation is defined in Table S.A.1.

	Age-class										
Year	1.1	1.2	1.3	2.2	1.4	2.3	1.5	2.4	1.6	2.5	Total
1994	0	19	807	0	570	0	58	0	0	0	1,454
1995	0	73	253	0	1,008	2	37	0	1	0	1,375
1996	0	7	248	0	1,076	11	844	2	0	0	2,188
1997	0	110	109	0	795	0	3	0	0	0	1,017
1998	0	74	797	0	310	0	40	0	0	0	1,222
1999	0	44	205	0	1,230	1	17	3	0	0	1,500
2000	0	5	112	0	225	0	9	1	0	0	352
2001	0	9	28	0	161	0	14	0	0	0	212
2002	0	48	155	0	276	0	42	0	0	0	521
2003	0	9	139	0	151	0	6	0	0	0	306
2004	1	187	378	1	744	0	16	0	0	0	1,326
2005	0	24	259	0	120	0	5	0	0	0	407
2006	0	49	545	0	594	2	1	2	0	0	1,192
2007	0	96	133	0	317	1	5	13	0	0	565
2008	0	18	118	0	62	1	4	1	0	0	204
2009	0	13	12	0	41	0	1	0	0	0	67
2010	1	142	260	0	97	3	8	1	0	0	512
2011	0	63	151	0	92	1	2	2	0	0	312
2012	0	27	111	0	82	1	2	1	0	0	225

Supplementary Table S.A.3. Exploitation rate estimates (terminal harvest/return) by age-class, for each sex separately, and for the entire population (total) of East Fork Andreafsky River Chinook Salmon. Only well-represented age-classes are shown, as limited samples for other age-classes produced inaccurate estimates. Age notation is defined in Table S.A.1.

	Age-class						
Year	1.2	1.3	1.4	1.5	Males	Females	Total
1994	0.030	0.144	0.200	0.205	0.140	0.188	0.155
1995	0.033	0.204	0.281	0.258	0.133	0.258	0.190
1996	0.032	0.097	0.746	0.930	0.262	0.570	0.425
1997	0.066	0.164	0.424	0.858	0.150	0.358	0.242
1998	0.088	0.217	0.402	0.529	0.207	0.285	0.228
1999	0.036	0.150	0.529	0.555	0.209	0.469	0.303
2000	0.022	0.107	0.257	0.814	0.144	0.182	0.161
2001	0.015	0.024	0.197	0.397	0.047	0.138	0.082
2002	0.037	0.079	0.216	0.439	0.084	0.194	0.112
2003	0.012	0.060	0.100	0.139	0.053	0.081	0.066
2004	0.054	0.103	0.297	0.233	0.090	0.211	0.137
2005	0.062	0.145	0.195	0.809	0.134	0.158	0.146
2006	0.034	0.112	0.218	1.000	0.107	0.162	0.132
2007	0.044	0.090	0.148	0.216	0.075	0.133	0.094
2008	0.139	0.036	0.063	0.055	0.043	0.048	0.045
2009	0.013	0.020	0.017	0.035	0.016	0.017	0.017
2010	0.095	0.151	0.240	0.237	0.112	0.174	0.136
2011	0.027	0.064	0.104	0.126	0.048	0.088	0.056
2012	0.058	0.039	0.067	0.234	0.045	0.058	0.049
Average	0.047	0.106	0.247	0.425	0.110	0.199	0.146

Supplementary Table S.A.4. Return estimates (escapement plus terminal harvest) by age-class and sex for the East Fork Andreafsky River Chinook Salmon population. Age-1.2 females may be misidentified males. Age notation is defined in Table S.A.1.

	Male age									Female age										
Year	1.1	1.2	1.3	2.2	1.4	2.3	1.5	2.4	Males	1.1	1.2	1.3	2.2	1.4	2.3	1.5	2.4	1.6	Females	Total
1994	0	646	5,013	11	897	0	0	0	6,568	0	0	605	0	1,953	0	284	0	0	2,842	9,410
1995	0	2,056	855	0	961	1	37	0	3,911	0	183	388	0	2,627	1	106	0	1	3,306	7,217
1996	0	111	1,687	0	487	6	104	33	2,426	8	97	853	0	955	6	804	0	0	2,722	5,148
1997	0	1,434	504	0	409	0	1	0	2,348	0	232	160	0	1,463	0	3	0	0	1,858	4,206
1998	0	792	2,805	0	340	6	0	0	3,944	0	53	860	0	431	0	75	0	0	1,420	5,364
1999	0	1,141	1,185	0	806	0	18	3	3,154	0	80	178	0	1,521	0	13	0	0	1,793	4,947
2000	0	131	724	0	311	0	11	1	1,178	0	109	326	0	563	0	0	0	0	998	2,176
2001	0	542	818	0	228	0	5	0	1,592	0	51	321	0	588	0	30	0	0	991	2,584
2002	0	1,287	1,662	0	492	0	11	0	3,453	0	19	300	0	789	0	84	0	0	1,192	4,645
2003	0	593	1,571	0	287	0	0	0	2,451	0	142	765	0	1,221	0	46	0	1	2,174	4,624
2004	1	2,820	2,853	1	310	0	0	0	5,986	0	645	811	0	2,194	0	69	0	0	3,718	9,704
2005	0	305	877	0	192	0	0	0	1,374	0	77	911	0	420	0	6	0	0	1,415	2,789
2006	0	1,178	3,105	0	615	1	0	2	4,901	0	249	1,743	0	2,110	1	1	0	0	4,104	9,005
2007	0	2,211	913	0	571	0	22	12	3,729	0	0	571	0	1,567	0	2	1	0	2,143	5,872
2008	1	126	2,441	1	231	0	29	4	2,832	0	0	858	0	747	17	50	0	0	1,672	4,504
2009	0	1,008	540	2	675	2	2	0	2,229	0	0	92	0	1,718	0	19	0	0	1,828	4,057
2010	1	1,496	667	42	29	22	0	0	2,258	0	0	1,051	14	376	15	32	2	0	1,490	3,748
2011	0	2,272	1,955	0	198	1	0	1	4,426	0	43	417	0	683	1	12	0	0	1,155	5,581
2012	0	472	2,379	0	342	1	0	2	3,195	0	0	466	0	897	1	7	0	0	1,370	4,565

Supplementary Table S.A.5. Brood recruit estimates by age-class and sex for the East Fork Andreafsky River Chinook Salmon population. Age-1.2 females may be misidentified males. Age notation is defined in Table S.A.1.

Brood year	Male age 1.1	1.2	1.3	2.2	1.4	2.3	1.5	2.4	Males	Female age 1.1	1.2	1.3	2.2	1.4	2.3	1.5	2.4	1.6	Females	Total
1987	–	–	–	–	–	–	0	0	–	–	–	–	–	–	–	284	0	1	–	–
1988	–	–	–	–	897	0	37	0	–	–	–	–	0	1,953	0	106	0	0	–	–
1989	–	–	5,013	11	961	1	104	33	–	–	–	605	0	2,627	1	804	0	0	–	–
1990	–	646	855	0	487	6	1	0	1,995	–	0	388	0	955	6	3	0	0	1,352	3,347
1991	0	2,056	1,687	0	409	0	0	0	4,153	0	183	853	0	1,463	0	75	0	0	2,574	6,726
1992	0	111	504	0	340	6	18	3	982	0	97	160	0	431	0	13	0	0	701	1,683
1993	0	1,434	2,805	0	806	0	11	1	5,059	8	232	860	0	1,521	0	0	0	0	2,622	7,680
1994	0	792	1,185	0	311	0	5	0	2,293	0	53	178	0	563	0	30	0	0	825	3,118
1995	0	1,141	724	0	228	0	11	0	2,104	0	80	326	0	588	0	84	0	1	1,078	3,182
1996	0	131	818	0	492	0	0	0	1,440	0	109	321	0	789	0	46	0	0	1,266	2,706
1997	0	542	1,662	0	287	0	0	0	2,491	0	51	300	0	1,221	0	69	0	0	1,641	4,132
1998	0	1,287	1,571	0	310	0	0	0	3,168	0	19	765	0	2,194	0	6	0	0	2,984	6,152
1999	0	593	2,853	1	192	0	0	2	3,642	0	142	811	0	420	0	1	0	0	1,373	5,016
2000	0	2,820	877	0	615	1	22	12	4,347	0	645	911	0	2,110	1	2	1	0	3,670	8,018
2001	1	305	3,105	0	571	0	29	4	4,014	0	77	1,743	0	1,567	0	50	0	0	3,439	7,453
2002	0	1,178	913	0	231	0	2	0	2,324	0	249	571	0	747	17	19	0	0	1,603	3,927
2003	0	2,211	2,441	1	675	2	0	0	5,329	0	0	858	0	1,718	0	32	2	0	2,610	7,940
2004	0	126	540	2	29	22	0	1	720	0	0	92	0	376	15	12	0	0	495	1,214
2005	1	1,008	667	42	198	1	0	2	1,919	0	0	1,051	14	683	1	7	0	0	1,754	3,673
2006	0	1,496	1,955	0	342	1	–	–	–	0	0	417	0	897	1	–	–	–	–	–
2007	1	2,272	2,379	–	–	–	–	–	–	0	43	466	–	–	–	–	–	–	–	–

Supplementary Table S.A.6. Recruits, escapement, and average age (years) estimates by brood year for the East Fork Andreafsky River Chinook Salmon population.

		Average brood age				Average spawner age			
Brood year	Recruits	Total	Males	Females	Escapement	Total	Males	Females	Productivity
1990	3,347	5.24	4.92	5.72	–	–	–	–	–
1991	6,726	4.97	4.60	5.56	–	–	–	–	–
1992	1,683	5.38	5.28	5.52	–	–	–	–	–
1993	7,680	5.09	4.88	5.49	–	–	–	–	–
1994	3,118	5.03	4.79	5.69	7,957	5.26	5.02	5.87	0.39
1995	3,182	4.93	4.58	5.63	5,842	5.11	4.63	5.76	0.54
1996	2,706	5.42	5.25	5.61	2,984	5.10	5.03	5.21	0.91
1997	4,132	5.25	4.90	5.80	3,188	4.85	4.45	5.52	1.30
1998	6,152	5.20	4.69	5.73	4,143	4.94	4.84	5.28	1.48
1999	5,016	4.98	4.89	5.20	3,459	4.98	4.71	5.68	1.45
2000	8,018	4.92	4.51	5.40	1,824	5.23	5.11	5.38	4.40
2001	7,453	5.26	5.08	5.46	2,382	5.05	4.77	5.54	3.13
2002	3,927	4.90	4.59	5.34	4,124	4.96	4.73	5.72	0.95
2003	7,940	5.03	4.71	5.68	4,342	5.15	4.84	5.52	1.83
2004	1,214	5.28	4.90	5.84	8,377	4.83	4.55	5.35	0.14
2005	3,673	4.97	4.58	5.40	2,382	5.06	4.89	5.22	1.54
2006	–	–	–	–	7,813	5.10	4.85	5.41	–
2007	–	–	–	–	5,306	4.95	4.54	5.72	–
2008	–	–	–	–	4,300	5.23	5.06	5.51	–
2009	–	–	–	–	3,992	5.35	4.85	5.96	–
2010	–	–	–	–	3,238	4.70	4.34	5.29	–
2011	–	–	–	–	5,271	4.73	4.52	5.56	–
2012	–	–	–	–	4,359	5.16	4.95	5.66	–
Average	4,748	5.12	4.82	5.57	4,489	5.04	4.77	5.54	1.51

Supplementary Table S.A.7. Escapement estimates by sex and age-class for the Kogrukluk River Chinook Salmon population. All total escapement numbers are from Alaska Department of Fish and Game (ADFG) estimates, implementing Bayesian methods to estimate missed sampling (Z. Liller, ADFG, unpublished data). The 2012 age and sex proportions were assumed to be the same as estimates for the entire Kuskokwim River due to limited sampling (Z. Liller, ADFG, unpublished data). Age notation is defined in Table S.A.1.

	Male age										Female age									
Year	0.2	1.1	1.2	1.3	2.2	1.4	2.3	1.5	2.4	Males	1.2	1.3	2.2	1.4	2.3	1.5	2.4	1.6	Females	Total
1981	0	48	1,158	4,489	0	3,105	0	209	0	9,010	32	386	0	6,259	0	418	0	0	7,095	16,089
1982	0	0	840	2,731	0	2,534	0	236	0	6,341	0	354	0	5,947	0	473	0	0	6,775	13,129
1983	0	4	358	337	0	532	0	13	0	1,243	0	14	0	469	0	63	0	0	546	1,791
1984	0	5	1,098	2,254	0	482	0	49	0	3,888	5	89	0	817	0	118	0	5	1,034	4,922
1985	0	0	720	1,488	0	786	0	49	0	3,043	0	98	0	1,208	0	93	0	4	1,404	4,443
1986	0	15	331	1,888	0	381	0	66	0	2,682	0	69	0	882	0	212	0	0	1,164	3,853
1987[ab]	0	23	893	777	0	732	0	23	0	2,447	0	23	0	754	0	0	0	0	777	3,224
1988	0	0	642	3,572	0	899	0	80	0	5,194	0	658	0	1,622	0	562	0	0	2,842	8,028
1989[ab]	0	0	2,095	3,349	0	3,729	0	128	0	9,301	0	256	0	4,540	0	128	0	0	4,924	14,231
1990[c]	0	293	2,432	4,875	0	262	0	0	0	7,862	0	1,332	0	868	0	30	0	0	2,231	10,093
1991	0	0	437	1,593	21	1,422	0	0	0	3,472	0	451	0	2,843	0	75	0	0	3,370	6,835
1992[b]	0	0	1,340	2,470	0	604	0	39	0	4,453	20	226	0	1,780	0	53	20	0	2,098	6,568
1993[b]	0	0	4,250	2,751	0	1,636	0	88	0	8,725	37	298	0	2,777	0	497	37	0	3,646	12,376
1994[ab]	0	0	1,611	7,688	64	1,755	0	0	0	11,118	0	1,994	0	2,728	0	105	0	0	4,826	15,951
1995	0	0	3,588	3,628	0	4,084	20	0	20	11,340	198	1,429	0	6,839	0	40	0	0	8,506	19,846
1996	0	0	1,735	6,859	0	1,667	55	152	0	10,467	0	702	0	1,818	0	785	0	0	3,306	13,773
1997	0	0	4,406	2,454	0	2,177	0	0	0	9,036	40	237	0	3,812	0	53	0	0	4,142	13,191
1998[b]	0	0	281	2,223	0	765	0	72	0	3,341	0	1,048	0	1,533	0	66	0	0	2,646	5,987
1999	0	17	299	1,186	17	1,081	0	0	0	2,600	0	211	0	2,650	0	83	0	0	2,944	5,544
2000	0	0	321	1,359	0	227	0	0	0	1,907	0	237	0	1,041	0	58	0	0	1,336	3,243
2001	0	0	1,115	2,701	0	1,489	0	45	0	5,350	30	239	0	1,788	0	67	0	0	2,125	7,483
2002	0	0	1,745	4,583	0	1,083	0	50	0	7,461	0	431	0	2,046	0	90	0	0	2,567	10,028
2003	0	0	2,245	4,815	0	1,201	0	0	0	8,261	0	300	0	3,122	0	336	0	0	3,758	12,007
2004	0	0	8,748	6,645	0	1,191	0	0	0	16,585	119	519	0	2,483	0	119	0	0	3,240	19,819
2005	0	65	5,276	6,888	0	1,942	0	87	0	14,259	44	3,247	0	4,161	0	109	0	0	7,560	21,819
2006	0	101	7,051	4,647	0	1,475	0	182	0	13,455	0	1,596	0	4,465	0	687	0	0	6,748	20,203
2007	0	0	4,473	3,642	0	1,689	0	97	0	9,901	0	928	0	2,700	0	305	0	0	3,933	13,848
2008	0	49	3,481	3,471	0	449	0	49	0	7,498	20	761	0	1,414	20	49	0	0	2,262	9,750
2009	0	0	1,972	4,230	67	572	0	0	0	6,841	143	762	0	1,610	38	133	0	0	2,687	9,528
2010	0	0	2,558	1,343	0	366	0	23	0	4,291	0	331	0	1,128	0	64	0	0	1,523	5,814

Year	Male age 0.2	1.1	1.2	1.3	2.2	1.4	2.3	1.5	2.4	Males	Female age 1.2	1.3	2.2	1.4	2.3	1.5	2.4	1.6	Females	Total
2011	0	0	3,181	1,780	20	379	0	0	0	5,359	0	419	0	945	0	0	0	0	1,364	6,733
2012[ad]	37	0	3,288	7,054	0	1,303	41	15	0	11,738	33	1,272	0	2,497	66	52	0	0	3,919	15,665
2013[e]	0	0	448	388	0	89	0	0	0	925	29	270	0	597	0	0	0	0	896	1,821

[a] Weir was inoperable for a majority of the season.

[b] Age and sex composition represents stratified estimates from limited samples. Considered the best estimates available.

[c] Potential age errors.

[d] Estimated age and sex composition from the entire Kuskokwim River was used.

[e] Age and sex composition represents samples collected only.

Supplementary Table S.A.8. Exploitation rate estimates (terminal harvest/return) by age-class, for each sex separately, and for the entire population (total) of Kuskokwim River Chinook Salmon (Z. Liller, Alaska Department of Fish and Game, unpublished data). Sample size for estimating harvest age proportions is presented. Only well-represented age-classes are shown, as limited samples of other age-classes produced inaccurate estimates. Age notation is defined in Table S.A.1.

			Age-class						
Year	Sample size	Total run	1.2	1.3	1.4	1.5	Males	Females	Total
1981	1,294	389,791	0.297	0.343	0.241	0.247	0.302	0.248	0.279
1982	1,137	187,354	0.746	0.637	0.518	0.441	0.616	0.521	0.572
1983	1,733	166,333	0.391	0.604	0.453	0.474	0.492	0.461	0.483
1984	2,070	188,238	0.279	0.431	0.592	0.560	0.428	0.576	0.467
1985	1,706	176,292	0.522	0.464	0.435	0.481	0.472	0.439	0.462
1986	850	129,168	0.570	0.516	0.597	0.378	0.535	0.565	0.545
1987	696	193,465	0.497	0.598	0.504	0.770	0.539	0.507	0.532
1988	1,542	207,818	0.778	0.557	0.632	0.468	0.617	0.591	0.608
1989	600	241,857	0.549	0.596	0.428	0.695	0.532	0.452	0.507
1990	805	264,802	0.566	0.508	0.840	0.959	0.550	0.748	0.617
1991	1,111	218,705	0.706	0.578	0.420	0.652	0.552	0.455	0.509
1992	2,393	284,846	0.367	0.496	0.504	0.590	0.466	0.506	0.479
1993	1,064	269,305	0.167	0.460	0.426	0.288	0.338	0.410	0.361
1994	935	365,246	0.277	0.264	0.444	0.647	0.302	0.390	0.331
1995	1,141	360,513	0.306	0.446	0.335	0.877	0.367	0.368	0.367
1996	1,293	302,603	0.324	0.331	0.434	0.116	0.346	0.358	0.349
1997	933	303,189	0.144	0.481	0.281	0.818	0.299	0.320	0.306
1998	643	213,873	0.779	0.417	0.546	0.673	0.522	0.508	0.516
1999	586	189,939	0.501	0.555	0.316	0.674	0.468	0.360	0.416
2000	586	136,618	0.340	0.552	0.537	0.526	0.525	0.539	0.531
2001	1,797	223,707	0.154	0.317	0.408	0.370	0.319	0.395	0.343
2002	4,365	246,296	0.123	0.305	0.449	0.506	0.299	0.432	0.339
2003	4,200	248,789	0.093	0.276	0.350	0.471	0.248	0.358	0.286
2004	5,483	388,136	0.108	0.299	0.400	0.527	0.220	0.385	0.253
2005	5,429	366,601	0.096	0.263	0.304	0.317	0.215	0.286	0.242
2006	4,910	307,662	0.095	0.354	0.402	0.266	0.245	0.379	0.296
2007	4,603	273,060	0.078	0.405	0.532	0.476	0.329	0.503	0.390
2008	4,910	237,074	0.249	0.493	0.511	0.518	0.404	0.504	0.430
2009	5,299	204,747	0.282	0.382	0.502	0.479	0.368	0.460	0.397
2010	3,021	118,507	0.247	0.678	0.664	0.616	0.508	0.665	0.562
2011	2,412	133,059	0.227	0.586	0.541	0.671	0.421	0.556	0.455
2012	871	99,807	0.173	0.225	0.271	0.627	0.217	0.262	0.229
2013	1,018	94,166	0.217	0.492	0.571	0.691	0.401	0.543	0.480
Average	2,165	234,290	0.341	0.452	0.466	0.542	0.408	0.456	0.422

Supplementary Table S.A.9. Estimated harvest by sex and age-class for the Kogrukluk River Chinook Salmon population. Age notation is defined in Table S.A.1.

	Male age										Female age									
Year	0.2	1.1	1.2	1.3	2.2	1.4	2.3	1.5	2.4	Males	1.2	1.3	2.2	1.4	2.3	1.5	2.4	1.6	Females	Total
1981	0	4	490	2,342	0	986	0	69	0	3,890	14	201	0	1,988	0	137	0	0	2,340	10,121
1982	0	0	2,464	4,794	0	2,720	0	187	0	10,164	0	622	0	6,384	0	373	0	0	7,380	27,707
1983	0	11	230	513	0	440	0	11	0	1,206	0	22	0	388	0	57	0	0	466	2,878
1984	0	14	426	1,705	0	701	0	63	0	2,908	2	67	0	1,187	0	150	0	0	1,407	7,222
1985	0	0	786	1,290	0	604	0	45	0	2,726	0	85	0	929	0	86	0	0	1,100	6,552
1986	0	32	439	2,015	0	566	0	40	0	3,091	0	74	0	1,309	0	129	0	0	1,512	7,695
1987	0	0	881	1,157	0	743	0	75	0	2,858	0	34	0	766	0	0	0	0	800	6,515
1988	0	0	2,250	4,491	0	1,546	0	71	0	8,357	0	828	0	2,789	0	494	0	0	4,110	20,825
1989	0	0	2,553	4,932	0	2,792	0	292	0	10,568	0	377	0	3,399	0	292	0	0	4,068	25,205
1990	0	13	3,172	5,042	0	1,370	0	0	0	9,597	0	1,378	0	4,543	0	715	0	0	6,636	25,830
1991	0	0	1,052	2,184	12	1,029	0	0	0	4,277	0	619	0	2,058	0	141	0	0	2,818	11,373
1992	0	0	778	2,431	0	614	0	57	0	3,880	11	223	0	1,808	0	76	33	0	2,150	9,911
1993	0	0	850	2,348	0	1,212	0	35	0	4,446	7	254	0	2,058	0	200	14	0	2,534	11,427
1994	0	0	616	2,764	20	1,400	0	0	0	4,800	0	717	0	2,176	0	192	0	0	3,085	12,684
1995	0	0	1,579	2,916	0	2,053	13	0	11	6,572	87	1,149	0	3,438	0	283	0	0	4,957	18,101
1996	0	0	832	3,393	0	1,276	16	20	0	5,537	0	347	0	1,392	0	103	0	0	1,842	12,915
1997	0	0	739	2,271	0	849	0	0	0	3,860	7	220	0	1,488	0	237	0	0	1,952	9,671
1998	0	0	989	1,592	0	922	0	148	0	3,651	0	750	0	1,847	0	136	0	0	2,733	10,035
1999	0	7	301	1,479	3	499	0	0	0	2,289	0	263	0	1,223	0	172	0	0	1,658	6,235
2000	0	0	165	1,675	0	264	0	0	0	2,104	0	292	0	1,209	0	65	0	0	1,565	5,773
2001	0	0	202	1,256	0	1,026	0	26	0	2,510	5	111	0	1,232	0	40	0	0	1,388	6,409
2002	0	0	244	2,009	0	884	0	51	0	3,188	0	189	0	1,670	0	93	0	0	1,952	8,328
2003	0	0	231	1,840	0	647	0	0	0	2,718	0	115	0	1,682	0	300	0	0	2,097	7,532
2004	0	0	1,054	2,830	0	795	0	0	0	4,679	14	221	0	1,658	0	132	0	0	2,026	11,384
2005	0	0	562	2,461	0	849	0	41	0	3,913	5	1,160	0	1,820	0	51	0	0	3,035	10,861
2006	0	26	744	2,541	0	991	0	66	0	4,368	0	873	0	2,999	0	249	0	0	4,121	12,857
2007	0	0	378	2,482	0	1,917	0	88	0	4,865	0	632	0	3,065	0	276	0	0	3,973	13,703
2008	0	30	1,155	3,373	0	468	0	52	0	5,078	6	739	0	1,475	21	52	0	0	2,295	12,451
2009	0	0	774	2,614	10	577	0	0	0	3,975	56	471	0	1,625	14	122	0	0	2,288	10,239
2010	0	0	837	2,831	0	723	0	37	0	4,428	0	699	0	2,226	0	103	0	0	3,027	11,883
2011	0	0	935	2,519	0	447	0	0	0	3,901	0	594	0	1,113	0	0	0	0	1,707	9,509
2012	0	0	687	2,052	0	485	0	26	0	3,250	7	370	0	929	0	87	0	0	1,393	7,892
2013	0	0	124	376	0	119	0	0	0	619	8	261	0	796	0	0	0	0	1,065	2,302

Supplementary Table S.A.10. Return estimates (escapement plus terminal harvest) by age-class and sex for the Kogrukluk River Chinook Salmon population. Age notation is defined in Table S.A.1.

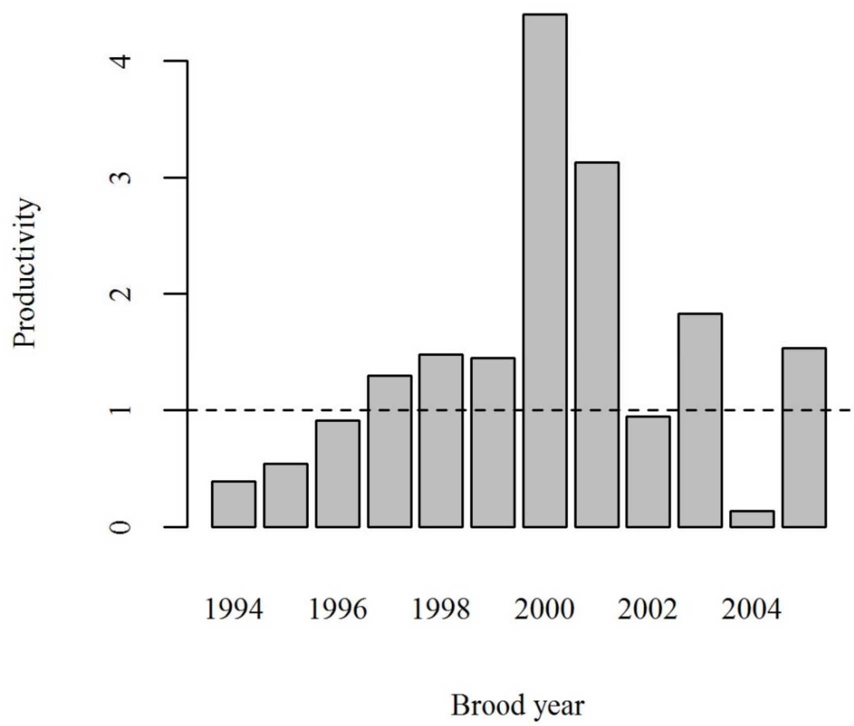
	Male age										Female age									
Year	0.2	1.1	1.2	1.3	2.2	1.4	2.3	1.5	2.4	Males	1.2	1.3	2.2	1.4	2.3	1.5	2.4	1.6	Females	Total
1981	0	52	1,648	6,831	0	4,091	0	278	0	12,900	46	588	0	8,246	0	555	0	0	9,435	22,335
1982	0	0	3,304	7,525	0	5,254	0	423	0	16,505	0	977	0	12,331	0	846	0	0	14,154	30,659
1983	0	15	588	850	0	972	0	24	0	2,449	0	36	0	857	0	119	0	0	1,013	3,461
1984	0	19	1,523	3,959	0	1,183	0	112	0	6,796	7	156	0	2,004	0	268	0	5	2,440	9,236
1985	0	0	1,506	2,779	0	1,391	0	94	0	5,770	0	182	0	2,137	0	180	0	5	2,504	8,273
1986	0	47	770	3,903	0	947	0	105	0	5,773	0	143	0	2,191	0	341	0	0	2,676	8,449
1987	0	23	1,774	1,934	0	1,475	0	98	0	5,305	0	56	0	1,521	0	0	0	0	1,577	6,859
1988	0	0	2,892	8,063	0	2,445	0	151	0	13,552	0	1,486	0	4,410	0	1,056	0	0	6,952	20,503
1989	0	0	4,648	8,281	0	6,520	0	420	0	19,870	0	633	0	7,939	0	420	0	0	8,992	28,862
1990	0	306	5,604	9,917	0	1,632	0	0	0	17,459	0	2,710	0	5,411	0	745	0	0	8,866	26,325
1991	0	0	1,490	3,776	33	2,451	0	0	0	7,750	0	1,070	0	4,902	0	216	0	0	6,188	13,937
1992	0	0	2,118	4,901	0	1,218	0	96	0	8,333	31	449	0	3,587	0	128	53	0	4,248	12,582
1993	0	0	5,100	5,099	0	2,849	0	123	0	13,171	45	552	0	4,835	0	697	51	0	6,180	19,324
1994	0	0	2,227	10,453	83	3,155	0	0	0	15,918	0	2,711	0	4,904	0	297	0	0	7,911	23,829
1995	0	0	5,167	6,544	0	6,138	33	0	30	17,912	286	2,578	0	10,277	0	323	0	0	13,463	31,406
1996	0	0	2,567	10,252	0	2,943	71	171	0	16,004	0	1,050	0	3,210	0	888	0	0	5,148	21,152
1997	0	0	5,145	4,725	0	3,026	0	0	0	12,896	46	457	0	5,300	0	290	0	0	6,094	18,989
1998	0	0	1,270	3,815	0	1,687	0	220	0	6,992	0	1,798	0	3,379	0	202	0	0	5,379	12,371
1999	0	24	601	2,665	19	1,580	0	0	0	4,889	0	473	0	3,873	0	255	0	0	4,602	9,490
2000	0	0	486	3,034	0	491	0	0	0	4,011	0	529	0	2,250	0	123	0	0	2,901	6,912
2001	0	0	1,317	3,957	0	2,515	0	71	0	7,861	35	351	0	3,020	0	107	0	0	3,514	11,374
2002	0	0	1,989	6,592	0	1,967	0	102	0	10,649	0	620	0	3,716	0	183	0	0	4,519	15,168
2003	0	0	2,476	6,654	0	1,848	0	0	0	10,979	0	415	0	4,804	0	636	0	0	5,855	16,834
2004	0	0	9,802	9,475	0	1,987	0	0	0	21,264	133	740	0	4,142	0	251	0	0	5,267	26,494
2005	0	65	5,838	9,349	0	2,791	0	128	0	18,171	48	4,407	0	5,981	0	160	0	0	10,596	28,803
2006	0	127	7,795	7,188	0	2,465	0	248	0	17,823	0	2,469	0	7,464	0	936	0	0	10,869	28,692
2007	0	0	4,851	6,124	0	3,607	0	185	0	14,766	0	1,560	0	5,765	0	581	0	0	7,906	22,672
2008	0	79	4,636	6,844	0	917	0	101	0	12,576	26	1,499	0	2,889	41	101	0	0	4,557	17,133
2009	0	0	2,747	6,844	77	1,149	0	0	0	10,816	199	1,233	0	3,236	52	256	0	0	4,975	15,792
2010	0	0	3,396	4,174	0	1,089	0	61	0	8,719	0	1,030	0	3,354	0	167	0	0	4,550	13,269
2011	0	0	4,116	4,298	20	826	0	0	0	9,260	0	1,013	0	2,058	0	0	0	0	3,071	12,309
2012	37	0	3,975	9,106	0	1,788	41	42	0	14,988	40	1,642	0	3,426	66	139	0	0	5,312	20,300
2013	0	0	572	764	0	208	0	0	0	1,544	37	531	0	1,393	0	0	0	0	1,961	3,505

Supplementary Table S.A.11. Brood recruit estimates by age-class and sex for the Kogrukluk River Chinook Salmon population. Age notation is defined in Table S.A.1.

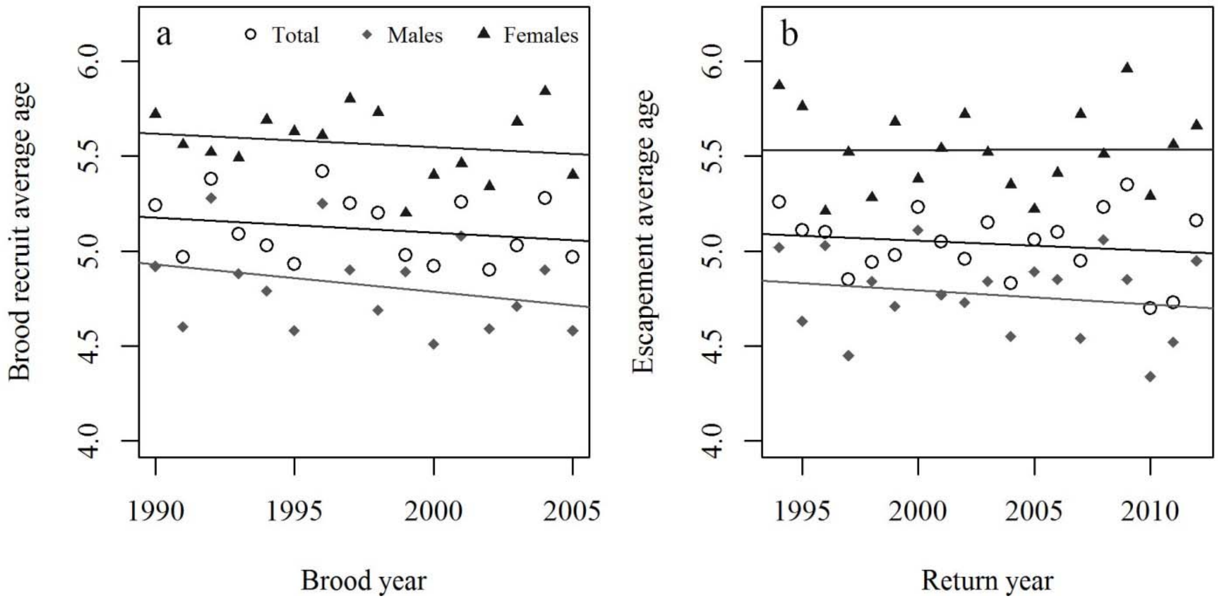
	Male age										Female age									
Brood year	0.2	1.1	1.2	1.3	2.2	1.4	2.3	1.5	2.4	Males	1.2	1.3	2.2	1.4	2.3	1.5	2.4	1.6	Females	Total
1975	–	–	–	–	–	4,091	0	423	0	–	–	–	–	8,246	0	846	0	0	–	–
1976	–	–	–	6,831	0	5,254	0	24	0	–	–	588	0	12,331	0	119	0	5	–	–
1977	–	–	1,648	7,525	0	972	0	112	0	10,256	46	977	0	857	0	268	0	5	2,153	12,409
1978	0	52	3,304	850	0	1,183	0	94	0	5,484	0	36	0	2,004	0	180	0	0	2,220	7,704
1979	0	0	588	3,959	0	1,391	0	105	0	6,043	0	156	0	2,137	0	341	0	0	2,633	8,677
1980	0	15	1,523	2,779	0	947	0	98	0	5,362	7	182	0	2,191	0	0	0	0	2,381	7,742
1981	0	19	1,506	3,903	0	1,475	0	151	0	7,054	0	143	0	1,521	0	1,056	0	0	2,720	9,774
1982	0	0	770	1,934	0	2,445	0	420	0	5,569	0	56	0	4,410	0	420	0	0	4,887	10,456
1983	0	47	1,774	8,063	0	6,520	0	0	0	16,405	0	1,486	0	7,939	0	745	0	0	10,169	26,574
1984	0	23	2,892	8,281	0	1,632	0	0	0	12,828	0	633	0	5,411	0	216	0	0	6,261	19,089
1985	0	0	4,648	9,917	0	2,451	0	96	0	17,112	0	2,710	0	4,902	0	128	53	0	7,793	24,905
1986	0	0	5,604	3,776	33	1,218	0	123	0	10,754	0	1,070	0	3,587	0	697	51	0	5,405	16,160
1987	0	306	1,490	4,901	0	2,849	0	0	0	9,545	0	449	0	4,835	0	297	0	0	5,580	15,125
1988	0	0	2,118	5,099	0	3,155	0	0	30	10,403	31	552	0	4,904	0	323	0	0	5,810	16,213
1989	0	0	5,100	10,453	83	6,138	33	171	0	21,978	45	2,711	0	10,277	0	888	0	0	13,920	35,898
1990	0	0	2,227	6,544	0	2,943	71	0	0	11,785	0	2,578	0	3,210	0	290	0	0	6,078	17,862
1991	0	0	5,167	10,252	0	3,026	0	220	0	18,664	286	1,050	0	5,300	0	202	0	0	6,837	25,502
1992	0	0	2,567	4,725	0	1,687	0	0	0	8,979	0	457	0	3,379	0	255	0	0	4,092	13,071
1993	0	0	5,145	3,815	0	1,580	0	0	0	10,540	46	1,798	0	3,873	0	123	0	0	5,840	16,381
1994	0	0	1,270	2,665	19	491	0	71	0	4,516	0	473	0	2,250	0	107	0	0	2,830	7,346
1995	0	0	601	3,034	0	2,515	0	102	0	6,251	0	529	0	3,020	0	183	0	0	3,732	9,983
1996	0	24	486	3,957	0	1,967	0	0	0	6,434	0	351	0	3,716	0	636	0	0	4,703	11,137
1997	0	0	1,317	6,592	0	1,848	0	0	0	9,757	35	620	0	4,804	0	251	0	0	5,711	15,468
1998	0	0	1,989	6,654	0	1,987	0	128	0	10,757	0	415	0	4,142	0	160	0	0	4,716	15,474
1999	0	0	2,476	9,475	0	2,791	0	248	0	14,990	0	740	0	5,981	0	936	0	0	7,657	22,648
2000	0	0	9,802	9,349	0	2,465	0	185	0	21,802	133	4,407	0	7,464	0	581	0	0	12,585	34,387
2001	0	0	5,838	7,188	0	3,607	0	101	0	16,733	48	2,469	0	5,765	0	101	0	0	8,383	25,117
2002	0	65	7,795	6,124	0	917	0	0	0	14,901	0	1,560	0	2,889	41	256	0	0	4,746	19,647
2003	0	127	4,851	6,844	0	1,149	0	61	0	13,031	0	1,499	0	3,236	52	167	0	0	4,953	17,984
2004	0	0	4,636	6,844	77	1,089	0	0	0	12,646	26	1,233	0	3,354	0	0	0	0	4,613	17,259
2005	0	79	2,747	4,174	0	826	0	42	0	7,866	199	1,030	0	2,058	0	139	0	0	3,425	11,292
2006	0	0	3,396	4,298	20	1,788	41	0	0	9,543	0	1,013	0	3,426	66	0	0	0	4,505	14,048
2007	0	0	4,116	9,106	0	208	0	–	–	–	0	1,642	0	1,393	–	–	–	–	–	16,465
2008	0	0	3,975	764	0	–	–	–	–	–	40	531	0	–	–	–	–	–	–	5,309

Supplementary Table S.A.12. Recruits, escapement, and average age (years) estimates by brood year for the Kogrukluk River Chinook Salmon population.

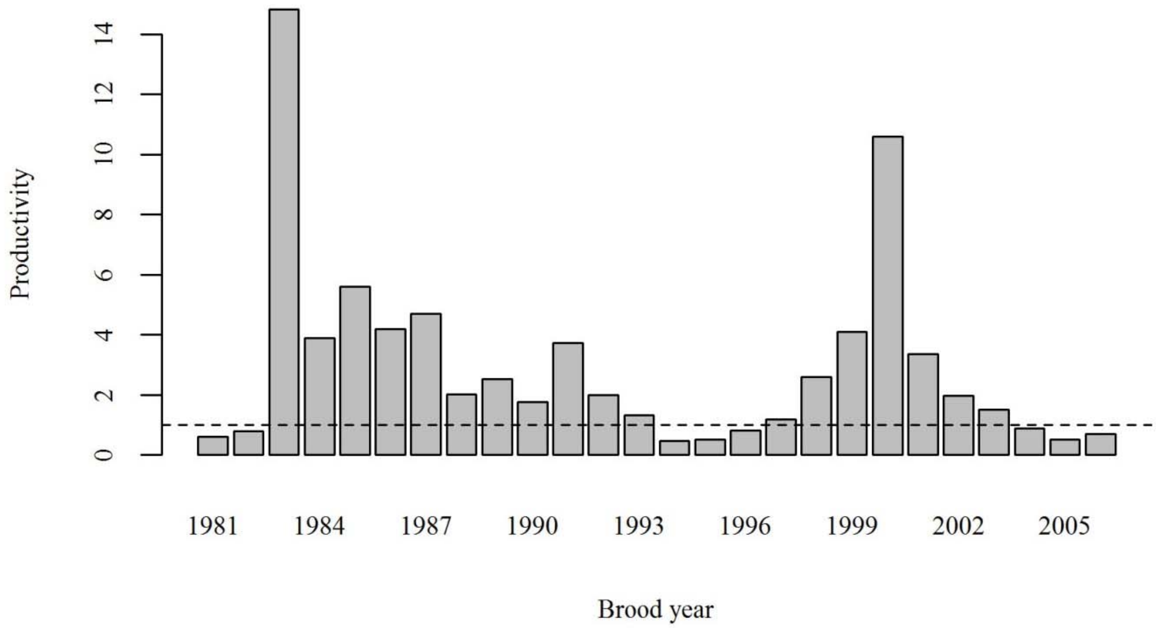
Brood year	Recruits	Average brood age			Escapement	Average spawner age			Productivity
		Total	Males	Females		Total	Males	Females	
1977	12,409	5.07	4.96	5.63	–	–	–	–	–
1978	7,704	5.04	4.63	6.06	–	–	–	–	–
1979	8,677	5.44	5.17	6.07	–	–	–	–	–
1980	7,742	5.23	4.92	5.92	–	–	–	–	–
1981	9,774	5.40	5.03	6.34	16,089	5.58	5.25	6.00	0.61
1982	10,456	5.74	5.45	6.07	13,129	5.69	5.34	6.02	0.80
1983	26,574	5.53	5.28	5.93	1,791	5.44	5.15	6.09	14.84
1984	19,089	5.24	4.90	5.93	4,922	5.11	4.86	6.03	3.88
1985	24,905	5.13	4.88	5.68	4,443	5.35	5.05	6.00	5.61
1986	16,160	5.06	4.62	5.94	3,853	5.38	5.06	6.12	4.19
1987	15,125	5.41	5.08	5.97	3,224	5.18	4.93	5.97	4.69
1988	16,213	5.41	5.11	5.95	8,028	5.39	5.08	5.97	2.02
1989	35,898	5.37	5.06	5.86	14,231	5.47	5.20	5.97	2.52
1990	17,862	5.26	5.07	5.62	10,093	4.82	4.65	5.42	1.77
1991	25,502	5.15	4.91	5.79	6,835	5.58	5.28	5.89	3.73
1992	13,071	5.23	4.90	5.95	6,568	5.19	4.85	5.91	1.99
1993	16,381	5.03	4.66	5.70	12,376	5.11	4.72	6.04	1.32
1994	7,346	5.25	4.86	5.87	15,951	5.19	5.01	5.61	0.46
1995	9,983	5.55	5.34	5.91	19,846	5.37	5.05	5.79	0.50
1996	11,137	5.58	5.22	6.06	13,773	5.27	5.03	6.03	0.81
1997	15,468	5.38	5.05	5.92	13,191	5.13	4.75	5.94	1.17
1998	15,474	5.30	5.02	5.95	5,987	5.38	5.19	5.63	2.58
1999	22,648	5.38	5.05	6.03	5,544	5.64	5.29	5.96	4.09
2000	34,387	5.04	4.68	5.67	3,243	5.33	4.95	5.87	10.60
2001	25,117	5.15	4.88	5.71	7,483	5.32	5.09	5.89	3.36
2002	19,647	4.82	4.53	5.73	10,028	5.17	4.92	5.87	1.96
2003	17,984	4.99	4.71	5.73	12,007	5.23	4.87	6.01	1.50
2004	17,259	4.99	4.72	5.72	19,819	4.75	4.54	5.80	0.87
2005	11,292	5.01	4.75	5.62	21,819	5.05	4.77	5.57	0.52
2006	14,048	5.14	4.84	5.78	20,203	5.02	4.60	5.87	0.70
2007	–	–	–	–	13,848	5.05	4.74	5.84	–
2008	–	–	–	–	9,750	4.84	4.60	5.67	–
2009	–	–	–	–	9,528	5.04	4.80	5.66	–
2010	–	–	–	–	5,814	4.85	4.50	5.82	–
2011	–	–	–	–	6,733	4.72	4.48	5.69	–
2012	–	–	–	–	15,665	5.04	4.83	5.67	–
2013	–	–	–	–	1,821	5.12	4.61	5.63	–
Average	16,844	5.24	4.94	5.87	10,231	5.21	4.91	5.86	2.96



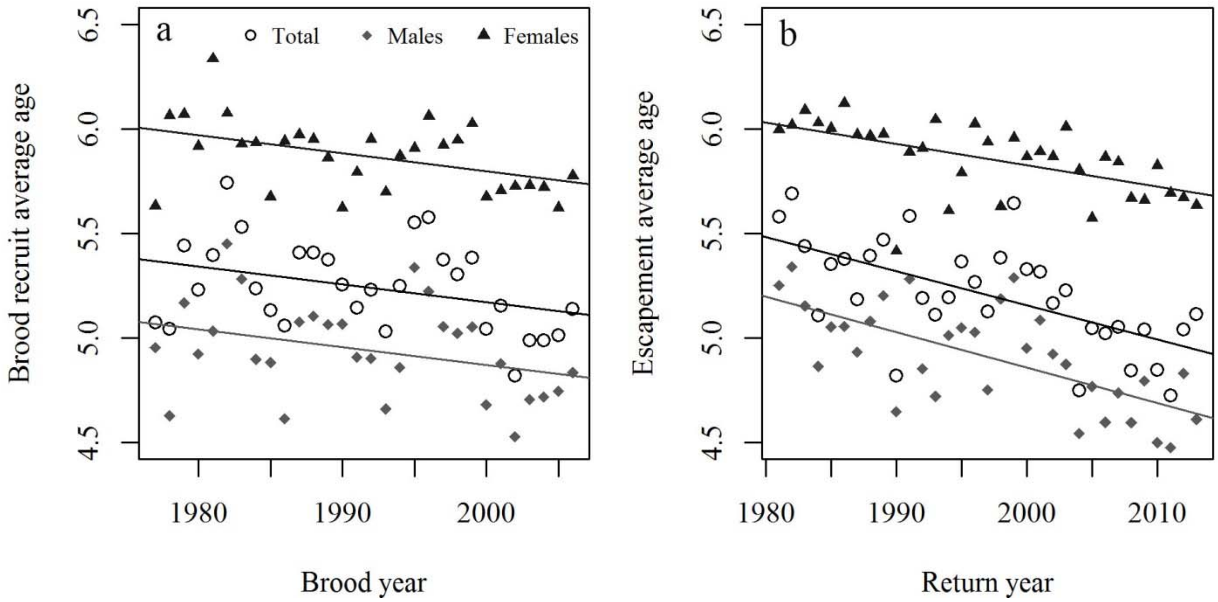
Supplementary Figure S.A.1. Estimated productivity (recruits per spawner) by brood year from run reconstruction for the East Fork Andreafsky River Chinook Salmon population. Brood year is defined as the year of the escapement that produced recruits. Spawners are estimated as the escapement above the monitoring weir in a single return year. Recruits are estimated as all returns (escapement plus harvest) originating from a single brood year. Replacement level is shown by the dashed line.



Supplementary Figure S.A.2. Estimated average **(a)** brood recruit age by brood year and **(b)** escapement age by return year for the Chinook Salmon population from the East Fork Andreafsky River. The average ages of the total population, males only, and females only are shown separately. Age-1.1 fish were not available for the estimation of average age in brood year 1990, and their absence was ignored due to their rarity or absence in all other brood years (Table S.A.5).



Supplementary Figure S.A.3. Estimated productivity (recruits per spawner) by brood year from run reconstruction for the Kogrukluk River Chinook Salmon population. Brood year is defined as the year of the escapement that produced recruits. Spawners are estimated as the escapement above the monitoring weir in a single return year. Recruits are estimated as all returns (escapement plus harvest) originating from a single brood year. Replacement level is shown by the dashed line.



Supplementary Figure S.A.4. Estimated average **(a)** brood recruit age by brood year and **(b)** escapement age by return year for the Chinook Salmon population from the Kogrukluk River. The average ages of the total population, males only, and females only are shown separately. Age-1.1 fish were not available for the estimation of average age in brood year 1977, and their absence was ignored due to their rarity or absence in all other brood years (Table S.A.11).

SUPPLEMENTAL REFERENCES

ADFG (Alaska Department of Fish and Game). 1996–2015. Origins of harvest in the Yukon River fisheries, years 1994–2012, 19 reports. ADFG, Fisheries Data Series/Regional Information Reports, Anchorage.

Brodersen, A. R., Z. W. Liller, and C. L. Truesdale. 2013. Salmon age, sex, and length catalog for the Kuskokwim area, 2012. Alaska Department of Fish and Game, Regional Information Report 13-07, Anchorage.

Hamazaki, T. In review. Estimates of stock-wise historical run and escapement of Yukon River Chinook Salmon, 1981–2012. Alaska Department of Fish and Game, Fisheries Data Series, Anchorage.

Hansen, T. R., and B. J. Blain. 2013. Kogrukluk River salmon studies, 2011. Alaska Department of Fish and Game, Fishery Data Series 13-13, Anchorage.

Liller, Z. W., A. R. Brodersen, and C. L. Truesdale. 2015. Salmon age, sex, and length catalog for the Kuskokwim area, 2013. Alaska Department of Fish and Game, Regional Information Report 3A15-07, Anchorage.

Mears, J. D. 2015. Abundance and run timing of adult Pacific salmon in the East Fork Andreafsky River, Yukon Delta National Wildlife Refuge, Alaska, 2014. U.S. Fish and Wildlife Service, Alaska Fisheries Data Series 2015-5, Fairbanks.

Molyneaux, D. B., A. R. Brodersen, and C. A. Shelden. 2009. Salmon, age, sex, and length catalog for the Kuskokwim Area, 2008, Appendix A: historical age, sex, and length of Chinook Salmon sampled from Kuskokwim area escapement projects. Alaska Department of Fish and Game, Regional Information Report 3A09-06, Anchorage.

Siegel, J. E. 2017. Determinants of life history variability in the Chinook Salmon (*Oncorhynchus tshawytscha*) of western Alaska. University of Alaska, Fairbanks.

USFWS (U.S. Fish and Wildlife Service). 1995–1999, 2003–2013. Abundance and run timing of adult Pacific salmon in the East Fork Andreafsky River, Yukon Delta National Wildlife Refuge, Alaska, years 1994–1998 and 2001–2012, 16 reports. USFWS, Alaska Fisheries Data Series, Fairbanks.

Volk, E. C., M. J. Evenson, and R. A. Clark. 2009. Escapement goal recommendations for select Arctic–Yukon–Kuskokwim region salmon stocks, 2010. Alaska Department of Fish and Game, Fisheries Manuscript Series 09-07, Anchorage.

Williams, D. L., and C. A. Shelden. 2010. Kogrukluk River salmon studies, 2009. Alaska Department of Fish and Game, Fishery Data Series 10-73, Anchorage.

Williams, D. L., and C. A. Shelden. 2011. Kogrukluk River salmon studies, 2010. Alaska Department of Fish and Game, Fishery Data Series 11-49, Anchorage.