Yukon River Chum Salmon: Report for Genetic Identification Studies, July 1, 1992-June 30, 1994

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by

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ABSTRACT

In 1987 a joint research effort between Alaska Department of Fish and Game, Canadian Department of Fisheries and Oceans, and U.S. Fish and Wildlife Service was initiated to determine the efficacy of the Genetic Stock Identification (GSI) method for Yukon River chum salmon *Oncorhynchus keta* to aid in U.S./Canada treaty negotiations. This progress report summarizes collection information and allele frequency estimates obtained by the Alaska Department of Fish and Game for Yukon River chum salmon populations sampled in 1991, 1992, and 1993.

Emphasis was placed on improving summer run and Tanana River drainage chum salmon baseline data. The number of potentially discriminating genetic characters was increased from 19 loci (Wilmot et al. 1992) to 31 loci after a screening of 66 loci on all new baseline collections.

Allele frequency estimates show significant heterogeneity between summer and fall run chum salmon, between drainages within a run time, and within the Anvik and Tanana drainages. Temporal stability was observed between populations sampled over multiple years. Incorporation of these data into the existing Yukon River genetic baseline and subsequent mixed fishery analyses is underway.

KEY WORDS: Chum salmon, genetic stock identification, Yukon River

INTRODUCTION

The success of protein electrophoretic data to discriminate stocks of chum salmon *Oncorhynchus keta* has been well documented (Wishard 1980, Kondzela et al. 1989, Shaklee et al. 1990a). As a result, in 1987 a cooperative investigation involving Alaska Department of Fish and Game (ADF&G), U.S. Fish and Wildlife Service (USFWS), and Canadian Department of Fisheries and Oceans (CDFO) was initiated to investigate the potential of Genetic Stock Identification (GSI) techniques to characterize Yukon River chum salmon stocks and to estimate the proportion of Canadian origin fall run chum salmon caught in Yukon River fisheries.

Preliminary results of USFWS data (Wilmot et al. 1992) indicate a strong genetic distinction between summer run and fall run stocks. Genetic relationships among populations generally reflect geographic lines. However, simulation studies suggest that the contribution of Anvik River and Koyukuk River stocks may be underestimated and that fall chum salmon harvests during the summer season may be overestimated when these data are applied to determine the components of in-river mixtures. These results generated concern over the adequacy of the baseline data.

In the early years of the project USFWS was solely responsible for laboratory analyses, with all other agencies contributing to the field collections. In 1990, ADF&G Commercial Fisheries Division (now Commercial Fisheries Management and Development Division, CFMD) established its own genetics laboratory and began contributing to the laboratory analyses of baseline collections.

The initial objective of ADF&G Genetics Laboratory was to improve the existing data set by: 1) adding new populations to the baseline and resampling populations of special concern, and 2) identifying additional genetic markers. This progress report summarizes Yukon River baseline collections made by ADF&G and USFWS staff during the 1991, 1992, and 1993 field seasons and preliminary allele frequency estimates for populations. The report covers work completed during the period July 1, 1992 through June 30, 1994.

METHODS

Populations of fall and summer run chum salmon were sampled in 1991, 1992, and 1993 (Table 1). Approximately 100 spawning adults were collected via beach seine or electroshocker by ADF&G or USFWS personnel. Muscle, liver, heart, and eye tissues were subsampled in the field and placed directly into liquid nitrogen in most cases. Fall run Tanana River stocks were transported whole to the Fairbanks laboratory, stored at -10° C, and then tissues were dissected in the laboratory and placed into liquid nitrogen. All samples were stored at -80° C until analysis.

Protein extracts from muscle, liver, heart, and eye tissues were electrophoresed and protein encoding loci resolved following the methods of Aebersold et al. (1987). Four buffer systems were used: amine-citric acid buffer, pH 6.0, 7.0, and 7.2 (Clayton and Tretiak 1972) modified with EDTA, NAD, or both (Harris and Hopkinson 1976); Tris-citric acid gel, pH 8.7 and lithium hydroxide-boric acid electrode buffer, pH 8.0 (Ridgway et al. 1970); Tris-boric acid-EDTA buffer, pH 8.7 (Boyer et al. 1963); and Tris-glycine pH 8.5 (Holmes and Masters 1970). Genetic nomenclature follows the American Fisheries Society standard (Shaklee et al. 1990b). Photographs were taken to document all protein polymorphisms.

Gels were scored in accordance with chum salmon models adopted by the Coastwide Genetic Stock Identification Consortium (CGSIC). CGSIC is an interagency cooperative with representatives from ADF&G - Anchorage, AK; USFWS - Anchorage, AK; National Marine Fisheries Service (NMFS) - Auke Bay, AK; CDFO - Pacific Biological Station, Nanaimo, BC; NMFS - Seattle, WA; Washington Department of Fisheries (WDF) - Olympia, WA; and University of California - Davis, CA. The goal of the Consortium is to collect and maintain a genetic database on chum salmon and chinook salmon from the Pacific Rim. Alleles are "sponsored" (short reports are distributed describing genetic models and allele coding) by individual laboratories to ensure polymorphic loci are scored identically among cooperating laboratories.

Allele frequencies were calculated and conformation of genotype frequencies to Hardy-Weinberg expected frequencies was tested using likelihood ratios. Isolocus allele frequency (*sAAT-1,2**, *sMDH-B1,B2**) calculations followed the CGSIC standard in which both loci are assumed to vary (one locus with four allelic doses). This differed from prior Yukon River baseline allele frequencies collected for these isoloci (Wilmot et al. 1992). Wilmot et al. (1992) assumes only a single locus varies in the isolocus pair. Average and expected heterozygosities were calculated as measures of genetic variability. Allele frequencies from populations sampled over multiple years were tested for inter-annual heterogeneity using G-statistics (modified from Weir 1990). Populations were pooled if no significant heterogeneity existed.

Nei's (1978) unbiased genetic distance was calculated from two subsets of loci with observed polymorphisms, and a UPGMA phenogram was constructed for each set of distances. We used 15 of 19 polymorphic loci analyzed in Wilmot et al. (1992); four loci were deleted because either the loci have not been accepted by the CGSIC (*bGLUA**, *PEPB-2**, *sMDH-A2**) or were

monomorphic (*TPI-1**). A second tree was constructed using 24 of 35 polymorphic loci detected in our laboratory (Figure 2). Seven loci were deleted from the analysis because polymorphisms were observed in only one population and therefore do not provide power to describe genetic relationships (*sAH**, *CK-A2**, *CK-B**, *sIDHP-1**, *PGM-2**, and *TPI-3**). *CK-A1** and *CK-A2** were also not included in the data analysis; cheek muscle was sampled instead of white skeletal muscle for two populations (Innoko River and Huslia River) and we were not sure if CK expression is homologous among these two tissues. Four additional loci were deleted because they are not approved by the CGSIC (*bGLUA**, *bGALA**) or because of the labile nature of the enzymes (*CK-C2**, *ESTD-2**).

Hierarchical analyses using G-statistics were used to determine if significant population substructuring existed between run times and within and among drainages. The G-statistics were calculated from the same subset of 24 loci used to derive the second UPGMA phenogram. We used $\alpha=0.01$ to take into account potential allele frequency differences due to overlapping generations in Pacific Salmon (Waples and Teel 1990).

Allele frequency estimates and statistical tests were calculated using Windows based applications (Microsoft Windows 3.1) developed by ADF&G Genetics Laboratory.

RESULTS AND DISCUSSION

Baseline Collections

During the 1991, 1992, and 1993 field seasons, ADF&G and USFWS focused sampling effort into adding new baseline collections, particularly for summer run stocks and resampling key stocks. New collections added to the baseline data set for summer run stocks include East Fork Andreafsky River, Innoko River, Huslia River (Koyukuk), and Chena River (Tanana). The West Fork Andreafsky River and Salcha River (Tanana) were resampled to further refine the database.

In the previously existing baseline (Wilmot et al. 1992), the Anvik River was sampled in 1987 and 1988, but for logistical reasons samples were taken in the river mainstem at a sonar station. Significant heterogeneity exists at allele frequencies between years, possibly due to a mixed origin of the individuals sampled in the mainstem. Therefore in 1992 and 1993, five spawning populations were sampled (two in both years) to improve allele frequency estimates for the Anvik drainage.

The Koyukuk River was sampled earlier in the year (July) than in the previous baseline sampling (August). This sampling strategy may have avoided the potential of sampling fall run stocks. In simulation studies done by Wilmot et al. (1992), up to 25% of misallocated Koyukuk chum salmon were designated as fall run, perhaps because fall run fish were inadvertently sampled in previous baseline samples.

The Tanana River mainstem was sampled to augment the fall chum salmon baseline. The Toklat River, Delta River, Bluff Cabin Slough, and Sheenjek River were resampled to refine allele frequency estimates and determine temporal stability of these estimates.

Laboratory Analyses

Gene products of 66 enzyme encoding loci were resolved from muscle, liver, heart, and eye tissues (Table 2). Allele frequency estimates for 30 polymorphic loci and phenotype frequency estimates for one polymorphic locus (only homozygote alternate phenotypes were scored for *PGMr**) were calculated (Table 3). Variant alleles for the following loci were verified against CGSIC standards: *mAAT-1*, *sAAT-3**, *LDH-A1**, *sMDH-A1*200*, *sMDH-B1,B2**, *mMEP-2**, *MPI**, and *PEPB-1**.

We did not collect data on one variant allele, *sMDH-A2*40*, and one polymorphic locus, *PEPB-2**, reported in Wilmot et al. (1992). The genetic inheritance of these markers has not been documented, and they have not yet been approved by CGSIC. However, our data increased the number of useful genetic markers from 19 loci originally scored by USFWS to 31 loci.

Six loci had genotype distributions that did not conform to Hardy-Weinberg expected ($P < 0.05$): *sAAT-3**: Delta River 1992, *ALAT** and *mMEP-2**: E. Fk. Andreafsky River, *mAH-3**,

Beaver River 1992: *MPI**: Toklat River 1992, and *PEPB-1**: Yellow River. No population had more loci out of Hardy-Weinberg than expected by chance and no locus was out of Hardy-Weinberg more frequently than any other. Observed and expected heterozygosities ranged from 0.067 to 0.081 and from 0.065 to 0.077 respectively, with summer run populations generally having increased heterozygosity.

Two UPGMA phenograms using Nei's unbiased genetic distance (Nei 1978) were constructed. Figure 1, derived from 15 loci, was similar to the tree in Wilmot et al. (1992). There was a strong genetic distinction between summer and fall run stocks, and also strong distinction between upper and lower Yukon River summer run stocks. Figure 2, derived from 25 loci, showed subdivision along geographic lines; the major split was not between summer and fall run groups but between upper and lower Yukon River stocks. However, the genetic relationships among fall run populations and the genetic difference between Tanana summer run stocks and lower river summer stocks was conserved in both phenograms.

Hierarchical analyses using likelihood ratios (modified from Weir 1991) were performed to determine at what level allele frequency differences were detectable (α=0.01) (Table 4). Significant allele frequency differences existed between fall and summer run stocks (P=0.000). Among summer run stocks, significant allele frequency differences occurred among drainages (P=0.000), and within the Anvik (P=0.008) and Tanana drainages (P=0.003). No allele frequency heterogeneity occurred among Andreafsky River stocks, or between multiple year samples from Beaver Creek (P=0.167) and Swift River (P=0.180).

Among fall run stocks, significant allele frequency differences occurred among drainages (P=0.000) and within the Tanana River (P=0.000). No overall allele frequency differences were detected between multiple year samples from Toklat River (P=0.309), Delta River (P=0.612), Tanana River mainstem (P=0.418), and Sheenjek River (P=0.114).

These preliminary results suggest that significant stock structure exists in the Yukon River. However, further work needs to be done to determine if any stock groupings can be identified in a mixture.

Objectives for 1994-1995

Our goals for the 1994 fiscal year are: 1) to continue refining the baseline; 2) to merge the USFWS and ADF&G genetic data sets into one comprehensive baseline, and 3) to evaluate the baseline using proof tests and simulations. By early 1995, we expect to present a finalized baseline and define genetic stock groupings of chum salmon in the Yukon River and to what extent these groupings are identifiable in mixtures.

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Table 1. Collection location and laboratory status of chum salmon populations sampled in the Yukon River drainage for genetic stock identification.

Location	N	Year	Analyzed To Date
CHUM SALMON			
Summer Run			
W. Fk. Andreafsky River	100	1993	yes
E. Fk. Andreafsky River	100	1993	yes
Innoko River[1]	88	1993	yes
Anvik River			
Anvik River Sonar	350	1991	no
Beaver Creek	100	1992	yes
Beaver Creek	100	1993	yes
Yellow River	100	1992	yes
Swift River	100	1992	yes
Swift River	100	1993	yes
Otter Creek	100	1993	yes
Canyon Creek	50	1993	yes
Koyukuk River			
Huslia River[1]	100	1993	yes
Tanana River			
Chena River	86	1992	yes
Salcha River	107	1992	yes
Fall Run			
Tanana River			
Toklat River	60	1991	yes
Toklat River	155	1992	yes
Toklat River[2]	200	1993	yes
Delta River	100	1991	yes

Table 1. Continued.

Location	N	Year	Analyzed To Date
Delta River	100	1992	yes
Bluff Cabin Slough	100	1992	yes
Tanana River mainstem	97	1992	yes
Tanana River mainstem	100	1993	yes
Porcupine River			
Sheenjek River	100	1992	yes
Sheenjek River	64	1993	yes

[1] Collected by USFWS.

[2] Not included in analyses.

Table 2. Enzyme loci resolved in Yukon River chum salmon genetic stock identification studies. Buffers and tissues (M = muscle, L = liver, H = heart, and E = eye) used to resolve loci are also given.

Enzyme or Protein	Enzyme Number	Locus	Tissue	Buffer[1]
Aspartate aminotransferase	2.6.1.1	*sAAT-1,2**	H	ACE7.2
		*sAAT-3**	E	TBCL, TG
		*mAAT-1**	H, M	ACE7.2
		*mAAT-2**	L, H	ACN6
Aconitate hydratase	4.2.1.3	*sAH**	L	ACE7.2
		*mAH-1,2**	H	ACE7.2
		*mAH-3**	H	ACE7.2
		*mAH-4**	H	ACE7.2
Alanine aminotransferase	2.6.1.2	*ALAT**	M	TBE
Creatine kinase	2.7.3.2	*CK-A1**	M	TBCL, TG
		*CK-A2**	M	TBCL, TG
		*CK-B**	E	TBCL, TG
		*CK-C1**	E	TG, ACEN7
		*CK-C2**	E	TG, ACEN7
Esterase-D	3.1.1-	*ESTD-1**	H	TBE
		*ESTD-2**	H	TBE
Fructose-biphosphate aldolase	4.1.2.13	*FBALD-3**	E	ACEN7
		*FBALD-4**	E	ACEN7
Fumarate hydratase	4.2.1.2	*FH**	M, H	ACE7.2
beta-N-Acetylgalactosaminidase	3.2.53	*bGALA**	H	ACE7.2

Table 2. Continued.

Enzyme or Protein	Enzyme Number	Locus	Tissue	Buffer[1]
Glyceraldehyde-3-phosphate dehydrogenase	1.2.1.12	*GAPDH-1**	H	ACE7.2
		*GAPDH-2**	H	ACE7.2
		*GAPDH-3**	H	ACE7.2
		*GAPDH-4**	H	ACEN7
		*GAPDH-5**	H	ACEN7
N-acetyl-beta-glucosaminidase	3.2.1.53	*bGLUA**	L	ACE7.2, ACN6
Glycerol-3-phosphate dehydrogenase	1.1.1.8	*G3PDH-1**	H	ACE7.2
		*G3PDH-2**	H	ACE7.2
		*G3PDH-3**	H	ACE7.2
Glucose-6-phosphate isomerase	5.3.19	*GPI-B1,2**	M	TBCL, TG
		*GPI-A**	M	TBCL, TG
beta-Glucuronidase	3.2.1.31	*GUS**	L	TBCL
Hydroxyacylglutathione hydrolase[2]	3.1.2.6	*HAGH**	H	TBE
L-Iditol dehydrogenase	1.1.1.14	*IDDH-1**	L	TBCL
		*IDDH-2**	L	TBCL
Isocitrate dehydrogenase (NADP+)	1.1.1.42	*sIDHP-1**	L	ACE7.2
		*sIDHP-2**	L	ACE7.2
		*mIDHP-1**	M	ACE7.2
		*mIDHP-2**	M	ACE7.2
L-Lactate dehydrogenase	1.1.1.27	*LDH-A1**	M	TBCL, TG

Table 2. Continued.

Enzyme or Protein	Enzyme Number	Locus	Tissue	Buffer[1]
		*LDH-A2**	M	TBCL, TG
		*LDH-B1**	E	TBCL, TG
		*LDH-B2**	E, L	TBCL, TG
		*LDH-C**	E	TBCL, TG
Malate dehydrogenase	1.1.1.37	*sMDH-A1**	L, H	ACN6
		*sMDH-A2**	L, H	ACN6
		*sMDH-B1,2**	H	ACE7.2, AC5.58
		*mMDH-1**	H	ACE7.2
Malic enzyme (NADP+)	1.1.1.40	*sMEP-1**	M	ACE7.2
		*mMEP-1**	M	ACE7.2
		*mMEP-2**	M	ACE7.2
Mannose-6-phosphate isomerase	5.3.1.8	*MPI**	H	TBE
Dipeptidase	3.4.-.-	*PEPA**	M	TBE
Tripeptide aminopeptidase	3.4.-.-	*PEPB-1**	H, L	TBE, AC5.85
Proline dipeptidase	3.4.13.9	*PEPD**	M	ACE7.2
Peptidase-LT	3.4.-.-	*PEP-LT**	L	ACE7.2
Phosphogluconate dehydrogenase	1.1.1.44	*PGDH**	L, H	ACE7.2
Phosphoglucomutase	5.4.2.2	*PGM-1**	H	ACE7.2
		*PGM-2**	H	ACE7.2
Phosphoglycerate kinase	2.7.2.3	*PGK-1**	M	ACE7.2
Superoxide dismutase	1.15.1.1	*sSOD-1**	H	TBE, ACE7.2

Table 2. Continued.

Enzyme or Protein	Enzyme Number	Locus	Tissue	Buffer[1]
Triose-phosphate isomerase	5.3.1.1	*TPI-1**	H, E	TBE, TG
		*TPI-2**	H, E	TBE, TG
		*TPI-3**	H, E	TBE, TG
		*TPI-4**	H, E	TBE, TG
Xanthine oxidase	1.2.3.2	*XO**	L	TBCL

[1] ACE7.2 = amine-citric acid-EDTA buffer, pH 7.2; ACEN7 = amine-citric acid-EDTA-NAD buffer, pH 7; ACN6 = amine-citric acid-NAD buffer, pH 6; AC5.85 = amine-citric acid buffer, pH 5.85; TBCL = Tris-citric acid gel buffer, lithium hydroxide-boric acid electrode buffer, pH 8.5; TG = Tris-glycine buffer, pH 8.5; TBE = Tris-boric acid-EDTA buffer, pH 8.7.

[2] *HAGH** and *FDH** (Formaldehyde dehydrogenase, E.C. 1.2.1.1) appear to be the same locus.

Table 3. Allele frequency estimates for polymorphic loci scored in populations of Yukon River chum salmon.

population \ locus	*mAAT-1**				*mAAT-2*[1]			*sAAT-1,2**			
	(N)	-100	-120	-70	(N)	-100	-145	(N)	100	120	65
E. Fk. Andreafsky R. 1993	100	0.890	0.000	0.110	99	0.722	0.278	99	0.967	0.033	0.000
W. Fk. Andreafsky R. 1993	100	0.900	0.005	0.095	100	0.755	0.245	188	0.965	0.035	0.000
Innoko R. 1993	85	0.882	0.006	0.112	85	0.676	0.324	168	0.952	0.048	0.000
Beaver R. 1992	99	0.929	0.000	0.071	97	0.691	0.309	196	0.967	0.033	0.000
Beaver R. 1993	100	0.885	0.000	0.115	100	0.690	0.310	200	0.967	0.032	0.000
Beaver R. (pooled)	199	0.907	0.000	0.093	197	0.690	0.310	396	0.967	0.033	0.000
Yellow R. 1992	100	0.875	0.000	0.125	95	0.721	0.279	200	0.947	0.052	0.000
Swift R. 1992	100	0.915	0.000	0.085	100	0.715	0.285	196	0.959	0.041	0.000
Swift R. 1993	100	0.925	0.000	0.075	100	0.690	0.310	200	0.950	0.050	0.000
Swift R. (pooled)	200	0.920	0.000	0.080	200	0.702	0.298	396	0.955	0.045	0.000
Otter Cr. 1993	100	0.940	0.000	0.060	99	0.702	0.298	200	0.970	0.030	0.000
Canyon Cr. 1993	50	0.870	0.000	0.130	50	0.770	0.230	100	0.970	0.030	0.000
Huslia R. 1993	99	0.879	0.000	0.121	94	0.665	0.335	198	0.957	0.043	0.000
Chena R. 1992	85	0.929	0.000	0.071	86	0.733	0.267	170	0.965	0.035	0.000
Salcha R. 1992	98	0.903	0.010	0.087	93	0.710	0.290	196	0.969	0.031	0.000
Toklat R. 1991	60	0.942	0.000	0.058	60	0.617	0.383	120	0.925	0.075	0.000
Toklat R. 1992	154	0.909	0.000	0.091	151	0.695	0.305	306	0.923	0.075	0.002
Toklat R. (pooled)	214	0.918	0.000	0.082	211	0.673	0.327	426	0.924	0.075	0.001
Delta R. 1991	100	0.930	0.000	0.070	100	0.685	0.315	200	0.947	0.052	0.000
Delta R. 1992	100	0.950	0.000	0.050	98	0.714	0.286	200	0.930	0.070	0.000
Delta R. (pooled)	200	0.940	0.000	0.060	198	0.699	0.301	400	0.939	0.061	0.000
Bluff Cabin Slough 1992	100	0.930	0.000	0.070	90	0.656	0.344	200	0.962	0.038	0.000
Tanana R. Mainstem 1992	97	0.948	0.000	0.052	93	0.672	0.328	194	0.928	0.072	0.000
Tanana R. Mainstem 1993	100	0.920	0.000	0.080	100	0.710	0.290	200	0.935	0.065	0.000
Tanana R. (pooled)	197	0.934	0.000	0.066	193	0.692	0.308	394	0.931	0.069	0.000
Sheenjek R. 1992	100	0.865	0.000	0.135	96	0.682	0.318	200	0.935	0.065	0.000
Sheenjek R. 1993	63	0.889	0.000	0.111	64	0.781	0.219	128	0.961	0.039	0.000
Sheenjek R. (pooled)	163	0.874	0.000	0.126	160	0.722	0.278	328	0.945	0.055	0.000

Table 3. Continued.

locus / population	*sAAT-3** (N)	100	90	*mAH-3** (N)	100	124	*sAH** (N)	100	96	106
E. Fk. Andreafsky R. 1993	99	0.500	0.500	87	0.448	0.552	100	0.995	0.000	0.005
W. Fk. Andreafsky R. 1993	99	0.444	0.556	84	0.470	0.530	100	1.000	0.000	0.000
Innoko R. 1993	85	0.424	0.576	77	0.513	0.487	85	1.000	0.000	0.000
Beaver R. 1992	76	0.546	0.454	93	0.505	0.495	100	1.000	0.000	0.000
Beaver R. 1993	99	0.470	0.530	97	0.438	0.562	100	1.000	0.000	0.000
Beaver R. (pooled)	175	0.503	0.497	190	0.471	0.529	200	1.000	0.000	0.000
Yellow R. 1992	88	0.369	0.631	99	0.525	0.475	100	1.000	0.000	0.000
Swift R. 1992	90	0.461	0.539	96	0.464	0.536	99	0.995	0.005	0.000
Swift R. 1993	100	0.370	0.630	87	0.397	0.603	100	1.000	0.000	0.000
Swift R. (pooled)	190	0.413	0.587	183	0.432	0.568	199	0.997	0.003	0.000
Otter Cr. 1993	100	0.375	0.625	94	0.431	0.569	100	1.000	0.000	0.000
Canyon Cr. 1993	50	0.480	0.520	46	0.446	0.554	50	1.000	0.000	0.000
Huslia R. 1993	100	0.420	0.580	95	0.489	0.511	99	1.000	0.000	0.000
Chena R. 1992	83	0.380	0.620	84	0.702	0.298	86	1.000	0.000	0.000
Salcha R. 1992	99	0.384	0.616	95	0.726	0.274	100	1.000	0.000	0.000
Toklat R. 1991	60	0.400	0.600	58	0.698	0.302	60	1.000	0.000	0.000
Toklat R. 1992	153	0.350	0.650	150	0.730	0.270	155	1.000	0.000	0.000
Toklat R. (pooled)	213	0.364	0.636	208	0.721	0.279	215	1.000	0.000	0.000
Delta R. 1991	100	0.330	0.670	82	0.872	0.128	100	1.000	0.000	0.000
Delta R. 1992	95	0.368	0.632	76	0.862	0.138	100	1.000	0.000	0.000
Delta R. (pooled)	195	0.349	0.651	158	0.867	0.133	200	1.000	0.000	0.000
Bluff Cabin Slough 1992	97	0.423	0.577	78	0.821	0.179	76	1.000	0.000	0.000
Tanana R. Mainstem 1992	68	0.382	0.618	95	0.868	0.132	97	1.000	0.000	0.000
Tanana R. Mainstem 1993	100	0.345	0.655	99	0.843	0.157	100	1.000	0.000	0.000
Tanana R. (pooled)	168	0.360	0.640	194	0.856	0.144	197	1.000	0.000	0.000
Sheenjek R. 1992	78	0.365	0.635	100	0.705	0.295	100	1.000	0.000	0.000
Sheenjek R. 1993	63	0.389	0.611	63	0.690	0.310	64	1.000	0.000	0.000
Sheenjek R. (pooled)	141	0.376	0.624	163	0.699	0.301	164	1.000	0.000	0.000

Table 3. Continued.

locus / population	*ALAT**			*CK-A1**			*CK-A2**		
	(N)	100	93	(N)	100	114	(N)	100	110
E. Fk. Andreafsky R. 1993	100	0.845	0.155	100	1.995	0.005	100	1.000	0.000
W. Fk. Andreafsky R. 1993	98	0.913	0.087	99	1.000	0.000	99	1.000	0.000
Innoko R. 1993	84	0.875	0.125	100	1.000	0.000	100	1.000	0.000
Beaver R. 1992	98	0.883	0.117	100	1.000	0.000	100	1.000	0.000
Beaver R. 1993	100	0.900	0.100	100	1.000	0.000	100	1.000	0.000
Beaver R. (pooled)	198	0.891	0.109	200	1.000	0.000	200	1.000	0.000
Yellow R. 1992	98	0.872	0.128	99	1.000	0.000	99	0.995	0.005
Swift R. 1992	100	0.905	0.095	99	0.995	0.005	99	1.000	0.000
Swift R. 1993	100	0.920	0.080	100	1.000	0.000	100	1.000	0.000
Swift R. (pooled)	200	0.913	0.087	199	0.998	0.002	199	1.000	0.000
Otter Cr. 1993	100	0.900	0.100	100	1.000	0.000	100	1.000	0.000
Canyon Cr. 1993	50	0.850	0.150	50	1.000	0.000	50	1.000	0.000
Huslia R. 1993	98	0.898	0.102	97	1.000	0.000	97	1.000	0.000
Chena R. 1992	85	0.941	0.059	85	1.000	0.000	85	1.000	0.000
Salcha R. 1992	99	0.975	0.025	100	1.000	0.000	100	1.000	0.000
Toklat R. 1991	60	0.925	0.075	60	1.000	0.000	60	1.000	0.000
Toklat R. 1992	153	0.938	0.062	150	1.000	0.000	150	1.000	0.000
Toklat R. (pooled)	213	0.934	0.066	210	1.000	0.000	210	1.000	0.000
Delta R. 1991	95	0.942	0.058	100	1.000	0.000	100	1.000	0.000
Delta R. 1992	95	0.947	0.053	100	1.000	0.000	100	1.000	0.000
Delta R. (pooled)	190	0.945	0.055	200	1.000	0.000	200	1.000	0.000
Bluff Cabin Slough 1992	100	0.920	0.080	100	1.000	0.000	100	1.000	0.000
Tanana R. Mainstem 1992	97	0.881	0.119	96	1.000	0.000	96	1.000	0.000
Tanana R. Mainstem 1993	100	0.885	0.115	100	1.000	0.000	100	1.000	0.000
Tanana R. (pooled)	197	0.883	0.117	196	1.000	0.000	196	1.000	0.000
Sheenjek R. 1992	100	0.985	0.015	100	1.000	0.000	100	1.000	0.000
Sheenjek R. 1993	64	0.930	0.070	64	1.000	0.000	64	1.000	0.000
Sheenjek R. (pooled)	164	0.963	0.037	164	1.000	0.000	164	1.000	0.000

Table 3. Continued.

locus / populations	*CK-B** (N)	100	97	*ESTD** (N)	100	90	*G3PDH-2** (N)	100	90
E. Fk. Andreafsky R. 1993	100	1.000	0.000	97	0.428	0.572	95	0.816	0.184
W. Fk. Andreafsky R. 1993	100	1.000	0.000	97	0.485	0.515	92	0.804	0.196
Innoko R. 1993	100	1.000	0.000	85	0.541	0.459	85	0.824	0.176
Beaver R. 1992	100	1.000	0.000	100	0.465	0.535	99	0.833	0.167
Beaver R. 1993	100	1.000	0.000	98	0.490	0.510	100	0.915	0.085
Beaver R. (pooled)	200	1.000	0.000	198	0.477	0.523	199	0.874	0.126
Yellow R. 1992	100	0.995	0.005	99	0.470	0.530	100	0.850	0.150
Swift R. 1992	94	1.000	0.000	98	0.474	0.526	97	0.799	0.201
Swift R. 1993	100	1.000	0.000	100	0.495	0.505	100	0.865	0.135
Swift R. (pooled)	197	1.000	0.000	198	0.485	0.515	197	0.832	0.168
Otter Cr. 1993	100	1.000	0.000	100	0.450	0.550	100	0.890	0.110
Canyon Cr. 1993	50	1.000	0.000	50	0.440	0.560	50	0.900	0.100
Huslia R. 1993	100	1.000	0.000	100	0.445	0.555	98	0.847	0.153
Chena R. 1992	86	1.000	0.000	85	0.412	0.588	82	0.774	0.226
Salcha R. 1992	100	1.000	0.000	100	0.455	0.545	97	0.892	0.108
Toklat R. 1991	60	1.000	0.000	60	0.267	0.733	59	0.822	0.178
Toklat R. 1992	153	1.000	0.000	155	0.261	0.739	153	0.846	0.154
Toklat R. (pooled)	213	1.000	0.000	215	0.263	0.737	212	0.840	0.160
Delta R. 1991	100	1.000	0.000	100	0.260	0.740	100	0.835	0.165
Delta R. 1992	99	1.000	0.000	100	0.210	0.790	100	0.850	0.150
Delta R. (pooled)	199	1.000	0.000	200	0.235	0.765	200	0.842	0.157
Bluff Cabin Slough 1992	99	1.000	0.000	100	0.240	0.760	100	0.890	0.110
Tanana R. Mainstem 1992	97	1.000	0.000	96	0.214	0.786	97	0.897	0.103
Tanana R. Mainstem 1993	100	1.000	0.000	100	0.225	0.775	100	0.850	0.150
Tanana R. (pooled)	197	1.000	0.000	196	0.219	0.781	197	0.873	0.127
Sheenjek R. 1992	100	1.000	0.000	100	0.310	0.690	100	0.880	0.120
Sheenjek R. 1993	64	1.000	0.000	64	0.352	0.648	64	0.813	0.188
Sheenjek R. (pooled)	164	1.000	0.000	164	0.326	0.674	164	0.854	0.146

Table 3. Continued.

locus / population	*GAPDH-2** (N)	100	160	75	*GPI-B1,2** (N)	100	145	*IDDH-2** (N)	100	125
E. Fk. Andreafsky R. 1993	100	1.000	0.000	0.000	200	1.000	0.000	98	1.000	0.000
W. Fk. Andreafsky R. 1993	100	0.995	0.000	0.005	200	1.000	0.000	98	1.000	0.000
Innoko R. 1993	85	1.000	0.000	0.000	170	1.000	0.000	85	1.000	0.000
Beaver R. 1992	100	1.000	0.000	0.000	200	1.000	0.000	90	1.000	0.000
Beaver R. 1993	100	1.000	0.000	0.000	200	1.000	0.000	100	1.000	0.000
Beaver R. (pooled)	200	1.000	0.000	0.000	400	1.000	0.000	190	1.000	0.000
Yellow R. 1992	100	1.000	0.000	0.000	192	1.000	0.000	92	0.995	0.005
Swift R. 1992	98	0.990	0.000	0.010	198	1.000	0.000	99	0.990	0.010
Swift R. 1993	100	1.000	0.000	0.000	200	0.998	0.002	100	0.995	0.005
Swift R. (pooled)	198	0.995	0.000	0.005	398	0.999	0.001	199	0.992	0.008
Otter Cr. 1993	100	1.000	0.000	0.000	200	1.000	0.000	100	1.000	0.000
Canyon Cr. 1993	50	1.000	0.000	0.000	100	1.000	0.000	49	1.000	0.000
Huslia R. 1993	99	0.985	0.015	0.000	196	0.997	0.003	97	1.000	0.000
Chena R. 1992	86	1.000	0.000	0.000	170	1.000	0.000	81	1.000	0.000
Salcha R. 1992	97	1.000	0.000	0.000	196	1.000	0.000	93	1.000	0.000
Toklat R. 1991	59	1.000	0.000	0.000	120	1.000	0.000	54	1.000	0.000
Toklat R. 1992	152	1.000	0.000	0.000	304	1.000	0.000	155	1.000	0.000
Toklat R. (pooled)	211	1.000	0.000	0.000	424	1.000	0.000	209	1.000	0.000
Delta R. 1991	100	1.000	0.000	0.000	200	1.000	0.000	100	1.000	0.000
Delta R. 1992	100	1.000	0.000	0.000	200	1.000	0.000	95	1.000	0.000
Delta R. (pooled)	200	1.000	0.000	0.000	400	1.000	0.000	195	1.000	0.000
Bluff Cabin Slough 1992	100	1.000	0.000	0.000	190	1.000	0.000	100	1.000	0.000
Tanana R. Mainstem 1992	97	1.000	0.000	0.000	190	1.000	0.000	97	1.000	0.000
Tanana R. Mainstem 1993	100	1.000	0.000	0.000	200	1.000	0.000	100	1.000	0.000
Tanana R. (pooled)	197	1.000	0.000	0.000	390	1.000	0.000	197	1.000	0.000
Sheenjek R. 1992	100	1.000	0.000	0.000	200	1.000	0.000	100	1.000	0.000
Sheenjek R. 1993	64	1.000	0.000	0.000	128	1.000	0.000	64	1.000	0.000
Sheenjek R. (pooled)	164	1.000	0.000	0.000	328	1.000	0.000	164	1.000	0.000

Table 3. Continued.

locus / population	*mIDHP-1** (N)	100	60	*sIDHP-1** (N)	100	130	*sIDHP-2** (N)	100	35	85	25
E. Fk. Andreafsky R. 1993	100	0.975	0.025	99	1.000	0.000	99	0.434	0.465	0.076	0.025
W. Fk. Andreafsky R. 1993	100	0.995	0.005	100	1.000	0.000	100	0.435	0.485	0.070	0.010
Innoko R. 1993	85	0.982	0.018	85	1.000	0.000	85	0.494	0.441	0.065	0.000
Beaver R. 1992	99	0.990	0.010	99	1.000	0.000	99	0.535	0.379	0.086	0.000
Beaver R. 1993	100	0.985	0.015	100	1.000	0.000	100	0.465	0.460	0.070	0.005
Beaver R. (pooled)	199	0.987	0.013	199	1.000	0.000	199	0.500	0.420	0.078	0.003
Yellow R. 1992	95	0.995	0.005	99	1.000	0.000	99	0.460	0.490	0.051	0.000
Swift R. 1992	100	0.975	0.025	97	1.000	0.000	97	0.490	0.438	0.072	0.000
Swift R. 1993	100	0.980	0.020	100	1.000	0.000	100	0.425	0.500	0.070	0.005
Swift R. (pooled)	200	0.978	0.023	197	1.000	0.000	197	0.457	0.470	0.071	0.003
Otter Cr. 1993	100	0.990	0.010	100	1.000	0.000	100	0.515	0.445	0.040	0.000
Canyon Cr. 1993	50	0.990	0.010	50	1.000	0.000	50	0.600	0.390	0.010	0.000
Huslia R. 1993	100	0.995	0.005	98	1.000	0.000	98	0.480	0.439	0.082	0.000
Chena R. 1992	86	0.913	0.087	84	1.000	0.000	84	0.560	0.369	0.071	0.000
Salcha R. 1992	99	0.985	0.015	99	1.000	0.000	99	0.571	0.364	0.066	0.000
Toklat R. 1991	60	0.925	0.075	60	1.000	0.000	60	0.575	0.383	0.042	0.000
Toklat R. 1992	155	0.977	0.023	155	1.000	0.000	155	0.539	0.416	0.045	0.000
Toklat R. (pooled)	215	0.963	0.037	215	1.000	0.000	215	0.549	0.407	0.044	0.000
Delta R. 1991	100	0.990	0.010	100	1.000	0.000	100	0.540	0.400	0.060	0.000
Delta R. 1992	99	0.995	0.005	100	1.000	0.000	100	0.515	0.455	0.030	0.000
Delta R. (pooled)	199	0.992	0.008	200	1.000	0.000	200	0.527	0.428	0.045	0.000
Bluff Cabin Slough 1992	100	0.990	0.010	100	0.995	0.005	100	0.470	0.490	0.040	0.000
Tanana R. Mainstem 1992	97	1.000	0.000	97	1.000	0.000	97	0.459	0.510	0.031	0.000
Tanana R. Mainstem 1993	100	0.990	0.010	100	1.000	0.000	100	0.525	0.430	0.045	0.000
Tanana R. (pooled)	197	0.995	0.005	197	1.000	0.000	197	0.492	0.470	0.038	0.000
Sheenjek R. 1992	100	0.985	0.015	100	1.000	0.000	100	0.400	0.550	0.050	0.000
Sheenjek R. 1993	64	1.000	0.000	64	1.000	0.000	64	0.336	0.617	0.047	0.000
Sheenjek R. (pooled)	164	0.991	0.009	164	1.000	0.000	164	0.375	0.576	0.049	0.000

Table 3. Continued.

locus / population	*LDH-A1** (N)	100	50	*LDH-B2** (N)	100	12	*sMDH-A1** (N)	100	200	-10
E. Fk. Andreafsky R. 1993	100	0.795	0.205	100	1.000	0.000	100	0.955	0.045	0.000
W. Fk. Andreafsky R. 1993	100	0.835	0.165	100	1.000	0.000	100	0.945	0.045	0.010
Innoko R. 1993	85	0.765	0.235	85	1.000	0.000	85	0.953	0.047	0.000
Beaver R. 1992	99	0.848	0.152	100	0.995	0.005	100	0.975	0.025	0.000
Beaver R. 1993	100	0.800	0.200	100	1.000	0.000	100	0.945	0.055	0.000
Beaver R. (pooled)	199	0.824	0.176	200	0.998	0.002	200	0.960	0.040	0.000
Yellow R. 1992	100	0.835	0.165	98	1.000	0.000	97	0.918	0.082	0.000
Swift R. 1992	100	0.840	0.160	100	1.000	0.000	99	0.949	0.045	0.005
Swift R. 1993	100	0.775	0.225	100	1.000	0.000	100	0.960	0.040	0.000
Swift R. (pooled)	200	0.808	0.192	200	1.000	0.000	199	0.955	0.043	0.003
Otter Cr. 1993	100	0.760	0.240	100	0.995	0.005	100	0.965	0.030	0.005
Canyon Cr. 1993	50	0.860	0.140	50	1.000	0.000	50	0.960	0.040	0.000
Huslia R. 1993	98	0.821	0.179	99	1.000	0.000	99	0.939	0.061	0.000
Chena R. 1992	85	0.765	0.235	86	1.000	0.000	86	0.965	0.035	0.000
Salcha R. 1992	100	0.750	0.250	100	1.000	0.000	99	0.919	0.081	0.000
Toklat R. 1991	60	0.783	0.217	60	1.000	0.000	60	0.958	0.042	0.000
Toklat R. 1992	154	0.711	0.289	155	1.000	0.000	155	0.897	0.103	0.000
Toklat R. (pooled)	214	0.731	0.269	215	1.000	0.000	215	0.914	0.086	0.000
Delta R. 1991	100	0.725	0.275	100	1.000	0.000	99	0.924	0.076	0.000
Delta R. 1992	100	0.685	0.315	100	1.000	0.000	100	0.960	0.040	0.000
Delta R. (pooled)	200	0.705	0.295	200	1.000	0.000	199	0.942	0.058	0.000
Bluff Cabin Slough 1992	100	0.665	0.335	99	1.000	0.000	100	0.965	0.035	0.000
Tanana R. Mainstem 1992	97	0.701	0.299	97	1.000	0.000	97	0.954	0.046	0.000
Tanana R. Mainstem 1993	100	0.735	0.265	100	1.000	0.000	100	0.925	0.075	0.000
Tanana R. (pooled)	197	0.718	0.282	197	1.000	0.000	197	0.939	0.061	0.000
Sheenjek R. 1992	99	0.687	0.313	100	1.000	0.000	100	0.880	0.120	0.000
Sheenjek R. 1993	64	0.750	0.250	64	1.000	0.000	64	0.891	0.109	0.000
Sheenjek R. (pooled)	163	0.712	0.288	164	1.000	0.000	164	0.884	0.116	0.000

Table 3. Continued.

locus		*sMDH-B1,2**				*mMEP-2**			*MPI**		
population	(N)	100	72	50	130	(N)	100	122	(N)	100	94
E. Fk. Andreafsky R. 1993	200	0.995	0.002	0.002	0.000	100	0.805	0.195	98	0.872	0.128
W. Fk. Andreafsky R. 1993	200	0.998	0.002	0.000	0.000	100	0.815	0.185	100	0.890	0.110
Innoko R. 1993	170	1.000	0.000	0.000	0.000	85	0.824	0.176	85	0.871	0.129
Beaver R. 1992	200	0.990	0.010	0.000	0.000	100	0.810	0.190	99	0.828	0.172
Beaver R. 1993	200	0.993	0.007	0.000	0.000	99	0.813	0.187	100	0.880	0.120
Beaver R. (pooled)	400	0.991	0.009	0.000	0.000	199	0.812	0.188	199	0.854	0.146
Yellow R. 1992	200	0.995	0.002	0.000	0.002	100	0.790	0.210	100	0.845	0.155
Swift R. 1992	194	0.992	0.003	0.003	0.003	100	0.800	0.200	98	0.898	0.102
Swift R. 1993	200	0.993	0.005	0.000	0.002	99	0.768	0.232	100	0.860	0.140
Swift R. (pooled)	394	0.992	0.004	0.001	0.003	199	0.784	0.216	198	0.879	0.121
Otter Cr. 1993	200	0.995	0.005	0.000	0.000	100	0.725	0.275	100	0.885	0.115
Canyon Cr. 1993	100	0.995	0.005	0.000	0.000	50	0.870	0.130	50	0.810	0.190
Huslia R. 1993	200	0.998	0.000	0.002	0.000	99	0.808	0.192	95	0.911	0.089
Chena R. 1992	172	0.991	0.009	0.000	0.000	85	0.859	0.141	86	0.924	0.076
Salcha R. 1992	200	0.990	0.010	0.000	0.000	100	0.890	0.110	98	0.954	0.046
Toklat R. 1991	120	1.000	0.000	0.000	0.000	60	0.917	0.083	59	0.847	0.153
Toklat R. 1992	310	0.998	0.002	0.000	0.000	154	0.909	0.091	151	0.864	0.136
Toklat R. (pooled)	430	0.999	0.001	0.000	0.000	214	0.911	0.089	210	0.860	0.140
Delta R. 1991	200	1.000	0.000	0.000	0.000	100	0.890	0.110	100	0.945	0.055
Delta R. 1992	200	1.000	0.000	0.000	0.000	100	0.940	0.060	99	0.934	0.066
Delta R. (pooled)	400	1.000	0.000	0.000	0.000	200	0.915	0.085	199	0.940	0.060
Bluff Cabin Slough 1992	200	1.000	0.000	0.000	0.000	100	0.875	0.125	100	0.890	0.110
Tanana R. Mainstem 1992	194	0.997	0.003	0.000	0.000	97	0.907	0.093	96	0.927	0.073
Tanana R. Mainstem 1993	200	1.000	0.000	0.000	0.000	100	0.940	0.060	100	0.940	0.060
Tanana R. (pooled)	394	0.999	0.001	0.000	0.000	197	0.924	0.076	196	0.934	0.066
Sheenjek R. 1992	200	1.000	0.000	0.000	0.000	100	0.935	0.065	100	0.920	0.080
Sheenjek R. 1993	128	1.000	0.000	0.000	0.000	64	0.953	0.047	63	0.897	0.103
Sheenjek R. (pooled)	328	1.000	0.000	0.000	0.000	164	0.942	0.058	163	0.911	0.089

Table 3. Continued.

locus / population	*PEPA** (N)	100	113	*PEPB-1** (N)	-100	-146	-126	*PEP-LT** (N)	100	85
E. Fk. Andreafsky R. 1993	99	1.000	0.000	100	0.910	0.075	0.015	100	0.965	0.035
W. Fk. Andreafsky R. 1993	100	0.990	0.010	97	0.959	0.031	0.010	99	0.955	0.045
Innoko R. 1993	84	0.994	0.006	85	0.912	0.088	0.000	84	0.958	0.042
Beaver R. 1992	94	1.000	0.000	100	0.910	0.070	0.020	97	0.964	0.036
Beaver R. 1993	100	0.990	0.010	100	0.865	0.115	0.020	100	0.965	0.035
Beaver R. (pooled)	194	0.995	0.005	200	0.887	0.093	0.020	197	0.964	0.036
Yellow R. 1992	100	1.000	0.000	100	0.910	0.075	0.015	94	1.000	0.000
Swift R. 1992	99	0.995	0.005	97	0.902	0.082	0.015	99	0.955	0.045
Swift R. 1993	100	0.995	0.005	100	0.960	0.030	0.010	100	0.990	0.010
Swift R. (pooled)	199	0.995	0.005	197	0.931	0.056	0.013	199	0.972	0.028
Otter Cr. 1993	100	0.995	0.005	100	0.945	0.040	0.015	100	0.980	0.020
Canyon Cr. 1993	50	1.000	0.000	50	0.920	0.080	0.000	50	0.960	0.040
Huslia R. 1993	100	0.995	0.005	88	0.875	0.108	0.017	100	0.975	0.025
Chena R. 1992	82	1.000	0.000	86	0.814	0.151	0.035	86	0.965	0.035
Salcha R. 1992	98	1.000	0.000	100	0.890	0.110	0.000	99	0.960	0.040
Toklat R. 1991	46	1.000	0.000	59	0.780	0.178	0.042	52	0.942	0.058
Toklat R. 1992	153	1.000	0.000	152	0.783	0.194	0.023	155	0.977	0.023
Toklat R. (pooled)	199	1.000	0.000	211	0.782	0.190	0.028	207	0.969	0.031
Delta R. 1991	100	1.000	0.000	100	0.825	0.155	0.020	100	0.965	0.035
Delta R. 1992	100	1.000	0.000	100	0.855	0.115	0.030	100	0.970	0.030
Delta R. (pooled)	200	1.000	0.000	200	0.840	0.135	0.025	200	0.967	0.032
Bluff Cabin Slough 1992	71	1.000	0.000	100	0.805	0.175	0.020	100	0.985	0.015
Tanana R. Mainstem 1992	75	1.000	0.000	97	0.825	0.144	0.031	93	0.973	0.027
Tanana R. Mainstem 1993	100	1.000	0.000	100	0.845	0.145	0.010	99	0.939	0.061
Tanana R. (pooled)	175	1.000	0.000	197	0.835	0.145	0.020	192	0.956	0.044
Sheenjek R. 1992	100	1.000	0.000	100	0.820	0.175	0.005	100	0.960	0.040
Sheenjek R. 1993	64	1.000	0.000	64	0.844	0.148	0.008	64	0.992	0.008
Sheenjek R. (pooled)	164	1.000	0.000	164	0.829	0.165	0.006	164	0.973	0.027

Table 3. Continued.

locus / population	*PGDH** (N)	100	88	*PGMr**[2] (N)	-100	null	*PGM-2** (N)	-100	-117
E. Fk. Andreafsky R. 1993	100	0.950	0.050	100	0.920	0.080	100	1.000	0.000
W. Fk. Andreafsky R. 1993	100	0.975	0.025	100	0.950	0.050	100	1.000	0.000
Innoko R. 1993	85	0.947	0.053	84	0.964	0.036	82	1.000	0.000
Beaver R. 1992	99	0.965	0.035	95	0.937	0.063	98	1.000	0.000
Beaver R. 1993	100	0.950	0.050	100	0.940	0.060	100	1.000	0.000
Beaver R. (pooled)	199	0.957	0.043	195	0.938	0.062	198	1.000	0.000
Yellow R. 1992	100	0.935	0.065	99	0.939	0.061	100	1.000	0.000
Swift R. 1992	100	0.945	0.055	98	0.959	0.041	97	0.995	0.005
Swift R. 1993	100	0.955	0.045	100	0.960	0.040	100	0.995	0.005
Swift R. (pooled)	200	0.950	0.050	198	0.960	0.040	197	0.995	0.005
Otter Cr. 1993	100	0.930	0.070	100	0.920	0.080	100	1.000	0.000
Canyon Cr. 1993	50	0.940	0.060	50	0.960	0.040	50	1.000	0.000
Huslia R. 1993	99	0.965	0.035	100	0.940	0.060	99	1.000	0.000
Chena R. 1992	86	0.965	0.035	85	0.929	0.071	85	1.000	0.000
Salcha R. 1992	100	0.965	0.035	97	0.907	0.093	97	1.000	0.000
Toklat R. 1991	60	0.983	0.017	59	0.949	0.051	59	1.000	0.000
Toklat R. 1992	155	0.981	0.019	149	0.940	0.060	149	1.000	0.000
Toklat R. (pooled)	215	0.981	0.019	208	0.942	0.058	208	1.000	0.000
Delta R. 1991	100	0.945	0.055	98	0.939	0.061	100	1.000	0.000
Delta R. 1992	100	0.925	0.075	80	0.913	0.087	80	1.000	0.000
Delta R. (pooled)	200	0.935	0.065	178	0.927	0.073	180	1.000	0.000
Bluff Cabin Slough 1992	100	0.950	0.050	100	0.910	0.090	100	1.000	0.000
Tanana R. Mainstem 1992	97	0.959	0.041	97	0.907	0.093	96	1.000	0.000
Tanana R. Mainstem 1993	100	0.940	0.060	100	0.920	0.080	100	1.000	0.000
Tanana R. (pooled)	197	0.949	0.051	197	0.914	0.086	196	1.000	0.000
Sheenjek R. 1992	100	0.960	0.040	100	0.940	0.060	100	1.000	0.000
Sheenjek R. 1993	64	0.961	0.039	64	0.938	0.063	64	1.000	0.000
Sheenjek R. (pooled)	164	0.960	0.040	164	0.939	0.061	164	1.000	0.000

Table 3. Continued.

locus / population	(N)	*TPI-3** 100	95
E. Fk. Andreafsky R. 1993	100	1.000	0.000
W. Fk. Andreafsky R. 1993	100	1.000	0.000
Innoko R. 1993	84	1.000	0.000
Beaver R. 1992	50	1.000	0.000
Beaver R. 1993	100	1.000	0.000
Beaver R. (pooled)	150	1.000	0.000
Yellow R. 1992	100	0.995	0.005
Swift R. 1992	91	1.000	0.000
Swift R. 1993	100	1.000	0.000
Swift R. (pooled)	191	1.000	0.000
Otter Cr. 1993	100	1.000	0.000
Canyon Cr. 1993	50	1.000	0.000
Huslia R. 1993	100	1.000	0.000
Chena R. 1992	85	1.000	0.000
Salcha R. 1992	100	1.000	0.000
Toklat R. 1991	60	1.000	0.000
Toklat R. 1992	155	1.000	0.000
Toklat R. (pooled)	215	1.000	0.000
Delta R. 1991	100	1.000	0.000
Delta R. 1992	91	1.000	0.000
Delta R. (pooled)	191	1.000	0.000
Bluff Cabin Slough 1992	100	1.000	0.000
Tanana R. Mainstem 1992	97	1.000	0.000
Tanana R. Mainstem 1993	100	1.000	0.000
Tanana R. (pooled)	197	1.000	0.000
Sheenjek R. 1992	100	1.000	0.000
Sheenjek R. 1993	64	1.000	0.000
Sheenjek R. (pooled)	164	1.000	0.000

[1]A third allele (*-*90*) was observed, but was pooled with *-*100*.
[2]These are phenotypic frequencies for a null allele expressed at PGM-1*.

Table 4. Heterogeneity analyses between run times and between and within drainages for chum salmon populations sampled in the Yukon River.

Source of Variation	Likelihood ratio	df	*P*
Between Run Times	890.66	34	0.000
Among Summer Run Stocks			
Among Drainages (Andreafsky/Innoko/Anvik/Koyukuk/Tanana)	335.51	136	0.000
Within Drainages			
Andreafsky River (W. Fk. Andreafsky/E. Fk. Andreafsky)	31.40	27	0.255
Anvik River (Beaver/Yellow/Swift/Otter/Canyon)	160.53	120	0.008
Between Year			
Beaver Creek (1992/1993)	30.56	24	0.167
Swift Creek (1992/1993)	35.78	29	0.180
Tanana River (Chena/Salcha)	44.72	22	0.003
Among Fall Run Stocks			
Among Drainages (Tanana/Porcupine)	93.58	22	0.000
Within Drainages			
Tanana River (Toklat/Delta/Bluff Cabin/Tanana Mainstem)	149.60	66	0.000
Between Year			
Toklat River (1991/1992)	24.75	22	0.309
Delta River (1991/1992)	17.63	20	0.612

Table 4. Continued.

Source of Variation	Likelihood ratio	df	*P*
Tanana River Mainstem (1992/1993)	21.68	21	0.418
Porcupine River			
Between Year			
Sheenjek River (1992/1993)	27.81	20	0.114

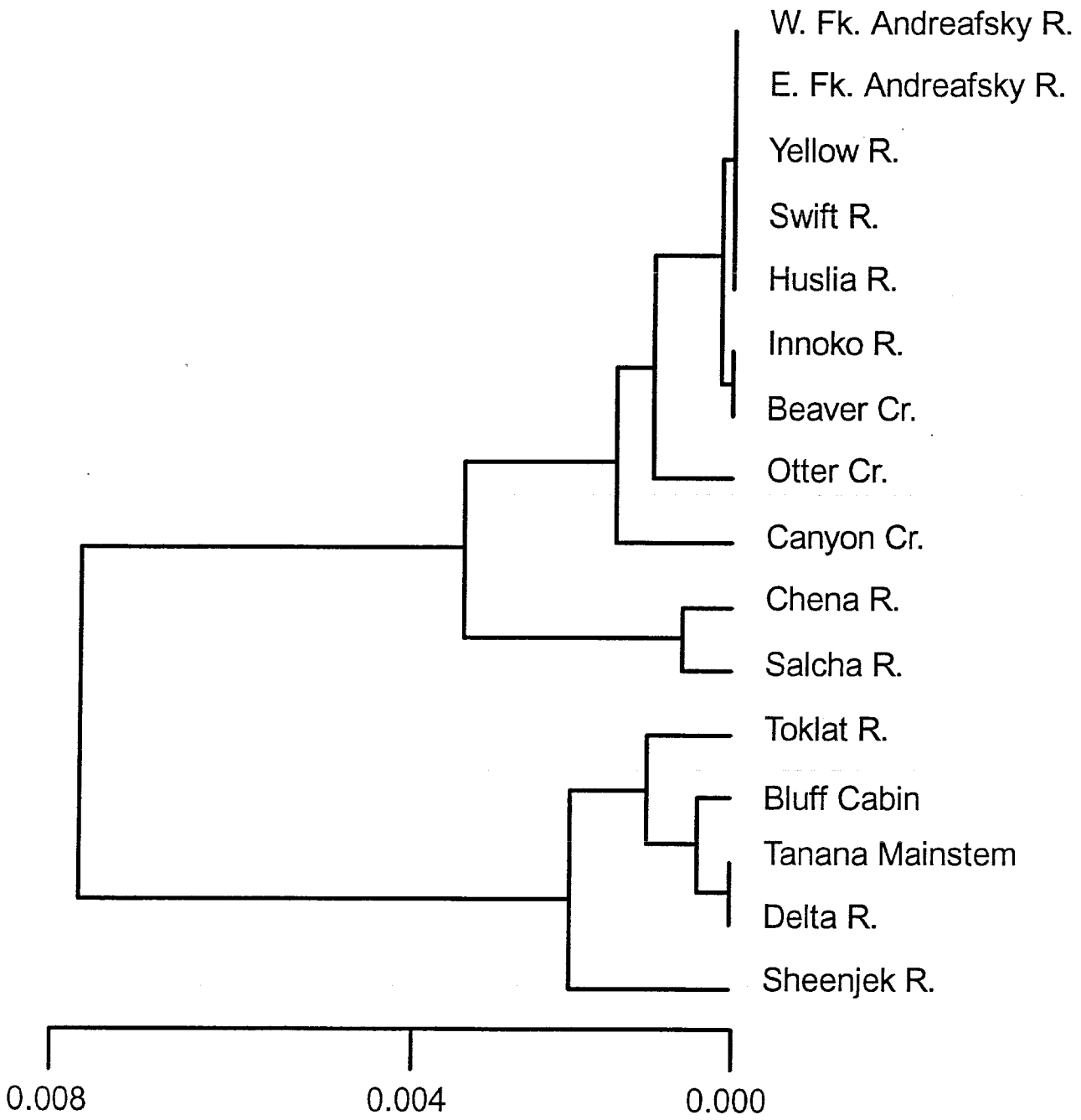

Figure 1. UPGMA tree derived from Nei's (1978) unbiased distance calculated from 15 polymorphic loci.

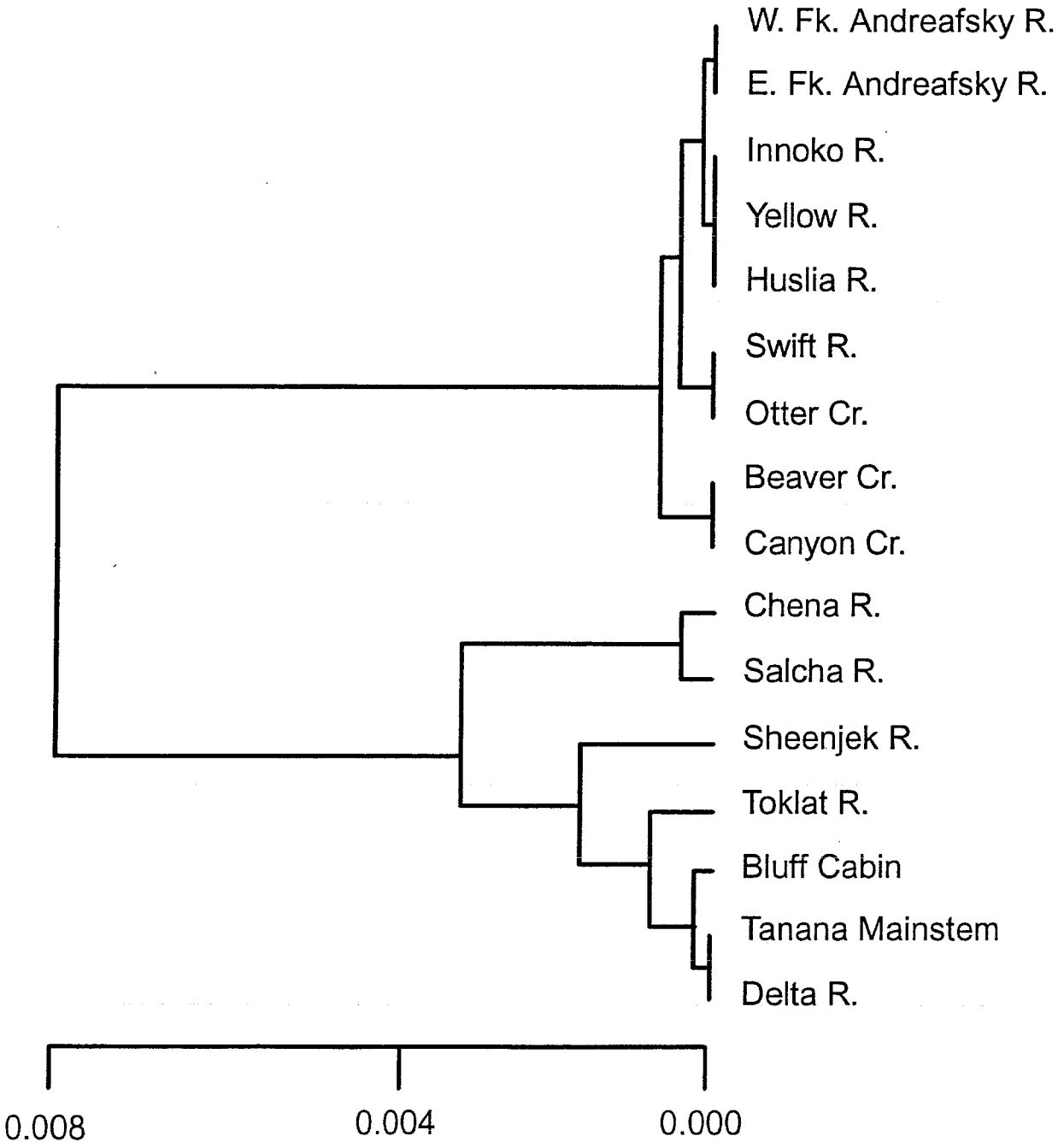

Figure 2. UPGMA tree derived from Nei's (1978) unbiased distance calculated from 24 polymorphic loci.

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