Fishery Data Series No. 11-21

Genetic Stock Composition of the Commercial Harvest of Sockeye Salmon in Bristol Bay, Alaska, 2009

by

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July 2011

Alaska Department of Fish and Game **Divisions of Sport Fish and Commercial Fisheries**

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Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
milliliter	mL
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
nautical mile	nmi
ounce	oz
pound	lb
quart	qt
yard	yd

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
degrees kelvin	K
hour	h
minute	min
second	s

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity (negative log of)	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

Alaska Administrative Code	AAC
all commonly accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.
all commonly accepted professional titles	e.g., Dr., Ph.D., R.N., etc.
at	@
compass directions:	
east	E
north	N
south	S
west	W
copyright	©
corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
District of Columbia	D.C.
et alii (and others)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.
Federal Information Code	FIC
id est (that is)	i.e.
latitude or longitude	lat. or long.
monetary symbols (U.S.)	$, ¢
months (tables and figures): first three letters	Jan,...,Dec
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S.C.	United States Code
U.S. state	use two-letter abbreviations (e.g., AK, WA)

Mathematics, statistics

all standard mathematical signs, symbols and abbreviations	
alternate hypothesis	H_A
base of natural logarithm	*e*
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	(F, t, χ^2, etc.)
confidence interval	CI
correlation coefficient (multiple)	R
correlation coefficient (simple)	r
covariance	cov
degree (angular)	°
degrees of freedom	df
expected value	*E*
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	$\log_2$, etc.
minute (angular)	'
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
variance	
population	Var
sample	var

FISHERY DATA SERIES NO. 11-21

GENETIC STOCK COMPOSITION OF THE COMMERCIAL HARVEST OF SOCKEYE SALMON IN BRISTOL BAY, ALASKA, 2009

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July 2011

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This document should be cited as:
Dann, T. H., C. Habicht, H. A. Hoyt, T. T. Baker, and F. W. West. 2011. Genetic stock composition of the commercial harvest of sockeye salmon in Bristol Bay, Alaska, 2009. Alaska Department of Fish and Game, Fishery Data Series No. 11-21, Anchorage.

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TABLE OF CONTENTS

Page

TABLE OF CONTENTS (Continued)

LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES (Continued)

LIST OF APPENDICES

LIST OF APPENDICES (Continued)

ABSTRACT

Bristol Bay Management Area supports the largest sockeye salmon *Oncorhynchus nerka* fishery in the world. Alaska Department of Fish and Game is responsible for managing fisheries under the sustained-yield principle. Sockeye salmon stocks in Bristol Bay can be exploited at rates up to 80%, so accurately estimating the stock composition of catch is critical to determining the total run (catch and escapement) of each stock. Accurate estimates of total runs are vital for managing under the sustained-yield principle because they provide the basis for establishing and meeting escapement goals. In recent years, the department has developed a genetics program for sockeye salmon in Bristol Bay to develop and apply genetics methods to identify the stock composition of commercial catch in the five commercial fishing districts. Here we present genetic results from 2009, compare them to results from 2006 through 2008, and to those based on traditional age-based methods. Similar to past years, the majority of sockeye salmon harvested in the Bristol Bay commercial fishery originated from rivers in the management area in which they were harvested (>99%). A similar number of North Peninsula (~21,000), but fewer Kuskokwim fish (~97,000), were harvested in 2009 than in 2006–2008. The stock composition of the 2009 commercial harvest of sockeye salmon in the five districts was generally similar to past years. Estimates of inshore run based upon the traditional and genetic methods were similar for some stocks in 2009 (Togiak, Nushagak, Wood, Naknek, and Egegik; differences <10%) and differed for others (Igushik, Alagnak, Kvichak, and Ugashik; differences >10%). All stocks, with the exception of Nushagak, have been over- and under-estimated by more than 10% using the age-based methods compared to genetic methods sometime during the past four years.

Key words: Pacific salmon, *Oncorhynchus nerka*, sockeye salmon, harvest, catch, allocation, commercial fishery, stock, composition, genetics, populations, mixed stock analysis, MSA, Bristol Bay, Kvichak River, Alagnak River, Naknek River, Egegik River, Ugashik River, Wood River, Igushik River, Nushagak River, Togiak River.

INTRODUCTION

Bristol Bay Management Area supports the largest sockeye salmon *Oncorhynchus nerka* fishery in the world. It encompasses all coastal and inland waters from Cape Menshikof to Cape Newenham (Figure 1). Commercial harvests of sockeye salmon have occurred since the 1880s and, since 1956, have ranged in size from 760 thousand in 1973 to 45 million fish in 1995. The average harvest during 2006 through 2009 was approximately 29.2 million fish (Morstad et al. 2010). Almost 50% of all of the sockeye salmon produced in the world originate from Bristol Bay drainages alone (Eggers and Irvine 2007; Bugaev et al. 2008). A key to the success of the sustainability of Bristol Bay sockeye salmon and the fisheries that depend on them has been the conservation of biodiversity, which is derived from a wide variety of life history types and multiple distinct, locally adapted populations (Hilborn et al. 2003; Schindler et al. 2010). Numerous discrete populations of sockeye salmon have been identified within each of the drainages in Bristol Bay (Habicht et al. 2007; Dann et al. 2009).

Alaska Department of Fish and Game (ADF&G), Division of Commercial Fisheries (DCF), is responsible for managing the commercial fisheries in Bristol Bay under the sustained-yield principle. The sustained-yield principle requires an understanding of the relationship between the number of fish that spawn in a drainage and the number of their offspring that make it to adulthood (i.e., brood table). The numbers of fish that escape into the drainages in Bristol Bay are counted by the department using counting towers or hydroacoustics (sonar). The number of offspring that return (i.e., total run) is calculated by adding number of spawners and number of fish harvested before reaching their spawning grounds. These calculations are done on a stock-by-stock basis. Accurately estimating the stock composition of catch within the fishing districts is critical to determining the total run of each stock, especially considering that sockeye salmon

stocks in Bristol Bay can be exploited at rates up to 80% and that two districts straddle multiple drainages and therefore catch multiple stocks (Figure 1).

ADF&G's traditional method to allocate the harvest to each stock is based upon age composition estimates from the harvest and escapement, run timing, and escapement strength (Bernard 1983). This method assumes that the stocks present in a district are equally exploited. This assumption is often not correct (Baker et al. 2006; Dann et al. 2009). Violating this assumption causes underestimation of productivity for some stocks and overestimation of productivity for others. In addition, although most of the catch in the single-drainage districts (Ugashik, Egegik, and Togiak districts) are assumed to be fish from those drainages, estimates of interceptions of stocks outside their district of origin, based on differences in scale growth patterns (Menard and Miller 1997) and genetic markers (Dann et al. 2009), have shown that this is not always true.

In recent years, ADF&G has developed a genetics program for sockeye salmon in Bristol Bay. The primary goal of the Bristol Bay genetics program was to develop and apply genetic methods to identify the stock composition of mixtures (mixed stock analysis; MSA). These methods were first applied to the Port Moller test fishery project (Flynn and Hilborn 2004), where timely genetic stock composition estimates have improved the usefulness of the Port Moller test fishery by providing managers with stock composition estimates for migrating fish prior to their arrival at the fishing districts within Bristol Bay.

The primary application of sockeye salmon MSA in Bristol Bay is to estimate the stock composition of the commercial harvest. Estimates for the 2006–2008 commercial harvest have previously been released (Dann et al. 2009). That study represented the most comprehensive investigation of stock composition of sockeye salmon captured in commercial fishing districts within Bristol Bay and was based upon a sampling design that not only included all districts, but was also stratified by subdistricts, fishing gear, and temporally segregated sampling within years. The stock composition estimates from these strata were applied to the harvest to estimate stock-specific harvest by strata, then combined strata within districts to produce districtwide stock-specific harvest, and finally, combined all districts to come up with total stock-specific harvest for the Bristol Bay sockeye salmon fishery. This method provided a means to investigate where and when fish from each stock were harvested in every district and will eventually provide the basis to reevaluate brood tables and escapement goals for all sockeye salmon stocks within Bristol Bay.

Over 99% of sockeye salmon harvested in Bristol Bay were produced from rivers within Bristol Bay in 2006, 2007, and 2008, and the majority of the sockeye salmon harvested within each district originated from rivers within the same district (i.e., local stock; Dann et al. 2009). When nonlocal stocks were in the harvest within a district, they usually came from rivers in adjacent districts. Eastside sockeye salmon stocks (stocks draining into Ugashik, Egegik, and Naknek/Kvichak districts; Figure 1) were rarely observed in Westside fisheries (Nushagak and Togiak districts) and vice versa (<1%; Dann et al. 2009). However, stock composition estimates were highly variable through space and time both among and within districts. Traditional estimates of inshore run were sometimes greater and sometimes less than estimates of inshore run based upon genetic stock composition estimates for some stocks, but showed consistent trends for others. For example, inshore run estimates based upon the traditional method for the Ugashik, Naknek, and Alagnak stocks were greater than estimates based upon genetic stock composition in some years and less in others. But inshore runs for the Egegik, Nushagak, Igushik, and Togiak stocks were overestimated by the traditional method in all three study years,

while Kvichak and Wood River stocks were consistently underestimated. However, the magnitude of these differences has varied considerably among years. Special harvest areas in the Egegik and Naknek-Kvichak districts were found to be an effective management tool for reducing the harvest of nonlocal stocks.

This report documents a continuation of the MSA of the commercial harvest of 2006–2008 described by Dann et al. (2009). We apply the same baseline and methodology described previously to the 2009 commercial harvest, which was sampled similarly based upon the same experimental design. In doing so, we report the continuation of ADF&G's effort to improve its understanding of stock productivity via accurate and precise estimates of stock-specific harvest in the Bristol Bay commercial sockeye salmon fishery.

DEFINITIONS

To reduce confusion associated with the methods, results, and interpretation of this study, basic definitions of commonly used genetic and salmon management terms are offered here.

Allele. Alternative form of a given gene or DNA sequence.

Bootstrapping. A method of resampling data with replacement to assess the variation of parameters of interest.

Brood (year). All salmon in a stock spawned in a specific year.

Credibility Interval. In Bayesian statistics, a credibility interval is a posterior probability interval. Credibility intervals are a direct statement of probability: i.e., a 90% credibility interval has a 90% chance of containing the true answer. This is different than the confidence intervals used in frequentist statistics.

District. Waters open to commercial salmon fishing. Commercial fishing districts, subdistricts and sections in Bristol Bay are defined in 5 AAC 06.200.

Escapement (or Spawning Abundance or Spawners). The annual estimated size of the spawning salmon stock; quality of escapement may be determined not only by numbers of spawners, but also factors such as sex ratio, age composition, temporal entry into the system, and spatial distribution with the salmon spawning habitat (from 5 AAC 39.222(f)).

F_{ST}. Fixation index, estimates the reduction in heterozygosity due to random genetic drift among populations; the proportion of the variation at a locus attributable to divergence among populations.

Gametic Disequilibrium. A state that exists in a population when alleles at different loci are not distributed independently in the population's gamete pool, often because the loci are physically linked.

Genetic Marker. A known DNA sequence that can be identified by a simple assay.

Genotype. The set of alleles for one or more loci for an individual.

Hardy-Weinberg Equilibrium (H-W). The genotype frequencies that would be expected from given allele frequencies assuming: random mating, no mutation (the alleles don't change), no migration or emigration (no exchange of alleles between populations), infinitely large population size, and no selective pressure for or against any traits.

Harvest. The number or weight of salmon taken from returning salmon prior to escapement as a result of fishing activities.

Harvest Rate. The fraction of returning salmon harvested.

Heterozygosity. The proportion of individuals in a population that are heterozygous at a particular marker; a measure of variability.

Locus (plural, Loci). A fixed position or region on a chromosome.

Linked Markers. Markers showing gametic disequilibrium.

Mixed Stock Analysis (MSA). A method that uses genetic information from populations and from harvest samples to estimate stock compositions of the harvest.

Population. A locally interbreeding group that has little interbreeding with other spawning aggregations other than the natural background stray rate, is uniquely adapted to a spawning habitat, and has inherently unique attributes (Ricker 1958) that result in different productivity rates (Pearcy 1992; NRC 1996). This population definition is analogous to the spawning aggregations described by Baker et al. (1996) and the demes by NRC (1996).

Reporting Group. A group of populations in a genetic baseline to which portions of a mixture are allocated during MSA. Groups are constructed based on a combination of management needs and genetic distinction and may be analogous to *stocks*. See definition for *Salmon Stock* for a breakdown of reporting groups (stocks) in Bristol Bay.

Run. The total number of salmon of a stock surviving to adulthood and returning to the vicinity of the natal stream in any calendar year. The annual run is composed of both the harvest of adult salmon and the escapement in any calendar year. With the exception of pink salmon, the run is composed of several age classes of mature fish from the stock, derived from the spawning of a number of previous brood years (from 5 AAC 39.222(f)).

Single Nucleotide Polymorphism (SNP). DNA sequence variation occurring when a single nucleotide (A, T, C, or G) at a specific locus differs among individuals or within an individual between paired chromosomes.

Salmon Stock. A locally interbreeding group of salmon (population) that is distinguished by a distinct combination of genetic, phenotypic, life history, and habitat characteristics or an aggregation of 2 or more interbreeding groups (populations) which occurs within the same geographic area and is managed as a unit (from 5 AAC 39.222(f)). For purposes of this study, a "stock" in Bristol Bay has been defined as a composite of all populations within each of the 9 major rivers within Bristol Bay and 2 for the adjacent regions (North Peninsula, Kuskokwim) that represent other populations that might be observed in Bristol Bay.

OBJECTIVES

1. Develop a baseline consisting of SNP allele frequencies from all major populations of sockeye salmon in Bristol Bay, North Peninsula, and Kuskokwim Bay and test the baseline's representation of the genetic diversity of the region and the baseline's ability to distinguish among stocks;
2. Provide postseason estimates of stock compositions of sockeye salmon harvested in commercial salmon fisheries by district within Bristol Bay.

METHODS

COMMERCIAL HARVEST AND ESCAPEMENT

Commercial Harvest

Commercial harvests in numbers of salmon, by district, were taken from summaries of fish tickets (sales receipts given to fishermen from buyers at the time of delivery). The final harvest numbers used for this report were from the final fish ticket reports compiled by ADF&G as of May 30, 2010.

Escapement

Bristol Bay salmon escapements were estimated with various methods (including counting towers and sonar) by DCF personnel. Sockeye salmon escapement estimates were based on visual counts made from counting towers on the banks of the Ugashik, Egegik, Naknek, Alagnak, Kvichak, Wood, Igushik, and Togiak rivers. At all tower projects, counts were made for 10 minutes every hour on each riverbank. Counting began on one bank at the start of each hour, followed by counting on the opposite bank. Each 10-minute count was expanded into an hourly estimate (x6) and these were added together to arrive at a total daily escapement (West et al. 2009). Side-looking sonar located in the lower Nushagak River near Portage Creek was used to estimate salmon escapements for the entire Nushagak River drainage (Brazil 2008).

TISSUE SAMPLING

Baseline and Escapement Sampling

We used the same baseline for all analyses reported in this study as was used to estimate the stock composition of the commercial harvest of sockeye salmon from 2006 to 2008 (described by Dann et al. 2009). As a result, all baseline and escapement samples used for single nucleotide polymorphism (SNP) analyses were the same as reported in Appendix A and Table 2, respectively, of Dann et al. (2009).

District Catch Sampling

Axillary processes were collected from individual salmon sampled from the commercial harvest in each district in the same manner as in 2006–2008 (Dann et al. 2009). Briefly, axillary processes collected from sockeye salmon were placed into 48-well trays (with 5 ml wells) filled with ethanol as part of the regular ASL catch sampling program. In general, we collected samples from sockeye salmon in the harvest in each district from June 20 to July 20. Sampling was conducted to be representative of the harvest in each district. District-specific time period strata were identified postseason that best represented different fishing areas, fishing times, tidal conditions, and/or fishing methods that might affect stock composition of the catch. A minimum target sample size of 190 fish was used for each analyzed district-period stratum and was constructed in proportion to the preliminary harvest estimates occurring on each day included in the stratum. In cases where inadequate numbers of samples were available for analysis on a given day within a stratum, all the samples collected that day were analyzed and the remainder (number selected minus number available) was selected from other days within the same stratum where adequate numbers of samples were available. These additional samples were selected from adjacent days. In the absence of genetic error, a sample size of 190 should provide estimates within 7% of its true value 90% of the time, based on the "worst-case" parameter value

for the multinomial distribution (Thompson 1987). Multiple periods may be combined within districts to produce overall stock composition estimates with tighter confidence intervals (e.g., N=380: within 5%, 90% of the time). Preliminary harvest estimates were used to select the number of samples to analyze. However, final harvest estimates were used in the genetic stock composition analysis and are presented in this report.

LABORATORY ANALYSIS

Assaying Genotypes

Genomic DNA was extracted using a DNeasy® 96 Tissue Kit by QIAGEN® (Valencia, CA). The same 45 sockeye salmon SNP markers assayed in the 2006–2008 samples were assayed in the 2009 samples; 3 mitochondrial and 42 nuclear DNA (Dann et al. 2009).

For some baseline collections, SNP genotyping was performed in 384-well reaction plates using the Applied Biosystems system described by Dann et al. (2009). For the remainder of the baseline collections and the 2009 district harvest samples, SNP genotyping was accomplished using the Fluidigm 48.48 Dynamic Array technology described by Dann et al. (2009). Genotypes collected from both instruments were entered into the GCL Oracle database, LOKI.

Laboratory Failure Rates and Quality Control

Overall failure rate was calculated by dividing the number of failed single-locus genotypes by the number of assayed single-locus genotypes.

Quality control measures were instituted to identify laboratory errors and to determine the reproducibility of genotypes. The process involved the reanalysis of 8 out of every 96 fish (one row per 96-well plate; approximately 8%) for all markers by staff not involved with the original analysis. Assuming that the inconsistencies among analyses were due equally to errors in original genotyping and errors during the quality control, error rates in the original genotyping can be estimated as ½ the rate of inconsistencies.

STATISTICAL ANALYSIS

Data Retrieval and Quality Control

We followed the same data retrieval and quality control analyses reported by Dann et al. (2009). Briefly, two quality control measures were conducted once genotypes were retrieved from LOKI. The first identified and excluded duplicate fish (defined as identical at 38 or more loci out of 45 loci) within collections. The second excluded mixture individuals with an excessive rate of unscorable markers, or dropouts, based upon the "80% rule" (i.e., missing genotypes for 20% or more of assayed markers).

Baseline Development

We used the same baseline to analyze 2009 commercial harvest samples as was used to analyze the 2006–2008 samples. The development of this baseline was described by Dann et al. (2009). Briefly, we validated population genetic assumptions (i.e., Hardy-Weinberg expectations and gametic linkage equilibrium), tested collections from geographically proximate locations and from similar locations in different years for homogeneity and pooled them when they were found not different from one another, tested the temporal stability of allele frequencies with a 3-level Analysis of Variance (ANOVA), and visualized genetic distances between pairs of populations

on genetic trees. We assessed the baseline's ability to identify the 11 reporting groups for MSA applications with proof tests and escapement samples.

Mixed Stock Analyses

We estimated stock composition of all 2009 district-time strata mixtures using the same BAYES protocol described by Dann et al. (2009) for the 2006–2008 mixtures, except for some changes to the definition of prior parameters for the first time stratum in a district. For 2009 mixtures, we used 2008 weighted total stock composition estimates identified in Table 13 of Dann et al. (2009), except for the prior parameters for Kvichak Section Set strata. For the first 2009 Kvichak Section Set stratum, we used the stock composition estimates from the 2008 Kvichak Section Set mixture (Appendix D9, Period 7; Dann et al. 2009) as the prior parameters. We believed that these estimates provided the best available informative prior parameters.

Prior parameters could not be less than 0.01 for any stock included in the analyses. As a result, prior parameters were set at 0.01 for stocks with informative estimates below 0.01, and for stocks considered to be from outside areas (e.g., Westside stocks in Eastside districts and Eastside stocks in Westside districts). Other than these changes to the initial time strata prior parameter definitions, prior parameters for the 2009 time strata were defined by the same "step-wise" protocol described by Dann et al. (2009): for subsequent time strata within the same district, the priors were the posterior means (i.e., the stock composition estimates) of the previous time stratum.

Inshore Run Size

We calculated inshore run size for each stock in the same manner as described by Dann et al. (2009). Briefly, harvest estimates and confidence intervals for each temporal stratum were calculated by multiplying the harvest from that stratum by its unrounded reporting group stock proportion estimate and upper and lower 90% bounds. Temporal strata were combined within districts into yearly estimates by weighting them by their respective harvests. Confidence intervals for the overall harvest of each stock in a district was estimated via Monte Carlo by re-sampling 100,000 draws of the posterior output from each of the constituent temporal strata and applying the harvest to the draws.

RESULTS

COMMERCIAL HARVEST AND ESCAPEMENT

Combined inshore harvest and escapement of sockeye salmon in Bristol Bay was 40,435,832 in 2009 (Table 1). A total of 30,887,279 sockeye salmon were commercially harvested in 2009. Sockeye salmon were harvested in Naknek-Kvichak (8,514,944), Egegik (11,527,462), Nushagak (7,730,168), Ugashik (2,555,263), and Togiak (559,442) districts. The Togiak District harvest includes the Kulukak Section harvest of 57,089 sockeye salmon. The escapement of sockeye salmon in Bristol Bay was 9,548,553 in 2009, ranging from 313,946 in Togiak River to 2,266,140 in Kvichak River.

TISSUE SAMPLING

Baseline and Escapement Sampling

We used the baseline comprised of 14,236 sockeye salmon captured in 144 collections from 1998 to 2008 for analyzing the 2009 mixtures (Appendix A in Dann et al. 2009). The average

sample size for each collection was 99 fish with a range from 30 to 192 fish. A total of 4,886 sockeye salmon from 17 samples representing escapement enumeration mixtures were captured to provide tests of the baseline (Table 2 in Dann et al. 2009).

District Catch Sampling

A total of 17,160 sockeye salmon were sampled for tissue suitable for genetic analysis from the commercial harvest throughout Bristol Bay in 2009 (Table 2). Twenty-nine periods were used to select genetic samples to estimate the stock composition of the harvest in each of the districts. Selected sample sizes for each period ranged from 184 to 380 fish. Samples were representatively selected in approximately equal numbers from all the samples collected in district-period strata (Appendix A). A total of 5,879 samples were selected to be included in the analysis (Table 2). Of the fish selected, 5,767 (98%) were successfully screened and included in MSA. Final samples sizes for these mixtures ranged from 173 to 375 fish.

LABORATORY ANALYSIS

Laboratory Failure Rates and Quality Control

As previously reported, the overall failure rate for representative Bristol Bay baseline genotypes at the 45 SNP markers was 2.3%. The quality control process demonstrated a low discrepancy rate of 0.52%. Assuming an equal error rate in the original and quality control genotyping process, and that this project accurately represents our genotyping process, our baseline collections were genotyped with a process that produced genotypes with an error rate of 0.26%.

The overall failure rate for the 2009 commercial harvest samples was 2.4%, and ranged from 0.8% to 3.1%. The overall discrepancy rate for 2009 commercial harvest collections was 0.40% and ranged from 0.00% to 0.74% (0.00% to 0.37% estimated error rate in the database).

STATISTICAL ANALYSIS

Data Retrieval and Quality Control

An average of 0.42 (0.4%) and 0 putative duplicate fish per collection were removed from baseline and 2009 district harvest collections, respectively, based upon the 38 loci criterion. For baseline and mixture collections, 108 (75%) and 8 (100%) had no duplicate individuals, respectively.

An average of 13.75 fish per collection (range of 3–40) was removed based upon the 80% rule for collections from district harvest fish. A total of 110 fish (2.0%) were removed based on the 80% rule.

Baseline Development

Observed heterozygosities among markers ranged widely from 0.007 to 0.482 and F_{ST} estimated over all loci was 0.090, but a few nuclear loci had considerably higher values, notably the two MHC loci (Dann et al. 2009). Significant departures from H-W equilibrium were not found in any populations for the 42 nuclear SNP loci after correcting for multiple tests. Significant gametic disequilibrium was found between 1 pair of nuclear SNP markers (*One_MHC2_190* and *One_MHC2_251*) in more than 50% of the collections. For the pair of linked nuclear SNP markers and the triplet of mitochondrial SNP markers (*One_CO1*, *One_Cytb_17*, and *One_Cytb_26*), genotypes from each locus were combined to form haplotype loci:

One_MHC2_190_251 and *One_CO1_Cytb17_26*, respectively. After combining the pair of linked nuclear markers and the 3 mtDNA markers, the final analyses included 41 independent nuclear loci and 1 mitochondrial locus.

The 144 collections reduced to a total of 96 unique populations after pooling collections taken from similar locations over multiple years and from nearby sites that exhibited genetic homogeneity (Appendix A in Dann et al. (2009)).

Allele frequency estimates within populations appeared to be temporally stable. The 3-level ANOVA indicated that the ratio of variation among temporal collections to the variation among populations was not different from 0.

Genetic relationships among baseline populations exhibited schematically in a Neighbor-Joining tree (Figure 2) were concordant with patterns of sockeye salmon population structure described in other studies: populations generally cluster in groups based upon river system and a common nursery lake. The tree exhibits useful genetic distinctions among the 11 reporting groups, although there is some interweaving of stocks (e.g., Togiak-Kuskokwim, Wood-Igushik).

All 11 reporting groups (stocks) met the critical level of 90% correct allocation in the 100% proof tests, with correct allocations above 95% for 8 reporting groups (Table 8 and Figure 4 in Dann et al. 2009). Similarly, all of the 17 escapement sample tests met the critical level of 90% correct allocation back to their reporting group of origin. In general, the escapement enumeration sample tests indicated that most reporting groups can be distinguished from one another with high accuracy (mean = 95%). For both the proof tests and escapement sample tests, when fish were misallocated they were often allocated to adjacent reporting groups or reporting groups with populations with similar allele frequencies as evidenced by the clustering of populations on the tree of genetic distances.

Mixed Stock Analyses

The prior parameters for the initial time strata in each district in 2009 were the weighted total stock composition estimates from 2008 and the estimates from the analysis of the 2008 Kvichak Section Set strata after adjustment for stocks with very small estimates (Table 3).

Ugashik District

The Ugashik District harvest in 2009 (2,555,263) was mostly comprised of sockeye salmon from the following stocks: Ugashik (77.8%; 1,987,049), followed by Egegik (21.5%; 549,748), and smaller percentages (≤0.2%) of North Peninsula, Naknek, Alagnak, Kvichak, Nushagak, Wood, Igushik, Togiak, and Kuskokwim (Table 4). The Ugashik stock contribution to the mixtures ranged from 36.4% to 97.8%, while the Egegik stock contribution to the mixtures ranged from 2.0% to 62.1% in different periods of 2009 (Figure 3; Appendix B.1).

Egegik District

The Egegik District harvest in 2009 (11,527,462) was mostly comprised of sockeye salmon from the following stocks: Egegik (89.5%; 10,315,704), followed by Naknek (5.9%; 675,822), Kvichak (1.3%; 154,517), Alagnak (1.0%; 111,764), and smaller percentages (≤0.8%) of North Peninsula, Ugashik, Nushagak, Wood, Igushik, Togiak, and Kuskokwim (Table 4). The Egegik stock contribution to the mixtures ranged from 80.3% to 96.8% in different periods of 2009 (Figure 4; Appendix B.2).

Naknek-Kvichak District

The Naknek-Kvichak District harvest in 2009 (8,514,944) was mostly comprised of sockeye salmon from the following stocks: Kvichak (47.4%; 4,040,185), followed by Naknek (29.6%; 2,517,796), Alagnak (14.4%; 1,229,830), Egegik (7.3%; 619,993), and smaller percentages (≤0.6%) of North Peninsula, Ugashik, Nushagak, Wood, Igushik, Togiak, and Kuskokwim (Table 4). The Kvichak stock contribution to the mixtures ranged from 17.6% in the full district to 86.6% in the Kvichak Section Set Gillnet Only period. The Naknek stock contribution to the mixtures ranged from 1.5% in the Kvichak Section Set Gillnet Only period to 56.7% in the full district. The Alagnak stock contribution to the mixtures ranged from 6.4% to 36.1% in different periods of 2009 (Figure 5; Appendix B.3).

Nushagak District

The Nushagak District harvest in 2009 (7,730,168) was comprised of sockeye salmon from the following stocks: Wood (80.1%; 6,194,885), Nushagak (17.8%; 1,374,177), Igushik (0.9%; 67,984), and much smaller percentages (≤0.8%) of North Peninsula, Ugashik, Egegik, Naknek, Alagnak, Kvichak, Togiak, and Kuskokwim (Table 4). The Wood stock contribution to the mixtures ranged from 71.5% to 89.1% in Nushagak District in different periods of 2009. The Nushagak stock contribution to the mixtures ranged from 8.9% to 27.5% and the Igushik stock contribution to the mixtures ranged from 0.0% to 4.0% (Figure 6; Appendix B.4).

Togiak District

The Togiak District harvest in 2009 (559,442) was comprised of sockeye salmon from the Togiak (91.1%; 509,491) and Kuskokwim stocks (7.4%; 41,662), and much smaller percentages (≤0.6%) of North Peninsula, Ugashik, Egegik, Naknek, Alagnak, Kvichak, Nushagak, Wood and Igushik (Table 4). The Togiak stock contribution to the mixtures ranged from 66.6% to 99.3% and the Kuskokwim stock contribution to the mixtures ranged from 0.5% to 32.3% in Togiak District in different periods of 2009 (Figure 7; Appendix B.5).

Bristol Bay

The overall Bristol Bay harvest in 2009 (30,887,279) was comprised of sockeye salmon from the following stocks: Egegik (37.2%; 11,494,857), Wood (20.2%; 6,236,991), Kvichak (13.6%; 4,202,927), Naknek (10.4%; 3,198,692), Ugashik (7.0%; 2,150,732), Nushagak (4.7%; 1,453,135), Alagnak (4.3%; 1,343,382), Togiak (1.7%; 526,815), Igushik (0.5%, 161,151), Kuskokwim (0.3%; 97,257), and North Peninsula (0.1%; 21,338) (Table 4; Figure 8).

Inshore Run Size

North Peninsula

In 2009, 21,338 North Peninsula stock sockeye salmon were incidentally harvested in Bristol Bay (Table 5). Harvests occurred in Ugashik (2,234), Egegik (4,633), Naknek-Kvichak (11,719), Nushagak (2,664), and Togiak (88) districts (Figure 9). North Peninsula drainages were outside the scope of this program; therefore, total run and harvest rates were not estimated.

Ugashik River

Inshore run of the Ugashik stock was 3,515,070 sockeye salmon in 2009 (Table 5; Figure 10). Harvest was 2,150,732 and escapement was 1,364,338 in Ugashik River. The overall harvest rate was 61.2% with district-specific harvest rates as follows: Ugashik (56.5%), Egegik (2.5%),

Naknek-Kvichak (0.4%), Nushagak (1.7%), and Togiak (~0.0%; Figure 11). The traditional inshore run estimate (based on age composition) was 12% greater than the inshore run estimated based on genetics (Table 5; Figure 12).

Egegik River

Inshore run of the Egegik stock was 12,641,133 sockeye salmon in 2009 (Table 5; Figure 13). Harvest was 11,494,857 and escapement was 1,146,276 in Egegik River. The overall harvest rate was 90.9% with district-specific harvest rates as follows: Ugashik (4.3%), Egegik (81.6%), Naknek-Kvichak (4.9%), Nushagak (0.1%), and Togiak (~0.0%; Figure 14). The traditional inshore run estimate (based on age composition) was not different from the inshore run estimated based on genetics (Table 5; Figure 12).

Naknek River

Inshore run of the Naknek stock was 4,368,158 sockeye salmon in 2009 (Table 5; Figure 15). Harvest was 3,198,692 and escapement was 1,169,466 in Naknek River. The overall harvest rate was 75.3% with district-specific harvest rates as follows: Ugashik (~0.0%), Egegik (15.5%), Naknek-Kvichak (57.6%), Nushagak (~0.0%), and Togiak (~0.0%; Figure 16). The traditional inshore run estimate (based on age composition) was 8% greater than the inshore run estimated based on genetics (Table 5; Figure 12).

Alagnak River

Inshore run of the Alagnak stock was 2,314,200 sockeye salmon in 2009 (Table 5; Figure 17). Harvest was 1,343,382 and escapement was 970,818 in Alagnak River. The overall harvest rate was 58.0% with district-specific harvest rates as follows: Ugashik (~0.0%), Egegik (4.8%), Naknek-Kvichak (53.1%), Nushagak (0.1%), and Togiak (~0.0%; Figure 18). The traditional inshore run estimate (based on age composition) was 13% greater than the inshore run estimated based on genetics (Table 5; Figure 12).

Kvichak River

Inshore run of the Kvichak stock was 6,469,067 sockeye salmon in 2009 (Table 5; Figure 19). Harvest was 4,202,927 and escapement was 2,266,140 in Kvichak River. The overall harvest rate was 65.0% with district-specific harvest rates as follows: Ugashik (0.1%), Egegik (2.4%), Naknek-Kvichak (62.5%), Nushagak (~0.0%), and Togiak (~0.0%; Figure 20). The traditional inshore run estimate (based on age composition) was 14% less than the inshore run estimated based on genetics (Table 5; Figure 12).

Nushagak River

Inshore run of the Nushagak stock was 1,937,284 sockeye salmon in 2009 (Table 5; Figure 21). Harvest was 1,453,135 and escapement was 484,149 in Nushagak River. The overall harvest rate was 75.0% with district-specific harvest rates as follows: Ugashik (0.1%), Egegik (3.7%), Naknek-Kvichak (0.2%), Nushagak (70.9%), and Togiak (0.1%; Figure 22). The traditional inshore run estimate (based on age composition) was 1% less than the inshore run estimated based on genetics (Table 5; Figure 12).

Wood River

Inshore run of the Wood stock was 7,556,223 sockeye salmon in 2009 (Table 5; Figure 23). Harvest was 6,236,991 and escapement was 1,319,232 in Wood River. The overall harvest rate

was 82.5% with district-specific harvest rates as follows: Ugashik (~0.0%), Egegik (0.3%), Naknek-Kvichak (0.2%), Nushagak (82.0%), and Togiak (~0.0%; Figure 24). The traditional inshore run estimate (based on age composition) was 5% less than the inshore run estimated based on genetics (Table 5; Figure 12).

Igushik River

Inshore run of the Igushik stock was 675,339 sockeye salmon in 2009 (Table 5; Figure 25). Harvest was 161,151 and escapement was 514,188 in Igushik River. The overall harvest rate was 23.9% with district-specific harvest rates as follows: Ugashik (0.2%), Egegik (5.7%), Naknek-Kvichak (7.8%), Nushagak (10.1%), and Togiak (0.1%; Figure 26). The traditional inshore run estimate (based on age composition) was 37% greater than the inshore run estimated based on genetics (Table 5; Figure 12).

Togiak River

Inshore run of the Togiak stock was 840,761 sockeye salmon in 2009 (Table 5; Figure 27). Harvest was 526,815 and escapement was 313,946 in Togiak River. The overall harvest rate was 62.7% with district-specific harvest rates as follows: Ugashik (0.3%), Egegik (0.9%), Naknek-Kvichak (0.3%), Nushagak (0.6%), and Togiak (60.6%; Figure 28). The traditional inshore run estimate (based on age composition) was 4% greater than the inshore run estimated based on genetics (Table 5; Figure 12).

Kuskokwim River

In 2009, 97,257 Kuskokwim stock sockeye salmon were incidentally harvested in Bristol Bay (Table 5). Harvests occurred in Ugashik (881), Egegik (37,221), Naknek-Kvichak (7,201), Nushagak (10,293), and Togiak (41,662) districts (Figure 29). Kuskokwim River and bay drainages were outside the scope of this program; therefore, total run and harvest rates were not estimated.

DISCUSSION

STOCK COMPOSITION AND STOCK-SPECIFIC HARVEST OF COMMERCIAL CATCH

We investigated the stock composition of sockeye salmon commercial harvest in the 5 districts of Bristol Bay in 2009. This work is a continuation of the analyses of the 2006–2008 commercial harvests, and used the same methodology and genetic baseline (Dann et al. 2009). As such, the same strengths (e.g., a comprehensive baseline based upon consistently accurate genotyping methods, highly identifiable reporting groups, robust sampling design, etc.) and weaknesses (unavoidable errors and bias in sampling) of those analyses apply to those reported here.

Similar to past years, the majority of sockeye salmon harvested in the Bristol Bay commercial fishery originated from rivers in the management area in which they were harvested (>99%; Table 4; Figure 8). A similar number of North Peninsula (~21,000; Figure 9), but fewer Kuskokwim sockeye (~97,000; Table 4; Figure 29), were harvested in the 2009 Bristol Bay commercial sockeye salmon fishery in comparison to 2006–2008.

The stock composition of the 2009 commercial harvest of sockeye salmon in the 5 districts was generally similar to past years (Table 4; Appendix B; Figures 30-34; Dann et al. 2009). The

2009 Ugashik District harvest was dominated by Ugashik fish, but, similar to past years, a large number of Egegik fish were harvested during one stratum (July 7-9 62% Egegik; Table 4; Figures 3 and 30). The 2009 harvest of sockeye salmon in Egegik District was again dominated by Egegik fish, but also had the lowest proportion of nonlocal fish when compared to past years. This may be due to the large return and harvest of Egegik River sockeye in 2009 relative to past years (Figure 13; Morstad et al. 2010). Ugashik fish were nearly absent from the Egegik District harvest in 2009 (Table 4; Figure 31). The 2009 Naknek-Kvichak District harvest of sockeye salmon differed from past years as Kvichak fish composed a greater proportion of the harvest than in past years, while the Naknek proportion was less than past years, which may be due to a large return and harvest of Kvichak sockeye relative to past years (Figure 19; Morstad et al. 2010). The proportion of Alagnak fish in the Naknek-Kvichak harvest was similar to past years (Figure 32). The stock composition of the commercial harvest of sockeye salmon in the Nushagak District in 2009 was nearly identical to the stock composition observed in 2008, with overlapping confidence intervals for all stock composition estimates for the 2 years (Figure 33). Finally, the 2009 harvest of sockeye salmon in the Togiak District differed from past years as fewer Kuskokwim fish were observed (7.4% in 2009 vs. 22.2% average for 2006-2008; Table 4; Figure 34) but, similar to past years, the estimated contribution of Kuskokwim fish to the Togiak harvest declined as the season progressed (Figure 7).

COMPARISON OF INSHORE RUN ESTIMATES

Estimates of inshore run based upon the traditional and genetic methods were very similar for some stocks in 2009 and differed to a similar degree to past years for others. The estimates of inshore run based upon the 2 methods for Egegik were less than 1% different from each other (Table 5; Figures 12, 35). Similarly, estimates of inshore run based upon the 2 methods were very similar for Nushagak, Togiak, Wood, and Naknek stocks (differences < 10%; Table 5; Figure 12). Where estimates of inshore run differed by more than 10% between the 2 methods, the differences were consistent with past observations (e.g., Ugashik 11.5% compared to 11.8% in 2009; Figure 35).

FUTURE WORK AND SUMMARY

Although the methods presented here provide the most accurate and precise information on stock composition of the harvest available, we are continuing to improve on the methods. We are in the middle of assembling a new baseline that will include additional collections and will be screened for more markers. Specifically, we have added collections of sockeye salmon from 2 rivers that drain into Togiak Bay, 2 collections of Snake Lake sockeye salmon, numerous Wood River collections, as well as others from the Ugashik, North Peninsula, and Kuskokwim areas. We have also selected a new set of 96 SNPs that should provide even better resolution than the 45 SNPs reported here. This updated baseline is currently in development, will be released in 2011, and will be the basis for future MSA studies in Bristol Bay.

This is an ongoing study to accurately and precisely estimate the productivity of sockeye salmon stocks in Bristol Bay. We plan to continue the Bristol Bay genetics program into the future to provide additional years of stock composition estimates. In addition, a study that isolated DNA from previously collected scale samples of harvests dating back to 1964, and determined stock compositions of historical harvests using MSA is almost complete. Over the next few years, the data gathered from these studies will be used to reconstruct inshore run and brood tables for each sockeye salmon stock. This will greatly improve our understanding of stock productivity within

Bristol Bay and set the foundations for establishing escapement goals based upon these new methods.

ACKNOWLEDGEMENTS

Building the baseline and the laboratory and statistical methods for MSA for sockeye salmon in Bristol Bay has been ongoing since the mid 1990s and has been financially supported through funding from Alaska Disaster Grant, Fish and Game General funds, National Park Service, Fish and Wildlife Service Office of Subsistence Management, North Pacific Anadromous Fish Commission, North Pacific Research Board, National Marine Fisheries Service, and Bristol Bay Science and Research Institute (BBSRI). Efforts to collect samples from the fishery were supported by ADF&G. We thank all the people who helped collect samples used in the baseline including: M. Witteveen and R. Murphy (ADF&G) for collections on Alaska Peninsula; S. Morstad, P. Salomone, and other staff from ADF&G King Salmon office for collections on eastern Bristol Bay; T. Sands, M. Jones, and other staff from ADF&G Dillingham office for collections on western Bristol Bay; T. Quinn and D. Schindler, and other faculty and students from University of Washington for collections in the Kvichak and Wood River drainages; C. A. Woody (U.S. Geological Survey) and C. Ramstad, (Victoria University of Wellington) for collections from Lake Clark drainages; J. Miller and D. Young (National Park Service) for collections from Naknek Lake and Lake Clark, respectively; P. Shoemaker (Kejulik River Lodge); and B. Hodson (Tikchik Narrows Lodge). J. Mueller and C. Tilly provided logistical support in King Salmon. We thank the many GCL lab staff and college interns who processed samples in the lab, with a special thanks to G. Robinson and T. Harrington for coordinating their efforts; J. Berger for tracking samples into the lab; A. Barclay and J. Jasper for providing analysis support; and E. Lardizabal for providing database support. This report benefited from reviews and constructive comments from W. Templin, J. Jasper and S. Aspelund.

REFERENCES CITED

Baker, T. T., L. F. Fair, R. A. Clark, and J. J. Hasbrouck. 2006. Review of salmon escapement goals in Bristol Bay, Alaska. 2006. Alaska Department of Fish and Game, Fishery Manuscript No. 06-05, Anchorage.

Bernard, D. R. 1983. Variance and bias of catch allocations that use age composition of escapement. Alaska Department of Fish and Game, Division of Commercial Fisheries, Informational Leaflet No. 227, Juneau.

Brazil, C. E. 2008. Sonar enumeration of Pacific salmon escapement into the Nushagak River, 2004. Alaska Department of Fish and Game, Fishery Data Series No. 08-31, Anchorage.

Bugaev, A. V., I. I. Glevov, E. V. Golub, K. W. Myers, J. E. Seeb, and M. Foster. 2008. Origin and distribution of sockeye salmon Oncorhynchus nerka local stocks in the western Bering Sea in August-October 2006. Izv. TINRO 153:88-108.

Dann, T. H., C. Habicht, J. R. Jasper, H. A. Hoyt, A. W. Barclay, W. D. Templin, T. T. Baker, F. W. West, and L. F. Fair. 2009. Genetic stock composition of the commercial harvest of sockeye salmon in Bristol Bay, Alaska, 2006-2008. Alaska Department of Fish and Game, Fishery Manuscript Series No. 09-06, Anchorage.

Eggers, D. M., and J. R. Irvine. 2007. Trends in abundance and biological characteristics for North Pacific sockeye salmon. North Pacific Anadromous Fish Commission Bulletin 4:53-75.

Flynn, L., and R. Hilborn. 2004. Test fishery indices for sockeye salmon (*Oncorhynchus nerka*) as affected by age composition and environmental variables. Canadian Journal of Fisheries and Aquatic Sciences 61:80-92.

Habicht, C., L. W. Seeb, and J. E. Seeb. 2007. Genetics and ecological divergence defines population structure of sockeye salmon populations returning to Bristol Bay, Alaska, and provides a tool for admixture analysis. Transactions of the American Fisheries Society 136:82-94.

Hilborn, R., T. P. Quinn, D. E. Schindler, and D. E. Rogers. 2003. Biocomplexity and fisheries sustainability. Proceedings of the National Academy of Sciences 100:6564-6568.

Menard, J., and J. D. Miller. 1997. Report to the Alaska Board of Fisheries on the stock composition of sockeye salmon catches within east side Bristol Bay fishing districts, 1983-1995. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report No. 2A97-31, Anchorage.

Morstad, S., M. Jones, T. Sands, P. Salomone, T. Baker, G. Buck, and F. West. 2010. 2009 Bristol Bay area annual management report. Alaska Department of Fish and Game, Fishery Management Report No. 10-25, Anchorage.

Schindler, D.E., R. Hilborn, B. Chasco, C.P. Boatright, T.P. Quinn, L.A. Rogers, and M.S. Webster. 2010. Population diversity and the portfolio effect in an exploited species. Nature 465:609-612.

Thompson, S. 1987. Sample size for estimating multinomial proportions. The American Statistician 41: 42-46.

West, F., L. Fair, T. Baker, S. Morstad, K. Weiland, T. Sands, and C. Westing. 2009. Abundance, age, sex, and size statistics for Pacific salmon in Bristol Bay, 2004. Alaska Department of Fish and Game, Fishery Data Series No. 09-51, Anchorage.

TABLES AND FIGURES

Table 1.–Commercial harvest by district and escapement by river for sockeye salmon in Bristol Bay, Alaska, 2009.

District/River	Harvest	Escapement	Total
Ugashik	2,555,263	1,364,338	3,919,601
Egegik	11,527,462	1,146,276	12,673,738
Naknek-Kvichak	8,514,944		12,921,368
Naknek River		1,169,466	
Alagnak River		970,818	
Kvichak River		2,266,140	
Nushagak	7,730,168		10,047,737
Nushagak River		484,149	
Wood River		1,319,232	
Igushik River		514,188	
Togiak	559,442	313,946	873,388
Total	30,887,279	9,548,553	40,435,832

Table 2.–Sockeye salmon commercial harvest and numbers of samples collected, selected, and successfully screened for genetic analysis by period in Bristol Bay, Alaska in 2009.

					Genetic Samples		
Period	Description	Start	End	Harvest	Collected	Selected	Screened
1	Ugashik District	6/9/2009	7/2/2009	464,673	1,565	190	186
2	Ugashik District	7/3/2009	7/6/2009	689,417	670	200	194
3	Ugashik District	7/7/2009	7/9/2009	658,265	426	190	188
4	Ugashik District	7/10/2009	7/12/2009	356,093	284	186	183
5	Ugashik District	7/13/2009	8/10/2009	386,815	498	186	181
Total (5 Periods)		6/9/2009	8/10/2009	2,555,263	3,443	952	932
1	Egegik District	6/9/2009	6/24/2009	1,986,862	793	187	185
2	Egegik District	6/25/2009	6/29/2009	3,360,561	677	378	373
3	Egegik District	6/30/2009	7/5/2009	3,428,762	720	380	375
4	Egegik District	7/6/2009	7/8/2009	1,091,124	278	190	186
5	Egegik District	7/9/2009	7/10/2009	676,573	253	189	188
6	Egegik District	7/11/2009	8/18/2009	983,580	823	190	183
Total (6 Periods)		6/9/2009	8/18/2009	11,527,462	3,544	1,514	1,490
1	Naknek -Kvichak District	6/15/2009	6/29/2009	1,854,913	1,043	188	184
2	Naknek -Kvichak District	6/30/2009	7/3/2009	1,475,629	549	190	186
3	Naknek -Kvichak District	7/4/2009	7/6/2009	1,605,295	399	190	173
4	Naknek -Kvichak District	7/7/2009	7/8/2009	1,164,256	383	189	185
5	Naknek -Kvichak District	7/9/2009	7/9/2009	395,447	287	189	186
6	Naknek -Kvichak District	7/10/2009	7/14/2009	899,781	567	189	185
7	Naknek -Kvichak District	7/15/2009	8/15/2009	371,632	500	185	181
8	Kvichak Section Set Gillnet	6/19/2009	7/29/2009	747,991	239	189	186
Total (8 Periods)		6/15/2009	8/15/2009	8,514,944	3,967	1,509	1,466
1	Nushagak District	6/9/2009	6/25/2009	894,088	239	189	189
2	Nushagak District	6/26/2009	6/29/2009	1,883,334	286	188	187
3	Nushagak District	6/30/2009	7/1/2009	716,527	275	188	187
4	Nushagak District	7/2/2009	7/3/2009	1,348,447	287	215	212
5	Nushagak District	7/4/2009	7/8/2009	1,762,599	757	188	186
6	Nushagak District	7/9/2009	7/11/2009	593,496	526	188	184
7	Nushagak District	7/12/2009	8/13/2009	531,677	730	184	182
Total (7 Periods)		6/9/2009	8/13/2009	7,730,168	3,100	1,340	1,327
1	Togiak District	6/22/2009	7/5/2009	63,193	814	188	183
2	Togiak District	7/6/2009	7/15/2009	212,619	860	190	189
3	Togiak District	7/16/2009	9/10/2009	283,630	1,432	186	180
Total (3 Periods)		6/22/2009	9/10/2009	559,442	3,106	564	552
Bristol Bay Total (29 Periods)		6/9/2009	9/10/2009	30,887,279	17,160	5,879	5,767

Note: Genetic samples were used to estimate stock composition and stock-specific harvest throughout Bristol Bay.

Table 3.–Predetermined start priors based on the best available information for the first stratum within each fishery within each district in 2009 for sockeye salmon from Bristol Bay, Alaska.

	Strata[a]					
Stock	Ugashik[b]	Egegik[b]	Naknek-Kvichak[b]	Kvichak Set[c]	Nushagak[b]	Togiak[b]
North Peninsula	0.01	0.01	0.01	0.01	0.01	0.01
Ugashik	0.77	0.01	0.01	0.01	0.01	0.01
Egegik	0.12	0.69	0.06	0.01	0.01	0.01
Naknek	0.01	0.13	0.49	0.04	0.01	0.01
Alagnak	0.03	0.02	0.17	0.42	0.01	0.01
Kvichak	0.01	0.09	0.21	0.46	0.01	0.01
Nushagak	0.01	0.01	0.01	0.01	0.14	0.01
Wood	0.01	0.01	0.01	0.01	0.75	0.01
Igushik	0.01	0.01	0.01	0.01	0.04	0.01
Togiak	0.01	0.01	0.01	0.01	0.01	0.68
Kuskokwim	0.01	0.01	0.01	0.01	0.01	0.23

Note: Strata composed of special harvest areas and setnet sections are included. All priors for subsequent strata for a district are based upon the posterior distribution of stock composition estimates from the preceding strata in that district. See methods for details.

[a] Start prior could not be less than 0.01 for any stock and we assumed there were no Westside stocks in the Eastside fisheries and vice versa.

[b] Start prior was previous year's weighted total estimate for each stock in a district.

[c] Start prior was based on 2008 estimates for the Kvichak Section set stratum.

Table 4.–Proportion and harvest estimates (including 90% credibility intervals) by reporting group from mixtures of sockeye salmon harvested in each district in Bristol Bay, Alaska, in 2009.

				Reporting Groups										
District	Description			North Peninsula	Ugashik	Egegik	Naknek	Alagnak	Kvichak	Nushagak	Wood	Igushik	Togiak	Kuskokwim
Ugashik District			Proportion	0.1%	77.8%	21.5%	0.1%	0.0%	0.2%	0.1%	0.1%	0.0%	0.1%	0.0%
	Year	2009	Lower 90% CI	0.0%	71.9%	15.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Start Date	06/09	Upper 90% CI	0.5%	83.9%	27.4%	0.5%	0.1%	0.7%	0.4%	0.6%	0.3%	0.6%	0.2%
	End Date	08/10	Harvest	2,234	1,987,049	549,748	1,742	550	5,404	1,529	2,402	1,230	2,495	881
	Harvest	2,555,263	Lower 90% CI	0	1,836,851	391,133	0	0	250	0	0	0	0	0
	n	932	Upper 90% CI	13,159	2,144,315	700,687	11,869	3,202	18,747	10,433	15,120	8,198	14,669	4,965
Egegik District			Proportion	0.0%	0.8%	89.5%	5.9%	1.0%	1.3%	0.6%	0.2%	0.3%	0.1%	0.3%
	Year	2009	Lower 90% CI	0.0%	0.0%	86.4%	3.9%	0.5%	0.3%	0.0%	0.0%	0.0%	0.0%	0.0%
	Start Date	06/09	Upper 90% CI	0.2%	3.1%	92.1%	8.0%	1.5%	3.1%	1.6%	0.8%	1.0%	0.4%	2.1%
	End Date	08/18	Harvest	4,633	89,264	10,315,704	675,822	111,764	154,517	71,321	21,755	38,262	7,201	37,221
	Harvest	11,527,462	Lower 90% CI	0	0	9,957,885	444,663	58,239	38,623	0	0	0	0	0
	n	1,490	Upper 90% CI	24,603	355,617	10,615,988	921,629	177,215	358,949	183,489	89,713	119,682	48,656	237,091
Naknek-Kvichak District			Proportion	0.1%	0.2%	7.3%	29.6%	14.4%	47.4%	0.1%	0.2%	0.6%	0.0%	0.1%
	Year	2009	Lower 90% CI	0.0%	0.0%	4.5%	25.4%	12.3%	43.5%	0.0%	0.0%	0.0%	0.0%	0.0%
	Start Date	06/15	Upper 90% CI	0.8%	1.0%	10.2%	34.1%	16.7%	51.4%	0.3%	0.6%	1.4%	0.1%	0.3%
	End Date	08/15	Harvest	11,719	13,857	619,993	2,517,796	1,229,830	4,040,185	4,633	14,401	52,956	2,373	7,201
	Harvest	8,514,944	Lower 90% CI	0	0	384,092	2,159,407	1,044,304	3,703,207	0	0	2,137	0	0
	n	1,466	Upper 90% CI	64,760	87,314	870,130	2,903,165	1,425,680	4,376,975	27,639	53,631	116,872	11,946	26,323
Nushagak District			Proportion	0.0%	0.8%	0.1%	0.0%	0.0%	0.0%	17.8%	80.1%	0.9%	0.1%	0.1%
	Year	2009	Lower 90% CI	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	14.6%	76.3%	0.0%	0.0%	0.0%
	Start Date	06/09	Upper 90% CI	0.2%	1.4%	0.7%	0.2%	0.1%	0.2%	21.0%	83.6%	3.2%	0.4%	0.8%
	End Date	08/13	Harvest	2,664	60,398	9,129	1,831	1,168	2,385	1,374,177	6,194,885	67,984	5,255	10,293
	Harvest	7,730,168	Lower 90% CI	0	9,047	0	0	0	0	1,131,902	5,895,226	0	0	0
	n	1,327	Upper 90% CI	16,973	107,818	50,965	11,886	6,689	13,741	1,621,757	6,461,992	249,444	32,563	58,835
Togiak District			Proportion	0.0%	0.0%	0.1%	0.3%	0.0%	0.1%	0.3%	0.6%	0.1%	91.1%	7.4%
	Year	2009	Lower 90% CI	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	85.7%	3.3%
	Start Date	06/22	Upper 90% CI	0.1%	0.1%	0.4%	1.4%	0.0%	0.6%	1.9%	3.4%	0.9%	95.2%	13.1%
	End Date	09/10	Harvest	88	164	285	1,501	71	438	1,475	3,549	718	509,491	41,662
	Harvest	559,442	Lower 90% CI	0	0	0	0	0	0	0	0	0	479,167	18,419
	n	552	Upper 90% CI	323	690	2,140	8,033	265	3,154	10,555	19,218	5,122	532,852	73,205

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Table 4.–Page 2 of 2.

District	Description			Reporting Groups										
				North Peninsula	Ugashik	Egegik	Naknek	Alagnak	Kvichak	Nushagak	Wood	Igushik	Togiak	Kuskokwim
Bristol Bay	Total		Proportion	0.1%	7.0%	37.2%	10.4%	4.3%	13.6%	4.7%	20.2%	0.5%	1.7%	0.3%
	Year	2009	Lower 90% CI	0.0%	6.2%	35.8%	9.0%	3.7%	12.4%	3.9%	19.2%	0.1%	1.6%	0.1%
	Start Date	06/09	Upper 90% CI	0.3%	8.0%	38.6%	11.8%	5.0%	14.8%	5.6%	21.1%	1.2%	1.9%	1.0%
	End Date	09/10	Harvest	21,338	2,150,732	11,494,857	3,198,692	1,343,382	4,202,927	1,453,135	6,236,991	161,151	526,815	97,257
	Harvest	30,887,279	Lower 90% CI	2	1,929,427	11,042,252	2,770,971	1,147,207	3,833,569	1,196,443	5,931,842	32,782	486,166	25,583
	n	5,767	Upper 90% CI	96,436	2,458,811	11,919,281	3,651,315	1,550,638	4,580,710	1,722,425	6,510,704	364,134	585,763	301,441

Note: The sample size based on the number of samples successfully screened (n) is included for each estimate.

Table 5.–Stock-specific harvest (including 90% credibility intervals) and harvest rates by fishing districts and summed across districts, escapement, and total run, based on genetic analysis of mixtures of sockeye salmon harvested in Bristol Bay, Alaska, 2009.

		Commercial Fishing Districts						Based on Traditional Methods		
				Naknek-					Difference	
Stock		Ugashik	Egegik	Kvichak	Nushagak	Togiak	Total	Total	Number	Percent
North	Harvest	2,234	4,633	11,719	2,664	88	21,338			
Peninsula	Lower 90% CI	0	0	0	0	0	2			
	Upper 90% CI	13,159	24,603	64,760	16,973	323	96,436			
Ugashik	Harvest Rate	56.5%	2.5%	0.4%	1.7%	0.0%	61.2%	65.2%		
	Harvest	1,987,049	89,264	13,857	60,398	164	2,150,732	2,555,263	404,531	19%
	Lower 90% CI	1,836,851	0	0	9,047	0	1,929,427			
	Upper 90% CI	2,144,315	355,617	87,314	107,818	690	2,458,811			
	Escapement						1,364,338	1,364,338		
	Total Run						3,515,070	3,919,601	404,531	12%
Egegik	Harvest Rate	4.3%	81.6%	4.9%	0.1%	0.0%	90.9%	91.0%		
	Harvest	549,748	10,315,704	619,993	9,129	285	11,494,857	11,527,462	32,605	0%
	Lower 90% CI	391,133	9,957,885	384,092	0	0	11,042,252			
	Upper 90% CI	700,687	10,615,988	870,130	50,965	2,140	11,919,281			
	Escapement						1,146,276	1,146,276		
	Total Run						12,641,133	12,673,738	32,605	0.26%
Naknek	Harvest Rate	0.0%	15.5%	57.6%	0.0%	0.0%	73.2%	75.3%		
	Harvest	1,742	675,822	2,517,796	1,831	1,501	3,198,692	3,564,319	365,627	11%
	Lower 90% CI	0	444,663	2,159,407	0	0	2,770,971			
	Upper 90% CI	11,869	921,629	2,903,165	11,886	8,033	3,651,315			
	Escapement						1,169,466	1,169,466		
	Total Run						4,368,158	4,733,785	365,627	8.4%
Alagnak	Harvest Rate	0.0%	4.8%	53.1%	0.1%	0.0%	58.0%	63.0%		
	Harvest	550	111,764	1,229,830	1,168	71	1,343,382	1,653,281	309,899	23%
	Lower 90% CI	0	58,239	1,044,304	0	0	1,147,207			
	Upper 90% CI	3,202	177,215	1,425,680	6,689	265	1,550,638			
	Escapement						970,818	970,818		
	Total Run						2,314,200	2,624,099	309,899	13.4%
Kvichak	Harvest Rate	0.1%	2.4%	62.5%	0.0%	0.0%	65.0%	59.3%		
	Harvest	5,404	154,517	4,040,185	2,385	438	4,202,927	3,297,344	-905,583	-22%
	Lower 90% CI	250	38,623	3,703,207	0	0	3,833,569			
	Upper 90% CI	18,747	358,949	4,376,975	13,741	3,154	4,580,710			
	Escapement						2,266,140	2,266,140		
	Total Run						6,469,067	5,563,484	-905,583	-14%

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Table 5.–Page 2 of 2.

Stock		Commercial Fishing Districts						Based on Traditional Methods		
									Difference	
		Ugashik	Egegik	Naknek-Kvichak	Nushagak	Togiak	Total	Total	Number	Percent
Nushagak	Harvest Rate	0.1%	3.7%	0.2%	70.9%	0.1%	75.0%	74.9%		
	Harvest	1,529	71,321	4,633	1,374,177	1,475	1,453,135	1,442,574	-10,561	-1%
	Lower 90% CI	0	0	0	1,131,902	0	1,196,443			
	Upper 90% CI	10,433	183,489	27,639	1,621,757	10,555	1,722,425			
	Escapement						484,149	484,149		
	Total Run						1,937,284	1,926,723	-10,561	-1%
Wood	Harvest Rate	0.0%	0.3%	0.2%	82.0%	0.0%	82.5%	81.7%		
	Harvest	2,402	21,755	14,401	6,194,885	3,549	6,236,991	5,876,154	-360,837	-6%
	Lower 90% CI	0	0	0	5,895,226	0	5,931,842			
	Upper 90% CI	15,120	89,713	53,631	6,461,992	19,218	6,510,704			
	Escapement						1,319,232	1,319,232		
	Total Run						7,556,223	7,195,386	-360,837	-5%
Igushik	Harvest Rate	0.2%	5.7%	7.8%	10.1%	0.1%	23.9%	44.4%		
	Harvest	1,230	38,262	52,956	67,984	718	161,151	411,440	250,289	155%
	Lower 90% CI	0	0	2,137	0	0	32,782			
	Upper 90% CI	8,198	119,682	116,872	249,444	5,122	364,134			
	Escapement						514,188	514,188		
	Total Run						675,339	925,628	250,289	37%
Togiak	Harvest Rate	0.3%	0.9%	0.3%	0.6%	60.6%	62.7%	64.1%		
	Harvest	2,495	7,201	2,373	5,255	509,491	526,815	559,442	32,627	6%
	Lower 90% CI	0	0	0	0	479,167	486,166			
	Upper 90% CI	14,669	48,656	11,946	32,563	532,852	585,763			
	Escapement						313,946	313,946		
	Total Run						840,761	873,388	32,627	4%
Kuskokwim	Harvest	881	37,221	7,201	10,293	41,662	97,257			
	Lower 90% CI	0	0	0	0	18,419	25,583			
	Upper 90% CI	4,965	237,091	26,323	58,835	73,205	301,441			
Total	Harvest Rate	6.3%	28.5%	21.1%	19.1%	1.4%	76.4%	76.4%		
	Harvest	2,555,263	11,527,462	8,514,944	7,730,168	559,442	30,887,279	30,887,279	0	0%
	Lower 90% CI	2,228,234	10,499,410	7,293,146	7,036,175	497,586	28,396,246			
	Upper 90% CI	2,945,363	13,132,632	9,964,434	8,632,664	655,556	33,741,659			
	Escapement						9,548,553	9,548,553		
	Total Run						40,435,832	40,435,832	0	0%

Note: Traditional estimates of harvest, harvest rates, and total run were compared to the genetic estimates.

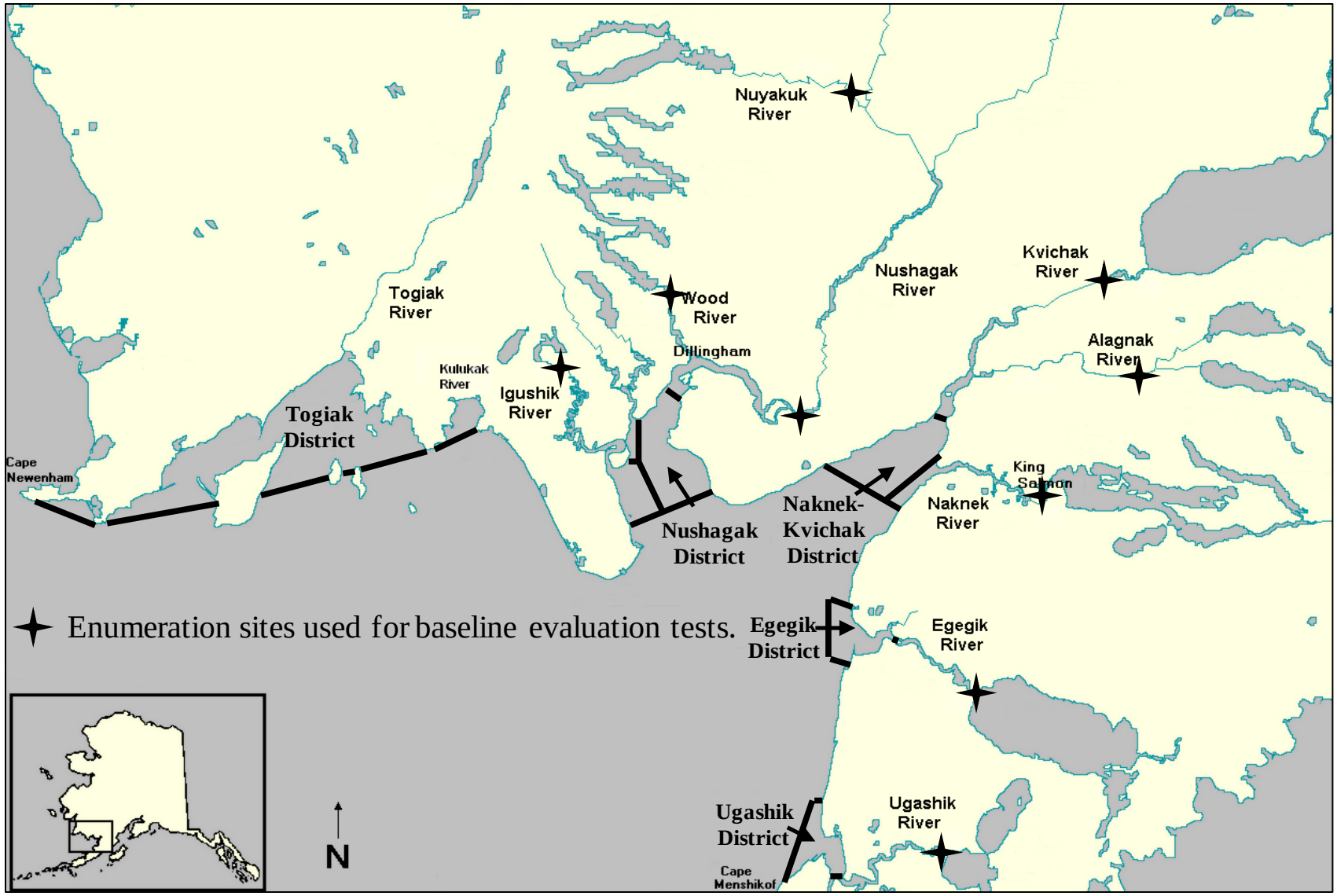
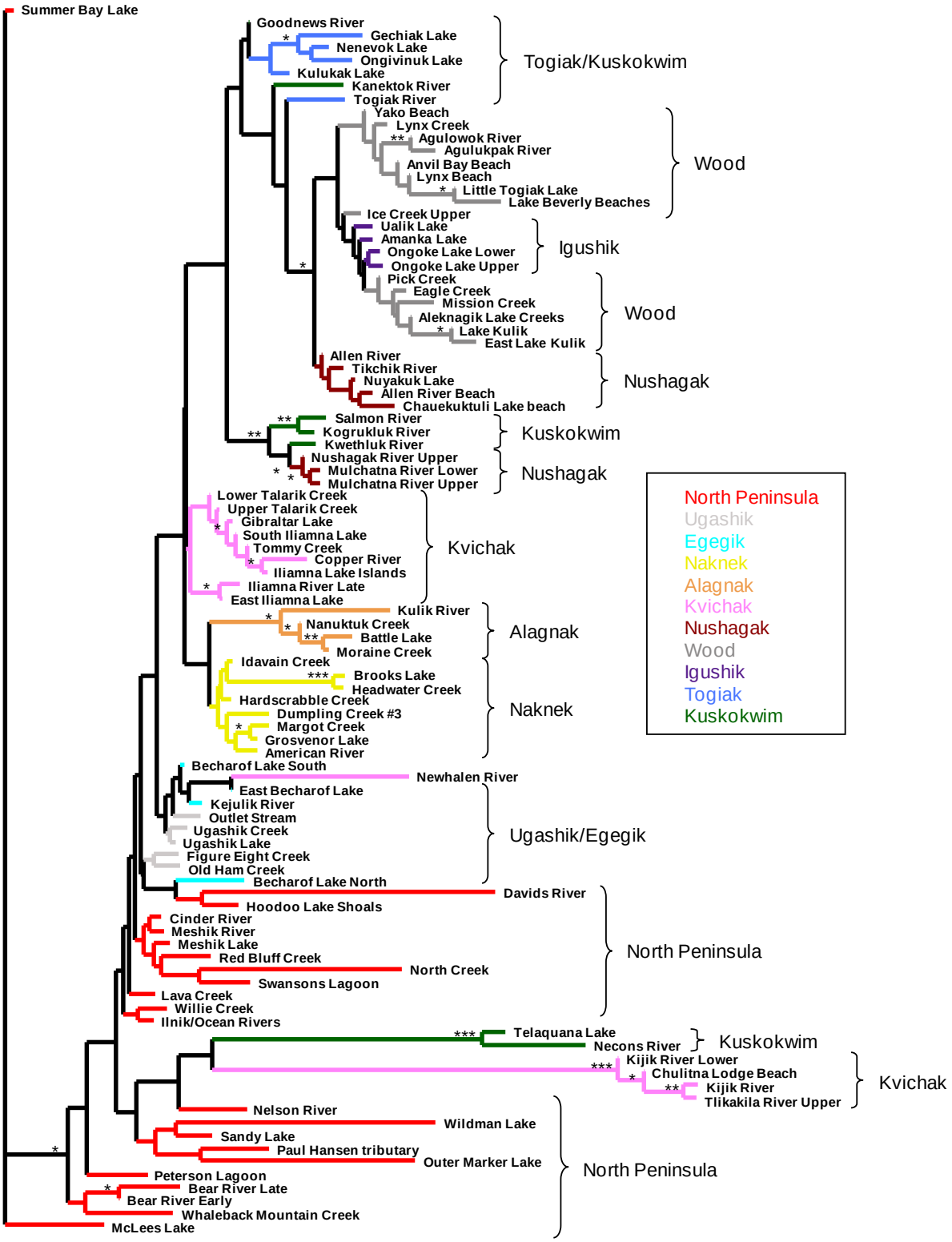


Figure 1.–Commercial salmon fishing districts and major river systems in Bristol Bay, Alaska.



Note: Colors denote reporting groups as in Dann et al. (2009). Bootstrap consensus nodes *** = 95-100%; ** = 70-95%; * = 50-70%.

Figure 2.–Consensus N-J tree based on the Nei (1972) genetic distances between sockeye salmon populations sampled from spawning areas in Bristol Bay, Alaska.

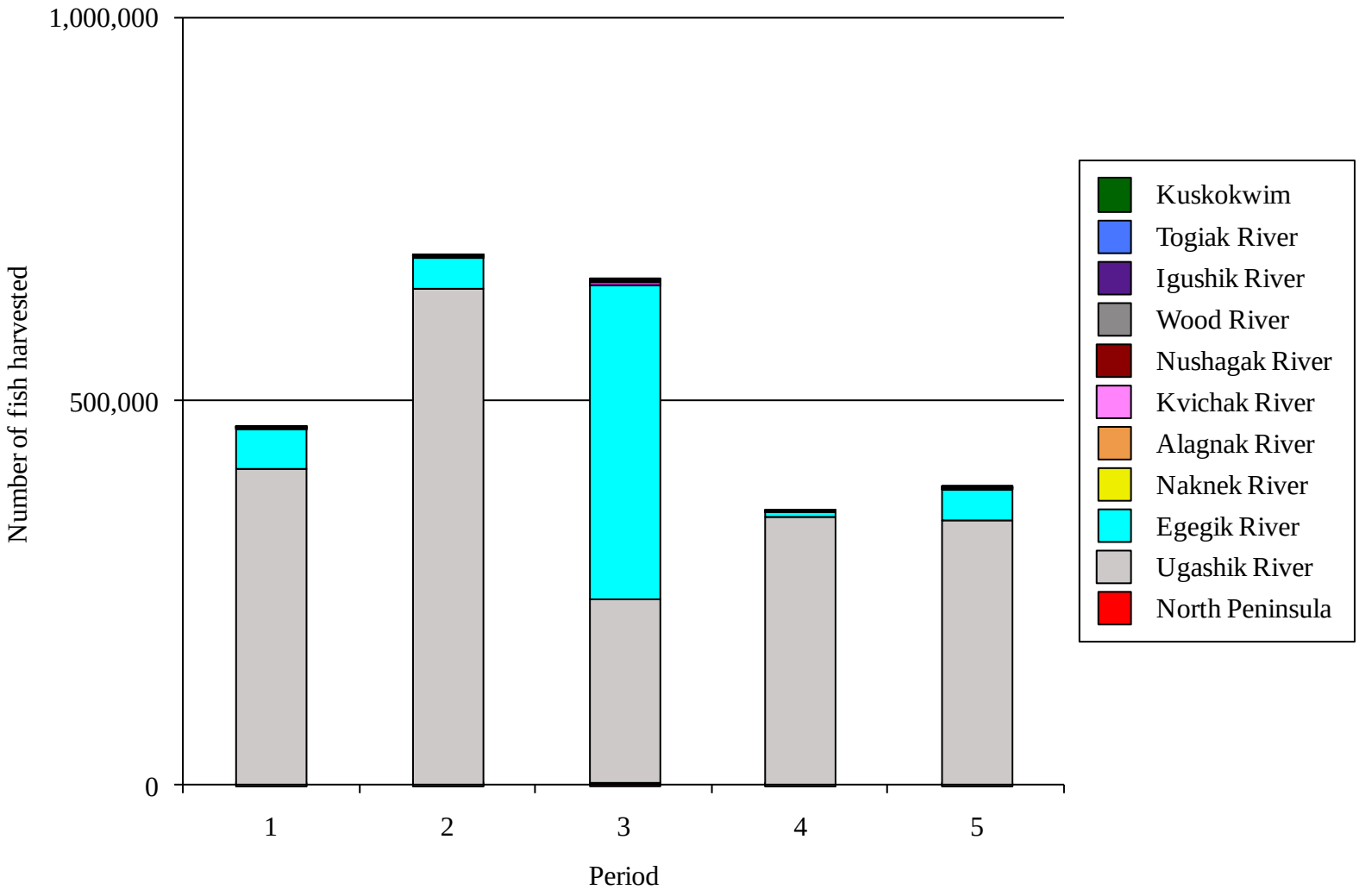


Figure 3.–The number of commercially harvested sockeye salmon captured in the Ugashik fishing district of Bristol Bay, Alaska, in 5 temporal periods in 2009 apportioned to stock.

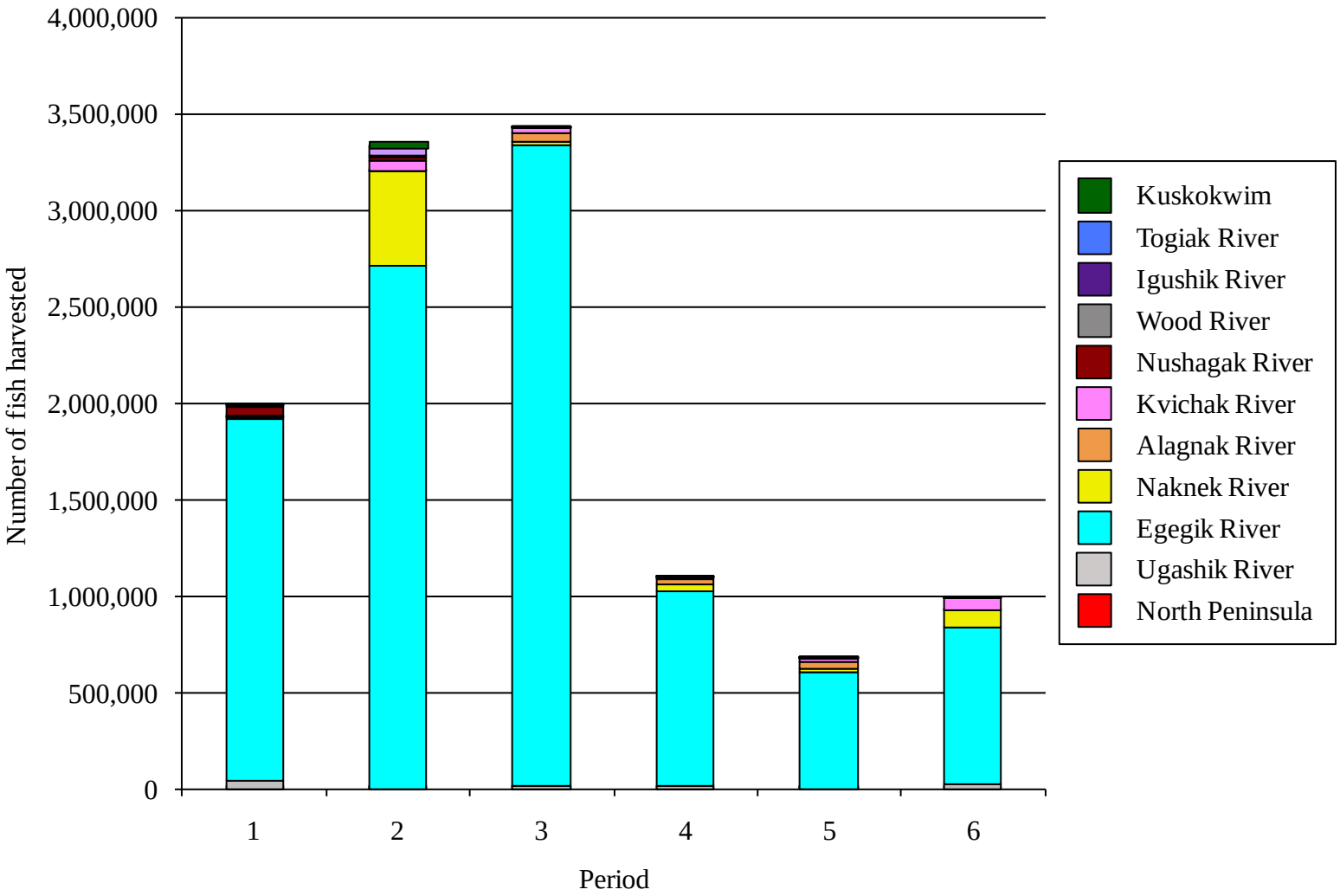
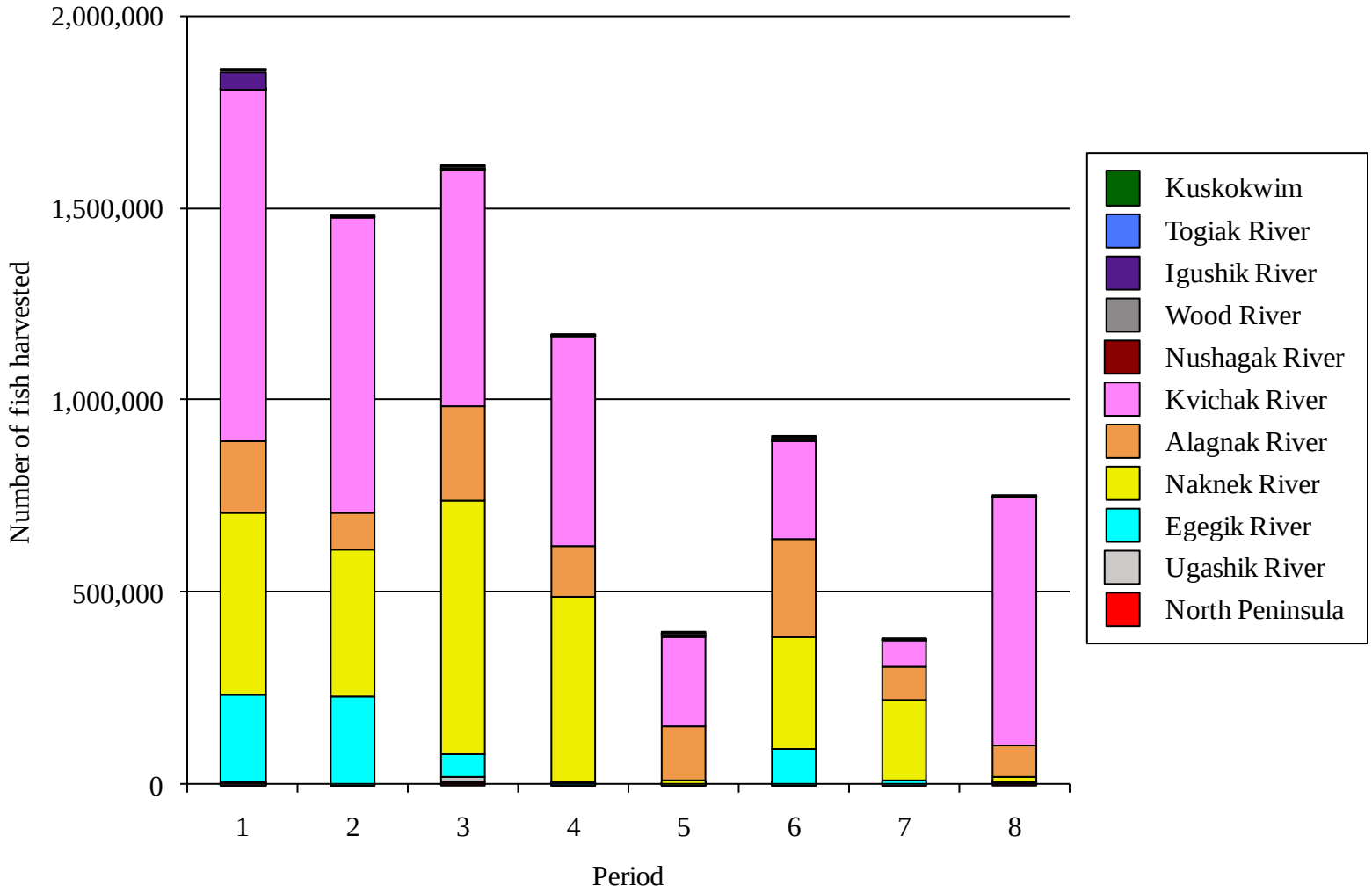


Figure 4.–The number of commercially harvested sockeye salmon captured in the Egegik fishing district of Bristol Bay, Alaska, in 6 temporal periods in 2009 apportioned to stock.



Note: Period 8 represents the Kvichak Section Set Gillnet fishery only.

Figure 5.–The number of commercially harvested sockeye salmon captured in the Naknek-Kvichak fishing district of Bristol Bay, Alaska, in 8 temporal periods in 2009 apportioned to stock.

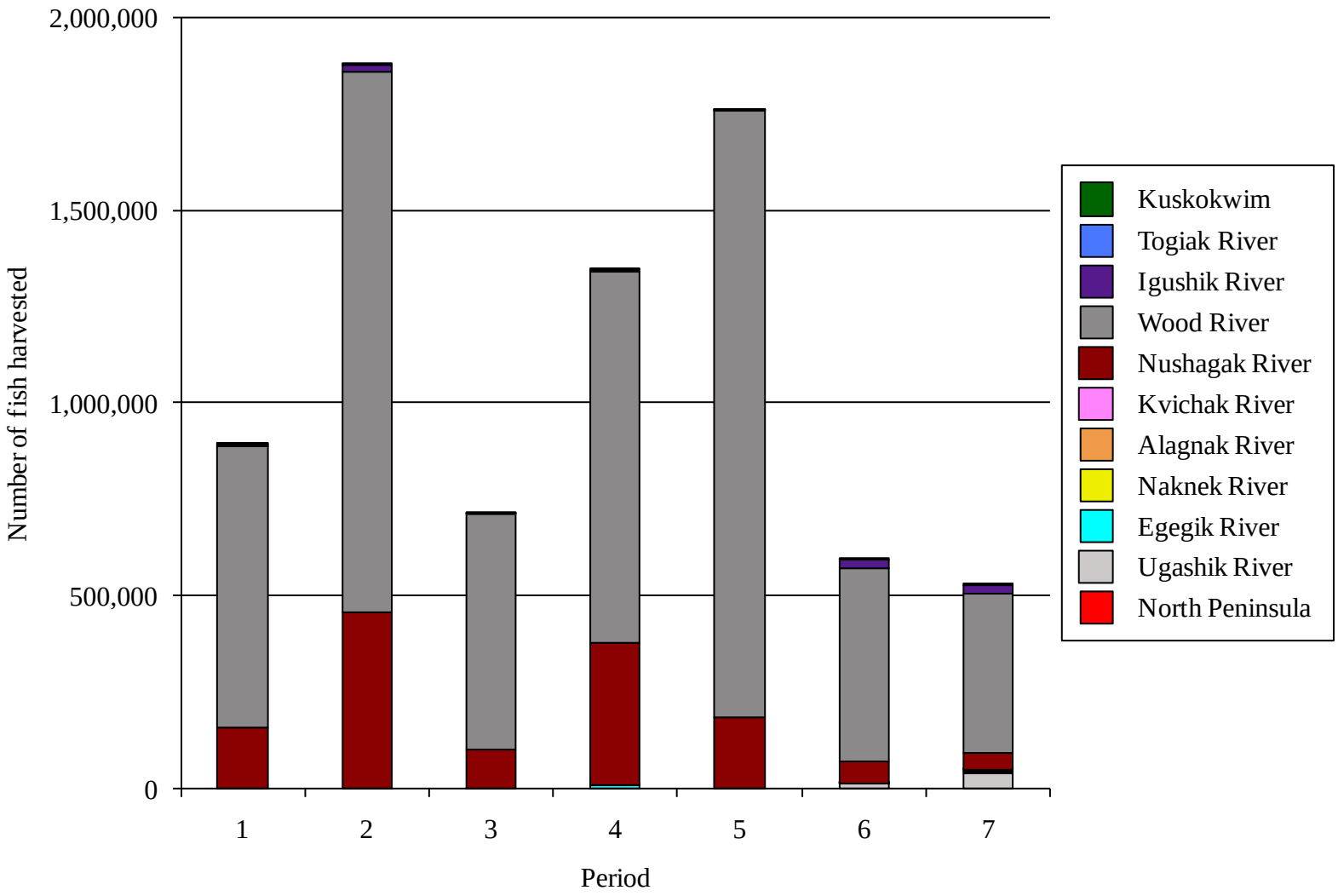


Figure 6.–The number of commercially harvested sockeye salmon captured in the Nushagak fishing district of Bristol Bay, Alaska, in 7 temporal periods in 2009 apportioned to stock.

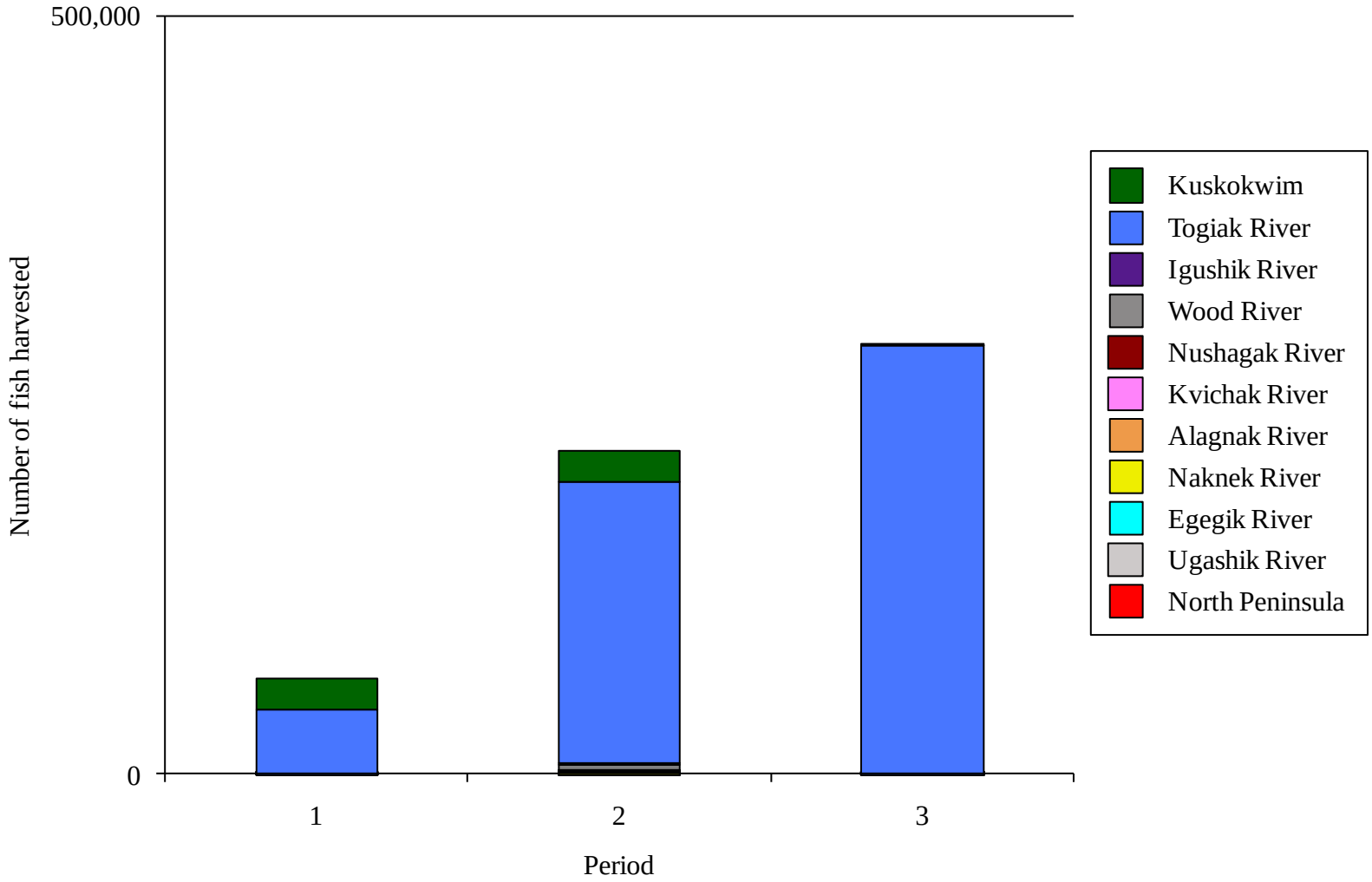


Figure 7.–The number of commercially harvested sockeye salmon captured in the Togiak fishing district of Bristol Bay, Alaska, in 3 temporal periods in 2009 apportioned to stock.

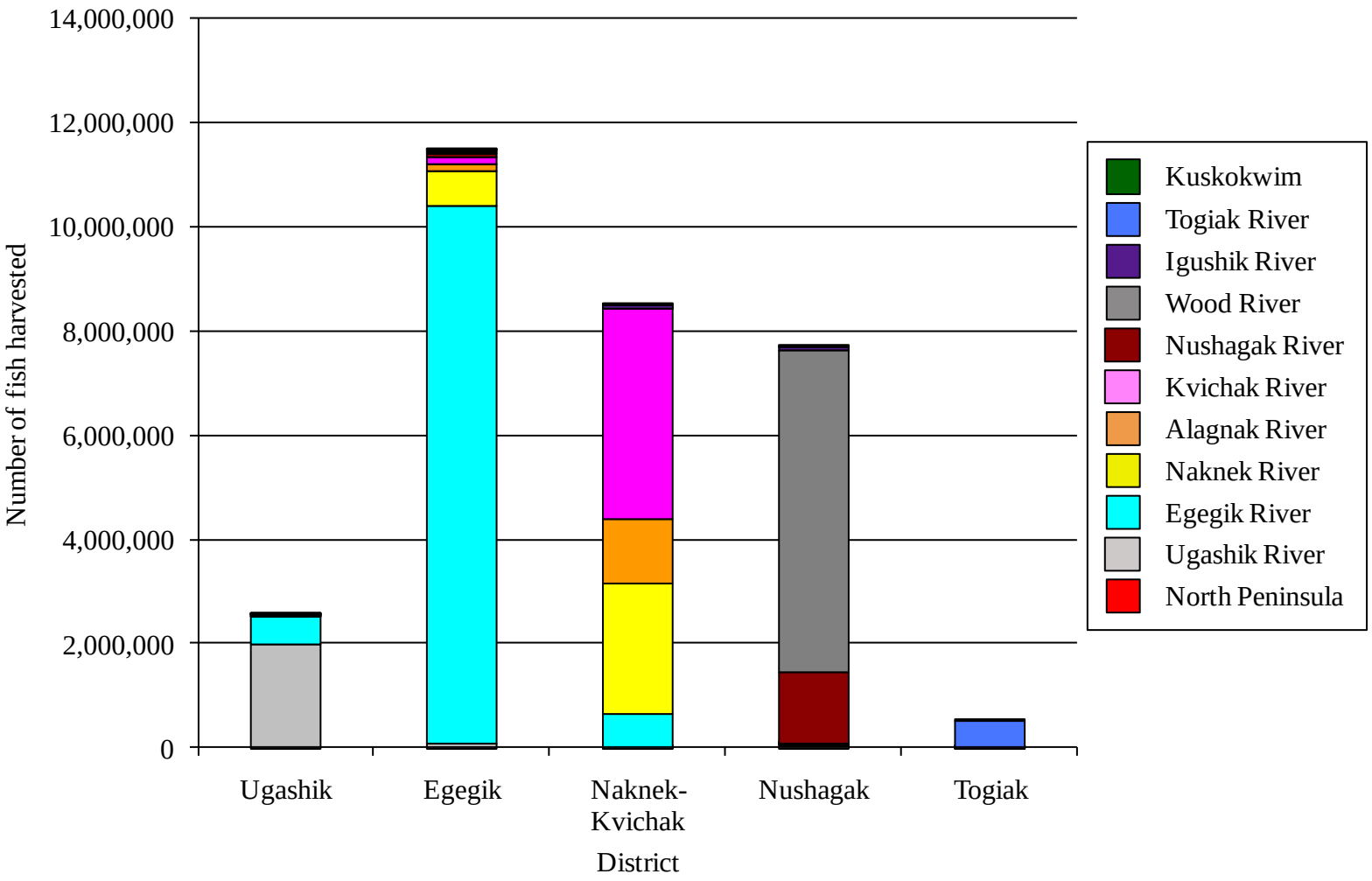
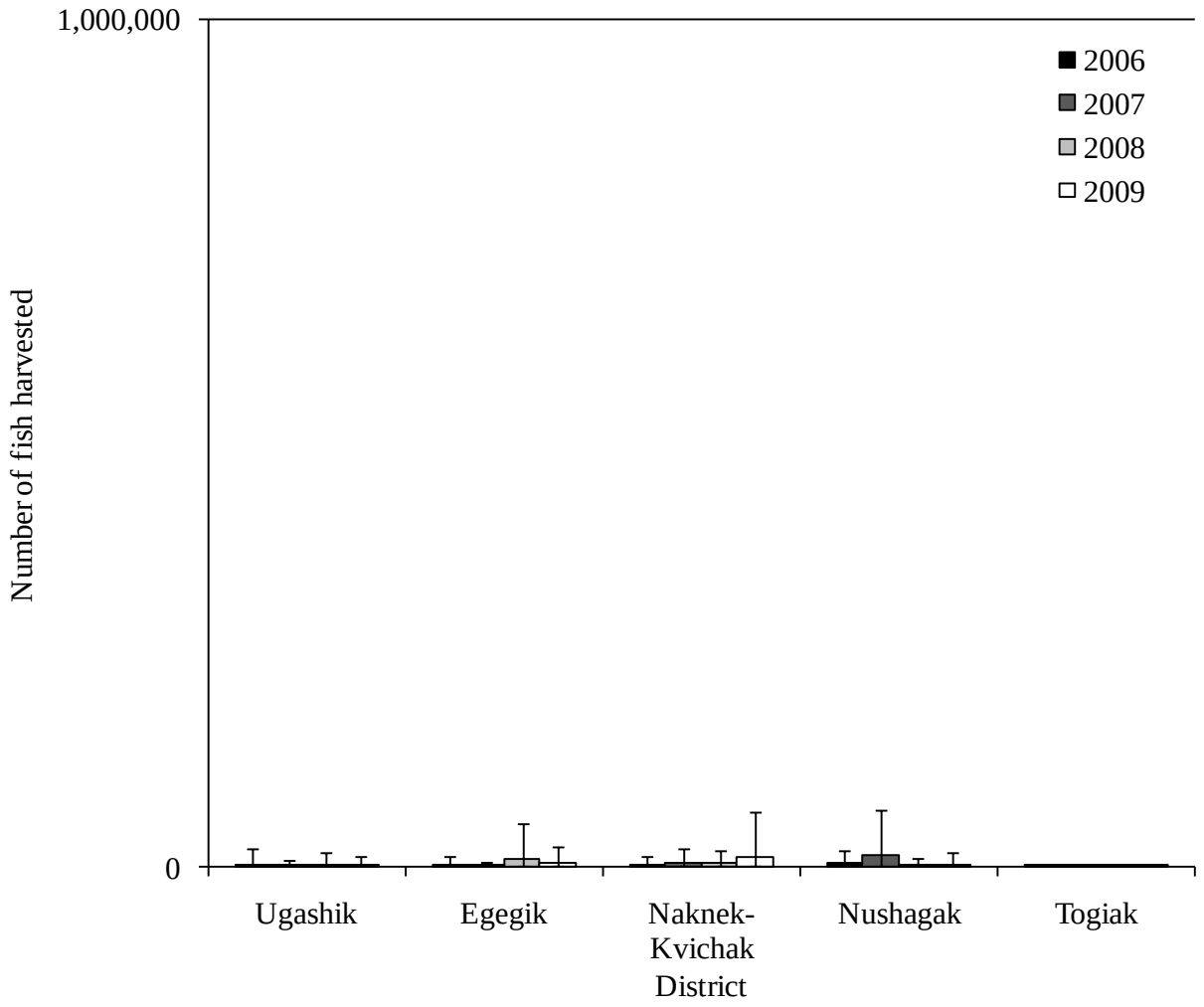


Figure 8.–The total number of commercially harvested sockeye salmon captured in the 5 fishing districts of Bristol Bay, Alaska, in 2009 apportioned to stock.



Note: The y-axis scale of figures of stock-specific harvest (Figures 9, 10, 13, 15, 17, 19, 21, 23, 25, 27, and 20) has been maintained in units of 1 million fish for consistency.

Figure 9.–The total number of North Peninsula stock sockeye salmon commercially harvested in the 5 fishing districts of Bristol Bay, Alaska, in 2006–2009.

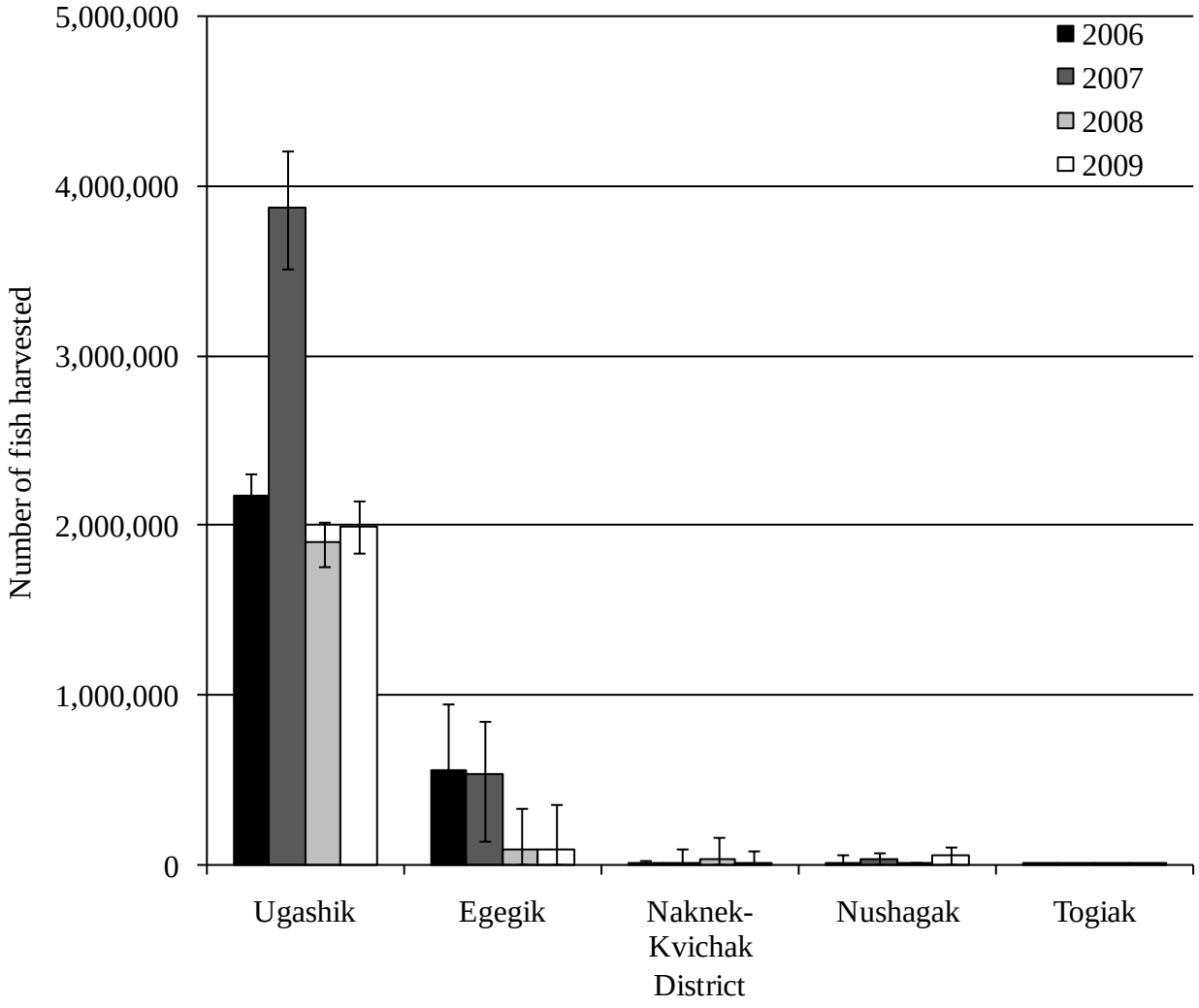
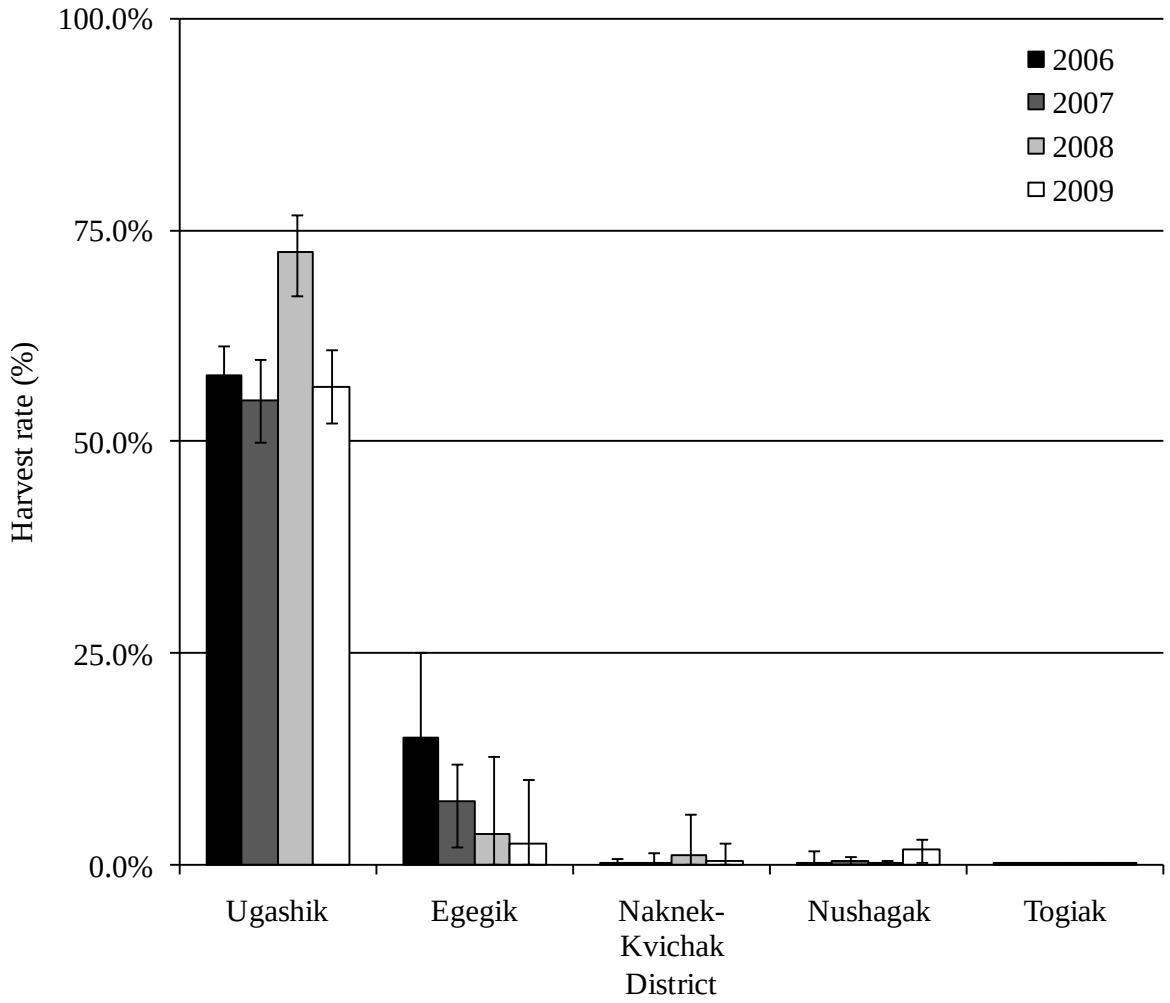


Figure 10.–The total number of Ugashik stock sockeye salmon commercially harvested in the 5 fishing districts of Bristol Bay, Alaska, in 2006–2009.



Note: These intervals are based upon error associated with harvest estimates and do not account for error in estimates of escapement.

Figure 11.–The harvest rate of Ugashik stock sockeye salmon commercially harvested in Bristol Bay, Alaska, in 2006–2009, by fishing district and 90% credibility intervals.

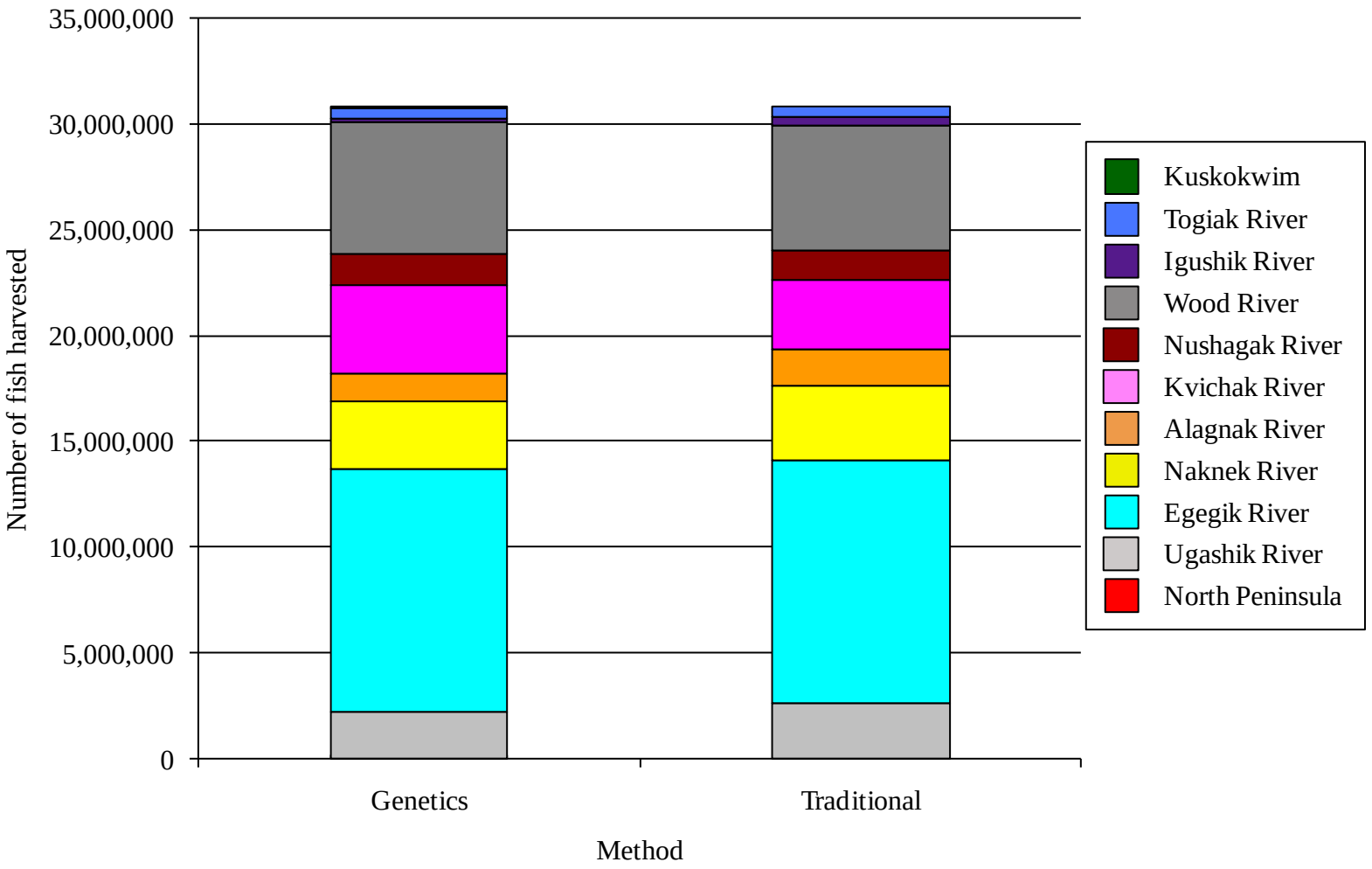


Figure 12.–A comparison of the total number of commercially harvested sockeye salmon captured in Bristol Bay, Alaska, in 2009 apportioned to stock by the genetic and traditional method.

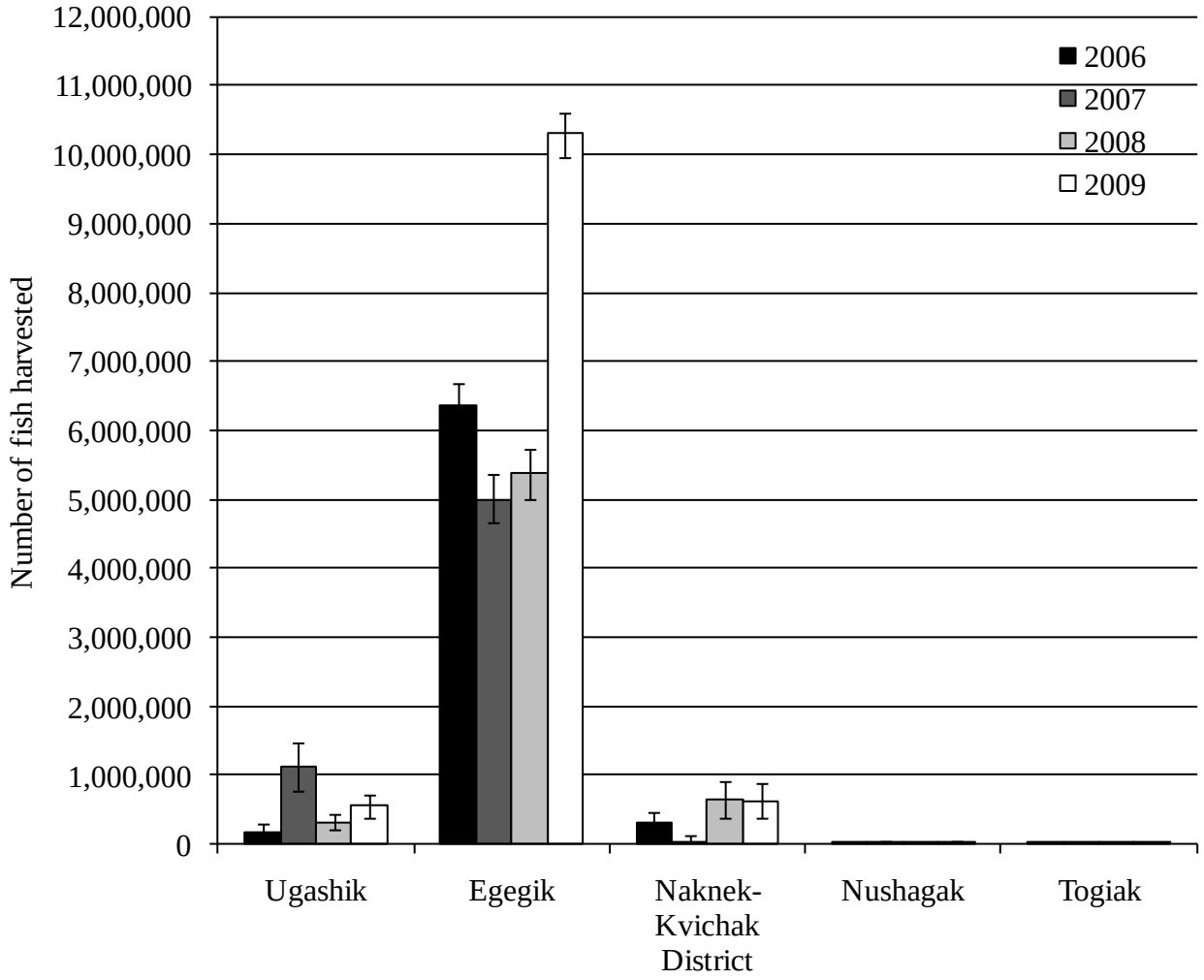
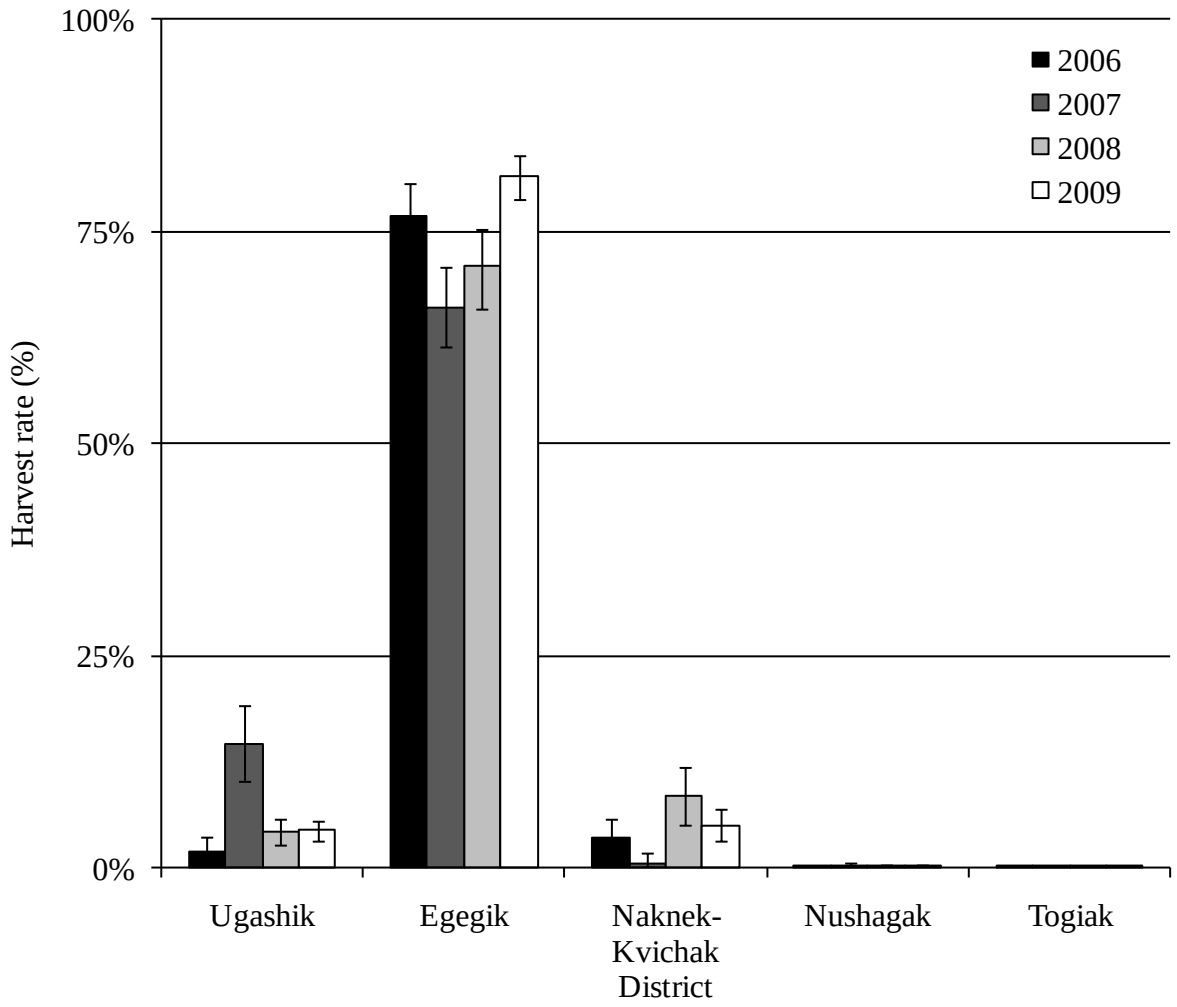


Figure 13.–The total number of Egegik stock sockeye salmon commercially harvested in the 5 fishing districts of Bristol Bay, Alaska, in 2006–2009.



Note: These intervals are based upon error associated with harvest estimates and do not account for error in estimates of escapement.

Figure 14.–The harvest rate of Egegik stock sockeye salmon commercially harvested in Bristol Bay, Alaska, in 2006–2009, by fishing district and 90% credibility intervals.

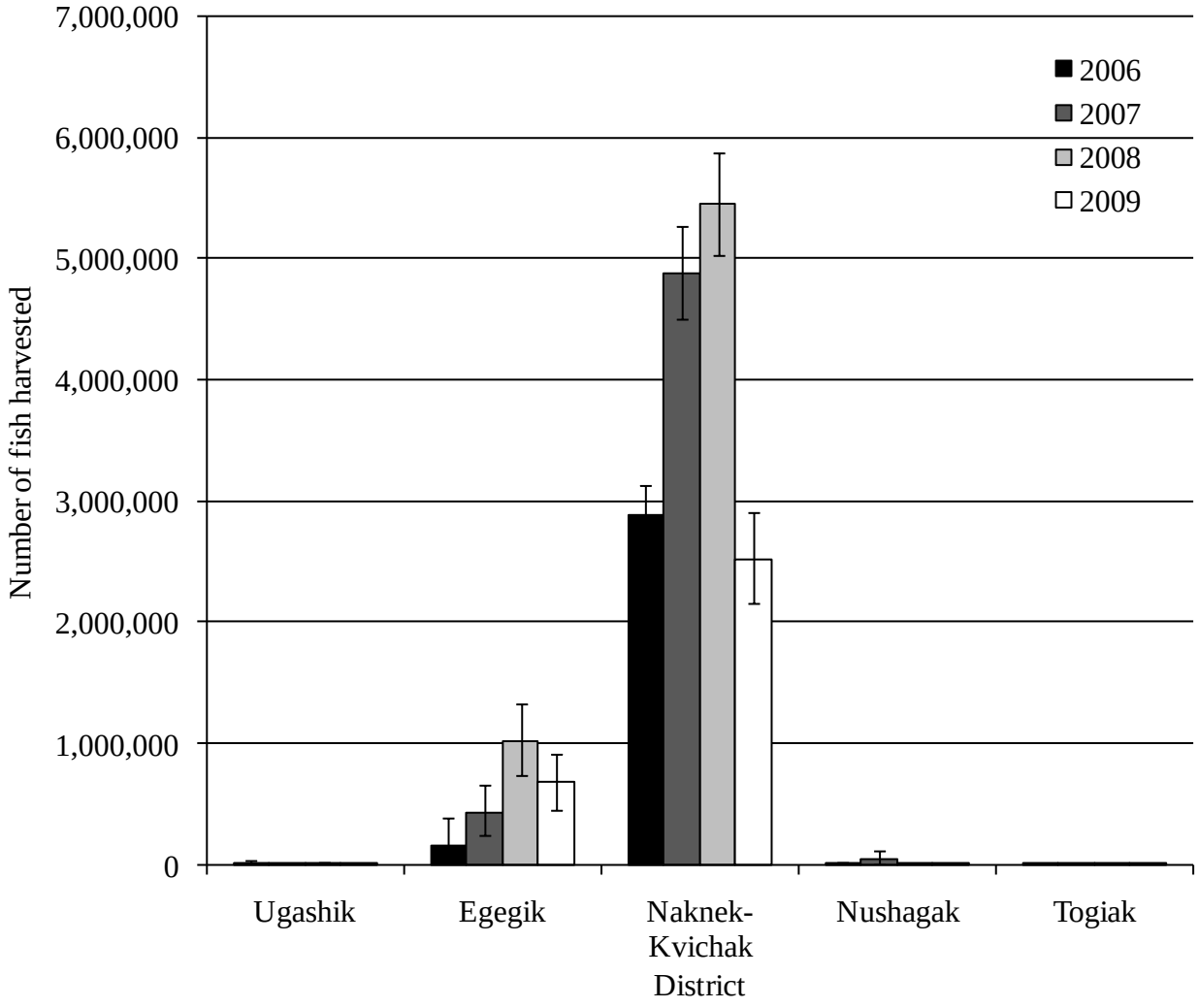
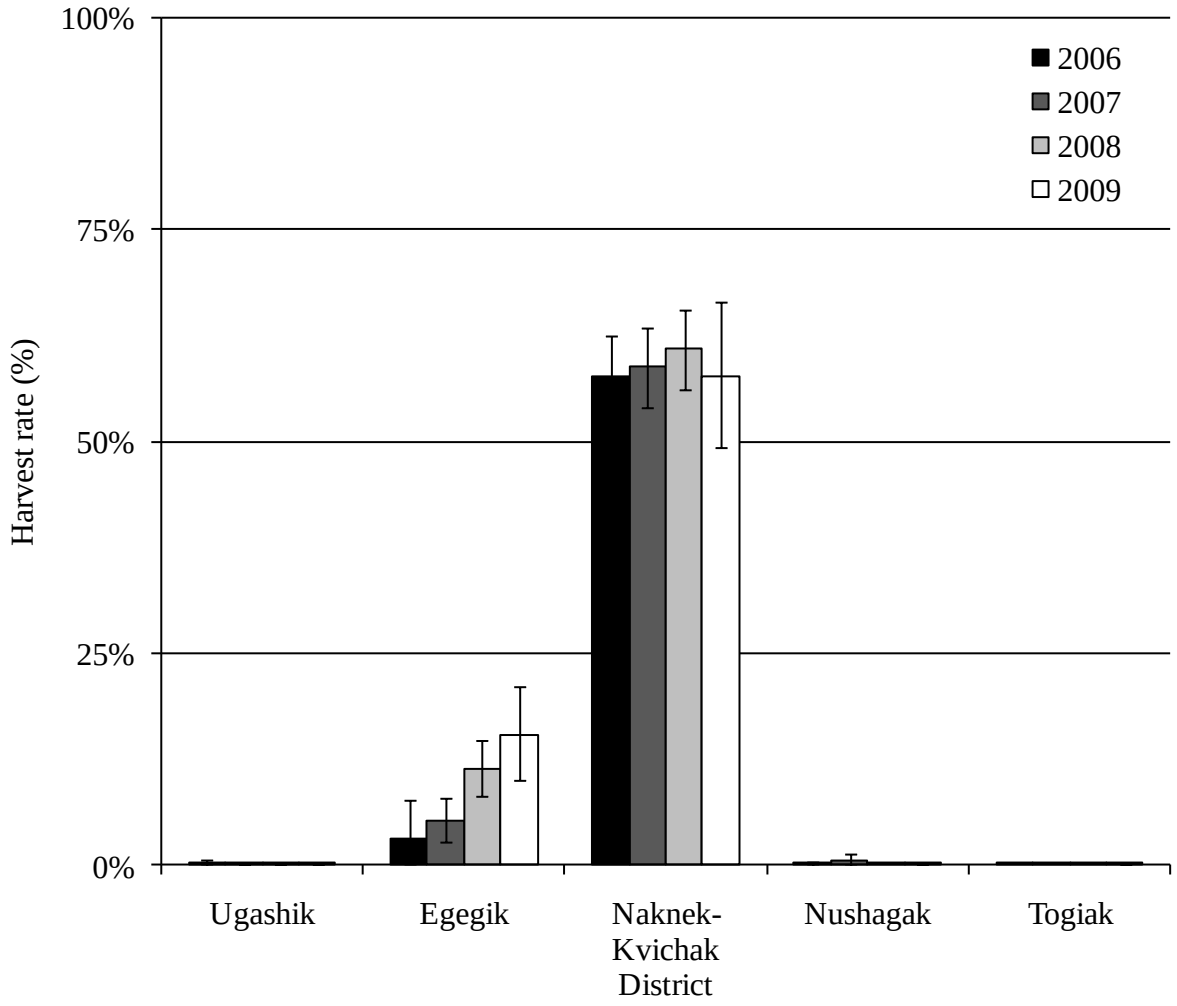


Figure 15.–The total number of Naknek stock sockeye salmon commercially harvested in the 5 fishing districts of Bristol Bay, Alaska, in 2006–2009.



Note: These intervals are based upon error associated with harvest estimates and do not account for error in estimates of escapement.

Figure 16.–The harvest rate of Naknek stock sockeye salmon commercially harvested in Bristol Bay, Alaska, in 2006–2009, by fishing district and 90% credibility intervals.

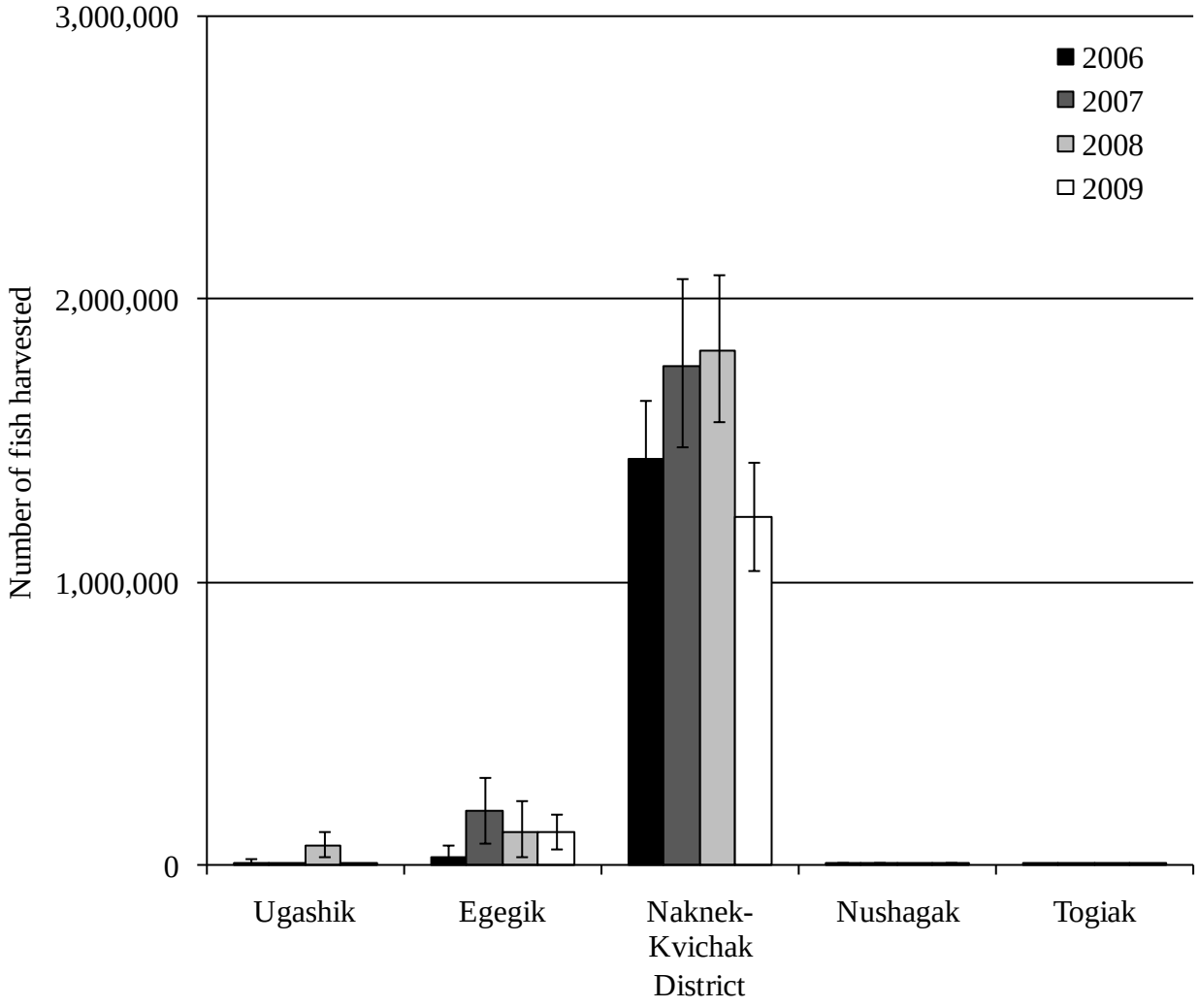
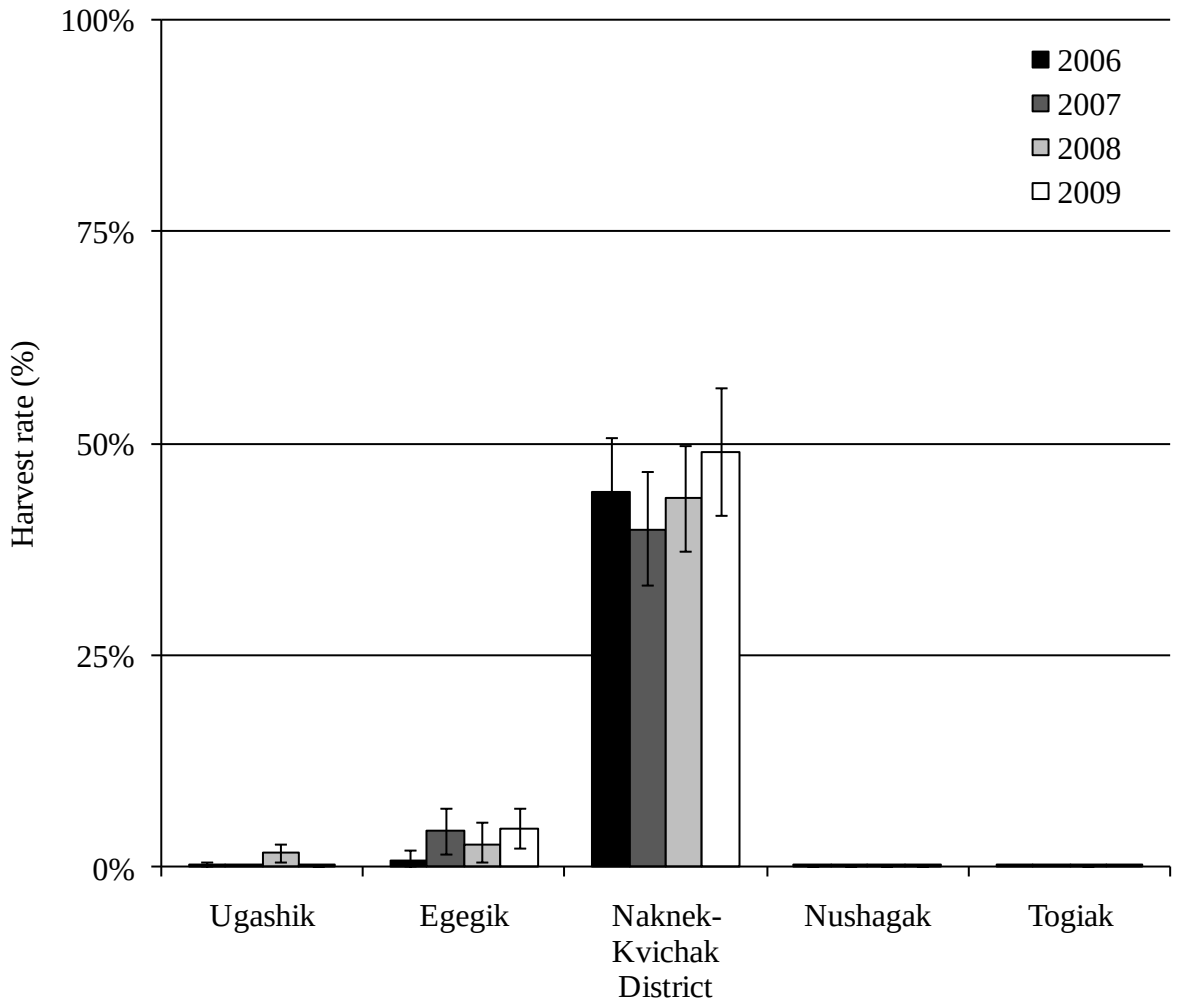


Figure 17.–The total number of Alagnak stock sockeye salmon commercially harvested in the 5 fishing districts of Bristol Bay, Alaska, in 2006–2009.



Note: These intervals are based upon error associated with harvest estimates and do not account for error in estimates of escapement.

Figure 18.–The harvest rate of Alagnak stock sockeye salmon commercially harvested in Bristol Bay, Alaska, in 2006–2009, by fishing district and 90% credibility intervals.

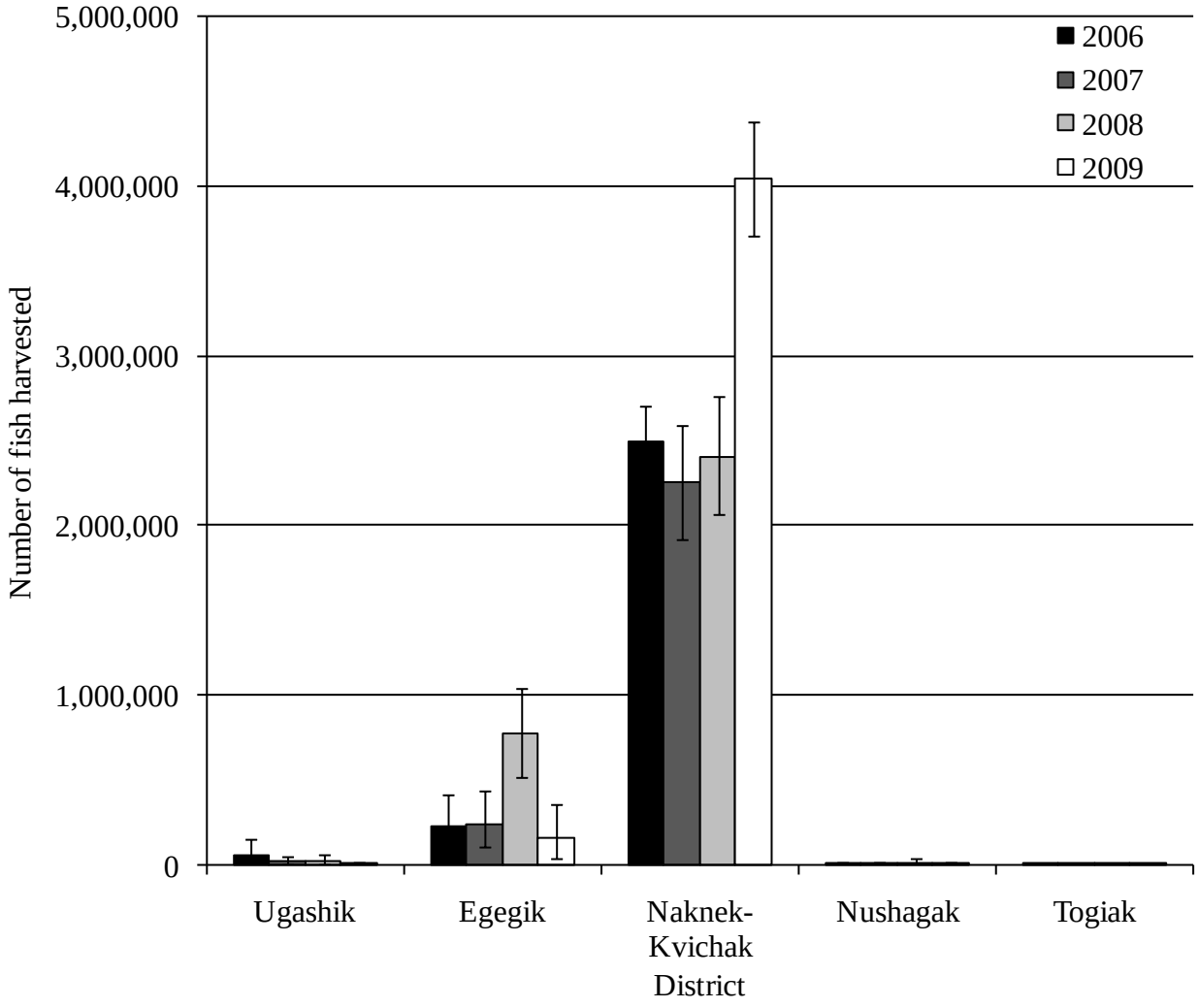
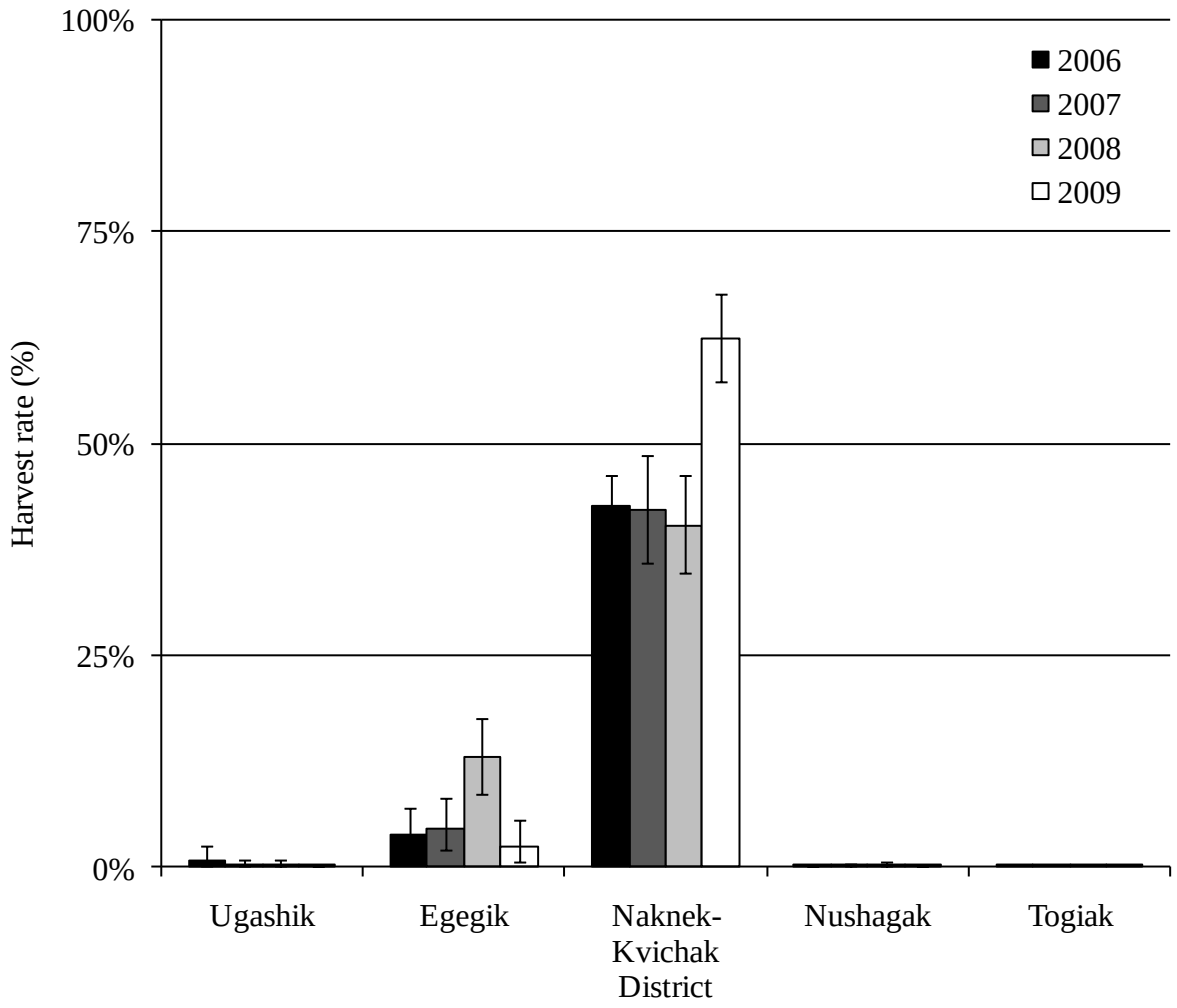


Figure 19.–The total number of Kvichak stock sockeye salmon commercially harvested in the 5 fishing districts of Bristol Bay, Alaska, in 2006–2009.



Note: These intervals are based upon error associated with harvest estimates and do not account for error in estimates of escapement.

Figure 20.–The harvest rate of Kvichak stock sockeye salmon commercially harvested in Bristol Bay, Alaska, in 2006–2009, by fishing district and 90% credibility intervals.

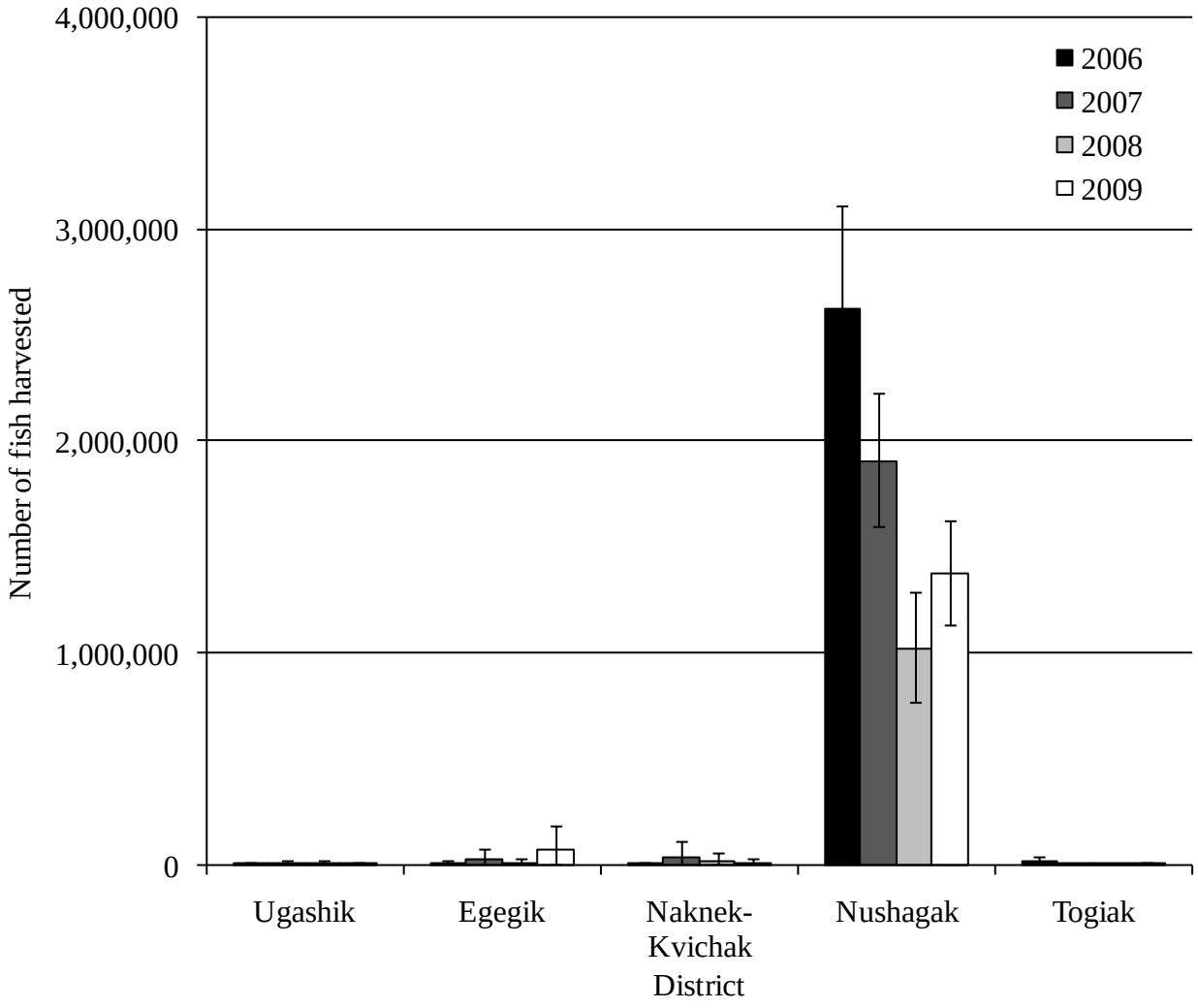
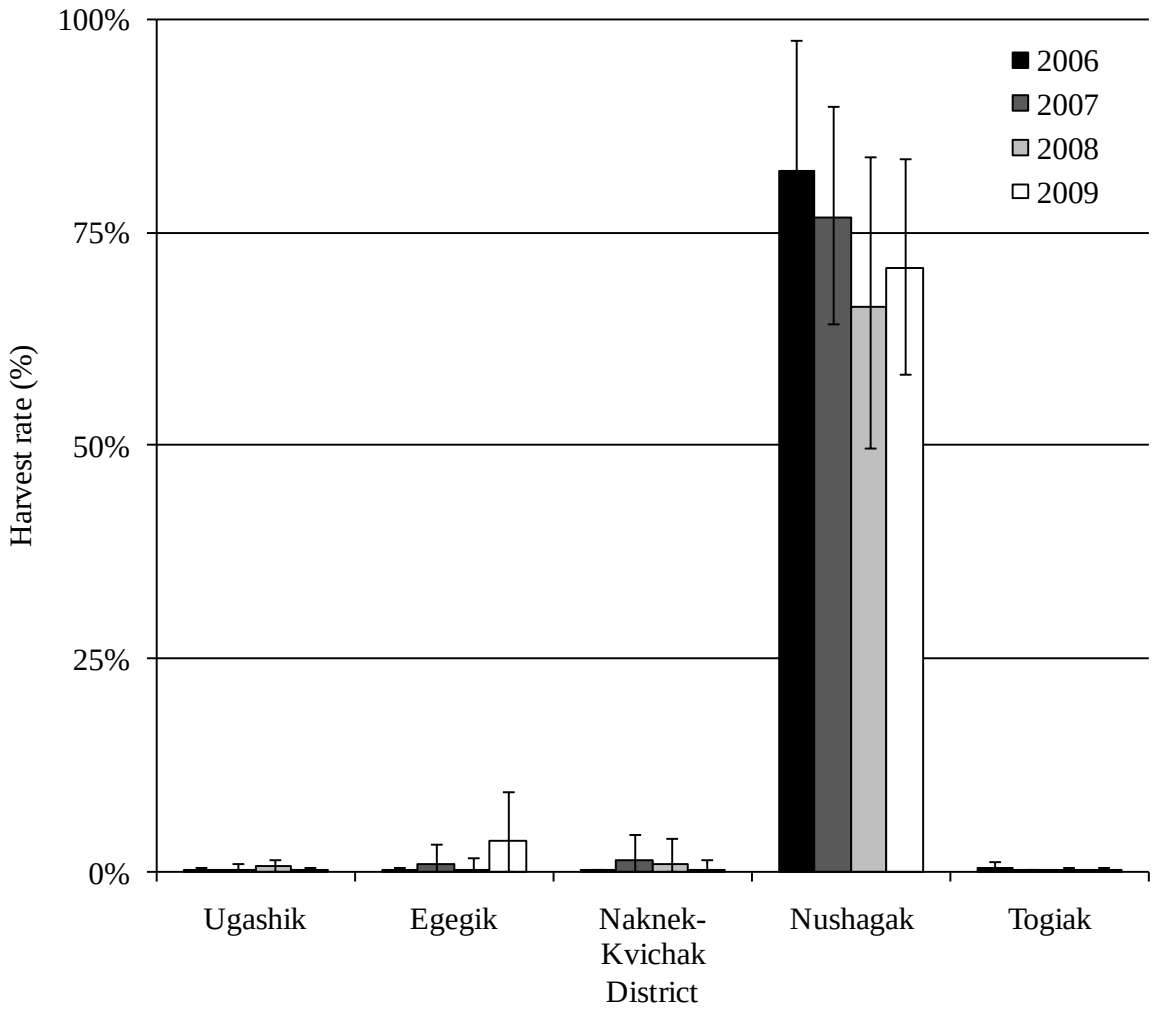


Figure 21.–The total number of Nushagak stock sockeye salmon commercially harvested in the 5 fishing districts of Bristol Bay, Alaska, in 2006–2009.



Note: These intervals are based upon error associated with harvest estimates and do not account for error in estimates of escapement.

Figure 22.–The harvest rate of Nushagak stock sockeye salmon commercially harvested in Bristol Bay, Alaska, in 2006–2009, by fishing district and 90% credibility intervals.

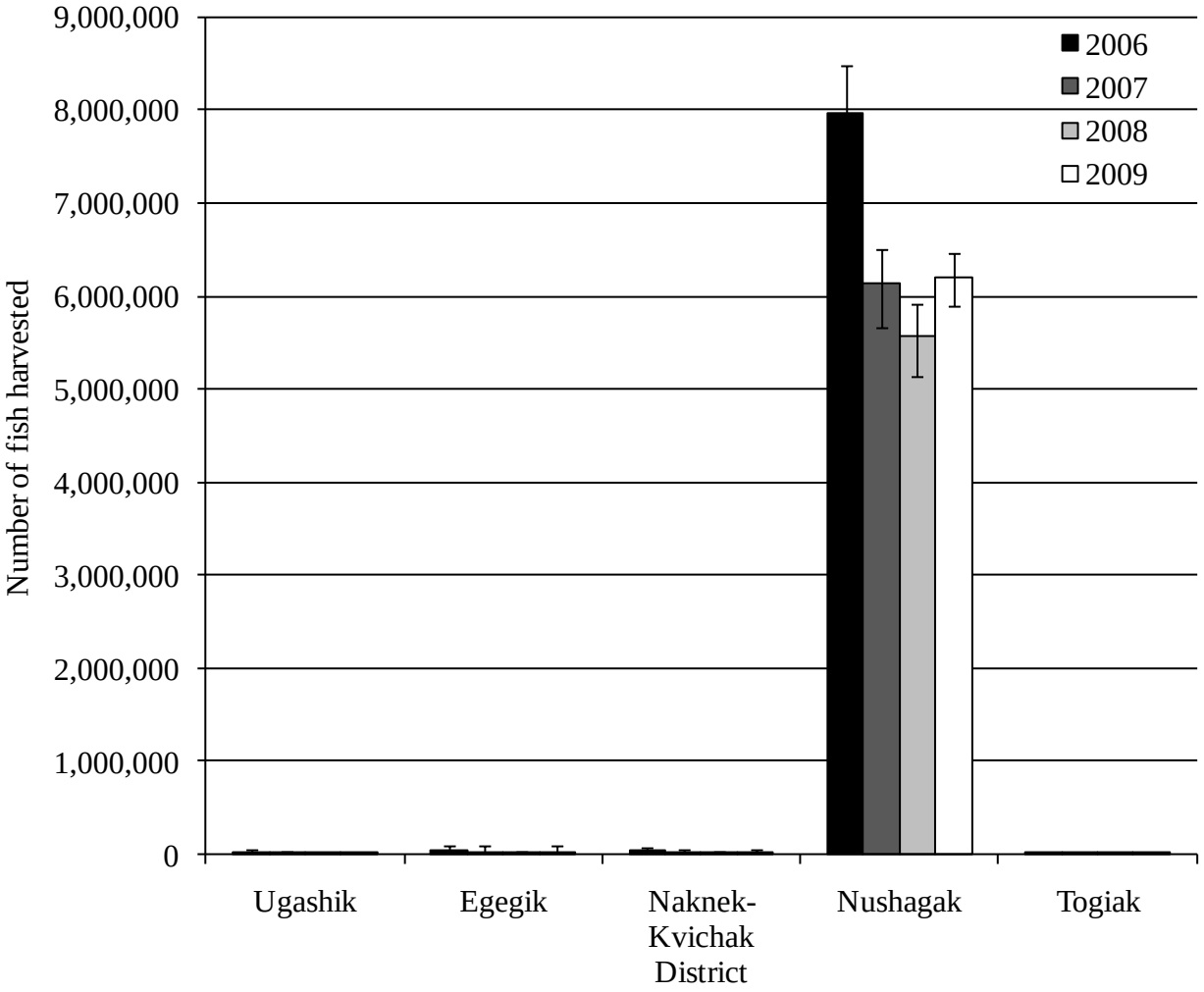
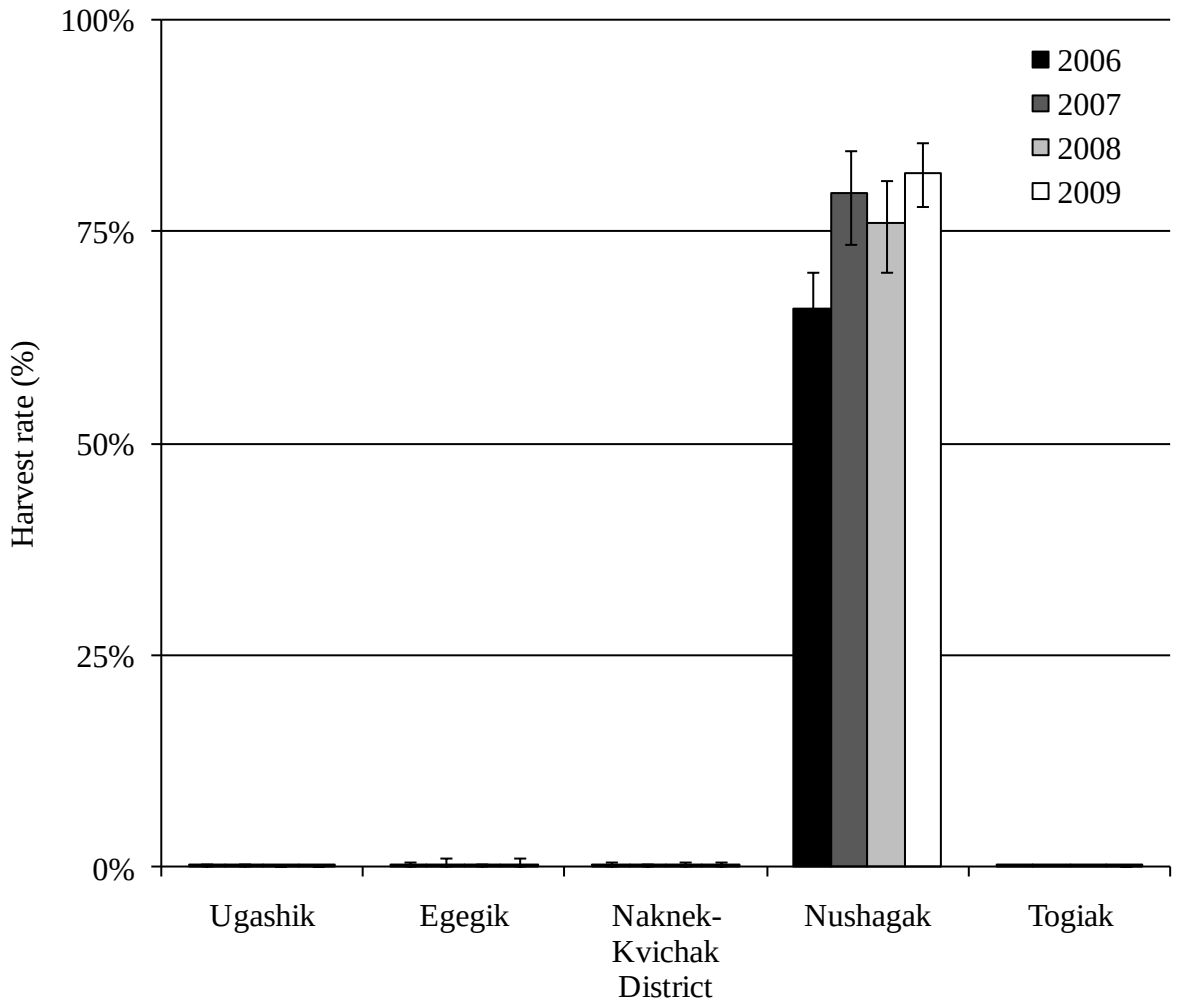


Figure 23.–The total number of Wood River stock sockeye salmon commercially harvested in the 5 fishing districts of Bristol Bay, Alaska, in 2006–2009.



Note: These intervals are based upon error associated with harvest estimates and do not account for error in estimates of escapement.

Figure 24.–The harvest rate of Wood River stock sockeye salmon commercially harvested in Bristol Bay, Alaska, in 2006–2009, by fishing district and 90% credibility intervals.

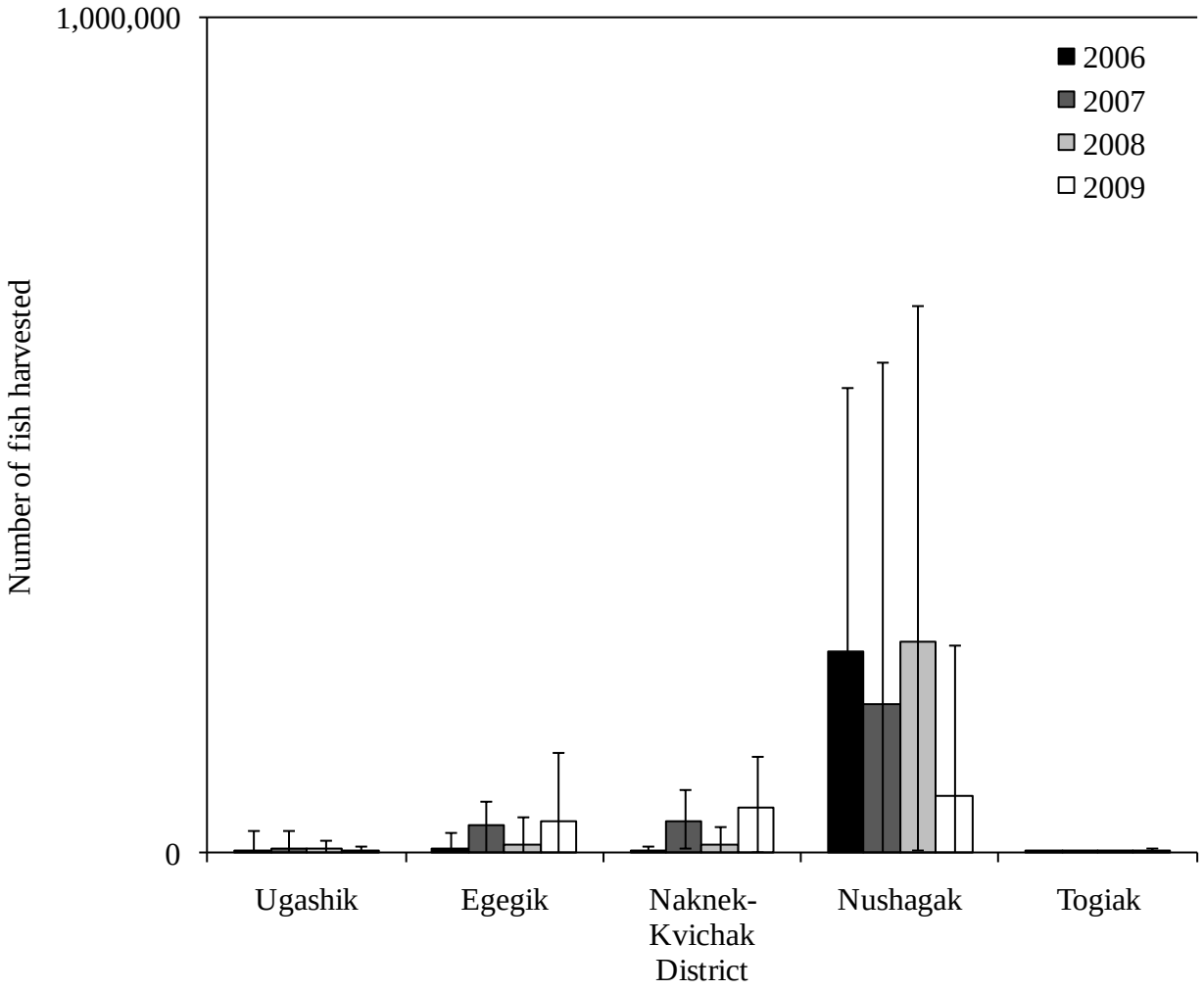
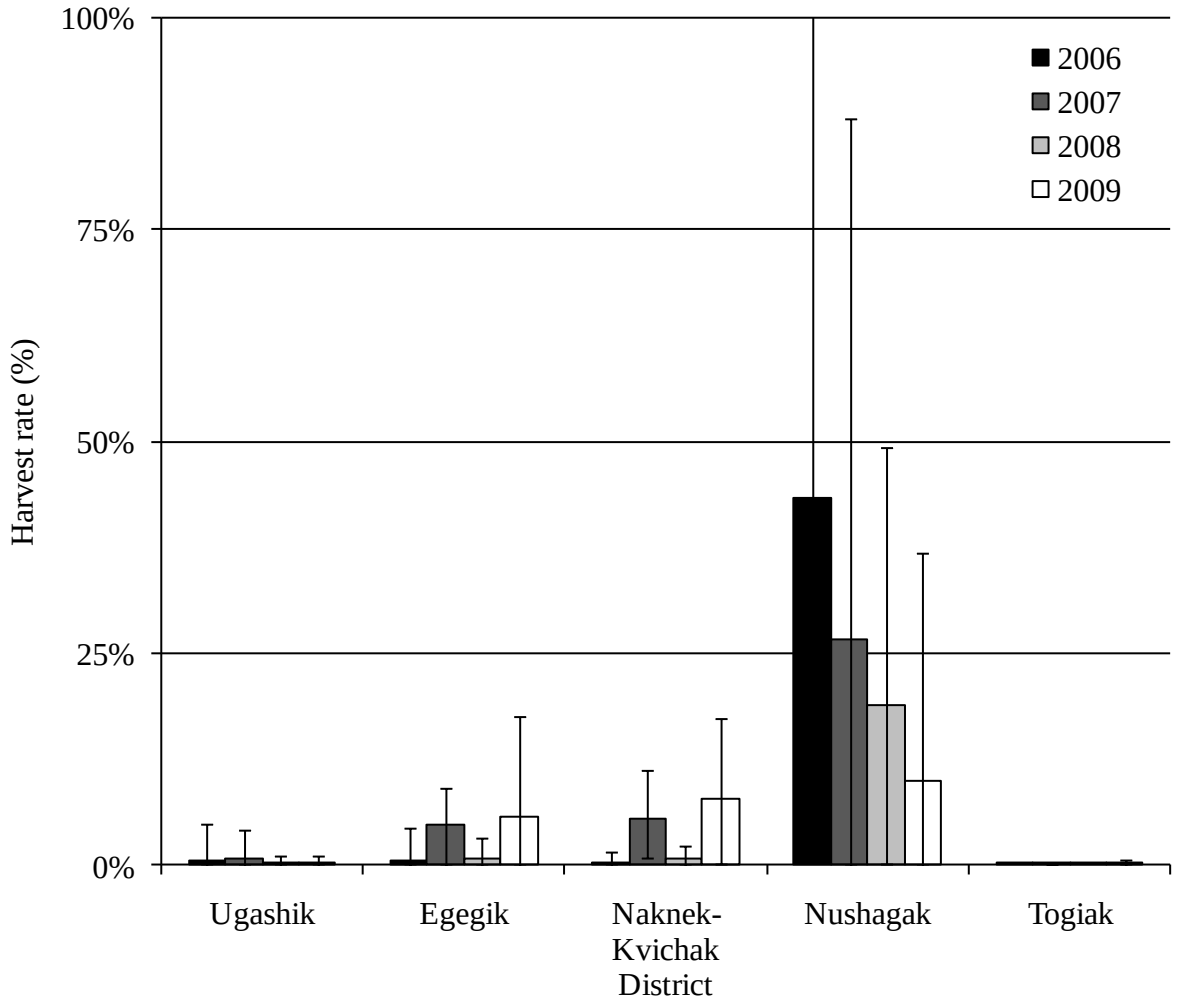


Figure 25.–The total number of Igushik stock sockeye salmon commercially harvested in the 5 fishing districts of Bristol Bay, Alaska, in 2006–2009.



Note: These intervals are based upon error associated with harvest estimates and do not account for error in estimates of escapement.

Figure 26.–The harvest rate of Igushik stock sockeye salmon commercially harvested in Bristol Bay, Alaska, in 2006–2009, by fishing district and 90% credibility intervals.

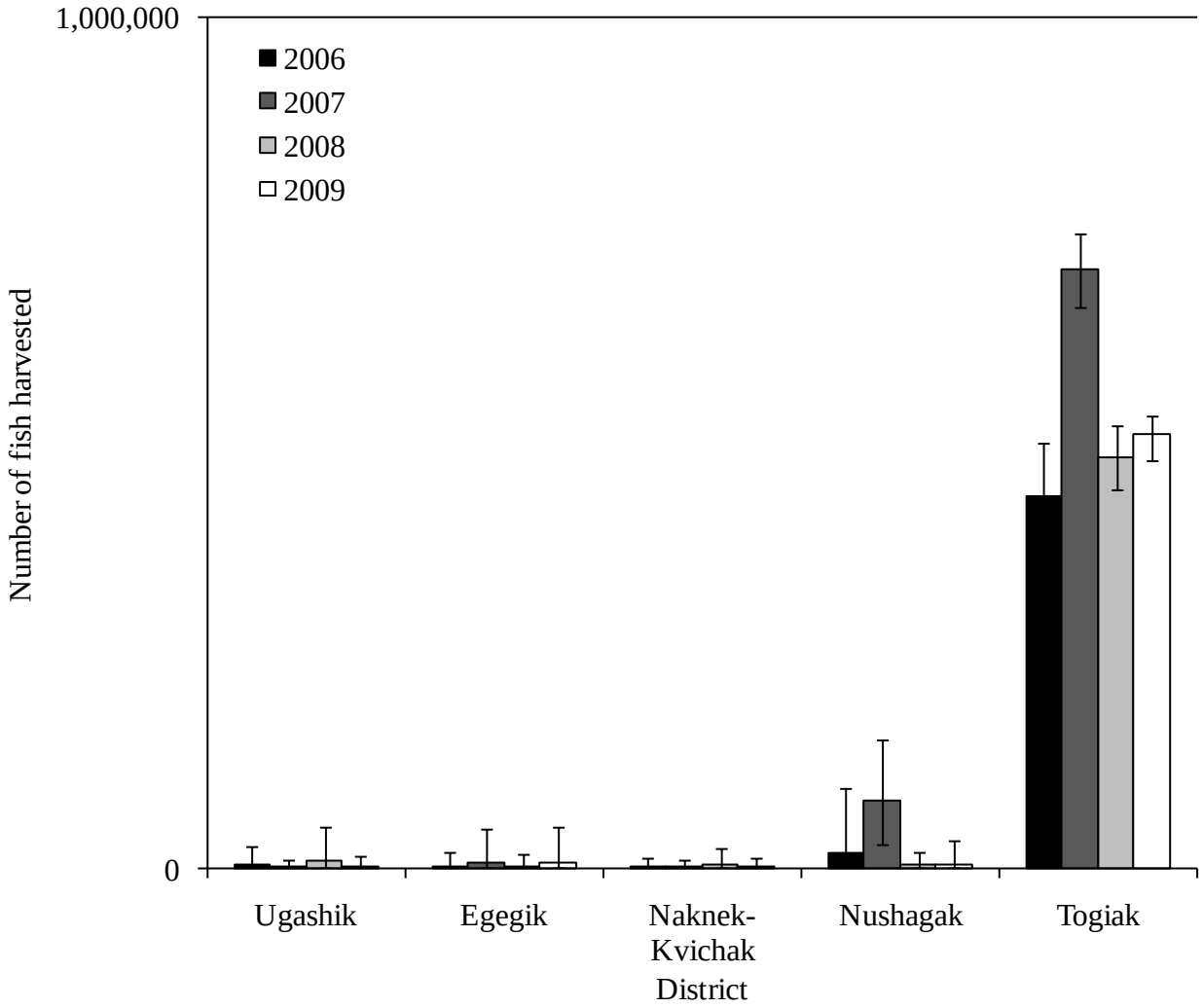
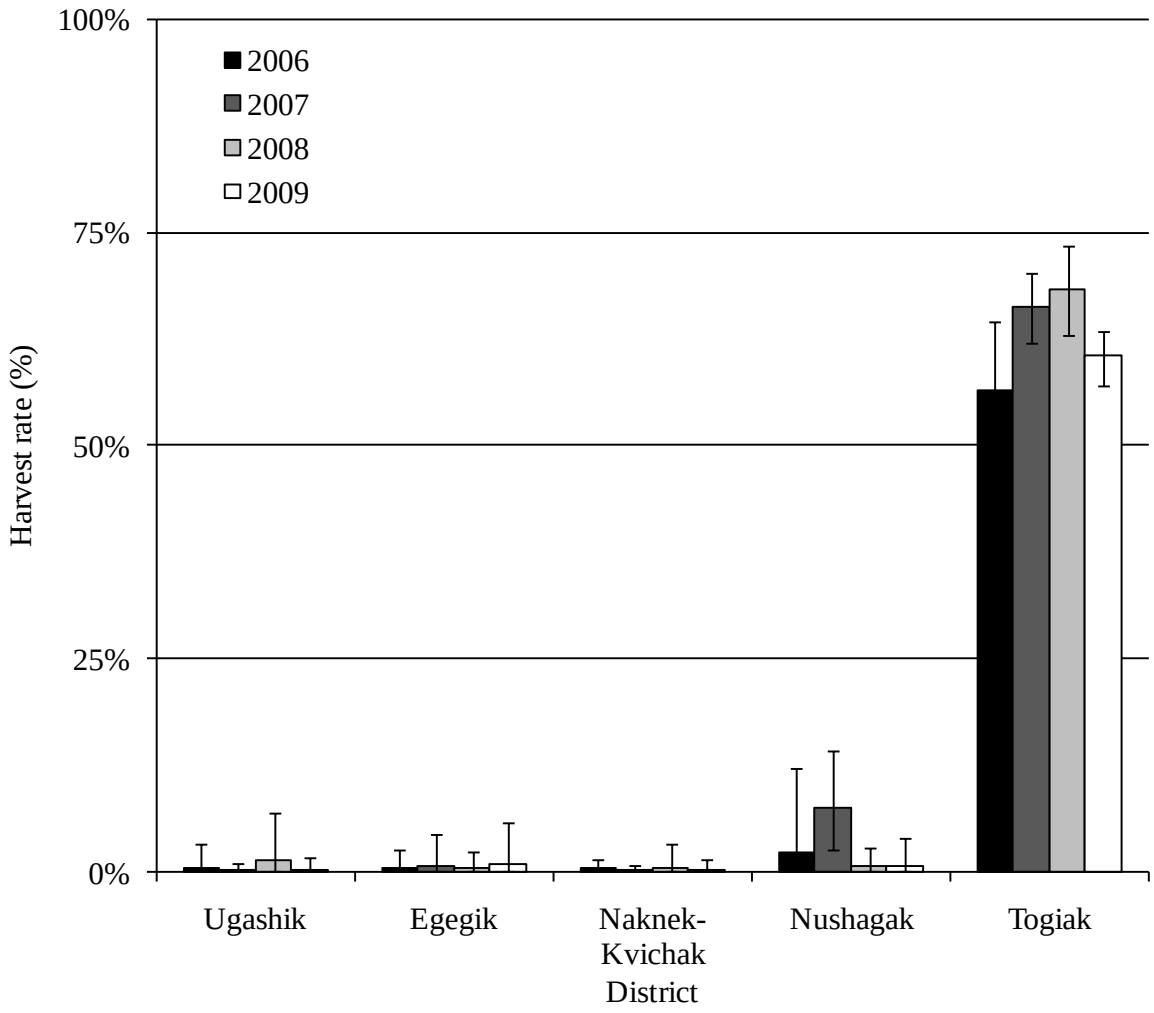


Figure 27.–The total number of Togiak stock sockeye salmon commercially harvested in the 5 fishing districts of Bristol Bay, Alaska, in 2006–2009.



Note: These intervals are based upon error associated with harvest estimates and do not account for error in estimates of escapement.

Figure 28.–The harvest rate of Togiak stock sockeye salmon commercially harvested in Bristol Bay, Alaska, in 2006–2009, by fishing district and 90% credibility intervals.

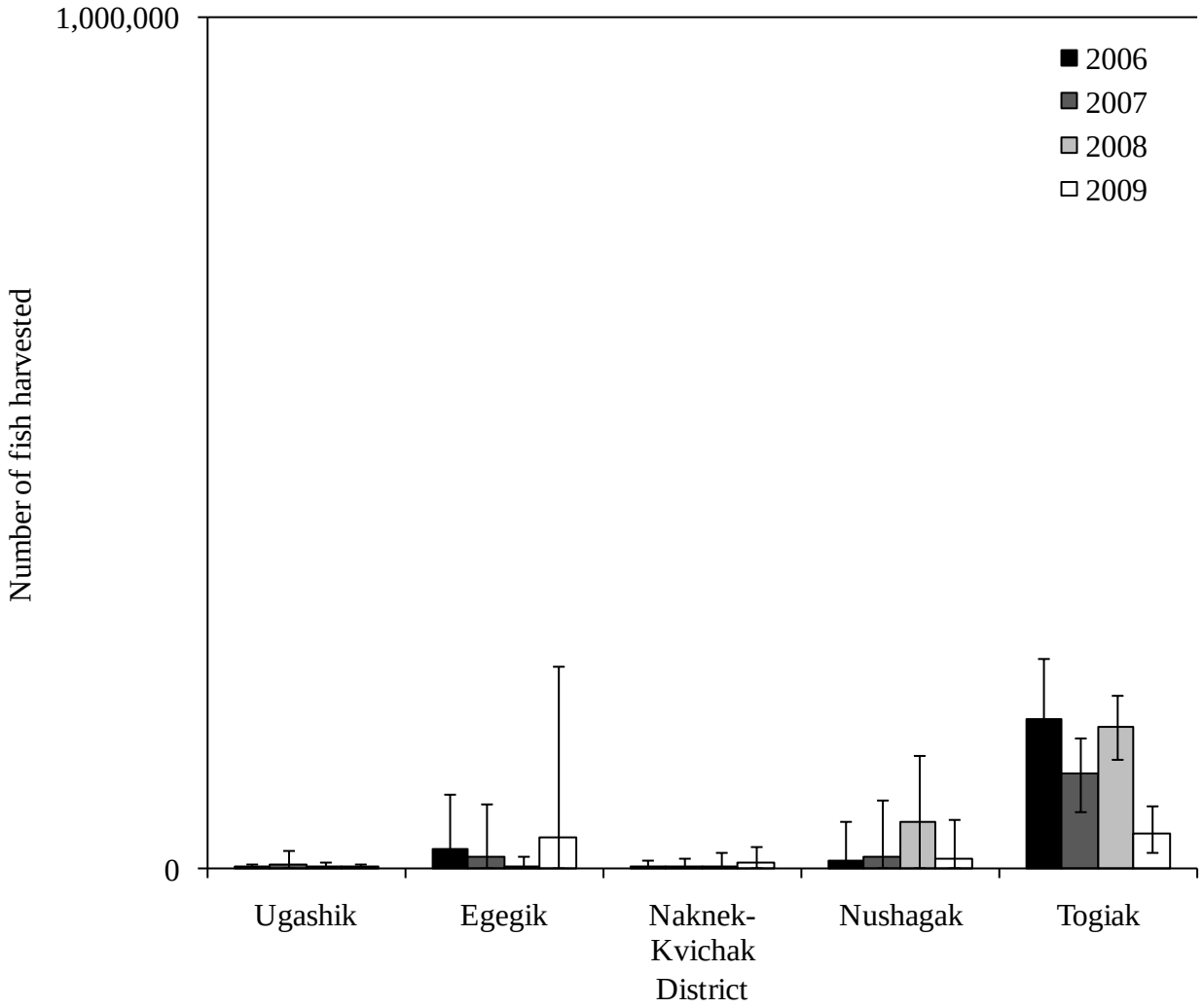


Figure 29.–The total number of Kuskokwim stock sockeye salmon commercially harvested in the 5 fishing districts of Bristol Bay, Alaska, in 2006–2009.

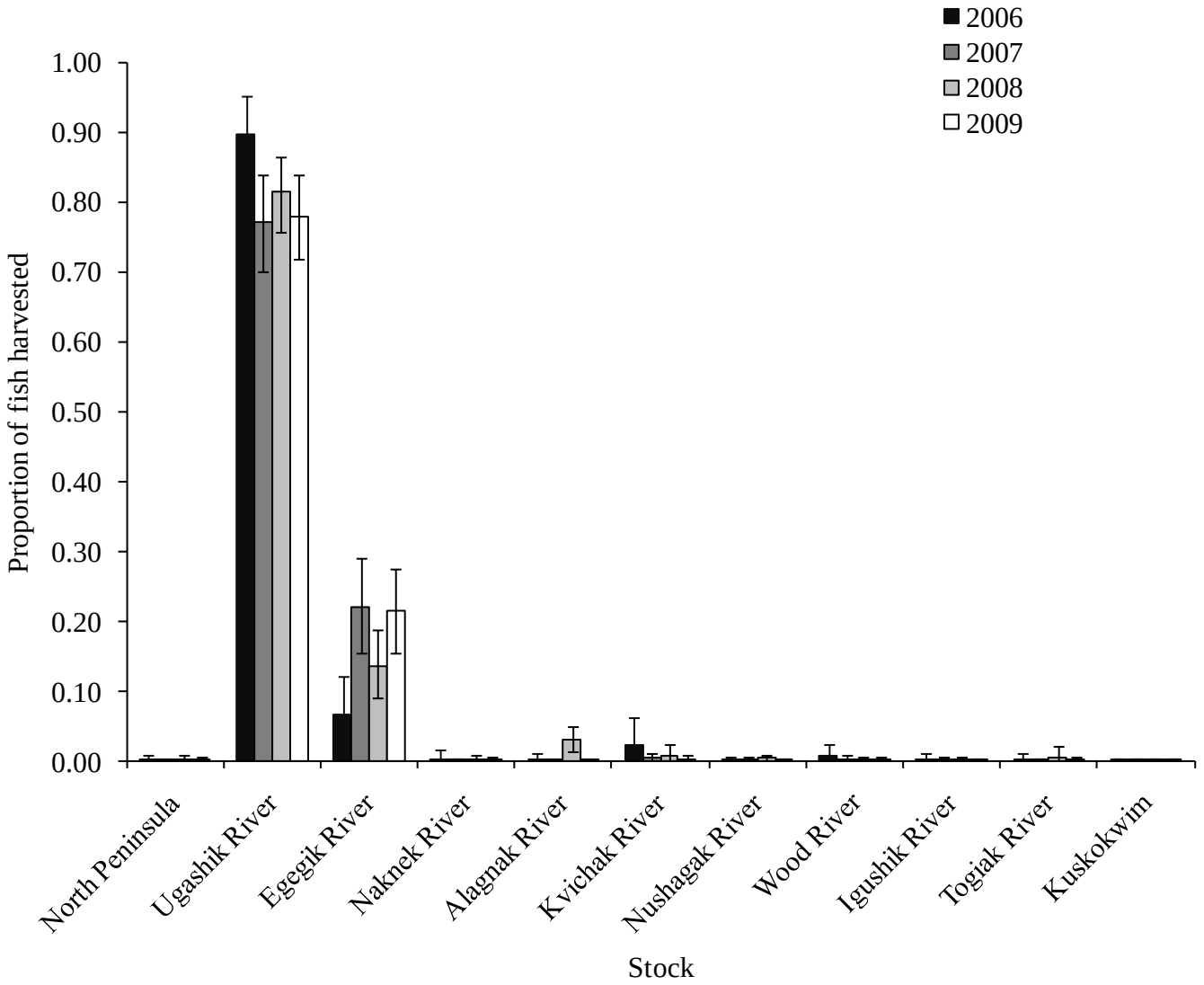


Figure 30.–Estimated proportion (and 90% credibility intervals) of sockeye salmon from each stock harvested within Ugashik District within Bristol Bay, Alaska, in 2006, 2007, 2008, and 2009.

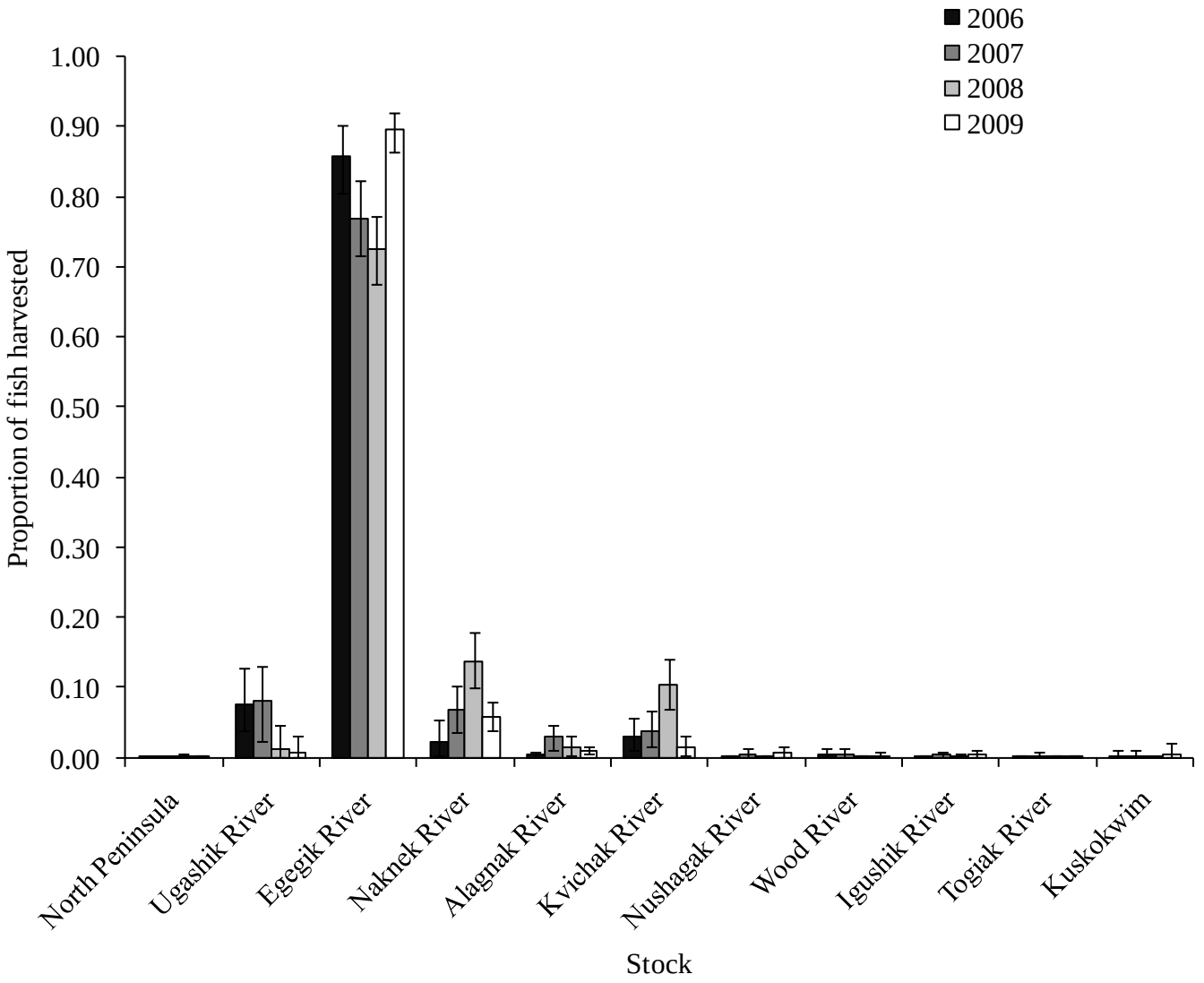


Figure 31.–Estimated proportion (and 90% credibility intervals) of sockeye salmon from each stock harvested within Egegik District within Bristol Bay, Alaska, in 2006, 2007, 2008, and 2009.

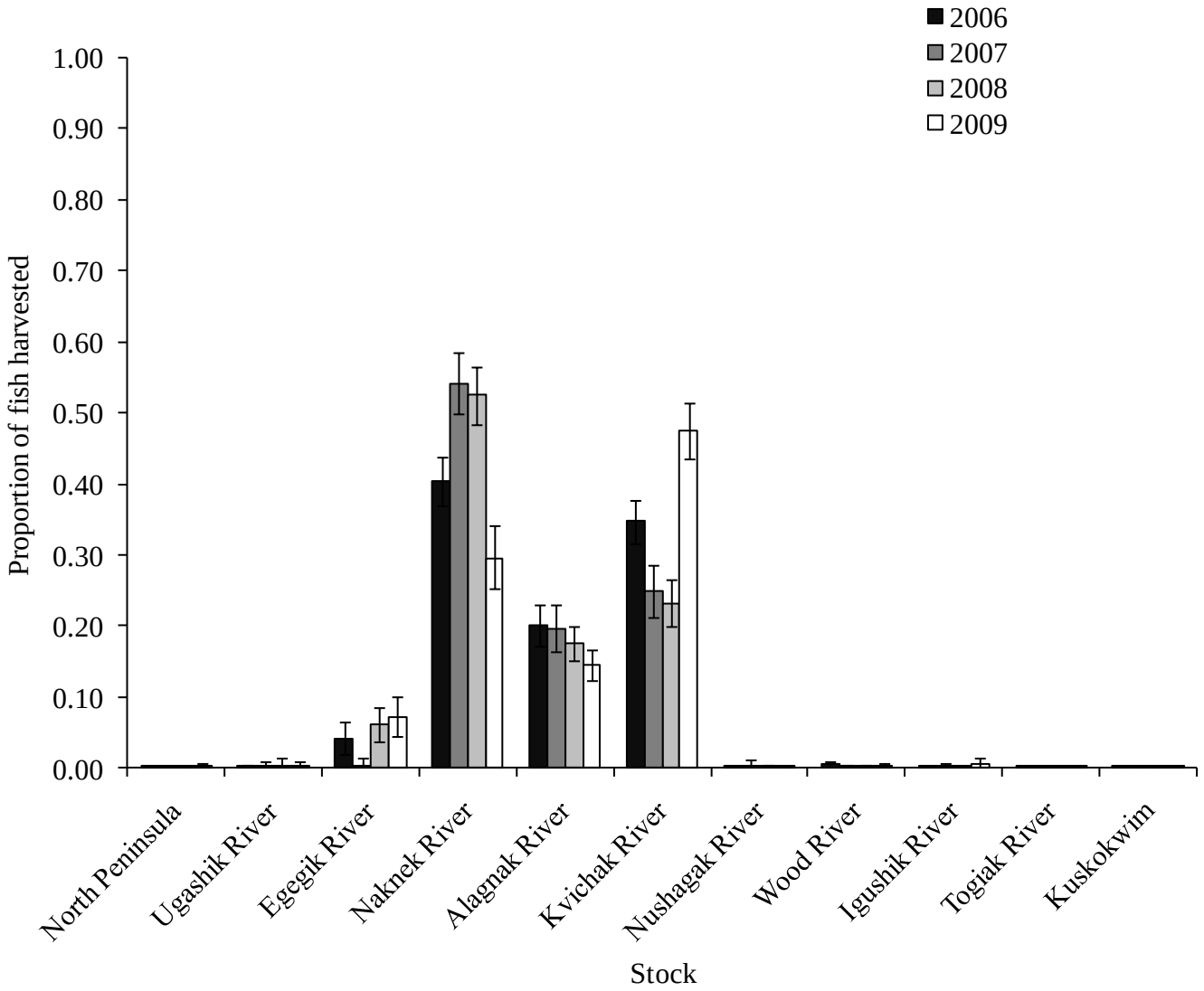


Figure 32.–Estimated proportion (and 90% credibility intervals) of sockeye salmon from each stock harvested within Naknek-Kvichak District within Bristol Bay, Alaska, in 2006, 2007, 2008, and 2009.

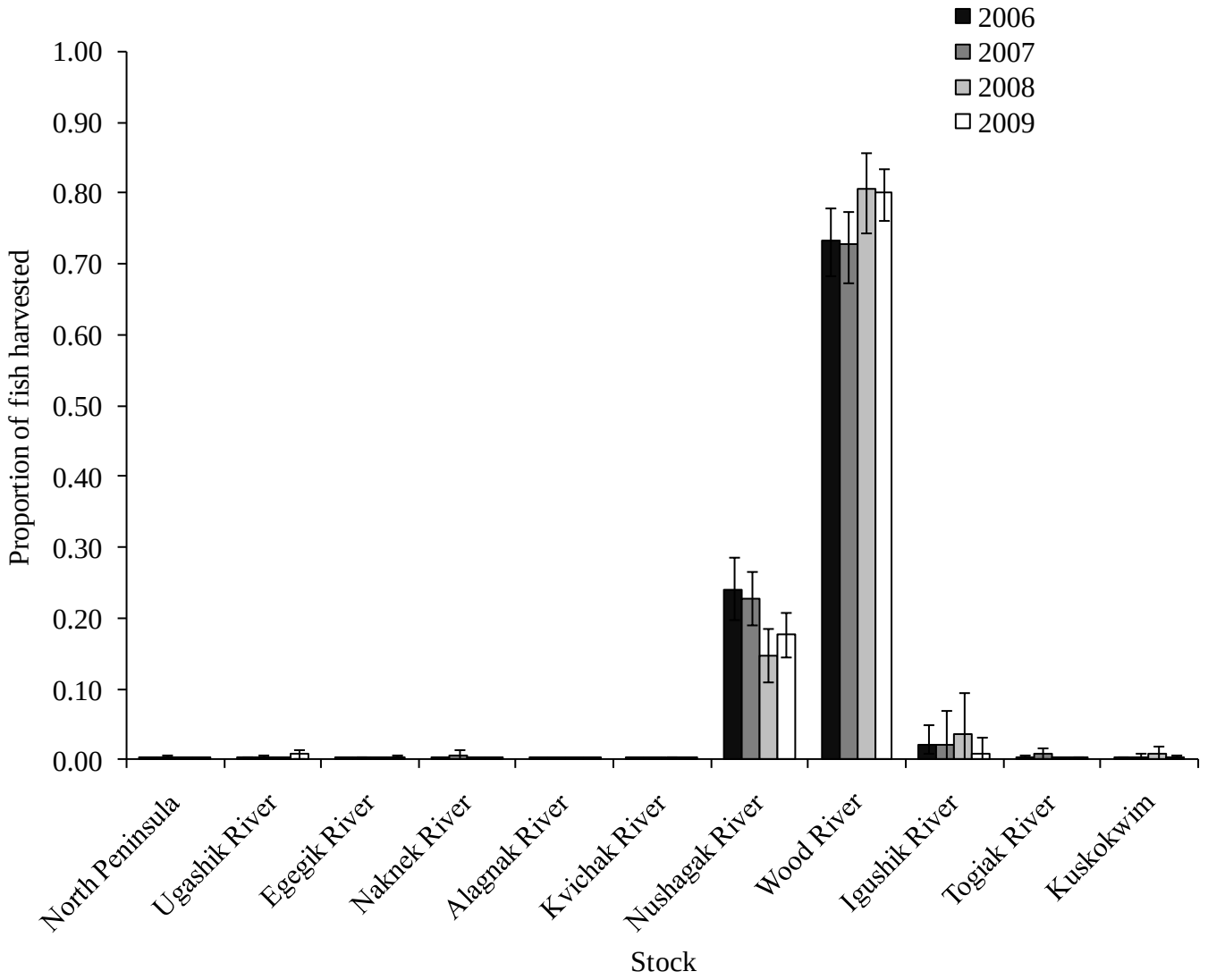


Figure 33.–Estimated proportion (and 90% credibility intervals) of sockeye salmon from each stock harvested within Nushagak District within Bristol Bay, Alaska, in 2006, 2007, 2008, and 2009.

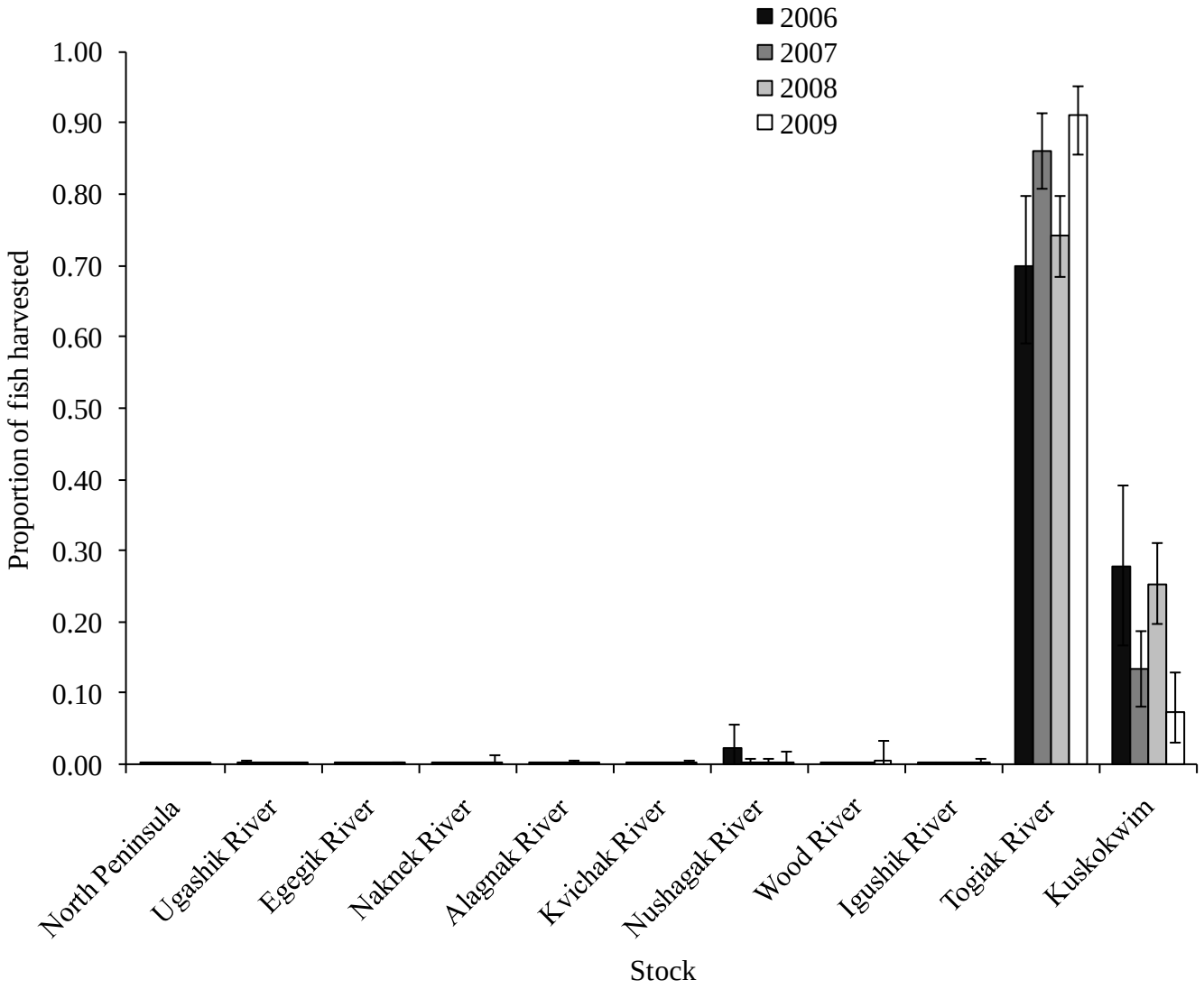
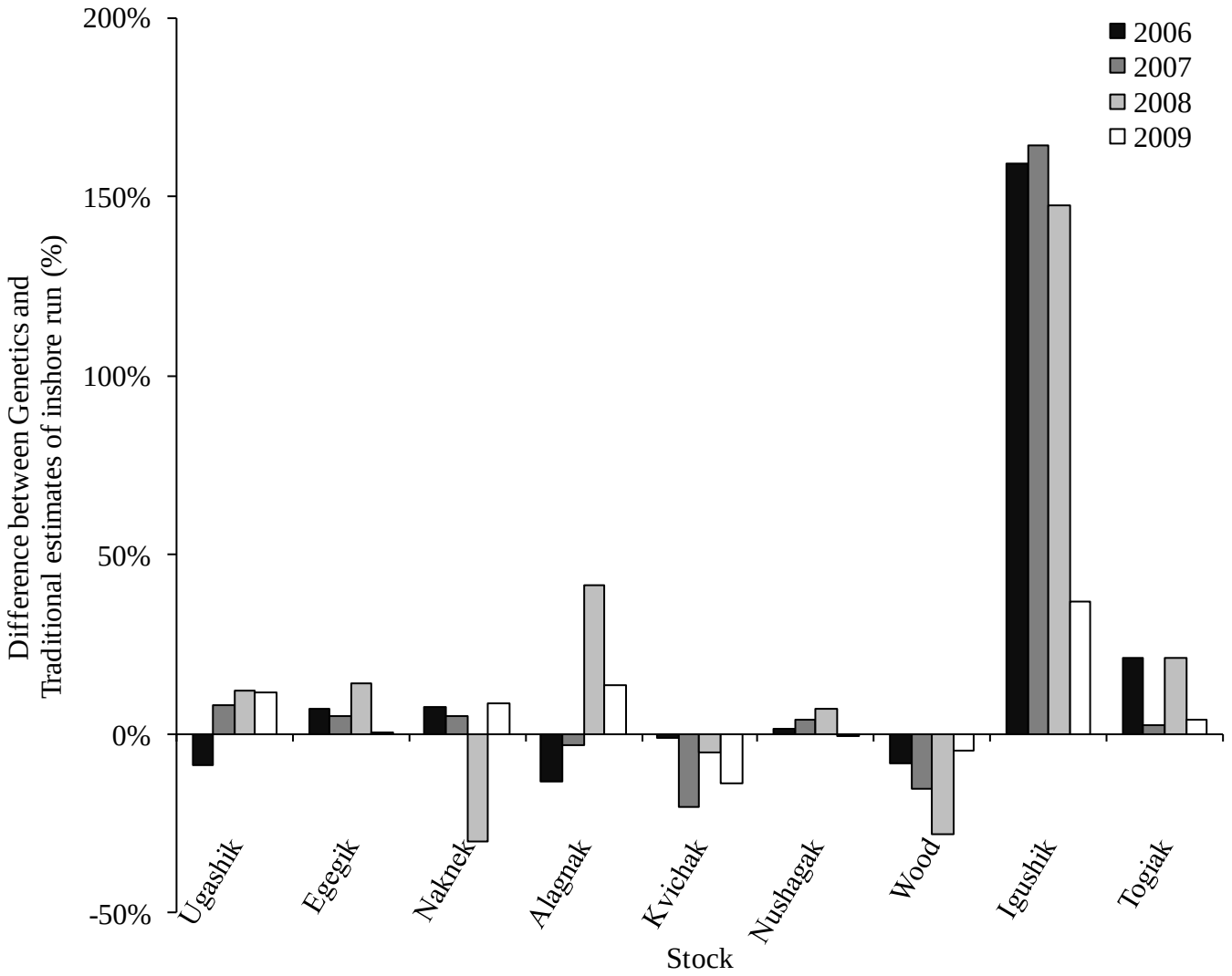


Figure 34.–Estimated proportion (and 90% credibility intervals) of sockeye salmon from each stock harvested within Togiak District within Bristol Bay, Alaska, in 2006, 2007, 2008, and 2009.



Note: See Table 5 and text for details.

Figure 35.–Differences between estimates of inshore run based upon Genetics and Traditional methods (Traditional minus Genetics divided by Genetics) for each stock of sockeye salmon in Bristol Bay, Alaska, for which estimates of total run were available in 2006–2009.

APPENDIX A: HARVEST AND SAMPLE INFORMATION BY DISTRICT AND PERIOD

Appendix A1.–Sockeye salmon commercial harvest and numbers of samples collected, selected and successfully screened for genetic analysis by date(s) and periods in the Ugashik District, Bristol Bay, Alaska, in 2009.

				Genetic Samples		
Period	Description	Date(s)	Harvest	Collected	Selected	Screened
1	Ugashik District	6/9-18/2009	29,299			
		6/19/2009	5,549	130	3	
		6/20-21/2009	0			
		6/22/2009	62,242	144	36	
		6/23-26/2009	2,790			
		6/27/2009	73,397	384	43	
		6/28/2009	33,062	240	19	
		6/29/2009	62,789	230	37	
		6/30/2009	69,245			
		7/1/2009	38,996			
		7/2/2009	87,304	437	52	
		Period Subtotal	464,673	1,565	190	186
2	Ugashik District	7/3/2009	122,239	238	34	
		7/4/2009	192,559	144	51	
		7/5/2009	172,513	144	49	
		7/6/2009	202,106	144	66	
		Period Subtotal	689,417	670	200	194
3	Ugashik District	7/7/2009	202,750	144	59	
		7/8/2009	210,602	144	61	
		7/9/2009	244,913	138	70	
		Period Subtotal	658,265	426	190	188
4	Ugashik District	7/10/2009	151,332	141	110	
		7/11/2009	108,890			
		7/12/2009	95,871	143	76	
		Period Subtotal	356,093	284	186	183

-continued-

Period	Description	Date(s)	Harvest	Genetic Samples		
				Collected	Selected	Screened
5	Ugashik District	7/13/2009	78,711	134	55	
		7/14/2009	82,249	94	71	
		7/15/2009	96,494			
		7/16/2009	60,565	128	45	
		7/17/2009	21,134	142	15	
		7/18/2009	12,635			
		7/19/2009	12,447			
		7/20/2009	1,407			
		7/21-30/2009	18,489			
		8/1-10/2009	2,684			
		Period Subtotal	386,815	498	186	181
Total			2,555,263	3,443	952	932

Note: Harvest was the number of sockeye salmon commercially harvested in drift and set gillnet fisheries. Samples were collected from the drift gillnet fishery and used to estimate stock composition and stock-specific harvest during each period (Appendix B1).

Appendix A2.–Sockeye salmon commercial harvest and numbers of samples collected, selected and successfully screened for genetic analysis by date(s) and periods in the Egegik District, Bristol Bay, Alaska in 2009.

				Genetic Samples		
Period	Description	Date(s)	Harvest	Collected	Selected	Screened
1	Egegik District	6/9-17/2009	92,865			
		6/18/2009	92,491	226	17	
		6/19/2009	137,715			
		6/20/2009	244,859	115	41	
		6/21/2009	224,464			
		6/22/2009	294,523	230	48	
		6/23/2009	409,415			
		6/24/2009	490,530	222	81	
		Period Subtotal	1,986,862	793	187	185
2	Egegik District	6/25/2009	417,288	143	47	
		6/26/2009	591,551	102	65	
		6/27/2009	781,658	144	88	
		6/28/2009	955,902	144	100	
		6/29/2009	614,162	144	78	
		Period Subtotal	3,360,561	677	378	373
3	Egegik District	6/30/2009	610,909			
		7/1/2009	535,105	288	124	
		7/2/2009	592,294			
		7/3/2009	540,065	288	126	
		7/4/2009	588,671			
		7/5/2009	561,718	144	130	
		Period Subtotal	3,428,762	720	380	375
4	Egegik District	7/6/2009	375,142	144	87	
		7/7/2009	453,541	134	103	
		7/8/2009	262,441			
		Period Subtotal	1,091,124	278	190	186
5	Egegik District	7/9/2009	406,293	110	101	
		7/10/2009	270,280	143	88	
		Period Subtotal	676,573	253	189	188

-continued-

Period	Description	Date(s)	Harvest	Genetic Samples		
				Collected	Selected	Screened
6	Egegik District	7/11/2009	195,817	134	63[a]	
		7/12/2009	146,470	144	45[a]	
		7/13/2009	110,107			
		7/14/2009	98,696	144	34[a]	
		7/15/2009	76,449	144	30[a]	
		7/16/2009	105,536	144	18[a]	
		7/17/2009	48,213	113		
		7/18/2009	46,310			
		7/19/2009	24,475			
		7/20/2009	23,840			
		7/21-31/2009	100,480			
		8/1-18/2009	7,187			
		Period Subtotal	983,580	823	190	183
Total			11,527,462	3,544	1,514	1,490

Note: Harvest was the number of sockeye salmon commercially harvested in drift and set gillnet fisheries. Samples were collected from the drift gillnet fishery and used to estimate stock composition and stock-specific harvest during each period (Appendix B2).

[a] We inadvertently did not select samples from 7/17 for extraction during the selection process and instead, chose additional samples from 7/14-16. The numbers of fish that should have been selected for extraction from this period are as follows: 7/11 (55), 7/12 (41), 7/14 (28), 7/15 (22), 7/16 (30), and 7/17 (14).

Appendix A3.–Sockeye salmon commercial harvest and numbers of samples collected, selected and successfully screened for genetic analysis by date(s) and periods in the Naknek-Kvichak District, Bristol Bay, Alaska in 2009.

				Genetic Samples		
Period	Description	Date(s)	Harvest	Collected	Selected	Screened
1	Naknek-Kvichak District	6/15-18/2009	9,437			
		6/19/2009	2,943	118	1	
		6/20-22/2009	114,414			
		6/23/2009	74,427	192	14	
		6/24/2009	143,702	190	33	
		6/25/2009	174,747	111	40	
		6/26/2009	217,726	144	47	
		6/27/2009	288,802			
		6/28/2009	260,360	288	53	
		6/29/2009	568,355			
		Period Subtotal	1,854,913	1,043	188	184
2	Naknek-Kvichak District	6/30/2009	285,749	288	45	
		7/1/2009	324,692			
		7/2/2009	382,857	144	62	
		7/3/2009	482,331	117	83	
		Period Subtotal	1,475,629	549	190	186
3	Naknek-Kvichak District	7/4/2009	667,819			
		7/5/2009	497,467	288	101	
		7/6/2009	440,009	111	89	
		Period Subtotal	1,605,295	399	190	173
4	Naknek-Kvichak District	7/7/2009	485,628	143	78	
		7/8/2009	678,628	240	111	
		Period Subtotal	1,164,256	383	189	185
5	Naknek-Kvichak District	7/9/2009	395,447	287	189	
		Period Subtotal	395,447	287	189	186
6	Naknek-Kvichak District	7/10/2009	335,302	144	80	
		7/11/2009	191,840	144	45	
		7/12/2009	156,610	142	35	
		7/13/2009	127,697	137	29	
		7/14/2009	88,332			
		Period Subtotal	899,781	567	189	185
7	Naknek-Kvichak District	7/15/2009	61,840	262	75	
		7/16/2009	69,119			
		7/17/2009	58,675	142	68	
		7/18/2009	23,723	96	42	
		7/19/2009	12,683			
		7/20/2009	54,943			
		7/21-31/2009	90,563			
		8/1-15/2009	86			
		Period Subtotal	371,632	500	185	181

-continued-

Period	Description	Date(s)	Harvest	Genetic Samples		
				Collected	Selected	Screened
8	Kvichak Section	6/22-7/29/2009	747,991	239	189	
	Set Gillnet Only	Period Subtotal	747,991	239	189	186
Total			8,514,944	3,967	1,509	1,466

Note: Harvest was the number of sockeye salmon commercially harvested in drift and set gillnet fisheries, except harvest was only from the set gillnet fishery in the Kvichak section (Period 8). Samples were collected from the drift gillnet fishery in the Naknek-Section and Naknek-Kvichak District, and from set gillnet fishery only in the Kvichak Section. Samples were used to estimate stock composition and stock-specific harvest during each period (Appendix B3).

Appendix A4.–Sockeye salmon commercial harvest and numbers of samples collected, selected and successfully screened for genetic analysis by date(s) and periods in the Nushagak District, Bristol Bay, Alaska in 2009.

				Genetic Samples		
Period	Description	Date(s)	Harvest	Collected	Selected	Screened
1	Nushagak District	6/9-21/2009	24,373			
		6/22/2009	14,737	95	69	
		6/23/2009	208,650			
		6/24/2009	280,906			
		6/25/2009	365,422	144	120	
		Period Subtotal	894,088	239	189	189
2	Nushagak District	6/26/2009	263,339	144	92	
		6/27/2009	197,711			
		6/28/2009	786,170			
		6/29/2009	636,114	142	96	
		Period Subtotal	1,883,334	286	188	187
3	Nushagak District	6/30/2009	389,678	133	105	
		7/1/2009	326,849	142	83	
		Period Subtotal	716,527	275	188	187
4	Nushagak District	7/2/2009	505,891	287	215	
		7/3/2009	842,556			
		Period Subtotal	1,348,447	287	215	212
5	Nushagak District	7/4/2009	234,914	144	33	
		7/5/2009	356,613			
		7/6/2009	486,978	134	63	
		7/7/2009	348,733	239	46	
		7/8/2009	335,361	240	46	
		Period Subtotal	1,762,599	757	188	186
6	Nushagak District	7/9/2009	299,774	239	95	
		7/10/2009	178,050	143	60	
		7/11/2009	115,672	144	33	
		Period Subtotal	593,496	526	188	184
7	Nushagak District	7/12/2009	152,436	160	67	
		7/13/2009	122,463	144	49	
		7/14/2009	61,336	144	31	
		7/15/2009	49,262	138	17	
		7/16/2009	47,499	144	20	
		7/17/2009	54,175			
		7/18/2009	21,403			
		7/19-30/2009	23,008			
		8/1-13/2009	95			
		Period Subtotal	531,677	730	184	182
Total			7,730,168	3,100	1,340	1,327

Note: Harvest was the number of sockeye salmon commercially harvested in drift and set gillnet fisheries. Samples were collected from the drift and set gillnet fisheries in the Nushagak District and used to estimate stock composition and stock-specific harvest during each period (Appendix B4).

Appendix A5.–Sockeye salmon commercial harvest and numbers of samples collected, selected and successfully screened for genetic analysis by date(s) and periods in the Togiak District, Bristol Bay, Alaska in 2009.

				Genetic Samples		
Period	Description	Date(s)	Harvest	Collected	Selected	Screened
1	Togiak District	6/18-28/2009	3,989			
		6/29/2009	6,675	431	51	
		6/30/2009	10,846	48	32	
		7/1/2009	12,065	335	105	
		7/2/2009	14,433			
		7/3/2009	8,932			
		7/4/2009	4,813			
		7/5/2009	1,440			
		Period Subtotal	63,193	814	188	183
2	Togiak District	7/6/2009	17,204			
		7/7/2009	22,558			
		7/8/2009	20,115			
		7/9/2009	15,057			
		7/10/2009	30,590			
		7/11/2009	31,023	204	76	
		7/12/2009				
		7/13/2009	22,052	384	54	
		7/14/2009	24,243	272	60	
		7/15/2009	29,777			
		Period Subtotal	212,619	860	190	189
3	Togiak District	7/16/2009	14,158	240	38	
		7/17/2009	7,231			
		7/18-19/2009	0			
		7/20/2009	27,300			
		7/21/2009	16,637			
		7/22/2009	33,220	476	61	
		7/23/2009	33,483	237	59	
		7/24/2009	28,681			
		7/25/2009	24,886			
		7/26/2009	2,880			
		7/27/2009	14,965	479	28	
		7/28/2009	16,112			
		7/29/2009	4,623			
		7/30/2009	10,267			
		7/31/2009	16,919			
		8/1-9/10/2009	32,268			
		Period Subtotal	283,630	1,432	186	180
Total			559,442	3,106	564	552

Note: Harvest was the number of sockeye salmon commercially harvested in drift and set gillnet fisheries. Samples were collected from the drift gillnet fishery and used to estimate stock composition and stock-specific harvest during each period (Appendix B5).

APPENDIX B: STOCK PROPORTION AND HARVEST ESTIMATES BY DISTRICT AND PERIOD

Appendix B1.–Proportion and harvest estimates by reporting group from mixtures of sockeye salmon harvested in Ugashik District, Bristol Bay, Alaska, 2009.

				Reporting Groups										
Period	Description			North Peninsula	Ugashik	Egegik	Naknek	Alagnak	Kvichak	Nushagak	Wood	Igushik	Togiak	Kuskokwim
1	Ugashik District		Proportion	0.00	0.88	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Year	2009	SD	0.00	0.05	0.05	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00
	Start Date	06/09	Lower 90% CI	0.00	0.79	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	End Date	07/02	Upper 90% CI	0.00	0.98	0.20	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
	Harvest	464,673	Harvest	52	410,993	51,548	324	214	846	214	188	142	83	70
	n	186	Lower 90% CI	0	368,043	5,083	0	0	0	0	0	0	0	0
			Upper 90% CI	19	454,480	94,422	209	1,035	5,641	176	355	126	35	38
2	Ugashik District		Proportion	0.00	0.94	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Year	2009	SD	0.01	0.04	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
	Start Date	07/03	Lower 90% CI	0.00	0.87	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	End Date	07/06	Upper 90% CI	0.00	1.00	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00
	Harvest	689,417	Harvest	477	645,196	40,772	521	79	262	161	152	89	1,454	253
	n	194	Lower 90% CI	0	596,494	0	0	0	0	0	0	0	0	0
			Upper 90% CI	229	689,364	88,730	834	28	118	62	87	32	11,737	201
3	Ugashik District		Proportion	0.00	0.36	0.62	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
	Year	2009	SD	0.01	0.12	0.12	0.00	0.00	0.01	0.01	0.01	0.01	0.00	0.00
	Start Date	07/07	Lower 90% CI	0.00	0.19	0.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	End Date	07/09	Upper 90% CI	0.01	0.56	0.80	0.00	0.00	0.02	0.01	0.02	0.01	0.00	0.00
	Harvest	658,265	Harvest	1,488	239,463	408,990	212	177	3,806	905	1,878	859	67	420
	n	188	Lower 90% CI	0	122,955	278,231	0	0	188	0	0	0	0	0
			Upper 90% CI	5,907	368,957	526,783	103	109	11,659	5,168	14,122	6,008	21	340
4	Ugashik District		Proportion	0.00	0.98	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Year	2009	SD	0.00	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Start Date	07/10	Lower 90% CI	0.00	0.93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	End Date	07/12	Upper 90% CI	0.00	1.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Harvest	356,093	Harvest	110	348,386	7,242	71	38	35	40	48	61	24	38
	n	183	Lower 90% CI	0	332,493	92	0	0	0	0	0	0	0	0
			Upper 90% CI	35	355,931	22,963	35	14	13	15	18	22	10	14

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Appendix B1.–Page 2 of 2.

Period	Description			Reporting Groups										
				North Peninsula	Ugashik	Egegik	Naknek	Alagnak	Kvichak	Nushagak	Wood	Igushik	Togiak	Kuskokwim
5	Ugashik District		Proportion	0.00	0.89	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Year	2009	SD	0.00	0.10	0.10	0.01	0.00	0.01	0.00	0.00	0.00	0.01	0.00
	Start Date	07/13	Lower 90% CI	0.00	0.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	End Date	08/10	Upper 90% CI	0.00	1.00	0.29	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00
	Harvest	386,815	Harvest	107	343,011	41,196	613	42	454	208	136	80	868	99
	n	181	Lower 90% CI	0	273,636	0	0	0	0	0	0	0	0	0
			Upper 90% CI	41	386,815	111,051	970	14	574	342	102	27	6,092	27
Total	Ugashik District		Proportion	0.00	0.78	0.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Year	2009	Lower 90% CI	0.00	0.72	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Start Date	06/09	Upper 90% CI	0.01	0.84	0.27	0.00	0.00	0.01	0.00	0.01	0.00	0.01	0.00
	End Date	08/10	Harvest	2,234	1,987,049	549,748	1,742	550	5,404	1,529	2,402	1,230	2,495	881
	Harvest	2,555,263	Lower 90% CI	0	1,836,851	391,133	0	0	250	0	0	0	0	0
	n	932	Upper 90% CI	13,159	2,144,315	700,687	11,869	3,202	18,747	10,433	15,120	8,198	14,669	4,965

Note: Harvest was the number of sockeye salmon commercially harvested in drift and set gillnet fisheries. Genetic samples were collected from the drift gillnet fishery. Sockeye salmon commercial harvest and numbers of samples collected and selected (successfully screened) for genetic analysis by date(s) and periods (Appendix A1). The 90% credibility intervals of harvest estimates may not include the point estimate for very low extrapolated harvest numbers because less than 5% of iterations had values below zero.

Appendix B2.–Proportion and harvest estimates by reporting group from mixtures of sockeye salmon harvested in Egegik District, Bristol Bay, Alaska, 2009.

				Reporting Groups										
Period	Description			North Peninsula	Ugashik	Egegik	Naknek	Alagnak	Kvichak	Nushagak	Wood	Igushik	Togiak	Kuskokwim
1	Egegik District		Proportion	0.00	0.02	0.94	0.01	0.00	0.00	0.02	0.00	0.00	0.00	0.00
	Year	2009	SD	0.01	0.04	0.05	0.01	0.00	0.01	0.02	0.01	0.00	0.00	0.00
	Start Date	06/09	Lower 90% CI	0.00	0.00	0.84	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	End Date	06/24	Upper 90% CI	0.00	0.13	0.99	0.03	0.00	0.01	0.06	0.03	0.00	0.00	0.00
	Harvest	1,986,862	Harvest	2,368	33,632	1,876,836	11,753	346	4,762	47,862	7,262	667	1,095	279
	n	185	Lower 90% CI	0	0	1,660,906	0	0	0	0	0	0	0	0
			Upper 90% CI	1,356	254,202	1,964,925	61,125	735	28,384	113,494	54,434	499	646	74
2	Egegik District		Proportion	0.00	0.00	0.80	0.15	0.00	0.01	0.01	0.00	0.01	0.00	0.01
	Year	2009	SD	0.00	0.01	0.04	0.04	0.00	0.02	0.01	0.01	0.01	0.00	0.02
	Start Date	06/25	Lower 90% CI	0.00	0.00	0.73	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	End Date	06/29	Upper 90% CI	0.00	0.01	0.86	0.21	0.00	0.07	0.04	0.02	0.03	0.00	0.07
	Harvest	3,360,561	Harvest	1,424	5,650	2,698,450	495,536	1,021	48,040	21,878	13,046	36,359	3,033	36,124
	n	373	Lower 90% CI	0	0	2,466,111	302,813	0	0	0	0	0	0	0
			Upper 90% CI	830	26,648	2,900,760	692,324	810	238,002	120,864	70,011	116,766	11,098	236,775
3	Egegik District		Proportion	0.00	0.00	0.97	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00
	Year	2009	SD	0.00	0.02	0.02	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00
	Start Date	06/30	Lower 90% CI	0.00	0.00	0.93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	End Date	07/05	Upper 90% CI	0.00	0.03	0.99	0.03	0.03	0.02	0.00	0.00	0.00	0.00	0.00
	Harvest	3,428,762	Harvest	277	13,928	3,319,655	22,676	43,665	24,755	244	704	389	2,150	318
	n	375	Lower 90% CI	0	0	3,194,529	0	8,678	4,595	0	0	0	0	0
			Upper 90% CI	82	92,311	3,389,325	88,192	93,084	57,425	89	518	206	13,890	89
4	Egegik District		Proportion	0.00	0.01	0.92	0.03	0.02	0.01	0.00	0.00	0.00	0.00	0.00
	Year	2009	SD	0.00	0.04	0.05	0.05	0.02	0.02	0.00	0.00	0.00	0.00	0.00
	Start Date	07/06	Lower 90% CI	0.00	0.00	0.82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	End Date	07/08	Upper 90% CI	0.00	0.10	0.99	0.14	0.06	0.04	0.00	0.00	0.00	0.00	0.00
	Harvest	1,091,124	Harvest	287	15,713	1,007,521	34,826	25,480	5,836	405	415	240	291	110
	n	186	Lower 90% CI	0	0	899,926	0	0	0	0	0	0	0	0
			Upper 90% CI	183	112,616	1,076,774	151,158	60,536	45,627	1,194	1,764	186	149	34
5	Egegik District		Proportion	0.00	0.00	0.88	0.03	0.06	0.02	0.00	0.00	0.00	0.00	0.00
	Year	2009	SD	0.00	0.00	0.04	0.04	0.02	0.03	0.00	0.00	0.01	0.00	0.00
	Start Date	07/09	Lower 90% CI	0.00	0.00	0.81	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00
	End Date	07/10	Upper 90% CI	0.00	0.00	0.95	0.12	0.09	0.08	0.00	0.00	0.00	0.00	0.00
	Harvest	676,573	Harvest	68	393	597,838	22,147	39,580	14,858	623	261	541	110	153
	n	188	Lower 90% CI	0	0	547,157	0	19,701	0	0	0	0	0	0
			Upper 90% CI	22	426	641,963	79,770	64,056	54,396	2,331	286	633	39	81

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Appendix B2.–Page 2 of 2.

Period	Description			Reporting Groups										
				North Peninsula	Ugashik	Egegik	Naknek	Alagnak	Kvichak	Nushagak	Wood	Igushik	Togiak	Kuskokwim
6	Egegik District		Proportion	0.00	0.02	0.83	0.09	0.00	0.06	0.00	0.00	0.00	0.00	0.00
	Year	2009	SD	0.00	0.05	0.06	0.04	0.01	0.04	0.00	0.00	0.00	0.00	0.00
	Start Date	07/11	Lower 90% CI	0.00	0.00	0.71	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	End Date	08/18	Upper 90% CI	0.00	0.13	0.92	0.16	0.01	0.12	0.00	0.00	0.00	0.00	0.00
	Harvest	983,580	Harvest	208	19,949	815,402	88,884	1,671	56,266	308	67	66	522	236
	n	183	Lower 90% CI	0	0	702,002	24,515	0	1,815	0	0	0	0	0
			Upper 90% CI	66	130,825	909,751	155,411	11,390	118,424	119	23	19	155	73
Total			Proportion	0.00	0.01	0.89	0.06	0.01	0.01	0.01	0.00	0.00	0.00	0.00
	Year	2009	Lower 90% CI	0.00	0.00	0.86	0.04	0.01	0.00	0.00	0.00	0.00	0.00	0.00
	Start Date	06/09	Upper 90% CI	0.00	0.03	0.92	0.08	0.02	0.03	0.02	0.01	0.01	0.00	0.02
	End Date	08/18	Harvest	4,633	89,264	10,315,704	675,822	111,764	154,517	71,321	21,755	38,262	7,201	37,221
	Harvest	11,527,462	Lower 90% CI	0	0	9,957,885	444,663	58,239	38,623	0	0	0	0	0
	n	1,490	Upper 90% CI	24,603	355,617	10,615,988	921,629	177,215	358,949	183,489	89,713	119,682	48,656	237,091

Note: Harvest was the number of sockeye salmon commercially harvested in drift and set gillnet fisheries. Genetic samples were collected from the drift gillnet fishery. Sockeye salmon commercial harvest and numbers of samples collected and selected (successfully screened) for genetic analysis by date(s) and periods (Appendix A2). The 90% credibility intervals of harvest estimates may not include the point estimate for very low extrapolated harvest numbers because less than 5% of iterations had values below zero.

Appendix B3.–Proportion and harvest estimates by reporting group from mixtures of sockeye salmon harvested in Naknek-Kvichak District, Bristol Bay, Alaska, 2009.

				Reporting Groups										
Period	Description			North Peninsula	Ugashik	Egegik	Naknek	Alagnak	Kvichak	Nushagak	Wood	Igushik	Togiak	Kuskokwim
1	Naknek-Kvichak District		Proportion	0.00	0.00	0.12	0.26	0.10	0.49	0.00	0.00	0.02	0.00	0.00
	Year	2009	SD	0.00	0.01	0.04	0.06	0.03	0.06	0.00	0.01	0.02	0.00	0.00
	Start Date	06/15	Lower 90% CI	0.00	0.00	0.07	0.16	0.06	0.39	0.00	0.00	0.00	0.00	0.00
	End Date	06/29	Upper 90% CI	0.00	0.00	0.19	0.36	0.15	0.59	0.00	0.01	0.06	0.00	0.00
	Harvest	1,854,913	Harvest	1,130	1,614	227,731	473,876	187,889	912,220	927	2,311	45,521	1,154	540
	n	184	Lower 90% CI	0	0	123,307	301,986	102,274	728,811	0	0	0	0	0
			Upper 90% CI	445	1,214	344,284	663,612	286,083	1,088,367	742	13,044	103,207	486	200
2	Naknek-Kvichak District		Proportion	0.00	0.00	0.16	0.26	0.06	0.52	0.00	0.00	0.00	0.00	0.00
	Year	2009	SD	0.00	0.00	0.07	0.09	0.03	0.07	0.00	0.00	0.00	0.00	0.00
	Start Date	06/30	Lower 90% CI	0.00	0.00	0.03	0.14	0.02	0.39	0.00	0.00	0.00	0.00	0.00
	End Date	07/03	Upper 90% CI	0.00	0.00	0.28	0.43	0.13	0.64	0.00	0.00	0.00	0.00	0.00
	Harvest	1,475,629	Harvest	299	256	228,725	381,716	94,917	767,369	1,070	368	615	119	175
	n	186	Lower 90% CI	0	0	45,847	204,047	27,967	579,482	0	0	0	0	0
			Upper 90% CI	77	118	409,134	639,854	191,174	947,527	2,518	276	2,242	44	52
3	Naknek-Kvichak District		Proportion	0.00	0.01	0.04	0.41	0.15	0.38	0.00	0.00	0.00	0.00	0.00
	Year	2009	SD	0.01	0.02	0.04	0.07	0.04	0.07	0.00	0.01	0.01	0.00	0.00
	Start Date	07/04	Lower 90% CI	0.00	0.00	0.00	0.29	0.09	0.28	0.00	0.00	0.00	0.00	0.00
	End Date	07/06	Upper 90% CI	0.03	0.05	0.11	0.53	0.22	0.49	0.00	0.02	0.01	0.00	0.00
	Harvest	1,605,295	Harvest	5,662	10,550	60,665	659,221	246,300	615,193	483	3,317	3,081	580	244
	n	173	Lower 90% CI	0	0	0	461,862	150,629	446,437	0	0	0	0	0
			Upper 90% CI	46,697	79,920	181,902	854,227	353,137	791,645	260	26,368	22,192	466	98
4	Naknek-Kvichak District		Proportion	0.00	0.00	0.00	0.41	0.11	0.47	0.00	0.00	0.00	0.00	0.00
	Year	2009	SD	0.00	0.00	0.01	0.06	0.03	0.05	0.00	0.00	0.00	0.00	0.00
	Start Date	07/07	Lower 90% CI	0.00	0.00	0.00	0.32	0.06	0.38	0.00	0.00	0.00	0.00	0.00
	End Date	07/08	Upper 90% CI	0.00	0.00	0.02	0.51	0.17	0.56	0.00	0.00	0.00	0.00	0.00
	Harvest	1,164,256	Harvest	109	589	3,920	481,019	130,966	546,474	364	111	122	113	470
	n	185	Lower 90% CI	0	0	0	376,455	72,481	438,834	0	0	0	0	0
			Upper 90% CI	30	327	28,030	596,168	198,095	648,680	193	52	52	37	172
5	Naknek-Kvichak District		Proportion	0.00	0.00	0.00	0.02	0.36	0.59	0.00	0.01	0.01	0.00	0.01
	Year	2009	SD	0.00	0.00	0.00	0.02	0.04	0.05	0.01	0.01	0.01	0.00	0.02
	Start Date	07/09	Lower 90% CI	0.00	0.00	0.00	0.00	0.29	0.51	0.00	0.00	0.00	0.00	0.00
	End Date	07/09	Upper 90% CI	0.00	0.00	0.00	0.05	0.43	0.66	0.00	0.04	0.03	0.00	0.05
	Harvest	395,447	Harvest	210	59	96	8,392	142,796	232,150	388	3,606	2,287	170	5,292
	n	186	Lower 90% CI	0	0	0	166	116,590	201,683	0	0	0	0	0
			Upper 90% CI	314	23	49	20,722	169,276	261,680	950	15,406	12,940	127	21,355

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Appendix B3.–Page 2 of 2.

Period	Description			Reporting Groups										
				North Peninsula	Ugashik	Egegik	Naknek	Alagnak	Kvichak	Nushagak	Wood	Igushik	Togiak	Kuskokwim
6	Naknek-Kvichak District		Proportion	0.00	0.00	0.10	0.32	0.28	0.28	0.00	0.01	0.00	0.00	0.00
	Year	2009	SD	0.00	0.00	0.04	0.06	0.04	0.04	0.01	0.01	0.01	0.00	0.00
	Start Date	07/10	Lower 90% CI	0.00	0.00	0.00	0.23	0.21	0.21	0.00	0.00	0.00	0.00	0.00
	End Date	07/14	Upper 90% CI	0.00	0.00	0.17	0.43	0.36	0.36	0.01	0.02	0.01	0.00	0.00
	Harvest	899,781	Harvest	143	393	90,797	291,642	255,548	253,876	1,248	4,564	1,106	115	349
	n	185	Lower 90% CI	0	0	7	209,532	190,539	192,348	0	0	0	0	0
			Upper 90% CI	43	177	153,308	384,818	323,077	319,944	8,463	21,569	8,019	27	556
7	Naknek-Kvichak District		Proportion	0.00	0.00	0.02	0.57	0.24	0.18	0.00	0.00	0.00	0.00	0.00
	Year	2009	SD	0.00	0.00	0.02	0.05	0.04	0.04	0.00	0.00	0.00	0.00	0.00
	Start Date	07/15	Lower 90% CI	0.00	0.00	0.00	0.48	0.17	0.10	0.00	0.00	0.00	0.00	0.00
	End Date	08/15	Upper 90% CI	0.00	0.00	0.07	0.66	0.31	0.25	0.00	0.00	0.00	0.00	0.00
	Harvest	371,632	Harvest	57	121	7,672	210,640	87,665	65,262	49	32	43	54	38
	n	181	Lower 90% CI	0	0	0	176,660	63,556	38,419	0	0	0	0	0
			Upper 90% CI	19	65	25,657	244,045	113,625	93,616	22	11	12	24	12
8	Kvichak Section Set Gillnet Only		Proportion	0.01	0.00	0.00	0.02	0.11	0.87	0.00	0.00	0.00	0.00	0.00
	Year	2009	SD	0.01	0.00	0.00	0.02	0.03	0.03	0.00	0.00	0.00	0.00	0.00
	Start Date	06/18	Lower 90% CI	0.00	0.00	0.00	0.00	0.07	0.81	0.00	0.00	0.00	0.00	0.00
	End Date	07/27	Upper 90% CI	0.04	0.00	0.00	0.06	0.16	0.92	0.00	0.00	0.00	0.00	0.00
	Harvest	747,991	Harvest	4,110	275	388	11,290	83,747	647,642	103	94	182	66	93
	n	186	Lower 90% CI	0	0	0	0	50,470	604,477	0	0	0	0	0
			Upper 90% CI	26,751	94	200	41,963	121,439	685,235	32	37	111	25	30
Total			Proportion	0.00	0.00	0.07	0.30	0.14	0.47	0.00	0.00	0.01	0.00	0.00
	Year	2009	Lower 90% CI	0.00	0.00	0.05	0.25	0.12	0.43	0.00	0.00	0.00	0.00	0.00
	Start Date	06/15	Upper 90% CI	0.01	0.01	0.10	0.34	0.17	0.51	0.00	0.01	0.01	0.00	0.00
	End Date	08/15	Harvest	11,719	13,857	619,993	2,517,796	1,229,830	4,040,185	4,633	14,401	52,956	2,373	7,201
	Harvest	8,514,944	Lower 90% CI	0	0	384,092	2,159,407	1,044,304	3,703,207	0	0	2,137	0	0
	n	1,466	Upper 90% CI	64,760	87,314	870,130	2,903,165	1,425,680	4,376,975	27,639	53,631	116,872	11,946	26,323

Note: Harvest was the number of sockeye salmon commercially harvested in drift and set gillnet fisheries, except harvest was only from the set gillnet fishery in the Kvichak section (Period 8). Genetic samples were collected from the drift gillnet fishery in the Naknek-Section and Naknek-Kvichak District, and from set gillnet fishery only in the Kvichak Section. Sockeye salmon commercial harvest and numbers of samples collected and selected (successfully screened) for genetic analysis by date(s) and periods (Appendix A3). The 90% credibility intervals of harvest estimates may not include the point estimate for very low extrapolated harvest numbers because less than 5% of iterations had values below zero.

Appendix B4.–Proportion and harvest estimates by reporting group from mixtures of sockeye salmon harvested in Nushagak District, Bristol Bay, Alaska, 2009.

				Reporting Groups										
Period	Description			North Peninsula	Ugashik	Egegik	Naknek	Alagnak	Kvichak	Nushagak	Wood	Igushik	Togiak	Kuskokwim
1	Nushagak District		Proportion	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	17.6%	81.7%	0.3%	0.2%	0.0%
	Year	2009	SD	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	5.7%	5.8%	1.4%	0.8%	0.2%
	Start Date	06/09	Lower 90% CI	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	10.1%	70.9%	0.0%	0.0%	0.0%
	End Date	06/25	Upper 90% CI	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	28.3%	89.6%	1.6%	1.8%	0.0%
	Harvest	894,088	Harvest	59	107	60	77	107	112	157,791	730,885	2,805	1,927	158
	n	189	Lower 90% CI	0	0	0	0	0	0	90,225	633,531	0	0	0
			Upper 90% CI	19	39	19	25	46	38	253,304	800,830	14,380	15,793	57
2	Nushagak District		Proportion	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	24.2%	74.5%	1.0%	0.0%	0.2%
	Year	2009	SD	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	5.1%	6.2%	3.6%	0.2%	1.1%
	Start Date	06/26	Lower 90% CI	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	15.9%	63.3%	0.0%	0.0%	0.0%
	End Date	06/29	Upper 90% CI	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	32.7%	83.4%	8.9%	0.0%	0.3%
	Harvest	1,883,334	Harvest	236	175	143	153	143	161	455,844	1,402,952	19,400	341	3,786
	n	187	Lower 90% CI	0	0	0	0	0	0	299,533	1,192,528	0	0	0
			Upper 90% CI	60	66	49	51	70	43	616,516	1,570,253	168,141	141	4,782
3	Nushagak District		Proportion	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	14.3%	85.1%	0.0%	0.1%	0.3%
	Year	2009	SD	0.1%	0.1%	0.1%	0.2%	0.1%	0.1%	4.7%	4.7%	0.4%	0.4%	1.3%
	Start Date	06/30	Lower 90% CI	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	7.2%	76.7%	0.0%	0.0%	0.0%
	End Date	07/01	Upper 90% CI	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	22.8%	92.3%	0.0%	0.1%	3.1%
	Harvest	716,527	Harvest	57	97	67	162	49	49	102,768	610,074	283	415	2,506
	n	187	Lower 90% CI	0	0	0	0	0	0	51,813	549,780	0	0	0
			Upper 90% CI	24	37	18	67	21	23	163,069	661,159	88	530	22,297
4	Nushagak District		Proportion	0.1%	0.4%	0.1%	0.0%	0.0%	0.0%	27.5%	71.5%	0.1%	0.1%	0.1%
	Year	2009	SD	0.4%	0.9%	0.3%	0.2%	0.2%	0.2%	4.9%	4.8%	0.9%	0.6%	0.5%
	Start Date	07/02	Lower 90% CI	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	19.2%	63.6%	0.0%	0.0%	0.0%
	End Date	07/03	Upper 90% CI	1.0%	2.3%	0.3%	0.0%	0.0%	0.1%	35.4%	79.6%	0.2%	0.4%	0.0%
	Harvest	1,348,447	Harvest	1,663	5,336	830	320	253	388	370,524	964,690	1,902	1,657	885
	n	212	Lower 90% CI	0	0	0	0	0	0	258,912	857,816	0	0	0
			Upper 90% CI	12,851	31,268	4,431	117	127	760	477,640	1,073,555	2,174	5,618	406
5	Nushagak District		Proportion	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	10.5%	89.1%	0.1%	0.0%	0.1%
	Year	2009	SD	0.1%	0.1%	0.1%	0.2%	0.2%	0.5%	3.2%	3.4%	1.0%	0.2%	0.6%
	Start Date	07/04	Lower 90% CI	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	5.9%	83.1%	0.0%	0.0%	0.0%
	End Date	07/08	Upper 90% CI	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%	16.3%	93.8%	0.1%	0.0%	0.1%
	Harvest	1,762,599	Harvest	312	253	152	449	476	1,470	184,469	1,570,546	2,467	436	1,570
	n	186	Lower 90% CI	0	0	0	0	0	0	104,394	1,464,228	0	0	0
			Upper 90% CI	185	104	51	196	397	4,632	286,462	1,652,876	1,792	249	1,754

Appendix B4.–Page 2 of 2.

				Reporting Groups										
Period	Description			North Peninsula	Ugashik	Egegik	Naknek	Alagnak	Kvichak	Nushagak	Wood	Igushik	Togiak	Kuskokwim
6	Nushagak District		Proportion	0.0%	2.5%	0.0%	0.0%	0.0%	0.0%	9.3%	84.6%	3.3%	0.0%	0.1%
	Year	2009	SD	0.2%	2.3%	0.3%	0.1%	0.1%	0.2%	5.2%	8.7%	7.1%	0.2%	0.6%
	Start Date	07/09	Lower 90% CI	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.7%	65.7%	0.0%	0.0%	0.0%
	End Date	07/11	Upper 90% CI	0.0%	6.8%	0.0%	0.0%	0.0%	0.0%	19.2%	94.3%	20.7%	0.0%	0.1%
	Harvest	593,496	Harvest	178	14,868	248	60	56	119	55,423	502,240	19,660	119	525
	n	184	Lower 90% CI	0	0	0	0	0	0	15,982	390,114	0	0	0
			Upper 90% CI	103	40,307	104	18	20	43	114,071	559,459	122,605	50	346
7	Nushagak District		Proportion	0.0%	7.4%	1.4%	0.1%	0.0%	0.0%	8.9%	77.8%	4.0%	0.1%	0.2%
	Year	2009	SD	0.3%	4.2%	3.2%	0.6%	0.1%	0.2%	4.7%	7.5%	6.4%	0.5%	1.0%
	Start Date	07/12	Lower 90% CI	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	3.4%	63.4%	0.0%	0.0%	0.0%
	End Date	08/13	Upper 90% CI	0.0%	13.5%	9.2%	0.4%	0.0%	0.0%	18.4%	87.5%	17.9%	0.1%	0.1%
	Harvest	531,677	Harvest	159	39,563	7,629	610	82	86	47,359	413,499	21,467	362	863
	n	182	Lower 90% CI	0	0	0	0	0	0	18,207	336,911	0	0	0
			Upper 90% CI	52	71,709	48,947	2,361	38	27	97,668	465,279	95,419	273	510
Total			Proportion	0.0%	0.8%	0.1%	0.0%	0.0%	0.0%	17.8%	80.1%	0.9%	0.1%	0.1%
	Year	2009	Lower 90% CI	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	14.6%	76.3%	0.0%	0.0%	0.0%
	Start Date	06/09	Upper 90% CI	0.2%	1.4%	0.7%	0.2%	0.1%	0.2%	21.0%	83.6%	3.2%	0.4%	0.8%
	End Date	08/13	Harvest	2,664	60,398	9,129	1,831	1,168	2,385	1,374,177	6,194,885	67,984	5,255	10,293
	Harvest	7,730,168	Lower 90% CI	0	9,047	0	0	0	0	1,131,902	5,895,226	0	0	0
	n	1,327	Upper 90% CI	16,973	107,818	50,965	11,886	6,689	13,741	1,621,757	6,461,992	249,444	32,563	58,835

Note: Harvest was the number of sockeye salmon commercially harvested in drift and set gillnet fisheries. Genetic samples were collected from the drift and set gillnet fisheries in the Nushagak District. Sockeye salmon commercial harvest and numbers of samples collected and selected (successfully screened) for genetic analysis by date(s) and periods (Appendix A4). The 90% credibility intervals of harvest estimates may not include the point estimate for very low extrapolated harvest numbers because less than 5% of iterations had values below zero.

Appendix B5.–Proportion and harvest estimates by reporting group from mixtures of sockeye salmon harvested in Togiak District, Bristol Bay, Alaska, 2009.

				Reporting Groups										
Period	Description			North Peninsula	Ugashik	Egegik	Naknek	Alagnak	Kvichak	Nushagak	Wood	Igushik	Togiak	Kuskokwim
1	Togiak District		Proportion	0.0%	0.0%	0.3%	0.6%	0.0%	0.0%	0.0%	0.0%	0.0%	66.6%	32.3%
	Year	2009	SD	0.1%	0.2%	1.2%	1.8%	0.1%	0.1%	0.2%	0.1%	0.3%	9.2%	9.6%
	Start Date	06/22	Lower 90% CI	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	51.0%	16.5%
	End Date	07/05	Upper 90% CI	0.0%	0.0%	2.7%	4.7%	0.0%	0.0%	0.0%	0.0%	0.0%	81.4%	48.4%
	Harvest	63,193	Harvest	6	11	206	399	10	6	14	10	28	42,092	20,410
	n	183	Lower 90% CI	0	0	0	0	0	0	0	0	0	32,247	10,428
			Upper 90% CI	3	4	1,710	2,979	3	2	7	5	25	51,440	30,602
2	Togiak District		Proportion	0.0%	0.1%	0.0%	0.5%	0.0%	0.2%	0.6%	1.6%	0.3%	87.4%	9.3%
	Year	2009	SD	0.2%	0.4%	0.2%	1.2%	0.1%	0.7%	1.7%	3.1%	1.2%	7.0%	7.2%
	Start Date	07/06	Lower 90% CI	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	74.5%	0.5%
	End Date	07/15	Upper 90% CI	0.0%	0.1%	0.0%	3.2%	0.0%	1.4%	4.9%	9.0%	2.4%	96.5%	22.9%
	Harvest	212,619	Harvest	50	123	49	957	29	402	1,339	3,479	658	185,763	19,769
	n	189	Lower 90% CI	0	0	0	0	0	0	0	0	0	158,328	1,041
			Upper 90% CI	20	148	19	6,753	11	3,038	10,325	19,083	5,108	205,101	48,651
3	Togiak District		Proportion	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	99.3%	0.5%
	Year	2009	SD	0.1%	0.1%	0.1%	0.3%	0.1%	0.1%	0.3%	0.2%	0.1%	1.7%	1.7%
	Start Date	07/16	Lower 90% CI	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	96.2%	0.0%
	End Date	09/10	Upper 90% CI	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	3.2%
	Harvest	283,630	Harvest	32	30	30	145	32	29	122	60	32	281,637	1,482
	n	180	Lower 90% CI	0	0	0	0	0	0	0	0	0	272,770	0
			Upper 90% CI	10	12	14	126	11	11	119	71	11	283,630	9,120
Total			Proportion	0.0%	0.0%	0.1%	0.3%	0.0%	0.1%	0.3%	0.6%	0.1%	91.1%	7.4%
	Year	2009	Lower 90% CI	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	85.7%	3.3%
	Start Date	06/22	Upper 90% CI	0.1%	0.1%	0.4%	1.4%	0.0%	0.6%	1.9%	3.4%	0.9%	95.2%	13.1%
	End Date	09/10	Harvest	88	164	285	1,501	71	438	1,475	3,549	718	509,491	41,662
	Harvest	559,442	Lower 90% CI	0	0	0	0	0	0	0	0	0	479,167	18,419
	n	552	Upper 90% CI	323	690	2,140	8,033	265	3,154	10,555	19,218	5,122	532,852	73,205

Note: Harvest was the number of sockeye salmon commercially harvested in drift and set gillnet fisheries. Genetic samples were collected from the drift gillnet fishery. Sockeye salmon commercial harvest and numbers of samples collected and selected (successfully screened) for genetic analysis by date(s) and periods (Appendix A5). The 90% credibility intervals of harvest estimates may not include the point estimate for very low extrapolated harvest numbers because less than 5% of iterations had values below zero.