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Addendum to FMS 16-03: Redefinition of Reporting Groups by Combining Ayakulik and Frazer into One Group for the Genetic Baseline of North American Sockeye Salmon for Mixed Stock Analyses of Kodiak Management Area Commercial Fisheries, 2014–2016

by

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

Symbols and Abbreviations

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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 MANUSCRIPT SERIES NO. 16-05

ADDENDUM TO FMS 16–03: REDEFINITION OF REPORTING GROUPS BY COMBINING AYAKULIK AND FRAZER INTO ONE GROUP FOR THE GENETIC BASELINE OF NORTH AMERICAN SOCKEYE SALMON FOR MIXED STOCK ANALYSES OF KODIAK MANAGEMENT AREA COMMERCIAL FISHERIES, 2014–2016

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ABSTRACT

Accurate, precise estimates of stock-specific harvests of sockeye salmon (*Oncorhynchus nerka*) are lacking for commercial fisheries in the Kodiak Management Area (KMA). Such information would be useful for reconstructing runs, building accurate brood tables to define escapement goals, and refining management by identifying spatial and temporal harvest patterns of local and nonlocal stocks. Hence, the Alaska Department of Fish and Game developed a genetic baseline for mixed stock analysis (MSA) to estimate the stock compositions of sockeye salmon harvests in select KMA commercial salmon fisheries from 2014 to 2016. This report describes additional baseline testing done to verify the accuracy and precision of MSA performance for Frazer and Ayakulik reporting groups given their shared ancestry and close genetic relationships. Specifically, these additional fishery scenario tests better reflect the temporal nature of KMA commercial harvest by testing MSA performance with different relative proportions of early- and late-run Ayakulik and Karluk fish. These additional fishery scenario tests indicate consistent, directional biases in the misallocation of fish between Frazer and Ayakulik. The baseline is unable to provide accurate and precise estimates of stock composition for Frazer and Ayakulik reporting groups separately, but is able to when they are combined. Thus, these 2 stocks will be combined into a composite Frazer/Ayakulik reporting group for future reporting of 2014–2016 KMA commercial harvest mixtures.

Key words: Kodiak, KMA, sockeye salmon, *Oncorhynchus nerka*, mixed stock analysis, genetic baseline, SNP

INTRODUCTION

The Alaska Department of Fish and Game is using genetic mixed stock analysis (MSA) to estimate the stock composition of commercial sockeye salmon (*Oncorhynchus nerka*) harvests in the Kodiak Management Area (KMA; Figures 1 and 2) from 2014 to 2016 (Foster and Dann 2014; Foster and Dann 2015). The foundation for genetic MSA of fishery samples is a genetic characterization of all stocks that might contribute to the fishery (hereafter *baseline*). The Gene Conservation Laboratory constructed a coastwide baseline of North American sockeye salmon containing 65,332 individuals from 762 collections representing 473 populations in 15 reporting groups (Shedd et al. 2016). In evaluating the 15 putative reporting groups, the Gene Conservation Laboratory applied standard baseline tests including 100% proof tests and fishery scenario tests to assure the accuracy and precision of future stock composition estimates of harvest samples. Two reporting groups of particular regional importance from a management perspective, Frazer and Ayakulik, were found to be identifiable, albeit weakly, by these standard tests. Populations from Frazer and Ayakulik exhibit less genetic distinction between one another than other groups due to their common ancestry; Frazer's stocking history included Ayakulik as a brood source (Burger et al. 2000; Shedd et al. 2016). The close genetic relationship between populations in the Frazer and Ayakulik reporting groups resulted in a loss of precision of stock composition estimates both within and between replicate fishery scenario tests, but little indication of a loss in the accuracy of estimates across replicates due to an asymmetrical bias (Shedd et al. 2016). This document revisits some of the implicit assumptions of the standard baseline tests performed in Shedd et al. (2016) and further evaluates the baseline's ability to provide accurate and precise stock composition estimates for the Frazer and Ayakulik reporting groups in temporally realistic mixtures.

REVISITING GENETIC SIMILARITY AMONG FRAZER AND AYAKULIK

Genetic diversity in sockeye salmon is often hierarchical in nature, with greater divergence among than within basins (Quinn 2005). Population divergence within basins is often observed between spawning ecotypes that differ in run timing, with early-run sockeye typically spawning in lake inlet tributaries and streams and late-run sockeye typically spawning on beaches and outlet rivers (Burgner 1991; Burger et al. 1995). Several lakes in southwest Kodiak have genetically distinct early- and late-run sockeye salmon populations, including Ayakulik (Red) Lake, Karluk Lake, and Upper Station (South Olga) lakes (Wattum 2016).

Frazer Lake was subject to a lengthy and varied stocking history, with significant attempts to stock at least 3 different donor sources from 1951 to 1971: early-run stream spawners from Red Lake (Ayakulik), late-run beach spawners from Karluk Lake, and late-run lake outlet spawners from Ruth Lake in the Egegik drainage (Stockley 1996; Burger et al. 2000). While sockeye populations within Frazer Lake are genetically distinct from each other and their donor sources (Figures 3 and 4; Burger et al. 2000), Frazer Lake populations remain weakly differentiated from their primary donor source, Ayakulik (Red) Lake.

CONCERN FOR BIAS IN MSA PERFORMANCE

Shedd et al. (2016) noted the decreased MSA performance in terms of precision of stock composition estimates and slight indications of bias (loss of accuracy) due to the genetic similarity between Frazer and Ayakulik populations. While Frazer had the lowest correct allocation of any of the 15 reporting groups in 100% proof tests, the average over 5 repeats was 91.8%, which met the Gene Conservation Laboratory's standard criteria of 90% correct allocation (Table 8 and Figure 18, Shedd et al. 2016). Furthermore, fishery scenario tests designed to mimic hypothetical fisheries mixtures indicated misallocation between Frazer and Ayakulik—resulting in wider 90% credibility intervals within repeats of a scenario and larger root mean square error values across repeats within a scenario, but no indication of directional bias in the misallocation (Tables 6 and 9, Figures 10–16, Shedd et al. 2016). The 90% credibility intervals contained the correct stock composition in 29 and 30 of the 35 tests (5 replicates of 7 fishery scenarios) for Frazer and Ayakulik reporting groups, respectively (Shedd et al. 2016).

Baseline evaluation tests were conducted and interpreted correctly but did not account for important temporal patterns of stock contributions to area fisheries. The 2 fishery scenario tests most pertinent to testing for bias in Frazer and Ayakulik reporting groups, June Ayakulik and July Alitak, may have been oversimplified. To construct the hypothetical fishery scenarios, known mixture individuals were sampled from the baseline without replacement according to the proportions for a given scenario, and then tested against the reduced baseline. The potential oversimplification resulted from known mixture individuals being sampled randomly within a reporting group. Thus, the individuals removed from the baseline for the Ayakulik reporting group always contained individuals from both early and late-run Ayakulik populations. As a result these fishery scenarios did not realistically test for MSA performance when only early- or late-run Ayakulik sockeye are present along with Frazer sockeye.

REDEFINING REPORTING GROUPS FOR KMA SOCKEYE FISHERIES

If there were differences in the level of genetic differentiation between Frazer populations and the early- and late-run Ayakulik populations, there is the potential for variable MSA performance throughout the season. Such variable performance could result in accurate and precise estimates of stock-specific harvests during parts of the fishing season but not others, limiting the ability of the project to achieve goals of reconstructing runs, building accurate brood tables to define escapement goals, and refining management by identifying spatial and temporal harvest patterns of local and nonlocal stocks. If variable MSA performance is present and Frazer and Ayakulik reporting groups are not consistently distinguishable throughout the season, it may be necessary to collapse them together into a single, composite reporting group.

OBJECTIVES

This document has 2 objectives:

1. Determine if the performance of the baseline for MSA with respect to Frazer and Ayakulik reporting groups depends on proportion of early- and late-run fish in the mixture.
2. Revisit, if necessary, the definition of reporting groups for reporting KMA commercial harvest from 2014 to 2016.

METHODS

REDEFINING REPORTING GROUPS

We redefined reporting groups for the 473 populations in the original baseline in order to test whether the MSA performance of Frazer and Ayakulik reporting groups depends on the proportion of early- and late-run Ayakulik sockeye in the mixture. Reporting groups were redefined to split both Ayakulik and Karluk reporting groups into their respective early- and late-run components—going from 15 reporting groups to 17. Frazer was not split as it is not thought to have early- and late-run components (Wattum 2016).

FISHERY SCENARIO TESTS

Two of the hypothetical fishery scenario tests that contained the highest proportions of Frazer and Ayakulik fish, June Ayakulik and July Alitak, were replicated, taking into account the run timing of Ayakulik and Karluk. For the June Ayakulik hypothetical scenario, only early-run fish were removed from Ayakulik and Karluk reporting groups. For the July Alitak hypothetical scenario, we analyzed 3 separate subscenarios: (1) only early-run fish from Ayakulik and Karluk, (2) a 50/50 mixture of early- and late-run fish from Ayakulik and Karluk, and (3) only late-run fish from Ayakulik and Karluk. Otherwise, methods were the same as reported in Shedd et al. (2016).

BAYES PROTOCOL

Stock compositions of these test mixtures were estimated with the program *BAYES* (Pella and Masuda 2001), following the methods reported in Shedd et al. (2016) with 2 minor differences. First, we performed 10 repeats (replicates) of each scenario instead of 5 repeats. Second, we only ran a single Markov Chain Monte Carlo chain of 40,000 iterations for each proof test repeat, as opposed to 5 chains. These differences were made to provide more observations of the baseline's accuracy and precision (more replicates) and greater analytical efficiency (fewer chains).

RESULTS

FISHERY SCENARIO TESTS

Fishery scenario proof tests suggested that the baseline cannot accurately and precisely estimate stock compositions of Frazer and Ayakulik reporting groups in proportions expected in 2 different KMA fisheries (Table 1; Figures 5–8). Frazer was consistently underestimated and Ayakulik consistently overestimated in the July Alitak scenario, regardless of the proportion of early- or late-run Ayakulik (Table 1; Figures 5–12). Average estimates of the Frazer reporting group were between 3.3% and 4.8% low for the 3 different July Alitak scenarios, with Ayakulik

Early having average estimates from 1.3% to 2.4% high, and and Ayakulik Late having average estimates from 0.8% to 1.8% high (Table 1). With regard to the precision among replicates (variation of the medians across replicates), root mean square error values remained elevated for the Frazer, Ayakulik Early, and Ayakulik Late reporting groups (Frazer range = 4.8–7.0%, average = 5.9%; Ayakulik Early range = 2.7–4.4%, average = 3.7%; Ayakulik Late range = 0–5.0%, average = 2.8%), indicating lower precision between replicates for scenarios than for the other 14 reporting groups (Table 1).

Overall, these additional fishery scenario proof tests analyzed with respect to genetic differences in run timing indicate an inability to reliably distinguish Frazer and Ayakulik stocks. Not only are stock composition estimates for Frazer and Ayakulik less precise than estimates for other groups, but they are biased towards Ayakulik at the expense of Frazer. Additionally, we continued to note the slight bias towards underestimation of the Cook Inlet reporting group.

When Frazer and Ayakulik were collapsed into a single reporting group, accuracy and precision were greatly improved. Average estimates of the Frazer/Ayakulik reporting group were between 0.4% low and 0.7% high across the 4 fishery scenarios. With regard to the precision among replications (variation of the medians across replicates), root mean square error values of the Frazer/Ayakulik reporting group ranged from 1.1% to 2.1% (average = 1.6%), which is more comparable to the level of precision seen in the other 13 reporting groups.

DISCUSSION

This report is an addendum to Shedd et al. (2016) describing additional tests to determine if the baseline can provide accurate and precise stock composition estimates for the Frazer and Ayakulik reporting groups. Previous fishery scenario tests described in Shedd et al. (2016) were conducted and interpreted correctly, but did not account for important temporal patterns of stock contributions to area fisheries. The tests conducted in this addendum evaluated what effect the relative proportion of early- and late-run Ayakulik fish in the mixture has on MSA performance for Frazer and Ayakulik reporting groups. We felt that it was important to include these additional tests, given that early temporal strata analyzed in the 2014–2016 KMA fisheries are likely to contain early-run fish from these reporting groups, and late temporal strata are likely to contain late-run fish. Frazer Lake was initially stocked with both early-run, stream spawning sockeye from Ayakulik (Red) Lake, and late-run, shore spawning sockeye from Karluk Lake (Stockley 1996; Burger et al. 2000), but exhibits intermediate run timing (Wattum 2016). While the previous fishery scenario tests reported in Shedd et al. (2016) were not incorrect, they sampled hypothetical mixture individuals from the baseline randomly within reporting groups. The effect of this sampling design was that mixture compositions reflected relative abundance among baseline sample sizes. As a result, the Ayakulik reporting group had an average 30/70 mix of early- and late-run Ayakulik fish in the original fishery scenario tests (Table 3, Shedd et al. 2016). The additional fishery scenario tests reported here sampled only early-run fish for the hypothetical June Ayakulik scenario and then 3 different mixtures for the July Alitak scenario: (1) all early-run fish, (2) 50/50 early- and late-run fish, and (3) only late-run fish. These additional tests better characterize the MSA performance of the baseline by taking into account temporal differences in run timing that we are likely to see in fishery mixtures.

REDEFINING REPORTING GROUPS FOR KMA SOCKEYE FISHERIES

The 4 new fishery scenario tests indicated unacceptable inaccuracy in the stock composition estimates for Frazer and Ayakulik reporting groups. A directional bias was present in stock composition estimates for Frazer and Ayakulik for the July Alitak scenario regardless of the relative proportion of early- and late-run Ayakulik fish in the mixture. Thus, it appears that the baseline cannot accurately and precisely distinguish between Frazer and Ayakulik stocks at any point in the season. However, the misallocations observed in these tests are primarily among the 3 reporting groups (Ayakulik early, Ayakulik late, and Fazer). These misallocations largely canceled each other out when these reporting groups are combined.

Thus, it is only appropriate to collapse these 2 stocks into a single, composite Frazer/Ayakulik reporting group. This decision is not taken lightly, as knowledge of stock-specific harvest for Frazer and Ayakulik stocks is of considerable importance to the Alaska Department of Fish and Game and stakeholders. Frazer and Ayakulik are not genetically distinct enough from each other to perform reliably for MSA, regardless of whether the baseline contains the full set of 96 SNPs used in WASSIP, or the 48 SNPs specifically highgraded for this project (Shedd et al. 2016). Nevertheless, a composite Frazer/Ayakulik reporting group will perform well for genetic MSA as these stocks are sufficiently differentiated from other KMA stocks. Future stock composition estimates for 2014–2016 KMA commercial harvest will report to only 14 reporting groups, not the 15 initially reported in Shedd et al. (2016).

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TABLES AND FIGURES

Table 1.–True stock composition, estimates of average stock composition, bias, root mean square error (RMSE), and 90% credibility interval (CI) width for 10 replicates of 4 different hypothetical fishery scenario proof tests of the coastwide sockeye salmon genetic baseline with 46 loci and 17 reporting groups. Each replicate was a sample of 400 individuals removed from the genetic baseline. Stock composition estimates (percentage) may not sum to 100 due to rounding error. See text for details.

	Hypothetical June Ayakulik (early-run) scenario					Hypothetical July Alitak (early-run) scenario				
Reporting group	True	Average	Bias	RMSE	CI Width	True	Average	Bias	RMSE	CI Width
West of Chignik	5.0	4.2	-0.8	1.1	4.0	9.0	9.3	0.3	0.8	6.1
Black Lake	5.0	4.9	-0.1	0.5	3.9	0.0	0.0	0.0	0.0	0.6
Chignik Lake	0.0	0.0	0.0	0.0	0.3	10.0	9.7	-0.3	0.7	5.7
Upper Station / Akalura	15.0	15.1	0.1	1.0	6.6	10.0	10.4	0.4	0.9	5.8
Frazer	10.0	10.1	0.1	4.8	13.0	30.0	25.2	-4.8	7.0	16.3
Ayakulik Early	30.0	29.8	-0.2	4.0	12.1	15.0	17.4	2.4	4.4	11.5
Ayakulik Late	0.0	0.0	0.0	0.0	3.4	0.0	1.2	1.2	2.6	7.0
Karluk Early	30.0	29.7	-0.3	1.6	9.5	5.0	5.6	0.6	1.9	6.0
Karluk Late	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	1.0
Uganik	0.0	0.0	0.0	0.0	0.3	1.0	1.2	0.2	0.5	2.5
Northwest Kodiak	0.0	0.0	0.0	0.0	0.5	1.0	0.8	-0.2	0.8	1.8
Afognak	0.0	0.0	0.0	0.0	0.3	1.0	1.0	-0.0	0.6	1.9
Eastside Kodiak	0.0	0.0	0.0	0.0	0.5	1.0	0.8	-0.2	0.9	1.9
Saltery	0.0	0.0	0.0	0.0	0.2	2.0	1.9	-0.1	0.6	2.9
Cook Inlet	5.0	4.5	-0.5	1.0	4.1	15.0	13.1	-1.9	2.1	6.8
Prince William Sound	0.0	0.0	0.0	0.0	0.4	0.0	0.1	0.1	0.2	0.9
South of Cape Suckling	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.4

-continued-

Table 1.–Page 2 of 2.

Reporting group	Hypothetical July Alitak (50/50 early/late-run) scenario					Hypothetical July Alitak (late-run) scenario				
	True	Average	Bias	RMSE	CI Width	True	Average	Bias	RMSE	CI Width
West of Chignik	9.0	8.6	-0.4	2.0	6.0	9.0	8.4	-0.6	1.3	5.7
Black Lake	0.0	0.0	0.0	0.1	1.1	0.0	0.3	0.3	1.0	0.9
Chignik Lake	10.0	10.0	-0.0	0.7	5.9	10.0	9.8	-0.2	1.1	5.7
Upper Station / Akalura	10.0	10.0	0.0	0.7	5.8	10.0	9.8	-0.2	1.0	5.7
Frazer	30.0	26.7	-3.3	6.7	20.0	30.0	26.1	-3.9	4.9	16.8
Ayakulik Early	7.5	9.1	1.6	3.7	10.7	0.0	1.3	1.3	2.7	4.6
Ayakulik Late	7.5	8.3	0.8	5.0	13.7	15.0	16.8	1.8	3.6	14.7
Karluk Early	2.5	3.2	0.7	2.1	5.0	0.0	0.3	0.3	1.0	2.1
Karluk Late	2.5	2.1	-0.4	1.7	4.0	5.0	5.0	0.0	1.9	5.5
Uganik	1.0	1.0	0.0	0.7	2.4	1.0	1.1	0.1	0.8	2.3
Northwest Kodiak	1.0	0.6	-0.4	0.6	1.5	1.0	0.8	-0.2	0.5	1.9
Afognak	1.0	1.0	0.0	0.4	2.1	1.0	1.0	0.0	0.5	2.0
Eastside Kodiak	1.0	0.7	-0.3	0.7	2.0	1.0	0.6	-0.4	0.8	2.2
Saltery	2.0	2.1	0.1	0.5	3.2	2.0	2.2	0.2	1.0	3.1
Cook Inlet	15.0	14.1	-0.9	1.9	6.8	15.0	14.2	-0.8	1.6	6.8
Prince William Sound	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.5
South of Cape Suckling	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.3

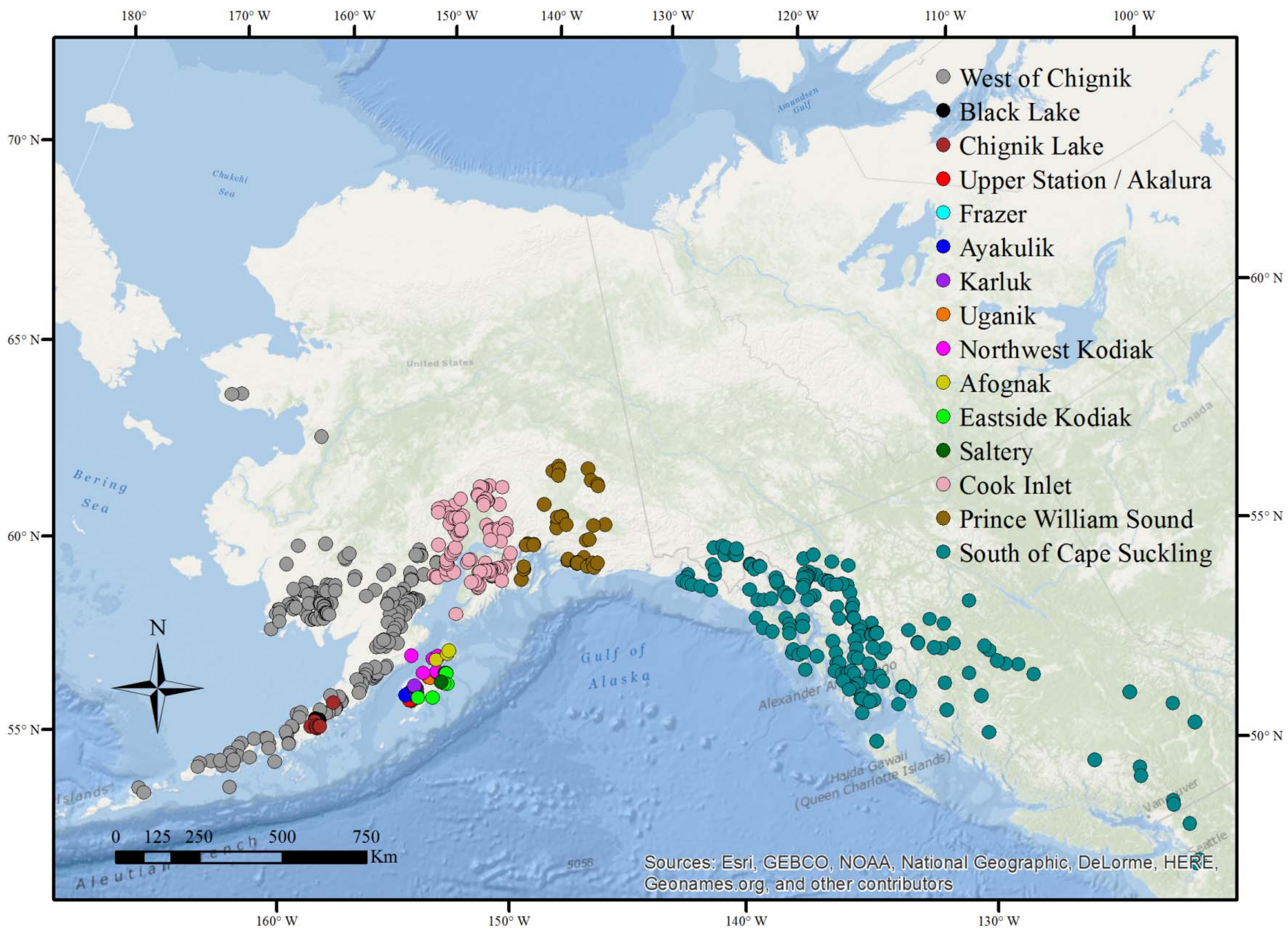


Figure 1.–The location and reporting group affiliation of 746 collections of sockeye salmon included in final coastwide baseline analyses for KMA commercial harvest, 2014–2016.

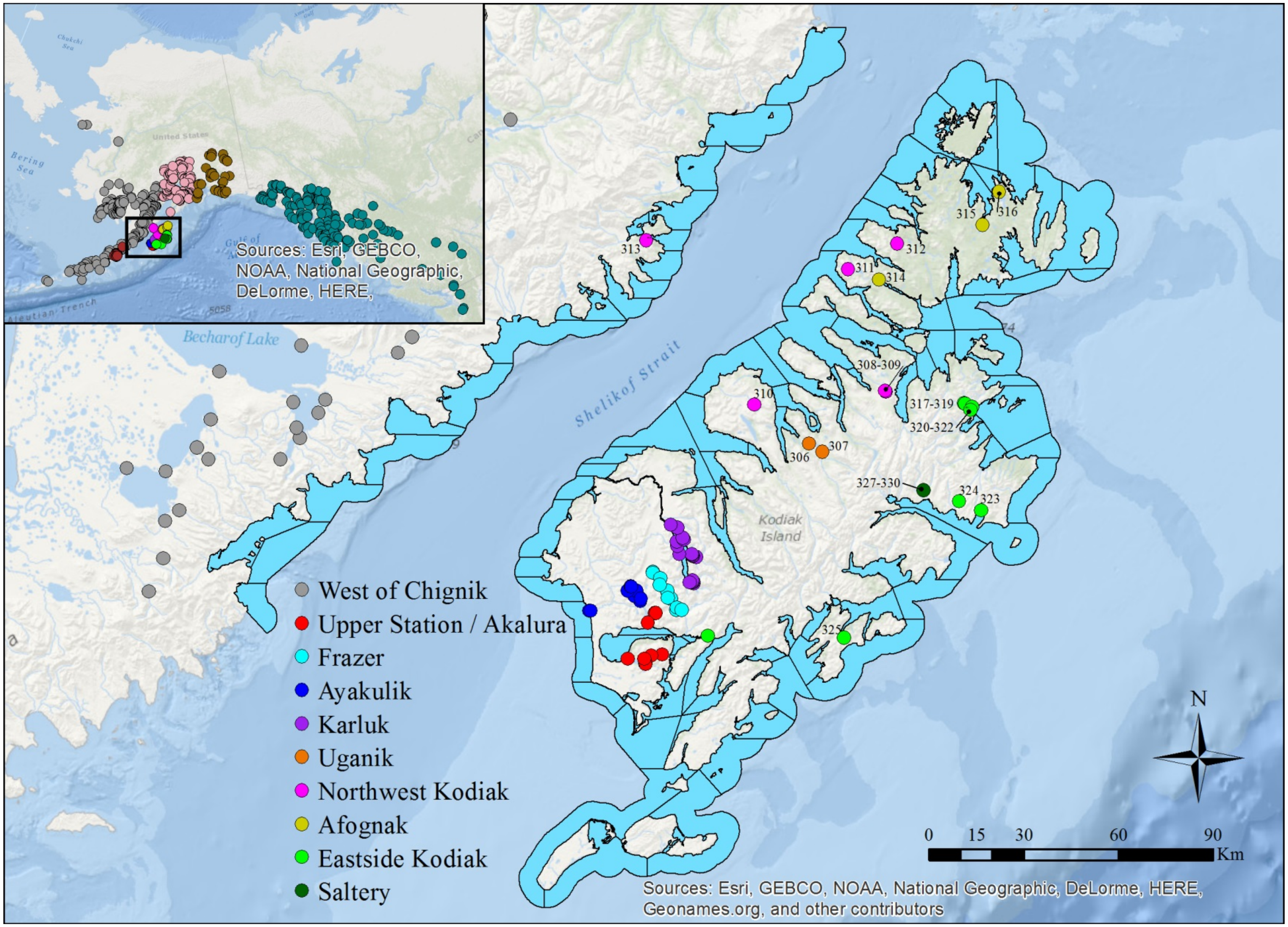


Figure 2.–The locations of collections of sockeye salmon from Kodiak Management Area reporting groups included in final baseline analyses for KMA commercial harvest, 2014–2016. Blue areas are the commercial fishing statistical areas of KMA.

Note: Numbers correspond to collection numbers listed in Table 3 of Shedd et al. (2016).

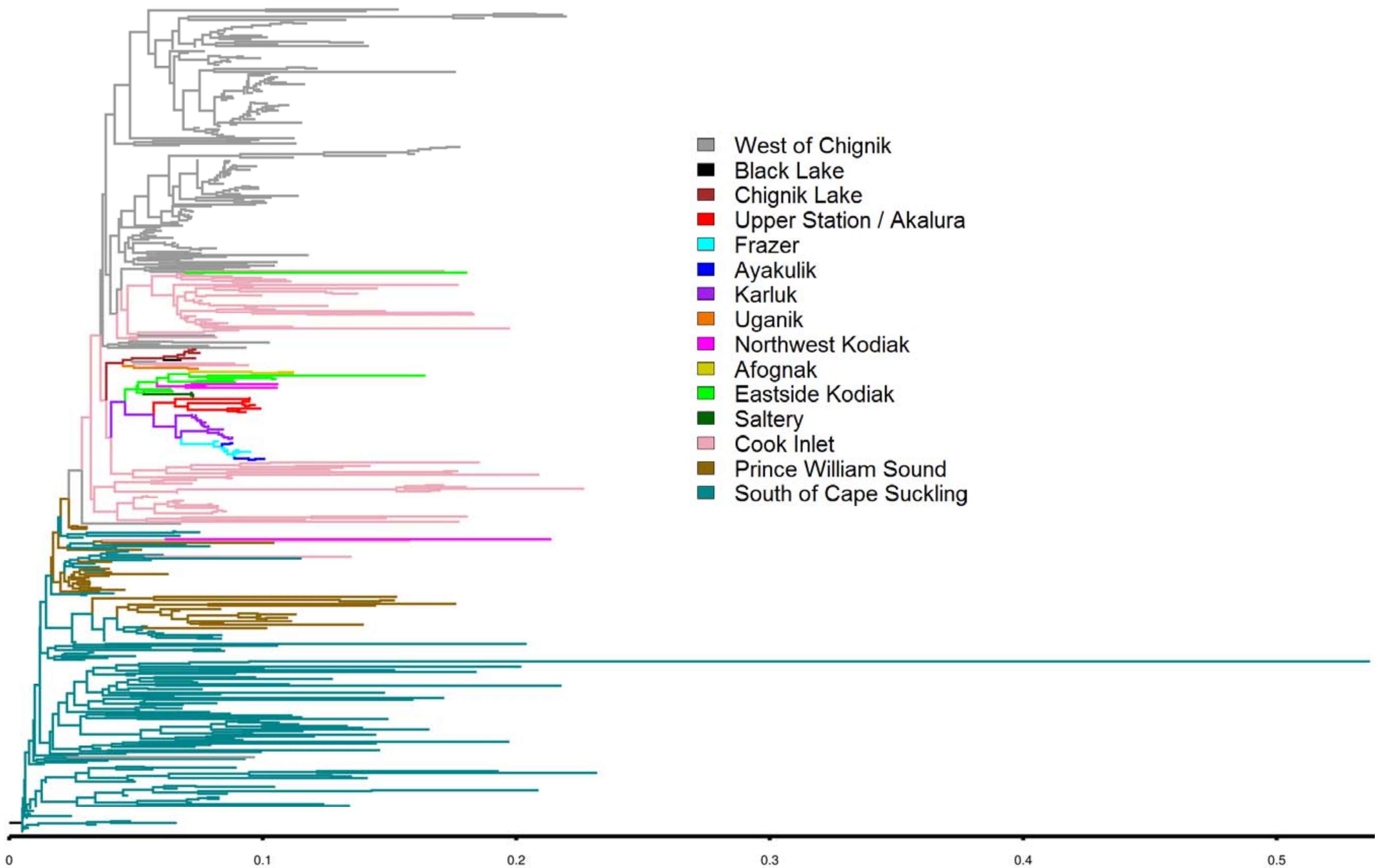


Figure 3.–Broad-scale view of a consensus Neighbor-Joining tree based upon pairwise F_{ST} among 473 populations of sockeye salmon included in the KMA coastwide sockeye salmon baseline. Tree branch colors denote reporting group affiliation of populations.

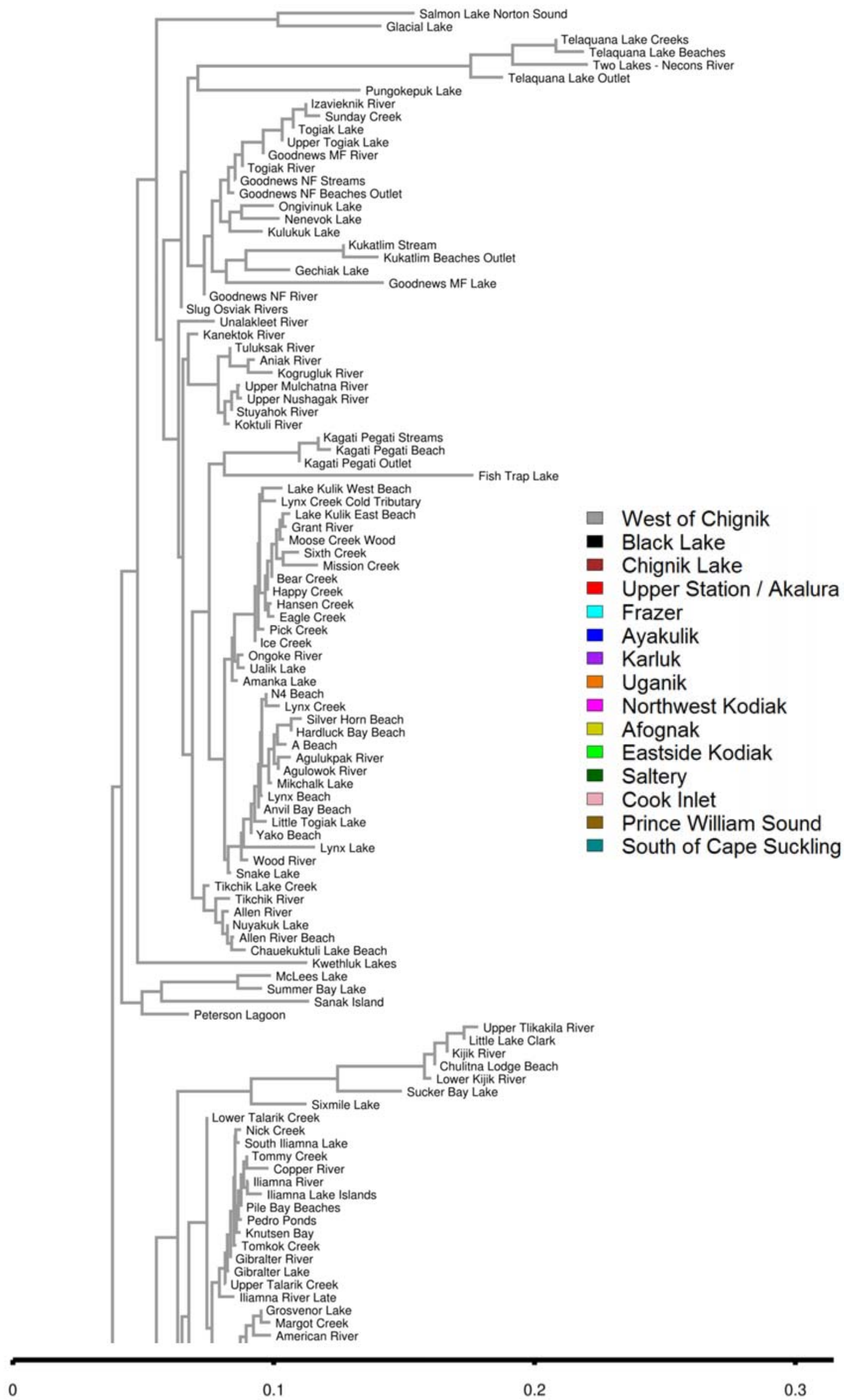


Figure 4.–Fine-scale view of a consensus Neighbor-Joining tree based on pairwise F_{ST} among 473 populations of sockeye salmon included in the KMA coastwide sockeye salmon baseline as characterized by 89 SNP loci. Tree branch colors denote reporting group affiliation of populations. Note that the branch for Kanalku Lake in the South of Cape Suckling reporting group is truncated (true length ~ 0.53).

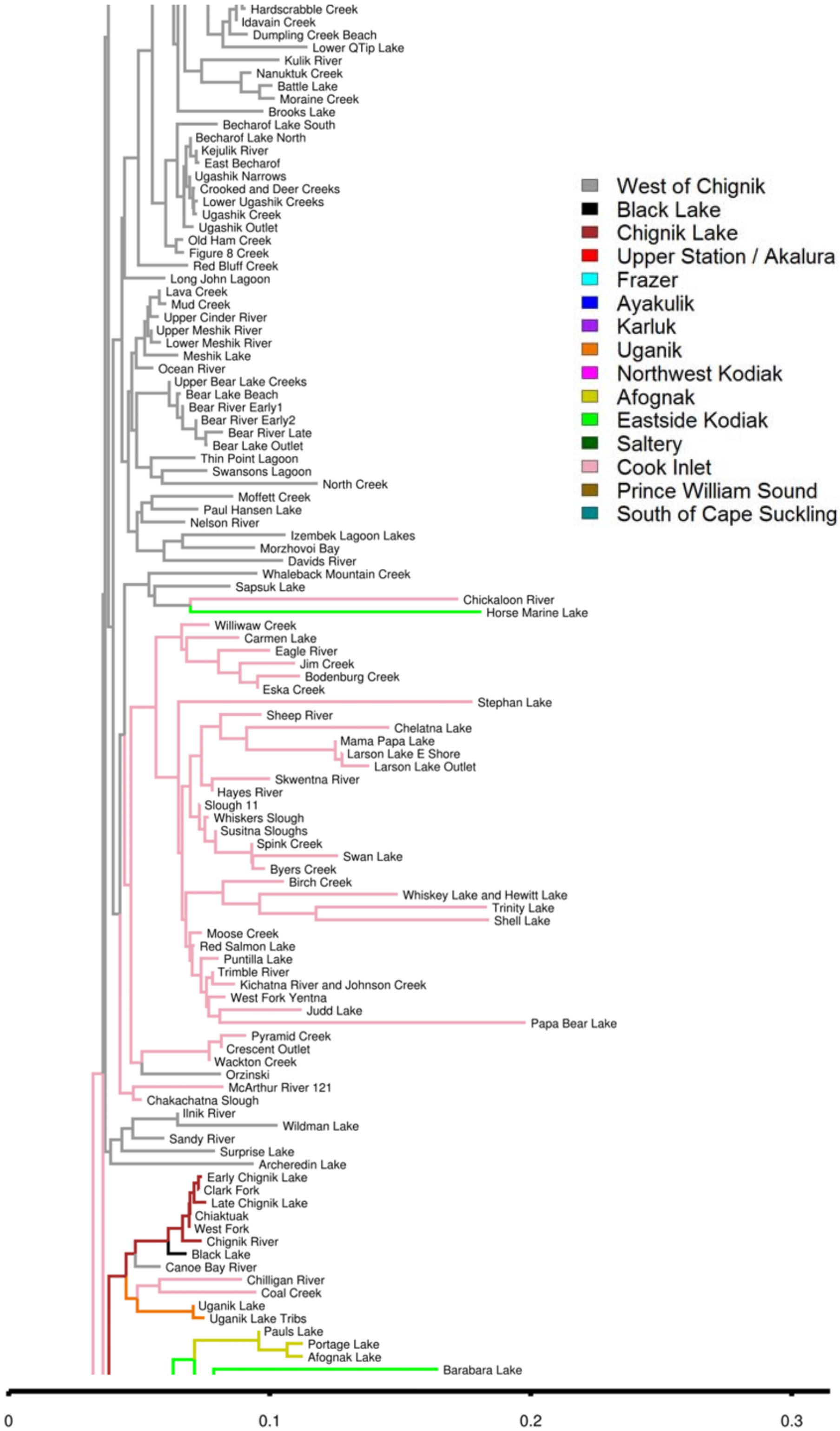


Figure 4.–Page 2 of 5.

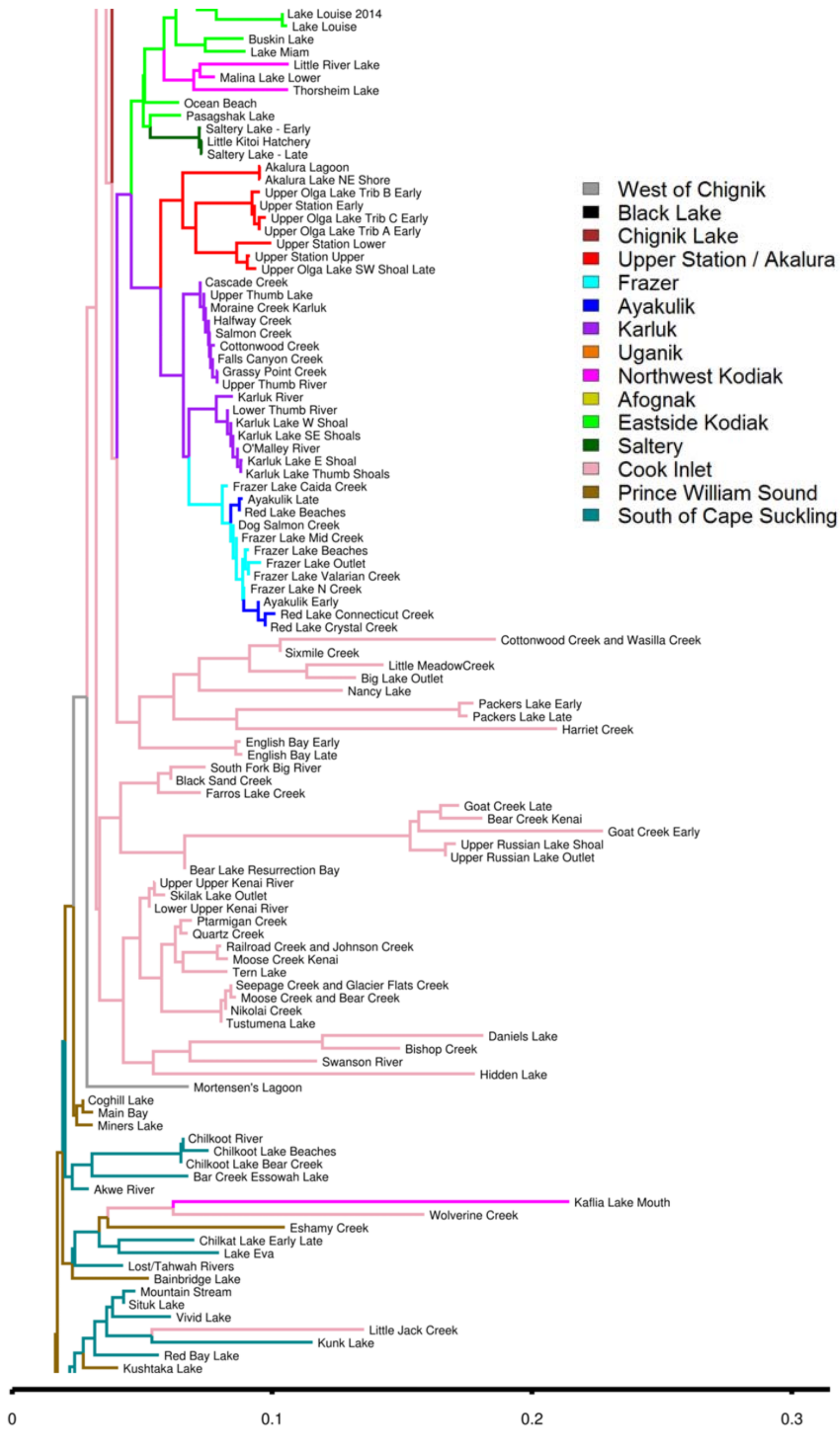
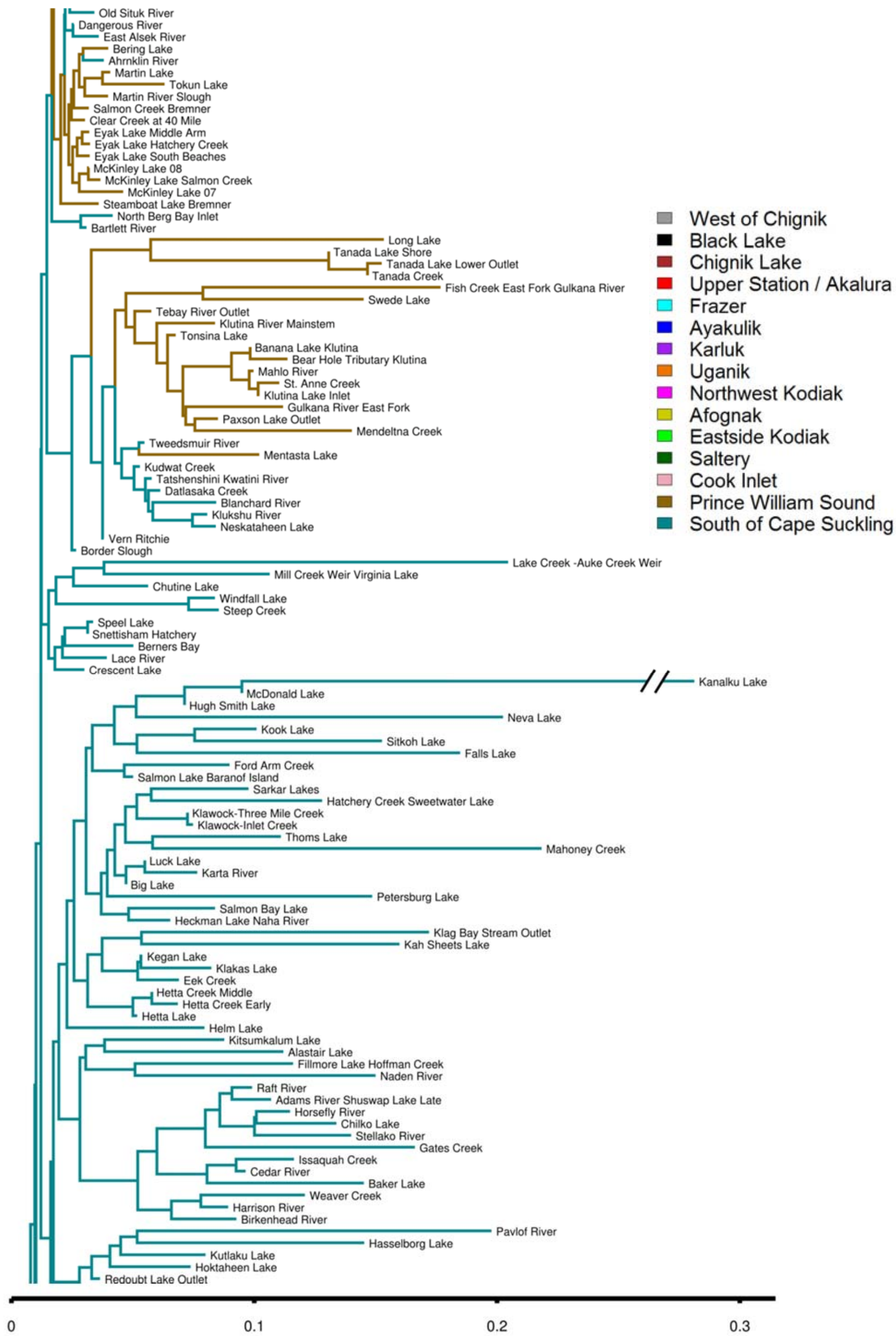


Figure 4.–Page 3 of 5.



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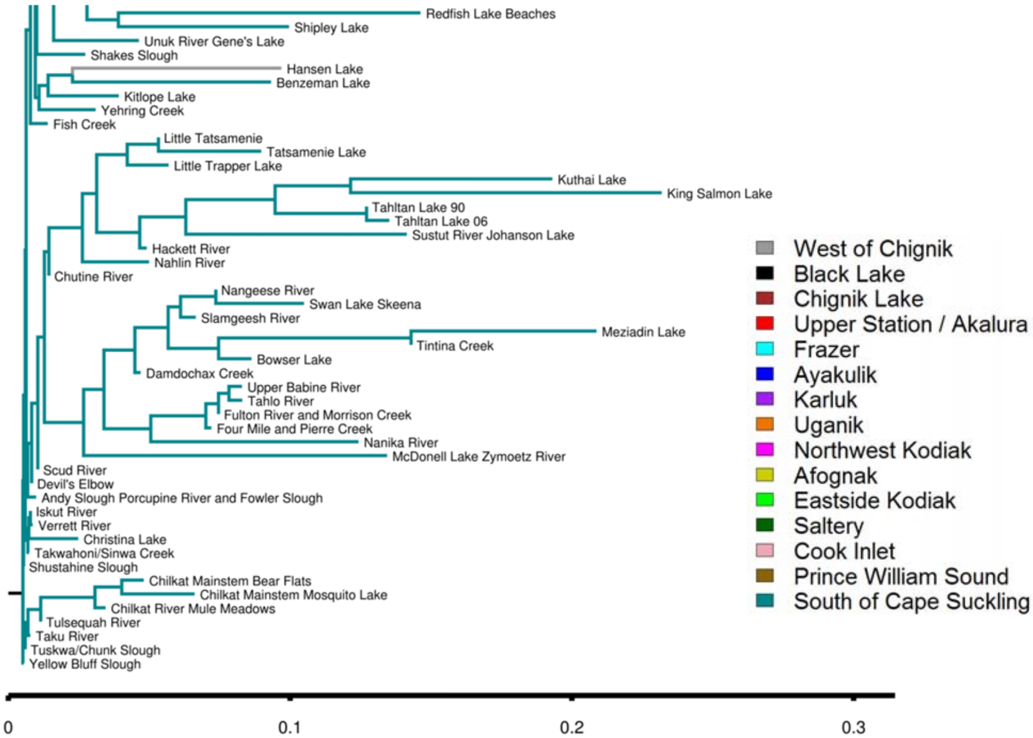

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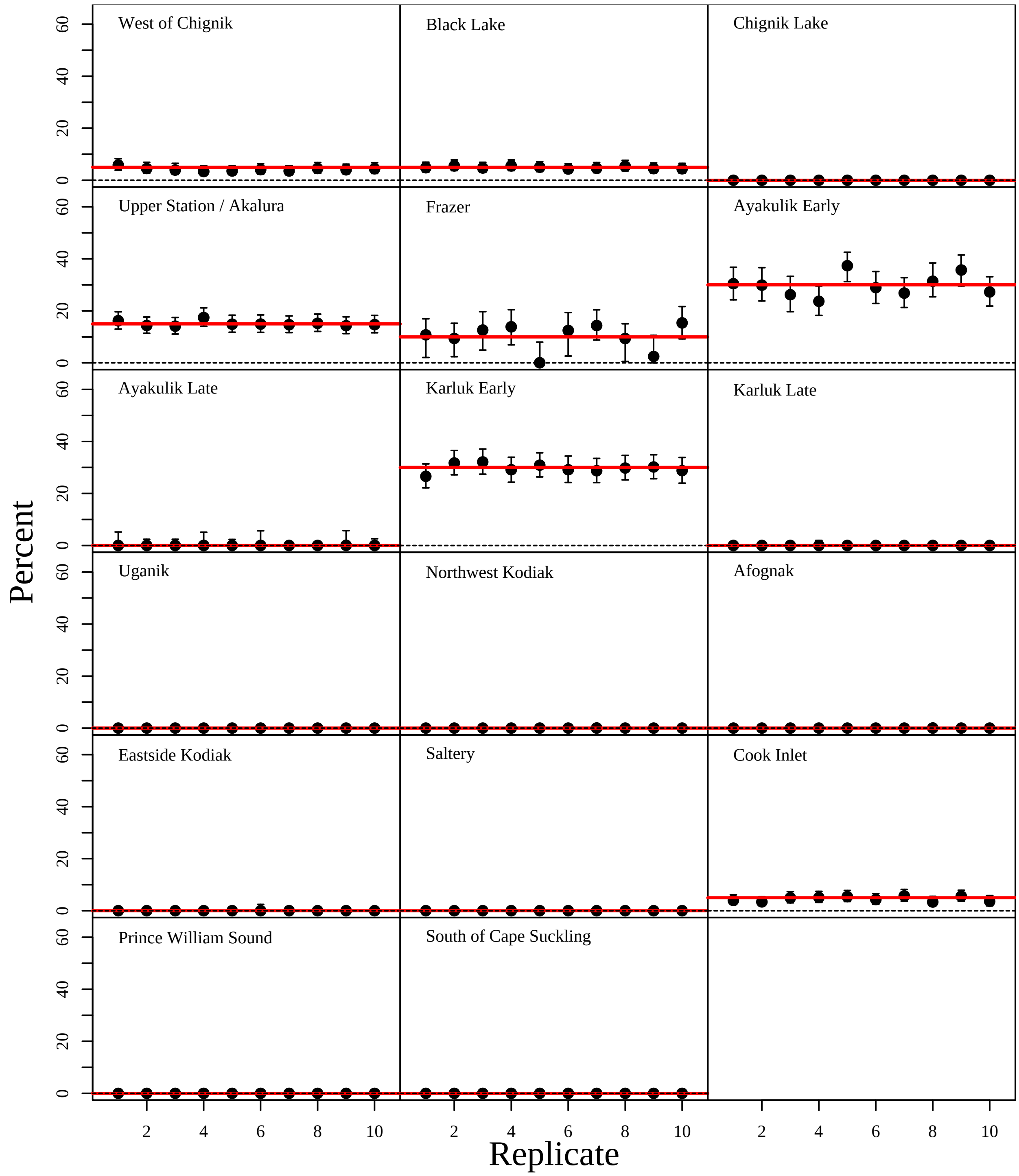

Figure 5.–Median (circles) and 90% credibility interval (bars) estimates for 10 replicates of a simulated, hypothetical June Ayakulik fishery that draws only early-run fish from Ayakulik and Karluk. Each replicate was a sample of 400 individuals removed from the baseline. Black circles and bars indicate results for a baseline of 46 loci. Each cell represents a reporting group, the red line shows the true stock composition of the simulation, and deviations from the red line show magnitude and direction of biases for each replicate.

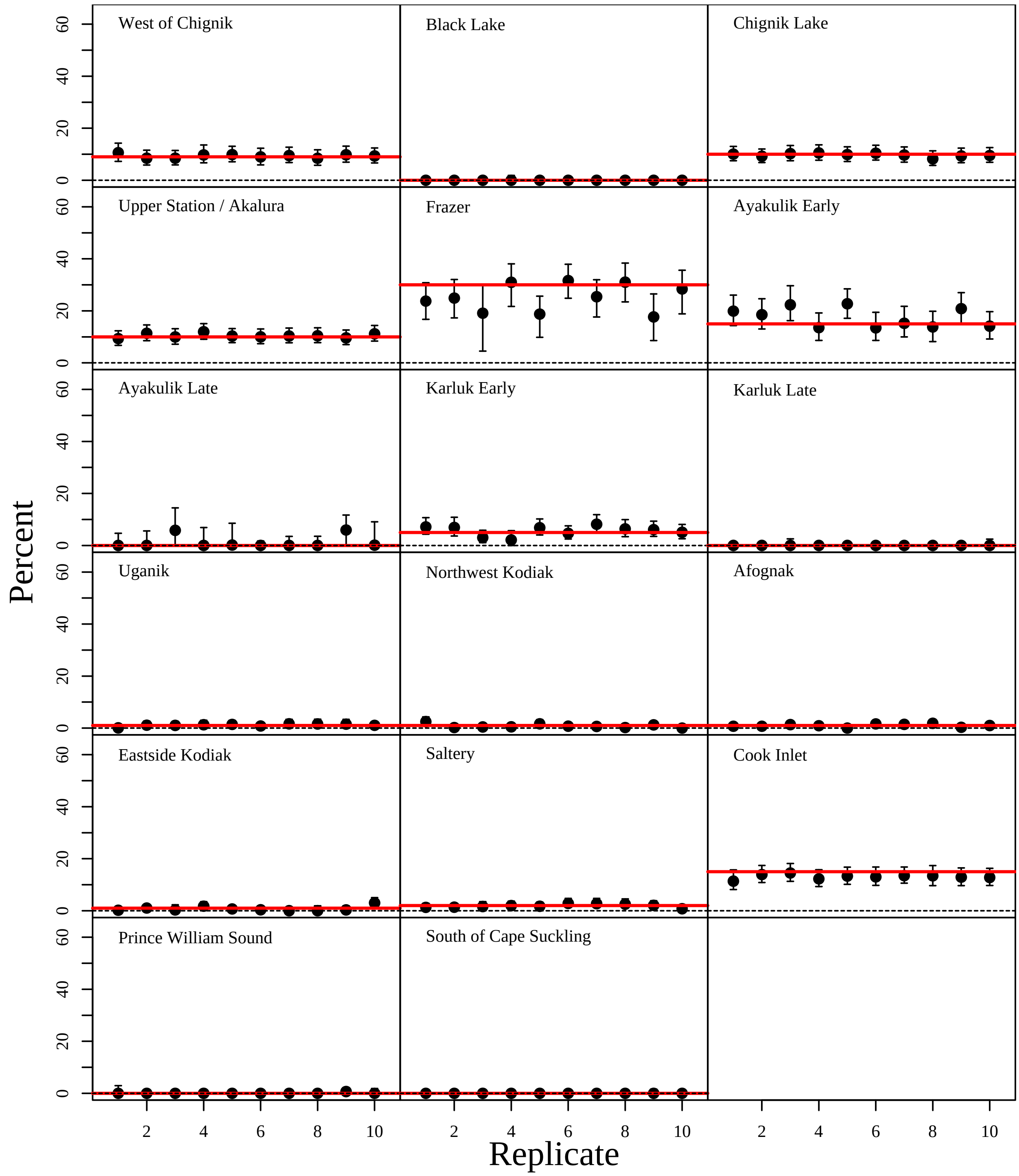

Figure 6.–Median (circles) and 90% credibility interval (bars) estimates for 10 replicates of a simulated, hypothetical July Alitak fishery that draws only early-run fish from Ayakulik and Karluk. Each replicate was a sample of 400 individuals removed from the baseline. Black circles and bars indicate results for a baseline of 46 loci. Each cell represents a reporting group, the red line shows the true stock composition of the simulation, and deviations from the red line show magnitude and direction of biases for each replicate.

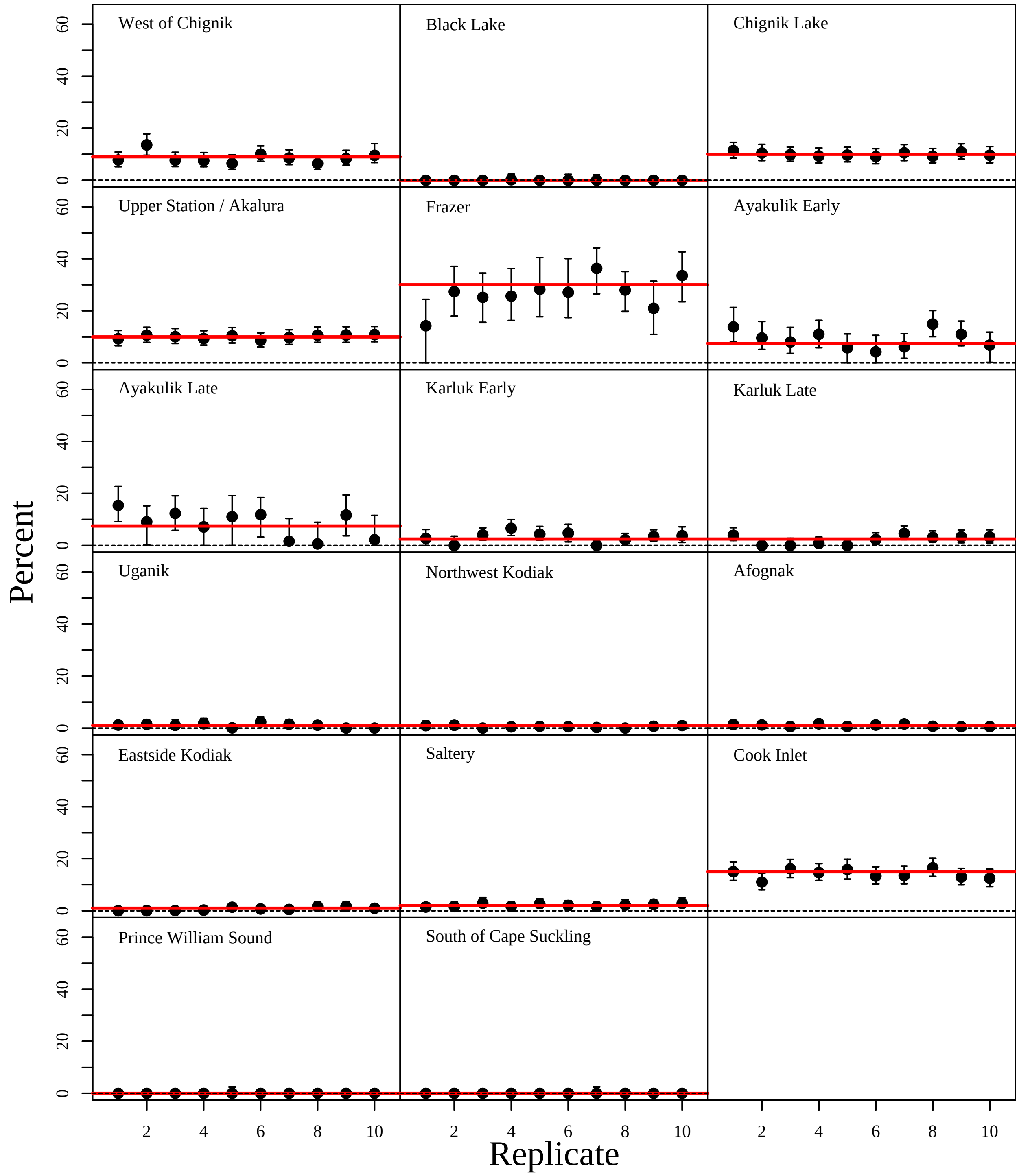

Figure 7.–Median (circles) and 90% credibility interval (bars) estimates for 10 replicates of a simulated, hypothetical July Alitak fishery that draws a 50/50 mix of early-run and late-run fish from Ayakulik and Karluk. Each replicate was a sample of 400 individuals removed from the baseline. Black circles and bars indicate results for a baseline of 46 loci. Each cell represents a reporting group, the red line shows the true stock composition of the simulation, and deviations from the red line show magnitude and direction of biases for each replicate.

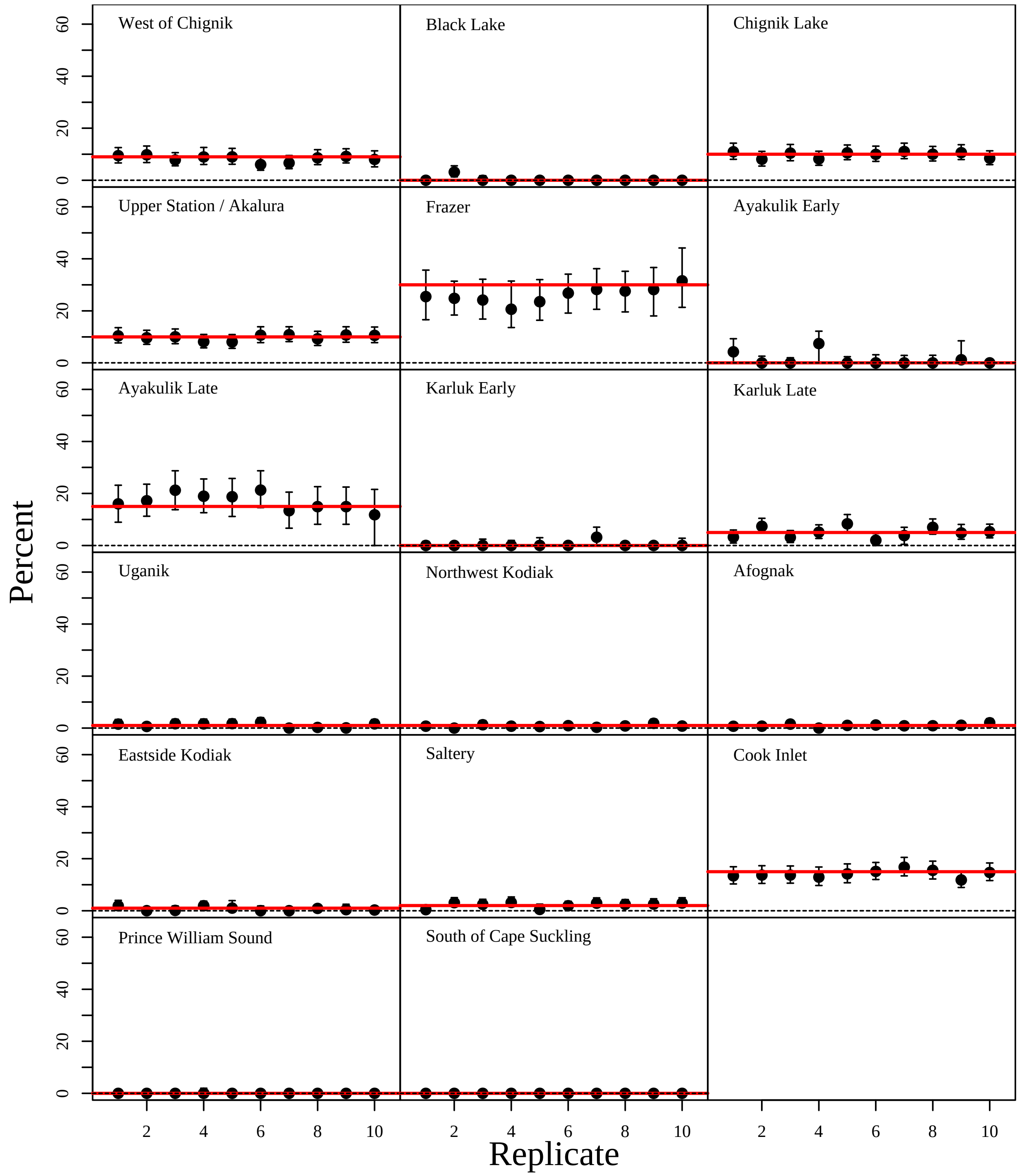

Figure 8.–Median (circles) and 90% credibility interval (bars) estimates for 10 replicates of a simulated, hypothetical July Alitak fishery that draws only late-run fish from Ayakulik and Karluk. Each replicate was a sample of 400 individuals removed from the baseline. Black circles and bars indicate results for a baseline of 46 loci. Each cell represents a reporting group, the red line shows the true stock composition of the simulation, and deviations from the red line show magnitude and direction of biases for each replicate.

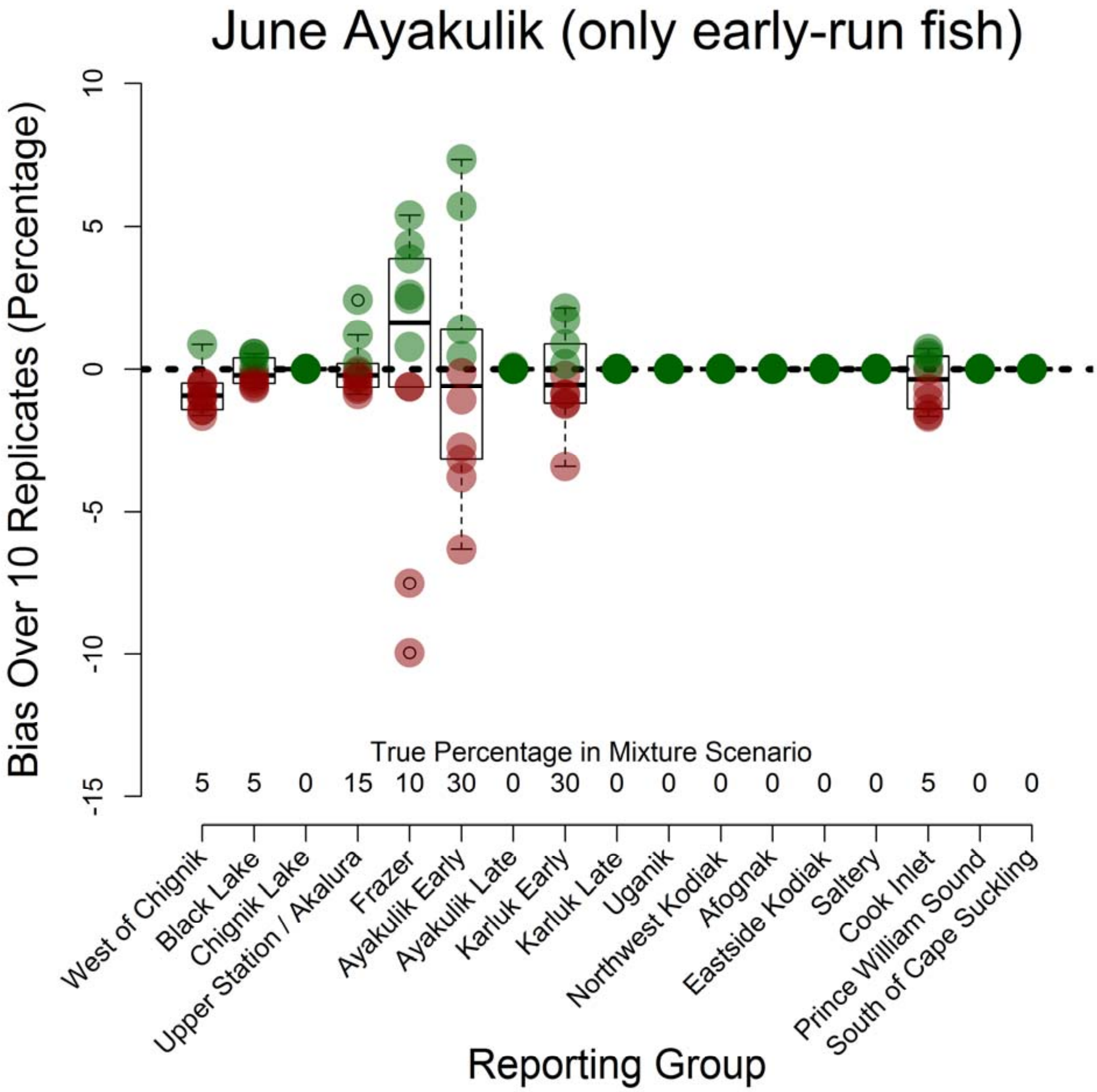

Figure 9.–Bias (circles) of the median estimate with respect to the true percentage for 10 replicates of a simulated, hypothetical June Ayakulik fishery that draws only early-run fish from Ayakulik and Karluk. Each replicate was a sample of 400 individuals removed from the baseline. Circles indicate median estimates with respect to the true percentage for each of the 10 replicates for all 17 reporting groups. Circles are green if there is a positive bias (overestimation of reporting group) and red if there is a negative bias (underestimation of a reporting group). Points are superimposed over boxplots showing the distribution of bias across replicates. Black lines indicate mean bias, boxes indicate the inner-quartile range (IQR; 25th to 75th percentile), and whiskers indicate either the most extreme value or 1.5 times the IQR away from the 25th or 75th percentile. The true percentages for each reporting group for a scenario are listed at the bottom of the graph. Note that if the true percentage for a reporting group is zero, that group cannot have a negative bias (estimates are never less than zero).

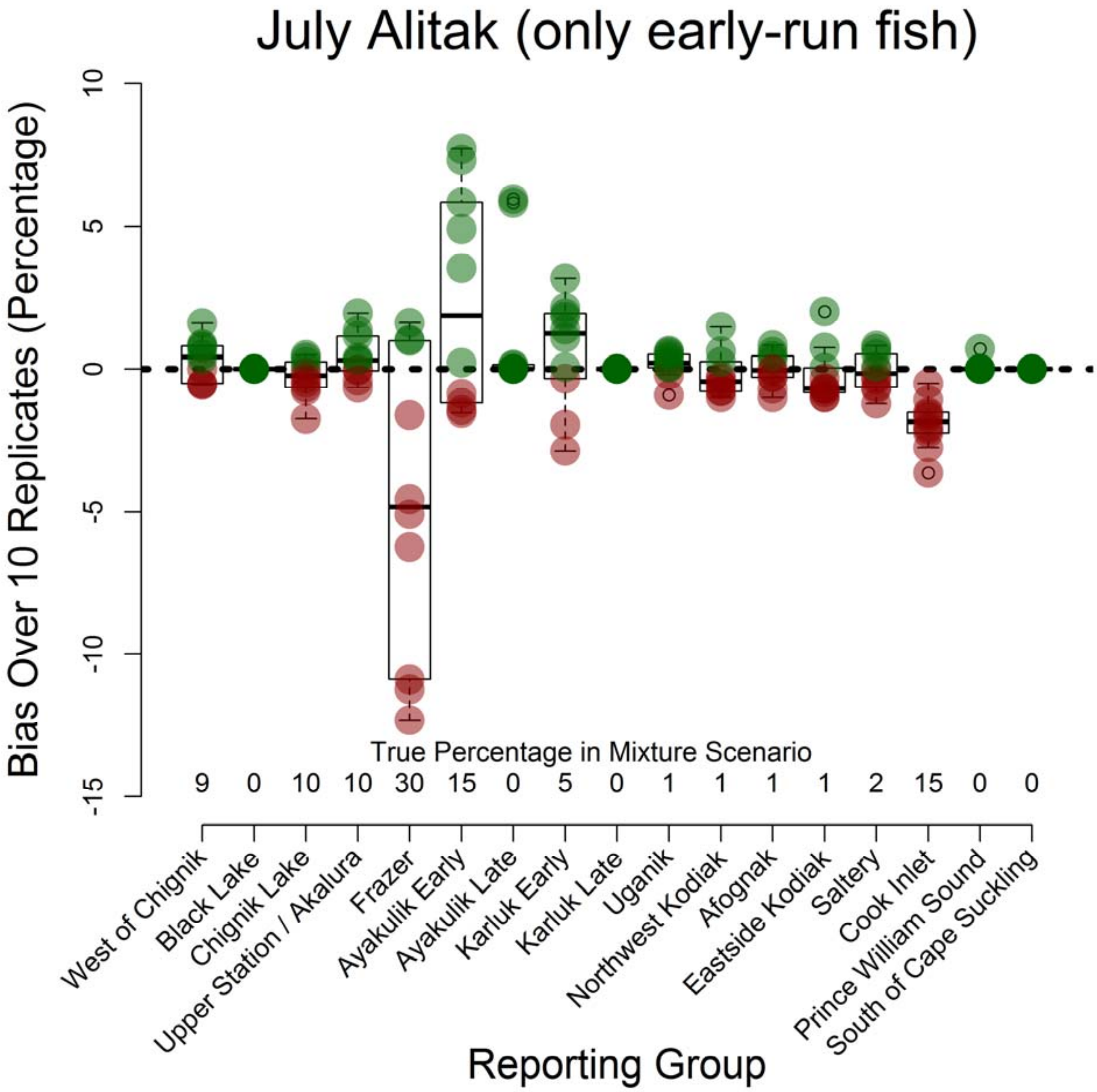

Figure 10.–Bias (circles) of the median estimate with respect to the true percentage for 10 replicates of a simulated, hypothetical July Alitak fishery that draws only early-run fish from Ayakulik and Karluk. Each replicate was a sample of 400 individuals removed from the baseline. Circles indicate median estimates with respect to the true percentage for each of the 10 replicates for all 17 reporting groups. Circles are green if there is a positive bias (overestimation of reporting group) and red if there is a negative bias (underestimation of a reporting group). Points are superimposed over boxplots showing the distribution of bias across replicates. Black lines indicate mean bias, boxes indicate the inner-quartile range (IQR; 25th to 75th percentile), and whiskers indicate either the most extreme value or 1.5 times the IQR away from the 25th or 75th percentile. The true percentages for each reporting group for a scenario are listed at the bottom of the graph. Note that if the true percentage for a reporting group is zero, that group cannot have a negative bias (estimates are never less than zero).

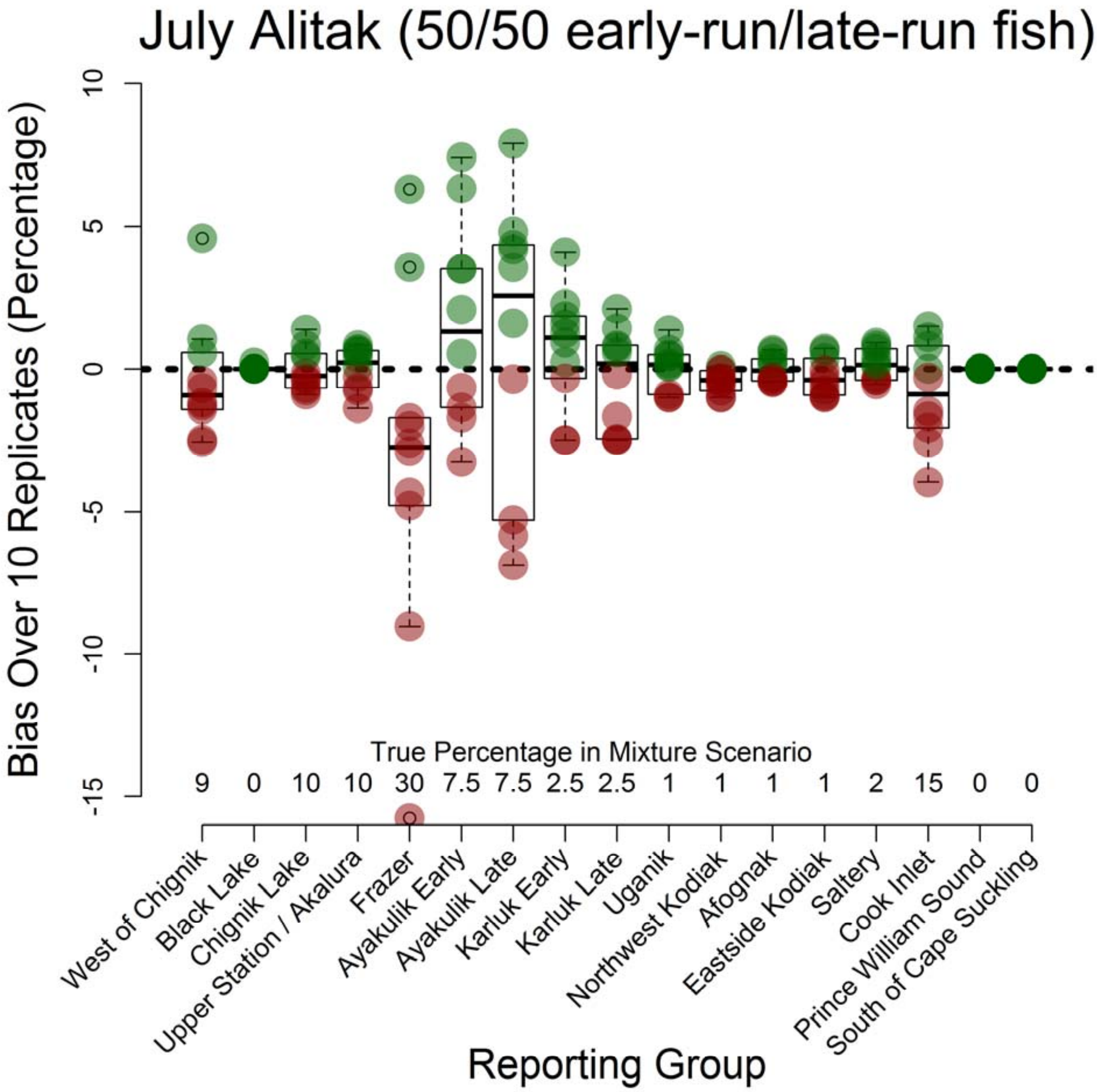

Figure 11.–Bias (circles) of the median estimate with respect to the true percentage for 10 replicates of a simulated, hypothetical July Alitak fishery that draws a 50/50 mix of early-run and late-run fish from Ayakulik and Karluk. Each replicate was a sample of 400 individuals removed from the baseline. Circles indicate median estimates with respect to the true percentage for each of the 10 replicates for all 17 reporting groups. Circles are green if there is a positive bias (overestimation of reporting group) and red if there is a negative bias (underestimation of a reporting group). Points are superimposed over boxplots showing the distribution of bias across replicates. Black lines indicate mean bias, boxes indicate the inner-quartile range (IQR; 25th to 75th percentile), and whiskers indicate either the most extreme value or 1.5 times the IQR away from the 25th or 75th percentile. The true percentages for each reporting group for a scenario are listed at the bottom of the graph. Note that if the true percentage for a reporting group is zero, that group cannot have a negative bias (estimates are never less than zero).

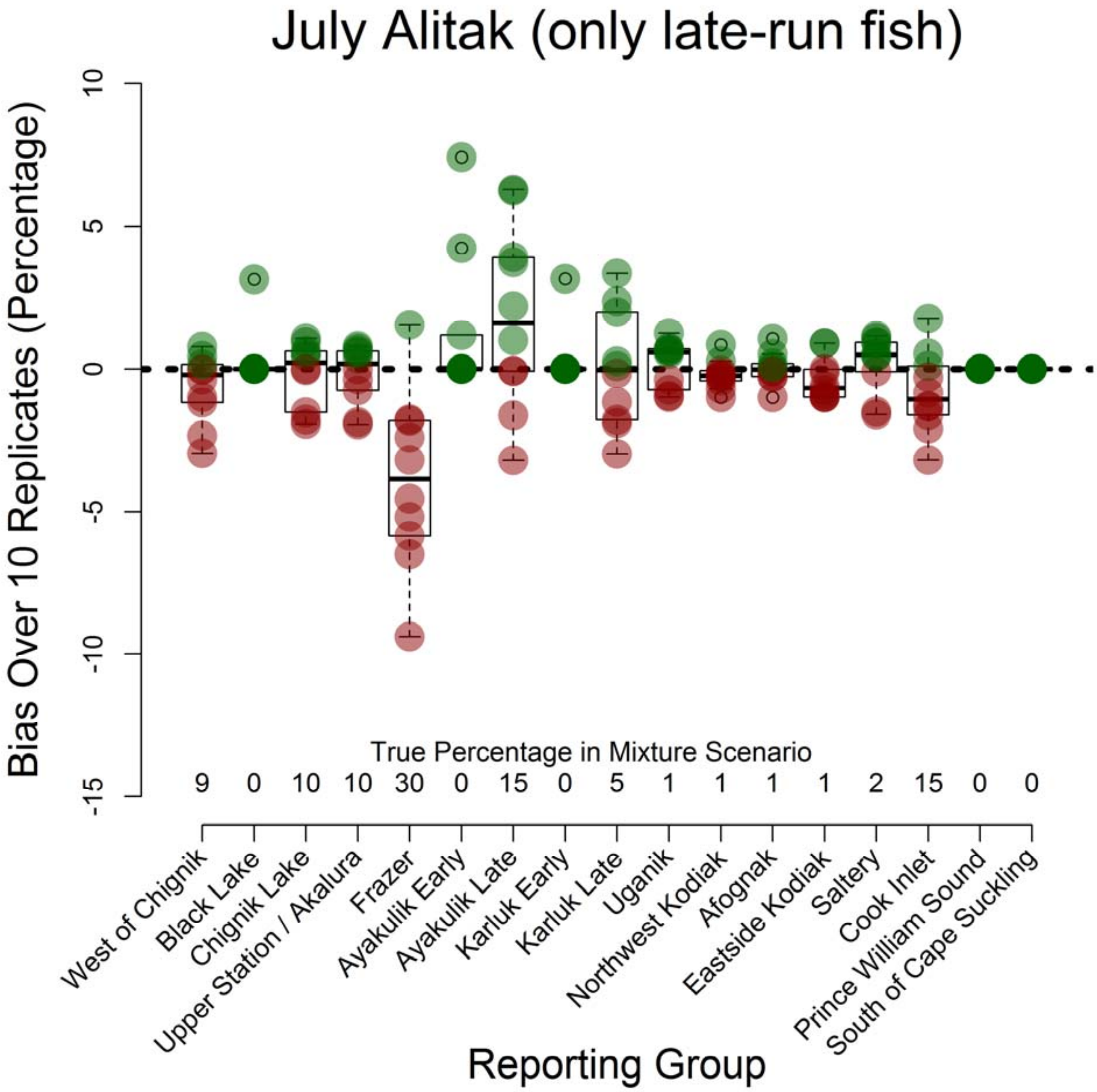

Figure 12.–Bias (circles) of the median estimate with respect to the true percentage for 10 replicates of a simulated, hypothetical July Alitak fishery that draws only early-run fish from Ayakulik and Karluk. Each replicate was a sample of 400 individuals removed from the baseline. Circles indicate median estimates with respect to the true percentage for each of the 10 replicates for all 17 reporting groups. Circles are green if there is a positive bias (overestimation of reporting group) and red if there is a negative bias (underestimation of a reporting group). Points are superimposed over boxplots showing the distribution of bias across replicates. Black lines indicate mean bias, boxes indicate the inner-quartile range (IQR; 25th to 75th percentile), and whiskers indicate either the most extreme value or 1.5 times the IQR away from the 25th or 75th percentile. The true percentages for each reporting group for a scenario are listed at the bottom of the graph. Note that if the true percentage for a reporting group is zero, that group cannot have a negative bias (estimates are never less than zero).