



NOAA Technical Memorandum NMFS-AFSC-285

Extension of Genetic Stock Composition Analysis to the Chinook Salmon Bycatch in the Gulf of Alaska Walleye Pollock (*Gadus chalcogrammus*) Trawl Fisheries, 2012

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U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
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ABSTRACT

The genetic stock composition of Chinook salmon (*Oncorhynchus tshawytscha*) samples from the 2012 U.S. Gulf of Alaska (GOA) trawl fishery for walleye pollock (*Gadus chalcogrammus*) was extended to provide an overall stock composition for the fishery bycatch and stock-specific harvests. Genetic samples were collected opportunistically in 2012 from Chinook salmon taken as the bycatch in this fishery. These samples had previously been genotyped for 43 single nucleotide polymorphism (SNP) DNA markers and the results were estimated using the available coastwide baseline of SNP markers for Chinook salmon. However, the opportunistic nature of the sampling raised concerns about applying the proportional composition of the samples to the entire bycatch because of unknown, but potentially significant, biases. Here we investigate the most appropriate means by which this extension can be made. While sample sizes varied widely and did not achieve the 10% target used to sample bycatch in the Bering Sea, using a stratified estimator weighted by stratum-specific bycatch, it was possible to estimate the stock composition of the total catch with acceptable accuracy and precision. Based on the reanalysis of 948 Chinook salmon bycatch samples, the proportions of reporting groups did not change significantly from previously published values: British Columbia (50%), U.S. West Coast (28%), and coastal Southeast Alaska (19%) made up the largest reporting groups.

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INTRODUCTION

The Gulf of Alaska (GOA) provides feeding habitat for multiple brood years of Chinook salmon (*Oncorhynchus tshawytscha*) originating from many different localities in North America and Asia. Determining the geographic origin and stock composition of salmon caught in federally managed fisheries is essential to understanding whether fisheries management could address conservation concerns. Chinook salmon bycatch samples collected from the 2012 U.S. GOA walleye pollock (*Gadus chalcogrammus*) trawl fisheries were analyzed in 2013 by Auke Bay Laboratories. The genetic stock identification (GSI) results were reported to the North Pacific Fishery Management Council (NPFMC) in April of 2014 (Guthrie et al. 2014). However, the opportunistic nature of sampling raised concerns about applying the proportional composition of the GSI samples to the entire bycatch because of unknown but potentially significant biases. The NPFMC recommended in April of 2014 that methods be explored to produce a reliable stock composition estimate for the bycatch in the entire 2012 fishery. To achieve this goal the following objectives need to be accomplished:

- 1) Investigate the extent to which Chinook salmon bycatch samples taken during the 2012 GOA pollock fishery can be used to estimate stock-specific bycatch for the fishery.
- 2) Provide stock-specific composition, bycatch estimates, and associated summary statistics.

For the purposes of this report, stocks will be defined as the genetically identifiable reporting groups reported in Templin et al. (2011) and used in Guthrie et al. (2014).

SAMPLE DISTRIBUTION

A complete description of sampling the Chinook salmon bycatch in the GOA pollock fishery is provided by Guthrie et al. (2014). For the purposes of this analysis we provide the

following overview. In the 2012 GOA pollock fishery, there was no initial requirement for full retention of Chinook salmon caught in the prohibited species catch although there were efforts by industry to facilitate the collection of samples in anticipation of Amendment 93 to the GOA groundfish fishery management plan. This plan required retention of all Chinook salmon intercepted in the pollock fisheries in the western and central GOA until an observer was able to count the number of salmon and collect scientific data or biological samples from a proportion of those salmon. The intention was to take genetic samples from the bycatch proportionately, one in every 10 Chinook salmon encountered.

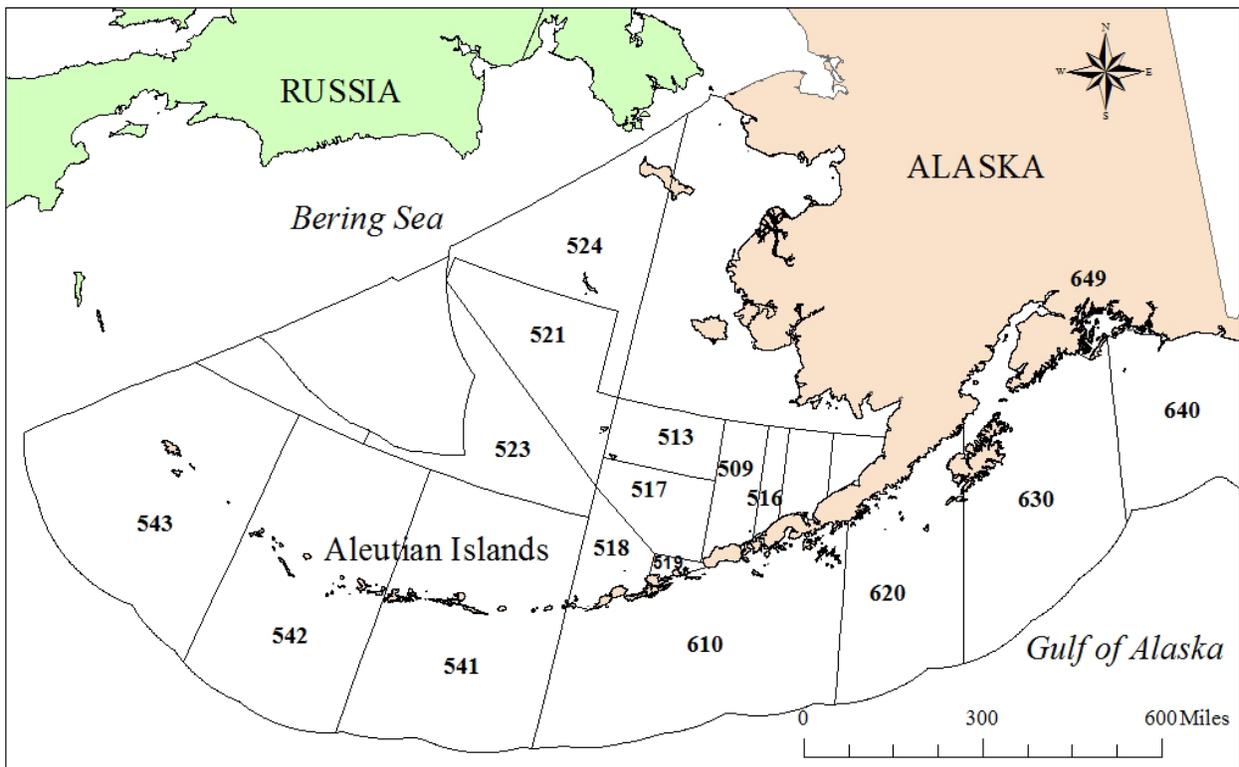


Figure 1. -- National Marine Fisheries Service statistical areas associated with the Bering Sea-Aleutian Islands (BSAI) and Gulf of Alaska (GOA) groundfish fisheries.

In 2012, an estimated 18,845 Chinook salmon were taken as bycatch in the GOA pollock trawl fisheries in National Marine Fisheries Service (NMFS) statistical areas 610, 620, 630, 640

and 649 (Fig. 1; NMFS 2012); this was less than half the estimated 44,779 Chinook salmon that were taken as bycatch in the 2010 pollock fishery (Fig. 2). Tissues for genetic analysis were sampled from 1,008 fish, corresponding to a sampling rate of 5% for the season. This was less than the 10% sampling goal and these samples were also not taken proportional to the overall bycatch within each statistical week (Fig. 3) or NMFS areas (or grouping of areas) (Fig. 4).

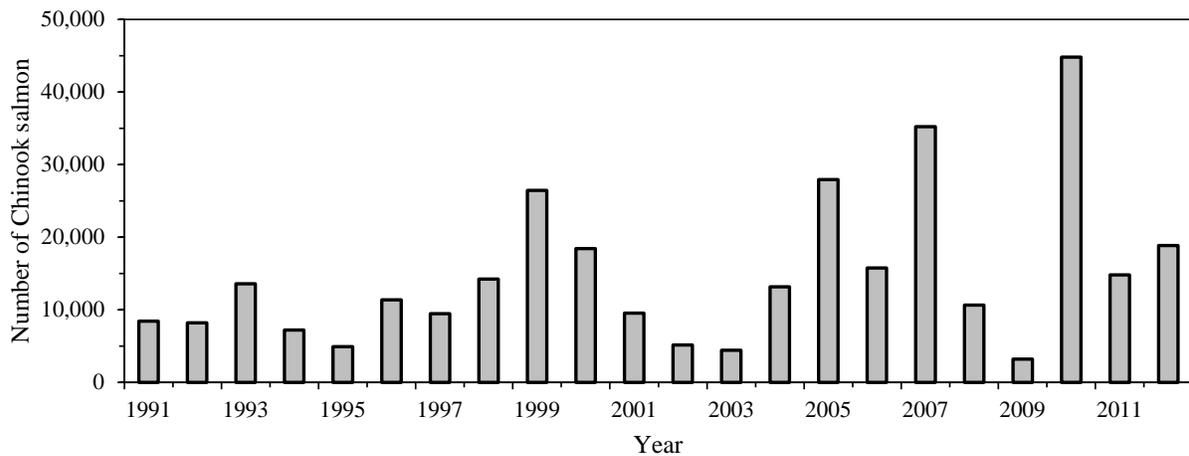


Figure 2 . -- Yearly estimates for the Chinook salmon bycatch from the Gulf of Alaska pollock trawl fishery (NMFS 2012).

The temporal distribution of genetic samples from the 2012 Chinook salmon GOA bycatch was compared to the overall distribution of bycatch by statistical week, which indicated that bycatch could be separated into two temporal periods and that a higher proportion of fish were sampled in the earlier period (Fig. 3). We also compared the spatial distribution of genetic samples with the Chinook salmon bycatch by NMFS statistical area over time, for early (statistical weeks 3-14) and late (statistical weeks 34-44) seasons, which indicated that there was less bycatch and fewer samples in the early season – dominated by Area 620 – and the majority of the bycatch and samples in the late season were from Area 610 (Fig. 4).

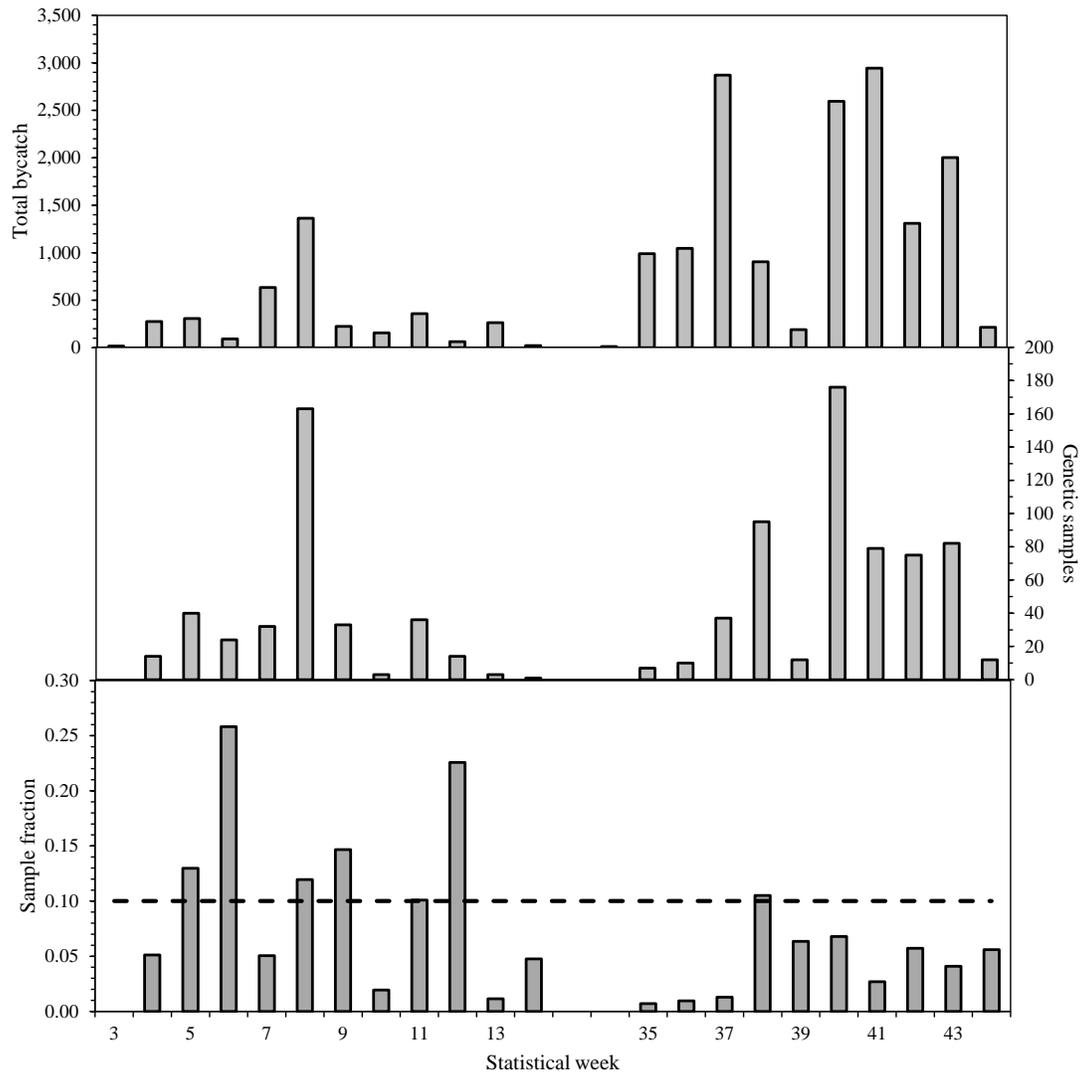


Figure 3. -- Number of Chinook salmon bycatch reported (top), genetic samples used for genetic stock identification (middle) and proportion of fish sampled (bottom) by statistical week in 2012 Gulf of Alaska pollock trawl fishery. Dashed line in bottom graph indicates 10% sample fraction.

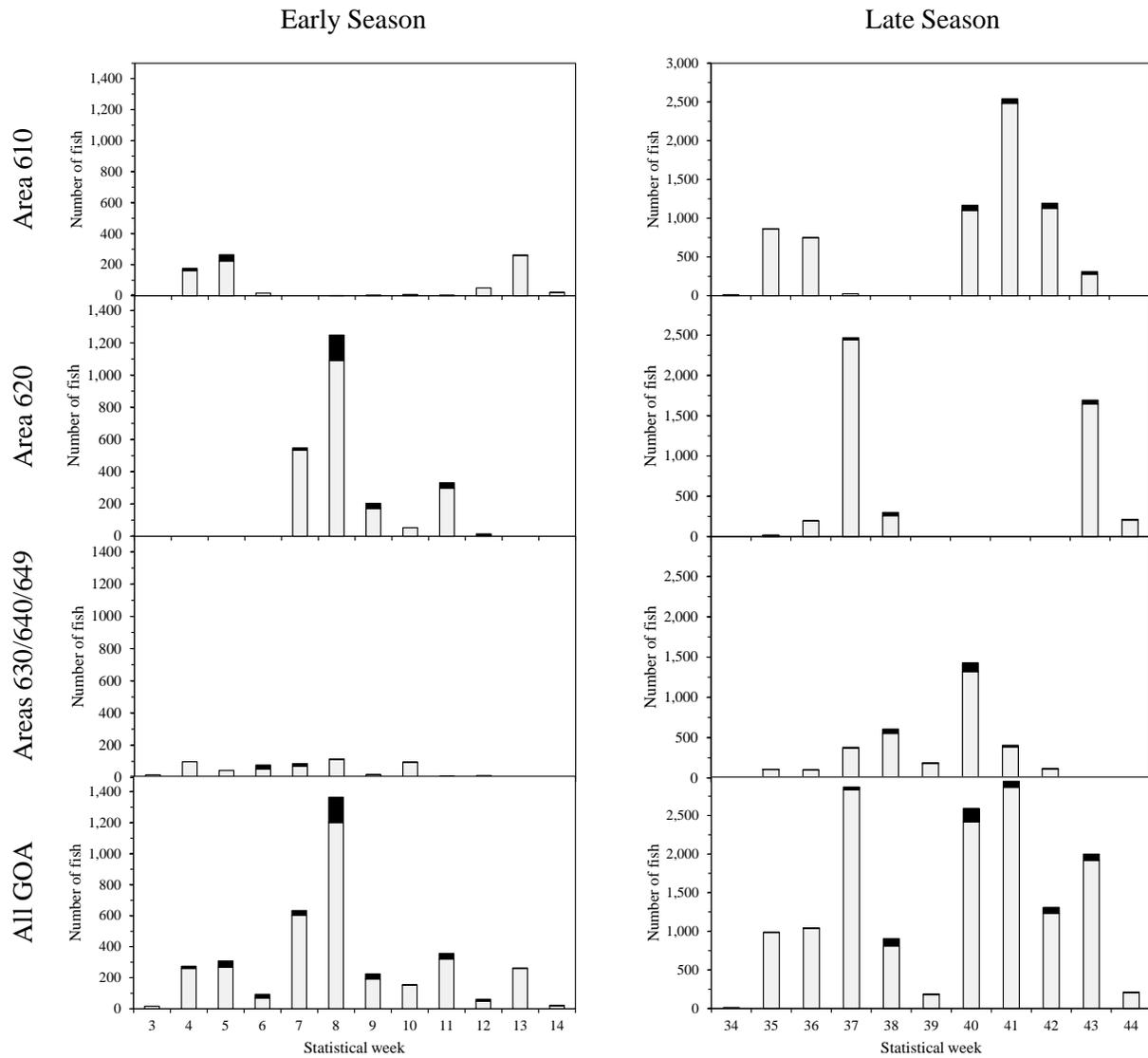


Figure 4. -- 2012 Gulf of Alaska Chinook salmon bycatch and samples used for genetic stock identification (black section of bar), by time and area strata. Note the difference in y-axis scale between early and late season strata.

METHODS

DNA was extracted from collected axillary process tissue and genotyping was performed as described previously (Guyon et al. 2010a) using a Sequenom MassARRAY iPLEX platform (Gabriel et al. 2009) to genotype 43 SNP DNA markers represented in the Alaska Department of Fish and Game (ADF&G) Chinook salmon baseline (Templin et al. 2011). This baseline contains genetic information for 172 populations of Chinook salmon grouped into 11 broad-scale reporting groups (Appendix A), which for this analysis will be considered stocks. This baseline was used previously to estimate stock composition of samples from the 2005-2012 Chinook salmon bycatch (NMFS 2009; Guyon et al. 2010a, b; Guthrie et al. 2012, 2013, and 2014; Larson et al. 2013). From the 2012 GOA Chinook salmon bycatch, a total of 1,008 samples were analyzed of which 948 were successfully genotyped for 35 or more of the 43 SNP loci (average of 41 markers/sample), a success rate of 94%. For further details see Guthrie et al. (2014).

Stratification

The successfully genotyped samples were stratified both temporally and spatially (Table 1). Temporally, weekly samples were combined into two strata, which corresponded to early season (statistical weeks 3-14) and late season (statistical weeks 34-44). As described in Guthrie et al. (2014), the samples were separated into three spatial strata that corresponded to NMFS statistical areas 610, 620, and the aggregate 630/640/649. Thus there were six strata, each with a corresponding mixture sample and observed bycatch. Areas 630, 640 and 649 were combined because of the generally small bycatch compared to NMFS statistical areas 610 and 620.

Table 1. -- Chinook salmon bycatch harvest, number of genotyped samples and sample fraction of bycatch for 2012 Gulf of Alaska pollock fishery stratified temporally and spatially into six strata. Early season includes statistical weeks 3 through 14 and late season includes statistical weeks 34 through 44.

Area	Early season			Late season		
	Bycatch	Sample size	Sample fraction	Bycatch	Sample size	Sample fraction
610	806	60	0.074	6,856	233	0.034
620	2,399	253	0.105	4,887	135	0.028
630/640/649	568	50	0.088	3,329	217	0.065

Stock Composition Estimates

The stock composition of the mixture representing each stratum was analyzed using the program BAYES (Pella and Masuda 2001) generally as described in Guthrie et al. (2014). The Dirichlet prior parameters for the stock proportions were defined to be one divided by the number of baseline populations. For each of the six strata, we ran 11 independent Markov Chain Monte Carlo (MCMC) chains of 20,000 iterations, initializing each chain by placing 90% of the allocation into one of each reporting group, and dividing the remaining 10% equally among the remaining groups, such that each group had one chain initialized at 90%. The first 10,000 iterations from each chain were discarded to remove the influence of the initial values.

To ensure that the BAYES output was an acceptable approximation of the stationary posterior distribution and that the stock composition estimates were valid, we assessed the 11 independent (MCMC) chains for convergence among chains using the Gelman-Rubin shrink factors that were computed for all stock groups (Guthrie et al. 2014).

For each reporting group, weighted average proportions were calculated from the following equation:

$$p_g = \frac{\sum_{t=1}^2 \sum_{s=1}^3 B_{t,s} p_{t,s,g}}{\sum_{t=1}^2 \sum_{s=1}^3 B_{t,s}}, \quad (1)$$

where $B_{t,s}$ was the bycatch occurring in season t of Area s ; $p_{t,s,g}$ was the proportion of reporting group g in this stratum; and p_g was the overall weighted average proportion of group g .

Applying Equation 1 across MCMC iterations contained within the BAYES posterior output files for all strata produced the posterior distribution of weighted averages from which summaries were derived.

Stock composition estimates were summarized from the posterior distributions of the MCMC iterates using the following statistics: mean and medians as measures of central tendency, the 95% credibility interval (i.e., the 2.5th and 97.5th percentiles), and standard deviation. We also report a statistic called $P = 0$, which is the probability that a stock composition estimate is effectively zero. This is the frequency of MCMC iterates in the posterior output that were less than a threshold that is calculated as 0.5 divided by the sum of the reported bycatch corresponding to the estimated proportion. This threshold is the value that would result in the estimated number of fish being rounded to zero fish when stock proportions are expanded to numbers of fish in the bycatch. This statistic is more useful for assessing support for the presence/absence of minor stocks than application of the credibility interval.

We report both the mean and median of the posterior distributions because at very small or very large stock compositions the posterior distributions may become skewed and the mean is more influenced by a few extreme iterates. Large differences between these statistics can be an

indication of skewness. Therefore, in these cases the median may be a preferred measure of central tendency of the posterior distribution. The drawbacks to the median, however, are: 1) their summation across stocks does not equal 1; and, 2) as a simple order statistic, they tend to ignore the evidence suggesting that the true value is not very small or large (as represented by the heavy tails).

Reporting Group-Specific Bycatch Estimates

Estimates of reporting group-specific bycatch were calculated by simply multiplying the stock composition point estimates by the sum of reported bycatch across strata. It should be noted that this assumes that the bycatch numbers are known with zero uncertainty.

RESULTS

Stratification

Bycatch in the six strata ranged from 568 in the combined NMFS statistical areas 630/640/649 in the early season to 6,856 in Area 610 in the late season (Table 1). Sample sizes for GSI within these six strata ranged from 50 to 253. Generally strata with low sample sizes (Area 610 and combined areas 630/640/649 for the early season) also had low bycatch so that sample fractions, while not achieving the target 10%, were above the overall average sample fraction of 5% for the 2012 GOA season ($> 7\%$). At the same time, while all other strata had lower sample fractions (2.8-6.5%), the sample sizes were of reasonable size (≥ 135 fish) given the relatively larger bycatches.

Stock Composition Estimates

The stock composition results indicate that 96.6% of the total 2012 bycatch in GOA was composed of three reporting groups: British Columbia contributing the most (50%), followed by the U.S. West Coast (28%) and coastal Southeast Alaska (19%) (Table 2). There were sufficient samples to allow further analysis of temporal and spatial differences in the bycatch.

When strata were combined across areas within season, estimates for the early season (statistical weeks 3-14) showed British Columbia contributed the most (41%), followed by coastal Southeast Alaska (33%) and the U.S. West Coast (23%) (Table 3). For the late season (statistical weeks 34-44), British Columbia Chinook salmon dominated (52%), followed by the U.S. West Coast (29%), and coastal Southeast Alaska (15%) (Table 4).

When strata were combined across seasons within areas, the westernmost area, 610, had the largest estimate from British Columbia (69%) with smaller components from the U.S. West Coast (16%), and coastal Southeast Alaska (12%) (Table 5). Moving east into NMFS statistical area 620, the estimated British Columbia contribution dropped (38%) while those from the U.S. West Coast (36%) and coastal Southeast Alaska (24%) increased at least two-fold (Table 6). For the combined easternmost areas (630, 640, and 649), estimates for British Columbia (37%), U.S. West Coast (36%) and coastal Southeast Alaska (24%) components were effectively the same as those from area 620 (Table 7). For comparison purposes, the stock composition results are plotted in Figure 5.

Table 2. -- Stock composition estimates of the Chinook salmon bycatch of the 2012 Gulf of Alaska (GOA) pollock trawl fishery using the stratified method (top table) compared with previously reported estimates (bottom table). Mean estimates are provided with the 95% credibility intervals (CI), probability that the stock contribution is 0 ($P = 0$), median value, and standard deviation (SD). H is the reported bycatch and n is the number of genetic samples used in the analysis.

Whole season (H = 18,845; n = 948)						
Reporting group	Proportion	95% CI		$P = 0$	Median	SD
		2.5%	97.5%			
Russia	0.000	0.000	0.002	0.63	0.000	0.001
Coastal Western AK	0.006	0.001	0.013	0.00	0.005	0.003
Middle Yukon R.	0.000	0.000	0.002	0.41	0.000	0.001
Upper Yukon R.	0.000	0.000	0.003	0.23	0.000	0.001
N AK Peninsula	0.001	0.000	0.004	0.41	0.000	0.001
NW GOA	0.020	0.011	0.033	0.00	0.020	0.006
Copper R.	0.001	0.000	0.004	0.11	0.001	0.001
NE GOA	0.005	0.001	0.012	0.00	0.004	0.003
Coastal SEAK	0.188	0.157	0.220	0.00	0.187	0.016
British Columbia	0.501	0.462	0.541	0.00	0.501	0.020
U.S. West Coast	0.277	0.246	0.310	0.00	0.277	0.016

Guthrie et al. (2014) estimates						
Reporting group	Proportion	95% CI		Median	SD	
		2.5%	97.5%			
Russia	0.000	0.000	0.000		0.000	0.000
Coastal Western AK	0.004	0.000	0.013		0.003	0.004
Middle Yukon R.	0.000	0.000	0.001		0.000	0.000
Upper Yukon R.	0.000	0.000	0.001		0.000	0.000
N AK Peninsula	0.000	0.000	0.003		0.000	0.001
NW GOA	0.021	0.012	0.032		0.020	0.005
Copper R.	0.001	0.000	0.005		0.000	0.001
NE GOA	0.005	0.001	0.012		0.005	0.003
Coastal SEAK	0.201	0.167	0.238		0.200	0.018
British Columbia	0.492	0.448	0.533		0.492	0.022
U.S. West Coast	0.277	0.246	0.308		0.276	0.016

Table 3. -- Stock composition estimates for the Chinook salmon bycatch during the early season (weeks 3-14) of the 2012 Gulf of Alaska (GOA) pollock trawl fishery – All areas. Mean estimates are provided with the 95% credibility intervals (CI), probability that the stock composition is 0 ($P = 0$), median value, and standard deviation (SD). H is the reported bycatch and n is the number of genetic samples used in the analysis.

Early season (All areas; H = 3,773; n = 363)						
Reporting group	Proportion	95% CI		$P = 0$	Median	SD
		2.5%	97.5%			
Russia	0.000	0.000	0.002	0.83	0.000	0.001
Coastal Western AK	0.014	0.001	0.034	0.01	0.013	0.009
Middle Yukon R.	0.000	0.000	0.004	0.69	0.000	0.001
Upper Yukon R.	0.001	0.000	0.005	0.54	0.000	0.001
N AK Peninsula	0.000	0.000	0.004	0.73	0.000	0.001
NW GOA	0.007	0.000	0.024	0.09	0.005	0.007
Copper R.	0.001	0.000	0.006	0.56	0.000	0.002
NE GOA	0.004	0.000	0.016	0.05	0.003	0.004
Coastal SEAK	0.326	0.263	0.390	0.00	0.326	0.032
British Columbia	0.412	0.347	0.481	0.00	0.412	0.034
U.S. West Coast	0.233	0.188	0.281	0.00	0.232	0.024

Table 4. -- Stock composition estimates for the Chinook salmon bycatch during the late season (weeks 34-44) of the 2012 Gulf of Alaska (GOA) pollock trawl fishery – All areas. Mean estimates are provided with the 95% credibility intervals (CI), probability that the stock composition is 0 ($P = 0$), median value, and standard deviation (SD). H is the reported bycatch and n is the number of genetic samples used in the analysis.

Late season (All areas; H = 15,072; n = 585)						
Reporting group	Proportion	95% CI		$P = 0$	Median	SD
		2.5%	97.5%			
Russia	0.000	0.000	0.002	0.77	0.000	0.001
Coastal Western AK	0.003	0.000	0.011	0.03	0.003	0.003
Middle Yukon R.	0.000	0.000	0.002	0.61	0.000	0.001
Upper Yukon R.	0.000	0.000	0.003	0.45	0.000	0.001
N AK Peninsula	0.001	0.000	0.005	0.57	0.000	0.001
NW GOA	0.024	0.012	0.039	0.00	0.023	0.007
Copper R.	0.001	0.000	0.005	0.21	0.001	0.001
NE GOA	0.005	0.001	0.014	0.00	0.004	0.004
Coastal SEAK	0.153	0.118	0.191	0.00	0.152	0.019
British Columbia	0.524	0.477	0.571	0.00	0.524	0.024
U.S. West Coast	0.289	0.251	0.328	0.00	0.288	0.020

Table 5. -- Stock composition estimates for the Chinook salmon bycatch in NMFS statistical area 610 during the 2012 Gulf of Alaska (GOA) pollock trawl fishery – all season. Mean estimates are provided with the 95% credibility intervals (CI), probability that the stock composition is 0 ($P = 0$), median value, and standard deviation (SD). H is the reported bycatch and n is the number of genetic samples used in the analysis.

Area: 610 (All season; H = 7,662; n = 293)						
Reporting group	Proportion	95% CI		$P = 0$	Median	SD
		2.5%	97.5%			
Russia	0.000	0.000	0.002	0.86	0.000	0.001
Coastal Western AK	0.004	0.000	0.017	0.08	0.003	0.005
Middle Yukon R.	0.000	0.000	0.003	0.74	0.000	0.001
Upper Yukon R.	0.000	0.000	0.004	0.61	0.000	0.001
N AK Peninsula	0.000	0.000	0.003	0.78	0.000	0.001
NW GOA	0.025	0.009	0.048	0.00	0.024	0.010
Copper R.	0.000	0.000	0.004	0.65	0.000	0.001
NE GOA	0.009	0.001	0.026	0.00	0.008	0.007
Coastal SEAK	0.117	0.077	0.164	0.00	0.116	0.022
British Columbia	0.686	0.624	0.745	0.00	0.687	0.031
U.S. West Coast	0.156	0.115	0.203	0.00	0.155	0.023

Table 6. -- Stock composition estimates for the Chinook salmon bycatch in NMFS statistical area 620 during the 2012 Gulf of Alaska pollock trawl fishery – all season. Mean estimates are provided with the 95% credibility intervals (CI), probability that the stock composition is 0 ($P = 0$), median value, and standard deviation (SD). H is the reported bycatch and n is the number of genetic samples used in the analysis.

Area: 620 (All season; H = 7,286; n = 388)						
Reporting group	Proportion	95% CI		$P = 0$	Median	SD
		2.5%	97.5%			
Russia	0.000	0.000	0.002	0.86	0.000	0.001
Coastal Western AK	0.008	0.000	0.020	0.02	0.007	0.005
Middle Yukon R.	0.000	0.000	0.003	0.75	0.000	0.001
Upper Yukon R.	0.000	0.000	0.004	0.62	0.000	0.001
N AK Peninsula	0.001	0.000	0.008	0.71	0.000	0.002
NW GOA	0.012	0.001	0.030	0.01	0.010	0.008
Copper R.	0.000	0.000	0.004	0.65	0.000	0.001
NE GOA	0.000	0.000	0.005	0.72	0.000	0.002
Coastal SEAK	0.236	0.180	0.296	0.00	0.235	0.030
British Columbia	0.380	0.314	0.449	0.00	0.380	0.034
U.S. West Coast	0.362	0.302	0.423	0.00	0.362	0.031

Table 7. -- Stock composition estimates for the Chinook salmon bycatch in NMFS statistical areas 630/640/649 of the 2012 Gulf of Alaska (GOA) pollock trawl fishery – all season. Mean estimates are provided with the 95% credibility intervals (CI), probability that the stock composition is 0 ($P = 0$), median value, and standard deviation (SD). H is the reported bycatch and n is the number of genetic samples used in the analysis.

Area: 630/640/649 (All season; H = 3,897; n = 267)						
Reporting group	Proportion	95% CI		$P = 0$	Median	SD
		2.5%	97.5%			
Russia	0.000	0.000	0.003	0.86	0.000	0.001
Coastal Western AK	0.004	0.000	0.021	0.22	0.002	0.006
Middle Yukon R.	0.000	0.000	0.003	0.77	0.000	0.001
Upper Yukon R.	0.001	0.000	0.004	0.65	0.000	0.001
N AK Peninsula	0.001	0.000	0.007	0.76	0.000	0.002
NW GOA	0.027	0.009	0.053	0.00	0.026	0.011
Copper R.	0.003	0.000	0.014	0.28	0.001	0.004
NE GOA	0.005	0.000	0.019	0.05	0.003	0.005
Coastal SEAK	0.236	0.166	0.303	0.00	0.237	0.035
British Columbia	0.365	0.294	0.450	0.00	0.363	0.040
U.S. West Coast	0.358	0.297	0.420	0.00	0.358	0.031

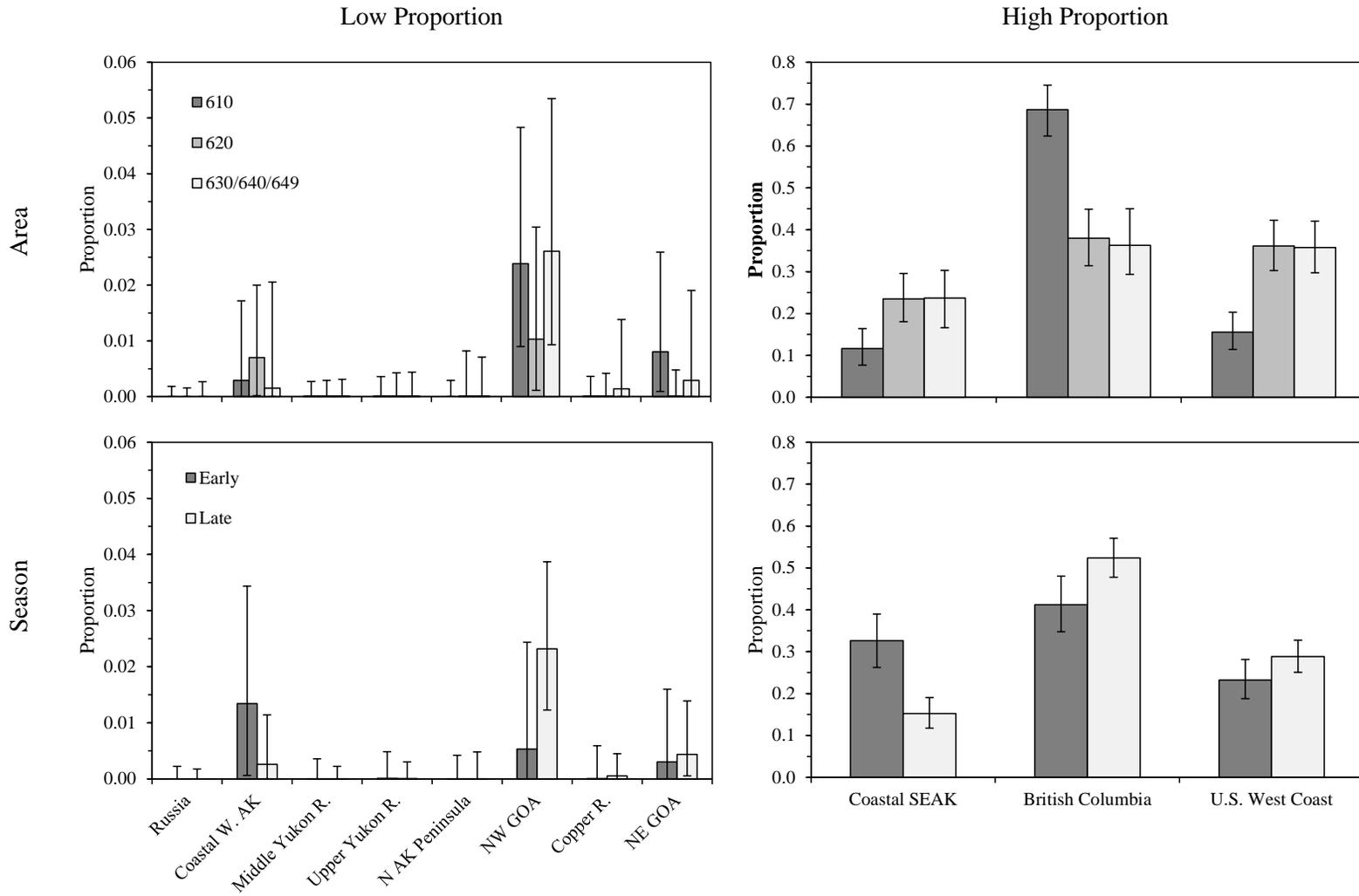


Figure 5. -- 2012 Gulf of Alaska Chinook salmon stock composition estimates (median and 95% credibility intervals), by area (top) and temporal strata (bottom). Stocks estimated to be in low proportions (i.e., <10%) are plotted on the left while the more abundant stocks (>10%) the bycatch are plotted on the right.

Reporting Group-specific Bycatch Estimates

The number of salmon taken from any single reporting group is dependent on both the relative stock proportion and total size of the bycatch. Using the reported number of Chinook salmon taken as bycatch in the 2012 GOA pollock trawl fishery and the estimated stock contributions, reporting group-specific harvest in the bycatch was calculated by multiplying the stock proportions by the total estimated bycatch. The resulting estimated take as bycatch for each reporting group was determined for the whole fishery (Table 8), by season (Tables 9 and 10), and by statistical area (Tables 11-13).

As an example of assessing the support for the presence/absence of reporting groups in the bycatch, in Tables 8-13 we highlighted reporting groups that had a 50% or greater probability of being absent from the bycatch based on the $P = 0$ statistics reported in Tables 3-7. Reporting groups can have similar small estimates of the mean number of Chinook salmon in the bycatch (e.g., Russia, middle Yukon, upper Yukon, N Alaska Peninsula, and Copper; 1-3 fish; Table 9), but the support for their absence from the bycatch during the early season ranged widely ($P = 0$ ranged from 0.54 for Upper Yukon to 0.83 for Russia; Table 3). The value of the $P = 0$ statistic is that, in conjunction with the other information presented, one can apply an appropriate critical value that helps them make their own interpretation of the level of support for the presence or absence of a given reporting group in the bycatch. Such a critical value should be made in consultation with the NPFMC Scientific and Statistical Committee and the end users.

Table 8 . -- Reporting group-specific estimates of number of Chinook salmon taken as bycatch in the 2012 Gulf of Alaska (GOA) pollock trawl fishery. Estimates are provided to the nearest fish with the mean, 95% credibility intervals (CI), median value, and standard deviation (SD). H is the reported bycatch and n is the number of genetic samples used in the analysis. Shaded rows indicate stocks that have a >50% chance of not truly being present based on $P = 0$ in Table 2.

Reporting group	Whole season (H = 18,845; n = 948)				
	Mean	95% CI		Median	SD
		2.5%	97.5%		
Russia	3	0	29	0	9
Coastal Western AK	106	20	242	97	57
Middle Yukon R.	5	0	37	1	12
Upper Yukon R.	9	0	50	3	15
N AK Peninsula	10	0	75	1	22
NW GOA	385	205	616	376	105
Copper R.	18	0	73	11	21
NE GOA	94	17	230	83	56
Coastal SEAK	3,536	2,955	4,149	3,528	305
British Columbia	9,450	8,710	10,194	9,450	378
U.S. West Coast	5,229	4,632	5,846	5,225	309
Total	18,845				

Table 9 . -- Reporting group-specific estimates of number of Chinook salmon harvested in the bycatch during the early season (weeks 3-14) of the 2012 Gulf of Alaska (GOA) pollock trawl fishery – all areas. Estimates are provided to the nearest fish with the mean, 95% credibility intervals (CI), median value, and standard deviation (SD). H is the reported bycatch and n is the number of genetic samples used in the analysis. Shaded rows indicate stocks that have a >50% chance of not truly being present based on $P = 0$ in Table 3.

Reporting group	Early season (All areas; H = 3,773; n = 363)				
	Mean	95% CI		Median	SD
		2.5%	97.5%		
Russia	1	0	8	0	3
Coastal Western AK	55	2	130	51	33
Middle Yukon R.	2	0	14	0	4
Upper Yukon R.	3	0	18	0	5
N AK Peninsula	2	0	16	0	5
NW GOA	27	0	92	20	26
Copper R.	3	0	22	0	7
NE GOA	16	0	60	11	16
Coastal SEAK	1,231	991	1,471	1,232	123
British Columbia	1,556	1,311	1,813	1,554	128
U.S. West Coast	878	708	1,061	876	90
Total	3,774				

Table 10. -- Reporting group-specific estimates of number of Chinook salmon harvested in the bycatch during the late season (weeks 34-44) of the 2012 Gulf of Alaska (GOA) pollock trawl fishery – all areas. Estimates are provided to the nearest fish with the mean, 95% credibility intervals (CI), median value, and standard deviation (SD). H is the reported bycatch and n is the number of genetic samples used in the analysis. Shaded rows indicate stocks that have a >50% chance of not truly being present based on $P = 0$ in Table 4.

Reporting group	Late season (All areas; H = 15,072; n = 585)				
	Mean	95% CI		Median	SD
		2.5%	97.5%		
Russia	2	0	27	0	9
Coastal Western AK	51	0	172	39	46
Middle Yukon R.	4	0	34	0	11
Upper Yukon R.	6	0	45	1	14
N AK Peninsula	9	0	73	0	21
NW GOA	358	185	583	349	102
Copper R.	15	0	68	8	20
NE GOA	77	8	209	66	53
Coastal SEAK	2,304	1,772	2,873	2,297	281
British Columbia	7,894	7,196	8,601	7,894	358
U.S. West Coast	4,351	3,782	4,937	4,347	295
Total	15,071				

Table 11. -- Reporting group-specific estimates of number of Chinook salmon taken as bycatch in Area 610 during the 2012 Gulf of Alaska (GOA) pollock trawl fishery – all season. Estimates are provided to the nearest fish with the mean, 95% credibility intervals (CI), median value, and standard deviation (SD). H is the reported bycatch and n is the number of genetic samples used in the analysis. Shaded rows indicate stocks that have a >50% chance of not truly being present based on $P = 0$ in Table 5.

Reporting group	Area: 610 (All season; H = 7,662; n = 293)				
	Mean	95% CI		Median	SD
		2.5%	97.5%		
Russia	1	0	14	0	6
Coastal Western AK	34	0	132	22	36
Middle Yukon R.	2	0	21	0	7
Upper Yukon R.	3	0	27	0	9
N AK Peninsula	2	0	22	0	9
NW GOA	192	69	370	183	78
Copper R.	3	0	28	0	9
NE GOA	72	7	199	62	51
Coastal SEAK	898	586	1,258	890	171
British Columbia	5,257	4,779	5,711	5,262	238
U.S. West Coast	1,197	877	1,557	1,190	174
Total	7,661				

Table 12. -- Reporting group-specific estimates of number of Chinook salmon taken as bycatch in Area 620 during the 2012 Gulf of Alaska (GOA) pollock trawl fishery – all season. Estimates are provided to the nearest fish with the mean, 95% credibility intervals (CI), median value, and standard deviation (SD). H is the reported bycatch and n is the number of genetic samples used in the analysis. Shaded rows indicate stocks that have a >50% chance of not truly being present based on $P = 0$ in Table 6.

Area: 620 (All season; H = 7,286; n = 388)					
Reporting group	Mean	95% CI		Median	SD
		2.5%	97.5%		
Russia	1	0	11	0	5
Coastal Western AK	57	1	146	51	38
Middle Yukon R.	2	0	21	0	8
Upper Yukon R.	4	0	31	0	11
N AK Peninsula	6	0	60	0	18
NW GOA	86	8	222	75	56
Copper R.	3	0	31	0	10
NE GOA	3	0	35	0	12
Coastal SEAK	1,718	1,314	2,156	1,711	215
British Columbia	2,769	2,291	3,271	2,766	250
U.S. West Coast	2,637	2,203	3,081	2,634	225
Total	7,286				

Table 13. -- Reporting group-specific estimates of number of Chinook salmon taken as bycatch in Areas 630/640/649 during the 2012 Gulf of Alaska (GOA) pollock trawl fishery – all season. Estimates are provided to the nearest fish with the mean, 95% credible intervals (CI), median value, and standard deviation (SD). H is the reported bycatch and n is the number of genetic samples used in the analysis. Shaded rows indicate stocks that have a >50% chance of not truly being present based on $P = 0$ in Table 7.

Area: 630/640/649 (All season; H = 3,897; n = 267)					
Reporting group	Mean	95% CI		Median	SD
		2.5%	97.5%		
Russia	1	0	10	0	4
Coastal Western AK	15	0	80	6	22
Middle Yukon R.	1	0	12	0	4
Upper Yukon R.	2	0	17	0	5
N AK Peninsula	3	0	28	0	9
NW GOA	107	36	208	102	44
Copper R.	11	0	54	5	15
NE GOA	18	0	74	11	20
Coastal SEAK	920	648	1,181	923	136
British Columbia	1,424	1,145	1,755	1,414	156
U.S. West Coast	1,395	1,159	1,638	1,393	122
Total	3,897				

SUMMARY

Using the stratified analysis described in this report, we were able to extend the stock composition estimates of the 2012 Chinook salmon GOA bycatch beyond the original GSI of available samples to describe the entire bycatch. When the results of this stock composition were compared with the results reported previously by Guthrie et al. (2014), the comparison showed little change in the stock compositions from using the stratification process (Table 2). This probably results from a combination of three factors.

First, while sampling was opportunistic and did not achieve the targeted 10% sample fraction for the season or within each statistical week, the samples were distributed across time and area strata in an opportune way that provided adequate representation in this particular data set for an initial estimate. In addition, the strata with small sample sizes had sample fractions >7% and those strata with small sample fractions had reasonable sample sizes (smallest was 135 fish). Intentional stratification and subsequent weighting of stock composition estimates with bycatch helped to further minimize potential bias.

Second, stock compositions between early and late seasons (across all areas) and among areas (across seasons) were relatively similar (Tables 3-7; Fig 5) suggesting that the 2012 stock compositions in the GOA were fairly consistent both spatially and temporally.

Third, bycatch in the GOA pollock fishery in 2012 was dominated by three reporting groups (coastal SEAK, British Columbia, and U.S. West Coast), making up about 97% of bycatch. The other eight reporting groups were present in low abundance (<0.1 to 2%). However, there was good evidence that some of these reporting groups were regularly detectable, with probability of not being present ($P = 0$) low for most stocks. Chinook salmon

from the north Alaska Peninsula and middle Yukon River (41% each) and Russia (63%) had the highest probability of truly being absent in the bycatch.

The convergence of these three factors mitigated the potential problems associated with using opportunistic samples, but this may not be the case in the future. Progress is being made to increase sampling of the bycatch, but until a stratified method of sampling (e.g., 1 in every 10 fish) is implemented, a post-analysis stratified weighted estimate method will be necessary. In addition, the consistent domination of stock composition by a small number of reporting groups may not continue in the future. Chinook salmon runs to the Pacific Northwest in 2013 and 2014 were large (WDFW, 2014), and these fish would have been in the western GOA during 2012. It would be reasonable to assume that stock compositions in the GOA bycatch change with fluctuations in production from rivers in southeast Alaska, British Columbia and the Pacific Northwest.

It should be noted that in this analysis we assume that there is no uncertainty in the reported bycatch numbers; therefore, the uncertainties presented in stock composition estimates and reporting group-specific bycatch numbers include only uncertainty associated with sampling and GSI analysis. In the future, incorporation of uncertainty in harvest numbers should be incorporated into the analysis to provide a more realistic assessment of the uncertainty in the bycatch stock composition estimates and probability of low abundance reporting groups being truly present in the bycatch.

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APPENDIX A

Chinook salmon reporting groups for genetic stock identification using the ADF&G SNP baseline (from Templin et al. 2011). Too few samples were available to allow fine-scale resolution of the West Coast U.S. reporting group.

Reporting group		Number of populations	Mean sample size (range)
Broad	Fine		
Russia		4	
	Okhotsk Sea Coast	2	86 (77-94)
	Bering Sea Coast	2	85 (50-119)
Coastal West Alaska		27	
	Norton Sound	3	89 (72-112)
	Lower Yukon	4	202 (95-290)
	Kuskokwim Bay	3	253 (147-368)
	Lower Kuskokwim	11	166 (93-252)
	Upper Kuskokwim	2	143 (96-191)
	West Bristol Bay	4	100 (57-159)
	East Bristol Bay	2	88 (66-110)
Middle Yukon		8	
	Upper U.S. Yukon	5	106 (51-175)
	Tanana	3	189 (187-193)
Upper Yukon		13	
	Canada Border	2	164 (79-249)
	Pelly River	4	142 (99-197)
	Carmacks	5	99 (55-169)
	Takhini	2	202 (161-242)
North Alaska Peninsula		6	
	Port Heiden	2	87 (42-131)
	Port Moller	4	77 (51-95)
Northwest Gulf of Alaska		19	
	Chignik/Kodiak	3	117 (75-140)
	Susitna River	5	100 (52-251)
	Kenai Early	5	190 (95-266)
	Kenai Late	2	211 (119-302)
	Kasilof River	2	314 (306-321)
	Lower Kenai Peninsula	2	181 (162-200)
Copper		11	
	Upper Copper River	5	109 (50-157)
	Middle Copper	2	178 (144-211)

Reporting group		Number of populations	Mean sample size (range)
Broad	Fine		
	Lower Copper	4	70 (62-75)
Northeast Gulf of Alaska		7	
	Cape Fairweather	2	159 (143-174)
	Northern Southeast Alaska	5	134 (83-178)
Coastal Southeast Alaska		25	
	Chickamin River	6	141 (56-331)
	Unuk River	6	142 (94-397)
	Behm Canal	2	120 (95-144)
	Andrew Creek	5	214 (94-397)
	Transboundary Rivers	6	122 (86-143)
British Columbia		36	
	North Coast BC	5	86 (65-115)
	Skeena	4	112 (86-142)
	Central BC Coast	3	143 (141-144)
	South BC Mainland	2	119 (83-154)
	West Vancouver Island	5	125 (104-160)
	East Vancouver Island	3	121 (93-144)
	Upper Fraser	3	118 (94-154)
	Middle Fraser	4	168 (120-246)
	North Thompson	2	166 (153-179)
	South Thompson	3	97 (46-144)
	Lower Fraser	2	95 (93-96)
U.S. West Coast		14	111 (52-191)

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