Regional Information Report 5J12-17

Western Alaska Salmon Stock Identification Project Technical Document 12: Tests of Togiak and Goodnews Reporting Groups for Sockeye Salmon

by

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May 2012

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

REGIONAL INFORMATION REPORT 5J12-17

WESTERN ALASKA SALMON STOCK IDENTIFICATION PROGRAM TECHNICAL DOCUMENT 12: TESTS OF TOGIAK AND GOODNEWS REPORTING GROUPS FOR SOCKEYE SALMON

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May 2012

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This document should be cited as:
Dann, T. H., C. Habicht, and W. D. Templin. 2012. Western Alaska Salmon Stock Identification Project Technical Document 12: Tests of Togiak and Goodnews reporting groups for sockeye salmon. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 5J12-17, Anchorage.

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ABSTRACT

Uncertainty about the magnitude, frequency, location, and timing of the nonlocal harvest of sockeye and chum salmon in Western Alaska fisheries was the impetus for the Western Alaska Salmon Stock Identification Project (WASSIP). The project was designed to use genetic data in mixed stock analysis (MSA) to reduce this uncertainty. Defining reporting groups for MSA provides the framework for reporting fishery stock composition estimates. Reporting groups refer to the groups of populations to which fishery mixtures will be allocated during mixed stock analyses. At the March 17, 2011 WASSIP meeting, the Gene Conservation Laboratory (GCL) proposed subregional reporting groups or to set the process to establish all subregional reporting groups, for sockeye salmon *Oncorhynchus nerka*. All proposed subregional reporting groups were approved by the advisory panel (AP) members with the exception of one (Goodnews/Togiak). The department proposed combining Goodnews and Togiak into one reporting group if these 2 reporting groups, separately, did not meet the 90% criterion in proof tests. There was no consensus among AP members present to accept this proposal primarily because these 2 reporting groups straddle 2 management regions (Arctic-Yukon-Kuskokwim and Central). The loss of drainage-specific information of the harvest would reduce the utility of WASSIP information for resource managers. The GCL was tasked with testing the identifiability of the Goodnews River and Togiak Bay reporting groups to determine if they met the 90% correct allocation criterion and to present the findings to the AP. Although the 90% criterion was not met in some of the tests, correct allocations for the most challenging tests averaged 86%. Given these results and the management complexities associated with combining the 2 subregional reporting groups, the department now recommends that they should be maintained separately.

Key words: Western Alaska Salmon Stock Identification Project, WASSIP, sockeye salmon, *Oncorhynchus nerka*, mixed stock analysis, MSA, reporting groups

INTRODUCTION

At the March 17, 2011 Western Alaska Salmon Stock Identification Program (WASSIP) meeting, the Gene Conservation Laboratory (GCL) proposed subregional reporting groups for sockeye salmon. There was consensus among attendees to either establish or to set the process to establish all subregional reporting groups except one pair: Goodnews/Togiak (Figure 1). Based on genetic relationships among collections from these 2 areas from the newly updated baseline (Figure 2), there were concerns that these 2 reporting groups might not meet the 90% correct allocation criterion established for reporting groups. The department proposed combining Goodnews and Togiak into one reporting group if separately these 2 reporting groups did not meet the 90% criterion in proof tests. There was no consensus among advisory panel (AP) members present to accept this proposal primarily because these 2 reporting groups straddle 2 management regions (Arctic-Yukon-Kuskokwim and Central).

The benefit of combining the Goodnews and Togiak reporting groups would be more accurate and precise estimates of the combined group in WASSIP mixtures, while the cost would be the loss of information important to the management of the resource. Fisheries that harvest sockeye salmon from both the Goodnews and Togiak rivers are managed by the Alaska Department of Fish and Game based upon the sustained yield principle, which 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 loss of drainage-specific information of the harvest represented by WASSIP mixtures would introduce complications to the estimation of run sizes and reduce the utility of WASSIP information.

The GCL was tasked with testing the identifiability of the Goodnews River and Togiak Bay reporting groups to determine if they met the 90% criterion. If these tests indicated that these reporting groups did not reach the 90% criterion, the GCL was tasked with convening a conference call with AP and technical committee (TC) members to resolve the Goodnews/Togiak reporting group issue. This document provides results for these tests and the

department's recommendation. Although the 90% criterion was not met in some of the tests, the correct allocations for the most challenging tests averaged 86%. In light of these results and the management complexities associated with combing these 2 subregional reporting groups, the department now recommends that they should be maintained separately.

METHODS

We evaluated the identifiability of the Goodnews and Togiak reporting groups with 3 types of baseline evaluation tests. The first were "100% proof tests", where 200 individuals were sampled without replacement from each reporting group and analyzed as a mixture against the reduced baseline. These tests provided an indication of the power of the baseline for mixed stock analysis (MSA) under the assumption that all the populations from a reporting group are represented in the baseline. The second used 2 samples of the escapement to the Middle Fork of the Goodnews River (MF) as independent mixtures to analyze with the full baseline. The first Goodnews River weir collection was taken on a single day (07/15/2001) and a second set of samples were taken over multiple days throughout June and July of 2007. These tests assumed that the fish sampled at the Goodnews River weir were destined to spawn upstream of the weir. The third test used a sample of the subsistence harvest from the village of Togiak as an independent mixture to analyze with the full baseline. The fish that made up this sample were collected over time (07/11/2008–08/01/2008) but little information exists on where they were harvested. However, this test assumed that the harvested fish were returning to spawning grounds within Togiak Bay.

The baseline used to estimate the stock composition of these tests is still in development but is based upon 91 independent SNP loci surveyed in populations of sockeye salmon ranging from Salmon Lake on the Seward Peninsula to Bering Lake near Cape Suckling. Initial results of baseline evaluation tests, based upon 289 populations, indicated that the baseline for the Goodnews reporting group was incomplete. Fortunately, we had screened a collection of river spawning sockeye salmon from the MF of the Goodnews River, but had excluded it from initial baseline evaluation tests because it did not meet the desired minimum samples size of 75 individuals. Given the apparent incompleteness of the baseline and the relatively large sample size of this collection (N=69), this collection was included in the baseline.

Stock compositions of these test mixtures were estimated with the program *BAYES* (Pella and Masuda 2001). The Bayesian model implemented by *BAYES* places a Dirichlet distribution as the prior distribution for the stock proportions, and the parameters for this distribution must be specified. We defined prior parameters for each reporting group to be equal (i.e., a "flat" prior) with the prior for each reporting group subsequently divided equally to populations within that reporting group. We set the sum of all prior parameters to one (prior weight), which is equivalent to adding 1 fish to each mixture (Pella and Masuda 2001). We ran 5 independent Markov Chain Monte Carlo chains of 40,000 iterations with different starting values and discarded the first 20,000 iterations to remove the influence of the initial start values. We combined the second half of each chain to form the posterior distribution and tabulated mean estimates and 90% credibility intervals from a total of 100,000 iterations. We also assessed the among-chain convergence of these estimates using the Gelman-Rubin shrink factor, which compares the variation within a chain to the total variation among chains (Gelman and Rubin 1992). If a shrink factor for any stock group estimate was greater than 1.2, we reanalyzed the mixture with 80,000-iteration chains following the same protocol. We repeated this procedure

for each test mixture. A critical level of 90% correct allocation was used to determine if the reporting group was acceptably identifiable (Seeb et al. 2000).

RESULTS

All stock composition estimates among chains converged for each mixture. The correct allocations for the proof tests were 82% for the Goodnews reporting group and 97% for the Togiak reporting group (Table 1; Figure 3). Only 1 of the 3 independent mixture samples returned a correct allocation greater than the 90% critical value, but the credibility intervals for all 3 included 90%. The correct allocation for the 2001 sample from the Goodnews River weir was greater than the 90% critical value (95%) but the 2007 mixture fell below (83%). The Togiak subsistence sample had a correct allocation of 79%.

DISCUSSION

Differences between the results of the different types of baseline evaluation tests within drainages likely reflect violations of test assumptions and differences in the completeness of the baseline. The differences between the results of the types of baseline evaluation tests between drainages likely reflect violations of assumptions of the proof tests (i.e. baseline is complete), the independent mixture tests (i.e. fish destined for proximate drainage), or both. The proof tests had a higher correct allocation than the mixture tests in the Togiak reporting group (proof = 97% vs. mixture = 79%). In contrast, the Goodnews proof test had a similar correct allocation to one mixture sample but was worse than the other (proof = 82% vs. mixtures = 83% and 95%). Previous baseline evaluations that did not include the MF river collection had very similar estimates for the mixture tests but markedly better proof test results. We believe that the proof tests of the previous, reduced baseline were overly optimistic because the complete baseline assumption of the test had been violated, and that the decrease in correct allocation for the current proof test reflects better representation of the Goodnews River reporting group in the baseline.

The discrepancy between the results of the 2 Goodnews River weir tests may be explained by differences in the compositions of populations present in these collections and sampling error due to relatively small mixture sizes. The river ecotype populations from Goodnews River are more genetically similar to Togiak area populations than the lake type populations (Figure 2). The 2001 collection (95% correct allocation) was sampled on July 15, while the 2007 collection (83% correct allocation) was sampled throughout June and July. Both collections are relatively small (2001=96 fish; 2007=140 fish). It is possible that the fish in the 2001 collection were disproportionally represented by distinct, lake ecotype populations than the 2007 fish. This may have occurred if the lake ecotype populations pass the weir later in the season or if these populations represented higher proportions of the escapement in 2001 than in 2007. These types of differences, coupled with the relatively small mixture sizes may explain the variation in correct allocations we see between the 2 Goodnews River weir collections. The performance of the weir samples relative to the proof tests does not support the hypothesis that there is missing baseline within the Goodnews River drainage after adding the sample of river-spawning sockeye salmon from the MF. In addition, because the Goodnews River weir is 16 river kilometers upstream from Goodnews Bay, it is unlikely that fish destined for other drainages would have been captured at the weir.

It is important to note that the MF of the Goodnews River produces only approximately 1/3 of the escapement to the Goodnews River drainage (10-year aerial survey count average: North Fork, 24,965; Middle Fork, 13,359; Taylor and Elison 2010) and that the Goodnews MF Lake population in the baseline appears to be the most divergent Goodnews River population (Figure 2). It is possible that a mixture sample that includes fish from the entire Goodnews River system might show even higher misallocations to the Togiak reporting group based on the similarity between the NF populations and the Togiak populations (Figure 2).

For the Togiak discrepancy, it is unclear which violation is more likely (missing baseline or non-Togiak fish in the mixture). We have little documentation about where and how the subsistence harvest samples were collected except that they were collected over time throughout the month of July. If some of the harvest occurred in nearshore marine waters, it is possible that some of the fish were not destined for Togiak Bay drainages. On the other hand, we know that the baseline is missing some important populations such as the Pungokepuk River, a tributary of the Togiak River that contributes approximately 9% of the escapement as estimated by aerial survey (1988–2008 average 1,139, 8.7% of total; Salomone et al. 2009), and the river-spawning sockeye salmon from the Togiak mainstem that are thought to represent between 1/4 and 1/3 of the escapement for this river. Therefore, it is also possible that we do not have the populations of the Togiak reporting group adequately represented in the baseline. Unfortunately we are unable to distinguish between these 2 hypotheses with available information. We plan to collect fish from the Togiak drainage in the summer of 2011, but will not be able to incorporate these into the baseline given the timeline set out to get WASSIP results published.

CONCLUSION

While the Goodnews and Togiak reporting groups did not always meet our target critical level of 90% correct allocation, due to the management implications of collapsing these 2 reporting groups into a single group and the generally fair identifiability suggested by our evaluation tests (average=87%), the department recommends that these 2 should be separate subregional reporting groups.

However, stock composition estimates for these 2 groups should be interpreted in context of these results, and we propose the following language accompany each reported estimate for these 2 groups from WASSIP:

"Note that baseline evaluations suggest that misallocation between the Togiak and Goodnews subregional groups may be as high as 21%."

Following the consensus of the WASSIP AP at the March 17, 2011 meeting, a final decision on the separation of these subregional reporting groups based upon these results and review by the TC should be made by the AP via e-mail correspondence or teleconference call.

ACKNOWLEDGEMENTS

The Technical Document series served as a record of communication between the Alaska Department of Fish and Game Commercial Fisheries Division and the Western Alaska Salmon Stock Identification Program (WASSIP) Technical Committee during the implementation of the program. The authors would like to thank the WASSIP Technical Committee and Advisory Panel for their constructive input on each of the documents throughout the project. The authors would also like to thank Erica Chenoweth who coordinated and prepared the Technical

Document series for publication and Publication Specialists Amy Carroll and Joanne MacClellan for implementing the series into Regional Information Reports.

REFERENCES CITED

Gelman, A., and D. B. Rubin. 1992. Inference from iterative simulation using multiple sequences. Statistical Science 7:457–511.

Pella, J., and M. Masuda. 2001. Bayesian methods for analysis of stock mixtures from genetic characters. Fishery Bulletin 99:151–167. BAYES can be obtained from ftp://ftp.afsc.noaa.gov/sida/mixture-analysis/bayes/

Salomone, P., S. Morstad, T. Sands, and M. Jones. 2009. Salmon spawning ground surveys in the Bristol Bay Area, Alaska, 2008. Alaska Department of Fish and Game, Fishery Management Report No. 09-42, Anchorage.

Seeb, L. W., C. Habicht, W. D. Templin, K. E. Tarbox, R. Z. Davis, L. K. Brannian, and J. E. Seeb. 2000. Genetic diversity of sockeye salmon of Cook Inlet, Alaska, and its application to management of populations affected by the Exxon Valdez oil spill. Transactions of the American Fisheries Society 129(6):1223–1249.

Taylor, D.V., and T.B. Elison. 2010. Goodnews River salmon monitoring and assessment, 2009. Alaska Department of Fish and Game, Fishery Data Series No. 10-74, Anchorage.

QUESTIONS FOR THE TECHNICAL COMMITTEE

1. Do you agree with our interpretation of these test results?
2. Will the potential reduction in the accuracy and precision of estimates of the Goodnews and Togiak groups to WASSIP fisheries substantially compromise our ability to achieve the program goals?
3. If you think we should collapse the 2 reporting groups, how do you suggest we apply combined estimates to the estimation of run sizes?

QUESTIONS FOR THE ADVISORY PANEL

1. Do you agree with the department's assessment that we should keep these 2 reporting groups separate?
2. If you think we should collapse the 2 reporting groups, how do you suggest we apply combined estimates to the estimation of run sizes?

TECHNICAL COMMITTEE REVIEW AND COMMENTS

Document 12: Tests of Togiak and Goodnews reporting groups for sockeye salmon

The Technical Committee and the Advisory Panel reached a consensus that the Goodnews and Togiak reporting groups should be kept separate for the purposes of WASSIP stock composition analysis for sockeye salmon.

TABLES

Table 1.–Estimates of stock composition, 90% credibility intervals, and standard deviations for mixtures of 200 known-origin fish removed from the baseline populations of sockeye salmon that comprise the Goodnews and Togiak reporting groups (100% proof test; "Proof"), 2 mixtures of the escapement to the Goodnews River ("Weir"), and a mixture of the 2008 subsistence harvest from Togiak ("Subsistence") using the program *BAYES* with a flat prior.

		Reporting Group								
Mixture		Norton Sound	Other Kuskokwim Bay	Goodnews	Togiak	Other Bristol Bay	North Peninsula	South Peninsula	Chignik	East of WASSIP
Goodnews Proof	Proportion	0.00	0.02	**0.82**	0.15	0.01	0.00	0.00	0.00	0.00
n=200	Lower 90% CI	0.00	0.00	0.75	0.09	0.00	0.00	0.00	0.00	0.00
	Upper 90% CI	0.00	0.06	0.89	0.21	0.03	0.01	0.00	0.00	0.00
	SD	0.00	0.02	0.04	0.04	0.01	0.01	0.00	0.00	0.00
Goodnews Weir 2001	Proportion	0.00	0.00	**0.95**	0.03	0.01	0.01	0.00	0.00	0.00
n=96	Lower 90% CI	0.00	0.00	0.85	0.00	0.00	0.00	0.00	0.00	0.00
	Upper 90% CI	0.00	0.01	1.00	0.12	0.02	0.03	0.02	0.01	0.01
	SD	0.00	0.01	0.05	0.04	0.01	0.01	0.01	0.01	0.00
Goodnews Weir 2007	Proportion	0.00	0.00	**0.83**	0.14	0.00	0.01	0.00	0.00	0.00
n=140	Lower 90% CI	0.00	0.00	0.75	0.08	0.00	0.00	0.00	0.00	0.00
	Upper 90% CI	0.00	0.01	0.91	0.22	0.02	0.04	0.00	0.00	0.00
	SD	0.00	0.01	0.05	0.04	0.01	0.01	0.00	0.00	0.00
Togiak Proof	Proportion	0.00	0.00	0.03	**0.97**	0.00	0.00	0.00	0.00	0.00
n=200	Lower 90% CI	0.00	0.00	0.00	0.88	0.00	0.00	0.00	0.00	0.00
	Upper 90% CI	0.00	0.00	0.11	1.00	0.01	0.01	0.00	0.00	0.00
	SD	0.00	0.00	0.04	0.04	0.00	0.00	0.00	0.00	0.00
Togiak Subsistence	Proportion	0.00	0.00	0.21	**0.79**	0.00	0.00	0.00	0.00	0.00
n=473	Lower 90% CI	0.00	0.00	0.08	0.67	0.00	0.00	0.00	0.00	0.00
	Upper 90% CI	0.00	0.00	0.32	0.92	0.00	0.00	0.00	0.00	0.00
	SD	0.00	0.00	0.07	0.07	0.00	0.00	0.00	0.00	0.00

Note: Correct allocations are in bold.

FIGURES

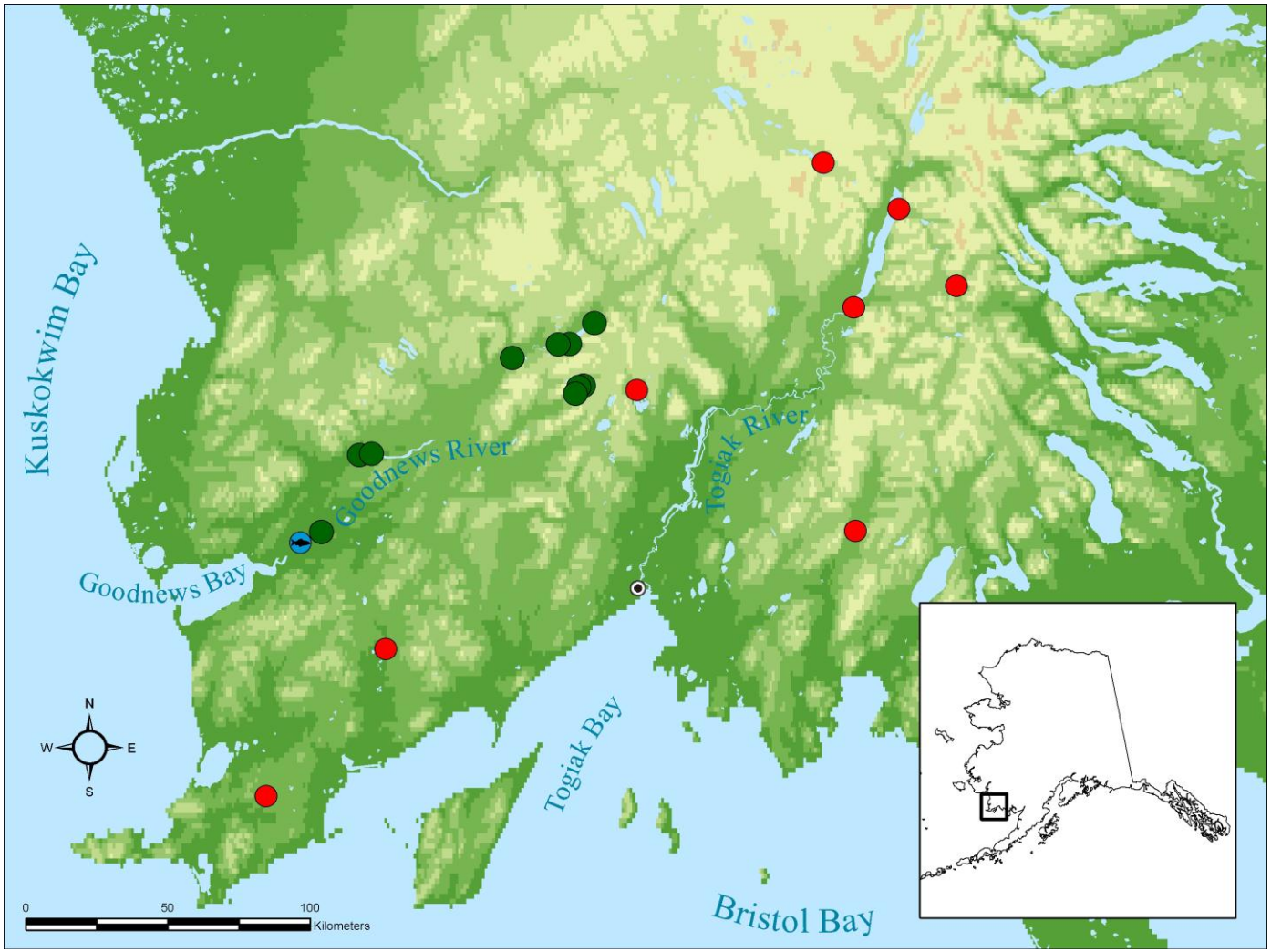

Figure 1.–Baseline collections from the Togiak (red) and Goodnews (green) sub-regional reporting groups, and the locations of the weir on the Middle Fork of the Goodnews River (blue) and the village of Togiak (black dot).

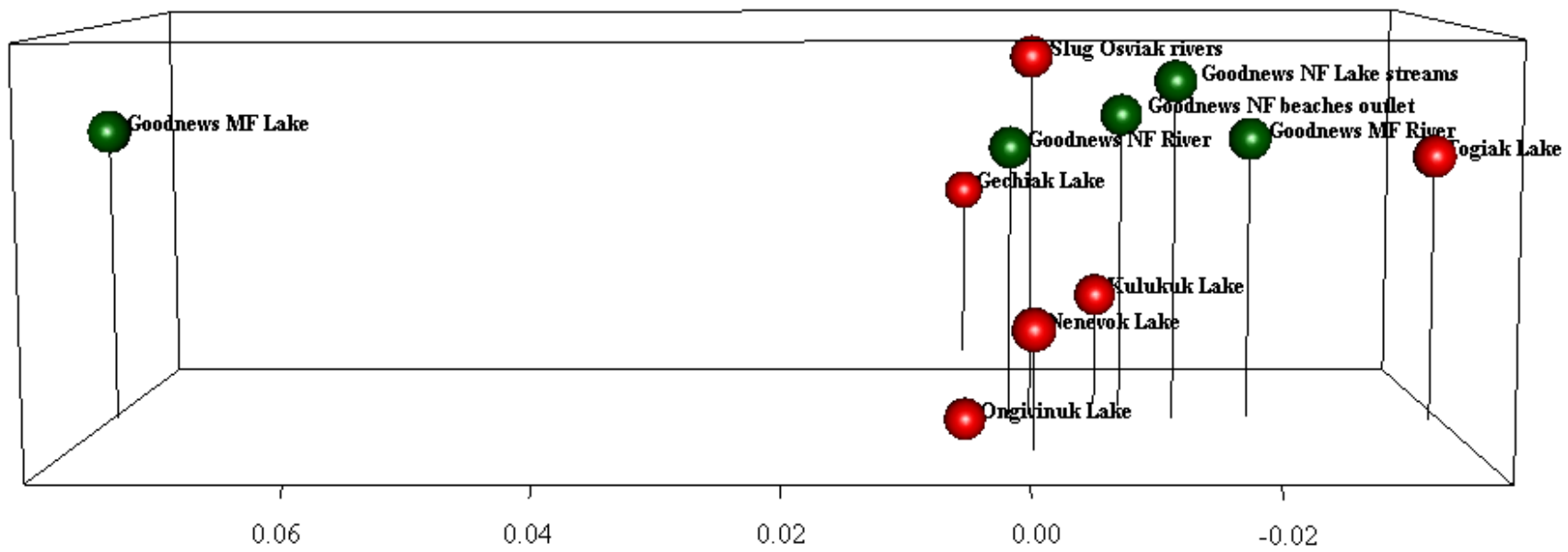

Figure 2.–Multidimensional scaling plot of pairwise F_{ST} distances based upon 91 loci among sockeye salmon populations from the Goodnews (green) and Togiak (red) reporting groups.

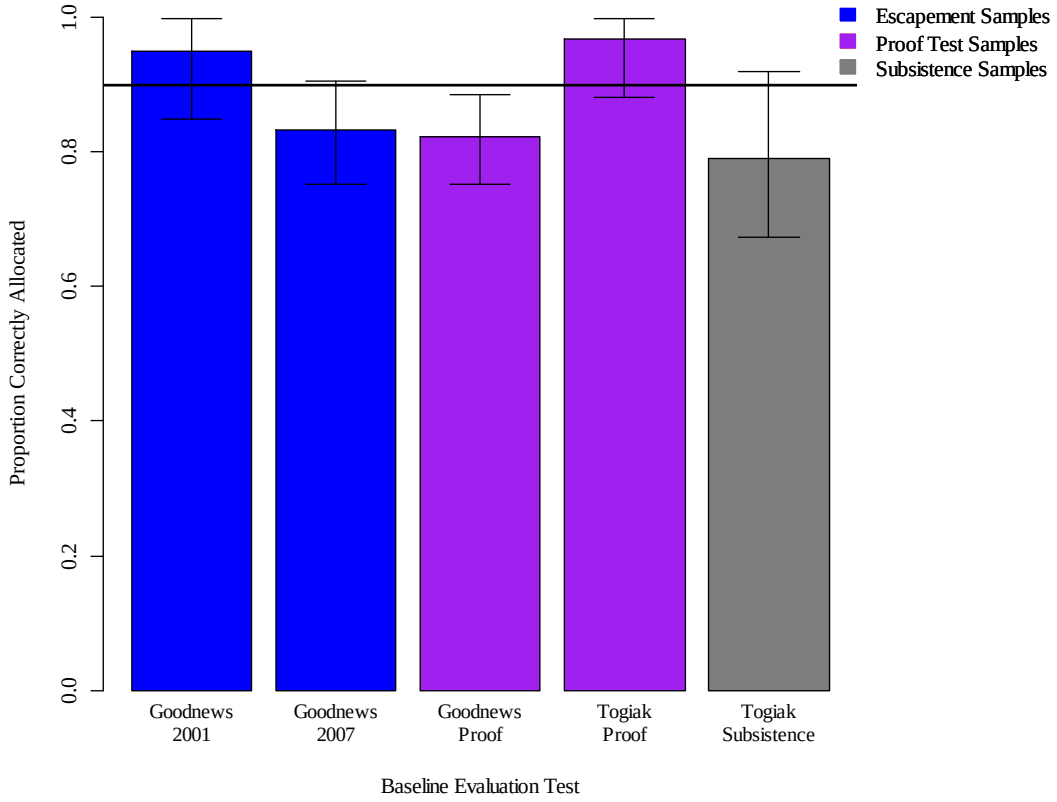

Figure 3.–Correct allocations and 90% credibility intervals for baseline evaluation tests of the Goodnews and Togiak reporting groups for sockeye salmon. Tests include samples of the escapement (blue), mixtures of 200 known-origin fish removed from the baseline populations that comprise each reporting group (e.g., "100% proof tests"; purple), and a sample of the subsistence harvest (grey).