2009 YUKON RIVER PANEL RESEARCH AND MANAGEMENT FUND FINAL REPORT

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Project Title: Yukon River summer chum salmon mixed-stock analysis, 2009

Project Location: Pilot Station, Yukon River

Objectives Summary: Estimate regional stock contributions and run timing of Yukon River summer chum salmon from Pilot Station sonar test fishery harvests.

Project Summary: Information on stock composition of Yukon River summer chum salmon, during the spawning run, has been limited. The disparate strength of individual chum salmon stocks within and among years, combined with overlapping multi-species spawning runs, the immense size of the drainage, and the inability to determine stock specific abundance and timing makes fishery management difficult. Knowledge of the origin of chum salmon as they enter the river would assist in managing fisheries to achieve adequate escapement and may allow for increased fishing opportunities by identifying harvestable surpluses, particularly with respect to the independent Tanana River terminal fisheries. A similar mixed-stock analysis project, funded by the U.S. Fish and Wildlife Service, Office of Subsistence Management (OSM #06-205) and Conservation Genetics Laboratory, has been conducted for fall chum salmon since 2004.

Here, estimates of stock compositions for major Yukon River summer chum salmon stock groups were provided during the spawning run to facilitate management. From the beginning of the spawning run, genetic samples were collected from the Pilot Station test fishery and analyzed on a weekly basis using Bayesian mixture modeling as implemented in the computer program BAYES (Pella and Masuda 2001).

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FINAL REPORT FOR PROJECT
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YUKON RIVER SUMMER CHUM SALMON MIXED-STOCK ANALYSIS, 2009

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Abstract

Genetic mixed-stock analysis (MSA) is used to derive stock composition estimates for Yukon River summer chum salmon with samples collected in the Pilot Station sonar test fishery. For the 2009 season, 87% of the chum salmon are from summer run stocks and 13% from fall run stocks. Within the summer run component, apportionments are 86% to the lower river stock group and 14% to the middle river stock group (6% upper Koyukuk and middle mainstem, 8% Tanana River). Lower river chum salmon are present throughout the run and are the largest contributing stock (>59%) until the week of July 28 – August 4, one week later than 2008, whereupon their contribution drops to 28%, and the largest contribution then comes from the fall stock group (55%). Fall chum salmon continue a trend since 2006 of late run timing, which, along with the presence of summer chum salmon well into August, should be addressed by fishery managers in order to sustain overall production and biodiversity. The stock composition estimate for the upper Koyukuk and middle mainstem appears to be inconsistent with escapement data. The inconsistencies are related to the level of resolution among stocks and the actual stock composition of the run. The Henshaw Creek and Tozitna River stocks, in the upper Koyukuk and middle mainstem region, are closely related to lower river stocks, with 15% and 11% misallocations to the lower river stock group in MSA simulations, respectively. Therefore, upper Koyukuk and middle mainstem stock composition estimates could be significantly biased if these stocks return in greater proportion than more distinct middle river stocks, which appears to have happened when Henshaw returned with a 38% increase over the five year average. Though Henshaw and Tozitna fit geographically in the middle river, the 2009 Pilot Station mixture analysis results and MSA simulations indicate that these stocks should be placed in the lower river stock group. Alternatively, a more conservative approach would be to create two summer groups, Tanana and other. This would reduce bias the most and may be appropriate given the management interest in the Tanana River terminal fisheries.

Introduction

Management of the Yukon salmon fishery is complex because of the disparate strength of individual chum salmon stocks within and among years, combined with overlapping multi-species spawning runs, the immense size of the drainage, and the inability to determine stock specific abundance and timing. Salmon fisheries within the Yukon River may harvest stocks that are up to several weeks and hundreds of miles from their spawning grounds. Because the Yukon River fisheries are largely mixed-stock fisheries, some tributary stocks may be under- or over-exploited.

The stock composition of Yukon River summer chum runs has been in flux for more than a decade. The Anvik River contribution to the overall Yukon River stock production above Pilot Station sonar (river mile 123) has decreased from approximately 46% during the period from 1995 – 2002 to an average of 24% post 2002. This reduction corresponds with increased production in other chum salmon spawning streams. Chum salmon in the Tanana River drainage also exhibit large fluctuations in abundance, with record escapements of over 100,000 summer chum salmon observed in Salcha River in 2005 and 2006, and less than 15,000 in 2007. Fluctuations have been observed elsewhere in the Yukon River drainage. The disparate strength of individual stocks within and among years makes it clear that in-season stock return data would facilitate fishery management. Knowledge of the origin of chum salmon as they enter the river would assist in managing fisheries to achieve adequate escapement and may allow for increased fishing opportunities by identifying harvestable surpluses, particularly with respect to the independently managed Tanana River terminal fisheries.

Based on the genetic and geographic stock relationships, two stock groups of summer chum salmon have been identified: lower river and middle river (Tanana). Mixed-stock analysis (MSA) simulations reveal that apportionment accuracies exceed 90% for these groups (Flannery et al. 2007), indicating that they are highly identifiable in actual fishery mixtures (Seeb and Crane 1999). A similar MSA project, funded by the U.S. Fish and Wildlife Service, Office of Subsistence Management (OSM #06-205) and the Conservation Genetics Laboratory (CGL), has been conducted for fall chum salmon MSA since 2004. Partial results from the fall chum salmon analysis are provided below; complete results will be presented in the OSM annual report. Here, we provide results for estimates of stock composition for major summer chum salmon stock groups determined in-season during the spawning run to facilitate their management.

Methods

Sample Collection

Genetic samples were collected from every chum salmon caught in the Pilot Station sonar test fishery from the start of the run until the end of test fishing and sent to the CGL every week (Note: sampling from July on continued under the OSM fall chum salmon MSA project 06-205; partial results of fall chum salmon stock composition are presented below). Samples were stored in individual vials with the following associated catch data recorded for each sample: river bank, date, time of day, gill net mesh size, drift time, and fish length. Samples were stratified by week; a subsample of 288 was analyzed for each stratum, with the daily sample size proportional to the daily sonar passage estimate within a stratum. Sample size was determined by MSA simulations using SPAM 3.7 (Debevec et al. 2000), so that 90% interval estimates of 10% contributions of the major stock groups excluded zero. An estimate with a 90% confidence interval that does not include zero provides evidence that the stock is actually present in the mixture at the 5% level of significance (Weir 1996).

Genetic Analysis

Total genomic DNA was extracted from fin tissue (~25mg) using a chelex-resin protocol. The following micosatellite loci were assayed for genetic variation: *Oki1*, *Oki2* (Smith et al. 1998); *Oki100* (Miller unpublished); *Omy1011* (Spies et al. 2005); *One102*, *One103*, *One104*, and *One114* (Olsen et al. 2000); *Ssa419* (Cairney et al. 2000); *OtsG68* (Williamson et al. 2002); *Ots103* (Beacham et al. 1998). An MJResearch DNA Engine® thermal cycler was used to perform polymerase chain reactions (PCR) in 10 µl volumes; general conditions were: 2.5 mM $MgCl_2$, 1X PCR buffer (20 mM Tris-HCl pH 8.0, 50 mM KCl), 200 µM of each dNTP, 0.40µM fluorescently labeled forward primer, 0.40 µM unlabeled reverse primer, 0.008 units *Taq* polymerase, and 1 µl of DNA (30ng/µl). Standard thermal cycling conditions were: initial denaturation cycle of 94°C for 3 min, followed by 94°C for 1 min, 50-62°C for 1 min (locus-specific annealing temperature), 72°C for 1 min, with a final single cycle of 72°C for 10 min.

One µl of PCR product was electrophoresed and visualized with the Applied Biosystems 3730 Genetic Analyzer utilizing a polymer denaturing capillary system. The sizes of bands were estimated and scored by the computer program GeneMapper® version 4.0. Applied Biosystems GeneScan™-600 LIZ® size standards, 20-600 bases, were loaded in all lanes as an internal lane standard. All scores were verified manually. Alleles were scored by two independent researchers, with any discrepancies being resolved by replicating the analysis for the samples in question and repeating the double scoring process until scores matched (unresolved scores were excluded from further analysis).

Statistical Analysis

The mixture data were compared to the genetic baseline (Figure 1) to estimate the relative stock compositions using the Bayesian mixture modeling method as implemented in the program BAYES (Pella and Masuda 2001). Stock composition estimates were reported to fishery managers as soon as possible after receiving the samples (typically 24-48 hours) for the following three tiered hierarchical stock grouping (Figure 1):

1a) Summer
- 2a) Lower
- 2b) Middle
  - 3a) Upper Koyukuk and middle mainstem
  - 3b) Tanana

1b) Fall

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 stock composition estimates.

Mixed-stock analysis simulations were performed for summer chum salmon stocks from and adjacent to the middle river group to assess the robustness of grouping strategy. Simulations were performed with SPAM 3.7 (Debevec et al. 2000). Simulated mixtures were created to represent 100% of each stock, and allocations were summed for the summer regional stock groups.

Results and Discussion

Sampling occurred from June 8 through September 7 at Pilot Station, with July 19 designated by the Alaska Department of Fish and Game (ADF&G) as the transition date between summer and fall management seasons. There are 11 sampling periods analyzed for stock composition (Table 1). For the 2009 season, 87% of the chum salmon are from summer run stocks, an increase of 9% from 2008, and 13% from fall run stocks. Within the summer run component, allocations are 86% to the lower river stock group and 14% to the middle river stock group (6% upper Koyukuk and middle mainstem, 8% Tanana). Stock abundance estimates, derived from the products of estimates of the stock composition (Table 1) and Pilot Station sonar passage (Table 2), range from 79,798 – 1,323,259 (Table 3).

Run timing differences among the summer stock groups are apparent. Lower river chum salmon are present throughout the run and are the largest contributing stock (>59%) until the week of July 28 – August 4, one week later than 2008, whereupon their contribution drops to 28%, and the largest contribution then comes from the fall stock group (55%). Tanana River summer chum salmon, like their fall counterpart, are the last to migrate.

Fall chum salmon do not comprise the majority of the run until July 28 to August 4 (Table 1, Figure 3). Based on the fall season management start date of July 19 at Pilot Station, this represents a delayed summer to fall run transition and continues a trend observed since 2006 (Flannery et al. 2008). This may be caused by delayed fall run timing or by a production shift increasing late summer chum salmon returns. The delayed run transition and presence of summer chum salmon well into August are issues that should be addressed by fishery managers in order to sustain overall production and biodiversity.

These results show consistencies and inconsistencies with other data. The presence of summer chum salmon after the switch to fall management is consistent with data from previous studies (Wilmot et al. 1992; ADF&G 2003; Flannery et al. 2007, 2008). However, the stock composition estimate for the upper Koyukuk and middle mainstem appears to be inconsistent with escapement data (ADF&G 2009). Henshaw Creek, a tributary of the upper Koyukuk, had 156,201 summer chum salmon return, but only 79,798 were estimated by genetic MSA and sonar to have returned to upper Koyukuk and middle mainstem region. There is limited escapement monitoring for summer chum salmon, so escapement should be less than sonar abundance, as was the case in 2008 when escapement estimates were much less than genetic MSA and sonar stock abundance estimates (Flannery et al. 2009; ADF&G 2009).

The inconsistencies are likely related to the level of resolution among stocks, the actual stock composition of the run, and sampling error. The Henshaw and Tozitna stocks, in the upper Koyukuk and middle mainstem region, are closely related to lower river stocks (Flannery et al. 2007), with 15% and 11% misallocations to the lower river stock group in MSA simulations, respectively (Table 4). Therefore, upper Koyukuk and middle mainstem stock composition estimates could be significantly biased if these stocks return in greater proportion than more distinct middle river stocks, which appears to have happened when Henshaw returned with a 38% increase over the 5-year average (ADF&G 2009). Though Henshaw and Tozitna fit geographically in the middle river, the 2009 Pilot Station mixture analysis results and MSA simulations (Table 4) indicate that these stocks should be placed in the lower river stock group. Lastly, 46% of the summer run passed Pilot Station sonar in one week (summer stratum 3; Table 2), so sampling error by both the test fishery and the genetic subsampling may have played a role.

The MSA simulations indicate that improved baseline performance is realized with moving Henshaw and Tozitna to the lower river stock group (Table 4). Both Henshaw and Tozitna are 96% accurate to the lower river stock group, a great reduction in misallocation compared to when they are grouped with middle river stocks. Less misallocation is also observed for lower river stocks that are geographically proximate to the middle river, Gisasa and Melozitna. Most other middle river stocks are distinct from Henshaw and Tozitna and are not largely affected by moving Henshaw and Tozitna to the lower river stock group. The exception is the South Fork Koyukuk early run, which has an increase in misallocation resulting from the move. However, the South Fork Koyukuk early run is much smaller than Henshaw (Troyer 1993; Wiswar 1997, 1998; ADF&G 2009), so overall MSA bias would be reduced. Alternatively, a more conservative approach would be to create two summer groups, Tanana and other. This would reduce bias the most and may be appropriate given the management interest in the Tanana terminal fisheries.

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Table 1. 2009 Pilot Station test fishery chum salmon stock composition estimates with associated standard deviations and 95% confidence intervals by stratum and stock group.

	Summer Stratum 1 6/8 – 6/15 Estimate	SD	95% CI		Summer Stratum 2 6/16 – 6/22 Estimate	SD	95% CI	
Summer	0.989	0.014	0.948	1.000	0.990	0.010	0.965	1.000
Lower	0.599	0.090	0.425	0.776	0.933	0.055	0.801	0.995
Middle	0.389	0.090	0.211	0.563	0.056	0.055	0.000	0.190
UppKoy+Main	0.385	0.091	0.205	0.562	0.052	0.055	0.000	0.186
Tanana	0.004	0.011	0.000	0.037	0.004	0.009	0.000	0.031
Fall	0.011	0.014	0.000	0.052	0.010	0.010	0.000	0.035

	Summer Stratum 3 6/23 – 6/29 Estimate	SD	95% CI		Summer Stratum 4 6/30 – 7/6 Estimate	SD	95% CI	
Summer	0.995	0.007	0.976	1.000	0.996	0.005	0.982	1.000
Lower	0.919	0.026	0.861	0.963	0.840	0.070	0.687	0.939
Middle	0.076	0.026	0.031	0.134	0.156	0.070	0.057	0.309
UppKoy+Main	0.010	0.018	0.000	0.064	0.075	0.073	0.000	0.238
Tanana	0.066	0.023	0.023	0.114	0.081	0.025	0.035	0.132
Fall	0.005	0.007	0.000	0.023	0.004	0.005	0.000	0.018

	Summer Stratum 5 7/7 – 7/13 Estimate	SD	95% CI		Summer Stratum 6 7/14 – 7/18 Estimate	SD	95% CI	
Summer	0.966	0.015	0.931	0.990	0.957	0.043	0.848	1.000
Lower	0.814	0.048	0.710	0.894	0.778	0.073	0.619	0.903
Middle	0.152	0.047	0.075	0.257	0.178	0.074	0.057	0.348
UppKoy+Main	0.045	0.046	0.000	0.158	0.036	0.059	0.000	0.211
Tanana	0.107	0.032	0.047	0.173	0.142	0.063	0.025	0.273
Fall	0.034	0.015	0.010	0.069	0.043	0.043	0.000	0.152

Continued

Table 1. Continued

	Fall Stratum 1 7/19 – 7/27				Fall Stratum 2 7/28 – 8/4			
	Estimate	SD	95% CI		Estimate	SD	95% CI	
Summer	0.859	0.053	0.744	0.949	0.447	0.076	0.299	0.595
Lower	0.535	0.098	0.320	0.709	0.277	0.057	0.172	0.390
Middle	0.324	0.098	0.159	0.542	0.170	0.076	0.021	0.325
UppKoy+Main	0.106	0.099	0.000	0.346	0.130	0.084	0.000	0.298
Tanana	0.218	0.069	0.091	0.362	0.040	0.049	0.000	0.161
Fall	0.141	0.053	0.050	0.256	0.553	0.076	0.405	0.701

	Fall Stratum 3 8/5 – 8/14				Fall Stratum 4 8/15 – 8/24			
	Estimate	SD	95% CI		Estimate	SD	95% CI	
Summer	0.122	0.043	0.049	0.218	0.129	0.061	0.031	0.267
Lower	0.049	0.027	0.001	0.106	0.046	0.029	0.003	0.115
Middle	0.072	0.046	0.001	0.176	0.083	0.061	0.000	0.221
UppKoy+Main	0.041	0.041	0.000	0.141	0.077	0.062	0.000	0.217
Tanana	0.031	0.032	0.000	0.105	0.007	0.016	0.000	0.060
Fall	0.878	0.043	0.782	0.951	0.871	0.061	0.733	0.968

	Fall Stratum 5 8/25 – 9/7				Total 6/8 – 9/7			
	Estimate	SD	95% CI		Estimate	SD	95% CI	
Summer	0.065	0.059	0.000	0.217	0.871	0.006	0.860	0.882
Lower	0.027	0.035	0.000	0.121	0.753	0.020	0.714	0.791
Middle	0.037	0.053	0.000	0.186	0.118	0.020	0.079	0.157
UppKoy+Main	0.031	0.050	0.000	0.177	0.053	0.019	0.015	0.090
Tanana	0.006	0.018	0.000	0.063	0.065	0.012	0.042	0.088
Fall	0.936	0.059	0.783	0.999	0.129	0.006	0.118	0.140

Table 2. Pilot Station sonar passage estimates for 2009.

Season	Period	Date	Passage
Summer	Stratum1	6/8 to 6/15	51,148
Summer	Stratum2	6/16 to 6/22	98,691
Summer	Stratum3	6/23 to 6/29	598,198
Summer	Stratum4	6/30 to 7/6	320,904
Summer	Stratum5	7/7 to 7/13	184,864
Summer	Stratum6	7/14 to 7/18	29,401
Fall	Stratum1	7/19 to 7/27	17,408
Fall	Stratum2	7/28 to 8/4	39,726
Fall	Stratum3	8/5 to 8/14	113,802
Fall	Stratum4	8/15 to 8/24	37,708
Fall	Stratum5	8/25 to 9/7	27,247
Total		6/8 to 9/7	1,519,097

Table 3. Stock abundance estimates derived from the products of the genetic stock composition estimates and Pilot Station sonar passage estimates for 2009. The standard deviations and 95% confidence intervals are based on the variances of the genetic estimates only.

	2009 6/8 – 9/7 Estimate	SD	95% CI	
Summer	1,323,259	8,450	1,306,696	1,339,821
Lower	1,143,520	30,091	1,084,541	1,202,499
Middle	178,971	30,450	119,290	238,652
UppKoy+Main	79,798	28,774	23,400	136,196
Tanana	99,108	17,755	64,307	133,908
Fall	195,838	8,451	179,274	212,403

Table 4. Mixed-stock simulation results. Mixtures, representing each stock, were allocated to regional stock groups. Group 1 has Henshaw and Tozitna in the Upper Koyukuk and middle mainstem group. Group 2 has Henshaw and Tozitna in the lower river group.

Gisasa

Group 1	Estimate	Group 2	Estimate
Lower	0.92	Lower	0.99
Middle	0.07	Middle	0.01
UppKoy+Main	0.07	UppKoy	0.00
Tanana	0.00	Tanana	0.00

Melozitna

Group 1	Estimate	Group 2	Estimate
Lower	0.92	Lower	0.98
Middle	0.07	Middle	0.01
UppKoy+Main	0.06	UppKoy	0.01
Tanana	0.01	Tanana	0.01

Henshaw

Group 1	Estimate	Group 2	Estimate
Lower	0.15	Lower	0.96
Middle	0.84	Middle	0.03
UppKoy+Main	0.82	UppKoy	0.01
Tanana	0.02	Tanana	0.02

SF Koyukuk
Early

Group 1	Estimate	Group 2	Estimate
Lower	0.07	Lower	0.14
Middle	0.88	Middle	0.81
UppKoy+Main	0.80	UppKoy	0.73
Tanana	0.08	Tanana	0.08

SF Koyukuk
Late

Group 1	Estimate	Group 2	Estimate
Lower	0.01	Lower	0.03
Middle	0.89	Middle	0.87
UppKoy+Main	0.83	UppKoy	0.82
Tanana	0.06	Tanana	0.06

Continued

Tabel 4. Continued.

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Group 1	Estimate	Group 2	Estimate
Lower	0.01	Lower	0.02
Middle	0.92	Middle	0.90
UppKoy+Main	0.85	UppKoy	0.83
Tanana	0.07	Tanana	0.07

Tozitna

Group 1	Estimate	Group 2	Estimate
Lower	0.11	Lower	0.96
Middle	0.88	Middle	0.02
UppKoy+Main	0.86	UppKoy	0.01
Tanana	0.01	Tanana	0.01

Chena

Group 1	Estimate	Group 2	Estimate
Lower	0.01	Lower	0.02
Middle	0.96	Middle	0.95
UppKoy+Main	0.04	UppKoy	0.03
Tanana	0.92	Tanana	0.92

Salcha

Group 1	Estimate	Group 2	Estimate
Lower	0.01	Lower	0.03
Middle	0.97	Middle	0.95
UppKoy+Main	0.04	UppKoy	0.03
Tanana	0.93	Tanana	0.93

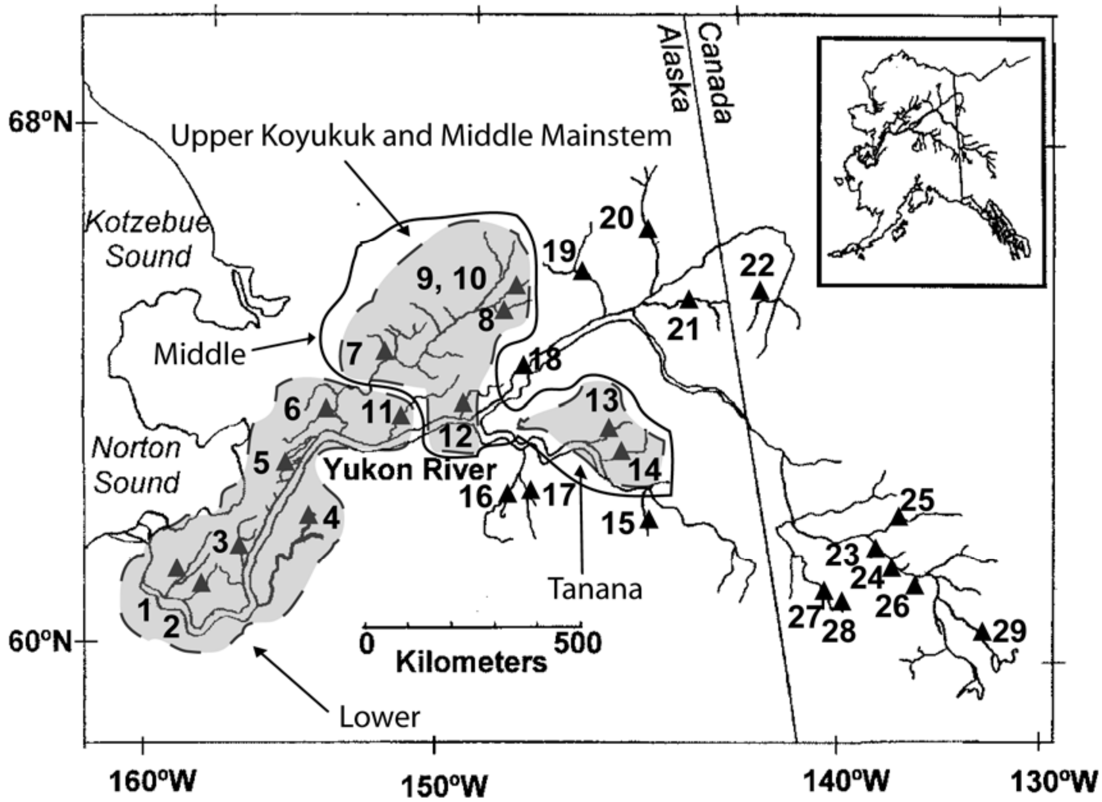

Figure 1. Baseline sampling locations: summer stocks are 1 – 14, and fall stocks are 15 – 29. 1 = Andreafsky, 2 = Chulinak, 3 = Anvik, 4 = California, 5 = Nulato, 6 = Gisasa, 7 =Henshaw, 8 = Jim, 9 = South Fork Koyukuk Early, 10 = South Fork Koyukuk Late, 11 = Melozitna, 12 = Tozitna, 13 = Chena, 14 = Salcha, 15 = Delta, 16 = Kantishna, 17 = Toklat, 18 = Big Salt, 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 summer stock groups. The middle river summer stock group is comprised of the Tanana and upper Koyukuk and middle mainstem and is circled by a solid black line. Fall chum salmon stocks (15 – 29) are not shaded.

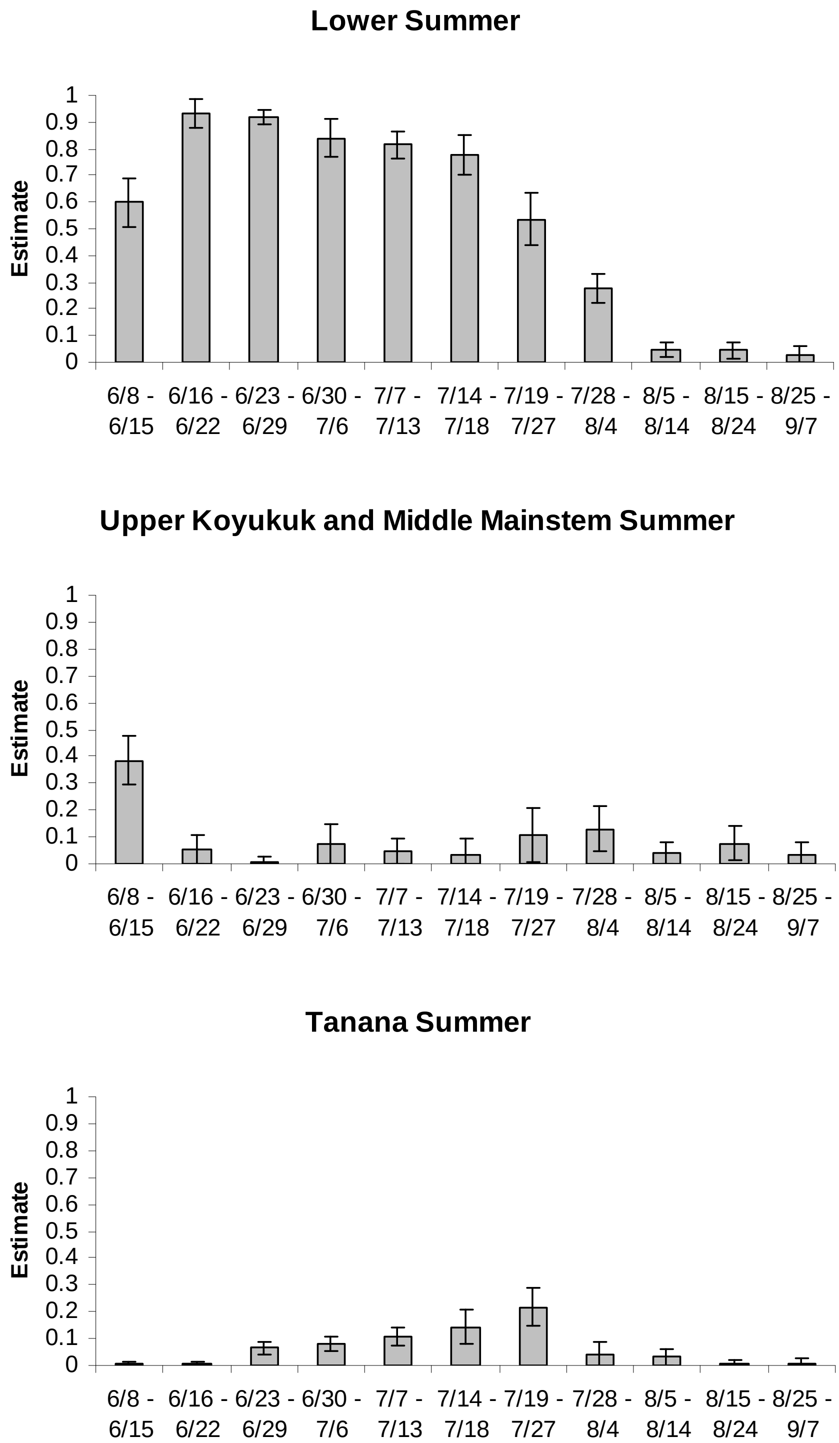

Figure 2. Pilot Station test fishery summer chum salmon stock composition estimates for 2009. Error bars represent one standard error.

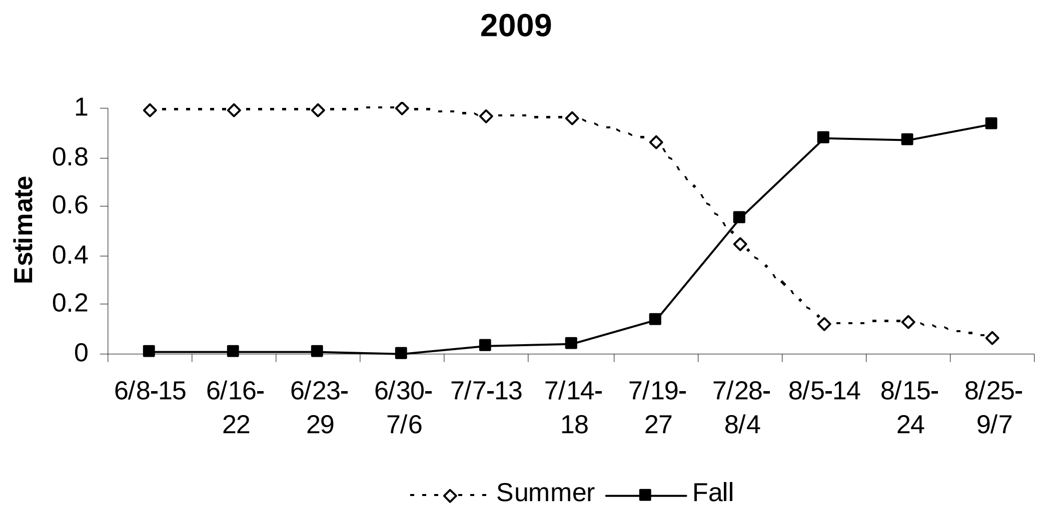

Figure 3. Stock composition estimates for Yukon River summer and fall chum salmon throughout the run.