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Application of Mixed-Stock Analysis for Yukon River Fall Chum Salmon, 2006

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Blair G. Flannery, Russell R. Holder, Gerald F. Maschmann, Eric J. Kretschmer, and John K. Wenburg

Abstract

This annual report documents the interim results of mixed-stock analysis (MSA) of Yukon River chum salmon harvested from the Pilot Station sonar test fishery in 2006 and represents a continuation of previous work by Flannery et al. (2007). Summer chum salmon continued to comprise >10% of the harvest through stratum 6, which ended on August 12. Fall chum salmon from the U.S. border region accounted for 43.8% of the total fall run, the largest contribution. The contributions of fall chum salmon from the other sampled regions were as follows: Tanana 20.6%, Canada mainstem 18.9%, Canada Porcupine 3.3%, White 12.7%, and Teslin 0.7%. The stock abundance estimates from the genetic and sonar data were concordant with those from the escapement and harvest data. The genetic and sonar stock abundance estimates continue to be less than the escapement and harvest estimates, though the disparity increased in 2006 when compared to 2004 and 2005. This discrepancy is not unexpected because, in addition to the effects of experimental error associated with the monitoring projects, it is estimated that a minimum of 5% of the run passes by Pilot Station after the sonar stops counting for the season at that location.

Introduction

This is an interim report documenting the 2006 results of an ongoing mixed-stock analysis (MSA) study of Yukon River chum salmon harvested from the Pilot Station sonar test fishery. This work represents a continuation of a study initiated in 2004 under the U.S. Fish and Wildlife Service, Office of Subsistence Management, Fisheries Resource Monitoring Program, project 04-228. The final report for that study (Flannery et al. 2007) described the MSA results for 2004 and 2005 and should be referenced for greater detail on baseline development and assessment.

Two seasonal races of chum salmon return as summer and fall runs to the Yukon River, which flows 3,200 km through Alaska and Canada. Chum salmon are an important resource for subsistence users in both countries. Summer chum salmon spawn only in the Alaska portion of the Yukon River, whereas fall chum salmon spawn in both Alaska and Canada. The runs are managed to meet escapement goals and provide harvest opportunities. Furthermore, fishery managers have additional obligations to conserve and equitably share fall chum salm-

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on with Canada, per the Yukon River Salmon Agreement, an annex of the 1985 U.S./Canada Pacific Salmon Treaty (PST).

Determining stock structure and relative contributions of stocks to harvests are essential for effective management (Larkin 1981). Such a task is difficult because fisheries harvest from stock mixtures, but genetic MSA, a method for estimating stock compositions of harvests (Cadrin et al. 2005), provides a means. Thus, genetic MSA was applied to Yukon River chum salmon from Pilot Station test fishery harvests, with regional stock composition estimates distributed in-season to assist in management decisions.

Methods

Sample collection and laboratory analysis—Tissue samples (axillary process) were collected from July 1, 2006 to August 31, 2006 from every chum salmon caught in the Pilot Station sonar test fishery, located 197 km upriver of the Yukon River mouth. Fall chum salmon typically begin entering the Yukon River mouth sometime in early July, but the fall management season does not officially begin until July 19 at Pilot Station, so sampling began prior to the start of the fall management date to accurately reflect the overall seasonal passage of fall chum salmon. Fall chum salmon enter the river in pulses, or surges of fish, that are associated with offshore wind events, high tides, or both. Samples were stratified by pulse of fish or time period, and a subsample size of 200 was selected for each stratum, with the daily sample size proportional to the daily sonar passage estimate within a stratum. The strata samples were genotyped as in Flannery et al. (2007) for the following loci: *Oki1, Oki2* (Smith et al. 1998); *Oki100* (Miller unpublished); *Omy1011* (Spies et al. 2005); *One102, One103, One104, One114* (Olsen et al. 2000); *Ots103* (Beacham et al. 1998); *OtsG68* (Williamson et al. 2002); and *Ssa419* (Cairney et al. 2000).

Data analysis—The stock compositions of the mixtures were estimated using the baseline data described in Flannery et al. (2007) and Bayesian mixture modeling (Pella and Masuda 2001). The estimates were summed to seasonal race, region, and country (Figure 1) and then distributed to fishery managers within three days of lab sample receipt. The stock composition for the entire sampling period was calculated by taking a weighted average of each stratum's estimate of stock composition based on the stratum's relative abundance for the entire period as determined from Pilot Station sonar passage estimates (Seeb et al. 1997). Stock specific abundance estimates were derived by combining the Pilot Station sonar passage estimates with the genetic stock composition estimates.

A post season analysis was conducted to compare the fall stock specific abundance estimates against escapement and harvest estimates to evaluate how closely the two matched. Summer stock specific abundance estimates were not included in this analysis because funding for sample analysis prior to July 1 was not obtained. Escapements from the following projects were compiled: upper Tanana River mark and recapture (Cleary and Hamazaki 2007), Kantishna River mark and recapture (Cleary and Hamazaki 2007), Chandalar River sonar (JTC 2007), Sheenjek River sonar (JTC 2007), Canada border sonar (JTC 2007), and Porcupine River mark and recapture (JTC 2007). Harvest estimates (upriver of Pilot Station) by river location were obtained from a post season survey of subsistence fishers conducted by the Alaska Department of Fish and Game (ADFG; JTC 2007). It was assumed that fishers were unlikely to report a summer chum salmon as a fall chum salmon. This assumption contains potential bias because the seasonal races overlap in run timing and because it is difficult to phenotypically distinguish the seasonal race of chum salmon. However, there is little fishing effort during the overlap (Busher et al. 2008), which reduces bias. Moreover, the number of chum salmon harvested is small compared to total escapement, so any remaining bias is negligible. Harvest was apportioned to the U.S. and Canada fall stocks in a stepwise upstream to downstream fashion by using the escapements to estimate the relative proportions of these stocks available at various locations and multiplying these proportions by the harvest at each location. These stock specific harvest estimates were then added to the appropriate escapements in order to allow a direct comparison between data sources.

Results and Discussion

In 2006, nine strata were analyzed. As expected, summer chum salmon comprised the majority of the harvest during strata one and two, which occurred prior to the fall management season (Figure 2, Table 1). Summer chum salmon continued to comprise >10% of the harvest through stratum 6, which ended on August 12 (Figure 2, Table 1). The presence of summer chum salmon after the switch to fall management is consistent with data from previous studies (Wilmot et al. 1992; ADFG 2003; Flannery et al. 2007). The pattern of earlier fall run timing during even years (ADFG 2003) was not observed in the 2006 estimates when compared to the 2005 estimates reported by Flannery et al. (2007), nor was it observed in MSA estimates (Wilmot et al. 1992) or test fishing indices (Fox and Hayes 2006). Further years of study are required to confirm the presence of an even/odd year run timing pattern, which should not be confused with the even/odd year abundance pattern (JTC 2007).

All studies have shown that stock compositions vary significantly from year to year; nevertheless, there are some apparent consistencies. Fall chum salmon from the Porcupine and U.S. border regions continued to have the earliest run timing, followed by fall chum salmon from the mainstem and White regions (Figure 2). Teslin fall chum salmon again were not appreciable contributors, and Tanana fall chum salmon continued to run last, slowly building until they comprised the majority of the final strata (Figure 2). While the above generalization holds, there are overlaps of run timing among the regions, with greater overlap for the more abundant regions. Fall chum salmon from the U.S. border region were again sustained throughout the run, with contributions ranging from 12% to 43%, depending on the stratum. U.S. border region fall chum salmon were the largest contributor, accounting for 44% of the total fall run, similar to 2005 results (Table 2). Contributions from Canada mainstem region fall chum salmon increased 7% from previous years, while fall chum salmon from other regions stayed within reported ranges (Table 2; Flannery et al. 2007). Despite this, the contribution of U.S. chum salmon to the fall run remained at approximately 67%. Canada border fall fish, which includes the Canada Porcupine and Canada mainstem regions, continued to return in greater numbers than upper Canada fall fish, which includes the White and Teslin regions. The contribution of Canada border fall fish was 1.7 times larger than upper Canada, a slight increase from 2004 and 2005 (Flannery et al. 2007), but much less than values reported by Wilmot et al. (1992) and Spearman and Miller (1997).

The post season comparison with the escapement and harvest data was performed using the stock composition estimates (Table 1) and the Pilot Station sonar passage estimates (Table 3). Overall, stock abundance based on the products of estimates of genetic stock composition and Pilot Station sonar passage ranged from 4,915 to 1,546,177 fish (Table 4). Escapement totals from the upriver monitoring projects ranged from 44,906 to 273,804 fish (Table 5). Subsistence harvests from the fishing districts, upriver of Pilot Station, were added to the escapement totals (Table 6). The stock abundance estimates from the genetic and sonar data were concordant with those from the escapement and harvest data (Figure 3). The genetic and sonar stock abundance estimates continue to be less than the escapement and harvest estimates, though the disparity increased in 2006 when compared to 2004 and 2005 (Flannery et al. 2007). Given that a minimum of 5% of the run passes after the Pilot Station sonar discontinues seasonal operations (JTC 2007) and the effects of experimental error associated with the monitoring projects, this discrepancy is not unexpected. Specifically, the genetic and sonar combination may underestimate because of genetic misallocation, incomplete sonar coverage, species apportionment test fishing error, and genetic subsampling error, whereas the upriver escapement projects may overestimate by counting summer chum salmon as fall because of geographic and temporal overlap between the seasonal races, especially in the Tanana River.

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Table 1. 2006 Pilot Station test fishery chum salmon stock composition estimates with associated standard deviations and 95% confidence intervals by stratum and management group.

	Stratum 1 7/1–7/8				Stratum 2 7/9–7/18			
	Estimate	SD	95% CI		Estimate	SD	95% CI	
Summer	0.990	0.013	0.952	1.000	0.888	0.045	0.792	0.964
Lower	0.905	0.038	0.826	0.976	0.836	0.056	0.724	0.940
Tanana	0.084	0.036	0.014	0.158	0.052	0.042	0.000	0.143
Fall	0.010	0.013	0.000	0.047	0.112	0.045	0.036	0.208
Tanana	0.004	0.009	0.000	0.031	0.030	0.034	0.000	0.112
U.S. Border	0.003	0.007	0.000	0.022	0.028	0.031	0.000	0.106
Canada Border	0.003	0.006	0.000	0.023	0.037	0.026	0.000	0.092
Porcupine	0.001	0.003	0.000	0.010	0.011	0.018	0.000	0.061
Mainstem	0.002	0.006	0.000	0.020	0.026	0.026	0.000	0.086
Upper Canada	0.001	0.003	0.000	0.010	0.016	0.011	0.001	0.043
White	0.001	0.002	0.000	0.007	0.016	0.011	0.001	0.042
Teslin	0.000	0.002	0.000	0.005	0.001	0.003	0.000	0.006
Fall U.S.	0.006	0.011	0.000	0.040	0.058	0.045	0.000	0.160
U.S.	0.996	0.007	0.975	1.000	0.946	0.028	0.887	0.992
Canada	0.004	0.007	0.000	0.024	0.054	0.028	0.008	0.113
U.S. Border + Canada	0.007	0.010	0.000	0.034	0.082	0.034	0.027	0.157
Mainstem + Upper Canada	0.003	0.006	0.000	0.022	0.042	0.028	0.004	0.105

Continued

Table 1. Continued

	Stratum 3 7/19–7/22				Stratum 4 7/23–7/27			
	Estimate	SD	95% CI		Estimate	SD	95% CI	
Summer	0.487	0.051	0.388	0.587	0.662	0.047	0.568	0.751
Lower	0.390	0.057	0.289	0.509	0.508	0.055	0.406	0.621
Tanana	0.097	0.040	0.028	0.182	0.154	0.042	0.078	0.239
Fall	0.513	0.051	0.413	0.612	0.338	0.047	0.249	0.432
Tanana	0.004	0.011	0.000	0.039	0.003	0.007	0.000	0.026
U.S. Border	0.401	0.073	0.261	0.540	0.226	0.053	0.128	0.332
Canada Border	0.079	0.057	0.000	0.195	0.061	0.039	0.000	0.143
Porcupine	0.064	0.055	0.000	0.171	0.005	0.015	0.000	0.054
Mainstem	0.015	0.023	0.000	0.079	0.057	0.040	0.000	0.137
Upper Canada	0.030	0.016	0.006	0.069	0.048	0.022	0.014	0.099
White	0.026	0.014	0.006	0.058	0.040	0.018	0.011	0.080
Teslin	0.003	0.009	0.000	0.033	0.008	0.013	0.000	0.043
Fall U.S.	0.405	0.073	0.265	0.545	0.228	0.053	0.129	0.338
U.S.	0.892	0.059	0.771	0.984	0.890	0.039	0.807	0.961
Canada	0.108	0.059	0.016	0.229	0.110	0.039	0.039	0.192
U.S. Border + Canada	0.509	0.050	0.409	0.605	0.336	0.047	0.247	0.428
Mainstem + Upper Canada	0.045	0.028	0.009	0.115	0.105	0.039	0.035	0.186

Continued

Table 1. Continued

	Stratum 5 7/28–8/5 Estimate	SD	95% CI		Stratum 6 8/6–8/12 Estimate	SD	95% CI	
Summer	0.114	0.037	0.057	0.202	0.220	0.057	0.117	0.338
Lower	0.113	0.036	0.057	0.200	0.194	0.062	0.083	0.322
Tanana	0.002	0.005	0.000	0.016	0.026	0.035	0.000	0.120
Fall	0.886	0.037	0.798	0.942	0.780	0.057	0.662	0.883
Tanana	0.136	0.053	0.027	0.239	0.052	0.060	0.000	0.194
U.S. Border	0.425	0.091	0.248	0.606	0.265	0.107	0.048	0.474
Canada Border	0.243	0.077	0.102	0.398	0.258	0.092	0.081	0.446
Porcupine	0.025	0.044	0.000	0.148	0.003	0.014	0.000	0.041
Mainstem	0.218	0.068	0.090	0.358	0.254	0.092	0.078	0.444
Upper Canada	0.081	0.029	0.032	0.142	0.205	0.043	0.128	0.294
White	0.080	0.028	0.032	0.140	0.202	0.041	0.127	0.288
Teslin	0.001	0.005	0.000	0.013	0.003	0.010	0.000	0.036
Fall U.S.	0.561	0.080	0.399	0.710	0.317	0.104	0.112	0.526
U.S.	0.676	0.080	0.515	0.824	0.537	0.095	0.349	0.724
Canada	0.324	0.080	0.176	0.485	0.463	0.095	0.276	0.651
U.S. Border + Canada	0.749	0.055	0.636	0.855	0.728	0.073	0.571	0.855
Mainstem + Upper Canada	0.299	0.072	0.165	0.441	0.460	0.095	0.274	0.650

Continued

Table 1. Continued

	Stratum 7 8/13–8/16				Stratum 8 8/17–8/24			
	Estimate	SD	95% CI		Estimate	SD	95% CI	
Summer	0.036	0.020	0.007	0.081	0.029	0.014	0.007	0.062
Lower	0.032	0.018	0.005	0.074	0.028	0.014	0.007	0.061
Tanana	0.004	0.010	0.000	0.034	0.001	0.003	0.000	0.008
Fall	0.964	0.020	0.919	0.993	0.971	0.014	0.938	0.993
Tanana	0.234	0.047	0.147	0.327	0.342	0.048	0.249	0.438
U.S. Border	0.433	0.058	0.323	0.545	0.286	0.065	0.160	0.417
Canada Border	0.089	0.046	0.003	0.188	0.230	0.060	0.120	0.351
Porcupine	0.001	0.005	0.000	0.013	0.021	0.038	0.000	0.128
Mainstem	0.088	0.046	0.002	0.187	0.209	0.063	0.089	0.335
Upper Canada	0.208	0.036	0.141	0.282	0.114	0.026	0.069	0.169
White	0.187	0.032	0.129	0.251	0.113	0.026	0.068	0.168
Teslin	0.021	0.019	0.000	0.066	0.001	0.002	0.000	0.006
Fall U.S.	0.667	0.054	0.556	0.768	0.628	0.062	0.503	0.743
U.S.	0.703	0.052	0.596	0.798	0.656	0.062	0.533	0.772
Canada	0.297	0.052	0.201	0.404	0.344	0.062	0.227	0.466
U.S. Border + Canada	0.730	0.047	0.636	0.817	0.630	0.048	0.534	0.722
Mainstem + Upper Canada	0.296	0.052	0.200	0.403	0.323	0.066	0.194	0.453

Continued

Table 1. Continued

	Stratum 9 8/25–8/31 Estimate	SD	95% CI		Total 7/1–8/31 Estimate	SD	95% CI	
Summer	0.015	0.017	0.000	0.062	0.620	0.011	0.598	0.642
Lower	0.007	0.010	0.000	0.038	0.565	0.019	0.527	0.602
Tanana	0.008	0.014	0.000	0.050	0.055	0.016	0.023	0.087
Fall	0.985	0.017	0.938	1.000	0.380	0.011	0.358	0.402
Tanana	0.536	0.057	0.428	0.649	0.078	0.012	0.055	0.102
U.S. Border	0.123	0.055	0.027	0.239	0.167	0.018	0.131	0.202
Canada Border	0.169	0.061	0.061	0.295	0.084	0.015	0.054	0.114
Porcupine	0.031	0.052	0.000	0.172	0.012	0.009	0.000	0.030
Mainstem	0.138	0.067	0.006	0.272	0.072	0.014	0.045	0.099
Upper Canada	0.157	0.037	0.092	0.235	0.051	0.006	0.039	0.063
White	0.154	0.035	0.090	0.229	0.048	0.006	0.036	0.060
Teslin	0.004	0.010	0.000	0.038	0.003	0.002	0.000	0.007
Fall U.S.	0.659	0.066	0.527	0.785	0.245	0.018	0.211	0.279
U.S.	0.674	0.064	0.543	0.795	0.865	0.016	0.834	0.896
Canada	0.326	0.064	0.205	0.457	0.135	0.016	0.104	0.166
U.S. Border + Canada	0.449	0.057	0.337	0.558	0.302	0.013	0.277	0.327
Mainstem + Upper Canada	0.295	0.072	0.150	0.434	0.123	0.014	0.094	0.151

Table 2. Overall estimates of 2004, 2005, and 2006 fall chum salmon stock proportions.

Year	Tanana	U.S. Border	Mainstem	Porcupine	White	Teslin
2004	0.370	0.312	0.116	0.079	0.118	0.004
2005	0.209	0.494	0.117	0.048	0.108	0.024
2006	0.206	0.438	0.189	0.033	0.127	0.007

Table 3. Pilot Station sonar passage estimates for 2006.

Year	Strata	Passage
2006	Stratum 1 (7/1–7/8)	723,825
	Stratum 2 (7/9–7/18)	273,252
	Stratum 3 (7/19–7/22)	111,102
	Stratum 4 (7/23–7/27)	63,355
	Stratum 5 (7/28–8/5)	298,452
	Stratum 6 (8/6–8/12)	49,538
	Stratum 7 (8/13–8/16)	134,237
	Stratum 8 (8/17–8/24)	90,935
	Stratum 9 (8/25–8/31)	42,944
	Total (7/1–8/31)	1,787,640

Table 4. Stock abundance estimates derived from the products of the genetic stock composition estimates and Pilot Station sonar passage estimates for 2006. The standard deviations and 95% confidence intervals are based on the variances of the genetic estimates only.

	2006 7/1–8/31 Estimate	SD	95% CI	
Summer	1,108,232	20,463	1,068,124	1,148,339
Lower	1,009,565	34,289	942,359	1,076,770
Tanana	98,255	29,007	41,402	155,108
Fall	679,408	20,463	639,301	719,516
Tanana	140,227	21,229	98,618	181,836
U.S. Border	297,859	32,391	234,372	361,346
Canada Border	150,563	27,327	97,002	204,124
Porcupine	22,208	16,030	0	53,628
Mainstem	128,465	24,414	80,614	176,316
Upper Canada	90,972	11,277	68,869	113,076
White	86,151	10,750	65,081	107,222
Teslin	4,915	3,596	0	11,964
Fall U.S.	437,940	31,319	376,554	499,326
U.S.	1,546,177	28,572	1,490,176	1,602,178
Canada	241,463	28,570	185,466	297,460
U.S. Border + Canada	539,246	22,934	494,294	584,197
Mainstem + Upper Canada	219,346	25,832	168,715	269,978

Table 5. Upriver escapement estimates for 2006.

Escapement project	Estimate
Upper Tanana River Mark-Recapture	202,669
Kantishna River Mark-Recapture	71,135
Total Tanana River	273,804
Chandalar Sonar	245,090
Sheenjek Sonar	160,178
Canada Border Passage (Mainstem + Upper)	236,386
Canada Porcupine River Mark-Recapture	44,906

Table 6. Subsistence harvest apportionments for 2006. Bold numbers indicate escapements estimated by the monitoring projects. Harvest was apportioned to the U.S. and Canada fall stocks in a stepwise upstream to downstream fashion by using the escapements to estimate the relative proportions of these stocks available at the river locations and multiplying these proportions by the harvest at the river locations.

		Abundance of Contributing Stocks				
Location	Harvest	Canada Mainstem + Upper	Canada Porcupine	Sheenjek	Chandalar	Tanana
Chandalar (w/ Black)	735				**245,090**	
Y6	17,258					**273,804**
Y5D Above Porcupine	17,494	**236,386**				
Ft. Yukon	5,178	253,880	**44,906**	**160,178**		
Y5D Below Chandalar	50	256,744	45,413	161,985	245,825	
Y5C	5,519	256,762	45,416	161,997	245,842	
Y5B	23,167	258,758	45,769	163,256	247,753	
Y5A	0					291,062
Y4	5,389	267,136	47,251	168,541	255,775	291,062
Y3	480	268,534	47,498	169,424	257,113	292,585
Y2 (Marshall only)	410	268,659	47,520	169,502	257,233	292,721
Total	75,680	268,765	47,539	169,569	257,334	292,837

	Proportion of Contributing Stocks				
Location	Canada Mainstem + Upper	Canada Porcupine	Sheenjek	Chandalar	Tanana
Chandalar (w/ Black)	0.00	0.00	0.00	1.00	0.00
Y6	0.00	0.00	0.00	0.00	1.00
Y5D Above Porcupine	1.00	0.00	0.00	0.00	0.00
Ft. Yukon	0.55	0.10	0.35	0.00	0.00
Y5D Below Chandalar	0.36	0.06	0.23	0.35	0.00
Y5C	0.36	0.06	0.23	0.35	0.00

Continued

Table 6. Continued

Y5B	0.36	0.06	0.23	0.35	0.00
Y5A	0.00	0.00	0.00	0.00	1.00
Y4	0.26	0.05	0.16	0.25	0.28
Y3	0.26	0.05	0.16	0.25	0.28
Y2 (Marshall only)	0.26	0.05	0.16	0.25	0.28

	Harvest Apportionment				
Location	Canada Mainstem + Upper	Canada Porcupine	Sheenjek	Chandalar	Tanana
Chandalar (w/ Black)	0	0	0	735	0
Y6	0	0	0	0	17,258
Y5D Above Porcupine	17,494	0	0	0	0
Ft. Yukon	2,864	507	1,807	0	0
Y5D Below Chandalar	18	3	11	17	0
Y5C	1,996	353	1,259	1,911	0
Y5B	8,378	1,482	5,286	8,022	0
Y5A	0	0	0	0	0
Y4	1,398	247	882	1,339	1,523
Y3	125	22	79	119	136
Y2 (Marshall only)	106	19	67	102	116
Total	32,379	2,633	9,391	12,244	19,033

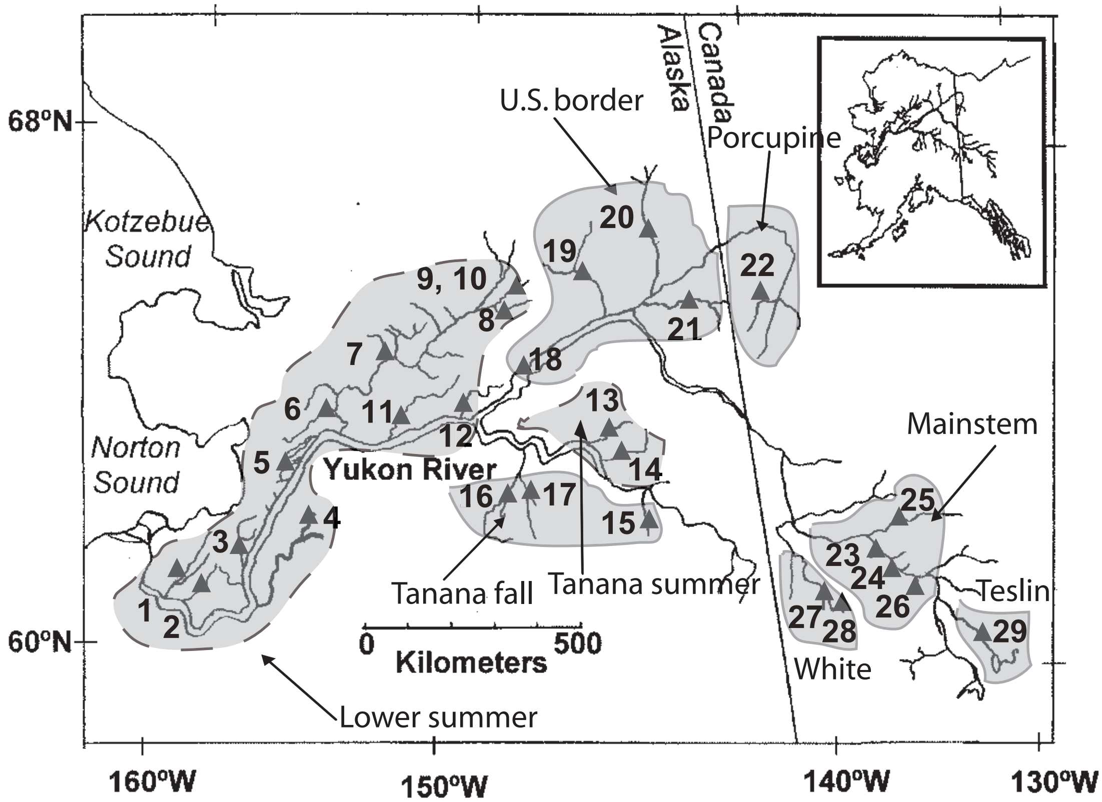

Figure 1. Baseline sampling locations, 1 = Andreafsky, 2 = Chulinak, 3 = Anvik, 4 = California, 5 = Nulato, 6 = Gisasa, 7 =Henshaw, 8 = Jim, 9 = South Fork Koyukuk Early, 10 = South Fork Koyukuk Late, 11 = Melozitna, 12 = Tozitna, 13 = Big Salt, 14 = Chena, 15 = Salcha, 16 = Delta, 17 = Kantishna, 18 = Toklat, 19 = Chandalar, 20 = Sheenjek, 21 = Black, 22 = Fishing Branch, 23 = Big Creek, 24 = Minto, 25 = Pelly, 26 = Tatchun, 27 = Donjek, 28 = Kluane, and 29 = Teslin. Pilot Station is located on the Yukon River mainstem near sample location 2. The grey shaded areas delineate fishery management regions, with summer regions outlined by dashed lines and fall regions by solid lines. The Canada border encompasses the Canada Porcupine and Canada mainstem regions, and upper Canada encompasses the White and Teslin regions.

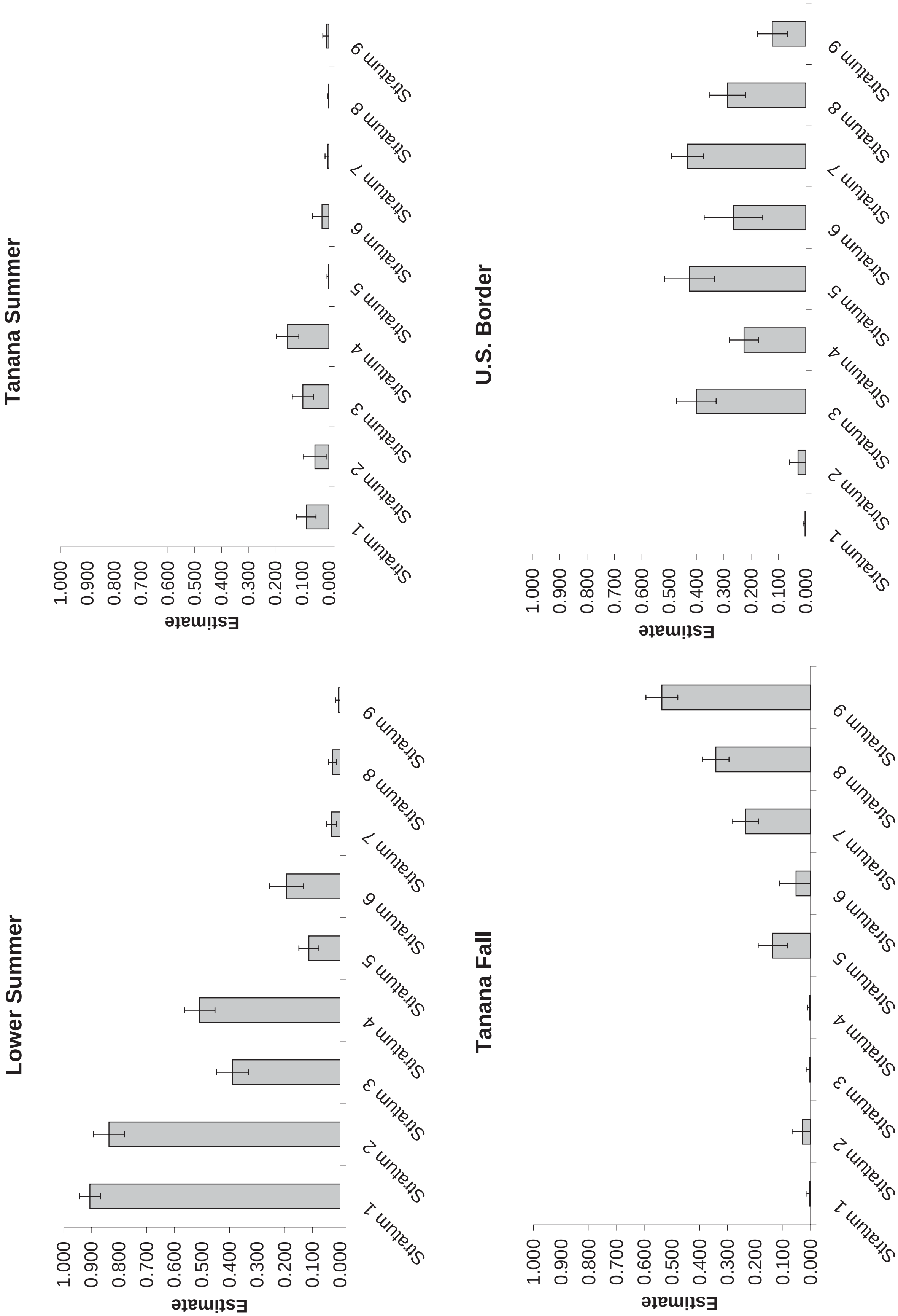

Figure 2. Pilot Station test fishery stock composition estimates for 2006. Error bars represent one standard error.

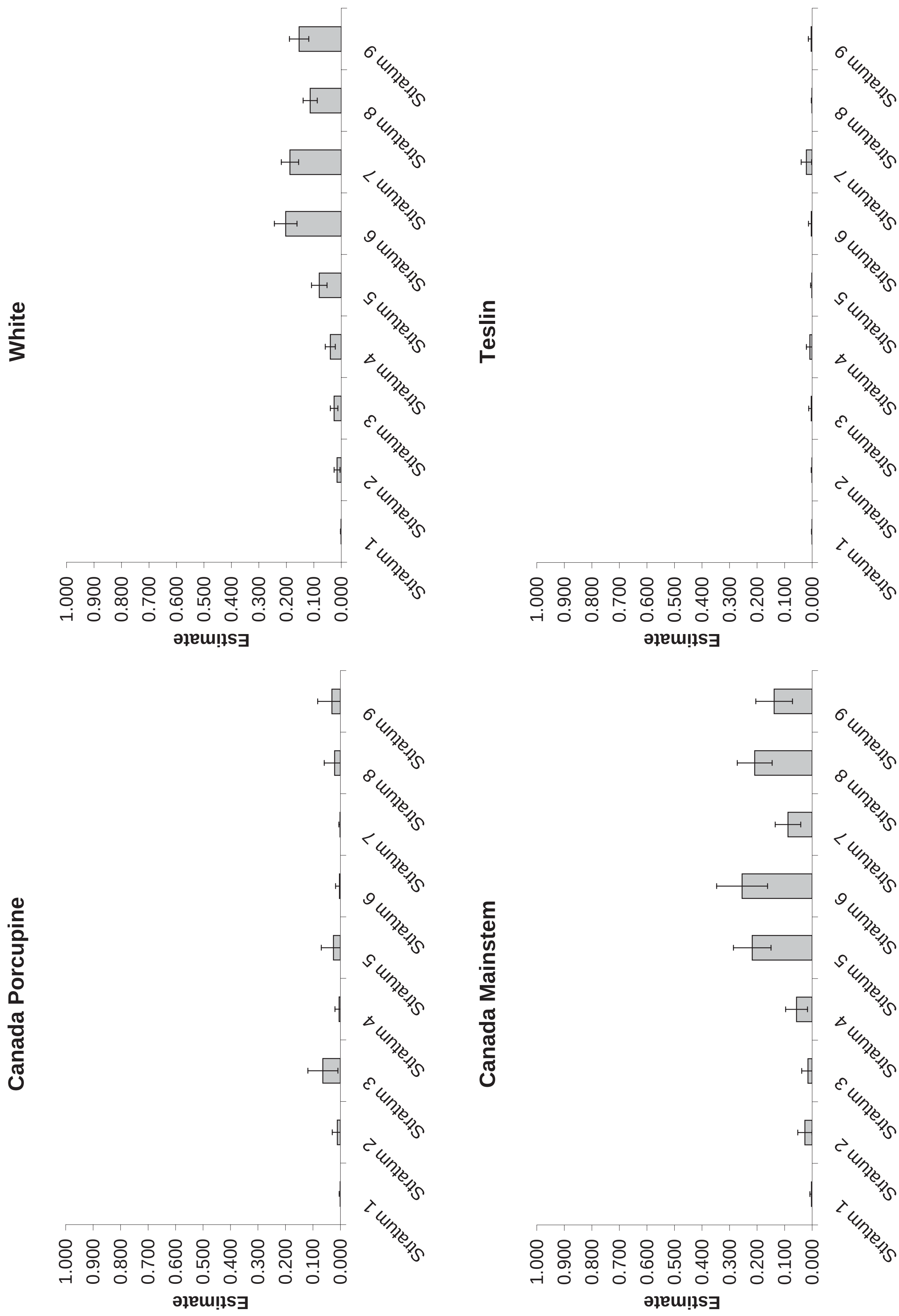

Figure 2. Continued

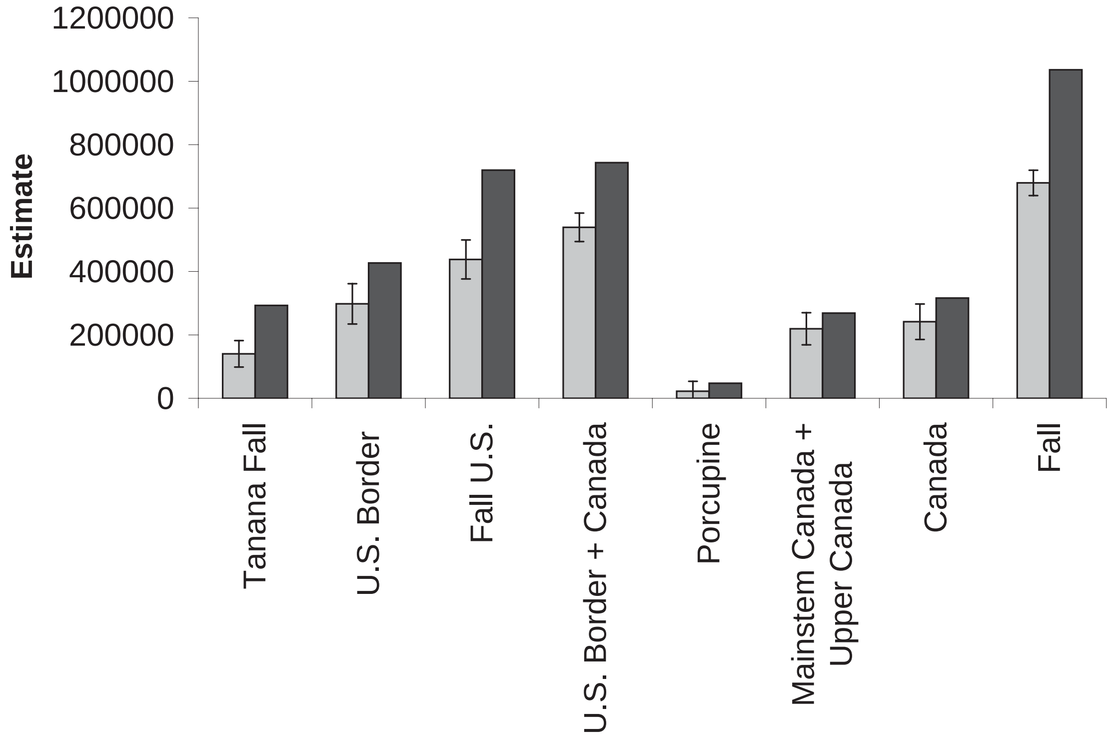

Figure 3. Comparisons of stock abundance estimates for 2006. Grey bars are genetic/sonar estimates. Black bars are escapement and harvest estimates. The 95% confidence intervals are based on the variances of the genetic estimates only.