NOAA Technical Memorandum NMFS-AFSC-391

Genetic Stock Composition Analysis of the Chinook Salmon Bycatch from the 2017 Bering Sea Trawl Fisheries

by
C. M. Guthrie, III, Hv. T. Nguyen, M. Marsh, J. T. Watson,
and J. R. Guyon

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Alaska Fisheries Science Center

April 2019

NOAA Technical Memorandum NMFS

The National Marine Fisheries Service's Alaska Fisheries Science Center uses the NOAA Technical Memorandum series to issue informal scientific and technical publications when complete formal review and editorial processing are not appropriate or feasible. Documents within this series reflect sound professional work and may be referenced in the formal scientific and technical literature.

The NMFS-AFSC Technical Memorandum series of the Alaska Fisheries Science Center continues the NMFS-F/NWC series established in 1970 by the Northwest Fisheries Center. The NMFS-NWFSC series is currently used by the Northwest Fisheries Science Center.

This document should be cited as follows:

Guthrie III, C. M., Hv. T. Nguyen, M. Marsh, J. T. Watson, and J. R. Guyon. 2019. Genetic stock composition analysis of the Chinook salmon bycatch samples from the 2017 Bering Sea trawl fisheries. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-391, 35 p.

Document available: https://www.afsc.noaa.gov/Publications/AFSC-TM/NOAA-TM-AFSC-391.pdf

NOAA Technical Memorandum NMFS-AFSC-391

Genetic Stock Composition Analysis of the Chinook Salmon Bycatch Samples from the 2017 Bering Sea Trawl Fisheries

C. M. Guthrie, III, Hv. T. Nguyen, M. Marsh, J. T. Watson,
and J. R. Guyon

Alaska Fisheries Science Center
National Marine Fisheries Service
National Oceanic and Atmospheric Administration
17109 Pt. Lena Loop Road
Juneau, AK 99801

www.afsc.noaa.gov

U.S. DEPARTMENT OF COMMERCE
Wilbur L. Ross Jr., Secretary
National Oceanic and Atmospheric Administration
Dr. Neil Jacobs, Acting Under Secretary and Administrator
National Marine Fisheries Service
Chris Oliver, Assistant Administrator for Fisheries

April 2019

This document is available to the public through:

National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road
Springfield, VA 22161

www.ntis.gov

ABSTRACT

A genetic analysis of samples from the Chinook salmon (*Oncorhynchus tshawytscha*) bycatch of the 2017 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 2017, genetic samples were collected using a systematic random sampling protocol where one out of every 10 Chinook salmon encountered was sampled. Based on analysis of 2,619 Chinook salmon bycatch samples collected throughout the 2017 BSAI pollock trawl fishery, British Columbia and Coastal Western Alaska regions (36%; 10,812 fish and 24%; 7,113 fish, respectively) dominated the sample set with smaller contributions from West Coast US (19%; 5,642 fish) and North Alaska Peninsula (15%; 4,490 fish) regions. Temporal groupings within the pollock "A" and "B" seasons revealed changes in stock composition over the course of the year. The percentage and number of fish from the Coastal Western Alaska (28%; 6,118 fish vs. 12%; 1,019 fish) and North Alaska Peninsula (21%; 4,465 fish vs. 2%; 154 fish) regions was higher in the "A" season than the "B" season, whereas the contribution from the West Coast US (11%; 2,303 fish vs. 39%; 3,291 fish) region was higher in the "B" season. The percentage contribution from the British Columbia (35%; 7,609 fish vs. 37%; 3,141 fish) region was similar across the two seasons, although due to the larger total bycatch in the "A" season, more than twice the number of fish were caught in the "A" season. The contribution from the Coastal Western Alaska region is the lowest since Auke Bay Laboratories genetic studies commenced in 2008. For the first time, nearly equal proportions of Chinook salmon bycatch from the 2017 Bering Sea "A" season originated from river systems directly flowing into the Bering Sea and

from southern regions, with the highest contribution from British Columbia instead of Coastal Western Alaska. In 2017, genetic samples from the bycatch of the BSAI non-pollock catcher processor fishery were collected by the fishing industry and based on genotyping of the 349 Bering Sea samples, 76% of the samples were from southern regions.

CONTENTS

INTRODUCTION

Pacific salmon (*Oncorhynchus* spp.) are prohibited species in the federally managed Bering Sea groundfish fisheries, which are subject to complex management rules (NPMFC 2017a) that are in part designed to reduce prohibited species catch, hereafter referred to as "bycatch". 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 Chinook salmon (*Oncorhynchus tshawytscha*) from many different localities in North America and Asia (Myers et al. 2007, Davis et al. 2009). Chinook salmon are economically valuable and highly prized in commercial, subsistence, and sport fisheries. Determining the geographic origin of salmon caught in federally managed fisheries is essential to understanding the effects that fishing has on Chinook salmon stocks, especially those with conservation concerns (NPFMC 2017a). This report provides genetic stock identification results for the Chinook salmon bycatch samples collected from the U.S. Bering Sea walleye pollock (*Gadus chalcogrammus*) trawl fishery. National Marine Fisheries Service (NMFS) geographical statistical areas (NMFS area) associated with the Bering Sea groundfish fishery (NMFS areas 509-524) and Alaska Department of Fish and Game (ADF&G) statistical areas[1] are shown in Figure 1 and are used later in the report to describe the spatial distribution of the Chinook salmon bycatch and genetic samples.

Amendment 91 to the North Pacific Fishery Management Council (NPFMC) Fishery Management Plan (FMP) for groundfish of the BSAI Management Area was enacted in 2010 and included retention of the all salmon caught in the pollock fishery. In 2011, a systematic random

[1] http://www.adfg.alaska.gov/static/fishing/PDFs/commercial/chart03_bs.pdf

sampling design recommended by Pella and Geiger (2009) was implemented by the Alaska Fisheries Science Center's (AFSC) Fisheries Monitoring and Analysis Division's (FMA) North Pacific Groundfish and Halibut Observer Program (Observer Program) to collect genetic samples from one out of every 10 Chinook salmon encountered as bycatch in the Bering Sea pollock fishery.

In 2017, genetic samples were collected by the Observer Program from the Chinook salmon bycatch of the Bering Sea pollock fishery by using the systematic sampling protocols recommended previously (Pella and Geiger 2009). The number of available samples and the unbiased sampling methodology facilitated the extrapolation of the sample stock composition to the overall Chinook bycatch from the Bering Sea pollock trawl fishery in 2017. Stock composition analyses were performed using the single nucleotide polymorphism (SNP) baseline provided by the ADF&G (Templin et al. 2011), the same baseline that was used previously to estimate stock composition of samples from the 2005-2016 Chinook salmon bycatch (NMFS 2009; Guyon et al. 2010a,b; Guthrie et al. 2012-2018; 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).

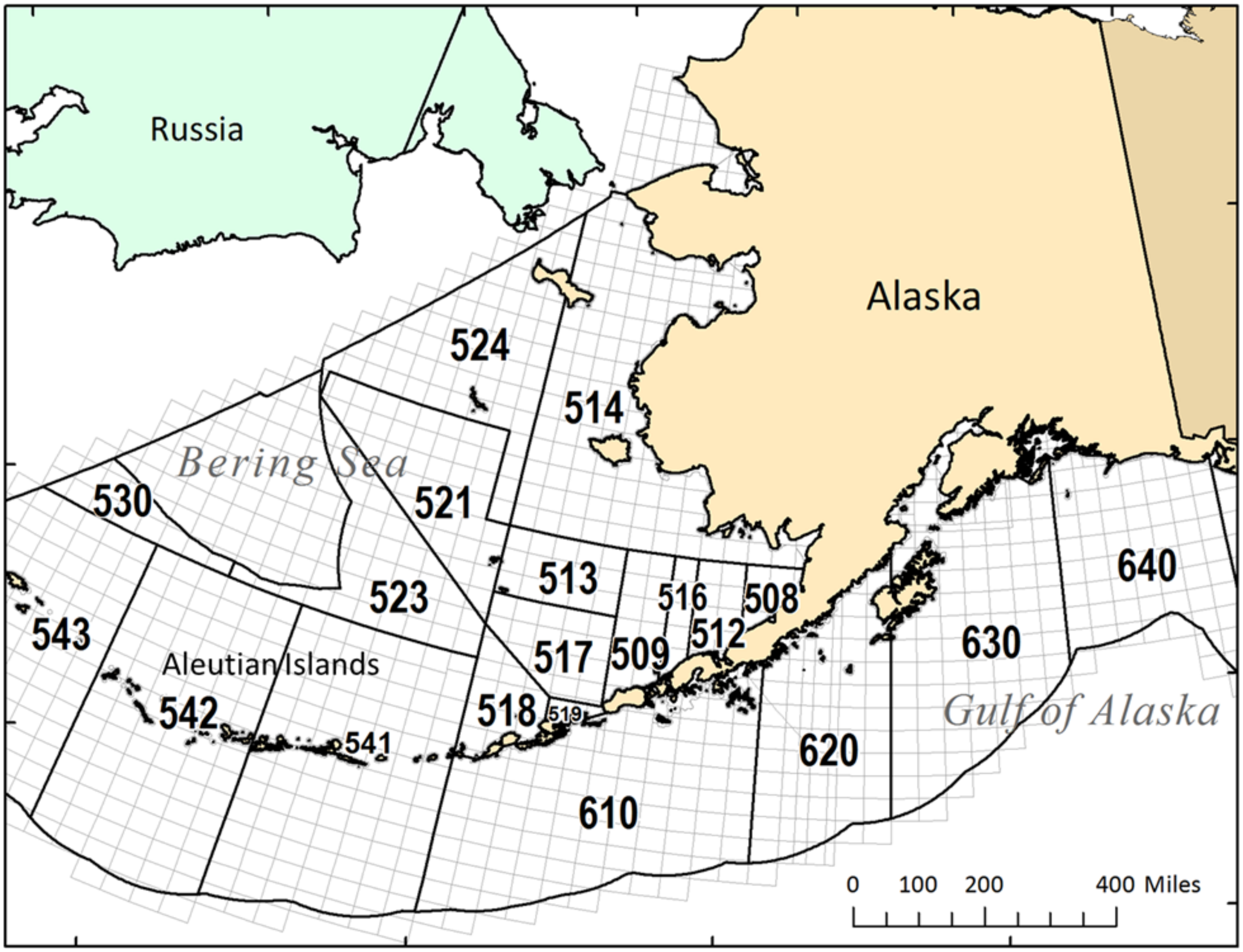


Figure 1. -- NMFS (outlined in black) and ADF&G (outlined in light gray) statistical areas associated with the Bering Sea and Gulf of Alaska groundfish fisheries.

SAMPLE DISTRIBUTION

Samples were collected from the Chinook salmon bycatch by the Observer Program for analysis at AFSC's Auke Bay Laboratories (ABL). Samples of axillary process tissue and scales were collected from the Chinook salmon bycatch throughout 2017. Axillary process tissues were stored in coin envelopes which were labeled, frozen, and shipped to ABL for analysis. Scales were collected as an additional source for genetic analysis and ageing (funding dependent).

In 2017, an estimated 30,076 Chinook salmon were taken in the bycatch of BSAI pollock trawl fisheries (NMFS 2019). The Chinook salmon bycatch estimate is 15% below the historical average (35,661) between 1991 and 2016, and far below the highest overall Chinook bycatch in 2007 when an estimated 124,723 fish were taken (Fig. 2; Table 1). Of the total 2017 bycatch, 21,828 were from the trawl "A" season (01/01/17 to 6/10/17) and 8,248 were from the "B" season (6/11/17 to 12/31/17). For the genetic analysis, the "B" season started 6/06/17, because all but 21 of the "A" season samples were collected by 4/25/17. This difference is reflected in Table 1, and Appendix 2.

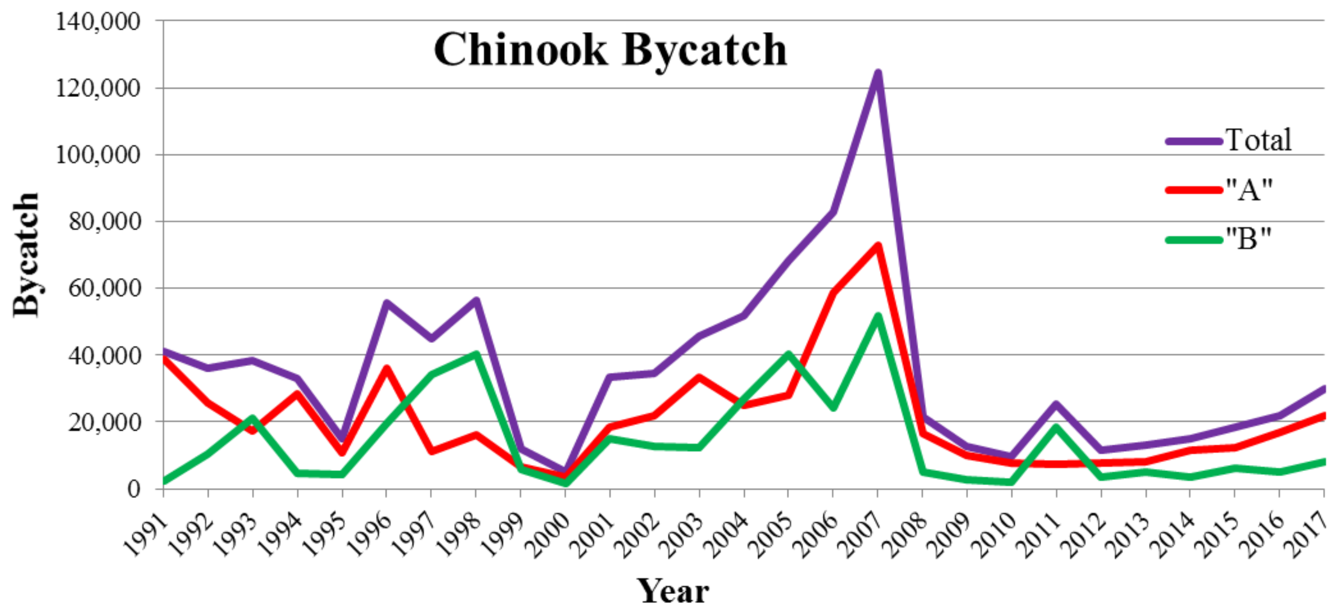


Figure 2. -- Annual "A" and "B" season estimates for the Chinook salmon bycatch from the Bering Sea pollock trawl fishery (NMFS 2019).

In 2017, there were 2,948 genetic samples received from the Bering Sea Chinook salmon bycatch collected by the Observer Program; of those samples, 2,619 were successfully genotyped for an overall genotyped sampling rate of 8.7% ("A" season N = 1,866 fish, 8.6% sampling rate; "B" season N = 753 fish, 8.9% sampling rate).

Table 1. **--** Annual “A” and “B” season estimates for the Chinook salmon bycatch from the Bering Sea-Aleutian Island pollock trawl fishery (NMFS 2019).

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	124,723	72,943	51,780
2008	21,307	16,495	4,811
2009	12,579	9,882	2,697
2010	9,720	7,649	2,071
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
2016	21,926	16,828	5,098
2017	30,076	21,603	8,473

Potential biases primarily introduced through spatial and temporal aspects of genetic sample collection from the bycatch are well documented and have the potential to affect resulting stock composition estimates (Pella and Geiger 2009). The distributions of 2017 Chinook salmon bycatch genetic samples were evaluated by comparing the collection of genetic samples with the overall bycatch distribution (Figs. 3 and 4). The temporal distribution of samples collected and successfully genotyped was evaluated across the two fishing seasons (Fig. 3). The sample spatial distribution was compared with the total bycatch by NMFS statistical area (NMFS area) over time (Fig. 4). 2017 was the seventh year that systematic random sampling was employed for collecting genetic tissue from the Bering Sea Chinook salmon bycatch and Figure 4 shows that the resulting genetic samples were spatially and temporally representative of the total Chinook bycatch (i.e., those fish not sampled from the bycatch). As in 2011-2016, the sample spatial and temporal distributions were well aligned in 2017 (Guthrie et al. 2012-2018).

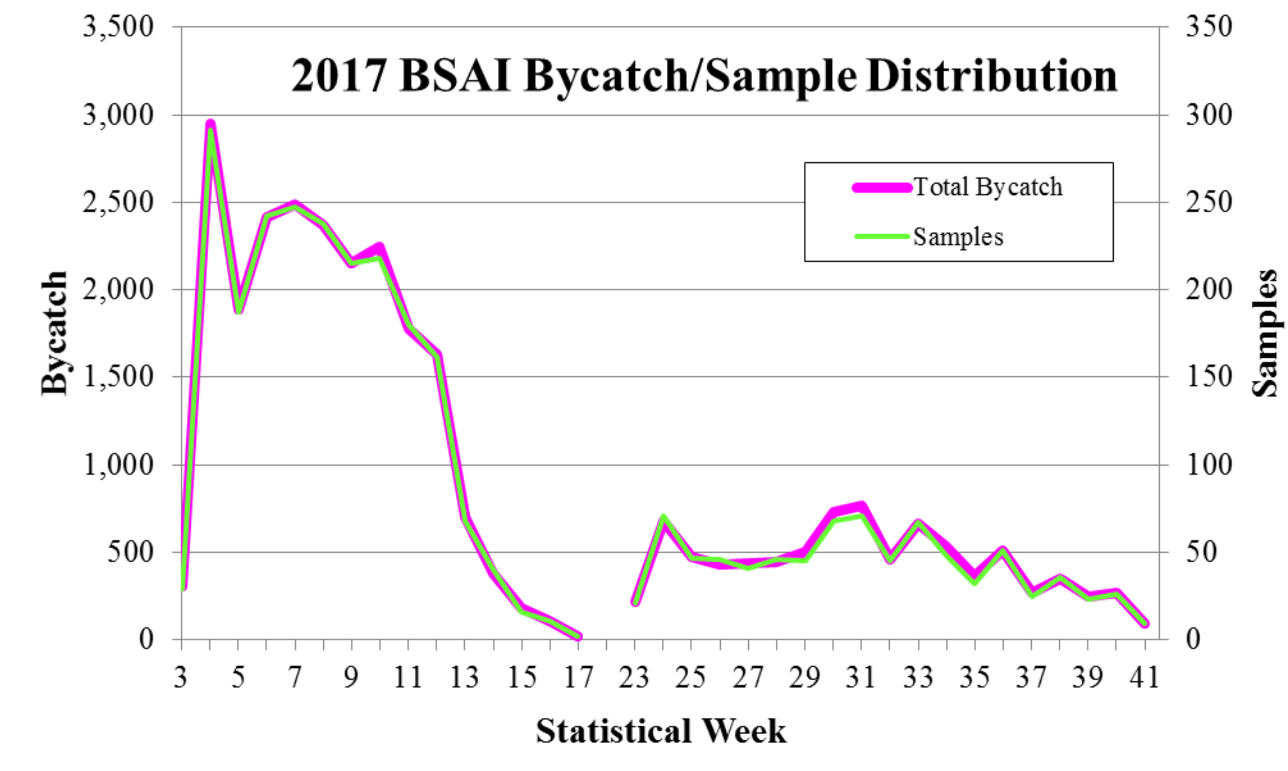


Figure 3. -- Number of Chinook salmon bycatch and genetic samples by statistical week. Weeks 3-17 correspond to the groundfish "A" season, whereas weeks 23-42 correspond to the "B" season.

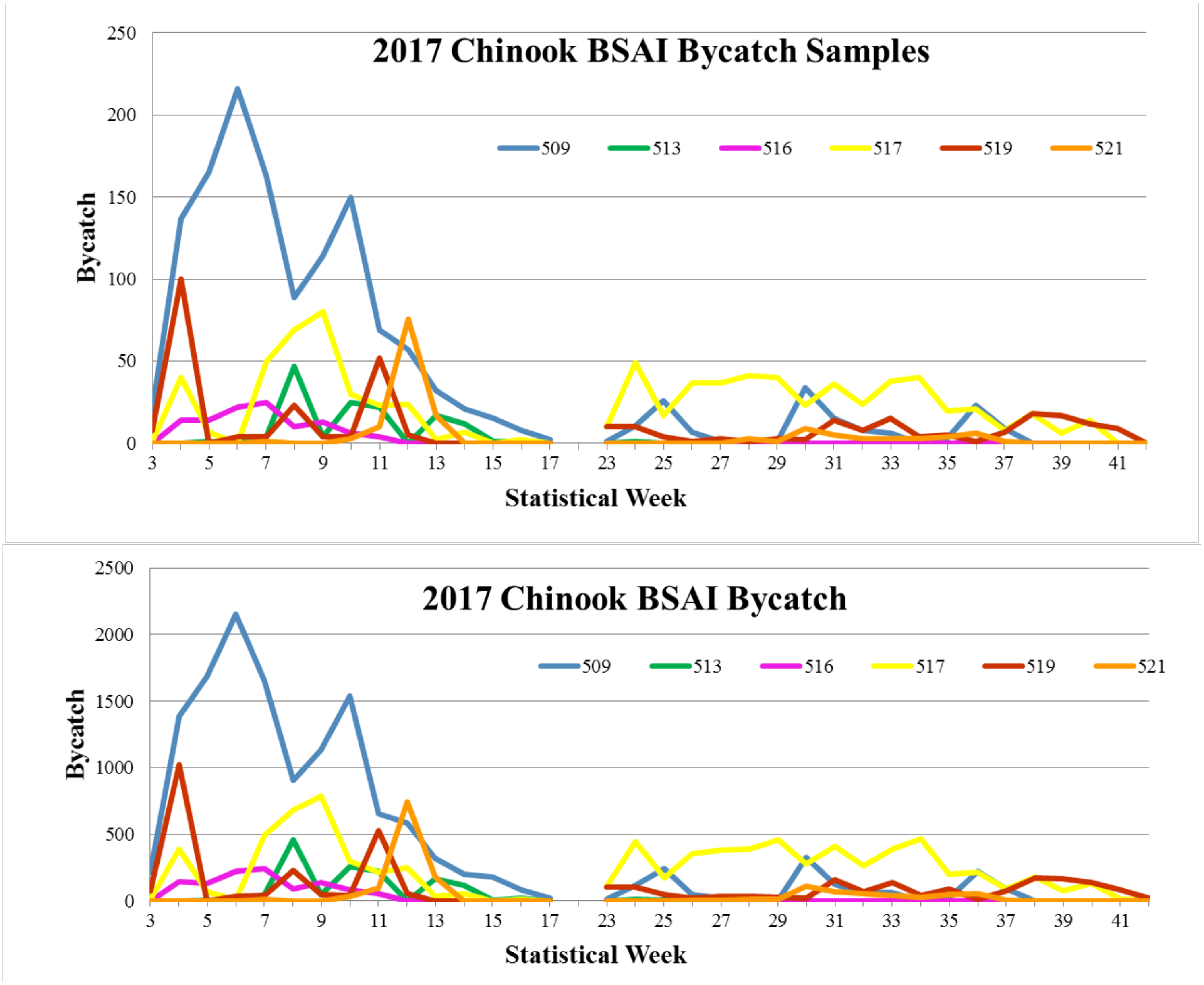


Figure 4. -- Comparison of the Chinook salmon bycatch by time and area with the distribution of available genetic samples. Top panel: Distribution of the 2,964 samples from the 2017 bycatch. Not graphed were 13 fish from NMFS area 523. Bottom panel: Distribution of the Chinook salmon caught in the 2017 Bering Sea pollock trawl fishery. Not graphed were 74 fish from NMFS area 523, and 3 fish from NMFS area 524. Weeks 3-17 correspond to the groundfish "A" season, whereas weeks 23-42 correspond to the "B" season.

BSAI non-pollock Catcher Processors Trawl Fishery

Samples (N = 349) were collected from the Chinook salmon bycatch of the federally managed 2017 Alaska BSAI non-pollock catcher processors (CP) trawl fisheries by the Alaska Seafood Cooperative and 324 (93%) were successfully analyzed at ABL. A subset from the "A" Season (N = 263) from the CP trawl fisheries was analyzed for stock composition (Fig. 5).

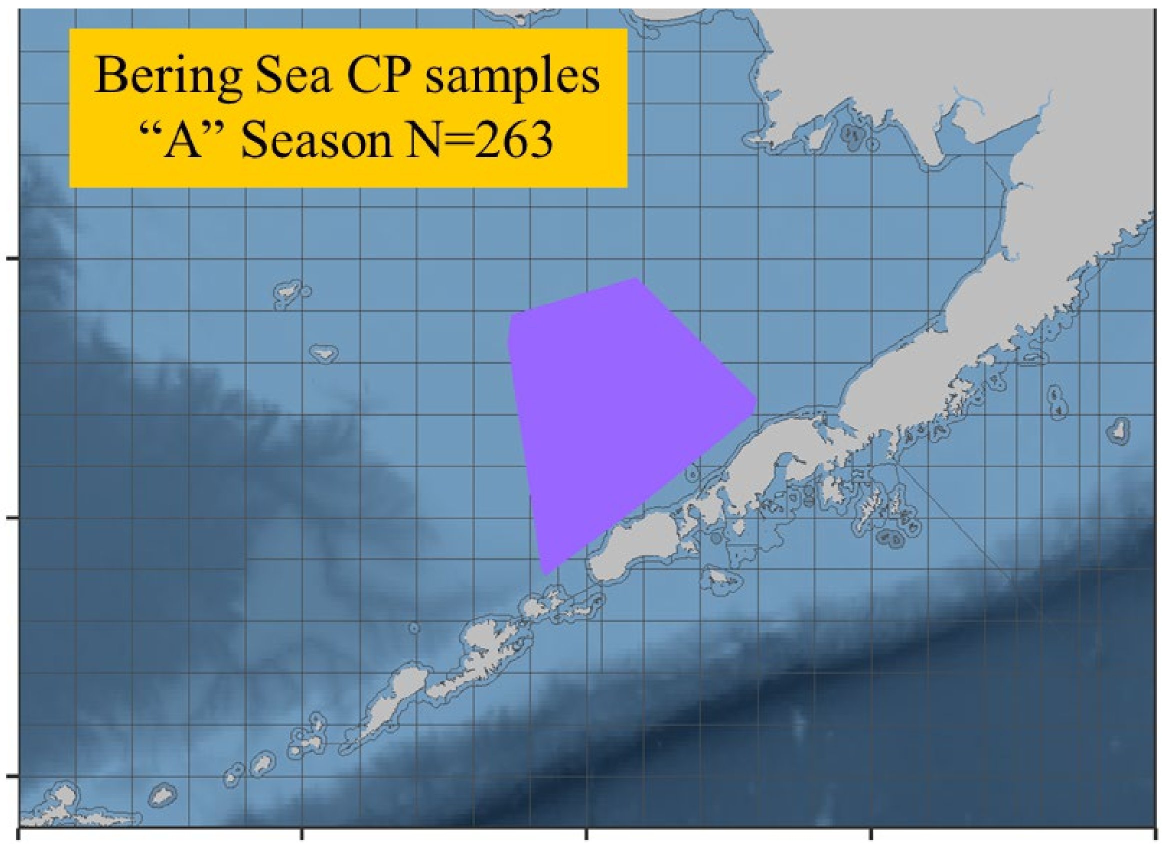


Figure 5. -- Relative location (shaded) of the 263 Chinook salmon bycatch samples from the 2017 Bering Sea "A" season CP non-pollock trawl fishery analyzed for stock composition analysis.

GENETIC STOCK COMPOSITION - PROCEDURE

DNA was extracted from axillary process tissue and genotyping was performed by using Taqman™ chemistries from Applied Biosystems Inc. on a Life Technologies QuantStudio™ or by matrix-assisted laser desorption/ionization - time of flight (MALDI-TOF) (Guyon et al. 2010a) on a Sequenom MassARRAY iPLEX platform (Gabriel et al. 2009) for the 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 (also known as stock groups or reporting groups) (Appendix 1). Proof tests performed previously have shown the baseline to be suitable for stock composition analysis (Templin et al. 2011). Replicate samples using 384-well format Taqman™ assays were compared with MALDI-TOF assays, with a concordance rate of 99.99%. In addition to internal MALDI-TOF chip controls, 10 (out of 384 on a chip) previously genotyped samples from ADF&G, which used TaqMan™ chemistries, were included on each chip during the analyses and resulting genotypes were compared. Concordance rates of 99.9% between the two chemistries for the 2017 controls confirmed the utility and compatibility of both genotyping methods.

From the 2017 Chinook salmon bycatch from the Bering Sea pollock trawl fishery, a total of 2,948 samples were analyzed of which 2,619 samples were successfully genotyped for 35 or more of the 43 SNP loci, a successful genotyping rate of 88.8%. From the Chinook salmon bycatch from the 2017 non-pollock CP trawl fishery, 324 of 349 samples received (93%) were successfully genotyped for 35 or more of the 43 SNP loci. The successfully genotyped samples had genetic information for an average of 42 of 43 markers.

Stock composition estimates were derived from BAYES software which uses a Bayesian algorithm to produce stock composition estimates and can account for missing alleles in the baseline (Pella and Masuda 2001). For each BAYES analysis, 11 Monte Carlo chains starting at disparate values of stock proportions were configured such that for each chain 95% of the stocks came from a single designated region with weights equally distributed among the stocks of that region. The designated region was unique in each chain. 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 (Gelman and Rubin 1992), which were 1.05 or less for all the estimates, conveying strong convergence to a single posterior distribution (Pella and Masuda 2001).

GENETIC STOCK COMPOSITION - RESULTS

Bering Sea Pollock Trawl Fishery

The stock composition results indicate that 50% of the 1,866 Chinook salmon samples from the "A" season originated from Alaska river systems flowing into the Bering Sea (which include Coastal Western Alaska, Middle Yukon, Upper Yukon, and North Alaska Peninsula regions) with the Coastal Western Alaska region contributing the most (28%; 6,118 fish), followed by the North Alaska Peninsula (21%; 4,465 fish). The other 50% were from southern regions (which include Northwest GOA, Copper River, Northeast GOA, Coastal Southeast Alaska, British Columbia, and West Coast US regions) including the largest single contributor of British Columbia (35%; 7,609 fish), followed by the West Coast US (11%; 2,303 fish) (Appendix 2). From the "B" season, more than 86% of the 753 samples originated from southern regions; the West Coast US region contributed the most (39%; 3,291 fish), followed closely by the British Columbia (37%; 3,141 fish) region, and then the Coastal Western Alaska (12%; 1,019 fish) and Coastal Southeast Alaska (7%; 575 fish) regions (Appendix 2).

For all of the samples, “A” and “B” seasons combined, 40% of the bycatch samples were estimated to be from Alaska river systems flowing into the Bering Sea with the Coastal Western Alaska region contributing the most (24%; 7,113 fish), trailed by the North Alaska Peninsula (15%; 4,490 fish). Sixty percent of all of the samples were from the southern regions with the British Columbia (36%; 10,812 fish) region contributing the most, followed by the West Coast US (19%; 5,642 fish) region (Appendix 2).

To investigate how stock compositions might vary among smaller areas, “A” season estimates were developed for four strata with sufficient numbers of samples as follows (Appendix 2, Figs. 1, 6-9): Northwest Bering (263 samples, Fig. 7), Catcher Vessel Operation Area (CVOA) (1,113 samples, Fig. 9), Southeast Bering (1,603 samples, Fig. 7), and NMFS Statistical Area 509 (area 509) (1,099 samples, Fig. 1, 8) (NMFS 2018). The CVOA, Southeast Bering, and Area 509 strata overlap; Southeast Bering includes all of Area 509, and most of the CVOA (Figs. 1, 7, 8, 9).

For the Northwest Bering stratum, 75% of the stock composition was estimated to be from Alaska river systems flowing into the Bering Sea. The largest contributor was Coastal Western Alaska (38%) and North Alaska Peninsula (27%), followed by Middle Yukon (6%) and Upper Yukon (5%). Twenty-four percent of the stock composition was estimated to be from southern regions, where the largest contributors were British Columbia (17%), West Coast US (4%) and Coastal Southeast Alaska (3%).

For the CVOA, Southeast Bering, and NMFS area 509 strata, more than half of the resulting stock composition estimates were from southern regions during the “A” season. The largest contributors were British Columbia (40% for CVOA, 38% for Southeast Bering, 40% for NMFS area 509), West Coast US (13% for CVOA, 12% for Southeast Bering, 12% for NMFS area 509), and Coastal Southeast Alaska (4% for CVOA, Southeast Bering, and NMFS area 509). Nearly half of the Chinook salmon caught in the CVOA (42%), Southeast Bering strata (46%), and NMFS area 509 (44%) were estimated to be from Alaska river systems flowing into the Bering Sea. The largest contributors were Coastal Western Alaska (27% for CVOA, 27% for Southeast Bering, and 23% for NMFS area 509), and North Alaska Peninsula (15% for CVOA, 19% for Southeast Bering, 21% for NMFS area 509).

BSAI non-pollock Catcher Processors Trawl Fishery

A stock composition analysis was performed on a subset of Chinook salmon bycatch samples collected from the Bering Sea non-pollock catcher processor trawl fishery during the "A" season (Appendix 2). Most of the 263 Chinook salmon samples (Fig. 5) originated from southern regions (71%), primarily from British Columbia (45%), West Coast US (19%), and Coastal Southeast Alaska (8%) regions (Appendix 2). The largest components originating north of the Aleutian Islands were Coastal Western Alaska (19%) and North Alaska Peninsula (9%).

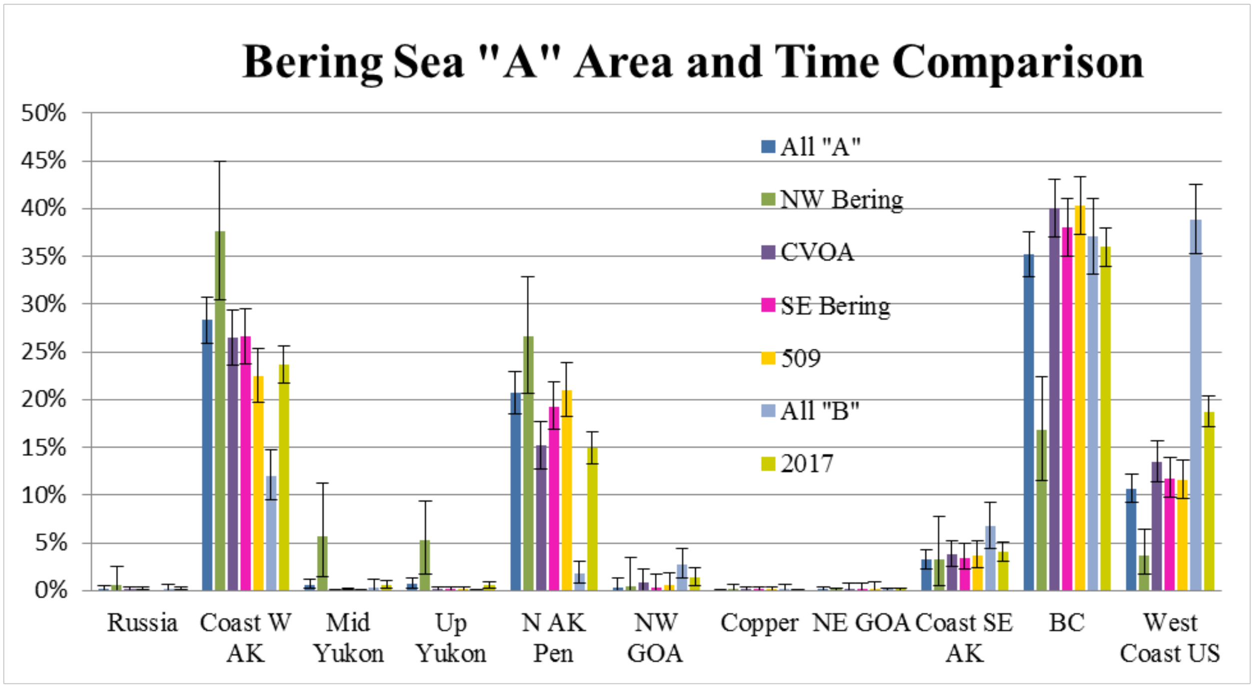


Figure 6. -- Area and time stock composition estimates with BAYES 95% credible intervals of the 2017 Bering Sea Chinook salmon bycatch for “A” season: All (1,866 samples), Northwest Bering (263 samples, Fig. 7), CVOA (1,113 samples, Fig. 9), Southeast Bering (1,603 samples, Fig. 7), and NMFS area 509 (1,099 samples, Fig. 8). Bering Sea “B” season (753 samples) and 2017 overall included for comparison.

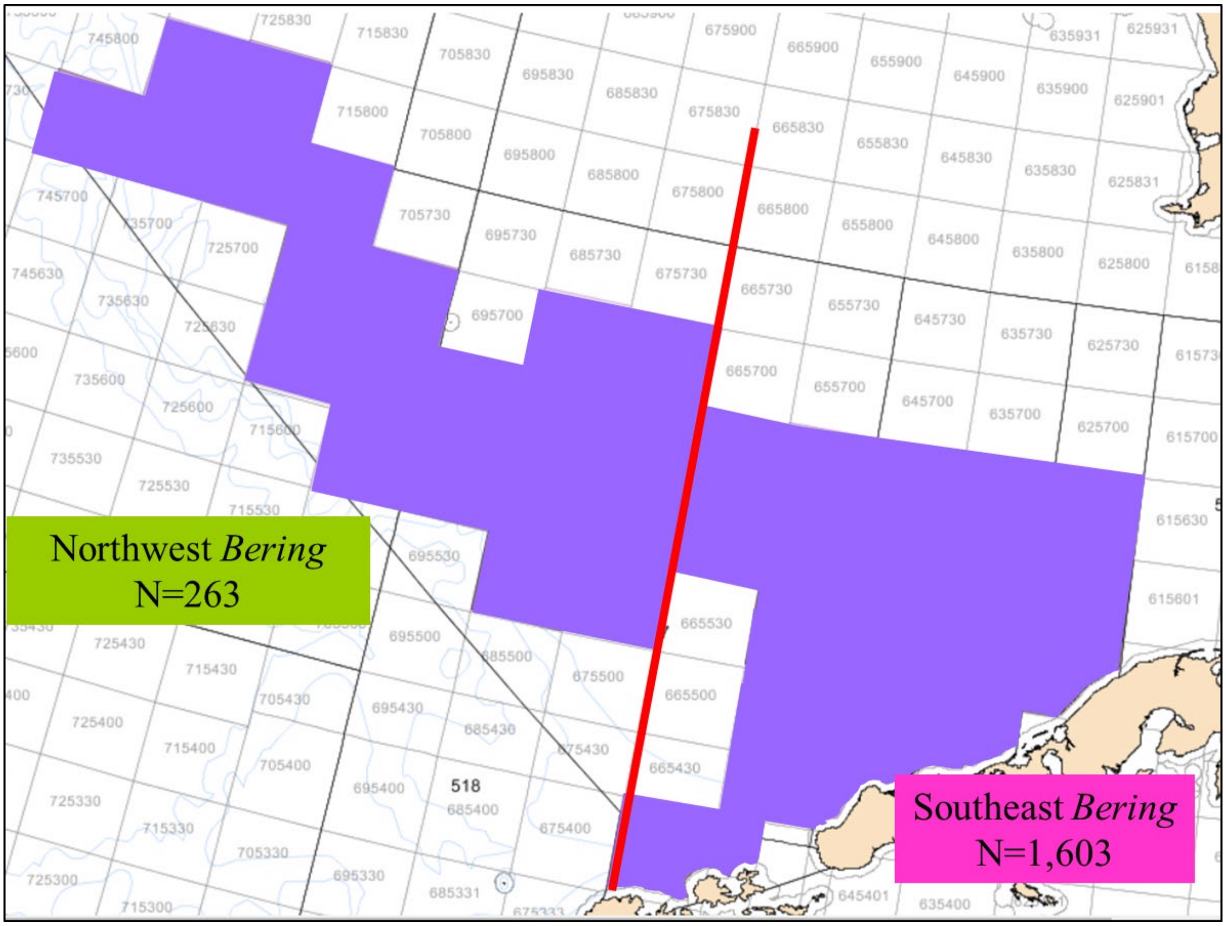


Figure 7. -- Location of Northwest Bering and Southeast Bering strata used in comparative stock composition estimates from the 2017 Bering Sea Chinook salmon bycatch for "A" season (NMFS 2018).

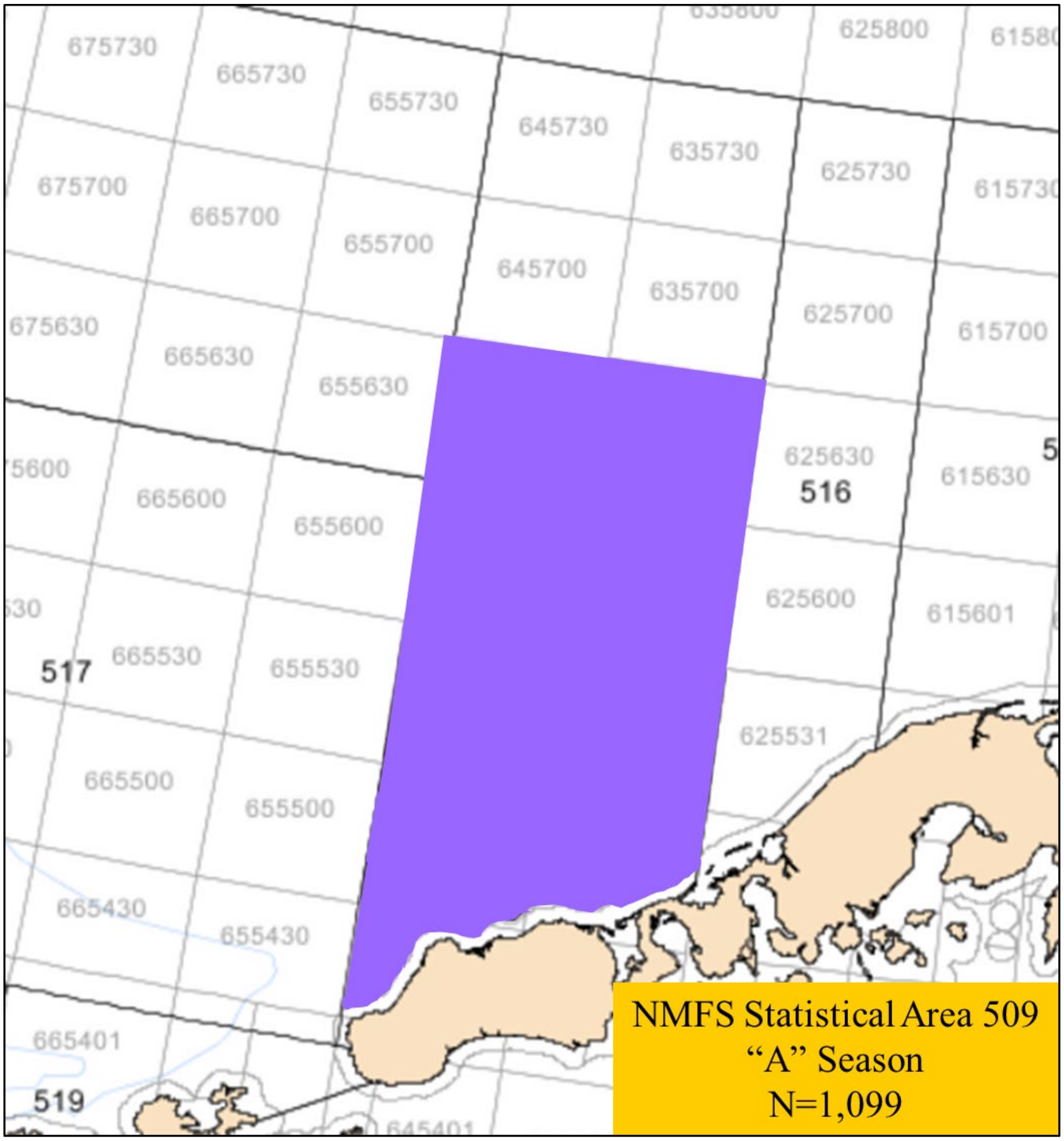


Figure 8. -- Location of samples from NMFS area 509 stratum used in comparative stock composition estimates from the 2017 Bering Sea Chinook salmon bycatch for "A" season (NMFS 2018).

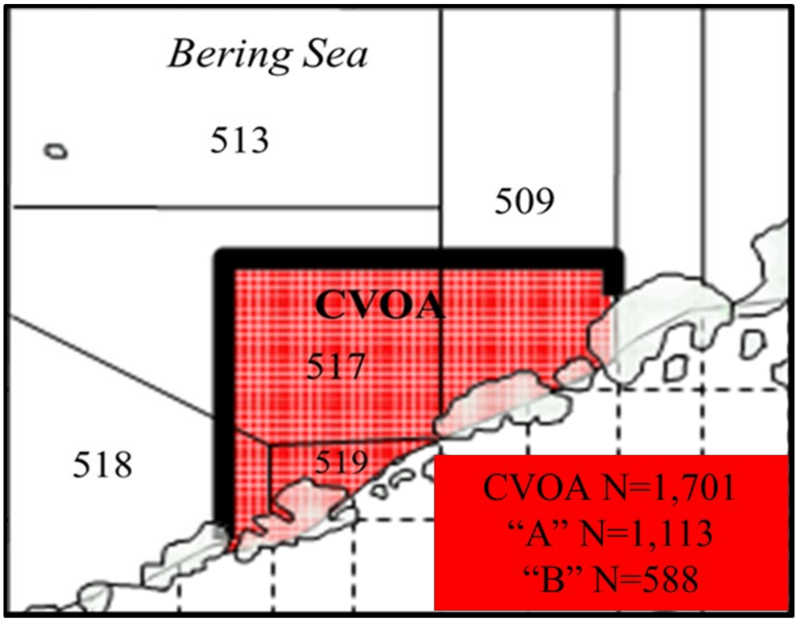


Figure 9. -- Location of Catcher Vessel Operational Area (CVOA) stratum used in comparative stock composition estimates from the 2017 Bering Sea Chinook salmon bycatch for "A" and "B" seasons (NMFS 2018).

For the "B" season, stock composition estimates were developed for CVOA (588 samples; Figs. 9, 10; Appendix 2) (NMFS 2018). The CVOA "B" season had a higher proportion of fish from southern regions (91%), than the "B" season overall (86%). It is notable that while the contribution from the British Columbia region remained at about 40% between the CVOA "A" and "B" seasons, the contribution from the Northern Alaska Peninsula region decreased from 15% to 1%, and the Coastal Western Alaska region also decreased from 27% to 7%, whereas the West Coast US region increased from 13% to 43% (Fig. 10). The contributions in the CVOA from the southern regions is significantly higher in the B season (91%) than the A season (58%) (Fig. 10)

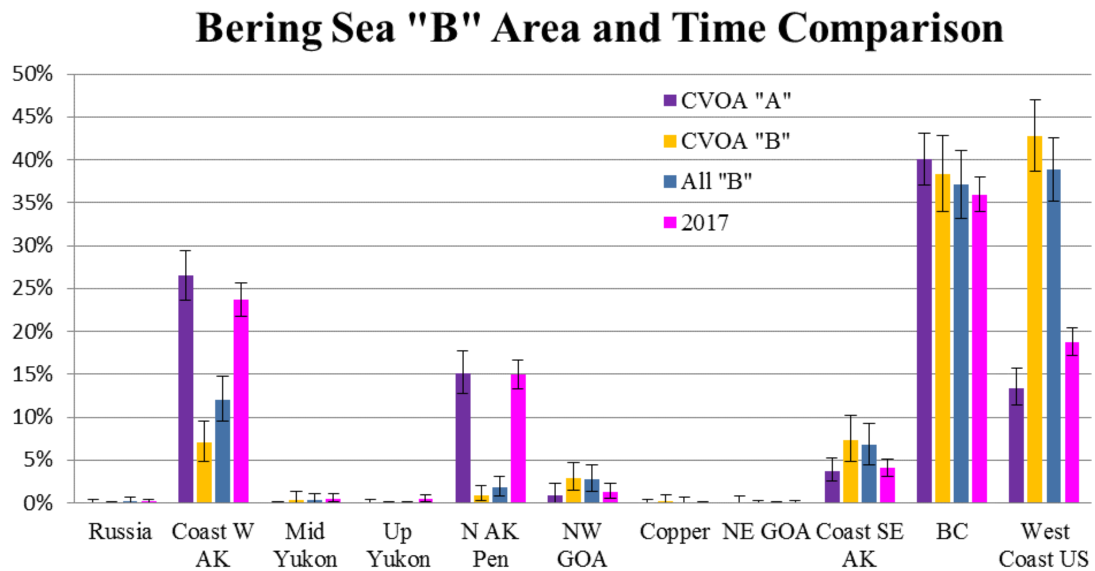


Figure 10. -- Area and time stock composition estimates with BAYES 95% credible intervals of the 2017 Bering Sea Chinook salmon bycatch for "B" season: All (753 samples) and CVOA "B" season (588 samples). Bering Sea CVOA "A" season (1,113 samples) and 2017 overall (2,619 samples) included for comparison.

COMPARISON WITH PREVIOUS ESTIMATES

In contrast to 2011 and similar to most other previous years studied, most of the Chinook salmon bycatch occurred in 2017 during the "A" season (Fig. 2). Stock compositions from the analysis of the 2017 "A" season Chinook salmon bycatch showed for the first time that the samples originated almost equally from river systems directly flowing into the Bering Sea and from southern regions (Fig. 11). For the first time, the Coastal Western Alaska region was not the largest contributor in the 2017 "A" season, with most Chinook originating instead from British Columbia. The 2017 "B" season stock composition estimates from Coastal Western Alaska continued to drop as observed across 2011-2017 (Fig. 11, Appendix 3). The 2017 "B" season estimates continued a pattern of increased contributions from British Columbia, West Coast US, and Coastal Southeast Alaska regions. The estimated relative contributions from these more southern regions have increased from a low of 20% in 2011 to a high of 86% in 2017 (Fig. 11, Appendix 3).

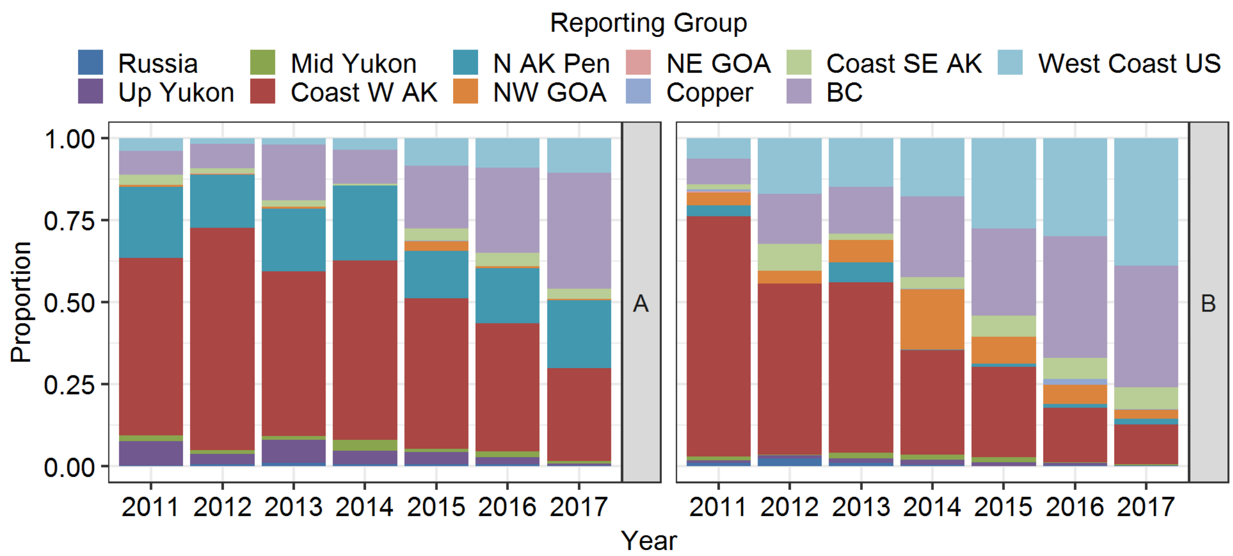


Figure 11. -- Annual "A" season (left) and "B" season (right) genetic stock composition estimates for 2011-2017 from the Bering Sea Chinook salmon bycatch. The same genetic baseline and regional groupings were used in all analyses.

As in previous years since 2011, systematic random sampling was employed in 2017, where genetic samples were collected from one of every 10 Chinook salmon encountered. While changes in sampling protocols prior to 2011 necessitate caution in comparing analyses across longer time periods, when the stock compositions were analyzed for the entire year, the Coastal Western Alaska region contribution trended downward between 2008 and 2010, increased in 2011, and then trended downward again through 2017 (Fig. 12). The North Alaska Peninsula region contribution of 15% was about average compared to previous years (Fig. 12). The upper and middle Yukon River, GOA, and Coastal Southeast Alaska contributions continued to be low in 2017, while contributions from the British Columbia and West Coast US regions have correspondingly trended upward (Fig. 12).

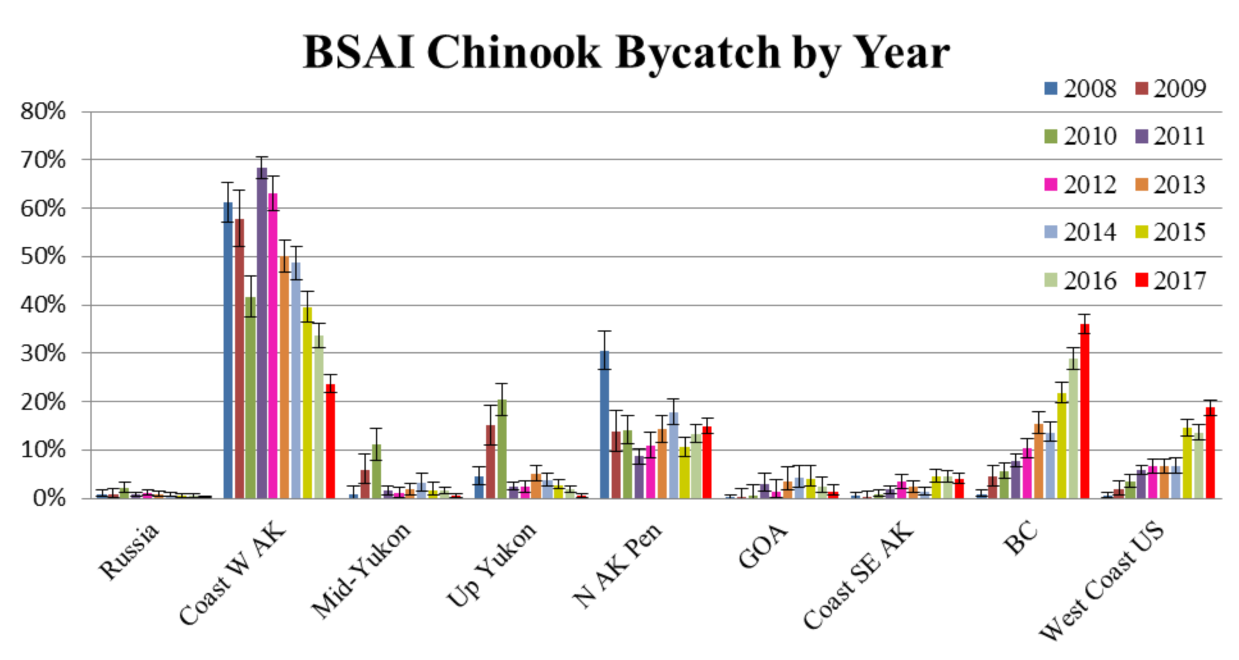
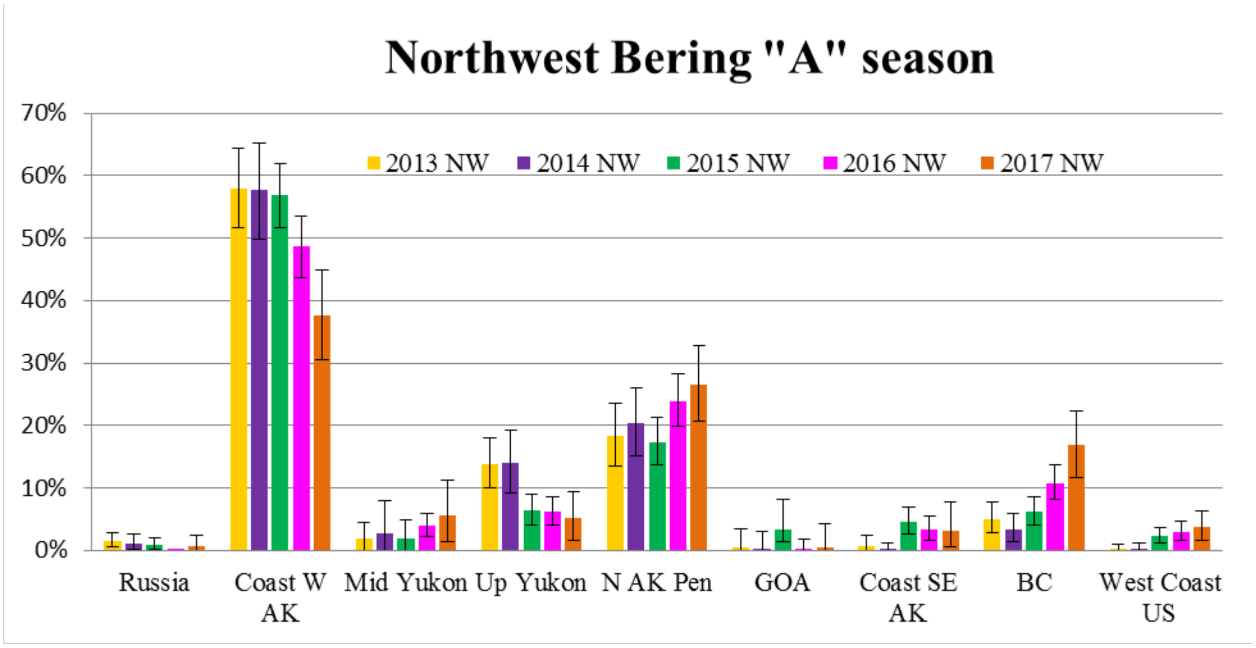


Figure 12. -- Annual (2008-2017) stock composition estimates with BAYES 95% credible intervals from the Bering Sea Chinook salmon bycatch. Estimates from 2011-2017 are overall bycatch estimates, whereas earlier estimates are of available sample sets. The same genetic baseline and general regional groupings were used in all analyses. Gulf of Alaska (GOA) group consists of combined values from the Northwest GOA, Copper, and Northeast GOA regions.

At the April 2017 meeting, the NPFMC Science and Statistical Committee (SSC) expressed interest in how smaller strata stock compositions might change between years (NPFMC 2017b). Subsequently, “A” season estimates were developed for the Northwest and Southeast Bering strata (Fig. 6) for which we had an adequate number of samples for analyses from years 2013-2017 (Fig. 13). The sample sizes were insufficient for analyses in 2011 and 2012. In the Northwest Bering stratum there is a decrease in the Coastal Western Alaska region contribution and an increase in the British Columbia region contribution since 2015. The pattern in the Southeast Bering stratum is similar to the Northwest Bering stratum except for a higher contribution from British Columbia and West Coast US and the absence of Middle and Upper Yukon fish.



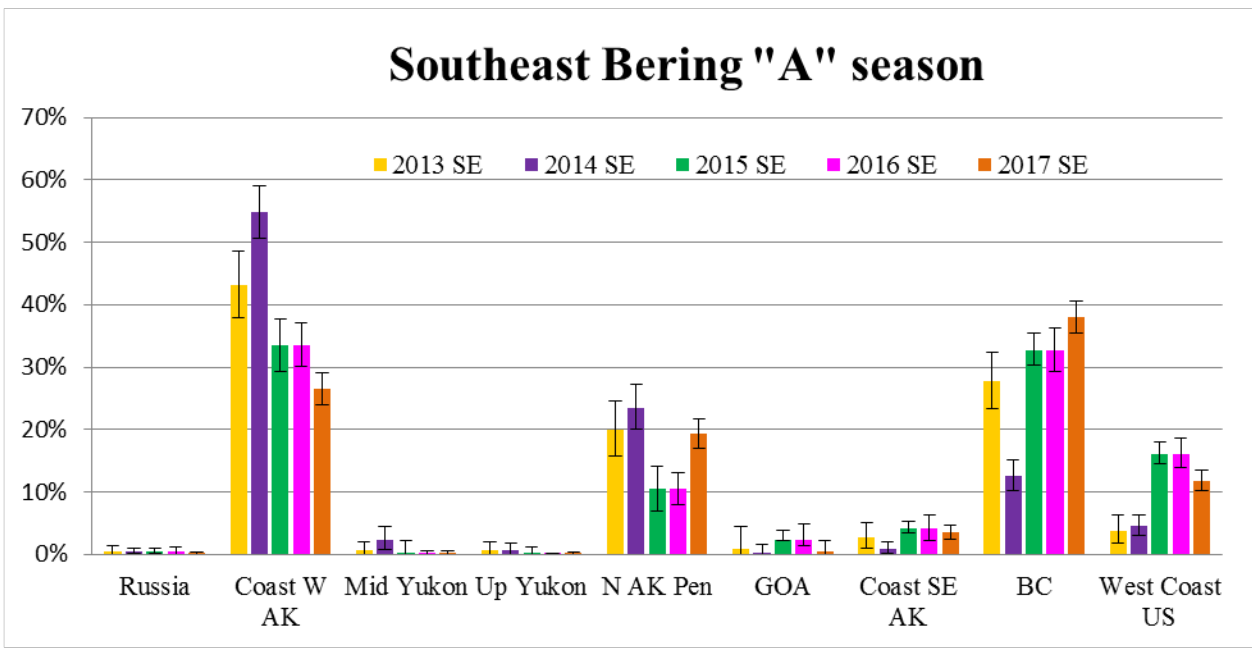


Figure 13. -- Annual (2013-2017) stock composition estimates with BAYES 95% credible intervals of the Chinook salmon bycatch from the Bering Sea "A" season Northwest Bering and Southeast Bering strata. Gulf of Alaska (GOA) group consists of combined values from the Northwest GOA, Copper, and Northeast GOA regions.

SUMMARY

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 (Ianelli and Stram 2015). The incidental harvest of Chinook salmon in the Bering Sea pollock fishery averaged 35,661 salmon per year between 1991 and 2016, with a peak of 124,723 in 2007 and a low of 4,961 in 2000 (Table 1; NMFS 2018). The Bering Sea Chinook salmon bycatch has abated in more recent years; in 2017, a total of 30,076 Chinook salmon were caught, below the 26-year average. This report provides stock composition estimates of the Chinook salmon bycatch from the 2017 Bering Sea pollock trawl fishery. The results and limitations of this analysis are summarized below.

Sampling Issues

With the implementation of systematic random sampling, 2017 is the seventh year from which representative samples have been collected from the Chinook salmon bycatch. Data prior to 2011 should be used with caution because the samples were not systematically collected. Systematic random sampling represents a significant effort on the part of the Observer Program to develop standardized protocols for collecting sets of samples from numerous observers both at sea and in shore-based processing plants, the results of which are clearly apparent in the representative nature of the sample sets (Figs. 3 and 4). The number of successfully genotyped Chinook salmon from the Bering Sea bycatch samples was 2,619, corresponding to an effective overall sampling rate in 2017 of 8.7%.

Stock Composition Estimates

Genetic stock composition analysis showed that the majority of Chinook salmon bycatch in BSAI pollock fisheries were from southern regions, which differs from all previous years, when the majority were from Alaska rivers draining into the Bering Sea. The stock composition of the Chinook salmon bycatch from the 2017 “A” season differed from the “B” season, demonstrating temporal differences (Appendix 2; Fig.11). This was especially apparent in the Coastal Western Alaska (28% vs. 12%), North Alaska Peninsula (21% vs. 2%), and West Coast US (11% vs. 39%) regions. Conversely, the largest contributor to both “A” and “B” seasonal fisheries was the British Columbia region which remained nearly constant across seasons (35-37%). This seasonal pattern was also evident in the CVOA, a smaller area strata of the Bering Sea (Figs. 9, 10). Spatial analysis showed that the stock compositions varied within season depending upon where the salmon in the bycatch were caught. For example, during the “A” season a higher proportion of Western Alaska origin Chinook salmon were intercepted in the northwestern area of the Bering Sea, and a higher proportion of southern origin Chinook salmon were intercepted in the southeastern area of the Bering Sea (Figs. 6, 7). However, given that the number of Chinook salmon bycatch in the northwestern Bering Sea is about one-sixth that in the southeastern Bering Sea during the “A” season, the total number of Chinook salmon bycatch from Western Alaska regions is lower in the northwestern Bering Sea (2,305 fish) than in the southeastern Bering Sea (8,549 fish). One must also consider that the bycatch in the “A” season is over two and a half times more abundant than in the “B” season, and that the seasonal stock composition differences may be due to relative abundance of stock, seasonal migration of stocks or avoidance behaviors by the fleet. Anomalous ocean conditions may have changed migration patterns in recent years, which has also been observed in the Southeast Alaska troll and sport fisheries (Gilk-Baumer et al. 2017). For example, the estimated number of West Coast US fish increases from 2,303 in the "A" season to 3,291 in the "B" season (a 43% increase; Appendix 2), while the proportion more than triples from 11% to 39%, likely due to the absence or lower proportion of other stock groups.

Application of Estimates

Stock composition estimates for the 2017 Bering Sea Chinook salmon bycatch were considered to be representative of the overall bycatch for this year and are presented in relative contributions as well as estimated numbers of fish. The extent to which any salmon stock is impacted by the bycatch of the Bering Sea trawl fishery is dependent on many stock-specific factors including 1) the overall numbers of the stock in the bycatch, 2) the ages of the salmon caught in the bycatch by stock, 3) the ages of the returning salmon by stock, and 4) the total annual run-size of the affected stocks. Because the effect of stock-specific number of Chinook salmon in the bycatch is moderated by a number of factors, a higher contribution of a particular stock one year does not necessarily imply greater impact than a smaller estimate the next.

ACKNOWLEDGMENTS

We are grateful for the help from the AFSC's Fisheries Monitoring and Analysis Division, and the many participating observers who provided genetic samples. Thanks to Rob Ames and Bob Ryznar for developing AKFIN Answer reports that helped us develop new strata for genetic analyses. We are grateful to Bill Templin, Andrew Munro, and Dani Evenson of ADF&G for their thoughtful reviews of this report. Special thanks to AFSC Communications Program staff, especially James Lee, for their rapid and thorough editorial review of this document.

CITATIONS

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.

Gabriel, S., L. Ziaugra, and D. Tabbaa. 2009. SNP genotyping using the Sequenom MassARRAY iPLEX platform. Current Protocols in Human Genetics Chapter 2, Unit 212.

Gelman, A., and D. B. Rubin. 1992. Inference from iterative simulation using multiple sequences. Stat. Sci. 7:457-511.

Gilk-Baumer, S., D. F. Evenson, K. Shedd, and E. L. Jones. 2017. Mixed stock analysis of Chinook salmon harvested in Southeast Alaska commercial troll and sport fisheries, 2016. Alaska Department of Fish and Game, Fishery Data Series No. 18-01, Anchorage.

Guthrie, C. M. III, Hv. Nguyen, and J. R. Guyon. 2012. Genetic stock composition analysis of Chinook salmon bycatch samples from the 2010 Bering Sea trawl fisheries. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-232, 22 p.

Guthrie, C. M. III, Hv. Nguyen, and J. R. Guyon. 2013. Genetic stock composition analysis of Chinook salmon bycatch samples from the 2011 Bering Sea and Gulf of Alaska trawl fisheries. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-244, 28 p.

Guthrie, C. M. III, Hv. Nguyen, and J. R. Guyon. 2014. Genetic stock composition analysis of Chinook salmon bycatch samples from the 2012 Bering Sea and Gulf of Alaska trawl fisheries. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-270, 33 p.

Guthrie, C. M. III, Nguyen, Hv.T., and J. R. Guyon. 2015. Genetic stock composition analysis of the Chinook salmon bycatch from the 2013 Bering Sea walleye pollock (*Gadus chalcogrammus*) trawl fishery. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-290, 21 p.

Guthrie, C. M. III, Nguyen, Hv.T., and J. R. Guyon. 2016. Genetic stock composition analysis of the Chinook salmon bycatch from the 2014 Bering Sea walleye pollock (*Gadus chalcogrammus*) trawl fishery. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-310, 25 p.

Guthrie, C. M. III, Nguyen, Hv.T., A. E. Thomson, and J. R. Guyon. 2017. Genetic stock composition analysis of the Chinook salmon bycatch from the 2015 Bering Sea walleye pollock (*Gadus chalcogrammus*) trawl fishery. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-342, 33 p.

Guthrie, C. M. III, Hv. T. Nguyen, A. E. Thomson, K. Hauch, and J. R. Guyon. 2018. Genetic stock composition analysis of the Chinook salmon (*Oncorhynchus tshawytscha*) bycatch from the 2016 Bering Sea walleye pollock (*Gadus chalcogrammus*) trawl fishery. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-365, 32 p.

Guyon, J. R., C. M. Guthrie, and H. Nguyen. 2010a. Genetic stock composition analysis of Chinook salmon bycatch samples from the 2008 Bering Sea pollock fishery, 32 p. Report to the North Pacific Fishery Management Council, 605 W. 4th Avenue, Anchorage AK 99510.

Guyon, J. R., C. M. Guthrie, and H. Nguyen. 2010b. Genetic stock composition analysis of Chinook salmon bycatch samples from the 2007 "B" season and 2009 Bering Sea trawl fisheries, p. 32. Report to the North Pacific Fishery Management Council, 605 W. 4th Avenue, Anchorage AK 99510.

Ianelli, J. N., and Stram, D. L. 2015. Estimating impacts of the pollock fishery bycatch on western Alaska Chinook salmon. – ICES J. Mar. Sci., 72: 1159–1172.

Larson, W. A., F. M. Utter, K. W. Myers, W. D. Templin, J. E. Seeb, C. M. Guthrie III, A. V. Bugaev, and L. W. Seeb. 2013. Single-nucleotide polymorphisms reveal distribution and migration of Chinook salmon (*Oncorhynchus tshawytscha*) in the Bering Sea and North Pacific Ocean. Can. J. Fish. Aquat. Sci. 70(1):128-141.

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). 2009. Bering Sea Chinook salmon bycatch management - Volume 1, Final Environmental Impact Statement, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Regional Office, Juneau, AK.

NMFS (National Marine Fisheries Service). 2018. 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). 2019. BSAI Chinook salmon mortality estimates, 1991-present, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Regional Office, Juneau, AK. https://alaskafisheries.noaa.gov/sustainablefisheries/inseason/chinook_salmon_mortality.pdf

NPFMC (North Pacific Fishery Management Council). 2017a. Fishery management plan for groundfish of the Bering Sea and Aleutian Islands management area. North Pacific Fishery Management Council, 605 W. 4th Ave., Anchorage, Alaska, 99501. https://www.npfmc.org/wp-content/PDFdocuments/fmp/BSAI/BSAIfmp.pdf

NPFMC (North Pacific Fishery Management Council). 2017b. Minutes of April 2017 meeting. https://www.npfmc.org/meeting-minutes

Pella, J., and H. J. Geiger. 2009. Sampling considerations for estimating geographic origins of Chinook salmon bycatch in the Bering Sea pollock fishery. Alaska Dep. Fish Game Spec. Pub. No. SP 09-08. 58 p.

Pella, J., and M. Masuda. 2001. Bayesian methods for analysis of stock mixtures from genetic characters. Fish. Bull., U. S. 99:151-167.

Templin, W. D., J. E. Seeb, J. R. Jasper, A. W. Barclay, and L. W. Seeb. 2011. Genetic differentiation of Alaska Chinook salmon: the missing link for migratory studies. Mol. Ecol. Res. 11 (Suppl. 1):226–246.

APPENDICES

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

Population name	Reg Num.	Region	Population name	Reg Num.	Region
Karluk River	6	NW GOA	Keta River	9	Coast SE AK
Kasilof River mainstem	6	NW GOA	King Creek	9	Coast SE AK
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

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

Appendix 2. -- Regional BAYES stock composition percentage estimates, standard deviations (SD), 95% credible intervals (CI), and estimated numbers of Chinook salmon from the the 2017 Bering Sea pollock trawl fisheries. Sample sizes are adjacent to the stratum designation. Total catch is the census for each stratum from AKFIN reports (NMFS 2018). Bering S. CP catch size is unknown, sample size given.

	"A" Season (N=1,866)				"B" Season (N=753)				Bering Sea all (N=2,619)			
Region	Est. #	Mean	SD	95% CI	Est. #	Mean	SD	95% CI	Est. #	Mean	SD	95% CI
Russia	35	0.2	0.12	(0.0,0.5)	19	0.2	0.19	(0.0,0.7)	54	0.2	0.10	(0.1,0.4)
Coast W AK	6,118	28.3	1.23	(25.9,30.8)	1,019	12.0	1.33	(9.5,14.7)	7,113	23.7	0.99	(21.7,25.6)
Mid Yukon	136	0.6	0.26	(0.2,1.2)	29	0.3	0.33	(0.0,1.1)	162	0.5	0.21	(0.2,1.0)
Up Yukon	156	0.7	0.27	(0.3,1.3)	1	0.0	0.04	(0.0,0.1)	162	0.5	0.20	(0.2,1.0)
N AK Pen	4,465	20.7	1.15	(18.5,23.0)	154	1.8	0.59	(0.8,3.1)	4,490	14.9	0.87	(13.3,16.7)
NW GOA	78	0.4	0.39	(0.0,1.4)	231	2.7	0.79	(1.3,4.4)	406	1.4	0.45	(0.6,2.3)
Copper	2	0.0	0.04	(0.0,0.1)	10	0.1	0.18	(0.0,0.6)	3	0.0	0.03	(0.0,0.1)
NE GOA	13	0.1	0.12	(0.0,0.4)	2	0.0	0.08	(0.0,0.2)	9	0.0	0.07	(0.0,0.3)
Coast SE AK	691	3.2	0.54	(2.2,4.3)	575	6.8	1.24	(4.5,9.3)	1,221	4.1	0.52	(3.1,5.1)
BC	7,609	35.2	1.18	(32.9,37.6)	3,141	37.1	2.01	(33.2,41.0)	10,812	36.0	1.03	(34.0,38.0)
West Coast US	2,303	10.7	0.75	(9.2,12.2)	3,291	38.8	1.87	(35.2,42.5)	5,642	18.8	0.81	(17.2,20.4)
Total Catch	21,603				8,473				30,076			

	CVOA "A" (N=1,113)				CVOA "B" (N=588)				CVOA (N=1,701)			
Region	Est. #	Mean	SD	95% CI	Est. #	Mean	SD	95% CI	Est. #	Mean	SD	95% CI
Russia	13	0.1	0.09	(0.0,0.4)	1	0.0	0.05	(0.0,0.1)	21	0.1	0.09	(0.0,0.3)
Coast W AK	3,418	26.5	1.46	(23.6,29.4)	466	7.1	1.17	(4.9,9.5)	3,831	19.6	1.08	(17.5,21.8)
Mid Yukon	1	0.0	0.04	(0.0,0.1)	23	0.4	0.37	(0.0,1.3)	6	0.0	0.07	(0.0,0.2)
Up Yukon	14	0.1	0.11	(0.0,0.4)	1	0.0	0.06	(0.0,0.2)	14	0.1	0.08	(0.0,0.3)
N AK Pen	1,959	15.2	1.28	(12.7,17.7)	60	0.9	0.46	(0.2,2.0)	1,968	10.1	0.88	(8.4,11.9)
NW GOA	107	0.8	0.65	(0.0,2.3)	196	3.0	0.84	(1.5,4.8)	391	2.0	0.58	(1.0,3.3)
Copper	5	0.0	0.10	(0.0,0.4)	17	0.3	0.28	(0.0,1.0)	6	0.0	0.07	(0.0,0.2)
NE GOA	14	0.1	0.22	(0.0,0.8)	1	0.0	0.10	(0.0,0.3)	23	0.1	0.23	(0.0,0.9)
Coast SE AK	483	3.7	0.69	(2.5,5.2)	482	7.3	1.38	(4.8,10.2)	988	5.1	0.65	(3.8,6.4)
BC	5,171	40.0	1.55	(37.0,43.1)	2,531	38.3	2.24	(34.0,42.8)	7,627	39.1	1.28	(36.6,41.6)
West Coast US	1,735	13.4	1.10	(11.4,15.7)	2,829	42.8	2.11	(38.7,47.0)	4,651	23.8	1.09	(21.7,26.0)
Total Catch	12,921				6,606				19,527			

	SE Bering S. "A" (N=1,603)				NW Bering S. "A" (N=263)				Area 509 "A" (N=1,099)			
Region	Est. #	Mean	SD	95% CI	Est. #	Mean	SD	95% CI	Est. #	Mean	SD	95% CI
Russia	31	0.2	0.11	(0.0,0.5)	19	0.6	0.73	(0.0,2.5)	0	0.0	0.02	(0.0,0.0)
Coast W AK	4,921	26.6	1.29	(24.1,29.1)	1,156	37.7	3.70	(30.5,45.0)	2,855	22.5	1.45	(19.7,25.3)
Mid Yukon	26	0.1	0.15	(0.0,0.5)	173	5.7	2.62	(1.4,11.2)	1	0.0	0.04	(0.0,0.1)
Up Yukon	26	0.1	0.13	(0.0,0.5)	161	5.2	1.99	(1.7,9.4)	14	0.1	0.11	(0.0,0.4)
N AK Pen	3,576	19.3	1.18	(17.0,21.7)	815	26.6	3.14	(20.6,32.9)	2,664	21.0	1.43	(18.2,23.8)
NW GOA	59	0.3	0.37	(0.0,1.3)	12	0.4	0.94	(0.0,3.4)	72	0.6	0.54	(0.0,1.9)
Copper	4	0.0	0.05	(0.0,0.2)	2	0.1	0.21	(0.0,0.6)	6	0.1	0.11	(0.0,0.4)
NE GOA	19	0.1	0.19	(0.0,0.7)	1	0.0	0.12	(0.0,0.3)	23	0.2	0.28	(0.0,1.0)
Coast SE AK	641	3.5	0.58	(2.4,4.7)	99	3.2	1.91	(0.5,7.8)	472	3.7	0.70	(2.5,5.2)
BC	7,042	38.0	1.29	(35.5,40.6)	517	16.9	2.76	(11.6,22.3)	5,127	40.3	1.56	(37.3,43.4)
West Coast US	2,182	11.8	0.85	(10.2,13.5)	114	3.7	1.21	(1.7,6.4)	1,480	11.6	1.03	(9.7,13.7)
Total Catch	18,527				3,069				12,715			

	Bering S. CP "A" (N=263)			
Region	Est. #	Mean	SD	95% CI
Russia	0	0.0	0.06	(0.0,0.1)
Coast W AK	39	19.0	2.79	(13.7,24.6)
Mid Yukon	0	0.0	0.13	(0.0,0.3)
Up Yukon	0	0.2	0.40	(0.0,1.4)
N AK Pen	19	9.4	2.15	(5.7,14.1)
NW GOA	1	0.2	0.45	(0.0,1.5)
Copper	0	0.0	0.13	(0.0,0.4)
NE GOA	1	0.0	0.12	(0.0,0.3)
Coast SE AK	34	7.5	2.29	(3.4,12.4)
BC	95	45.2	3.50	(38.3,52.0)
West Coast US	74	18.5	2.51	(13.8,23.6)
Sample Size Total	263			

Appendix 3. -- Regional BAYES stock composition percentage estimates and estimated numbers of previous years of Chinook salmon from the Bering Sea pollock trawl fisheries. The BAYES mean estimates are also provided with standard deviations (SD), and the 95% credible intervals (CI). Sample sizes are adjacent to stratum designation.

2016	"A" Season (N=1,866)				"B" Season (N=753)				Bering Sea all (N=2,619)			
Region	Est. #	Mean	SD	95% CI	Est. #	Mean	SD	95% CI	Est. #	Mean	SD	95% CI
Russia	35	0.2	0.12	(0.0,0.5)	19	0.2	0.19	(0.0,0.7)	54	0.2	0.10	(0.1,0.4)
Coast W AK	6,118	28.3	1.23	(25.9,30.8)	1,019	12.0	1.33	(9.5,14.7)	7,113	23.7	0.99	(21.7,25.6)
Mid Yukon	136	0.6	0.26	(0.2,1.2)	29	0.3	0.33	(0.0,1.1)	162	0.5	0.21	(0.2,1.0)
Up Yukon	156	0.7	0.27	(0.3,1.3)	1	0.0	0.04	(0.0,0.1)	162	0.5	0.20	(0.2,1.0)
N AK Pen	4,465	20.7	1.15	(18.5,23.0)	154	1.8	0.59	(0.8,3.1)	4,490	14.9	0.87	(13.3,16.7)
NW GOA	78	0.4	0.39	(0.0,1.4)	231	2.7	0.79	(1.3,4.4)	406	1.4	0.45	(0.6,2.3)
Copper	2	0.0	0.04	(0.0,0.1)	10	0.1	0.18	(0.0,0.6)	3	0.0	0.03	(0.0,0.1)
NE GOA	13	0.1	0.12	(0.0,0.4)	2	0.0	0.08	(0.0,0.2)	9	0.0	0.07	(0.0,0.3)
Coast SE AK	691	3.2	0.54	(2.2,4.3)	575	6.8	1.24	(4.5,9.3)	1,221	4.1	0.52	(3.1,5.1)
BC	7,609	35.2	1.18	(32.9,37.6)	3,141	37.1	2.01	(33.2,41.0)	10,812	36.0	1.03	(34.0,38.0)
West Coast US	2,303	10.7	0.75	(9.2,12.2)	3,291	38.8	1.87	(35.2,42.5)	5,642	18.8	0.81	(17.2,20.4)
Total Catch	21,603				8,473				30,076			
2015	"A" Season (N=1,181)				"B" Season (N=576)				Bering Sea all (N=1,757)			
Region	Est. #	Mean	SD	95% CI	Est. #	Mean	SD	95% CI	Est. #	Mean	SD	95% CI
Russia	75	0.6	0.29	(0.2,1.3)	5	0.1	0.20	(0.0,0.7)	93	0.5	0.21	(0.2,1.0)
Coast W AK	5,644	45.9	1.87	(42.2,49.5)	1,651	27.4	2.36	(22.9,32.1)	7,256	39.6	1.60	(36.4,42.7)
Mid Yukon	119	1.0	0.76	(0.0,2.7)	97	1.6	0.67	(0.6,3.2)	304	1.7	0.71	(0.6,3.2)
Up Yukon	448	3.6	0.68	(2.4,5.1)	65	1.1	0.55	(0.2,2.3)	502	2.7	0.48	(1.9,3.7)
N AK Pen	1,785	14.5	1.33	(12.0,17.2)	60	1.0	0.85	(0.0,3.0)	1,943	10.6	1.00	(8.7,12.6)
NW GOA	349	2.8	0.82	(1.4,4.6)	496	8.2	1.95	(4.6,12.3)	724	4.0	0.83	(2.5,5.7)
Copper	21	0.2	0.36	(0.0,1.3)	3	0.1	0.12	(0.0,0.4)	11	0.1	0.18	(0.0,0.7)
NE GOA	2	0.0	0.10	(0.0,0.2)	4	0.1	0.22	(0.0,0.7)	4	0.0	0.11	(0.0,0.3)
Coast SE AK	475	3.9	0.72	(2.6,5.4)	381	6.3	1.39	(3.8,9.3)	828	4.5	0.67	(3.3,5.9)
BC	2,355	19.1	1.21	(16.8,21.6)	1,603	26.6	2.06	(22.6,30.7)	3,998	21.8	1.08	(19.7,24.0)
West Coast US	1,030	8.4	0.84	(6.8,10.1)	1,659	27.5	1.95	(23.8,31.4)	2,665	14.5	0.88	(12.9,16.3)
Total Catch	12,304				6,025				18,329			
2014	"A" Season (N=1,066)				"B" Season (N=319)				Bering Sea all (N=1,385)			
Region	Est. #	Mean	SD	95% CI	Est. #	Mean	SD	95% CI	Est. #	Mean	SD	95% CI
Russia	74	0.6	0.26	(0.2,1.2)	13	0.4	0.50	(0.0,1.7)	96	0.6	0.23	(0.3,1.2)
Coast W AK	6,301	54.6	2.17	(50.4,58.8)	1,109	31.8	3.09	(25.8,37.9)	7,314	48.7	1.79	(45.2,52.2)
Mid Yukon	380	3.3	1.24	(1.2,5.9)	58	1.7	0.98	(0.1,3.9)	484	3.2	0.91	(1.5,5.1)
Up Yukon	477	4.1	0.79	(2.7,5.8)	55	1.6	0.86	(0.3,3.6)	564	3.8	0.66	(2.6,5.1)
N AK Pen	2,624	22.7	1.58	(19.7,25.9)	3	0.1	0.31	(0.0,1.0)	2,666	17.7	1.35	(15.2,20.4)
NW GOA	16	0.1	0.32	(0.0,1.1)	642	18.4	2.68	(13.4,23.9)	630	4.2	1.00	(2.4,6.3)
Copper	1	0.0	0.05	(0.0,0.1)	5	0.1	0.37	(0.0,1.3)	5	0.0	0.09	(0.0,0.3)
NE GOA	1	0.0	0.05	(0.0,0.1)	3	0.1	0.32	(0.0,1.1)	3	0.0	0.08	(0.0,0.2)
Coast SE AK	68	0.6	0.36	(0.0,1.4)	124	3.6	1.41	(1.3,6.7)	207	1.4	0.43	(0.6,2.3)
BC	1,174	10.2	0.98	(8.3,12.2)	855	24.5	2.59	(19.6,29.7)	2,049	13.6	1.01	(11.7,15.7)
West Coast US	422	3.7	0.63	(2.5,5.0)	624	17.9	2.21	(13.8,22.4)	1,013	6.7	0.76	(5.2,8.3)
Total Catch	11,539				3,492				15,031			
2013	"A" Season (N=792)				"B" Season (N=454)				Bering Sea all (N=1,246)			
Region	Est. #	Mean	SD	95% CI	Est. #	Mean	SD	95% CI	Est. #	Mean	SD	95% CI
Russia	74	0.9	0.40	(0.4,1.7)	43	0.9	0.50	(0.2,2.0)	117	0.9	0.30	(0.4,1.5)
Coast W AK	4,135	50.2	2.20	(46.0,54.5)	2,490	51.9	2.80	(46.4,57.3)	6,530	50.1	1.80	(46.7,53.5)
Mid Yukon	91	1.1	0.60	(0.0,2.6)	91	1.9	1.00	(0.4,4.2)	235	1.8	0.70	(0.6,3.1)
Up Yukon	593	7.2	1.10	(5.1,9.4)	67	1.4	0.90	(0.0,3.4)	652	5.0	0.80	(3.5,6.7)
N AK Pen	1,573	19.1	1.80	(15.7,22.8)	283	5.9	1.50	(3.4,9.0)	1,851	14.2	1.40	(11.6,17.0)
NW GOA	41	0.5	0.70	(0.0,2.4)	331	6.9	1.80	(3.5,10.7)	443	3.4	1.00	(1.8,5.5)
Copper	8	0.1	0.10	(0.0,0.5)	5	0.1	0.30	(0.0,0.9)	13	0.1	0.20	(0.0,0.7)
NE GOA	0	0.0	0.10	(0.0,0.4)	0	0.0	0.20	(0.0,0.4)	0	0.0	0.10	(0.0,0.3)
Coast SE AK	157	1.9	0.70	(0.8,3.4)	91	1.9	1.10	(0.1,4.5)	313	2.4	0.60	(1.3,3.6)
BC	1,400	17.0	1.40	(14.2,19.8)	686	14.3	1.90	(10.8,18.2)	2,020	15.5	1.10	(13.4,17.8)
West Coast US	165	2.0	0.60	(1.0,3.3)	710	14.8	1.70	(11.6,18.2)	873	6.7	0.80	(5.2,8.2)
Total Catch	8,237				4,797				13,034			

Appendix 3. -- Continued

2012	"A" Season (N=759)				"B" Season (N=352)				Bering Sea all (N=1,111)			
Region	Est. #	Mean	SD	95% CI	Est. #	Mean	SD	95% CI	Est. #	Mean	SD	95% CI
Russia	42	0.5	0.27	(0.2,1.2)	86	2.4	0.83	(1.1,4.3)	126	1.1	0.32	(0.6,1.8)
Coast W AK	5,266	67.8	2.22	(63.4,72.1)	1,863	52.1	2.92	(46.3,57.7)	7,152	63.1	1.83	(59.4,66.6)
Mid Yukon	92	1.2	0.82	(0.0,3.1)	6	0.2	0.32	(0.0,1.1)	115	1.0	0.59	(0.0,2.3)
Up Yukon	241	3.1	0.82	(1.6,4.8)	35	1.0	0.64	(0.1,2.5)	271	2.4	0.60	(1.3,3.7)
N AK Pen	1,256	16.2	1.88	(12.7,20.0)	3	0.1	0.25	(0.0,0.8)	1,227	10.8	1.35	(8.3,13.6)
NW GOA	19	0.2	0.35	(0.0,1.2)	135	3.8	1.44	(1.3,6.9)	155	1.4	0.73	(0.2,3.1)
Copper	2	0.0	0.12	(0.0,0.3)	2	0.1	0.17	(0.0,0.5)	2	0.0	0.07	(0.0,0.2)
NE GOA	6	0.1	0.26	(0.0,0.9)	2	0.1	0.20	(0.0,0.6)	6	0.1	0.17	(0.0,0.6)
Coast SE AK	128	1.7	0.78	(0.3,3.4)	292	8.2	1.84	(4.5,11.9)	381	3.4	0.73	(2.0,4.9)
BC	568	7.3	1.12	(5.2,9.6)	547	15.3	2.24	(11.2,20.0)	1,159	10.2	1.01	(8.3,12.3)
West Coast US	146	1.9	0.51	(1.0,3.0)	609	17.0	2.09	(13.1,21.3)	749	6.6	0.78	(5.1,8.2)
Total Catch	7,765				3,579				11,344			
2011	"A" Season (N=695)				"B" Season (N=1,778)				Bering Sea all (N=2,473)			
Region	Est. #	Mean	SD	95% CI	Est. #	Mean	SD	95% CI	Est. #	Mean	SD	95% CI
Russia	12	0.2	0.16	(0.0,0.6)	184	1.0	0.25	(0.6,1.6)	196	0.8	0.19	(0.5,1.2)
Coast W AK	3,856	54.0	2.28	(49.6,58.5)	13,549	73.8	1.28	(71.3,76.2)	17,421	68.3	1.16	(66.0,70.6)
Mid Yukon	127	1.8	0.76	(0.6,3.6)	233	1.3	0.46	(0.5,2.2)	411	1.6	0.46	(0.8,2.5)
Up Yukon	526	7.4	1.12	(5.3,9.7)	119	0.7	0.35	(0.1,1.4)	627	2.5	0.47	(1.6,3.4)
N AK Pen	1,556	21.8	1.94	(18.1,25.7)	628	3.4	0.65	(2.2,4.8)	2,201	8.6	0.81	(7.1,10.3)
NW GOA	41	0.6	0.60	(0.0,2.2)	654	3.6	0.89	(2.0,5.5)	663	2.6	0.67	(1.4,4.1)
Copper	1	0.0	0.07	(0.0,0.2)	105	0.6	0.30	(0.0,1.2)	69	0.3	0.24	(0.0,0.8)
NE GOA	1	0.0	0.09	(0.0,0.2)	26	0.1	0.24	(0.0,0.8)	13	0.1	0.12	(0.0,0.4)
Coast SE AK	218	3.1	0.86	(1.6,4.9)	259	1.4	0.46	(0.6,2.4)	459	1.8	0.41	(1.1,2.6)
BC	515	7.2	1.13	(5.1,9.6)	1,425	7.8	0.71	(6.4,9.2)	1,984	7.8	0.62	(6.6,9.0)
West Coast US	283	4.0	0.78	(2.6,5.6)	1,181	6.4	0.61	(5.3,7.7)	1,461	5.7	0.49	(4.8,6.7)
Total Catch	7,137				18,362				25,504			

RECENT TECHNICAL MEMORANDUMS

Copies of this and other NOAA Technical Memorandums are available from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22167 (web site: *www.ntis.gov)*. Paper and electronic (.pdf) copies vary in price.

AFSC-

390 GUTHRIE III, C. M., Hv. T. NGUYEN, M. MARSH, and J. R. GUYON. 2019. Genetic stock composition analysis of Chinook salmon bycatch samples from the 2017 Gulf of Alaska trawl fisheries, 30 p. NTIS number pending.

389 LINDEBERG, M. R., and S. C. LINDSTROM. 2019. Assessment and catalog of benthic marine algae from the Alaska Peninsula, May 2016, 22 p + Appendices. NTIS number pending.

388 KEARNEY, K. A. 2019. Freshwater Input to the Bering Sea, 1950–2017, 46 p. NTIS No. PB2019-100329.

387 FENSKE, K. H., A. M. BERGER, B. CONNORS, J.M. COPE, S. P. COX, M. A. HALTUCH, D. H. HANSELMAN, M. KAPUR, L. LACKO, C. LUNSFORD, C. RODGVELLER, and B. WILLIAMS. 2019. Report on the 2018 International Sablefish Workshop, 107 p. NTIS No. PB2019-100329.

386 LANG, C. A., J. I. RICHAR, and R. J. FOY. 2019. The 2018 eastern Bering Sea continental shelf and northern Bering Sea trawl surveys: Results for commercial crab species, 220 p. NTIS No. PB2019-100298.

385 JEFFERSON, T. A., M. E. DAHLHEIM, A. N. ZERBINI, J. M. WAITE, and A. S. KENNEDY. 2019. Abundance and seasonality of Dall's porpoise (*Phocoenoides dalli*) in Southeast Alaska, 45 p. NTIS No. PB2019-100297.

384 RUSSELL, J. R., S. C. VULSTEK, J. E. JOYCE, R. P. KOVACH, and D. A. TALLMON. 2018. Long-term changes in length at maturity of Pacific salmon in Auke Creek Alaska, 28 p. NTIS No. PB2019-100295.

383 LEW, D. K., and J. LEE. 2018. Costs, earnings, and employment in the Alaska saltwater sport fishing charter sector, 2015, 85 p. NTIS No. PB2019-100296.

382 MCKELVEY, D., and K. WILLIAMS. 2018. Abundance and distribution of age-0 walleye pollock in the eastern Bering Sea shelf during the Bering Arctic Subarctic Integrated Survey (BASIS) in 2014, 48 p. NTIS No. PB2018-101437.

381 BRYAN, D. R., M. LEVINE, and S. MCDERMOTT. 2018. Results of the 2016 and 2017 Central and Western Aleutian Islands underwater camera survey of Steller sea lion prey fields, 87 p. NTIS No. PB2018-101436.

380 SEUNG, C. K., and S. MILLER. 2018. Regional economic analysis for North Pacific fisheries, 86 p. NTIS No. PB2018-101435.

379 GANZ, P., S. BARBEAUX, J. CAHALAN, J. GASPER, S. LOWE, R. WEBSTER, and C. FAUNCE. 2017. Deployment performance review of the 2016 North Pacific Groundfish and Halibut Observer Program, 68 p. NTIS No. PB2018-101537.