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Genetic Stock Composition Analysis of Chinook Salmon Bycatch Samples from the 2011 Bering Sea and Gulf of Alaska Trawl Fisheries

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U.S. DEPARTMENT OF COMMERCE
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National Marine Fisheries Service
Alaska Fisheries Science Center

March 2013

NOAA Technical Memorandum NMFS

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ABSTRACT

A genetic analysis of samples from the Chinook salmon (*Oncorhynchus tshawytscha*) bycatch of the 2011 Bering Sea-Aleutian Island (BSAI) and Gulf of Alaska (GOA) pollock trawl fisheries was undertaken to determine the stock composition of the sample set. 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 2011, genetic samples from the Bering Sea were collected using a systematic random sampling protocol from one out of every 10 Chinook salmon encountered. Based on the analysis of 2,473 Chinook salmon bycatch samples collected throughout the 2011 BSAI walleye pollock (*Theragra chalcogramma*) trawl fishery, Coastal Western Alaska stocks dominated the sample set (68%) with smaller contributions from North Alaska Peninsula (9%), British Columbia (8%), and U.S. west coast (6%) stocks. Analysis of temporal groupings within the pollock "A" and "B" seasons revealed changes in stock composition during the course of the year with lower contributions of North Alaska Peninsula and Yukon River stocks during the "B" season. Genetic samples were also collected from Chinook salmon taken in the bycatch of the 2011 Gulf of Alaska (GOA) pollock trawl fisheries. In contrast with the Bering Sea, genetic samples were collected opportunistically in the GOA during 2011; consequently, the resulting stock composition estimates should be considered as stock compositions of the sample set rather than a representative composition of the entire GOA Chinook salmon bycatch. Based on the analysis of 240 Chinook salmon bycatch samples, British Columbia (40%) and U.S. west coast (26%) stocks comprised the largest stock groups with smaller contributions from Northwest GOA (15%) and Coastal Southeast Alaska (14%) stocks.

CONTENTS

INTRODUCTION

The Bering Sea and the Gulf of Alaska (GOA) are known feeding habitats for multiple brood years of Chinook salmon (*Oncorhynchus tshawytscha*) originating from many different localities in North America and Asia. Determining the geographic origin and stock composition of salmon caught in federally managed fisheries is essential to understanding whether fisheries management could address conservation concerns. This report provides genetic stock identification results for a set of Chinook salmon bycatch samples collected from the U.S. Bering Sea-Aleutian Island (BSAI) and GOA pollock trawl fisheries. National Marine Fisheries Service

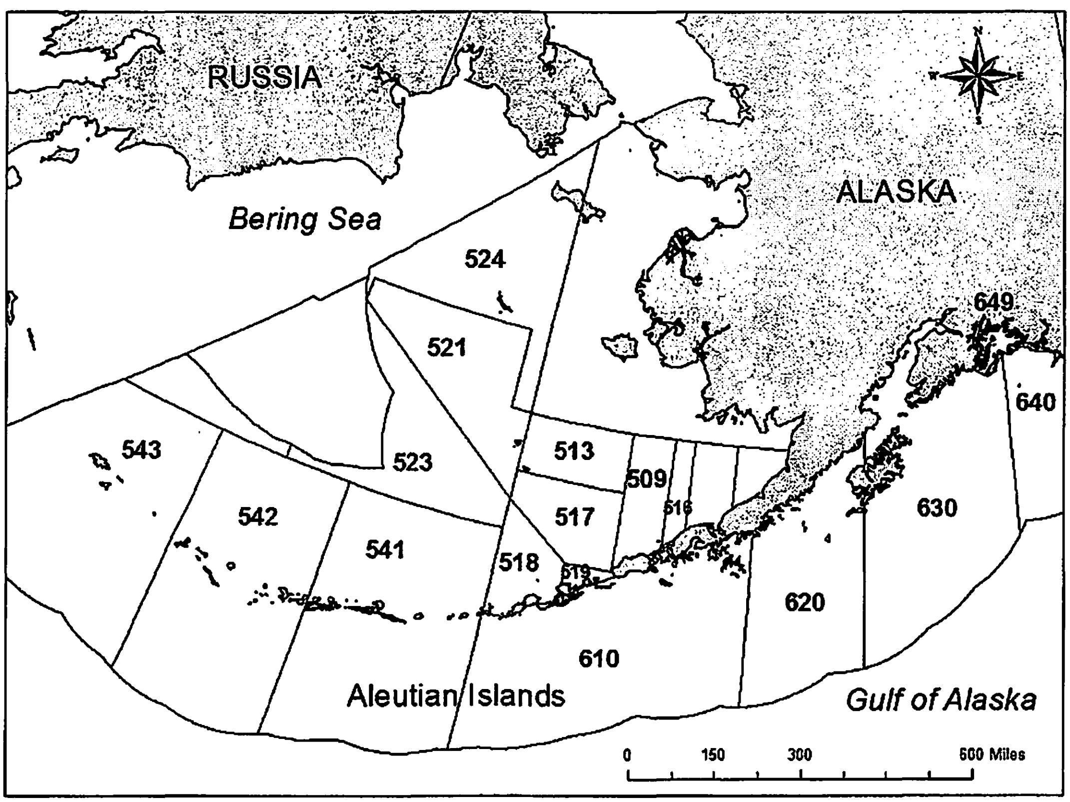


Figure 1. -- NMFS statistical areas associated with the Bering Sea-Aleutian Island (BSAI) and Gulf of Alaska (GOA) groundfish fisheries.

(NMFS) geographical statistical areas associated with the groundfish fishery 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.

The goal of this report is to present stock composition estimates for samples collected from the bycatch of the BSAI and GOA fishery management regions from the pollock trawl fishery, but it is important to understand the limitations for making accurate estimates of the entire bycatch imposed by the genetic baseline and the sampling distribution, especially regarding the stock composition analysis of the GOA Chinook salmon bycatch samples which were collected opportunistically in 2011. The analysis uses a single nucleotide polymorphism (SNP) baseline provided by the Alaska Department of Fish and Game (ADF&G) (Templin et al. 2011) and was used previously to estimate stock composition of samples from the 2005-2010 Chinook salmon bycatch (NMFS 2009; Guyon et al. 2010a and b; Guthrie et al. 2012; Larson et al. 2013). For additional information regarding background and methodology, this report is intended to be supplemented with the Chinook salmon bycatch report prepared previously for the 2008 Bering Sea trawl fishery (Guyon et al. 2010a).

SAMPLE DISTRIBUTION

Samples were collected from the Chinook salmon bycatch by the Alaska Fisheries Science Center's (AFSC) Fisheries Monitoring and Analysis Division (FMA) for its Auke Bay Laboratories (ABL). Amendment 91 to the Fishery Management Plan for Groundfish of the BSAI Management Area was enacted in 2010 and included retention of the salmon caught in the prohibited species catch. In 2011, a systematic random sampling design recommended by Pella and Geiger (2009) was implemented by the North Pacific Groundfish Observer program to collect genetic samples from one out of every 10 Chinook salmon encountered as bycatch in the BSAI pollock fishery. In the 2011 GOA pollock fishery, there was no requirement for full retention of Chinook salmon caught in the prohibited species catch and genetic samples were collected opportunistically when encountered by observers.

Samples of axillary process tissue for genetic analysis were collected throughout 2011 from the BSAI and GOA. Axillary process tissue was stored in coin envelopes which were labeled, frozen, and shipped to ABL. The majority of the Chinook salmon bycatch genetic samples were derived from the bottom and midwater pollock trawl fishery, with the exception of 12 samples from BSAI where the target species was Pacific cod (*Gadus macrocephalus*).

Bering Sea-Aleutian Islands

In 2011, an estimated 25,499 Chinook salmon were taken in the bycatch of BSAI pollock trawl fisheries (NMFS 2012), of which 7,136 were estimated from the trawl "A" season and 18,363 were estimated for the "B" season. Since 1991, the year with the highest overall Chinook bycatch in the BSAI was 2007 (Fig. 2) when an estimated 121,770 fish were taken. The genetic sample set for the 2011 "A" season Chinook salmon bycatch was 695 fish, corresponding to a sampling rate of 9.7%. The genetic sample set for the 2011 "B" season Chinook bycatch was 1,778 fish, corresponding to a sampling rate of 9.7%. The annual sampling rate for the entire year was 9.7%. There were more Chinook salmon taken in the "B" season than in the "A" season for the first time since 2005 (Fig. 2).

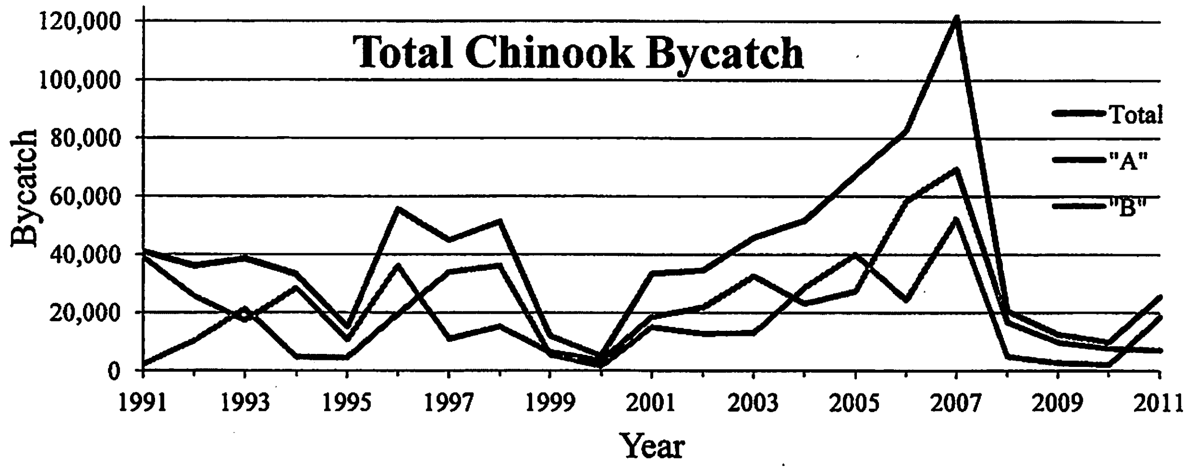


Figure 2. -- Yearly, "A" season, and "B" season estimates for the Chinook salmon bycatch from the BSAI pollock trawl fishery (NMFS 2012).

Potential biases associated with the collection of genetic samples from the bycatch are well documented and have the potential to affect resulting stock composition estimates (Pella and Geiger 2009). Potential spatial and temporal biases associated with the 2011 Chinook salmon bycatch sample sets were evaluated by comparing the genetic sample distribution with the overall bycatch distribution (Fig. 3). During 2011, the overall bycatch and genetic samples were comparable in their temporal distribution. To evaluate the sample spatial distribution, the Chinook salmon bycatch was compared with the bycatch samples by statistical area over time (Fig. 4). Spatial and temporal sample biases can become more apparent at these higher resolution scales. For samples collected from offloads in which the vessel fished in multiple areas, the sample location of the entire catch of a fishing trip was identified as the location of the most abundant haul, although generally those areas were in close proximity to each other.

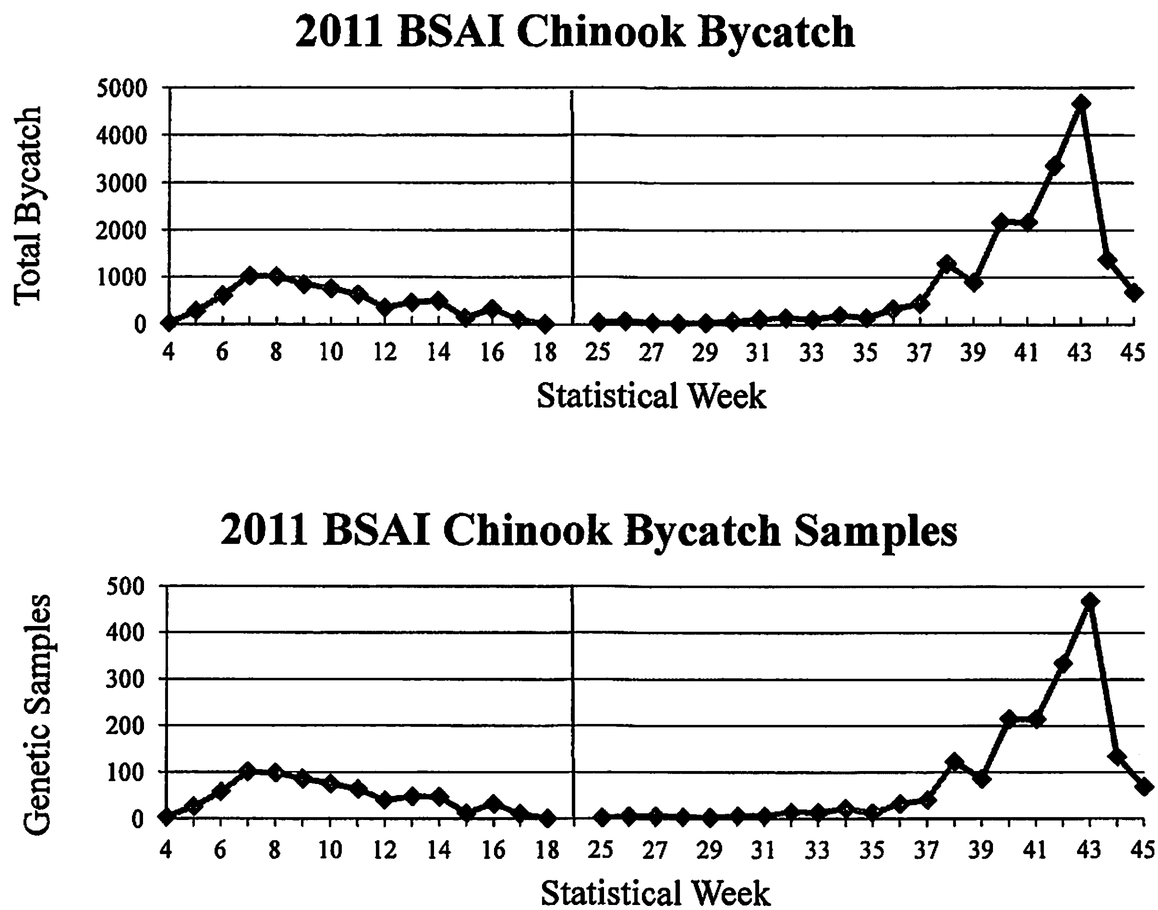


Figure 3.-- Number of Chinook salmon bycatch and genetic samples graphed by statistical week. Top panel: Distribution of all Chinook salmon caught in the 2011 Bering Sea pollock trawl fishery. Bottom panel: Distribution of the available 2,473 genetic samples from the 2011 bycatch. Weeks 4-18 correspond to the groundfish "A" season, whereas weeks 25-45 correspond to the "B" season, the demarcation of which is a vertical line.

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

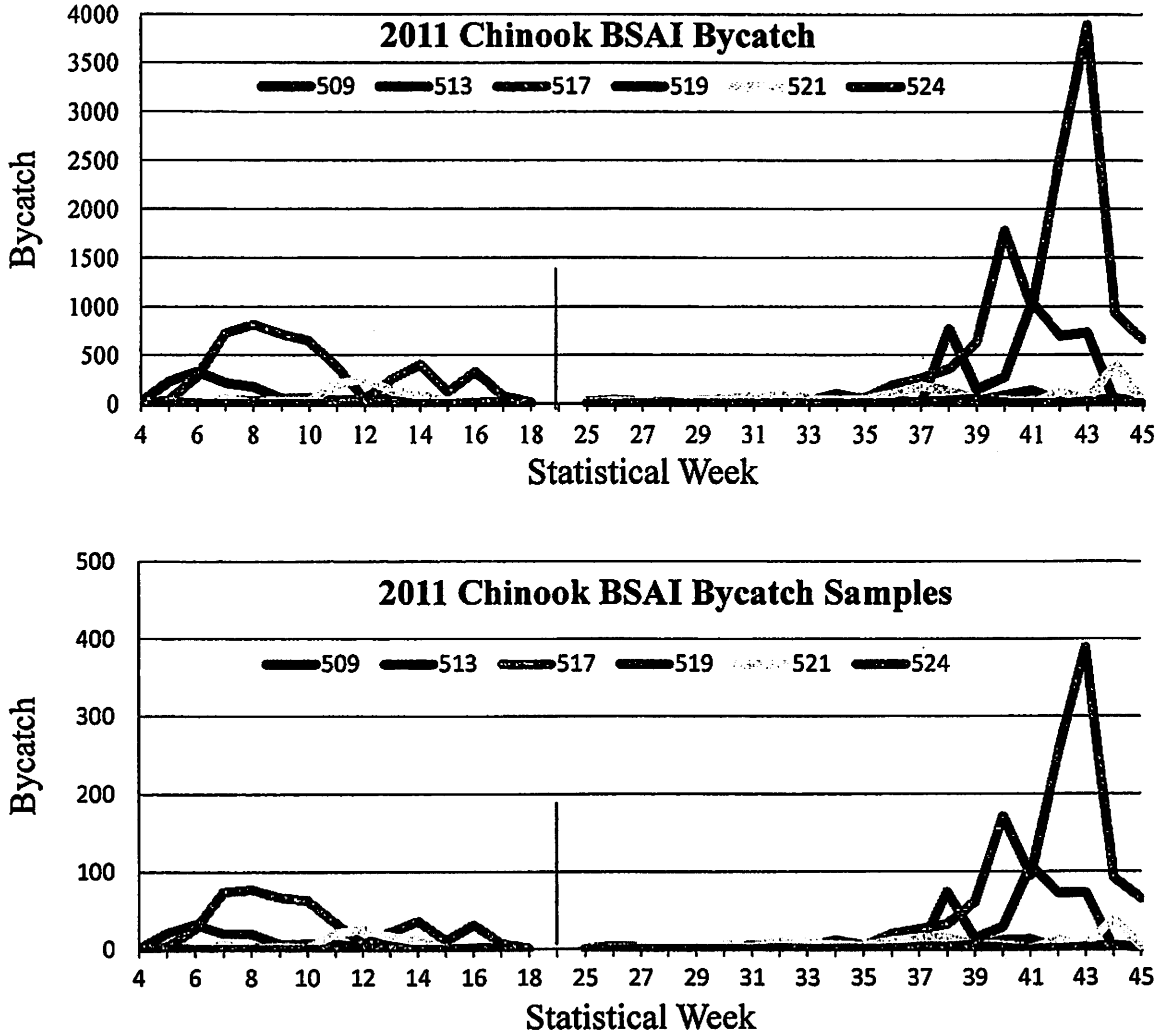


Figure 4.-- Comparison of the Chinook salmon bycatch by time and area with the distribution of available genetic samples. Top panel: Distribution of the estimated Chinook salmon caught in the 2011 BSAI pollock trawl fishery. Bottom panel: Distribution of the available 2,473 genetic samples from the 2011 bycatch. Not graphed were 11 fish from area 541, and 1 from 542. Weeks 4-18 correspond to the groundfish "A" season, whereas weeks 25-45 correspond to the "B" season, the demarcation of which is a vertical line.

Gulf of Alaska

In 2011, an estimated 13,837 Chinook salmon were taken in the bycatch of GOA pollock trawl fisheries (NMFS 2012). The year with the highest overall Chinook bycatch in the GOA was 2010 (Fig. 5) when an estimated 44,779 fish were taken. The genetic sample set for the 2011

Chinook salmon bycatch was 240 fish, corresponding to a sampling rate of 1.7%. Unlike the BSAI samples, the sampling was not systematic; consequently, the resulting stock composition estimates correspond to the sample set rather than the overall GOA Chinook salmon bycatch.

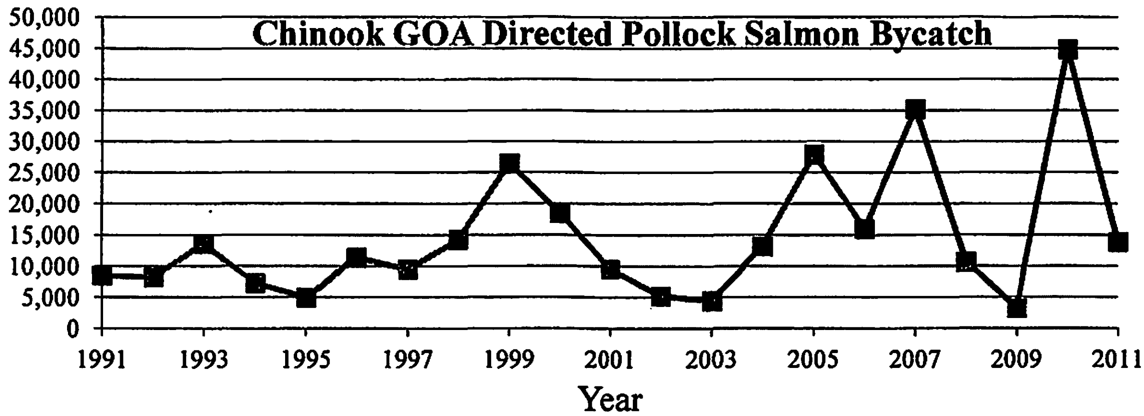
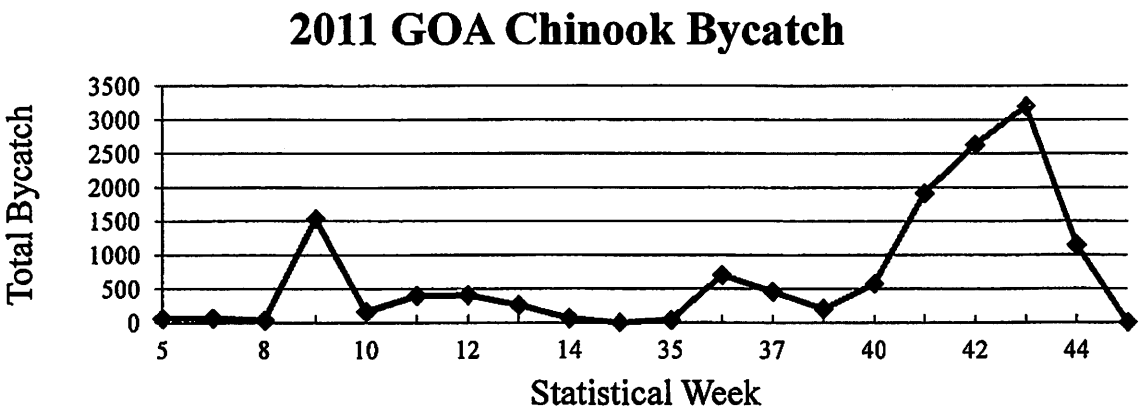


Figure 5. -- Yearly estimates for the Chinook salmon bycatch from the GOA pollock trawl fishery (NMFS 2012).

Potential spatial and temporal biases associated with the 2011 Chinook salmon GOA bycatch sample sets were evaluated by comparing the genetic sample distribution with the overall bycatch estimate distribution showing similarities in temporal distribution (Fig. 6). To evaluate the sample spatial distribution, the GOA Chinook salmon bycatch was compared with the bycatch samples by statistical area over time (Fig. 7) highlighting time/space sample distribution issues often associated with opportunistic sampling. The samples were not representative of all areas; for example, area 610 was underrepresented.



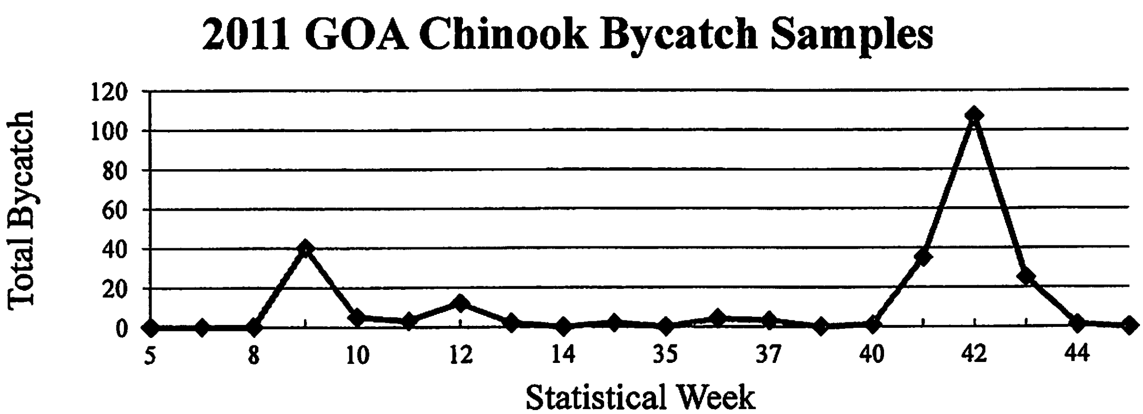
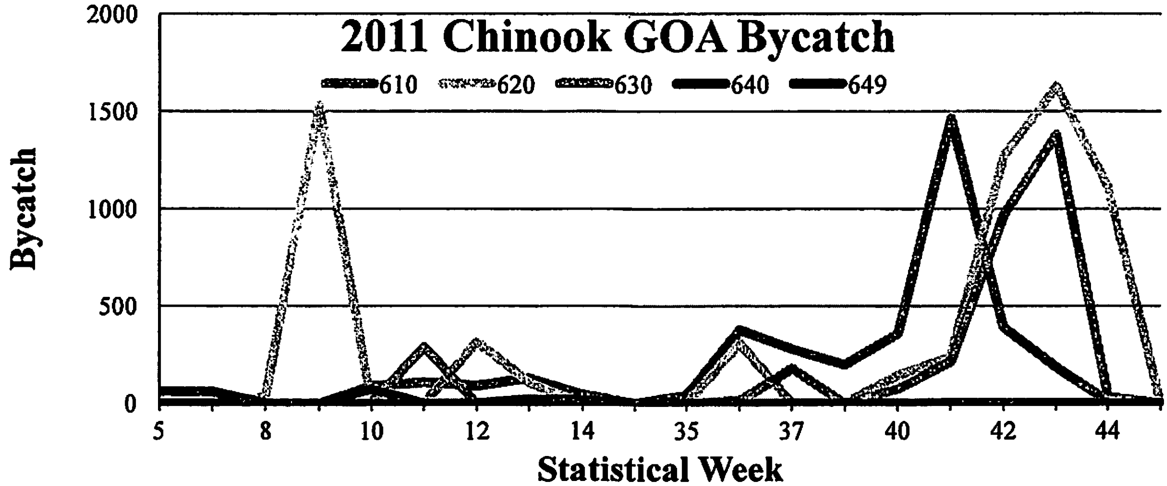


Figure 6.-- Number of Chinook salmon bycatch and genetic samples by statistical week. Top panel: Distribution of all Chinook salmon caught in the 2011 GOA pollock trawl fishery. Bottom panel: Distribution of the available 240 genetic samples from the 2011 bycatch.



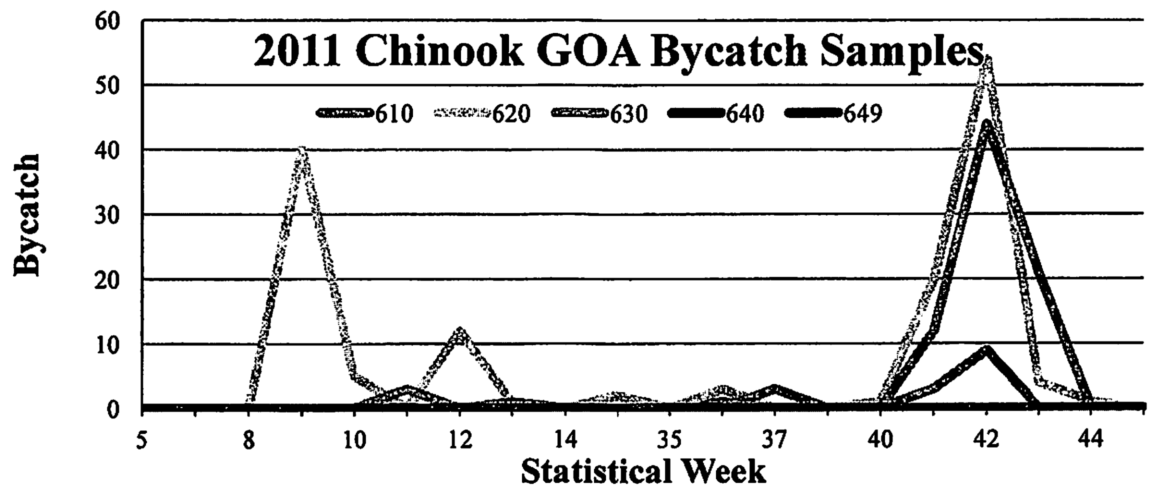


Figure 7.-- Comparison of the Chinook salmon bycatch by time and area with the distribution of available genetic samples. Top panel: Distribution of the estimated Chinook salmon caught in the 2011 GOA pollock trawl fishery. Bottom panel: Distribution of the available 240 genetic samples from the 2011 bycatch.

GENETIC STOCK COMPOSITION

DNA was extracted from axillary process tissue and matrix-assisted laser desorption/ionization - time of flight (MALDI-TOF) genotyping was performed as described previously (Guyon et al. 2010a) using a Sequenom MassARRAY iPLEX platform (Gabriel et al. 2009) to genotype 43 SNP DNA markers represented in the Chinook salmon baseline (Templin et al. 2011). The SNP baseline contains genetic information for 172 populations of Chinook salmon grouped into 11 geographic regions. This baseline was used previously for the genetic analysis of the 2005-2010 Chinook bycatch (NMFS 2009; Guyon et al. 2010a, b, 2011; Guthrie 2012). In addition to internal MALDI-TOF chip controls, 10 previously genotyped samples were included on each chip during the analyses and resulting genotypes were compared to those from ADF&G, which used TaqMan chemistries (Applied Biosystems). Concordance rates of 99.9% between the two chemistries for the 2011 controls confirmed the utility and compatibility of both genotyping methods.

From the 2011 Chinook salmon bycatch, a total of 2,756 samples were analyzed of which 2,720 samples were successfully genotyped for 35 or more of the 43 SNP loci, a success rate of 98.7%. These genotypes were analyzed both in GenAlEx (Peakall and Smouse 2006) and using C++ programs written by the Auke Bay Laboratories Genetics Program to confirm data integrity which resulted in the removal of three fish with duplicate genotypes from adjacent wells. An additional four were removed for lack of area information. Of the remaining 2,713, there were 2,473 which from the BSAI and 240 were from the GOA. The remaining samples had genetic information for an average of 41.2 of 43 markers. Stock composition estimates were derived using both BAYES (Bayesian analysis) and SPAM (maximum likelihood analysis) software and both methods yielded almost identical stock composition estimates (Tables 1-4).

BAYES software uses a Bayesian algorithm to produce stock composition estimates and can account for missing alleles in the baseline (Pella and Masuda 2001). In contrast, SPAM uses a conditional maximum likelihood approach in which the mixture genotypes are compared directly with the baseline (ADF&G 2003). Although Version 3.7b of the SPAM software allows Bayesian modeling of baseline allele frequencies, these options were not utilized for the stock composition analyses. Convergence of the SPAM estimates was monitored with the "Percent of

Maximum" value which was determined to be 90.7 (BSAI "A" estimate), 90.1 (BSAI "B" estimate), 90.3 (BSAI overall estimate) and 90.3 (GOA estimate), exceeding the 90% guaranteed percent achievement of the maximal likelihood. For each BAYES analysis, 11 Monte Carlo chains starting at disparate values of stock proportions were configured such that 95% of the stocks came from one designated region with weights equally distributed among the stocks of that region. The remaining 5% was equally distributed among remaining stocks from all other regions. For all estimates, a flat prior of 0.005814 (calculated as 1/172) was used for all 172 baseline populations. The analyses were completed for a chain length of 10,000 with the first 5,000 deleted during the burn-in phase when determining overall stock compositions. Convergence of the chains to posterior distributions of stock proportions was determined with Gelman and Rubin shrink statistics, which were all 1.05 or less for all the estimates, conveying strong convergence to a single posterior distribution (Pella and Masuda 2001).

Bering Sea-Aleutian Islands

Results (BAYES) suggest that 85% of the 695 samples from the "A" season originated from Alaskan river systems flowing into the Bering Sea with the Coastal Western Alaska stock contributing the most (54%), followed by the North Alaska Peninsula (22%), and Upper Yukon (7%). The other major contributor was British Columbia (7%) (Table 1). For the "B" season, over 79% of the 1,778 samples originated from Alaskan river systems flowing into the Bering Sea with the Coastal Western Alaska region contributing the most (74%). This was followed by British Columbia (8%) and the U.S. west coast stock (6%) (Table 2).

Table 1. -- Regional BAYES and SPAM stock composition estimates for the 695 Chinook salmon samples from the bycatch of the 2011 "A" season BSAI pollock trawl fishery. The BAYES mean estimates are also provided with standard deviations (SD), 95% credible intervals, and the median estimate. Standard deviations for the SPAM estimates were determined by the analysis of 1,000 bootstrap resamplings of the mixture.

Region	BAYES	SD	2.5%	Median	97.5%	SPAM	SD
Russia	**0.002**	0.002	0.000	0.001	0.006	**0.002**	0.002
Coast W AK	**0.540**	0.023	0.496	0.541	0.585	**0.536**	0.020
Mid-Yukon	**0.018**	0.008	0.006	0.017	0.036	**0.028**	0.004
Up Yukon	**0.074**	0.011	0.053	0.073	0.097	**0.071**	0.007
N AK Penn	**0.218**	0.019	0.181	0.218	0.257	**0.198**	0.012
NW GOA	**0.006**	0.006	0.000	0.004	0.022	**0.022**	0.003
Copper	**0.000**	0.001	0.000	0.000	0.002	**0.000**	0.000
NE GOA	**0.000**	0.001	0.000	0.000	0.002	**0.000**	0.000
Coast SE AK	**0.031**	0.009	0.016	0.030	0.049	**0.030**	0.002
BC	**0.072**	0.011	0.051	0.072	0.096	**0.075**	0.006
WA/OR/CA	**0.040**	0.008	0.026	0.039	0.056	**0.039**	0.004

Table 2. -- Regional BAYES and SPAM stock composition estimates for the 1,778 Chinook salmon samples from the bycatch of the 2011 "B" season BSAI pollock trawl fishery. The BAYES mean estimates are also provided with standard deviations (SD), 95% credible intervals, and the median estimate. Standard deviations for the SPAM estimates were determined by the analysis of 1,000 bootstrap resamplings of the mixture.

Region	BAYES	SD	2.5%	Median	97.5%	SPAM	SD
Russia	**0.010**	0.003	0.006	0.010	0.016	**0.010**	0.002
Coast W AK	**0.738**	0.013	0.713	0.738	0.762	**0.733**	0.013
Mid-Yukon	**0.013**	0.005	0.005	0.013	0.022	**0.011**	0.001
Up Yukon	**0.007**	0.004	0.001	0.006	0.014	**0.008**	0.000
N AK Penn	**0.034**	0.007	0.022	0.034	0.048	**0.033**	0.003
NW GOA	**0.036**	0.009	0.020	0.035	0.055	**0.038**	0.003
Copper	**0.006**	0.003	0.000	0.006	0.012	**0.006**	0.001
NE GOA	**0.001**	0.002	0.000	0.000	0.008	**0.004**	0.000
Coast SE AK	**0.014**	0.005	0.006	0.014	0.024	**0.015**	0.001
BC	**0.078**	0.007	0.064	0.077	0.092	**0.078**	0.002
WA/OR/CA	**0.064**	0.006	0.053	0.064	0.077	**0.064**	0.003

Table 3. -- Regional BAYES and SPAM stock composition estimates for the 2,473 Chinook salmon samples from the bycatch of the 2011 BSAI pollock trawl fishery. The BAYES mean estimates are also provided with standard deviations (SD), 95% credible intervals, and the median estimate. Standard deviations for the SPAM estimates were determined by the analysis of 1,000 bootstrap resamplings of the mixture.

Region	BAYES	SD	2.5%	Median	97.5%	SPAM	SD
Russia	**0.008**	0.002	0.005	0.008	0.012	**0.008**	0.001
Coast W AK	**0.683**	0.012	0.660	0.683	0.706	**0.679**	0.011
Mid-Yukon	**0.016**	0.005	0.008	0.016	0.025	**0.017**	0.001
Up Yukon	**0.025**	0.005	0.016	0.024	0.034	**0.025**	0.002
N AK Penn	**0.086**	0.008	0.071	0.086	0.103	**0.079**	0.004
NW GOA	**0.026**	0.007	0.014	0.026	0.041	**0.033**	0.002
Copper	**0.003**	0.002	0.000	0.002	0.008	**0.004**	0.001
NE GOA	**0.001**	0.001	0.000	0.000	0.004	**0.002**	0.000
Coast SE AK	**0.018**	0.004	0.011	0.018	0.026	**0.019**	0.001
BC	**0.078**	0.006	0.066	0.078	0.090	**0.079**	0.002
WA/OR/CA	**0.057**	0.005	0.048	0.057	0.067	**0.056**	0.002

Table 4. -- Regional BAYES and SPAM stock composition estimates for the 240 Chinook salmon samples from the bycatch of the 2011 GOA pollock trawl fishery. The BAYES mean estimates are also provided with standard deviations (SD), 95% credible intervals, and the median estimate. Standard deviations for the SPAM estimates were determined by the analysis of 1,000 bootstrap resamplings of the mixture.

Region	BAYES	SD	2.5%	Median	97.5%	SPAM	SD
Russia	**0.000**	0.001	0.000	0.000	0.001	**0.000**	0.000
Coast W AK	**0.006**	0.009	0.000	0.001	0.030	**0.006**	0.004
Mid-Yukon	**0.000**	0.001	0.000	0.000	0.002	**0.000**	0.000
Up Yukon	**0.000**	0.001	0.000	0.000	0.003	**0.000**	0.000
N AK Penn	**0.000**	0.001	0.000	0.000	0.002	**0.000**	0.000
NW GOA	**0.146**	0.025	0.100	0.145	0.198	**0.140**	0.018
Copper	**0.041**	0.017	0.011	0.040	0.078	**0.046**	0.010
NE GOA	**0.002**	0.006	0.000	0.000	0.021	**0.010**	0.001
Coast SE AK	**0.144**	0.032	0.085	0.142	0.211	**0.125**	0.009
BC	**0.402**	0.040	0.323	0.401	0.480	**0.410**	0.027
WA/OR/CA	**0.260**	0.030	0.205	0.260	0.320	**0.263**	0.022

For the entire year, an estimated 81% of the bycatch samples were estimated to be from Alaskan river systems flowing into the Bering Sea with the Coastal Western Alaska stock contributing the most (68%), trailed by the North Alaska Peninsula (9%). Other contributors were British Columbia (8%), and U.S. west coast (6%) (Table 3). The "overall" and "B" season stock compositions were similar, which was anticipated given that 72% of the samples were from the "B" season. In 2011, 72% of the Chinook salmon bycatch was from the "B" season of the Bering Sea pollock fishery.

Gulf of Alaska

The BAYES results estimate that 99% of the 240 samples from the GOA originated from GOA/Pacific coastal regions, with the British Columbia contributing the most (40%), followed by the West Coast US (26%) and Coastal Southeast Alaska (14%; Table 4).

COMPARISON WITH PREVIOUS ESTIMATES

Although comparisons among years are complicated due to different sampling strategies employed in different years, stock compositions from the analysis of the 2011 "A" season Chinook salmon bycatch samples were in general agreement with the 2008 and 2010 "A" season estimates. For example, most samples continued to be from stocks originating from river systems directly flowing into the Bering Sea, although differences were apparent between the 2010 and 2011 "A" season sample sets including the Upper and Middle Yukon estimated contribution which decreased in 2011 while the Western Alaska and the North Alaska Peninsula estimated contributions increased (Fig. 8). Although the 2008 and 2011 "A" season contribution estimates were more similar, larger amounts of more southern stocks (Coastal Southeast Alaska, British Columbia, and west coast US) were estimated in 2011 than 2008 and 2010.

Likewise, the 2007, 2008, and 2011 "B" season stock composition estimates were similar with large amounts from Coastal Western Alaska (Fig 8.) In contrast with the 2010 "B" season estimate, the 2011 "B" season estimate identified smaller contributions from British Columbia, West Coast U.S. and Coastal Southeast Alaska stocks. Unlike previous years studied, most of the Chinook salmon bycatch occurred during the "B" season such that the sample set was relatively large this year. In addition, 2011 was the first year systematic random sampling was employed where genetic samples were collected from one of every 10 Chinook salmon encountered. The combined size of the sample set and the proportional sampling methods employed help make the 2011 "B" season estimates representative of the total catch.

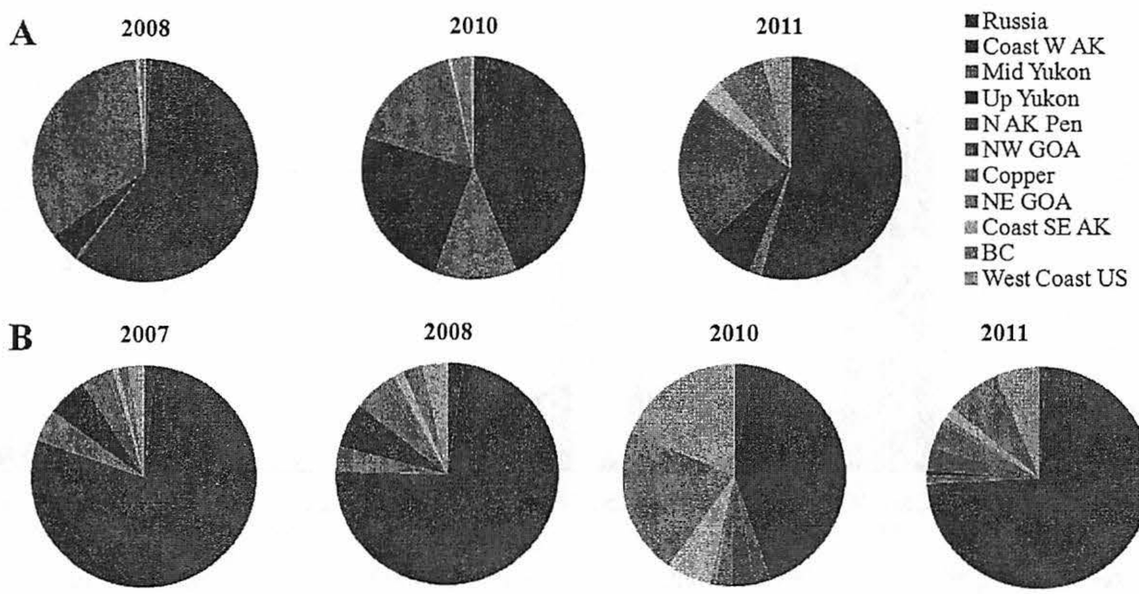


Figure 8.-- Comparison of "A" season genetic stock composition estimates for 2008,2010 and 2011 based on available genetic samples from the BSAI Chinook salmon bycatch. Comparison of "B" season genetic stock composition estimates for 2007, 2008, 2010, and 2011 stock composition estimates based on available genetic samples from the BSAI "B" season Chinook salmon bycatch. The same genetic baseline and regional groupings were used in all analyses.

While changes in sampling protocols between years necessitate caution in comparing annual analyses across years, when the stock compositions were analyzed for the entire year, Coastal Western Alaska and North Alaska Peninsula stock compositions trended downward between 2008 and 2010 but increased in 2011 (Fig. 10). The Yukon River contribution dropped to its lowest levels in 2011, while British Columbia and West Coast U.S. stock compositions continued to trend upward (Fig. 9).

For the GOA, the opportunistic sampling protocols employed between 2010 and 2011 limit the results to indentifying only presence of individual stocks. In addition, available sample numbers were very low, with 161 samples from 2010 (0.4% sampling rate) and 240 samples in

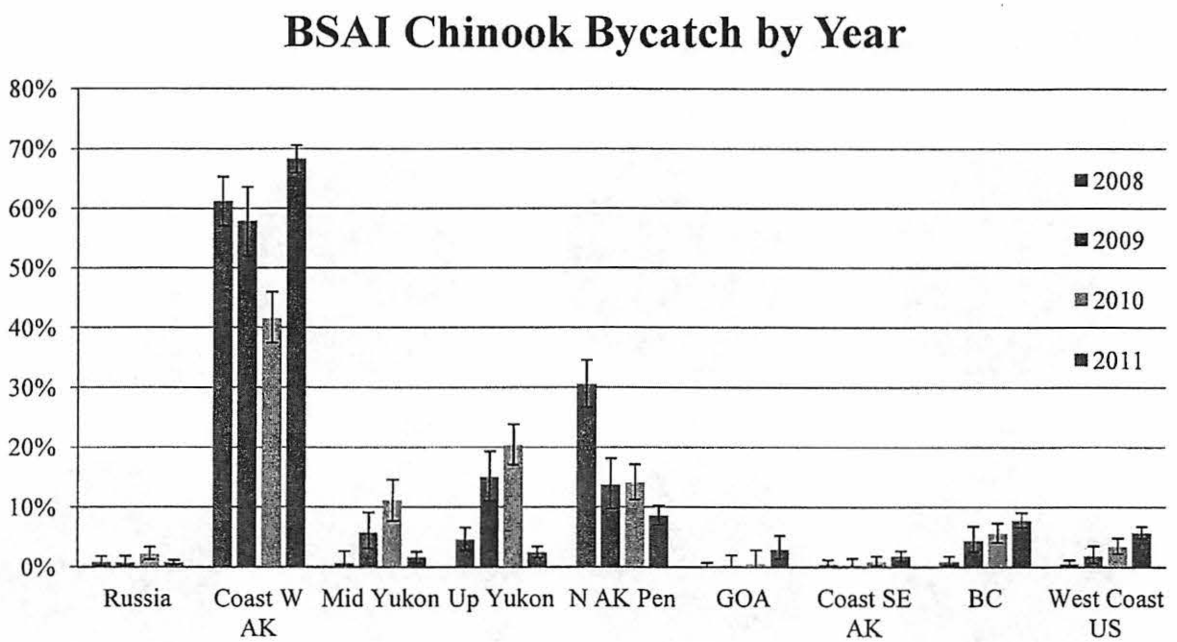


Figure 9. -- Comparison of yearly stock composition estimates (2008-2011) based on genetic samples from the Bering Sea Chinook salmon bycatch. The same genetic baseline and general regional groupings were used in all analyses. GOA group consists of combined values for NWGOA, Copper, and NE GOA. BAYES 95% credible intervals are plotted for yearly estimates.

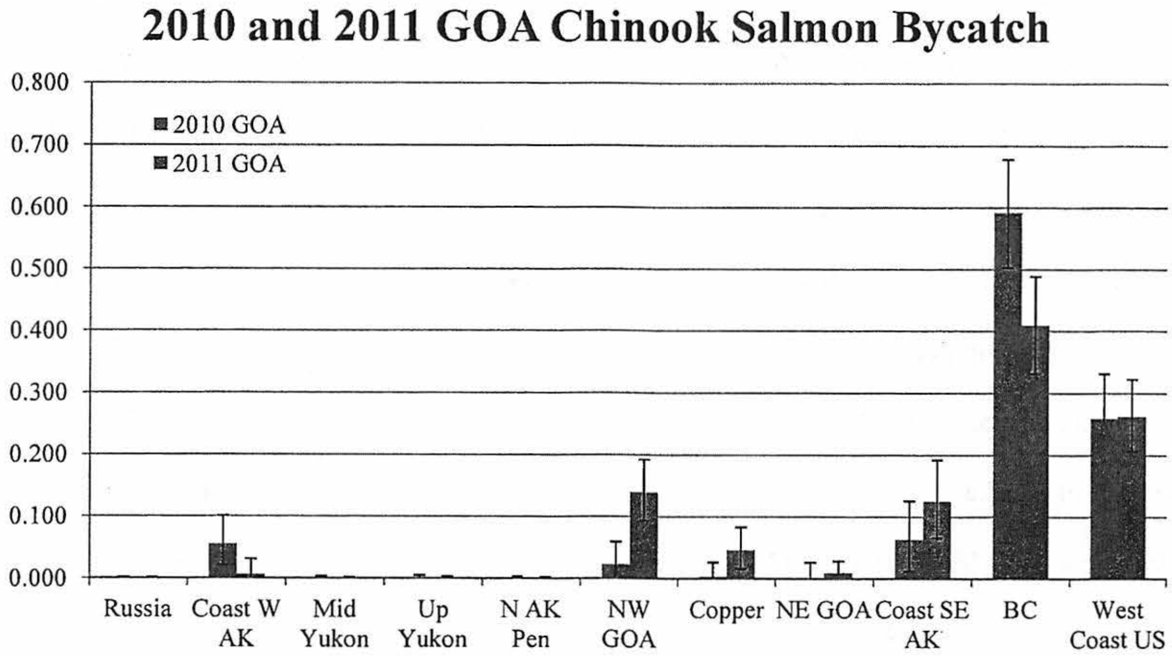


Figure 10. -- Comparison of yearly stock composition estimates (2010-2011) based on available genetic samples from the GOA Chinook salmon bycatch. The same genetic baseline and general regional groupings were used in all analyses. BAYES 95% credible intervals are plotted for yearly estimates.

2011 (1.7% sampling rate). Recognizing these limitations, Figure 10 shows the stock composition of the GOA collected in 2010 and 2011, and both years show an abundance of Southern stock groups; British Columbia, West Coast US, NW GOA, and Coastal Southeast Alaska.

SUMMARY

Communities in western Alaska and elsewhere are dependent on Chinook salmon for subsistence and commercial purposes. Decreasing Chinook salmon returns to western Alaska rivers have caused hardships in these communities and led to the recent declaration of a fisheries disaster for Yukon River Chinook salmon in 2010 and 2012 by the U. S. Secretaries of Commerce (Locke 2010, Blank 2012), and in the Kuskokwim Rivers, and Cook Inlet in 2012

(Blank 2012). Salmon-dependent communities have expressed concern regarding the numbers of salmon caught as bycatch in the Bering Sea trawl fishery. The incidental harvest of Chinook salmon in the Bering Sea pollock fishery averaged 39,888 salmon per year during 1991-2011, but steadily increased to a peak of 121,638 in 2007. The Bering Sea Chinook salmon bycatch has abated in more recent years dropping to a total of 25,499 Chinook salmon in 2011, a number which is approximately 14,000 fish below the 20-year average, but the most since 2007.

In addition to the Bering Sea, there is also a federally managed pollock trawl fishery in the Gulf of Alaska. The incidental harvest of Chinook salmon in the GOA averaged 14,574 salmon per year during 1991-2011, with a peak of 44,779 in 2010. The GOA Chinook salmon bycatch dropped to just below the 21-year average in 2011 to 13,837 Chinook salmon. Stock composition estimates of the Chinook salmon bycatch are needed for pollock and salmon fishery managers to understand the biological effects of the incidental take of salmon in the trawl fishery. This report provides a stock composition analysis of genetic sample sets from the 2011 Bering Sea and GOA Chinook salmon bycatch. The results and limitations of this analysis are summarized below.

Sampling Issues

Bering Sea-Aleutian Islands

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

(Figs. 3 and 4). The observed genetic sampling rate in 2011 was 9.7%, the highest ever observed and in close agreement with the one in 10 sampling goal. The resulting Chinook salmon Bering Sea bycatch sample set was 2,473, about four times the size of the sample sets from previous Bering Sea analyses.

Gulf of Alaska

Although opportunistic sampling was employed in both 2010 and 2011 for the collection of the GOA Chinook salmon bycatch genetic samples, the sampling effort improved from a 0.4% sampling rate in 2010 to 1.7% in 2011 although the overall sample set remained quite small at 240 samples in 2011. The lack of representative samples and the small sample size preclude calculating statistically reliable stock composition estimates of the 2011 GOA Chinook salmon bycatch as a whole. Nonetheless the stock composition of the available samples provides at least an indication of stock presence.

Stock Composition Estimates

Bering Sea-Aleutian Islands

Genetic stock composition analysis showed the majority of bycatch samples were from Alaskan stocks predominantly originating from river systems directly flowing into the Bering Sea. The Chinook salmon bycatch stock composition estimates for the 2011 "A" season differed from those of the 2011 "B" season, suggesting temporal differences in the available Chinook salmon stocks. This was especially apparent in the following stock groups: Coastal Western Alaska (54% vs.74%), Middle/Upper Yukon (9% vs. 2%), and the North Alaska Peninsula (22% vs. 3%). For the first time since 2005, the size of the Bering Sea Chinook salmon bycatch was higher in the "B" season than the "A" season. Approximately (72%) of the Chinook salmon genetic samples were collected from the 2011 "B" season, a result that might help explain differences in overall stock contribution between previous years (Fig. 9).

Gulf of Alaska

As in 2010, the opportunistic nature in which genetic samples were collected from the GOA Chinook salmon bycatch limits the 2011 stock composition results to presence indicators. As in 2010, the 2011 GOA Chinook salmon bycatch samples were predominantly from the west coast of the United States, British Columbia, and Coastal Southeast Alaska (Fig. 10).

Application of These Estimates

The extent to which any salmon stock is impacted by the bycatch of the Bering Sea trawl fishery is dependent on many factors including 1) the overall size of the bycatch, 2) the age of the salmon caught in the bycatch, 3) the age of the returning salmon, and 4) the total escapement of the affected stocks taking into account lag time for maturity and returning to the river. As such, a higher contribution of a particular stock one year does not necessarily infer greater impact than a smaller estimate the next. Stock composition estimates for the Bering Sea Chinook salmon bycatch were performed using representative samples and the estimates are considered to be representative of the overall bycatch. Opportunistic sampling and the small sample sets used for the GOA estimates limit the application of those estimates to presence of a stock group.

ACKNOWLEDGMENTS

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APPENDIX

Appendix 1.-- Chinook salmon populations in the ADF&G SNP baseline with the regional designations used in the analyses of this report.

ADF&G number	Population name	Region number	Region
1	Bistraya River	1	Russia
2	Bolshaya River	1	Russia
3	Kamchatka River late	1	Russia
4	Pakhatcha River	1	Russia
8	Andreafsky River	2	Coast W AK
40	Aniak River	2	Coast W AK
9	Anvik River	2	Coast W AK
34	Arolik River	2	Coast W AK
54	Big Creek	2	Coast W AK
44	Cheeneetnuk River	2	Coast W AK
36	Eek River	2	Coast W AK
45	Gagaryah River	2	Coast W AK
41	George River	2	Coast W AK
10	Gisasa River	2	Coast W AK
7	Golsovia River	2	Coast W AK
33	Goodnews River	2	Coast W AK
35	Kanektok River	2	Coast W AK
38	Kisaralik River	2	Coast W AK
42	Kogrukluk River	2	Coast W AK
37	Kwethluk River	2	Coast W AK
51	Mulchatna River	2	Coast W AK
53	Naknek River	2	Coast W AK
50	Nushagak River	2	Coast W AK
5	Pilgrim River	2	Coast W AK
48	Salmon River - Pitka Fork	2	Coast W AK
43	Stony River	2	Coast W AK
52	Stuyahok River	2	Coast W AK
46	Takotna River	2	Coast W AK
47	Tatlawiksuk River	2	Coast W AK
49	Togiak River	2	Coast W AK
11	Tozitna River	2	Coast W AK
39	Tuluksak River	2	Coast W AK
6	Unalakleet River	2	Coast W AK
17	Beaver Creek	3	Mid Yukon
18	Chandalar River	3	Mid Yukon
15	Chena River	3	Mid Yukon
12	Henshaw Creek	3	Mid Yukon
14	Kantishna River	3	Mid Yukon
16	Salcha River	3	Mid Yukon
19	Sheenjek River	3	Mid Yukon
13	South Fork Koyukuk River	3	Mid Yukon
27	Big Salmon River	4	Up Yukon

ADF&G number	Population name	Region number	Region
24	Blind River	4	Up Yukon
20	Chandindu River	4	Up Yukon
21	Klondike River	4	Up Yukon
26	Little Salmon River	4	Up Yukon
23	Mayo River	4	Up Yukon
30	Nisutlin River	4	Up Yukon
29	Nordenskiold River	4	Up Yukon
25	Pelly River	4	Up Yukon
22	Stewart River	4	Up Yukon
31	Takhini River	4	Up Yukon
28	Tatchun Creek	4	Up Yukon
32	Whitehorse Hatchery	4	Up Yukon
59	Black Hills Creek	5	N AK Pen
55	King Salmon River	5	N AK Pen
56	Meshik River	5	N AK Pen
57	Milky River	5	N AK Pen
58	Nelson River	5	N AK Pen
60	Steelhead Creek	5	N AK Pen
78	Anchor River	6	NW GOA
62	Ayakulik River	6	NW GOA
72	Benjamin Creek	6	NW GOA
61	Chignik River	6	NW GOA
69	Crescent Creek	6	NW GOA
76	Crooked Creek	6	NW GOA
65	Deception Creek	6	NW GOA
64	Deshka River	6	NW GOA
73	Funny River	6	NW GOA
70	Juneau Creek	6	NW GOA
63	Karluk River	6	NW GOA
77	Kasilof River mainstem	6	NW GOA
75	Kenai River mainstem	6	NW GOA
71	Killey Creek	6	NW GOA
79	Ninilchik River	6	NW GOA
67	Prairie Creek	6	NW GOA
74	Slikok Creek	6	NW GOA
68	Talachulitna River	6	NW GOA
66	Willow Creek	6	NW GOA
81	Bone Creek	7	Copper
82	E. Fork Chistochina River	7	Copper
85	Gulkana River	7	Copper
80	Indian River	7	Copper
87	Kiana Creek	7	Copper
88	Manker Creek	7	Copper
86	Mendeltna Creek	7	Copper
83	Otter Creek	7	Copper
84	Sinona Creek	7	Copper
90	Tebay River	7	Copper
89	Tonsina River	7	Copper
92	Big Boulder Creek	8	NE GOA

ADF&G number	Population name	Region number	Region
95	Kelsall River	8	NE GOA
96	King Salmon River	8	NE GOA
116	Klukshu River	8	NE GOA
91	Situk River	8	NE GOA
93	Tahini River	8	NE GOA
94	Tahini River - Pullen Creek Hatchery	8	NE GOA
111	Andrews Creek	9	Coast SE AK
110	Blossom River	9	Coast SE AK
102	Butler Creek	9	Coast SE AK
98	Chickamin River	9	Coast SE AK
99	Chickamin River - Little Port Walter	9	Coast SE AK
100	Chickamin River - Whitman Lake Hatchery	9	Coast SE AK
103	Clear Creek	9	Coast SE AK
104	Cripple Creek	9	Coast SE AK
112	Crystal Lake Hatchery	9	Coast SE AK
121	Dudidontu River	9	Coast SE AK
105	Genes Creek	9	Coast SE AK
114	Hidden Falls Hatchery	9	Coast SE AK
101	Humpy Creek	9	Coast SE AK
106	Kerr Creek	9	Coast SE AK
109	Keta River	9	Coast SE AK
97	King Creek	9	Coast SE AK
117	Kowatua River	9	Coast SE AK
118	Little Tatsemenie River	9	Coast SE AK
115	Macaulay Hatchery	9	Coast SE AK
113	Medvejie Hatchery	9	Coast SE AK
120	Nakina River	9	Coast SE AK
122	Tahltan River	9	Coast SE AK
108	Unuk River - Deer Mountain Hatchery	9	Coast SE AK
107	Unuk River - Little Port Walter	9	Coast SE AK
119	Upper Nahlin River	9	Coast SE AK
143	Big Qualicum River	10	BC
157	Birkenhead River spring	10	BC
128	Bulkley River	10	BC
148	Chilko River summer	10	BC
152	Clearwater River summer	10	BC
138	Conuma River	10	BC
124	Damdochax Creek	10	BC
130	Ecstall River	10	BC
158	Harrison River	10	BC
123	Kateen River	10	BC
125	Kincolith Creek	10	BC
133	Kitimat River	10	BC
135	Klinaklini River	10	BC
126	Kwinageese Creek	10	BC
153	Louis River spring	10	BC
154	Lower Adams River fall	10	BC
132	Lower Atnarko River	10	BC
131	Lower Kalum River	10	BC

ADF&G number	Population name	Region number	Region
155	Lower Thompson River fall	10	BC
139	Marble Creek	10	BC
156	Middle Shuswap River summer	10	BC
145	Morkill River summer	10	BC
136	Nanaimo River	10	BC
149	Nechako River summer	10	BC
140	Nitinat River	10	BC
127	Oweegee Creek	10	BC
137	Porteau Cove	10	BC
150	Quesnel River summer	10	BC
144	Quinsam River	10	BC
141	Robertson Creek	10	BC
146	Salmon River summer	10	BC
142	Sarita River	10	BC
151	Stuart River summer	10	BC
129	Sustut River	10	BC
147	Torpy River summer	10	BC
134	Wannock River	10	BC
168	Alsea River fall	11	West Coast US
166	Carson Hatchery spring	11	West Coast US
171	Eel River fall	11	West Coast US
160	Forks Creek fall	11	West Coast US
164	Hanford Reach	11	West Coast US
170	Klamath River	11	West Coast US
165	Lower Deschutes River fall	11	West Coast US
163	Lyons Ferry Hatchery summer/fall	11	West Coast US
159	Makah National Fish Hatchery fall	11	West Coast US
167	McKenzie River spring	11	West Coast US
172	Sacramento River winter	11	West Coast US
169	Siuslaw River fall	11	West Coast US
162	Soos Creek Hatchery fall	11	West Coast US
161	Upper Skagit River summer	11	West Coast US

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Genetic Stock Composition Analysis of Chum Salmon Bycatch Samples from the 2011 Bering Sea Walleye Pollock Trawl Fishery

by
C. M. Kondzela, C. T. Marvin, S. C. Vulstek,
H. T. Nguyen, and J. R. Guyon

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

March 2013

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ABSTRACT

A genetic analysis of samples from the chum salmon (*Oncorhynchus keta*) bycatch from the 2011 Bering Sea walleye pollock (*Theragra chalcogramma*) trawl fishery was undertaken to determine the overall stock composition of the sample set. Samples were genotyped for 11 microsatellite markers and results were estimated using the current chum salmon microsatellite baseline. In 2011, genetic samples were collected systematically as part of a special project to reduce sample biases that exist in collections from previous years that have the potential to affect stock composition analysis results. One genetic sample was collected for every 31.1 chum salmon caught in 97% of the midwater trawl fishery that was sampled. Evaluation of sampling based on time, location, and vessel indicated that the genetic samples were representative of the total bycatch. Based on the analysis of 1,472 chum salmon bycatch samples collected throughout the 2011 Bering Sea trawl fishery, the Eastern Gulf of Alaska (GOA)/Pacific Northwest (PNW) stocks dominated the sample set (38%), with moderate contributions from East Asian (17%), North Asian (18%), and Western Alaska (16%) stocks, and smaller contributions from Upper/Middle Yukon River (9%) stocks. The estimates for the 2011 chum salmon bycatch sample set differed from the 2005–2010 estimates, indicating a change in the consistency of the regional stock contributions across the previous 6 years, possibly due to the larger proportion of bycatch caught later in the season and in the more southeastern NMFS reporting areas in 2011. There were significant spatial differences in stock distribution, with the Asian stocks dominating the central Bering Sea area and the Eastern GOA/PNW stocks dominating the southeastern Bering Sea. Analysis of temporal groupings revealed changes in stock composition during the course of the season with decreasing contribution of East Asia and Upper/Middle Yukon stocks and increasing contribution of Eastern GOA/PNW stocks over time.

CONTENTS

INTRODUCTION

It is important to understand the stock composition of salmon caught in Bering Sea fisheries because this area is a known feeding habitat for multiple brood years of chum salmon (*Oncorhynchus 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 to understanding the effects that fishing has on chum salmon stocks, especially those with conservation concerns. This report includes genetic stock identification results for the chum salmon bycatch samples collected from the 2011 U.S. Bering Sea groundfish trawl fishery. National Marine Fisheries Service (NMFS) reporting areas associated with the groundfish fishery are shown in Figure 1 and are presented later to describe the spatial distribution of the chum salmon bycatch and genetic samples.

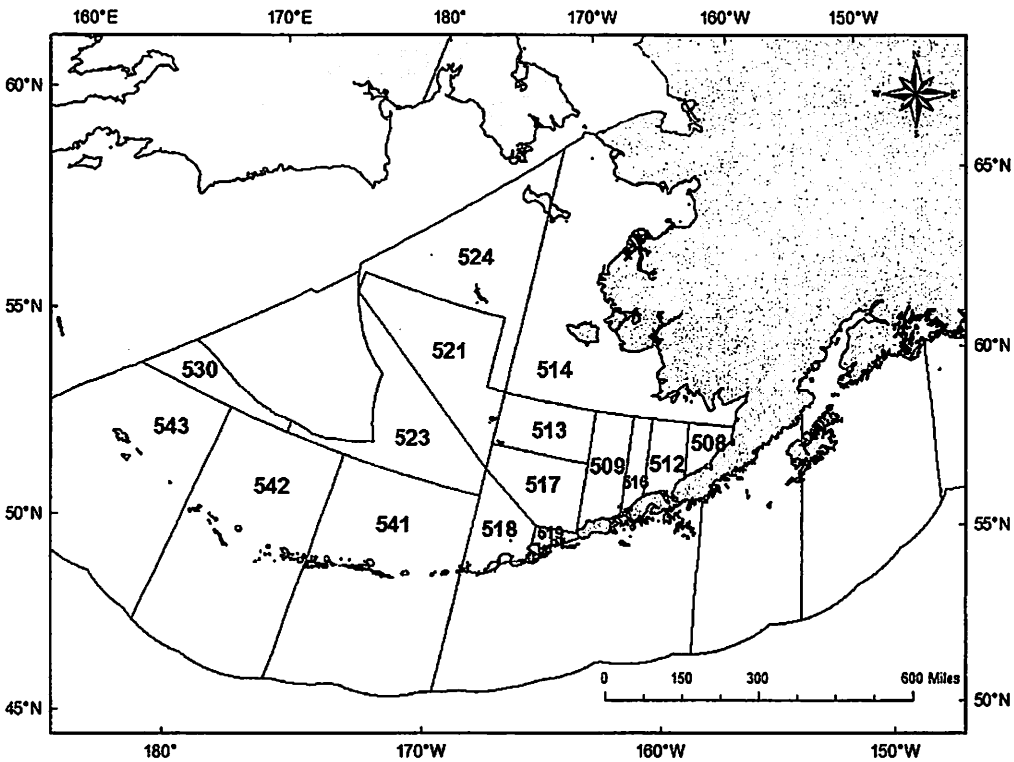

Figure 1. -- NMFS reporting areas associated with the Bering Sea-Aleutian Island groundfish fishery.

We present the stock composition estimates for the 2011 chum salmon bycatch samples collected from the Bering Sea. This report is divided into seven sections: Introduction, Sample Distribution, Genetic Stock Composition, Comparison with Previous Estimates, Temporal Stratification, Spatial Stratification, and Summary. For additional background and methods, this report is intended to be supplemented with the chum salmon reports prepared previously for the 2005–2010 Bering Sea trawl fisheries (Guyon et al. 2010; Marvin et al. 2011; Gray et al. 2011a,b; Gray et al. 2010; Kondzela et al. 2012). The chum salmon bycatch is designated as non-Chinook in the NMFS database and comprises over 99% of the non-Chinook category (NPFMC 2005).

SAMPLE DISTRIBUTION

Genetic samples were collected from the salmon bycatch of the Bering Sea trawl fishery by the Alaska Fisheries Science Center's (AFSC) North Pacific Observer Program in 2011 for the AFSC's Auke Bay Laboratories. Sampling was changed from previous years to implement a systematic sampling protocol recommended by Pella and Geiger (2009). With a goal to sample approximately every 30th chum salmon, axillary processes (for genetic analysis) and scales (for ageing) were collected throughout the season and stored in coin envelopes that were labeled, frozen, and shipped to the Auke Bay Laboratories. All of the chum salmon genetic samples were collected from bycatch in the midwater walleye pollock (*Theragra chalcogramma*) trawl fishery.

In 2011, an estimated 191,441 chum salmon were incidentally taken as bycatch in the pollock-directed midwater and bottom trawl fisheries, accounting for more than 98% of the total chum salmon bycatch taken in the Bering Sea groundfish fisheries (NMFS 2012). This is the fourth largest non-Chinook salmon bycatch in the pollock fisheries between 1994 and 2010, ~37% more than the average of 139,660 fish, and nearly three times larger than the median of 65,988 (Fig. 2). The 2011 genetic samples were collected from the midwater trawl fishery in North Pacific Fishery Management Council statistical areas 509-524. Of the 189,537 chum salmon caught in this fishery, genetic samples were collected from 6,102 fish, which represents a sampling rate of one of every 31.1 chum salmon (or 3.2% of the midwater trawl chum salmon bycatch). Due to the large number of samples collected, the genetic analysis was based on a sub-sample of every fourth fish from the total genetic samples.

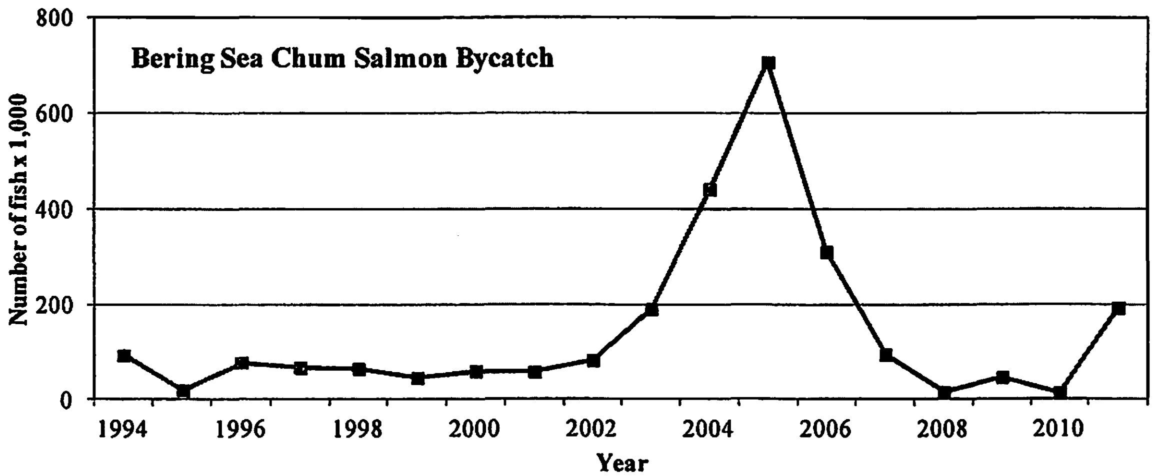

Figure 2. -- Yearly estimates for the non-Chinook salmon bycatch from the Bering Sea pollock directed trawl fisheries (NMFS 2012).

Biases and errors associated with past collections of genetic samples from the bycatch are well documented, and have the potential to affect stock composition estimates. The systematic sampling protocols recommended by Pella and Geiger (2009) were implemented in 2011 to reduce sampling error and bias, the efficacy of which was evaluated by visually comparing the genetic sample distributions with the overall bycatch estimates. Temporal bias by statistical week ending on Sunday was minimal (Fig. 3) when samples were pooled across management areas. Nearly all of the chum salmon bycatch occurred in the pollock "B" season (99.9%), where temporal biases were also minimal at finer spatial scales (Fig. 4). Due to the uncertainty of catch location for samples collected from shore-side deliveries in which the hauls were mixed, the NMFS reporting area of the entire catch of a fishing trip was identified as the area of the most abundant haul. For vessels that fished in multiple areas during a trip, the NMFS reporting area was identified as the area where the fishery target species was most abundant.

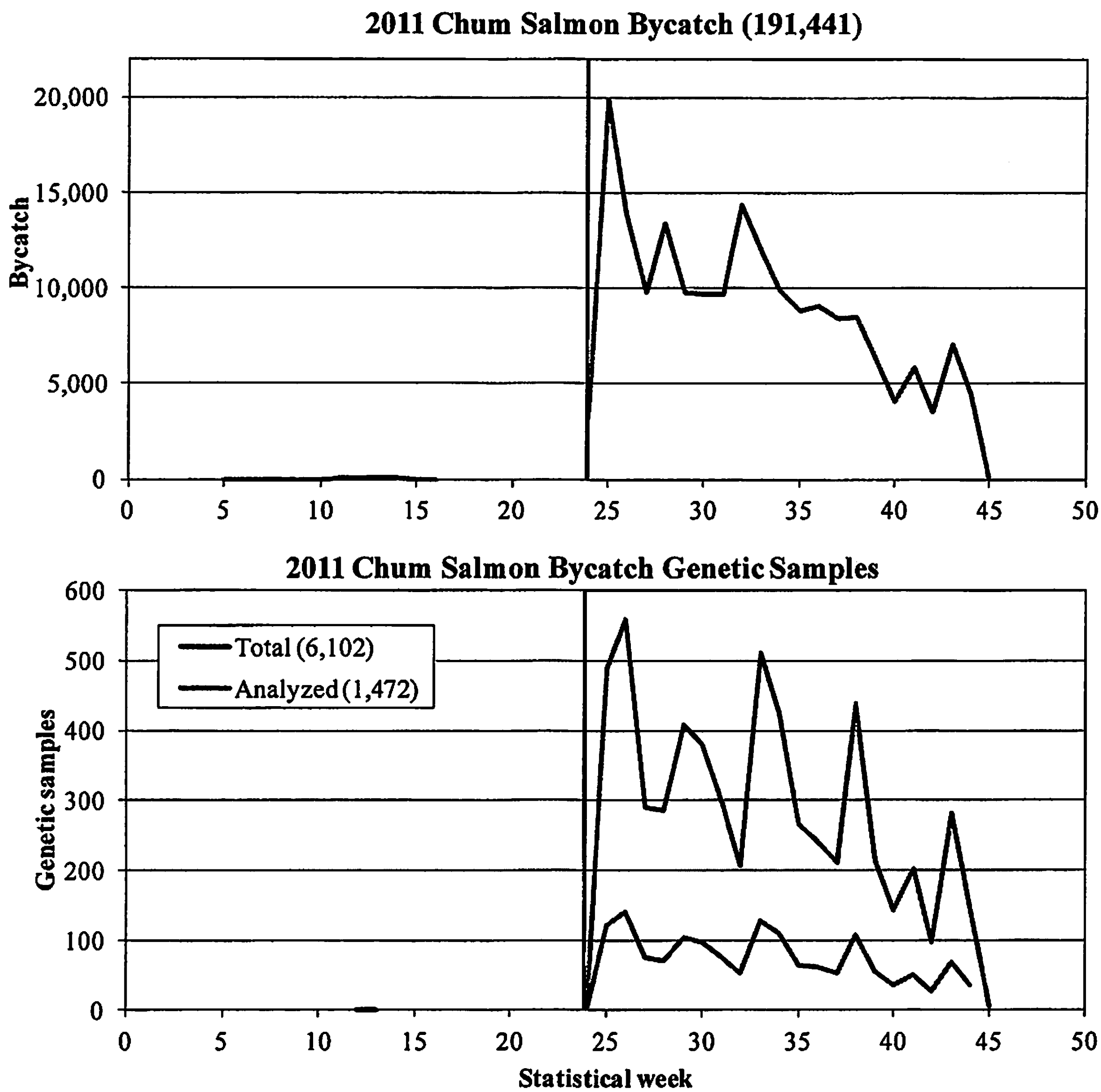

Figure 3. -- Number of Bering Sea chum salmon bycatch and genetic samples from 2011 by statistical week. Total numbers of chum salmon caught in the Bering Sea pollock midwater trawl fishery (top panel) compared with the available 6,102 and 1,472 genetic samples collected and analyzed, respectively (bottom panel). Weeks 3-23 correspond to the groundfish "A" season, whereas weeks 24-45 correspond to the "B" season, the demarcation of which is a vertical line.

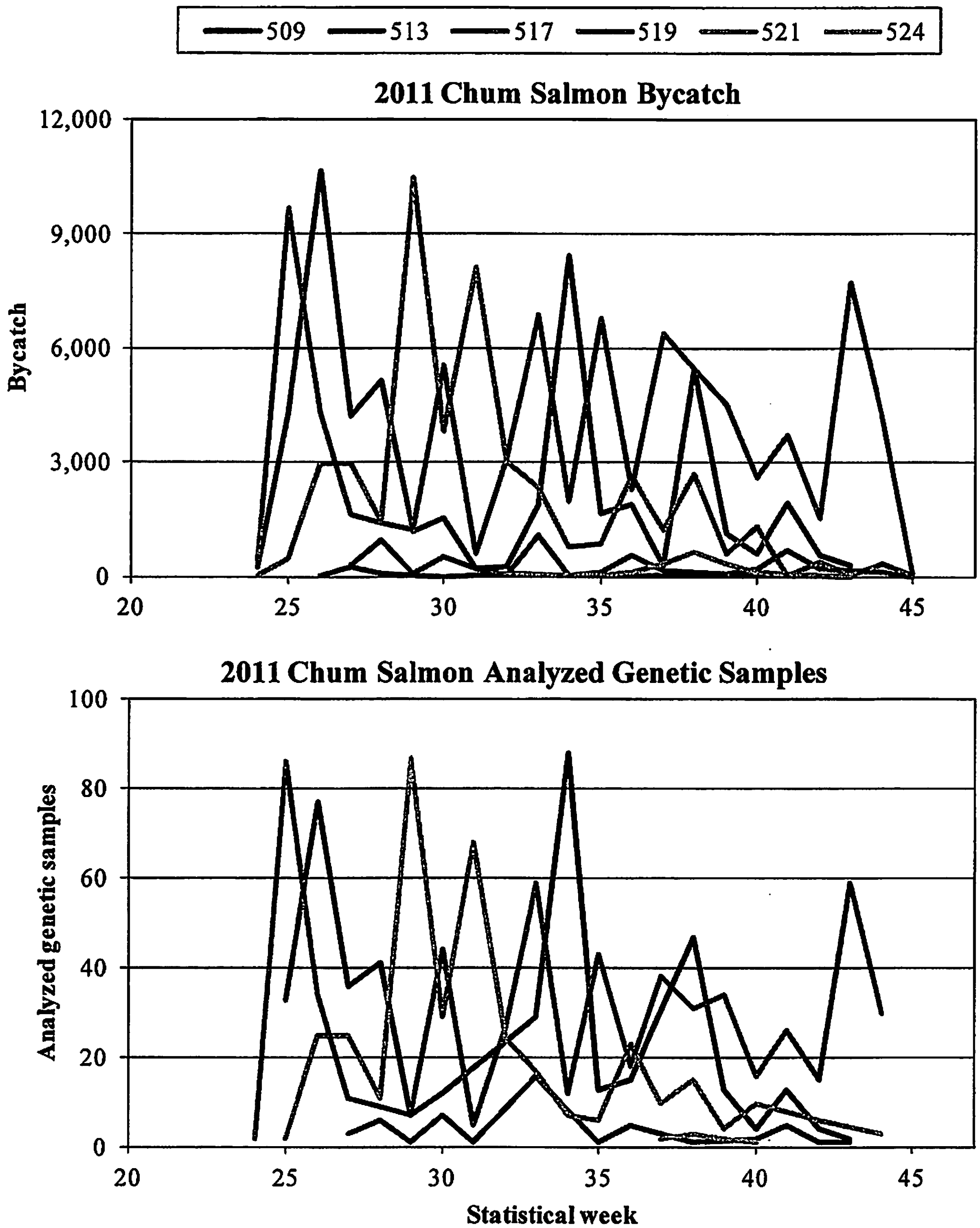

Figure 4. -- Number of Bering Sea chum salmon bycatch and analyzed genetic samples from the 2011 "B" season by statistical week and NMFS reporting area. Not shown in the chum salmon bycatch are an estimated 33 fish from statistical area 514, 56 fish from area 516, and 4 fish from area 523. One fish from area 519 for statistical week 32 is not shown for the analyzed genetic sample set. NMFS reporting areas are designated in the legend.

The systematic collecting protocol was also evaluated by comparing the total number of chum salmon caught on each vessel to the number of genetic samples collected from each vessel. During the "B" season, a subset of genetic samples was collected from 97% of the chum salmon bycatch (Fig. 5, top panel). All of the 90 vessels that participated in the midwater trawl fishery caught chum salmon. The entire catch from 82 vessels and part of the catch from 8 vessels, representing 93% and 4% of the total chum salmon bycatch, respectively, was sampled. Approximately twice as many vessels were undersampled, and by a wider margin, than vessels that were oversampled. Of the bycatch that was sampled (Fig. 5, bottom panel), the sampling ratio of numbers of bycatch to numbers of genetic samples per vessel ranged from 23 to 39 fish, with a mean of 30.3 fish, which is very close to the protocol sampling goal of one genetic sample collected from every 30th chum salmon caught.

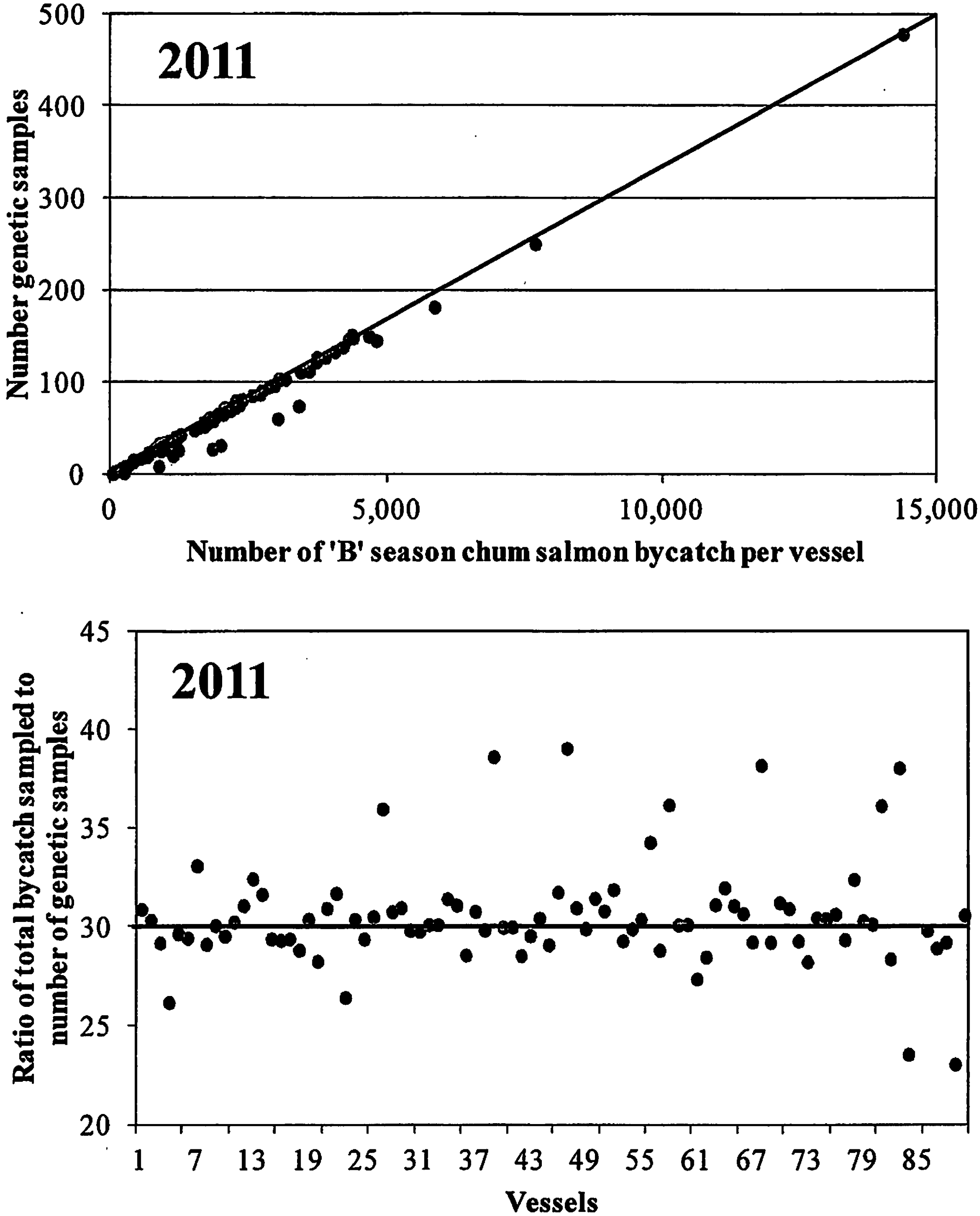

Figure 5. -- Bering Sea chum salmon bycatch and genetic samples from the 2011 pollock "B" season. Number of genetic samples collected from the total number of chum salmon bycatch from each of 90 vessels; black diagonal line represents the expected sampling rate (top panel). The ratio of total number of bycatch sampled to number of genetic samples collected per vessel (excluding one vessel that caught fewer than 30 chum salmon); black horizontal line represents the expected sampling ratio (bottom panel).

GENETIC STOCK COMPOSITION

DNA was extracted from the axillary processes for all but 13 of the 1,525 of chum salmon samples genetically analyzed. Those 13 fish had DNA extracted from a pool of 4-8 scales per sample. DNA extraction and microsatellite genotyping was performed as described previously (Guyon et al. 2010). Briefly, samples were genotyped for the following 11 microsatellite loci: *Oki100* (Beacham et al. 2009a), *Omm1070* (Rexroad et al. 2001), *Omy1011* (Spies et al. 2005), *One101, One102, One104, One114* (Olsen et al. 2000), *Ots103* (Nelson and Beacham 1999), *Ots3* (Greig and Banks 1999), *Otsg68* (Williamson et al. 2002), and *Ssa419* (Cairney et al. 2000). Thermal cycling for the amplification of DNA fragments with the polymerase chain reaction (PCR) was performed on a dual 384-well GeneAmp PCR System 9700 (Applied Biosystems, Inc.). Samples from the PCR reactions were diluted into 96-well plates for analysis by a 16-capillary, 36 cm array on the ABI 3130xl Genetic Analyzer. Genotypes were double-scored with GeneMapper 4.0 software (Applied Biosystems, Inc.) and exported to Excel spreadsheets (Microsoft, Inc.).

A total of 1,525 samples from the 2011 chum salmon bycatch were analyzed, of which 1,472 samples were successfully genotyped for 8 or more of the 11 loci. No duplicate genotypes were detected with GENALEX (Peakall and Smouse 2006). Previous simulation analyses have demonstrated that a set of 8 selected loci can provide similar levels of stock resolution as the entire set of 11 loci (Gray et al. 2010); this is also supported by results reported in the literature for other loci sets (Beacham et al. 2009b). The remaining 1,472 samples had genetic information for an average of 10.82 loci (out of 11). There were 1,276 samples with data for all 11 loci, 140 with 10 loci, 41 with 9 loci, and 15 with 8 loci. There were six alleles observed in eight individuals that were not present in the chum salmon baseline; those alleles and the associated haplotype were removed from further analysis. Of the 13 fish whose DNA was extracted from scales, we saw evidence of cross-contamination (more than two peaks in the Genemapper software) within only one sample, which was removed from subsequent analyses.

Quality control of genotyping was examined by plating DNA from the bottom row of each the 16 elution plates onto two 96-well plates for a total of 192 samples that were then processed for genotyping as described above. Genotypes from the quality control dataset were then compared to the genotypes of the original dataset. Overall, the genotyping error was low; there were a total of 22 differences in allele calls across 11 loci, which represented an overall error rate of 0.56% (22/3,936, where 3,936 is the number of alleles with unquestionable scores obtained from the original and quality control datasets). There were few differences in allele calls between the two datasets; only one locus (*Omm1070*) had differences higher than 1% (Table 1).

Table 1. -- Number of allele differences by locus between the original and quality control datasets for samples with non-questionable genotypes.

Locus	Number alleles compared	Number allele differences	% differences
Oki100	356	3	0.84
Omm1070	346	6	1.73
Omy1011	346	1	0.29
One101	342	3	0.88
One102	342	2	0.58
One104	374	0	0
One114	374	2	0.53
Ots103	378	2	0.53
Ots3	362	1	0.28
OtsG68	366	2	0.55
Ssa419	350	0	0

For the mixture files, allele designations were converted to match those in the Fisheries and Oceans Canada (DFO) chum salmon microsatellite baseline (Beacham et al. 2009b,c). Genotypes from converted mixtures were then exported from Excel as text files, and C++ programs were used to format the data into mixture files compatible with SPAM and BAYES software. Stock compositions were determined by comparing mixture genotypes with allele frequencies from reference baseline populations. As described previously (Gray et al. 2010), baseline populations were grouped into the following six regions: East Asia, North Asia, Western Alaska, Upper/Middle Yukon, Southwest Alaska, and the Eastern Gulf of Alaska/Pacific Northwest (Prince William Sound to Washington State). A listing of the individual populations grouped by region is shown in the Appendix.

As with previous chum bycatch analyses (Guyon et al. 2010; Marvin et al. 2011; Gray et al. 2010; Gray et al. 2011a,b; Kondzela et al. 2012), stock composition analysis for the 2011 chum bycatch samples was performed with previously published maximum-likelihood (SPAM 3.7 software; ADF&G 2003) and Bayesian (BAYES software; Pella and Masuda 2001) procedures. Because the maximum-likelihood estimates were in close agreement with the Bayesian estimates, the maximum-likelihood estimates are not shown. The Bayesian method uses an algorithm to produce stock composition estimates and can account for missing alleles in the baseline (Pella and Masuda 2001). BAYES stock composition estimates based on data from all 11 loci were derived for the six regional groupings (Table 2). For each analysis, six Monte Carlo chains starting at disparate values of stock proportions were configured such that 95% of the stocks came from one designated region with weights equally distributed among the stocks of that region. The remaining 5% was equally distributed among remaining stocks from all other regions. For all estimates, a flat prior of 0.002625 (calculated as 1/381) was used for all 381 populations. The stock composition analyses were completed for a chain length of 40,000 with the first 20,000 deleted during the burn-in phase. Convergence of the chains to posterior distributions of stock proportions was determined with Gelman and Rubin shrink statistics, which were all 1.02 or less (Table 2), conveying strong convergence to a single posterior distribution (Pella and Masuda 2001).

Table 2. --Regional BAYES stock composition estimates for 1,472 chum salmon samples from the bycatch of the 2011 Bering Sea pollock midwater trawl fishery. BAYES estimates used information from all 11 loci. BAYES mean estimates are provided with standard deviations (SD), 95% credible intervals, median estimate, and the associated Gelman and Rubin shrink statistic.

BAYES Region	**Mean**	**SD**	**2.5%**	**Median**	**97.5%**	**Shrink**
East Asia	**0.173**	0.011	0.153	0.173	0.194	1.00
North Asia	**0.184**	0.013	0.158	0.184	0.210	1.00
Western Alaska	**0.162**	0.013	0.138	0.162	0.188	1.01
Upper/Middle Yukon	**0.089**	0.010	0.070	0.089	0.108	1.02
Southwest Alaska	**0.015**	0.005	0.007	0.014	0.026	1.01
Eastern GOA/PNW	**0.378**	0.014	0.351	0.378	0.405	1.00

COMPARISON WITH PREVIOUS ESTIMATES

The stock composition results from the analysis of the 2011 chum salmon bycatch samples differed somewhat from previous estimates (Fig. 6). The primary difference in 2011 appears to be the higher contribution from the Eastern GOA/PNW and lower contributions from East and North Asia in comparisons across years. Contributions in 2011 from Western Alaska are similar to the 1994, 1995, 2005 – 2010 average, and the contributions from the Upper/Middle Yukon and Southwest Alaska were below 10%, as in other years. Caution must be used in comparisons across years because there are differences in where and when genetic bycatch samples were collected each year.

The 1994-1995 chum salmon bycatch estimates were produced with allozyme data (Wilmot et al. 1998), whereas the 2005 (Guyon et al. 2010), 2006 (Marvin et al. 2011), 2007 (Gray et al. 2011a), 2008 (Gray et al. 2011b), 2009 (Gray et al. 2010), 2010 (Kondzela et al. 2012), and 2011 (this report) chum salmon bycatch sample estimates were derived from DNA-based microsatellite loci. The allozyme (77 populations) and microsatellite DNA (381 populations) baselines have data from many of the same populations and have similar regional groupings. The effect of the bycatch on chum salmon populations is influenced by the overall size of the bycatch; the large variation in total chum salmon bycatch in 1994, 1995, 2005 – 2010 (Fig. 2) is reflected in the high standard errors of the mean number of bycatch by region when stock composition estimates are extrapolated to the total bycatch from the Bering Sea groundfish fisheries (Fig. 6, lower panel). It is worth noting that for the first time, in 2011 the genetic samples were collected systematically from the bycatch, resulting in the numerical extrapolations being relatively free of sample bias. The location and timing of collections from other years was not always representative of the entire bycatch within a given year.

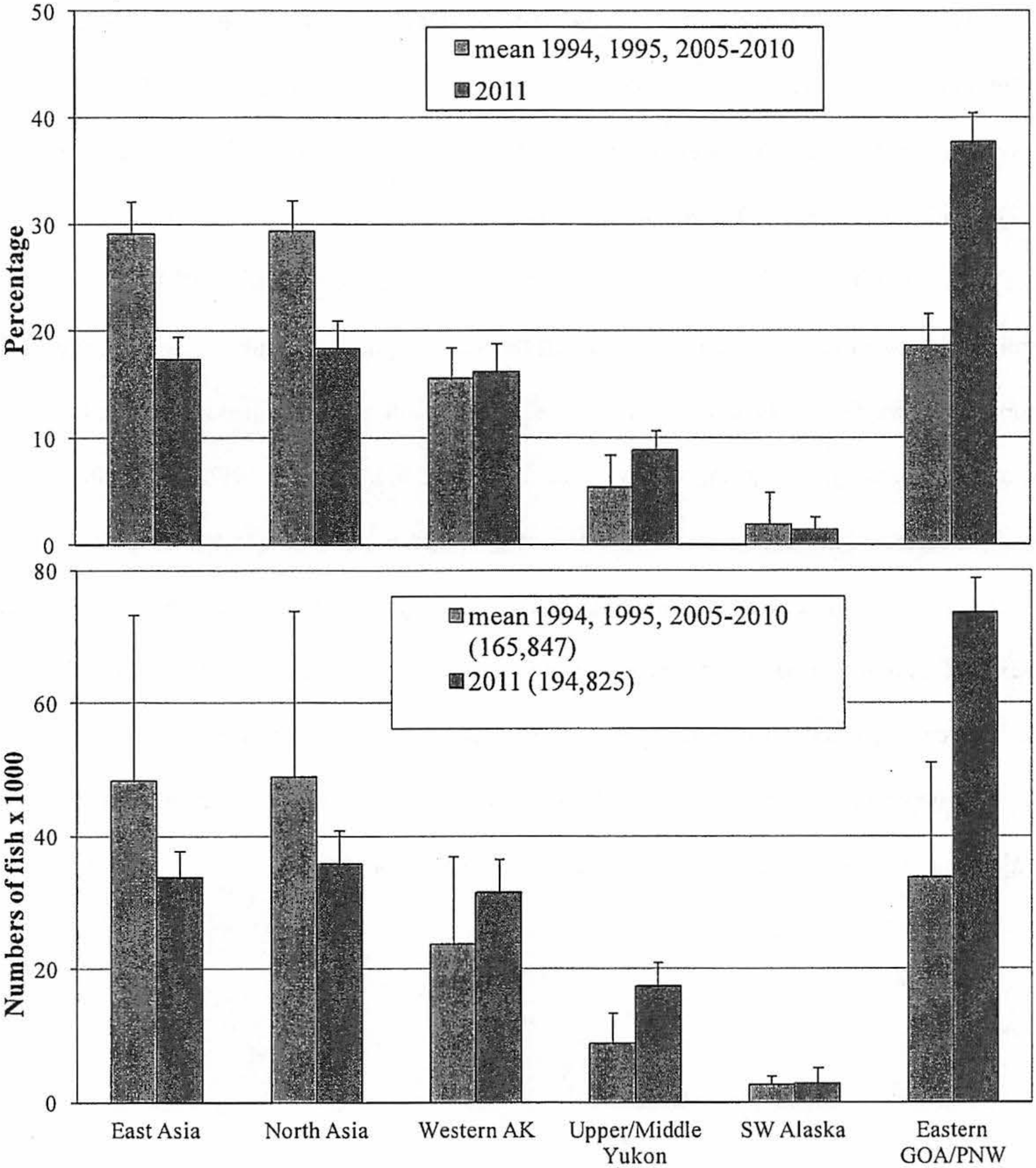

Figure 6. -- Comparison of the 2011 Bering Sea chum salmon bycatch with the mean stock composition estimates of available genetic samples from 1994, 1995, and 2005 – 2010. Percentages in top panel; numbers of fish in bottom panel, which for comparison purposes across years are based on the total chum salmon bycatch in all groundfish fisheries. Standard errors of the mean estimates are shown for the combined years; 95% BAYES credible intervals are shown for the 2011 analysis. Error bars are based on only the mixed-stock analyses and do not include errors associated with the overall annual bycatch size estimation or potential biases in sample distribution. Total chum salmon bycatch from the Bering Sea groundfish fisheries is shown in parentheses in the bottom figure legend; 1994-2010 are estimates and 2011 is a census.

TEMPORAL STRATIFICATION

An understanding of the temporal distribution of the chum salmon bycatch is important. For example, if the samples are randomly distributed or represent a distribution that can be described mathematically, temporally biased estimates could be adjusted with respect to the overall bycatch rate. With the systematic sampling approach used in 2011, the temporal estimates should accurately reflect the total bycatch stock contributions present within each time period. Likewise, if the bycatch stock distribution changes consistently over time, the bycatch could be managed in a manner to minimize effects on critical stocks.

As with the 2005–2010 analyses, the 2011 sample set was temporally split into three "B" season time periods: early, middle, and late (Table 3, Fig. 7). Stock composition analyses for 2011 and similar temporal strata of the average 2005–2010 chum salmon bycatch sample sets are included for comparison purposes (Fig. 8). Results from this analysis should be used cautiously because spatial differences exist in the time-stratified sample sets and these differences are known to affect the stock composition estimates.

Table 3. -- Temporal groupings from the 2011 "B" season chum salmon bycatch genetic sample sets.

Time period	Weeks	Dates	Number samples
Early	24-29	June 12 – July 23	503
Middle	30-34	July 24 – August 27	446
Late	35-44	August 28 – November 5	522

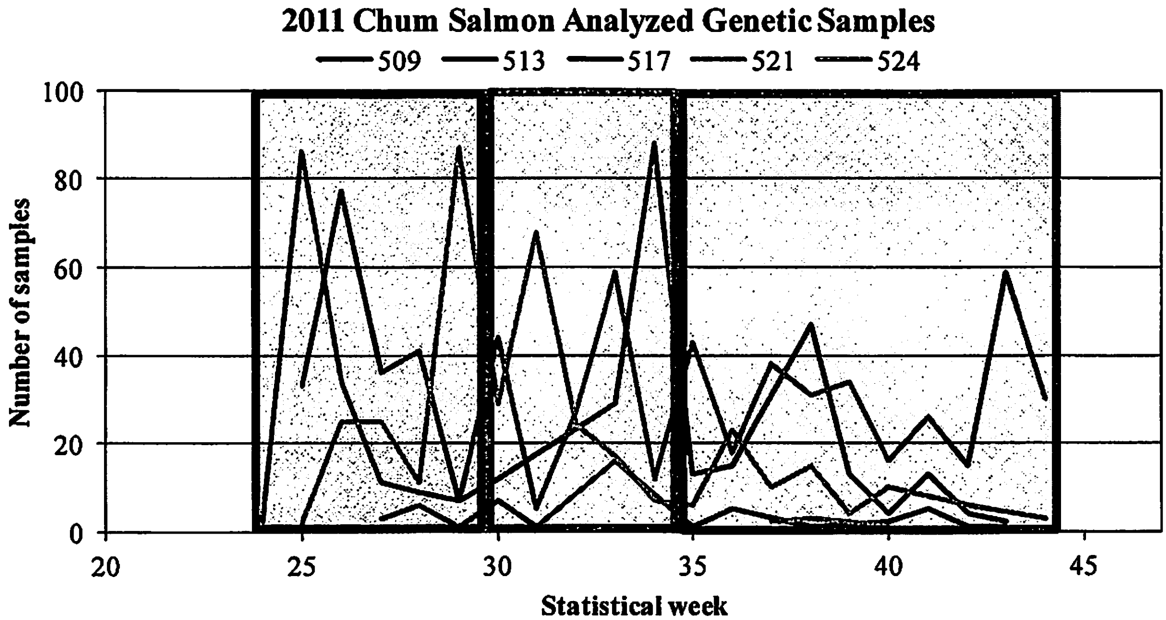

Figure 7. -- Analyzed genetic samples from the 2011 "B" season chum salmon bycatch identified by early (blue), middle (brown), and late (green) temporal groupings. NMFS reporting areas are designated in the legend.

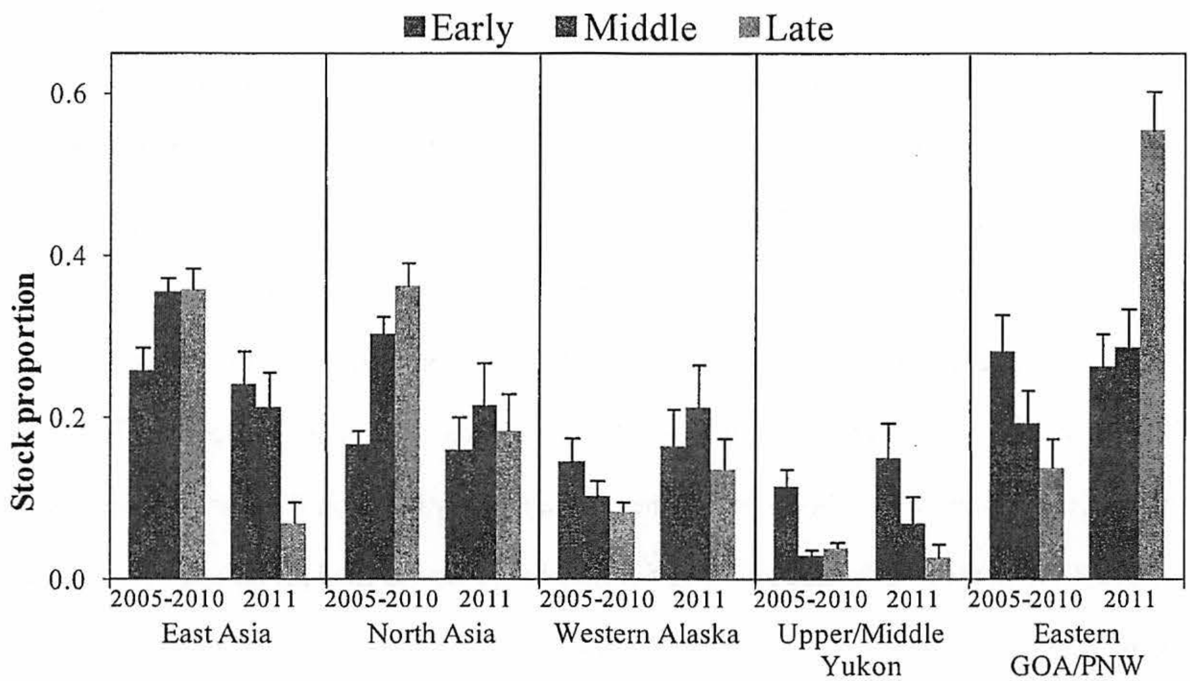

Figure 8. -- BAYES stock composition estimates for the early, middle, and late periods (defined in Table 3) from the 2005–2010 (mean) and 2011 chum salmon bycatch. Standard errors of the mean estimates are shown for the combined years; 95% BAYES credible intervals are shown for the 2011 analysis. Not shown is the Southwest Alaska region for which estimates never exceeded 5.6%.

BAYES stock composition estimates were made as described previously for each of the three temporal strata for. Gelman and Rubin shrink statistics were in all cases below 1.02 and suggested strong convergence to a single posterior distribution. The stock composition estimates of the 2011 genetic samples differed across the three time periods (Fig. 8). Within 2011, the contribution of fish from East Asia and Upper/Middle Yukon decreased over the three time periods and was significantly lower in the third time period (Weeks 35-44). The North Asia and Western Alaska contribution was highest in the middle time period (Weeks 30-34). The prevalence of fish from the Eastern GOA/PNW was similar in the first two time periods, but nearly doubled in the latest period (Weeks 35-44) and resulted in the highest proportion observed for any region across the 7-year time period.

In addition, some differences were observed in the pattern of 2011 within-season temporal stock contributions from the trends reported previously with the 2005–2010 chum salmon bycatch samples (Guyon et al. 2010; Marvin et al. 2011; Gray et al. 2011a,b; Gray et al. 2010; Kondzela et al. 2012). The decrease in contribution from East Asia and the nearly uniform contribution from North Asia across the three time periods in 2011 differs from the pattern more typical of these regions in previous years, a result of the unusually high proportion of GOA/PNW fish in the late mixture. Whereas the Upper/Middle Yukon contribution was highest in the early part of the season (Weeks 24-29) as in other years, the very high contribution from the Eastern GOA/PNW in the latest period (Weeks 35-44) had not been reported previously. The higher contribution from the Eastern GOA/PNW in the latest period may be due to the prevalence of samples from the southeastern Bering Sea areas 509 and 517 during the late part of the "B" season. This demonstrates that stock composition of the chum salmon bycatch changes during the course of the season, and how the temporal changes are interrelated to the spatial differences is addressed below.

SPATIAL STRATIFICATION

An understanding of the spatial distribution of the chum salmon bycatch is also important for the same reasons and concerns described for temporal stratification. In 2011, for the first time, the AFSC's North Pacific Observer Program undertook a complete census of chum salmon bycatch from the Bering Sea trawl fisheries. More than half of the chum salmon bycatch was counted and sampled at shoreside facilities where catches were offloaded from vessels that theoretically can participate in multiple fishery management areas on a particular cruise before an offload. For vessels that fished in multiple NMFS reporting areas during a trip, the area was identified as the area where most of the fishery target species were caught.

The 2011 genetic samples were spatially split into two areas: the southeastern Bering Sea (reporting areas 509, 513, 517; n = 1,090 samples) and the central Bering Sea (reporting areas 521, 524; n = 381 samples). The single sample from area 519 was not included. BAYES stock composition estimates were made as described previously for each of the two spatial strata. Gelman and Rubin shrink statistics were 1.02 or less for both datasets and suggested strong convergence to a single posterior distribution. The stock composition estimates differed between the spatial strata (Fig. 9). Nearly three-quarters of the chum salmon bycatch in the more southeastern areas (509, 513, and 517) was of North American origin, with the highest proportion from the Eastern GOA/PNW region. In the central Bering Sea, in areas 521 and 524, chum salmon from Asia were dominant (~60%).

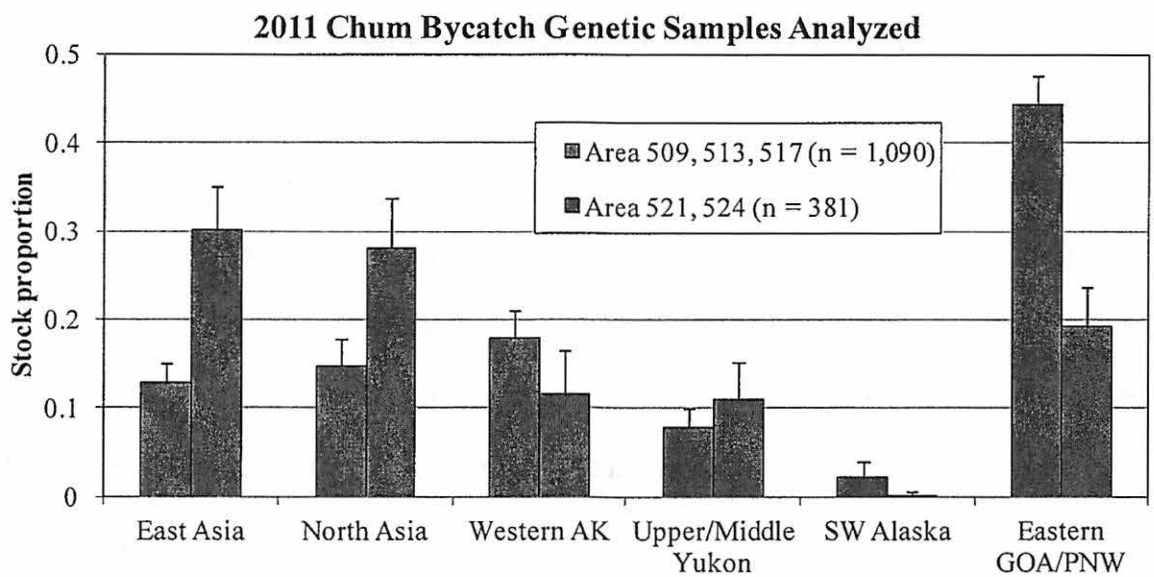

Figure 9. -- BAYES stock composition estimates and 95% credible intervals for the 2011 chum salmon bycatch genetic samples from the NMFS reporting areas of the central (521, 524) and southeastern (509, 513, 517) Bering Sea (Fig. 1).

To better understand the bycatch stock distribution across time and space, the 2011 sample set was split into the NMFS reporting areas and each of the reporting area datasets was split into three time periods (Table 4). Samples from areas 513, 519, and 524 were not included due to small sample sizes in those areas.

Table 4. -- Spatial and temporal groupings from the 2011 chum salmon bycatch genetic sample sets across three time periods (Table 3) for the reporting areas with the most samples.

Reporting area	Time period	Number of samples
509	early	194
509	middle	129
509	late	111
517	early	149
517	middle	147
517	late	310
521	early	150
521	middle	145
521	late	77

BAYES stock composition estimates were made for each of the spatial and temporal strata as described above, with the exception that the stock composition analyses were completed for a chain length of 10,000 with the first 5,000 deleted during the burn-in phase. Gelman and Rubin shrink statistics were in all cases below 1.10. The stock distribution changed across the time periods, with some of the changes consistent in all three NMFS reporting areas (Fig. 10). In general, the contribution from East Asia decreased over time, whereas the contribution from North Asia increased over time. There was a small increase followed by a small decrease in the proportion from Western Alaska over time. The contribution from Western Alaska in area 521 was about half that in the more southeastern areas across all time periods. In all three reporting areas, the chum salmon bycatch from the Upper/Middle Yukon decreased over the time periods and by September, fish from that region appear to have migrated out of that part of the Bering Sea open to the trawl fisheries. The contribution from Southwest Alaska was negligible in all three areas and time periods. In all three areas, the Eastern GOA/PNW contribution increased over the time periods, most notably in areas 517 and 521 in the late period. It should be noted that the numbers of fish from a region within a given area may not change over time, but the proportion will change if fish from other regions move into or out of the area.

The similarity of stock distributions among the areas and time periods may be due, at least in part, to vessels fishing near area boundaries. For example, the southern corner of area 521 shares the northwestern edge of area 517. Latitude and longitude information was not available for many samples, so the location of the bycatch samples within each area is unknown. In addition, more than half of the total bycatch was sampled from shoreside deliveries in which vessels may have fished in multiple areas--for each cruise, the NMFS reporting area was identified as the area most of the fishery target species were caught. Thus, for an unknown proportion of the chum salmon bycatch samples, the area designation may not be correct.

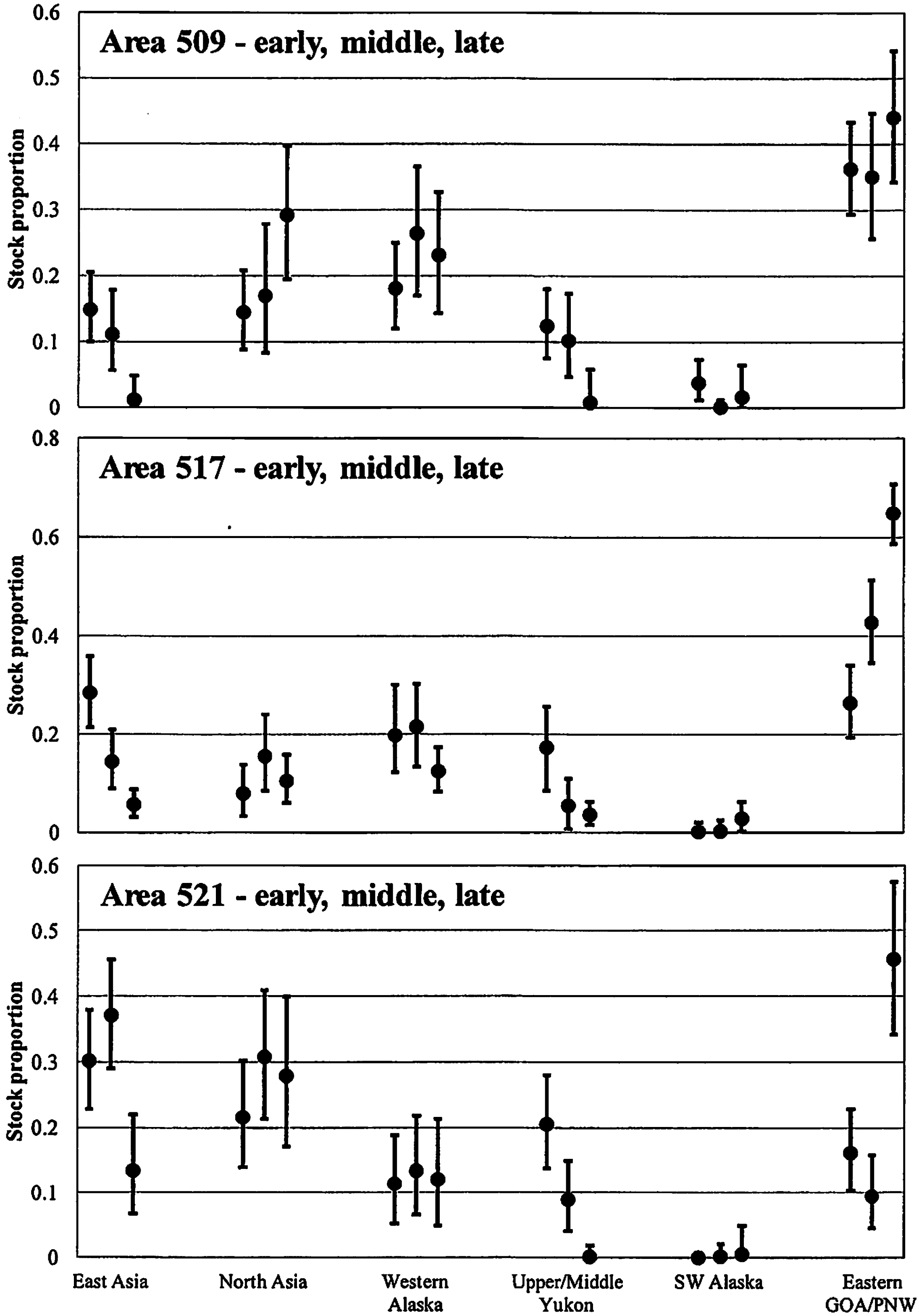

Figure 10. -- BAYES stock composition estimates and 95% credible intervals for the NMFS reporting areas 509, 517, and 521 for the early, middle, and late time periods (Table 4) from the 2011 chum salmon bycatch genetic samples.

SUMMARY

Stock composition estimates of the salmon bycatch in the Bering Sea groundfish fisheries are needed for fishery managers to understand the impact of these fisheries on salmon populations, particularly those in western Alaska. This report provides a stock composition analysis of a set of 1,472 individuals sampled from the 2011 chum salmon bycatch. The limitations and results of this analysis are summarized below.

Sampling Issues

We highlight the reduced spatial and temporal biases in the 2011 sample set (Figs. 3 and 4) that were inherent in collections from previous years. Reduction of those biases improves the application of the 2011 genetic sample stock composition estimate to the entire chum salmon bycatch. Implementation of Amendment 91 to the fishery management plan for groundfish of the Bering Sea and Aleutian Islands Management Area (75 FR 53026, August 30, 2010) requires that all salmon taken as bycatch in the Bering Sea pollock fishery be sorted by species and counted to ensure compliance with the salmon bycatch caps for the pollock fishery. This new regulation led to the collection of representative samples from 97% of the chum salmon bycatch for genetic analysis (Fig. 5), and improved the capability to characterize the origin of salmon taken as bycatch in the Bering Sea pollock fishery.

Stock Composition Estimates

Overall, the genetic samples collected from the 2011 bycatch of Bering Sea chum salmon were predominantly from Eastern GOA/PNW stocks (38%) although substantial contributions were also from Western Alaska (16%), Upper/Middle Yukon (9%), East Asia (17%), and North Asia (18%). These stock proportions differ from estimates from previous years, particularly the higher proportion from the Eastern GOA/PNW and the lower proportion from Asia. Although samples in 2011 were collected representatively from the bycatch, there were differences in where and when genetic bycatch samples were collected from previous years, so that caution must be used in making year-to-year comparisons.

Temporal and Spatial Effects on Stock Composition Estimates

A temporal analysis was completed to determine whether stock compositions differed across the fishing season. This was limited to a time-stratified analysis of the bycatch from the pollock "B" season, when the majority of chum salmon are intercepted. In 2011, unlike in most other years, the Eastern GOA/PNW fish contribution was predominant across all three sampling periods and increased throughout the season to dominate the late sampling period. For the most part, stock composition estimates changed across the three sampling periods in a manner unlike that observed across previous years, suggesting a shift in the temporal stratification of chum salmon stocks in the Bering Sea, changes in sampling or fishing locations, or both.

A spatial analysis was completed to determine whether stock compositions differed between two broad areas of the Bering Sea where most of the chum salmon bycatch occurred in 2011: the central Bering Sea, represented by NMFS reporting areas 524 and 521, and the southeastern Bering Sea, represented by areas 509, 513, and 517. The majority of chum salmon bycatch in the central Bering Sea was from Asia, whereas most of bycatch in the southeastern Bering Sea was from North America, principally from the Eastern GOA/PNW region (Fig. 9).

An examination of stock estimates on both spatial and temporal strata suggests that although there were some differences in stock distribution across areas or time periods, there were also consistent temporal changes in stock distribution within areas (Fig. 10). For example, the Upper/Middle Yukon and East Asia contributions decrease, and the Eastern GOA/PNW and

North Asia contributions increase over time in all three reporting areas. These changes across time regardless of area may tie in with the observation that the larger chum salmon leave early from the fishery (e.g., mature summer-run Yukon River chum salmon) and the smaller fish arrive later into the fishery (Myers et al. 2009, Stram and Ianelli 2009).

Application of These Estimates

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

ACKNOWLEDGMENTS

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APPENDIX

Appendix -- Chum salmon populations in the DFO microsatellite baseline with the regional designations used in the analyses of this report.

DFO number	Population name	Region number	Region
41	Abashiri	1	East Asia
215	Avakumovka	1	East Asia
40	Chitose	1	East Asia
315	Gakko_River	1	East Asia
292	Hayatsuki	1	East Asia
44	Horonai	1	East Asia
252	Kawabukuro	1	East Asia
313	Koizumi_River	1	East Asia
300	Kushiro	1	East Asia
37	Miomote	1	East Asia
391	Namdae_R	1	East Asia
231	Narva	1	East Asia
298	Nishibetsu	1	East Asia
293	Ohkawa	1	East Asia
297	Orikasa	1	East Asia
214	Ryazanovka	1	East Asia
312	Sakari_River	1	East Asia
311	Shari_River	1	East Asia
36	Shibetsu	1	East Asia
299	Shikiu	1	East Asia
253	Shiriuchi	1	East Asia
310	Shizunai	1	East Asia
217	Suifen	1	East Asia
35	Teshio	1	East Asia
39	Tokachi	1	East Asia
38	Tokoro	1	East Asia
314	Tokushibetsu	1	East Asia
291	Toshibetsu	1	East Asia
296	Tsugaruishi	1	East Asia
316	Uono_River	1	East Asia
309	Yurappu	1	East Asia
218	Amur	2	North Asia
207	Anadyr	2	North Asia
384	Apuka_River	2	North Asia
382	Bolshaya	2	North Asia
380	Dranka	2	North Asia
223	Hairusova	2	North Asia
378	Ivashka	2	North Asia
213	Kalininka	2	North Asia
225	Kamchatka	2	North Asia

DFO number	Population name	Region number	Region
219	Kanchalan	2	North Asia
379	Karaga	2	North Asia
294	Kikchik	2	North Asia
209	Kol_	2	North Asia
233	Magadan	2	North Asia
211	Naiba	2	North Asia
295	Nerpichi	2	North Asia
381	Okhota	2	North Asia
212	Oklan	2	North Asia
222	Ola_	2	North Asia
386	Olutorsky_Bay	2	North Asia
228	Ossora	2	North Asia
224	Penzhina	2	North Asia
385	Plotnikova_R	2	North Asia
221	Pymta	2	North Asia
220	Tauy	2	North Asia
383	Tugur_River	2	North Asia
226	Tym_	2	North Asia
230	Udarnitsa	2	North Asia
290	Utka_River	2	North Asia
208	Vorovskaya	2	North Asia
387	Zhypanova	2	North Asia
348	Agiapuk	3	Western Alaska
376	Alagnak	3	Western Alaska
3	Andreafsky	3	Western Alaska
357	Aniak	3	Western Alaska
301	Anvik	3	Western Alaska
80	Chulinak	3	Western Alaska
347	Eldorado	3	Western Alaska
358	George	3	Western Alaska
307	Gisasa	3	Western Alaska
371	Goodnews	3	Western Alaska
288	Henshaw_Creek	3	Western Alaska
339	Imnachuk	3	Western Alaska
361	Kanektok	3	Western Alaska
362	Kasigluk	3	Western Alaska
328	Kelly_Lake	3	Western Alaska
340	Kobuk	3	Western Alaska
343	Koyuk	3	Western Alaska
363	Kwethluk	3	Western Alaska
336	Kwiniuk_River	3	Western Alaska
303	Melozitna	3	Western Alaska
373	Mulchatna	3	Western Alaska
372	Naknek	3	Western Alaska
330	Niukluk	3	Western Alaska
329	Noatak	3	Western Alaska
345	Nome	3	Western Alaska

DFO number	Population name	Region number	Region
302	Nulato	3	Western Alaska
374	Nunsatuk	3	Western Alaska
13	Peel_River	3	Western Alaska
322	Pikmiktalik	3	Western Alaska
331	Pilgrim_River	3	Western Alaska
346	Shaktoolik	3	Western Alaska
341	Snake	3	Western Alaska
368	Stuyahok_River	3	Western Alaska
375	Togiak	3	Western Alaska
154	Tozitna	3	Western Alaska
342	Unalakleet	3	Western Alaska
344	Ungalik	3	Western Alaska
8	Big_Creek	4	Upper/Middle Yukon
89	Big_Salt	4	Upper/Middle Yukon
86	Black_River	4	Upper/Middle Yukon
87	Chandalar	4	Upper/Middle Yukon
28	Chandindu	4	Upper/Middle Yukon
82	Cheena	4	Upper/Middle Yukon
81	Delta	4	Upper/Middle Yukon
7	Donjek	4	Upper/Middle Yukon
5	Fishing_Br	4	Upper/Middle Yukon
88	Jim_River	4	Upper/Middle Yukon
85	Kantishna	4	Upper/Middle Yukon
2	Kluane	4	Upper/Middle Yukon
59	Kluane_Lake	4	Upper/Middle Yukon
181	Koyukuk_late	4	Upper/Middle Yukon
90	Koyukuk_south	4	Upper/Middle Yukon
10	Minto	4	Upper/Middle Yukon
6	Pelly	4	Upper/Middle Yukon
439	Porcupine	4	Upper/Middle Yukon
83	Salcha	4	Upper/Middle Yukon
4	Sheenjek	4	Upper/Middle Yukon
1	Tatchun	4	Upper/Middle Yukon
9	Teslin	4	Upper/Middle Yukon
84	Toklat	4	Upper/Middle Yukon
360	Alagoshak	5	Southwest Alaska
333	American_River	5	Southwest Alaska
366	Big_River	5	Southwest Alaska
354	Coleman_Creek	5	Southwest Alaska
355	Delta_Creek	5	Southwest Alaska
359	Egegik	5	Southwest Alaska
332	Frosty_Creek	5	Southwest Alaska
365	Gertrude_Creek	5	Southwest Alaska
370	Joshua_Green	5	Southwest Alaska
364	Meshik	5	Southwest Alaska
283	Moller_Bay	5	Southwest Alaska
369	Pumice_Creek	5	Southwest Alaska

DFO number	Population name	Region number	Region
367	Stepovak_Bay	5	Southwest Alaska
335	Sturgeon	5	Southwest Alaska
350	Uganik	5	Southwest Alaska
334	Volcano_Bay	5	Southwest Alaska
356	Westward_Creek	5	Southwest Alaska
239	Ahnuhati	6	Eastern GOA/PNW
69	Ahta______	6	Eastern GOA/PNW
155	Ain_	6	Eastern GOA/PNW
183	Algard	6	Eastern GOA/PNW
58	Alouette	6	Eastern GOA/PNW
325	Alouette_North	6	Eastern GOA/PNW
270	Andesite_Cr	6	Eastern GOA/PNW
428	Arnoup_Cr	6	Eastern GOA/PNW
153	Ashlulm	6	Eastern GOA/PNW
156	Awun	6	Eastern GOA/PNW
133	Bag_Harbour	6	Eastern GOA/PNW
164	Barnard	6	Eastern GOA/PNW
16	Bella_Bell	6	Eastern GOA/PNW
79	Bella_Coola	6	Eastern GOA/PNW
49	Big_Qual	6	Eastern GOA/PNW
201	Big_Quilcene	6	Eastern GOA/PNW
281	Bish_Cr	6	Eastern GOA/PNW
198	Bitter_Creek	6	Eastern GOA/PNW
103	Blackrock_Creek	6	Eastern GOA/PNW
390	Blaney_Creek	6	Eastern GOA/PNW
138	Botany_Creek	6	Eastern GOA/PNW
264	Buck_Channel	6	Eastern GOA/PNW
169	Bullock_Chann	6	Eastern GOA/PNW
61	Campbell_River	6	Eastern GOA/PNW
323	Carroll	6	Eastern GOA/PNW
78	Cascade	6	Eastern GOA/PNW
76	Cayeghle	6	Eastern GOA/PNW
42	Cheakamus	6	Eastern GOA/PNW
398	Cheenis_Lake	6	Eastern GOA/PNW
51	Chehalis	6	Eastern GOA/PNW
19	Chemainus	6	Eastern GOA/PNW
47	Chilliwack	6	Eastern GOA/PNW
392	Chilqua_Creek	6	Eastern GOA/PNW
117	Chuckwalla	6	Eastern GOA/PNW
139	Clapp_Basin	6	Eastern GOA/PNW
107	Clatse_Creek	6	Eastern GOA/PNW
118	Clyak	6	Eastern GOA/PNW
62	Cold_Creek	6	Eastern GOA/PNW
77	Colonial	6	Eastern GOA/PNW
353	Constantine	6	Eastern GOA/PNW
168	Cooper_Inlet	6	Eastern GOA/PNW
197	County_Line	6	Eastern GOA/PNW

DFO number	Population name	Region number	Region
12	Cowichan	6	Eastern GOA/PNW
414	Crag_Cr	6	Eastern GOA/PNW
161	Dak_	6	Eastern GOA/PNW
259	Dana_Creek	6	Eastern GOA/PNW
123	Date_Creek	6	Eastern GOA/PNW
250	Dawson_Inlet	6	Eastern GOA/PNW
91	Dean_River	6	Eastern GOA/PNW
261	Deena	6	Eastern GOA/PNW
170	Deer_Pass	6	Eastern GOA/PNW
46	Demamiel	6	Eastern GOA/PNW
210	Dipac_Hatchery	6	Eastern GOA/PNW
319	Disappearance	6	Eastern GOA/PNW
269	Dog-tag	6	Eastern GOA/PNW
177	Draney	6	Eastern GOA/PNW
114	Duthie_Creek	6	Eastern GOA/PNW
427	East_Arm	6	Eastern GOA/PNW
266	Ecstall_River	6	Eastern GOA/PNW
94	Elcho_Creek	6	Eastern GOA/PNW
193	Ellsworth_Cr	6	Eastern GOA/PNW
203	Elwha	6	Eastern GOA/PNW
276	Ensheshese	6	Eastern GOA/PNW
263	Fairfax_Inlet	6	Eastern GOA/PNW
32	Fish_Creek	6	Eastern GOA/PNW
429	Flux_Cr	6	Eastern GOA/PNW
102	Foch_Creek	6	Eastern GOA/PNW
179	Frenchman	6	Eastern GOA/PNW
227	Gambier	6	Eastern GOA/PNW
96	Gill_Creek	6	Eastern GOA/PNW
166	Gilttoyee	6	Eastern GOA/PNW
145	Glendale	6	Eastern GOA/PNW
135	Gold_Harbour	6	Eastern GOA/PNW
11	Goldstream	6	Eastern GOA/PNW
66	Goodspeed_River	6	Eastern GOA/PNW
136	Government	6	Eastern GOA/PNW
205	Grant_Creek	6	Eastern GOA/PNW
100	Green_River	6	Eastern GOA/PNW
450	GreenRrHatchery	6	Eastern GOA/PNW
237	Greens	6	Eastern GOA/PNW
141	Harrison	6	Eastern GOA/PNW
438	Harrison_late	6	Eastern GOA/PNW
64	Hathaway_Creek	6	Eastern GOA/PNW
234	Herman_Creek	6	Eastern GOA/PNW
17	Heydon_Cre	6	Eastern GOA/PNW
407	Hicks_Cr	6	Eastern GOA/PNW
400	Homathko	6	Eastern GOA/PNW
411	Honna	6	Eastern GOA/PNW
204	Hoodsport	6	Eastern GOA/PNW

DFO number	Population name	Region number	Region
185	Hooknose	6	Eastern GOA/PNW
406	Hopedale_Cr	6	Eastern GOA/PNW
412	Hutton_Head	6	Eastern GOA/PNW
278	Illiance	6	Eastern GOA/PNW
152	Inch_Creek	6	Eastern GOA/PNW
146	Indian_River	6	Eastern GOA/PNW
92	Jenny_Bay	6	Eastern GOA/PNW
115	Kainet_River	6	Eastern GOA/PNW
144	Kakweiken	6	Eastern GOA/PNW
268	Kalum	6	Eastern GOA/PNW
395	Kanaka_Cr	6	Eastern GOA/PNW
402	Kano_Inlet_Cr	6	Eastern GOA/PNW
162	Kateen	6	Eastern GOA/PNW
389	Kawkawa	6	Eastern GOA/PNW
95	Kemano	6	Eastern GOA/PNW
192	Kennedy_Creek	6	Eastern GOA/PNW
238	Kennell	6	Eastern GOA/PNW
351	Keta_Creek	6	Eastern GOA/PNW
101	Khutze_River	6	Eastern GOA/PNW
126	Khutzeymateen	6	Eastern GOA/PNW
282	Kiltuish	6	Eastern GOA/PNW
93	Kimsquit	6	Eastern GOA/PNW
187	Kimsquit_Bay	6	Eastern GOA/PNW
419	Kincolith	6	Eastern GOA/PNW
273	Kispiox	6	Eastern GOA/PNW
106	Kitasoo	6	Eastern GOA/PNW
99	Kitimat_River	6	Eastern GOA/PNW
275	Kitsault_Riv	6	Eastern GOA/PNW
163	Kitwanga	6	Eastern GOA/PNW
271	Kleanza_Cr	6	Eastern GOA/PNW
437	Klewnuggit_Cr	6	Eastern GOA/PNW
21	Klinaklini	6	Eastern GOA/PNW
418	Ksedin	6	Eastern GOA/PNW
125	Kshwan	6	Eastern GOA/PNW
423	Kumealon	6	Eastern GOA/PNW
112	Kwakusdis_River	6	Eastern GOA/PNW
436	Kxngeal_Cr	6	Eastern GOA/PNW
127	Lachmach	6	Eastern GOA/PNW
262	Lagins	6	Eastern GOA/PNW
131	Lagoon_Inlet	6	Eastern GOA/PNW
448	LagoonCr	6	Eastern GOA/PNW
167	Lard	6	Eastern GOA/PNW
160	Little_Goose	6	Eastern GOA/PNW
50	Little_Qua	6	Eastern GOA/PNW
413	Lizard_Cr	6	Eastern GOA/PNW
119	Lockhart-Gordon	6	Eastern GOA/PNW
176	Lower_Lillooet	6	Eastern GOA/PNW

DFO number	Population name	Region number	Region
137	Mace_Creek	6	Eastern GOA/PNW
242	Mackenzie_Sound	6	Eastern GOA/PNW
116	MacNair_Creek	6	Eastern GOA/PNW
55	Mamquam	6	Eastern GOA/PNW
121	Markle_Inlet_Cr	6	Eastern GOA/PNW
27	Martin_Riv	6	Eastern GOA/PNW
338	Mashiter_Creek	6	Eastern GOA/PNW
109	McLoughin_Creek	6	Eastern GOA/PNW
178	Milton	6	Eastern GOA/PNW
194	Minter_Cr	6	Eastern GOA/PNW
254	Mountain_Cr	6	Eastern GOA/PNW
111	Mussel_River	6	Eastern GOA/PNW
157	Naden	6	Eastern GOA/PNW
337	Nahmint_River	6	Eastern GOA/PNW
444	Nakut_Su	6	Eastern GOA/PNW
14	Nanaimo	6	Eastern GOA/PNW
122	Nangeese	6	Eastern GOA/PNW
422	Nass_River	6	Eastern GOA/PNW
399	Necleetsconnay	6	Eastern GOA/PNW
113	Neekas_Creek	6	Eastern GOA/PNW
321	Neets_Bay_early	6	Eastern GOA/PNW
320	Neets_Bay_late	6	Eastern GOA/PNW
173	Nekite	6	Eastern GOA/PNW
104	Nias_Creek	6	Eastern GOA/PNW
143	Nimpkish	6	Eastern GOA/PNW
53	Nitinat	6	Eastern GOA/PNW
191	Nooksack	6	Eastern GOA/PNW
186	Nooseseck	6	Eastern GOA/PNW
318	NorrishWorth	6	Eastern GOA/PNW
159	North_Arm	6	Eastern GOA/PNW
377	Olsen_Creek	6	Eastern GOA/PNW
184	Orford	6	Eastern GOA/PNW
287	Pa-aat_River	6	Eastern GOA/PNW
260	Pacofi	6	Eastern GOA/PNW
56	Pallant	6	Eastern GOA/PNW
65	Pegattum_Creek	6	Eastern GOA/PNW
48	Puntledge	6	Eastern GOA/PNW
98	Quaal_River	6	Eastern GOA/PNW
147	Quap	6	Eastern GOA/PNW
108	Quartcha_Creek	6	Eastern GOA/PNW
199	Quinault	6	Eastern GOA/PNW
110	Roscoe_Creek	6	Eastern GOA/PNW
397	Salmon_Bay	6	Eastern GOA/PNW
195	Salmon_Cr	6	Eastern GOA/PNW
134	Salmon_River	6	Eastern GOA/PNW
200	Satsop	6	Eastern GOA/PNW
236	Sawmill	6	Eastern GOA/PNW

DFO number	Population name	Region number	Region
410	Seal_Inlet_Cr	6	Eastern GOA/PNW
158	Security	6	Eastern GOA/PNW
130	Sedgewick	6	Eastern GOA/PNW
393	Serpentine_R	6	Eastern GOA/PNW
317	Shovelnose_Cr	6	Eastern GOA/PNW
249	Shustnini	6	Eastern GOA/PNW
206	Siberia_Creek	6	Eastern GOA/PNW
25	Silverdale	6	Eastern GOA/PNW
196	Skagit	6	Eastern GOA/PNW
274	Skeena	6	Eastern GOA/PNW
171	Skowquiltz	6	Eastern GOA/PNW
447	SkykomishRiv	6	Eastern GOA/PNW
132	Slatechuck_Cre	6	Eastern GOA/PNW
43	Sliammon	6	Eastern GOA/PNW
15	Smith_Cree	6	Eastern GOA/PNW
54	Snootli	6	Eastern GOA/PNW
180	Southgate	6	Eastern GOA/PNW
26	Squakum	6	Eastern GOA/PNW
142	Squamish	6	Eastern GOA/PNW
128	Stagoo	6	Eastern GOA/PNW
265	Stanley	6	Eastern GOA/PNW
52	Stave	6	Eastern GOA/PNW
396	Stawamus	6	Eastern GOA/PNW
409	Steel_Cr	6	Eastern GOA/PNW
424	Stewart_Cr	6	Eastern GOA/PNW
416	Stumaun_Cr	6	Eastern GOA/PNW
327	Sugsaw	6	Eastern GOA/PNW
324	Surprise	6	Eastern GOA/PNW
75	Taaltz	6	Eastern GOA/PNW
30	Taku	6	Eastern GOA/PNW
18	Takwahoni	6	Eastern GOA/PNW
251	Tarundl_Creek	6	Eastern GOA/PNW
149	Theodosia	6	Eastern GOA/PNW
22	Thorsen	6	Eastern GOA/PNW
129	Toon	6	Eastern GOA/PNW
279	Tseax	6	Eastern GOA/PNW
202	Tulalip	6	Eastern GOA/PNW
97	Turn_Creek	6	Eastern GOA/PNW
430	Turtle_Cr	6	Eastern GOA/PNW
247	Tuskwa	6	Eastern GOA/PNW
165	Tyler	6	Eastern GOA/PNW
33	Tzoonie	6	Eastern GOA/PNW
124	Upper_Kitsumkal	6	Eastern GOA/PNW
140	Vedder	6	Eastern GOA/PNW
70	Viner_Sound	6	Eastern GOA/PNW
45	Wahleach	6	Eastern GOA/PNW
172	Walkum	6	Eastern GOA/PNW

DFO number	Population name	Region number	Region
73	Waump	6	Eastern GOA/PNW
232	Wells_Bridge	6	Eastern GOA/PNW
352	Wells_River	6	Eastern GOA/PNW
105	West_Arm_Creek	6	Eastern GOA/PNW
267	Whitebottom_Cr	6	Eastern GOA/PNW
326	Widgeon_Slough	6	Eastern GOA/PNW
277	Wilauks_Cr	6	Eastern GOA/PNW
120	Wilson_Creek	6	Eastern GOA/PNW
401	Worth_Creek	6	Eastern GOA/PNW
60	Wortley_Creek	6	Eastern GOA/PNW
248	Yellow_Bluff	6	Eastern GOA/PNW
434	Zymagotitz	6	Eastern GOA/PNW

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232 GUTHRIE, C. M. III, H. T. NGUYEN, and J. R. GUYON. 2012. Genetic stock composition analysis of chinook salmon bycatch samples from the 2010 Bering Sea trawl fisheries, 22 p. NTIS No. PB2012-104700.

231 SMITH, K. R., R. A. MCCONNAUGHEY, and C. E. ARMISTEAD. 2011. Benthic invertebrates of the Eastern Bering Sea: A synopsis of the life history and ecology of snails of the genus *Neptunea*., 58 p. NTIS No. PB2012-108929.

230 HIMES-CORNELL, A., C. PACKAGE, and A. DURLAND. 2011. Improving community profiles for the North Pacific fisheries, 85 p. NTIS No. PB2012-108928.

229 YANG, M-S. 2011. Diet of nineteen mesopelagic fishes in the Gulf of Alaska, 67 p. NTIS No. PB2012-PB2012-102005.

228 LEW, D. K., and A. HIMES-CORNELL. 2011. A guide to designing, testing, and implementing Alaska Fisheries Science Center economic and social surveys, 43 p. NTIS No. PB2012100169.

227 LAUTH, R. R. 2011. Results of the 2010 eastern and northern Bering Sea continental shelf bottom trawl survey of groundfish and invertebrate fauna, 256 p. NTIS No. PB2012100168.

on the project Web site at: *http://www.nmfs.noaa.gov/pr/permits/eis/arctic.htm.*

Alternatives (Chapter 2)

- Section 2.4.7 contains the description of the newly added alternative.
- Sections 2.4.8 and 2.4.9 are the new Alternatives 5 and 6, previously described as Alternatives 4 and 5 in the 2011 DEIS.
- Section 2.4.8.2 contains the updated list of time/area closures contemplated under Alternative 5 and as additional mitigation measures under Alternatives 2, 3, 4, and 6.

Baseline Information (Chapter 3)

- Sections 3.2.4 and 3.3.2 contained updated information regarding marine mammals and subsistence resources based on literature and data provided during the public comment period.

Mitigation Measure Analysis (Chapter 4)

- Sections 4.5.2.4.15 and 4.5.2.4.16 contain the updated analysis of standard and additional mitigation measures, respectively, with the primary purpose of reducing impacts to marine mammals.
- Sections 4.5.3.2.3 and 4.5.3.2.5 contain the updated analysis of standard and additional mitigation measures, respectively, with the primary purpose of reducing impacts to subsistence uses of marine mammals.
- For each measure, we outlined activities to which it applies (e.g. just seismic surveys or just exploratory drilling or all activities), the purpose of the measure, the science, support for reduction of impacts to marine mammals or subsistence availability of marine mammals, the likelihood of effectiveness, the history of implementation of the measure, practicability for applicant implementation, and recommendation for how, and if, to apply the measure in future MMPA ITAs.

Impact Analyses (Chapter 4)

- Table 4.5–19, page 4–91, and Table 4.5–25, page 4–184 contain revised impact criteria for the assessment of potential impacts to marine mammals and subsistence resources to include additional factors that more closely align with analyses conducted under the MMPA.
- Section 4.2.6 is a new section in this Supplemental DEIS. This section includes information regarding the process NMFS has initiated to revise the acoustic criteria, which are currently used by NOAA to determine the received sound level at which injury or behavioral harassment of marine mammals from seismic airguns may occur. The acoustic criteria process will (separate from this EIS process) include both a public and external peer review process. At this time, we are still in the internal review process for the acoustic criteria, but we have included key basic information about the likely nature of the revisions to the criteria that adds value to the environmental analysis contained in this Supplemental DEIS. We refer the public to the separate acoustic criteria document for comment when it is made available in the coming months. The schedules for finalization of the Final EIS and the acoustic criteria are similar.

Public Meetings

Comments will be accepted at public meetings and during the public comment period, and must be submitted to NMFS by the comment deadline (see DATES). We request that you include background documents to support your comments as appropriate.

Public meetings will be held the week of April 8, 2013, in the communities of Barrow and Kotzebue and in Anchorage. Dates, times, and locations of each meeting will be announced in advance in local media. Comments will be accepted at all public meetings, as well as during the public comment period and can be submitted via the methods described earlier in this document (see ADDRESSES).

Dated: March 26, 2013.

Helen M. Golde,

Acting Director, Office of Protected Resources, National Marine Fisheries Service.

[FR Doc. 2013–07312 Filed 3–28–13; 8:45 am]

BILLING CODE 3510–22–P

DEPARTMENT OF COMMERCE

National Oceanic and Atmospheric Administration

RIN 0648–XC583

Fisheries of the Exclusive Economic Zone Off Alaska; Monitoring Requirements for American Fisheries Act Catcher Vessels Subject to Amendment 91; Public Workshops

AGENCY: National Marine Fisheries Service (NMFS), National Oceanic and Atmospheric Administration (NOAA), Commerce.

ACTION: Notice of public workshop.

SUMMARY: NMFS announces a workshop to solicit input from owners and operators of American Fisheries Act (AFA) catcher vessels and shoreside processors participating in the pollock fishery in the Bering Sea off Alaska. The workshop concerns accurate accounting of Chinook salmon bycatch in the Bering Sea pollock fishery under Amendment 91 to the Fishery Management Plan for Groundfish of the Bering Sea and Aleutian Islands. The workshop will discuss potential regulatory changes to address (1) the practice of leaving significant amounts of loose fish on the deck not contained inside the codend; (2) the installation of software and communication equipment to enhance observer data collection; and (3) the definition of directed fishing for pollock. The meeting is open to the public, but NMFS is particularly seeking participation by people who are knowledgeable about AFA catcher vessel operations in the Bering Sea pollock fishery and who can discuss with NMFS the potential operational impacts of the proposed monitoring requirements.

DATES: The workshop will be held on Thursday, May 16, 2013, from 9 a.m. to 12 p.m. Pacific daylight savings time.

ADDRESSES: The workshop will be held at the Swedish Cultural Center, 1920 Dexter Avenue N., Seattle, WA 98109. Directions to the Swedish Cultural Center are on its Web site at *http://www.swedishculturalcenter.org/contacts.htm.*

FOR FURTHER INFORMATION CONTACT: Jennifer Watson, 907–586–7537, or Michael Camacho, 907–586–7471.

SUPPLEMENTARY INFORMATION: NMFS is developing proposed revisions to some monitoring components of Amendment 91 for AFA catcher vessels in the Bering Sea pollock fishery. Currently, all salmon are required to be stored in refrigerated saltwater tanks prior to delivery to a shoreside processor. The intent of this requirement is to reduce the potential for sorting of catch, to prevent unlawful discarding of salmon, and to make all salmon available to the observer for census and sampling at delivery. However, loose fish on deck not contained inside the codend creates numerous challenges to the intent of this requirement.

In addition to the agency's concerns about loose fish on deck not contained inside the codend, there are additional revisions that will improve the monitoring and enforcement of Chinook salmon bycatch regulations under Amendment 91. These revisions include a requirement for all AFA catcher vessels to maintain a computer and an electronic transmission system for use by an observer and a change to specify that the Amendment 91 monitoring requirements apply when a catcher vessel named in the AFA is using pelagic gear in the Bering Sea.

This meeting is open to the public, but NMFS is particularly seeking participation by people who are knowledgeable about operations aboard AFA catcher vessels and the feasibility of preventing loose fish from remaining on deck outside the codend.

Special Accommodations

The meeting will be physically accessible to people with disabilities. Requests for sign language interpretation or other auxiliary aids should be directed to Jennifer Watson, 907–586–7537, at least 10 workdays prior to the meeting date.

Dated: March 26, 2013.

Kara Meckley,

Acting Deputy Director, Office of Sustainable Fisheries, National Marine Fisheries Service.

[FR Doc. 2013–07351 Filed 3–28–13; 8:45 am]

BILLING CODE 3510–22–P

DEPARTMENT OF COMMERCE

National Oceanic and Atmospheric Administration

RIN 0648–XC601

Mid-Atlantic Fishery Management Council; Public Meeting

AGENCY: National Marine Fisheries Service (NMFS), National Oceanic and Atmospheric Administration (NOAA), Commerce.

ACTION: Notice of public meeting.

SUMMARY: The Council's Atlantic Mackerel, Squid, and Butterfish (MSB) Advisory Panel (AP) will meet to develop Fishery Performance Reports for the Atlantic Mackerel, Squid, and Butterfish fisheries in preparation for the Council's setting of specifications for 2014.

DATES: The meeting will be held on Wednesday, April 17, 2013, from 10:30 a.m. to 6 p.m.

ADDRESSES: The meeting will be held at the Hilton Garden Inn Baltimore/Arundel Mills; 7491 New Ridge Rd., Hanover, MD 21076; telephone: (410) 878–7200

Council address: Mid-Atlantic Fishery Management Council, 800 N. State Street, Suite 201, Dover, DE 19901; telephone: (302) 674–2331.

FOR FURTHER INFORMATION CONTACT: Christopher M. Moore Ph.D., Executive Director, Mid-Atlantic Fishery Management Council, 800 N. State Street, Suite 201, Dover, DE 19901; telephone: (302) 526–5255.

SUPPLEMENTARY INFORMATION: The purpose of the meeting is to create Fishery Performance Reports by the Council's Atlantic Mackerel, Squid, and Butterfish (MSB) Advisory Panel (AP). The intent of these reports is to facilitate structured input from the Advisory Panel members into the Atlantic Mackerel, Squid, and Butterfish specifications process. The Advisory Panel will also review the findings of a recent workshop on squid management and may develop related recommendations.

Although non-emergency issues not contained in this agenda may come before this group for discussion, those issues may not be the subject of formal action during this meeting. Action will be restricted to those issues specifically listed in this notice and any issues arising after publication of this notice that require emergency action under section 305(c) of the Magnuson-Stevens Fishery Conservation and Management Act, provided the public has been notified of the Council's intent to take final action to address the emergency.

Special Accommodations

The meeting is physically accessible to people with disabilities. Requests for sign language interpretation or other auxiliary aids should be directed to M. Jan Saunders at the Mid-Atlantic Council Office, (302) 526–5251, at least 5 days prior to the meeting date.

Dated: March 26, 2013.

Tracey L. Thompson,

Acting Deputy Director, Office of Sustainable Fisheries, National Marine Fisheries Service.

[FR Doc. 2013–07361 Filed 3–28–13; 8:45 am]

BILLING CODE 3510–22–P

DEPARTMENT OF COMMERCE

National Oceanic and Atmospheric Administration

RIN 0648–XC603

Pacific Fishery Management Council; Public Meeting

AGENCY: National Marine Fisheries Service (NMFS), National Oceanic and Atmospheric Administration (NOAA), Commerce.

ACTION: Notice of public meeting.

SUMMARY: The Stock Assessment Review Panels (STAR Panels) will hold work sessions to review stock assessments using data-moderate methods, as well as tier 1 benchmark stock assessments for petrale sole and darkblotched rockfish, rougheye rockfish and aurora rockfish, shortspine thornyhead and longspine thornyheads, and cowcod and Pacific sanddabs, all of which are open to the public.

DATES: The meetings will be held April 22–26, 2013; May 13–17, 2013; July 8–12, 2013; July 22–26, 2013; and August 5–9, 2013. See **SUPPLEMENTARY INFORMATION** for specific dates and times.

ADDRESSES: The meetings will be held in Santa Cruz, CA and Seattle, WA. See **SUPPLEMENTARY INFORMATION** for specific locations.

Council address: Pacific Fishery Management Council (Pacific Council), 7700 NE Ambassador Place, Suite 101, Portland, OR 97220–1384.

FOR FURTHER INFORMATION CONTACT: Ms. Stacey Miller, NMFS Northwest Fisheries Science Center; telephone: (541) 961–8475; or Mr. John DeVore, Pacific Fishery Management Council; telephone: (503) 820–2280.

SUPPLEMENTARY INFORMATION: The meetings will be held in April, May, July and August. The meeting dates and times are listed below.

The Stock Assessment Review Panel for data moderate assessments will be held beginning at 8:30 a.m., Monday, April 22, 2013 and end at 5:30 p.m. or as necessary to complete business for the day. The Panel will reconvene on Tuesday, April 23, 2013 and will continue through Friday, April 26, 2013 beginning at 8:30 a.m. and ending at 5:30 p.m. each day, or as necessary to complete business. The Panel will adjourn on Friday, April 26.

The Stock Assessment Review Panel for Petrale sole and darkblotched rockfish stock assessments will be held beginning at 8:30 a.m., Monday, May 13, 2013 and end at 5:30 p.m. or as necessary to complete business for the day. The Panel will reconvene on Tuesday, May 14, 2013 and will continue through Friday, May 17, 2013 beginning at 8:30 a.m. and ending at 5:30 p.m. each day, or as necessary to complete business. The Panel will adjourn on Friday, May 17.

The Stock Assessment Review Panel for the rougheye rockfish and aurora rockfish stock assessments will be held beginning at 8:30 a.m., Monday, July 8, 2013 and end at 5:30 p.m. or as necessary to complete business for the day. The Panel will reconvene on Tuesday, July 9, 2013 and will continue through Friday, July 12, 2013 beginning at 8:30 a.m. and ending at 5:30 p.m. each day, or as necessary to complete business. The Panel will adjourn on Friday, July 12.

The Stock Assessment Review Panel for the shortspine thornyhead and longspine thornyhead stock assessments will be held beginning at 8:30 a.m., Monday, July 22, 2013 and end at 5:30 p.m. or as necessary to complete

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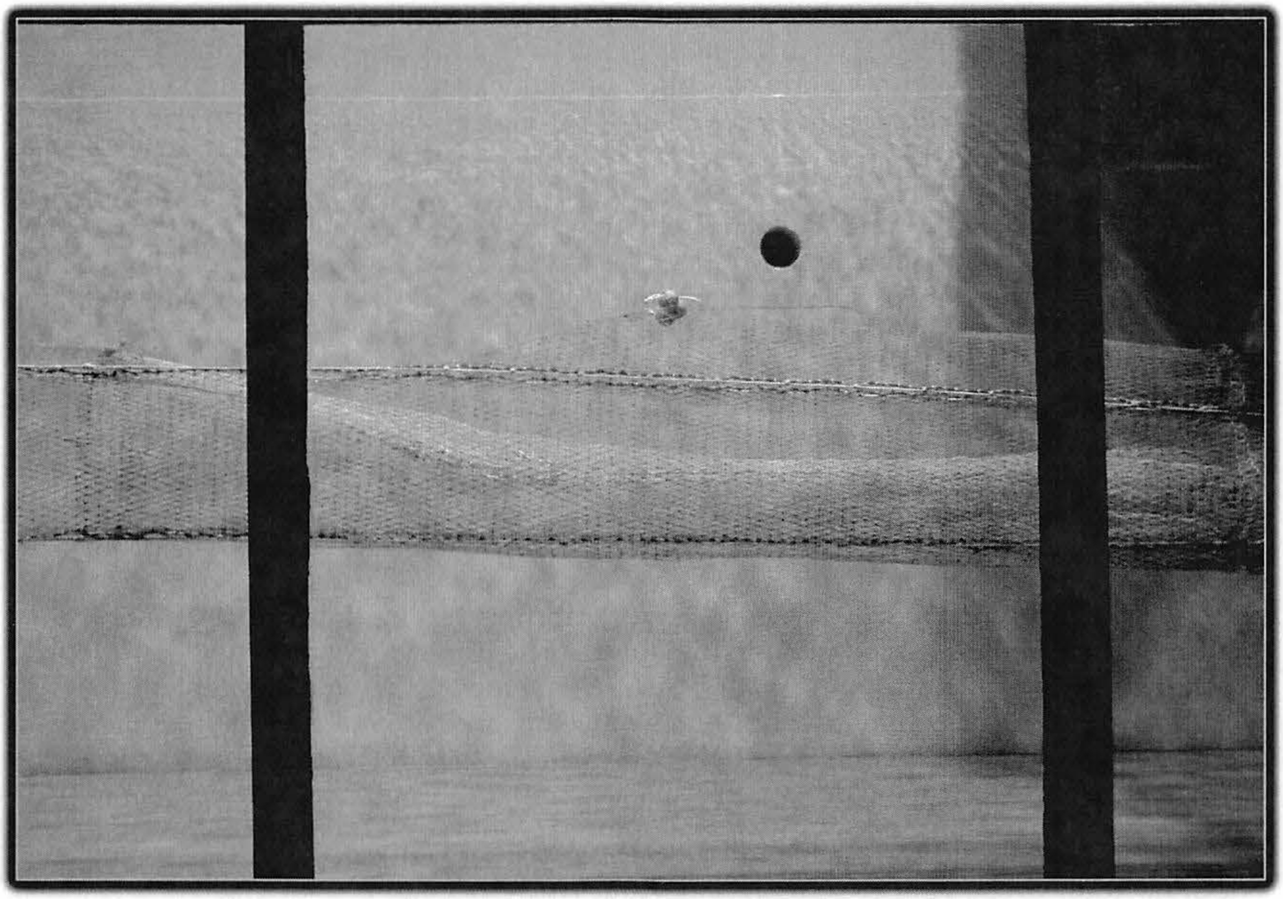
NMFS IPA No. __CP IPA__

Chinook Salmon Bycatch Reduction Incentive Plan



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April 1, 2013

Introduction

Amendment 91 to the Bering Sea and Aleutian Islands Groundfish Fishery Management Plan (BSAI FMP) limits Chinook salmon bycatch in the eastern Bering Sea (EBS) pollock fishery. The rules and regulations implementing Amendment 91 came into force at the start of the 2011 fishery. Amendment 91 is an innovative approach to managing Chinook salmon bycatch in that it combines a prohibited species catch (PSC) limit on the amount of Chinook salmon that may be caught incidentally by the fishery with an incentive plan agreement (IPA) and performance-standard requirement designed to minimize bycatch to the extent practicable in all years. The approach is designed to motivate fishery participants to avoid Chinook salmon bycatch at the individual vessel level under any condition of pollock and Chinook abundance in all years. The vessel-level incentives are created through contracts among the fishery participants.

The Chinook Salmon Bycatch Reduction Incentive Plan (CP IPA) reported on here is designed to provide the incentives necessary to accomplish the goals and objectives of Amendment 91. The plan builds on experience gained in the development and refinement of time-and-area-based, rolling "hot-spot" avoidance programs. The plan creates incentives to avoid salmon bycatch by restricting the pollock fishing opportunities of vessels with poor Chinook bycatch performance while allowing vessels with good performance less restricted access to the fishing grounds. Losing access to good pollock fishing increases vessel operating costs and reduces product values. Avoiding grounds restrictions reduces operating costs and allows for the production of more high-value products (especially during the A-season), thus increasing profits.

The incentive plan is designed to work in concert with the annual Chinook salmon PSC limits specified in Amendment 91. The limits depend on whether the fishery participants develop IPAs. If IPAs are developed, then the annual PSC limit is 60,000 Chinook during any two-out-of-seven years, and 47,591 Chinook in other years. During 2011 all pollock vessels participated in an IPA and the catcher-processor (CP) sector IPA participants included vessels harvesting the American Fisheries Act (AFA) CP Sector and Alaska Community Development Quota (CDQ) pollock allocations. For the CP sector, the Chinook PSC limit is 17,040 fish (under the 60,000 fish annual limit) and the pollock quota is 36 percent of the non-CDQ directed fishing allocation. For the CDQ sector, the Chinook PSC limit is 4,896 fish (under the 60,000 fish annual limit) and the pollock quota is 10 percent of the annual directed fishing allocation.

Each year the IPA participants begin to manage Chinook bycatch using the lower 47,591 annual limit. For this limit, the CP sector Chinook quota is 13,516 fish and the CDQ sector Chinook quota is 3,883 fish. These pollock and Chinook quotas are further allocated among the seasons and the participating vessels. Table 1 shows the CP IPA 2012 "day-one" allocations of pollock and Chinook salmon PSC quota.

Primary IPA components include: (1) data gathering, monitoring, reporting, and information sharing; (2) identification of bycatch avoidance areas (BAA); and (3) fishing-area prohibitions for vessels with poor bycatch performance. Additional components include: (4) an A-season closed area of approximately 755 square nautical miles on the northern flank of the Bering Canyon; and (5) a set of conditional, B-season closed areas of approximately 1,295 square miles along the outermost EBS shelf.

Vessels are prohibited from fishing in the B-season areas beginning on October 15th and continuing through to the end of the season during those years when the aggregate bycatch of all plan vessels during the month of September exceeds a preset threshold.

Table 1. CP IPA Day-One Allocations of Pollock and Chinook Salmon, 2012.

Vessel	A-Season Pollock (tons)	A-Season Chinook (n)	B-Season Pollock (tons)	B-Season Chinook (n)
American Dynasty	17,346	1,076	26,018	269
American Triumph	17,346	1,076	26,018	269
Northern Eagle	17,346	1,076	26,018	269
Northern Jaeger	17,345	1,077	26,018	269
Ocean Rover	17,345	1,077	26,018	269
Arctic Fjord	15,506	990	23,260	248
Arctic Storm	16,368	990	24,551	248
Northern Hawk	15,921	992	23,881	248
Alaska Ocean	18,488	1,148	27,731	287
Pacific Glacier	18,488	1,148	27,731	287
Starbound	15,899	1,006	23,848	252
Island Enterprise	10,051	618	15,076	154
Kodiak Enterprise	10,051	618	15,076	154
Seattle Enterprise	10,051	618	15,076	154
Ocean Peace	0	0	1,270	66
Northern Glacier	0	0	0	0
Katie Ann	0	0	0	0
	Allocation Buffer		0	446
	Total Allocation		545,140 *	17,399

* includes 6,100 tons AI pollock roll-over on 1/17/12.

Incentive Measures

One of the most practical and direct methods to create incentives to avoid Chinook salmon bycatch is to limit the pollock fishing opportunities of a vessel when bycatch performance is poor. This simple approach works especially well for catcher-processors because efficient processing requires an uninterrupted flow of fish, and this can be achieved most reliably with unrestricted access to the grounds. Because experience has shown that high, local concentrations of pollock may often be found where concentrations of Chinook are also high (the vessels can "see" the pollock but not the Chinook), limiting access to local areas of relatively high Chinook bycatch is an efficient way to create a financial incentive to avoid Chinook salmon bycatch. The reason for this is that losing access to good pollock fishing grounds increases vessel operating costs and reduces the amount of products that can be produced during a day of fishing. A vessel that retains nearly unrestricted access to good pollock fishing opportunities avoids costs associated with moving and finding pollock in other areas, and so the vessel can produce more products each day.

About a decade of industry experience has shown that the most efficient way to reduce salmon bycatch to the maximum extent practicable is to focus incentive programs on those areas where Chinook salmon bycatch is highest when compared to the amount of pollock harvested. To accomplish this, vessel performance benchmarks are calculated in a way that reflects the amount of pollock harvested. The first step in creating a program to avoid Chinook bycatch is to employ data gathering, reporting, and information sharing to identify local areas of relatively high Chinook abundance on the pollock grounds. Pollock catch and Chinook bycatch records from all fishery participants are gathered, compiled, and evaluated each week during which an IPA vessel catches pollock. In this analysis, areas of relatively high Chinook bycatch are identified (bycatch avoidance areas; BAA). Should vessels continue to fish in these areas, high Chinook bycatch is likely to occur because local concentrations of Chinook routinely persist in time and space for several weeks.

An important component the evaluation of potential BAA is the generation of a useful grounds-wide index of salmon abundance. This "baseline" index of relative salmon abundance on the grounds over time is called the base rate. More information about the methods used to identify the base rate is in the IPA agreement (available at: www.fakr.noaa.gov/sustainablefisheries/bycatch/salmon/chinook/ipa/chinook_salmon_ipa_2010.pdf).

To establish and maintain incentives to avoid Chinook bycatch under any condition of pollock and Chinook salmon abundance, the bycatch performance of the IPA vessels is measured both currently (most recent two weeks) and cumulatively (over the entire fishing season). To evaluate current performance, vessel performance is measured during the prior two weeks and compared to a standard that represents better-than-average performance. The measure of current vessel bycatch performance is called the vessel bycatch ratio. The bycatch ratio is calculated by dividing the number of Chinook caught incidentally by the vessel during the prior two weeks by the metric tons of pollock caught by the vessel during the prior two weeks. A two week period is used because experience has shown that day-to-day vessel bycatch performance is influenced by random factors associated with changes in weather, winds, water temperatures, and currents, and measuring performance over a two-week period "dampens" the effects of these random influences. This increases the usefulness of the measure in the creation of an incentive for the individual vessel to avoid bycatch.

If the current bycatch performance of an IPA vessel is not better than average, then the vessel is prohibited from fishing in the BAA for a week. Because the base rate is calculated by aggregating pollock catch and bycatch data from all vessels fishing for pollock, the base rate provides a measure of the average bycatch performance of the vessels fishing for pollock. The plan establishes the better-than-average-performance standard at 75 percent of the base rate. So every plan vessel with current bycatch performance higher than 75 percent of the base rate is prohibited from fishing within the BAA for seven days (i.e., the following week). If during the following week the current bycatch performance of a vessel operating under a fishing prohibition remains higher than 75 percent of the base rate, then the vessel is prohibited again from fishing in the bycatch avoidance areas for an additional seven days. A seven-day fishing prohibition is called a weekly fishing prohibition.

The cumulative bycatch performance of a vessel is measured as the total amount (number) of Chinook salmon bycatch by the vessel during the fishing year relative to the pollock allocation assigned to that vessel (Table 1 shows the day-one" assignments for 2012). So the measure of cumulative vessel performance accumulates from the first day of fishing through to the last. Vessel cumulative bycatch performance is evaluated against a standard designed to magnify the incentive to avoid salmon bycatch during years when the baseline abundance of Chinook is medium and high. Based on analysis of more than a decade of CP catch records, an annual bycatch of 8,500 Chinook indicates a year when Chinook abundance on the grounds traditionally fished by CP vessels is at a medium level.

Cumulative bycatch performance is evaluated only for those vessels that receive a weekly fishing prohibition. For these vessels, if the cumulative Chinook bycatch rate is higher than the medium-abundance standard, then the vessel is prohibited from fishing in the BAA for two weeks. This standard is called the vessel cumulative amount, and a fourteen-day fishing prohibition is called an extended fishing prohibition. If vessel Chinook bycatch is greater than its cumulative amount, then it is subject to the extended fishing prohibition. Additional information about how the vessel cumulative amount is determined is in the IPA agreement.

Chinook Salmon Conservation Areas

Chinook salmon feeding migrations produce concentrations of Chinook in discrete, local areas along the EBS outer continental shelf, and many of these areas are well known to pollock fishermen. The areas are known to pollock fishermen because more often than not high concentrations of pollock are found in the areas. However, the precise times during which pollock and Chinook may be concentrated in any local area depends on a host of environmental and physical-oceanographic conditions that change with the seasons and the weather, such that it is not generally possible to know precisely where and when pollock and Chinook are concentrated together before going fishing for pollock.

Analysis of catch records over a decade or more has revealed the existence of one area along the outer continental shelf within which it seems that high concentrations of Chinook salmon exist almost every year during the winter fishery. Based on this analysis, an A-season fishing prohibition within an approximately 735 square mile area is included in the plan as a means to reduce bycatch. The area is called the A-season Chinook Salmon Conservation Area (CSCA; maps and the latitude and longitude coordinates of all CSCA boundaries are provided in the IPA agreement).

Analysis of B season catch records over two decades shows that when migrating Chinook arrive on the outer continental shelf in sufficient numbers during September, the odds that high concentrations of Chinook will be encountered by the fishery in October appear to increase. To create an incentive to reduce bycatch during the latter portion of the B-season, the CP IPA includes "triggered" fishing prohibition for three areas of approximately 1,295 square miles along the outermost shelf. These areas are called the B-season Chinook Salmon Conservation Area. To implement the incentive, all vessels are prohibited from fishing in the areas beginning on October 15th and continuing through to the end of the season during those years when the aggregate bycatch rate for all vessels during the month of September exceeds 0.015 Chinook per metric ton of pollock harvest (n/t; hereafter metric tons are referred to simply as tons). The CP IPA also specifies the penalties levied on a vessel for violating a BAA prohibition or fishing in a CSCA when fishing there is prohibited. These penalties are $10,000 for the first annual violation, $15,000 for a second annual violation, and $20,000 for a third and each subsequent violation during a year, with every trawl inside a prohibited area considered a separate violation.

Effects of Incentive Measures on Individual Vessels

This annual report provides a qualitative evaluation and some quantitative information on the effectiveness of the plan. The CP IPA incentive program is largely an area-based program, and this evaluation relies heavily on spatial analysis of pollock trawl locations as well as the bycatch performance of the individual vessels. To begin an assessment of the IPA incentives on the individual vessels, the aggregate performance of the vessels in the 2011 and 2012 fisheries is tabulated and compared to performance during prior years. Table 2 shows the aggregate bycatch performance of CP IPA vessels during 2012.

Comparing years since just before the implementation of the AFA, Chinook salmon bycatch during 2011 and 2012 was low, especially when adjusted for the size of the pollock catch. Since 1998, the number of bycatch Chinook is the fourth lowest, and only 25 percent higher than the lowest annual bycatch since then. After adjustment for the size of the pollock catch, the 2011 bycatch ratio is the second lowest over the time period, and just 15 percent above the lowest value (a difference of one salmon for every 1,000 tons of pollock catch).

Figure 1 shows how aggregate CP IPA Chinook bycatch performance during 2011 and 2012 compares with that of prior years. Since 1998 climate conditions over the EBS shelf and coastal Alaska are believed to have mainly determined the abundance of Chinook salmon on the pollock grounds, with the warm period during 2001 through 2005 believed to have increased both freshwater and marine survival. In 2012 the bycatch ratio remained at a very low level, continuing a slow downward trend that began in 2008.

Figure 2 shows how aggregate 2011 and 2012 CP IPA chum bycatch performance compares with that of prior years. The coincidence of the warm-weather years and the high chum bycatch ratios of the vessels is consistent with high chum salmon abundance on the pollock grounds during the warm years. The bycatch ratios also indicate that the abundance of chum salmon was likely higher in 2011 than during recent years. This is consistent with the summer of 2011 likely providing relatively favorable conditions for salmon on the EBS shelf, at least compared to recent years, and these conditions probably persisted into the fall when concentrations of Chinook first moved onto the EBS shelf to feed.

Table 2. CP IPA Chinook Salmon Bycatch Performance, 2012.

Season	Pollock (t)	Chinook Salmon (n)	Average Ratio (n/t)
A	218,011	2,836	0.013
B	327,004	97	0.000
A + B	545,015	2,933	0.005

Figure 1. Chinook Bycatch Ratios by Sector, Bering Sea Pollock Fishery, 1998-2012.

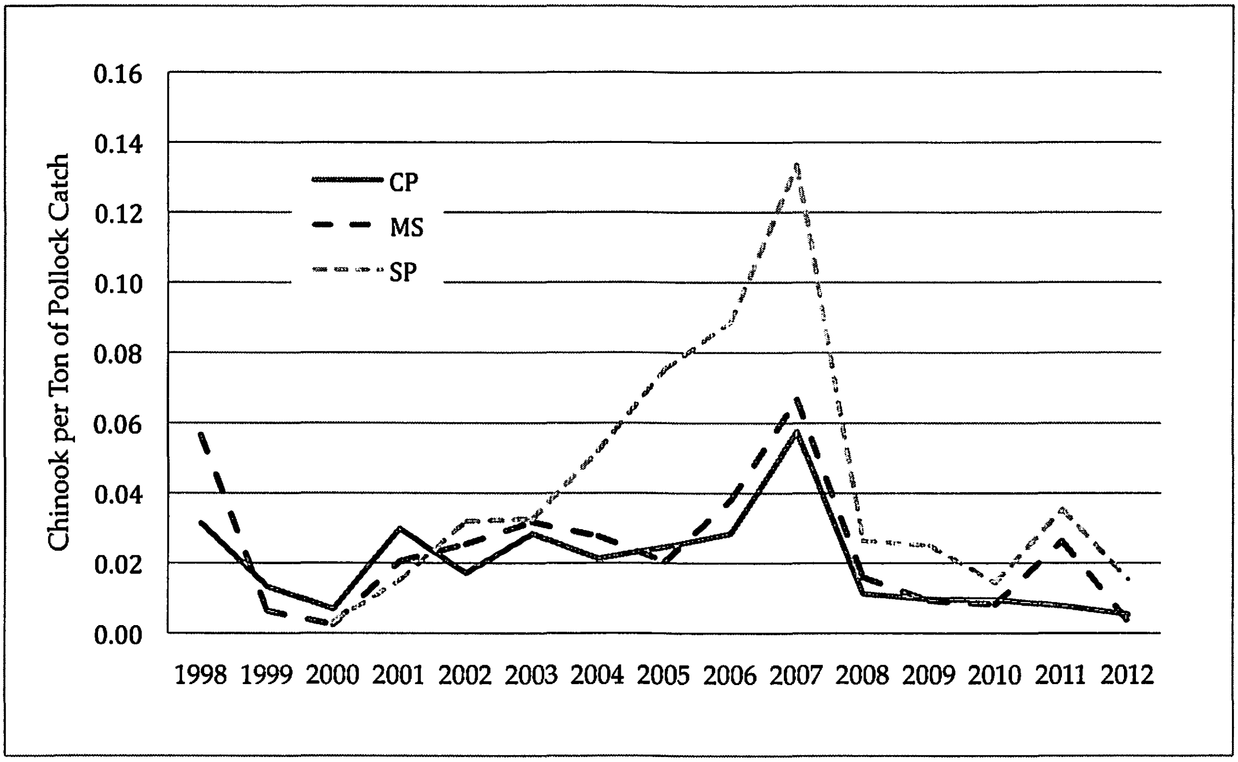


Figure 2. Chum Bycatch Ratios by Sector, Bering Sea Pollock B-Season, 1998-2012.

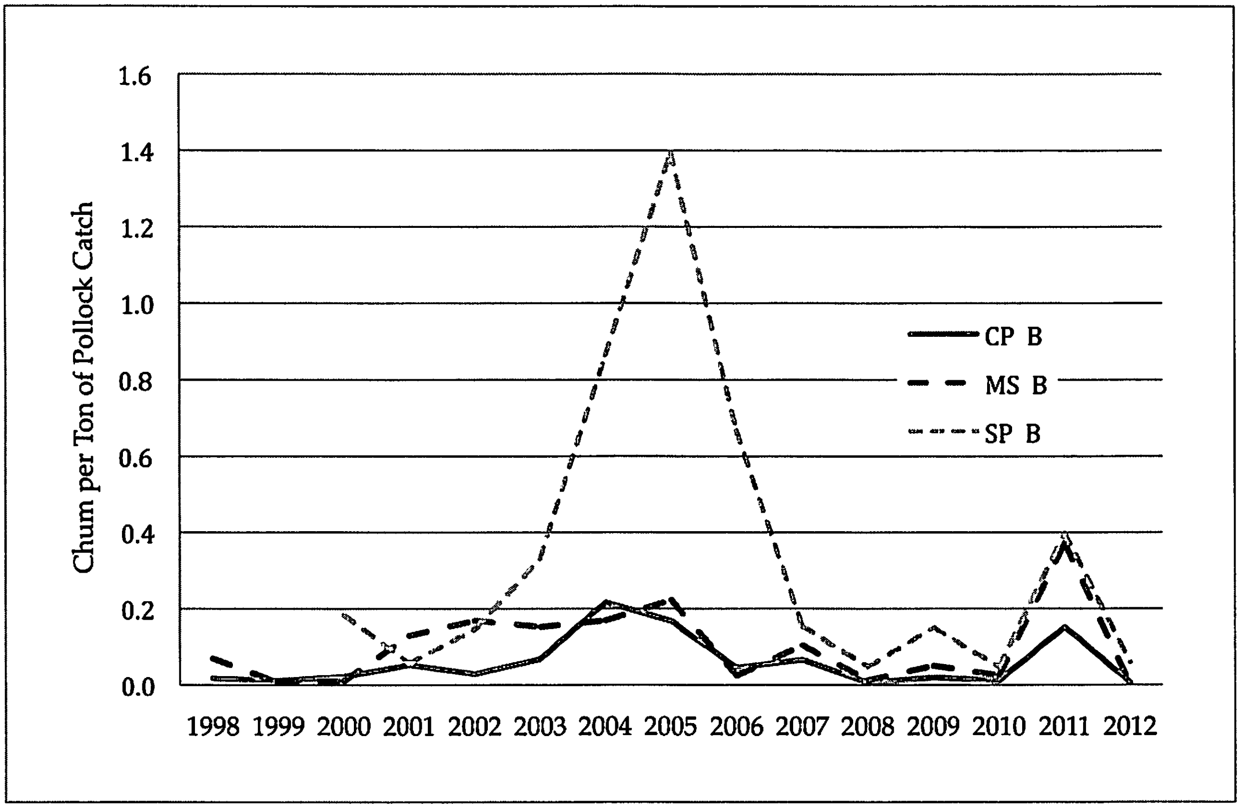


Table 3 shows the Chinook salmon bycatch performance of the IPA vessels. Performance is shown by season because the Chinook bycatch environment is different during the A-and B-seasons. During the A-season, bycatch ratios are often double those of the B-season because when the season starts Chinook salmon are already feeding on the EBS shelf. As the season progresses, Chinook salmon migrate to basin waters, and abundance on the grounds generally reaches a low level by mid March.

During the B-season, and when fishing starts quickly, it is sometimes possible to almost complete fishing operations before Chinook salmon arrive on the shelf in the fall to feed. In other years they arrive earlier and great effort must be concentrated on limiting the bycatch. Table 3 shows the range of vessel bycatch performance during the 2012 B-season. The ratio of Chinook bycatch to pollock catch was the second lowest recorded since 1998 (average ratio of 0.0003 n/t), and perhaps the best bycatch performance since then when adjusted for the size of the pollock TAC (the 2010 B-season shows a slightly lower ratio of 0.00023 n/t but pollock catch during the 2012 B-season was greater by 107,000 tons).

The CP IPA agreement specifies that all fishing in the B-season CSCA is prohibited beginning on October 15th in those years when the bycatch performance for all plan vessels combined exceeds 0.015 n/t during the month of September. The

Table 3. CP IPA Pollock Catch and Chinook Bycatch Performance by Season and Vessel, 2012.

Vessel	A-Season Pollock (t)	Chinook Salmon A (n)	B-Season Pollock (t)	Chinook Salmon B (n)	A-Season Ratio (n/t)	B-Season Ratio (n/t)
American Dynasty	16,128	119	26,794	4	0.007	0.000
American Triumph	17,297	313	25,737	1	0.018	0.000
Northern Eagle	17,836	152	27,039	7	0.009	0.000
Northern Jaeger	17,877	139	24,758	2	0.008	0.000
Ocean Rover	17,882	299	27,001	9	0.017	0.000
Arctic Fjord	18,849	215	25,619	1	0.011	0.000
Arctic Storm	13,063	54	22,483	4	0.004	0.000
Northern Hawk	15,947	160	23,929	1	0.010	0.000
Alaska Ocean	20,399	162	29,622	3	0.008	0.000
Pacific Glacier	16,666	196	26,359	3	0.012	0.000
Starbound	13,819	258	23,754	3	0.019	0.000
Island Enterprise	10,876	210	13,736	30	0.019	0.002
Kodiak Enterprise	10,856	236	10,651	4	0.022	0.000
Seattle Enterprise	10,517	323	19,521	25	0.031	0.001
Northern Glacier	0	0	0	0		
Katie Ann	0	0	0	0		
Ocean Peace	0	0	0	0		
Ocean Peace	0	0	0	0		
Forum Star	0	0	0	0		
American Challenger	0	0	0	0		
Ocean Harvester	0	0	0	0		
Tracy Anne	0	0	0	0		
Neahkanie	0	0	0	0		
Sea Storm	0	0	0	0	Weighted	Weighted
Muir Milach	0	0	0	0	Average	Average
Total	218,011	2,836	327,004	97	0.013	0.000

IPA vessels caught 20 Chinook salmon and 35,056 tons of pollock during September, resulting in a bycatch ratio of 0.0006 n/t. As such, no IPA vessels were prohibited from fishing in the CSCA during the last two weeks of October.

Another way to look at the effect of the IPA program on vessel bycatch performance is to make an evaluation using statistics. In this case, the statistics describe the distribution of the vessel bycatch ratios (relative performance). The hypothesis is that the Amendment 91 IPA program creates a more uniform incentive to avoid Chinook salmon bycatch among the individual vessels. In the prior program, the bycatch performance of a cooperative vessel group was evaluated against a performance benchmark, and under some circumstances, incentives to avoid bycatch weakened for an individual vessel. With a more uniform incentive, the distribution of vessel bycatch performance is expected to narrow, reflecting more uniform vessel performance.

The standard deviation of a distribution provides information about data dispersion. A low standard deviation indicates that the data points tend to be very close to the mean, whereas high standard deviation indicates that the data points are spread out over a large range of values. To interpret this statistic, it is believed that stronger, more uniform incentives for the individual vessel would reduce the "variability" of the observations. In this case, the standard deviation would be lower.

Skewness is another statistic that may provide some perspective on incentive changes. Skewness is a measure of the asymmetry of the distribution of a random variable, and can be positive or negative. Negative skew indicates that the tail on the left side of the distribution (lower bycatch ratio) is longer than the right side; a positive skew indicates that the right-side tail is longer than the left. A zero value indicates that the ratios are relatively evenly distributed on both sides of the mean, usually implying a symmetric distribution. To interpret this statistic, it is believed that stronger incentives for the individual vessel would reduce the likelihood of poor-performance outliers, thus increasing the symmetry of the distribution and resulting in a value for skewness close to zero.

Table 4 shows features of the IPA vessel Chinook bycatch performance distribution during the 2008-2012 A-seasons. Changes in the distribution features during 2011 coincide with the implementation of the Amendment 91 CP IPA. Analysis of the IPA vessel data 2008-2012 seems to indicate approximately similar Chinook abundance on the grounds. A similar comparison of B-season performance was not considered useful, as the bycatch environment was more difficult in 2011 than during the 2012 B-season (97 Chinook) or any of the previous three B-seasons (total IPA vessel bycatch for the 2008-2010 B-seasons combined was 797 Chinook). When a large change in bycatch conditions occurs during the same year that a change in bycatch incentives is implemented, it is difficult to measure the separate effect of the incentive change.

The IPA vessel A-season pollock catch also changed during 2008-2012, ranging from a low of 140,000 tons in 2009 to a high of 224,000 tons in 2011. However, the influence of a larger pollock quota on the strength of the individual vessel incentive to avoid Chinook bycatch is a matter of opinion. The "experimental" conditions that did occur provide data consistent with a more uniform distribution of IPA vessel bycatch performance during the 2011 A-season. A skew of zero indicates that there were no poor-performance outliers in the distribution (no right-hand tail). The distribution coefficient of variation, which is a normalized measure of dispersion (standard deviation corrected for scale), was reduced by roughly half during 2011. For the 2012 A-season, the coefficient of variation is similar to the 2008-2010 seasons but the mean performance and standard deviation are lower by about 40 percent. Table 3 shows that half-a-dozen vessels had bycatch ratios somewhat higher than the average during the 2012 A-season, causing higher distribution skewness when compared to the 2011 A-season. At the vessel level, these higher ratios were the result of marginal increases in Chinook bycatch of about 100 fish.

Table 4. IPA Vessel A-season Bycatch Performance Distribution Features, 2008-2012.

Year	N (vessels)	Mean Ratio (n/t)	Standard Deviation (n/t)	Skewness	Coefficient of Variation
2008	16	0.026	0.013	0.2	0.49
2009	12	0.022	0.011	0.7	0.49
2010	13	0.025	0.011	0.8	0.43
2011	14	0.010	0.003	0.0	0.25
2012	14	0.014	0.007	0.9	0.50

A-Season Fishery Details

The A-season fishery began on January 20th with vessels fishing at the head of the Bering Canyon and along the 50 fathom curve to the west of the Alaska Peninsula. All vessels experienced good daily catch rates with little Chinook bycatch and few trawls with ratios higher than 0.075 n/t.[1] The incentive plan mandates that a short period at the beginning of each season be used to gather and evaluate catch and bycatch information and to assess the baseline abundance of Chinook on the grounds. The A-season period extends from January 20th to February 14th, and during this period the base rate is set at 0.040 n/t. The initial vessel performance evaluation was made on February 2nd (using the start-up base rate), and no BAA were identified. The average bycatch ratio (cumulative) through February 2nd was 0.015 n/t and the vessel performance benchmark was 0.030 n/t (75 percent of the base rate).

[1] A rule of thumb for quick appraisal of vessel annual bycatch performance is the 0.050 n/t benchmark (one salmon in every 20 tons of pollock). When Chinook salmon is relatively abundant on the pollock grounds, it is a significant challenge for vessels to remain under this standard given experience and existing technology. The figure legend breakpoints correspond to the 0.05 n/t benchmark as per the equation (0.40x0.075) + (0.60x0.035) = 0.05 (i.e., breakpoints in the A-season legends are twice those of the B-season).

The A-season fishery generated nine performance evaluations and these identified a persistent area of high Chinook abundance in deeper water around the east end of the CSCA beginning during the first week of February (roughly the same BAA was identified in six of the nine evaluations; the other three evaluations showed no fishing areas with bycatch higher than the base rate). Figure 3 shows vessel trawl locations during the two weeks prior to the BAA identified on February 16th (BAA shown in blue outline). At this time the base rate was set to its minimum value of 0.035 n/t because the three-week fishery-wide bycatch ratio was 0.025 n/t. Four vessels with two-week performance greater than 0.0263 n/t (75 percent of the base rate) were prohibited from fishing in the BAA. The prohibition notice indicated that trawls with more than 100 Chinook were made by vessels testing salmon excluders in the CSCA, but no trawls with such poor performance were observed outside of the CSCA.

Figure 3. IPA Vessel Trawl Locations and Bycatch Ratios, February 2-16, 2012.

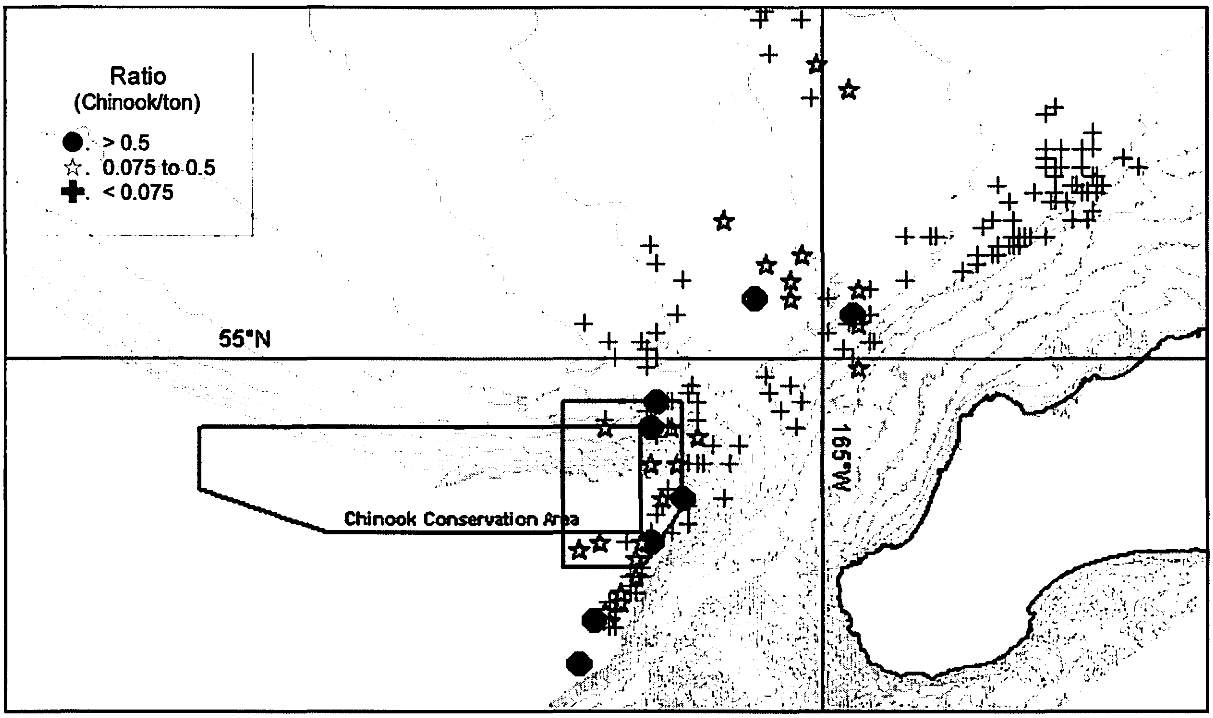


Figure 4 shows vessel trawl locations during the week after the BAA was identified. After the discovery of the concentration of Chinook in the BAA, virtually the entire fleet of IPA vessels moved fishing away from deep water in the Bering Canyon. As it turned out, most of the vessels relocated fishing to areas along the 50 fathom curve in the vicinity of the Pribilof Islands, well back from the shelf break (100 fathom curve). Figure 5 shows IPA vessel trawl locations in the vicinity of the BAA during the subsequent week. The concentration of Chinook appears to have moved offshore somewhat, with very low bycatch ratios for trawl locations shallower than 80 fathoms.

Figure 4. IPA Vessel Trawl Locations and Bycatch Ratios, February 16-23, 2012.

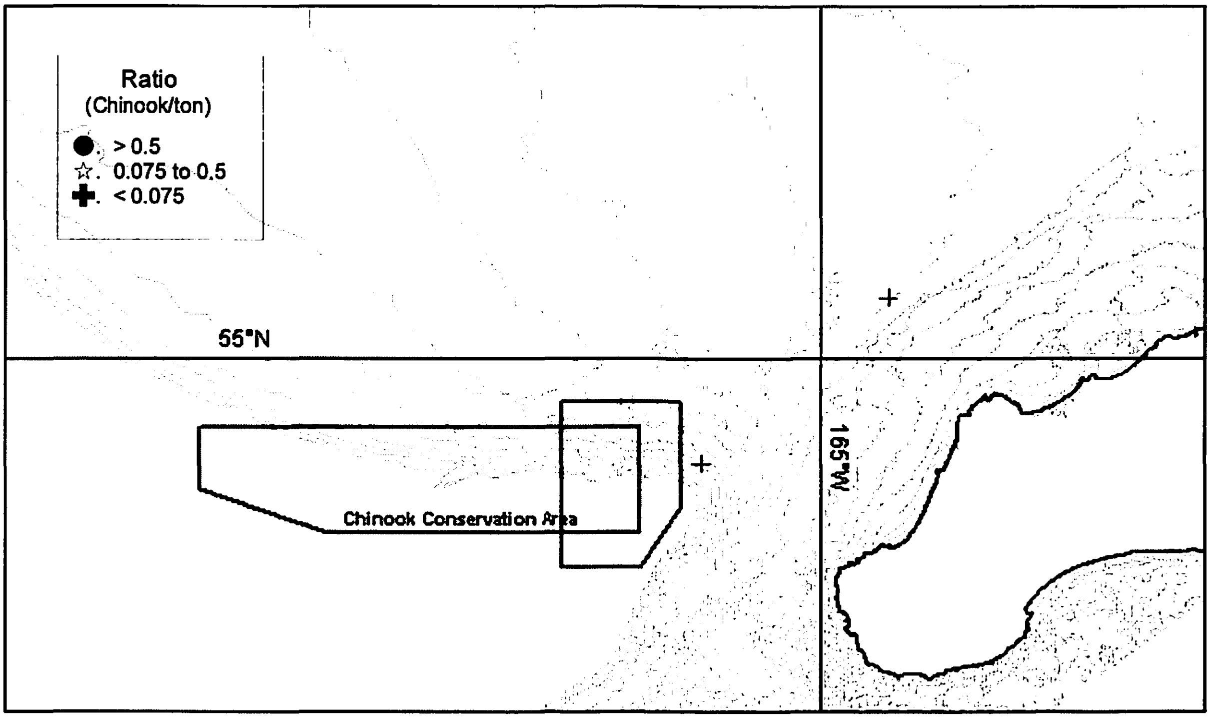
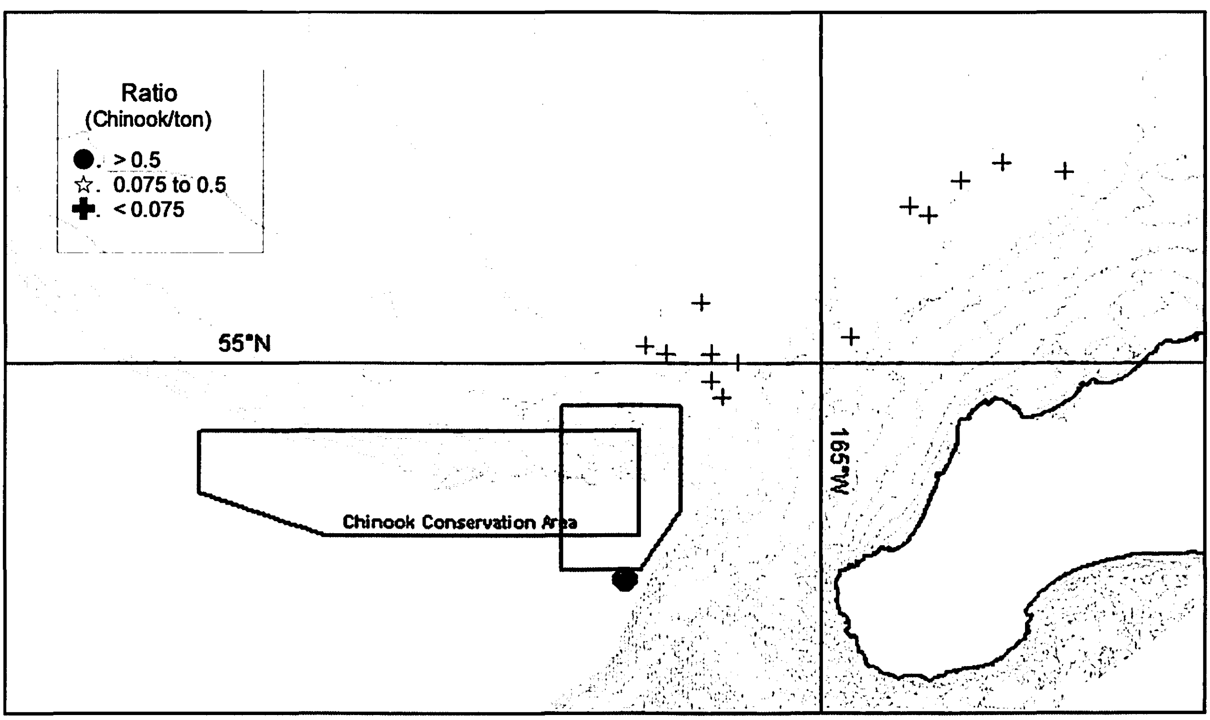


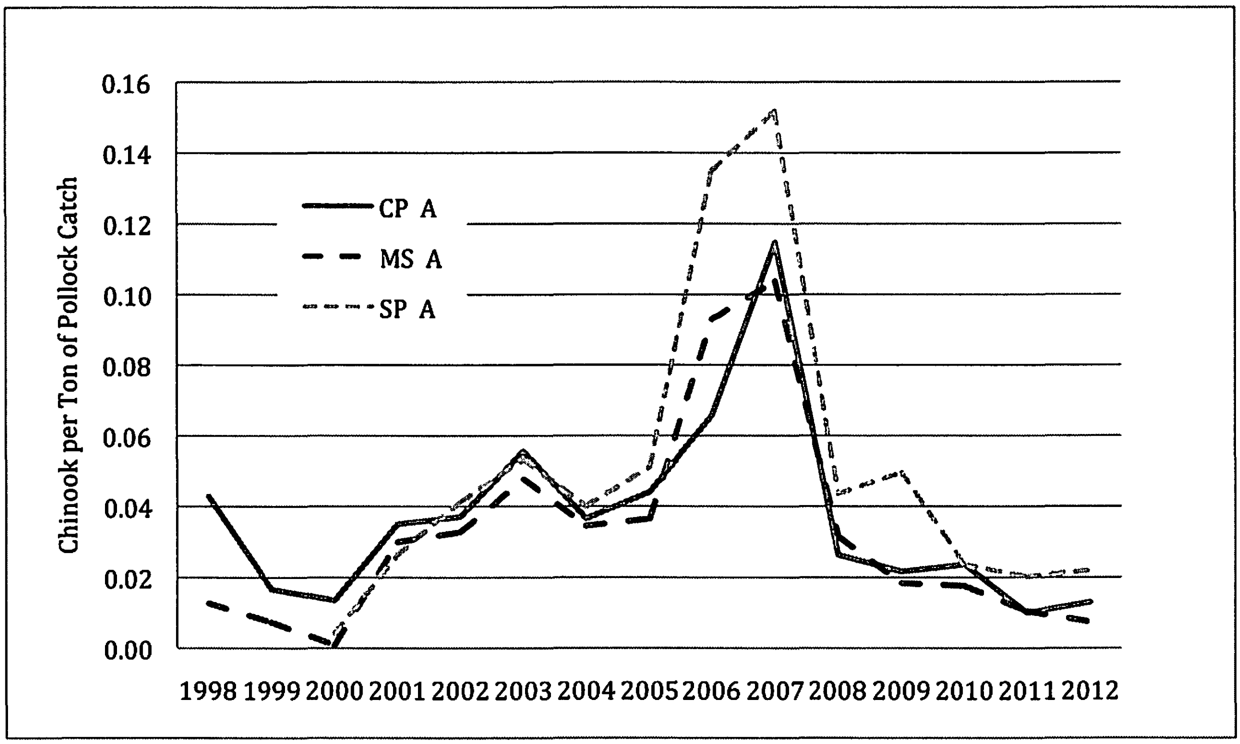
Figure 5. IPA Vessel Trawl Locations and Bycatch Performance, Feb. 16- Mar. 2, 2012.



The last A-season notice was provided on March 29th and showed the same persistent concentration of Chinook just outside of the eastern portion of the CSCA. Seven vessels were prohibited from fishing in a BAA that was slightly larger and covered deeper water than that shown in Figures 3-5. The final performance evaluation showed a cumulative vessel average bycatch ratio of 0.013 n/t.

Figure 6 shows A-season bycatch ratios from 1998 through 2012. Despite what is believed to have been a similar levels of Chinook abundance on the pollock grounds as during 2008-2010, the IPA vessels managed to achieve relatively low Chinook bycatch during 2011 and 2012 A-seasons, and so accelerated a trend toward improved bycatch performance that began in 2008 (average bycatch ratio during the 2011 and 2012 A-seasons was about half of the average ratio during the 2008-2010 A-seasons).

Figure 6. Chinook Bycatch Ratios, Bering Sea Pollock A-Season, 1998-2012.

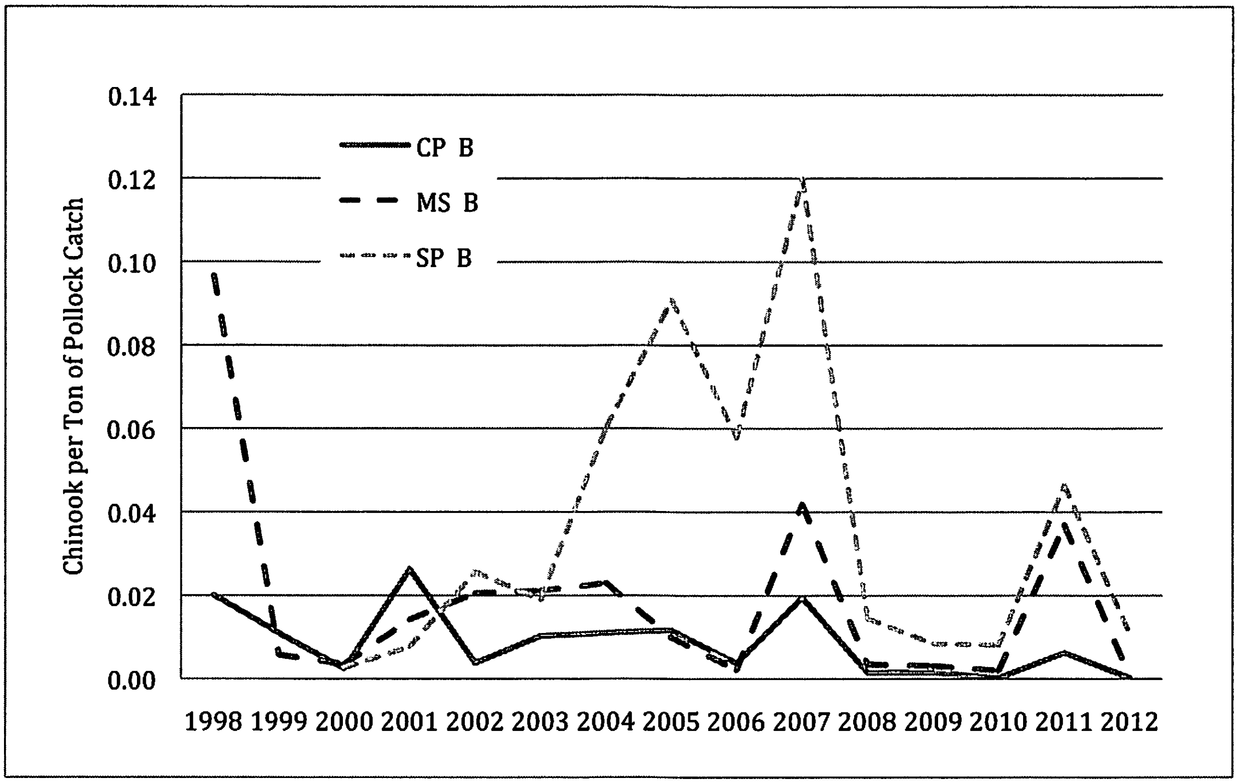


B-Season Fishery Details

Virtually all IPA vessels were on the grounds as the B-season opened. The B-season data-gathering period extends from June 10th to July 14th, and during this period the base rate is set at 0.035 n/t. The initial vessel performance evaluation was made on July 21st using the start-up base rate and no BAA were identified. Pollock daily catch rates were good from the season start through to the end of July with virtually all fishing west of 170° West longitude. Very few concentrations of Chinook were encountered and no BAA were identified; bycatch was 52 Chinook. During August and September the same bycatch environment persisted, no BAA were identified, and bycatch by the end of September was 97 Chinook. Four vessels finished fishing before the end of August, and all but one vessel finished prior to October. The last of 17 B-season performance evaluations was provided on October 11 and showed no Chinook bycatch during October and a cumulative average bycatch ratio of 0.0003 n/t (three Chinook for every 10,000 tons of pollock catch).

Figure 7 shows Chinook bycatch ratios for the pollock fishery during the 1998-2012 B-seasons. The data shows that an unexpected, abrupt change in pollock abundance during the 2011 B-season resulted in a relatively adverse Chinook bycatch environment, at least when compared to recent years (during 2011 most IPA vessels were forced to fish until the end of the season, for two weeks after the second wave of Chinook arrived on the grounds, a circumstance where Chinook abundance in local areas can reach very high levels).

Figure 7. Chinook Bycatch Ratios by Sector, Bering Sea Pollock B-Season, 1998-2012.



Chinook Salmon Savings

The CP IPA is a time-and-area-based program that prohibits fishing in areas with high concentrations of Chinook salmon when compared to the abundance of pollock. Because performance benchmarks are calculated for each vessel individually, the program generates incentives to avoid Chinook bycatch for the individual vessel. This simple approach works especially well for CP vessels because efficient processing requires an uninterrupted flow of fish, and this can be achieved most reliably with unrestricted access to the grounds. Because CP vessels fully integrate catching and processing activities, the benefit of unrestricted access to good pollock fishing grounds includes economic profits that reflect both catching value and processing value. This obvious difference in operational structure is believed to play an outsized role in motivating the IPA vessels to avoid potentially significant risks to both catching and processing value from unexpected, repeated episodes of high Chinook bycatch. This economic motivation remains even when bycatch is anticipated to remain below the annual limit. [1]

Figure 8 shows pollock A-season fishing locations before and after the Implementation of BSAI FMP Amendment 91. A close examination of the trawl locations in space and time, their bycatch ratios, and the bycatch performance of all of the IPA vessels shows clearly that the vessels changed their fishing strategy to avoid Chinook bycatch. The most salient feature of this changed approach was for vessels to locate initial fishing operations away from the outer margins of the shelf. Depending on the locations of pollock concentrations, any profitable movement of fishing to deeper water was accomplished via a deliberate, slow, and cautious progression while maintaining awareness of information about Chinook concentrations within the area. Evidence of local Chinook concentrations generally caused vessels fishing in deep water to move fishing to more shallow grounds. This behavior was most pronounced during the A-season and occurred in multiple areas when trawl bycatch ratios showed high concentrations of salmon, as e.g., when a wave of Chinook salmon moved into a local area to feed. During the B-season fishing was also moved ahead in time to avoid fishing during the latter portion of September and at any time during October.

The 2011 year was the first for the Chinook CP IPA program. The program identified relatively few BAA during both seasons, and most were selected based on the bycatch performance at shore-plant and mothership catcher-vessel fishing locations. During 2012 the average A-season bycatch ratio was slightly higher than for 2011, but nevertheless still very low. The 2012 B-season bycatch ratio was exceedingly low and no BAA were identified. In sum, the bycatch performance of the IPA vessels during 2011 and 2012 was just about the best recorded since 1998, and this period includes the salmon "crisis" years during which Chinook abundance on the grounds was also low. The analyses carried out to assess the effectiveness of the CP IPA leaves an impression that the vessels relied on spatial, temporal, and bycatch performance data from a large number of individual pollock trawls to guide a cautious adaptation to the new program. The changed fishing strategy that resulted is thought to have limited the number of BAA identified during 2011 and 2012.

<u>IPA Amendments</u>

There were no amendments to the CP IPA during 2012.

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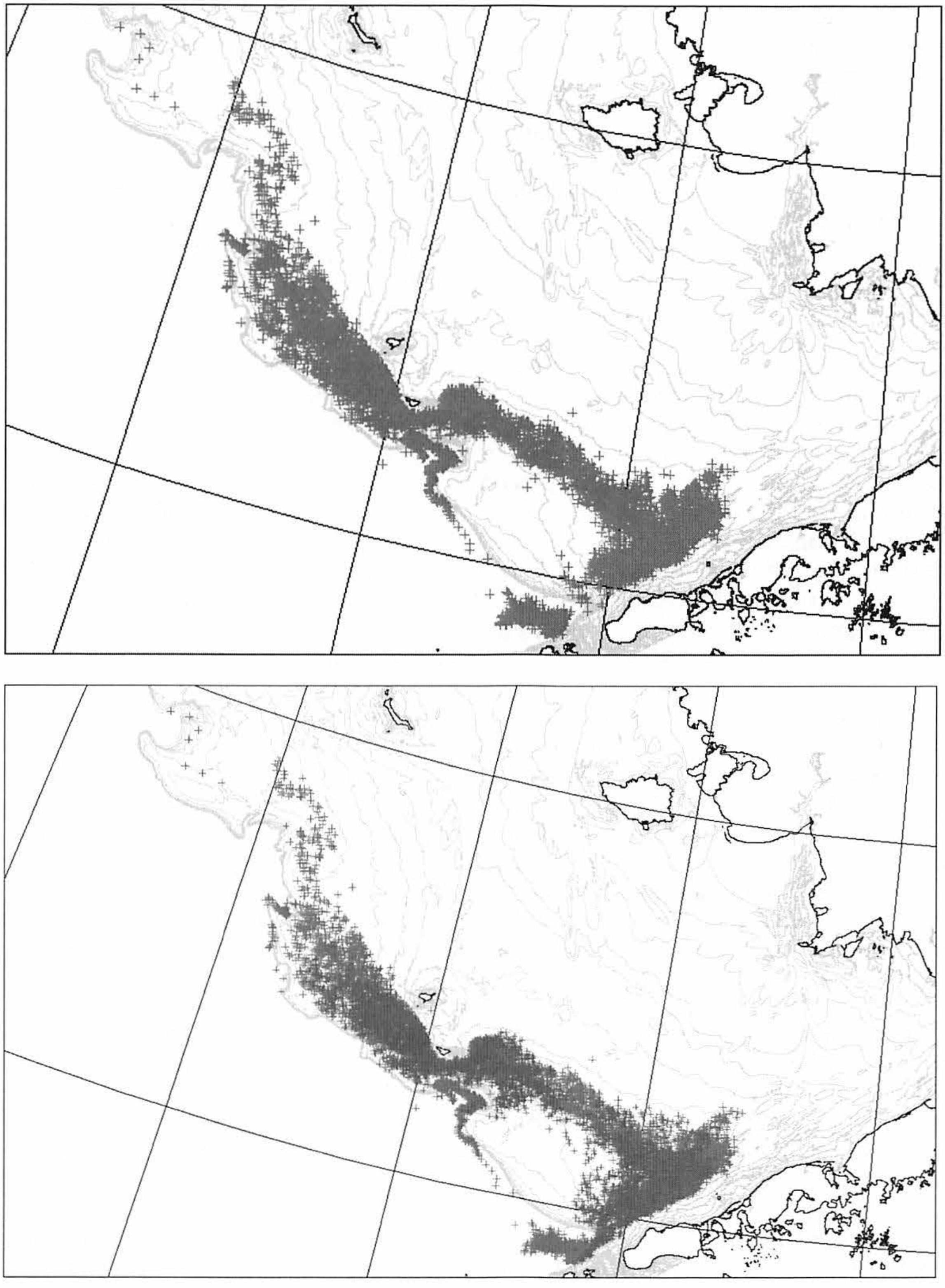
[1] A mothership and its catcher-vessels also integrate catching and processing activities, but the incentives in the mothership catcher-vessel IPA do not extend all the way down to the individual vessel.

Figure 8. Catcher-Processor A-Season Fishing Locations Before (Green 2007-10) and After (Blue 2011-12) Implementation of BSAI FMP Amendment 91.



Salmon Bycatch Research

The EBS pollock industry has supported research to reduce salmon bycatch for about ten years. During 2011 support was provided for research to improve the genetic baseline used to identify the stock of origin of chum salmon, and for efforts to develop a trawl-net section designed to reduce salmon bycatch. The design of the trawl-net section allows salmon caught by the trawl to swim free before the net is hauled back. A pelagic pollock trawl with the section installed is a salmon-excluder trawl.

Most but not all excluder-trawl development has been supported by the North Pacific Fishery Research Foundation via the development and execution of exempted fishing permits (EFP). The current EFP allowed research to proceed during the 2011 and 2012 pollock seasons. A final report on these activities is expected to be available during May, 2013.

Excluder-trawl trials during 2011 focused on measuring chum-salmon escapement using the excluder-trawl design developed during 2010. Trials were made using a catcher vessel and a high-horsepower, catcher-processor vessel. The most recent design places the excluder section just in front of the cod end where water flow (inside the net) is slowest. Prior designs placed the section more forward, where water flow is faster, in part due to the tapered shape of the net. Because chum salmon are not thought to be strong swimmers, it was believed that chum escapement rates from earlier designs (generally poor, less than three percent) could be improved upon with a revised design that would be easier for salmon to escape from. However, the trials did not reveal any improvement in chum escapement, with an average for all trials less than ten percent (but pollock escapement remained very low, about one-half of one percent).

The initial A-season trials occurred in an area with some intermittent Chinook salmon bycatch as well as reliable chum bycatch of between 30 and 100 fish. When Chinook were encountered, escapement averaged close to 40 percent, but chum escapement remained less than ten percent. The results reinforced conclusions drawn from video observations that chum and Chinook salmon behave differently inside the trawl and-or have different swimming abilities, or may react differently to escape path location. However, the EFP allowed for a total bycatch of just 125 Chinook for the A-season trials, and so research operations had to leave the area after making only eight trials. This limited the amount of data obtained about simultaneous Chinook and chum escapement.

Experimental fishing trials during the 2011 B-season were designed to investigate a modification of the excluder design that reduced somewhat the escape path. The hypothesis was that the change might allow slowly-swimming salmon to escape more frequently. The trials showed no change for both chum and pollock escapement. As no Chinook salmon were present where the trials were made, no information was obtained on whether the modification might affect Chinook escapement.

During 2011 the pollock industry also supported a research project to conduct a comprehensive gap analysis of deficiencies in genetic sample locations, sample sizes, and sample quality for Bering Sea and North Pacific Rim chum salmon populations. The project is headed by Dr. Tony Gharrett at the University of Alaska and the objective is to add genetic information for approximately 50 populations to the coast-wide genetic baseline for chum salmon. A second part of the project will develop new, single nucleotide polymorphism (SNP) markers to improve discrimination of coastal western Alaskan chum salmon, including lower Yukon River, Kuskokwim River, and Norton Sound populations.

If successful, the project will provide some new methods that may be used by NOAA Fisheries and Alaska Department of Fish and Game geneticists to detect and estimate the proportions of western Alaska chum salmon stocks taken in both directed and incidental fisheries. In particular, improved stock-of-origin estimates can be used to inform estimates of impacts of groundfish fisheries on chum stocks as well as provide temporal and spatial information that may be useful for forecasts of salmon abundance. This work is relevant to management of western Alaska chum salmon populations that support subsistence and commercial fisheries, and also should provide useful information about other North Pacific Ocean stocks of conservation and treaty interest.

Use of New Gear Technologies

Figure 9 shows the frequency with which the IPA vessels used Chinook salmon-excluder trawls during the 2012 fishery. While experimental trials have resulted in repeated escapements of 20-40 percent of Chinook bycatch with very low pollock escapement, it is nevertheless possible for pollock to escape the trawl, especially during periods when the trawl is short-wired. As such, some vessel captains remain somewhat reluctant to deploy salmon-excluder trawls exclusively, especially at times and places (e.g., early in the B-season) when there is evidence that Chinook abundance on the grounds is very low. During 2013 the CP IPA vessels will begin a program to confirm low pollock escapement during trawl haul-backs using video observations. This program may promote increased use of excluder-trawls.

Figure 9. Frequency of IPA Vessel Chinook Salmon-Excluder Trawl Use, 2012.