AGENDA D-3(a, b)
FEBRUARY 2010

MEMORANDUM

TO: Council, SSC and AP Members

FROM: Chris Oliver for
Executive Director

DATE: February 2, 2010

SUBJECT: Bering Sea Chum salmon bycatch

ESTIMATED TIME
8 HOURS
(All D-3 items)

ACTION REQUIRED

(a) Review of analytical methods for BS chum salmon bycatch analysis (SSC only)

(b) Review of new area closure options for chum bycatch alternatives Council & Everyone

BACKGROUND

(a) Review of analytical methods for BS chum salmon bycatch analysis (SSC only)

The Council is in the process of refining alternatives for analysis for chum salmon bycatch management measures. Currently these alternatives consider both transferable and non-transferable hard caps (fishery-wide and allocated by sector) and triggered time/area closures. Final refinement of alternatives will occur in June 2010 in order for staff to begin the analysis in the summer of 2010. Consideration of the data needs and methodological approach for this analysis is provided in a discussion paper attached as Item D-3(a)(1). This paper describes the available biological data for the forthcoming analysis, some consideration on fleet conditions and changes under the recent Chinook action (Amendment 91) and some of the analytical frameworks being considered for that analysis. Review and comment from the SSC is solicited at this meeting in order to provide for a more thorough review of the proposed analytical methodology in June in conjunction with the Council's refinement of the final alternatives for analysis.

Given that genetic information on chum stock of origin and data availability are a critical aspect to the proposed impact analysis, attached as Item D-3(a)(2) is a report on genetic analysis of the 2005 chum bycatch from the EBS pollock fishery. The results of this evaluation (in conjunction with other available bycatch data as described under Item D-3(a)(1)) will be incorporated into the chum bycatch analysis. Dr. Jeff Guyon of AFSC, Auke Bay Lab, will provide a presentation of this report and be available to answer questions on Monday.

(b) Review of new area closure options for chum bycatch alternatives

The draft alternatives for the chum salmon bycatch measures include two different alternative time/area triggered closure configurations. The first was developed by staff in 2008 with iterative review and modification by the Council while the second results from work following the December 2009 Council meeting per request for staff to develop new candidate closures. A discussion paper is attached as Item D-3(b)(1) which review the following information as it relates to alternative time/area closures: 1- the alternative closure already contained in the Council's draft suite of alternatives and its methodological approach; 2- new candidate area closures; 3-timing and trigger cap formulations and application related to area closures. The full Council motion on the chum salmon bycatch alternatives from December 2009 is attached to the discussion paper.

At this meeting the Council will review the candidate closures and trigger applications as described in this paper. The Council should refine alternatives as necessary and provide direction to staff for revisions to area options, trigger levels and applications as necessary to allow for final review and revisions to Alternative 3 in June 2010. At the June meeting the Council will refine its final set of alternatives for the chum salmon bycatch management measures analysis. Preliminary review of that analysis is scheduled for February 2011 with initial review in June 2011.

Chum salmon bycatch: analytical considerations

This paper provides an overview of the available data for potential use in the Council's upcoming chum salmon bycatch analysis, some specific considerations of current fleet conditions under implementation of Amendment 91, and some of the analytical frameworks, in relation to the potential data limitations, which might best address these limitations. A full review of the proposed methodological approach will be provided at the June 2010 SSC meeting. At the June meeting the Council will be refining draft alternatives in order to initiate the chum salmon bycatch analysis. Analysis by staff of the proposed alternatives is scheduled to begin in the summer of 2010. Preliminary review of the draft analysis is scheduled for February 2011 with initial review in June 2011.

Impact analysis elements

The recent impact analysis of Chinook salmon bycatch management measures (EIS for Amendment 91) was based on a retrospective approach that evaluated three aspects:

1) estimation of salmon 'saved' based on proposed sector/seasonal fishery constraints (i.e., hard-cap closures);
2) analogous potential forgone gross revenue by the pollock fishery; and
3) estimated change in bycatch impacts on adult equivalent (AEQ) returns in aggregate, and by regional river systems, to examine the biological and economic effects.

For the first two aspects (salmon saved and pollock forgone catch and revenue), a 5 year time frame was used. The most recent time frame at the time of the Chinook salmon analysis (2003-2007) was selected to best represent the current fleet, and biological, conditions. These years also have consistent reporting of bycatch data in the catch accounting system (CAS) by sector, which was necessary for that analysis. Fleet-wide and sector-specific constraints were then evaluated against the actual catch, by fleet and sector and by season over that time frame, to evaluate constraints that would be placed on the fishery by each of the alternatives. Chapter 3 of the EIS contains a detailed description of these calculations.

The third aspect, estimating adult equivalents via the AEQ model developed specifically for the Chinook salmon bycatch analysis, accounted for the fact that salmon bycaught in the pollock fishery were of different ages and hence had different impacts on adult salmon returns. Genetic stock composition estimates from bycatch during the 2005-2007 seasons were used to estimate AEQ mortality impact to individual regional river systems. Overall (i.e. aggregated) AEQ estimates were provided in addition to impacts broken out to the individual river systems in Western Alaska. Chapter 3 of the EIS contains a detailed description of these methods.

For chum bycatch analysis, several methods used for the Chinook analysis will require modification due to the characteristics of the chum salmon bycatch relative to fleet operations and data limitations.

Analytical time frame

A retrospective analysis over the more recent time frame is unlikely to reflect current fleet conditions. Specifically, amendment 91, which imposes a regulatory system of transferable Chinook bycatch caps on the fishery, with embedded incentive program agreements (IPAs), will modify fleet behavior. This program is due to be implemented in January 2011. Thus, by the time the initial review draft of the chum salmon bycatch analysis is available in June 2011, the first season (e.g. pollock A season) of operation under the new program will have occurred. A pilot program by catcher vessels may also be implemented voluntarily in 2010, and may provide additional information on fleet operations under the new system. It will be important to characterize operations under the Chinook program within the chum analysis in order to understand the impact of overlaying chum regulations on the existing, although quite new, Chinook bycatch regulations of Amendment 91.

In December 2009 the Council requested that industry participants develop these IPAs, in conjunction with the amendment 91 program, and provide staff with written details of the proposed program by mid-March of 2010. This request is designed to provide information useful for evaluating potential future management modifications in the context of the chum bycatch analysis.

Analysts are considering characterizing impacts of chum bycatch management alternatives by evaluating a range of scenarios of assumed bycatch and fleet dynamics. These scenarios would evaluate historical patterns within the fleet and categorize vessels according to their historic chum salmon bycatch amounts. The analysis could compare characteristics of high performers (i.e., those with low bycatch rates) with low performers (i.e. those with high bycatch rates) and evaluate the consequences of proposed management measures on each based on assumed spatial-temporal chum salmon bycatch patterns and observed performance history. Such fleet behavior modifications, in terms of higher and lower directed catch rates of pollock and bycatch rates of chum salmon, may characterize responses to existing proposed IPAs. This contrasts with the retrospective analysis (over a fixed time-frame) done for Chinook salmon bycatch and may be preferred, in this case of chum salmon bycatch, since it would account for likely changes in fleet behavior resulting from Chinook salmon bycatch management. Alternatively a retrospective analysis could be repeated, and possibly contrasted with the one season of actual observed behavior under the Amendment 91 regulations.

Adult equivalency analysis

The analysis will need to account for impacts on adult equivalent numbers of returning salmon (potential spawners) due to bycatch in the pollock fishery. The table below shows the main data requirements in developing an AEQ model for chum and a relative indication of the availability of such data. Additional biological needs for the impact analysis are then summarized further below.

Data	Availability	Other issues
Bycatch and pollock catch data (spatial and temporal) by sector	Yes	Time frame:
		1991-present (some CDQ data limited in early years)
		2003-present (more consistent treatment by sector)
Age data	Some	Time frame:
		1988-2005 [being processed, but available Spring 2010]
		2006-2009 [possible]
		Length at age data for Bering Sea [should be available in conjunction with age-data over same time period]
Maturity data	Some rivers?	Proxy available?
Stock of origin	Some	Time frame:
		2005, 2009 [to be available June 2010]
		[2006 available Oct 2010, 2007-2008 available Dec 2010]
		1994, 1995 [published reports]
Other data needs (not necessarily for AEQ):	**Availability**	**Other issues**
Run size estimates	Some	Insufficient, in aggregate, to develop appropriate comparisons with stock of origin breakouts (e.g., WAK aggregate)
Oceanic abundances by region	Modeled (Mantua et al. 2009)	Estimates may serve as background over time (run size estimates to regions, possible with estimates of stock composition uncertainty)

Main limitations:

Bycatch stock of origin availability:
A report to the Council by Guyon et al. (2010) reviews the chum salmon genetic information, limitations given current sampling and genetic data availability, and estimates of genetic origin of chum salmon bycatch in the pollock fishery in 2005. Genetic data for chum salmon bycatch from 2005 and 2009 will be available to analysts by June of 2010. Additional years of data (2006-2008) are anticipated to be available in October (2006 data) and December (2007-2008 data) of 2010. Additionally, some data from 1994-96 may be available from published reports.

Aggregate level impact analysis:
Evaluation of impacts of returning adult chum salmon must be consistent with the genetics information available at this time. Stock of origin will be aggregated for most western Alaska stocks according to genetic data as presented in Guyon et al., 2010 (i.e., three groups: Upper/middle Yukon, the Alaska Peninsula, and then one aggregate Western Alaska grouping of the remaining WAK stocks). Thus impacts of chum salmon returning to individual streams in western Alaska will not be estimated. As a

result, and directly due to limitations of chum salmon genetic information, some of the comparative information that was included by river system in the Chinook EIS (i.e., comparison of AEQ estimates by year with commercial, subsistence and sport catches) is not possible in the chum salmon analysis.

Proposed approaches for AEQ impact analysis:

Unlike the Chinook salmon analysis, broad oceanic estimates of chum salmon abundances by region and in-river runs have been modeled, and estimates (with uncertainty) are available that may help provide a backdrop for potential sources of chum bycatch (Mantua et al. 2009; Nathan Taylor pers. comm.). This model, called the "Model for Assessing Links Between Ecosystems" (MALBEC), is designed as a policy gaming tool with the potential to explore the impacts of climate change, harvest policies, hatchery policies, and freshwater habitat capacity changes on salmon at the North Pacific scale (Mantua et al. 2009; Mantua et al. 2007). The model apportions run reconstructions, as depicted in Figure 1, to oceanic regions (Figure 2) and estimates are available over time (Figure 3). The MALBEC model may also provide some insight on plausible oceanic survival rates for chum salmon. The approach for the chum salmon AEQ analysis will, at a minimum, use an estimated mean difference in age of chum taken as bycatch and chum returning to rivers to derive a crude estimate of the impact of chum salmon bycatch to all rivers in aggregate. Depending on the extent and availability of age data, bycatch length frequencies recorded by observers will be used to estimate the seasonal and area age composition information and used to refine estimates of AEQ values for chum salmon.

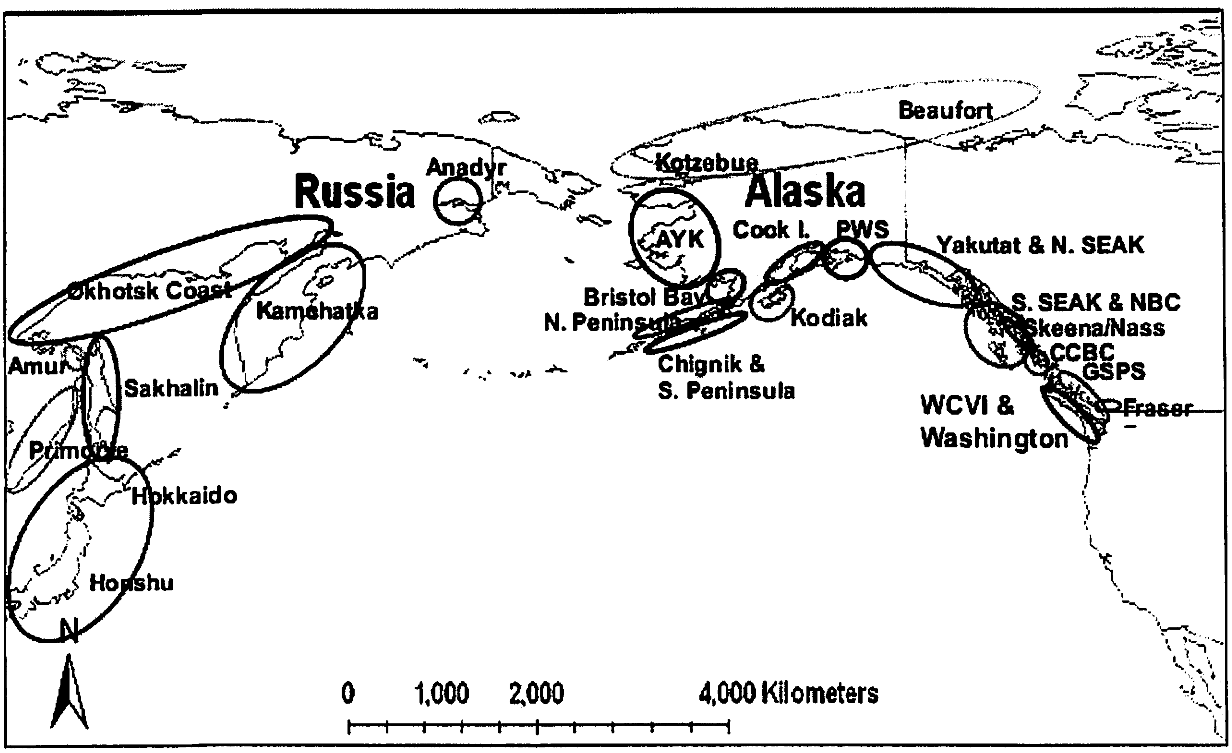

Figure 1. The approximate geographic locations of regional stock groups used in MALBEC. Stock groups are listed in Table 1. Korea is not shown. AYK= Arctic-Yukon-Kuskokwim CCBC=Central Coast British Columbia, GSPS=Georgia St. (BC) & Puget Sound (WA), PWS= Prince William Sound, SEAK=Southeast Alaska, WCVI=West Coast Vancouver Island (BC). *From Mantua et al. 2009.*

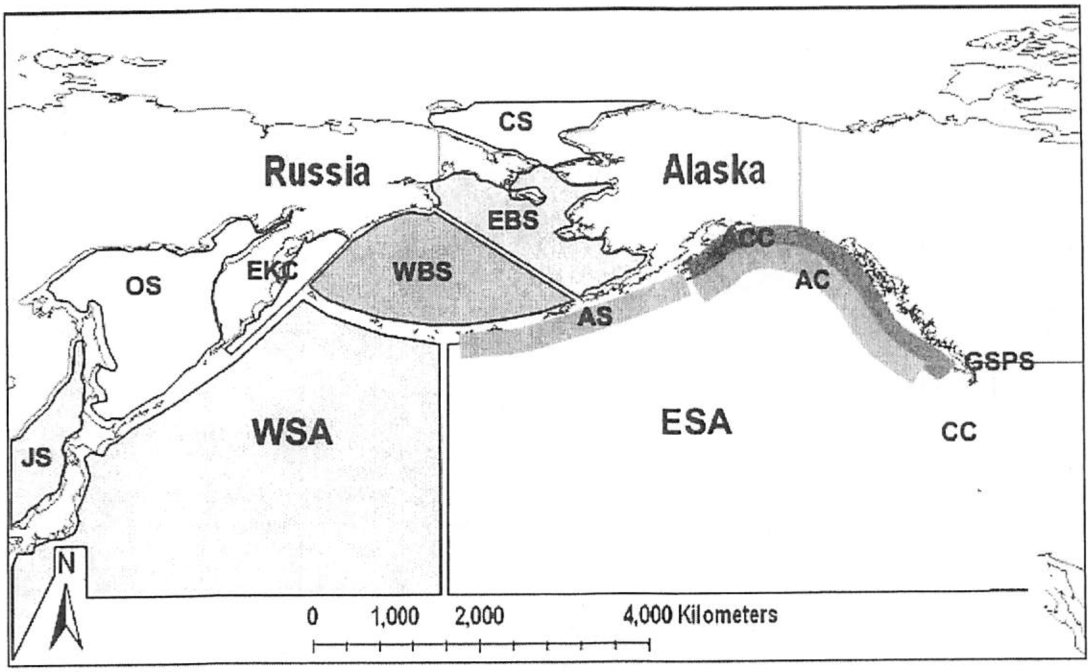

Figure 2. Extent of spatial dis-aggregation of the MALBEC model estimates of abundances of chum salmon from different river systems around the North Pacific (from Mantua et al. 2009). AC = Alaska Current, ACC = Alaska Coastal Current, AS = Alaska Stream, CC = California Current, CS = Chukchi Sea, EBS = Eastern Bering Sea, EKC = Eastern Kamchatka Current, ESA = Eastern Sub-Arctic, GSPS = Georgia St. & Puget Sound, JS = Japan Sea, OS = Okhotsk Sea, WBS = Western Bering Sea, WSA = Western Sub-Arctic.

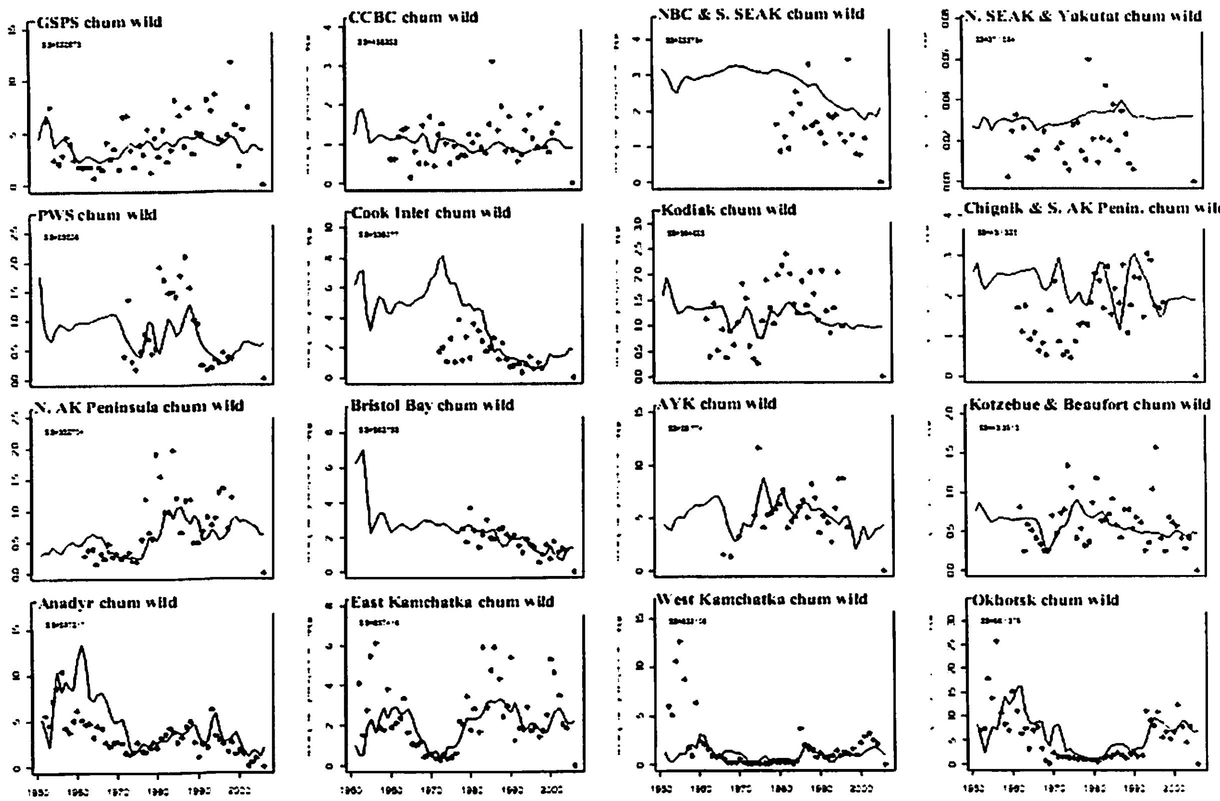

Figure 3 Model fit to total run size for wild chum salmon. *From Mantua et al. 2009.*

References

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Report to the North Pacific Fishery Management Council

Genetic Stock Composition Analysis of Chum Salmon Bycatch Samples from the 2005 Bering Sea Groundfish Fishery

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Introduction

The Bering Sea provides habitat for chum salmon from many populations throughout their geographic range during their residence in the marine environment (Abe et al., 2007; Friedland et al., 2001). In some years, large numbers of chum salmon are incidentally caught as bycatch in the Bering Sea trawl fishery for walleye pollock (Stram and Ianelli, 2009; Witherell et al., 2002). When escapement of chum salmon in several western Alaska areas declined in the early 1990s (Eggers, 1995), the incidental chum salmon harvest in the trawl fishery became of concern. This led to changes in the management of that fishery (Ackley, 1997) and the first genetic stock identification analyses of chum salmon bycatch. It was during this time that many fishery agencies worked to develop coastwide genetic baselines that could be used to estimate the stock contributions to mixtures of fish such as chum salmon (Seeb et al., 1995). The Auke Bay Laboratory analyzed samples from three years in the mid-1990s to estimate the regional contribution of chum salmon stocks to the bycatch. More recently, numbers of chum salmon caught as bycatch in the Bering Sea groundfish fishery have increased to a high of over 700,000 fish in 2005. This report presents preliminary genetic stock identification results for a subset of samples collected in 2005.

The first genetic analysis of chum salmon bycatch was completed for the 1994 and 1995 summer/fall B-season walleye pollock fishery (Wilmot et al., 1998). This study used a genetic baseline of 77 populations surveyed for 20 allozyme loci. Based on a sample set of 457 chum salmon caught in the 1994 B-season pollock fishery, the stock composition of the chum salmon samples was partitioned to Asia (39-55%), western Alaska (20-35%), and southeast Alaska, British Columbia, and Washington (21-29%). Based on a larger sample set of 1,853 chum salmon harvested from the 1995 "B" fishery (11% of the total bycatch), stock estimates were partitioned to Asia (13-51%), western Alaska (33-53%), and southeast Alaska, British Columbia, and Washington (9-46%). The range of estimates reflects differences in the stocks present during different time periods and areas of capture in the fishery.

The second genetic analysis was completed by the Alaska Fisheries Science Center's Auke Bay Laboratory for the 1996 groundfish fishery (Seeb et al., 2004). In this analysis, a baseline representing 356 populations assayed for 20 allozyme markers was used. Nearly 3,000 chum salmon were collected from the eastern fishing districts, where approximately half of the catch in the 1996 B-season fishery occurred. The stock composition estimates for this section of the fishery were partitioned to Asia (30%), western Alaska (16%), Alaska Peninsula, Prince William Sound, and Kodiak (12%), and southeast Alaska, British Columbia, and Washington (42%).

In addition to these genetic analyses, two studies examined scale patterns to investigate the contribution of stocks to the chum salmon bycatch. In one study, scale analysis was used to age chum salmon from the 1993 B-season bycatch (Myers et al., 1994). The proportion of ages represented were 0.2 (22%), 0.3 (65%), 0.4 (12%), and 0.5 (1%). While a specific stock composition analysis was not completed for that particular study, many characteristics showed stratification of chum stocks in the Bering Sea including (1) reduced amount of growth in the 3rd year (a characteristic of Asian fish), and (2) differences in age of the affected fish based on the month and area in which fish were collected. In the second study, a scale pattern analysis (SPA) was used to estimate the stock composition of the 1994 chum bycatch. Based on SPA of 1,204 age 0.3 fish, the stock estimation of the sample set was partitioned to Asia (50%), western and central Alaska (18%), and SE Alaska, British Columbia and

Washington (32%) (Patton et al., 1998). As in the genetic studies, the stock composition estimates from SPA varied by date and statistical area.

Presented below are stock composition estimates for a subset of chum salmon bycatch samples from the 2005 Bering Sea groundfish fishery. This is the first analysis of chum salmon bycatch samples that utilizes DNA-based genetic markers. Genetic samples of the chum salmon bycatch were collected in 2005 from the North Pacific groundfish fishery as part of a Special Project. A subset of these samples, supplemented with available scales, was used for an Arctic/Yukon/Kuskokwim Sustainable Salmon Initiative (AYKSSI) funded project to determine the spatial and temporal distribution of chum salmon in the Bering Sea. Four distinct areas in the eastern Bering Sea were identified such that samples within those areas could be pooled and stock composition estimates compared. Whereas potential sample biases within the genetic samples of the bycatch are well documented (Pella and Geiger, 2009), the samples analyzed for the 2005 study were specifically selected with regard for their spatial and temporal distributions rather than by quantity of overall bycatch. With that caveat, a subset of over a thousand 2005 samples was analyzed and the resulting stock composition estimates were similar to those produced previously using allozymes or scale pattern analysis. Despite the issues associated with sample collection bias, the analysis of the 2005 chum bycatch samples provides a rough measure of stock distribution, and at a minimum, provides an indication of the presence and/or absence of specific stocks.

The goal of this report is to present a stock composition estimate for the 2005 AYKSSI chum bycatch samples, but it is important to understand the limitations for making accurate estimates of the entire bycatch imposed by the sampling protocols and the genetic baseline. Hence, this report is divided into three main sections. First, the sampling protocols are documented and the distribution of the AYKSSI genetic samples is compared to the overall chum bycatch (designated as non-Chinook in the NMFS database as chum salmon comprise over 99.6% of the total non-Chinook bycatch (NPFMC, 2005)). Second, the efficacy of the microsatellite DNA baseline is evaluated using principal coordinate analyses based on genetic distances, simulation studies of hypothetical mixtures, and the available phylogenetic trees. Finally, stock composition estimates are provided as a composite of all available samples as well as from three distinct time periods to determine if there continues to be a temporal effect on the composition of the bycatch.

Methods

Sample collection and DNA isolation

All samples were collected by the Alaska Fisheries Science Center's (AFSC) North Pacific Observer Program as part of either a Special Project (designated "Salmon Genetic Project" in 2005) for the Auke Bay Laboratory for genetic analysis (axillary processes) or for species identification/aging purposes (scales) (Figure 1, Table 1). Axillary processes and scales for aging were collected opportunistically throughout the season and stored in coin envelopes which were labeled, frozen and shipped to the Auke Bay Laboratories. Scales for species identification were collected in coin envelopes and shipped to the AFSC's Fisheries Monitoring and Analysis Division for storage and analysis. DNA was extracted from the axillary processes and scales into 96-well plates with either the QIAGEN DNeasy Blood and Tissue Kits or Corbett X-tractor Gene reagents as described by the manufacturer (QIAGEN, Inc.)[1]. Extracted DNA had a final concentration of approximately 10-25 ng/ul (scales slightly less than axillary process tissue) and was stored at -20 °C.

Data acquisition

Genotypes were obtained for 11 microsatellite DNA markers. First, 1 uL of a 1:4 dilution of extracted DNA was transferred to 384-well plates.[2] Then, the microsatellite loci were polymerase chain reaction (PCR) amplified in four multiplexed panels. Each PCR reaction was conducted in a 5 ul volume containing the template DNA, QIAGEN Multiplex PCR Mastermix, 0.2 uM of each primer, and RNase-free water. Primer sequences for the 11 loci have been described in the following publications: *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* (Banks et al., 1999), *Otsg68* (Williamson et al., 2002), and *Ssa419* (Cairney et al., 2000). Thermal cycling for the PCR was performed on a dual 384-well GeneAmp PCR System 9700 (Applied Biosystems, Inc.) with the following protocol: initial denaturation at 95°C for 15 minutes, then 33 cycles at 94°C for 30 seconds, 60°C for 1.5 minutes, and polymerization at 72°C for 1 minute, followed by a final polymerization step at 60°C for 30 minutes and then storage at 15°C until removal from the thermocycler.

Samples from the PCR reactions were diluted into 96-well plates for analysis with a 16-capillary, 36 cm array on the ABI 3130xl Genetic Analyzer as follows: 1 ul diluted (1:25) PCR product, 4.4 ul Hi-Di formamide, 4.4 ul ddH2O, 0.2 ul LIZ 600 size standard (Applied Biosystems, Inc.). Samples were denatured for 3 minutes at 95°C, then cooled to 4°C and stored until analysis on the 3130xl. Genotypes were identified with GeneMapper software (Applied Biosystems, Inc.) and exported to Excel spreadsheets (Microsoft, Inc.) for further analysis.

Baseline and mixture conversion to SPAM and BAYES formats/stock composition analysis

Baseline allele frequencies were downloaded from the Division of Fisheries and Oceans Canada (DFO) Molecular Genetics web page (http://www-sci.pac.dfo-mpo.gc.ca/mgl/data_e.htm) and a SPAM (ADFG, 2003) baseline file was created within Excel. To generate the BAYES baseline, a program was written in C to convert the allele frequencies into allele counts for the BAYES format. For the mixture files, allele designations were converted to match those in the baseline. Compatibility of our allele designations to the DFO baseline was confirmed with a set of samples from the DFO Molecular Genetics Lab that were analyzed on the Auke Bay Laboratory's Applied Biosystems 3130xl Genetic Analyzer. Lookup tables were generated within Excel to convert our allele calls to match those in the DFO baseline. Genotypes from converted mixtures were then exported from Excel as text files and C programs were used to format the data into both SPAM and BAYES mixture files. Stock composition analysis was performed with both the SPAM and BAYES software by using previously published procedures (ADFG, 2003; Pella and Masuda, 2001).

Principal coordinate analysis (PCO) and baseline evaluation

The baseline was examined to determine major regional groupings of populations that would then be used for stock identification analyses of the chum salmon mixtures. Larger reporting groups were used to increase estimation accuracy and to compare estimates with those from previous studies. Population genetic structure was examined in three ways. First, population groupings were evaluated

[1] Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.
[2] Most liquid handling steps were performed with a Perkin-Elmer Janus AJL8M01 Robot.

based on the published neighbor-joining dendrogram of Cavalli-Sforza and Edwards chord distances (Beacham et al., 2009b). Second, Nei's genetic distance was calculated in the software NT-SYS (Applied Biostatistics, Inc.) from the allele frequencies of the baseline populations. Population structure was examined using a principal coordinate analysis (PCO) and resulting eigenvalues were plotted in 3-dimensional graphs. Third, baseline simulation studies were performed to evaluate the effectiveness of the baseline to allocate stocks to the correct regions. Three different types of simulation tests were performed with SPAM software (Version 3.7) by using hypothetical mixtures of 400 fish containing either 100%, equal or selected stock proportions as described in the text. In these simulations, the hypothetical mixtures were derived from the appropriate regions and then re-evaluated with the baseline to determine the percentage that reallocated back to the correct region.

Understanding the quality of the samples for the purpose of determining stock composition

Stock identification results presented in this report are from a subset of samples collected from the 2005 chum bycatch that was specifically selected for an AYKSSI project to address the spatial and temporal distributions of chum salmon in the Bering Sea rather than provide an overall stock composition estimate of the bycatch. Because the sampling was not proportional with the bycatch, there may be bias in the overall stock composition estimate of the chum salmon bycatch for reasons of variable spatial and temporal sampling rates. In total, 1,084 samples were genetically analyzed from a total chum bycatch of 705,963 fish, which is an overall sample rate of 0.15%.

For the AYKSSI project, samples from four regions were selected to examine possible temporal and spatial differences (Figure 1, Table 1); however, they were not in proportion to the total catch throughout the season. Potential temporal biases in the AYKSSI sample set are observed as differences in proportionality to the catch (Figure 2). For example, the peak of the bycatch was in statistical weeks 30-32 (Figure 2, top panel), while the majority of samples analyzed for stock composition were taken in statistical weeks 25-27 and 36-38 (Figure 2, bottom panel), on the shoulders of the primary take in the bycatch. Later, we present a stock composition estimate for the entire set of genetic samples analyzed as well as composition estimates for subsets of samples taken over time to determine the significance of temporal sampling on the composition estimate.

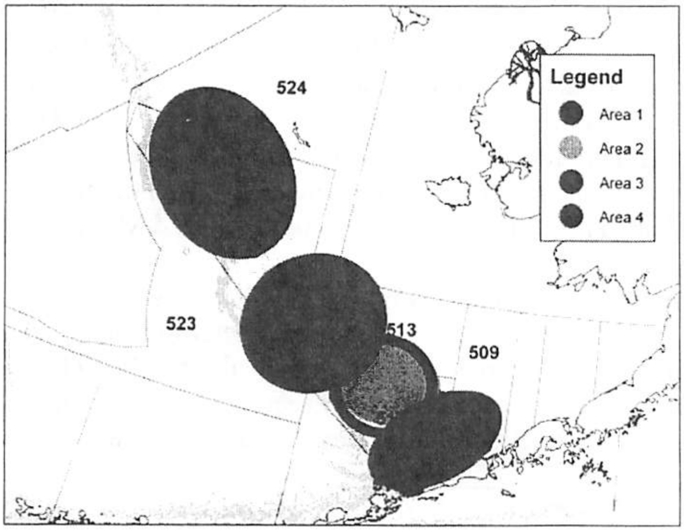


Figure 1. The salmon bycatch areas used in the AYKSSI project to determine the spatial distribution of chum salmon in the Bering Sea. The open circle designates the area of highest chum bycatch in 2005 (NPFMC Bering Sea Chum salmon discussion paper, October 2008).

Table 1. Total number of analyzed genetic samples from the 2005 chum salmon bycatch grouped by areas designated in the AYKSSI project.

Area	Total
1	394
2	170
3	190
4	330
Total	1084

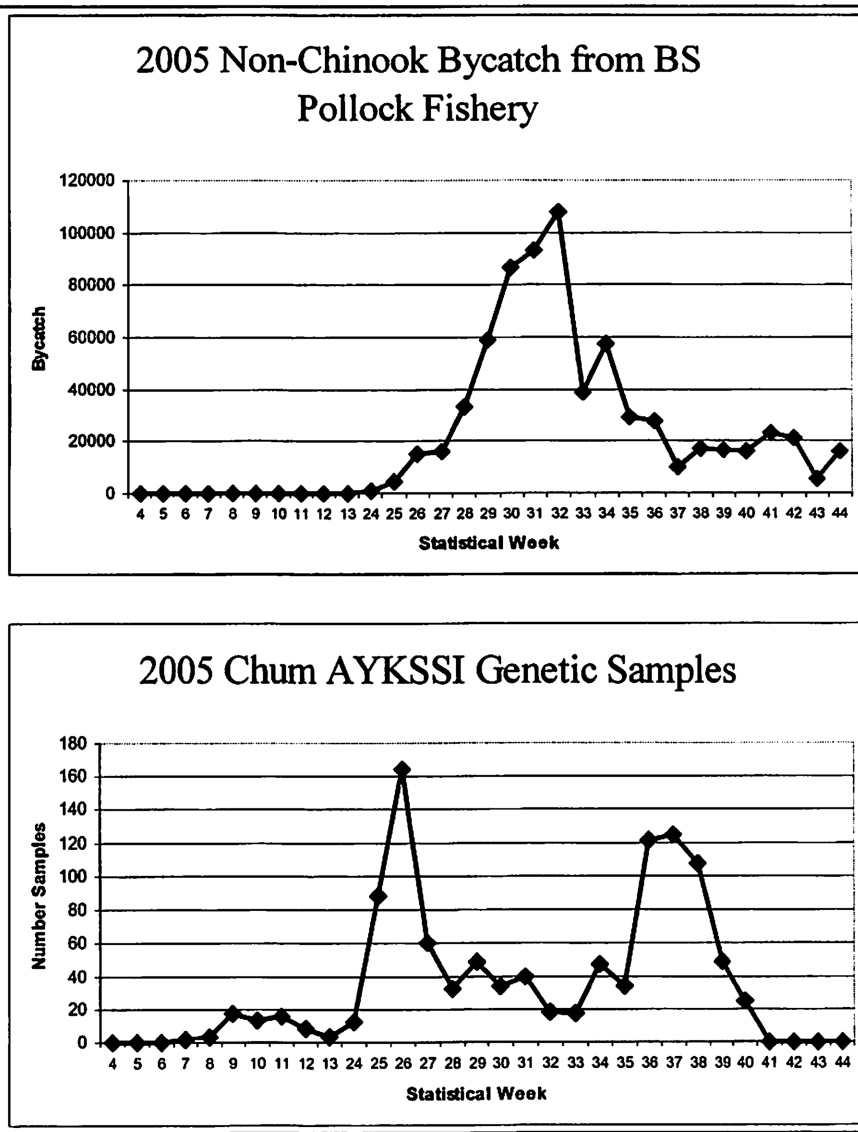


Figure 2. 2005 chum salmon bycatch and AYKSSI genetic samples graphed by statistical week. Total number of chum bycatch (top panel) compared with the AYKSSI samples genotyped from the 2005 bycatch (bottom panel).

In addition to a temporal stratification, samples were also selected for the AYKSSI project for evaluating stock differences within the four specific areas of the Bering Sea, three of which are outside the area of peak chum salmon bycatch in 2005 (Figure 1, compare circle with AYKSSI sample areas). Only AYKSSI Area 2 closely coincides with the peak bycatch location, suggesting that stock composition estimates for that one area could be more representative of the overall bycatch than the composition estimate from all four areas. In the selected AYKSSI sample set for 2005, the smallest number of genetic samples came from Area 2 (Table 1). This combination of potential spatial and temporal biases can be visualized in the AYKSSI sample set by plotting the numbers of samples collected per area per week (Figure 3). The peaks highlight the temporal and spatial groupings that can be compared in the AYKSSI project. For example, Areas 1, 3, and 4 can be compared for weeks 35-38 to examine spatial distribution, while Area 1 can be compared for weeks 25-28 and weeks 35-37 to examine temporal distribution. Results from the AYKSSI project are anticipated in the spring of 2011. In contrast to the 2005 AYKSSI samples, genetic samples collected for the analysis of the 2006-2009 chum bycatch were not subsampled, although significant bias in those sample sets may still exist (Pella and Geiger, 2009) highlighting the need for representative sampling for future analyses. Potential biases in the 2005 AYKSSI sample set indicate that care should be taken when interpreting overall bycatch stock composition results with these samples, but, at a minimum, the presence or absence of specific stocks can be identified.

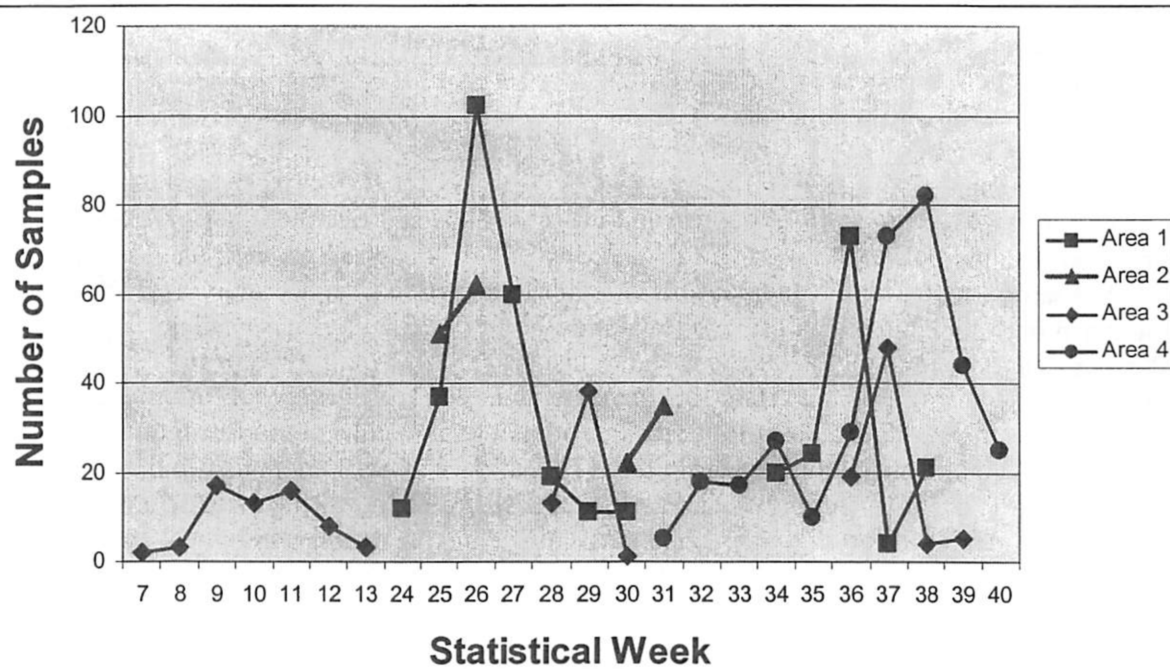


Figure 3. AYKSSI chum salmon bycatch genetic samples grouped by statistical week and area.

Evaluation and adequacy of the baseline

A microsatellite DNA baseline representative of chum salmon populations from throughout the entire Pacific Rim has recently been published, is available for anonymous download, and has been selected for the analysis of the 2005 AYKSSI chum bycatch samples. This baseline contains 381 populations of chum salmon (see Appendix 1 for stream origins) assayed for 14 microsatellite markers (Beacham et al., 2009b). For our analysis, 11 of the markers were used: *Oki100, Omm1070, Omy1011, One101, One102, One104, One114, Ots103, Ots3, Otsg68,* and *Ssa419*; while *Oki2* and *One111* may be available in future analyses, pending optimization. Attempts to optimize the final loci, *Oke3*, have been unsuccessful.

To determine the ability of the 11 microsatellite markers to discriminate population structure, two different descriptive analyses were used. First, regional groupings were approximated using the published neighbor-joining dendrogram of Cavalli-Sforza and Edwards chord distances (Beacham et al., 2009b). Second, PCO was used based on Nei's genetic distance calculated from the allele frequencies of the baseline populations. By using all 381 populations in the baseline, PCO showed one population to be much different from the others (Sturgeon River on Kodiak Island) and it was excluded from further analysis to better highlight regional separations (Figure 4), although it was retained in the baseline in the Alaska Peninsula region for the stock composition analyses.

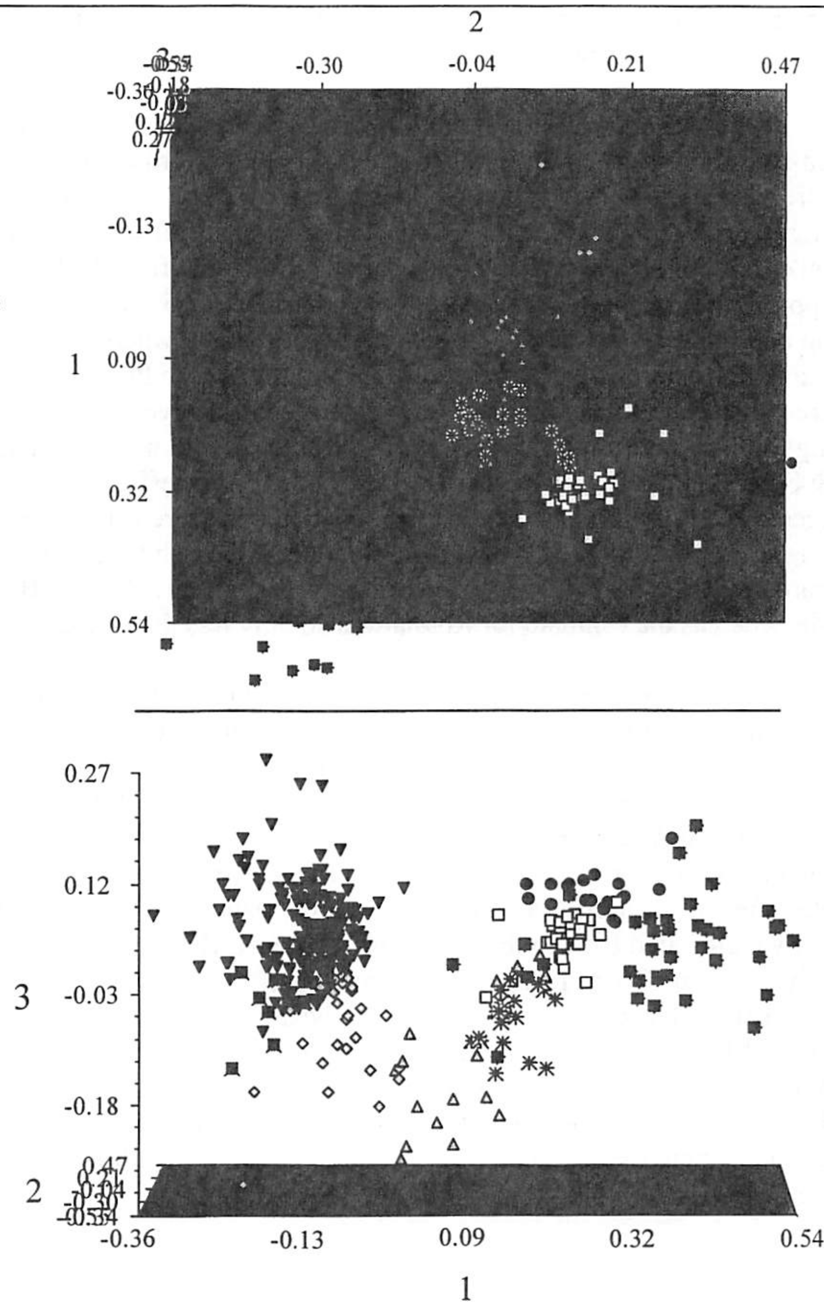


Figure 4. Principal coordinate analysis of 380 chum populations analyzed for 11 microsatellite markers. Eigenvalues were plotted in 3 dimensional space with "1" being the most informative (55.0%), "2" the second most (25.7%), and "3" the least (9.7%). Top panel shows dimensions 1 and 2 (most informative), bottom panel shows dimensions 1 and 3. Populations are designated with the following symbols: Japan/S. Russia (green plus signs), Russia (stars), Upper/Middle Yukon (red circles), Western Alaska (yellow squares), Alaska Peninsula (light blue triangles), Southeast Alaska/Northern BC (light green diamonds), British Columbia/Washington (purple down-triangles), and Skeena (magenta crosses).

From the PCO and the neighbor-joining dendrogram, the following eight regional groupings were apparent: Russia, Japan/Korea/China/S. Russia (designated "Japan/S. Russia"), Upper/Middle Yukon, coastal western Alaska (designated "Western Alaska"), Alaska Peninsula, SE Alaska/Prince William Sound/N. British Columbia (designated "SE Alaska/N. BC"), Skeena, and British Columbia/Washington (designated "BC/Washington"). Most regional groupings were clearly delineated although some were more distinct than others. For example, the Skeena region is a small group of populations that clusters on the neighbor-joining tree, but it is hard to discriminate in the PCO from the other British Columbia stocks, whereas the Upper/Middle Yukon stocks are clearly distinguishable from the Western Alaska stocks (which includes the lower Yukon). These 8 regional groupings were used for all further analyses in this report. The individual populations and the associated groupings are identified in Appendix 1.

To evaluate the ability of the 11 markers to effectively separate the 8 regional groupings in mixed-stock analyses, three simulation studies were performed in which fish from a hypothetical mixture were partitioned back to their respective regions. All simulations were performed with SPAM software. In the first simulation, an equal number of fish from each region (or 12.5% from each region) were used generate a hypothetical mixture of 400 fish. If this mixture correctly reallocates to the appropriate regions, each region would contribute 12.5% of the total. Four regions allocated to within one standard deviation of the known contribution, whereas the BC/Washington and Western Alaska regions were slightly overestimated and the Alaska Peninsula and Skeena regions were slightly underestimated (Figure 5, top panel). Previous studies have shown that many chum salmon in the Bering Sea originate from Japan/S. Russia, Russia, Western Alaska, and BC/Washington (Patton et al., 1998; Seeb et al., 2004; Wilmot et al., 1998). To test the efficacy of the baseline to distinguish between these four regional groupings, a simulated mixture was analyzed containing 25% from each of these four regions. Simulation estimates reallocate the fish back to their respective region within one standard deviation of the expected contribution for Western Alaska, BC/Washington, and Japan/S. Russia, whereas the estimate for Russia was slightly less than expected (Figure 5, bottom panel).

As a final measure of the ability of the baseline to discriminate the eight individual regions, 100% simulation studies were completed in which all samples of a hypothetical mixture were from one region and that mixture was re-evaluated against the baseline to determine the percentage reallocating back to the correct region. This analysis was completed for all 8 regions (Table 2). Upper/Middle Yukon, Western Alaska, BC/Washington, Skeena, and Japan/S. Russia all allocated back to the correct region with 87-96% accuracy whereas 83% correctly reallocated to the Russia region (5% misclassified to Western Alaska), 82% correctly reallocated to the Alaska Peninsula region, and 77% correctly reallocated back to the Southeast Alaska/N. BC region (17% misclassified to BC/Washington). These results corroborate those from the previous simulation studies (Figure 5) and suggest that stock composition estimates derived from the use of this baseline may overestimate the numbers of BC/Washington fish and underestimate the numbers of fish from the Alaska Peninsula and SE Alaska/N. BC, two areas with relatively small contributions to the overall bycatch (Patton et al., 1998; Seeb et al., 2004; Wilmot et al., 1998). The overestimation of the BC/Washington region may be due to the increased variability in that large group of populations (see PCO analysis, Figure 4).

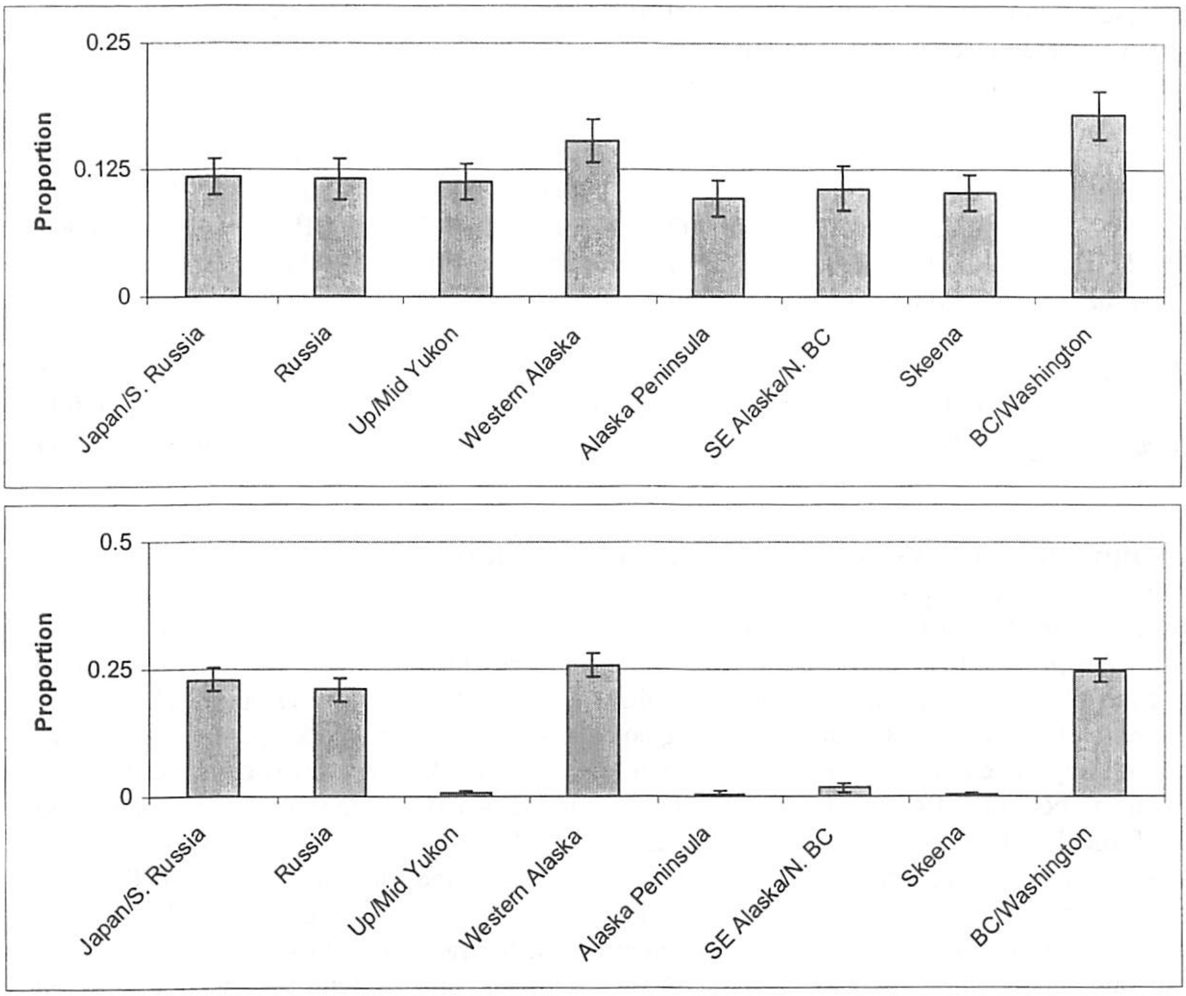


Figure 5. Baseline evaluation - results from mixed stock simulation experiments. Mixtures of fish were derived from equal proportions of all regions (top panel) and for only the Western Alaska, BC/Washington, Japan/S. Russia, and Russia regions (bottom panel). Stock compositions of the hypothetical mixtures were allocated back to the region with SPAM software based on the characteristics in the genetic baseline. Standard deviations are shown for all estimates.

The simulation results indicate that the characteristics in the 11 marker microsatellite genetic baseline describe relatively strong population structure suitable for use in performing stock composition estimates from stock mixtures, especially those that contain chum salmon originating from regions encompassing the entire Pacific Rim. In addition to the eleven microsatellite markers used in our study, the published microsatellite baseline contains an additional three loci that, if optimized, may improve estimation accuracies. Additionally, at least two other genetic baselines are currently being developed, both of which utilize single nucleotide polymorphism (SNP) markers. Once reviewed, published, and made publicly available, those baselines may be used in future analyses if found to be more effective in identifying stock origins.

Table 2. Results from simulation studies in which 100% of a hypothetical mixture of 400 fish was derived from one region (columns) and reallocated back to the region (rows) with SPAM software. The fraction of fish from each region is designated.

Region	*Japan*	*Russia*	*U. Yukon*	*W. AK*	*AK Penn*	*SE AK*	*Skeena*	*BC/Wash*
Japan/S.Russia	**0.873**	0.041	0.001	0.003	0.015	0.005	0.001	0.002
Russia	0.036	**0.835**	0.002	0.009	0.047	0.019	0.002	0.005
Upper/Middle Yukon	0.000	0.002	**0.934**	0.010	0.001	0.000	0.000	0.000
Western Alaska	0.008	0.055	0.059	**0.960**	0.040	0.005	0.001	0.002
Alaska Peninsula	0.002	0.007	0.000	0.004	**0.819**	0.010	0.002	0.002
SE Alaska/N. BC	0.003	0.010	0.000	0.002	0.029	**0.770**	0.039	0.038
Skeena	0.000	0.001	0.000	0.000	0.002	0.009	**0.874**	0.007
BC/Washington	0.013	0.034	0.001	0.008	0.040	0.173	0.078	**0.936**

Stock composition analyses, including temporal trends

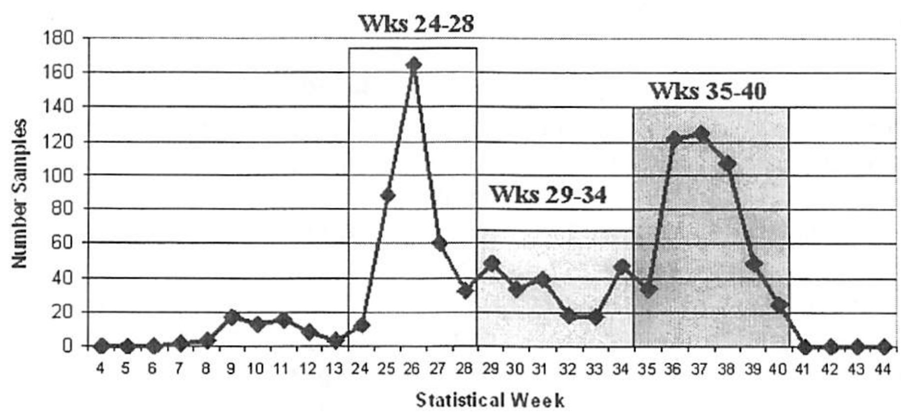
Stock composition analysis of all samples

Stock origin of the 1,084 genetic samples (genotyped for 11 microsatellite markers) was determined to be primarily of Asian origin, while the most represented fish from North America were primarily from Western Alaska and British Columbia/Washington (Table 3). The samples had relatively complete data with 787 samples missing no data, 44 missing one marker, 246 missing two markers, 2 missing three markers, and 5 missing four markers. Stock composition estimates were derived by using both the SPAM and BAYES software and yielded almost identical stock composition estimates (Table 3). BAYES software uses a Bayesian algorithm to produce stock composition estimates and can account for missing alleles in the baseline (Pella and Masuda, 2001), something considered critical for microsatellite baselines with loci containing multiple alleles derived from a limited number of samples from each baseline population. In contrast, SPAM uses a maximum likelihood approach in which the mixture genotypes are compared directly with the baseline. Although Version 3.7 of the SPAM software allows Bayesian modeling of baseline allele frequencies, these

Table 3. Regional SPAM and BAYES stock composition estimates for the 1,084 chum salmon samples from the 2005 AYKSSI sample set. SE is the SPAM standard error. SD is the BAYES standard deviation. The 95% credible interval is provided for all BAYES estimates.

Region	**SPAM Estimate**	**SE**	**BAYES Mean**	**SD**	**2.50%**	**Median**	**97.50%**
Japan/S. Russia	**0.281**	0.009	**0.292**	0.015	0.264	0.292	0.322
Russia	**0.253**	0.008	**0.289**	0.018	0.255	0.289	0.325
Upper/Middle Yukon	**0.057**	0.002	**0.052**	0.010	0.034	0.051	0.074
Western Alaska	**0.166**	0.005	**0.162**	0.015	0.132	0.161	0.192
Alaska Peninsula	**0.022**	0.001	**0.015**	0.005	0.007	0.014	0.026
SE Alaska/N. BC	**0.037**	0.001	**0.032**	0.009	0.015	0.031	0.052
Skeena	**0.000**	0.000	**0.001**	0.002	0.000	0.000	0.006
BC/Washington	**0.172**	0.005	**0.158**	0.014	0.131	0.158	0.185

options were not utilized for the stock composition analyses. For each BAYES analysis, eight Monte Carlo chains starting at disparate starting 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. 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 the Gelman and Rubin shrink statistics which were all less than 1.15 conveying strong convergence to a single posterior distribution (Pella and Masuda, 2001).



Mixtures	2005 Dates	Number of Fish
Week 24-28	June 11 - July 6	356
Week 29-34	July 12 - August 18	205
Week 35-40	August 23 - September 29	461
Total		**1022**

Figure 6. Genetic samples identified by early, middle, and late temporal groupings. Top panel, graph showing the 3 temporal groupings. Bottom panel, dates corresponding to the statistical week groupings and the number of fish in each temporal group.

Temporal changes in stock contributions

There was a shift in the regional contributions of the stock composition estimate over time, with western Alaska more dominant in the early sampling and Asian fish more dominant in the later. The AYKSSI sample set has the potential for both temporal and spatial biases (Figure 1 and 2) for determining overall bycatch stock composition estimates. These sample strata will be fully evaluated in the report for the AYKSSI project, but an analysis of the overall temporal effects is presented below. The large number of samples (1,084) allowed the temporal splitting of the sample set into three time segments: early peak, middle, late peak with sample sizes of 356 (early), 205 (middle) to 461 (late) (Figure 6). The goal of the analysis was to determine if regional contributions to the bycatch changed over time.

Understanding the temporal distribution of the chum salmon bycatch is important. For example, if the samples are randomly distributed or represent a distribution which can be described mathematically, temporally biased estimates could be adjusted with respect to the overall bycatch rate. Both BAYES and SPAM stock composition estimates were made from the three sample sets (Table 4). All BAYES stock composition estimates were again performed using eight Monte Carlo chains starting at disparate starting values of stock proportions. Gelman and Rubin shrink statistics were calculated and in all cases, they were below 1.10 suggesting strong convergence to a single posterior distribution. The SPAM and BAYES estimates were very similar to each other; however, the stock composition estimates differed between time periods (Table 4).

Table 4. SPAM and BAYES stock composition estimates for the early, middle, and late time periods of the AYKSSI subset of 2005 chum salmon bycatch samples. SE is the SPAM standard error. SD is the BAYES standard deviation. The 95% credible interval is provided for all BAYES estimates.

		SPAM		**BAYES**				
Wk 24-28	**Region**	**Estimate**	**SE**	**Mean**	**SD**	**2.50%**	**Median**	**97.50%**
	Japan/S. Russia	**0.169**	0.009	**0.181**	0.023	0.139	0.180	0.227
	Russia	**0.175**	0.009	**0.158**	0.028	0.106	0.158	0.215
	Upper/Middle Yukon	**0.112**	0.006	**0.115**	0.023	0.072	0.114	0.160
	Western Alaska	**0.257**	0.014	**0.274**	0.033	0.213	0.273	0.344
	Alaska Peninsula	**0.046**	0.002	**0.044**	0.015	0.019	0.042	0.076
	SE Alaska/N. BC	**0.028**	0.002	**0.023**	0.017	0.000	0.021	0.061
	Skeena	**0.000**	0.000	**0.001**	0.003	0.000	0.000	0.009
	BC/Washington	**0.211**	0.011	**0.205**	0.026	0.155	0.205	0.258
Wk 29-34	**Region**							
	Japan/S. Russia	**0.360**	0.025	**0.376**	0.036	0.307	0.375	0.448
	Russia	**0.259**	0.018	**0.284**	0.039	0.210	0.284	0.364
	Upper/Middle Yukon	**0.057**	0.004	**0.052**	0.020	0.018	0.051	0.097
	Western Alaska	**0.149**	0.010	**0.148**	0.033	0.088	0.147	0.215
	Alaska Peninsula	**0.014**	0.001	**0.007**	0.006	0.000	0.005	0.024
	SE Alaska/N. BC	**0.022**	0.002	**0.011**	0.012	0.000	0.007	0.043
	Skeena	**0.004**	0.000	**0.006**	0.011	0.000	0.000	0.039
	BC/Washington	**0.116**	0.008	**0.116**	0.027	0.067	0.115	0.173
Wk 35-40	**Region**							
	Japan/S. Russia	**0.357**	0.016	**0.369**	0.024	0.323	0.369	0.416
	Russia	**0.266**	0.012	**0.298**	0.027	0.246	0.298	0.353
	Upper/Middle Yukon	**0.025**	0.001	**0.022**	0.013	0.001	0.020	0.051
	Western Alaska	**0.113**	0.005	**0.105**	0.020	0.068	0.104	0.145
	Alaska Peninsula	**0.011**	0.001	**0.016**	0.009	0.002	0.015	0.036
	SE Alaska/N. BC	**0.031**	0.001	**0.030**	0.015	0.006	0.029	0.063
	Skeena	**0.000**	0.000	**0.001**	0.002	0.000	0.000	0.006
	BC/Washington	**0.176**	0.008	**0.160**	0.020	0.122	0.159	0.200

The differences in stock structure by week were significant for both the SPAM and BAYES estimates (Figure 7, see non-overlapping differences in the plotted 95% credible intervals). For example, fish from Western Alaska and the Upper/Middle Yukon were more prevalent in the early part of the season (Weeks 24-28) than the later (Weeks 35-40) whereas the inverse relationship was apparent for stocks from Asia (Figure 7). This is similar to trends observed previously for chum salmon bycatch samples genetically analyzed from the 1994 and 1995 years (Wilmot et al., 1998).

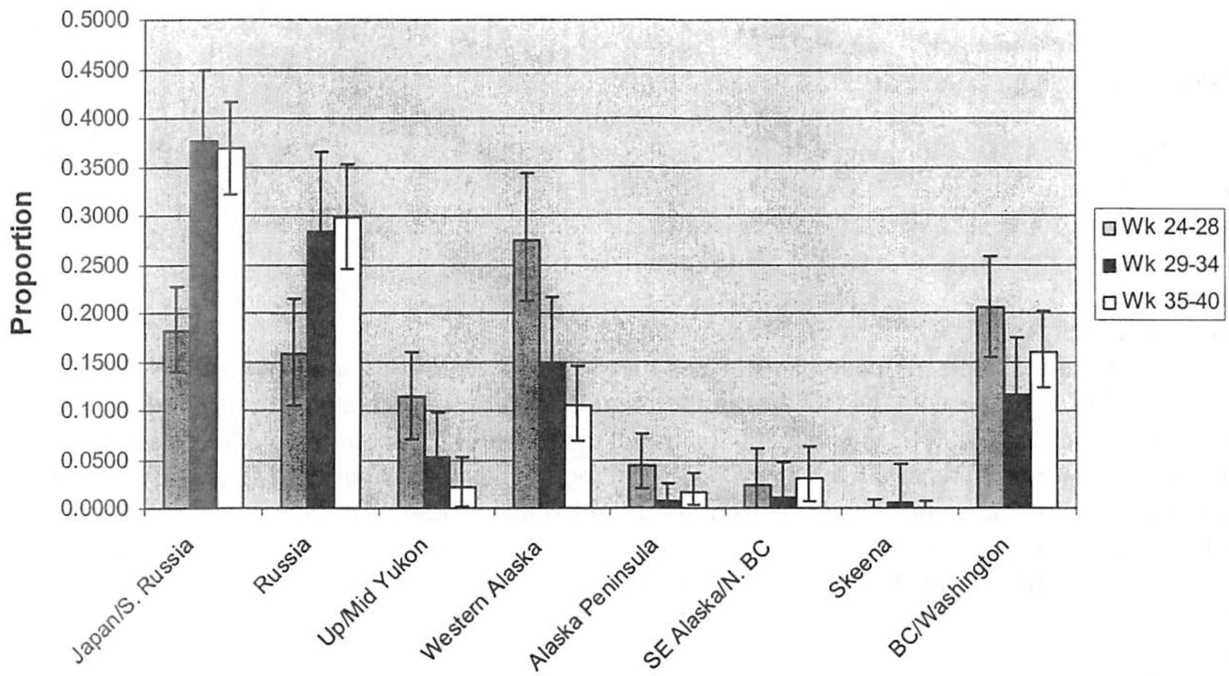
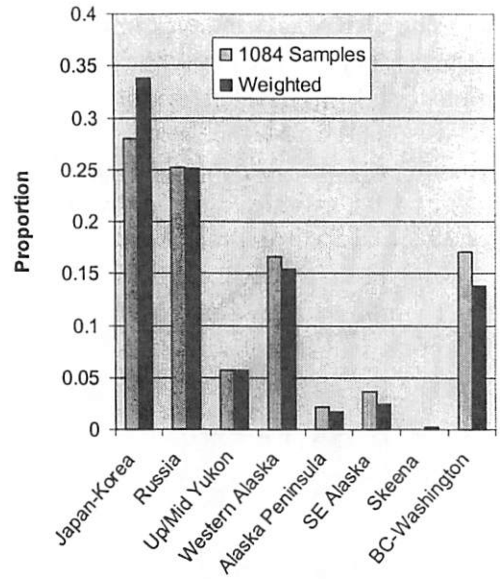


Figure 7. Early, middle, and late BAYES stock composition estimates and 95% credible intervals for the three temporal periods from the AYKSSI subset of samples from the 2005 chum salmon bycatch. Early designates weeks 24-28, middle designates 29-34, and late designates weeks 35-40.

The stock composition of the chum salmon bycatch varied during the course of the season even within closely spaced temporal groupings. For example, disregarding the changing spatial distributions of the sample set (Figure 3), estimates for weeks 24-28 and 35-40 show strong stock differences yet are only separated by 6 weeks. One way to adjust for the effects of the changing distribution is to weight the estimates by the proportion of bycatch caught in each time interval and then compare that estimate with the overall estimate determined for the 1,084 sample set (Table 3). The weighted stock composition estimates were very similar to the estimate produced from the 1,084 samples as a whole (Figure 8) suggesting the potential for a simple linear relationship in which the two sample peaks could be averaged to identify the stock composition of the entire bycatch. For example, if Western Alaska and Yukon stocks decline over time while Asia stocks increase, a weighted average (stock composition estimates for each time period expanded by the integrated total bycatch over the same time periods) between the two peaks may produce an acceptable stock composition estimate for the entire bycatch. Such an analysis would not account for the strong spatial biases in the AYKSSI sample set (Figure 1), but could account for temporal biases.

Figure 8. Comparison of the aggregated stock composition estimate produced from the available 1,084 genetic samples with a weighted estimate based on the temporal stock compositions weighted by the proportion of bycatch caught in each time interval.



Stock Composition Summary

The unweighted stock composition results from the AYKSSI chum bycatch sample set indicate that the major contributing regions were: Upper/Middle Yukon (5-6%), western Alaska (16%), BC/Washington (16-17%), Japan/S. Russia (28-29%) and Russia (25-29%). There was little contribution from southeast Alaska/Northern British Columbia, Alaska Peninsula, or Skeena. SPAM simulation studies described above indicate some potential to misallocate SE Alaska fish/N. BC to BC/Washington (Table 2), but because stock composition estimates for the SE Alaska/N. BC stocks were low, they were combined in Figure 9 with the BC/Washington region to allow comparison with previous estimates (Patton et al., 1998; Seeb et al., 2004; Wilmot et al., 1998). Although the AYKSSI genetic sample distribution is different than the overall non-Chinook bycatch distribution (Figure 2), the results derived from our study are similar to those from the 1994 bycatch (Figure 9). The 1994-1996 chum bycatch estimates were produced with allozyme data and the 2005 chum bycatch estimates were derived for the first time from DNA based microsatellite markers.

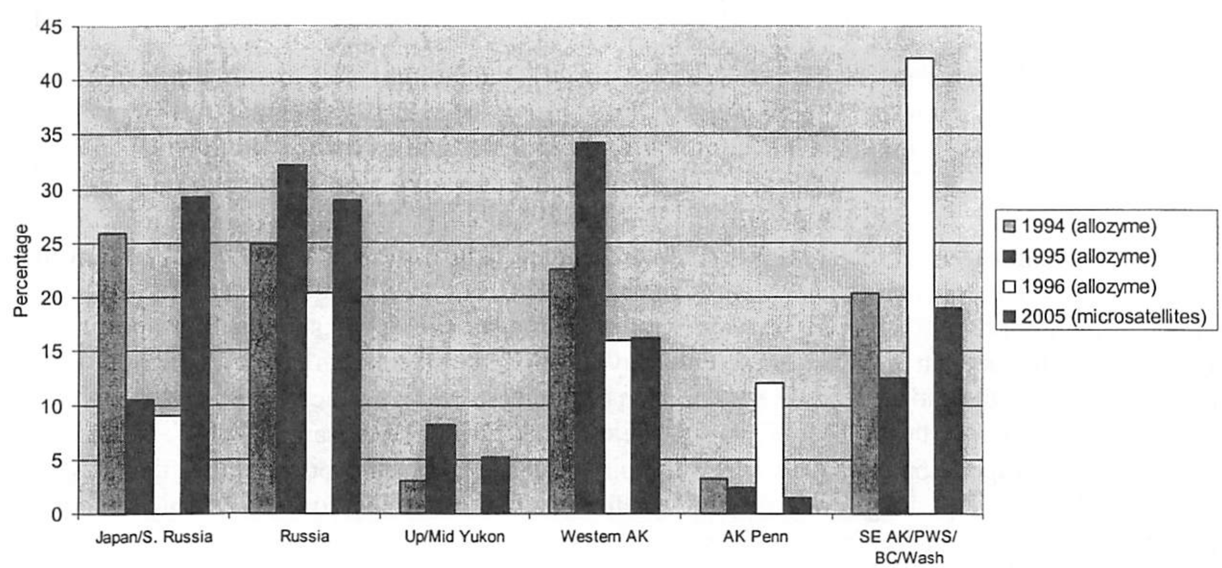


Figure 9. Comparison of 2005 stock composition estimates with those from the 1994-1996 years. The 1994-1996 estimates were derived using allozyme markers while the 2005 estimates were produced for the first time using DNA based markers. For estimates across different years, not all areas may contain the same populations as different baselines were used in producing these estimates.

Age structure of AYKSSI genetic samples

Ocean migration patterns influence the age at which salmon are caught in the trawl fisheries. As part of the AYKSSI project, spatial and temporal changes of the chum salmon distribution in the Bering Sea will be analyzed with respect to ocean age; consequently, 618 scales from the 2005 chum salmon bycatch from the Bering Sea groundfish fishery were analyzed. Acetate impressions were made and digitized into TIFF files. Scale analysis shows that the majority of samples came from ocean age 3 fish (Figure 10, left panel). Other ages appear to be part of a normal distribution centered about the mean (Figure 10, right panel).

Ocean Age	Number
0.1	4
0.2	84
0.3	415
0.4	108
0.5	6
0.6	1
	618 Total

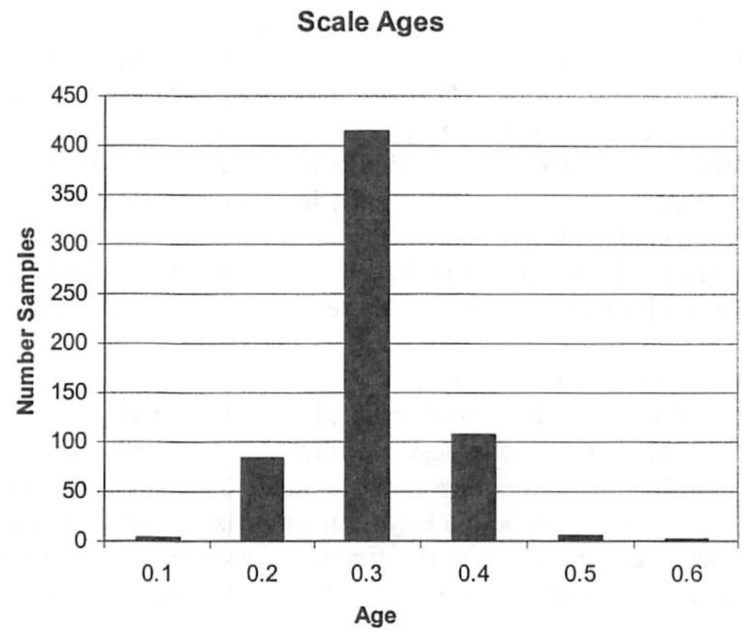


Figure 10. Age estimates for 618 genetic samples of chum salmon. Left panel, number of scale acetate impressions that have been analyzed for chum salmon samples taken as bycatch from the 2005 Bering Sea groundfish fishery. Right panel, graphical illustration of the age distribution showing an apparent normal distribution between ocean ages 1 and 6.

Summary and discussion with future implications

Communities in western Alaska and elsewhere are dependent on salmon for subsistence and commercial purposes. Decreasing salmon returns to western Alaska have caused hardships in these communities. Salmon-dependent communities have expressed concerns that the Bering Sea pollock fisheries could be responsible for the decreasing salmon returns due to the inadvertent catch of salmon as bycatch. Stock composition estimates of the salmon bycatch are needed for pollock and salmon fishery managers to understand whether the pollock fisheries may be impacting salmon returns, however much work remains before such estimates can be produced. To guide the efforts to estimate the stock composition of the total bycatch, this report provides a stock composition analysis of a stratified sample set from the 2005 chum salmon bycatch. The limitations of this analysis for understanding the stock composition of the bycatch are summarized below.

Sampling issues:

Samples from the 2005 chum salmon bycatch were specifically collected for an AYKSSI funded project to determine spatial and temporal distributions of chum salmon in the Bering Sea. We highlight the inherent spatial and temporal biases in the sample set, which limits the application of the AYKSSI sample stock composition estimate to the entire 2005 chum salmon bycatch. With the need to fully understand the effects of the salmon bycatch on western Alaska salmon escapements, changes to the sample collection protocols are being reviewed and new procedures are expected to be implemented during the 2011 fishing season.

Evaluation of the baseline:

We have selected a chum salmon microsatellite baseline developed by Dr. Beacham at the Division of Fisheries and Oceans Canada (DFO) because it is the only publicly available baseline with known populations and references (Beacham et al., 2009b). This baseline represents 381 chum populations distributed throughout the Pacific Rim and is available for anonymous download through a Division of Fisheries and Oceans web portal. While only 11 of the 14 markers have been utilized, these markers provide discriminatory power to identify stock distributions for 8 regional groupings. Additional markers may be added in the future as they are standardized. In addition, at least two other chum salmon baselines are currently being developed and may be considered in future analyses after they are made publicly available, published, and evaluated. Improvements in stock composition estimates will require further baseline development with additional markers and populations, as well as periodic checks to determine if there is drift of allele frequencies or migration within the baseline.

Stock composition estimates:

Overall, Asian fish dominated the AYKSSI sample set, with Western Alaska and BC/Washington as the largest contributors from North American stocks. For this analysis, over one thousand samples were genotyped from the 2005 AYKSSI sample set. Stock composition estimates were prepared using both a Bayesian and maximum likelihood approach (SPAM), both of which provided very similar overall estimates. These results suggest that the genetic baseline provided criteria from which to confidently identify the 8 identified regional groupings of chum salmon.

Temporal effects on stock composition estimates of the AYKSSI chum salmon sample set:

Western Alaska fish dominated in the early part of the sampling effort; Asian fish dominated in the middle and late sampling times. As the AYKSSI genetic sample temporal distribution was dissimilar to the overall chum bycatch in 2005 (Figure 2), separate stock composition estimates were produced for samples taken at three different time periods (early, middle, and late) in the bycatch. Stock composition estimates for these three time periods differed, suggesting temporal stratification of chum salmon stocks in the Bering Sea and/or changes in fishing locations. When stock composition estimates were adjusted for sampling rate, the weighted stock composition estimate was remarkably similar to the composite stock composition estimate of the 1,084 initial samples. This suggests the potential for a simple linear relationship over time in which some stocks decrease (Western Alaska and Upper/Middle Yukon) while others increase (Asia).

Comparison of 2005 with earlier years:

The 2005 AYKSSI stock composition estimates were comparable to those from the 1994 bycatch samples, although it is recognized that small changes in stock composition could represent large changes in individual stocks at the escapement level. The 2005 analysis is the first year for which DNA-based markers have been used to analyze chum salmon bycatch samples and the similarity with estimates originally derived using both scale pattern and protein markers helps validate the more cost-efficient DNA based methods.

Future estimates:

Proportionate sampling in future years will yield stock composition estimates with greater certainty in the origin of stocks and the proportion of critical stocks in the bycatch. Also, questions such as the composition in time and space, and warm versus cold years, can be tested to see if changes in harvest strategy would have less impact on critical stocks. In addition, the suitability of more refined regional reporting groups will be explored in consultation with other genetic laboratories. Such an analysis with more than 50 reporting groups has recently been reported for chum salmon collections taken from the Gulf of Alaska (Beacham et al., 2009c).

Acknowledgements

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Appendices

Appendix 1. Chum salmon populations in the DFO microsatellite baseline with regional designations used in the analyses of this report.

DFO Number	Population Name	Region Number	Region
8	Big_Creek	1	Upper/Middle Yukon
89	Big_Salt	1	Upper/Middle Yukon
86	Black_River	1	Upper/Middle Yukon
87	Chandalar	1	Upper/Middle Yukon
28	Chandindu	1	Upper/Middle Yukon
82	Cheena	1	Upper/Middle Yukon
81	Delta	1	Upper/Middle Yukon
7	Donjek	1	Upper/Middle Yukon
5	Fishing_Br	1	Upper/Middle Yukon
88	Jim_River	1	Upper/Middle Yukon
85	Kantishna	1	Upper/Middle Yukon
2	Kluane	1	Upper/Middle Yukon
59	Kluane_Lake	1	Upper/Middle Yukon
181	Koyukuk_late	1	Upper/Middle Yukon
90	Koyukuk_south	1	Upper/Middle Yukon
10	Minto	1	Upper/Middle Yukon
6	Pelly	1	Upper/Middle Yukon
439	Porcupine	1	Upper/Middle Yukon
83	Salcha	1	Upper/Middle Yukon
4	Sheenjek	1	Upper/Middle Yukon
1	Tatchun	1	Upper/Middle Yukon
9	Teslin	1	Upper/Middle Yukon
84	Toklat	1	Upper/Middle Yukon
348	Agiapuk	2	Coastal Western Alaska/Lower Yukon
376	Alagnak	2	Coastal Western Alaska/Lower Yukon
3	Andreafsky	2	Coastal Western Alaska/Lower Yukon
357	Aniak	2	Coastal Western Alaska/Lower Yukon
301	Anvik	2	Coastal Western Alaska/Lower Yukon
80	Chulinak	2	Coastal Western Alaska/Lower Yukon
347	Eldorado	2	Coastal Western Alaska/Lower Yukon
358	George	2	Coastal Western Alaska/Lower Yukon
307	Gisasa	2	Coastal Western Alaska/Lower Yukon
371	Goodnews	2	Coastal Western Alaska/Lower Yukon
288	Henshaw_Creek	2	Coastal Western Alaska/Lower Yukon
339	Imnachuk	2	Coastal Western Alaska/Lower Yukon
361	Kanektok	2	Coastal Western Alaska/Lower Yukon
362	Kasigluk	2	Coastal Western Alaska/Lower Yukon
328	Kelly_Lake	2	Coastal Western Alaska/Lower Yukon
340	Kobuk	2	Coastal Western Alaska/Lower Yukon
343	Koyuk	2	Coastal Western Alaska/Lower Yukon
363	Kwethluk	2	Coastal Western Alaska/Lower Yukon
336	Kwiniuk_River	2	Coastal Western Alaska/Lower Yukon
303	Melozitna	2	Coastal Western Alaska/Lower Yukon

373	Mulchatna	2	Coastal Western Alaska/Lower Yukon
372	Naknek	2	Coastal Western Alaska/Lower Yukon
330	Niukluk	2	Coastal Western Alaska/Lower Yukon
329	Noatak	2	Coastal Western Alaska/Lower Yukon
345	Nome	2	Coastal Western Alaska/Lower Yukon
302	Nulato	2	Coastal Western Alaska/Lower Yukon
374	Nunsatuk	2	Coastal Western Alaska/Lower Yukon
13	Peel_River	2	Coastal Western Alaska/Lower Yukon
322	Pikmiktalik	2	Coastal Western Alaska/Lower Yukon
331	Pilgrim_River	2	Coastal Western Alaska/Lower Yukon
346	Shaktoolik	2	Coastal Western Alaska/Lower Yukon
341	Snake	2	Coastal Western Alaska/Lower Yukon
368	Stuyahok_River	2	Coastal Western Alaska/Lower Yukon
375	Togiak	2	Coastal Western Alaska/Lower Yukon
154	Tozitna	2	Coastal Western Alaska/Lower Yukon
342	Unalakleet	2	Coastal Western Alaska/Lower Yukon
344	Ungalik	2	Coastal Western Alaska/Lower Yukon
323	Carroll	3	SE AK/PWS/N. BC
353	Constantine	3	SE AK/PWS/N. BC
414	Crag_Cr	3	SE AK/PWS/N. BC
210	Dipac_Hatchery	3	SE AK/PWS/N. BC
319	Disappearance	3	SE AK/PWS/N. BC
276	Ensheshese	3	SE AK/PWS/N. BC
227	Gambier	3	SE AK/PWS/N. BC
237	Greens	3	SE AK/PWS/N. BC
234	Herman_Creek	3	SE AK/PWS/N. BC
162	Kateen	3	SE AK/PWS/N. BC
238	Kennell	3	SE AK/PWS/N. BC
351	Keta_Creek	3	SE AK/PWS/N. BC
437	Klewnuggit_Cr	3	SE AK/PWS/N. BC
423	Kumealon	3	SE AK/PWS/N. BC
127	Lachmach	3	SE AK/PWS/N. BC
448	LagoonCr	3	SE AK/PWS/N. BC
444	Nakut_Su	3	SE AK/PWS/N. BC
422	Nass_River	3	SE AK/PWS/N. BC
321	Neets_Bay_early	3	SE AK/PWS/N. BC
320	Neets_Bay_late	3	SE AK/PWS/N. BC
377	Olsen_Creek	3	SE AK/PWS/N. BC
236	Sawmill	3	SE AK/PWS/N. BC
249	Shustnini	3	SE AK/PWS/N. BC
416	Stumaun_Cr	3	SE AK/PWS/N. BC
30	Taku	3	SE AK/PWS/N. BC
18	Takwahoni	3	SE AK/PWS/N. BC
247	Tuskwa	3	SE AK/PWS/N. BC
232	Wells_Bridge	3	SE AK/PWS/N. BC
352	Wells_River	3	SE AK/PWS/N. BC
248	Yellow_Bluff	3	SE AK/PWS/N. BC
360	Alogoshak	4	Alaska Peninsula
333	American_River	4	Alaska Peninsula
366	Big_River	4	Alaska Peninsula

354	Coleman_Creek	4	Alaska Peninsula
355	Delta_Creek	4	Alaska Peninsula
359	Egegik	4	Alaska Peninsula
332	Frosty_Creek	4	Alaska Peninsula
365	Gertrude_Creek	4	Alaska Peninsula
370	Joshua_Green	4	Alaska Peninsula
364	Meshik	4	Alaska Peninsula
283	Moller_Bay	4	Alaska Peninsula
369	Pumice_Creek	4	Alaska Peninsula
367	Stepovak_Bay	4	Alaska Peninsula
335	Sturgeon	4	Alaska Peninsula
350	Uganik	4	Alaska Peninsula
334	Volcano_Bay	4	Alaska Peninsula
356	Westward_Creek	4	Alaska Peninsula
239	Ahnuhati	5	BC/Washington
69	Ahta______	5	BC/Washington
155	Ain_	5	BC/Washington
183	Algard	5	BC/Washington
58	Alouette	5	BC/Washington
325	Alouette_North	5	BC/Washington
428	Arnoup_Cr	5	BC/Washington
153	Ashlulm	5	BC/Washington
156	Awun	5	BC/Washington
133	Bag_Harbour	5	BC/Washington
164	Barnard	5	BC/Washington
16	Bella_Bell	5	BC/Washington
79	Bella_Coola	5	BC/Washington
49	Big_Qual	5	BC/Washington
201	Big_Quilcene	5	BC/Washington
281	Bish_Cr	5	BC/Washington
198	Bitter_Creek	5	BC/Washington
103	Blackrock_Creek	5	BC/Washington
390	Blaney_Creek	5	BC/Washington
138	Botany_Creek	5	BC/Washington
264	Buck_Channel	5	BC/Washington
169	Bullock_Chann	5	BC/Washington
61	Campbell_River	5	BC/Washington
78	Cascade	5	BC/Washington
76	Cayeghle	5	BC/Washington
42	Cheakamus	5	BC/Washington
398	Cheenis_Lake	5	BC/Washington
51	Chehalis	5	BC/Washington
19	Chemainus	5	BC/Washington
47	Chilliwack	5	BC/Washington
392	Chilqua_Creek	5	BC/Washington
117	Chuckwalla	5	BC/Washington
139	Clapp_Basin	5	BC/Washington
107	Clatse_Creek	5	BC/Washington
118	Clyak	5	BC/Washington
62	Cold_Creek	5	BC/Washington

77	Colonial	5	BC/Washington
168	Cooper_Inlet	5	BC/Washington
197	County_Line	5	BC/Washington
12	Cowichan	5	BC/Washington
161	Dak_	5	BC/Washington
259	Dana_Creek	5	BC/Washington
250	Dawson_Inlet	5	BC/Washington
91	Dean_River	5	BC/Washington
261	Deena	5	BC/Washington
170	Deer_Pass	5	BC/Washington
46	Demamiel	5	BC/Washington
177	Draney	5	BC/Washington
114	Duthie_Creek	5	BC/Washington
427	East_Arm	5	BC/Washington
94	Elcho_Creek	5	BC/Washington
193	Ellsworth_Cr	5	BC/Washington
203	Elwha	5	BC/Washington
263	Fairfax_Inlet	5	BC/Washington
32	Fish_Creek	5	BC/Washington
429	Flux_Cr	5	BC/Washington
102	Foch_Creek	5	BC/Washington
179	Frenchman	5	BC/Washington
96	Gill_Creek	5	BC/Washington
166	Gilttoyee	5	BC/Washington
145	Glendale	5	BC/Washington
135	Gold_Harbour	5	BC/Washington
11	Goldstream	5	BC/Washington
66	Goodspeed_River	5	BC/Washington
136	Government	5	BC/Washington
205	Grant_Creek	5	BC/Washington
100	Green_River	5	BC/Washington
450	GreenRrHatchery	5	BC/Washington
141	Harrison	5	BC/Washington
438	Harrison_late	5	BC/Washington
64	Hathaway_Creek	5	BC/Washington
17	Heydon_Cre	5	BC/Washington
407	Hicks_Cr	5	BC/Washington
400	Homathko	5	BC/Washington
411	Honna	5	BC/Washington
204	Hoodsport	5	BC/Washington
185	Hooknose	5	BC/Washington
406	Hopedale_Cr	5	BC/Washington
412	Hutton_Head	5	BC/Washington
278	Illiance	5	BC/Washington
152	Inch_Creek	5	BC/Washington
146	Indian_River	5	BC/Washington
92	Jenny_Bay	5	BC/Washington
115	Kainet_River	5	BC/Washington
144	Kakweiken	5	BC/Washington
395	Kanaka_Cr	5	BC/Washington

402	Kano_Inlet_Cr	5	BC/Washington
389	Kawkawa	5	BC/Washington
95	Kemano	5	BC/Washington
192	Kennedy_Creek	5	BC/Washington
101	Khutze_River	5	BC/Washington
126	Khutzeymateen	5	BC/Washington
282	Kiltuish	5	BC/Washington
93	Kimsquit	5	BC/Washington
187	Kimsquit_Bay	5	BC/Washington
419	Kincolith	5	BC/Washington
106	Kitasoo	5	BC/Washington
99	Kitimat_River	5	BC/Washington
275	Kitsault_Riv	5	BC/Washington
21	Klinaklini	5	BC/Washington
418	Ksedin	5	BC/Washington
125	Kshwan	5	BC/Washington
112	Kwakusdis_River	5	BC/Washington
436	Kxngeal_Cr	5	BC/Washington
262	Lagins	5	BC/Washington
131	Lagoon_Inlet	5	BC/Washington
167	Lard	5	BC/Washington
160	Little_Goose	5	BC/Washington
50	Little_Qua	5	BC/Washington
413	Lizard_Cr	5	BC/Washington
119	Lockhart-Gordon	5	BC/Washington
176	Lower_Lillooet	5	BC/Washington
137	Mace_Creek	5	BC/Washington
242	Mackenzie_Sound	5	BC/Washington
116	MacNair_Creek	5	BC/Washington
55	Mamquam	5	BC/Washington
121	Markle_Inlet_Cr	5	BC/Washington
27	Martin_Riv	5	BC/Washington
338	Mashiter_Creek	5	BC/Washington
109	McLoughin_Creek	5	BC/Washington
178	Milton	5	BC/Washington
194	Minter_Cr	5	BC/Washington
254	Mountain_Cr	5	BC/Washington
111	Mussel_River	5	BC/Washington
157	Naden	5	BC/Washington
337	Nahmint_River	5	BC/Washington
14	Nanaimo	5	BC/Washington
399	Necleetsconnay	5	BC/Washington
113	Neekas_Creek	5	BC/Washington
173	Nekite	5	BC/Washington
104	Nias_Creek	5	BC/Washington
143	Nimpkish	5	BC/Washington
53	Nitinat	5	BC/Washington
191	Nooksack	5	BC/Washington
186	Nooseseck	5	BC/Washington
318	NorrishWorth	5	BC/Washington

159	North_Arm	5	BC/Washington
184	Orford	5	BC/Washington
287	Pa-aat_River	5	BC/Washington
260	Pacofi	5	BC/Washington
56	Pallant	5	BC/Washington
65	Pegattum_Creek	5	BC/Washington
48	Puntledge	5	BC/Washington
98	Quaal_River	5	BC/Washington
147	Quap	5	BC/Washington
108	Quartcha_Creek	5	BC/Washington
199	Quinault	5	BC/Washington
110	Roscoe_Creek	5	BC/Washington
397	Salmon_Bay	5	BC/Washington
195	Salmon_Cr	5	BC/Washington
134	Salmon_River	5	BC/Washington
200	Satsop	5	BC/Washington
410	Seal_Inlet_Cr	5	BC/Washington
158	Security	5	BC/Washington
130	Sedgewick	5	BC/Washington
393	Serpentine_R	5	BC/Washington
317	Shovelnose_Cr	5	BC/Washington
206	Siberia_Creek	5	BC/Washington
25	Silverdale	5	BC/Washington
196	Skagit	5	BC/Washington
171	Skowquiltz	5	BC/Washington
447	SkykomishRiv	5	BC/Washington
132	Slatechuck_Cre	5	BC/Washington
43	Sliammon	5	BC/Washington
15	Smith_Cree	5	BC/Washington
54	Snootli	5	BC/Washington
180	Southgate	5	BC/Washington
26	Squakum	5	BC/Washington
142	Squamish	5	BC/Washington
128	Stagoo	5	BC/Washington
265	Stanley	5	BC/Washington
52	Stave	5	BC/Washington
396	Stawamus	5	BC/Washington
409	Steel_Cr	5	BC/Washington
424	Stewart_Cr	5	BC/Washington
327	Sugsaw	5	BC/Washington
324	Surprise	5	BC/Washington
75	Taaltz	5	BC/Washington
251	Tarundl_Creek	5	BC/Washington
149	Theodosia	5	BC/Washington
22	Thorsen	5	BC/Washington
129	Toon	5	BC/Washington
279	Tseax	5	BC/Washington
202	Tulalip	5	BC/Washington
97	Turn_Creek	5	BC/Washington
430	Turtle_Cr	5	BC/Washington

165	Tyler	5	BC/Washington
33	Tzoonie	5	BC/Washington
140	Vedder	5	BC/Washington
70	Viner_Sound	5	BC/Washington
45	Wahleach	5	BC/Washington
172	Walkum	5	BC/Washington
73	Waump	5	BC/Washington
105	West_Arm_Creek	5	BC/Washington
326	Widgeon_Slough	5	BC/Washington
277	Wilauks_Cr	5	BC/Washington
120	Wilson_Creek	5	BC/Washington
401	Worth_Creek	5	BC/Washington
60	Wortley_Creek	5	BC/Washington
270	Andesite_Cr	6	Skeena
123	Date_Creek	6	Skeena
269	Dog-tag	6	Skeena
266	Ecstall_River	6	Skeena
268	Kalum	6	Skeena
273	Kispiox	6	Skeena
163	Kitwanga	6	Skeena
271	Kleanza_Cr	6	Skeena
122	Nangeese	6	Skeena
274	Skeena	6	Skeena
124	Upper/Middle_Kitsumkal	6	Skeena
267	Whitebottom_Cr	6	Skeena
434	Zymagotitz	6	Skeena
41	Abashiri	7	Japan/Korea/China/S. Russia
218	Amur	7	Japan/Korea/China/S. Russia
215	Avakumovka	7	Japan/Korea/China/S. Russia
40	Chitose	7	Japan/Korea/China/S. Russia
315	Gakko_River	7	Japan/Korea/China/S. Russia
292	Hayatsuki	7	Japan/Korea/China/S. Russia
44	Horonai	7	Japan/Korea/China/S. Russia
213	Kalininka	7	Japan/Korea/China/S. Russia
252	Kawabukuro	7	Japan/Korea/China/S. Russia
313	Koizumi_River	7	Japan/Korea/China/S. Russia
300	Kushiro	7	Japan/Korea/China/S. Russia
37	Miomote	7	Japan/Korea/China/S. Russia
211	Naiba	7	Japan/Korea/China/S. Russia
391	Namdae_R	7	Japan/Korea/China/S. Russia
231	Narva	7	Japan/Korea/China/S. Russia
298	Nishibetsu	7	Japan/Korea/China/S. Russia
293	Ohkawa	7	Japan/Korea/China/S. Russia
297	Orikasa	7	Japan/Korea/China/S. Russia
214	Ryazanovka	7	Japan/Korea/China/S. Russia
312	Sakari_River	7	Japan/Korea/China/S. Russia
311	Shari_River	7	Japan/Korea/China/S. Russia
36	Shibetsu	7	Japan/Korea/China/S. Russia
299	Shikiu	7	Japan/Korea/China/S. Russia
253	Shiriuchi	7	Japan/Korea/China/S. Russia

310	Shizunai	7	Japan/Korea/China/S. Russia
217	Suifen	7	Japan/Korea/China/S. Russia
35	Teshio	7	Japan/Korea/China/S. Russia
39	Tokachi	7	Japan/Korea/China/S. Russia
38	Tokoro	7	Japan/Korea/China/S. Russia
314	Tokushibetsu	7	Japan/Korea/China/S. Russia
291	Toshibetsu	7	Japan/Korea/China/S. Russia
296	Tsugaruishi	7	Japan/Korea/China/S. Russia
383	Tugur_River	7	Japan/Korea/China/S. Russia
226	Tym_	7	Japan/Korea/China/S. Russia
230	Udarnitsa	7	Japan/Korea/China/S. Russia
316	Uono_River	7	Japan/Korea/China/S. Russia
309	Yurappu	7	Japan/Korea/China/S. Russia
207	Anadyr	8	Russia
384	Apuka_River	8	Russia
382	Bolshaya	8	Russia
380	Dranka	8	Russia
223	Hairusova	8	Russia
378	Ivashka	8	Russia
225	Kamchatka	8	Russia
219	Kanchalan	8	Russia
379	Karaga	8	Russia
294	Kikchik	8	Russia
209	Kol_	8	Russia
233	Magadan	8	Russia
295	Nerpichi	8	Russia
381	Okhota	8	Russia
212	Oklan	8	Russia
222	Ola_	8	Russia
386	Olutorsky_Bay	8	Russia
228	Ossora	8	Russia
224	Penzhina	8	Russia
385	Plotnikova_R	8	Russia
221	Pymta	8	Russia
220	Tauy	8	Russia
290	Utka_River	8	Russia
208	Vorovskaya	8	Russia
387	Zhypanova	8	Russia

Chum Salmon Bycatch Draft Alternatives: Area closures

Staff Discussion Paper

February 2010

The draft alternatives for the chum salmon bycatch measures include two different alternative time/area triggered closure configurations. The first was developed by staff in 2008 with iterative review and modification by the Council while the second results from work following the December 2009 Council meeting per request for staff to develop new candidate closures. This paper review the following information as it relates to alternative time/area closures: 1- the first alternative closure (already contained in the Council's draft suite of alternatives) and its methodological approach; 2- new candidate area closures; 3-timing and trigger cap formulations and application related to area closures. The full Council motion on the chum salmon bycatch alternatives from December 2009 is attached as Appendix 1.

Sections are labeled according to the structure of the Council's components and options in the draft suite of alternatives. Alternative 3 is the triggered closure alternative, and currently has 7 components with various options beneath each (see Appendix 1). Not all components of Alternative 3 are discussed in this paper. The components discussed include the following under Alternative 3-Triggered Closure:

Component 1: Trigger Cap Formulation

a) Cap level

1. 25,000
2. 50,000
3. 75,000
4. 125,000
5. 200,000

b) Application of Trigger Caps

1. Apply trigger to all chum bycatch
2. Apply trigger to all chum bycatch between specific dates
3. Apply trigger to all chum bycatch in a specific area.

Component 5: Area Option

a) Area identified in October, 2008 discussion paper (B-season chum bycatch rate-based closure described on pages 14-15 of December 2009 discussion paper)
b) New areas [to be identified by staff] which are small, discrete closure areas, each with its own separate cap whereby bycatch in that area only accrues towards the cap

Component 6: Timing Option – Dates of Area Closure

New closure dates [to be developed from staff analysis of seasonal proportions of pollock and chum salmon by period across additional ranges of years]

Discussion of components in this paper begins with proposed area options, their relative timing of highest bycatch and proposed methods for application of trigger caps by individual area or for all closures. Where possible staff suggestions are included for modification of language, alternative structure or interpretation of overlapping options. The action before the Council at this meeting is to review area closures and provide direction to staff as necessary for refining alternatives for Council review in June 2010. The Council will refine final alternatives for analysis at the June 2010 meeting.

Component 5 a: Large area closure

This closure was identified by rate-based analysis delineating regions where average bycatch rate exceeded 0.9 chum salmon per ton of pollock (Fig. 1). Over the entire B season, this area accounts for 49% of the chum salmon on average (1994-2007) and only 12% of the pollock catch (Fig. 1)

Table 1 Area closure coordinates.

55° 53'	165° 30'	56° 00'	169° 15'
55° 00'	166° 38'	56° 23'	167° 23'
55° 00'	167° 45'	55° 53'	167° 00'
55° 23'	168° 15'	55° 53'	165° 30'

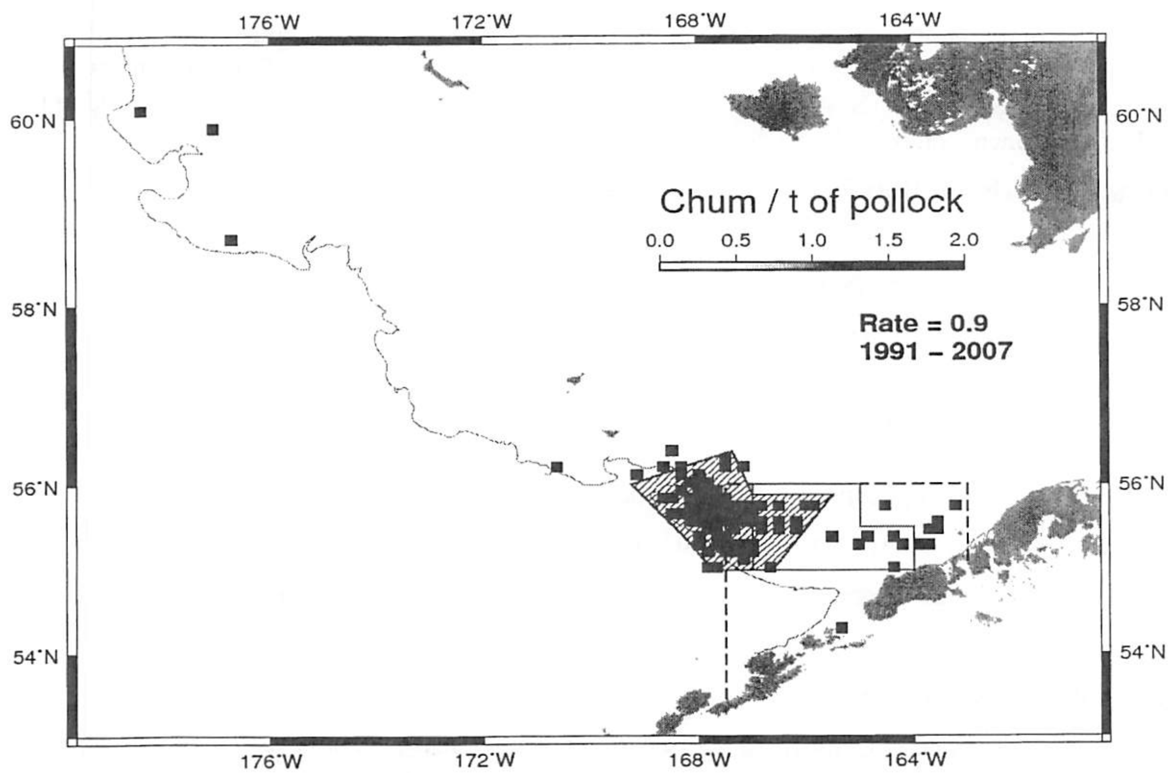

Figure 1 B-season chum salmon proposed closure (red-hatched closure) over different rates based on 1991-2007 NMFS observer data. Filled in 10x10km cells represent locations where the average bycatch rate exceeded 0.9 chum salmon per t of pollock. Existing Chum Salmon Savings Area closure shown in pink line (no hatching).

Table 2 Average seasonal proportions by periods for 1993-2007 based on NMFS observer data (effort is relative hours towed, salmon are relative numbers, and pollock are relative tons).

Periods	Seasonal pollock proportion	Seasonal "other" salmon proportion	Seasonal effort proportion
Jun 1-7	0%	1%	1%
Jun 8-14	1%	1%	1%
Jun 15-21	2%	2%	2%
Jun 22-30	4%	3%	3%
Jul 1-7	4%	4%	3%
Jul 8-14	4%	2%	4%
Jul 15-21	4%	6%	3%
Jul 22-31	7%	6%	6%
Aug 1-7	5%	9%	5%
Aug 8-14	6%	5%	5%
Aug 15-21	7%	10%	7%
Aug 22-31	11%	7%	11%
Sep 1-7	9%	9%	9%
Sep 8-14	8%	9%	9%
Sep 15-21	8%	9%	9%
Sep 22-30	8%	5%	9%
Oct 1-7	5%	5%	6%
Oct 8-14	4%	4%	4%
Oct 15-21	2%	2%	3%
Oct 22-31	2%	1%	2%

Table 3 Average 1993-2007 seasonal pattern of other salmon bycatch per t of pollock in and outside of candidate closure area by different periods.

Periods	Rate In	Rate Outside	Pollock inside	Chum Inside	Effort Inside
All of B	1.216	0.144	5%	33%	5%
Jun 1-7	-	0.338	0%	0%	0%
Jun 8-14	0.221	0.186	0%	0%	0%
Jun 15-21	0.034	0.283	3%	0%	3%
Jun 22-30	0.372	0.161	3%	6%	3%
Jul 1-7	0.040	0.255	5%	1%	4%
Jul 8-14	0.289	0.104	12%	27%	11%
Jul 15-21	2.473	0.118	8%	66%	8%
Jul 22-31	0.965	0.131	5%	28%	5%
Aug 1-7	3.137	0.138	8%	66%	7%
Aug 8-14	0.607	0.166	6%	18%	6%
Aug 15-21	1.363	0.200	6%	32%	7%
Aug 22-31	0.833	0.109	3%	21%	4%
Sep 1-7	0.970	0.148	6%	30%	7%
Sep 8-14	2.199	0.137	3%	37%	4%
Sep 15-21	1.519	0.128	6%	44%	6%
Sep 22-30	0.963	0.108	4%	25%	4%
Oct 1-7	0.940	0.128	6%	33%	6%
Oct 8-14	1.538	0.153	3%	26%	3%
Oct 15-21	0.817	0.152	7%	29%	7%
Oct 22-31	0.383	0.111	14%	37%	12%

Component 5 b: New candidate closure areas

In December 2009, the Council moved the following as an additional area option to be considered in the chum salmon bycatch alternatives package:

"New areas [to be identified by staff] which are small, discrete closure areas, each with its own separate cap whereby bycatch in that area only accrues towards the cap"

A proposed methodology and candidate closures to address this alternative are provided in this section. The Council may wish to consider whether these statistical area closures meet their concept of small and discrete areas and provide direction to staff at this time for any revisions to area closure alternatives for review in June 2010. At that time draft alternatives for analysis (including candidate area closures) are scheduled to be approved for analysis. Discussion of trigger caps and their application to individual areas based on the range of approved cap numbers is provided following a description of the candidate closures.

Candidate areas were selected from observer data compiled from 1991-2007[1]. State statistical areas were selected as the smallest candidate closures. Initially all statistical areas were considered over all years, understanding that only a subset of areas would qualify for likely candidates. The first step to reducing the candidate areas was to rank them and examine the curvature of the cumulative proportion. This indicates that the top 20 areas had over 80% of the chum bycatch (Fig. 2).

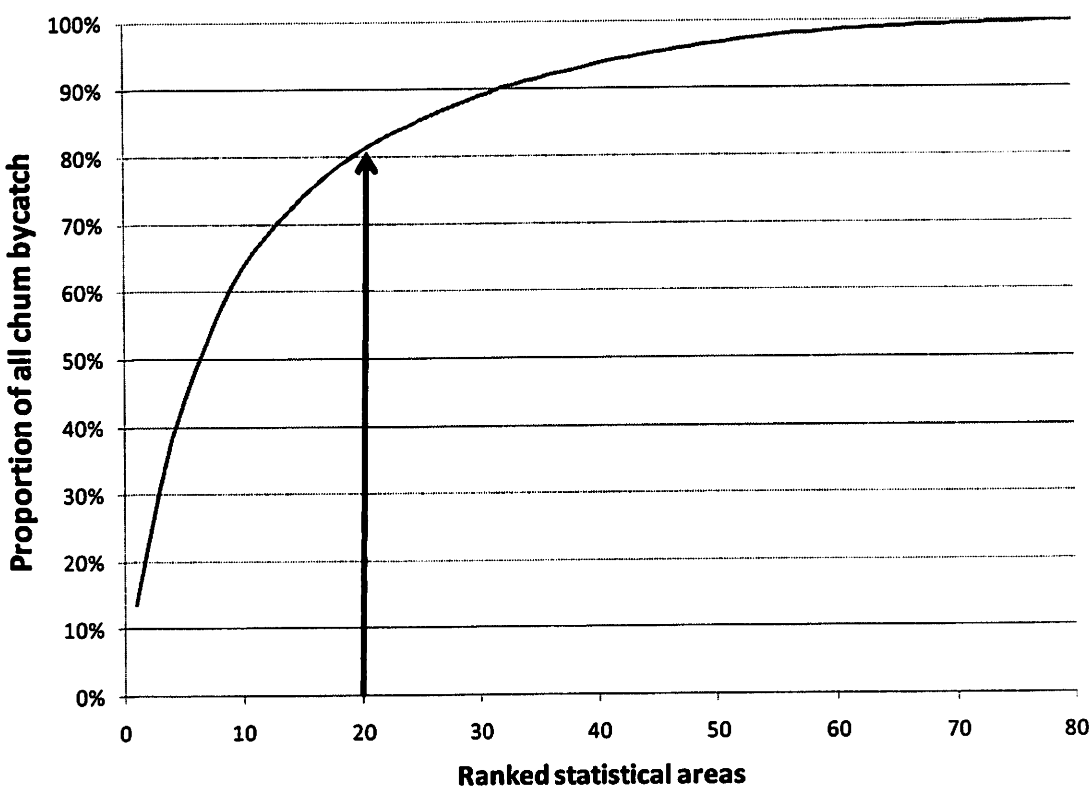

Figure 2. Proportion of ADFG statistical areas ranked by total chum bycatch. The top 20 areas were selected for further consideration.

1 Data from 2008 and 2009 could also be used for comparison against data compiled through 2007. These data were not easily available for use at this time but per request similar analyses could be evaluated for the June 2010 review of alternatives.

The next step was to evaluate these regions for consistency of bycatch, the bycatch rate (relative to pollock), and the total chum salmon bycatch. The consistency measure was computed as 1/CV where CV is the coefficient of variation of annual bycatch rate (standard deviation divided by mean rate). Weighting each of these three factors equally, combined and ranked provides a way to compare this aggregate measure with the individual criteria (Fig. 3). These areas are shown in Fig. 4. The corresponding statistical area names (6-digit) for these ranks are listed in Table 4.

In order to examine areas together with time (within a year), the data were parsed by area-week (since June 1st). Computing the bycatch magnitude, rate, and consistency along with the aggregate measure as above, shows which weeks and areas had the highest bycatch (Fig. 5). Broken out by week, the data show that total chum bycatch (observed) was highest in mid-July through the middle or end of August, depending on area (1991-2007; Fig. 6). This is similar to the recent years (2004-2006; Fig. 7). However, when 2004-2006 are omitted the timing of the bycatch appears to be primarily from August through mid-September and the "worst" area had relatively little bycatch compared to the areas ranked 2-5 (Fig. 8). The early period with high bycatch (1992-1994) showed similar areas and weeks (Fig. 9).

The weekly rates (chum / t of pollock) over these year groupings indicate a broader variability between locations and times which generally are different from the high bycatch areas (Figs. 10 and 11). This suggests that some of the highest bycatch may have come from areas with low bycatch rates. A summary of highest weeks (overall bycatch and by rate) by area for these various year-sets is indicated in Table 5.

Table 4. Rank of the twenty highest bycatch areas for chum salmon, 1991-2007, based on observer data only. Ranked areas are depicted in Figure 4.

Ranking	Stat Area	Ranking	Stat Area
1	675530	11	665430
2	655430	12	665530
3	675500	13	655530
4	645501	14	665500
5	655500	15	775930
6	675600	16	755900
7	685600	17	765930
8	685530	18	695600
9	705600	19	755930
10	655409	20	665600

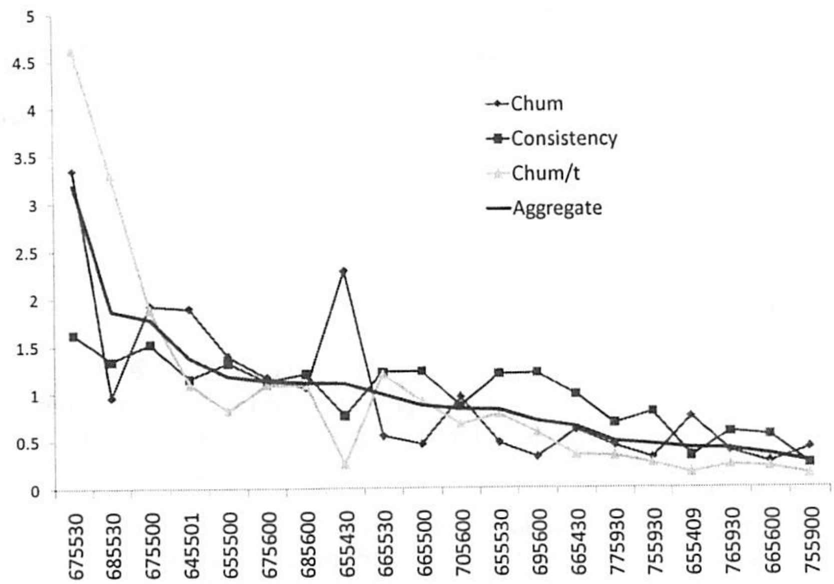

Figure 3. Ranked selected ADFG statistical areas for all years (1991-2007) showing relative measures of chum bycatch, chum rates (number / t of pollock), inter-annual consistency in chum rates between years, and a weighted aggregate measure of these three factors (based solely on observer data).

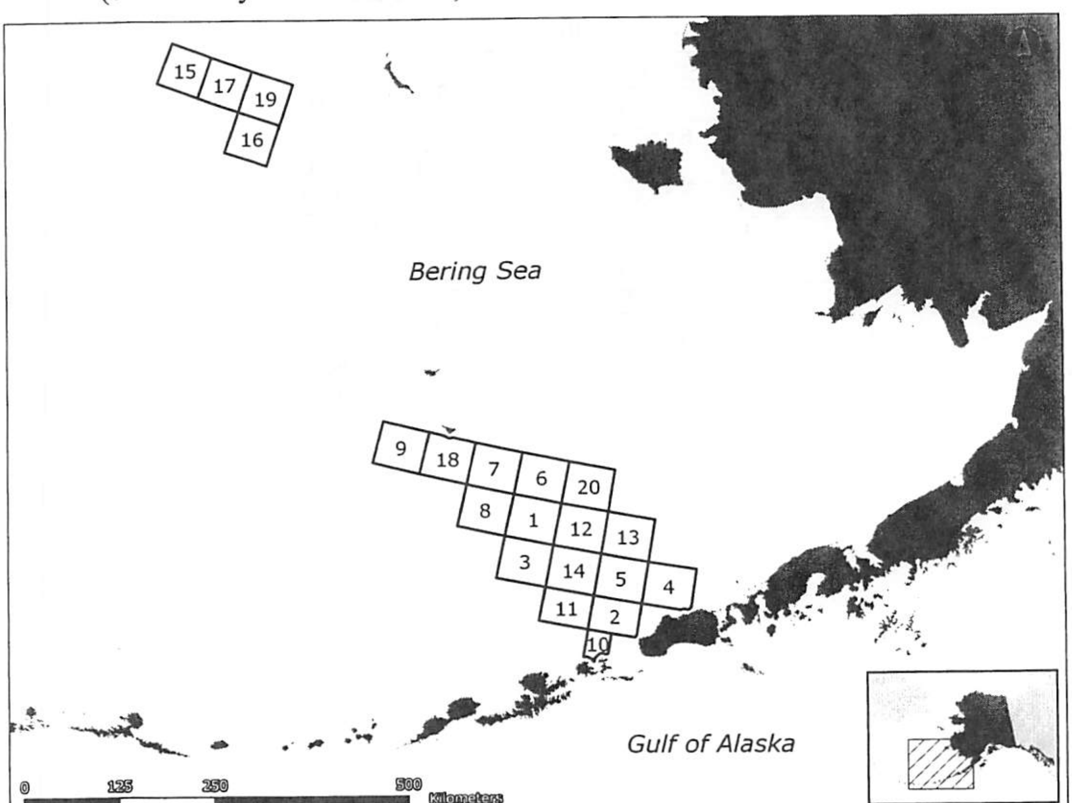

Figure 4. Top 20 ranked selected ADFG statistical areas by week (since June 1st) for all years (1991-2007) as indicated in Figure 3.

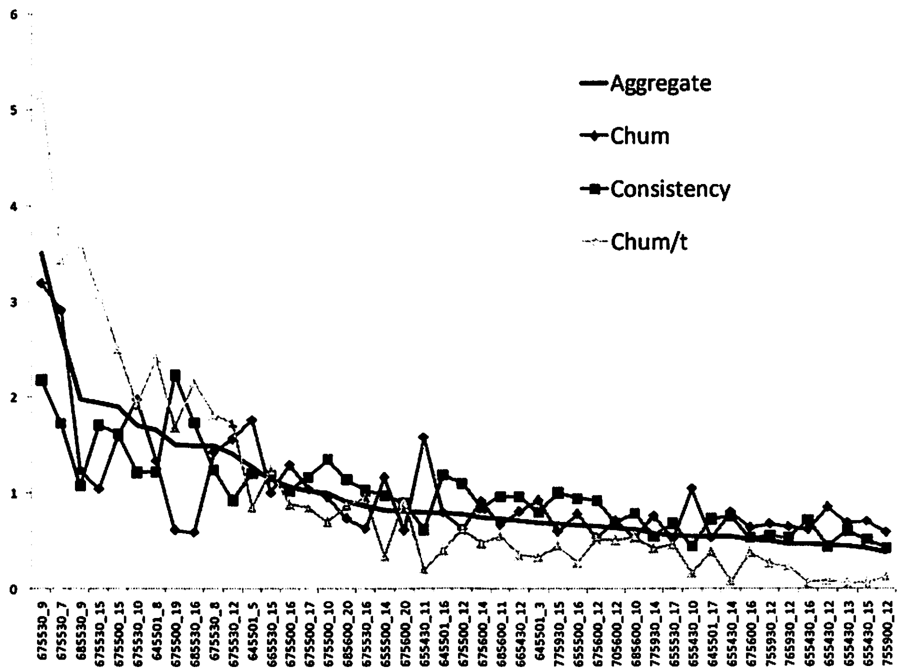

Figure 5. Ranked selected ADFG statistical areas by week (since June 1st) for all years (1991-2007) showing relative measures of chum bycatch, chum rates (number / t of pollock), inter-annual consistency in chum rates between years, and a weighted aggregate measure of these three factors (based solely on observer data).

Begin week date

ADFG Stat Area — Year(s) (All)	1-Jun	8-Jun	15-Jun	22-Jun	29-Jun	6-Jul	13-Jul	20-Jul	27-Jul	3-Aug	10-Aug	17-Aug	24-Aug	31-Aug	7-Sep	14-Sep	21-Sep	28-Sep	5-Oct	12-Oct	19-Oct	26-Oct
675530	0	0	0	1	0	1	49	24	53	33	3	26	1	7	17	10	5	3	1	3	0	0
655430	0	1	6	6	5	3	5	3	4	17	26	14	11	13	12	10	6	7	5	4	1	0
675500	0	0	0	0	0	1	3	2	1	16	4	10	3	4	27	21	17	7	10	4	3	4
645501	0	2	15	9	29	3	1	22	5	2	0	1	1	7	7	13	9	3	3	2	1	0
655500	0	1	3	6	7	4	4	7	7	2	1	2	2	19	6	13	4	4	6	1	0	0
675600	0	0	0	4	0	0	1	3	7	4	6	9	2	15	1	11	4	6	1	10	0	0
685600	0	0	0	1	0	1	0	2	7	9	11	2	3	2	1	3	5	8	3	12	2	3
685530	0	0	0	0	0	0	0	0	21	8	8	5	3	3	0	10	2	4	2	0	0	0
705600	0	3	1	1	1	0	8	1	8	3	4	12	3	4	2	4	1	2	4	3	3	0
655409	0	0	0	1	2	2	1	1	1	4	1	2	2	3	4	9	5	8	3	4	0	0
665430	0	0	0	0	0	0	2	1	3	1	7	13	3	0	4	2	1	0	2	2	0	0
665530	0	0	0	0	0	5	0	4	2	1	0	0	0	2	17	1	1	1	0	3	1	0
655530	0	0	0	1	2	0	1	0	2	1	0	0	0	5	3	3	9	1	0	4	0	0
665500	0	0	0	0	0	2	1	0	2	2	7	6	0	1	4	5	1	0	0	0	0	0
775930	0	0	0	0	0	0	0	0	0	0	0	1	4	13	10	1	1	2	0	0	0	0
755900	0	0	0	0	0	0	0	0	0	1	7	10	2	1	3	1	2	2	0	0	0	0
765930	0	0	0	0	0	0	0	0	0	0	2	11	4	6	1	1	1	0	0	0	0	0
695600	0	0	0	0	0	1	0	0	1	2	5	1	4	0	0	3	0	3	2	1	0	0
755930	0	0	0	0	0	0	0	0	0	1	1	11	1	1	2	5	1	0	0	0	0	0
665600	0	0	1	1	1	1	0	0	0	0	0	1	2	1	2	1	3	1	2	2	0	0

ADFG Stat Area — Year(s) (All)	1-Jun	8-Jun	15-Jun	22-Jun	29-Jun	6-Jul	13-Jul	20-Jul	27-Jul	3-Aug	10-Aug	17-Aug	24-Aug	31-Aug	7-Sep	14-Sep	21-Sep	28-Sep	5-Oct	12-Oct	19-Oct	26-Oct
675530	0	0	0	1	1	1	50	74	127	160	163	189	190	197	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
655430	0	1	8	14	19	23	28	31	35	52	78	92	104	117	129	139	146	153	158	162	163	163
675500	0	0	0	0	0	1	3	5	6	22	26	37	39	43	70	91	108	115	126	130	133	137
645501	0	2	17	26	55	58	59	81	87	89	89	90	91	97	104	117	126	129	132	134	135	135
655500	0	1	4	10	17	21	25	32	39	41	42	44	45	65	71	84	88	92	98	99	99	99
675600	0	0	0	4	4	4	5	8	15	19	24	33	35	51	51	62	66	72	72	83	83	83
685600	0	0	0	1	1	2	3	5	12	21	32	34	37	39	40	42	47	55	58	70	72	76
685530	0	0	0	0	0	1	1	1	22	29	38	43	46	49	50	59	61	65	67	68	68	68
705600	0	3	4	5	6	6	14	15	23	26	30	42	45	49	51	55	56	57	62	65	68	68
655409	0	0	0	1	3	5	6	7	8	12	13	15	17	20	24	33	37	45	49	53	53	53
665430	0	0	0	0	0	0	3	3	6	8	15	29	32	33	36	38	39	39	41	43	43	44
665530	0	0	0	0	0	5	6	9	11	12	13	13	13	15	31	33	34	35	35	38	39	39
655530	0	0	0	1	3	3	4	5	7	8	8	8	8	13	17	19	28	29	29	33	33	34
665500	0	0	0	0	0	2	3	3	5	7	15	20	20	22	26	30	32	32	32	32	33	33
775930	0	0	0	0	0	0	0	0	0	0	0	1	5	18	28	28	29	31	32	32	32	32
755900	0	0	0	0	0	0	0	0	0	2	8	18	20	21	24	26	28	29	30	30	30	30
765930	0	0	0	0	0	0	0	0	0	0	2	13	16	22	24	25	26	27	27	28	28	28
695600	0	0	0	0	0	1	1	1	2	4	9	10	14	14	14	18	18	20	22	23	23	23
755930	0	0	0	0	0	0	0	0	0	1	1	13	14	15	16	21	22	22	22	23	23	23
665600	0	0	1	2	3	4	4	5	5	6	6	7	9	10	11	12	15	16	17	19	19	19

Figure 6. Chum bycatch totals (1,000s) by selected areas and weeks, 1991-2007 (observer data only). The top panel shows weekly totals, the bottom panel shows cumulative totals from June 1st. Shading (and circles) indicate relative intensity of bycatch. Open circles represent lower 5th, solid circles upper 5th, half-filled are middle 5th etc.

ADFG Stat Area

04-06	1-Jun	8-Jun	15-Jun	22-Jun	29-Jun	6-Jul	13-Jul	20-Jul	27-Jul	3-Aug	10-Aug	17-Aug	24-Aug	31-Aug	7-Sep	14-Sep	21-Sep	28-Sep	5-Oct	12-Oct	19-Oct	26-Oct
675530	0	0	0	1	0	1	49	24	[illegible]	32	2	25	0	5	17	8	1	3	0	2	0	0
655430	0	1	6	6	5	2	5	2	1	7	3	3	4	0	1	0	1	1	2	0	0	0
675500	0	0	0	0	0	1	2	1	1	14	1	1	0	0	24	11	4	7	7	1	3	3
645501	0	2	15	9	29	2	1	21	2	0	0	0	0	0	0	1	0	0	0	0	0	0
655500	0	1	3	5	6	1	4	4	1	0	0	0	0	2	0	0	0	0	0	0	0	0
675600	0	0	0	4	0	0	1	3	7	4	6	8	1	1	0	10	3	1	1	9	0	0
685600	0	0	0	1	0	1	0	2	6	8	11	1	1	0	0	2	4	2	2	9	2	3
685530	0	0	0	0	0	0	0	0	20	8	8	5	2	0	0	10	1	4	2	0	0	0
705600	0	3	1	0	0	0	7	1	8	2	4	11	2	4	2	4	0	1	3	3	0	0
655409	0	0	0	0	1	2	1	1	1	3	0	1	1	1	2	1	1	4	2	4	0	0
665430	0	0	0	0	0	0	2	0	0	0	3	1	3	0	0	0	0	0	0	0	0	0
665530	0	0	0	0	0	5	0	4	0	0	0	0	0	1	17	0	0	0	0	2	1	0
655530	0	0	0	1	2	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0
665500	0	0	0	0	0	2	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
775930	0	0	0	0	0	0	0	0	0	0	0	1	3	8	0	1	0	0	0	0	0	0
755900	0	0	0	0	0	0	0	0	0	1	6	9	1	1	0	0	1	1	0	0	0	0
765930	0	0	0	0	0	0	0	0	0	0	2	11	2	4	1	1	1	0	0	0	0	0
695600	0	0	0	0	0	1	0	0	1	2	5	1	3	0	0	3	0	0	0	0	0	0
755930	0	0	0	0	0	0	0	0	0	1	1	11	1	1	1	5	1	0	0	0	0	0
665600	0	0	1	1	1	1	0	0	0	0	0	1	2	0	1	0	0	0	1	2	0	0

Year(s)

ADFG Stat Area

04-06	1-Jun	8-Jun	15-Jun	22-Jun	29-Jun	6-Jul	13-Jul	20-Jul	27-Jul	3-Aug	10-Aug	17-Aug	24-Aug	31-Aug	7-Sep	14-Sep	21-Sep	28-Sep	5-Oct	12-Oct	19-Oct	26-Oct
675530	0	0	0	1	1	1	50	74	127	159	161	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
655430	0	1	7	13	18	20	25	26	28	35	38	40	44	44	45	46	46	47	48	49	49	49
675500	0	0	0	0	0	1	3	4	5	19	21	22	22	22	46	57	61	68	74	75	78	81
645501	0	2	17	26	54	56	57	79	80	80	80	80	80	81	81	81	82	82	82	82	82	82
655500	0	1	4	10	16	17	21	26	26	26	26	26	27	29	29	29	29	29	29	30	30	30
675600	0	0	0	4	4	4	5	8	15	19	24	32	33	34	35	44	48	49	49	59	59	59
685600	0	0	0	1	1	2	3	5	11	20	31	32	33	33	34	36	40	41	44	52	55	58
685530	0	0	0	0	0	0	1	1	21	29	36	41	43	43	43	52	53	58	60	60	60	60
705600	0	3	4	4	4	4	12	13	21	23	27	38	39	43	45	48	49	49	53	56	56	56
655409	0	0	0	1	2	3	4	5	6	9	9	10	11	12	14	15	17	21	23	26	26	27
665430	0	0	0	0	0	0	3	3	3	3	6	7	9	10	10	10	10	10	10	10	11	11
665530	0	0	0	0	0	5	6	9	9	9	9	10	10	11	28	28	28	28	28	29	30	30
655530	0	0	0	1	3	3	3	3	3	3	3	3	3	4	4	4	4	4	4	5	5	5
665500	0	0	0	0	0	2	3	3	4	5	5	5	5	5	5	5	5	5	5	5	5	5
775930	0	0	0	0	0	0	0	0	0	0	0	1	4	13	13	14	14	14	14	14	14	14
755900	0	0	0	0	0	0	0	0	0	2	8	17	18	19	20	20	21	21	21	21	21	21
765930	0	0	0	0	0	0	0	0	0	0	2	13	15	19	20	21	22	22	22	22	22	22
695600	0	0	0	0	0	1	1	1	2	4	9	9	12	13	13	15	16	16	16	16	16	16
755930	0	0	0	0	0	0	0	0	0	1	1	13	14	14	15	20	20	20	21	21	21	21
665600	0	0	1	2	3	4	4	4	5	5	5	5	7	7	8	8	8	8	9	11	11	11

Figure 7. Chum bycatch totals (1,000s) by selected areas and weeks, 2004-2006 (observer data only). The top panel shows weekly totals, the bottom panel shows cumulative totals from June 1st. Shading (and circles) indicate relative intensity of bycatch. Open circles represent lower 5th, solid circles upper 5th, half-filled are middle 5th etc.

Begin week date

ADFG Stat Area

Year(s) all but 04-06	1-Jun	8-Jun	15-Jun	22-Jun	29-Jun	6-Jul	13-Jul	20-Jul	27-Jul	3-Aug	10-Aug	17-Aug	24-Aug	31-Aug	7-Sep	14-Sep	21-Sep	28-Sep	5-Oct	12-Oct	19-Oct	26-Oct
675530	0	0	0	0	0	0	0	0	0	1	1	1	1	2	0	2	4	0	0	1	0	0
655430	0	1	0	0	0	1	1	1	3	10	24	11	8	13	11	10	6	6	3	4	0	0
675500	0	0	0	0	0	0	0	1	0	2	3	9	2	3	3	10	14	0	3	4	0	1
645501	0	0	0	0	1	1	0	1	4	2	0	1	1	6	7	13	9	2	3	2	1	0
655500	0	0	0	0	1	2	0	3	6	2	1	2	1	17	6	13	4	4	6	1	0	0
675600	0	0	0	0	0	0	0	0	0	0	0	1	1	14	0	1	1	4	0	1	0	0
685600	0	0	0	0	0	0	0	0	0	0	0	1	2	2	1	0	1	6	0	3	0	0
685530	0	0	0	0	0	0	0	0	0	0	1	0	2	3	0	0	1	0	0	0	0	0
705600	0	0	0	0	1	0	0	0	0	1	0	1	1	1	1	0	0	1	1	0	3	0
655409	0	0	0	1	1	0	0	0	1	1	0	1	1	1	2	7	3	4	2	0	0	0
665430	0	0	0	0	0	0	0	0	3	1	4	13	1	0	3	2	1	0	2	1	0	0
665530	0	0	0	0	0	0	0	0	2	1	0	0	0	0	0	1	1	1	0	1	0	0
655530	0	0	0	0	0	0	1	0	2	1	0	0	0	4	3	3	9	1	0	4	0	0
665500	0	0	0	0	0	0	0	0	1	1	7	6	0	1	4	5	1	0	0	0	0	0
775930	0	0	0	0	0	0	0	0	0	0	0	0	1	4	10	0	0	2	0	0	0	0
755900	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2	1	1	1	0	0	0	0
765930	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	0	0	0	0	0
695600	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	3	2	0	0	0
755930	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
665600	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	3	1	0	0	0	0

ADFG Stat Area

Year(s) all but 04-06	1-Jun	8-Jun	15-Jun	22-Jun	29-Jun	6-Jul	13-Jul	20-Jul	27-Jul	3-Aug	10-Aug	17-Aug	24-Aug	31-Aug	7-Sep	14-Sep	21-Sep	28-Sep	5-Oct	12-Oct	19-Oct	26-Oct
675530	0	0	0	0	0	0	0	0	0	1	2	3	3	5	5	8	12	12	13	13	13	13
655430	0	1	1	1	2	3	3	4	7	17	41	52	60	73	84	94	100	106	109	113	113	114
675500	0	0	0	0	0	0	0	1	1	3	6	15	17	21	24	34	48	48	51	55	55	56
645501	0	0	0	0	1	2	2	3	6	8	8	9	10	17	23	36	45	47	49	52	53	53
655500	0	0	0	0	1	4	4	6	13	15	16	17	19	36	42	55	58	62	68	69	70	70
675600	0	0	0	0	0	0	0	0	0	0	0	1	2	16	17	17	18	23	23	24	24	25
685600	0	0	0	0	0	0	0	0	0	1	1	2	4	5	6	6	8	14	14	17	18	18
685530	0	0	0	0	0	0	0	0	0	1	1	2	4	7	7	7	8	8	8	8	8	8
705600	0	0	0	0	2	2	2	2	2	3	4	4	6	6	7	7	7	8	9	9	12	12
655409	0	0	0	1	2	2	2	2	3	4	4	5	6	8	10	17	20	24	26	26	27	27
665430	0	0	0	0	0	0	0	0	3	5	9	22	23	23	27	28	29	30	32	33	33	33
665530	0	0	0	0	0	0	0	0	2	3	3	3	3	4	4	5	7	8	8	9	9	9
655530	0	0	0	0	0	0	1	2	4	5	5	5	5	9	13	15	24	25	25	29	29	29
665500	0	0	0	0	0	0	0	0	2	2	10	16	16	17	21	26	27	27	27	28	28	28
775930	0	0	0	0	0	0	0	0	0	0	0	0	1	5	15	15	15	17	17	17	17	17
755900	0	0	0	0	0	0	0	0	0	0	0	1	2	2	5	6	7	8	8	8	8	8
765930	0	0	0	0	0	0	0	0	0	0	0	0	1	3	3	4	5	5	5	5	5	5
695600	0	0	0	0	0	0	0	0	0	0	0	1	2	2	2	2	2	5	7	7	7	7
755930	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	2	2	2	2	2
665600	0	0	0	0	0	0	0	0	1	1	1	2	2	3	3	4	7	8	8	8	8	8

Figure 8. Chum bycatch totals (1,000s) by selected areas and weeks, 1991-2003, and 2007 (observer data only). The top panel shows weekly totals, the bottom panel shows cumulative totals from June 1st. Shading (and circles) indicate relative intensity of bycatch. Open circles represent lower 5th, solid circles upper 5th, half-filled are middle 5th etc.

Begin week date

ADFG Stat Area — Year(s) 1992-94	1-Jun	8-Jun	15-Jun	22-Jun	29-Jun	6-Jul	13-Jul	20-Jul	27-Jul	3-Aug	10-Aug	17-Aug	24-Aug	31-Aug	7-Sep	14-Sep	21-Sep	28-Sep	5-Oct	12-Oct	19-Oct	26-Oct
675530	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
655430	0	0	0	0	0	0	0	0	0	1	5	7	3	4	2	2	1	1	0	0	0	0
675500	0	0	0	0	0	0	0	0	0	1	2	7	1	1	0	1	0	0	0	0	0	0
645501	0	0	0	0	0	0	0	0	0	0	0	1	0	3	5	6	1	0	0	0	0	0
655500	0	0	0	0	0	0	0	0	0	2	1	2	1	7	2	4	1	2	0	0	0	0
675600	0	0	0	0	0	0	0	0	0	0	0	0	0	14	0	0	0	0	0	0	0	0
685600	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0
685530	0	0	0	0	0	0	0	0	0	0	0	0	2	3	0	0	1	0	0	0	0	0
705600	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
655409	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
665430	0	0	0	0	0	0	0	0	3	1	2	8	0	0	1	1	0	0	0	0	0	0
665530	0	0	0	0	0	0	0	0	2	1	0	0	0	0	0	1	0	0	0	0	0	0
655530	0	0	0	0	0	0	1	0	1	0	0	0	0	2	0	1	8	0	0	0	0	0
665500	0	0	0	0	0	0	0	0	0	1	7	6	0	1	4	4	0	0	0	0	0	0
775930	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
755900	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
765930	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
695600	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
755930	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
665600	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

ADFG Stat Area — Year(s) 1992-94	1-Jun	8-Jun	15-Jun	22-Jun	29-Jun	6-Jul	13-Jul	20-Jul	27-Jul	3-Aug	10-Aug	17-Aug	24-Aug	31-Aug	7-Sep	14-Sep	21-Sep	28-Sep	5-Oct	12-Oct	19-Oct	26-Oct
675530	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1
655430	0	0	0	0	0	0	0	0	1	2	6	14	16	21	23	25	[illegible]	[illegible]	25	26	[illegible]	26
675500	0	0	0	0	0	0	0	0	0	1	3	10	11	12	12	13	13	13	13	13	13	13
645501	0	0	0	0	0	0	0	0	0	0	1	1	2	5	10	16	17	17	17	17	17	17
655500	0	0	0	0	0	0	0	0	1	3	3	5	6	13	15	19	20	22	22	22	22	22
675600	0	0	0	0	0	0	0	0	0	0	0	0	0	14	14	14	15	15	15	15	15	15
685600	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	2	2	2	2	2	2	2
685530	0	0	0	0	0	0	0	0	0	0	0	0	2	4	4	4	5	5	5	5	5	5
705600	0	0	0	0	0	0	0	0	0	0	0	0	1	2	2	2	2	2	2	2	2	2
655409	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1
665430	0	0	0	0	0	0	0	0	3	4	6	13	14	14	16	16	17	17	17	17	17	17
665530	0	0	0	0	0	0	0	0	2	3	3	3	3	3	3	4	4	4	4	4	4	4
655530	0	0	0	0	0	0	1	1	2	2	2	2	2	4	5	6	14	14	14	14	14	14
665500	0	0	0	0	0	0	0	0	0	1	9	15	15	15	19	23	23	23	23	23	23	23
775930	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
755900	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
765930	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
695600	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1
755930	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
665600	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1

Figure 9. Chum bycatch totals (1,000s) by selected areas and weeks, 1992-1994 (observer data only). The top panel shows weekly totals, the bottom panel shows cumulative totals from June 1st. Shading (and circles) indicate relative intensity of bycatch. Open circles represent lower 5th, solid circles upper 5th, half-filled are middle 5th etc.

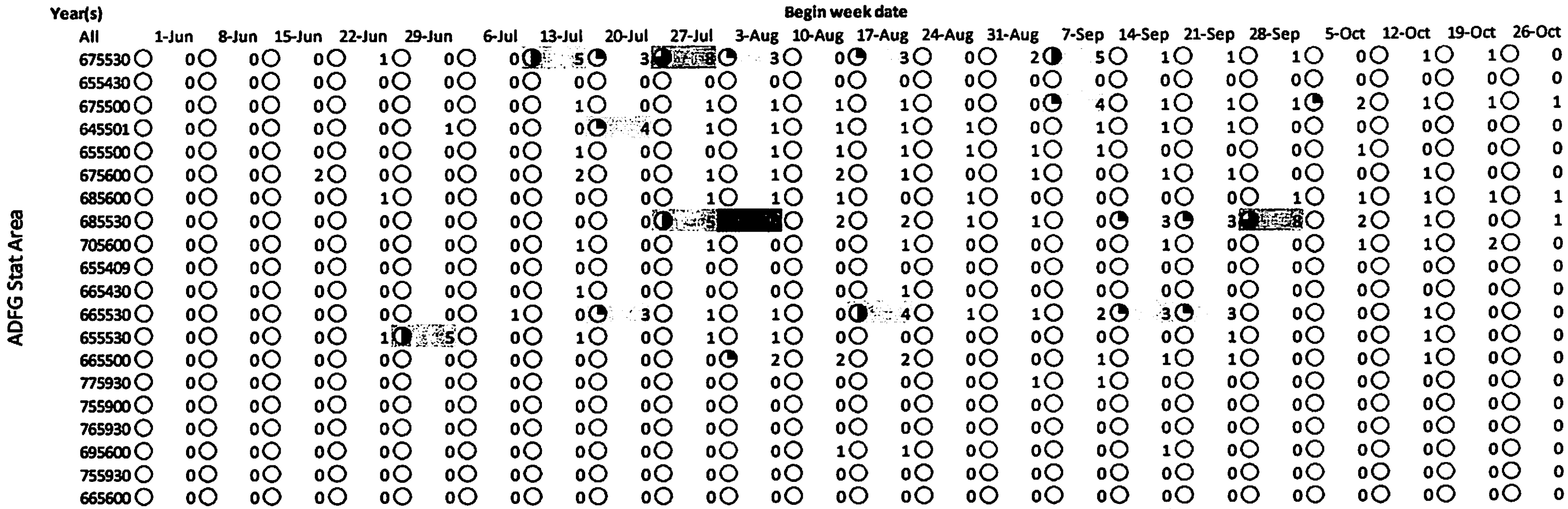

Figure 10. Chum bycatch **rates** per ton of pollock by selected areas and weeks, 1991- 2007 from June 1st (observer data only). Shading (and circles) indicate relative intensity of bycatch. Open circles represent lower 5th, solid circles upper 5th, half-filled are middle 5th etc.

ADFG Stat Area

all but 04-06	1-Jun	8-Jun	15-Jun	22-Jun	29-Jun	6-Jul	13-Jul	20-Jul	27-Jul	3-Aug	10-Aug	17-Aug	24-Aug	31-Aug	7-Sep	14-Sep	21-Sep	28-Sep	5-Oct	12-Oct	19-Oct	26-Oct
675530	0	0	0	1	0	0	5	3	8	3	0	2	0	1	5	1	0	1	0	1	1	0
655430	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
675500	0	0	0	0	0	0	1	0	1	1	0	0	0	0	3	1	0	1	2	0	1	0
645501	0	0	0	0	1	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
655500	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
675600	0	0	2	0	0	0	2	0	1	1	2	1	0	0	0	1	1	0	0	1	0	0
685600	0	0	0	1	0	0	0	0	1	1	1	0	0	0	0	0	0	0	1	1	1	1
685530	0	0	0	0	0	0	0	0	5	[illegible]	1	2	0	0	0	3	2	8	2	1	0	0
705600	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	1	0	0	0	1	0	0
655409	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
665430	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
665530	0	0	0	0	0	1	0	3	0	0	0	4	1	1	2	0	0	0	0	1	0	0
655530	0	0	0	1	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
665500	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
775930	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
755900	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
765930	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
695600	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0
755930	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
665600	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

ADFG Stat Area

1992-94	1-Jun	8-Jun	15-Jun	22-Jun	29-Jun	6-Jul	13-Jul	20-Jul	27-Jul	3-Aug	10-Aug	17-Aug	24-Aug	31-Aug	7-Sep	14-Sep	21-Sep	28-Sep	5-Oct	12-Oct	19-Oct	26-Oct
675530	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0
655430	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
675500	0	0	0	0	0	0	0	0	0	2	2	2	0	0	0	0	0	0	0	0	0	0
645501	0	0	0	0	1	0	0	1	0	0	0	1	2	2	1	1	1	0	0	0	0	0
655500	0	0	0	1	0	0	0	0	[illegible]	1	3	1	2	2	1	1	1	1	1	0	0	0
675600	0	0	0	0	0	0	0	0	0	0	5	0	0	1	0	0	1	0	0	0	0	0
685600	0	0	0	0	0	0	0	0	0	0	[illegible]	0	0	0	0	0	1	0	0	0	0	0
685530	0	0	0	0	0	0	0	0	0	0	0	0	[illegible]	1	0	0	4	0	0	0	0	0
705600	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
655409	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
665430	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
665530	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	4	0	0	0	0	0	0
655530	0	0	0	0	0	1	1	1	1	0	0	0	0	2	1	1	2	0	0	0	0	0
665500	0	0	0	0	0	0	0	0	1	1	2	2	0	0	1	1	0	0	0	0	0	0
775930	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
755900	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
765930	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
695600	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
755930	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
665600	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure 11. Chum bycatch rates per ton of pollock by selected areas and weeks, 1991- 2003, and 2007 (top panel) and from 1992-1994 (bottom panel). Shading (and circles) indicate relative intensity of bycatch. Open circles represent lower 5th, solid circles upper 5th, half-filled are middle 5th etc.

Timing of closures and trigger caps for alternatives

The Council included the following language referring to delineating specific dates for closures under Component 6: Timing Option – Dates of Area Closure.

> New closure dates [to be developed from staff analysis of seasonal proportions of pollock and chum salmon by period across additional ranges of years]

Information on time frames for highest overall bycatch and by rate (figures 6-11) is included to evaluate appropriate closure periods for each area closure in Figure 4. Based on these initial evaluations, weeks with highest bycatch by area are not always equivalent to the weeks with highest bycatch *rates* (Table 5). Data for the large area closure were not summarized by equivalent years or exact dates for direct comparison with the new closures but some inference can be made by comparison with similar weeks.

Table 5 Summary of information in Figures 6-11 relative to areas (indicated by Area # to go with Figure 4) with highest bycatch overall and by rate for 1991-2007 years. Bolded numbers show where the same area has both a high overall number and by rate while '—' indicate where no area had a high enough bycatch (overall or rate) to rank for that week.

Week		Highest relative areas by **number** of chum	Highest relative areas by **rate** of chum
June	1-7	--	--
	8-14	--	--
	15-21	4	--
	22-28	--	--
July	Jun 29-Jul 5	4	13
	6-12	--	--
	13-19	**1**	**1**
	20-26	**1, 4**	**1, 4**, 12
August	Jul 27-Aug 2	**1, 8**	**1, 8**
	3-9	1, 2, 3	1, 8, 14
	10-16	2, 7	--
	17-23	1, 2, 9, 11, 19, 17	1, 12
	24-30	2	--
September	Aug 31-Sep 6	2, 5, 6, 15	--
	7-13	1, 2, **3**, 12	1, **3**
	14-20	3, 4, 5	8, 12
	21-27	3	8, 12
October	Sep 28-Oct 4	--	8
	5-11	--	3
	12-18	7	--
	19-25	--	--
	26-31	--	--

Further consideration of the timing aspect of closure is discussed after the application of trigger caps as it relates to more than one aspect of the components under Alternative 3.

Application of trigger caps

The draft alternatives specify a range of trigger caps as well as their application under Component 1.

Component 1: Trigger Cap Formulation

a) Cap level

1. 25,000
2. 50,000
3. 75,000
4. 125,000
5. 200,000

b) Application of Trigger Caps

1. Apply trigger to all chum bycatch
2. Apply trigger to all chum bycatch between specific dates
3. Apply trigger to all chum bycatch in a specific area.

In order to equate trigger caps and application with actual areas, some relationship is needed to relate relative rates by area to overall chum bycatch. Table 6-Table 8 show the overall regional estimates of salmon bycatch by year (Table 6), the aggregate overall number by year (and year-set considerations as noted) and area (Table 7) as well as the relative proportion of bycatch by area for the closures in Component 5b (Table 8). Note that for Table 7 and Table 8, observer data only was used thus numbers are lower than those in Table 6 where the overall bycatch by year includes the extrapolation to the unobserved fleet. For purposes of this initial evaluation, observed proportions by area are considered to be representative of the relative catch by area overall. Further information on seasonal proportions of pollock catch over these time frames are summarized in Table 9 and Table 10.

Table 6. Non-Chinook salmon catch (numbers of fish) in the BSAI pollock trawl fishery (all sectors) 1991-2009, CDQ is indicated separately and by season where available. 'na' indicates that data were not available in that year. 2009 data through 10/10/09

Year	Annual with CDQ	Annual without CDQ	Annual CDQ only	A season	B season	A season	B season	A season	B season
				With CDQ		Without CDQ		CDQ only	
1991	Na	28,951	na	na	na	2,850	26,101	na	na
1992	na	40,274	na	na	na	1,951	38,324	na	na
1993	na	242,191	na	na	na	1,594	240,597	na	na
1994	92,672	81,508	11,165	3,991	88,681	3,682	77,825	309	10,856
1995	19,264	18,678	585	1,708	17,556	1,578	17,100	130	456
1996	77,236	74,977	2,259	222	77,014	177	74,800	45	2,214
1997	65,988	61,759	4,229	2,083	63,904	1,991	59,767	92	4,137
1998	64,042	63,127	915	4,002	60,040	3,914	59,213	88	827
1999	45,172	44,610	562	362	44,810	349	44,261	13	549
2000	58,571	56,867	1,704	213	58,358	148	56,719	65	1,639
2001	57,007	53,904	3,103	2,386	54,621	2,213	51,691	173	2,930
2002	80,782	77,178	3,604	1,377	79,404	1,356	75,821	21	3,453
2003	189,184	180,782	8,402	3,834	185,350	3,597	177,185	237	8,165
2004	440,472	430,284	10,188	422	440.050	395	429,889	27	10,161
2005	704,590	696,880	7,710	595	703,995	563	696,317	32	7,678
2006	309,643	308,429	1,214	1,332	308,311	1,266	307,163	66	1,148
2007	93,660	87,191	6,469	8,523	85,137	7,368	79,823	1,155	5,314
2008	15,423	14,992	431	320	15,103	247	14,745	73	358
2009	45,905	44,911	994						

Table 7. Total chum by area and year-subsets (observer data only; 1991-2007).

Ranked Area	All years	1992-1994	2004-06	All but 04 - 06	All but 92-94
Outside	349,444	28,140	166,956	182,488	321,304
1	238,087	1,096	224,840	13,247	236,991
2	163,083	26,406	49,171	113,912	136,676
3	136,960	13,121	81,243	55,717	123,840
4	136,674	17,337	82,336	54,338	119,337
5	99,483	21,921	29,543	69,940	77,562
6	83,629	14,509	58,835	24,794	69,120
7	75,908	2,472	57,903	18,005	73,436
8	69,038	4,996	60,782	8,256	64,042
9	68,165	1,587	56,334	11,831	66,577
10	56,428	1,209	26,994	29,434	55,218
11	43,736	17,104	10,552	33,184	26,632
12	39,116	4,475	30,336	8,780	34,641
13	33,661	14,524	4,820	28,841	19,137
14	32,674	23,000	4,895	27,779	9,673
15	31,764	8	14,335	17,429	31,756
16	29,594	0	21,463	8,131	29,594
17	27,597	1	22,448	5,149	27,596
18	23,223	1,132	16,185	7,038	22,091
19	22,553	12	20,750	1,803	22,541
20	19,520	1,037	11,123	8,397	18,483
Totals	1,780,335	194,087	1,051,844	728,491	1,586,248

Table 8. Proportions of chum by area and year-subsets.

Ranked Area	All years	1992-1994	2004-06	All but 04 - 06	All but 92-94
Outside	20%	14%	16%	25%	20%
1	13%	1%	21%	2%	15%
2	9%	14%	5%	16%	9%
3	8%	7%	8%	8%	8%
4	8%	9%	8%	7%	8%
5	6%	11%	3%	10%	5%
6	5%	7%	6%	3%	4%
7	4%	1%	6%	2%	5%
8	4%	3%	6%	1%	4%
9	4%	1%	5%	2%	4%
10	3%	1%	3%	4%	3%
11	2%	9%	1%	5%	2%
12	2%	2%	3%	1%	2%
13	2%	7%	0%	4%	1%
14	2%	12%	0%	4%	1%
15	2%	0%	1%	2%	2%
16	2%	0%	2%	1%	2%
17	2%	0%	2%	1%	2%
18	1%	1%	2%	1%	1%
19	1%	0%	2%	0%	1%
20	1%	1%	1%	1%	1%

Table 9. Total pollock by area and year-subsets (observer data only; 1991-2007). Millions of t.

Ranked Area	All years	1992-1994	2004-06	All but 04 - 06	All but 92-94
Outside	7,776	954	1,804	5,972	6,822
1	104	2	54	50	102
2	1,735	350	187	1,548	1,385
3	147	22	41	105	125
4	1,554	207	394	1,161	1,348
5	553	111	106	447	441
6	263	26	72	191	237
7	434	59	142	292	375
8	175	18	82	94	157
9	275	62	68	208	213
10	787	129	89	698	658
11	285	136	35	250	149
12	83	9	21	62	74
13	222	55	27	195	167
14	96	39	29	67	57
15	189	16	64	125	173
16	414	3	175	239	411
17	231	4	107	124	227
18	321	68	94	227	253
19	174	11	82	93	163
20	373	28	58	316	345
Totals	16,192	2,308	3,730	12,462	13,884

Table 10. Proportions of pollock by area and year-subsets.

Ranked Area	All years	1992-1994	2004-06	All but 04 - 06	All but 92-94
Outside	48%	41%	48%	48%	49%
1	1%	0%	1%	0%	1%
2	11%	15%	5%	12%	10%
3	1%	1%	1%	1%	1%
4	10%	9%	11%	9%	10%
5	3%	5%	3%	4%	3%
6	2%	1%	2%	2%	2%
7	3%	3%	4%	2%	3%
8	1%	1%	2%	1%	1%
9	2%	3%	2%	2%	2%
10	5%	6%	2%	6%	5%
11	2%	6%	1%	2%	1%
12	1%	0%	1%	0%	1%
13	1%	2%	1%	2%	1%
14	1%	2%	1%	1%	0%
15	1%	1%	2%	1%	1%
16	3%	0%	5%	2%	3%
17	1%	0%	3%	1%	2%
18	2%	3%	3%	2%	2%
19	1%	0%	2%	1%	1%
20	2%	1%	2%	3%	2%

Proposed application of trigger caps

Under Component 1b as described above, there are three options for application of the trigger cap. Here we discuss option 1: apply trigger to all chum bycatch and 3: apply trigger to all chum bycatch in a specific area. Option 2: apply trigger to all chum bycatch between specific dates was not yet evaluated at this time. Suggestions for clarifying the overlap between some aspects of Component 1 and those under Components 5 and 6 will be provided at the meeting.

Single EBS-wide cap

Several methods are proposed for applying the draft suite of trigger caps to the candidate areas. The first would be to trigger closures when a cap levels specified under Component 1a was attained. Given temporal bycatch variability for different areas, closures could be established for specified date ranges (i.e. each area or set of areas would have a specified closure time frame should the overall cap be triggered). Areas would close at different times, but the mechanism that triggers such closures in a season would be a single cap. Triggering the cap then results in a patchwork of time/area closures over the remainder of the season.

For example, proposed closure periods (for highest bycatch by individual areas) would be fixed time periods and enacted only if the overall cap were triggered (Table 11). Some closure dates may not be enacted under higher overall cap levels (e.g. Area 4 in June), but if triggered the remaining closure dates would go into affect by area for the remainder of the season. The selected dates will depend upon the time frame over which the bycatch is evaluated by area thus Table 11 provides an example at this time using the years 1991-2007.

Table 11 Example of fixed closure dates by area under a EBS-wide cap using 1991-2007 year-sets for identifying highest bycatch by region.

Ranked Area	Dates of closure if overall cap triggered				
	June	July	August	September	October
1		13-31	1-9; 17-23	7-13	
2			3-31	1-13	
3			3-9	7-27	
4	15-21; 29-30	1-5; 20-26	14-20		
5			14-20		
6			31	1-6	
7		10-16			12-18
8		27-31			
9			17-23		
10					
11			17-23		
12				7-13	
13					
14					
15			31	1-6	
16					
17			17-21		
18					
19					
20					

Discrete area caps
Alternatively, each closure could have its own discrete cap, with bycatch towards that cap accruing for each area. In this case, some proportion of the cap levels would be distributed to individual areas. Alternative methods for doing this might be:

a) assume that the overall trigger cap is proportioned out to the 20 areas without compensating for the bycatch outside of those areas,
b) discount the caps for the proportion of bycatch which accrues outside of the areas and proportion the remaining amongst the twenty areas. For example, using the calculations over 1991-2007 (inclusive of all years), the relative proportion of bycatch outside of the 20 closures was 20%.
c) account for baseline rates (chum per ton of pollock) to project the likelihood of individual area bycatch totals and select those areas for closure (until a specified high-bycatch period ended).

Thus under proposed mechanism b) above, the cap options are discounted first for the proportion outside of the areas, and then proportionally amongst the 20 areas (Table 12). Under proposed mechanism a), each cap would be higher as there would be no initial discounting for bycatch outside of the candidate areas and the relative proportion of the cap by area would be increased. Proportions by area (and resulting trigger caps) could also be considered for high and low bycatch year-sets.

Table 12. Example of proportioning trigger caps amongst 20 ranked areas by discounting for bycatch which accrues outside of all closures. Proportions are related to the relative proportion in each area based on 1991-2007 data.

		Cap level				
Ranked Area	**Proportion of cap**	**25,000**	**50,000**	**75,000**	**125,000**	**200,000**
Outside	*20%*	*5,000*	*10,000*	*15,000*	*25,000*	*40,000*
1	13%	3,250	6,500	9,750	16,250	26,000
2	9%	2,250	4,500	6,750	11,250	18,000
3	8%	2,000	4,000	6,000	10,000	16,000
4	8%	2,000	4,000	6,000	10,000	16,000
5	6%	1,500	3,000	4,500	7,500	12,000
6	5%	1,250	2,500	3,750	6,250	10,000
7	4%	1,000	2,000	3,000	5,000	8,000
8	4%	1,000	2,000	3,000	5,000	8,000
9	4%	1,000	2,000	3,000	5,000	8,000
10	3%	750	1,500	2,250	3,750	6,000
11	2%	500	1,000	1,500	2,500	4,000
12	2%	500	1,000	1,500	2,500	4,000
13	2%	500	1,000	1,500	2,500	4,000
14	2%	500	1,000	1,500	2,500	4,000
15	2%	500	1,000	1,500	2,500	4,000
16	2%	500	1,000	1,500	2,500	4,000
17	2%	500	1,000	1,500	2,500	4,000
18	1%	250	500	750	1,250	2,000
19	1%	250	500	750	1,250	2,000
20	1%	250	500	750	1,250	2,000

Council considerations at this meeting

At this meeting the Council will review the candidate closures and trigger applications as described in this paper. The Council should refine alternatives as necessary and provide direction to staff for revisions to area options, trigger levels and applications as necessary to allow for final review and revisions to Alternative 3 in June 2010. At the June meeting the Council will refine its final set of alternatives for the chum salmon bycatch management measures analysis. Preliminary review of that analysis is scheduled for February 2011 with Initial review in June 2011.

Appendix 1. December 2009 Council motion on Bering Sea Chum salmon management measures

C-4(b) Bering Sea Salmon Bycatch

Council motion: strike-outs and underlines to indicate additions and deletions from original alternative set

Alternative 1 – Status Quo

Alternative 1 retains the current program of the Chum Salmon Savings Area (SSA) closures triggered by separate non-CDQ and CDQ caps with the fleet's exemption to these closures per regulations for Amendment 84 and as modified by the Amendment 91 Chinook bycatch action.

Alternative 2 – Hard Cap

Component 1: Hard Cap Formulation (with CDQ allocation of 10.7%)

- a) ~~58,000~~ 50,000
- b) ~~206,000~~ 75,000
- c) ~~353,000~~ 125,000
- d) ~~488,000~~ 200,000
- e) 300,000
- f) 353,000

Component 2: Sector Allocation

Use blend of CDQ/CDQ partner bycatch numbers for historical average calculations.

- a) No sector allocation
- b) Allocations to Inshore, Catcher Processor, Mothership, and CDQ
  - 1) Pro-rata to pollock AFA pollock sector allocation
  - 2) Historical average
    - i. ~~2004-2006~~ 2007-2009
    - ii. ~~2002-2006~~ 2005-2009
    - iii. ~~1997-2006~~ 2000-2009
    - iv. 1997–2009
  - 3) Allocation based on 75% pro-rata and 25% historical
  - 4) Allocation based on 50% pro-rata and 50% historical
  - 5) Allocation based on 25% pro-rata and 75% historical
- c) Allocate 10.7% to CDQ, remainder divided among other sectors

Component 3: Sector Transfer

- a) No transfers or rollovers
- b) Allow NMFS-approved transfers between sectors

  Suboption: Limit transfers to the following percentage of salmon that is available to the transferring entity at the time of transfer:
  - 1) 50%
  - 2) 70%
  - 3) 90%
- c) Allow NMFS to roll-over unused bycatch allocation to sectors that are still fishing

Component 4: Cooperative Provision

a) Allow allocation at the co-op level for the inshore sector, and apply transfer rules (Component 3) at the co-op level for the inshore sector.
   Suboption: Limit transfers to the following percentage of salmon that is available to the transferring entity at the time of transfer:
   1) 50%
   2) 70%
   3) 90%

b) Allow NMFS to rollover unused bycatch allocation to inshore cooperatives that are still fishing.

Alternative 3 – Trigger Closure

Component 1: Trigger Cap Formulation

Cap level

a) ~~45,000~~ 25,000
b) ~~58,000~~ 50,000
c) ~~206,000~~ 75,000
d) ~~353,000~~ 125,000
e) ~~488,000~~ 200,000

Application of Trigger Caps

a) Apply trigger to all chum bycatch

~~b) Apply trigger to all chum bycatch in the CVOA~~
~~c)~~ b) Apply trigger to all chum bycatch between specific dates
~~d)~~ c) Apply trigger to all chum bycatch in a specific area.

Component 2: Sector allocation

Use blend of CDQ/CDQ partner bycatch numbers for historical average calculations.

a) No sector allocation
b) Allocations to Inshore, Catcher Processor, Mothership, and CDQ
   1) Pro-rata to pollock AFA pollock sector allocation
   2) Historical average
      i. ~~2004-2006~~ 2007-2009
      ii. ~~2002-2006~~ 2005-2009
      iii. ~~1997-2006~~ 2000-2009
      iv. 1997-2009
   3) Allocation based on 75% pro-rata and 25% historical
   4) Allocation based on 50% pro-rata and 50% historical
   5) Allocation based on 25% pro-rata and 75% historical
c) Allocate 10.7% to CDQ, remainder divided among other sectors

Component 3: Sector Transfer

a) No transfers or rollovers
b) Allow NMFS-approved transfers between sectors
   Suboption: Limit transfers to the following percentage of salmon that is available to the transferring entity at the time of transfer:
   1) 50%
   2) 70%
   3) 90%
c) Allow NMFS to roll-over unused bycatch allocation to sectors that are still fishing
   Suboption: Limit transfers to the following percentage of salmon that is available to the transferring entity at the time of transfer:

1) 50%
2) 70%
3) 90%

Components 4: Cooperative Provisions

a) Allow allocation at the co-op level for the inshore sector, and apply transfer rules (Component 3) at the co-op level for the inshore sector.
   Suboption: Limit transfers to the following percentage of salmon that is available to the transferring entity at the time of transfer:
   1) 50%
   2) 70%
   3) 90%
b) Allow NMFS to roll-over unused bycatch allocation to cooperatives that are still fishing

Component 5: Area Option

b) Area identified in October, 2008 discussion paper (B-season chum bycatch rate-based closure described on pages 14-15 of December 2009 discussion paper)
~~c) Existing Chum Salmon Savings Area (differs from status quo with application of other components)~~
b) New areas [to be identified by staff] which are small, discrete closure areas, each with its own separate cap whereby bycatch in that area only accrues towards the cap

Component 6: Timing Option – Dates of Area Closure
~~a) Existing closure dates (August 1 – August 31 and September 1 through October 14 if trigger is reached.)~~
b) New closure dates [to be developed from staff analysis of seasonal proportions of pollock and chum salmon by period across additional ranges of years]

Component 7: Rolling Hot Spot (RHS) Exemption – Similar to status quo, participants in a vessel-level (platform level for Mothership fleet) RHS would be exempt from regulatory triggered closure(s).
a) Sub-option: RHS regulations would contain an ICA provision that the regulatory trigger closure (as adopted in Component 5) apply to participants that do not maintain a certain level of rate-based chum salmon bycatch performance.

Component 7 Rolling Hot Spot (RHS) Exemption - Similar to status quo, participants in a vessel-level (platform level for mothership fleet) RHS would be exempt from regulatory triggered closure(s).

Sub-option (a) RHS regulations would contain an ICA provision that the regulatory trigger closure (as adopted in Component 5) apply to participants that do not maintain a certain level of rate-based chum salmon bycatch performance.

Component 7, without the suboption, would continue some form of the current approach to managing chum salmon bycatch in the BS pollock fishery in the future. The current approach has three two components (1) a cap that triggers closure of the chum salmon savings area, and (2) exemption from closure of the chum salmon savings area for vessels that are members of AFA cooperatives or fishing on behalf of a CDQ group that is participating in a an RHS intercooperative agreement (ICA) approved by NMFS.

The ICA is a contract among the AFA cooperatives and CDQ groups. Representatives of the cooperatives and CDQ groups sign the ICA on behalf of the owners of all vessels that are members of the cooperative and the operators of all vessels that are fishing for pollock in the BS on behalf of a CDQ group. Regulations include a detailed list of the provisions that must be in the ICA. Using a process specified in regulations, the person hired to "facilitate vessel bycatch avoidance behavior and information sharing" (Sea State) assigns vessels in a cooperative to one of three tiers based on the chum salmon bycatch rates of all vessels in that cooperative relative to a base rate specified in regulation and in the ICA. Area closures are made under the ICA to cooperatives in tiers associated with higher bycatch rates. Sea State selects the areas to close based on general guidelines in regulation. Monitoring and enforcement of area closures issued under the ICA is done through provisions included in the contract. An independent compliance audit must be conducted each year and presented to the Council as part of the ICA annual report.

Under Component 7, current regulations governing the provisions that must be in a proposed ICA approved by NMFS could continue unchanged. The regulations governing non-Chinook salmon bycatch management will be revised under Amendment 91, primarily to remove the requirements to include Chinook salmon in the RHS ICA and require the ICA to include only provisions related to a RHS program for non-Chinook. Regulations that require the ICA to include RHS components for non Chinook salmon, including the base rates, specification of Chinook Salmon Savings Area closures and notices, and assignment of vessels in cooperatives to tiers based on the cooperative's Chinook salmon bycatch, would not be changed under Amendment 91. Although NMFS regulations would no longer require that the ICA include Chinook salmon in a VRHS system, the industry could continue to include Chinook salmon in their RHS ICA on a voluntary basis.

Sub-option (a) RHS regulations would contain an ICA provision that the regulatory trigger closure (as adopted in Component 5) apply to participants that do not maintain a certain level of rate-based chum salmon bycatch performance.

Under the suboption, exemption from the area closures that would be occuring upon attainment of the trigger cap specified under Components 1, 5, and 6 would not necessarily apply to all vessels that are members of cooperatives participating in the ICA or all vessels fishing on behalf of a CDQ group participating in the ICA. Rather, the exemption would apply only to vessels that maintain chum salmon bycatch below certain bycatch rates that would be specified in the ICA, provided those areas are not part of the areas closed under other provisions of the ICA.

The bycatch rate standard that would allow vessels fishing under the ICA to continue to fish in the closure area(s) once the trigger cap(s) is/are reached would be determined by the participants in the ICA and specified in the ICA. The Council would not specify the chum salmon bycatch rate or other bycatch performance that would provide the exemption. Enforcement of compliance with the area closures for vessels that do not meet the ICA bycatch rate performance standard would not be done by NOAA Office of Law Enforcement (OLE). Rather, enforcement of these area closures for vessels that do not meet the ICA standards for the exemption would be done in the same manner as enforcement of area closures under the current RHS ICA is done, which is through the enforcement procedures contained in their contract.

When do we call this non-Chinook salmon vs chum salmon?

PUBLIC TESTIMONY SIGN-UP SHEET

Agenda Item: D-3(b) Chum Bycatch

	NAME *(PLEASE PRINT)*	TESTIFYING ON BEHALF OF:
1	BRENT PAINE; JOHN GRUVER; Glenn Reed	UCB, ICA, PSA
2	Steph Madsen / Ed Richardson	PCC
3	JOE PLESHA	TRIDENT
4	Becca Robbins Gisclair	YRDFA
5		
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NOTE to persons providing oral or written testimony to the Council: Section 307(1)(I) of the Magnuson-Stevens Fishery Conservation and Management Act prohibits any person " to knowingly and willfully submit to a Council, the Secretary, or the Governor of a State false information (including, but not limited to, false information regarding the capacity and extent to which a United State fish processor, on an annual basis, will process a portion of the optimum yield of a fishery that will be harvested by fishing vessels of the United States) regarding any matter that the Council, Secretary, or Governor is considering in the course of carrying out this Act.

D-3(b) Area Closure Options for Chum Bycatch Alternatives
February 15, 2010

> *The Council requests staff develop an expanded discussion paper based on Advisory Panel recommendations. Additions to the Advisory Panel recommendations are shown underlined and deletions in strikethrough.*

The ~~AP recommends the~~ Council moves ~~forward with~~ the following revised ~~(bold)~~ components for analysis:

Component 5: Area Option

a) Large area closure
b) Discrete, small area closures identified by staff in February Discussion paper (20 ADF&G statistical areas, identified in Table 4)
c) Groupings of the small area closures (described in Option b above) into 3 zones that could be triggered independently with subarea, rather than statistical area, level closures

Component 6: Timing Option – Dates of Area Closures

a) Trigger closure of Component 5 areas when the overall cap level specified under Component 1(a) was attained
b) Under Component 5(b) discrete small closures would close when an overall cap was attained and would close for the time period corresponding to periods of high historical bycatch, considering both number of salmon and bycatch rate (i.e. Table 11 in February Discussion Paper)
   Under Component 5(c) subareas within a zone would close for the time period corresponding to periods of high historical bycatch within the subarea when a zone level cap was attained

c) Under Component 5, areas close when bycatch cap is attained within that area (i.e. Table 12 in February Discussion Paper)
   a. for the remainder of year
   b. for specific date range

Component 7 Rolling Hot Spot (RHS) Exemption - Similar to status quo, participants in a vessel-level (platform level for mothership fleet) RHS would be exempt from regulatory triggered closure(s).

Sub-option (a) RHS regulations would contain an ICA provision that the regulatory trigger closure (as adopted in Component 5) apply to participants that do not maintain a certain level of rate-based chum salmon bycatch performance.

In addition, include the following items in the next discussion paper:

- Analyze discrete area approach normalized across years (i.e. proportion of salmon caught in an area in a year rather than numbers of salmon)

- Discuss how Component 7 and suboption would be applied
- In depth description of the rolling hot spot regulations (Amendment 84), focusing on parameters that could be adjusted if the Council found a need to refine the program to meet objectives under Component 7
- Discussion from NMFS of catch accounting for specific caps for discrete areas, and area aggregations described in Component 5 and for areas within those footprints that may have other shapes that could be defined by geographic coordinates ~~[Component 6(e)]~~
- Discussion from NMFS on the ability to trigger a regulatory closure based on relative bycatch within a season (with respect to catch accounting system and enforcement limitations) considering changes in bycatch monitoring under Amendment 91
- Contrast a regulatory closure system (Components 5 and 6) to the ICA closure system (Component 7) including data limitations, enforcement, potential level of accountability (i.e., fleet-wide, sector, cooperative, or vessel level)
- Examine differences between high bycatch years (i.e. 2005) and other years to see what contributes to high rates (i.e. timing/location, including fleet behavior and environmental conditions)
- Examine past area closures and potential impacts of those closures on historical distribution of bycatch and on bycatch rates (qualitative); include 2008 and 2009 data and contrast bycatch distribution under VRHS versus the Chum Salmon Savings Area

AUDIT OF SALMON CLOSURE ZONE COMPLIANCE MONITORING, BERING SEA POLLOCK FISHERY, 2009

FINAL REPORT

Prepared for

Sea State Inc.
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February 2010

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BACKGROUND

Closure zones were established for the Bering Sea pollock (*Theragra calcogramma*) fishery to ensure that fishing vessels would avoid areas with the potential for substantial bycatch of chinook and chum salmon (*Oncorhynchus tshawytscha* and *O. keta*). Vessel Monitoring System (VMS) units monitored the movement and location of fishing vessels, and fisheries observers and vessel logbooks recorded whether vessels were actively fishing. Sea State, Inc. establishes these closure zones and monitors vessel compliance of these zones using VMS data. In addition to these requirements, The National Oceanic and Atmospheric Administration (NOAA) Fisheries, Alaska Region, requires "an external audit designed to evaluate the accuracy of the approach used by Sea State to monitor compliance" be prepared for the pollock fishery. The audit, which NOAA required be based on an "[e]xamination of a randomly selected subset of vessel/days representing 10% of the catch" was conducted by ABR, Inc.—Environmental Research and Services (hereafter, ABR) for Sea State, Inc. This report presents the methods used to meet the selection criteria and the analytical methods and results of the audit.

STUDY OBJECTIVES

The objectives of the audit were twofold: (1) assess the compliance of fishing vessels within salmon closure zones by sampling 10% of the 2009 fishing effort, and (2) compare the audit findings with Sea State's conclusions regarding closure violations.

ASSUMPTIONS

The audit is based upon the following assumptions, which we have not independently verified:

1) Observer data and vessel logbook records are always correct, and these sources never report non-fishing activity when fishing actually was occurring.
2) The following data provided by Sea State are free from errors: the table of VMS locations; the tables of observer data indicating haul start and stop times, and catch weights; and the table of fish ticket data indicating trip start and stop dates, and catch weights.

3) All coordinates specified in the VMS location tables and vessel closure announcements were in the same horizontal datum, namely World Geodetic System 1984 (WGS1984).

AUDIT METHODS

SUBSET SELECTION

The pollock fishery has three major sectors and we applied the 10% sampling criteria within each sector:

- Catcher/processors (CP)
- Catcher vessels supplying motherships (CVM)
- Catcher vessels supplying shoreside fish processors (CVS)

Although the NOAA Fisheries requirement stipulated that "vessel/days representing 10% of the catch" were to be audited, we did not interpret this literally because fish catches were not reported by day. Catch was reported for each haul and/or for each individual fishing trip. These catch totals might cover a portion of a day or portions of multiple days. We believe our sampling method, described below, was consistent with the intent of the permit stipulation.

Data collected by fisheries observers provided full coverage for the CP and CVM sectors, with start times, stop times, and catch weight for each haul. To randomly select vessel/days representing 10% of the catch (separately for each sector), individual hauls were selected without replacement until the total proportion of the catch exceeded 10% (Appendix 1).

Only partial fisheries-observer data were available for the CVS sector because smaller CVS vessels only had an observer 30% of the time. The fish-ticket data provided full coverage for the fishing effort of the CVS sector. Fish tickets reported the catch for whole fishing trips rather than by day or by haul. To randomly sample vessel/days representing 10% catch in the CVS sector, fishing trips were selected without replacement until the total proportion of the catch exceeded 10% (Appendix 2). For both observer and unobserved trips, data on vessel locations were assessed during hauls from 12:00 AM on the reported "trip start date" until 11:59:59 PM on the day after the reported "activity date."

IDENTIFICATION OF CANDIDATE CLOSURE ZONE VIOLATIONS

Before performing any analyses on the VMS location data, we verified the closure locations and tier status information by examining all closure notification memos and building closure polygons based on these memos. The dates that a closure applied for each Permit cooperative unit (coop) was also recorded from the original memos.

All VMS points (i.e., a 'point' is a specific latitude-longitude coordinate for the fishing vessel) were then passed through a series of geoprocessing operations and database filters to reduce the full set of data down to a limited number of potential closure zone violations (Figure 1).

First, the VMS points were intersected with the dataset of closure polygons (i.e., the geographic area of the closure zones) for all points that were within a closure when the closure was operational. This overlay excluded all points that were outside of closure zones, or were inside zones when the closure was not in effect. Each occurrence of a point within a closure zone resulted in an output table row linking the VMS point with the closure zone.

Next, these intersections of VMS points and closures were reduced by removing all intersections that weren't part of the 10% random sample of trips or hauls we generated earlier. The remaining point / closure intersections represent the list of 'candidate' (i.e. possible) violation points.

BUFFER FILTER

There were four data providers for VMS locations, Faria, SkyMate / Nobletec , CLS America, and Thrane and Thrane. We only have information on the accuracy of the Thrane and Thrane system. For these locations we applied a two-stage buffering operation, forming a polygon from each point by adding and subtracting a pair of data transmission error terms ($\pm$0.000333 degrees for rounding errors and $\pm$0.000667 degrees for truncation errors) to each location, and then applying a second 30 meter buffer representing the positional accuracy of the satellite locations. For the other three systems, we had no information on how the data was transmitted, so we applied a simple 30 meter buffer around each point.

The buffered polygon boundaries around each location point were next compared to closure zone boundaries. When the buffer polygons were partially outside the closure zone of interest, the corresponding points were flagged as "excluded by buffer" and these points were eliminated from further consideration.

Because of the uncertainty surrounding the different systems, we performed three analyses designed to characterize the quality of the data for each system. The first was a simple pass through the data to determine the speed and heading of each vessel from each point to the next point along their path, counting the number of points where speed exceeds a reasonable threshold (15 knots) for vessels in the fleet. We also performed a window analysis of the speed and heading data, calculating the standard deviation of speed and heading for moving windows of 16 points across each vessel track and averaging these deviations for all windows and all tracks that were part of each system. Finally, we used an approach used for characterizing animal telemetry data based on the angle between three consecutive points and the speeds traveled along each leg (Keating 1994) of that triangle. Points where the central angle is small (< 20 degrees in our analysis) and the speeds are high (> 5.6 knots) are much more likely to be inaccurate than those that don't pass these thresholds.

The results of these analyses are not adequate to characterize the accuracy of individual points and were not used in filtering process, but they are useful in determining the data quality of each VMS provider.

TIER STATUS FILTER

Location points that still remained as candidate violations were then compared to the tier status reports to determine whether the vessel was exempt from the closure restrictions at the time of the candidate violation. Some closures applied to all vessels, regardless of tier status. Other closures were advisory only, and so technically did not apply to any vessels. The remainder of closures applied to only certain vessels—some vessels were exempt, based on past performance of their coop at avoiding salmon bycatch. Candidate violations that occurred when the vessel was exempt from closure restrictions were flagged as "exempt from closure due to tier status" and excluded from further consideration.

At this point, all remaining observations with observer data were considered closure zone violations. These observations were flagged as "possible violation."

SPEED FILTER

The remaining undetermined location points were all from unobserved CVS-sector fishing trips. Because no observer was reporting when the vessel was actually fishing, the travel routes to and from the fishing areas were included, although vessels are allowed to travel through closure zones as long as they are not fishing. To deal with this problem, we applied the simple speed threshold we developed for our assessment of the 2006 season (Macander and Dissing 2007). This is an automated way to filter out many points that clearly corresponded to rapid vessel travel, rather than potential fishing activity.

The speed filter applied several criteria to candidate violations to determine whether they could be excluded on the basis of vessel speed. Locational points met the speed test criteria and were excluded based on a high sustained speed, if they had 1) GPS coordinates, 2) at least 5-min elapsed time from the previous point, 3) at least 5-min elapsed time to the next point, 4) a calculated speed of >5.6 knots from the previous point, and 5) a calculated speed of >5.6 knots to the next point. Accuracy of the speed filter was able to predict fishing activity correctly for 99.83% of examined points in 2006 (Macander and Dissing 2007). The low failure rate of this method is acceptable, especially because visual examination of the points in question is likely to have a similar, if not higher, failure rate.

To develop the data necessary to apply the speed filter, the minimum sustained speed and the time interval to and from successive VMS locations was calculated for all of the selected CVS trips. Speeds were calculated from the difference in time and the distance between successive VMS locations. These values corresponded to a minimum speed because vessels traveling a zig-zag course between two observations would have a speed higher than the calculated speed. Candidate violations from the unobserved CVS sector that met our speed test criteria were flagged as "excluded due to high sustained speed." These data were excluded from further consideration.

VISUAL EXAMINATION

The remaining CVS-sector candidate violations were reviewed manually. Clearly, some of the points that did not pass the conservative speed test corresponded to non-fishing activity. For example, some points, which were just below the speed threshold, were along a straight line with several other points that did meet the criteria of the speed filter. Points that did not meet the speed test, but which were determined to correspond to running out to the fishing ground (based on visual review), were flagged as "excluded by manual review: vessel running." These data were excluded from further consideration.

VESSEL LOGBOOKS

For the remaining CVS-sector candidate violations without observer data, logbook records were requested to determine whether the vessel was fishing at the time of the candidate violation. Points that were determined to correspond to non-fishing activity (based on review of logbooks) were flagged as "excluded based on vessel logbook review: vessel not fishing." If the logbook was illegible, semi-legible, or inconsistent and a definitive determination could not be made, the point was flagged as "possible violation: logbook unclear." Remaining points corresponded to fishing in closure zones, and were flagged as "possible violation: logbook indicates fishing in closure."

Violations were reported to Sea State and the North Pacific Fisheries Management Council (NPFMC). A database containing the relevant attribute data for these violations, and maps for each violation, were provided to Sea State and NPFMC. The names of the vessels we identified as violations are not included in this draft report, because the vessels are entitled to appeal and the cases have not yet been officially resolved.

COMPARISON WITH SEA STATE DETERMINATIONS

A comparison of the violations reported by ABR was made to those reported by Sea State. All of the location points that were part of ABR's 10% selection were considered in this assessment.

RESULTS AND DISCUSSION

IDENTIFICATION OF CANDIDATE CLOSURE ZONE VIOLATIONS

IDENTIFYING CANDIDATE VIOLATIONS

The identification of candidate violations was entirely automated, without any interpretation or subjective thresholds (Table 1). This automated approach efficiently reduced the number of points requiring closer examination from 662,968 for the total fishery to the 559 locations that were assessed for potential closure zone violation.

CATEGORIZING CANDIDATE VIOLATIONS

A small degree of subjectivity is involved in setting the buffer distances and vessel speed thresholds, as well as in the process of reviewing vessel tracks manually. We believe, however, that our approach was cautious, well-documented, and reasonable. The buffers, tier status, and speed threshold tests, as applied here, reduced the number of candidate violation points from 559 to 30 (Table 2).

These 30 points required manual examination. Visual examination to identify a vessel running and not fishing excluded an additional 27 points, leaving 3 points from three vessels. To determine the fishing status of these points, we requested the logbook for each. Two vessels were exonerated as the logbooks indicated they were not fishing while inside the salmon closure zone. These points were flagged as "excluded based on vessel logbook review: vessel not fishing."

Logbooks for the third vessel (Appendix 3) showed that they were fishing inside the closure area, a potential violation (Figure 2). Sea State also identified this potential violation, but indicated they did not feel they had a strong enough case for this single-point violation. While we agree with the weakness of the case for this violation, due to the combination of uncertainty surrounding the VMS provider used on that vessel (SkyMate / Nobletec) and the nature of the ship track surrounding the violating point, according to our criteria this point represents a violation of the closure zone restriction on that date.

ANALYSIS OF VMS LOCATION SYSTEMS

Tables 3, 4, and 5 show the results of our analysis of the accuracy of each of the VMS location providers. Of primary concern in these results is the high frequency of points from the SkyMate / Nobletec system where the speed calculated from one point to the next was greater than any of the vessels in the fleet could travel over the course of the typical VMS reporting interval (30 minutes). The SkyMate / Nobletec system also had the highest average standard deviation for both speed (which makes sense given the high speeds recorded) and heading when averaged over a complete set of moving windows through the vessel tracks. The Keating 1994 angle and speed analysis of all related sets of three points found such a high rate of inaccurate points for all VMS providers that we believe this technique is not applicable for this type of data. It may be that the VMS reporting interval is too large to assume three points in a series are along a similar path, or that the nature of fishing activities automatically yields a lot of suspect data with this technique. We recommend the data providers be required to identify the accuracy of their systems, preferably in such a way that the accuracy of individual points can be assessed, and that the reporting interval be more frequent.

COMPARISON WITH SEA STATE DETERMINATIONS

A complete list of candidate violations was compiled and for each candidate violation we identified, our verdict and the verdict of Sea State are listed (Appendix 4). A summary of the ABR and Sea State determinations (Tables 6 and 7) categorizes all verdicts. Table 6 shows all the candidate locations that were automatically excluded in Sea State's process, but which fell into one of our filters and were similarly excluded. Table 7 shows the combination of Sea State and ABR verdicts and how they were reached. We found that our verdicts agreed with Sea State's determination in all cases. Our 10% subsample did not identify any errors in Sea State's original determinations, and we did not further investigate locations outside of our subsample.

CONCLUSIONS

Overall, ABR agreed with the determinations of Sea State for the 10% sample that we examined. Of points examined, our determination agreed with Sea State for all 27,329 candidate locations in our subsample. Minor discrepancies in the reason points were excluded were found, but this is because our filtering methods differed. Some points included in ABR's list of candidate violations were excluded from the Sea State analysis by preliminary filters based on other criteria, including instantaneous speed and tier status, and we were able to eliminate a lot of points from consideration using our speed filtering. Despite differences in methods, however, there was complete agreement by ABR and Sea State on final verdicts of all fishing.

With the exception of the closure zone data, which we reconstruct from the closure documents, ABR's assessment was based on our review and processing of data tables developed and provided by Sea State, Inc. As a result, our audit does not systematically assess any errors that might have occurred during Sea State's data compilation process. This could be addressed in the future by extending the compliance audit to include a systematic comparison of raw data (for example, fish tickets and VMS files) with Sea State's tables for a fraction of each table.

LITERATURE CITED

Keating, K.A. 1994. An alternative index of satellite telemetry location error. The Journal of Wildlife Management. Vol. 58, No. 3, pp. 414-421.

Macander, M.J. and D, Dissing. 2007. Audit of salmon closure zone compliance monitoring Bering Sea pollock fishery. ABR, Inc.-Environmental Research & Services, Fairbanks, AK, 99708. pp. 48.

Table 1. Number of vessel locations considered at different stages of the closure violation audit, Bering Sea pollock fishery, 2009.

	Catcher/Processor (CP)	Catcher Vessel/ Mothership (CVM)	Catcher Vessel/ Shoreside, no Observer (CVS_NO)	Catcher Vessel/ Shoreside, Observer (CVS_O)	Total
All VMS Locations	(Not separated by sector)				662,968
Select 10% of Hauls or Trips	3,364	1,994	18,436	3,480	27,274
Points in Closure when Closed (Candidate Violations)	1	0	486	72	559
Violations	0	0	1	0	1

Table 2. Results of ABR review of candidate violations of the closure zones, Bering Sea pollock fishery, 2009.

	Catcher/Processor (CP)	Catcher Vessel/ Mothership (CVM)	Catcher Vessel/ Shoreside, no Observer (CVS_NO)	Catcher Vessel/ Shoreside, Observer (CVS_O)	Total
Candidate Violations	1	0	486	72	559
Excluded by Buffer	0	0	7	0	7
Excluded based on tier status	1	0	319	72	392
Excluded by speed filter	n/a	n/a	130	n/a	130
Excluded by visual review	n/a	n/a	27	n/a	27
Excluded by review of vessel logbook	n/a	n/a	2	n/a	2
Violations	0	0	1	0	1

Table 3. Speed analysis of four different VMS location providers, Bearing Sea Pollock fishery, 2009.

VMS location system	Total locations	Locations with unlikely speeds	Frequency (%)
Faria	15,412	3	0.02
CLS America	34,354	4	0.01
SkyMate / Nobletec	74,041	707	0.95
Thrane and Thrane	363,916	99	0.03

Table 4. Standard deviation analysis of speed and heading for data windows along vessel tracks for each VMS location provider, Bering Sea Pollock fishery, 2009.

VMS location system	Total locations	Average standard deviation, Speed (knots)	Average standard deviation, Heading (degrees)
Faria	15,412	1.42	44.2
CLS America	34,354	1.40	59.6
SkyMate / Nobletec	74,041	2.22	75.8
Thrane and Thrane	363,916	1.53	61.4

Table 5. Keating analysis of speed and heading data for each VMS location provider, Bering Sea Pollock fishery, 2009.

VMS location system	Total locations	Locations classified as inaccurate	Frequency (%)
Faria	15,129	2,434	16.1
CLS America	32,804	5,052	15.4
SkyMate / Nobletec	65,842	4,552	6.9
Thrane and Thrane	349,126	39,911	11.4

Table 6. Comparison of ABR and uncategorized Sea State Inc. assessments of closure zone violations for the 10% catch of vessel/days reviewed by ABR, Bering Sea Pollock fishery, 2009.

ABR Verdict	Sea State Inc. Verdict	Number of Locations (Points)	Verdict in agreement?
Excluded: buffer	Excluded	4	Yes
Excluded: manual review, running	Excluded	8	Yes
Excluded: high sustained speed	Excluded	106	Yes
Excluded: tier status	Excluded	350	Yes
	Total Locations:	468	

Table 7. Comparison of ABR and categorized Sea State Inc. assessments of closure zone violations for the 10% catch of vessel/days reviewed by ABR, Bering Sea Pollock fishery, 2009.

ABR Verdict	Sea State Inc. Verdict	Number of Locations (Points)	Verdict in agreement?
Excluded: buffer	Excluded: manual review, running	3	Yes
Excluded: high sustained speed	Excluded: manual review, running	11	Yes
Excluded: high sustained speed	Excluded: logbook review, not fishing	7	Yes
Excluded: high sustained speed	Excluded: Observed trip, not fishing	6	Yes
Excluded: manual review, running	Excluded: Observed trip, not fishing	1	Yes
Excluded: manual review, running	Excluded: manual review, running	16	Yes
Excluded: manual review, running	Excluded: logbook review, not fishing	2	Yes
Excluded: tier status	Excluded: tier status	42	Yes
Excluded: logbook review, not fishing	Excluded: logbook review, not fishing	2	Yes
Possible violation	Possible violation	1	Yes
	Total Locations:	91	

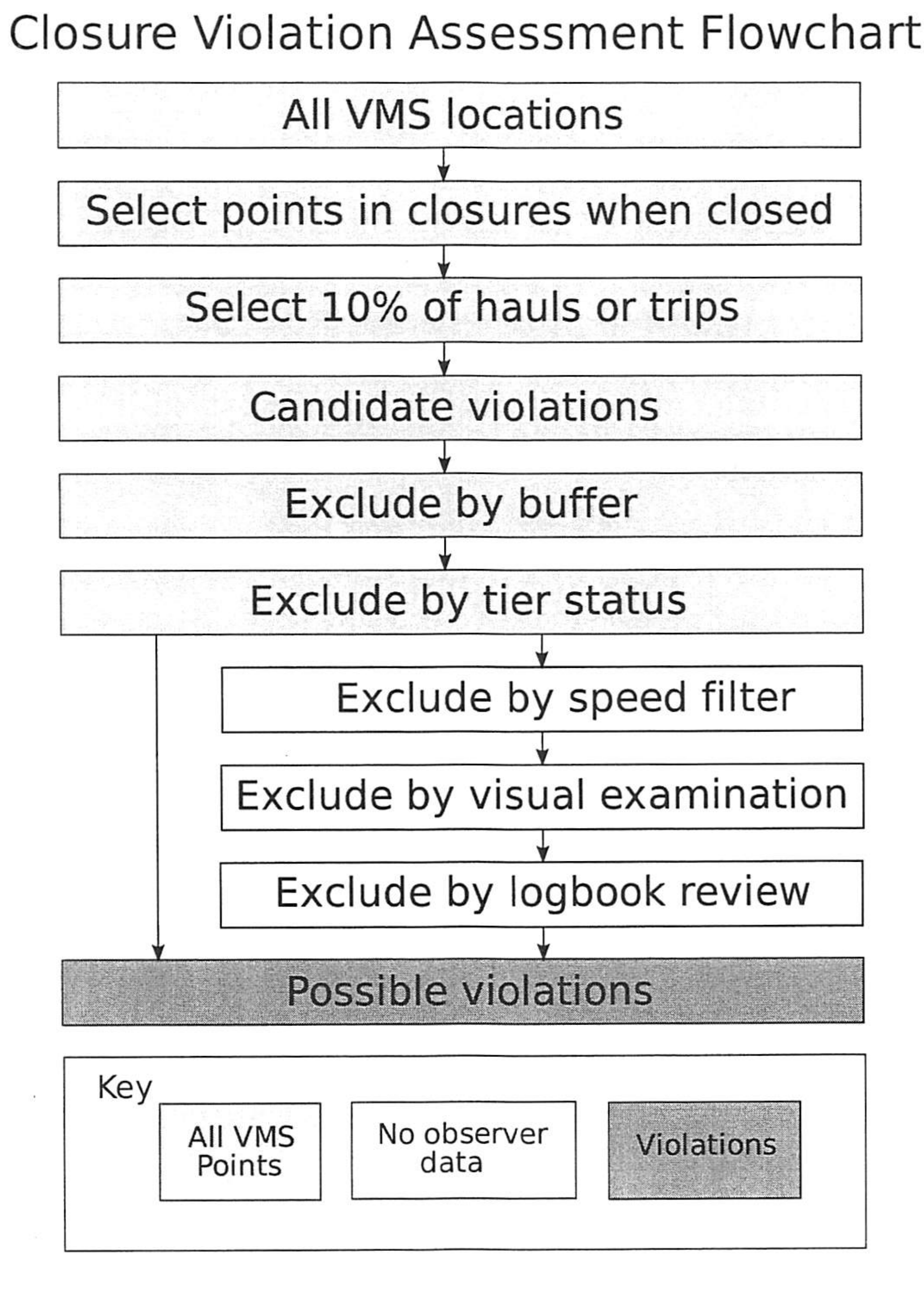

Figure 1. Closure violation assessment flowchart.

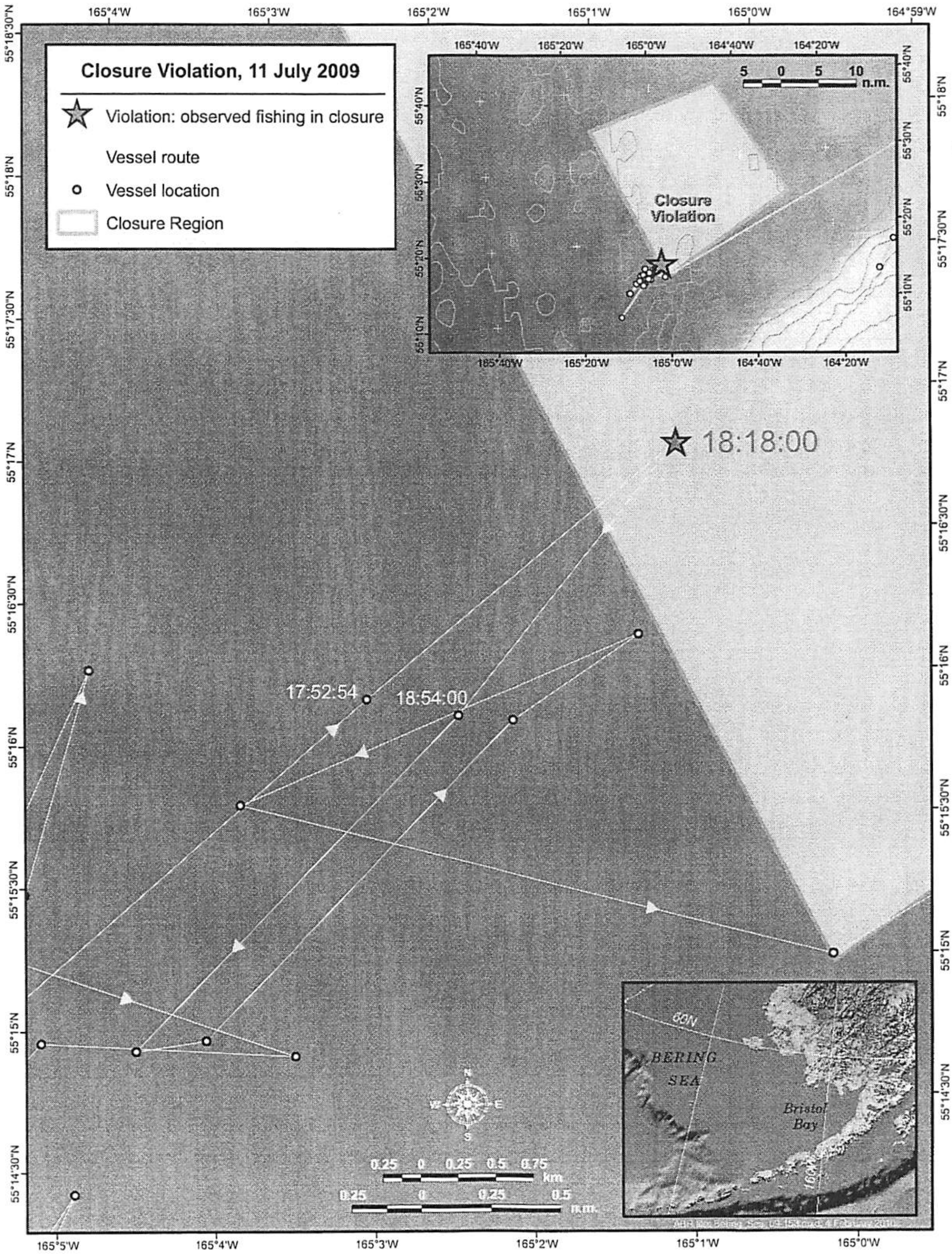

Figure 2. Location of fishing violation in closure region, 11 July 2009.