UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
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MEMORANDUM FOR: William W. Stelle, Jr.
Administrator, Northwest Region

FROM: James W. Balsiger, Ph.D.
FR Administrator, Alaska Region

SUBJECT: 2010 Annual Report for the Alaska Groundfish Fisheries Salmon Incidental Catch and Endangered Species Act Consultation

We are providing to you the 2010 annual report on salmon incidental catch in the Alaska groundfish fisheries. This report fulfills one of the terms and conditions of the December 2, 2009, and the January 11, 2007, supplements to the November 30, 2000, Biological Opinion (BiOp) regarding Authorization of Bering Sea/Aleutian Islands (BSAI) and Gulf of Alaska (GOA) Groundfish Fisheries. This memorandum and attachments provide the latest information regarding salmon incidental catch in the Alaska groundfish fisheries and the progress on developing management measures to reduce the take of salmon in the groundfish fisheries. Issues addressed include the 2010 incidental catch of salmon, the Coded-Wire Tag (CWT) recoveries, genetic studies, and the development and implementation of new management measures to reduce salmon incidental catch in the Bering Sea and GOA pollock fisheries. Each issue is detailed below.

Incidental Catch of Salmon in the Alaska Fisheries and the Incidental Take Statement for Chinook Salmon

Attachment 1 provides updated information regarding salmon incidental catch in the BSAI and GOA groundfish fisheries for the years 2004 through December 31, 2010. Approximately 87% of this incidental catch occurred in the pollock pelagic trawl fishery.

The amount of Chinook salmon incidental catch in the BSAI groundfish fisheries in 2010 was one of the lowest years on record since 1991 and is estimated at 12,532 fish (Attachment 2). This amount is well below the incidental catch range of 36,000 to 87,500 Chinook salmon in the supplemental BiOp for the BSAI groundfish fisheries. The 2009 supplemental BiOp specified the Incidental Take Statement in the 2007 supplemental BiOp will continue to define the level of expected take in 2010 for all components of the BSAI fishery. The Incidental Take amount for 2011 was revised in accordance with Amendment 91 (NMFS, 2009a). Sector specific salmon catch in the BSAI pollock fishery is provided in Attachment 3. The majority of the salmon

bycatch in the pollock fishery continues to be taken by catcher vessels delivery to shoreside processors.

For the GOA groundfish fisheries in 2010, the estimated incidental catch of Chinook salmon was above the incidental take statement of 40,000 fish in the 2007 supplemental BiOp. Of the estimated 54,576 fish incidentally caught in 2010, 79 % was taken in the pelagic trawl fishery (Attachment 1). NMFS Alaska Region reinitiated Endangered Species Act (ESA) Section 7 consultation with the NMFS Northwest Region on November 17, 2010.

Observer Program Bycatch Sampling

The North Pacific Groundfish Observer Program (Observer Program) collects catch data used for management and inseason monitoring of the commercial groundfish fisheries occurring in Federal waters off Alaska. Composition sampling for salmon on observed pollock catcher vessels is conducted as follows: (1) Samples are taken from each tow while the vessel is at-sea, and (2) the entire observed offload is followed into the shoreside processing plant as the catch is delivered and a census (a total count of every salmon) of salmon is completed. Salmon censused at the plant are added to the number of any salmon discarded at sea to obtain a final census of all salmon in each observed delivery. Full retention of salmon is required in the BSAI pollock fisheries and full discard of salmon is required in the GOA groundfish fisheries. In rare circumstances where the off-load census is not completed, NMFS Alaska Region uses the at-sea samples and extrapolates that sample to the entire delivery. The census of the salmon in observed pollock catcher vessel deliveries is then extrapolated to all unobserved pollock catcher vessel deliveries for an overall estimate of salmon bycatch. In 2010, the Bering Sea groundfish fleet had 100% coverage for the catcher/vessels and catcher/processors greater than 125 ft. Catcher vessels between 60 ft. and 125 ft. had at least 30% coverage. The majority of the GOA groundfish fleet is subject to approximately 30% observer coverage. Data from the observed vessels provides an indication of the relative numbers and species of salmon incidentally taken in the Alaska groundfish fisheries.

Genetic samples, comprised of a pelvic axillary processes, maturity information, sex/length/weight and five scales were collected from Chinook and chum salmon in the 2010 pollock fisheries. In addition, scale samples for species identification, and snouts from salmon with a missing adipose fin (CWT recovery) were collected.

In 2010, the data collection guidelines for the collection of genetic samples varied between the BSAI and GOA due to the differences in observer coverage levels between these fisheries. All catcher vessel and catcher processor and mothership observers in the BSAI pollock fishery were instructed to collect a genetic sample from every Chinook and chum salmon encountered in their species composition samples. Plant and floating processor observers were instructed to collect a genetic sample from randomly selected Chinook and chum salmon using a temporal sampling frame.

In contrast, vessel observers in the GOA pollock fishery collected genetic samples and associated data only from Chinook and chum salmon encountered in their species composition samples.

Shoreside plant observers were not responsible for collecting salmon genetic samples from the pollock deliveries in the GOA.

NMFS recently published regulations implementing Amendment 91 to the Fishery Management Plan for Groundfish of the Bering Sea and Aleutian Islands Management Area (75 FR 53026, August 30, 2010). With the regulations implementing Amendment 91 effective January 1, 2011, NMFS is requiring 100% observer coverage in the Bering Sea pollock fisheries regardless of vessel length, a census of all salmon species in every haul or fishing trip, and an expanded biological sampling program. Also, shoreside processors are required (under their Catch Monitoring and Control Plan) to provide a location from which the observer will be able to view all sorting and weighing of fish simultaneously. This will greatly improve our information on Chinook salmon bycatch in the Bering Sea pollock fishery. Amendment 91 is discussed further below. In 2011, GOA salmon bycatch sampling procedures will be revised to be as consistent as possible with changes occurring in the Bering Sea pollock fishery. The genetic samples noted above will be collected systematically from all salmon encountered in observed pollock hauls and deliveries. This should provide samples from throughout the observed deliveries in the GOA. Table 1 lists preliminary 2010 estimates of the number of salmon by species measured (by length) and sampled by observers in the BSAI and GOA groundfish fisheries.

Table 1. - Estimated numbers of salmon measured and sampled by observers, by region and species, 2010.

Region	Species	Species Name	# Measured	Total Salmon
BSAI	221	CHUM SALMON	6,611	8,169
BSAI	222	CHINOOK SALMON	4,526	4,792
BSAI	223	COHO SALMON	4	4
BSAI	224	SOCKEYE SALMON	5	7
BSAI	225	PINK SALMON	39	43
GOA	221	CHUM SALMON	126	172
GOA	222	CHINOOK SALMON	4,546	8,506
GOA	223	COHO SALMON	23	27
GOA	224	SOCKEYE SALMON	1	1
GOA	225	PINK SALMON	0	0

Source: Ren Narita, NMFS FMA Observer Program, personal communication, February 2011

Observers are deployed in the field for up to three months at a time, and debrief with FMA Division staff following their deployment. The 2010 data will not be finalized until all observers have returned from the field, are debriefed, and quality control on data is completed. Generally, the observer data are finalized in late February to early March of the year following the fishery. Any catch information provided on 2010 is preliminary until the observer data are finalized after the fishing year is completed.

Coded-Wire Tag Results

CWTs are an important source of information for the stock-specific ocean distribution of those Chinook salmon stocks that are tagged with CWTs and caught as bycatch in the BSAI and GOA groundfish fisheries. The Regional Mark Processing Center (RPMC) operated by the Pacific States Marine Fisheries Commission provides the regional coordination of the organizations involved in marking anadromous salmonids throughout the Pacific Region. The coastwide CWT

system is coordinated through the activities of two principal organizations: (1) Regional Mark Committee and (2) Pacific Salmon Commission (established by the United States–Canada Pacific Salmon Treaty) (Nandor et al., 2010). The RMPC is the United States site for exchanging United States CWT data with Canada for Pacific Salmon Treaty requirements. After 40 years, the CWT program in the greater Pacific region of North America continues to be an important tool for salmonid research and management and remains the only stock identification tool that is Pacific coastwide in scope and provides unparalleled information about ocean distribution patterns, fishery impacts, and survival rates for Pacific salmon along the Pacific coast (Nandor et al., 2010).

Although CWT recoveries provide reliable documentation of the presence of a stock in the bycatch, the recoveries to date can't be used to establish the relative abundance of stocks in the bycatch, nor to estimate the number harvested from any one stock as bycatch due to sampling issues. CWTs do not represent the true composition of all stocks of Chinook salmon in the bycatch in the groundfish fisheries. For instance, there are no CWT tagging programs on Western Alaska Chinook salmon stocks, so these stocks are not represented in stock composition estimates based on CWT recoveries. Additionally, not all Chinook salmon stocks along the Pacific coast are marked at equal rates. Furthermore, although there are CWT tagging programs on wild stocks of Chinook salmon all along the Pacific coast, wild stocks are probably under-represented by CWTs as compared with hatchery stocks, which are much easier to tag in large numbers. Exploitation rates for naturally spawning populations of Chinook salmon are difficult to estimate. The capture and tagging of juveniles and enumeration of adult escapement from wild stocks is logistically challenging and costly. The impacts of fisheries on naturally spawning populations can be estimated based on CWT-based age- and fishery-specific exploitation rates of hatchery stock indicators. However, direct validation of the assumption that selected hatchery indicator stocks are representative of their associated natural stocks is also difficult and costly (PSC, 2005).

Sources of uncertainty of CWT-based estimates include variance and bias. Variance exists among estimated catches of and impacts on CWT groups of salmon based on recoveries of individual CWT fish, size of CWT release groups, and sampling rates in fisheries and spawning escapements. Bias, both positive and negative, measures the difference between the expected (or average) values of estimates and the true but unknown quantities being estimated (e.g., total fishery-related mortalities) (PSC, 2005).

Recommendations for improving CWT programs include reviewing the indicator stocks for adequate coverage in representing natural stocks and evaluating all Chinook salmon indicator stocks for consistency with statistical guidelines. The CWT Workgroup has recommended that particular attention be paid to the adequacy of CWT release sizes in light of trends and variability in survival rates and changes in fishery exploitation rates (PSC, 2008).

In 2010, the North Pacific Fishery Management Council (Council) contracted with Cramer Fish Sciences to compile a database of CWT release groups of ESA-listed west coast salmonids based on Mark Center information. In 2011, a new contract was implemented, and CWT analyses in the BSAI and GOA will include a new summary table in the database on the annual production of stream type (spring run) Chinook salmon ESA-listed ESUs originating from Washington,

Oregon, and Idaho. The database will include all production (counted and estimated, tagged and untagged) of both wild and hatchery components of each ESU on an annual basis, dating back to when each ESU was first defined by NMFS.

CWT Expansions

Ideally, it would be preferable to calculate a total estimated contribution of Chinook salmon from ESA-listed Evolutionarily Significant Units (ESUs) harvested in the BSAI and GOA in order to determine the impact of groundfish fisheries on these stocks. Total estimated contributions for CWT recoveries can be calculated in a two-step process involving a sampling expansion factor and a marking expansion factor (see Attachment 4 on Recovery Estimation Technique for a more detailed explanation).

Unfortunately, sampling expansion factors cannot be calculated for the CWT recoveries of ESA-listed ESUs in the BSAI and GOA because of data limitations. For most of the recoveries of CWTs in the GOA trawl fishery, it is unknown whether the CWTs were collected from inside or outside the sample. A sampling expansion factor can only be calculated from CWTs recovered from inside a sample where the total number of sampled fish is known. CWT recoveries from outside the sample ("select" recoveries where the total number of fish examined is unknown) cannot be used to calculate a sampling expansion factor. Of the 69 documented CWT recoveries of Chinook salmon from ESA-listed ESUs in the GOA trawl fishery, only two CWTs are known to have been recovered from inside the sample. Two CWTs are known to have been recovered outside the sample. For the other 65 recoveries, it is unknown whether the CWT was recovered from inside or outside the sample. Sampling expansion factors cannot be calculated on CWTs without knowing with reasonable certainty which CWTs were recovered from inside the sample. However, marking expansions can still be calculated for each CWT recovery from the mark expansion factors for each tag code. Because not all fish in a tag release group are actually tagged with CWTs, marking expansion factors account for the fraction of each release group that is tagged (see Recovery Estimation Technique). Without being able to calculate total estimated contributions because of unknown sampling expansion factors, mark expansions offer the closest approximation to the contribution of Chinook salmon from ESA-listed ESUs for the CWTs recovered from the BSAI and GOA groundfish fisheries. Mark expansions should be considered a very minimal estimate for the actual total contribution of Chinook salmon from ESA-listed ESUs in the BSAI and GOA groundfish fisheries.

Occurrence of ESA-listed Chinook salmon ESUs in the GOA and BSAI

Recoveries of CWTs from outside the sample (or from unknown sample origin) are still important for documenting occurrence of Chinook salmon from ESA-listed ESUs in the GOA and BSAI trawl fisheries. Chinook salmon from the Lower Columbia River (LCR), Upper Willamette River (UWR), and Upper Columbia River (UCR) Spring ESUs have been recovered in the GOA trawl fishery. Since 1984, CWTs have been recovered from 23 LCR, 97 UWR, and 1 UCR Chinook salmon in the GOA trawl fishery, and from 9 LCR and 12 UWR Chinook salmon in the BSAI trawl fishery, both pre- and post-listing (Attachment 5, Tables 1 and 2). By applying mark expansion factors, the estimated numbers increase to 112 LCR, 275 UWR, and 1

UCR Chinook salmon in the GOA and 9 LCR and 62 UWR Chinook salmon in the BSAI (Attachment 5, Tables 1 and 2).

These numbers should be considered as very minimum estimates of the number of ESA-listed ESUs in the GOA and BSAI groundfish fisheries. Until adequate numbers of CWTs are recovered from inside the observers' samples, where the total number of fish sampled is known, an estimate of total contribution of ESA-listed ESUs in the GOA fishery will remain unknown and indeterminable.

Research surveys have documented the occurrence of other ESUs of ESA-listed Chinook salmon in the GOA besides the LCR, UWR, and UCR. Small numbers of the Puget Sound (PS) Chinook ESU, the Snake River Spring/Summer (SRS/S) Chinook ESU, and the Snake River Basin (SRB) steelhead ESUs have also been recovered in the GOA. Since 1991, CWTs have been recovered from 3 LCR, 1 PS, 5 SRS/S, 4 UCR, 11 UWR Chinook salmon, and 1 SRB steelhead in domestic and foreign research surveys in the GOA (Attachment 5, Tables 3 and 4). By applying mark expansion factors, the estimated numbers increase to 6 LCR, 1 PS, 9 SRS/S, 4 UCR, 72 UWR Chinook salmon, and 1 SRB steelhead. The purpose of providing these research CWT recoveries is to determine potential occurrence of these ESA-listed ESUs in Alaskan waters where groundfish fisheries occur. They are not intended to represent bycatch of these ESA-listed ESUs in the groundfish fisheries.

Origins of CWT Chinook salmon in the GOA

The majority of CWT Chinook salmon recovered as bycatch in the GOA originated from British Columbia and Alaska. Recoveries of CWT Chinook salmon in the bycatch of the GOA groundfish fishery are summarized by state or province of origin (Attachment 6, Table 1). Since 1995, 34% of the observed CWTs of Chinook salmon in the GOA fishery have originated from British Columbia, followed by Alaska (31%), Oregon (21%), Washington (13%), and Idaho (<1%). When accounting for mark expansions for each tag code (see section on Recovery Estimation Techniques), British Columbia provided 52% of Chinook CWTs recovered in the bycatch, followed by Alaska (33%), Oregon (8%), Washington (7%), and Idaho (<1%). In 6 out of those 16 years, however, Alaska was the major provider of the year's CWT Chinook salmon recovered from the bycatch in the GOA.

Alaskan Chinook salmon represented by CWTs and harvested in the GOA originated from two basins, Cook Inlet and Southeast Alaska. Most of the CWT Alaskan Chinook salmon recovered in the GOA originated from Southeast Alaska (Attachment 7, Table 1). Since 1995, 73% of the observed CWTs of Alaska-origin Chinook salmon in the GOA originated from Southeast Alaska and 27% from Cook Inlet. When accounting for mark expansions, Southeast Alaska provided 91% of Alaska-origin Chinook salmon CWTs recovered from the bycatch in the GOA, with Cook Inlet at 9%.

Maps of CWT Chinook salmon distribution in the North Pacific Ocean, GOA, and Bering Sea by state or province of origin are shown (Attachment 8, Figures 1–7). These maps are compiled from CWT recoveries from high seas commercial fisheries and research surveys, 1981–2010,

and are updated annually (Celewycz et al. 2010). The high seas data in these reports includes waters in the U.S. Exclusive Economic Zone.

Most of the Chinook salmon represented by CWTs and harvested in the GOA originated from hatchery production (Attachment 7, Table 2). Overall since 1995, 96% of the CWT Chinook salmon recovered from the bycatch was of hatchery origin, 3% from wild stocks, and 1% of mixed hatchery-wild stocks. For Alaska-origin CWT Chinook salmon, however, wild stocks increased to 8% of the recoveries in the bycatch in the GOA groundfish fishery, with hatcheries providing the other 92%. For all the CWT Chinook salmon that have been released in Alaska from the 1992 brood onward, 87% were of hatchery origin, and 13% were from wild stocks. Washington was the only other state of origin for wild stocks recovered in the GOA.

Chinook salmon represented by CWTs and recovered in the GOA groundfish fishery were composed of a variety of run-types, and the percentage of each run-type varied by state or province of origin (Attachment 7, Table 3). The different designated run-types are determined by the tagging agency. Overall, the most prevalent run-type of CWT Chinook salmon in the GOA was Spring, followed by Fall, Summer, and small numbers of other run-types. Percent composition of different run-types varied by state or province of origin. For Alaska stocks, 100% of CWT recoveries were Spring run-type. For British Columbia, the most prevalent run-type was Summer (41%), followed by Fall (33%) and Spring (26%). Washington Chinook salmon were predominantly Fall run-type (57%), followed by Summer (26%), Spring (9%), Late Fall (5%), and Late Fall Upriver Bright (3%). Oregon Chinook salmon were predominantly Spring (55%), followed by Fall (43%) and Winter (2%).

Genetic Analysis of Salmon Bycatch

Bering Sea Chinook salmon genetic sampling and analysis

Since 1979, four separate stock composition estimates of Chinook salmon bycatch samples from the eastern Bering Sea groundfish fisheries have been made, all showing that the majority of Chinook salmon samples were from Western Alaska stocks. Scale pattern analysis (SPA) was originally used to analyze the 1979–1982 Chinook salmon bycatch, and results suggested that 60% of the fish originated from Western Alaska, 17% from Southcentral Alaska, 14% from Asia, and 9% from Southeast Alaska and British Columbia (Myers and Rogers, 1988). A second study, also based on SPA, showed a similar stock composition from the 1997–1999 Chinook salmon bycatch with 56% from Western Alaska, 31% from Cook Inlet, 8% from Southeast Alaska-British Columbia, and 5% from Russia (Myers et al., 2004).

The third and fourth studies were completed more recently, and both used DNA characteristics available in the Alaska Department of Fish and Game (ADF&G) single nucleotide polymorphism (SNP) genetic baseline (Templin et al*.,* 2011). This baseline includes information for 45 SNP markers assayed in 23,269 fish from 288 collections representing 172 Chinook salmon populations ranging from the Kamchatka Peninsula in Russia to the Central Valley in California. Baseline populations were organized hierarchically into 11–15 large regions based on genetic clustering, geography, and management needs.

Between 2005 and 2009, genetic samples used for these analyses were collected opportunistically by the Observer Program as part of a special project, but sample biases have the potential to affect stock composition analysis results. Consequently, the associated stock composition estimates apply to the sample sets for each analysis and may not represent the entire Chinook salmon bycatch, but at a minimum, give indications of presence or absence of specific stocks and establish efficient protocols for future analyses.

In the first of the two DNA based analyses, the ADF&G used SNPs to estimate the stock composition of the Chinook salmon bycatch in the 2005–2007 Bering Sea pollock fishery based on the available sample set (NMFS, 2009b). Genetic samples of the Chinook salmon bycatch from the fall “B” 2005, spring “A” 2006, and fall “B” 2006 pollock fishing seasons were analyzed, whereas the 2007 “A” (spring) estimates were derived from a limited sample set of 360 salmon collected during a test of a salmon excluder device. The only complete year for which stock composition estimates were available was 2006, and when normalized to total bycatch, approximately 42% of the samples were estimated to come from Western Alaska, 23% from north Alaska Peninsula, 2% from Middle Yukon, 3% from Upper Yukon, 2% from Cook Inlet, 2% from Taku River-transboundary region, 23% from Pacific Northwest, 1% from Russia, and 2% from other regions.

In 2010, the NMFS Alaska Fisheries Science Center Auke Bay Laboratories (Auke Bay Lab) reported genetic stock identification results for a subset of Chinook salmon bycatch samples collected in the Bering Sea from the bycatch of the fall 2007 “B”, year 2008, and year 2009 pollock seasons (Guyon et al., 2010a; Guyon et al., 2010b). Samples were genoptyed for the 43 unlinked SNP markers represented in the ADF&G genetic baseline. When annual bycatch sample stock composition estimates were compared, the majority of Chinook salmon bycatch samples originated from Alaska river systems directly flowing into the Bering Sea although estimate deviations were apparent for individual regions specifically with regard to coastal Western Alaska (~42% in 2006 versus ~55% in 2008 and 2009), north Alaska Peninsula (~27% in 2006 and 2008 versus 14% in 2009), Middle/Upper Yukon stocks (~5% in 2006 and 2008 versus 21% in 2009), and the Pacific Northwest (23% in 2006 and ~4% in 2008 and 2009) (Attachment 9). Due to sampling issues, it is unknown whether these changes represent actual changes in the stock composition or reflect inter-annual variability in sample distribution.

When the seasonal estimates were compared, the 2006 and 2008 spring “A” season Chinook salmon stock composition estimates were generally similar with a high proportion of samples from coastal Western Alaska (~45%) and the north Alaska Peninsula (~32%), although they differed significantly in the numbers of samples from the Pacific Northwest (23% in 2006 “A” and 1% in 2008 “A”). With regard to the fall “B” pollock season, Chinook salmon bycatch stock composition estimates from 2007 and 2008 were similar with three-quarters of the samples deriving from coastal Western Alaska. Regional stock composition estimates of the Chinook salmon bycatch between the 2007 “B” and 2008 “B” seasons appear to differ from the 2005 “B” and 2006 “B” seasons, as the most current estimates have a larger proportion from coastal western Alaska (~75% versus ~55%) and decreased numbers from the Pacific Northwest (~5% versus ~22%). However, caution must be used in comparisons across years as there are differences in both the sampling rate and where/when genetic samples were collected from year to year. In addition, the extent to which any salmon stock is impacted by the bycatch of the

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

Recommendations for improving sample representation

In 2009, a study was completed providing recommendations for improving sample representation to meet the data requirements for estimating geographic stock origins of the Bering Sea salmon bycatch based on genetic markers (Pella and Geiger, 2009). The report proposed a systematic random sampling regimen for the collection of both Chinook and chum bycatch samples, whereby observers would sample every n^{th} fish from the census of salmon. Because all Chinook salmon stocks are not randomly distributed at sea (Guyon et al., 2010a; NMFS, 2009b), systematic random sampling was preferred as a means to generate a random sample set from a non-uniform distribution. An unbiased sample set, achieved by incorporating randomness at all levels of sampling so that each fish caught in the bycatch has an equal probability of being included in the sample set, is required for producing unbiased stock composition estimates of the salmon bycatch, both in the Bering Sea and the GOA. In addition, the sample set must be large enough to facilitate analysis of stock identification at pre-determined time and space domains. Due to the presence of a wide variety of salmon stocks in both the GOA and the Bering Sea, a goal of 400 representative genetic samples was established based on (1) sample sizes used in previous genetic analyses (Guyon et al., 2010a; Guyon et al., 2010b; NMFS, 2009b), and (2) recommendations that the coefficient of variation be no greater than 50% (defined as Standard Deviation/Estimated Value) for estimates with a 95% confidence that the individual stock contributed to the fishery (Marlowe and Busack, 1995). Even with this criteria, a sample set of 400 would only be 2% of a hypothetical total bycatch of 20,000. Given the non-random distribution of stocks, it is possible that even with a sample set size of 400, that the sample set may not be fully representative of rare stocks.

GOA Chinook salmon genetic sampling and analysis

Unlike the Bering Sea, limited sampling of the salmon bycatch has occurred in the GOA where very few genetic samples are available. For example, there are approximately 19 genetic samples from the 2007 “B” season, 38 from 2008, and 10 from 2009. This small number of Chinook salmon bycatch samples is insufficient to represent the annual catch for stock composition analysis, especially for an average annual bycatch of 21,596 between 2007 and 2009. Efforts are currently underway to improve genetic sampling in the GOA (Martin Loefflad, NMFS FMA Observer Program, personal communication, February 2011) so that stock composition analysis of the GOA bycatch can be accurately completed. More refined regional stock composition analyses than that currently available using the ADF&G SNP baseline will require a combined approach using both CWT information (Celewycz et al., 2010) and increased baseline coverage of Pacific Northwest salmon populations.

2010 and 2011 Chinook salmon genetic sampling and analysis

For the 2010 genetic analyses, approximately 1,000 Chinook salmon axillary process samples have been received by Auke Bay Lab from the Alaska groundfish fisheries bycatch. Although the exact collection locations are protected under the Magnuson-Stevens Fishery Conservation and Management Act, approximate locations are available based on the cruise number and offload or haul number through interrogations of the Observer Database. As in previous years, it is anticipated that the vast majority of Chinook salmon bycatch samples will be from the Bering Sea pollock trawl fishery.

Amendment 91 requires that all salmon taken as bycatch in the Bering Sea pollock fishery be sorted by species and counted to ensure compliance with the salmon bycatch caps for the pollock fishery. This has provided additional opportunities for observers to provide representative samples from the salmon bycatch for genetic analysis, and improve the capability to characterize the origin of salmon taken as bycatch in the Bering Sea pollock fishery. In 2011, systematic random sampling is being employed to take genetic samples from every tenth incidental caught Chinook salmon from the pollock trawl fishery. In 2011, GOA salmon bycatch sampling procedures have been revised to be as consistent as possible with changes occurring in the Bering Sea pollock fishery.

Chinook Salmon Management Measures

Bering Sea management measures – Amendment 91

Amendment 91 is an innovative approach to managing Chinook salmon bycatch in the Bering Sea pollock fishery that combines a Prohibited Species Catch (PSC) limit on the amount of Chinook salmon that may be caught incidentally with an incentive plan agreement (IPA) and performance standard designed to minimize bycatch to the extent practicable in all years. Under Amendment 91, the pollock fleet is prevented from exceeding the 60,000 Chinook salmon PSC limit in every year. Each year, NMFS will allocate the 60,000 Chinook salmon PSC limit to the mothership sector, catcher/processor sector, inshore cooperatives, and CDQ groups if an IPA is formed and approved by NMFS. The sector-level performance standard of 47,591 Chinook salmon is a tool to ensure that each sector does not fully harvest its Chinook salmon PSC allocation in most years. For a sector to continue to receive Chinook salmon PSC allocations under the 60,000 Chinook salmon PSC limit, that sector may not exceed its portion of 47,591 in any three years within seven consecutive years. If a sector fails this performance standard, it will permanently be allocated a portion of the 47,591 Chinook salmon PSC limit. All vessels choosing to not participate in an IPA would fish under a portion of the “opt-out” cap of 28,496 Chinook salmon. Chinook salmon PSC limit and would be ineligible to participate in management measures intended to offer flexibility to vessels harvesting pollock.

With the IPA component and the performance standard, Amendment 91, as implemented by the final rule, will result in a greater reduction of Chinook salmon bycatch over time than the PSC limits. NMFS will monitor all salmon bycatch by each vessel in the pollock fishery through a census, 100 % observer coverage, and an expanded biological sampling program. Annual reports and the proposed economic data collection program are designed to evaluate whether and how

incentive plans influence a vessel's operational decisions to avoid Chinook salmon bycatch. If information becomes available to indicate that Amendment 91 is not providing the expected Chinook salmon savings, NMFS will work with the Council to take additional actions to minimize Chinook salmon bycatch to the extent practicable. Amendment 91 applies only to management of the Bering Sea pollock fishery and will not affect the management of pollock fisheries in the Aleutian Islands.

Amendment 91 also removed from regulations the 29,000 Chinook salmon PSC limit in the Bering Sea, the Chinook Salmon Savings Areas in the Bering Sea, exemption from Chinook Salmon Savings Area closures for participants in the Voluntary Rolling Hotspot System Intercooperative Agreement (VHRS ICA), and Chinook salmon as a component of the VRHS ICA. The final rule did not change any regulations affecting the management of Chinook salmon in the Aleutian Islands or non-Chinook salmon in the BSAI. The Council is currently considering a separate action to modify the non-Chinook salmon management measures to minimize non-Chinook salmon bycatch in the Bering Sea. For more information see http://www.fakr.noaa.gov/npfmc/current_issues/bycatch/bycatch.htm.

GOA management measures

The Council updated a discussion paper on Chinook salmon bycatch in the GOA in December 2010 and is in the process of evaluating management options to reduce Chinook salmon bycatch in the GOA pollock trawl fisheries (Attachment 10). At the February 2011 meeting, the Council reviewed two staff discussion papers and a workplan to address Chinook salmon bycatch in the GOA. The proposed action includes alternatives to implement Chinook salmon bycatch caps (PSC limits) in the Central and Western GOA pollock fisheries and/or a cooperative program to address Chinook bycatch in these fisheries. The Council plans to take final action on this issue in June 2011, which could allow implementation of the proposed action in mid-2012.

Salmon Excluder Device EFP

Since 2005, several Exempted Fishing Permits (EFPs) have been issued to allow testing of a salmon excluder device on pollock trawl gear. Progress has been made in the development of a device that allows escapement of salmon without escapement of pollock. The Environmental Assessment for EFP 08-02 to support the development of a salmon excluder device (NMFS, 2008) and the final report for the work under EFP 08-02 (Gauvin et al., 2010) detail the steps leading up to the application for this EFP and continuing changes to the design. Working with the industry, Dr. Craig Rose of the Alaska Fisheries Science Center used images of salmon behavior in a pollock trawl net to develop an excluder that would permit the escapement of salmon without the loss of pollock. EFP 08-02 resulted in the current flapper excluder designed to allow escapement during towing (Attachment 11). This design is based on installing the flapper in the straight tube section just ahead of the packing tube or codend. Weight is placed on the forward part of the flapper panel and floatation on the aft section of the escapement hole is used to achieve lift and additional room for escapement. The flapper excluder achieved between 25% and 35% Chinook salmon escapement by number with pollock (groundfish) escapement in the range of one-half to one and one-half percent by weight. As was noted in the final tests on

Pacific Prince, adding artificial light above or around the escapement hole may increase the Chinook escapement rate.

In November 2010, NMFS received an application to issue an EFP from fall 2011 through fall 2012. The primary objective of the research will be the development and testing of an excluder that reduces chum salmon bycatch rates without significant negative effects on pollock fishing. A secondary objective is to improve the Chinook salmon bycatch reduction performance of the final version of the Chinook salmon excluder developed under EFP 08-02. An analysis of this application is currently underway.

Reducing salmon incidental catch continues to be an important issue for the Council, Alaska Region, Western Alaska communities, and the fishing industry. If you have any questions, please contact Mary Grady at mary.grady@noaa.gov or 907-586-7172.

<u>Attachments</u>

1. BSAI and GOA groundfish fisheries total Chinook salmon catch 2004–2010
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9. Comparison of yearly stock composition estimates based on available genetic samples from the Bering Sea Chinook salmon bycatch.
10. Council discussion paper on GOA Chinook salmon bycatch
11. Final Report for EFP 08-02 to explore the potential for flapper-style salmon excluders for the Bering Sea pollock fishery

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Attachment 1

Table 1. BSAI groundfish fisheries total Chinook salmon catch 2004–2010

BSAI Chinook Salmon Count			2004	2005	2006	2007	2008	2009	2010
Trawl Gear	Pelagic	Pollock Target	48,733	65,445	80,954	116,128	20,895	11,977	9,402
	Non-Pelagic	Pacific Cod Target	5,599	3,764	3,620	6,287	2,068	1,054	1,266
		Flatfish	2,166	2,839	680	1,148	246	110	609
		Other Targets	404	123	11	276	231	354	883
Non-Trawl Gear		All Targets	57	55	25	74	19	11	37
TOTAL			**56,960**	**72,226**	**85,290**	**123,913**	**23,460**	**13,505**	**12,197**

BSAI Groundfish			2004	2005	2006	2007	2008	2009	2010
Trawl Gear	Pelagic	Pollock Target	1,452,486	1,461,785	1,474,792	1,341,376	980,865	810,392	803,465
	Non-Pelagic	Pacific Cod Target	109,816	81,216	85,564	93,077	43,859	38,238	36,910
		Flatfish	180,893	192,555	194,683	217,734	293,334	245,562	276,934
		Other Targets	75,530	78,422	80,320	85,251	83,688	99,496	100,458
Non-Trawl Gear		All Targets	160,425	167,116	146,677	122,831	143,843	143,824	137,767
TOTAL			**1,979,151**	**1,981,113**	**1,982,108**	**1,860,288**	**1,545,589**	**1,337,596**	**1,355,582**

BSAI Chinook Salmon Bycatch Rate			2004	2005	2006	2007	2008	2009	2010
Trawl Gear	Pelagic	Pollock Target	0.034	0.045	0.055	0.087	0.021	0.015	0.012
	Non-Pelagic	Pacific Cod Target	0.051	0.046	0.042	0.068	0.047	0.028	0.034
		Flatfish	0.012	0.015	0.003	0.005	0.001	0.000	0.002
		Other Targets	0.005	0.002	0.000	0.003	0.003	0.004	0.009
Non-Trawl Gear		All Targets	0.000	0.000	0.000	0.001	0.000	0.000	0.000
TOTAL			**0.029**	**0.036**	**0.043**	**0.067**	**0.015**	**0.010**	**0.009**

2010 data are preliminary

Source: NMFS Alaska Region Catch Accounting System, 2/10/2011

Table 2. GOA groundfish fisheries total Chinook salmon catch 2004–2010

GOA Chinook Salmon Count			2004	2005	2006	2007	2008	2009	2010
Trawl Gear	Pelagic	Pollock Target	12,506	26,631	15,564	34,990	10,397	2,821	42,862
		Other Targets	-	63	-	304	761	213	156
	Non-Pelagic	Pollock Target	646	1,296	380	50	30	278	1,893
		Pacific Cod Target	908	41	882	624	433	111	442
		Flatfish	2,800	2,853	1,909	2,654	2,822	3,787	7,753
		Other Targets	885	387	263	1,733	1,519	1,219	1,470
Non-Trawl Gear		All Targets	32	-	-	39	-	-	-
TOTAL			**17,777**	**31,270**	**19,004**	**40,395**	**15,962**	**8,430**	**54,576**

GOA Groundfish			2004	2005	2006	2007	2008	2009	2010
Trawl Gear	Pelagic	Pollock Target	57,984	83,218	73,225	51,778	46,485	39,558	74,743
		Other Targets	977	1,433	3,497	4,647	4,522	3,381	4,743
	Non-Pelagic	Pollock Target	7,195	897	3,259	1,351	3,556	1,921	2,994
		Pacific Cod Target	16,785	12,443	11,403	13,605	22,856	8,736	17,228
		Flatfish	20,449	29,622	41,313	42,573	47,036	52,052	42,620
		Other Targets	26,094	21,884	22,148	20,337	20,467	22,579	24,203
Non-Trawl Gear		All Targets	59,180	50,758	53,899	54,092	56,174	55,019	71,109
TOTAL			**188,664**	**200,254**	**208,745**	**188,383**	**201,096**	**183,246**	**237,640**

GOA Chinook Salmon Bycatch Rate			2004	2005	2006	2007	2008	2009	2010
Trawl Gear	Pelagic	Pollock Target	0.216	0.320	0.213	0.676	0.224	0.071	0.573
		Other Targets	-	0.044	-	0.065	0.168	0.063	0.033
	Non-Pelagic	Pollock Target	0.090	1.445	0.117	0.037	0.009	0.145	0.632
		Pacific Cod Target	0.054	0.003	0.077	0.046	0.019	0.013	0.026
		Flatfish	0.137	0.096	0.046	0.062	0.060	0.073	0.182
		Other Targets	0.034	0.018	0.012	0.085	0.074	0.054	0.061
Non-Trawl Gear		All Targets	0.001	-	-	0.001	-	-	-
TOTAL			**17,777**	**31,270**	**19,004**	**40,395**	**15,962**	**8,430**	**54,576**

2010 data are preliminary

Source: NMFS Alaska Region Catch Accounting System, 2/10/2011

Attachment 2

Table 1. Chinook salmon mortality in BSAI groundfish fisheries

	Annual	Annual	Annual	A season	B season	A season	B season	A season	B season
Year	with CDQ	without CDQ	CDQ only	With CDQ		Without CDQ		CDQ only	
1991	na	48,880	na	na	na	46,392	2,488	na	na
1992	41,955	na	na	31,419	10,536	na	na	na	na
1993	46,014	na	na	24,688	21,326	na	na	na	na
1994	43,821	40,635	3,186	38,921	4,900	36,699	3,936	2,223	963
1995	23,436	21,430	2,006	18,939	4,497	18,284	3,146	655	1,351
1996	63,205	60,802	2,402	43,316	19,888	42,028	18,774	1,289	1,114
1997	50,530	48,050	2,481	16,401	34,129	14,905	33,144	1,496	985
1998	55,431	50,313	5,118	18,930	36,501	17,991	32,322	939	4,179
1999	14,599	12,937	1,662	8,794	5,805	8,205	4,732	589	1,073
2000	8,223	7,474	749	6,568	1,655	6,138	1,336	430	319
2001	40,547	37,986	2,561	24,871	15,676	23,093	14,893	1,778	783
2002	39,684	37,581	2,103	26,277	13,407	24,859	12,722	1,418	685
2003	53,571	50,858	2,713	40,044	13,527	38,249	12,609	1,795	918
2004	59,967	56,960	3,007	30,717	29,250	29,588	27,372	1,129	1,878
2005	74,267	72,225	2,042	33,636	40,631	32,334	39,891	1,302	740
2006	87,084	85,290	1,794	62,582	24,502	60,974	24,316	1,608	186
2007	129,567	123,914	5,653	77,108	52,459	74,004	49,910	3,104	2,549
2008	24,167	23,450	717	19,045	5,122	18,441	5,009	604	113
2009	14,008	13,505	503	11,075	2,933	10,661	2,844	414	89
2010	12,532	12,197	335	9,513	3,019	9,178	3,019	335	0
2011	2,498	2,344	154	2,498	na	2,344	na	154	na

Table 2. Chinook salmon mortality in BSAI pollock directed fisheries

	Annual	Annual	Annual	A season	B season	A season	B season	A season	B season
Year	with CDQ	without CDQ	CDQ only	With CDQ		Without CDQ		CDQ only	
1991	na	40,906	na	na	na	38,791	2,114	na	na
1992	35,950	na	na	25,691	10,259	na	na	na	na
1993	38,516	na	na	17,264	21,252	na	na	na	na
1994	33,136	30,593	2,543	28,451	4,686	26,871	3,722	1,580	963
1995	14,984	12,978	2,006	10,579	4,405	9,924	3,053	655	1,351
1996	55,623	53,220	2,402	36,068	19,554	34,780	18,441	1,289	1,114
1997	44,909	42,437	2,472	10,935	33,973	9,449	32,989	1,487	985
1998	51,322	46,205	5,118	15,193	36,130	14,253	31,951	939	4,179
1999	11,978	10,381	1,597	6,352	5,627	5,768	4,614	584	1,013
2000	4,961	4,242	719	3,422	1,539	2,992	1,250	430	289
2001	33,444	30,937	2,507	18,484	14,961	16,711	14,227	1,773	734
2002	34,495	32,402	2,093	21,794	12,701	20,378	12,024	1,416	677
2003	45,586	43,021	2,565	32,609	12,977	30,916	12,105	1,693	872
2004	51,696	48,733	2,963	23,093	28,603	21,964	26,769	1,129	1,834
2005	67,361	65,445	1,916	27,331	40,030	26,032	39,413	1,299	617
2006	82,695	80,954	1,741	58,391	24,305	56,806	24,149	1,585	156
2007	121,757	116,128	5,629	69,408	52,349	66,307	49,821	3,101	2,528
2008	21,535	20,895	640	16,679	4,856	16,075	4,820	604	36
2009	12,424	11,977	447	9,688	2,736	9,330	2,647	358	89
2010	9,737	9,402	335	7,661	2,076	7,326	2,076	335	0
2011	2,462	2,308	336	2,462	na	2,308	na	154	na

2010, 2011 data are preliminary
Source: NMFS Alaska Region Catch Accounting System, 2/14/2011

Attachment 3

Table 1. Chinook salmon bycatch by sector in Alaska pollock fisheries

	BSAI			GOA	
Year	CP	S	M	CP	S
2004	17,347	35,865	3,747	2,333	15,445
2005	19,185	50,337	2,704	2,784	28,486
2006	20,546	59,625	5,119	1,628	17,376
2007	36,392	80,847	6,647	2,984	37,411
2008	5,583	16,540	1,328	12,995	2,967
2009	3,842	9,024	639	2,406	6,024
2010	5,007	6,609	581	49,894	4,683
Average	15,415	36,978	2,966	10,718	16,056

2010 data are preliminary
CP=Catcher Processor, M=Mothership, S=Shoreshide Processor
Source: NMFS Alaska Region Catch Accounting System, 2/10/2011

Attachment 4

Recovery Estimation Technique

The total estimated contributions of ESA-listed salmon ESUs caught in the GOA and BSAI fisheries for each year can be estimated in a two-step process (Nandor et al. 2010). The first step is to calculate a sampling expansion factor (a) for each fishery in each year (Johnson 2004):

> a = (total catch of each species by fishery by year)/ (sampled catch of each species by fishery by year).

However, a sampling expansion factor can only be calculated from CWTs recovered from *inside* a sample where the number of sampled fish is known. CWT recoveries from *outside* the sample ("select" recoveries where the total number of fish examined is unknown) cannot be used to calculate a sampling expansion factor.

For the sampled catch, the estimated total recoveries of tags for each release group from each ESU by fishery and year are calculated:

$$R_{Ti} = aR_{O};$$

R_{Ti} = estimated total recoveries of tags for the i^{th} release group;
R_{Oi} = observed number of tags for the i^{th} release group release group;
a = sampling expansion factor for each fishery in each year.

The second step is to account for the fraction of each release group of interest that was tagged (Johnson 2004):

$$C_T = \sum_{i=1}^{n} b_i R_{Ti};$$

C_T = the total estimated contribution for a given ESU;
b_i = a marking expansion factor for the i^{th} release group = (total fish released)/ (total fish marked) for the i^{th} release group;
R_{Ti} = estimated total recoveries of tags for the i^{th} release group.

These are the simplest forms of recovery expansion equations (Nandor 2010).

For recoveries in high seas research cruises, because the total catch is usually sampled for tags, the sampling expansion factor (a) typically = 1.

Attachment 5

Table 1. Observed Number and Mark Expansion of ESA-listed CWT salmon by ESU captured in the bycatch of the GOA and BSAI trawl fisheries, summed over pre-listing and post-listing periods, 1984–2010

		GOA		BSAI	
Listing Status	**ESU Name**	**Observed Number**	**Mark Expansion**	**Observed Number**	**Mark Expansion**
Pre-listing	Lower Columbia River Chinook	12	82.1	0	0.0
	Upper Willamette River Chinook	40	129.7	2	2.0
Post-listing	Lower Columbia River Chinook	11	29.8	9	9.1
	Upper Willamette River Chinook	57	145.4	10	59.9
	Upper Columbia River spring Chinook	1	1.0	0	0.0

Source: NMFS Alaska Fisheries Science Center Auke Bay Lab, Adrian Celewycz, 2/3/2011

Attachment 5 cont.

Table 2. Observed Number and Mark Expansion of ESA-listed CWT salmon bycatch of the GOA and BSAI groundfish fisheries by ESU by year

A. Lower Columbia River Chinook ESU			GOA		BSAI	
Listing Status	ESU Name	Run Year	Observed Number	Mark Expansion	Observed Number	Mark Expansion
Pre-listing	Lower Columbia River Chinook	1984	5	14.1	0	0.0
		1985	1	1.0	0	0.0
		1986	0	0.0	0	0.0
		1987	1	1.3	0	0.0
		1988	0	0.0	0	0.0
		1989	0	0.0	0	0.0
		1990	1	1.0	0	0.0
		1991	0	0.0	0	0.0
		1992	1	1.6	0	0.0
		1993	1	60.3	0	0.0
		1994	2	2.8	0	0.0
		1995	0	0.0	0	0.0
		1996	0	0.0	0	0.0
Post-listing	Lower Columbia River Chinook	1997	0	0.0	0	0.0
		1998	2	18.8	0	0.0
		1999	4	5.9	0	0.0
		2000	2	2.0	0	0.0
		2001	2	2.0	1	1.0
		2002	0	0.0	1	1.0
		2003	0	0.0	0	0.0
		2004	1	1.1	3	3.0
		2005	0	0.0	3	3.1
		2006	0	0.0	1	1.0
		2007	0	0.0	0	0.0
		2008	0	0.0	0	0.0
		2009	0	0.0	0	0.0
		2010	0	0.0	0	0.0

Attachment 5, Table 2. cont.

B. Upper Willamette River Chinook ESU			GOA		BSAI	
Listing Status	ESU Name	Run Year	Observed Number	Mark Expansion	Observed Number	Mark Expansion
Pre-listing	Upper Willamette River Chinook	1984	11	16.8	1	1.0
		1985	0	0.0	0	0.0
		1986	0	0.0	0	0.0
		1987	0	0.0	0	0.0
		1988	0	0.0	0	0.0
		1989	0	0.0	0	0.0
		1990	4	4.0	0	0.0
		1991	1	13.3	0	0.0
		1992	4	28.5	0	0.0
		1993	14	52.1	0	0.0
		1994	3	8.8	0	0.0
		1995	2	4.9	0	0.0
		1996	1	1.3	1	1.0
Post-listing	Upper Willamette River Chinook	1997	1	7.5	0	0.0
		1998	4	30.7	0	0.0
		1999	20	49.3	1	1.0
		2000	16	16.6	1	1.0
		2001	7	7.1	1	1.0
		2002	1	1.0	2	12.4
		2003	1	5.3	0	0.0
		2004	1	5.8	1	7.9
		2005	0	0.0	2	10.9
		2006	1	1.0	0	0.0
		2007	0	0.0	0	0.0
		2008	1	6.5	0	0.0
		2009	1	1.8	1	10.2
		2010	3	12.8	1	15.5

Attachment 5, Table 2 cont.

C. Upper Columbia River spring Chinook ESU			GOA		BSAI	
Listing Status	ESU Name	Run Year	Observed Number	Mark Expansion	Observed Number	Mark Expansion
Pre-listing	Upper Columbia River spring Chinook	1984	0	0.0	0	0.0
		1985	0	0.0	0	0.0
		1986	0	0.0	0	0.0
		1987	0	0.0	0	0.0
		1988	0	0.0	0	0.0
		1989	0	0.0	0	0.0
		1990	0	0.0	0	0.0
		1991	0	0.0	0	0.0
		1992	0	0.0	0	0.0
		1993	0	0.0	0	0.0
		1994	0	0.0	0	0.0
		1995	0	0.0	0	0.0
		1996	0	0.0	0	0.0
Post-listing	Upper Columbia River spring Chinook	1997	0	0.0	0	0.0
		1998	1	1.0	0	0.0
		1999	0	0.0	0	0.0
		2000	0	0.0	0	0.0
		2001	0	0.0	0	0.0
		2002	0	0.0	0	0.0
		2003	0	0.0	0	0.0
		2004	0	0.0	0	0.0
		2005	0	0.0	0	0.0
		2006	0	0.0	0	0.0
		2007	0	0.0	0	0.0
		2008	0	0.0	0	0.0
		2009	0	0.0	0	0.0
		2010	0	0.0	0	0.0

Source: NMFS Alaska Fisheries Science Center Auke Bay Lab, Adrian Celewycz, 2/3/2011

Attachment 5 cont.

Table 3. Observed Number and Mark Expansion of ESA-listed CWT salmon captured in GOA research surveys, post-listing, 1991-2010. No pre-listing ESUs were ever captured in GOA research surveys, and no ESA-listed CWT salmon have ever been recovered in BSAI research surveys

		GOA	
Listing Status	**ESU Name**	**Observed Number**	**Mark expansion**
Post-listing	Lower Columbia River Chinook	3	6.5
	Puget Sound Chinook	1	1.0
	Snake River spring/summer Chinook	5	9.2
	Upper Columbia River spring Chinook	4	4.1
	Upper Willamette River Chinook	11	72.0
	Snake River Basin steelhead	1	1.0

Source: NMFS Alaska Fisheries Science Center Auke Bay Lab, Adrian Celewycz, 2/3/2011

Table 4. Observed Number and Mark Expansion of ESA-listed CWT salmon captured in GOA research surveys by ESU, by run year, post-listing, 1991-2010. No pre-listing ESUs were ever captured in GOA research surveys, and no ESA-listed CWT salmon have ever been recovered in BSAI research surveys

A. Lower Columbia River Chinook ESU			**GOA**	
Listing Status	**ESU Name**	**Run Year**	**Observed Number**	**Mark expansion**
Post-listing	Lower Columbia River Chinook	1997	0	0.0
		1998	1	4.5
		1999	1	1.0
		2000	0	0.0
		2001	1	1.0
		2002	0	0.0
		2003	0	0.0
		2004	0	0.0
		2005	0	0.0
		2006	0	0.0
		2007	0	0.0
		2008	0	0.0
		2009	0	0.0
		2010	0	0.0

Attachment 5, Table 4 cont.

C. Snake River spring/summer Chinook ESU			GOA	
Listing Status	ESU Name	Run Year	Observed Number	Mark expansion
Post-listing	Snake River spring/summer Chinook	1992	0	0.0
		1993	0	0.0
		1994	0	0.0
		1995	0	0.0
		1996	0	0.0
		1997	0	0.0
		1998	1	2.9
		1999	0	0.0
		2000	0	0.0
		2001	0	0.0
		2002	1	1.1
		2003	3	5.3
		2004	0	0.0
		2005	0	0.0
		2006	0	0.0
		2007	0	0.0
		2008	0	0.0
		2009	0	0.0
		2010	0	0.0

D. Upper Columbia River spring Chinook ESU			GOA	
Listing Status	ESU Name	Run Year	Observed Number	Mark expansion
Post-listing	Upper Columbia River spring Chinook	1999	1	1.0
		2000	2	2.1
		2001	0	0.0
		2002	0	0.0
		2003	1	1.0
		2004	0	0.0
		2005	0	0.0
		2006	0	0.0
		2007	0	0.0
		2008	0	0.0
		2009	0	0.0
		2010	0	0.0

Attachment 5, Table 4 cont.

E. Upper Willamette River Chinook ESU			GOA	
Listing Status	ESU Name	Run Year	Observed Number	Mark expansion
Post-listing	Upper Willamette River Chinook	1998	2	2.3
		1999	0	0.0
		2000	0	0.0
		2001	5	33.6
		2002	3	26.6
		2003	1	9.5
		2004	0	0.0
		2005	0	0.0
		2006	0	0.0
		2007	0	0.0
		2008	0	0.0
		2009	0	0.0
		2010	0	0.0

Attachment 5, Table 4 cont.

F. Snake River Basin steelhead ESU			GOA	
Listing Status	ESU Name	Run Year	Observed Number	Mark expansion
Post-listing	Snake River Basin Steelhead	1991	0	0.0
		1992	0	0.0
		1993	0	0.0
		1994	0	0.0
		1995	0	0.0
		1996	0	0.0
		1997	0	0.0
		1998	1	1.0
		1999	0	0.0
		2000	0	0.0
		2001	0	0.0
		2002	0	0.0
		2003	0	0.0
		2004	0	0.0
		2005	0	0.0
		2006	0	0.0
		2007	0	0.0
		2008	0	0.0
		2009	0	0.0
		2010	0	0.0

Source: NMFS Alaska Fisheries Science Center Auke Bay Lab, Adrian Celewycz, 2/3/2011

Attachment 6

Table 1. Observed Number and Mark Expansion of CWT Chinook salmon captured in the bycatch of the GOA groundfish fishery by run year and state or province of origin, 1995–2010

	Alaska		British Columbia		Idaho		Oregon		Washington		TOTAL	
Run Year	Observed Number	Mark Expansion	Observed Number	Mark Expansion	Observed Number	Mark Expansion	Observed Number	Mark Expansion	Observed Number	Mark Expansion	Observed Number	Mark Expansion
1995	4	11.9	17	177.3	0	0.0	4	7.0	2	2.0	27	198.2
1996	14	92.4	10	152.9	0	0.0	3	3.5	2	2.0	29	250.7
1997	2	17.4	12	82.9	0	0.0	4	10.6	1	3.7	19	114.6
1998	30	157.8	50	585.3	1	1.0	10	55.2	9	19.0	100	818.3
1999	45	244.3	51	295.9	0	0.0	32	76.7	17	127.9	145	744.7
2000	24	224.9	18	38.1	0	0.0	32	50.0	10	16.2	84	329.1
2001	10	100.2	6	74.8	0	0.0	12	16.5	4	4.0	32	195.6
2002	10	47.2	5	113.0	0	0.0	4	4.3	3	3.7	22	168.2
2003	2	22.4	2	28.6	0	0.0	4	8.3	1	1.0	9	60.3
2004	3	30.5	4	22.0	0	0.0	5	16.9	1	1.1	13	70.6
2005	3	33.6	4	86.5	0	0.0	2	3.1	2	2.2	11	125.4
2006	10	58.3	7	158.3	0	0.0	2	2.1	5	14.5	24	233.1
2007	13	99.1	3	50.9	0	0.0	2	2.1	5	21.3	23	173.3
2008	3	16.8	1	1.0	0	0.0	2	7.9	9	9.8	15	35.6
2009	4	40.4	2	5.2	0	0.0	2	2.8	1	1.1	9	49.4
2010*	0	0.0	1	1.0	0	0.0	1	5.4	4	7.0	6	13.4
TOTAL	177	1197.1	193	1873.7	1	1.0	121	272.5	76	236.3	568	3580.6
mean	11.1	74.8	12.1	117.1	0.1	0.1	7.6	17.0	4.8	14.8	35.5	223.8
average % of total	31%	33%	34%	52%	0%	0%	21%	8%	13%	7%	100%	100%

*preliminary
Source: NMFS Alaska Fisheries Science Center Auke Bay Lab, Adrian Celewycz, 2/3/2011

Attachment 7

Table 1. Observed Number and Mark Expansion of CWT Alaska-origin Chinook salmon captured in the bycatch of the GOA groundfish fishery by run year and release basin, 1995–2010

	Cook Inlet, Alaska		Southeast Alaska		Alaska TOTAL	
Run Year	Observed Number	Mark Expansion	Observed Number	Mark Expansion	Observed Number	Mark Expansion
1995	1	4.0	3	8.0	4	11.9
1996	4	10.7	10	81.7	14	92.4
1997	1	5.3	1	12.1	2	17.4
1998	14	41.4	16	116.4	30	157.8
1999	20	37.6	25	206.6	45	244.3
2000	2	4.2	22	220.7	24	224.9
2001	2	2.0	8	98.2	10	100.2
2002	1	1.0	9	46.2	10	47.2
2003	0	0.0	2	22.4	2	22.4
2004	0	0.0	3	30.5	3	30.5
2005	0	0.0	3	33.6	3	33.6
2006	0	0.0	10	58.3	10	58.3
2007	0	0.0	13	99.1	13	99.1
2008	2	2.0	1	14.8	3	16.8
2009	1	1.0	3	39.4	4	40.4
2010*	0	0.0	0	0.0	0	0.0
TOTAL	48	109.2	129	1087.9	177	1197.1
mean	3.0	6.8	8.1	68.0	11.1	74.8
average % of total	27%	9%	73%	91%	100%	100%

*preliminary
Source: NMFS Alaska Fisheries Science Center Auke Bay Lab, Adrian Celewycz, 2/3/2011

Attachment 7 cont.

Table 2. Observed Number of CWT Chinook salmon captured in the bycatch of the GOA groundfish fishery by state or province of origin, 1995–2010

	Rearing Type				
Origin	Unknown	Hatchery	Mixed	Wild	TOTAL
Alaska	0	163	0	14	177
British Columbia	0	193	0	0	193
Idaho	1	0	0	0	1
Oregon	0	121	0	0	121
Washington	0	69	5	2	76
TOTAL	1	546	5	16	568
average % of total	0%	96%	1%	3%	100%

2010 data are preliminary
Source: NMFS Alaska Fisheries Science Center Auke Bay Lab, Adrian Celewycz, 2/3/2011

Table 3. Percent run-type of CWT Chinook salmon captured in the bycatch of the GOA groundfish fishery by state or province of origin, 1995–2010

	Run-type						
Origin	Spring	Summer	Fall	Winter	Late Fall	Late Fall Upriver Bright	TOTAL
Alaska	100%	0%	0%	0%	0%	0%	100%
British Columbia	26%	41%	33%	0%	0%	0%	100%
Oregon	55%	0%	43%	2%	0%	0%	100%
Washington	9%	26%	57%	0%	5%	3%	100%
Mean	49%	19%	30%	0%	1%	0%	100%

2010 data are preliminary
Source: NMFS Alaska Fisheries Science Center Auke Bay Lab, Adrian Celewycz, 2/3/2011

Attachment 8

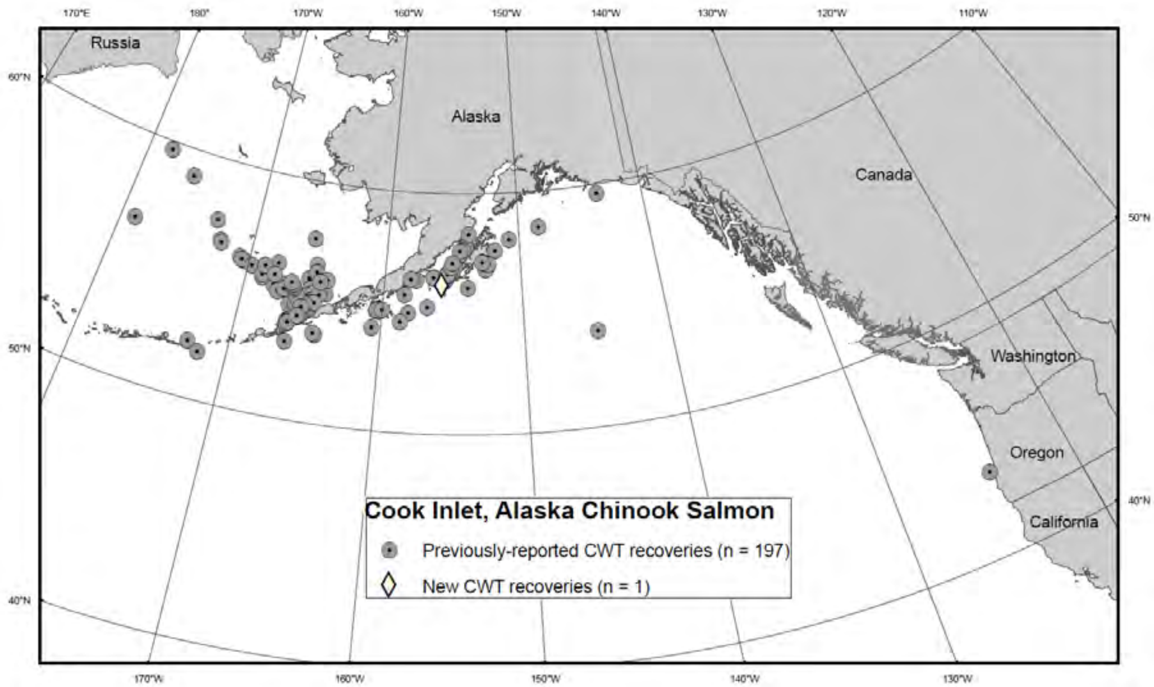

Figure 1. Ocean distribution for Cook Inlet Chinook salmon from CWT recoveries in high seas commercial fisheries and research surveys, 1981–2010. Data for 2010 are preliminary. Source: NMFS Alaska Fisheries Science Center Auke Bay Lab, Adrian Celewycz, 2/3/2011

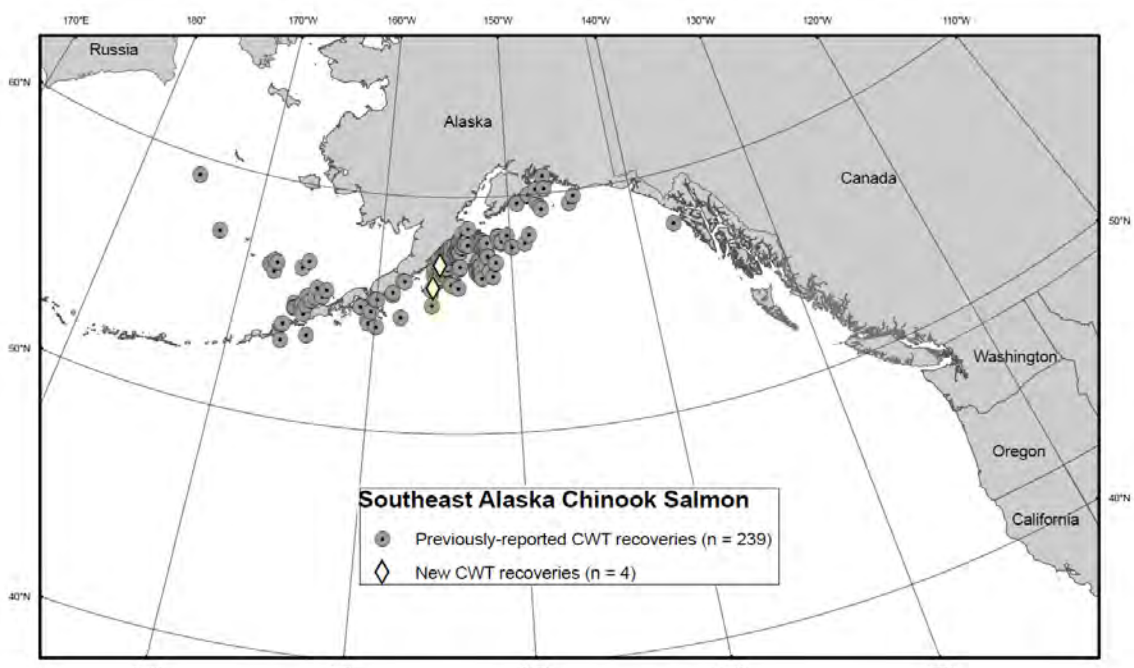

Figure 2. Ocean distribution for Southeast Alaska Chinook salmon from CWT recoveries in high seas commercial fisheries and research surveys, 1981–2010. Data for 2010 are preliminary. Source: NMFS Alaska Fisheries Science Center Auke Bay Lab, Adrian Celewycz, 2/3/2011

Attachment 8 cont.

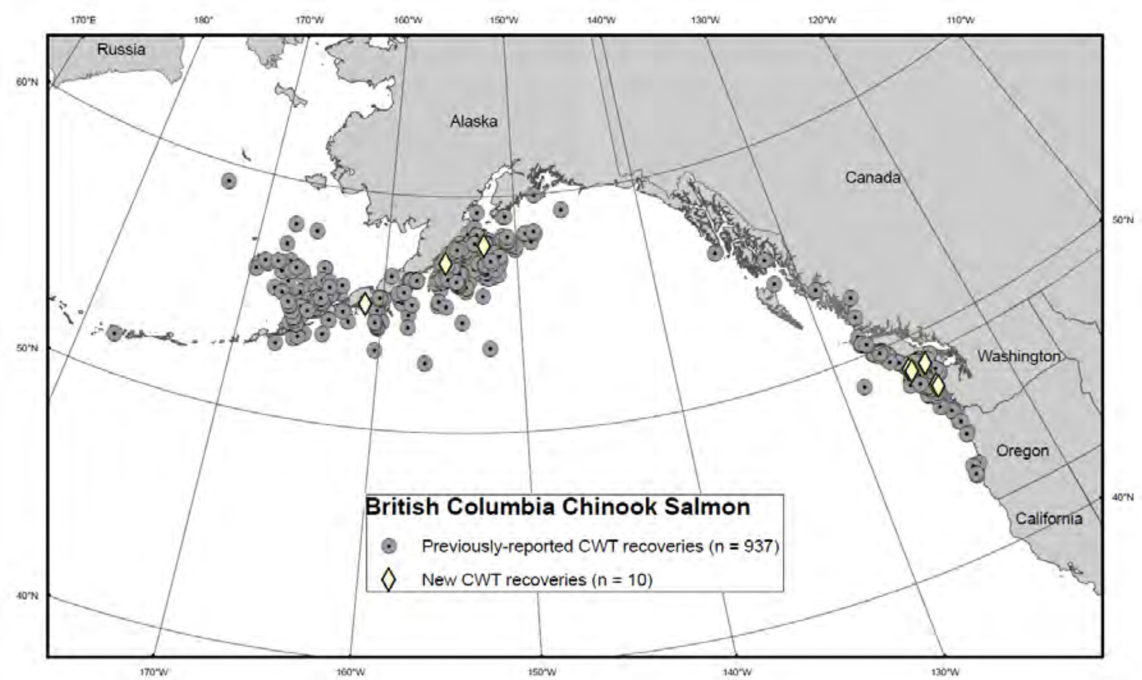

Figure 3. Ocean distribution for British Columbia Chinook salmon from CWT recoveries in high seas commercial fisheries and research surveys, 1981–2010. Data for 2010 are preliminary. Source: NMFS Alaska Fisheries Science Center Auke Bay Lab, Adrian Celewycz, 2/3/2011

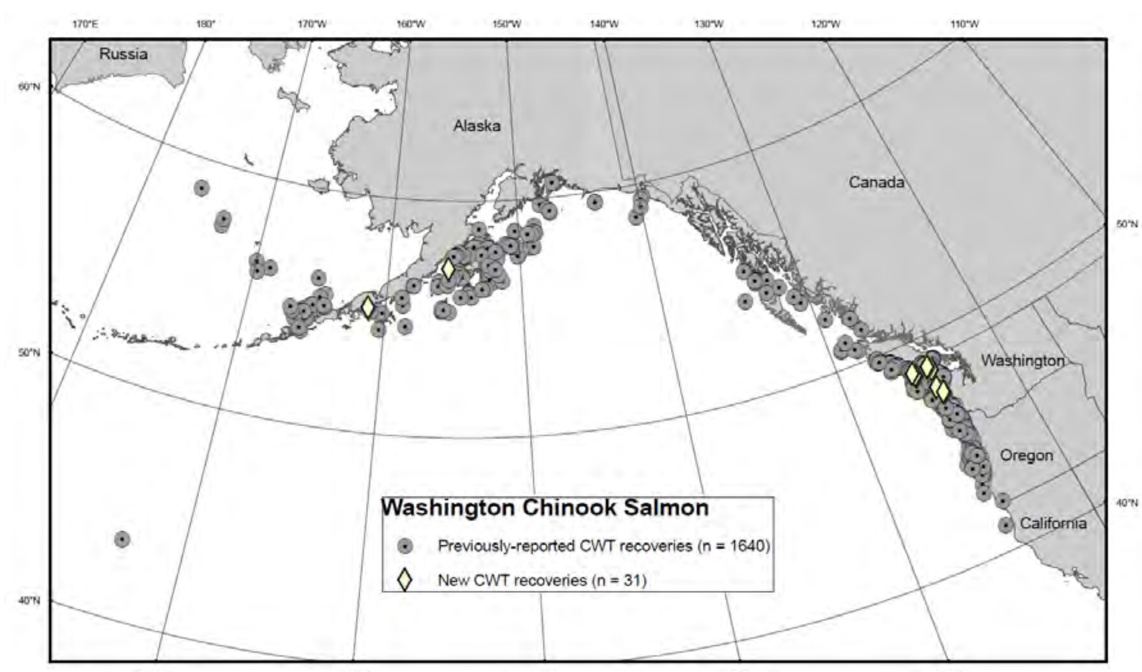

Figure 4. Ocean distribution for Washington Chinook salmon from CWT recoveries in high seas commercial fisheries and research surveys, 1981–2010. Data for 2010 are preliminary. Source: NMFS Alaska Fisheries Science Center Auke Bay Lab, Adrian Celewycz, 2/3/2011

Attachment 8 cont.

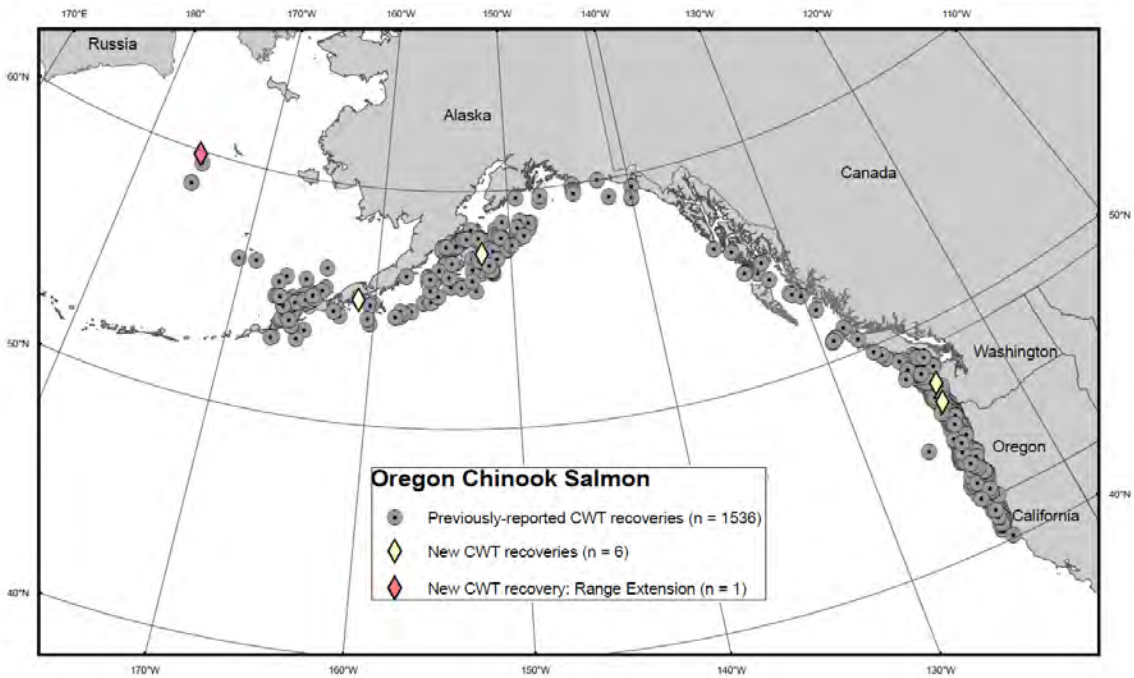

Figure 5. Ocean distribution for Oregon Chinook salmon from CWT recoveries in high seas commercial fisheries and research surveys, 1981–2010. Data for 2010 are preliminary. Source: NMFS Alaska Fisheries Science Center Auke Bay Lab, Adrian Celewycz, 2/3/2011

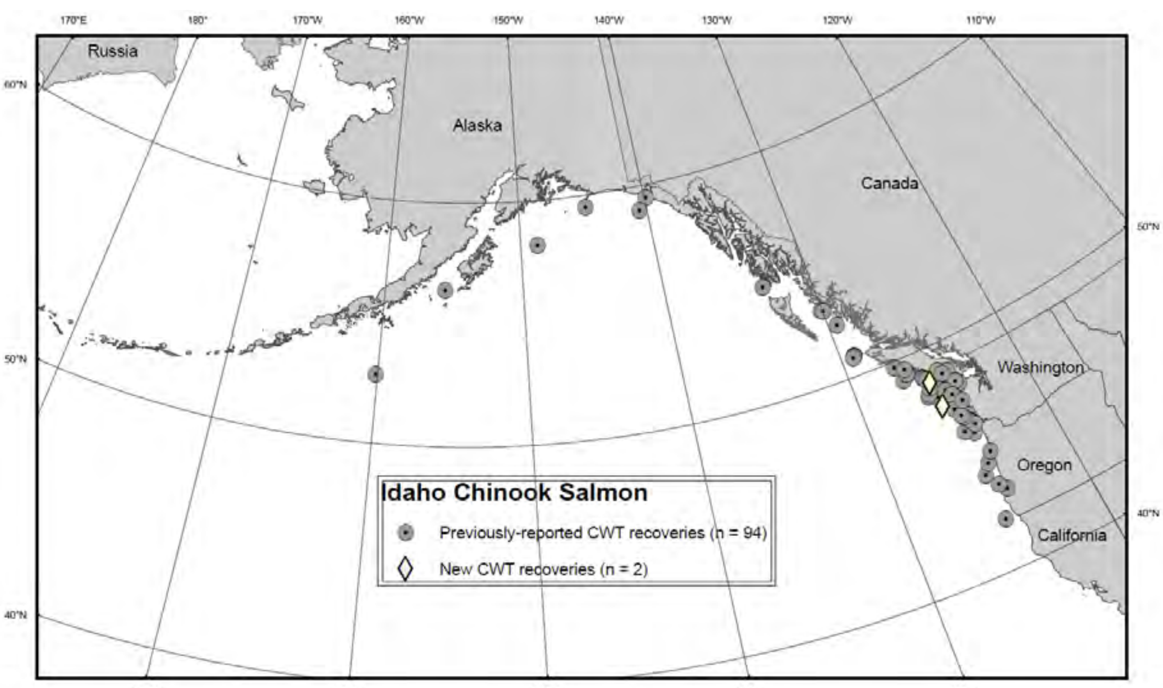

Figure 6. Ocean distribution for Idaho Chinook salmon from CWT recoveries in high seas commercial fisheries and research surveys, 1981–2010. Data for 2010 are preliminary. Source: NMFS Alaska Fisheries Science Center Auke Bay Lab, Adrian Celewycz, 2/3/2011

Attachment 8 cont.

Figure 7. Ocean distribution for California Chinook salmon from CWT recoveries in high seas commercial fisheries and research surveys, 1981–2010. Data for 2010 are preliminary. Source: NMFS Alaska Fisheries Science Center Auke Bay Lab, Adrian Celewycz, 2/3/2011

Attachment 9

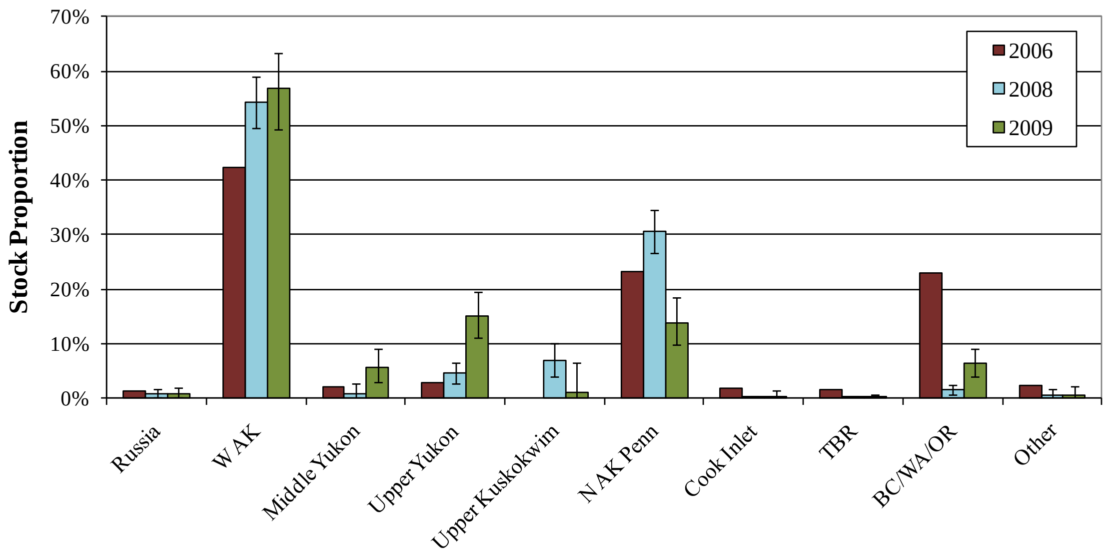

Figure 1. Comparison of yearly stock composition estimates based on available genetic samples from the Bering Sea Chinook salmon bycatch. The same genetic baseline and general regional groupings were used in all analyses. BAYES 95% credible intervals are plotted for available 2008 and 2009 yearly estimates. Source: Guyon et al. 2010b

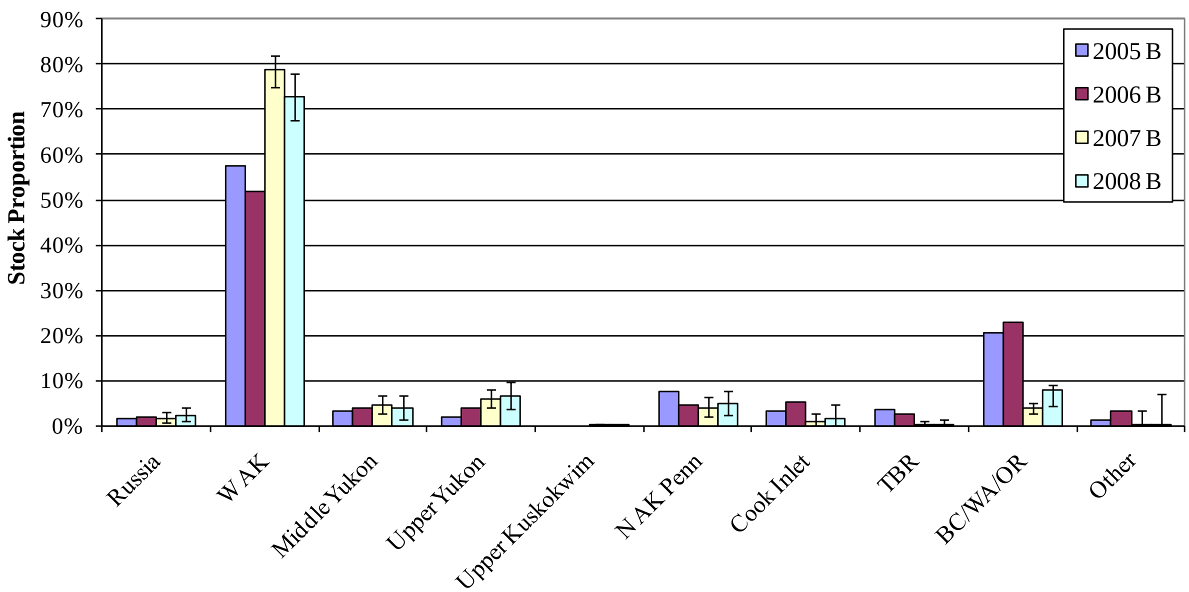

Figure 2. Comparison of “B” season genetic stock composition estimates based on available genetic samples from the Bering Sea Chinook salmon bycatch. The same genetic baseline and general regional groupings were used in all analyses. BAYES 95% credible intervals are plotted for 2007 and 2008 estimates. Source: Guyon et al. 2010b

Attachment 10

Chinook Salmon Bycatch in Gulf of Alaska Groundfish Fisheries

November 2010

Staff Discussion Paper

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1 Introduction

Since the implementation of the groundfish fishery management plans for Alaska, the North Pacific Fishery Management Council (Council) has adopted measures intended to control the bycatch of species taken incidentally in groundfish fisheries. Certain species are designated as ‘prohibited’ in the groundfish fishery management plans, as they are the target of other domestic fisheries. Catch of these species and species groups must be avoided while fishing for groundfish, and when incidentally caught, they must be immediately returned to sea with a minimum of injury[1]. These species include Pacific halibut, Pacific herring, Pacific salmon, steelhead trout, king crab, and tanner crab.

To further reduce the bycatch of these prohibited species, various bycatch control measures have been instituted in the Alaska groundfish fisheries (a history is provided in NMFS 2004, Appendix F.5). In the Gulf of Alaska (GOA) groundfish fisheries, halibut bycatch limits (which close the groundfish target fisheries after the limits are reached) and bottom trawl seasonal and permanent closure areas to protect red king crab have been established. The Council recently adopted a nonpelagic trawl closure area and areas requiring increased observer coverage off the eastern coast of Kodiak, in order to provide additional conservation for Tanner crab. To date, no bycatch control measures have been implemented for salmon species taken incidentally in GOA groundfish fisheries.

The Council has at various times in the past several years requested staff prepare and update discussion papers examining the scope of salmon and crab bycatch in the GOA groundfish fisheries, and proposed management options that might be considered to regulate such bycatch. During this process, the Council focused the scope of the discussion paper two species and two areas with potentially high bycatch levels: Chinook salmon (*Oncorhynchus tshawytscha*) and *Chinoecetes bairdi* Tanner crab, in the central and western GOA. In October 2009, the Council initiated a separate analysis for protection measures for *C. bairdi* crab, which have since been adopted by the Council. This discussion paper now focuses exclusively on Chinook salmon bycatch in the groundfish fisheries, and provides a general overview of the available information on bycatch levels for Chinook (Section 3.4), and species abundance and directed fisheries (Section 8). In previous iterations of this discussion paper, preliminary alternatives were proposed for bycatch management measures, as well as strawman closure areas that may be considered for managing bycatch, which are both included in Section 9.

2 Changes to the discussion paper since April 2010

The Council reviewed a draft of this discussion paper most recently in April 2010. At that time, the Council requested that the paper be expanded with further discussion of the following:

- Requirement for full retention of salmon in the GOA groundfish fisheries
- Data updates showing Chinook salmon bycatch by target fishery, statistical reporting area, statistical week indicating total catch, number of Chinook salmon bycatch, and bycatch rate
- Disaggregated spatial maps of Chinook bycatch by month and year for specific fisheries

The Council also requested that to the extent possible, additional background should be provided on current stock assessment data for the larger GOA Chinook salmon producing streams, information on the known relationships between environmental variables and the abundance of GOA Chinook salmon, stock of origin information for GOA Chinook salmon bycatch, and an expanded discussion on the limitations of the GOA observer data for enforcing PSC limits, MRA caps, and directing inseason management

[1] Except when their retention is authorized by other applicable law, such as the Prohibited Species Donation Program.

decisions. The Council also wrote a letter to NMFS to request that the agency accelerate the establishment of protocols to identify stock of origin of GOA Chinook salmon bycatch, including analysis of existing GOA Chinook salmon bycatch samples.

To the extent possible in the time available, staff has addressed the Council's main requests. The discussion of full retention is included in Section 3.4 of the discussion paper. Updated bycatch data is included in Section 4. Some additional disaggregated mapping, on an annual basis, is discussed in Section 5, and included in Section 14 at the end of this paper. A complete seasonal and fishery spatial analysis has not been included in this discussion paper, however, for reasons discussed in Section 5.

The items requested for additional background have not yet been addressed in this discussion paper, but will be updated for a future draft. Note, the discussion of management measures and strawman closures in Section 9 has not been updated at all since October 2009, and the strawman closures themselves were developed in December 2008.

The level of GOA Chinook salmon bycatch in 2010 has exceeded the incidental take amount authorized in the Biological Opinion for endangered Chinook salmon stocks, and consequently consultation has been reinitiated between NMFS Alaska Region and the Northwest Region office. A letter reporting on information about the Chinook salmon incidental catch in 2010 has been sent by NMFS to the Northwest Region, and will be available at the December Council meeting. Additionally, the agency is also planning to respond to the Council's letter concerning a stock of origin sampling protocol in time for the December Council meeting.

3 Estimating Chinook salmon bycatch in the GOA groundfish fisheries

NMFS estimates Chinook salmon bycatch based on data from the North Pacific Groundfish Observer Program, Weekly Production Reports (WPR), and Alaska Department of Fish and Game fish tickets. The observer data is used to create bycatch rates, and landings data (observer data, fish tickets or WPRs) are multiplied against the rates to provide bycatch estimates. In the Alaska Region, the source for landings data is observer data for 100% observed vessels, WPR data for catcher/processors with 30% observer coverage, and fish tickets for all shoreside deliveries. The estimation procedures for bycatch are designed to meet two key requirements. First, the estimation procedures are designed to provide a quick turn-around of the data so that inseason managers have useful information as quickly as possible. The system makes maximum use of small amounts of observer data quickly (at coarser aggregation levels) which are updated and refined as more data becomes available. Second, the system is flexible, so that changes to the management structure can be mirrored in the catch accounting structure to allow inseason management to stay current with fisheries regulations and specifications.

3.1 Observer program bycatch sampling

The Fisheries Monitoring and Analysis (FMA) Observer Program (Observer Program) collects catch and incidental catch data used for management and inseason monitoring of groundfish fisheries. Data from observed vessels are used to estimate the numbers of salmon by species taken as bycatch in the Alaska groundfish fisheries. Chinook salmon are the dominant salmon species taken as bycatch in the GOA, followed by chum. Very small numbers of sockeye salmon, coho salmon, pink salmon, and steelhead are also taken as bycatch in the GOA groundfish fisheries.

Chinook salmon are caught as bycatch primarily in the directed pollock trawl fisheries, although some salmon are also taken as bycatch in other trawl target fisheries (see Section 4.1). Very few salmon are taken by non-trawl gear fisheries.

Observer sampling for salmon composition in the GOA directed pollock fishery is a labor intensive process, as NMFS strives to obtain a census of all the salmon which are caught when an observer is on board. The census is challenging because salmon are interspersed in the high volume pollock catch and are rarely sorted out at sea. To get a good count of all the salmon in the catch, the entire catch is monitored as it is delivered to shore-side processing plants. This ensures that all salmon in the observed delivery are sorted out, identified, and counted. NMFS extrapolates the salmon bycatch numbers from the observed pollock trips to unobserved trips following the procedures outlined in NOAA Technical Memorandum NMFS -AFSC-205 (Cahalan et al. 2010).

Estimates for non-pollock fisheries are obtained from samples taken at-sea by observers. Vessels which are not fishing for pollock generally sort salmon at-sea. Thus, there is no need to follow the fish into the processing plants.

Observers send their data in to NMFS after each trip and those data are used to make in-season estimates of catch. Observers are deployed in the field for up to three months at a time, and debrief with FMA Division staff following their deployment to ensure the data were collected following NMFS protocols. Changes may occur to the data during the debriefing, and this is a routine and normal process. The 2010 data will not be finalized until all observers have returned from the field, are debriefed, and quality control on data is completed. Generally, the observer data are finalized in late February to early March of the year following the fishery. **Any 2010 information is preliminary until the observer data are finalized after the fishing year is completed**.

3.2 Prohibited species bycatch estimation procedure

Management of prohibited species catch (PSC) species, including Chinook salmon, is based solely on estimates derived from independent observer information, rather than from industry reported catch. PSC estimates are based on observer data, and estimates are made using automated procedures within NMFS catch accounting system. The estimation procedures are run daily to incorporate new data or any edits to existing data. It is assumed that unobserved vessels have incidental catch rates, and the bycatch rates are applied to unobserved catch as well.

All available observer data which have been received by NMFS are used in the calculation of PSC estimates. PSC are calculated and managed in numbers of animals for crab and salmon, and in weights for halibut and herring, and are reported to the public on the NMFS website as the fisheries progress throughout the year.

The technical mechanics of how NMFS uses observer sampling ratios to estimate PSC are described in detail in NOAA Technical Memorandum NMFS -AFSC-205 (Cahalan et al. 2010). Detailed instructions on the procedures observers use to collect the data which are inputs into the estimation process can be found in the series of observer manuals available at:
http://www.afsc.noaa.gov/FMA/Manual_pages/MANUAL_pdfs/manual2010.pdf.

In order to continue to improve the NMFS catch accounting processes, the Alaska Fisheries Science Center and Alaska Region contracted with the Pacific States Marine Fisheries Commission to review the current data and data systems used for inseason management and catch accounting in Alaska. The purpose of the multi-year contract is to identify the types of data that are available, their limitations, and to look at the statistical assumptions associated with all estimation procedures. It is intended that the evaluation will

result in recommendations for practical system design changes to improve estimation and to recognize statistical uncertainty in NMFS estimates of catch and bycatch. The first component, documenting the processes, was released as an AFSC publication in February 2010 (Cahalan et al. 2010).

3.3 Proportion of GOA groundfish catch that is observed

The North Pacific Groundfish Observer Program collects catch and bycatch data used for management and inseason monitoring of groundfish fisheries. Under the current Observer Program, the amount of observer coverage is based on vessel length. Since 1990, all vessels larger than 60 ft (length overall) participating in the groundfish fisheries have been required to have observers onboard at least part of the time. No vessels less than 60 ft are required to have observers onboard. Trawl and hook and line vessels that are 60 ft to 125 ft must have an observer onboard for 30% of fishing days, by quarter. Similar gear vessels that are larger than 125 ft must have an observer onboard 100% of the time, and shore-based processing facilities must have an observer present for 100% of the time. All pot vessels greater than 60 ft LOA must have observer coverage while 30% of their pots are pulled for the calendar year.

In October 2010, the Council took final action to restructure the Observer Program for vessels and processors that are determined to need less than 100% observer coverage in the federal fisheries including previously uncovered sectors such as the commercial halibut sector and <60' groundfish sector. The restructured program is intended to provide NMFS with the flexibility to deploy observers in response to fishery management needs and to reduce the bias inherent in the existing program, to the benefit of the resulting data.

There is a greater prevalence of smaller vessels participating in the GOA groundfish fisheries, and over the past 10 years, participation by smaller vessels in the GOA groundfish fisheries has generally increased, particularly catcher vessels less than 60 ft length overall (NPFMC 2003). Because current observer coverage requirements are generally based on vessel length, the proportion of total catch that is observed in GOA groundfish fisheries is much lower than, for example, in the Bering Sea fisheries. The majority of the GOA fleet is subject to 30% observer coverage. Table 1 illustrates the total groundfish catch in the western and central GOA, the total amount of groundfish that is caught while an observer is onboard the vessel, and the resulting percentage[2]. In the western GOA, the proportion of catch that is caught while an observer is onboard ranges from 25-36% over the years 2004-2007; in the central GOA the range is from 32% to 37%. In comparison, the average percentage of observed catch in the Bering Sea is approximately 86%, and in the Aleutian Islands is approximately 95%. Please note that the percentage of observed catch provides only a gross overview as to the quality of information. The goal is to have an unbiased estimate that is sufficiently precise to meet the management need for the information. The precision of bycatch estimates depends upon the number of vessels observed and the fraction of hauls sampled (Karp and McElderry 1999). Because of the relatively lower levels of observer coverage in the GOA, estimates of salmon and crab bycatch are less precise in the GOA than in Bering Sea groundfish fisheries. To what degree they are less precise, however, is not known, as current PSC estimates do not include a measure of uncertainty.

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[2] The proportion of hauls, sets, or pots that are sampled while an observer is onboard is approximately 70% for hook and line and pot gear, 75% for nonpelagic trawl gear, and 85% for pelagic trawl gear (pers. comm., J. Mondragon 11/25/08).

Table 1 Total catch, observed catch, and percent observed catch by area and year

Area	Year	Total (mt)	Observed (mt)	Percent
Western GOA	2004	50,853	14,414	28%
	2005	53,142	13,195	25%
	2006	51,944	17,253	33%
	2007	46,968	16,882	36%
Central GOA	2004	108,707	37,744	35%
	2005	120,030	41,586	35%
	2006	131,271	42,349	32%
	2007	118,871	44,113	37%

Note: This table does not include jig gear, but otherwise includes all targets.
Source: http://www.fakr.noaa.gov/sustainablefisheries/inseason/percent_observed.pdf

Detailed information on percent of harvest observed in the GOA groundfish fisheries has been presented to the Council meeting as part of their reports from the Observer Advisory Committee, and in previous iterations of this discussion paper. Table 2 looks specifically at the pollock fishery, and provides information on how much of the fleet's attributed Chinook salmon bycatch is derived directly from observed vessels, and how much is estimated using one of the precedence rate aggregations described in Section 3.2.

Table 2 Sum of Chinook salmon bycatch in the pollock fishery, by year and reporting area, as aggregated using different observed rates

Year	Area	Observer onboard vessel	Rate for unobserved landings calculated using:	Total
2005	610	852	5,099	5,951
	620	1,622	5,148	6,770
	630	3,843	10,728	14,570
	640		474	474
2005 Total		6,317	21,448	27,765
2006	610	564	3,966	4,529
	620	1,105	3,752	4,857
	630	1,750	4,531	6,280
	640		54	54
2006 Total		3,419	12,302	15,721
2007	610	303	3,056	3,359
	620	21,815	6,220	28,035
	630	698	2,878	3,577
	640		34	34
2007 Total		22,816	12,189	35,005
2008	610		2,106	2,106
	620	2,103	4,593	6,696
	630	264	1,012	1,275
	640		340	340
2008 Total		2,367	8,050	10,417
2009	610	23	418	441
	620	367	992	1,359
	630	449	252	701
	640	13	17	31
2009 Total		852	1,680	2,532
2010*	610	3,555	26,283	29,839
	620	1,634	4,371	6,004
	630	2,422	3,533	5,955
	640	19	390	408
2010 Total		7,630	34,576	42,206

* 2010 data through November 12, preliminary.
Source: M. Furuness, NMFS inseason management

3.4 Retention of salmon

Currently, retention of salmon is prohibited in the GOA groundfish fisheries, though the retention of salmon in the pollock fishery is a longstanding practice. This is because of the operational characteristics whereby large volumes of pollock are brought aboard and rapidly stowed in below deck tanks. Detecting salmon as the pollock are brought aboard and stowed is not practical, and is considered generally unsafe due to stability concerns. Several industry members have commented that this practice of retaining salmon should be recognized in the regulations and potentially encouraged to enable observer sampling.

Regulations are currently in place in the Bering Sea pollock fishery requiring full retention of salmon by all participants in the fishery. Regulations require retention of salmon "until the number of salmon has been determined by the observer and the observer's collection of any scientific data or biological samples

from the salmon has been completed," (50 CFR 679.21(c)(1)). It would be possible for NMFS to implement a similar regulation in the GOA pollock fishery. This would require processors to put salmon aside and count them.

In order to understand how best to implement such a regulation, however, it is important to consider what the full retention is intended to address. There are two policy goals which could be forwarded through full retention: 1) implementing a systematic sampling program to help inform genetic tissue sampling for stock composition of GOA Chinook bycatch; and 2) encouraging donations of bycaught salmon to the salmon food bank program.

Full retention may be a useful step in designing a sampling program for Chinook bycatch in the GOA fisheries. While the requisite elements are not in place in the GOA to implement the same census and sampling system that is going into effect in 2011 in the Bering Sea under Amendment 91 (see further discussion in Section 7), the potential exists to improve sampling if fish were made available shoreside. NMFS is addressing this issue in a letter to the Council which should be available at the December 2010 meeting.

SeaShare, the Alaska food bank donation program, does not currently receive deliveries of GOA Chinook salmon. Since the recent increase in bycatch, however, there has been interest in expanding the program to the GOA. A requirement for full retention of salmon might encourage the expansion of this program.

4 Chinook Salmon Bycatch in GOA groundfish fisheries

Pacific salmon, including Chinook, chum (*O. keta*), coho *(O. kisutch*), sockeye (*O. nerka*), and pink (*O. gorbuscha*) are taken incidentally in the groundfish fisheries within the Gulf of Alaska. Salmon bycatch is currently grouped as Chinook salmon or 'other' salmon, which consists of the other four species combined. Bycatch of Chinook salmon in the last five years (average of 26,732 salmon, 2006–2010) exceeds that of the twenty-year average (average of 20,185 salmon, 1991–2010, Table 3). During the recent time period, there have been two years (2007 and 2010) with particularly high bycatch of Chinook salmon. For the purpose of this discussion paper, it is assumed that salmon caught as bycatch have a 100% mortality rate in the groundfish fisheries.

The following sections provide updated information on Chinook salmon bycatch in the GOA groundfish fisheries. A historical report on salmon bycatch in groundfish fisheries off Alaska as it pertains to the GOA is provided in Witherell et al. (2002). Catch and bycatch data were obtained from the NMFS catch accounting database, and analyzed to represent the amount, species composition, timing, and location of salmon and crab caught incidentally in GOA groundfish fisheries. All NMFS data were screened to ensure confidentiality is maintained. The process that is used to estimate bycatch for GOA groundfish fisheries is described in Section 3. In short bycatch rates from observed vessels are applied to the fleet as a whole. The resulting estimates are used in Sections 4.1 and 4.2.

Table 3 Bycatch of Pacific salmon in Gulf of Alaska groundfish trawl fisheries, by species, 1990-2010

Year	Chinook	'Other' salmon[a]	Chum	Coho	Sockeye	Pink
1990	16,913		2,541	1,482	85	64
1991	38,894		13,713	1,129	51	57
1992	20,462		17,727	86	33	0
1993	24,465		55,268	306	15	799
1994	13,973		40,033	46	103	331
1995	14,647		64,067	668	41	16
1996	15,761		3,969	194	2	11
1997	15,119		3,349	41	7	23
1998	16,941	13,539				
1999	30,600	7,529				
2000	26,705	10,996				
2001	14,946	5,995				
2002	12,921	3,218				
2003	15,172	10,362				
2004	17,596	5,816				
2005	30,724	6,694				
2006	18,726	4,273				
2007	40,320	3,487				
2008	15,299	2,156				
2009	7,767	2,355				
2010[c]	51,550	1,747				
20-year average 1991–2010	**20,185**	**14,013[b]**				
5-year average 2006–2010	**26,732**	**2,804**				

[a] Combines chum, coho, sockeye, and pink salmon.

[b] Average combines chum, coho, sockeye, and pink salmon bycatch for 1990-1997.

[c] 2010 data preliminary, through November 6, 2010.

Source: NMFS catch reports (http://www.fakr.noaa.gov/sustainablefisheries/catchstats.htm) for 1990-2002 (all species) and 2003-2010 (non-Chinook species); NMFS PSC database for 2003-2010 (Chinook).

4.1 Bycatch by area, gear type, and target fishery

In the GOA, Chinook salmon bycatch primarily occurs in the western and central regulatory areas, and corresponds to the locations of the trawl fisheries. Table 4 illustrates bycatch for 2003-2010 across western and central regulatory and reporting areas (Figure 1). The eastern regulatory area salmon bycatch is less than 2% of total Chinook bycatch, and since 1998, has been closed to all trawling, with the implementation of Amendment 58 to the GOA groundfish FMP. Prior to 2010, Chinook bycatch in the western regulatory area as a proportion of total GOA Chinook bycatch varied between a 7% and 26%, by year, but averaged to approximately 18%. The remainder of salmon bycatch, in the central GOA, has been on average, divided evenly between reporting areas 620 and 630 (Chignik and Kodiak). In 2010, however, an especially high amount of Chinook salmon were caught as bycatch in the western GOA, amounting to 31,039 salmon, based on preliminary data.

Table 4 Chinook salmon bycatch by reporting area, 2003-2010, in Gulf of Alaska groundfish fisheries

Year	Western		Central				Total
	610		620		630		
	Number of salmon	% of total	Number of salmon	% of total	Number of salmon	% of total	
2003	2,860	19%	3,876	26%	8,437	56%	15,172
2004	4,184	24%	5,320	30%	8,092	46%	17,596
2005	7,567	25%	6,987	23%	16,170	53%	30,724
2006	4,880	26%	5,678	30%	8,169	44%	18,727
2007	3,666	9%	28,942	72%	7,712	19%	40,320
2008	2,398	16%	7,173	47%	5,730	37%	15,300
2009	558	7%	3,041	39%	4,168	54%	7,767
2010*	31,039	61%	8,165	16%	12,054	24%	51,258
Average 2003-2010	**7,144**	**23%**	**8,648**	**35%**	**8,816**	**41%**	**24,608**

*preliminary data

Source: NMFS Catch Accounting System. Data compiled by AKFIN, November 2010.

Figure 1 Regulatory and reporting areas in the GOA

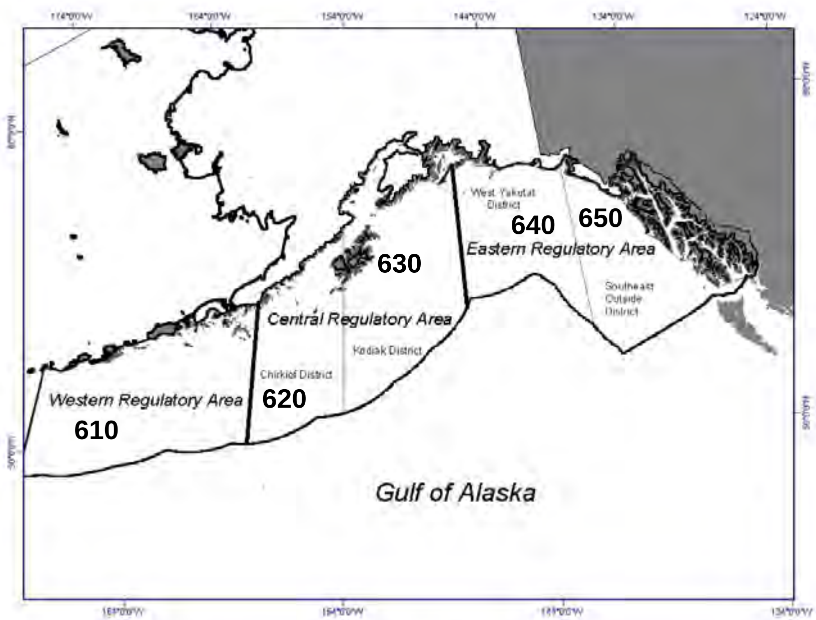


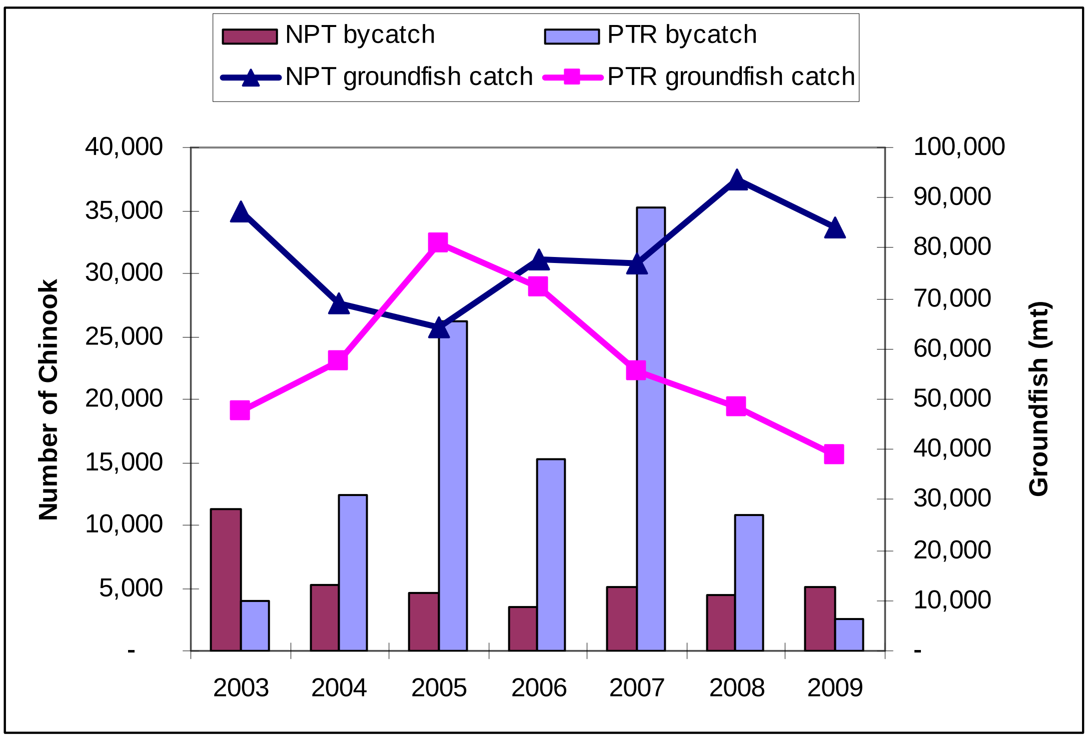
Table 5 identifies Chinook bycatch for 2003-2010, by gear type. Pelagic and non-pelagic trawling are almost entirely responsible for Chinook salmon bycatch. In 2004-2008, pelagic trawl gear accounted for over 70% of Chinook bycatch, however in 2003 and 2009, nonpelagic trawl caught 74% and 67% of the Chinook salmon. The relationship between groundfish catch and pelagic trawl Chinook bycatch is shown in Figure 2 for 2003-2009, and was consistent in all years except 2007. For nonpelagic trawl vessels, the bycatch trend paralleled groundfish catch for 2003-2005, but since then groundfish catch has generally increased, while bycatch has remained relatively constant.

Table 5 Chinook salmon bycatch by gear type, in western and central groundfish fisheries, 2003-2010

Year	Pelagic trawl		Nonpelagic trawl		Hook and line		Pot		Total
	Number of salmon	% of total	% of total	Number of salmon	Number of salmon	% of total	Number of salmon	% of total	
2003	3,903	26%	74%	11,269	-	-	-	-	15,172
2004	12,411	71%	29%	5,164	21	0%	-	-	17,596
2005	26,148	85%	15%	4,576	-	-	-	-	30,724
2006	15,293	82%	18%	3,434	-	-	-	-	18,727
2007	35,249	87%	13%	5,062	8	0%	-	-	40,320
2008	10,803	71%	29%	4,498	-	-	-	-	15,300
2009	2,489	32%	68%	5,278	-	-	-	-	7,767
2010*	40,625	79%	21%	10,633	-	-	-	-	51,258
Average 2003-2010	**18,365**	**67%**	**33%**	**6,239**	**4**	**0%**	**-**	**-**	**196,864**

*preliminary data
Source: NMFS Catch Accounting System. Data compiled by AKFIN, November 2010.

Figure 2 Chinook bycatch and groundfish catch in GOA pelagic and nonpelagic trawl fisheries, 2003-2009



Source: NMFS Catch Accounting System. Data compiled by AKFIN, February 2010.

Chinook bycatch with pelagic trawl gear occurs predominantly in the pollock target fishery (Table 6), and accounts for most of the western and central Chinook bycatch, an average of 72% over 2003-2009, or 14,900 fish. Table 7 illustrates the distribution of bycatch in the pollock pelagic fishery in the western and central GOA. While bycatch in the western GOA prior to 2010 has been generally lower than it is in areas 620 and 630, the proportional bycatch by area within all years 2003-2008 is highly variable. 2010 is the year of highest bycatch, primarily occurring in the western GOA (610). 2007 was also a year of high bycatch, primarily occurring in the Chignik area (620). In the Kodiak area (630), 2005 was the highest

bycatch year with 13,370 Chinook. In 2009, trawl bycatch in the pollock fishery in all areas was considerably lower than in the previous five years.

Table 6 Chinook salmon bycatch by target fishery, in western and central groundfish fisheries, 2003-2010

Gear type	Target fishery	2003	2004	2005	2006	2007	2008	2009	2010*	Average 2003-2010
Pelagic trawl	Pollock	3,872	12,411	26,085	15,287	34,955	10,057	2,285	40,508	18,183
	Rockfish	-		63	-	294	746	203	118	178
Nonpelagic trawl	Arrowtooth Flounder	3,348	359	1,798	408	1,502	2,608	6	4,044	1,759
	Flathead Sole	598	1,446	16	56	-	-	118	149	298
	Pacific Cod	3,167	908	41	882	624	433	111	461	828
	Pollock	423	571	1,296	380	50	30	278	1,287	539
	Rex Sole	2,819	498	982	1,444	714	-	1,907	2,237	1,325
	Rockfish	799	885	387	263	1,733	1,212	1,102	1,443	978
	Shallow Water Flatfish	116	498	56	-	438	213	1,756	1,013	511

*preliminary data
- = data is confidential. If cell is blank, no bycatch was recorded in those months.
Source: NMFS Catch Accounting System. Data compiled by AKFIN, November 2010.

Table 7 Chinook salmon bycatch in the pollock trawl fishery, by reporting area, 2003-2010

Year	Pelagic trawl			Nonpelagic trawl		
	610	620	630	610	620	630
2003	738	1,121	2,044	2,122	2,755	6,393
2004	2,013	4,886	5,513	2,164	430	2,570
2005	5,951	6,764	13,433	1,616	222	2,738
2006	4,529	4,843	5,921	351	835	2,248
2007	3,359	28,036	3,854	304	904	3,853
2008	2,116	6,685	2,001	282	488	3,728
2009	441	1,143	904	117	1,898	3,264
2010*	29,839	5,425	5,362	1,201	2,741	6,692
Average 2003-2010	**6,123**	**7,363**	**4,879**	**1,019**	**1,284**	**3,936**

*preliminary data
Source: NMFS Catch Accounting System. Data compiled by AKFIN, November 2010.

Table 8 also provides overall Chinook bycatch numbers for the trawl sector, by target fishery for 2000-2010, although without distinguishing between pelagic and nonpelagic gear types. The table additionally provides the rate of bycatch, measured as number of Chinook salmon per mt of total groundfish. The bycatch rate averages 0.25 in the GOA pollock fishery, although annually it varies between 0.07 and 0.66 over the time series. (Note, the numbers in Table 8 and Table 9 are slightly different from the numbers reported in the remainder of the tables, as they were queried on different days). Table 9 looks specifically at 2010, and breaks down the Chinook salmon bycatch rate in the pollock target fishery by month and reporting area. From this table, it is evident that the bycatch rate in October was highest in the western GOA, at 3.62 salmon per mt groundfish. Even in 630, the bycatch rate was higher than the average in October, at 0.64. Data is also presented in this table for pollock catch in 640, which has only a small pollock quota and is not subject to the seasonal restrictions of the other GOA reporting areas. The bycatch

rate for September was particularly high, but only a very small amount of pollock was taken in that area during that month.

Table 8 Chinook salmon bycatch (number of salmon) by trawl target fishery, 2000-2010, and bycatch rate (number of salmon per mt of groundfish)

Target		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Ave. 2000-2010
Pollock	Bycatch	9,531	18,413	5,161	4,400	13,152	27,927	15,944	35,040	10,427	2,620	42,206	
	Rate	0.13	0.25	0.10	0.09	0.20	0.33	0.21	0.66	0.21	0.07	0.55	0.25
Pacific Cod	Bycatch	2,747	2,830	4,066	3,167	908	41	888	624	433	111	461	
	Rate	0.11	0.10	0.27	0.20	0.05	0.00	0.08	0.04	0.02	0.01	0.03	0.08
Rockfish	Bycatch	445	1,153	1,250	919	885	450	263	2,038	2,280	1,432	1,627	
	Rate	0.02	0.05	0.05	0.04	0.03	0.02	0.01	0.09	0.09	0.06	0.06	0.05
Flatfish	Bycatch	2,297	2,443	4,392	6,909	2,800	2,853	1,909	2,654	2,822	3,787	7,442	
	Rate	0.06	0.10	0.11	0.15	0.13	0.10	0.05	0.06	0.06	0.07	0.18	0.10

Source: NMFS Catch Accounting System, November 2010.

Table 9 2010 Chinook salmon bycatch rates in the pollock fishery (pelagic and nonpelagic trawl gear combined), by month, all reporting areas

Reporting Area	Month	Total Chinook bycatch (number)	Total pollock catch (weight in MT)	Rate
610	January	329	942	0.35
	February	621	3,939	0.16
	March	384	2,207	0.17
	April	426	2,651	0.16
	August	353	1,631	0.22
	September	1,529	7,187	0.21
	October	26,241	7,251	3.62
620	January	42	42	0.99
	February	3,376	7,464	0.45
	March	198	11,607	0.02
	September	1,530	3,853	0.40
	October	1,010	4,607	0.22
630	January	-	102	0.00
	February	35	347	0.10
	March	1,105	6,206	0.18
	September	1,437	4,757	0.30
	October	3,380	5,274	0.64
640	March	215	1,428	0.15
	September	189	87	2.18

Source: NMFS Catch Accounting System. Data compiled by AKFIN, November 2010.

Chinook bycatch in the rockfish target fishery has increased since the implementation of the rockfish pilot program in 2007, by both nonpelagic and pelagic trawl vessels. The number of vessels employing pelagic trawl gear in the rockfish fishery has increased under the pilot program, likely in an effort to reduce halibut bycatch (Table 6). For non-pelagic trawl gear, bycatch is distributed among several target fisheries. In 2003–2008, the combined flatfish non-pelagic trawl target fisheries accounted for approximately 7-18% of Chinook bycatch in the western and central GOA. In 2003 and 2009, the flatfish

target fisheries accounted for 46% and 48% of Chinook bycatch, respectively. For the nonpelagic trawl fishery, bycatch is consistently highest in area 630.

4.2 Timing of Chinook bycatch

The timing of salmon bycatch follows a predictable pattern in most years. Chinook salmon are caught in high quantities regularly from the start of the trawl fisheries on January 20 through early April, and again during September/October in the pollock fisheries (Table 10). Figure 3 illustrates the difference in seasonal bycatch patterns between the pelagic and non-pelagic trawl fisheries for 2003-2009, with respect to Chinook bycatch. Chinook bycatch in the pelagic trawl fishery pulses in correlation with the seasons of the pollock target fishery. The annual TAC for pollock is divided into four seasons, as a protection measure for Steller sea lions (which prey on pollock). The regulatory pollock seasons are as follows: A season (January 20 to March 10), B season (March 10 to May 31), C season (August 25 to October 1), and D season (October 1 to November 1), although in most instances, the available TAC will be caught (and the fishery will be closed) well before the end of the season, often in only a few days. Table 11 provides the bycatch numbers, by month, for the pelagic trawl fishery only. For the nonpelagic trawl fisheries, Figure 3 illustrates that Chinook bycatch is caught consistently throughout the year, although in higher quantities in the spring months. Because of the varied target fisheries in which the non-pelagic trawl vessels participate, Chinook bycatch does not correlate well to groundfish catch by that sector as a whole. The spike in nonpelagic trawl groundfish catch in July is due to participation in the rockfish fisheries, which incurs very low Chinook bycatch.

Table 10 Chinook salmon bycatch by month, 2003-2010, in western and central groundfish fisheries

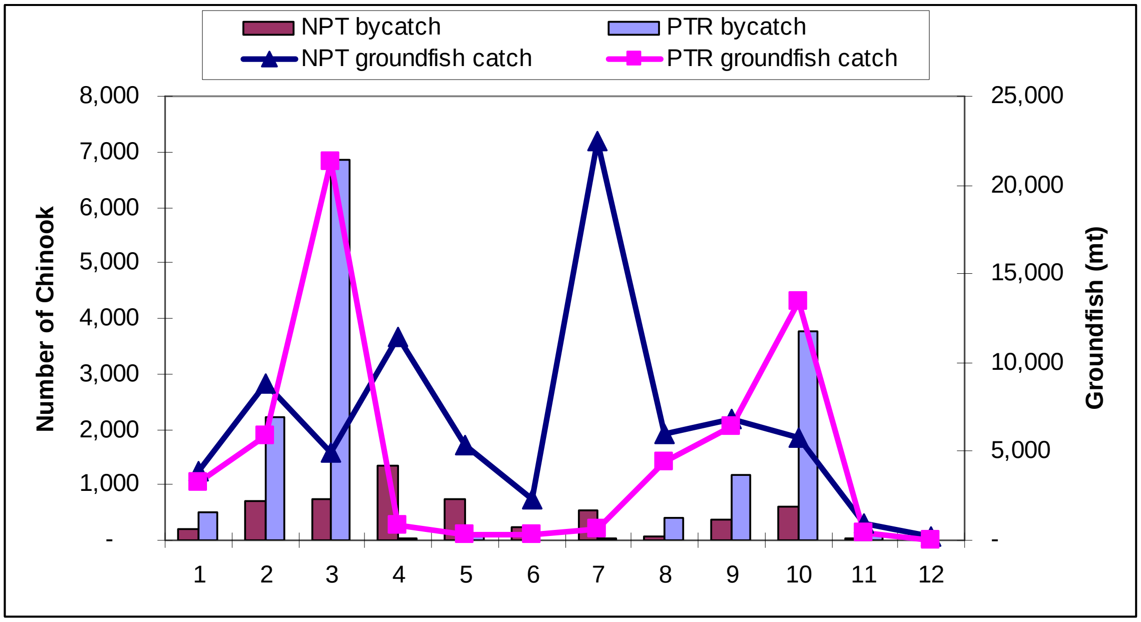
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2003	1,173	2,311	1,026	2,991	2,608	-	810	1,203	470	2,580	-	
2004	285	3,763	3,552	629	38	35	1,033	1,484	1,639	5,138	-	
2005	924	10,400	6,734	451	56	5	450	121	954	10,629	-	-
2006	1,952	1,816	4,498	1,355	10	-	263	13	4,896	3,786	138	
2007	167	1,265	28,594	202	1,338	1,153	630	150	2,433	3,704	634	50
2008	151	458	7,294	2,727	1,225	368	363	183	224	2,217	91	-
2009	162	411	1,466	1,171	595	157	406	170	233	2,579	233	183
2010*	371	4,363	2,127	4,768	729	594	559	380	5,110	32,256	-	
Average 2003-2010	**648**	**3,098**	**6,911**	**1,787**	**825**	**289**	**564**	**463**	**1,995**	**7,861**	**137**	**29**

*preliminary data

- = data is confidential. If cell is blank, no bycatch was recorded in those months.

Source: NMFS Catch Accounting System. Data compiled by AKFIN, November 2010.

Figure 3 Average Chinook bycatch and groundfish catch by vessels using pelagic and non-pelagic trawl gear, by month, 2003-2009



Source: NMFS Catch Accounting System. Data compiled by AKFIN, February 2010.

Table 11 Chinook salmon bycatch by pelagic trawl gear, by month, 2003-2010

YEAR	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2003	238	339	263	12		**	**	948	**	2,101		
2004	283	3,275	1,572					1,465	723	5,092		
2005	798	9,717	5,072	**	**		63	121	919	9,458		
2006	1,847	910	4,102				-	13	4,823	3,460	138	
2007	165	1,091	28,483		131	8	82	23	1,341	3,310	615	
2008	77	218	7,157	173	600	65	81	166	223	2,003	41	
2009	16	**	1,264		49	4	4	33	161	928	**	
2010*	329	3,543	1,352	426	111	**	5	347	4,359	30,154		
Average 2003-2010	**469**	**2,387**	**6,158**	**76**	**111**	**10**	**29**	**390**	**1,569**	**7,063**	**99**	

*preliminary data
- = data is confidential. If cell is blank, no bycatch was recorded in those months.
Source: NMFS Catch Accounting System. Data compiled by AKFIN, November 2010.

5 Spatial analysis of bycatch patterns

The data presented in Section 4 is from the NMFS catch accounting prohibited species catch data, which applies bycatch rates from observed fishing trips to unobserved groundfish catch within each target, gear type, and reporting area (see Section 3). In order to examine the spatial distribution of bycatch at a finer scale than that of the reporting area, we rely on bycatch data from observed trips only, as only these observed hauls are associated with geographical coordinates. As only a small proportion of total groundfish catch in the GOA is observed, however, it should be remembered that the mapped data may not represent the total activity of the fisheries.

There is an important limitation in the observer program data for PSC from the shoreside pollock fishery when it is used for spatial analysis. The limitation is due to a technical database problem, which was corrected by NMFS re-design of the observer database implemented in 2008. The issue is that PSC in the shoreside pollock fishery are sampled at the plant, rather than onboard the vessel. This is because of the particular handling of large volumes of catch in the pollock fishery. Typically, catch is rapidly placed in below deck refrigerated seawater tanks and there is limited opportunity to take large samples. As all hauls are mixed together in the vessel's hold, the entire delivery is monitored for PSC at the shoreside plant upon delivery. Prior to 2008, the Observer Program database did not allow for capturing the delivery level information. Instead, the delivery levels were proportioned back to individual tows made during the trip. This was done to fit the data into the existing system.

We caution that care must be exercised when attempting to interpret PSC rates at the haul level. The spatial distribution currently displayed in the document maps the bycatch data by individual tows. In effect, this averages the bycatch among several hauls at several locations, when in fact it could possibly be the case that all the bycatch was caught during one haul in one location, and other locations had little or no associated bycatch. To address this problem, it may be more appropriate, in future iterations of this discussion paper, to look at clusters of tows from deliveries with high bycatch. This analysis of the data will be important if the data are used identify regulatory closure areas, and the impact would need to be investigated at that point.

Two sets of maps are provided in the Section 14, mapping Chinook salmon bycatch. First, Figure 6 through Figure 11, provided by NMFS inseason management,offer an annual illustration of observed GOA Chinook salmon bycatch from 2006 to 2010. Figure 6 provides an overview of bycatch aggregated for all five years, and Figure 7 through Figure 11 present each year's distribution. It is apparent from the annual illustrations that there is considerable interannual variability in the locations of high Chinook bycatch.

Additionally, another set of aggregated maps is included, as presented in previous versions of this discussion paper. Figure 12 and Figure 14, in Section 14 at the end of this document, map the total number of Chinook observed during the aggregated years 2001-2008, in fisheries using pelagic and nonpelagic trawl gear, respectively. Figure 13 and Figure 15 illustrate the total bycatch rate, number of Chinook per metric ton of total catch, for the period 2001 to 2008, for the same gear types.

6 Hatchery releases of Chinook salmon

The United States and Canada account for the highest numbers of hatchery releases of juvenile Chinook salmon, although a limited number are released from Russia. The North Pacific Anadromous Fish Commission compiles reports that summarize these hatchery releases (Table 12). Hatchery releases in each region have decreased in recent years.

The United States has the highest number of annual releases (81% of total in 2006), followed by Canada (18%). Of the US releases, the highest numbers are coming from the State of Washington (61% in 2006), followed by California (16% in 2006), and then Oregon (11% in 2007). Hatcheries in Alaska are located in southcentral and southeast Alaska. Since 2004, the number of hatcheries has ranged from 33 (2004–2005) to 31 (2006), with the majority of hatcheries (18–22) located in southeast Alaska, while 11 hatcheries are in Cook Inlet and 2 in Kodiak (Eggers, 2005a; 2006; Josephson, 2007).

The highest numbers of Canadian releases of Chinook in 2006 occurred in the West Coast Straits of Georgia (20 million fish) followed by Vancouver Island area (12.4 million fish) the Lower Fraser River (3.3 million fish) (Cook and Irvine, 2007).

No correlation is discernable between the bycatch of salmon in the GOA and the release from any of these hatchery sites.

Table 12 Hatchery releases of juvenile Chinook salmon, by country, compared to GOA groundfish bycatch, in millions of fish

Year	Russia	Canada	USA	Total	Total GOA groundfish Chinook bycatch
1999	0.6	54.4	208.1	**263.1**	.031
2000	0.5	53.0	209.5	**263.0**	.027
2001	0.5	45.5	212.1	**258.1**	.015
2002	0.3	52.8	222.1	**275.2**	.013
2003	0.7	50.2	210.6	**261.5**	.015
2004	1.17	49.8	173.6	**224.6**	.021
2005	0.84	43.5	184.0	**228.3**	.031
2006	0.78	41.3	181.2	**223.3**	.019

Source: North Pacific Anadromous Fisheries Commission reports: Russia (Anon. 2007; TINRO-centre 2006, 2005); Canada (Cook and Irvine 2007); USA (Josephson 2007; Eggers 2006, 2005a; Bartlett 2005, 2006, 2007).

7 River of origin of GOA Chinook salmon bycatch

The direct effects of GOA groundfish bycatch of Chinook salmon on the sustainability of salmon populations are difficult to interpret without specific information on the river of origin of each bycaught salmon. Limited information is available in the GOA groundfish fisheries on the river of origin of salmon species.

Genetic samples (pelvic axillary processes), maturity information, and scales from Chinook salmon were collected by observers in the 2010 GOA pollock fishery. All vessel observers collect a genetic sample, length, sex, and maturity information from every Chinook salmon in the species composition samples. Plant and floating processor observers collect genetic samples, length, sex, and maturity information from randomly selected Chinook salmon using a temporal sampling frame.

In 2011, these sampling procedures will be revised to be consistent with changes occuring in the Bering Sea polllock fishery. In 2011, the genetic samples noted above will be taken systematically from all salmon encountered in observed pollock deliveries. This should provide sample from throughout the observed deliveries in the Gulf of Alaska.

Genetic analysis of Chinook salmon is an ongoing coordinated effort among the Alaska Department of Fish and Game, Alaska Fisheries Science Center Auke Bay Laboratories (Auke Bay Lab), and the University of Washington. Research on stock discrimination for Chinook salmon is being conducted by evaluating DNA variation, specifically single nucleotide polymorphisms (SNPs). A baseline has been developed that identifies the DNA composition of many BSAI and GOA salmon stocks.

The Alaska Fishery Science Center has developed a comprehensive plan for counting all Chinook bycatch (a census) in the Bering Sea pollock fishery, and taking a systematic sample from that bycatch. This census and sample is scheduled for implementation in 2011. Full retention of salmon is currently required in the Bering Sea pollock fishery, and under the implementation of Amendment 91 in 2011, a minimum of 100% observer coverage will also be required on all vessels participating in the pollock fishery, regardless of length. Also, shoreside processors are required (under their Catch Monitoring and Control Plan) to provide a location from which the observer will be able to view all sorting and weighing of fish

simultaneously. Most recently in April 2010, the Council wrote to NMFS to request that a similar Chinook salmon bycatch sampling protocol be put in place in the GOA groundfish fisheries, and that genetic analysis of samples collected from Chinook salmon in the GOA groundfish fisheries be initiated. NMFS will provide a written response to the Council's request prior to the December 2010 Council meeting.

Currently, coded wire tags (CWTs) are the primary source of information for the stock-specific ocean distribution of those Chinook salmon stocks which are tagged and caught as bycatch in the GOA groundfish fisheries. The High Seas Salmon Research Program of the University of Washington routinely tags and monitors Pacific salmon species. It should be noted that CWT information may not accurately represent the true distribution of hatchery-released salmon. Much of the CWT tagging occurs within the British Columbia hatcheries and thus, most of the tags that are recovered also come from those same hatcheries. CWT tagging does occur in some Alaskan hatcheries, specifically in Cook Inlet, Prince William Sound, other Kenai region hatcheries, as well as in hatcheries in Southeast Alaska (Johnson, 2004). We should note that numerous runs of Chinook salmon do not have coded wire tags.

Chinook salmon tags have been recovered in the area around Kodiak through recovery projects in 1994, 1997, and 1999. The contribution of hatchery-produced Chinook salmon to the sampled harvested in the Kodiak commercial fishery ranged from 16% in 1999 to 34% in 1998; hatchery fish from British Colombia made up the majority of these fish. The study concluded that there was only a low incidental harvest of Cook Inlet Chinook salmon in the Kodiak area (Clark and Nelson 2001, Dinnocenzo and Caldentey 2008).

Other CWT studies have tagged Washington and Oregon salmon, and many of these tagged salmon have been recovered in the GOA (Myers et al. 2004). In 2006, 63 tags were recovered in the eastern Bering Sea and GOA (Celewycz et al. 2006). Of these, 8 CWT Chinook salmon were recovered from the Gulf of Alaska trawl fishery in 2006 and 2007, 8 CWT Chinook salmon were recovered from the Bering Sea-Aleutian Islands trawl fishery in 2006 and 2007, 44 CWT Chinook salmon were recovered from the Pacific hake trawl fishery in the North Pacific Ocean off WA/OR/CA in 2006, and 3 CWT steelhead were recovered from Japanese gillnet research in the central North Pacific Ocean.

Overall, tagging results in the GOA showed the presence of Columbia River Basin Chinook and Oregon Chinook salmon tag recoveries (from 1982–2003). Some CWT recovered by research vessels in this time period also showed the recoveries of coho salmon from the Cook Inlet region and southeast Alaska coho salmon tag recoveries along the southeastern and central GOA (Myers et al 2004).

7.1 Bycatch of ESA-listed Pacific salmon stocks in the GOA groundfish fisheries

Of the larger number of Chinook salmon evolutionarily significant units (ESUs) in the Pacific Northwest that are listed on the Endangered Species Act, three are known to have been caught as bycatch in the Alaska groundfish fisheries. Chinook salmon from the Lower Columbia River (LCR), Upper Willamette River (UWR), and Upper Columbia River (UCR) Spring ESUs have been recovered in the GOA trawl fishery. A biological opinion dated November 30, 2000, and supplemented in January 11, 2007, was issued regarding the authorization of the Alaska groundfish fisheries. An incidental take statement was included in the Biological Opinion, which established a threshold of 40,000 Chinook salmon caught as bycatch in the GOA groundfish fisheries. If, during the course of the fisheries, the specified level of take is exceeded, a reinitiation of consultation is required, along with a review of the reasonable and prudent measures identified in the supplemental Biological Opinion.

Since 1984, CWTs have been recovered from 23 LCR, 98 UWR, and 1 UCR Chinook salmon in the GOA trawl fishery, both pre- and post-listing (Table 13). By applying mark expansion factors (which offer the

closest approximation to the contribution of ESA-listed ESUs in the GOA), the estimated numbers increase to 112 LCR, 282 UWR, and 1 UCR Chinook salmon. Note, the most recent CWT recoveries in this table occurred in February 2010. A single Chinook salmon from the UWR has to date been analyzed and recorded. NMFS Auke Bay Lab is currently analyzing further CWTs that were recovered later in 2010. The results of this analysis may be available by the time of the December 2010 Council meeting.

The numbers provided here should be considered as minimum estimates of the number of ESA-listed ESUs in the GOA groundfish fisheries. Until adequate numbers of CWTs are recovered from *inside* the observers' samples, where the total number of fish sampled is known, an estimate of total contribution of ESA-listed ESUs in the GOA groundfish fisheries will remain unknown and indeterminable.

Table 13 Observed Number and Mark Expansion of ESA-listed coded wire tagged salmon, by evolutionarily significant unit (ESU), captured in the GOA trawl fishery, pre-listing and post-listing, 1984–2010.

Listing Status	ESU Name	GOA Observed Number	GOA Mark Expansion
Pre-listing	Lower Columbia River Chinook	12	82.1
	Upper Willamette River Chinook	43	143.8
Post-listing	Lower Columbia River Chinook	11	29.7
	Upper Columbia River spring Chinook	1	1.0
	Upper Willamette River Chinook	55	138.1

*2010 data are preliminary. The most recent CWT recoveries occurred in February 2010.
Source: NMFS Alaska Fisheries Science Center Auke Bay Lab, Adrian Celewycz, 11/8/2010

Because the 2010 GOA groundfish fisheries have exceeded the incidental take statement's threshold of 40,000 Chinook salmon caught as bycatch, NMFS Alaska Region has requested that formal consultation be reinitiated under Section 7 of the ESA. A memorandum to this effect is being sent to NMFS Northwest Region, and an annual report will be prepared in the early part of 2011. A copy of the memorandum will be available by the December 2010 Council meeting.

8 Chinook salmon stocks and directed fisheries

The State of Alaska manages commercial, subsistence and sport fishing of salmon in Alaskan rivers and marine waters and assesses the health and viability of individual salmon stocks accordingly. The catches of Chinook salmon in Southeast Alaska are regulated by quotas set under the Pacific Salmon Treaty. In other regions of Alaska, Chinook salmon fisheries are also closely managed to ensure stocks of Chinook salmon are not overharvested. No gillnet fishing for salmon is permitted in Federal waters (3-200 miles), nor commercial fishing for salmon in offshore waters west of Cape Suckling.

8.1 GOA Chinook salmon stocks

A brief overview of Chinook stocks by area is included in this section. Available information on individual stocks and run strengths varies greatly by river and management area.

Southeast Alaska and Yakutat

Chinook salmon are known to occur in 34 rivers in the Southeast region of Alaska, or draining into the region from British Colombia or Yukon Territory, Canada (known as transboundary rivers). The

southeast Alaska Chinook stocks enter spawning streams during the spring and early summer months. 11 watersheds have been designated to track spawning escapement, and counts of these 11 stocks are used as indicators of relative salmon abundance as part of a coast-wide Chinook model (Pahlke 2007). The Pacific Salmon Commission addresses coordinated management of the transboundary stocks of the Taku, Stikine, and Alsek Rivers. The Taku, Stikine, and Chilkat rivers together make up over 75% of the summed escapement goals in the region.

In 2007, escapements on 8 of the 11 tracked systems were above or within goals, with the Alsek, Taku, Chilkat, and Blossom Rivers being below goal, however Maximum Sustained Yield goals indicated that all Southeast Alaska and Transboundary River stocks were healthy and stable (Lynch and Skannes 2008).

Prince William Sound

The Prince William Sound management area encompasses all coastal waters and inland drainages entering the north central Gulf of Alaska between Cape Suckling and Cape Fairfield. A Sustainable Escapement Goal is established for the Copper River, at 24,000 Chinook, and inriver escapement to the upper Copper River is established for all salmon species combined (Hollowell et al. 2007). In 2007, escapement was 35,957 fish, meeting the escapement goal (Lewis et al 2008).

Cook Inlet

The Cook Inlet management area is divided into 2 areas, the Upper Cook Inlet (northern and central districts) and the Lower Cook Inlet. Inseason management of Cook Inlet commercial salmon fisheries is based upon salmon run abundance and timing indicators. Catch data, catch per effort data, test fish data, catch composition data, and escapement information from a variety of sources is used to assess stock strength on an inseason basis. For Chinook salmon, surveys are made to index escapement abundance (Clark et al 2006).

There are three biological escapement goals (Kenai River early and late runs, Deshka River) and 18 sustainable escapement goals in effect for Chinook salmon spawning in Upper Cook Inlet. In 2008 and 2009, Chinook salmon escapement on the Deshka was below the escapement goal (13,000-28,000) for the first time since 1996, at 7,533 fish in 2008 and 11,960 in 2009 (Shields 2009, Eggers et al 2010). From 1999-2006, escapement exceeded the upper end of the escapement range. Kenai River escapement is monitored via sonar by the Division of Sport Fish. The late-run Chinook salmon returns have been relatively stable through 2008, and escapement objectives have been achieved (Shields 2009). The remainder of the northern Cook Inlet salmon escapements are monitored by a single aerial survey, which is the least reliable index method of escapements.

There are 3 sustainable escapement goals in effect for Chinook in the Lower Cook Inlet. Chinook salmon is not normally a commercially important species in the Lower Cook Inlet. Very little escapement information is available for this area.

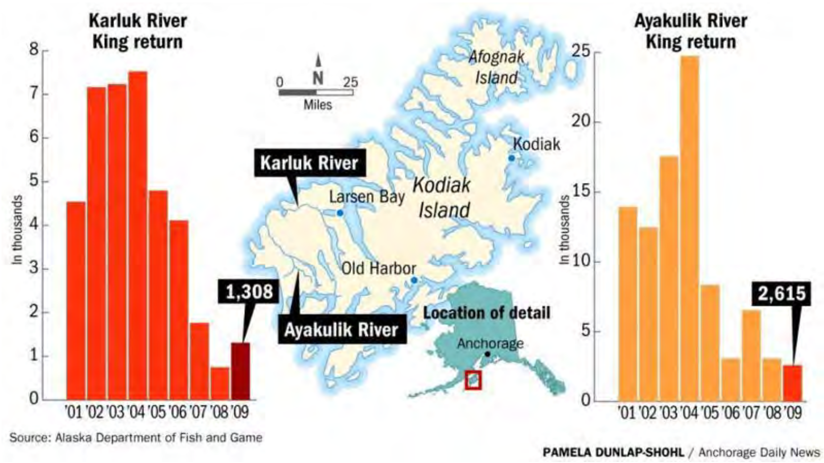
Kodiak

There are three streams that support viable Chinook salmon in the Kodiak management area: Ayakulik River, Karluk River, and Dog Salmon Creek. Commercial harvest occurs during targeted sockeye salmon fisheries. Escapement objectives have been estimated for the Ayakulik and Karluk river systems, and escapement for all three rivers is estimated using fish counting weirs.

The escapement goal range for the Ayakulik is 4,800-9,600 fish; in 2006, 2008, and 2009 escapement has been below the goal range. In 2009, 2,615 Chinook were counted through the weir (Campbell 2010; Figure 4), well below the ten-year average for 1997-2006 of 14,274 salmon (Dinnocenzo and Caldentey

2008). In 2010, the count increased to 5,319 Chinook salmon, which still falls below the ten-year average. For the Karluk, 2007-09 escapement has been below the escapement goal range of 3,600 to 7,300, although between 1998 and 2006, escapements have been within the goal range. Escapement in 2008, especially, was extremely weak, at 752 Chinook, even though retention by seine gear of Chinook salmon greater than 28 inches in length was prohibited in June and July (Dinnocenzo 2010). In 2010, escapement increased to 2,917 fish, which continues to fall below the escapement goal range. Escapements averaged 370 fish for Dog Salmon Creek from 1998 to 2007, however only 90 Chinook were counted through the weir in 2008 (Dinnocenzo 2010). In 2010, 354 Chinook were counted through the weir, which falls slightly below the ten-year average. No escapement goal has been established for this system.

Figure 4 Chinook returns to the Karluk and Ayakulik Rivers, in Kodiak, 2001-2009



Chignik

The Chignik River is the only Chinook salmon producing stream within the Chignik management area, and has an escapement goal range of 1,300-2,700 fish. The 2009 escapement through the weir was 1,680 Chinook (Eggers et al 2010), lower than the 2008 escapement of 1,730 Chinook, and the 5-, 10-, and 20-year averages. Average escapement for 2003-2007 was 5,255 fish, and for 1998-2007 was 4,393 fish (Jackson and Anderson 2009). In 2010, escapement through the weir was 3,679 fish, which represents an increase over the last two years, although still falls below the ten-year average.

South Alaska Peninsula

There are no Chinook spawning streams in the South Alaska Peninsula district.

8.2 Salmon fisheries

Directed commercial Chinook salmon fisheries occur in the Southeast Alaska troll fishery in the GOA, and in the Yukon River, Norton Sound District, Nushagak District, and Copper River. In all other areas, Chinook are taken incidentally, and mainly in the early portions of the sockeye salmon fisheries. Catches in the Southeast Alaska troll fishery have been declining in recent years due to U.S./Canada treaty restrictions and declining abundance of Chinook salmon in British Columbia and the Pacific Northwest. Chinook salmon catches have been moderate to high in most regions over the last 20 years (Eggers 2004).

Forecasts of salmon runs (catch plus escapement) for major salmon fisheries, and projections of statewide commercial harvest are published annually by ADFG. For purposes of evaluating the relative amount of GOA groundfish bycatch as compared to the commercial catch of salmon by area, Table 14 shows the commercial catch of Chinook species by management area between 2003 and 2009.

Table 14 Chinook salmon GOA commercial catch, by area, compared to western and central groundfish bycatch, 2003-2009, in 1000s of fish

Year	Southeast	Prince William Sound	Cook Inlet	Kodiak	Chignik	South Alaska Peninsula	Total	Total GOA groundfish Chinook bycatch
2003	431	49	20	19	3	3	**525**	15
2004	497	39	29	29	3	7	**575**	21
2005	462	36	29	14	3	5	**549**	31
2006	379	32	19	20	2	5	**457**	19
2007	359	41	18	17	2	5	**442**	40
2008	241	12	13	17	1	4	**288**	15
2009	268	11	9	7	3	6	**304**	8

Source: ADFG (http://www.cf.adfg.state.ak.us/geninfo/finfish/salmon/catchval/blusheet/07exvesl.php), Volk et al 2009, Eggers et al 2010, Harthill 2009, AKFIN Comprehensive PSC data, February 2010.

Southeast Alaska and Yakutat

Based on current information from age composition, coded wire tagging studies, and general productivity considerations, the majority of Chinook salmon harvested in the Southeast Alaska troll fishery originate from spawning streams and hatcheries in the Pacific Northwest and Canada (Lynch and Skannes 2008). The Pacific Salmon Treaty Agreements determine Chinook allocations for Treaty fish; the fishery also harvests Alaskan hatchery fish. The Chinook salmon all-gear treaty quota for Southeast Alaska was 218,800 fish in 2009, divided among troll, purse seine, drift and set gillnet, and sport fisheries (Eggers et al 2010). In addition, a harvest sharing agreement with Canada under the treaty allows harvest in the Taku River; there was no directed fishery for Chinook salmon on the Stikine River in 2009 due to low forecast returns. The total regional fishery Chinook harvest, including Treaty fish and Alaskan hatchery fish, was 268,500[3], which is below the long-term average harvest of 301,000 and the recent 10-year harvest of 339,000 (Eggers et al 2010).

Prince William Sound

Chinook harvest in the Copper River District in 2009 was 9,456 Chinook salmon, below the previous 10-year average of 37,000 fish (Eggers et al 2010). Chinook were harvested in the drift gillnet fishery. In 2007, harvest of Chinook in the Copper River District was 51,768 Chinook, with 76% harvested commercially, 2% through educational and subsistence permits, 12% by upriver personal use and subsistence usres, and 8% by sport users (Lewis et al 2008). In 2010, Chinook harvest (through September 15) was 9,353 Chinook, which continues to be below the previous 10-year average.

Harvest of Chinook in commercial fisheries by other gear types or in other Prince William Sound districts totaled 428 fish in 2009, and 360 in 2010 (through September 15). 876 Chinook were harvested in personal use fisheries, and 50 by educational permit (ADFG 2010). Sport and subsistence permit harvests were not yet available.

Cook Inlet

Poor returns in the 2008 and 2009 Deshka River salmon runs resulted in closures for both sport and commercial fisheries. Commercial harvest of Chinook salmon in 2008 was 13,202 fish, lower than the 1998-2007 average of 16,166 fish. 396 Chinook were harvested in 2008 under educational permits, and 1,600 in personal use fisheries (Shields 2009). Approximately 9,000 Chinook were harvested in 2009.

[3] The salmon catch accounting year period extends from October 1, 2008 to September 30, 2009.

The 2009 total harvest of 1,266 Chinook in the Northern District was the third lowest harvest since 1986 (Eggers et al 2010). Preliminary catch totals for 2010 through August 30 report 9,631 Chinook salmon harvest.

In 2008, harvest of Chinook salmon in the Lower Cook Inlet (while not normally a commercially important species) totaled just under 200 fish, or less than 20% of the average for the previous 10 years (Hammerstrom and Ford 2009). The 2009 harvest in the Lower Cook Inlet totaled 84 fish, the lowest total since 1971(Eggers et al 2010). In both years, virtually all catch was taken in the Southern District, primarily the commercial set gillnet fishery, which targets sockeye salmon.

In 2008, personal use catch of Chinook was 2 fish in the Lower Cook Inlet, the lowest since 1974 and much lower than the long term average (1967-2007) of 46 fish. This is attributable to the discontinuation (after 1999) of the Division of Sport Fish program to stock late run juvenile Chinook at the Homer Spit (Hammarstrom and Ford 2009).

Kodiak

There are no directed Chinook commercial fisheries in the Kodiak management area, but Chinook are harvested incidentally in target sockeye salmon fisheries. The 2009 commercial harvest was 7,219 Chinook, considerably lower than the 2008 harvest of 17,176 fish, as well as the previous 10-year average (19,000 Chinook) (Dinnocenzo 2010, Eggers et al 2010). No commercial openings were allowed in the Inner or Outer Karluk or the Inner Ayakulik sections in June and July of 2009, and due to low returns, non-retention of Chinook salmon was implemented during the one fishing period allowed in the Outer Ayakulik, in July 2009. In 2010, the total Chinook harvest through September 13, 2010 was 12,727 Chinook, which remains below the previuos 10-year average.

Due to weak Chinook runs on the Ayakulik and Karluk Rivers, subsistence fishing for Chinook was closed by emergency order in June 2008. In 2008, commercial finfish permit holders reported retention of 76 Chinook from their commercial harvest, for personal use (Dinnocenzo 2010).

Chignik

3,319 Chinook were commercially harvested in 2009, which exceeds recent average harvests (Eggers et al 2010). The majority of the harvest occurred from late June through July. Harvest in 2008 was the lowest since 1977, at 970 Chinook (Jackson and Anderson 2009). Average harvest for 2003-2007 was 2,433 fish. In 2010, fishermen have harvested an estimated 10,000 Chinook, a considerable increase from recent years.

15 Chinook were retained in 2008 for personal use, compared to an average from 2003-2007 of 169 fish.

South Alaska Peninsula

In 2009, 3,800 Chinook were caught in the South Unimak and Shumagin Islands June fisheries, 152 in the Southeastern District Mainland fishery, and 1,900 in the South Peninsula post-June fishery (Eggers et al 2010). The 2009 harvest was higher than the 2008 harvest of 4,839 fish, and also higher than the 4,839 fish average 1998-2007 Chinook harvest for the South Peninsula (Harthill 2009).

9 Review of Existing Closures

There are already seasonal and permanent area closures that have been implemented for the GOA groundfish fisheries, many of which were instituted to reduce bycatch or interactions with Steller sea

lions. It is important to consider the development of new spatial controls to reduce bycatch within the context of existing time and area closures. The various State and Federal closures affecting the GOA groundfish fisheries are described below, along with their intended purpose. The year the closure was implemented is noted in parentheses. Figure 16 (in Section 14 at the end of the document) maps the existing closures in the entire GOA management area; Figure 17 and Figure 18 pinpoint the western and central regulatory areas, respectively, which are the focus of this discussion paper.

Kodiak red king crab closures: Type 1 and Type II (1993). **Nonpelagic trawl closure areas,** designed to protect Kodiak red king crab because of the poor condition of the king crab resource off Kodiak and because trawl bycatch and mortality rates are highest during the spring months when king crab migrate inshore for reproduction. The molting period off Kodiak begins around February 15 and ends by June 15. Type I areas have very high king crab concentrations and, to promote rebuilding of the crab stocks, are closed all year to all trawling except with pelagic gear. Type II areas have lower crab concentrations and are only closed to non-pelagic gear from February 15 through June 15. In a given year, there may also be Type III areas, which are closed only during specified ‘recruitment events’, and are otherwise opened year-round.

Steller Sea Lion (SSL) 3-nautical mile (nm) no transit zone (2003). **Groundfish fishing closures** related to SSL conservation establish 3-nm no-transit zones surrounding rookeries to protect endangered Steller sea lions.

SSL no-trawl zones for pollock and Pacific cod (2003). **Pollock and Pacific cod trawl fishing closures** related to SSL conservation establish 10- to 20-nm fishing closures surrounding rookeries to protect endangered Steller sea lions. Some hook and line and pot gear closures for Pacific cod fishing are also in effect off Chignik, and around Marmot, Sugarloaf, and Outer Pye Islands in the northeast Kodiak and southeast Kenai peninsula areas.

Scallop closures (1995). **Year-round closure to scallop dredging** to reduce high bycatch of other species (i.e., crabs) and avoid and protect biologically critical areas such as nursery areas for groundfish and shellfish.

Prince William Sound rookeries no fishing zone (2003). **Groundfish fishing closures** related to SSL conservation include two rookeries in the PWS area, Seal Rocks (60° 09.78' N. lat., 146° 50.30' W. long.) and Wooded Island (Fish Island) (59° 52.90' N. lat., 147° 20.65' W. long.). Directed commercial fishing for groundfish is closed to all vessels within 3 nautical miles of each of these rookeries.

Cook Inlet bottom trawl closure (2001). **Prohibits non-pelagic trawling** in Cook Inlet to control crab bycatch mortality and protect crab habitat in an areas with depressed king and Tanner crab stocks.

State Water no bottom trawling (2000). **Prohibit commercial bottom trawling** in all state waters (0–3 nm) to protect nearshore habitats and species. However, specific areas in the Shelikof Straits along the west side of Kodiak Island are open to bottom trawling from January 20 to April 30 and October 1 to November 30, and areas around Shumagin and Sanak Islands are open year round.

Southeast Alaska no trawl closure (1998). **Year-round trawl closure** E. of 140° initiated as part the license limitation program.

10 Management options to reduce Chinook salmon bycatch

In order for the Council to move forward with management options to reduce bycatch, it is important to determine what is the Council's desired objective, as this influences what management options will appropriately address the problem. The Council's purpose in trying to reduce Chinook salmon bycatch is likely to be one of the following factors, or a combination of them: a. groundfish bycatch of this species represents a conservation concern; b. groundfish bycatch of this species is impacting directed fisheries for this species; or c. mortality caused by groundfish bycatch of this species is at a socially unacceptable level (note, this ties into one of the Council's management objectives for the groundfish fisheries).

In all cases, the Council is evaluating whether the groundfish fisheries' bycatch levels cross a threshold at which corrective action is warranted. For various reasons, information is not available to determine, with specificity, to what degree the amount of bycatch taken in groundfish fisheries is likely to affect the sustainability of salmon populations. Section 8 provides limited information on Chinook populations, with which to put in context the bycatch numbers presented in the discussion paper. Based on this information, the Council will decide further action should be considered, and management options to reduce bycatch should be instituted.

The type of management options available to the Council include seasonal and permanent area restrictions to a particular gear type or target fishery; temporal area restrictions, that may be triggered by attainment of a bycatch limit; or creation of industry-level bycatch management entities that can effect real-time communication to avoid 'hotspot' areas of high bycatch. All of these management options have benefits and disadvantages, which cannot be fully analyzed in this discussion paper, but which will be addressed in detail should the Council choose to initiate an analysis. The sections below provide a brief outline of the management options that could be included in an analysis, as well as some preliminary strawman closures to illustrate some of the options.

10.1 Draft alternatives

The following suite of draft alternatives for reducing salmon bycatch in the GOA groundfish fisheries was first proposed by the Council in December 2003, and has been iteratively refined since that time. In June 2008, the Council eliminated alternatives for salmon species other than Chinook salmon, and requested staff to begin to develop strawman closures to pair with the draft alternatives. The following are the draft alternatives:

Chinook Salmon

Alternative 1:	Status quo (no bycatch controls).
Alternative 2:	Trigger bycatch limits for salmon. Specific areas with high bycatch (or high bycatch rates) are closed seasonally (could be for an extended period of time) if or when a trigger limit is reached by the pollock fishery.
Alternative 3:	Seasonal closure to all trawl fishing in areas with high bycatch or high bycatch rates.
Alternative 4:	Voluntary bycatch cooperative for hotspot management.

In June 2005, the Council also provided, in their motion, the following comments on developing trigger limits, and general recommendations for an analysis.

<u>Trigger limits:</u>

1- Average numbers are not an appropriate approach to establishing trigger limits. The analysis should instead focus upon the use of biomass-based approaches for establishing appropriate trigger levels.
2- Trigger limits under consideration should be separated by gear type (i.e. separate limits for pot gear versus trawl gear)
3- Rather than considering an improperly defined duration of a triggered closure, the Council recommends moving in the direction of dynamic revolving closures (hot spots) which reflect the distribution and mobility of the crab population.

<u>General recommendations for the analysis:</u>

1- Differential discard mortality rates by gear type should be addressed in the analysis using the most up-to-date and applicable information.
2- Additional information must be included with respect to the overall precision of bycatch estimates given the low levels of observer coverage in many of the fisheries under consideration.
3- The addition of another alternative (from staff discussion paper) for an exemption from time and area closures if an observer is on board, seems pre-mature at this time.
4- Emphasis should be focused on alternatives 3 and 4 rather than focusing attention on trigger limits under alternative 2.
    a. With respect to alternative 3, additional information may be necessary (in addition to ADFG survey information and bycatch information from the NOAA groundfish observer program) in order to appropriately identify sensitive regions for year-round or seasonal closures.
    b. Alternative 4 should include the concept of required participation in a contractual agreement for a hot spot management system
5- A rate-based approach format should be added as much as possible in all graphs and figures for the analysis.

10.2 Estimating trigger limits

Trigger limits, as proposed under Alternatives 2, would close designated areas to all or specified gear types or target fisheries once a bycatch limit has been reached. PSC limits and associated closures have been used for salmon bycatch in the Bering Sea groundfish fisheries (Witherell and Pautzke 1997). For instance, the pelagic trawl pollock fishery accounts for a high percentage of GOA Chinook bycatch. The Council might set a bycatch limit for Chinook salmon, and once it has been attained (either by the fleet as a whole, or exclusively by the pollock fishery), a designated area might be closed to pollock fishing for the remainder of the year or season.

In the past, the Council has provided direction to staff with respect to establishing trigger limits. Staff were encouraged to look at abundance-based methodologies for developing potential trigger limits. This abundance-based approach has been used in the BSAI groundfish fisheries for crab species. A stair-step procedure of increasing PSC limits corresponding to higher population levels is in place for red king crab; an abundance-based zonal approach is used for *C. bairdi* Tanner crab; and the snow crab PSC limit is based on the percentage of annual biomass estimates. Biomass-based limits, however, require a good understanding of the relative stock status for that species, which may not be available for Chinook salmon in the GOA. Section 8 provide an overview of stock status for Chinook salmon, but a detailed understanding of the health and vulnerability of salmon stocks would be integral to determining the appropriate mechanism for establishing trigger limits, if the Council chooses to include a trigger limit management option in a future analysis.

The proposed alternatives using trigger closures would work similar to other existing PSC management measures. Currently in the GOA, PSC limits are only set for halibut in the flatfish fisheries, so that if the PSC limit for the target fishery (or group of target fisheries) is reached within a given season, the fishery (or fisheries) is closed for the remainder of the season. Establishing trigger bycatch limits for Chinook salmon, as proposed under Alternatives 2, would result in a similar procedure. Inseason management would monitor the accrual of bycatch toward the PSC limit. As most of the GOA groundfish fisheries are subject to less than 100% observer coverage, bycatch rates from observed vessels would be applied to catch on unobserved vessels using the catch accounting database estimation procedure, described in Section 3.

In order to establish PSC limits for Chinook, the Council would first establish what type of bycatch would accrue to the trigger limit (e.g., all bycatch by any gear type, or specific bycatch by gear type, target fishery, and/or regulatory area). Next, the Council would establish what the consequence of arriving at the limit would be (e.g., an area closure for the remainder of the year or season), and to whom the consequence would apply (e.g., a particular gear type and/or target fishery).

It has been suggested that establishing trigger PSC limits for managing Chinook salmon bycatch in the GOA is problematic. The low proportion of observed catch in the GOA means that the reporting of total bycatch numbers involves considerable extrapolation. Inherent in the catch estimation procedure is the fact that a catch of one salmon in a small groundfish haul (resulting in a high bycatch rate) can sometimes be extrapolated to very large amounts of catch, resulting in exceedingly high bycatch totals for the GOA as a whole. The Alaska Fisheries Science Center is looking into the possibility of including estimates of statistical confidence into the bycatch estimation procedure, but for the moment, the current procedure is the best available. It is also the procedure that is currently used to manage the PSC limit for halibut in the GOA.

10.3 Determining appropriate area closures

Year-round and seasonal closures, such as those proposed under Alternatives 3, have also been used in both the GOA and BSAI fisheries to control the bycatch of prohibited species. Currently, in the GOA, trawl closure areas have been implemented around Kodiak Island to protect red king crab. In a separate action, the Council is currently considering establishing area closures around Kodiak Island for protection of *C. bairdi* crab. Area closures can also be associated with PSC trigger limits, as under Alternative 2, so that a particular area is closed once the PSC limit is reached.

For salmon, the highest bycatch is seasonal, and is tied to the timing of the pollock fishery. Seasonal closures of hot spot locations could merit examination, rather than year-round closures. Seasonal salmon closures have been used to control salmon bycatch in the BSAI groundfish fisheries, although in recent years these closures have been problematic, and measures to address salmon bycatch, including revised area closures and PSC limits that would close the pollock fishery when triggered, are currently under review (NMFS 2008). Given that the Council is currently revising bycatch reduction measures for salmon in the BSAI, any measures evaluated in the GOA should consider and build upon lessons learned in the BSAI.

There are various methodologies available for identifying appropriate areas to close in order to reduce bycatch of salmon. One such is to look at areas of high abundance of the species in question, and restrict fishing in those areas, however this methodology is less effective for Chinook salmon. Another methodology that was used by the Council to create habitat closures in the Aleutian Islands and the northern Bering Sea is the footprint approach. For example, in the Aleutian Islands, closures were intended to protect coral (and fish habitat), and little is known about the abundance of coral in those areas.

Closures in this instance were identified to contain fishing within historic limits. The footprint approach is also not necessarily helpful when protecting highly mobile species such as salmon, however.

The default methodology for this preliminary analysis is to use bycatch locations as a proxy for abundance, and identify closure areas based on the locations of hauls with observed bycatch. High incidence of bycatch and high bycatch rates, summed over the years 2003-2007, were used to identify the strawman closures described below. There are many problems with this approach, some of which have already been described above. The observer data is the best available data for designing closures based on where the fishery encounters bycatch. However, the observed fishing trips represent only a relatively small proportion of total fishing trips in the western and central GOA. Also, for vessels that are not 100% observed, the areas where a vessel chooses to fish while it has an observer onboard may be purposefully different than the areas where it fishes without an observer. This might occur if a vessel chooses not to make longer trips with an observer onboard, because it might require paying the observer for a longer duration than is necessary to meet the observer requirement. If this is the case, basing a spatial analysis of where bycatch is occurring on the observer data may not always produce an accurate representation of actual bycatch distribution. Another issue with using the observer data for identifying regulatory closures was discussed in Section 5 with respect to sampling bycatch at the plant in the pollock fishery, and the fact that it effectively averages the bycatch caught on a trip across all the hauls that occurred during that trip.

Additionally, areas with high numbers of bycatch also tend to be the areas where most of the catch is occurring. By prohibiting vessels from fishing in areas of high catch per unit effort, bycatch closures would force vessels to fish longer in other, less productive areas, which may result in higher bycatch rates in the long run. This issue can be addressed by looking at areas with high bycatch rates (e.g. crab/mt groundfish) instead of looking at absolute bycatch numbers. However, bycatch rates are also a problematic methodology, because some of the highest bycatch rates arise from having one salmon or crab caught in a small tow of groundfish, which may not necessarily be representative of a high abundance area that would benefit from a closure.

Bycatch patterns are also highly variable from year to year. The correlation between the location of fishery catch and salmon bycatch has not been fully investigated, but preliminary analysis seems to indicate that the variability is as much a function of salmon life history changes or abundance as it is changes in the fleet’s fishing patterns. This complicates the identification of appropriate closure areas to protect Chinook salmon, as a closure that might be appropriate to protect the species in one year may be ineffective in another one. This appears to have been the case with the salmon closure areas for Chinook and chum salmon in the BSAI, which have recently been revised or are under review by the Council. Since the initial evaluation of strawman closures was made, in the version of this discussion paper dated December 2008, staff have mapped and included additional years of observed bycatch history: 2001, 2002, and 2008. Consequently, it is the strawman closures that are described below, based on 2003-2007 bycatch, are often mapped against the 2001-2008 time series, or against 2008 alone. This comparison will allow the Council to see the annual variability in bycatch patterns, and some of the problems with establishing closure areas as a mechanism to reduce Chinook bycatch in the GOA groundfish fisheries.

10.4 Preliminary strawman closures for Chinook salmon (developed in November 2008)

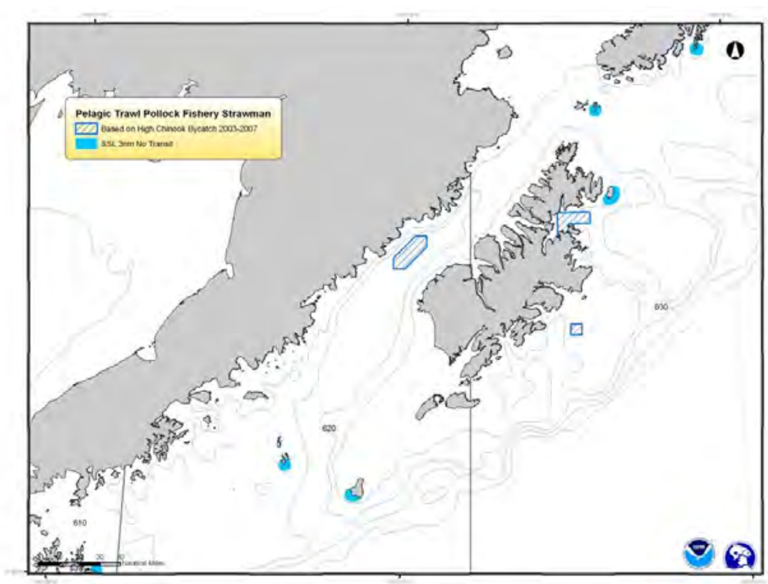
For Chinook salmon, staff tried to look at separate strawman closures for vessels using pelagic and non-pelagic trawl gear. While the majority of salmon overall is taken in the pollock pelagic trawl fishery, the non-pelagic trawl fisheries combined contribute an average of 25% to the total GOA Chinook bycatch. Based on the observer data, however, it was very difficult to identify hotspot bycatch areas that could serve as strawman closure areas for the non-pelagic trawl fleet. For this reason, strawman closures for non-pelagic trawl gear are not included in this discussion paper, although it is possible that further

detailed analysis of the observer data may be able to suggest a different methodology for identifying closures for this gear type in the future.

For pelagic trawl, strawman closures were identified based on high incidence of Chinook salmon in the pelagic pollock trawl fishery during 2003-2007 (Figure 5). The closures were identified by selecting areas with the highest category of observed bycatch during those years, extrapolated to the haul level, and also include any areas of the second highest category that surround it. An attempt was made to include areas of at least two blocks of high or highest catch. The closure areas are overlaid on maps of the observed number of Chinook salmon from 2001-2008 (Figure 19), in Section 14 at the end of the document), and for 2008 only (Figure 20), which provides information on the spatial variability of the catch on an annual basis. Additionally, the strawman closures are compared to the bycatch rate of salmon, from 2001-2008, for the pelagic trawl fishery (Figure 21). This methodology results in three closure areas, all of which occur in the central GOA.

As discussed in Section 5 and above, prohibited species in the pollock fishery are sampled at the plant, and the location of the bycatch is averaged among all hauls in a given trip. **Should the Council proceed with an analysis of closure areas for pelagic trawl gear, a more detailed spatial analysis would need to be conducted to investigate the impact of this averaging on the delineation of appropriate closure areas.**

Figure 5 Chinook salmon strawman closures for pelagic trawl gear, based on high incidence of bycatch summed for 2003-2007



Catch statistics for strawman closures

Table 15 provides a synthesis of the strawman closures identified above. The data, summed for 2001 to 2008, is from the observer database which was used to map the distribution of Chinook bycatch in the western and central GOA. The table provides the overall bycatch rate of Chinook salmon per total catch in the western and central GOA, by gear type, for 2001-2008, and compares it to the bycatch rates in the areas encompassed under the sets of strawman closure areas. Additionally, the total number of tows occurring in each set of closure areas is compared to the total number of hauls that contain Chinook salmon, which gives an idea for the degree to which bycatch is pervasive in the strawman closures. The final columns identify how much of the total observed catch and total observed bycatch come from the strawman closure areas.

Table 15 Total observed catch and Chinook bycatch in strawman closures, by gear type, compared to catch and bycatch of that gear type in the western and central (W/C) GOA, summed over 2001-2008

Area and gear type	Total Chinook bycatch[2] (number)	Total fishery catch[2] (mt)	Bycatch rate (bycatch/ total catch)	Total number of tows in strawman areas	Total tows with Chinook bycatch in strawman areas	% of total W/C GOA bycatch occurring in strawman areas	% of total W/C GOA catch occurring in strawman areas
Pelagic trawl in western and central GOA	24,299	119,638	0.20				
Pelagic trawl strawman closures based on high incidence of Chinook[1]	9,524	32,567	0.29	965	702	39.2%	27.2%

Source: NMFS observer database, March 2009.
[1] The methodology used to identify the strawman closures is described earlier in Section 10.3, and the closures themselves are illustrated in Section 14 at the end of the document).
[2] These numbers are based on observer data that has been extrapolated to the haul level. Observers do not sample the entire haul from a fishing tow, but rather collect one or several samples. The number of a particular bycatch species collected within the sample(s) is extrapolated by the Observer Program to represent the number of that bycatch species caught in the entire haul.

For the pelagic trawl gear strawman closures for Chinook, the bycatch rate increases from an average of 0.20 GOA-wide to 0.29 in the strawman closure areas as a group. 73% of all observed tows in the strawman closure areas contained Chinook bycatch. The strawman closure areas encompass areas where almost 40% of the observed Chinook bycatch was reportedly caught[4], but they also represent areas where 27% of the total catch in the pelagic trawl fishery was harvested. Consequently, if these areas were made into regulatory closures, a quarter of the effort in the fishery would be dispersed into other areas. Should the Council choose to pursue an analysis with this as an alternative, the analysis would have to look at the likely areas where the fishery could recoup that effort, and what the bycatch rates would be likely to be in those areas.

10.5 Voluntary bycatch cooperatives

Alternative 4 would establish a bycatch pool or cooperative for hotspot area management. This alternative is designed after the current BSAI bycatch cooperatives, in use by industry to control salmon bycatch in the pollock fishery. Currently in the BSAI, a program of voluntary area closures is in place with selective access to those areas for fleets which demonstrate success in controlling bycatch (Haflinger 2003, NMFS 2008). Voluntary area closures can change on a weekly basis, and depend upon the supply and monitoring of information by fishermen. The sharing of bycatch rates among vessels in the fleet has allowed these bycatch hotspots to be mapped and identified on a real-time basis, so that individual vessels can avoid these areas (Smoker 1996, Haflinger 2003, NMFS 2008). This system relies upon information voluntarily reported to Sea State by the fleet per their cooperative agreements.

One problem with implementing a voluntary cooperative program in the GOA is the fact that the GOA fisheries tend to be of short duration. In the Bering Sea, hotspot areas can be closed on a weekly basis, however this approach would not work in the GOA fisheries. Additionally, the program is more easily

[4] See Section 5 for discussion of the sampling mechanism for the GOA pollock fishery, and impacts on the averaging of bycatch across multiple haul locations.

implemented in the Bering Sea pollock fishery because the fishery is rationalized, and the agreement is between cooperatives with dedicated pollock allocations. An extensive discussion of the BSAI intercooperative agreement is included in the Final Environmental Impact Statement for Bering Sea Chinook Salmon Bycatch (NMFS 2008).

11 Action by the Council

The decision before the Council is whether to initiate an analysis to examine one or more of the management options proposed in this discussion paper, or others that the Council may wish to include in an analysis. Strawman closures were developed by staff in previous drafts of this paper, in order to provide a starting point for discussion of management options that include spatial or temporal fishery closures. This spatial analysis was, however, prepared in November 2008, and does not incorporate recent data. Additionally, for the pollock fishery, the closures do not account for the averaging of a trip bycatch rate across several hauls which may have occurred in different locations.

If the Council chooses to initiate an analysis, the Council should articulate a problem statement for this action, and a set of alternatives to analyze.

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14 Color figures

Figure 6 Observed Chinook salmon bycatch in the GOA groundfish fishery, summed over 2006-2010

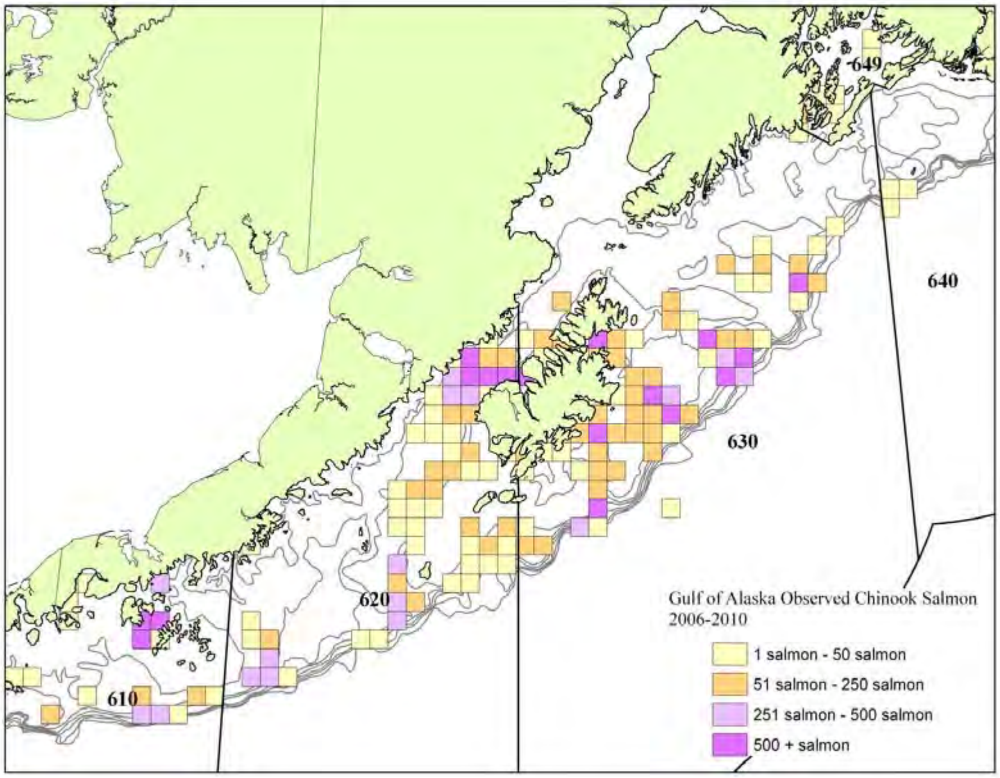


Figure 7 Observed Chinook salmon bycatch in the GOA groundfish fishery, 2006

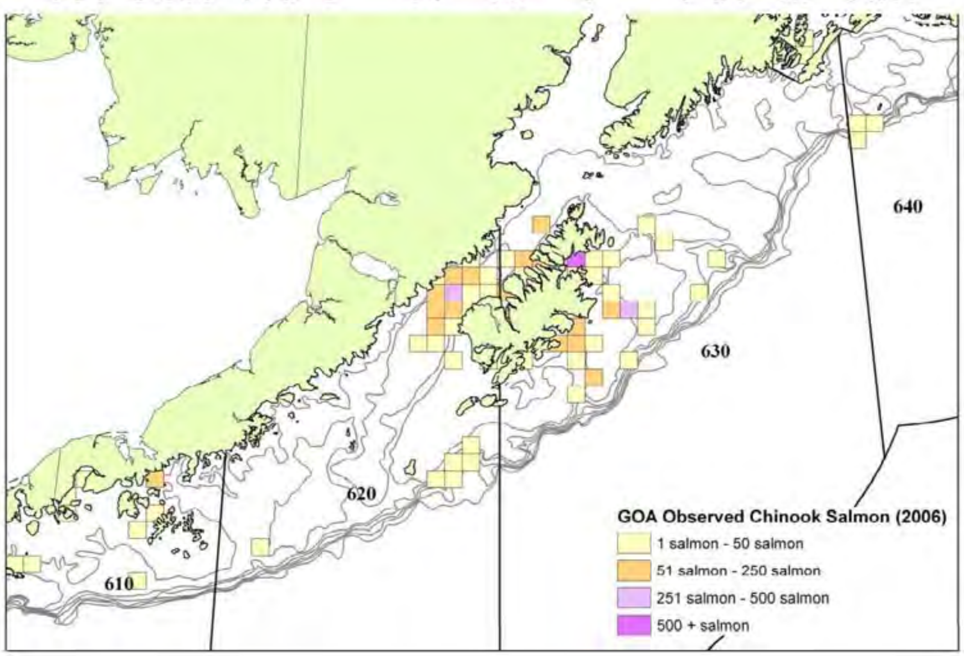


Figure 8 Observed Chinook salmon bycatch in the GOA groundfish fishery, 2007

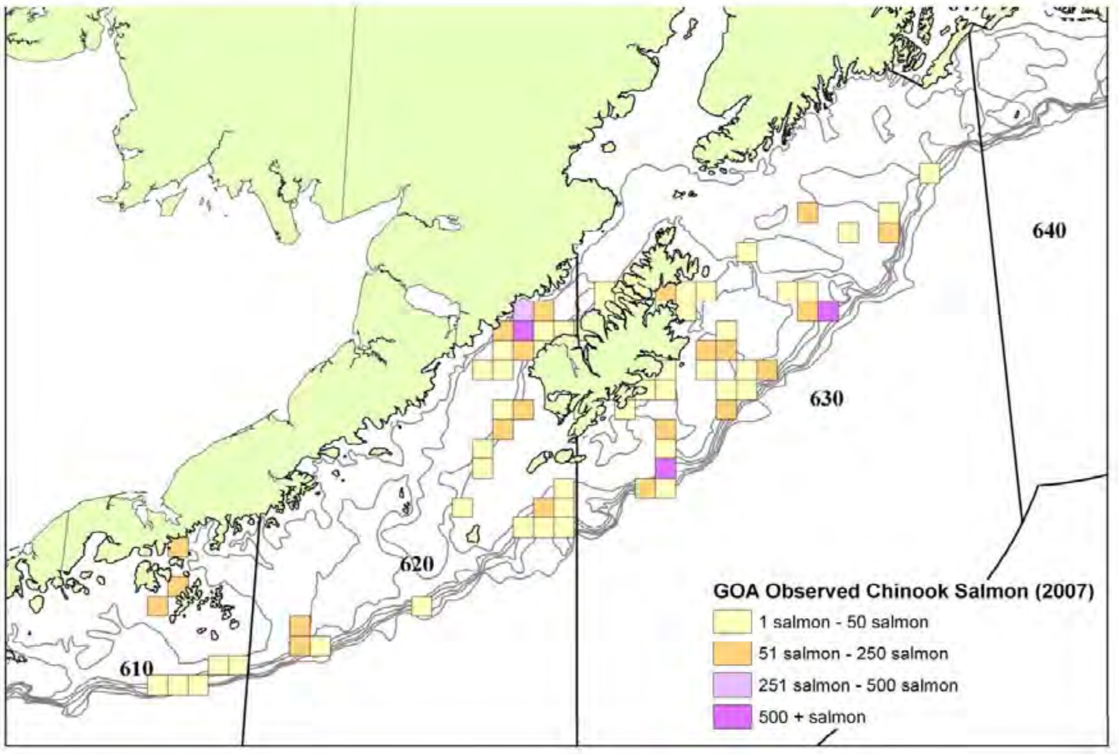


Figure 9 Observed Chinook salmon bycatch in the GOA groundfish fishery, 2008

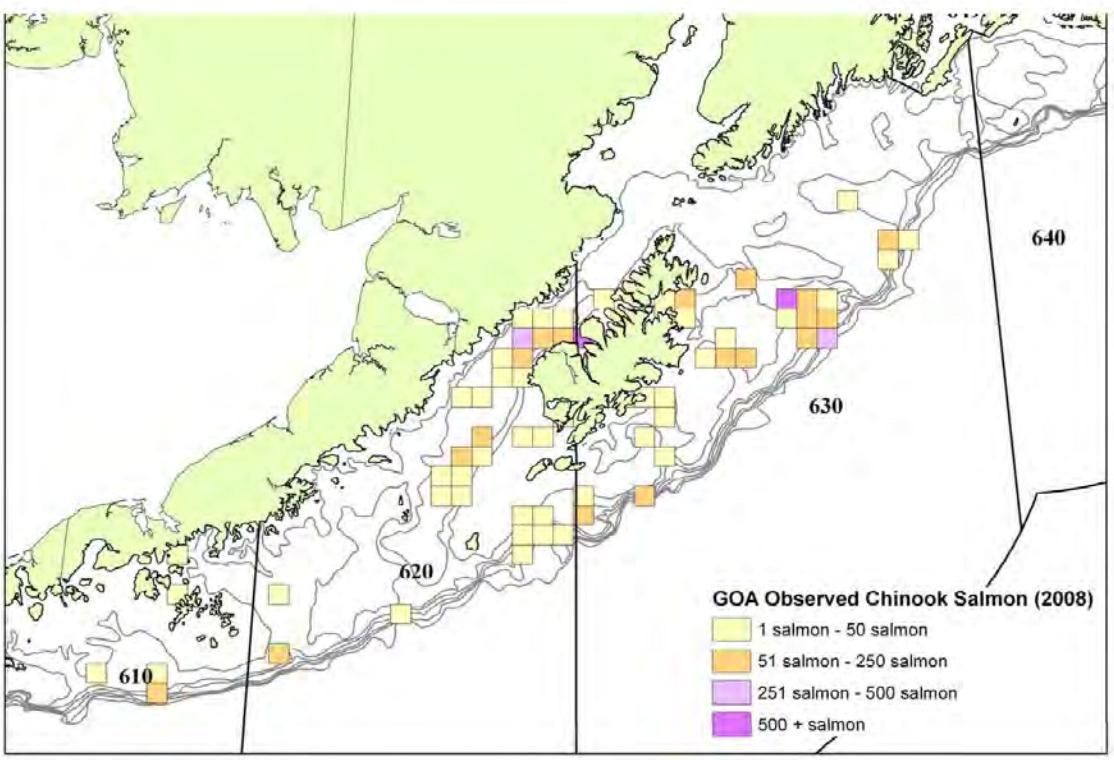


Figure 10 Observed Chinook salmon bycatch in the GOA groundfish fishery, 2009

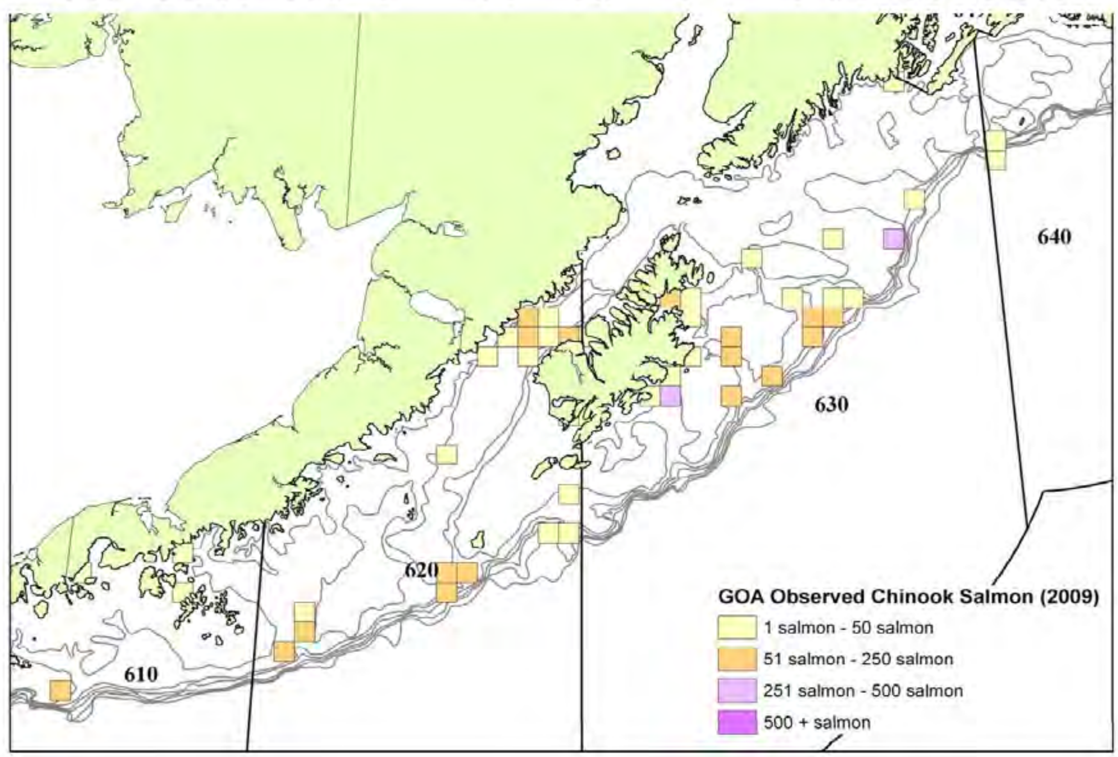


Figure 11 Observed Chinook salmon bycatch in the GOA groundfish fishery, 2010

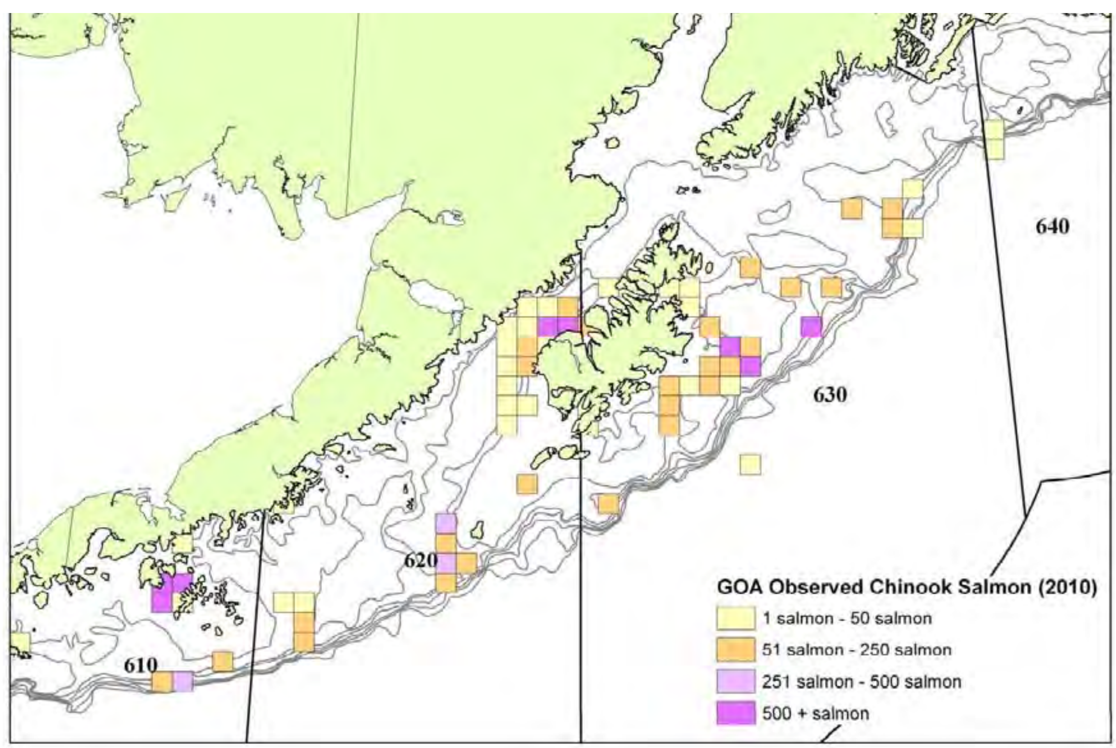


Figure 12 Observed Chinook salmon bycatch in the pelagic trawl fishery, summed over 2001-2008

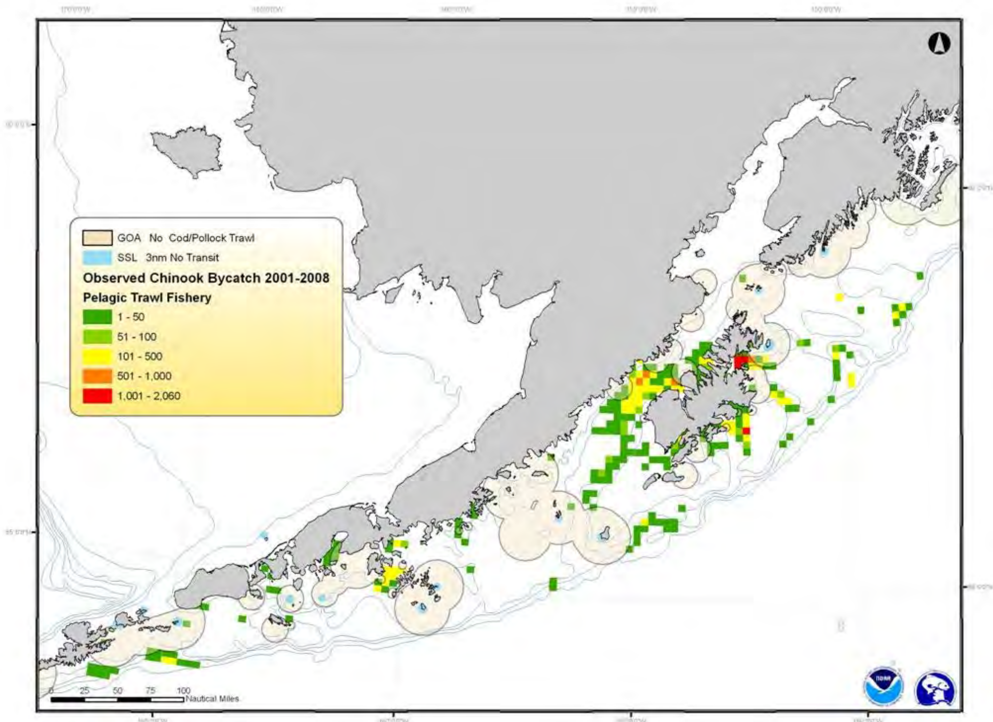


Figure 13 Observed Chinook salmon bycatch rate in the pelagic trawl fishery, summed over 2001-2008, number of salmon per metric ton of total catch

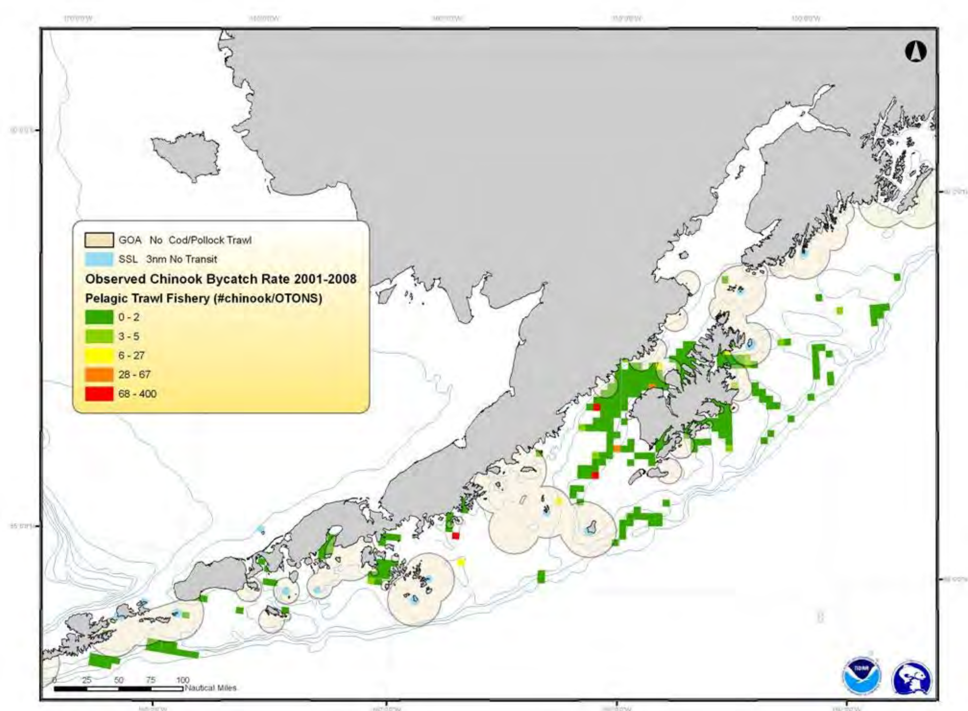


Figure 14 Observed Chinook salmon bycatch in the non-pelagic trawl fishery, summed over 2001-2008

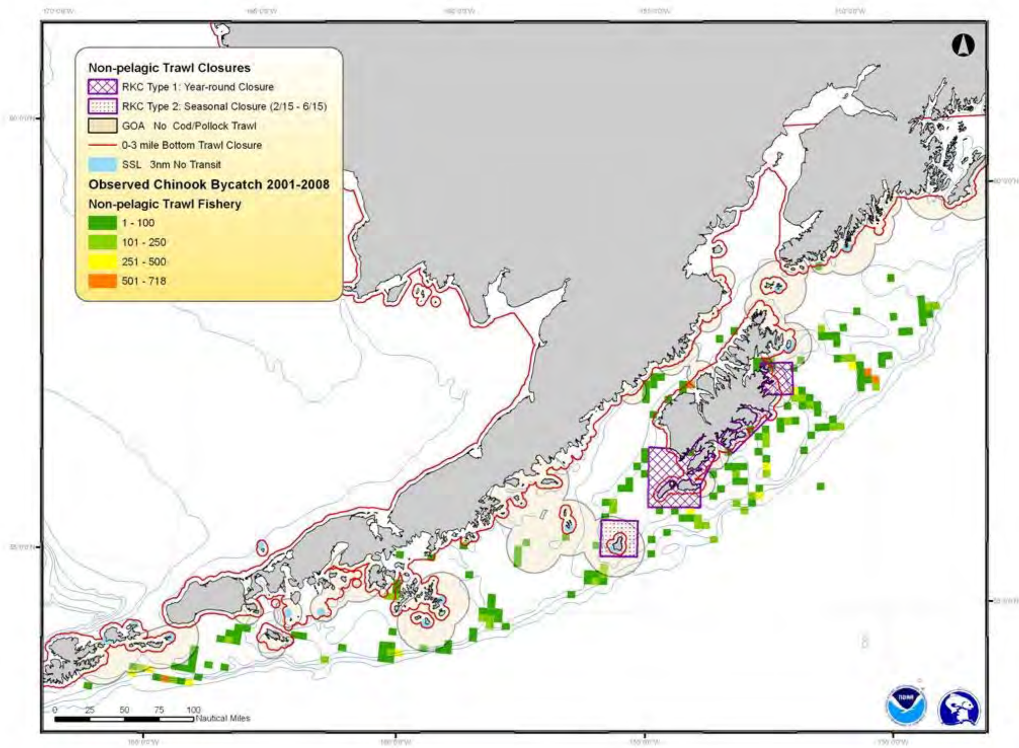


Figure 15 Observed Chinook salmon bycatch rate in the non-pelagic trawl fishery, summed over 2001-2008, number of salmon per metric ton of total catch

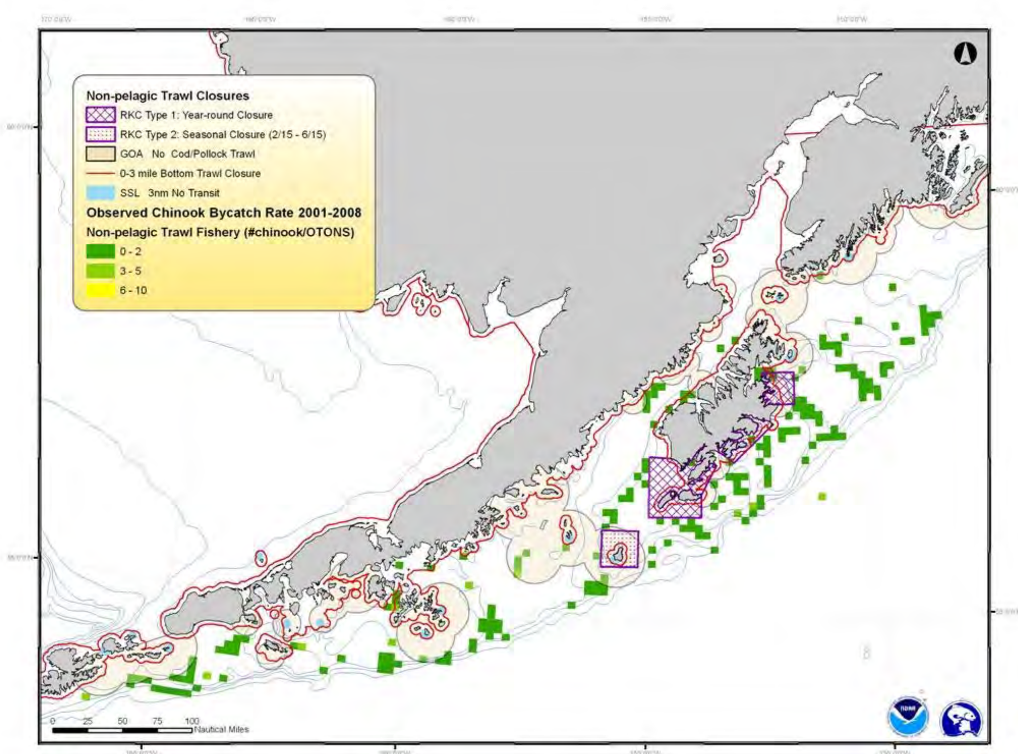


Figure 16 Locations of existing trawl fishery and crab protection closures in the Gulf of Alaska

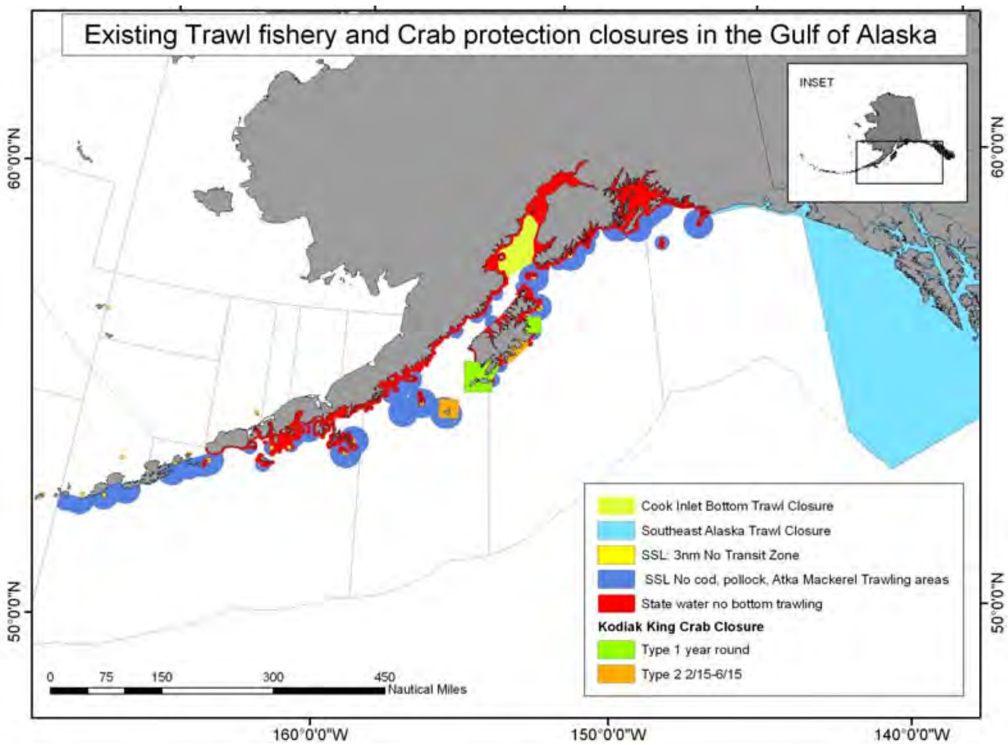


Figure 17 Locations of existing trawl fishery and crab protection closures in the Western Gulf of Alaska

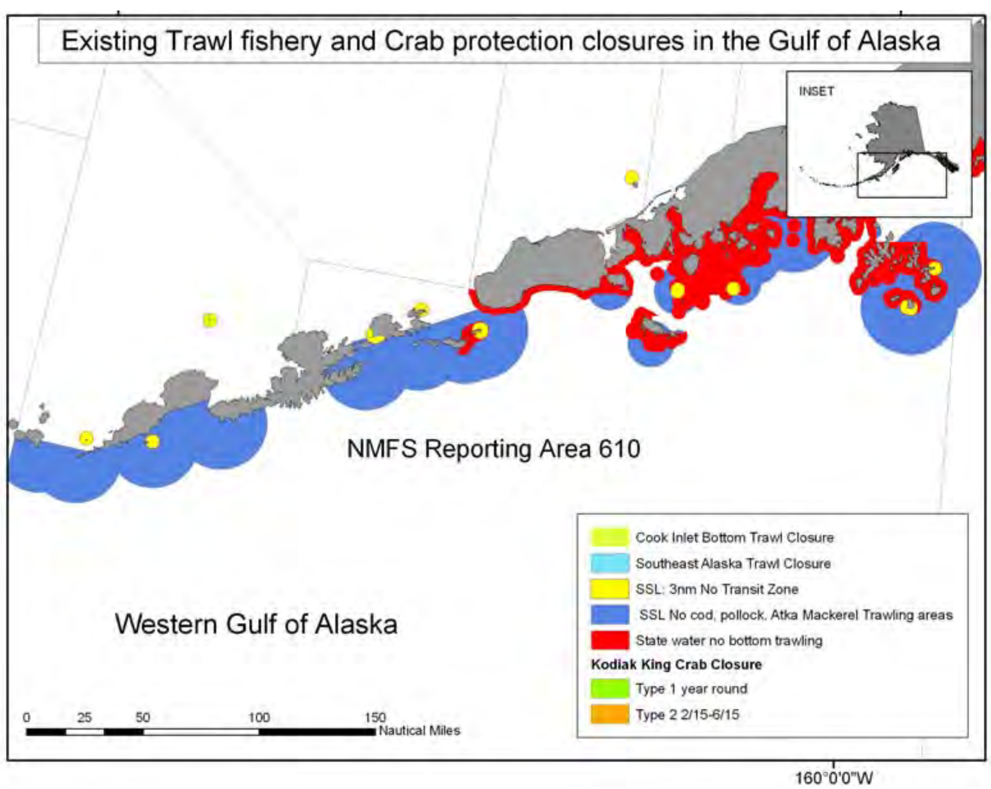


Figure 18 Locations of existing trawl fishery and crab protection closures in the Central Gulf of Alaska

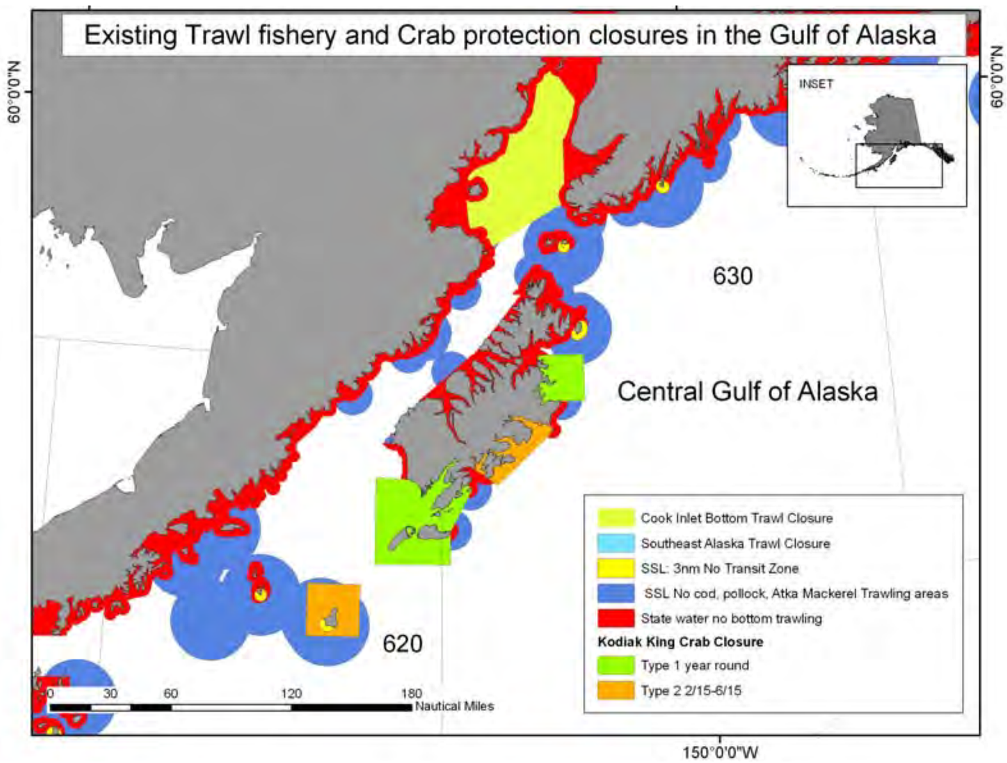


Figure 19 Chinook salmon strawman closures for pelagic trawl gear, based on high incidence of bycatch in 2003-2007, compared to areas with high bycatch incidence in 2001-2008

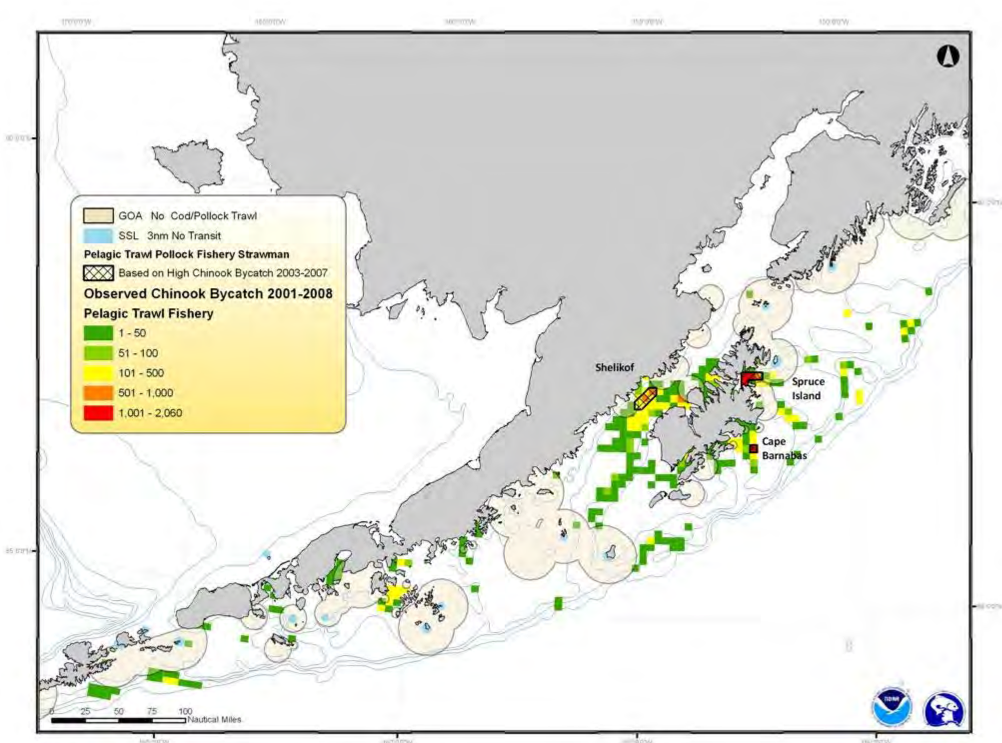


Figure 20 **Chinook salmon strawman closures for pelagic trawl gear, based on high incidence of bycatch in 2003-2007, compared to areas with high bycatch incidence in 2008 only**

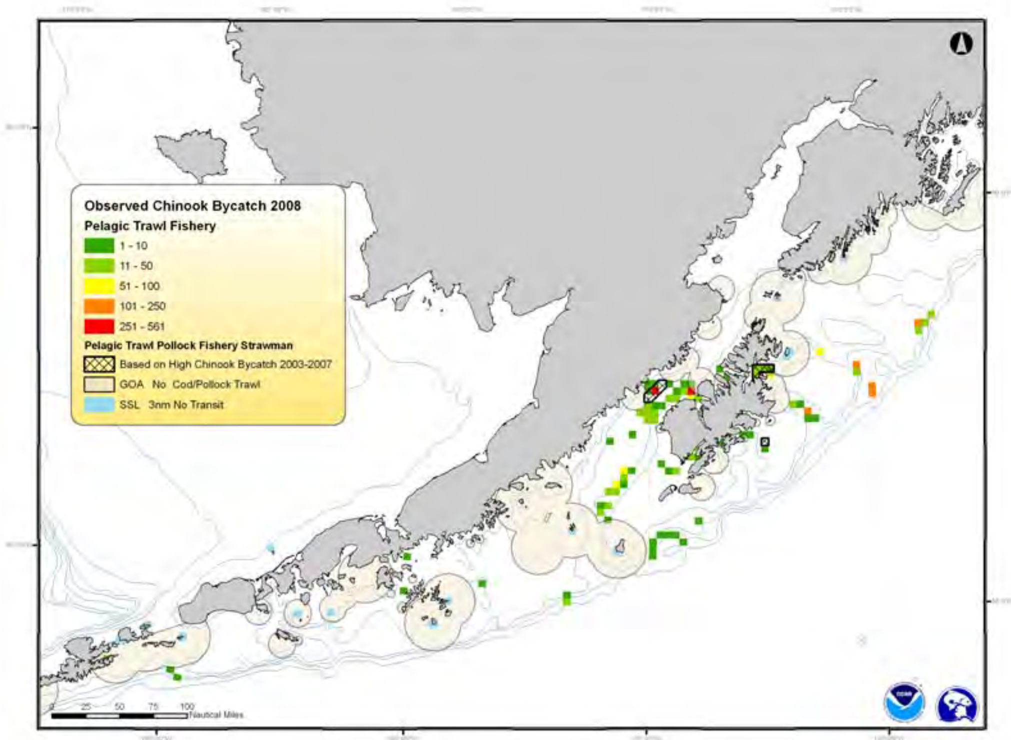
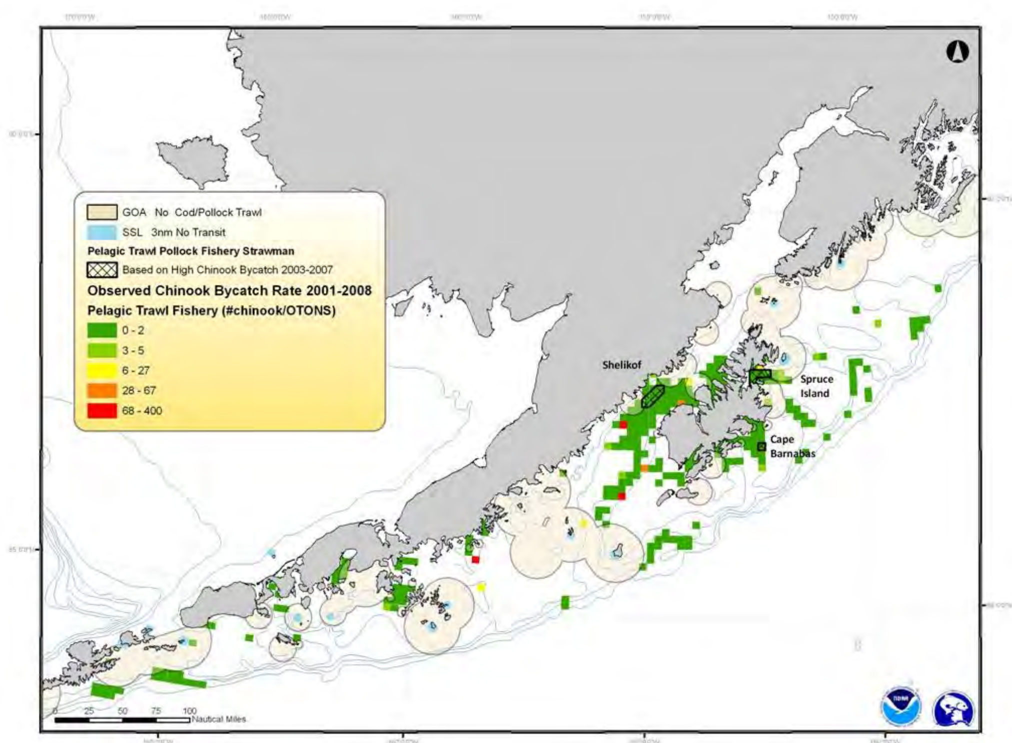
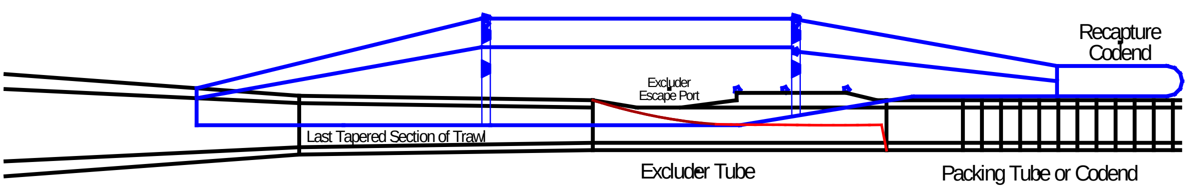


Figure 21 **Chinook salmon strawman closures for pelagic trawl gear, based on high incidence of bycatch in 2003-2007, compared to areas with high bycatch rates in 2001-2008**



Attachment 11

Final Report for EFP 08-02 to explore the potential for flapper-style salmon excluders for the Bering Sea pollock fishery



Co-investigators: John Gauvin, Gauvin and Associates LLC on behalf of the North Pacific Fisheries Research Foundation; John Gruver, United Catcher Boats Association, Craig Rose, Alaska Fisheries Science Center

Final Report for EFP 08-02 to explore the potential for flapper-style salmon excluders for the Bering Sea pollock fishery

Co-investigators: John Gauvin, Gauvin and Associates LLC on behalf of the North Pacific Fisheries Research Foundation; John Gruver, United Catcher Boats Association, Craig Rose, Alaska Fisheries Science Center

The objective of EFP 08-02 was to evaluate a new salmon excluder design called the "flapper" excluder. In its initial concept, the "flapper" was simply a panel of webbing that trails back with the water flow at towing speed to prevent access to the escapement hole located above the panel. Access to the escapement hole would be achieved only when the vessel reduced its speed to approximately one-half its normal towing speed. Weight placed on the flapper panel was designed to allow the panel to drop down during the slowdown and salmon to escape. Depending on the amount of weight and towing direction relative to the tide, it might take as little as a few minutes to almost 10 minutes for the panel to descend when speed is reduced to one-half of normal towing speed. For effective salmon escapement, slowdowns to allow salmon to escape would have to be done periodically during a tow. The weight was placed on the aft part of the flapper panel such that it would create a sort of ramp for salmon swimming forward in the net during a slowdown to swim out of the escapement hole at the top of the trawl.

The flapper excluder in its initial concept was quite different from earlier excluders because it was designed to allow salmon escapement only during periodic slowdowns. This meant that conducting periodic slowdowns at approximately one-half towing speed was necessary to achieve salmon escapement. The impetus for this alternative approach was that observations in earlier field work with tunnel and funnel excluder designs showed that salmon were capable of swimming ahead of the codend as it filled with pollock. Some of these salmon were observed moving forward when the vessel speed was reduced at the time when the net sounder (third wire) device was being removed from the headrope.

From video footage recorded during earlier trials with earlier excluder designs, salmon escapements (principally Chinook) were observed to occur both during normal towing operations and when the vessel speed was reduced at the end of towing operations. So while it was known that some salmon would escape during slowdowns, the fraction of escapements attributable to slowdowns versus immediate escapes at normal towing speeds was not known. This is because testing methods with a recapture net were not designed to specifically account for escapements in one manner versus the other and there was no way to redesign a recapture net or use video to allow for separate accounting of escapement paths.

The motivation to explore flapper-style excluders as an alternative to earlier designs was due to problems encountered with the earlier excluders, particularly for higher horsepower vessels. Earlier designs such as the funnel and tunnel excluders showed significant promise for Chinook escapement with performance in the range of 25-42%. The basic concept behind those earlier

excluders was the use of a tapered square mesh panel to reduce the effective diameter of the last section of tapered intermediate. Several different locations for the square mesh funnel or tunnel excluders were evaluated. These were in the 4 inch and sometimes 6 inch mesh sections just ahead of the straight section or "stuffing tube" used on most nets. This is approximately 100 meshes in front of the cod end.

The concept for the earlier excluders was that the aft end of the tapered square mesh panel created an area of slower water flow above the funnel or tunnel panel. This area was also out of the flow of the catch as fish exited the reduced diameter tapered square mesh section inside the intermediate. The principle was that salmon, being stronger swimmers, could make use of this slower water outside the main flow of fish to rest and eventually move up so they could access the escapement hole (in some excluder versions multiple escapement holes were used). So escapement in the earlier excluder designs was expected to occur during normal towing operations instead of during periodic slowdowns as was the case for our initial focus on flapper excluders later on.

While escapement rates for Chinook were consistently attractive in our EFP trials of funnel and tunnel excluders, restricting the flow of water through the trawl with a square mesh tunnel or funnels unfortunately created a strongly negative outcome. The main problem was that the trawl intermediate sometimes bulged as fish became pinned against the entrance to the funnel or tunnel. This was thought to occur because there was insufficient room for a large quantity of pollock to move through the rigid excluder section of the trawl when pollock catch rates were high.

Unlike diamond mesh, square mesh will not provide any flexibility or "give" in terms of being able to accommodate additional catch. Square mesh was, however, essential for creating the proper shape of the tapered section that reduced the diameter of the trawl. The rigidity created by the square mesh section had the downside of creating a place where fish moving through the net could become pinned. Once pinned against the webbing just in front of the excluder, a collection point was created for more fish as the shape of the intermediate changed. In the extreme, the webbing at the entrance to the excluder turned against the direction of water flow down the net. When this occurred, trawl door spread was reduced and in extreme cases, the net became damaged, particularly with higher horsepower vessels.

When damage to the net did occur, this was mostly associated with high-horsepower vessels fishing in dense schools of pollock or when jellyfish became pinned at the leading edge of the excluder. For the former situation, the potential remedy of advising fishermen to avoid dense schools of pollock was inherently unappealing. The latter part of EFP 05-02 in 2006 attempted to evaluate buffer strips and slower tapers to address "bulge" problems. But when these approaches created as many problems as they addressed, the need to explore other approaches to excluding salmon became evident.

As an alternative approach to mitigating these problems, several fishermen attending a salmon excluder workshop during the winter of 2006 suggested an alternative that became the first design of the flapper excluder. This alternative design was simply to have a sheet of weighted webbing that would fully close off access to escapement hole under normal towing speeds via water flow at normal towing speeds. This “trap door” or “flapper” concept would necessitate periodic slowdowns to allow salmon to escape. But because the flow of water through the trawl was not reduced appreciably by the flapper sheet, bulging of the net with fish becoming pinned would not be likely to occur. Although requiring slowdowns, the workings of the flapper excluder (Figures 1 and 2 below) were viewed by many in the fleet as the best way to achieve salmon escapement without impairing the ability of pollock nets to fish on a day to day basis.

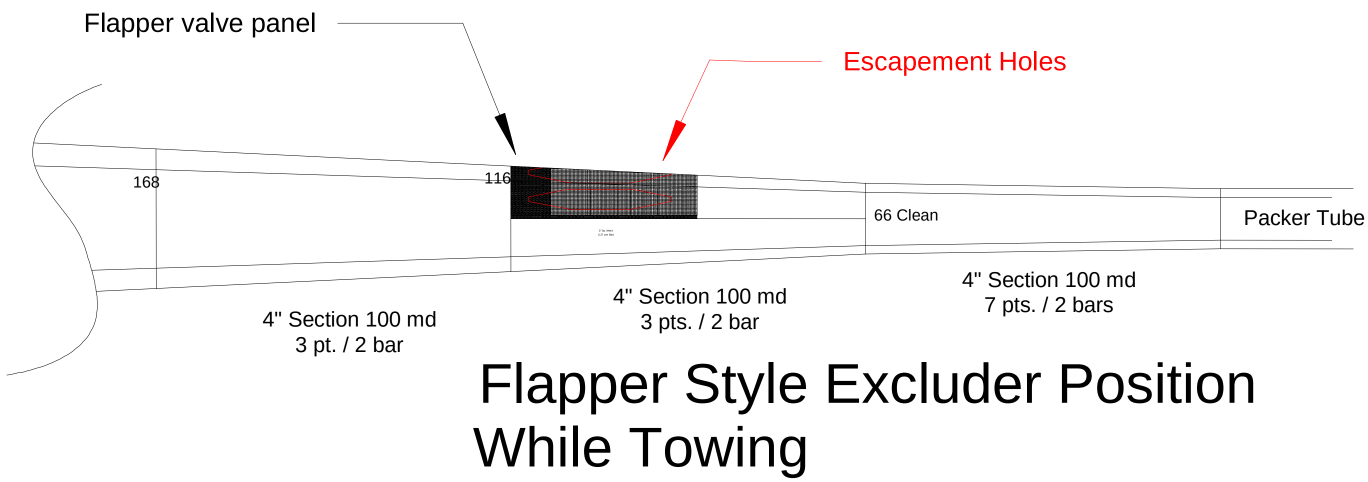
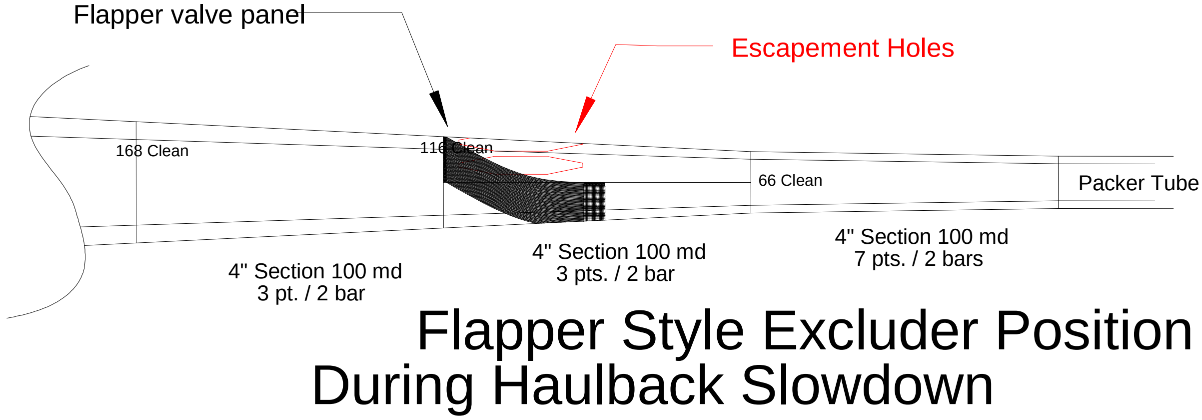


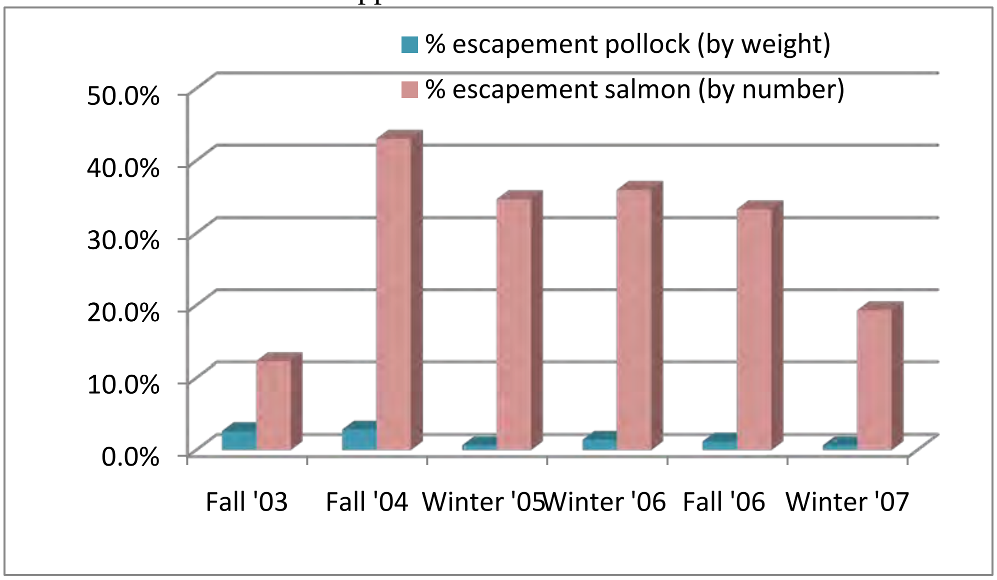
Figure 1: 2008 version of flapper excluder while at normal towing speed

Figure 2: 2008 version of a flapper excluder with vessel speed reduced to one-half of towing speed



As the concept of a flapper excluder began to take shape, the impetus to examine how it would work and how escapement rates might differ from those attained from funnel and tunnel excluders increased. To that end, an early version of a flapper excluder was tested by the *Pacific Prince* during the last stage of fieldwork on EFP 05-02 in winter of 2007. Overall, those tests showed some promise. An average escapement rate of 19% for Chinook salmon was achieved in the test. Additionally, the winter 2007 results showed Chinook escapement rates on some tows (nominal escapement rates) in the neighborhood of the rates attained in tests of later versions of funnel and tunnel devices (approximately 30 to 42% escapement for Chinook salmon, in earlier EFPs, as seen in Figure 3).

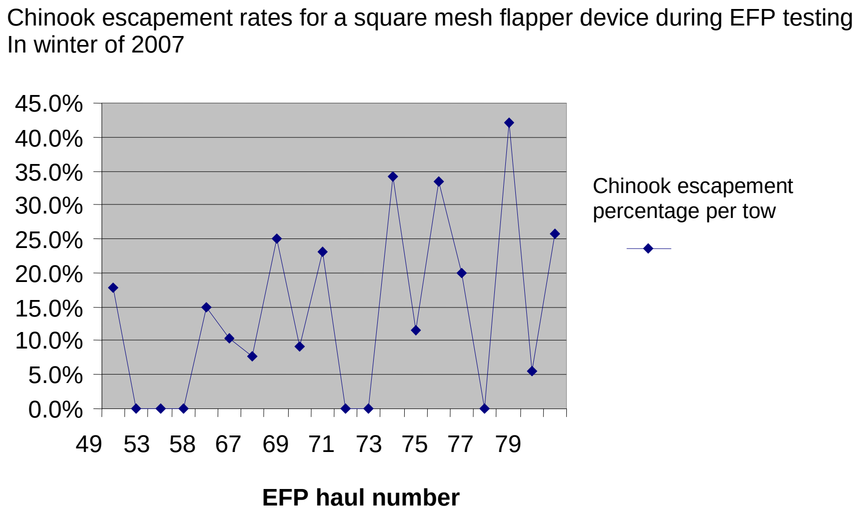
Figure 3: Contrasting average salmon and pollock escapement rates in earlier EFP testing to the results from winter 2007 where a flapper excluder was tested for the first time



Even more promising in terms of practicality for the fishery, was that the early tests of the flapper showed that the bulge problems were eliminated. This was significant because the testing during winter of 2007 encountered high catch rate conditions for pollock such that bulge problems with earlier designs would likely have occurred.

Of particular note from those winter 2007 tests of a flapper excluder on the *Pacific Prince* was the high degree of variability in Chinook salmon escapement rates. Effectively, many of the tows showed little or no Chinook escapement and the others in the range of 20-40 percent escapement (Figure 4).

Figure 4: Tow by tow Chinook salmon escapement rates from March 2007 EFP tests of the flapper excluder



The tow to tow variability raised the important question of why the flapper excluder seemed to have performed as well as earlier excluders in terms of Chinook escapement on some tows and so poorly on others. Hypotheses considered included: the flapper panel failed to drop down to allow escapement on some tows; towing direction relative to the direction of the tide/current affected the ability of the panel to drop; tow duration or catch rate for pollock affected salmon escapement; timing of salmon capture. Unfortunately, the test at the end of work on EFP 05-02 was not designed to provide reliable information on separate factors (covariates) affecting overall escapement rates. Also, the relatively small number of tows in the first test of the flapper excluder left little room for attempting to develop even preliminary inferences about factors. Our application for EFP 08-02 noted that there appeared to be sufficient impetus to take a more complete look at the potential for the flapper design since it appeared to show potential for significant Chinook escapement as well as avoiding the bulge problems that plagued earlier excluder use.

Step by step evaluation of flapper excluders in EFP 08-02

Fall 2009: During the review phase of our application for EFP 08-02, the Science and Statistical Committee (SSC) of the North Pacific Fishery Management Council recommended the first part of the new EFP research be dedicated to repeating the flapper experiment done at the last stage of fieldwork on the 2005-2007 EFP. The SSC was particularly interested in seeing the degree to which results would be consistent. This was important to the panel because repetition of the same gear configuration in a test had never been done in our previous EFP tests. So this left open questions of repeatability. Additionally, the highly variable results from the first flapper test in winter 2007 clearly begged the question of whether additional testing would stabilize the results to some degree.

While the SSC's suggestion made good sense from a scientific perspective, the increasing problem of salmon bycatch for the pollock fishery also created a growing interest in the speedy development of an effective excluder. Many pollock fishermen were convinced that further work on a flapper excluder, a simpler and easier to use design, was the way to go. For this reason, some fishery participants urged that all effort should be devoted to testing different ideas for improving the flapper excluder instead of looking retrospectively at how variable our results would be with a repeat test. The advice of the SSC was heeded, however, and we revamped our testing schedule to start with a repeat of the winter 2007 test. The earliest opportunity to do this was the fall of 2008.

Fall of 2008: Given that potential for a "vessel effect" on excluder performance was great, it was decided that the repeat experiment should utilize the same vessel, same net, and same excluder as the one used in the winter 2007 test. The reasoning behind the assumption of a vessel effect came from fishermen who had noted over time that different vessels fishing the same area often had rather different salmon bycatch rates. This was thought to be due to differences in the way different vessels towed their nets or how fish reacted to the herding effects of different nets. Given that EFP 08-02 provided limited seasonal allocations of pollock and salmon to cover testing from fall 2008 to winter 2010, it was hoped that the repeat experiment could be accomplished in the fall of 2008 and then the work could turn to improvements in flapper excluder designs.

Potential for a successful test on Chinook salmon (normally mostly encountered as bycatch in winter pollock fishing) existed because in some years Chinook bycatch rates increase in the fall as conditions start to turn into those occurring in winter towards the end of the pollock "B" season. Also, the availability of sufficiently high Chinook bycatch conditions for a repeat test in the fall season appeared to be likely given that Chinook bycatch rates had been relatively high in winter of 2007 and relatively high at times in the 2008 B season even as early as August 2008. Thus the plan was to attempt to get the repeat test done in September and October of 2008 so that other approaches to flapper devices could be tested as early as winter 2009.

Unfortunately, fishing conditions in the fall of 2008 did not match expectations. Specifically, the only fishing grounds that had sufficient Chinook salmon bycatch conditions resembling those needed for our testing methods offered poor pollock catch rates in mid-September 2008. This was the time window we had pre-arranged with the owners of the *Pacific Prince* to conduct the

repeat test. Even in that location, Chinook bycatch rates were highly variable with reports from vessels fishing in the “Horseshoe” area near Dutch Harbor showing some promise but it was clearly an “on again, off again” situation for the smaller boats working there.

In spite of this the *Pacific Prince* endeavored to find conditions resembling those of the 2007 winter season (relatively high catch rates for pollock and Chinook) but finding those conditions proved to be largely unattainable. Because the vessel in all our EFP tests needs to cover its costs of operation from the sale of catches during the EFP, this created a dilemma. After approximately two weeks of searching for the elusive medium to high pollock catch rates and high Chinook conditions needed to repeat the winter 2007 EFP test, the EFP vessel had landed less than 200 tons of pollock and only 24 Chinook.   This is considerably less pollock than was needed to cover the fuel cost of operating the vessel for the experiment.

Therefore, attempts to repeat the flapper test at the end of EFP 05-02 were rescheduled for the winter of 2009. The plan for that next test included the additional goal of examining diamond mesh flapper panel that offered the attributes that many in the pollock industry thought were better than the square mesh flapper panel.

<u>Winter 2009:</u> With the plan for phase one of the winter 2009 testing being a second attempt to repeat the winter 2007 square mesh flapper experiment, the *Pacific Prince* was once again tasked with finding the necessary conditions for the repeat test. The period of testing on the *Pacific Prince* during the winter of 2009 spanned from January 23 to March 1 and the repeat of the winter 2009 test occupied roughly the first half of this time period. Results for the re-do were quite similar to the winter 2007 test in terms of highly variable Chinook escapement on a tow by tow basis. On the repeat test, the average escapement rate for Chinook was 11% by number and pollock escapement was approximately 3% by weight (see result for winter 2009 “P1” (phase 1) in Table 1 below)

Table 1: Overall salmon escapement results from EFP 08-02

Test /date	Vessel	Codend salmon #	Recap salmon #	Salmon escape %
Winter 2009 P1	Pac Prince	726	91	11.1%
Winter 2009 P2	Pac Prince	1079	209	16.2%
Winter 2009	Starbound	720	70	8.9%
Fall 2009 P1 (chum)	Starbound	196	5	2.5%
Fall 2009 P2 (chum)	Starbound	643	34	5.0%
Winter 2010 P1	Pac Prince	122	62	33.7%
Winter 2010 P2	Pac Prince	37	25	40.3%
Winter 2010 P1	Starbound	150	49	24.6%
Winter 2010 P2	Starbound	38	21	35.6%

In addition to obtaining an effective salmon escapement rate, minimizing groundfish escapement is also important. Groundfish escapement rates have remained under three percent for all salmon excluders EFPs and escapement at this level is generally not seen as problematic for pollock fishermen as long as salmon escapement is proportionally much higher. Table 2 reports groundfish escapement rates for the winter 2009 repeat test of the flapper excluder (see the result for "winter 2009 P1") and other testing done under EFP 08-02. Overall, the 4% groundfish escapement rate was not troubling by itself. But with only 11% Chinook escapement the selectivity of the flapper excluder in the repeat test was admittedly disappointing.

Table 2: groundfish escapement rates in EFP 08-02

	Test /date	Vessel	Codend groundfish	Recap groundfish	Groundfish %
	Winter 2009 P1	Pac Prince	445	18.6	4.0%
	Winter 2009 P2	Pac Prince	806	27.9	3.3%
	Winter 2009	Starbound	1482	7.1	0.5%
	Fall 2009 P1 (chum)	Starbound	814	22.6	2.7%

	Fall 2009 P2 (chum)	Starbound	574	14.1	2.4%
	Winter 2010 P1	Pac Prince	849	14.2	1.6%
	Winter 2010 P2	Pac Prince	396	6.8	1.7%
	Winter 2010 P1	Starbound	689	2.8	0.4%
	Winter 2010 P2	Starbound	433	2.1	0.5%

One major distinction between the winter 2009 test and the earlier test was that two vendor companies that provide sonar systems to fishermen built monitoring devices for the flapper to help answer one of the most pressing issues of flapper excluder performance. These vendors made demo units of their monitoring prototype devices available to the EFP test in winter 2009. With this, the position of the flapper could be monitored on a real time basis during the EFP testing and the capability to know if the flapper panel actually descended to allow escapement on all tows was finally at hand. The devices differed in specific technique but both had the same purpose of allowing real time flapper position monitoring on the test vessel. One device was designed to monitor the distance between the sending unit and the receiver. The other was an “eco-sounder” designed to show the position of the flapper panel as it reflected the sound transmissions from the sender unit placed on the bottom of the trawl intermediate just under the flapper panel.

Another motivation for having flapper monitoring devices was to help answer the persistent question of whether towing direction relative to the tide and relative speed was affecting the ability of the flapper panel to descend to allow salmon escapement. Of interest also was monitoring in real time how long a vessel would need to slowdown in order for the flapper panel to descend to allow escapement. While lighted video could have been used to help address these questions, lights would be expected to affect fish behavior so they could not be used in the EFP testing.

The flapper monitoring devices described above helped to elucidate some of the factors affecting the variability in escapement rates during the winter 2009 tests. In addition to showing that the flapper position during slowdowns was in fact affected by direction of towing relative to the tide and currents, it was also clear that the time needed for the flapper to descend varied greatly depending on the time needed for the vessel to slow to 2.5 knots. For example, on some tows the flapper panel only descended to approximately one-fourth of the distance of the diameter of the intermediate during the 10 minutes. On other tows the panel extended all the way down in a matter of minutes.

Even more interesting in terms of learning about flapper panels used with periodic slowdowns was the observation by the captain of the *Pacific Prince* during the EFP test that salmon bycatch overall might be increased by doing periodic slowdowns. Comparing notes with other captains fishing in proximity to his vessel during the EFP, the *Pacific Prince*’s captain seemed to be

catching more salmon than the other vessels that were not engaged in the test. In other words, while fishing with the flapper excluder may have been reducing the EFP vessel's salmon bycatch rate by the proportion seen in the test (fraction in recapture net compared to overall number), slowdowns associated with using the flapper might actually be increasing the number of salmon that the test vessel was catching.

The reason slowdowns could increase overall salmon catches despite escapement via the excluder is uncertain but fishermen reasoned it could occur in the following manner. Slowdowns involve hauling the net up slowly during the duration of the slowdown to prevent the back end of the net from sinking to the seafloor. Because hauling the net lifts the net higher into the water column during the slowdown, potential for this to increase the time the net spent in a zone with potentially higher abundance of salmon could be the mechanism for increasing salmon bycatch relative to not doing slowdowns.

While data to confirm the possibility that slowdowns were increasing salmon catch rates was not available (boats outside the test did not have the sorting facilities to count salmon on each haul), the captain of the *Pacific Prince* became deeply concerned about this issue. As this matter was discussed among pollock captains during the EFP and at meetings following the test, more and more captains agreed that slowdowns could increase salmon catch rates overall. This simply seemed to make intuitive sense and as a result the fleet's interest in a flapper excluder that required periodic slowdowns diminished considerably and the feeling of "back to the drawing board" once again prevailed.

The next direction for development of a salmon excluder starting in fall of 2009 was how to make a flapper excluder that would remain partially in the "down" (open to escapement) position at normal towing speeds. This could allow some of the salmon passing through the net to escape on their way back rather than relying on escapement during slowdowns. Using the flapper in this manner would obviate the need for slowdowns.

Meetings between the PIs and the pollock industry prior to the winter 2009 testing focused on how to add additional weight to the flapper panel so that it would remain open while towing. The concept was that even with the flapper panel hanging down one-third to one-half of the way during towing operations, bulging of the net would not be created because dense schools of pollock moving through the net would simply push the flapper up as the fish passed through the excluder section of the net. The absence of a rigid tapered square mesh funnel or tunnel used in the earlier excluder designs would, therefore, avoid the bulge problem even at high catch rates of pollock.

Accordingly, the next phase of testing was devoted to evaluating how much weight was necessary and where it should be placed to allow salmon to access the escapement hole during regular towing. Another aspect of this was to see if salmon escapement rates would be higher with this partially open flapper design than those in the tests of flappers that were completely closed to escapement during towing. Related to this was whether pollock escapement rates would be high with these heavily weighted flappers relative to escapement rates with funnel and tunnel excluders.

Placing weight on a panel of webbing creates potential challenges because the panel is made of relatively soft material. So exactly how the weight is placed on the panel affects the shape of the panel during towing. This means that the expectation that the weight will achieve a desired shape such as a gradually downward sloping ramp to allow salmon to follow it to the escapement hole is not at all a guarantee. In fact, we soon learned that every adjustment to the heavily-weighted flapper excluders designed to allow escapement while towing in the pre-test tows on each EFP vessel raised new questions and challenges. For instance, placing nearly all the weight at the aft edge of the flapper panel might sink the back edge of the flapper panel during towing but the middle portion of the flapper panel might tend to billow up and close off access to the escapement portal.

On CP *Starbound*, the additional towing force of a large horsepower factory trawler presented even bigger challenges. One challenge was simply getting the panel to stay down at all during towing. Pre-test tows with incremental increases in weighting showed that more than 700 lbs of lead-core line (leadline) was needed before the flapper would stay down at all during normal towing speeds. Even then, the panel would be open only about one-fourth of the diameter of the intermediate and this varied to nil at times depending on the towing direction relative to the tide. In the extreme, a set of strong elastic lines were used during pre-test tows to pull the flapper panel down. Unfortunately, this achieved small gains in terms of opening access to the escapement hole during towing but it served to distort the shape of the panel. Once again billowing of the panel was noted at points where the rubber cords were not actually pulling the panel down.

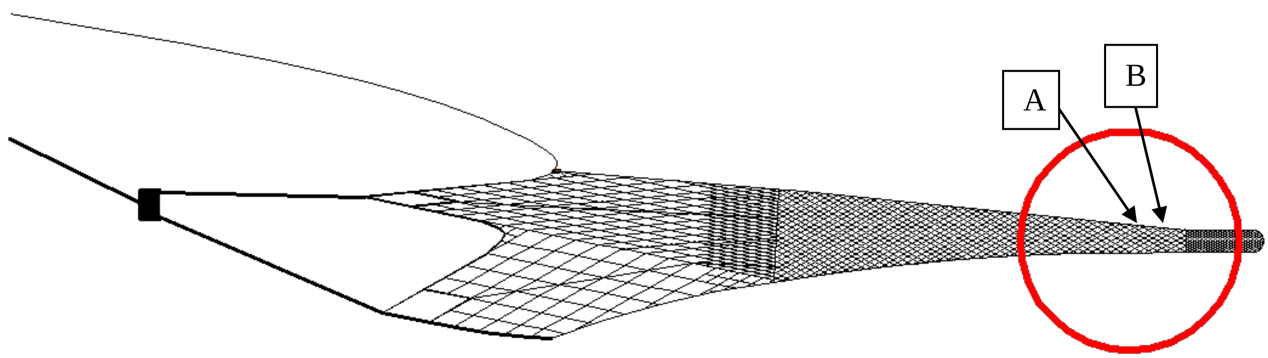
After the pre-test tows for the phase two tests in the winter of 2009 where adjustments were made to achieve some meaningful escapement opening for salmon at normal towing speeds, the EFP test was conducted to measure the escapement performance for salmon and groundfish with the “highly weighted” flapper panels on the two EFP vessels. Results from the phase two tests on *Pacific Prince* showed minimal improvement in escapement of Chinook and practically the same result in terms of loss of pollock relative to the first phase of the winter 2009 work (Tables 1 and 2). For *Starbound*, a rate of less than 10% salmon escapement occurred although pollock escapement was small (Tables 1 and 2). The video obtained during the testing on *Starbound* showed that even with some opening to allow escapement during towing, fish struggled to move forward in the strong flow of water aft of the flapper panel. This suggested that challenges for highly weighted flapper panels on factory trawlers might be even greater.

<u>Fall 2009:</u> The plan for fall 2009 shifted somewhat in response to information brought forward by one of the pollock trawl manufacturers that had been working with some of the catcher processor vessels on similar flapper excluders. The information presented at the excluder workshop held for the pollock industry suggested that some of the challenges with the high degree of water flow could be addressed by moving the location of the excluder closer to the codend. For the video shown at the workshop, the flapper panel was equipped with weight of approximately 120 pounds (similar to what we had evaluated for flapper excluders requiring slowdowns to achieve escapement) but the panel appeared to provide a useful pathway for salmon to reach the escapement hole even at regular towing speeds. The difference was that this

excluder was located in the straight tube section just ahead of the codend. Water flow in this section was expected to be slower in that straight section of the end.

What was also clear from the video footage reviewed at that workshop was that flapper panel located in the straight section just ahead of the codend suffered from some billowing and inconsistent opening space but did appear to create some opportunities for escapement during towing. Placement in the straight tube therefore could be advantageous in terms of opportunity for salmon escapement relative to where the excluder had been placed in earlier tests at the aft tapered section of the intermediate (Figure 5). But achieving reasonable access to the escapement hole was not necessarily going to be easy. Based on this, the EFP test for fall 2009 would look at an approach similar to what was seen in the video but with some additional weight to create increased opportunities for escapement.

Figure 5: Stylized depiction of potential flapper excluder placement locations comparing the aft section of the tapered intermediate (A) or in the straight tube section just ahead of the codend or stuffing tube (B)



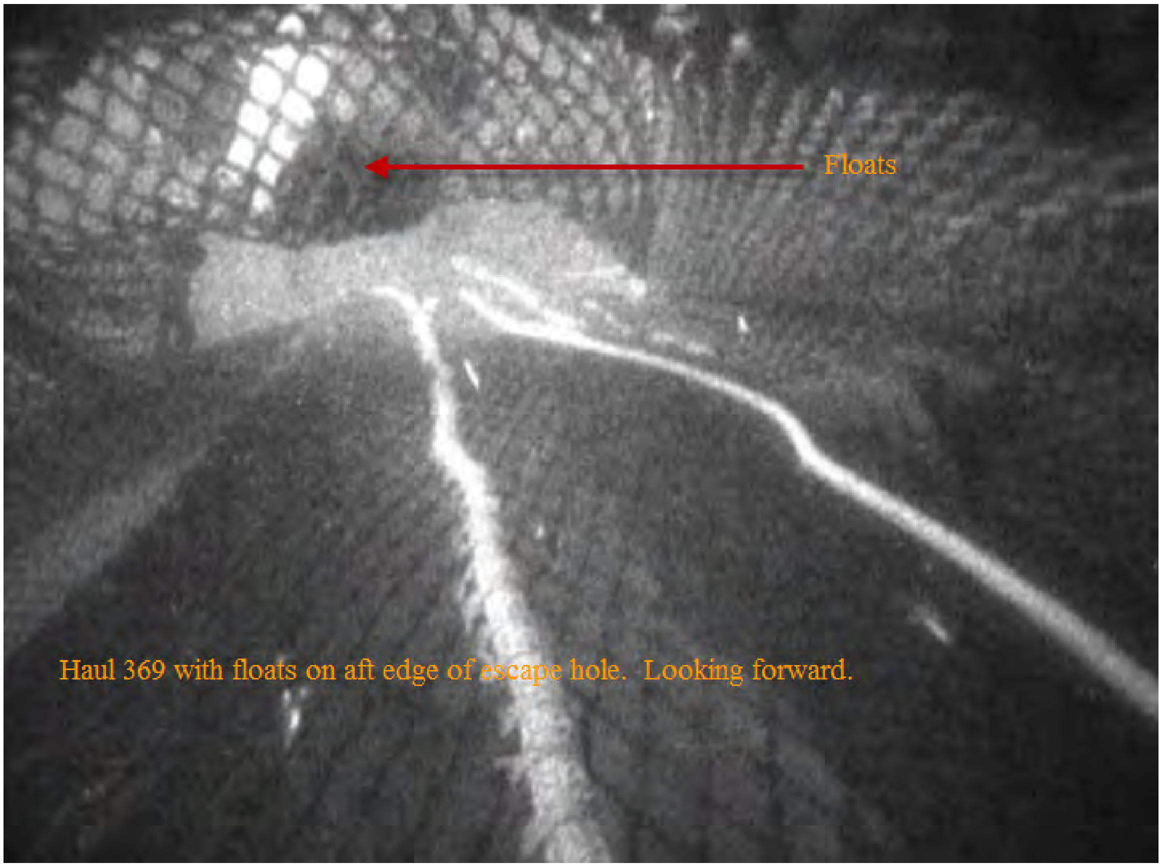
The vessel selected for the fall 2009 test was once again the CP *Starbound*. As part of their application to conduct the EFP test, *Starbound* agreed to install a flapper excluder in the straight section of their net just in front of the cod end prior to the EFP test. Additionally, *Starbound* agreed to use one of the underwater video systems that many pollock industry companies had purchased in 2009 to get some video images of the excluder position at towing speed. This would allow the test to focus on measuring the escapement performance of the excluder instead of spending a lot of effort "tuning" the weighting to get the excluder to remain open during fishing.

With the work *Starbound* did prior to the EFP, useful information was available for our review before starting the EFP test in September 2009. In taking a close look at the video, it was noted that the panel remained partially open at the aft end of the panel but once again billowing of the panel created a somewhat imperfect escapement pathway for salmon. The question was whether salmon would swim the required distance of approximately four meters from the aft edge of the excluder panel all the way to the escapement hole in a fairly narrow pathway where webbing appeared to be billowing up with the flow of water (see underwater camera shot of pathway in Figure 6 below). Our best estimate looking at the video was that the aft edge of the flapper panel was down approximately one-fourth of the diameter of the intermediate although the billowing panel materials reduced this amount at times. Additionally, the video showed that billowing of

the flapper panel near the escapement hole potentially created insufficient room for salmon to access the escapement hole. To remedy this, a set of eight inch trawl floats were added to the aft edge of the escapement hole in an attempt to create some lift and potentially increase the space available between the flapper panel and the top of the escapement panel (Figure 6).

Results from the fall 2009 tests were unfortunately somewhat discouraging (Tables 1 and 2). Salmon escapement rates (mostly chum salmon) were quite low (about 2.5% and 5%). Areas with sufficient numbers of Chinook salmon bycatch were not located during the fall 2009 test. What was perhaps more discouraging was that pollock escapement rates were in the range of 2.5% for both tests. While not necessarily problematic when compared to previous groundfish escapement rates in earlier tests, the basic issue was that salmon and pollock escapement was nearly the same so the device appeared to be almost random escapement. The lack of selectivity was unfortunately not unlike simply just cutting a hole in the net.

Figure 6: Underwater camera view of pathway for salmon escapement with flapper located in straight section of pollock trawl



<u>Flume Tank work and the plan for our final testing in winter 2010</u>: Following the disheartening but still informative test results from the fall of 2009, the EFP investigators met to consider everything that had been learned from our testing, and reports from other industry efforts regarding flapper excluders, and particularly flapper excluders designed to allow escapement while towing. The objective was to come up with a set of changes that would make the flapper work because the advantages of the flapper in terms of avoiding bulging problems made it the industry's best hope for an effective excluder.

The focus of discussion was whether or not to work in the tapered section where faster water flow made it easier to achieve the desired flapper shape although necessitating heavier weights. The alternative was to place the excluder in the straight tube section where slower water may allow easier escapement but billowing of the flapper might be problematic. The discussion led to a plan for addressing these questions prior to settling on a design for the final stage of testing under our EFP which would occur in the winter of 2010 pollock "A" season. The plan was to go to a test tank (flume tank) facility at Memorial University in St. Johns Newfoundland with a set of scale models to answer as many questions as we could and come up with a design for the upcoming tests in January 2010.

The trip to Newfoundland was made in early November of 2009. A group of pollock captains and crewmen who had been most involved with the recent flapper development and testing as well as several interested pollock net manufacturers joined the investigators for the trip. Several other researchers and pollock industry leaders also joined the delegation going to Newfoundland given the exceedingly high importance of coming up with a workable excluder for Chinook to help the industry cope with new restrictions to protect Chinook salmon that had recently been approved and are scheduled to come into effect in 2011.

Prior to our departure, we constructed three flume tank models that were the most basic versions of flapper excluders placed in tapered and straight sections of model net intermediates. From our past experience, use of the flume tank facility at Memorial University is ideal for resolving basic water flow and shape issues. The Newfoundland facility is sufficiently large to provide adequate space and water flow capacity to test models constructed of full scale materials. Our models included only the intermediate and codend sections of the net and a towing "hoop" was used to open the meshes to the proper degree. Additionally, our models were scaled down by reducing the number of meshes for each section. In most flume tank work models include all components of the trawl and model doors are rarely used to open the net. For our purposes, this would have meant that the intermediate section of the net was considerably smaller and therefore made it more difficult to visualize the effects of water flow on the weighted section of the flapper.

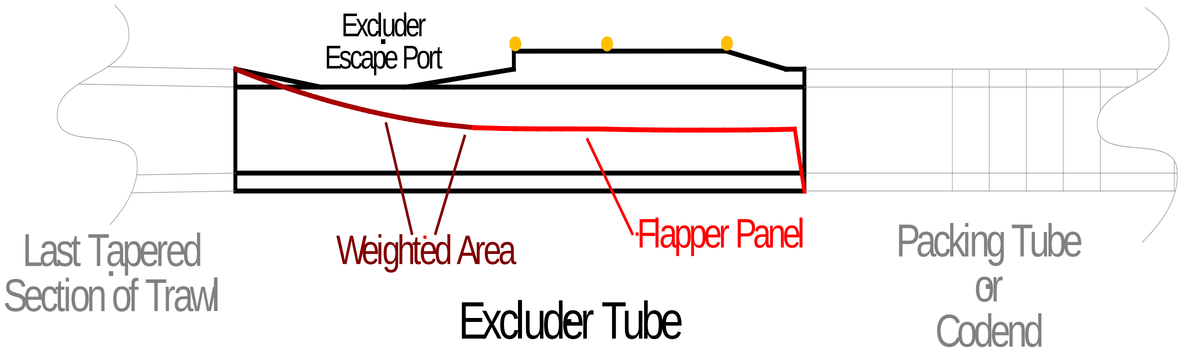
The flume tank trip work led to some important breakthroughs in flapper excluder design. One was that weighting could be placed at the front part of the flapper panel. In this manner, the portion of the panel aft of where the weight was applied would stream nearly straight back. Secondly, the effects of flow seen in our earlier field work on the tapered section versus straight tube were confirmed in the flume tank. The straight tube section clearly allowed for more practical amounts of weight (120 to 200 lbs when scaled up to full scale) to keep the flapper panel down about half way during normal towing speeds. Finally, additional room for escapement of salmon could be achieved by "gusseting" the aft edge of the escapement hole and attaching a few small trawl floats to the gusset. The "hood" that this created was designed to provide additional salmon escapement opportunity because even if the flapper panel was not one-half way down (open) because flow of target catch through the excluder section lifted up the flapper panel, there could still be sufficient room for salmon passing back at the same time to get out of the flow of pollock and eventually move forward and up to escape.

The picture below taken of one of our flume tank models illustrates the combined design features of the flapper excluder developed at the final stages of fall 2009 work on the flapper excluder at Memorial University's flume tank (Figure 7).

Figure 7: Final design product for an improved flapper excluder from fall 2009 flume tank work

Note in the photo the weight (here simple chain instead of leadline that would be used in an actual excluder) is applied in the forward portion of the flapper panel and that the remaining portion of the panel trails back fairly straight from where the weight is applied. Additionally, small trawl floats applied to the gusseted aft edge of the escapement hole create a great deal of lift to increase the space available for a salmon attempting to swim forward to escape the flow of pollock passing through the excluder section. Figure 8 below is a stylized depiction of these design changes as they were developed from the flume tank work.

Figure 8: Design changes to the flapper excluder in preparation for winter 2010 EFP testing



<u>Results from winter 2010 testing of the flapper design reflecting October 2009 flume tank work:</u>
The two vessels that had been involved with recent flapper testing were once again selected for these important final tests of flapper excluders under EFP 08-02. The reasoning for using these vessels once more was that the crews had demonstrated a willingness and ability to work under the constraints of the testing protocol and most importantly the *Pacific Prince* and *Starbound* provided a range of horsepower differences needed for the evaluation without adding any new unknowns in terms of towing speeds and fishing practices.

As with the fall 2009 tests, each vessel was asked to use some of its 2010 AFA groundfish quota to pre-test the weighting on the excluder panel. This would mean that when the EFP tests started, we would be confident that the shape parameters from the flume tank work would already be in place when the EFP test was started. In these pre-tests, *Starbound* was also asked to conduct some tows under the same experimental protocol that would be used for the EFP testing to the extent possible given partial haul rather than a full census of salmon catch on each tow is the norm for observer sampling on AFA factory trawlers. Additionally, it was known from the outset that *Starbound* would not be able to conduct the pre-testing in areas of high Chinook bycatch because AFA vessels were subject to the industry's regular "rolling hotspot" bycatch avoidance program.

Winter 2010 tests went relatively well and both vessels encountered sufficient pollock and Chinook to achieve the desired sample size for evaluation of the performance of the excluder for each test. For the first phase of the testing ("P1" results in Tables 1 and 2 above), F/T *Starbound* achieved an average Chinook escapement rate of 25% and *Pacific Prince* achieved 35%. Groundfish escapement in this same test was lower for *Starbound* (less than half a percent by weight) than for *Pacific Prince* (about 1.5%).

The difference in the excluder configuration between vessels was that *Starbound* had applied 160 lbs of leadline on the flapper panel according to the design parameters of the flume tank work (as had *Pacific Prince*) but this may have been relatively lightly weighted compared to *Pacific Prince* given the greater towing force of the factory trawler *Starbound*.

Of note from the *Starbound*'s video during pre-testing was that the flapper panel remained nearly one-half down (open) during regular towing operations but tended to lift up and stay up longer than the flapper on the *Pacific Prince*. Having noted this, however, it is important to point out that there are multiple factors that complicate such a comparison. In any case, the lower escapement rate for both Chinook salmon and pollock makes intuitive sense in the context of the possible difference in effective weighting. Escapement rates for both Chinook and pollock were promising compared to past results with flapper excluders. Further, no negative effects on fishing from bulging or other practical aspects of fishing with the excluder (e.g. setting the net) were detected.

Once a sufficient number of Chinook were encountered during the tests to achieve the statistical significance and practicality assessment objectives of the EFP test, the EFP collaborators came up with a plan for adjustments to the excluder for Phase II testing with the remaining groundfish and Chinook salmon allowances. This was done in consultation with the EFP captains and crews. With a 35% Chinook escapement rate from the first test, the captain of the *Pacific Prince* thought that no changes to the weighting of the flapper panel should be done. Instead, he was curious to see if artificial lighting placed in the recapture net above the escapement hole would entice salmon to swim up and therefore increase the escapement rate. His rationale for this was that his own testing outside the EFP seemed to suggest that salmon at fishing depths were attracted to the lighting for the camera he had used.

For EFP testing, we have been careful in all previous tests to avoid potentially influencing salmon behavior with light. Thus, only extremely light-sensitive cameras have been used without artificial light. In this case, however, everything else could be held constant and the light in the recapture net was essentially a treatment variable of interest for the phase two test. When this was done, the escapement did nominally increase to approximately 40% for *Pacific Prince's* phase two testing (P2 in Table 1). But because the remaining groundfish allowance was not sufficient to achieve the minimum number of salmon for the statistical power goals of the test, this P2 result is far less certain than the P1 result. What was clear from this result, however, was that additional testing of the effects of adding light positioned to increase escapement of salmon may be useful in future EFPs because potential for this to increase escapement performance of flapper excluders is worth examining.

For the second phase of testing on *Starbound*, the adjustment to the excluder flowed naturally out of the questions surrounding why *Starbound*'s salmon escapement rate was lower than that of *Pacific Prince*. The only difference was the relative amount of weight on the flapper (compared to towing force). So for the second test on *Starbound*, 40 lbs of leadline was added to the top of the flapper panel in the same position of the earlier weight placements. The phase two results for *Starbound* did in fact show a nominal increase in Chinook escapement to 35% but once again this test fell slightly short of the desired Chinook sample size as well. Additionally, overall tow to tow escapement rates for both phases of testing on *Starbound* (Figure 9) seemed more variable than for *Pacific Prince* (Figure 10). So the certainty that the weighting differences between phase one and phase two were responsible for the salmon escapement performance difference is likely quite limited.

Figure 9: Per tow escapement rates of Chinook for phase one and phase two of winter 2010 EFP testing

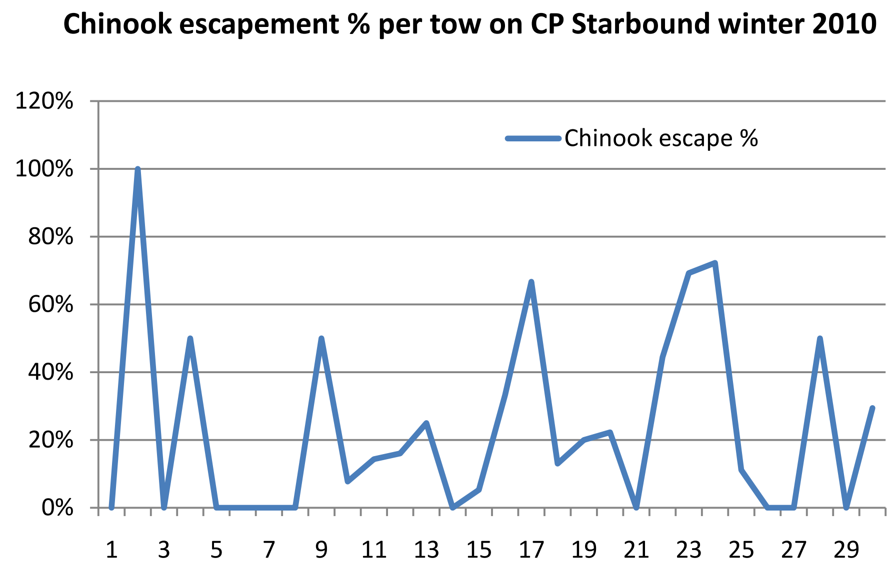
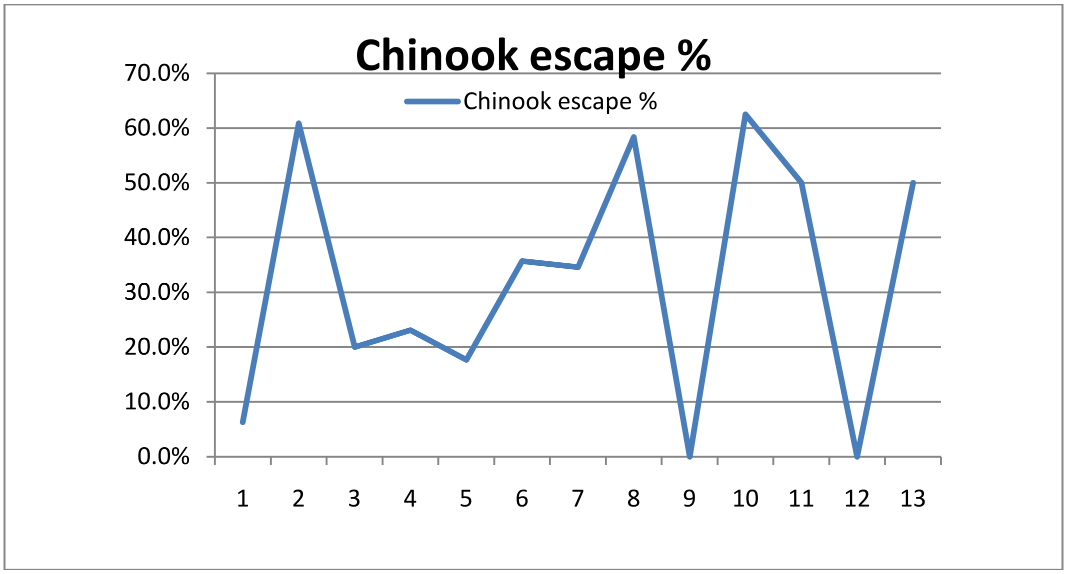


Figure 10: Tow by tow escapement rates for *Pacific Prince* in winter 2010 EFP testing phase 1:



Summary of findings and direction for future research on flapper excluders:

EFP 08-02 successfully conducted an extensive assessment of the potential for flapper excluders to reduce salmon bycatch rates and avoid the problems encountered with earlier excluder designs. With the highly suggestive first stage results on a prototype flapper used in the final stage of testing during the 05-02 EFP, the flapper excluder appeared from the outset to be a viable excluder design for reducing Chinook salmon bycatch rates. As testing of the first flapper design was being conducted with periodic slowdowns, a more realistic assessment of escapement potential became clear. At the same time, the potential for slowdowns to allow escapement but potentially increase salmon bycatch catch overall (with the increased time of the net in the water column above pollock schools) became a significant issue for pollock fishermen. While never demonstrated concretely, the intuitive reasoning that slowdowns might increase salmon bycatch even if some manage to escape and the anecdotal evidence from vessels fishing near the EFP with markedly lower salmon bycatch rates were enough to persuade EFP investigators and interested industry to abandon the flapper concept that was designed around vessel slowdowns.

Once the direction away from slowdowns was agreed upon by everyone, EFP 08-02 used its remaining effort and groundfish and salmon allowances for testing flapper excluders designed to allow escapement during towing. Water flow differences between tapered versus straight tube sections of the net and tradeoffs with excluder shape and salmon escapement performance potential were the focus of the remainder of the EFP work. In this regard, the design arrived at iteratively represents what we feel is a workable excluder that may contribute significantly to the pollock industry's ability to control its salmon bycatch rates.

This final design is based on installing the flapper in the straight tube section just ahead of the packing tube (where applicable) or codend. Weight is placed on the forward part of the flapper panel and floatation on the aft section of the escapement hole is used to achieve lift and additional room for escapement. Configured in this manner, the flapper excluder achieved between 25% and 35% Chinook escapement by number with pollock (groundfish) escapement in the range of one-half to one and one-half percent by weight. This is a significant accomplishment given the inherent difficulty of developing a bycatch reduction device that works solely on differences in swimming ability and other behavioral aspects that differ between salmon and pollock. As was noted in the final tests on *Pacific Prince*, adding artificial light above or around the escapement hole may increase the Chinook escapement rate as well but additional testing would be needed to help confirm this possibility.

The final version of a flapper excluder arrived at through EFP 08-02 appears to avoid problems occurring with earlier designs of excluders such as bulges in the net. Additionally, no operational problems or detrimental effects on fishing occurred in the winter 2010 testing. So presumptively this excluder avoids the once seemingly insurmountable problem affecting earlier excluder designs. But this conclusion (as well as all results from the EFP) is strictly applicable to the limited set of conditions under which testing occurred in the EFP. Further, the results are most applicable to the types of vessels selected for the EFP. It should be noted that even though we specifically selected these vessels to be applicable to the Bering Sea pollock fishery, our focus was mostly on higher horsepower boats relative to smaller catcher vessels because it was on the

higher horsepower vessels where problems with the bulging in the net appeared to occur most frequently with the early funnel and tunnel excluder designs.

Finally, achievement of these promising Chinook escapement rates in the EFP was done under relatively high catch rate conditions and overall fishing conditions under which testing occurred as described above. Our testing specifically focused on areas with high Chinook catch rates and medium to high pollock catch rates. Further, testing was not done in areas with high density of jellyfish or other factors that appeared to be problematic for earlier excluder designs. The flapper design seems to us to be less vulnerable to jellyfish problems but this inference is based on design elements and not from testing results.

Likewise, all testing in the latter part of the EFP was done following considerable pre-testing by the EFP vessel to “tune” the excluder weighting such that it achieved the desired shape prior to the start of the test. We therefore advise pollock fishermen interested in using the concepts and designs described in this report to make use of cameras to verify that the flapper excluder they are installing is actually achieving the design parameters described herein. These are: shape of the excluder panel and intermediate as described above; flapper panel that remains 50% open during towing; and sufficient weight on the flapper panel to allow recovery of the flapper panel to 50% open following being lifted up by a mass of pollock passing under the panel. All three EFP investigators are available for consultation on these design and performance issues relevant to the work done in this EFP.

From here a few directions for further research in this regard are apparent. First and foremost, additional proofing of the current flapper excluder by interested pollock fishermen is needed. This would allow the excluder to be evaluated under a wider array of fishing conditions than occurred in the limited EFP testing. This expanded testing will likely raise interesting and important questions and issues regarding the general effectiveness of the excluder under an expanded set of fishing conditions.

The pathway to excluder improvements for bycatch reduction performance for Chinook salmon will undoubtedly be a combination of additional informal testing by pollock fishermen and further systematic testing through EFPs. At this point, for increasing Chinook salmon escapement rates, the leading direction would be, based on our initial efforts, whether adding artificial light (e.g. glow sticks) would improve salmon escapement rates. To adequately address this issue, some systematic testing would be preferred to ad hoc testing efforts with no scientific controls.

In a bigger context for the future of salmon excluder development, a clear priority for salmon excluder development would be to focus on chum salmon. To date and for unknown reasons, chum salmon have not responded measurably to all the excluder designs that have been developed thus far. An obvious priority for future research would be to do a systematic test of the current flapper design to see if it is at all effective for chum salmon. Depending on that result, the next step may be to explore alternative design modifications to the current excluder including escapement holes that are not on the top of the trawl intermediate.

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