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**U.S. DEPARTMENT OF COMMERCE**
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# Genetic Stock Composition Analysis of the Chinook Salmon Bycatch from the 2015 Bering Sea Walleye Pollock (*Gadus chalcogrammus*) Trawl Fishery

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# ABSTRACT

A genetic analysis of samples from the Chinook salmon (*Oncorhynchus tshawytscha*) bycatch of the 2015 Bering Sea-Aleutian Island (BSAI) trawl fishery for walleye pollock (*Gadus chalcogrammus*) was undertaken to determine the overall stock composition of the bycatch. Samples were genotyped for 43 single nucleotide polymorphism (SNP) DNA markers and results were estimated using the Alaska Department of Fish and Game (ADF&G) SNP baseline. In 2015, genetic samples from the Bering Sea were collected using a systematic random sampling protocol where one out of every 10 Chinook salmon encountered was sampled. Based on the analysis of 1,757 Chinook salmon bycatch samples collected throughout the 2015 BSAI walleye pollock trawl fishery, Coastal Western Alaska stocks dominated the sample set (40%) with smaller contributions from British Columbia (22%), West Coast U.S. (WA/OR/CA) (15%), and North Alaska Peninsula (11%) stocks. Analysis of temporal groupings within the pollock "A" and "B" seasons revealed changes in stock composition during the course of the year with lower contributions of Coastal Western Alaska, North Alaska Peninsula, and Upper Yukon stocks and higher contributions of West Coast U.S. (WA/OR/CA), British Columbia, NW Gulf of Alaska, and Coastal Southeast Alaska stocks during the "B" season.

CONTENTS

# INTRODUCTION

The Bering Sea is known as a 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 Pacific salmon caught in federally managed fisheries is essential to understanding whether fisheries management could address conservation concerns. This report provides genetic stock identification results for the Chinook salmon bycatch samples collected from the U.S. Bering Sea-Aleutian Island (BSAI) pollock trawl fishery. National Marine Fisheries Service (NMFS) geographical statistical areas associated with the BSAI groundfish fishery (areas 509-524) are shown in Figure 1 and are used

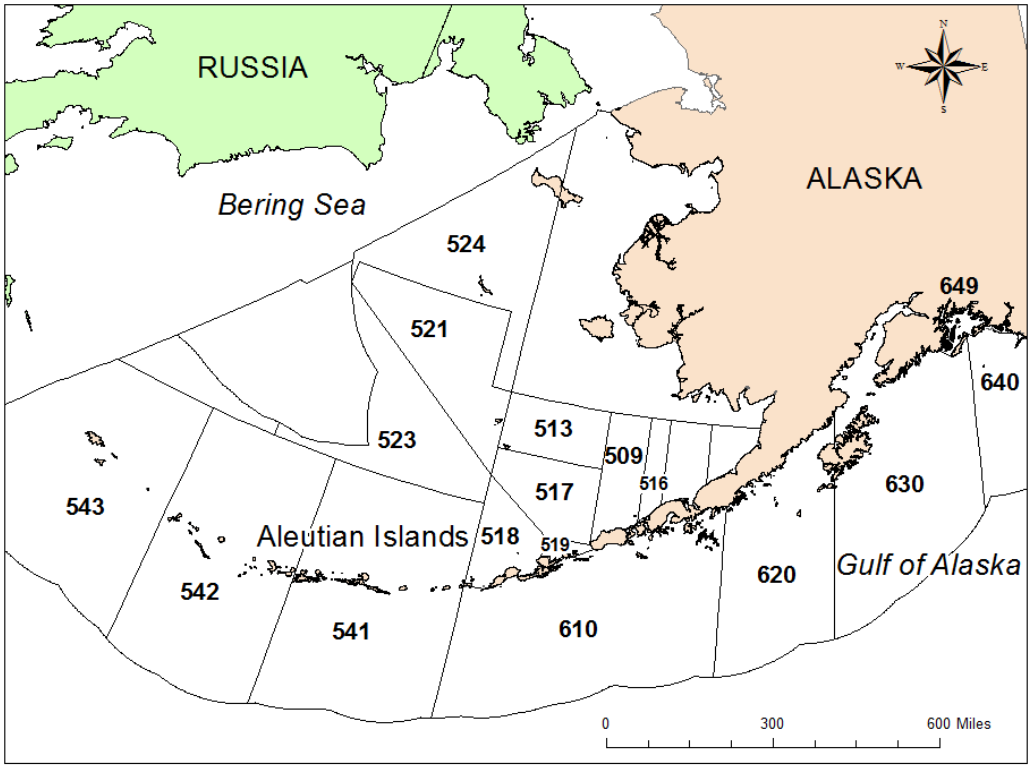


**Figure 1**. -- NMFS statistical areas associated with the Bering Sea-Aleutian Island (BSAI) and Gulf of Alaska (GOA) groundfish fisheries.

Later in this report to describe the spatial distribution of the Chinook salmon bycatch and genetic samples.

In 2015, genetic samples were collected by the AFSC's North Pacific Groundfish Observer Program (NPGOP) from the Chinook salmon bycatch of the BSAI pollock fishery using the systematic sampling protocols recommended previously (Pella and Geiger 2009). The number of available samples and the unbiased methodology in which they were collected facilitated the extrapolation of the sample stock composition to the overall Chinook bycatch from the BSAI pollock trawl fishery in 2015. Stock composition analyses were performed using the single nucleotide polymorphism (SNP) baseline provided by the Alaska Department of Fish and Game (ADF&G) (Templin et al. 2011), the same baseline that was used previously to estimate stock composition of samples from the 2005-2014 Chinook salmon bycatch (NMFS 2009; Guyon et al. 2010a, b; Guthrie et al. 2012, 2013, 2014, 2015, and 2016; Larson et al. 2013). For additional information regarding background and methodology, refer to the Chinook salmon bycatch report prepared previously for the 2008 Bering Sea trawl fishery (Guyon et al. 2010a).

## SAMPLE DISTRIBUTION

Samples were collected from the Chinook salmon bycatch by the NPGOP for analysis at AFSC's Auke Bay Laboratories (ABL). Amendment 91 to the North Pacific Fishery Management Council (NPFMC) fishery management plan for groundfish of the BSAI Management Area was enacted in 2010 and included retention of the salmon caught in the prohibited species catch. In 2011, a systematic random sampling design recommended by Pella and Geiger (2009) was implemented by the NPGOP to collect genetic samples from one out of every 10 Chinook salmon encountered as bycatch in the BSAI pollock fishery. Samples of

axillary process tissue were collected from the Chinook salmon bycatch throughout 2015. Axillary process tissues were stored in coin envelopes which were labeled, frozen, and shipped to ABL for analysis.

In 2015, an estimated 18,329 Chinook salmon were taken in the bycatch of BSAI pollock trawl fisheries (NMFS 2015). Of the total bycatch, 12,304 were from the trawl "A" season and 6,025 were from the "B" season. The Chinook salmon bycatch estimate is 49% below the historical average (35,845) for the Bering Sea between 1991 and 2015 (Fig. 2) (Table 1). Since 1991, the year with the highest overall Chinook bycatch in the BSAI was 2007 (Fig. 2) when an estimated 121,770 fish were taken. In 2015, there were 1,816 genetic samples from the BSAI Chinook salmon bycatch collected by the NPGOP; of those 1,757 were successfully genotyped for an overall sampling rate of 9.6% ("A" season -1,181 fish, 9.6% sampling rate; "B" season - 576 fish, 9.6% sampling rate).

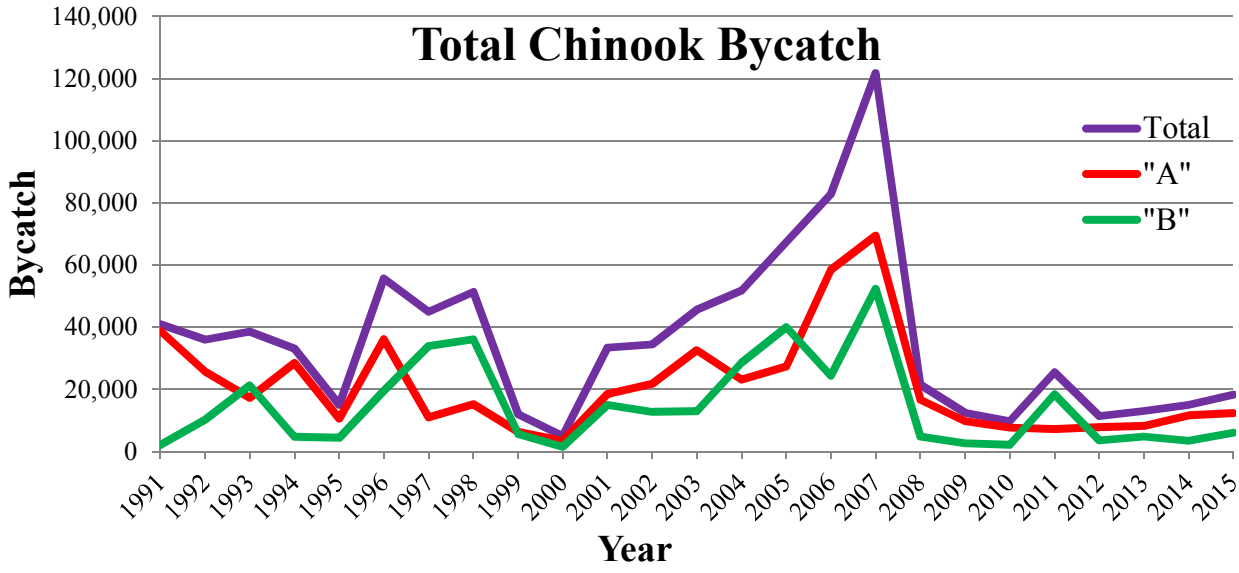


**Figure 2**. -- Yearly, "A" season, and "B" estimates for the Chinook salmon bycatch from the Bering Sea Aleutian Island (BSAI) pollock trawl fishery (NMFS 2016).

**Table 1**. --Yearly, “A” season, and “B” estimates for the Chinook salmon bycatch from the Bering Sea-Aleutian Island pollock trawl fishery (NMFS 2016).

| Year | Total | "A" Season | "B" Season |
|---|---|---|---|
| 1991 | 40,906 | 38,791 | 2,114 |
| 1992 | 35,950 | 25,691 | 10,259 |
| 1993 | 38,516 | 17,264 | 21,252 |
| 1994 | 33,136 | 28,451 | 4,686 |
| 1995 | 14,984 | 10,579 | 4,405 |
| 1996 | 55,623 | 36,068 | 19,554 |
| 1997 | 44,909 | 10,935 | 33,973 |
| 1998 | 51,322 | 15,193 | 36,130 |
| 1999 | 11,978 | 6,352 | 5,627 |
| 2000 | 4,961 | 3,422 | 1,539 |
| 2001 | 33,444 | 18,484 | 14,961 |
| 2002 | 34,495 | 21,794 | 12,701 |
| 2003 | 45,586 | 32,609 | 12,977 |
| 2004 | 51,696 | 23,093 | 28,603 |
| 2005 | 67,362 | 27,331 | 40,030 |
| 2006 | 82,695 | 58,391 | 24,304 |
| 2007 | 121,770 | 69,420 | 52,350 |
| 2008 | 21,480 | 16,638 | 4,842 |
| 2009 | 12,369 | 9,711 | 2,658 |
| 2010 | 9,697 | 7,630 | 2,067 |
| 2011 | 25,499 | 7,137 | 18,362 |
| 2012 | 11,344 | 7,765 | 3,579 |
| 2013 | 13,034 | 8,237 | 4,797 |
| 2014 | 15,031 | 11,539 | 3,492 |
| 2015 | 18,329 | 12,304 | 6,025 |

Potential biases associated with the collection of genetic samples from the bycatch are well documented and have the potential to affect resulting stock composition estimates (Pella and Geiger 2009). Sample distributions for the 2015 Chinook salmon bycatch sample sets were evaluated by comparing the collection of genetic samples with the overall bycatch distribution which were comparable in their temporal distribution (Fig. 3). To evaluate the sample spatial distribution, the Chinook salmon bycatch was compared with the bycatch samples by statistical

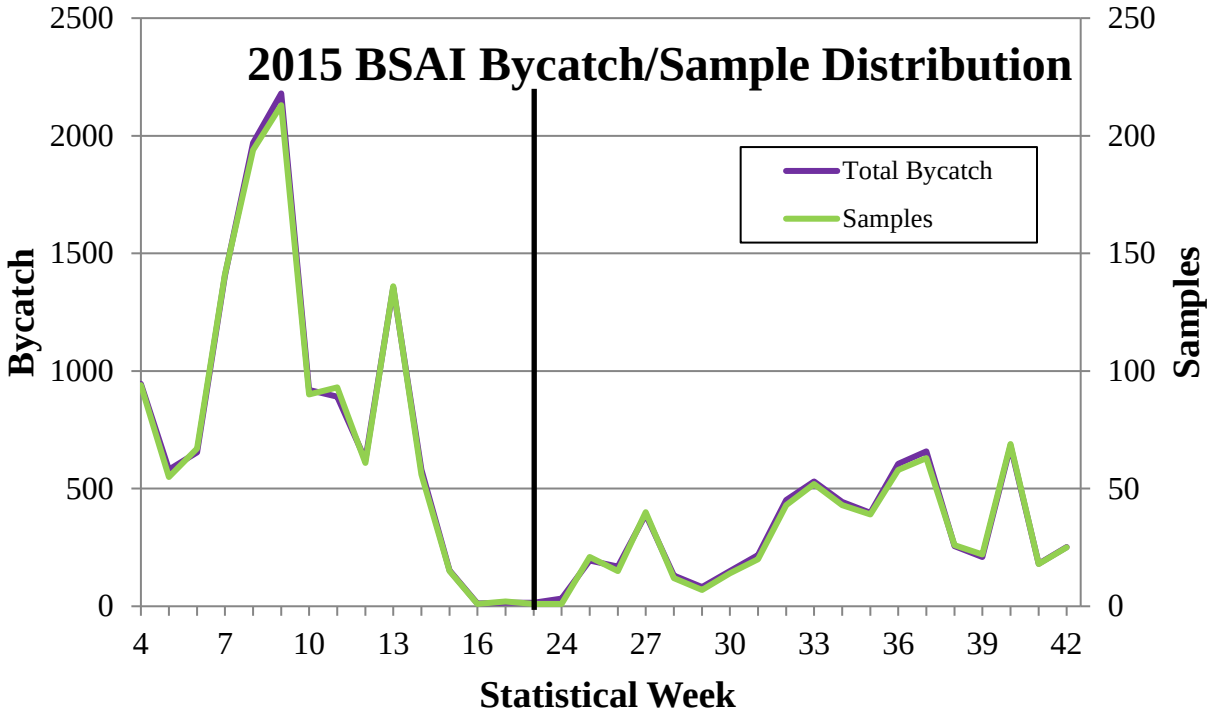


**Figure 3**. -- Number of Chinook salmon bycatch and genetic samples graphed by statistical week. Distribution of all Chinook salmon caught in the 2015 Bering Sea-Aleutian Island (BSAI) pollock trawl fishery versus the distribution of the 1,757 samples from the 2015 bycatch. Weeks 4-18 correspond to the groundfish "A" season, whereas weeks 24-42 correspond to the "B" season, the demarcation of which is a vertical line.

area over time (Fig. 4). 2015 was the fifth year systematic random sampling was employed for collecting genetic tissue from the Bering Sea Chinook salmon bycatch and Figure 4 shows that the resulting samples were collected in proportion through time and space with the total catch. As in 2011, 2012, 2013, and 2014, the sample spatial and temporal distribution was excellent in 2015 compared to previous years when samples were collected more opportunistically (Guyon et al. 2010a, 2010b; Guthrie et al. 2012, 2013, 2014, 2015, 2016).

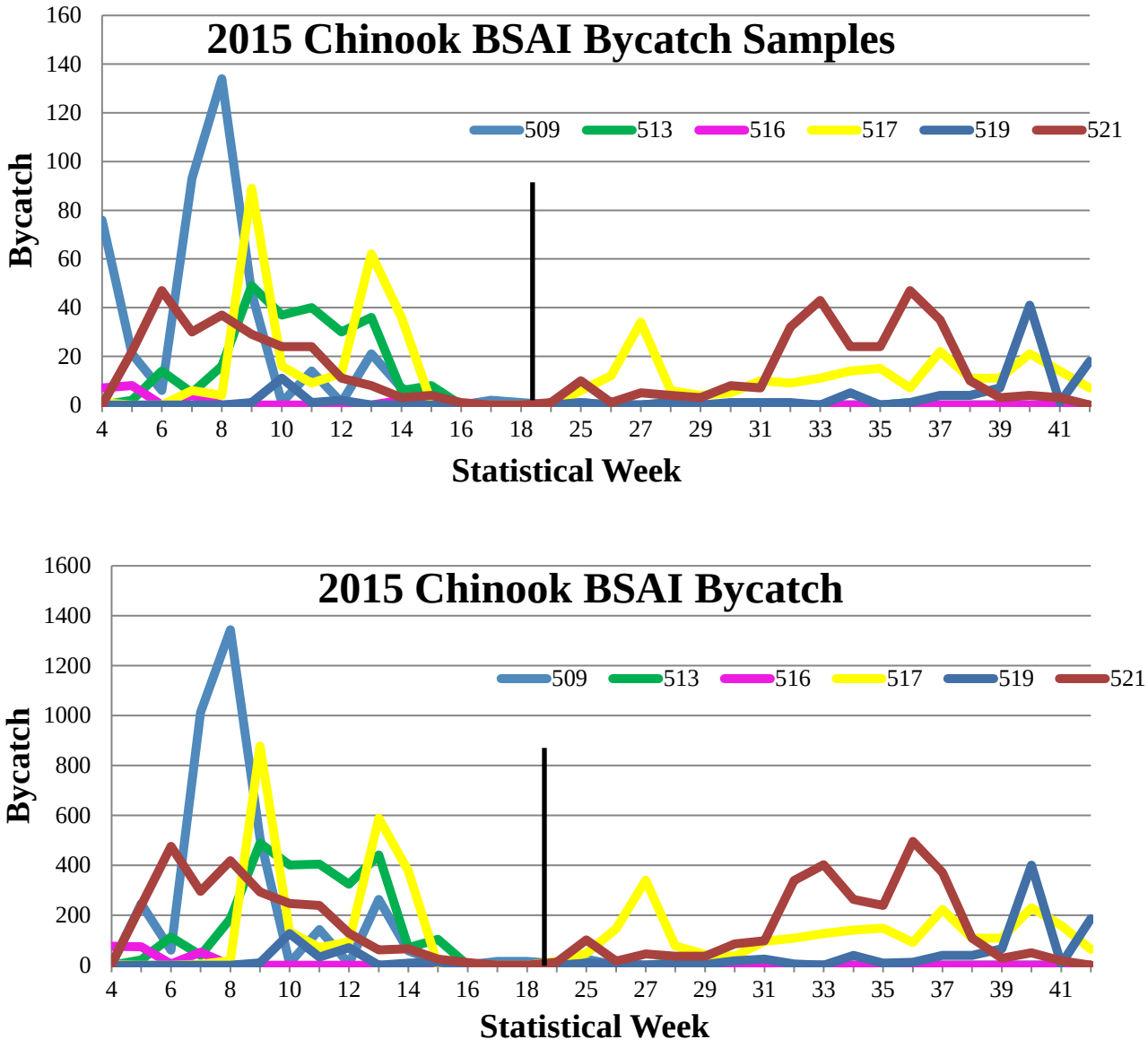


**Figure 4**. -- Comparison of the Chinook salmon bycatch by time and area with the distribution of available genetic samples. Top panel: Distribution of the 1,757 genotyped samples from the 2015 bycatch. Not graphed were 2 fish each from NMFS areas 523 and 524. Bottom panel: Distribution of the Chinook salmon caught in the 2015 Bering Sea-Aleutian Island (BSAI) pollock trawl fishery. Not graphed were 28 fish each from NMFS area 523, and 31 fish from NMFS area 524. Weeks 4-18 correspond to the groundfish "A" season, whereas weeks 24-42 correspond to the "B" season, the demarcation of which is a vertical line.

## GENETIC STOCK COMPOSITION

DNA was extracted from axillary process tissue and matrix-assisted laser desorption/ionization - time of flight (MALDI-TOF) 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 Chinook salmon baseline (Templin et al. 2011). The SNP baseline contains genetic information for 172 populations of Chinook salmon grouped into 11 geographic regions (see Appendix). Proof tests performed previously have shown the baseline to be suitable for stock composition analysis (Templin et al. 2011). This baseline was used previously for the genetic analyses of the 2005-2014 Chinook bycatch (NMFS 2009; Guyon et al. 2010a, b; Guthrie et al. 2012, 2013, 2014, and 2015). In addition to internal MALDI-TOF chip controls, 10 previously genotyped samples were included on each chip during the analyses and resulting genotypes were compared to those from ADF&G, which used TaqMan chemistries (Applied Biosystems Inc.). Concordance rates of 99.8% between the two chemistries for the 2015 controls confirmed the utility and compatibility of both genotyping methods.

From the 2015 Chinook salmon bycatch from the BSAI pollock trawl fishery, a total of 1,816 samples were analyzed of which 1,757 samples were successfully genotyped for 35 or more of the 43 SNP loci, a success rate of 96.8%. The remaining 1,757 samples had genetic information for an average of 41.9 of 43 markers. Stock composition estimates were derived using both BAYES (Bayesian analysis) and SPAM (maximum likelihood analysis) software and both methods yielded almost identical stock composition estimates (Tables 2-4).

BAYES software uses a Bayesian algorithm to produce stock composition estimates and can account for missing alleles in the baseline (Pella and Masuda 2001). In contrast, SPAM uses a conditional maximum likelihood approach in which the mixture genotypes are compared

directly with the baseline (ADF&G 2003). Convergence of the SPAM estimates was monitored with the "Percent of Maximum" value and all exceeded the 90% guaranteed percent achievement of the maximal likelihood. For each BAYES analysis, 11 Monte Carlo chains starting at disparate values of stock proportions were configured such that 95% of the stocks came from one designated region with weights equally distributed among the stocks of that region. The remaining 5% was equally distributed among remaining stocks from all other regions. For all estimates, a flat prior of 0.005814 (calculated as 1/172) was used for all 172 baseline populations. The analyses were completed for a chain length of 10,000 with the first 5,000 deleted during the burn-in phase when determining overall stock compositions. Convergence of the chains to posterior distributions of stock proportions was determined with Gelman and Rubin shrink statistics, which were 1.10 or less for all the estimates, conveying strong convergence to a single posterior distribution (Pella and Masuda 2001).

Results (BAYES) suggest that 66% of the 1,181 samples from the "A" season originated from Alaska river systems flowing into the Bering Sea with the Coastal Western Alaska stock contributing the most (46%), followed by the North Alaska Peninsula (15%), Upper Yukon (4%), and Northwest GOA (3%). The other major contributors were British Columbia (19%) and West Coast U.S. stock (8%) (Table 2). For the "B" season, over 60% of the 576 samples originated from river systems flowing into the GOA with the West Coast U.S. region contributing the most 28%. This was followed by the Coastal Western Alaska region (27%), British Columbia (27%), Northwest GOA (8%), and Coastal Southeast Alaska (6%) (Table 3).

**Table 2**. -- Regional BAYES and SPAM stock composition estimates for the 1,181 Chinook salmon samples from the bycatch of the 2015 "A" season Bering Sea-Aleutian Island pollock trawl fishery. The BAYES mean estimates are also provided with standard deviations (SD), 95% credible intervals, and the median estimate. Standard deviations for the SPAM estimates were determined by the analysis of 1,000 bootstrap resamplings of the mixture.

| Region | BAYES | SD | 2.5% | Median | 97.5% | SPAM | SD |
|---|---|---|---|---|---|---|---|
| Russia | **0.006** | 0.003 | 0.002 | 0.006 | 0.013 | **0.009** | 0.002 |
| Coast W AK | **0.459** | 0.019 | 0.422 | 0.459 | 0.495 | **0.436** | 0.013 |
| Mid-Yukon | **0.010** | 0.008 | 0.000 | 0.009 | 0.027 | **0.017** | 0.001 |
| Up Yukon | **0.036** | 0.007 | 0.024 | 0.036 | 0.051 | **0.038** | 0.003 |
| N AK Penn | **0.145** | 0.013 | 0.120 | 0.145 | 0.172 | **0.140** | 0.006 |
| NW GOA | **0.028** | 0.008 | 0.014 | 0.028 | 0.046 | **0.039** | 0.003 |
| Copper | **0.002** | 0.004 | 0.000 | 0.000 | 0.013 | **0.008** | 0.001 |
| NE GOA | **0.000** | 0.001 | 0.000 | 0.000 | 0.002 | **0.000** | 0.000 |
| Coast SE AK | **0.039** | 0.007 | 0.026 | 0.038 | 0.054 | **0.038** | 0.002 |
| BC | **0.191** | 0.012 | 0.168 | 0.191 | 0.216 | **0.191** | 0.007 |
| WA/OR/CA | **0.084** | 0.008 | 0.068 | 0.084 | 0.101 | **0.084** | 0.004 |

**Table 3.** -- Regional BAYES and SPAM stock composition estimates for the 576 Chinook salmon samples from the bycatch of the 2015 "B" season Bering Sea-Aleutian Island pollock trawl fishery. The BAYES mean estimates are also provided with standard deviations (SD), 95% credible intervals, and the median estimate. Standard deviations for the SPAM estimates were determined by the analysis of 1,000 bootstrap resamplings of the mixture.

| Region | BAYES | SD | 2.5% | Median | 97.5% | SPAM | SD |
|---|---|---|---|---|---|---|---|
| Russia | **0.001** | 0.002 | 0.000 | 0.000 | 0.007 | **0.003** | 0.002 |
| Coast W AK | **0.274** | 0.024 | 0.229 | 0.274 | 0.321 | **0.256** | 0.014 |
| Mid-Yukon | **0.016** | 0.007 | 0.006 | 0.015 | 0.032 | **0.019** | 0.002 |
| Up Yukon | **0.011** | 0.006 | 0.002 | 0.010 | 0.023 | **0.009** | 0.002 |
| N AK Penn | **0.010** | 0.009 | 0.000 | 0.009 | 0.030 | **0.017** | 0.002 |
| NW GOA | **0.082** | 0.020 | 0.046 | 0.082 | 0.123 | **0.089** | 0.007 |
| Copper | **0.001** | 0.001 | 0.000 | 0.000 | 0.004 | **0.002** | 0.000 |
| NE GOA | **0.001** | 0.002 | 0.000 | 0.000 | 0.007 | **0.003** | 0.000 |
| Coast SE AK | **0.063** | 0.014 | 0.038 | 0.063 | 0.093 | **0.066** | 0.003 |
| BC | **0.266** | 0.021 | 0.226 | 0.266 | 0.307 | **0.258** | 0.012 |
| WA/OR/CA | **0.275** | 0.020 | 0.238 | 0.275 | 0.314 | **0.277** | 0.013 |

**Table 4**. -- Regional BAYES and SPAM stock composition estimates for the 1,757 Chinook salmon samples from the bycatch of the 2015 Bering Sea-Aleutian Island pollock trawl fishery. The BAYES mean estimates are also provided with standard deviations (SD), 95% credible intervals, and the median estimate. Standard deviations for the SPAM estimates were determined by the analysis of 1,000 bootstrap resamplings of the mixture.

| Region | BAYES | SD | 2.5% | Median | 97.5% | SPAM | SD |
|---|---|---|---|---|---|---|---|
| Russia | **0.005** | 0.002 | 0.002 | 0.005 | 0.010 | **0.006** | 0.001 |
| Coast W AK | **0.396** | 0.016 | 0.364 | 0.396 | 0.427 | **0.380** | 0.010 |
| Mid-Yukon | **0.017** | 0.007 | 0.006 | 0.016 | 0.032 | **0.019** | 0.001 |
| Up Yukon | **0.027** | 0.005 | 0.019 | 0.027 | 0.037 | **0.029** | 0.002 |
| N AK Penn | **0.106** | 0.010 | 0.087 | 0.106 | 0.126 | **0.101** | 0.004 |
| NW GOA | **0.040** | 0.008 | 0.025 | 0.039 | 0.057 | **0.051** | 0.003 |
| Copper | **0.001** | 0.002 | 0.000 | 0.000 | 0.007 | **0.005** | 0.001 |
| NE GOA | **0.000** | 0.001 | 0.000 | 0.000 | 0.003 | **0.001** | 0.000 |
| Coast SE AK | **0.045** | 0.007 | 0.033 | 0.045 | 0.059 | **0.046** | 0.001 |
| BC | **0.218** | 0.011 | 0.197 | 0.218 | 0.240 | **0.216** | 0.006 |
| WA/OR/CA | **0.145** | 0.009 | 0.129 | 0.145 | 0.163 | **0.147** | 0.005 |

For the entire year, 55% of the bycatch samples were estimated to be from Alaska river systems flowing into the Bering Sea with the Coastal Western Alaska stock contributing the most (40%), trailed by the North Alaska Peninsula (11%), Upper Yukon (3%) and Middle Yukon (2%). Other contributors were British Columbia (22%), West Coast U.S. (15%), Coastal Southeast Alaska (5%). and Northwest GOA (4%) (Table 4).

To investigate how stock compositions might change between smaller areas, “A” season estimates were developed for the following five strata with the largest number of samples (Fig. 5, Tables 5-9): Saint George Island (523 samples, Fig. 6, Table 5), Northwest Bering (645 samples, Fig. 7, Table 6), CVOA (414 samples, Fig. 8, Table 7), Southeast Bering (478 samples, Fig. 7, Table 8), and area 509 (393 samples, Table 9)(NMFS 2015). It should be noted that some of these strata overlap. For the Saint George and Northwest Bering strata, the resulting stock compositions showed that 84% were estimated to be from Alaska river systems flowing into the

Bering Sea. The largest contributors were Coastal Western Alaska (56% for Saint George, 57% for Northwest Bering) and North Alaska Peninsula (18% for Saint George, 17% for Northwest Bering), Upper Yukon (6% for Saint George and Northwest Bering). Sixteen percent were from Southern stock groups, the largest contributors were British Columbia (7% for Saint George, 6% for Northwest Bering), and Coastal Southeast Alaska (5% for Saint George, 4% for Northwest Bering). For the Catcher Vessel Operational Area (CVOA) (55%), Southeast Bering (55%), and area 509 (58%) strata, the resulting stock composition estimates were from Southern regions, the largest contributors were British Columbia (33% for CVOA and Southeast Bering, 36% for area 509), West Coast U. S. (17% for CVOA, 16% for Southeast Bering, 17% for area 509), and Coastal Southeast Alaska (3% for CVOA, 4% for Southeast Bering area 509). Forty-five percent of for CVOA and Southeast Bering strata, and slightly less of Area 509 (41%) were estimated to be from Alaskan river systems flowing into the Bering Sea. The largest contributors were Coastal Western Alaska (35% for CVOA, 34% for Southeast Bering, 28% for area 509), and North Alaska Peninsula (9% for CVOA, 10% for Southeast Bering, 13% for area 509).

**Table 5**. -- Regional BAYES and SPAM stock composition estimates for the 523 Chinook salmon samples from the bycatch of the 2015 Bering Sea-Aleutian Island pollock trawl fishery from "A" season from around Saint George Island (ADF&G Statistical Areas 705600, 695600, 685600, 705630, 695631-2, and 685630) (Fig. 6). The BAYES mean estimates are also provided with standard deviations (SD), 95% credible intervals, and the median estimate. Standard deviations for the SPAM estimates were determined by the analysis of 1,000 bootstrap resamplings of the mixture.

| Region | BAYES | SD | 2.5% | Median | 97.5% | SPAM | SD |
|---|---|---|---|---|---|---|---|
| Russia | **0.008** | 0.005 | 0.001 | 0.007 | 0.020 | **0.008** | 0.003 |
| Coast W AK | **0.561** | 0.031 | 0.500 | 0.562 | 0.620 | **0.538** | 0.022 |
| Mid-Yukon | **0.031** | 0.019 | 0.000 | 0.030 | 0.070 | **0.038** | 0.003 |
| Up Yukon | **0.056** | 0.013 | 0.031 | 0.055 | 0.083 | **0.056** | 0.006 |
| N AK Penn | **0.180** | 0.021 | 0.140 | 0.179 | 0.223 | **0.169** | 0.010 |
| NW GOA | **0.030** | 0.012 | 0.010 | 0.029 | 0.056 | **0.042** | 0.006 |
| Copper | **0.002** | 0.004 | 0.000 | 0.000 | 0.016 | **0.010** | 0.003 |
| NE GOA | **0.001** | 0.003 | 0.000 | 0.000 | 0.011 | **0.007** | 0.001 |
| Coast SE AK | **0.042** | 0.012 | 0.022 | 0.041 | 0.067 | **0.036** | 0.002 |
| BC | **0.070** | 0.013 | 0.046 | 0.069 | 0.097 | **0.078** | 0.004 |
| WA/OR/CA | **0.021** | 0.007 | 0.009 | 0.020 | 0.036 | **0.018** | 0.004 |

**Table 6**. -- Regional BAYES and SPAM stock composition estimates for the 645 Chinook salmon samples from the bycatch of the 2015 Bering Sea-Aleutian Island pollock trawl fishery from "A" season in the Northwest Bering Sea (Fig. 7). The BAYES mean estimates are also provided with standard deviations (SD), 95% credible intervals, and the median estimate. Standard deviations for the SPAM estimates were determined by the analysis of 1,000 bootstrap resamplings of the mixture.

| Region | BAYES | SD | 2.5% | Median | 97.5% | SPAM | SD |
|---|---|---|---|---|---|---|---|
| Russia | **0.010** | 0.005 | 0.002 | 0.009 | 0.021 | **0.009** | 0.002 |
| Coast W AK | **0.569** | 0.026 | 0.517 | 0.570 | 0.619 | **0.543** | 0.020 |
| Mid-Yukon | **0.019** | 0.014 | 0.000 | 0.018 | 0.048 | **0.031** | 0.002 |
| Up Yukon | **0.064** | 0.012 | 0.042 | 0.063 | 0.089 | **0.066** | 0.006 |
| N AK Penn | **0.174** | 0.019 | 0.137 | 0.173 | 0.212 | **0.163** | 0.009 |
| NW GOA | **0.031** | 0.010 | 0.013 | 0.030 | 0.054 | **0.042** | 0.005 |
| Copper | **0.004** | 0.007 | 0.000 | 0.000 | 0.024 | **0.012** | 0.002 |
| NE GOA | **0.000** | 0.002 | 0.000 | 0.000 | 0.004 | **0.004** | 0.000 |
| Coast SE AK | **0.045** | 0.011 | 0.026 | 0.045 | 0.068 | **0.038** | 0.002 |
| BC | **0.062** | 0.012 | 0.040 | 0.062 | 0.086 | **0.071** | 0.004 |
| WA/OR/CA | **0.023** | 0.007 | 0.012 | 0.022 | 0.037 | **0.022** | 0.003 |

**Table 7**. -- Regional BAYES and SPAM stock composition estimates for the 414 Chinook salmon samples from the bycatch of the 2015 Bering Sea-Aleutian Island pollock trawl fishery from "A" season in the CVOA (Fig. 8). The BAYES mean estimates are also provided with standard deviations (SD), 95% credible intervals, and the median estimate. Standard deviations for the SPAM estimates were determined by the analysis of 1,000 bootstrap resamplings of the mixture.

| Region | BAYES | SD | 2.5% | Median | 97.5% | SPAM | SD |
|---|---|---|---|---|---|---|---|
| Russia | **0.004** | 0.004 | 0.000 | 0.003 | 0.014 | **0.006** | 0.005 |
| Coast W AK | **0.351** | 0.027 | 0.298 | 0.351 | 0.404 | **0.328** | 0.019 |
| Mid-Yukon | **0.002** | 0.004 | 0.000 | 0.000 | 0.012 | **0.004** | 0.000 |
| Up Yukon | **0.008** | 0.006 | 0.000 | 0.007 | 0.021 | **0.007** | 0.003 |
| N AK Penn | **0.087** | 0.017 | 0.056 | 0.086 | 0.123 | **0.080** | 0.008 |
| NW GOA | **0.027** | 0.012 | 0.009 | 0.025 | 0.057 | **0.049** | 0.007 |
| Copper | **0.004** | 0.006 | 0.000 | 0.000 | 0.022 | **0.010** | 0.002 |
| NE GOA | **0.000** | 0.001 | 0.000 | 0.000 | 0.003 | **0.000** | 0.000 |
| Coast SE AK | **0.025** | 0.010 | 0.007 | 0.024 | 0.047 | **0.022** | 0.001 |
| BC | **0.325** | 0.024 | 0.279 | 0.325 | 0.373 | **0.325** | 0.018 |
| WA/OR/CA | **0.167** | 0.019 | 0.131 | 0.167 | 0.206 | **0.169** | 0.011 |

**Table 8**. -- Regional BAYES and SPAM stock composition estimates for the 478 Chinook salmon samples from the bycatch of the 2015 Bering Sea-Aleutian Island pollock trawl fishery from "A" season in the Southeast Bering Sea (Fig. 7). The BAYES mean estimates are also provided with standard deviations (SD), 95% credible intervals, and the median estimate. Standard deviations for the SPAM estimates were determined by the analysis of 1,000 bootstrap resamplings of the mixture.

| Region | BAYES | SD | 2.5% | Median | 97.5% | SPAM | SD |
|---|---|---|---|---|---|---|---|
| Russia | **0.004** | 0.003 | 0.000 | 0.003 | 0.012 | **0.005** | 0.004 |
| Coast W AK | **0.335** | 0.024 | 0.289 | 0.335 | 0.383 | **0.321** | 0.018 |
| Mid-Yukon | **0.001** | 0.002 | 0.000 | 0.000 | 0.009 | **0.004** | 0.000 |
| Up Yukon | **0.001** | 0.002 | 0.000 | 0.000 | 0.007 | **0.003** | 0.002 |
| N AK Penn | **0.104** | 0.017 | 0.073 | 0.104 | 0.139 | **0.094** | 0.008 |
| NW GOA | **0.023** | 0.010 | 0.008 | 0.021 | 0.046 | **0.039** | 0.005 |
| Copper | **0.001** | 0.003 | 0.000 | 0.000 | 0.009 | **0.003** | 0.000 |
| NE GOA | **0.000** | 0.001 | 0.000 | 0.000 | 0.002 | **0.000** | 0.000 |
| Coast SE AK | **0.042** | 0.012 | 0.021 | 0.041 | 0.067 | **0.037** | 0.002 |
| BC | **0.328** | 0.023 | 0.284 | 0.328 | 0.373 | **0.330** | 0.017 |
| WA/OR/CA | **0.162** | 0.018 | 0.129 | 0.161 | 0.198 | **0.164** | 0.011 |

**Table 9**. -- Regional BAYES and SPAM stock composition estimates for the 393 Chinook salmon samples from the bycatch of the 2015 Bering Sea-Aleutian Island pollock trawl fishery from "A" season in area 509 (Fig. 6). The BAYES mean estimates are also provided with standard deviations (SD), 95% credible intervals, and the median estimate. Standard deviations for the SPAM estimates were determined by the analysis of 1,000 bootstrap resamplings of the mixture.

| Region | BAYES | SD | 2.5% | Median | 97.5% | SPAM | SD |
|---|---|---|---|---|---|---|---|
| Russia | **0.004** | 0.004 | 0.000 | 0.004 | 0.014 | **0.006** | 0.005 |
| Coast W AK | **0.284** | 0.026 | 0.234 | 0.284 | 0.336 | **0.328** | 0.019 |
| Mid-Yukon | **0.001** | 0.003 | 0.000 | 0.000 | 0.009 | **0.004** | 0.000 |
| Up Yukon | **0.001** | 0.003 | 0.000 | 0.000 | 0.009 | **0.007** | 0.003 |
| N AK Penn | **0.126** | 0.021 | 0.087 | 0.125 | 0.168 | **0.080** | 0.008 |
| NW GOA | **0.014** | 0.014 | 0.000 | 0.010 | 0.048 | **0.049** | 0.007 |
| Copper | **0.002** | 0.003 | 0.000 | 0.000 | 0.012 | **0.010** | 0.002 |
| NE GOA | **0.000** | 0.001 | 0.000 | 0.000 | 0.002 | **0.000** | 0.000 |
| Coast SE AK | **0.042** | 0.014 | 0.017 | 0.041 | 0.071 | **0.022** | 0.001 |
| BC | **0.356** | 0.026 | 0.306 | 0.356 | 0.407 | **0.325** | 0.018 |
| WA/OR/CA | **0.170** | 0.020 | 0.133 | 0.169 | 0.210 | **0.169** | 0.011 |

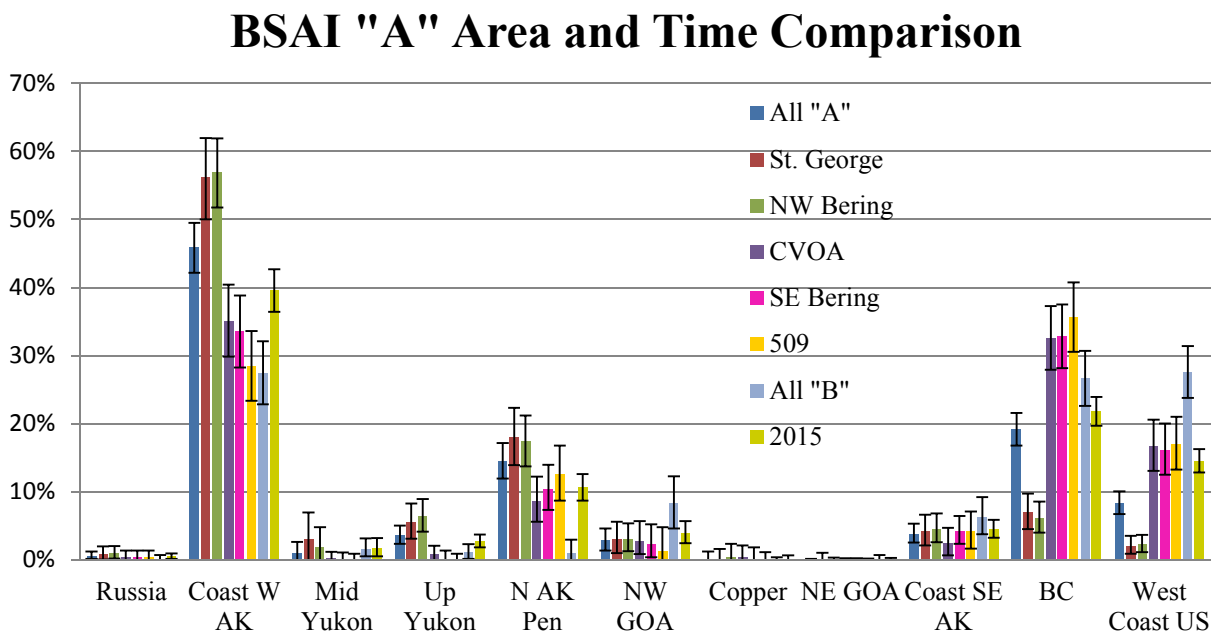


**Figure 5.** -- Comparison of area and time stock composition estimates from the 2015 Bering Sea-Aleutian Island (BSAI) Chinook salmon bycatch for "A" season: All (1,181 samples), Saint George Island (523 samples, Fig. 6), Northwest Bering (645 samples, Fig. 7), CVOA (414 samples), Southeast Bering (478 samples, Fig. 7), and area 509 (393 samples). Bering Sea "B" season (576 samples) and 2015 overall included for comparison. BAYES 95% credible intervals are plotted for yearly estimates.

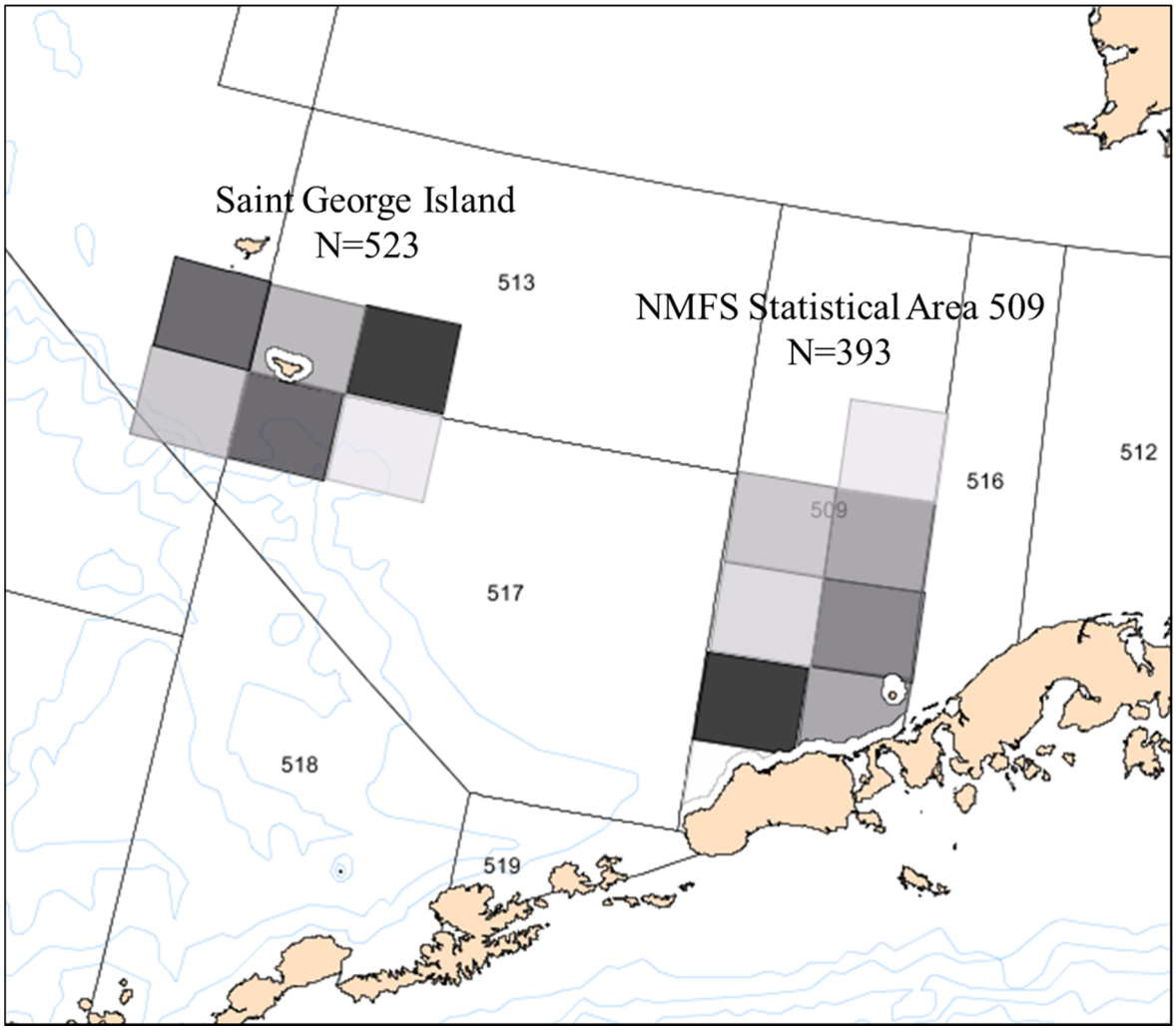


**Figure 6.** -- Location of Saint George Island and area 509 strata used in comparative stock composition estimates from the 2015 Bering Sea-Aleutian Island Chinook salmon bycatch for "A" season (NMFS 2015).

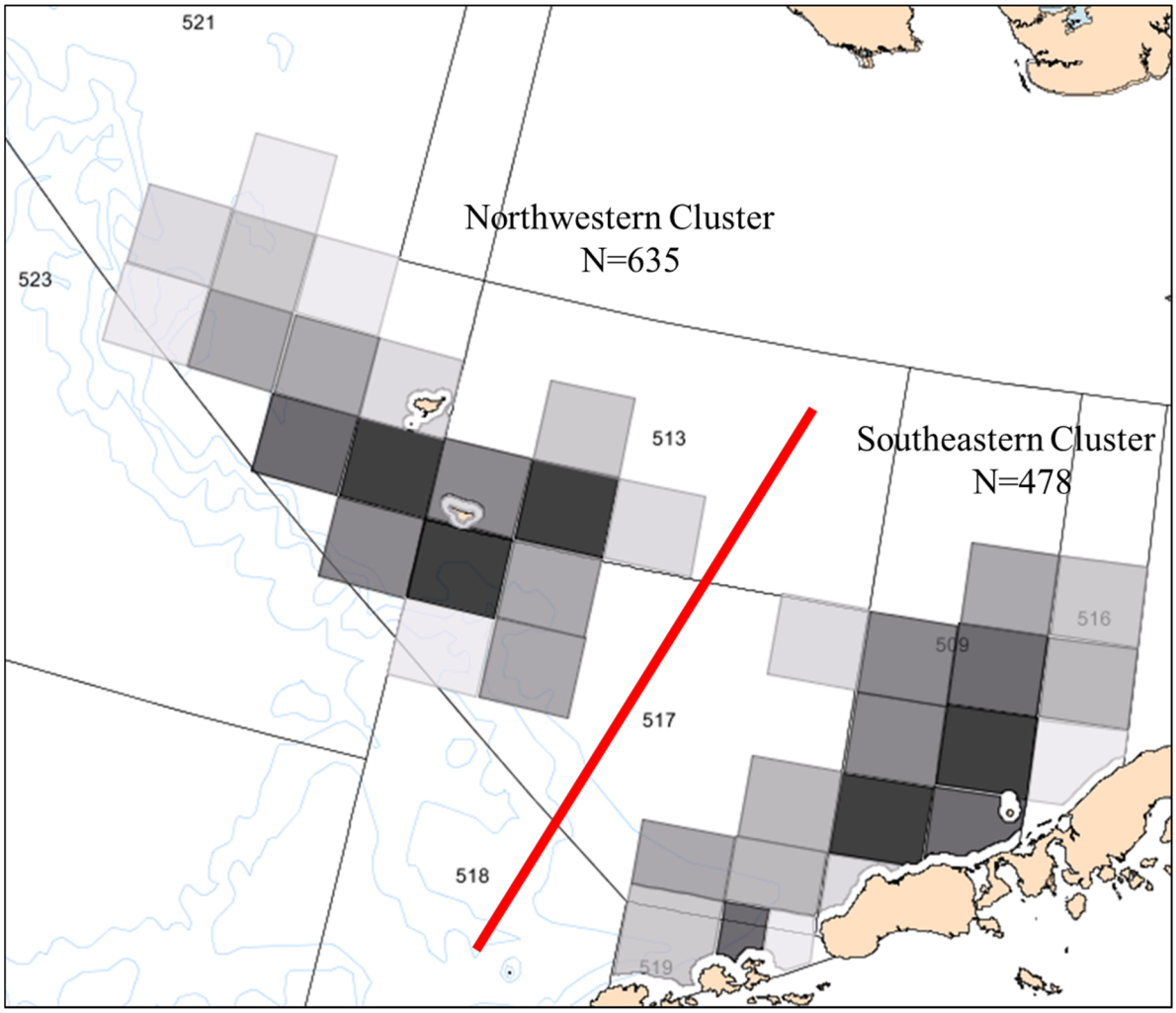


**Figure 7. --** Location of Northwest Bering and Southeast Bering strata used in comparative stock composition estimates from the 2015 Bering Sea-Aleutian Island Chinook salmon bycatch for "A" season (NMFS 2015).

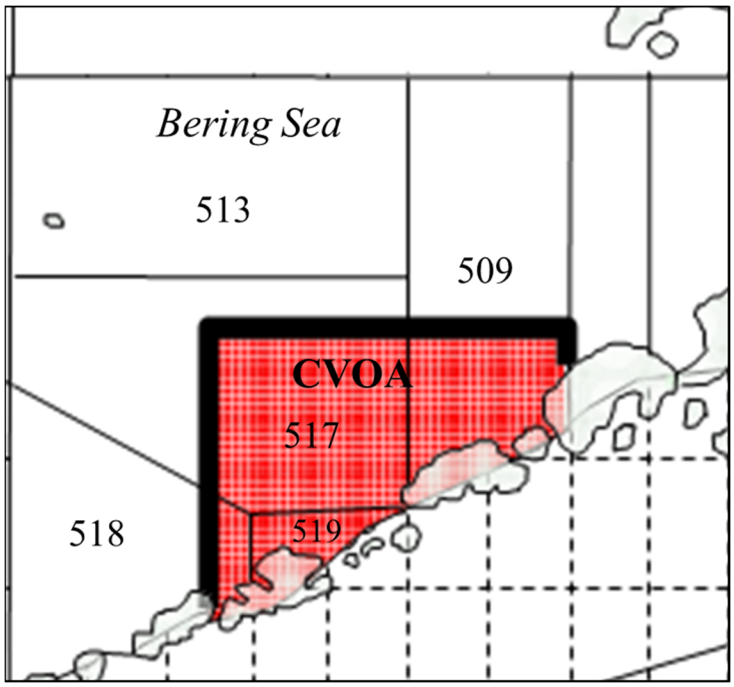


**Figure 8.** -- Location of Catcher Vessel Operational Area (CVOA) strata used in comparative stock composition estimates from the 2015 Bering Sea-Aleutian Island Chinook salmon bycatch for "A" season.

For the "B" season, estimates were developed for the following four strata with the largest number of samples (Fig. 9, Tables 10-13): area 521 (264 samples, Fig. 1, Table 10), area 521 and ADF&G Statistical Area 695600 (289 samples, Fig. 10, Table 11), areas 517 and 519 (301 samples, Fig. 1, Table 12), and area 517 without ADF&G Statistical Area 695600 and area 519 (280 samples, Fig. 10, Table 13)(NMFS 2015). Larger stock differences were seen when comparing area 521 composition with those of areas 517 and 519. For example, in area 521, the stock composition from the salmon bycatch in the "B" season showed a larger proportion of fish from river drainages flowing into the Bering Sea (55%) compared to areas 517 and 519 (11%). Areas 517 and 519 had a higher proportion of fish from river drainages flowing into the GOA and Pacific Ocean (89%) compared to area 521 (43%). The addition of ADF&G Statistical Area 695600 to area 521 (54%), nor its omission from area 517 and 519 (92%) did not change these differences appreciably (Fig. 9, Tables 11 and 13).

**Table 10**. -- Regional BAYES and SPAM stock composition estimates for the 264 Chinook salmon samples from the bycatch of the 2015 Bering Sea-Aleutian Island pollock trawl fishery from "B" season in area 521. The BAYES mean estimates are also provided with standard deviations (SD), 95% credible intervals, and the median estimate. Standard deviations for the SPAM estimates were determined by the analysis of 1,000 bootstrap resamplings of the mixture.

| Region | BAYES | SD | 2.5% | Median | 97.5% | SPAM | SD |
|---|---|---|---|---|---|---|---|
| Russia | **0.003** | 0.004 | 0.000 | 0.002 | 0.013 | **0.004** | 0.000 |
| Coast W AK | **0.481** | 0.036 | 0.410 | 0.481 | 0.550 | **0.463** | 0.029 |
| Mid-Yukon | **0.025** | 0.013 | 0.006 | 0.023 | 0.055 | **0.025** | 0.004 |
| Up Yukon | **0.025** | 0.012 | 0.006 | 0.024 | 0.052 | **0.025** | 0.005 |
| N AK Penn | **0.016** | 0.012 | 0.000 | 0.014 | 0.044 | **0.022** | 0.002 |
| NW GOA | **0.019** | 0.021 | 0.000 | 0.013 | 0.070 | **0.029** | 0.008 |
| Copper | **0.000** | 0.001 | 0.000 | 0.000 | 0.004 | **0.000** | 0.000 |
| NE GOA | **0.001** | 0.002 | 0.000 | 0.000 | 0.006 | **0.003** | 0.000 |
| Coast SE AK | **0.071** | 0.021 | 0.033 | 0.069 | 0.116 | **0.061** | 0.004 |
| BC | **0.210** | 0.028 | 0.158 | 0.209 | 0.268 | **0.219** | 0.015 |
| WA/OR/CA | **0.150** | 0.023 | 0.108 | 0.149 | 0.197 | **0.150** | 0.012 |

**Table 11**. -- Regional BAYES and SPAM stock composition estimates for the 289 Chinook salmon samples from the bycatch of the 2015 Bering Sea-Aleutian Island pollock trawl fishery from "B" season in area 521 and ADF&G Statistical Area 695600. The BAYES mean estimates are also provided with standard deviations (SD), 95% credible intervals, and the median estimate. Standard deviations for the SPAM estimates were determined by the analysis of 1,000 bootstrap resamplings of the mixture.

| Region | BAYES | SD | 2.5% | Median | 97.5% | SPAM | SD |
|---|---|---|---|---|---|---|---|
| Russia | **0.003** | 0.003 | 0.000 | 0.002 | 0.012 | **0.004** | 0.000 |
| Coast W AK | **0.469** | 0.034 | 0.402 | 0.469 | 0.534 | **0.442** | 0.027 |
| Mid-Yukon | **0.022** | 0.011 | 0.005 | 0.021 | 0.048 | **0.023** | 0.004 |
| Up Yukon | **0.023** | 0.011 | 0.006 | 0.022 | 0.047 | **0.022** | 0.005 |
| N AK Penn | **0.022** | 0.012 | 0.001 | 0.020 | 0.049 | **0.025** | 0.004 |
| NW GOA | **0.015** | 0.018 | 0.000 | 0.008 | 0.060 | **0.036** | 0.007 |
| Copper | **0.000** | 0.001 | 0.000 | 0.000 | 0.003 | **0.000** | 0.000 |
| NE GOA | **0.001** | 0.002 | 0.000 | 0.000 | 0.006 | **0.006** | 0.001 |
| Coast SE AK | **0.066** | 0.019 | 0.031 | 0.065 | 0.107 | **0.054** | 0.003 |
| BC | **0.220** | 0.027 | 0.169 | 0.219 | 0.274 | **0.227** | 0.015 |
| WA/OR/CA | **0.160** | 0.022 | 0.119 | 0.159 | 0.206 | **0.162** | 0.013 |

**Table 12**. -- Regional BAYES and SPAM stock composition estimates for the 301 Chinook salmon samples from the bycatch of the 2015 Bering Sea-Aleutian Island pollock trawl fishery from "B" season in areas 517 and 519. The BAYES mean estimates are also provided with standard deviations (SD), 95% credible intervals, and the median estimate. Standard deviations for the SPAM estimates were determined by the analysis of 1,000 bootstrap resamplings of the mixture.

| Region | BAYES | SD | 2.5% | Median | 97.5% | SPAM | SD |
|---|---|---|---|---|---|---|---|
| Russia | **0.000** | 0.002 | 0.000 | 0.000 | 0.004 | **0.003** | 0.004 |
| Coast W AK | **0.096** | 0.024 | 0.053 | 0.095 | 0.146 | **0.082** | 0.009 |
| Mid-Yukon | **0.008** | 0.006 | 0.000 | 0.007 | 0.023 | **0.009** | 0.001 |
| Up Yukon | **0.000** | 0.001 | 0.000 | 0.000 | 0.003 | **0.000** | 0.000 |
| N AK Penn | **0.006** | 0.009 | 0.000 | 0.000 | 0.029 | **0.013** | 0.004 |
| NW GOA | **0.127** | 0.027 | 0.077 | 0.127 | 0.182 | **0.125** | 0.013 |
| Copper | **0.002** | 0.004 | 0.000 | 0.000 | 0.014 | **0.007** | 0.001 |
| NE GOA | **0.003** | 0.007 | 0.000 | 0.000 | 0.024 | **0.009** | 0.002 |
| Coast SE AK | **0.063** | 0.023 | 0.025 | 0.061 | 0.114 | **0.079** | 0.005 |
| BC | **0.304** | 0.032 | 0.242 | 0.303 | 0.367 | **0.281** | 0.018 |
| WA/OR/CA | **0.391** | 0.029 | 0.335 | 0.391 | 0.449 | **0.394** | 0.024 |

**Table 13**. -- Regional BAYES and SPAM stock composition estimates for the 280 Chinook salmon samples from the bycatch of the 2015 Bering Sea-Aleutian Island pollock trawl fishery from "B" season in area 517 without ADF&G Statistical Area 695600 and area 519. The BAYES mean estimates are also provided with standard deviations (SD), 95% credible intervals, and the median estimate. Standard deviations for the SPAM estimates were determined by the analysis of 1,000 bootstrap resamplings of the mixture.

| Region | BAYES | SD | 2.5% | Median | 97.5% | SPAM | SD |
|---|---|---|---|---|---|---|---|
| Russia | **0.000** | 0.002 | 0.000 | 0.000 | 0.005 | **0.004** | 0.004 |
| Coast W AK | **0.069** | 0.023 | 0.030 | 0.067 | 0.120 | **0.057** | 0.008 |
| Mid-Yukon | **0.009** | 0.007 | 0.000 | 0.007 | 0.025 | **0.009** | 0.001 |
| Up Yukon | **0.000** | 0.001 | 0.000 | 0.000 | 0.003 | **0.000** | 0.000 |
| N AK Penn | **0.001** | 0.003 | 0.000 | 0.000 | 0.010 | **0.004** | 0.000 |
| NW GOA | **0.146** | 0.027 | 0.094 | 0.146 | 0.202 | **0.143** | 0.014 |
| Copper | **0.003** | 0.005 | 0.000 | 0.000 | 0.018 | **0.008** | 0.001 |
| NE GOA | **0.002** | 0.006 | 0.000 | 0.000 | 0.022 | **0.009** | 0.002 |
| Coast SE AK | **0.070** | 0.026 | 0.027 | 0.067 | 0.128 | **0.088** | 0.006 |
| BC | **0.300** | 0.034 | 0.235 | 0.299 | 0.366 | **0.274** | 0.018 |
| WA/OR/CA | **0.400** | 0.030 | 0.342 | 0.399 | 0.459 | **0.403** | 0.025 |

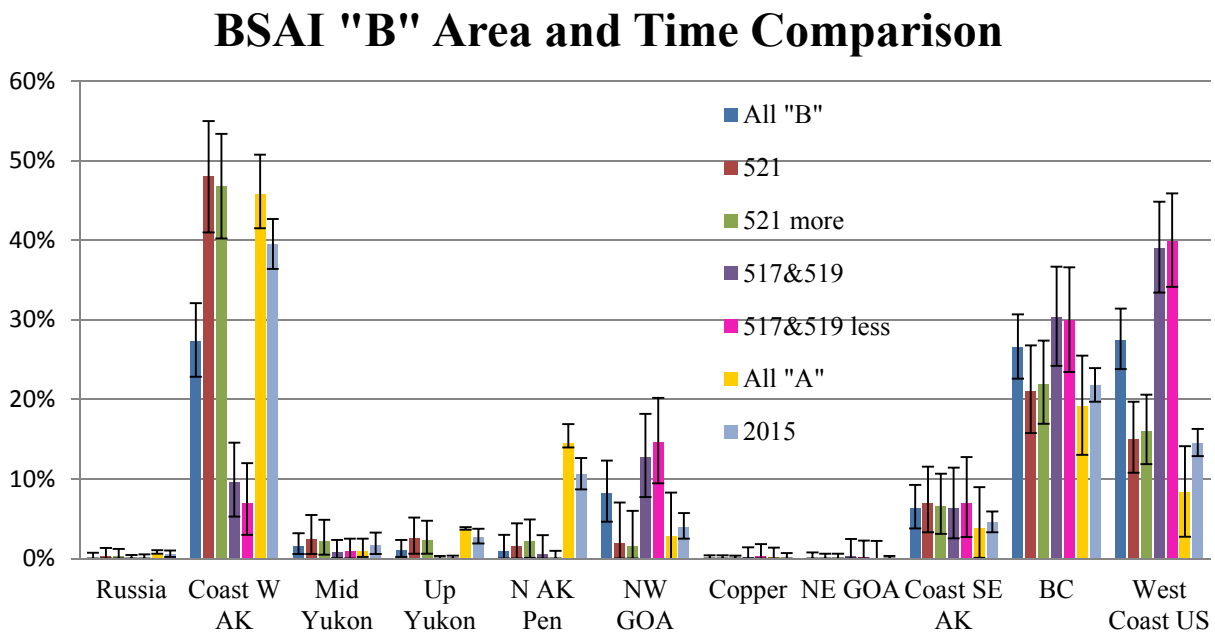


**Figure 9. --** Comparison of area and time stock composition estimates from the 2015 Bering Sea-Aleutian Island (BSAI) Chinook salmon bycatch for "B" season: All (576 samples), NMFS Area 521 (264 samples), NMFS Area 521 plus and ADF&G Statistical Area 695600 (289 samples, Fig. 10), NMFS Areas 517/519 (301 samples), and NMFS Areas 517/519 without ADF&G Statistical Area 695600 (280 samples, Fig. 9). Bering Sea "A" season (1,181 samples) and 2015 overall included for comparison purposes. BAYES 95% credible intervals are plotted for yearly estimates.

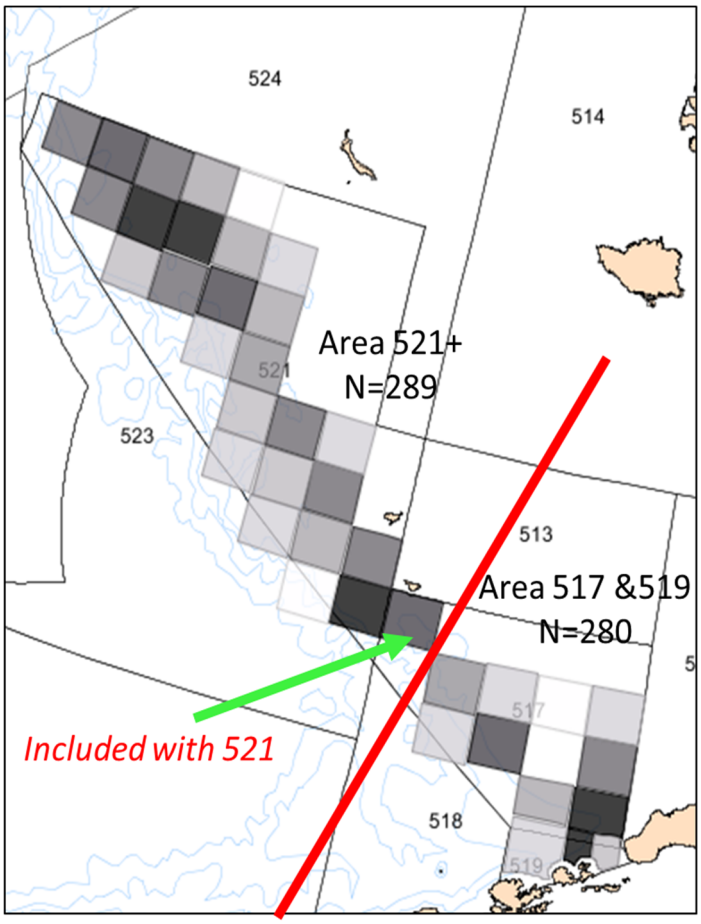


**Figure 10.** -- Location or area 521 and ADF&G Statistical Area 695600, and areas 517/519 without ADF&G Statistical Area 695600 strata used in comparative stock composition estimates from the 2015 Bering Sea-Aleutian Island Chinook salmon bycatch for "A" season (NMFS 2015).

## COMPARISON WITH PREVIOUS ESTIMATES

Stock compositions from the analysis of the 2015 "A" season Chinook salmon bycatch showed most samples continued to be from stocks originating from river systems directly flowing into the Bering Sea but were lower than in previous, with an increase from river drainages flowing into the GOA and Pacific Ocean. The Upper and Middle Yukon estimated contribution in 2011, 2013, 2014 and 2015 were at similar levels with 2012 being slightly lower

(Fig. 11). The 2015 "A" Coastal Western Alaska stock continued to be the largest contributor, but was lower than all previous years (Fig. 11).

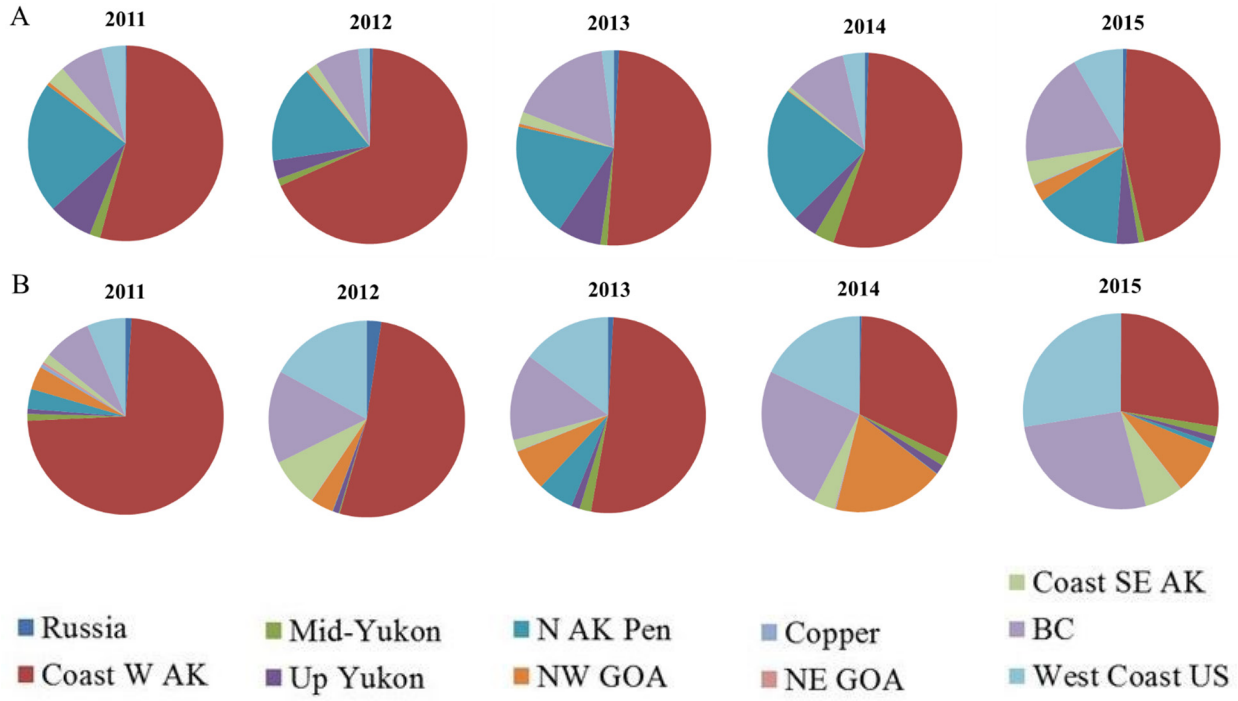


**Figure 11. --** Comparison of "A" season genetic stock composition estimates for 2011-2015 from the Bering Sea-Aleutian Island Chinook salmon bycatch (BSAI). Comparison of "B" season genetic stock composition estimates for 2011-2015 stock composition estimates from the BSAI "B" season Chinook salmon bycatch. The same genetic baseline and regional groupings were used in all analyses.

The 2015 "B" season stock composition estimates from Coastal Western Alaska continued to drop in comparison to the 2011-2014 estimates, a 46% decline in its proportion (Fig. 11). The 2015 "B" season estimates, continued the trend of increased contributions from British Columbia, West Coast U.S., and Coastal Southeast Alaska stocks (Fig. 11). The estimated relative contributions from the river drainages flowing into the GOA and Pacific Ocean have increased 48% since 2011 (Fig. 11). In contrast to 2011 and similar to most other previous years studied, most of the Chinook salmon bycatch occurred in 2015 during the "A" season.

As in previous years since 2011, systematic random sampling was employed in 2015, where genetic samples were collected from one of every 10 Chinook salmon encountered. While changes in sampling protocols between years necessitate caution in comparing analyses across years, when the stock compositions were analyzed for the entire year, the Coastal Western Alaska stock contribution trended downward between 2008 and 2010 but increased in 2011, and trended downward through 2015 (Fig. 12). The North Alaska Peninsula stock contribution has declined for the first time since 2009 composing 11% of the bycatch in 2015 (Fig. 12). The upper and middle Yukon River contribution continued to be low in 2015, while contributions from the Gulf of Alaska and Pacific Ocean migrating stocks have trended upward (Fig. 12).

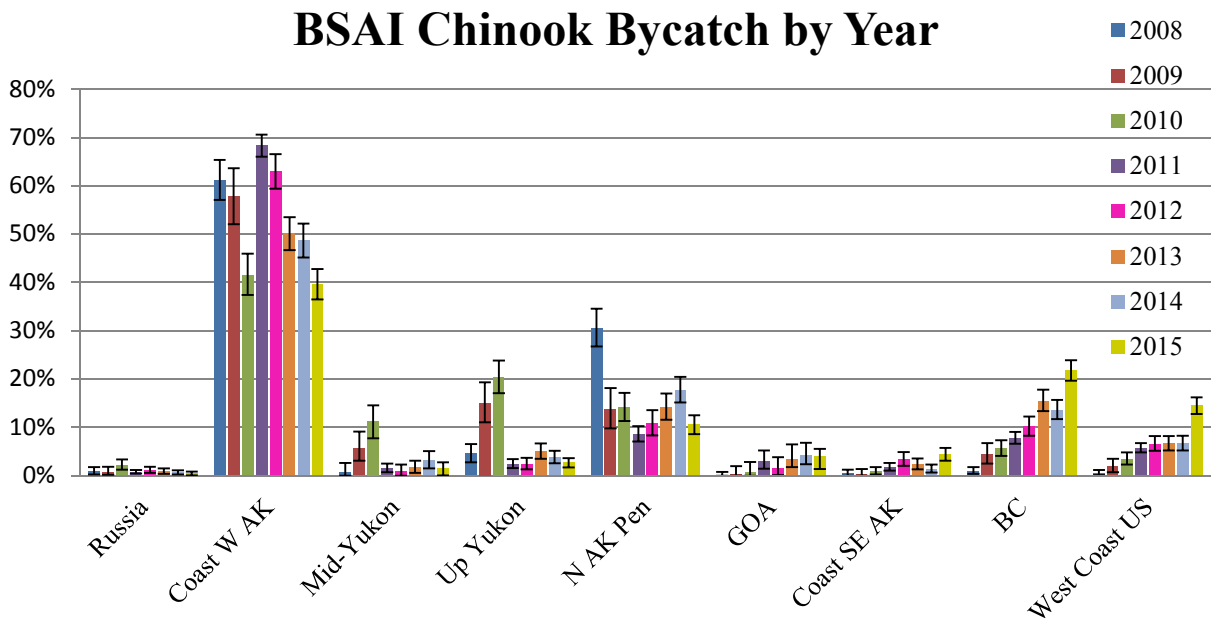


**Figure 12.** -- Comparison of yearly stock composition estimates (2008-2015) from the Bering Sea-Aleutian Island Chinook salmon bycatch. Estimates from 2011-2015 are overall bycatch estimates, whereas earlier compositions are of available sample sets. The same genetic baseline and general regional groupings were used in all analyses. Gulf of Alaska (GOA) group consists of combined values for Northwest GOA, Copper, and Northeast GOA. BAYES 95% credible intervals are plotted for yearly estimates.

# SUMMARY

Communities in western Alaska and elsewhere are dependent on Chinook salmon for subsistence and commercial purposes. Decreasing Chinook salmon returns to western Alaska rivers have caused hardships in these communities and led to fisheries disaster declarations for Yukon River Chinook salmon in 2010 and 2012 by the U.S. Secretary of Commerce (Locke 2010, Blank 2012), and in the Kuskokwim Rivers, and Cook Inlet in 2012 (Blank 2012). Salmon-dependent communities have expressed concern regarding the numbers of salmon caught as bycatch in the Bering Sea trawl fishery (Gisclair 2009). The incidental harvest of Chinook salmon in the Bering Sea pollock fishery averaged 35,845 salmon per year between 1991 and 2015, but increased to a peak of 121,770 in 2007 (NMFS 2016). The Bering Sea Chinook salmon bycatch has abated in more recent years dropping to a total of 18,329 Chinook salmon in 2015, a number which is 17,515 fish below the 25-year average. Stock composition estimates of the Chinook salmon bycatch are needed for pollock and salmon fishery managers to understand the biological effects of the incidental take of salmon in the trawl fishery. This report provides stock composition analysis of the Chinook salmon bycatch from the 2015 Bering Sea pollock trawl fishery. The results and limitations of this analysis are summarized below.

## Sampling Issues

With the implementation of systematic random sampling in the 2011, 2015 is the fifth year from which representative samples have been collected from the Chinook salmon bycatch. This represents a lot of effort over many years to develop standardized protocols for collecting sets of samples from numerous observers both at sea and in shore-based processing plants, the efforts of which are clearly apparent in the representative nature of the sample sets (Figs. 3 and

4). The final number of successfully genotyped Chinook salmon Bering Sea bycatch samples was 1,757, corresponding to an overall sampling rate in 2015 of 9.6%.

## Stock Composition Estimates

Genetic stock composition analysis showed the majority of bycatch samples collected in the Bering Sea were from Alaska stocks predominantly originating from river systems directly flowing into the Bering Sea. The stock composition of the Chinook salmon bycatch during the 2015 "A" season differed from the 2015 "B" season, demonstrating temporal differences in the stocks intercepted. This was especially apparent in the Coastal Western Alaska (46% vs. 27%), North Alaska Peninsula (15% vs. 1%), NW GOA (3% vs. 8%), British Columbia (19% vs. 27%), and West Coast U.S. (8% vs. 28%) stock groups. Spatial analysis showed that the stock compositions varied within season depending where the salmon in the bycatch were caught. For example, there was a higher concentration of Western Alaska origin stocks intercepted in the northern areas of the Bering Sea, and Pacific Northwest stocks intercepted in the southern areas of the Bering Sea (Figs. 5 and 9).

## Application of Estimates

The extent to which any salmon stock is impacted by the bycatch of the Bering Sea trawl fishery is dependent on many factors including 1) the overall size of the bycatch, 2) the age of the salmon caught in the bycatch, 3) the age of the returning salmon, and 4) the total escapement of the affected stocks taking into account lag time for maturity and returning to the river. As such, a higher contribution of a particular stock one year does not necessarily imply greater impact than a smaller estimate the next. Stock composition estimates for the 2015 Bering Sea

Chinook salmon bycatch were performed using representative samples and the estimates are considered to be representative of the overall bycatch for this year.

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# APPENDIX

Chinook salmon populations in the ADF&G SNP baseline with the regional designations used in the analyses of this report. S. = South, R. = River, H. = Hatchery, and L. = Lake.

| Population name | Reg num. | Region | Population name | Reg num. | Region |
|---|---|---|---|---|---|
| Bistraya River | 1 | Russia | Henshaw Creek | 3 | Mid Yukon |
| Bolshaya River | 1 | Russia | Kantishna River | 3 | Mid Yukon |
| Kamchatka River late | 1 | Russia | Salcha River | 3 | Mid Yukon |
| Pakhatcha River | 1 | Russia | Sheenjek River | 3 | Mid Yukon |
| Andreafsky River | 2 | Coast W AK | S. Fork Koyukuk River | 3 | Mid Yukon |
| Aniak River | 2 | Coast W AK | Big Salmon River | 4 | Up Yukon |
| Anvik River | 2 | Coast W AK | Blind River | 4 | Up Yukon |
| Arolik River | 2 | Coast W AK | Chandindu River | 4 | Up Yukon |
| Big Creek | 2 | Coast W AK | Klondike River | 4 | Up Yukon |
| Cheeneetnuk River | 2 | Coast W AK | Little Salmon River | 4 | Up Yukon |
| Eek River | 2 | Coast W AK | Mayo River | 4 | Up Yukon |
| Gagaryah River | 2 | Coast W AK | Nisutlin River | 4 | Up Yukon |
| George River | 2 | Coast W AK | Nordenskiold River | 4 | Up Yukon |
| Gisasa River | 2 | Coast W AK | Pelly River | 4 | Up Yukon |
| Golsovia River | 2 | Coast W AK | Stewart River | 4 | Up Yukon |
| Goodnews River | 2 | Coast W AK | Takhini River | 4 | Up Yukon |
| Kanektok River | 2 | Coast W AK | Tatchun Creek | 4 | Up Yukon |
| Kisaralik River | 2 | Coast W AK | Whitehorse Hatchery | 4 | Up Yukon |
| Kogrukluk River | 2 | Coast W AK | Black Hills Creek | 5 | N AK Pen |
| Kwethluk River | 2 | Coast W AK | King Salmon River | 5 | N AK Pen |
| Mulchatna River | 2 | Coast W AK | Meshik River | 5 | N AK Pen |
| Naknek River | 2 | Coast W AK | Milky River | 5 | N AK Pen |
| Nushagak River | 2 | Coast W AK | Nelson River | 5 | N AK Pen |
| Pilgrim River | 2 | Coast W AK | Steelhead Creek | 5 | N AK Pen |
| Salmon R. -Pitka Fork | 2 | Coast W AK | Anchor River | 6 | NW GOA |
| Stony River | 2 | Coast W AK | Ayakulik River | 6 | NW GOA |
| Stuyahok River | 2 | Coast W AK | Benjamin Creek | 6 | NW GOA |
| Takotna River | 2 | Coast W AK | Chignik River | 6 | NW GOA |
| Tatlawiksuk River | 2 | Coast W AK | Crescent Creek | 6 | NW GOA |
| Togiak River | 2 | Coast W AK | Crooked Creek | 6 | NW GOA |
| Tozitna River | 2 | Coast W AK | Deception Creek | 6 | NW GOA |
| Tuluksak River | 2 | Coast W AK | Deshka River | 6 | NW GOA |
| Unalakleet River | 2 | Coast W AK | Funny River | 6 | NW GOA |
| Beaver Creek | 3 | Mid Yukon | Juneau Creek | 6 | NW GOA |
| Chandalar River | 3 | Mid Yukon | Karluk River | 6 | NW GOA |
| Chena River | 3 | Mid Yukon | Kasilof River mainstem | 6 | NW GOA |

| Population name | Reg num. | Region | Population name | Reg num. | Region |
|---|---|---|---|---|---|
| Kenai River mainstem | 6 | NW GOA | Kowatua River | 9 | Coast SE AK |
| Killey Creek | 6 | NW GOA | Little Tatsemenie River | 9 | Coast SE AK |
| Ninilchik River | 6 | NW GOA | Macaulay Hatchery | 9 | Coast SE AK |
| Prairie Creek | 6 | NW GOA | Medvejie Hatchery | 9 | Coast SE AK |
| Slikok Creek | 6 | NW GOA | Nakina River | 9 | Coast SE AK |
| Talachulitna River | 6 | NW GOA | Tahltan River | 9 | Coast SE AK |
| Willow Creek | 6 | NW GOA | Unuk R.-Deer Mountain H. | 9 | Coast SE AK |
| Bone Creek | 7 | Copper | Unuk River - LPW | 9 | Coast SE AK |
| E. Fork Chistochina River | 7 | Copper | Upper Nahlin River | 9 | Coast SE AK |
| Gulkana River | 7 | Copper | Big Qualicum River | 10 | BC |
| Indian River | 7 | Copper | Birkenhead River spring | 10 | BC |
| Kiana Creek | 7 | Copper | Bulkley River | 10 | BC |
| Manker Creek | 7 | Copper | Chilko River summer | 10 | BC |
| Mendeltna Creek | 7 | Copper | Clearwater River summer | 10 | BC |
| Otter Creek | 7 | Copper | Conuma River | 10 | BC |
| Sinona Creek | 7 | Copper | Damdochax Creek | 10 | BC |
| Tebay River | 7 | Copper | Ecstall River | 10 | BC |
| Tonsina River | 7 | Copper | Harrison River | 10 | BC |
| Big Boulder Creek | 8 | NE GOA | Kateen River | 10 | BC |
| Kelsall River | 8 | NE GOA | Kincolith Creek | 10 | BC |
| King Salmon River | 8 | NE GOA | Kitimat River | 10 | BC |
| Klukshu River | 8 | NE GOA | Klinaklini River | 10 | BC |
| Situk River | 8 | NE GOA | Kwinageese Creek | 10 | BC |
| Tahini River | 8 | NE GOA | Louis River spring | 10 | BC |
| Tahini River - Pullen Creek H. | 8 | NE GOA | Lower Adams River fall | 10 | BC |
| Andrews Creek | 9 | Coast SE AK | Lower Atnarko River | 10 | BC |
| Blossom River | 9 | Coast SE AK | Lower Kalum River | 10 | BC |
| Butler Creek | 9 | Coast SE AK | Lower Thompson River fall | 10 | BC |
| Chickamin River | 9 | Coast SE AK | Marble Creek | 10 | BC |
| Chickamin River-LPW | 9 | Coast SE AK | Middle Shuswap R. summer | 10 | BC |
| Chickamin R.Whitman L. H. | 9 | Coast SE AK | Morkill River summer | 10 | BC |
| Clear Creek | 9 | Coast SE AK | Nanaimo River | 10 | BC |
| Cripple Creek | 9 | Coast SE AK | Nechako River summer | 10 | BC |
| Crystal Lake Hatchery | 9 | Coast SE AK | Nitinat River | 10 | BC |
| Dudidontu River | 9 | Coast SE AK | Oweegee Creek | 10 | BC |
| Genes Creek | 9 | Coast SE AK | Porteau Cove | 10 | BC |
| Hidden Falls Hatchery | 9 | Coast SE AK | Quesnel River summer | 10 | BC |
| Humpy Creek | 9 | Coast SE AK | Quinsam River | 10 | BC |
| Kerr Creek | 9 | Coast SE AK | Robertson Creek | 10 | BC |
| Keta River | 9 | Coast SE AK | Salmon River summer | 10 | BC |
| King Creek | 9 | Coast SE AK | Sarita River | 10 | BC |

| Population name | Reg num. | Region | Population name | Reg num. | Region |
|---|---|---|---|---|---|
| Stuart River summer | 10 | BC | Lower Deschutes R. fall | 11 | West Coast US |
| Sustut River | 10 | BC | Lyons Ferry H. summer/fall | 11 | West Coast US |
| Torpy River summer | 10 | BC | Makah National Fish H. fall | 11 | West Coast US |
| Wannock River | 10 | BC | McKenzie River spring | 11 | West Coast US |
| Alsea River fall | 11 | West Coast US | Sacramento River winter | 11 | West Coast US |
| Carson Hatchery spring | 11 | West Coast US | Siuslaw River fall | 11 | West Coast US |
| Eel River fall | 11 | West Coast US | Soos Creek Hatchery fall | 11 | West Coast US |
| Forks Creek fall | 11 | West Coast US | Upper Skagit River summer | 11 | West Coast US |
| Hanford Reach | 11 | West Coast US | | | |
| Klamath River | 11 | West Coast US | | | |

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