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Genetic Stock Composition Analysis of Chum Salmon from the Prohibited Species Catch of the 2020 Bering Sea Walleye Pollock Trawl Fishery

P. D. Barry, C. M. Kondzela, J. A. Whittle, J. T. Watson,
K. Karpan, K. D'Amelio, and W. A. Larson

November 2022

U.S. DEPARTMENT OF COMMERCE

National Oceanic and Atmospheric
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National Marine Fisheries Service
Alaska Fisheries Science Center

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ABSTRACT

We analyzed genetic stock compositions of chum salmon prohibited species catch (PSC), referred to as “bycatch”, samples collected from the 2020 walleye pollock (*Gadus chalcogrammus*) fishery in the Bering Sea. Samples were genotyped for 84 single nucleotide polymorphism markers from which stock contributions were estimated using a range-wide chum salmon baseline developed by the Alaska Department of Fish and Game. The chum salmon bycatch was 343,821 fish, up from the 10-year average of 226,304. The timing of the chum salmon bycatch was atypically late in 2020, with 50% of the bycatch encountered by statistical week 35 (average of 2011–2019 was week 33). Environmental covariates (Pacific Decadal Oscillation, sea surface temperature, warm pool, and sea ice extent) were evaluated for correlations with bycatch timing measured as the statistical week by which 50% of the chum salmon bycatch had been caught. Mean sea ice extent from January and February was positively correlated with bycatch timing; however, fishing effort was also delayed, with fewer hauls occurring prior to week 25 than in previous years. The contribution of Western Alaska and Upper/Middle Yukon fish was smaller than in previous years (9% versus an average of ~20% over the last decade). Even though the total chum salmon bycatch was higher than average, the number of Western Alaska and Upper/Middle Yukon fish caught was lower (30,908 in 2020 compared to an average of 51,515 from 2011 to 2019). Relative to prior years the contribution of Eastern Gulf of Alaska/Pacific Northwest (EGOA/PNW) stocks was larger than typical (42.5% versus a long-term average of ~28%, which was similar to 2015, when EGOA/PNW stocks comprised 51.4% of the bycatch and bycatch occurred later in the season. Conversely, the contribution from Northeast Asia stocks was slightly below average (32% versus a long-term average of 36%). In summary, although total chum bycatch was higher than average, the contribution of Western Alaska and Upper/Middle Yukon fish was lower than average, leading to a lower catch of Western Alaska and Upper/Middle Yukon fish.

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INTRODUCTION

Pacific salmon (*Oncorhynchus* spp.) are prohibited species in the federally managed Bering Sea and Gulf of Alaska (GOA) groundfish fisheries, which are subject to complex management rules (NPFMC 2020a, b) that are in part designed to reduce prohibited species catch (PSC). It is important to understand the stock composition of Pacific salmon caught in these fisheries, which take place in areas that are known feeding habitat for multiple brood years of chum salmon (*O. keta*) from many different localities in North America and Asia (Myers et al. 2007, Davis et al. 2009, Urawa et al. 2009). Determining the geographic origin of salmon caught in federally managed fisheries is essential for understanding the effects that fishing has on chum salmon stocks, especially those with conservation concerns (NPFMC 2012).

We present the genetic stock composition estimates for the samples of chum salmon PSC collected during 2020 from the U.S. Bering Sea walleye pollock (*Gadus chalcogrammus*) trawl fishery. In 2020, the Bering Sea pollock fishery accounted for 97% of the total chum salmon taken in the groundfish fisheries (NMFS 2022a). The samples collected from the 2020 GOA groundfish fisheries were not analyzed due to restricted access to the laboratory during the COVID-19 pandemic.

For additional background and methods, this report is intended to be supplemented with the chum salmon reports prepared previously for the 2005-2019 Bering Sea trawl fisheries (Guyon et al. 2010; Marvin et al. 2011; Gray et al. 2010, 2011a,b; Kondzela et al. 2012, 2013, 2016, 2017, 2021; Vulstek et al. 2014; Whittle et al. 2015, 2018, 2021a, b). The chum salmon PSC is designated as non-Chinook (*O. tshawytscha*) in the NMFS database and comprises over 95% of the non-Chinook category in the Bering Sea (NPFMC 2007).

METHODS

Bycatch Sampling and Genotyping

Data from the Alaska Fisheries Science Center (AFSC) Fisheries Monitoring and Analysis Observer Program (Observer Program), total chum salmon bycatch, and genetic sample

information were downloaded from the AFSC schema in the Alaska Fisheries Information Network (AKFIN) database (NMFS 2022b). The AFSC Auke Bay Laboratories (ABL) Genetics Program received 11,261 genetic samples from the Bering Sea and 104 samples from the Gulf of Alaska (GOA). Because of the small number of samples and restrictions on access to the genetics laboratory during the COVID pandemic, the GOA chum salmon samples were not analyzed. Biases and errors associated with non-systematic collections of genetic samples from the salmon bycatch have the potential to affect stock composition estimates (NMFS 2009, Pella and Geiger 2009). Since 2011, the bycatch in the Bering Sea has been sampled with a systematic sampling protocol (Pella and Geiger (2009) to reduce sampling error and bias. We evaluated the sampling proportions by plotting the bycatch by statistical week and NMFS statistical area and using Chi-square test where statistical weeks were pooled if the expected number of genetic samples were fewer than five.

After inventorying the Bering Sea genetic samples received, a 1-in-5 subsample was conducted for genotyping. DNA from 2,628 chum salmon, 23.3% of the total genetic samples collected by the Observer Program, was extracted and amplified for the 84-single nucleotide polymorphism (SNP) GT-Seq panel (Appendix Table A-1). The subsample exceeded the target of 20% (1-in-5) to obtain sufficient sample sizes for certain temporal and spatial strata (e.g., Cluster 4 Late). Samples that were not genotyped for greater than 80% of the GT-Seq panel (minimum of 68 loci) were omitted from analyses. Of the 2,628 samples amplified, 2,258 (86%) were of adequate quality to include for stock composition analyses (20.1% of the total sample collection).

We re-amplified and re-genotyped 3% of the subset samples in the laboratory for quality control. The allele calls of these quality control samples were compared with the allele calls of the originally genotyped samples to estimate the genotyping error rates. The average agreement over loci was 99.7% and the average agreement among individuals was also high, 99.1%, indicating high genotyping accuracy and correct sample organization.

Mixed Stock Analysis

Sequencing libraries were prepared using the Genotyping-in-Thousands by Sequencing (GT-seq) protocol (Campbell et al. 2015). PCR was performed on extracted DNA with primers

that amplify 84 SNP loci in the WASSIP chum panel (DeCovich et al. 2012; Appendix Table A-1). These PCR products were then indexed in a barcoding PCR, normalized using SequelPrep plates (Invitrogen), and each 96-well plate was subsequently pooled. Next, a double-sided bead size selection was performed using AMPure XP beads (Beckman Coulter), in ratios of 0.5× beads-to-library to remove larger non-target fragments and then 1.2× to retain the desired amplicon. Libraries were sequenced on a MiSeq™ System (Illumina) using a single 150-cycle lane run with 2 × 75 bp paired-end (PE) chemistry. PE reads for each individual were joined with FLASH2 (Magoč and Salzberg, 2011; <https://github.com/dstrett/FLASH2>). Merged reads were genotyped with the R package GTscore (McKinney; <https://github.com/gjmckinney/GTscore>). Individuals with low-quality multilocus genotypes (< 80% of loci scored) were discarded.

Mixtures of genotyped fish were created by separating sampled fish into spatial and temporal strata from Observer Program data in the AKFIN database. Genetic stock identification was performed with the conditional genetic stock identification model in the R package rubias (Moran and Anderson 2019). As described previously (Gray et al. 2010) and with minor changes to regional group names, baseline populations were grouped into six regions: Southeast Asia (SE Asia), Northeast Asia (NE Asia), Western Alaska (W Alaska), Upper/Middle Yukon (Up/Mid Yukon), Southwest Alaska (SW Alaska), and the Eastern Gulf of Alaska/Pacific Northwest (EGOA/PNW; Fig. 1; Appendix Table B-1). For all estimates, the Dirichlet prior parameters for the stock proportions were defined by region to be $1/(GC_g)$, where C_g is the number of baseline populations in region g , and G is the number of regions. To ensure convergence to the posterior distribution, six separate MCMC chains of 100,000 iterations (burn-in of 50,000) of the non-bootstrapped model were run. Each chain was started at disparate values of stock proportions and configured such that for each chain 95% of the mixture came from a single designated region (with probability equally distributed among the populations within that region) and the remaining 5% equally distributed among remaining populations from all other regions. The convergence of chains for each regional group estimate was assessed with the Gelman-Rubin statistic (Gelman and Rubin 1992) estimated with the `gelman.diag` function in the coda library (Plummer et al. 2006) within R. Once chain convergence was confirmed, inference was conducted with the conditional genetic stock identification model with bootstrapping over regional groups (MCMC chains of 100,000 iterations, burn-in of 50,000, 100 bootstrap iterations).

The stock composition estimates were summarized by the mean, standard deviation, median, 95% credible interval (2.5th and 97.5th percentile of the MCMC iterates in the posterior output), and $P = 0$, which is the probability that a stock composition estimate is effectively zero (Munro et al. 2012). The $P = 0$ statistic is the frequency of the last half of the MCMC iterates of each chain for which the individual regional contribution to the mixture was less than a threshold of $0.5E^{-6}$. This statistic may be more useful than the credible interval for assessing the presence or absence of minor stocks.

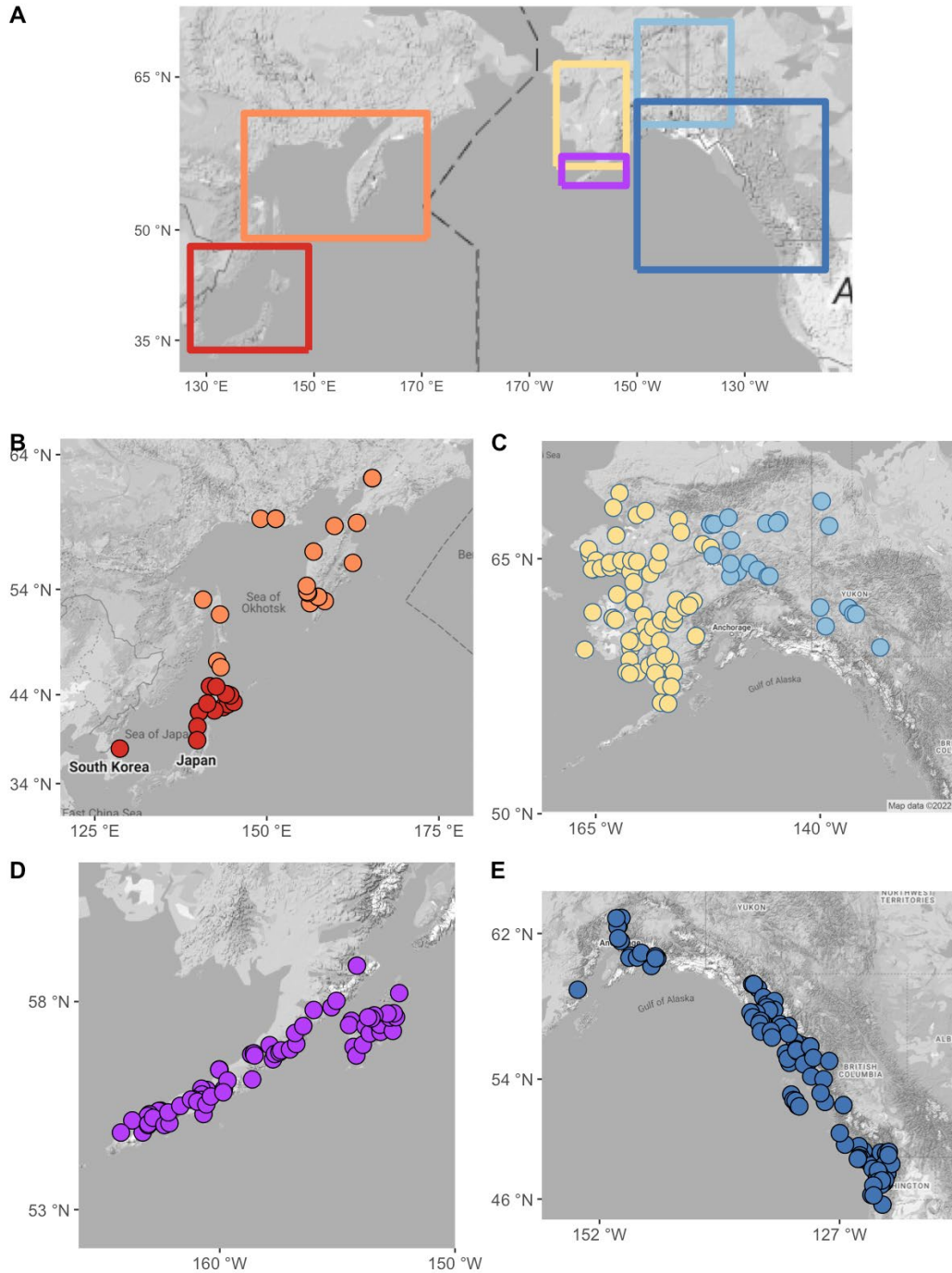


Figure 1. -- Six regional groups of baseline chum salmon populations used in this report, circles represent individual populations represented in the baseline. (A) Range wide distribution of the six regional groups. (B) SE Asia (red) and NE Asia (orange), (C) W Alaska (yellow) and Up/Mid Yukon (medium blue), (D) SW Alaska (purple), and (E) EGOA/PNW (dark blue) regional groups. For a complete list of populations within each regional group see Appendix Table B-1.

SAMPLING DISTRIBUTION

Genetic sampling among statistical weeks and NMFS statistical areas was representative of the overall bycatch ($\chi^2 = 1086$, $df = 1764$, $p = 0.24$). While there was some under-sampling of small catches in NMFS areas 521 and 523 late in the B-season (Fig. 2), there was no evidence to suggest substantial bias in either spatial or temporal representation. When evaluated on a per vessel basis, the correlation between the number of genetic samples collected closely followed the 1-in-30 Observer Program sampling protocol ($r^2 = 0.99$; AFSC 2019).

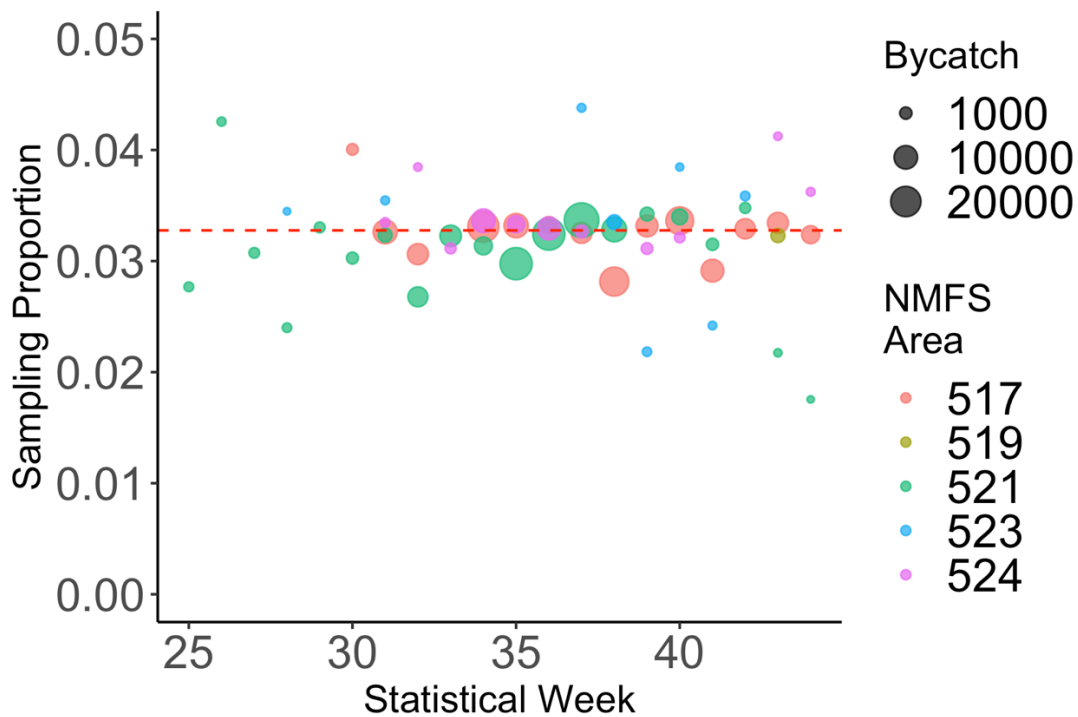


Figure 2. -- Sampling proportion of chum salmon prohibited species catch (PSC) for the B-season from the Bering Sea pollock-directed trawl fishery by statistical week and NMFS statistical areas. The dotted horizontal line represents the realized mean sampling rate over NMFS statistical area and week (0.033) which was the same as the Observer Program 1-in-30 sampling protocol.

BYCATCH SUMMARY

Temporal Trends

The chum salmon prohibited species catch, referred to as “bycatch” throughout this report, in the Bering Sea walleye pollock trawl fishery was 343,821 fish in 2020, with 343,014 fish in the B-season (Fig. 3). This was 117,517 fish greater than the 10-year average of 226,304 (SD 145,306). As is typical, over 99% of the bycatch of chum salmon occurred in the B-season (between June and October). Within the B-season, the chum salmon were caught later than in the previous six years (Fig. 4). For example, the 2020 chum salmon bycatch did not increase until after the 30th statistical week, when nearly 75% of the bycatch had already occurred in 2017.

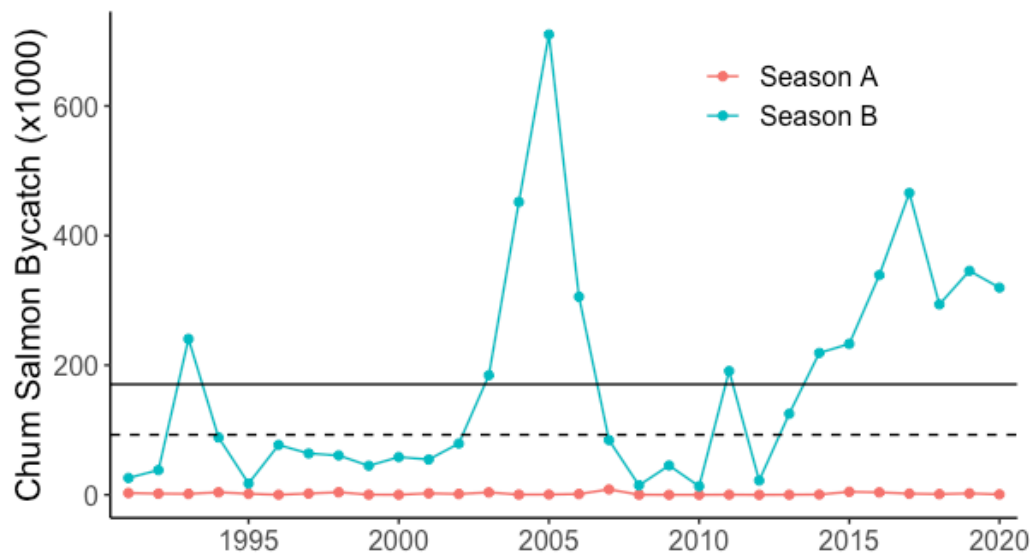


Figure 3. -- Chum salmon prohibited species catch (PSC; bycatch) for the A- and B-seasons from the Bering Sea pollock trawl fishery. The solid horizontal line represents the mean PSC and the dashed line represents the median PSC from 1991 to 2019.

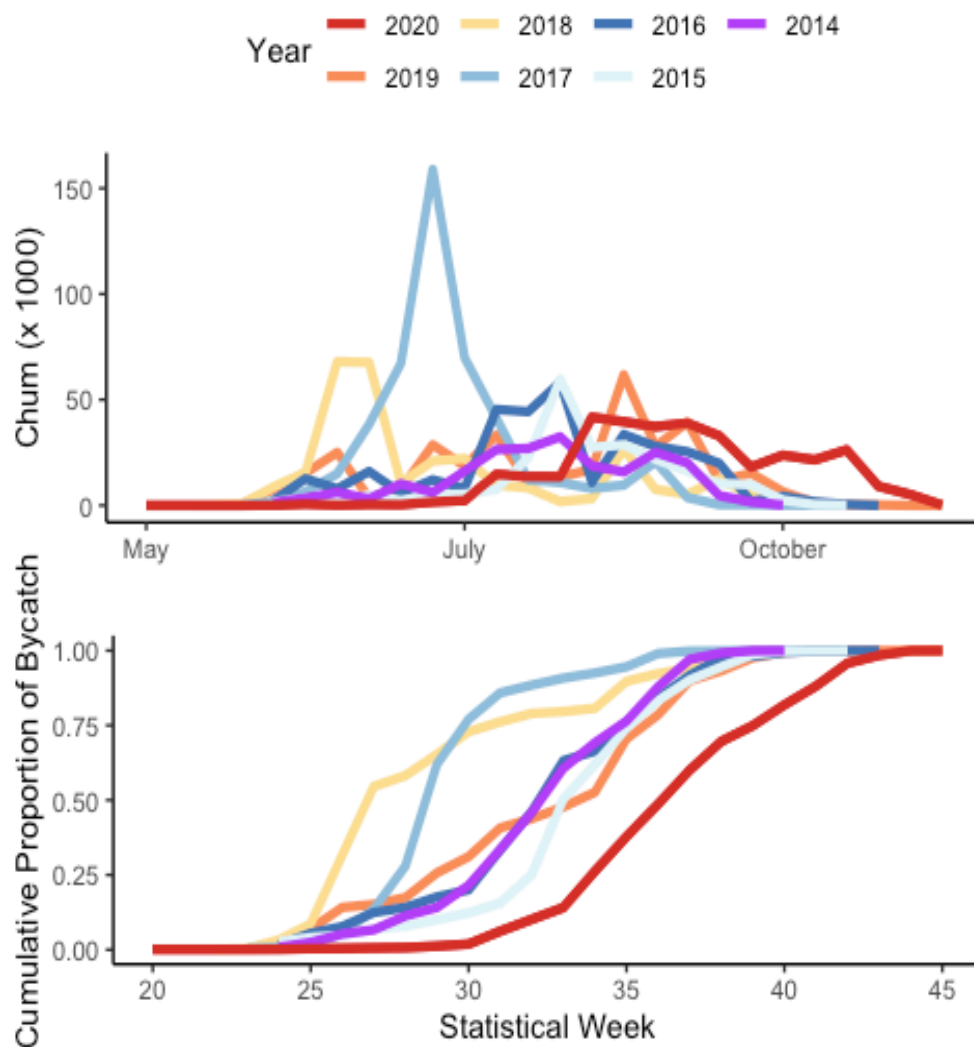


Figure 4. -- Number of chum salmon caught during the B-season (top) and cumulative proportion of chum salmon catch (bottom) from the Bering Sea pollock trawl fishery by statistical week for years 2015 to 2020.

The timing of the chum salmon bycatch could be the result of the seasonally changing spatial distribution of chum salmon in response to environmental conditions, following prey species that may be responding to environmental conditions, how the fleet allocates fishery effort, or a combination of these and other factors. We explored several environmental covariates with bycatch encounter data. We investigated the correlations between bycatch timing, as measured by when fifty percent of the bycatch was caught, and climate drivers such as sea surface temperature (SST), the Pacific Decadal Oscillation (PDO), sea ice extent, and warm pool

extent (Hoerling et al. 2010). Climate data were downloaded from NOAA’s Physical Science Laboratory climate indices data repository (<https://psl.noaa.gov/data/climateindices/>). All climate covariates for the time series, except for SST were expressed in anomalies or deviations from the long-term average.

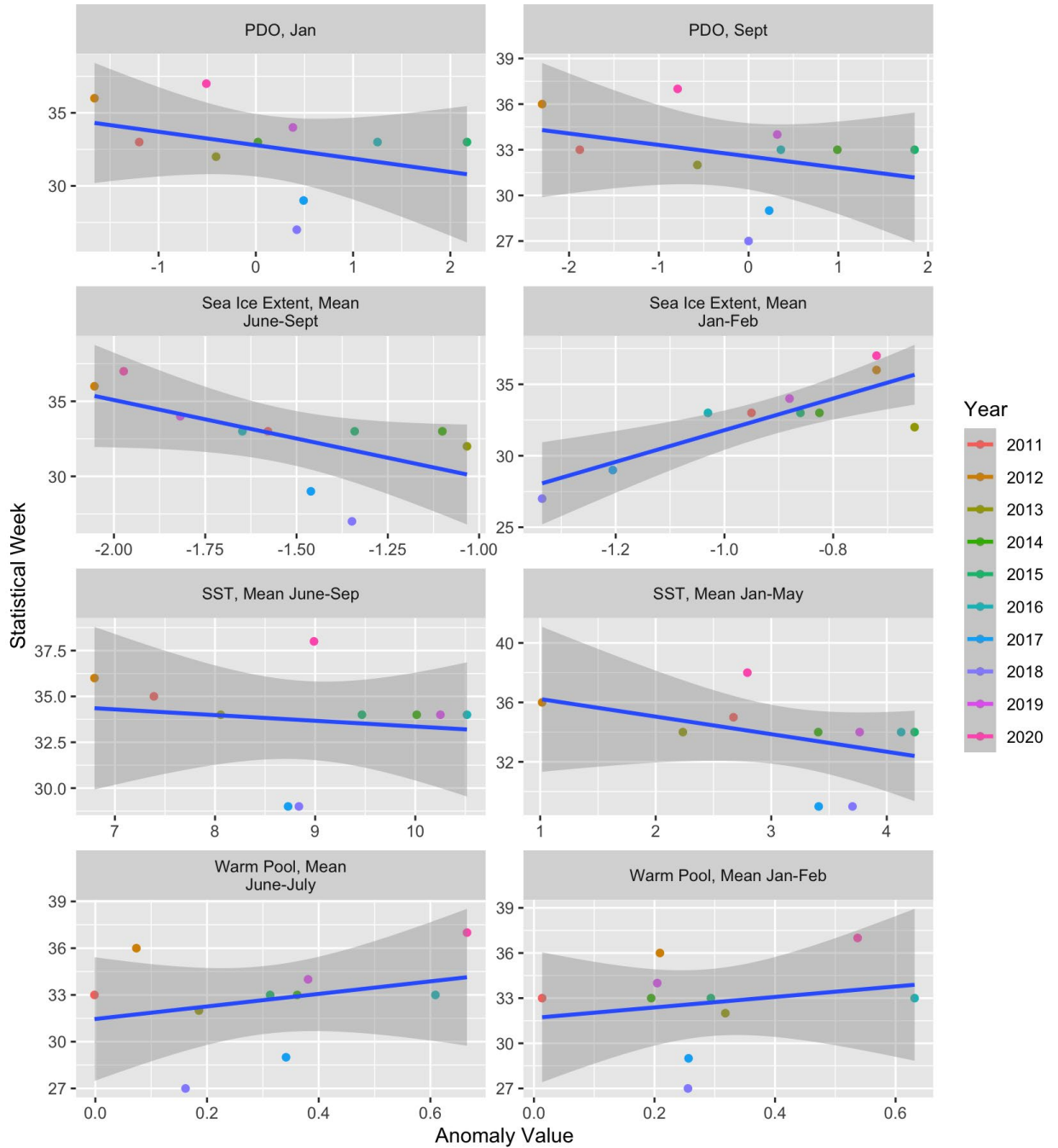


Figure 5. -- Correlation of climate covariates – PDO, sea ice extent, SST, and warm pool extent – and the statistical week by which 50% of the chum salmon PSC were caught.

The correlations between climate indices and timing of chum salmon catch are not strong (Fig. 5), potentially due in part to the substantial variation in the timing of bycatch, particularly in 2017 and 2018 when most of the chum salmon were caught very early in the B-season. We evaluated the relationship between chum salmon bycatch timing and the environmental indices measured over individual months and aggregated over seasons, but only those periods with the strongest correlations for each index are displayed in this report. The extent of sea ice was the environmental covariate with the strongest correlation (Fig. 5, second row down). As the sea ice extent anomaly between June and September becomes more negative (less sea ice), chum salmon tend to be caught earlier. However, as the sea ice extent anomaly between January and February becomes less negative, the chum salmon bycatch occurs later, although 2017 and 2018 have high leverages in determining the relationship. The oscillating control hypothesis (OCH) states that when there is early ice retreat, there is a later plankton bloom with warmer waters is dominated by smaller copepod species. Alternatively, when the ice retreat is late there is an early bloom associated with colder water and large *Calanus* copepods dominate (Hunt Jr. et al. 2002). In warmer years, when large copepods or euphausiids are not as abundant, we speculate that chum salmon may delay migrating onto the shelf area where the majority of pollock trawls occur.

We also investigated the fishing behavior of the fleet as chum salmon bycatch encounter timing could be a byproduct of fishing effort that occurs either earlier or later in the B-season. The number of unique pollock hauls by statistical week was used as a proxy of effort, without accounting for the haul duration (Fig. 6). These data are non-confidential and weeks with fewer than three unique vessels have been excluded, which removes the early and late ends of the distributions, but is inconsequential for the general trend. In 2011 and 2020, two of the years in which chum salmon bycatch occurred late in the B-season, substantial fishing effort continued later into the season than in other years. In contrast, the 2017 and 2018 B-season were characterized by high bycatch early in the season (Fig. 4) with earlier fishing effort (Fig. 6).

In summary, there appears to be a relationship between the timing of chum salmon bycatch and both environmental covariates as well as the timing of fishing effort; however, to disentangle environmental factors and trends in fishing effort a more thorough investigation is required, which is outside the scope of this report.

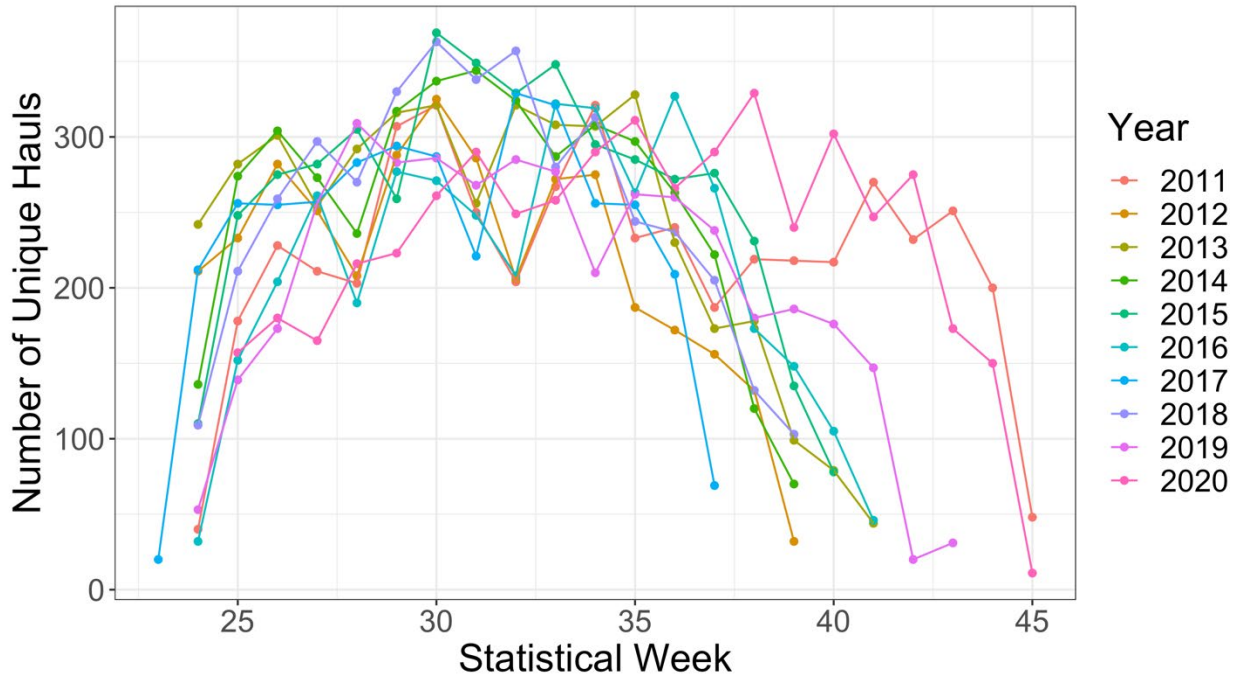


Figure 6. -- Number of unique hauls per week by pollock trawl vessels fishing in the Bering Sea, B-season.

Spatial Trends

The geographical distribution of the chum salmon bycatch was highly dispersed over the continental shelf in 2020 (Fig. 7), with high rates of bycatch in each of the four spatial clusters of Alaska Department of Fish and Game (ADF&G) groundfish statistical areas previously defined by the AFSC ABL Genetics Program (Appendix Table C-1). The highly dispersed bycatch in 2020 is consistent with the observation that years with colder summers (e.g., 2011 and 2012) are typically characterized by lower adult pollock abundance (J. Watson, pers. comm.), and the fleet is more dispersed with some catcher-processor vessels traveling far to the northwest (but see Eisner et al. 2020).

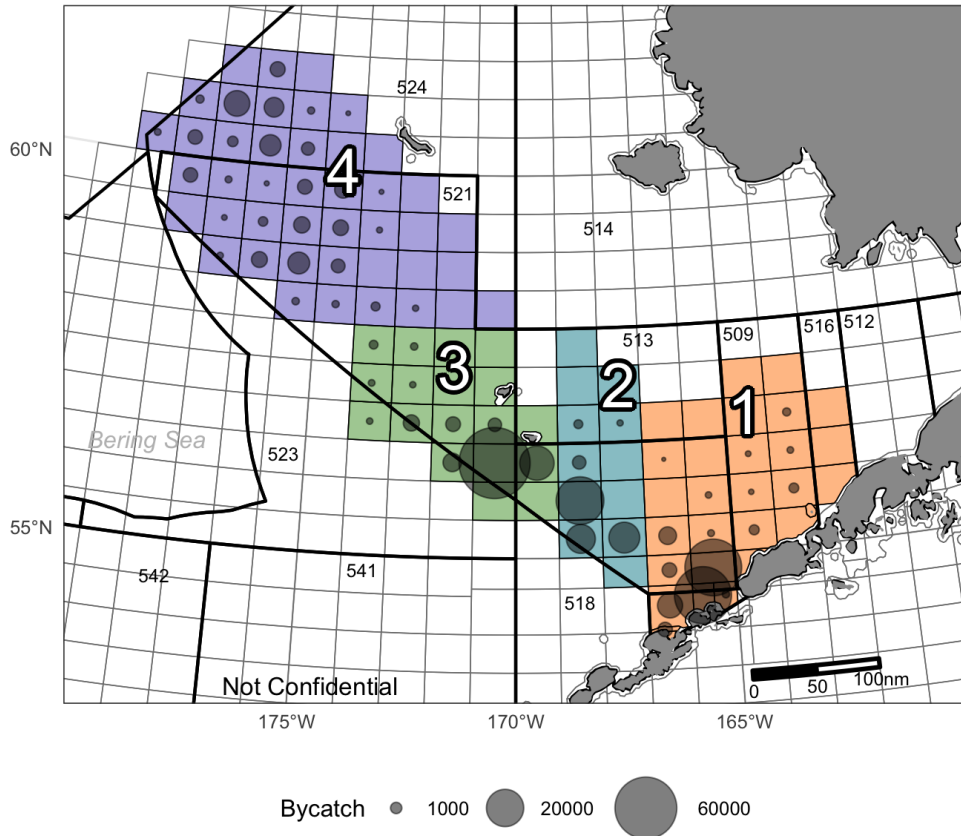


Figure 7. -- Spatial distribution of chum salmon bycatch caught in the 2020 Bering Sea, B-season pollock fishery. ADF&G groundfish statistical areas are highlighted based on the four geographic strata assigned in prior genetic analyses. For a complete list of ADF&G stat areas included in each cluster see Appendix Table C-1.

To evaluate shifts in the distribution of the chum salmon bycatch, the centroid (center of the bycatch) was calculated for each year by sector: catcher-processor (CP), mothership (M), and shoreside (S). The spatial arrangement of the centroid was investigated for associations with sea surface temperature (not shown) and sea ice extent anomaly. The centroid of the 2020 chum salmon bycatch for all sectors was further west than on average. The catcher-processor sector was nearly the most western of the time series (2011–2020), most similar to 2014 and 2019 (Fig. 8, CP). Also, in years with more negative sea ice extent anomalies (less sea ice), the centroid of the catcher-processor sector is further west than in years with a less negative sea ice

extent anomaly. The exception to this pattern occurred in 2014 which had a less negative anomaly but was the most western centroid. The 2020 centroid for the mothership sector was similarly farther west than typical (Fig. 8, M) and was similar to years 2014 and 2019. The distribution of the shoreside sector centroids was much more concentrated than the catcher-processor and mothership sectors and the 2020 centroid was also the farthest west of the time series.

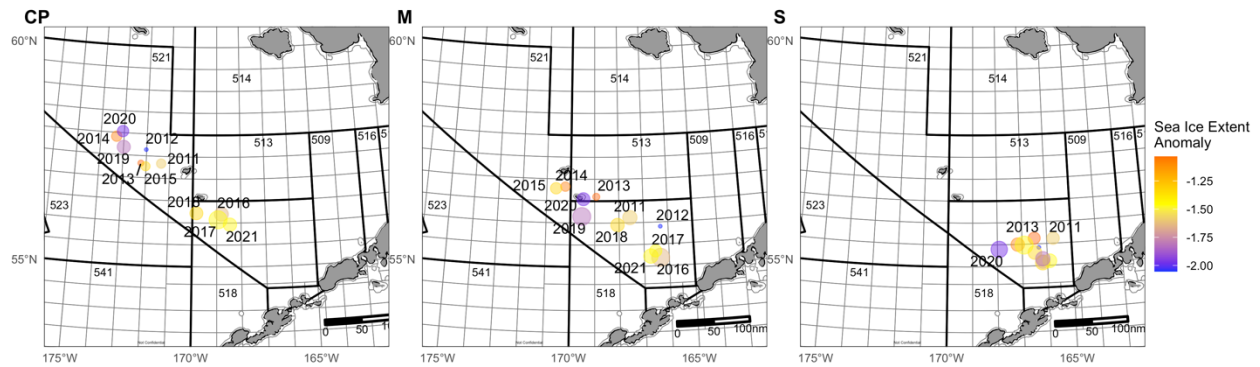


Figure 8. -- Change in the spatial distribution of chum salmon bycatch as measured by the centroid of the bycatch by sector; catcher-processor (CP), mothership (M), and shoreside (S). Point sizes reflect the relative size of the bycatch and point colors reflect the mean sea ice extent anomaly between June and September.

GENETIC STOCK COMPOSITION

Overall Trends

Consistent with prior years, the three Alaska-only regional groups comprised the smallest contribution (13%) to the chum salmon bycatch in the 2020 Bering Sea, B-season (Fig. 9, Table 1). The highest contributions were from SE Asia and NE Asia (44.6%) and EGOA/PNW (42.5%) regional groups, the latter being considerably higher than the long-term average of ~28% (2011–2019). The large estimate of the EGOA/PNW stock group is not however completely atypical. In 2015, 51% of the B-season bycatch was comprised of EGOA/PNW fish. In both 2015 and 2020 the bycatch occurred late in the season (Fig. 4). It is possible that delayed fishing effort results in a larger proportion of EGOA/PNW stocks represented in the bycatch, particularly if the majority of the bycatch occurs within the shoreside sector in the Eastern Bering Sea near the Alaska Peninsula (Figs. 7 and 8). Alternatively, increasing contributions of

EGOA/PNW fish may be occurring throughout the B-season. The mean age of bycatch samples has decreased though time (E. Yasumiishi, AFSC-ABL, pers. comm.), which supports an increase in abundance of EGOA/PNW stocks as chum salmon of southern origin; that is, Gulf of Alaska and Pacific Northwest stocks, mature at younger ages than in the northern Bering Sea stocks (Salo 1991). Changes in age of the chum salmon bycatch may signify a shift of southern stocks into northern waters; however, the age at maturity of salmon across their range has been decreasing (Oke et al. 2020). These hypotheses are being evaluated with paired age and genetic information from 2005 to 2019 (E. Yasumiishi, AFSC-ABL, pers. comm.).

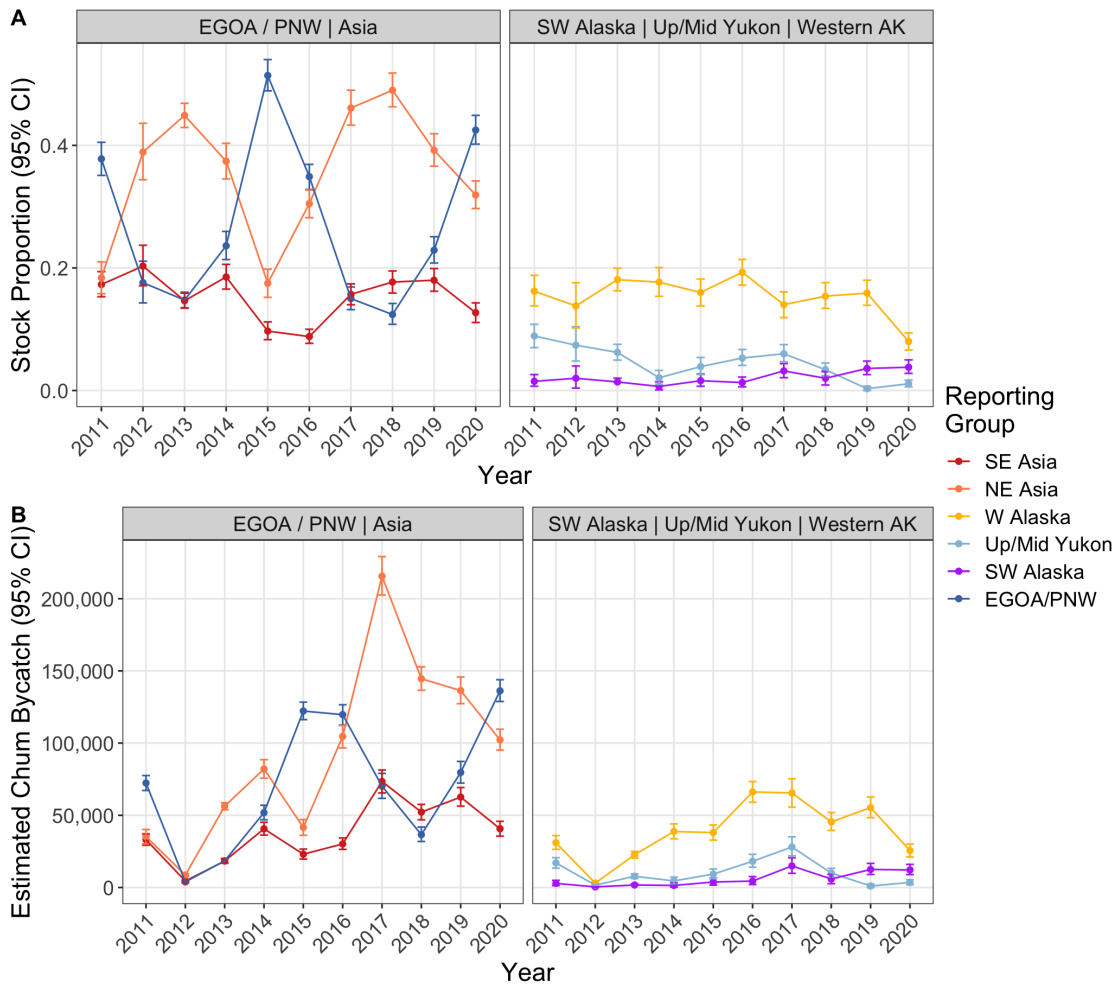


Figure 9. -- Annual bycatch estimates of B-season chum salmon PSC from 2011 to 2021; (A) stock proportions with 95% credible intervals and (B) estimated number of chum salmon with 95% credible intervals.

Table 1. -- Regional stock composition estimates of chum salmon from the 2020 Bering Sea, B-season pollock fishery (PSC = 343,014; n = 1,816 samples). The estimated number of chum salmon bycatch and credible interval, and mean proportion are provided with 95% credible intervals, median estimate, P = 0 statistic and the Gelman-Rubin shrink factor (SF).

Region	Est. num.	Est. CI	Mean	2.5%	Median	97.5%	P=0	SF
SE Asia	43,465	38,106-49,027	0.127	0.111	0.127	0.143	0.00	1.00
NE Asia	109,335	101,646-117,209	0.319	0.297	0.319	0.342	0.00	1.00
W Alaska	27,246	22,665-32,150	0.080	0.066	0.079	0.094	0.00	1.00
Up/Mid Yukon	3,607	1,910-5,809	0.011	0.006	0.010	0.017	0.00	1.00
SW Alaska	13,174	9,644-17,135	0.038	0.028	0.038	0.050	0.00	1.00
E GOA/PNW	145,562	137,521-153,579	0.425	0.402	0.425	0.449	0.00	1.00

Temporal Trends

The B-season was divided into Middle (weeks 30–34) and Late (post-week 34) time periods to evaluate if regional group contributions changed through the season. Too few samples were available to run an analysis on the Early time period (prior to week 30). For each of the Alaska stocks, the Middle and Late stock contributions were similar. However, there was a substantial shift in catch composition between the Middle and Late time periods (Fig. 10). The EGOA/PNW stocks increased from 23% in the Middle time period to 49% in the Late time period and the NE Asia stocks, which had the opposite trend, decreasing from 47.5% in the Middle time period to 27.3% in the Late time period. In 2015, a year with a similarly high contribution of EGOA/PNW stocks, there was a similar increase from the Early time period (13%) to the Middle and Late time periods (55%).

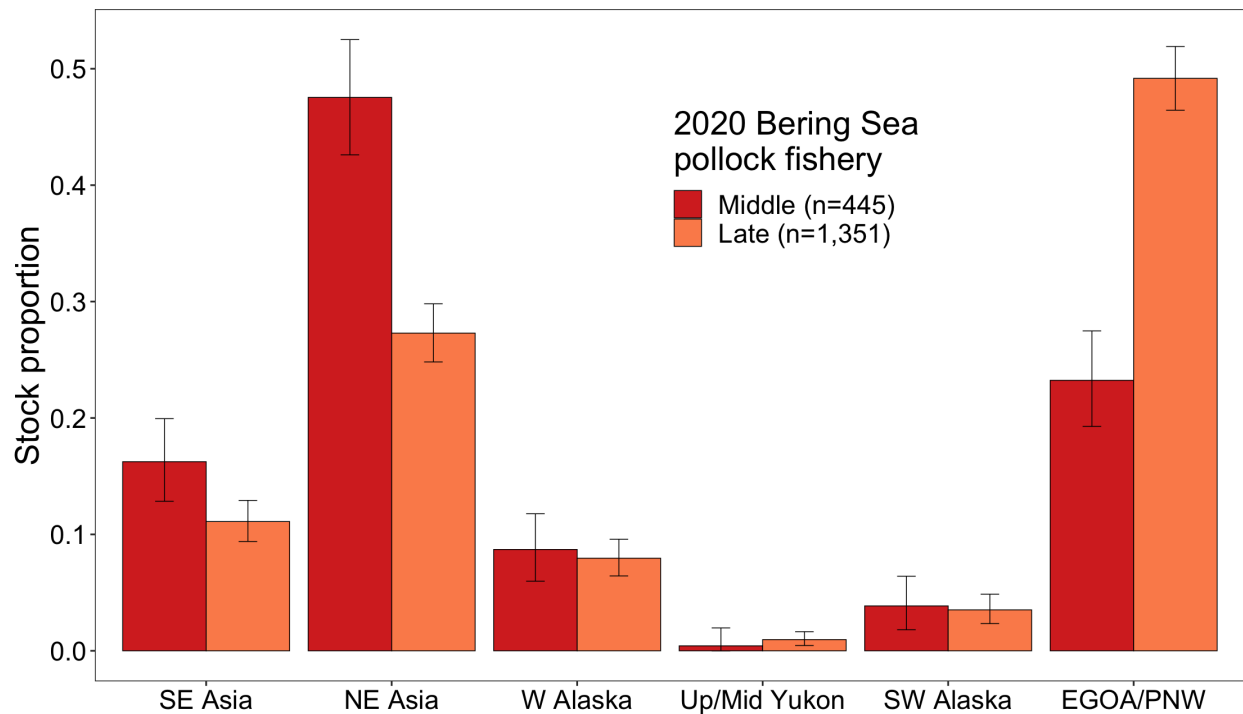


Figure 10. -- Stock composition estimates and 95% credible intervals for chum salmon bycatch from the Middle and Late time periods of the 2020 Bering Sea B-season pollock fishery.

Spatial Trends

Typically, more Asian stocks, particularly from SE Asia, are intercepted west of 170°W, whereas Alaska and EGOA/PNW stocks often have higher contributions east of 170°W. This pattern was generally true for the 2020 chum salmon bycatch. SE Asia contributed more to catches in the west while Western Alaska and Southwest Alaska contributions were higher east of 170°W (Fig. 11). However, the EGOA/PNW stocks contributed relatively more west of 170°W.

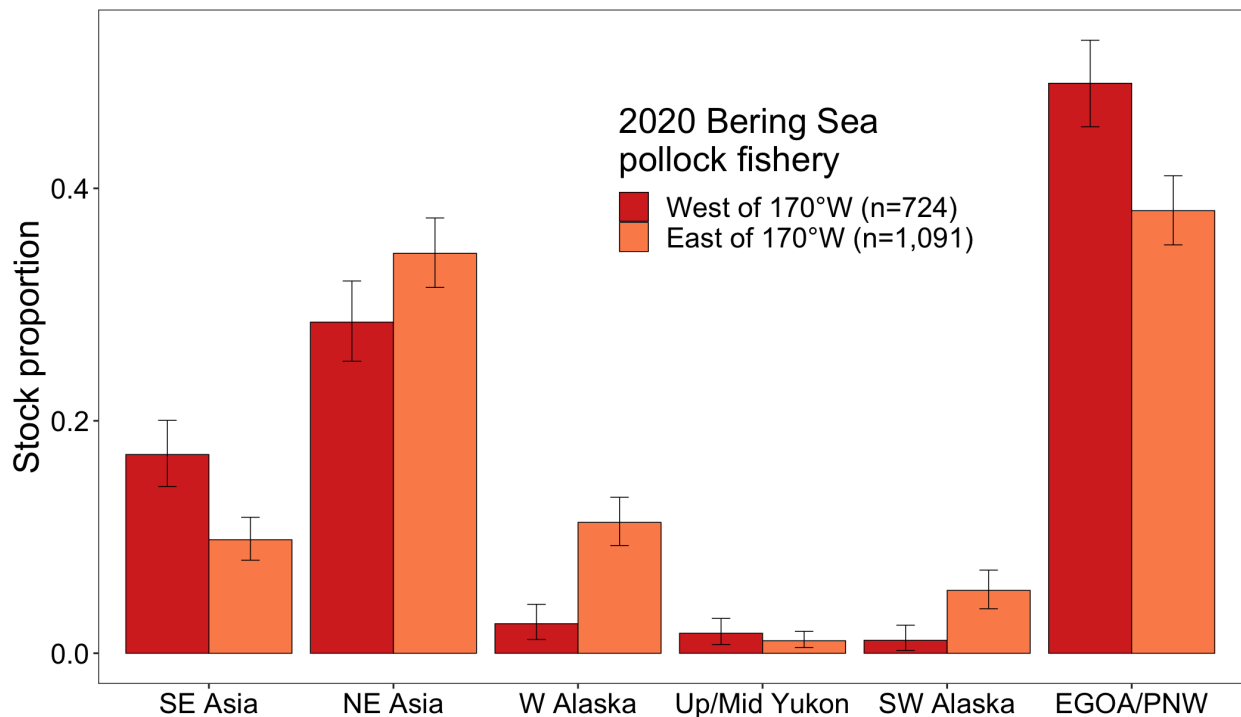


Figure 11. -- Stock composition estimates for the chum salmon bycatch from the 2020 Bering Sea B-season pollock fishery from the U.S. waters of the Bering Sea west of 170°W and the southeastern Bering Sea east of 170°W.

The ABL has previously separated the Bering Sea into finer-scale spatial strata (four clusters of ADF&G groundfish statistical areas), and incorporated temporal stratification (Early and Late) to evaluate the spatiotemporal stock-specific contributions. The 2020 stock composition estimates were mostly consistent with historic trends. The Asian component decreased from west to east and from Early to Late (Fig. 12, left panels). Both Western Alaska (late time period) and Southwest Alaska stock contributions increased from west to east (Fig. 12, middle panels). And the EGOA/PNW stock contributions increased from Early to Late with the largest contribution in cluster 3 during the Late time period (Fig. 12, right panel). Based on the large contribution of EGOA/PNW stocks to the overall B-season bycatch, we might expect greater numbers of hauls and salmon bycatch during the Late time period in cluster 3. However, the greatest number of hauls and the majority of the chum salmon bycatch were taken in the Late time period in cluster 1 (Fig. 13). The decrease in total chum salmon bycatch in cluster 2 during the Late time period is reflected in the decrease in the number of hauls.

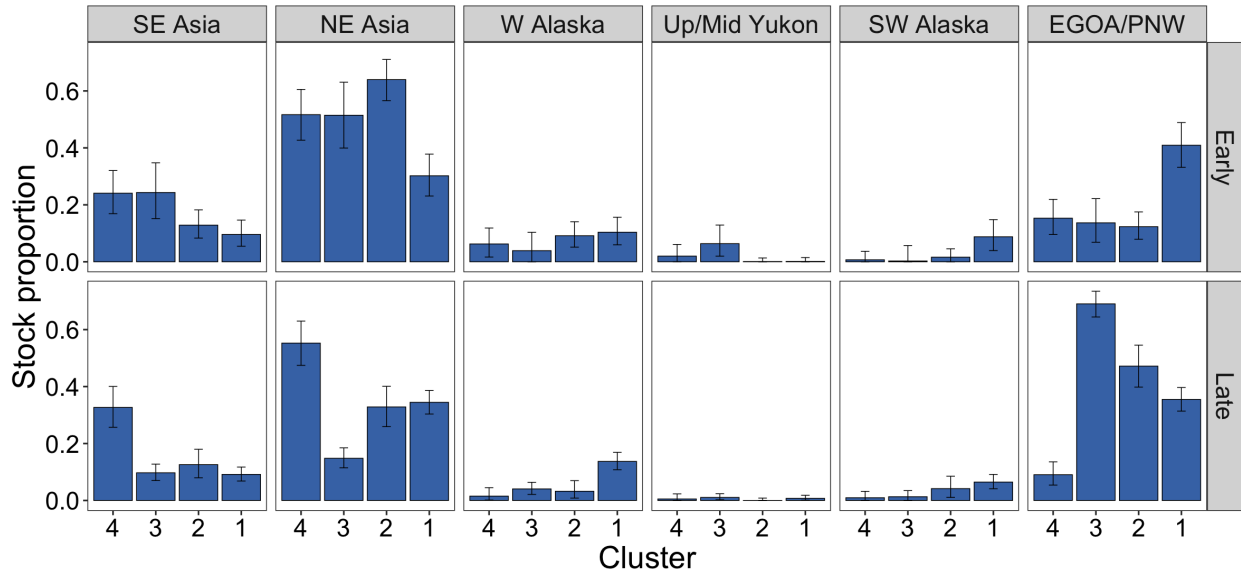


Figure 12. -- Stock composition estimates for the chum salmon bycatch collected from four spatial clusters along the continental shelf edge during Early (Weeks 24–32) and Late (Weeks 33–43) time periods of the 2020 Bering Sea B-season pollock fishery. Clusters are ordered from west (cluster 4) to east (cluster 1). See map in Fig. 7.

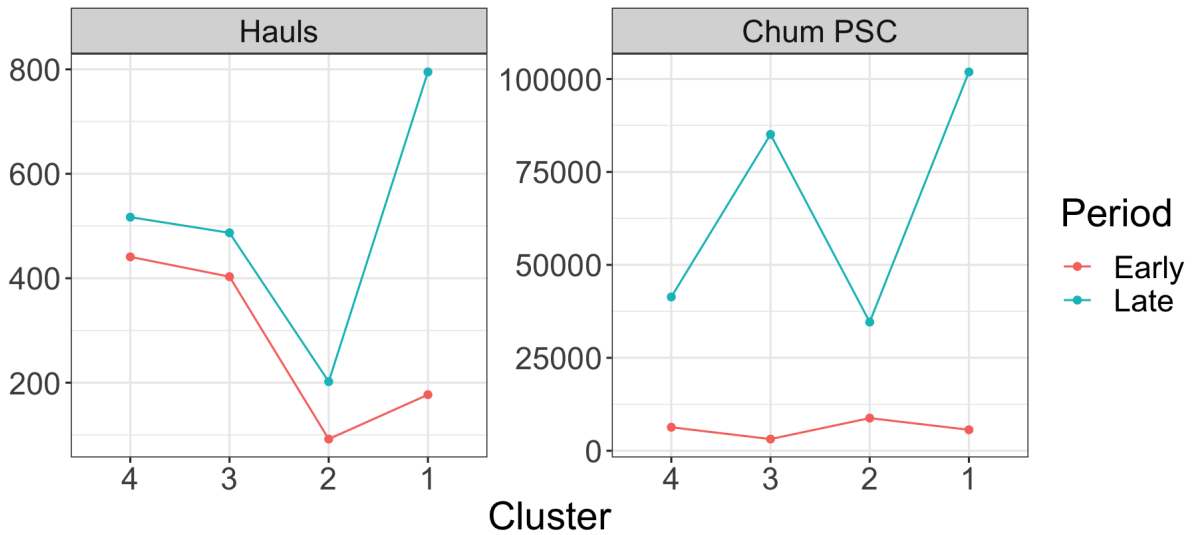


Figure 13. -- Number of hauls and total chum salmon bycatch from four spatial clusters along the continental shelf edge during Early (Weeks 24–32) and Late (Weeks 33–43) time periods of the 2020 Bering Sea B-season pollock fishery.

Age Trends

The total age of individual fish was estimated as the number of freshwater and saltwater annuli formed on the scale plus one to account for the winter spent rearing in fresh water. A total of 2,220 chum salmon were aged. Of those, 1,918 had genotypic information and were included in stock composition analyses.

Historically, age-3 chum salmon are typically dominated by EGOA/PNW stocks while age-5 chum salmon are overwhelmingly from NE Asian stocks, a pattern supported by maturation at an earlier age in southern stocks and at a later age in northern stocks (Salo 1991). In 2020, age patterns were consistent with historic trends. The EGOA/PNW stocks comprised 48% of age-3 fish and decreased to 6% of age-5 fish, whereas NE Asia stocks comprised 27% of age-3 fish and increased to 62% of age-5 fish (Fig. 14). Fish from SE Asia, Southwest Alaska, Western Alaska and Up/Mid Yukon had relatively similar representation across age classes. Additional stock estimates for many combinations of age, time, and spatial strata are available in Appendix D.

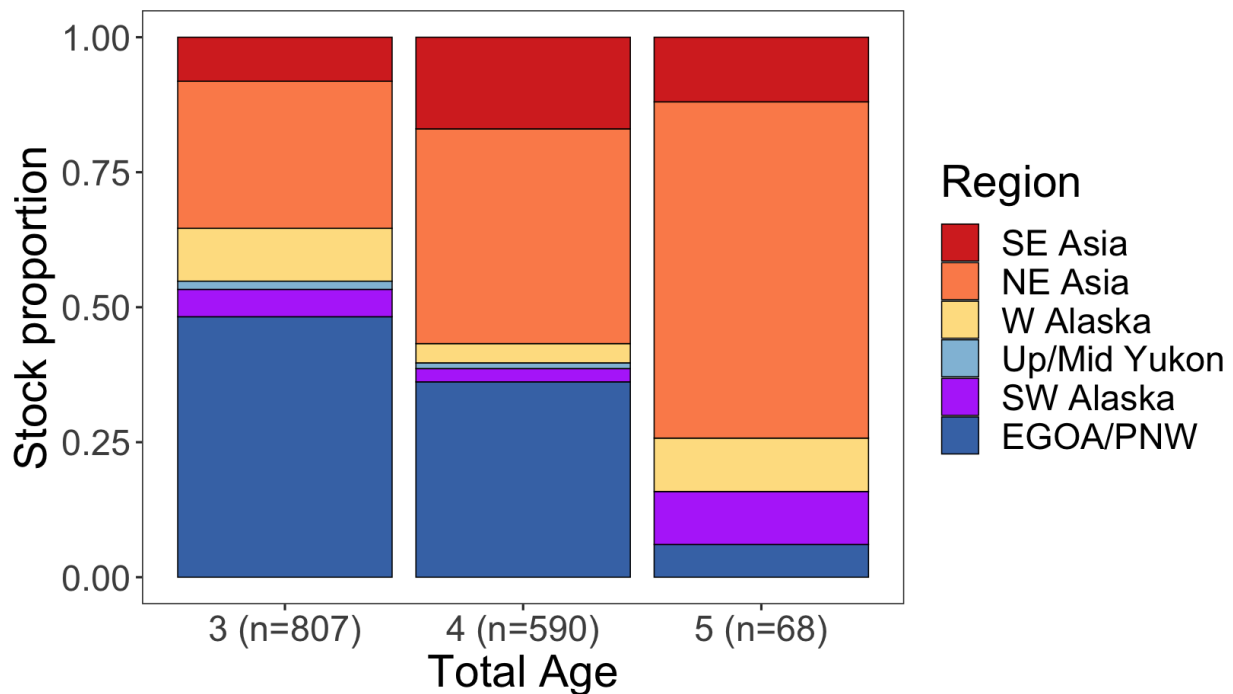


Figure 14. -- Stock composition estimates for the three predominate ages of chum salmon from the 2020 Bering Sea B-season pollock fishery.

Sector Trends

Stock contribution estimates of chum salmon bycatch from each fishing sector were consistent with historic patterns. The majority of the bycatch from the catcher-processor sector was from Asian stocks and the majority of the bycatch from the shoreside sector was from EGOA/PNW and Alaska stocks (Fig. 15). The credible intervals on the mothership estimates reflect greater uncertainty because of small sample size ($n = 92$) relative to the shoreside and catcher-processor sectors ($n = 1,343$ and $n = 381$, respectively). The catcher-processor sector had higher proportions of Asian fish than the shoreside sector, which is likely due at least in part to the high proportion of catcher-processor vessels that fished in the northwestern area of the fishery where Asian fish are more prevalent.

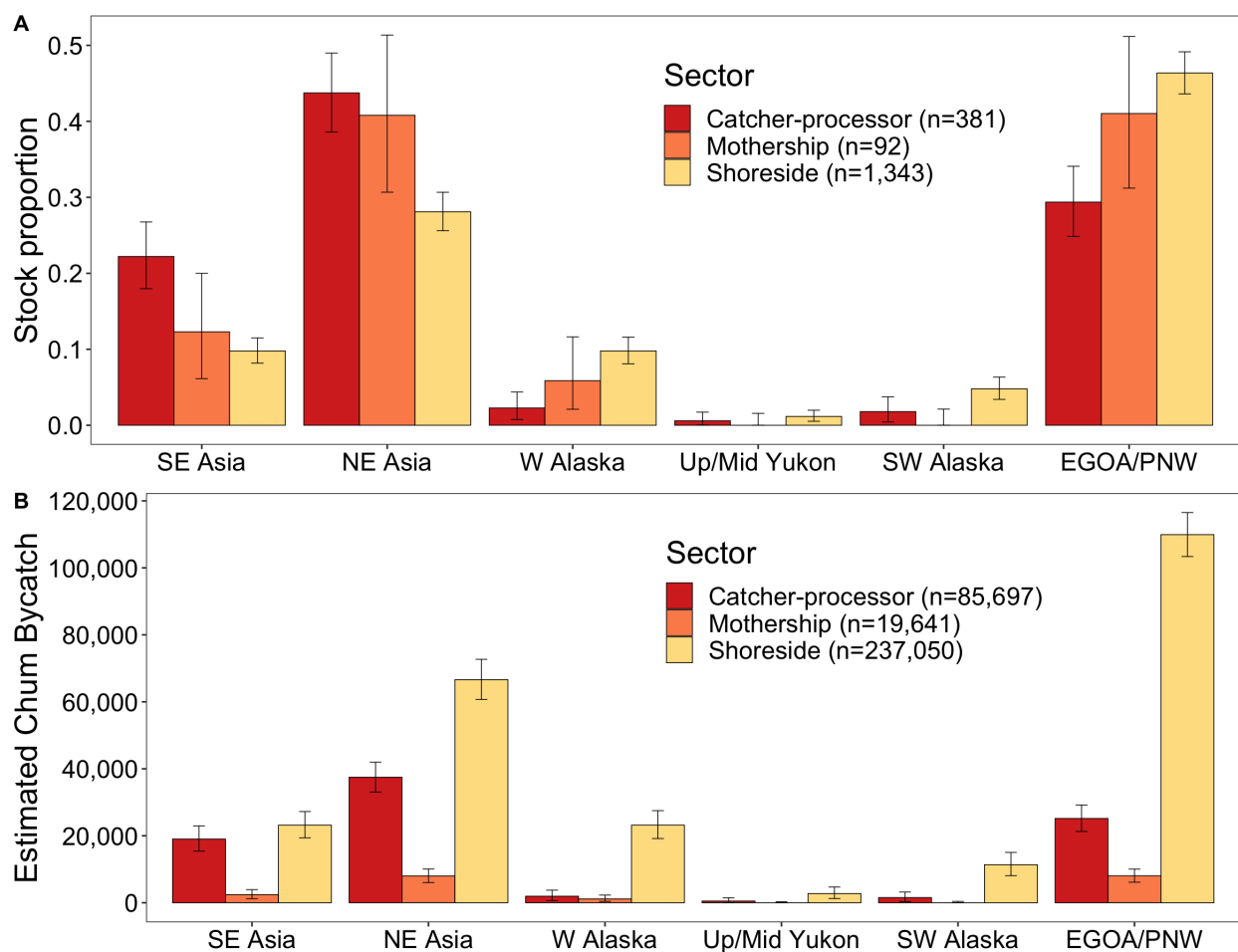


Figure 15. -- Stock composition estimates for chum salmon bycatch from the 2020 Bering Sea, B-season pollock fishery from the catcher-processor, shoreside, and mothership fishing sectors. (A) Stock proportions with sample sizes for mixture analysis given in the legend. (B) Estimated number of chum salmon with total bycatch for each fishing sector in the legend.

General trends for W Alaska and Up/Mid Yukon stocks

Chum salmon bycatch in 2020 was higher than average and occurred later and further west than in previous years. Despite high variation in the timing and spatial distribution of chum salmon bycatch across years, the average contributions of Western Alaska and Up/Mid Yukon stocks had been relatively consistent, with an average of ~20%. However, the contribution of Western Alaska and Up/Mid Yukon stocks was much lower than average in 2020 (9%).

Additionally, even though chum salmon bycatch was higher than average, the number of Western Alaska and Up/Mid Yukon chum salmon that were caught was lower than average. We hypothesize that the lower-than-average contribution of Western Alaska and Up/Mid Yukon stocks may be correlated with the low recent returns of chum salmon to western Alaska. It is important to note that although contributions from Western Alaska and Up/Mid Yukon stocks were lower than average, there were still strata with relatively high contributions from these stocks. For example, the easternmost cluster (cluster 1) in the Late time period contained 14% or 13,977 (11,007–17,224) Western Alaska fish (See Appendix D). Research to better understand spatiotemporal trends for Western Alaska and Up/Mid Yukon stocks with the goal of reducing interception rates for these stocks is ongoing.

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CITATIONS

- AFSC (Alaska Fisheries Science Center). 2019. 2020 Observer sampling manual. Fisheries Monitoring and Analysis Division, North Pacific Groundfish Observer Program. AFSC, 7600 Sand Point Way N.E., Seattle, WA 98115.
- Campbell, N. R., S. A. Harmon, and S. R. Narum. 2015. Genotyping-in-Thousands by Sequencing (GT-Seq): A cost effective SNP genotyping method based on custom amplicon sequencing. *Mol. Ecol. Res.* 15(4):855–867. doi: 10.1111/1755-0998.12357
- Davis, N. D., A. V. Volkov, A. Y. Efimkin, N. A. Kuznetsova, J. L. Armstrong, and O. Sakai. 2009. Review of BASIS salmon food habits studies. *N. Pac. Anadr. Fish. Comm. Bull.* 5:197-208.
- DeCovich, N., T. H. Dann, S. D. Rogers Olive, H. L. Liller, E. K. C. Fox, J. R. Jasper, E. L. Chenoweth, C. Habicht, and W. D. Templin. 2012. Chum Salmon Baseline for the Western Alaska Salmon Stock Identification Program. Alaska Department of Fish and Game Special Publication 12-26.
- Eisner, L. B., Y. I. Zuenko, E. O. Basyuk, L. L. Britt, J. T. Duffy-Anderson, S. Kotwicki, C. Ladd, and W. Cheng. 2020. Environmental impacts on walleye pollock (*Gadus chalcogrammus*) distribution across the Bering Sea shelf. *Deep Sea Res. Part II Top. Stud. Oceanogr.* 181-182: 104881.
- Gelman, A. and D. B. Rubin. 1992. Inference from iterative simulation using multiple sequences. *Stat. Sci.* 7:457-511.
- Gray, A., T. McCraney, C. Kondzela, C. Marvin, and J. R. Guyon. 2011a. Genetic stock composition analysis of chum salmon bycatch samples from the 2007 Bering Sea trawl fisheries. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-220, 28 p. <https://repository.library.noaa.gov/view/noaa/3823>
- Gray, A. K., W. T. McCraney, C. T. Marvin, C. M. Kondzela, H. T. Nguyen, and J. R. Guyon. 2011b. Genetic stock composition analysis of chum salmon bycatch samples from the 2008 Bering Sea groundfish fisheries. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-222, 29 p. <https://repository.library.noaa.gov/view/noaa/3824>
- Gray, A., C. Marvin, C. Kondzela, T. McCraney, and J. R. Guyon. 2010. Genetic stock composition analysis of chum salmon bycatch samples from the 2009 Bering Sea trawl fisheries. Report to the North Pacific Fishery Management Council, 605 W. 4th Ave., Anchorage, AK 99510. 23 p.
- Guyon, J. R., C. Kondzela, T. McCraney, C. Marvin, and E. Martinson. 2010. Genetic stock composition analysis of chum salmon bycatch samples from the 2005 Bering Sea groundfish fishery. Report to the North Pacific Fishery Management Council, 605 W. 4th Ave., Anchorage, AK 99510. 31 p.

- Hoerling, M.P., J. Eischeid, and J. Perlwitz. 2010. Regional precipitation trends: Distinguishing natural variability from anthropogenic forcing. *J. Clim.* 23:2131-2145.
- Hunt Jr, G. L., P. Stabeno, G. Walters, E. Sinclair, R. D. Brodeur, J. M. Napp, and N. A. Bond. 2002. Climate change and control of the southeastern Bering Sea pelagic ecosystem. *Deep-sea Res. Pt. II: Top. Stud. Oceanogr.* 49(26):5821-5853.
- Kondzela, C. M., J. A. Whittle, P. D. Barry, H. T. Nguyen, E. M. Yasumiishi, D. W. Nicolls, J. T. Watson, and W. A. Larson. 2021. Genetic stock composition analysis of chum salmon from the prohibited species catch of the 2019 Bering Sea walleye pollock trawl fishery. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-422, 69 p. <https://repository.library.noaa.gov/view/noaa/31530>
- Kondzela, C. M., J. A. Whittle, S. C. Vulstek, H. T. Nguyen, and J. R. Guyon. 2017. Genetic stock composition analysis of chum salmon from the prohibited species catch of the 2015 Bering Sea walleye pollock trawl fishery and Gulf of Alaska groundfish fisheries. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-345, 64 p. <https://repository.library.noaa.gov/view/noaa/13521>
- Kondzela, C. M., J. A. Whittle, D. Yates, S. C. Vulstek, H. T. Nguyen, and J. R. Guyon. 2016. Genetic stock composition analysis of chum salmon from the prohibited species catch of the 2014 Bering Sea walleye pollock trawl fishery and Gulf of Alaska groundfish fisheries. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-314, 49 p. <https://repository.library.noaa.gov/view/noaa/8688>
- Kondzela, C. M., C. T. Marvin, S. C. Vulstek, H. T. Nguyen, and J. R. Guyon. 2013. Genetic stock composition analysis of chum salmon bycatch samples from the 2011 Bering Sea walleye pollock trawl fishery. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-243, 39 p. <https://repository.library.noaa.gov/view/noaa/4367>
- Kondzela, C. M., W. T. McCraney, H. T. Nguyen, and J. R. Guyon. 2012. Genetic stock composition analysis of chum salmon bycatch samples from the 2010 Bering Sea groundfish fisheries. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-233, 29 p. <https://repository.library.noaa.gov/view/noaa/4052>
- Magoč, T. and S. L. Salzberg. 2011. FLASH: fast length adjustment of short reads to improve genome assemblies. *Bioinformatics* 27(21):2957-2963. <https://doi.org/10.1093/bioinformatics/btr507>
- Marvin, C. T, S. L. Wildes, C. M. Kondzela, H. T. Nguyen, and J. R. Guyon. 2011. Genetic stock composition analysis of chum salmon bycatch samples from the 2006 Bering Sea groundfish fisheries. U. S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-220, 29 p. <https://repository.library.noaa.gov/view/noaa/3822>
- Moran, B. M., and E. C. Anderson. 2019 Bayesian inference from the conditional genetic stock identification model. *Can. J. Fish. Aquat. Sci.* 76:551-560.

- Munro, A. R., C. Habicht, T. H. Dann, D. M. Eggers, W. D. Templin, M. J. Witteveen, T. T. Baker, K. G. Howard, J. R. Jasper, S. D. Rogers Olive, H. L. Liller, E. L. Chenoweth, and E. C. Volk. 2012. Harvest and harvest rates of chum salmon stocks in fisheries of the Western Alaska Salmon Stock Identification Program (WASSIP), 2007–2009. Alaska Department of Fish and Game, Special Publication No. 12-25, Anchorage.
- Myers, K. W., N. V. Klovach, O. F. Gritsenko, S. Urawa, and T. C. Royer. 2007. Stock-specific distributions of Asian and North American salmon in the open ocean, interannual changes, and oceanographic conditions. *N. Pac. Anadr. Fish. Comm. Bull.* 4:159-177.
- NMFS (National Marine Fisheries Service). 2022a. BSAI non-Chinook salmon mortality estimates, 1991-present, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Regional Office, Juneau, Alaska. Retrieved on May 26, 2022 from https://www.fisheries.noaa.gov/sites/default/files/akro/chum_salmon_mortality2020.html
- NMFS (National Marine Fisheries Service). 2022b. Catch Accounting System data. NMFS Alaska Regional Office. Data compiled by Alaska Fisheries Information Network for Alaska Fisheries Science Center, Juneau. [URL not publicly available as some information is confidential.]
- NMFS (National Marine Fisheries Service). 2009. Bering Sea Chinook salmon bycatch management, Volume I. Final Environmental Impact Statement, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Regional Office, Juneau, Alaska.
- NPFMC (North Pacific Fishery Management Council). 2020a. Fishery management plan for groundfish of the Bering Sea and Aleutian Islands management area. North Pacific Fishery Management Council, 605 W. 4th Ave., Anchorage, AK 99501. <https://www.npfmc.org/wp-content/PDFdocuments/fmp/BSAI/BSAIfmp.pdf>
- NPFMC (North Pacific Fishery Management Council). 2020b. Fishery management plan for groundfish of the Gulf of Alaska. North Pacific Fishery Management Council, 605 W. 4th Ave., Anchorage, AK 99501. <https://www.npfmc.org/wp-content/PDFdocuments/fmp/GOA/GOAfmppdf>
- NPFMC (North Pacific Fishery Management Council). 2012. Bering Sea non-Chinook salmon PSC management measures, initial review draft environmental assessment. North Pacific Fishery Management Council, 605 W. 4th Ave., Anchorage, AK 99501.

- NPFMC (North Pacific Fishery Management Council). 2007. Environmental assessment/regulatory impact review/final regulatory flexibility analysis for modifying existing Chinook and chum salmon savings areas: Amendment 84 to the fishery management plan for groundfish of the Bering Sea and Aleutian Islands management area. North Pacific Fishery Management Council, 605 W. 4th Ave., Anchorage, AK 99501.
- Oke, K. B., C. J. Cunningham, P. A. H. Westley, M. L. Baskett, S. M. Carlson, J. Clark, A. P. Hendry, et al. 2020. Recent declines in salmon body size impact ecosystems and fisheries. *Nature Comm.* 11(1):4155Oke. |<https://doi.org/10.1038/s41467-020-17726-z>
- Pella, J. and H. J. Geiger. 2009. Sampling considerations for estimating geographic origins of Chinook salmon bycatch in the Bering Sea pollock fishery. Alaska Department of Fish and Game Special Publication No. SP 09-08.
- Plummer, M., N. Best, K. Cowles, and K. Vines. 2006 CODA: Convergence Diagnosis and Output Analysis for MCMC. *R News* 6:7-11.
- Salo, E. O. 1991. Life history of chum salmon (*Oncorhynchus keta*), p. 231-309. *In*: Groot, C. and L. Margolis (eds.), *Pacific Salmon Life Histories*. UBC Press, Vancouver.
- Urawa, S., S. Sato, P. A. Crane, B. Agler, R. Josephson, and T. Azumaya. 2009. Stock-specific ocean distribution and migration of chum salmon in the Bering Sea and North Pacific Ocean. *N. Pac. Anadr. Fish Comm. Bull.* 5:131-146.
- Vulstek, S. C., C. M. Kondzela, C. T. Marvin, J. Whittle, and J. R. Guyon. 2014. Genetic stock composition analysis of chum salmon bycatch and excluder device samples from the 2012 Bering Sea walleye pollock trawl fishery. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-271, 35 p. <https://repository.library.noaa.gov/view/noaa/4659>
- Whittle, J. A., S. C. Vulstek, C. M. Kondzela, and J. R. Guyon. 2015. Genetic stock composition analysis of chum salmon bycatch from the 2013 Bering Sea walleye pollock trawl fishery. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-292, 50 p. <https://repository.library.noaa.gov/view/noaa/4852>
- Whittle, J. A., C. M. Kondzela, Hv. T. Nguyen, K. Hauch, D. Cuadra, and J. R. Guyon. 2018. Genetic stock composition analysis of chum salmon bycatch from the 2016 Bering Sea walleye pollock trawl fishery and Gulf of Alaska groundfish fisheries. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-366, 58 p. <https://repository.library.noaa.gov/view/noaa/17119>
- Whittle, J. A., C. M. Kondzela, J. T. Watson, P. D. Barry, Hv. T. Nguyen, E. M. Yasumiishi, D. Nicolls, and W. A. Larson. 2021a. Genetic stock composition analysis of chum salmon from the prohibited species catch of the 2017 Bering Sea walleye pollock trawl fishery and Gulf of Alaska groundfish fisheries. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-419, 73 p. <https://repository.library.noaa.gov/view/noaa/30602>

Whittle, J. A., C. M. Kondzela, J. T. Watson, P. D. Barry, H. T. Nguyen, E. M. Yasumiishi, D. Nicolls, and W. A. Larson. 2021b. Genetic stock composition analysis of chum salmon from the prohibited species catch of the 2018 Bering Sea walleye pollock trawl fishery and Gulf of Alaska groundfish fisheries. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-420, 81 p. <https://repository.library.noaa.gov/view/noaa/30603>

APPENDIX A – Genetic Markers

Appendix Table A-1: Single nucleotide polymorphisms included in the 84-SNP panel used for stock composition analysis of chum salmon samples from the 2020 Bering Sea, B-season pollock trawl fishery.

Locus	Ploidy	SNPpos	Allele1	Allele2	Probe1	Probe2	Primer	Primer Conc. (uM)
Oke_ACOT-100	2	1	C	G	CTTCCGCTCTACTCC	TTCCGCTCTGACTCC	TCAGGGACGATA AAGGGATCATCTT	0.2000
Oke_ATP5L-105	2	1	C	G	AGTATATTGAGATGAATCCCAC	ATATTGAGATGAATGCCAC	GTGCACACCAATCCATTTCTGAAT	0.2500
Oke_AhR1-78	2	1	G	A	CAGCCTCGGTGCCAT	TCAGCCTCAGTGCCAT	AGCAGAACCAGCACCTACAG	0.2000
Oke_CATB-60	2	1	C	T	CAGGAACGGGTATGAG	CAGGAACGGGTATGAG	GCTTCTATGGTCTACTACCGTAT	0.2500
Oke_CD81-108	2	1	G	T	TCCGGCATGTCCAG	TCCGGCATTCCCCAG	CAGTATCATCATACAGCAGATACAACA	0.2500
Oke_CD81-173	2	1	A	C	CAGTCACAGAGAGTCAC	AGTCACAGCGAGTCAC	GATGACTGGAGTCAGCTTGCA	0.2000
Oke_CKS-389	2	1	G	A	AAATGAATGATAATGTGTTCTG	AAATGAATGATAATATGTTCTG	GGCCATTCTCGAGTTCAGT	0.2500
Oke_CKS1-94	2	1	G	T	TCTGGATAAATTTGTGATTC	TTCTGGATAAATTTGTATTCT	TCTTCGCATGTTTAATCGAACAGAAGT	0.2500
Oke_DCXR-87	2	1	A	T	CCTGTTTGTGTAACCGTA	CCTGTTTGTGTAACCGTA	GTCACCCAGAACAATAGAATGAGTCT	0.2500
Oke_FANK1-166	2	1	C	T	CTACAGCCCAGCTGTG	CTACAGCCCAGCTGTG	ACTCACGTGTGGTAGAGACAGA	0.2500
Oke_FBXL5-61	2	1	G	A	TCTGAGGAAAAGCTGC	TCTGAGGAAAAGCTGC	TGGTGTGTAACGTCAGTGACTTAAAG	0.3000
Oke_GHII-3129	2	1	G	A	CAGGGCGACTCTAT	ACAGGGCAACTCTAT	GTC AAGCTGATA CCACTCAAATCTCA	0.3000
Oke_GPDH-191	2	1	T	A	CGGAGCCACTTCCAGTA	CGGAGCCACTACCAGTA	CCTGTACTTATAGGGCAACTTCA	0.2000
Oke_GPH-105	2	1	T	G	CCAGTAATTGGTATTTTGA	CCAGTAATTGGTCTTTTGA	CAGATCAACCCCTGGAAAAATATCTGATGT	0.2500
Oke_HP-182	2	1	A	C	AGAAAAGGTGAGCTGATATG	AAAAGGTGAGCTCGTATG	CCGATGACTCCAAGAAGTTGCT	0.2500
Oke_IL8r2-406	2	1	T	G	AAACACAAAACCCC	AAACACAAAACCCC	GGATGGACATTACAGTCTGGTT	0.2000
Oke_KPNA2-87	2	1	T	A	ACAGAACAGAAACAGTG	AACAGAACAGTAACAGTG	AGGCAGCCAGGTAAGTCAGTA	0.1875
Oke_LAMP2-186	2	1	A	G	CTAACTTTTACAAAGCACCTGC	AACCTTTACAAAGGCACCTGC	TTCTAGCCATGACCAATGAAAGG	0.2500
Oke_MLRN-63	2	1	G	A	CTGGTGATTGACGATCC	CTGGTGATTAAACGATCC	CCATTTGAGCATTGCCAGATTTGAAA	0.2500
Oke_Moesin-160	2	1	T	G	CATTTTGTAAATCTAATTTAAGC	ATTTTGTAAATCTAATGTTAAGC	TTTCAGCAAATGAAGAGAACATCAAACCTG	0.2500
Oke_NUPR1-70	2	1	G	T	CTATGAGGACGGGTACA	ACTATGAGGACTGGTACA	AGACGGTGAACCTCTGCTGTAGA	0.3000
Oke_PPA2-635	2	1	C	T	TTGCCTCCCCGGCTC	TTATTGCCTCTCCCGCTC	ACACAACCTGACCATATTGACTTTCCA	0.2500
Oke_RFC2-618	2	1	G	A	CAGCTCCTGGACTCA	CAGCTCCTGACTCA	GACAATGTGTTAGTGTAGGCTTCACT	0.2000
Oke_RH1op-245	2	1	C	T	AGTGGTGAAGCCTC	TAGTGGTAAAGCCTC	TGGCCGATCTCTCATGGTAATC	0.2500
Oke_RS27-81	2	1	G	A	TGTCCAGGCGTCATGA	TGTCCAGGCGTCATGA	GCAACAAAGTGACTATCACATTGAA	0.3000
Oke_RSPRY1-106	2	1	A	T	TAGTCTCTTTACATAATCTC	TAGTCTCTTTACTTAATCTC	GTCTCCCTATTCTTCCACTTACCT	0.2500
Oke_TCP1-78	2	1	A	G	ATACTGCTCCAGAGACG	CTGCTCCAGGGACG	CTCCAGGGCATCAGCAAATG	0.2000
Oke_Tf-278	2	1	C	A	ATTTTACAGTTGACATTCAA	TTTTACAGTTGAAATCAA	GCCACAATTGTAATTCTAGATCCAGAGT	0.2500
Oke_U1008-83	2	1	A	G	CCGTTCTCTCTTGGACAC	CGTTCTCTCTTGGACAC	GTCACCAAACATCCTGCGAATG	0.3000
Oke_U1010-251	2	1	A	G	ATAGAGGTGAGCATTGACAT	TAGAGGTGAGCACTGACAT	CACCTCAATCAATCAATGATTTATAAGCCA	0.1875
Oke_U1012-241	2	1	C	G	ATGGAAAAGAAGCTGTTACT	ATGGAAAAGAAGCTGTTACT	GCAGAGGTTATACCCATTTAGATGCA	0.2500
Oke_U1015-255	2	1	A	G	CAACACACACAGAGCC	AAACACAGCAGAGCC	CAGAGTGCAGAGTAATACGCATACA	0.2500
Oke_U1016-154	2	1	C	T	CCATGTTTTCGGTATGT	CCATGTTTTCGAGTATGT	GCAGGTTGCTAAGTCATGTTACACA	0.3000
Oke_U1017-52	2	1	C	T	AGAGAGTTGTGCTTCATC	AGAGAGTTGTGCTTCATC	TGGCAATGGGATGTCAAGTTATGA	0.3000
Oke_U1018-50	2	1	C	T	CTGGGCACGTACAGCT	CTGGGCACATACAGCT	TCCAGGTTGCTGACAATGTAAGG	0.3000
Oke_U1022-139	2	1	A	G	CTGGAACATGGAAGCAA	TGGAACATGGAGCAA	AACATTAACCTGTGTTTTCACCTCTTG	0.2500
Oke_U1023-147	2	1	A	C	CATCAGGGAAAAGCCTACAAA	AGGGAAAAGCCGACAAA	TCTTAAAATGGAGAGAGCGATTAATGAAGG	0.2500
Oke_U1024-113	2	1	A	G	CCAGAAAACAACCTAATTAT	CAGAAAACAACCTAATTAT	CATGCTGGTGAATATTGGACAATGT	0.2500
Oke_U1025-135	2	1	G	T	ACTTAGTCTATTTGTAACTTT	ACTTAGTCTATTTGTAACTTT	GGCTAGGTTCTATTTGGACCAT	0.2500
Oke_U2007-190	2	1	C	G	CTAAAAGCTGAGAATAAAT	AAAGCTGACAATAAAT	ACAGGCTGTGATGAGTTAACAATGAAA	0.2500
Oke_U2011-107	2	1	G	T	TTCTGTGAGAGATTTAG	TTTCTGTGAGATATTTAG	CCGTTTCTGTCAGACTCTGGTAAA	0.1250
Oke_U2015-151	2	1	C	T	AATTGATCACGATCATT	ATTGATCACAAATCATT	GCATTTTATCCTCAAACCTTTCAACTGACA	0.2500

Appendix Table A-1. – Continued.

Locus	Ploidy	SNPpos	Allele1	Allele2	Probe1	Probe2	Primer	Primer Conc. (uM)
Oke_U2025-86	2	1	G	A	ACTTTTTTGTCTGTTTTTTT	ACTTTTTTGTCTTTTTTTT	AAATCCCCATGGAGAAACACAATGA	0.2000
Oke_U2029-79	2	1	C	T	AGGTGTACTGAAGAGAC	AGGTGTACTAAAGAGAC	GGTTTGATTTTCGTCGCGATTTGA	0.2500
Oke_U2032-74	2	1	G	A	CAATAAAGTGCTAGGTGTCC	CAATAAAGTGCTAAGTGTC	GCTATTCATGTAATCCTGTACTGTGT	0.2000
Oke_U2034-55	2	1	C	T	ATGTCAAATCACGCTGATG	ATGTCAAATCACACTGATG	GGGAAGAAAAGCCTACCATAAACAG	0.2500
Oke_U2035-54	2	1	G	A	CACCAATAACGTCCTAATC	CACCAATAACATCCTAATC	CGCCAATAACGCTCCAACAAC	0.2500
Oke_U2041-84	2	1	G	T	CAGATCCGGTGTATGC	ACAGATCCTGTGTATGC	CCAGACCATGTGCTTGTGTGCATA	0.2500
Oke_U2043-51	2	1	G	A	TCTGGAGGCGTATTGG	CTGGAGGCATATTGG	CACAAACCTACTACAGACAGCAGTT	0.2000
Oke_U2048-91	2	1	A	C	CAGCCTCATAAGATGTTTA	CAGCCTCATAAGCTGTTTA	AGTTGGGTCTTAAAGATGATCATTGGCT	0.2000
Oke_U2050-101	2	1	C	T	AATTGATCTACAGCTGCACG	AATTGATCTACAACTCGACG	CTCTGAGTGTCACAATCACATATCGT	0.2000
Oke_U2053-60	2	1	C	T	CACACATATGAGATGCC	CACACATAAAGATGCC	TCTGCTTTTGTGCTCTCACAA	0.1875
Oke_U2054-58	2	1	C	T	ATGCCAATTACGTCAGCA	TGCCAATTACATCAGCA	CGTCTATTGAGCTCTTTGATGTC	0.2000
Oke_U2056-90	2	1	G	T	CGAAGTGATGAAGGTGACAA	CGAAGTGATGAATGTGACAA	CCATCACGTCACCATTACACTGT	0.1875
Oke_U2057-80	2	1	A	G	CACGTTTTCCTCTTTCTC	ACGTTTTCCTCTTCTC	GCAGTTGTCATGGCAGTAAGG	0.2500
Oke_U212-87	2	1	C	A	CTTGTGACATTCCTCTCT	CTTGTGACATTACTCTCT	TTGATTCATACTCAAGGTGAGCAGATT	0.2500
Oke_U302-195	2	1	C	A	TTGTCAAAGGAATCATT	TGTCAAAGGAATAATT	GACCCTCAGCTATTTAAGAACCCTCAA	0.2500
Oke_U504-228	2	1	A	G	TGGCTCAAACCTTG	TTGGCTCGAACCTTG	CTTAACTCAGTCACACCAACTCACT	0.2500
Oke_U506-110	2	1	C	T	TTGTAAGTTGTGGCTAAAA	TTGTAAGTTGTGACTAAAA	CGTGGTTGGTTTCATTGACTCTCA	0.2000
Oke_U507-286	2	1	T	G	CTGCTGTTTATGAAAGTA	CTGCTGTTTATGAAAGTA	TGGTCATAGCTTGCCTGTACAAA	0.3000
Oke_U509-219	2	1	C	T	CCTCTCTGCAGGGCT	CCCTCTCTACAGGGCT	GCACCCACCTGGCTT	0.1250
Oke_arf319	2	1	T	C	CTGTGTGAATTGCTC	CTGTGTGAACTCGCTC	TGCAGAAACTGATCATTGGTAGTGG	0.1875
Oke_azin1-90	2	1	C	T	CCTTTATCTGAGGAAGCTG	CCTTTATCTGAAGAAGCTG	GGGAATAGTGTGATTTGGGATGCAT	0.2500
Oke_brd2-118	2	1	C	T	ATGACGAAGCTCTCC	ATGACGAAGCTCTCC	CTCAAGCCCTCCACACTCA	0.2000
Oke_brp16-65	2	1	C	T	ACGTTGCTGTCCAC	ACGTTGCTGTCCAC	TCCACGTCACTCAGCATGATG	0.2500
Oke_ced16-77	2	1	A	C	CCAGCCCCCTCTGAAA	AGCCCCCGCTGAAA	TGTCTTCAGAATCCAATGCTTTCTC	0.1875
Oke_e2ig5-50	2	1	C	T	CATCTTTGTATCTGTGCCATT	TCATCTTTGTATCTATGCCATT	GCACCTGCTCATCTGTGCACATG	0.2500
Oke_eif4g1-43	2	1	G	T	CTGAGATTCTTCATCTTTTAC	TGAGATTCTTCATATTTTAC	GCACCCAACAGTTTCATCATGTAAGT	0.2500
Oke_f5-71	2	1	C	T	CAGGTGCGTGCAGTAA	TCAGGTGCGATGCAGTAA	CTCAAATTTCCCTTTGACATCAATTCATCA	0.2500
Oke_gdh1-62	2	1	C	T	TTCTGTGTCCCCTGACCT	CTGTGTCCCCTGACCT	CCACGTGATACAGGGAGATGTG	0.2000
Oke_glr1-78	2	1	C	T	TGGGCATTTAGAGTTTATT	TGGGCATTTAGAAATTATT	CGTCCGTCCAGTGATGTC	0.2500
Oke_il-1racp-67	2	1	G	A	CGTACGAGATGTAGATGT	CGTACGAGATATAGATGT	AATTGCTCCTCCTCGCTATTCTC	0.2000
Oke_mgl1-49	2	1	A	T	ATTTATGGGTGTTCCCT	TTATGGGAGTTCCCT	ACATTGTAATCTGTATTAGTCCAATGCAGAC	0.2500
Oke_nc2b-148	2	1	A	C	TTTAGTCTAGTCAAAAAGTAG	TAGTTCTAGTCAAAAAGTAG	CCAGCCTATTTCCTTTAGTGATATGA	0.2500
Oke_pgap-111	2	1	C	T	AGCTAGCAGGCTAAAG	AGCTAGCAAGCTAAAG	TGCAGATCTCAATTTGAACGACCTAT	0.2000
Oke_psm49-57	2	1	C	T	CATTGGCGGTGTAACG	TCATTGGCAGTGTAAACG	ACTGTAGTACTGCATTTCATATTGCT	0.2000
Oke_rab5a-117	2	1	C	T	CAGCTGTTTTCTTGTAGCCT	AGCTGTTTTCTTATAGCCT	GGGAATAACAGTCAATGCAGCATTT	0.2000
Oke_ras1-249	2	1	T	G	CACCAAGGTAATAAAT	CCAAGGGAATAAAT	GGATGACTAAGAGCGACTGTATGTG	0.2500
Oke_serpin-140	2	1	A	T	CAAGAAGTACCTTAGACAC	AAGAAGTACCTTTGACAC	TCCACAGTGAGTAATAAAGTTGCACAT	0.2000
Oke_slc1a3a-86	2	1	C	T	CCCAACGCGGTGATG	CCCAACGCGAGTGATG	TGTCCTCATCTGTGGACTCCTACA	0.3000
Oke_sylc-90	2	1	A	T	ATATCTTTGAGACTGATTA	CTTTGAGACAAGATTA	TTGAGGAAACCACTGGTCTTACAAG	0.1875
Oke_thic-84	2	1	C	T	ATGGAATGACAGCAATGT	ATGGAATGACAACAATGT	GCTGTCTTAAACCAATCTTACA	0.2500
Oke_u200-385	2	1	G	T	CATTATCTCCCTGAATGTA	CATTATCTCCATGAATGTA	CCCATAATTTTGCAACCTAGTCACA	0.2000
Oke_u217-172	2	1	T	C	CACTCTTACAAAAACA	CACTCTTACGAAAAACA	GGATGGAAGAAGTTAGTTGTGTCAGA	0.3000

APPENDIX B – Genetic Baseline

Appendix Table B-1: Chum salmon populations in the Alaska Department of Fish and Game (ADF&G) single nucleotide polymorphism baseline grouped by six regional groups used in the analyses of this report.

Population	Reporting Group	Samples	Population	Reporting Group	Samples
Abashiri River	SE Asia	80	Pymta	NE Asia	147
Chitose River - early	SE Asia	80	Tauy	NE Asia	41
Gakko River - early	SE Asia	78	Tym River	NE Asia	53
Kushiro River	SE Asia	79	Udarnitza River	NE Asia	44
Namdae River	SE Asia	90	Vorovskaya	NE Asia	101
Nishibetsu River	SE Asia	79	Agiapuk River	W Alaska	94
Sasanai River	SE Asia	77	Alagnak River	W Alaska	92
Shari River	SE Asia	75	American River	W Alaska	86
Shinzunai River	SE Asia	78	West Fork Andreafsky River	W Alaska	85
Teshio River	SE Asia	80	Andreafsky River - East Fork weir	W Alaska	94
Tokachi River	SE Asia	78	Aniak River	W Alaska	92
Tokoro River	SE Asia	69	Yellow River - Anvik	W Alaska	80
Tokushibetsu River	SE Asia	80	Otter Creek - Anvik	W Alaska	156
Yurappu River - early	SE Asia	80	Big River	W Alaska	94
Yurappu River - late	SE Asia	75	Black River	W Alaska	93
Amur River - summer run	NE Asia	60	Big Creek - Naknek River	W Alaska	69
Bistraya River	NE Asia	66	Chulinak	W Alaska	92
Bolshaya River	NE Asia	93	Clear Creek	W Alaska	94
Hairusova River	NE Asia	85	Eldorado River	W Alaska	89
Kamchatka River	NE Asia	49	Fish River	W Alaska	92
Kanchalan	NE Asia	77	George River	W Alaska	95
Kol River	NE Asia	123	Gisasa River	W Alaska	95
Magadan	NE Asia	77	Goodnews River	W Alaska	137
Naiba	NE Asia	98	Henshaw Creek - early	W Alaska	94
Oklan River	NE Asia	75	Holokuk River	W Alaska	103
Ola River - Hatchery	NE Asia	78	Huslia River, Koyukuk - Set B	W Alaska	95
Ossora	NE Asia	87	Inmachuk River	W Alaska	91
Ozerki Hatchery	NE Asia	93	Iowithla River	W Alaska	95
Palana River	NE Asia	90	Kaltag River	W Alaska	92
Paratunka River	NE Asia	94	Kanektok River weir	W Alaska	94
Penzhina	NE Asia	43	Kasigluk River	W Alaska	55

Appendix Table B-1 – Continued.

Population	Reporting Group	Samples	Population	Reporting Group	Samples
Kelly Lake - Noatak River	W Alaska	95	Stony River	W Alaska	150
Kobuk River - at Kiana	W Alaska	95	Stuyahok River	W Alaska	86
Kisaralik River - (Set F)	W Alaska	93	Sunshine Creek	W Alaska	47
Klutuspak Creek	W Alaska	70	Takotna River - 2 mile above Takotna Village	W Alaska	94
Kobuk - Salmon River (Mile 4)	W Alaska	99	Tatlawiksuk River weir	W Alaska	95
Kogrukluq River weir	W Alaska	95	Togiak River	W Alaska	175
Kokwok River	W Alaska	131	Tozitna River	W Alaska	92
Koyuk River	W Alaska	43	Tubutulik River	W Alaska	93
Kwethluk River	W Alaska	143	Tuluksak River Weir	W Alaska	92
Kwiniuk River	W Alaska	94	Unalakleet	W Alaska	188
Mekoryuk River	W Alaska	104	Ungalik River	W Alaska	144
Melozitna River	W Alaska	91	Wandering Creek - tributary of Dog Salmon River	W Alaska	50
Mulchatna River - Upper Nushagak River	W Alaska	91	Whale Mountain Creek, (King Salmon River, Egegik Bay)	W Alaska	189
Necons River	W Alaska	95	Windy Fork Kuskokwim	W Alaska	93
Niukluk River	W Alaska	93	Innoko River (Yukon A)	W Alaska	85
Noatak River - above hatchery	W Alaska	92	American River	SW Alaska	95
Nome River	W Alaska	94	Foster Creek - Balboa Bay	SW Alaska	182
Nulato River	W Alaska	189	Dog Bay	SW Alaska	95
Nunsatuk River - (Set A)	W Alaska	92	Kizhuyak River	SW Alaska	174
Upper Nushagak	W Alaska	97	Peterson Lagoon	SW Alaska	181
Osviak River	W Alaska	88	Uganik River	SW Alaska	175
Pikmiktalik River	W Alaska	95	Alligator Hole	SW Alaska	183
Pilgrim River	W Alaska	75	Main Creek - Amber Bay	SW Alaska	85
Pumice Creek	W Alaska	95	Barling Bay Creek	SW Alaska	92
Salmon River	W Alaska	95	Belkovski River	SW Alaska	87
Selby Slough	W Alaska	90	Big River (Hallo Bay)	SW Alaska	95
South Fork Koyukuk River - Early	W Alaska	90	Big Sukhoi	SW Alaska	189
South Fork Kuskokwim - fall	W Alaska	95	Canoe Bay	SW Alaska	186
Shaktoolik River	W Alaska	94	Chichagof Bay	SW Alaska	180
Snake River	W Alaska	90	Chiginagak Bay River	SW Alaska	159
Solomon River	W Alaska	62	Coal Valley	SW Alaska	94

Appendix Table B-1 – Continued.

Population	Reporting Group	Samples	Population	Reporting Group	Samples
Coleman Creek	SW Alaska	95	Russell Creek	SW Alaska	185
Coxcomb Creek	SW Alaska	89	Russian River	SW Alaska	185
Deadman River	SW Alaska	95	Sandy Cove	SW Alaska	186
Deer Valley	SW Alaska	91	Sitkinak Island	SW Alaska	93
Delta Creek (Cold Bay)	SW Alaska	95	Spiridon River - Upper	SW Alaska	89
Dry Bay River	SW Alaska	71	St. Catherine Cove	SW Alaska	171
Eagle Harbor	SW Alaska	94	Big River - Stepovak Bay	SW Alaska	143
Frosty Creek	SW Alaska	190	Stepovak River	SW Alaska	94
Gull Cape Creek	SW Alaska	186	Sturgeon River	SW Alaska	109
Three Hills River	SW Alaska	49	Traders Cove	SW Alaska	76
Ivanof River	SW Alaska	181	Volcano Bay (Cold Bay)	SW Alaska	95
Joshua Green	SW Alaska	92	Bear Bay Creek	SW Alaska	187
Karluk Lagoon	SW Alaska	83	North Fork Creek, Aniakchak River	SW Alaska	94
Kialagvik Creek (Wide Bay)	SW Alaska	177	Alagogshak River	SW Alaska	94
Kitoi Hatchery	SW Alaska	194	Portage Creek	SW Alaska	190
Lawrence Valley Creek	SW Alaska	190	North Fork Creek, Kujulik Bay	SW Alaska	164
Little John Lagoon	SW Alaska	172	Wiggly Creek - Cinder	SW Alaska	177
Meshik River	SW Alaska	78	West Kiliuda Creek	SW Alaska	87
Braided Creek (Meshik River)	SW Alaska	94	Zachary Bay	SW Alaska	76
Moffet Creek	SW Alaska	95	Zachar River	SW Alaska	66
Nakililock River	SW Alaska	95	17 Mile Slough (Nenana) - fall run	Up/Mid Yukon	90
North of Cape Seniavin	SW Alaska	96	Big Creek - Canadian Mainstem (Yukon)	Up/Mid Yukon	100
Northeast Creek	SW Alaska	94	Black River	Up/Mid Yukon	95
Sapsuk River, Nelson Lagoon	SW Alaska	144	Bluff Cabin	Up/Mid Yukon	99
Ocean Bay	SW Alaska	78	Big Salt River	Up/Mid Yukon	69
Pass Creek - Wide Bay	SW Alaska	94	Chandalar River	Up/Mid Yukon	92
Plenty Bear Creek (Meshik River)	SW Alaska	138	Chena River	Up/Mid Yukon	77
NE Portage - Alitak	SW Alaska	94	Delta River - Fairbanks	Up/Mid Yukon	149
Right Hand Moller Bay	SW Alaska	94	Donjek River	Up/Mid Yukon	60
Rough Creek	SW Alaska	77	Fishing Branch	Up/Mid Yukon	90
Ruby's Lagoon (Cold Bay)	SW Alaska	92	Henshaw Creek - late	Up/Mid Yukon	60

Appendix Table B-1 – Continued.

Population	Reporting Group	Samples	Population	Reporting Group	Samples
Henshaw Creek - late	Up/Mid Yukon	60	Dosewallips River - summer run	EGOA/PNW	86
Jim River	Up/Mid Yukon	146	Dry Bay Creek	EGOA/PNW	94
Kantishna River	Up/Mid Yukon	94	Ecstall	EGOA/PNW	50
Kluane River	Up/Mid Yukon	114	Elwha River	EGOA/PNW	93
Minto Slough	Up/Mid Yukon	91	Fish Creek - early	EGOA/PNW	131
Old Crow - Porcupine River	Up/Mid Yukon	92	DIPAC Hatchery	EGOA/PNW	281
Pelly River	Up/Mid Yukon	84	Fish Creek - late	EGOA/PNW	49
Salcha River	Up/Mid Yukon	83	Ford Arm Lake - fall	EGOA/PNW	95
South Fork Koyukuk River - Late	Up/Mid Yukon	92	Goldstream River	EGOA/PNW	95
Sheenjek River	Up/Mid Yukon	93	Grays River - fall run	EGOA/PNW	93
Tanana River Mainstem	Up/Mid Yukon	95	Hamma Hamma River - summer	EGOA/PNW	108
Tatchun Creek	Up/Mid Yukon	92	Hamma Hamma River	EGOA/PNW	94
Teslin River	Up/Mid Yukon	92	Harding River	EGOA/PNW	45
Toklat River - Geiger Ck. (Set A) -Mainstream	Up/Mid Yukon	95	Herman Creek - Chilkat River	EGOA/PNW	94
Keta Creek	EGOA/PNW	95	Hidden Falls Hatchery	EGOA/PNW	95
Admiralty Creek	EGOA/PNW	64	Hidden Inlet	EGOA/PNW	82
Aloutte River	EGOA/PNW	95	I-205 Seeps - fall run	EGOA/PNW	72
Bag Harbor	EGOA/PNW	49	Inch Creek	EGOA/PNW	181
Beartrap Creek	EGOA/PNW	582	Jimmy Creek - summer run	EGOA/PNW	92
Big Qualicum River	EGOA/PNW	72	Johns Creek - summer run	EGOA/PNW	92
Big Mission Creek Fall Run	EGOA/PNW	55	Kalama Creek - winter run	EGOA/PNW	54
Carmen Lake	EGOA/PNW	67	Karta River	EGOA/PNW	56
Carroll River	EGOA/PNW	85	Kitasoo Creek	EGOA/PNW	169
Chilkat - mainstem	EGOA/PNW	76	Kitimat River	EGOA/PNW	104
Chunilna River	EGOA/PNW	83	Kitwanga River	EGOA/PNW	74
Constantine Creek	EGOA/PNW	594	Klahini River	EGOA/PNW	50
Conuma River	EGOA/PNW	96	Klehini River - Chilkat River	EGOA/PNW	92
Dewatto River - fall chum	EGOA/PNW	74	Lagoon Creek - fall run	EGOA/PNW	166
Diru Creek - Tribal Hatchery	EGOA/PNW	45	Little Creek - fall run	EGOA/PNW	92
Disappearance Creek - fall run	EGOA/PNW	162	Lilliwaup River - summer run	EGOA/PNW	45
Disappearance Creek	EGOA/PNW	143	Lilliwaup River - fall run	EGOA/PNW	92

Appendix Table B-1 – Continued.

Population	Reporting Group	Samples	Population	Reporting Group	Samples
Long Bay	EGOA/PNW	159	Sarita River	EGOA/PNW	63
Little Qualicum River	EGOA/PNW	98	Satsop River	EGOA/PNW	95
Lower Skagit River - fall run	EGOA/PNW	91	Sawmill Creek - Berners Bay	EGOA/PNW	95
Little Susitna River weir	EGOA/PNW	95	Sedgewick	EGOA/PNW	50
McNeil River Lagoon	EGOA/PNW	108	Sherwood Creek - fall run	EGOA/PNW	87
Medvejie Hatchery	EGOA/PNW	119	Sherwood Creek - summer run	EGOA/PNW	88
Mill Creek - fall run	EGOA/PNW	80	Sisters Lake	EGOA/PNW	86
Nahmint River	EGOA/PNW	95	Siwash Creek	EGOA/PNW	362
Nakat Inlet - summer	EGOA/PNW	95	Skamokawa Creek - fall run	EGOA/PNW	76
Nakwasina River	EGOA/PNW	93	Skykomish River - fall run	EGOA/PNW	87
North Arm Creek	EGOA/PNW	97	Snootli Creek	EGOA/PNW	190
North Creek - fall run	EGOA/PNW	93	Snoqualmie River	EGOA/PNW	84
Neets Bay - fall	EGOA/PNW	95	Sooke River	EGOA/PNW	50
Neets Bay - Summer	EGOA/PNW	145	Spink Creek	EGOA/PNW	44
Nimpkish River	EGOA/PNW	187	Stagoo	EGOA/PNW	49
Nisqually River Hatchery	EGOA/PNW	94	Sugsaw River	EGOA/PNW	60
Nitinat River	EGOA/PNW	113	Surprise	EGOA/PNW	50
Norrish Creek	EGOA/PNW	91	Susitna River (Slough 11)	EGOA/PNW	94
Pallant Creek	EGOA/PNW	209	Swan Cove Creek	EGOA/PNW	88
Prospect Creek	EGOA/PNW	89	Taku River - fall	EGOA/PNW	93
Puntledge River	EGOA/PNW	99	Talkeetna River	EGOA/PNW	50
Olsen Creek (PWS) - Set A	EGOA/PNW	94	Traitors Cove Creek	EGOA/PNW	91
Quilcene - summer run	EGOA/PNW	63	Union River - summer	EGOA/PNW	109
Ralph's Creek	EGOA/PNW	95	Upper Sauk River - fall run	EGOA/PNW	86
Saginaw Creek	EGOA/PNW	41	West Arm Creek	EGOA/PNW	186
Salmon Creek - summer run	EGOA/PNW	82	West Crawfish	EGOA/PNW	92
Salmon River	EGOA/PNW	47	Weaver Creek	EGOA/PNW	96
Saltery Bay	EGOA/PNW	48	Wells River	EGOA/PNW	597
Sample Creek	EGOA/PNW	74	Wells Bridge	EGOA/PNW	46
Sanborn Creek	EGOA/PNW	94	Wally Noerenberg Hatchery	EGOA/PNW	385
Saook Bay	EGOA/PNW	94	Willow Creek	EGOA/PNW	89

APPENDIX C – SPATIAL CLUSTERS OF ADF&G STATISTICAL AREAS

Appendix Table C-1 -- Four spatial clusters of ADF&G groundfish statistical areas¹ of chum salmon prohibited species catch sampled from 2013 to 2020 during the B-season of the Bering Sea pollock trawl fishery and analyzed for genetic stock composition.

Cluster 1: 625504, 625531, 625600, 625630, 625700, 625730, 635501, 635504, 635530, 635600, 635630, 635700, 635730, 645434, 645501, 645502, 645530, 645600, 645630, 645700, 645730, 655407, 655409, 655410, 655430, 655500, 655530, 655600, 655630, 655700, 655730, 665335, 665336, 665401, 665403, 665404, 665430, 665500, 665530, 665600, 665630, 665700, 665730

Cluster 2: 675430, 675500, 675530, 675600, 675630, 675700, 675730, 685500, 685530, 685600, 685630, 685700, 685730

Cluster 3: 695530, 695600, 695631, 695632, 705530, 705600, 705630, 705701, 705730, 715600, 715630, 715700, 715730, 725630, 725700, 725730, 735630, 735700, 735730, 745730

Cluster 4: 705800, 705830, 715800, 715830, 725800, 725830, 725900, 735800, 735830, 735900, 735930, 745800, 745830, 745900, 745930, 746000, 755800, 755830, 755900, 755930, 756000, 765830, 765900, 765930, 766000, 766030, 775830, 775900, 775930, 776000, 776030, 785900, 785930, 786000, 786030

¹ <http://www.adfg.alaska.gov/index.cfm?adfg=fishingCommercialByFishery.statmaps>

APPENDIX D – GSI ESTIMATES

Regional stock composition estimates of chum salmon samples from the 2020 Bering Sea, B-season pollock trawl fishery. Note that total PSC was tabulated from the AKFIN database with observer records and is slightly smaller than the NMFS Alaska Regional Office mortality estimate for the B-season.

West of 170° (PSC = 144,086; n = 724)

Region	Est. num.	Est. CI	Mean	2.5%	Median	97.5%	P=0	SF
SE Asia	24,635	20,666-28,874	0.171	0.143	0.171	0.200	0.00	1.00
NE Asia	41,049	36,205-46,151	0.285	0.251	0.285	0.320	0.00	1.00
W Alaska	3,662	1,710-6,069	0.025	0.012	0.025	0.042	0.00	1.00
Up/Mid Yukon	2,478	1,074-4,318	0.017	0.007	0.017	0.030	0.00	1.00
SW Alaska	1,600	346-3,483	0.011	0.002	0.010	0.024	0.00	1.00
E GOA/PNW	70,658	65,265-75,998	0.490	0.453	0.490	0.527	0.00	1.00

East of 170° (PSC = 198,305; n = 1,091)

Region	Est. num.	Est. CI	Mean	2.5%	Median	97.5%	P=0	SF
SE Asia	19,362	15,879-23,204	0.098	0.080	0.097	0.117	0.00	1.00
NE Asia	68,241	62,413-74,269	0.344	0.315	0.344	0.375	0.00	1.00
W Alaska	22,329	18,364-26,612	0.113	0.093	0.112	0.134	0.00	1.00
Up/Mid Yukon	2,136	964-3,740	0.011	0.005	0.010	0.019	0.00	1.00
SW Alaska	10,721	7,596-14,190	0.054	0.038	0.054	0.072	0.00	1.00
E GOA/PNW	75,513	69,676-81,475	0.381	0.351	0.381	0.411	0.00	1.00

Middle (PSC = 85,910; n = 445)

Region	Est. num.	Est. CI	Mean	2.5%	Median	97.5%	P=0	SF
SE Asia	13,954	11,033-17,133	0.162	0.128	0.162	0.199	0.00	1.00
NE Asia	40,839	36,602-45,106	0.475	0.426	0.475	0.525	0.00	1.00
W Alaska	7,476	5,136-10,115	0.087	0.060	0.086	0.118	0.00	1.00
Up/Mid Yukon	365	0-1,689	0.004	0.000	0.002	0.020	0.28	1.00
SW Alaska	3,312	1,552-5,504	0.039	0.018	0.038	0.064	0.00	1.00
E GOA/PNW	19,960	16,558-23,607	0.232	0.193	0.232	0.275	0.00	1.00

Late (PSC = 252,850; n = 1,351)

Region	Est. num.	Est. CI	Mean	2.5%	Median	97.5%	P=0	SF
SE Asia	28,071	23,743-32,668	0.111	0.094	0.111	0.129	0.00	1.00
NE Asia	69,003	62,739-75,370	0.273	0.248	0.273	0.298	0.00	1.00
W Alaska	20,114	16,258-24,237	0.080	0.064	0.079	0.096	0.00	1.00
Up/Mid Yukon	2,432	1,141-4,153	0.010	0.005	0.009	0.016	0.00	1.00
SW Alaska	8,890	5,910-12,297	0.035	0.023	0.035	0.049	0.00	1.00
E GOA/PNW	124,337	117,418-131,258	0.492	0.464	0.492	0.519	0.00	1.00

Catcher-processor (PSC = 85,697; n = 381)

Region	Est. num.	Est. CI	Mean	2.5%	Median	97.5%	P=0	SF
SE Asia	19,037	15,406-22,932	0.222	0.180	0.222	0.268	0.00	1.00
NE Asia	37,486	33,066-41,984	0.437	0.386	0.437	0.490	0.00	1.00
W Alaska	1,950	642-3,757	0.023	0.007	0.022	0.044	0.00	1.00
Up/Mid Yukon	510	23-1,479	0.006	0.000	0.005	0.017	0.01	1.00
SW Alaska	1,540	370-3,208	0.018	0.004	0.017	0.037	0.00	1.00
E GOA/PNW	25,171	21,295-29,211	0.294	0.248	0.293	0.341	0.00	1.00

Shoreside (PSC = 237,050; n = 1,343)

Region	Est. num.	Est. CI	Mean	2.5%	Median	97.5%	P=0	SF
SE Asia	23,188	19,378-27,243	0.098	0.082	0.098	0.115	0.00	1.00
NE Asia	66,616	60,689-72,695	0.281	0.256	0.281	0.307	0.00	1.00
W Alaska	23,197	19,177-27,509	0.098	0.081	0.098	0.116	0.00	1.00
Up/Mid Yukon	2,754	1,245-4,689	0.012	0.005	0.011	0.020	0.00	1.00
SW Alaska	11,366	8,074-15,034	0.048	0.034	0.048	0.063	0.00	1.00
E GOA/PNW	109,926	103,391-116,521	0.464	0.436	0.464	0.492	0.00	1.00

Mothership (PSC = 19,641; n = 92)

Region	Est. num.	Est. CI	Mean	2.5%	Median	97.5%	P=0	SF
SE Asia	2,415	1,206-3,927	0.123	0.061	0.120	0.200	0.00	1.00
NE Asia	8,013	6,025-10,087	0.408	0.307	0.407	0.514	0.00	1.00
W Alaska	1,153	414-2,284	0.059	0.021	0.055	0.116	0.00	1.00
Up/Mid Yukon	0	0-308	0.000	0.000	0.000	0.016	0.78	1.00
SW Alaska	0	0-418	0.000	0.000	0.000	0.021	0.78	1.00
E GOA/PNW	8,059	6,130-10,049	0.410	0.312	0.410	0.512	0.00	1.00

Age-3 (PSC = 170,270; n = 807)

Region	Est. num.	Est. CI	Mean	2.5%	Median	97.5%	P=0	SF
SE Asia	13,868	10,634-17,439	0.081	0.062	0.081	0.102	0.00	1.00
NE Asia	46,375	40,936-51,980	0.272	0.240	0.272	0.305	0.00	1.00
W Alaska	16,689	12,712-21,019	0.098	0.075	0.098	0.123	0.00	1.00
Up/Mid Yukon	2,570	696-5,111	0.015	0.004	0.014	0.030	0.00	1.00
SW Alaska	8,634	5,599-12,104	0.051	0.033	0.050	0.071	0.00	1.00
E GOA/PNW	82,131	76,021-88,233	0.482	0.446	0.482	0.518	0.00	1.00

Age-4 (PSC = 140,349; n = 590)

Region	Est. num.	Est. CI	Mean	2.5%	Median	97.5%	P=0	SF
SE Asia	23,816	19,478-28,446	0.170	0.139	0.169	0.203	0.00	1.00
NE Asia	55,811	50,017-61,683	0.398	0.356	0.398	0.439	0.00	1.00
W Alaska	5,054	2,914-7,636	0.036	0.021	0.035	0.054	0.00	1.00
Up/Mid Yukon	1,440	353-3,024	0.010	0.003	0.010	0.022	0.00	1.00
SW Alaska	3,455	1,521-5,959	0.025	0.011	0.024	0.042	0.00	1.00
E GOA/PNW	50,770	45,304-56,377	0.362	0.323	0.362	0.402	0.00	1.00

Age-5 (PSC = 17,582; n = 68)

Region	Est. num.	Est. CI	Mean	2.5%	Median	97.5%	P=0	SF
SE Asia	2,104	907-3,675	0.120	0.052	0.116	0.209	0.00	1.00
NE Asia	10,948	8,785-12,995	0.623	0.500	0.624	0.739	0.00	1.00
W Alaska	1,741	695-3,199	0.099	0.040	0.095	0.182	0.00	1.00
Up/Mid Yukon	0	0-311	0.000	0.000	0.000	0.018	0.78	1.00
SW Alaska	1,723	521-3,315	0.098	0.030	0.094	0.189	0.00	1.00
E GOA/PNW	1,064	257-2,367	0.061	0.015	0.056	0.135	0.00	1.00

Cluster 1 Early (PSC = 5,643; n = 170)

Region	Est. num.	Est. CI	Mean	2.5%	Median	97.5%	P=0	SF
SE Asia	541	308-826	0.096	0.055	0.094	0.146	0.00	1.00
NE Asia	1,704	1,303-2,134	0.302	0.231	0.301	0.378	0.00	1.00
W Alaska	585	336-883	0.104	0.060	0.102	0.156	0.00	1.00
Up/Mid Yukon	6	0-84	0.001	0.000	0.000	0.015	0.66	1.00
SW Alaska	495	222-835	0.088	0.039	0.086	0.148	0.00	1.00
E GOA/PNW	2,309	1,871-2,759	0.409	0.332	0.409	0.489	0.00	1.00

Cluster 1 Late (PSC = 101,893; n = 558)

Region	Est. num.	Est. CI	Mean	2.5%	Median	97.5%	P=0	SF
SE Asia	9,317	6,959-11,959	0.091	0.068	0.091	0.117	0.00	1.00
NE Asia	35,116	30,933-39,371	0.345	0.304	0.344	0.386	0.00	1.00
W Alaska	13,977	11,007-17,224	0.137	0.108	0.137	0.169	0.00	1.00
Up/Mid Yukon	755	107-1,847	0.007	0.001	0.007	0.018	0.00	1.00
SW Alaska	6,578	4,198-9,321	0.065	0.041	0.064	0.091	0.00	1.00
E GOA/PNW	36,146	31,970-40,417	0.355	0.314	0.355	0.397	0.00	1.00

Cluster 2 Early (PSC = 8,780; n = 184)

Region	Est. num.	Est. CI	Mean	2.5%	Median	97.5%	P=0	SF
SE Asia	1,129	730-1,600	0.129	0.083	0.127	0.182	0.00	1.00
NE Asia	5,617	4,969-6,239	0.640	0.566	0.640	0.711	0.00	1.00
W Alaska	802	451-1,235	0.091	0.051	0.090	0.141	0.00	1.00
Up/Mid Yukon	7	0-117	0.001	0.000	0.000	0.013	0.69	1.00
SW Alaska	141	0-400	0.016	0.000	0.014	0.046	0.04	1.00
E GOA/PNW	1,081	694-1,537	0.123	0.079	0.122	0.175	0.00	1.00

Cluster 2 Late (PSC = 34,620; n = 185)

Region	Est. num.	Est. CI	Mean	2.5%	Median	97.5%	P=0	SF
SE Asia	4,356	2,759-6,224	0.126	0.080	0.124	0.180	0.00	1.00
NE Asia	11,371	8,976-13,880	0.328	0.259	0.328	0.401	0.00	1.00
W Alaska	1,118	290-2,410	0.032	0.008	0.030	0.070	0.00	1.00
Up/Mid Yukon	0	0-290	0.000	0.000	0.000	0.008	0.78	1.00
SW Alaska	1,440	371-2,948	0.042	0.011	0.039	0.085	0.00	1.00
E GOA/PNW	16,333	13,785-18,886	0.472	0.398	0.472	0.546	0.00	1.00

Cluster 3 Early (PSC = 3,141; n = 81)

Region	Est. num.	Est. CI	Mean	2.5%	Median	97.5%	P=0	SF
SE Asia	763	476-1,092	0.243	0.152	0.241	0.348	0.00	1.00
NE Asia	1,616	1,255-1,981	0.515	0.399	0.515	0.631	0.00	1.00
W Alaska	122	0-325	0.039	0.000	0.035	0.103	0.03	1.00
Up/Mid Yukon	199	62-405	0.064	0.020	0.060	0.129	0.00	1.00
SW Alaska	8	0-179	0.003	0.000	0.000	0.057	0.68	1.00
E GOA/PNW	429	215-697	0.137	0.069	0.134	0.222	0.00	1.00

Cluster 3 Late (PSC = 85,085; n = 443)

Region	Est. num.	Est. CI	Mean	2.5%	Median	97.5%	P=0	SF
SE Asia	8,267	5,957-10,863	0.097	0.070	0.097	0.128	0.00	1.00
NE Asia	12,601	9,755-15,724	0.148	0.115	0.147	0.185	0.00	1.00
W Alaska	3,451	1,810-5,429	0.041	0.021	0.040	0.064	0.00	1.00
Up/Mid Yukon	903	212-2,010	0.011	0.002	0.010	0.024	0.00	1.00
SW Alaska	1,116	0-2,945	0.013	0.000	0.012	0.035	0.04	1.00
E GOA/PNW	58,744	54,828-62,531	0.690	0.644	0.691	0.735	0.00	1.00

Cluster 4 Early (PSC = 6,318; n = 133)

Region	Est. num.	Est. CI	Mean	2.5%	Median	97.5%	P=0	SF
SE Asia	1,521	1,068-2,025	0.241	0.169	0.239	0.321	0.00	1.00
NE Asia	3,264	2,698-3,824	0.517	0.427	0.517	0.605	0.00	1.00
W Alaska	395	105-749	0.063	0.017	0.061	0.119	0.00	1.00
Up/Mid Yukon	125	2-384	0.020	0.000	0.016	0.061	0.00	1.00
SW Alaska	44	0-233	0.007	0.000	0.003	0.037	0.33	1.00
E GOA/PNW	967	606-1,385	0.153	0.096	0.152	0.219	0.00	1.00

Cluster 4 Late (PSC = 41,370; n = 182)

Region	Est. num.	Est. CI	Mean	2.5%	Median	97.5%	P=0	SF
SE Asia	13,520	10,637-16,567	0.327	0.257	0.326	0.400	0.00	1.00
NE Asia	22,861	19,632-26,064	0.553	0.475	0.553	0.630	0.00	1.00
W Alaska	631	63-1,860	0.015	0.002	0.013	0.045	0.00	1.00
Up/Mid Yukon	217	0-957	0.005	0.000	0.003	0.023	0.23	1.00
SW Alaska	397	0-1,327	0.010	0.000	0.008	0.032	0.12	1.00
E GOA/PNW	3,741	2,235-5,613	0.090	0.054	0.089	0.136	0.00	1.00

Age-3 Cluster 1 (PSC = 53,477; n = 333)

Region	Est. num.	Est. CI	Mean	2.5%	Median	97.5%	P=0	SF
SE Asia	3,220	1,937-4,784	0.060	0.036	0.059	0.089	0.00	1.00
NE Asia	17,841	15,059-20,754	0.334	0.282	0.333	0.388	0.00	1.00
W Alaska	7,464	5,454-9,700	0.140	0.102	0.139	0.181	0.00	1.00
Up/Mid Yukon	824	161-1,883	0.015	0.003	0.014	0.035	0.00	1.00
SW Alaska	4,137	2,401-6,157	0.077	0.045	0.076	0.115	0.00	1.00
E GOA/PNW	19,988	17,106-22,955	0.374	0.320	0.373	0.429	0.00	1.00

Age-3 Cluster 1 Late (PSC = 50,671; n = 289)

Region	Est. num.	Est. CI	Mean	2.5%	Median	97.5%	P=0	SF
SE Asia	2,971	1,682-4,548	0.059	0.033	0.058	0.090	0.00	1.00
NE Asia	18,554	15,671-21,522	0.366	0.309	0.366	0.425	0.00	1.00
W Alaska	7,188	5,081-9,531	0.142	0.100	0.141	0.188	0.00	1.00
Up/Mid Yukon	1,004	275-2,177	0.020	0.005	0.018	0.043	0.00	1.00
SW Alaska	3,106	1,391-5,166	0.061	0.027	0.060	0.102	0.00	1.00
E GOA/PNW	17,845	14,960-20,827	0.352	0.295	0.352	0.411	0.00	1.00

Age-3 Cluster 2 (PSC = 21,582; n = 124)

Region	Est. num.	Est. CI	Mean	2.5%	Median	97.5%	P=0	SF
SE Asia	2,539	1,440-3,885	0.118	0.067	0.116	0.180	0.00	1.00
NE Asia	6,622	4,911-8,466	0.307	0.228	0.306	0.392	0.00	1.00
W Alaska	1,552	667-2,764	0.072	0.031	0.069	0.128	0.00	1.00
Up/Mid Yukon	4	0-333	0.000	0.000	0.000	0.015	0.78	1.00
SW Alaska	811	65-1,916	0.038	0.003	0.035	0.089	0.01	1.00
E GOA/PNW	10,052	8,164-11,980	0.466	0.378	0.466	0.555	0.00	1.00

Age-3 Cluster 2 Late (PSC = 17,216; n = 77)

Region	Est. num.	Est. CI	Mean	2.5%	Median	97.5%	P=0	SF
SE Asia	2,096	1,040-3,472	0.122	0.060	0.119	0.202	0.00	1.00
NE Asia	2,743	1,418-4,373	0.159	0.082	0.156	0.254	0.00	1.00
W Alaska	620	48-1,645	0.036	0.003	0.031	0.096	0.00	1.00
Up/Mid Yukon	20	0-427	0.001	0.000	0.000	0.025	0.72	1.00
SW Alaska	1,079	272-2,315	0.063	0.016	0.058	0.134	0.00	1.00
E GOA/PNW	10,655	8,726-12,475	0.619	0.507	0.620	0.725	0.00	1.00

Age-3 Cluster 3 (PSC = 43,874; n = 222)

Region	Est. num.	Est. CI	Mean	2.5%	Median	97.5%	P=0	SF
SE Asia	3,352	1,928-5,102	0.076	0.044	0.075	0.116	0.00	1.00
NE Asia	5,269	3,409-7,457	0.120	0.078	0.119	0.170	0.00	1.00
W Alaska	2,246	762-4,030	0.051	0.017	0.050	0.092	0.00	1.00
Up/Mid Yukon	758	106-1,960	0.017	0.002	0.015	0.045	0.00	1.00
SW Alaska	467	0-1,875	0.011	0.000	0.007	0.043	0.29	1.00
E GOA/PNW	31,780	28,967-34,371	0.724	0.660	0.725	0.783	0.00	1.00

Age-3 Cluster 3 Late (PSC = 42,312; n = 198)

Region	Est. num.	Est. CI	Mean	2.5%	Median	97.5%	P=0	SF
SE Asia	2,367	1,148-3,950	0.056	0.027	0.055	0.093	0.00	1.00
NE Asia	2,529	1,178-4,273	0.060	0.028	0.058	0.101	0.00	1.00
W Alaska	1,784	383-3,599	0.042	0.009	0.040	0.085	0.00	1.00
Up/Mid Yukon	932	122-2,356	0.022	0.003	0.020	0.056	0.00	1.00
SW Alaska	1,001	0-2,628	0.024	0.000	0.022	0.062	0.08	1.00
E GOA/PNW	33,696	31,024-36,106	0.796	0.733	0.797	0.853	0.00	1.00

Age-3 Cluster 4 (PSC = 23,715; n = 132)

Region	Est. num.	Est. CI	Mean	2.5%	Median	97.5%	P=0	SF
SE Asia	5,656	3,943-7,528	0.239	0.166	0.237	0.317	0.00	1.00
NE Asia	12,427	10,252-14,579	0.524	0.432	0.524	0.615	0.00	1.00
W Alaska	1,220	290-2,456	0.051	0.012	0.049	0.104	0.00	1.00
Up/Mid Yukon	232	0-919	0.010	0.000	0.007	0.039	0.16	1.00
SW Alaska	512	6-1,627	0.022	0.000	0.018	0.069	0.00	1.00
E GOA/PNW	3,665	2,295-5,255	0.155	0.097	0.153	0.222	0.00	1.00

Age-3 Cluster 4 Late (PSC = 20,573; n = 72)

Region	Est. num.	Est. CI	Mean	2.5%	Median	97.5%	P=0	SF
SE Asia	5,903	3,871-8,176	0.287	0.188	0.285	0.397	0.00	1.00
NE Asia	10,195	7,598-12,765	0.496	0.369	0.496	0.620	0.00	1.00
W Alaska	866	13-2,415	0.042	0.001	0.037	0.117	0.00	1.00
Up/Mid Yukon	324	0-1,239	0.016	0.000	0.011	0.060	0.12	1.00
SW Alaska	415	0-1,704	0.020	0.000	0.013	0.083	0.26	1.00
E GOA/PNW	2,866	1,413-4,722	0.139	0.069	0.136	0.230	0.00	1.00

Age-4 Cluster 1 (PSC = 44,080; n = 180)

Region	Est. num.	Est. CI	Mean	2.5%	Median	97.5%	P=0	SF
SE Asia	5,073	3,144-7,360	0.115	0.071	0.114	0.167	0.00	1.00
NE Asia	18,781	15,507-22,106	0.426	0.352	0.426	0.502	0.00	1.00
W Alaska	3,674	2,034-5,719	0.083	0.046	0.082	0.130	0.00	1.00
Up/Mid Yukon	0	0-357	0.000	0.000	0.000	0.008	0.78	1.00
SW Alaska	2,262	737-4,291	0.051	0.017	0.049	0.097	0.00	1.00
E GOA/PNW	14,287	11,234-17,529	0.324	0.255	0.324	0.398	0.00	1.00

Age-4 Cluster 1 Early (PSC = 2,313; n = 78)

Region	Est. num.	Est. CI	Mean	2.5%	Median	97.5%	P=0	SF
SE Asia	364	196-573	0.158	0.085	0.154	0.248	0.00	1.00
NE Asia	821	572-1,084	0.355	0.247	0.354	0.468	0.00	1.00
W Alaska	235	95-425	0.102	0.041	0.099	0.184	0.00	1.00
Up/Mid Yukon	0	0-40	0.000	0.000	0.000	0.018	0.78	1.00
SW Alaska	38	0-201	0.017	0.000	0.008	0.087	0.38	1.00
E GOA/PNW	852	601-1,119	0.369	0.260	0.367	0.484	0.00	1.00

Age-4 Cluster 1 Late (PSC = 41,766; n = 102)

Region	Est. num.	Est. CI	Mean	2.5%	Median	97.5%	P=0	SF
SE Asia	3,585	1,551-6,282	0.086	0.037	0.083	0.150	0.00	1.00
NE Asia	20,157	15,912-24,365	0.483	0.381	0.483	0.583	0.00	1.00
W Alaska	2,973	1,141-5,509	0.071	0.027	0.068	0.132	0.00	1.00
Up/Mid Yukon	0	0-593	0.000	0.000	0.000	0.014	0.78	1.00
SW Alaska	3,619	1,414-6,678	0.087	0.034	0.083	0.160	0.00	1.00
E GOA/PNW	11,431	7,868-15,357	0.274	0.188	0.272	0.368	0.00	1.00

Age-4 Cluster 2 (PSC = 17,790; n = 165)

Region	Est. num.	Est. CI	Mean	2.5%	Median	97.5%	P=0	SF
SE Asia	3,142	2,131-4,275	0.177	0.120	0.175	0.240	0.00	1.00
NE Asia	10,287	8,858-11,674	0.578	0.498	0.579	0.656	0.00	1.00
W Alaska	544	165-1,135	0.031	0.009	0.029	0.064	0.00	1.00
Up/Mid Yukon	41	0-349	0.002	0.000	0.000	0.020	0.56	1.00
SW Alaska	359	18-994	0.020	0.001	0.017	0.056	0.01	1.00
E GOA/PNW	3,415	2,397-4,550	0.192	0.135	0.191	0.256	0.00	1.00

Age-4 Cluster 2 Early (PSC = 3,599; n = 92)

Region	Est. num.	Est. CI	Mean	2.5%	Median	97.5%	P=0	SF
SE Asia	571	318-872	0.159	0.088	0.157	0.242	0.00	1.00
NE Asia	2,383	2,006-2,740	0.662	0.557	0.663	0.761	0.00	1.00
W Alaska	167	31-373	0.047	0.009	0.043	0.104	0.00	1.00
Up/Mid Yukon	9	0-112	0.003	0.000	0.000	0.031	0.62	1.00
SW Alaska	117	16-301	0.033	0.004	0.029	0.084	0.00	1.00
E GOA/PNW	349	161-600	0.097	0.045	0.094	0.167	0.00	1.00

Age-4 Cluster 2 Late (PSC = 14,191; n = 73)

Region	Est. num.	Est. CI	Mean	2.5%	Median	97.5%	P=0	SF
SE Asia	2,809	1,559-4,313	0.198	0.110	0.195	0.304	0.00	1.00
NE Asia	6,808	5,078-8,537	0.480	0.358	0.480	0.602	0.00	1.00
W Alaska	82	0-690	0.006	0.000	0.000	0.049	0.27	1.00
Up/Mid Yukon	0	0-245	0.000	0.000	0.000	0.017	0.78	1.00
SW Alaska	115	0-931	0.008	0.000	0.000	0.066	0.51	1.00
E GOA/PNW	4,374	2,954-5,938	0.308	0.208	0.307	0.418	0.00	1.00

Age-4 Cluster 3 (PSC = 36,164; n = 199)

Region	Est. num.	Est. CI	Mean	2.5%	Median	97.5%	P=0	SF
SE Asia	5,967	4,143-8,025	0.165	0.115	0.164	0.222	0.00	1.00
NE Asia	8,964	6,825-11,272	0.248	0.189	0.247	0.312	0.00	1.00
W Alaska	1,094	374-2,145	0.030	0.010	0.029	0.059	0.00	1.00
Up/Mid Yukon	565	117-1,350	0.016	0.003	0.014	0.037	0.00	1.00
SW Alaska	140	0-837	0.004	0.000	0.002	0.023	0.38	1.00
E GOA/PNW	19,431	16,897-21,922	0.537	0.467	0.538	0.606	0.00	1.00

Age-4 Cluster 3 Late (PSC = 34,877; n = 172)

Region	Est. num.	Est. CI	Mean	2.5%	Median	97.5%	P=0	SF
SE Asia	4,832	3,096-6,846	0.139	0.089	0.137	0.196	0.00	1.00
NE Asia	7,577	5,544-9,880	0.217	0.159	0.216	0.283	0.00	1.00
W Alaska	985	257-2,083	0.028	0.007	0.026	0.060	0.00	1.00
Up/Mid Yukon	221	2-807	0.006	0.000	0.004	0.023	0.00	1.00
SW Alaska	248	0-1,038	0.007	0.000	0.005	0.030	0.20	1.00
E GOA/PNW	21,011	18,401-23,548	0.602	0.528	0.603	0.675	0.00	1.00

Age-4 Cluster 4 (PSC = 19,547; n = 128)

Region	Est. num.	Est. CI	Mean	2.5%	Median	97.5%	P=0	SF
SE Asia	6,124	4,476-7,867	0.313	0.229	0.312	0.402	0.00	1.00
NE Asia	11,088	9,279-12,872	0.567	0.475	0.568	0.658	0.00	1.00
W Alaska	103	1-602	0.005	0.000	0.001	0.031	0.00	1.00
Up/Mid Yukon	32	0-358	0.002	0.000	0.000	0.018	0.63	1.00
SW Alaska	116	0-602	0.006	0.000	0.003	0.031	0.32	1.00
E GOA/PNW	2,082	1,152-3,250	0.107	0.059	0.105	0.166	0.00	1.00

Age-4 Cluster 4 Late (PSC = 16,957; n = 72)

Region	Est. num.	Est. CI	Mean	2.5%	Median	97.5%	P=0	SF
SE Asia	5,907	3,884-8,053	0.348	0.229	0.347	0.475	0.00	1.00
NE Asia	9,853	7,686-11,989	0.581	0.453	0.581	0.707	0.00	1.00
W Alaska	0	0-284	0.000	0.000	0.000	0.017	0.78	1.00
Up/Mid Yukon	5	0-288	0.000	0.000	0.000	0.017	0.76	1.00
SW Alaska	0	0-280	0.000	0.000	0.000	0.016	0.78	1.00
E GOA/PNW	1,191	399-2,358	0.070	0.024	0.066	0.139	0.00	1.00

Age-4 Early (PSC = 14,066; n = 77)

Region	Est. num.	Est. CI	Mean	2.5%	Median	97.5%	P=0	SF
SE Asia	2,439	1,316-3,802	0.173	0.094	0.171	0.270	0.00	1.00
NE Asia	7,746	6,071-9,389	0.551	0.432	0.551	0.667	0.00	1.00
W Alaska	165	0-887	0.012	0.000	0.004	0.063	0.39	1.00
Up/Mid Yukon	710	74-1,642	0.050	0.005	0.047	0.117	0.01	1.00
SW Alaska	627	113-1,622	0.045	0.008	0.038	0.115	0.00	1.00
E GOA/PNW	2,376	1,289-3,726	0.169	0.092	0.166	0.265	0.00	1.00

Age-4 Late (PSC = 126,282; n = 513)

Region	Est. num.	Est. CI	Mean	2.5%	Median	97.5%	P=0	SF
SE Asia	21,251	17,127-25,716	0.168	0.136	0.168	0.204	0.00	1.00
NE Asia	47,330	41,830-52,927	0.375	0.331	0.375	0.419	0.00	1.00
W Alaska	5,155	3,023-7,747	0.041	0.024	0.040	0.061	0.00	1.00
Up/Mid Yukon	382	0-1,616	0.003	0.000	0.002	0.013	0.24	1.00
SW Alaska	3,049	1,290-5,328	0.024	0.010	0.023	0.042	0.00	1.00
E GOA/PNW	49,112	43,776-54,502	0.389	0.347	0.389	0.432	0.00	1.00



U.S. Secretary of Commerce

Gina M. Raimondo

Under Secretary of Commerce for
Oceans and Atmosphere

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