Mixed Stock Analysis of Chinook Salmon Harvested in Southeast Alaska Commercial Troll Fisheries, 2015

by
Sara Gilk-Baumer
Danielle F. Evenson
Kyle Shedd
and
William D. Templin
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by

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December 2017
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ABSTRACT

The Southeast Alaska (SEAK) troll fishery harvests Chinook salmon originating from Alaska, British Columbia, and the Pacific Northwest. Owing to its mixed stock nature, the overall SEAK Chinook salmon fishery is managed as 1 of 3 such fisheries under provisions of the Pacific Salmon Treaty (PST) Agreement. The Alaska Department of Fish and Game has used genetic mixed stock analysis to estimate the stock composition of Chinook salmon harvests in the SEAK commercial troll fishery since 2004 based on a genetic baseline developed by the Genetic Analysis of Pacific Salmonids group for use in PST fisheries. Genetic methods allow direct estimation of the major stock groups contributing to fisheries. This project estimated the relative stock composition of seasonal troll fishery harvests from fishery accounting year 2015 (Oct. 1, 2014 – Sept. 30, 2015). The major contributors to the Southeast Alaska troll fisheries from largest to smallest were the Interior Columbia River (Summer/Fall), Southeast Alaska/Transboundary River, North/Central British Columbia, Oregon Coast, South Thompson, Washington Coast, and West Vancouver reporting groups. Collectively, these 7 stock aggregates accounted for 91% of the harvest and are referred to as driver stocks. Results indicate considerable temporal and spatial variation in the composition of troll harvests in accounting year 2015, but consistent patterns of composition across years. Stock composition data from this and other stock assessments are being used to provide fisheries information, including stock-specific run reconstructions and forecasting of run sizes to transboundary rivers, determining the origin of catches in the SEAK troll fishery by age to assist in evaluation of the Pacific Salmon Commission Chinook Model, and estimating some terminal run sizes of stocks in the PST area that drive the SEAK fishery.

Key words: Chinook salmon, Southeast Alaska, troll fishery, mixed stock analysis, microsatellite, Pacific Salmon Treaty

INTRODUCTION

Chinook salmon *Oncorhynchus tshawytscha* are commercially harvested in Southeast Alaska (SEAK) and Yakutat troll fisheries in State of Alaska and Federal Exclusive Economic Zone waters east of Cape Suckling and north of Dixon Entrance (Skannes et al. 2016). This area is divided into 4 quadrants for stock assessment purposes: Northern Outside (NO), Northern Inside (NI), Southern Outside (SO), and Southern Inside (SI; Figure 1). The troll fishery harvests mixed stocks of Chinook salmon, including salmon originating from Alaska, British Columbia (BC), and the Pacific Northwest, and is therefore under the jurisdiction of the Pacific Salmon Treaty (PST). The principles of the PST call for cooperative management and research on fisheries harvesting Chinook salmon from populations in Canada and the U.S., and variable annual Chinook harvest ceilings to limit interceptions of Chinook salmon in SEAK and 2 other mixed stock fisheries along the North American coast as per PST Annexes and related Agreements (CTC 2017).

The annual all-gear harvest limit for Chinook salmon in SEAK is specified in Chapter 3, Annex IV of the PST. The majority of the PST harvest limit is allocated to the commercial troll fishery under State of Alaska management plans (i.e., the purse seine fishery is allocated 4.3% of the harvest, the gillnet fishery is allocated 2.9% of the harvest, and the setnet fishery is allocated 1,000 fish; the remaining portion of the annual ceiling is allocated 80% to the troll fishery and 20% to the sport fishery). Thus, careful monitoring of the troll harvest throughout seasonal fisheries is essential to prevent exceeding the annual ceiling (Pryor et al. 2009; Skannes et al. 2016).

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1 In this report, population refers to a locally interbreeding group of salmon that is distinguished by a distinct combination of genetic, phenotypic, life history, and habitat characteristics, and stock refers to an aggregation of one or more populations that occur in the same geographic area and are managed as a unit. Reporting groups refers to an aggregation of one or more stocks that can be identified using genetic mixed stock analysis.
The annual SEAK troll harvest of Chinook salmon occurs over 3 seasonal fisheries: winter, spring, and summer. The winter fishery occurs from October 11 to April 30 of the following year, or until the guideline harvest level of 45,000 non-Alaska hatchery-produced Chinook salmon is reached. The fishery is split into early winter (October 11 – December 31) and late winter (January 1 – April 30) components, and the open fishing area is restricted to within the troll boundary of the outer coast surf line. The spring troll fishery (May 1 or earlier, through June 30) is managed to target Chinook salmon from SEAK hatcheries, many of which are exempt from the annual ceiling. The summer troll fishery accounts for the majority of the annual Chinook salmon harvest. The summer fishery is closely monitored and managed to prevent exceeding the troll portion of the annual ceiling by allowing retention of Chinook salmon during 2 or more periods in most years. The first summer troll fishery opening, commencing on July 1, allows harvest in the waters of frequent high Chinook salmon abundance and is intended to not exceed 70% of the remaining troll portion of the annual ceiling. Once the July fishery is closed, Chinook salmon retention by the troll fleet is not allowed unless it is determined that additional openings will not result in exceeding the annual ceiling. August (and sometimes September) openings are conducted in most years to allow troll retention if it is determined that the annual ceiling will not be exceeded; if these openings occur, the waters of frequent high Chinook salmon abundance remain closed to troll gear.

The annual PST Chinook salmon ceiling for SEAK depends on the projected abundance of Chinook salmon forecasted by the Chinook Technical Committee (CTC) using the Pacific Salmon Commission (PSC) Chinook Model (CTC 2017; Skannes et al. 2016). The PSC Chinook Model uses catch, escapement, coded wire tag (CWT) recovery, and recruitment information to forecast relative abundance of stocks in PST fisheries. Relative stock proportion information is an important component of the PSC Chinook Model, and currently CWT data are used for this purpose. However, reliance on stock composition estimates solely from CWT data can be problematic because CWTs are only applied to a subset of indicator stocks contributing to the fishery, most are hatchery stocks, and the resulting estimates of escapement and terminal run size of important stocks—and particularly wild stocks—are often not available or are poorly determined. Genetic mixed stock analysis (MSA) provides a complementary set of stock composition estimates for major contributors to the fishery.

Genetic MSA has been used extensively to estimate the contribution of genetic aggregates of Chinook salmon to mixed stock fisheries occurring throughout the PST area (Blankenship et al. 2007; Hess et al. 2011; Templin et al. 2011; Beacham et al. 2012). This method uses the genetic variation in allele frequencies at multiple loci among populations (baseline) to estimate the contribution of each stock to a mixture given the multilocus genotypes of fish in the mixture. Since 1999, the State of Alaska Department of Fish and Game (ADF&G) has used MSA based on coastwide baselines (allozymes: Teel et al. 1999; microsatellites: Seeb et al. 2007) to estimate the composition of Chinook salmon harvested in the commercial troll fishery (Crane et al. 2000; Templin et al. 2011; Gilk-Taumer et al. 2013, In prep[a]). Genetic MSA is possible for PST fisheries due to the CTC-funded Genetic Analysis of Pacific Salmonids (GAPS) project, a cooperative project among 10 laboratories with the goal of developing a standardized DNA

baseline for stock identification of Chinook salmon (Moran et al. 2004). This process began in 2002, and a standardized baseline was available during the summer of 2005 (Seeb et al. 2007). The baseline can be used, with acceptable accuracy and precision, to identify 44 reporting groups in mixtures (Seeb et al. 2007). For the SEAK fisheries, these were combined into 26 reporting groups based on management needs and stock presence (Table 1). This baseline continues to be improved through the addition of populations; the current baseline (version 3.0) contains allele frequencies from 357 populations contributing to PSC fisheries, ranging from the Situk River in Alaska to the Central Valley of California (Appendix A1).

The expectation behind investment in genetic capabilities was that genetic MSA could be integrated into a coordinated coastwide management system—the subject of workshops held by the PSC (PSC 2008). One conclusion at the workshop was that an important advantage of genetic MSA (over CWT-based methods) is the complete coverage of all stocks and all individuals in the stocks (PSC 2008). Coded wire tags have been used for cohort analysis of individual release groups and are an integral part of the PSC Chinook Model. However, CWT-based assessments are based upon the assumption that the release of juvenile Chinook salmon with a CWT (usually of hatchery origin) will provide valid surrogates for a stock of interest, typically a Chinook salmon stock of wild origin. Often these critical assumptions are unverified and multiple studies have demonstrated that hatchery-origin fish mature and survive at rates different than their wild counterparts due to differences in growth rates, release locations, and release sizes (CTC 2015; Peterson et al. 2016). On the other hand, CWT methods are one of the only ways of detecting and estimating stocks of Chinook salmon that are minor contributors to a fishery because the numeric tags minimize the problem of misclassification and more catch is sampled for CWTs on a coastwide basis (~20%) to recover these tags. By contrast, genetic MSA is best suited for estimating contributions of major stocks, i.e., those making up relatively large proportions (≥5%) of the sample.

Stocks of Chinook salmon originating from streams and hatcheries along the Southeast Alaska, Northern/Central British Columbia, West Vancouver Island, Washington, and Oregon coasts, and in the South Thompson and Upper Columbia3 rivers consistently contribute more than 5% to the troll harvest in SEAK, and consequently are important stocks that help drive catch allocations under the PST (Table 1; CTC 2017). Collectively these 7 aggregate stocks compose a large proportion (typically >90%; Gilk-Baumer et al. 2017) of all Chinook salmon annually harvested in SEAK troll fisheries, and thus genetic MSA is the preferred method for providing accurate and precise stock composition estimates for these driver stocks in SEAK fisheries (PSC 2008).

The information reported herein are the results of genetic MSA based on the most recent standardized baseline of microsatellites (GAPS version 3.0) to provide independent estimates of the stock composition of Chinook salmon harvested in the SEAK troll fishery in Accounting Year4 (AY) 2015. Results focus primarily on the 7 driver stocks important for SEAK fisheries managed under the PST, although broad- and fine-scale information is also provided for context.

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3 All summer and fall Chinook salmon transiting Bonneville Dam from June 1 through November 15, 2015, are destined for areas above McNary Dam and the Deschutes River.

4 The PST accounting year begins with the start of the winter fishery on October 11 of the previous calendar year and ends the following September; e.g., AY 2015 is October 1, 2014, through September 30, 2015.
 OBJECTIVES

The goal of this genetic MSA program was to estimate the stock composition of Chinook salmon harvested in SEAK commercial troll fisheries during AY 2015. Project objectives were as follows:

1. Sample Chinook salmon from the SEAK troll fishery harvests in a representative manner to provide stock composition estimates of the harvest within 5% of the true value 90% of the time.

2. Survey Chinook salmon sampled from the SEAK troll fishery for individual genotypes at the 13 microsatellite loci in the coastwide baseline (GAPS version 3.0).

3. Estimate the relative contribution of 26 fine-scale reporting groups for the following fisheries in AY 2015:
   a. Early winter (October–December) and late winter (January–April) troll fisheries in the NO quadrant, and across all quadrants;
   b. Spring troll fisheries (May–June) with separate estimates for Chinook salmon harvested in the NO, NI, and SI quadrants; and
   c. Summer troll fisheries (July–September) with separate estimates for the first Chinook salmon opening and subsequent openings combined for Chinook salmon harvested across all quadrants and in the NO quadrant alone.

 METHODS

FISHERY SAMPLING

Traditionally, sample sizes for the estimation of stock composition have been set at 400 individuals per stratum for fishery samples from highly mixed locations where many stocks contribute to the harvest (e.g., Seeb et al. 2000). According to sampling theory, under the worst-case scenario (3 stocks contributing equal proportions) a sample of this size should provide estimates of relative proportions within 5% of the true value 90% of the time (Thompson 1987) when stocks are genetically identifiable. The same statistical approach indicates that under worst-case conditions a sample of 200 will be within approximately 7% of the true value 90% of the time. Thus, given these levels of precision and accuracy, the need to balance costs of fisheries sampling and costs of laboratory analysis, and the resolution of stock composition information needed to support fishery management, sample sizes were set to target a minimum of 400 samples per stratum for the following strata:

1. Early winter fishery (October–December)
   a. NO quadrant
   b. Regionwide
2. Late winter fishery (January–April)
   a. NO quadrant
   b. Regionwide
3. Spring fishery (April–June)
   a. NO quadrant
   b. NI quadrant
   c. SI quadrant
4. Summer fishery (July–September)
   a. First retention period (July)
      i. NO quadrant
      ii. Regionwide
   b. Second and subsequent retention periods (August–September)
      i. NO quadrant
      ii. Regionwide

When necessary, sample goals were moved between ports within a stratum to achieve minimum sample sizes for some strata (Table 2). Sample sizes in the NO quadrant were set so that stock contributions to the harvest in this quadrant could be estimated for each of the time periods in addition to an all-quadrant estimate. Goals varied among ports depending on expectations for deliveries (processor availability), availability of port samplers, and the vagaries of each seasonal fishery.

Details regarding port sampling procedures are outlined in Buettner et al. (2017). In short, Chinook salmon were targeted for collection from landings at processors at various ports in SEAK (Table 2 and Table 3; Figure 1). Fish were selected for sampling without regard to size, sex, presence of an adipose fin, or position in the vessel hold or tote, and sampling was conducted in such a manner to be as representative as possible of that week’s commercial catch. Axillary processes (the modified and elongated structure found at the anterior base of the pelvic fin) were excised from each fish and placed in a 2 ml cryovial in at least 95% denatured ethanol or dried on Whatman paper. Troll fishermen were interviewed to determine the quadrant (NO, NI, SO, or SI) from which the Chinook salmon were harvested. At the end of the season, samples were shipped air cargo back to the ADF&G Gene Conservation Laboratory in Anchorage for analysis. Associated data were archived as part of the age-sex-length database maintained by ADF&G.

**MIXED STOCK ANALYSIS**

**Laboratory Analysis**

Samples were assayed for 13 microsatellite loci developed by the GAPS group for use in Treaty fisheries (CTC standardized baseline loci; Seeb et al. 2007). Genomic DNA was extracted from tissue samples using a NucleoSpin 96 Tissue Kit by Macherey-Nagel (Düren, Germany). Polymerase chain reaction (PCR) was carried out in 10 ul reaction volumes (10 mM Tris-HCl, 50 mM KCl, 0.2 mM each dNTP, 0.5 units Taq DNA polymerase [Promega, Madison, WI]) using an Applied Biosystems (AB; Foster City, CA) thermocycler. Primer concentrations, MgCl₂ concentrations, and the corresponding annealing temperature for each primer are available in Seeb et al. 2007. PCR fragment analysis was done on an AB 3730 capillary DNA sequencer. A 96-well reaction plate was loaded with 0.5 ul PCR product along with 0.5 ul of GS500LIZ (AB) internal lane size standard and 9.0 ul of Hi-Di (AB). PCR bands were visualized and separated into bin sets using AB GeneMapper software v4.0. All laboratory analyses followed protocols accepted by the CTC.

Genetic data were collected as individual multilocus genotypes. According to the convention implemented by the CTC, at each locus, a standardized allele is one that has a recognized holotype specimen from which the standardized allele can be reproduced using commonly applied fragment analysis techniques. By the process of sizing the alleles from the holotype specimens, any individual laboratory should be able to convert allele sizes obtained in the
ADF&G laboratory to standardized allele names. Genotype data were stored as GeneMapper (*.fsa) files on a network drive that was backed up nightly. Long-term storage of the data was in an Oracle database (LOKI) on a network drive maintained by ADF&G computer services.

Several measures were implemented to ensure the quality of data produced. First, each individual tissue sample was assigned a unique accession identifier. At the time DNA was extracted or analyzed from each sample, a sample sheet was created that linked each individual sample’s code to a specific well number in a uniquely numbered 96-well plate. This sample sheet then followed the sample through all phases of the project, minimizing the risk of misidentification of samples through human-induced errors. Second, genotypes were assigned to individuals using a system in which 2 people score the genotype data independently. Discrepancies between the 2 sets of scores were then resolved with 1 of 2 possible outcomes: (1) 1 score was accepted and the other rejected, or (2) both scores were rejected and no score was retained. Lastly, approximately 8% of the individuals, 8 samples from each 96-well DNA extraction plate, were reanalyzed for all loci. This enabled detection and correction of laboratory mistakes and allowed estimation of genotyping error rates. Error rates were calculated as the number of conflicting genotypes divided by the total number of genotypes examined.

Statistical Analysis

Mixture Subsampling

Representative mixtures of individuals for MSA were created by subsampling individuals from the collected tissue samples in proportion to harvest by quadrant. The harvest of Chinook salmon in each quadrant for a given troll fishery opening was obtained from the ADF&G Mark, Tag, and Age Laboratory website (https://mtalab.adfg.alaska.gov/CWT/reports/default.aspx) using the criteria in Table 4. The relative proportion of the total period harvest that was caught in each quadrant was then calculated for each fishery opening.

Typically 11 mixtures are necessary to generate stock composition estimates for the strata described above; however, in 2015 only 9 mixtures were necessary because only 1 retention period occurred for the summer troll fishery. For regionwide (all quadrant) estimates, separate mixtures were made for the (1) NO quadrant and (2) all other quadrants combined, and then pooled into regionwide estimates by weighting by each quadrant’s harvest (Templin et al. 2011). For each fishery and quadrant, individual samples were randomly selected from the entire set of samples available from each quadrant such that the contribution of each quadrant to the sample mixture reflected the composition of the harvest. When sufficient samples were available, the target sample size for each mixture was 400. In some cases, fewer than 400 individuals were available; in these cases, a minimum sample size was set at 200. In addition, in some cases fewer than 200 individuals were available to generate an estimate. Although a sample size below 200 did not meet objectives for precision and accuracy, strata with sample sizes of 100–200 were deemed useful over the option of no information; thus estimates were generated, but only to the 4 broad-scale reporting groups outlined in Table 1. No estimates were generated for sample sizes less than 100.

BAYES Analysis

The stock composition of fishery mixtures was estimated using the program BAYES (Pella and Masuda 2001). The Bayesian method of MSA is used to estimate the proportion of stocks caught within each fishery using 4 pieces of information: (1) a baseline of allele frequencies for each
population, (2) the grouping of populations into the reporting groups desired for MSA, (3) prior information about the stock proportions of the fishery, and (4) the genotypes of fish sampled from the fishery.

The baseline of allele frequencies for Chinook salmon populations was obtained from the GAPS database (v3.0; http://www.nwfsc.noaa.gov/research/divisions/cb genetics/standardization.cfm). Results from 100% proof tests indicate that the 26 fine-scale reporting groups used herein can be identified in mixtures with a 91% correct allocation or better (Gilk-Baumer et al. In prep[a]).

The choice of prior information about stock proportions in a fishery (the prior probability distribution hereafter referred to as the prior) is important for increasing MSA accuracy (Habicht et al. 2012a). In this analysis, the estimated stock proportions from the previous year in a given stratum were used as the prior for that stratum (i.e., 2014 estimates were used as prior parameters when generating 2015 estimates). The prior information about stock proportions was incorporated in the form of a Dirichlet probability distribution. The sum of all prior parameters was set to 1 (prior weight), which is equivalent to adding 1 fish to each mixture (Pella and Masuda 2001).

For each fishery mixture, 5 independent Markov Chain Monte Carlo chains of 40,000 iterations were run with different starting values and the first 20,000 iterations were discarded to remove the influence of the start values. In order to assess the among-chain convergence, the Gelman-Rubin shrink factors computed for all stock groups in BAYES were examined (Gelman and Rubin 1992). If a shrink factor for any stock group in a mixture was greater than 1.2, the mixture was reanalyzed with 80,000 iterations. If a mixture still had a shrink factor greater than 1.2 after the reanalysis, results from the 5 chains were averaged and a note was made in the results. We combined the second half of the 5 chains to form the posterior distribution and tabulated mean estimates, 90% credibility intervals, and standard deviations from a total of 100,000 iterations. In addition, we report the marginal median of the posterior distribution as a measure of central tendency for stock proportions (Pella and Masuda 2001). Misallocations to reporting groups that are either absent or at low proportions within mixtures can occur in MSA when the discriminant methods do not produce perfect identifiability (Pella and Milner 1987; Pella and Masuda 2001). Previous work has shown that the posterior distribution of these misallocations can be highly skewed and the mean is much more sensitive to extreme values than the median (e.g., Habicht et al. 2012b).

For regionwide estimates for the winter and summer fisheries, estimates from (1) the NO quadrant and (2) all other quadrants combined were pooled into total-area estimates by weighting each quadrant’s estimate by their respective harvests (stratified estimator). This approach to analysis is described in detail in Templin et al. (2011).

In order to better describe annual trends across a longer time frame for those stocks that make up the largest proportion of harvest in SEAK Chinook salmon fisheries (i.e., driver stocks), the 26 fine-scale reporting groups were condensed into 8 reporting groups that consisted of 7 driver stocks and an Other group (Table 1). Where feasible, these reporting groups were aligned with stock groups used by the CTC for the PSC Chinook Model, and these groups perform well in genetic MSA. Further, the fine-scale groups were combined into 4 broad-scale reporting groups for describing trends on a large geographic scale (Table 1). When reporting groups were combined, credibility intervals were calculated from the raw BAYES output using the new groupings in order to accurately reflect the uncertainty in the estimates.
These reporting groups are large and in some situations do not provide the desired resolution. To enable accurate and precise investigation at a finer scale, proportional contributions are also provided graphically for a subset of the fine-scale reporting groups estimated to consistently contribute at least 5% to the harvest in at least 1 seasonal fishery per year. Again, all other stocks are included in an additional Other group.

RESULTS

FISHERY SAMPLING

A total of 4,281 tissue samples were collected across all fisheries for AY 2015, which is slightly less than the original sampling goal of 4,495. Goals were generally met for all fishery periods, but missed at some ports (Table 2). This was primarily caused by reduced fishing effort or less intensive harvest sampling during portions of the harvest season.

In AY 2015, sampling of Chinook salmon during the winter fisheries began with the early winter opening on October 11, 2014, and continued until the late winter fishery closed March 25, 2015. The sampling goals for winter fisheries by port are heavily weighted towards Sitka (70%) where the vast majority of the fishing effort is concentrated (typically 70–75%). A total of 531 samples (sampling goal: 545) were collected from the early winter troll fisheries, and 569 samples (sampling goal: 580) were collected from the late winter troll fisheries. Goals were met for every port except Ketchikan in the early winter and Craig in the late winter.

Sampling of Chinook salmon during the spring troll fishery occurred between April 16 and June 30. Sample goals were met for every port except Yakutat (Table 2). The sample size was only 184 from the NI quadrant; therefore, estimates were generated to the broad-scale reporting groups only (Table 1).

Sampling of Chinook salmon during the first retention period of the summer troll fishery occurred July 1–8; no second retention period occurred in AY 2015. Sample goals were met for every port except Elfin Cove where no samples were collected, and exceeded in Ketchikan and Sitka (Table 2). The total sample size of 1,558 was sufficient to generate estimates to the fine-scale reporting groups.

MIXED STOCK ANALYSIS

Laboratory Analysis

Quality control demonstrated a low error rate for the samples that were analyzed. A total of 258 fish were examined for quality control, or 3,354 genotype comparisons. The discrepancy rate was 1.67%.

Statistical Analysis

Early Winter Troll Fishery

For broad-scale reporting groups, the US South group (stocks originating from Washington, Oregon, and California) was the highest contributor during the early winter troll fishery of AY 2015 (54%), followed by Canada (33%) and Alaska (12%). The Transboundary group had a low contribution (<1%; Appendix B1).

For driver stock reporting groups, the largest contributor to the regionwide early winter troll fishery was the Interior Columbia Su/F group (44%), followed by the NCBC (23%), Other
(16%), and SEAK/TBR (12%) groups (Figure 2). Results for driver stock reporting groups are available in Appendix B2.

For fine-scale reporting groups the largest contributors to the regionwide early winter troll fishery were the Interior Columbia Su/F (44%), BC Coast/Haida Gwaii (22%), S Southeast Alaska (8.5%), Puget Sound (6%), and East Vancouver (5%) reporting groups (Figure 3). Results for fine-scale reporting groups are available in Appendix B3.

When considering harvest from the NO quadrant only, the contributions for driver stock reporting groups were similar with the Interior Columbia Su/F group being the largest contributor (51%), followed by the NCBC group (20%; Figure 2). Results for driver stock reporting groups are available in Appendix B2; results for fine-scale reporting groups are available in Figure 3 and Appendix B3.

Late Winter Troll Fishery

For broad-scale reporting groups, the US South group was the highest contributor during the late winter troll fishery (49%), followed by Canada (39%) and Alaska (11%). The Transboundary group had a low contribution (<2%; Appendix B1).

For driver stock reporting groups, the largest contributor to the regionwide late winter troll fishery was the Interior Columbia Su/F group (32%), followed by the NCBC, Other, and West Vancouver reporting groups (each 17%; Figure 2). SEAK/TBR contributed 12% in this fishery. Results for driver stock reporting groups are available in Appendix B2.

When considering fine-scale reporting groups, the largest contributor to the regionwide late winter fishery was the Interior Columbia River Su/F reporting group (32%) followed by the West Vancouver (17%), BC Coast/Haida Gwaii (15%), Willamette (10%) and S Southeast Alaska (6%) reporting groups (Figure 4). Results for fine-scale reporting groups are available in Appendix B4.

When considering harvest from the NO quadrant only, contributions for driver stock reporting groups were similar to regionwide estimates with the Interior Columbia Su/F reporting groups as the largest contributor (39%), followed by the West Vancouver and Other groups (each 18%; Figure 2). Results for driver stock reporting groups are available in Appendix B2; results for fine-scale reporting groups are available in Figure 4 and Appendix B4.

Spring Troll Fishery

During the spring troll fisheries, the contributions of the broad-scale reporting groups were highly variable across the 3 quadrants analyzed. In the NO quadrant, the US South group was the highest contributor (41%), followed by the Alaska group (36%) and the Canada group (23%; Appendix B1). In the SI quadrant, the Alaska group contributed the majority of the harvest (63%) followed by the Canada group (26%) and the US South group (9%). Conversely, the Canada broad-scale reporting group was the largest contributor to the harvest in the NI quadrant (41%) followed by the Alaska group (39%) and the US South group (15%; Appendix B1). The Transboundary group had a low contribution across all quadrants (range: <1–4%).

For the driver stock reporting groups, contributions were also variable amongst quadrants during the spring troll fisheries. The largest contributor to the NO quadrant harvest was the SEAK/TBR reporting group (36%), followed by the Interior Columbia Su/F (24%), Other (16%), and West Vancouver (11%) groups (Figure 2). In the SI quadrant, the largest contributor was also the
SEAK/TBR reporting group (66%), followed by the NCBC group (17%). Results for driver stock reporting groups are available in Appendix B2.

At fine-scale reporting groups, similar variability between quadrants was observed. In the NO quadrant, the highest proportion of Chinook salmon was from the Andrew reporting group (31%), which includes production from hatcheries which use Andrew Creek broodstock (Figure 5), followed by the Interior Columbia Su/Fa group (24%). The Canada group contribution was dominated by West Vancouver stocks (11%) followed by BC Coast/Haida Gwaii (7%). In the SI quadrant, the Alaska reporting group was the largest contributor with harvests dominated by the Southeast Alaska reporting group (36%), followed by the Andrew reporting group (27%; Figure 5). The BC Coast/Haida Gwaii group was the next highest contributor (14%). Results for fine-scale reporting groups are available in Appendix B5.

In the NI quadrant, estimates are not available for either the driver stock reporting groups or fine-scale reporting groups because sample sizes were insufficient.

**Summer Troll Fishery, First Retention Period**

The stock composition of the summer troll fishery tends to be the most varied of the seasonal fisheries with greater representation of non-Alaska stocks. At the broad-scale reporting groups during the first retention period, the US South reporting group accounted for the vast majority of the regionwide harvest (71%), followed by Canada (23%), and Alaska (6%). The Transboundary group had a low contribution (<1%; Appendix B1).

For driver stock reporting groups, the greatest contributor to the regionwide harvest during the first retention of the summer troll fishery was the Interior Columbia Su/Fa reporting group (45%), followed by the Oregon Coast (12%) and South Thompson (11%) reporting groups (Figure 2). Results for driver stock reporting groups are available in Appendix B2.

At the fine-scale, the first retention period of the summer troll regionwide fishery was dominated by the Interior Columbia Su/Fa reporting group (45%). The South Thompson, Washington Coast and North Oregon Coast reporting groups contributed approximately equal proportions to the regionwide harvest (~10%; Figure 6). Results for fine-scale reporting groups are available in Appendix B6.

Stock compositions in the NO quadrant during the first retention period were similar to estimates for the entire area at the driver stock reporting groups, with harvests dominated by the Interior Columbia Su/Fa reporting group (48%; Figure 2). The Oregon Coast (14%), Washington Coast (10%), and South Thompson (9%) reporting groups were also substantial contributors. Results for driver stock reporting groups are available in Appendix B2.

**Summer Troll Fishery, Second Retention Period**

Fishing effort and catch rates were unusually high during the first retention period and the PST harvest quota was reached in early July. Consequently, no second retention period occurred in 2015.

**DISCUSSION**

Genetic MSA has been successfully used to estimate the composition of the commercial troll fishery harvest since 1999 (e.g., Gilk-Baumer et al. 2013; In prep[a]). Because the 7 aggregate driver stocks make up the vast majority (>90%) of all Chinook salmon annually harvested in
SEAK fisheries, these stock aggregates drive the SEAK fisheries and their catch allocations under the PST (Gilk-Baumer et al. 2013, In prep[a]). Genetic MSA is the preferred method to provide accurate and precise harvest estimates for these large aggregates of driver stocks. These estimates indicate that the composition of the harvest varies spatially and by seasonal fishery, but the same constituent stocks are present year to year (Gilk-Baumer et al. In prep[a]).

**INTRA-ANNUAL VARIABILITY**

Comparison of the composition of harvests among seasonal fisheries in AY 2015 shows considerable variability. The composition of early and late winter fisheries includes a mixture of more stocks than other seasonal fisheries; the 7 driver stocks account for 84% of the early winter harvest and 82% of the late winter harvest. By contrast, during the spring troll fishery, when fishing effort is directed at harvesting SEAK-origin hatchery stocks, the contribution of Alaska stocks (47%) was considerably higher than at other times of the year. More than 90% of the spring harvest composition was accounted for by the 7 driver stocks. The summer troll catch composition was heavily dominated by Interior Columbia Su/F stocks (45%) and 94% was contributed by driver stocks.

Although the 7 driver stocks accounted for the vast majority of the harvests in AY 2015, the proportional contribution of each stock varied across seasons. The SEAK/TBR, NCBC, and West Vancouver stocks were larger contributors to winter and spring fisheries, and less prevalent during the summer (Figure 2). Interior Columbia Su/F stocks accounted for large proportions of the harvest in all seasonal fisheries in AY 2015 and were particularly large contributors during winter and summer fisheries (Figure 2). Stocks originating from the South Thompson, Washington Coast, and Oregon Coast were small contributors to winter and spring fisheries (<3%), but contributed substantially to the summer troll fishery particularly in the NO quadrant. Because the majority of the annual harvest limit was taken during the summer troll fishery in AY 2015, these 3 stocks still contributed more than 7% each to the annual harvest.

Variation in stock composition also occurs spatially among the fishery quadrants. In general, stock contribution estimates based on samples from the NO quadrant had the most diverse stock compositions and the highest proportion of stocks originating south of Alaska. In the spring fishery, the SI quadrant had the highest proportion of Alaska and Transboundary stocks, which made up 2/3 of the harvest, whereas the proportions of those stocks in outside quadrants were 36–39%. For summer fisheries, stock contribution estimates based on samples from the NO quadrant were similar to estimates based on samples from all quadrants. This likely reflects the high proportion of fish harvested in this quadrant relative to the other quadrants.

**INTERANNUAL TRENDS**

Some interesting trends can be observed for the composition of SEAK troll fisheries under the current PST fishing regime with the data reported herein and similar studies dating back to AY 2009 (Gilk-Baumer et al. 2013; In prep[a]; Appendix B7). In general, there has been an increasing trend in recent years in the prevalence of US South stocks and a decreasing prevalence of Alaska stocks across most fisheries. This is most obvious in NO quadrant fisheries (Gilk-Baumer et al. In prep[a]). These trends correspond with an increase in productivity of the Interior Columbia Su/F reporting group, which accounted for 37% of the annual regionwide harvest in AY 2015 (Appendix B7). This increase was mirrored by a decrease in productivity for SEAK/TBR stocks (Figure 7). Stocks originating from West Vancouver and South Thompson
were also harvested in below average proportions in AY 2015. The contribution from Washington Coast and Oregon Coast stocks remained more consistent from AY 2009 to AY 2015.

At the fine-scale, the decreasing trend observed by Gilk-Baumer et al. (In prep[a]) in harvests of the N Southeast Alaska stock group in the NI quadrant across years continued in AY 2015, which corresponds to decreases in escapements, terminal run sizes, and decreased productivity for the constituent stocks (CTC 2017). Similarly, a decreasing trend across years was observed for the presence of the S Southeast Alaska stock group harvested in the SI quadrant, which mirrors recent lower escapements to Unuk, Keta, Blossom, and Chickamin rivers, a decrease in productivity of these wild stocks, and decreased survival of hatchery stocks of Chinook salmon in the southern portion of Southeast Alaska (CTC 2017). Consequently, special management actions were taken in the SI Quadrant during the spring troll fishery in AY 2015 in the form of time and area closures to protect these stocks.

Specific comparisons between analyses using the most recent microsatellite baseline (GAPS version 3.0; Gilk-Baumer et al. In prep[a]; and this report) versus those using older microsatellite baselines (GAPS version 2.2; 2004–2009; Gilk-Baumer et al. 2013) and those using allozyme baselines (1999–2003; Templin et al. 2011) can be made, but must be interpreted carefully as both the number of populations and reporting groups changed between the studies. Because of these changes in the genetic baselines, comparisons across years prior to 2010 are more reliable at the broad-scale than at finer scale levels.

APPLICATIONS TO THE PACIFIC SALMON TREATY

These results present a comprehensive assessment using MSA to estimate the stock composition of Chinook salmon harvested in the SEAK troll fishery. Stock composition data from this program are currently being used in several other studies with a broad array of applications:

1. These MSA stock composition estimates have already proven considerably valuable for fishery management in terminal and near-terminal areas and are being used in run reconstructions to generate better forecasts of run strength for transboundary rivers under Chapter 1 of the PST.

2. These MSA stock composition estimates are being combined with individual assignment, otolith mark, CWT, age, and harvest information to provide independent abundance estimates of some PSC Chinook Model stocks to assist in evaluation of the PSC Chinook Model. The PSC Chinook Model may not reliably determine the composition of the harvest in SEAK because (1) it does not include fish originating from transboundary rivers (i.e., Taku, Stikine, Alsek rivers), (2) only 1 of its 30 model stocks originates from SEAK and it only represents a small proportion of the natural production of SEAK Chinook salmon, and (3) the model is based on treaty Chinook which excludes nearly all of the Southeast Alaska hatchery-produced Chinook salmon harvested in SEAK fisheries. For domestic applications, the preferred way to estimate the composition of the SEAK Chinook salmon harvest is to apply fishery stock composition data from MSA to harvest data. This approach has been successfully applied to the SEAK commercial troll fishery from 1999 through 2014 (Templin et al. 2011; Gilk-Baumer et al. 2013, In prep[a]) and SEAK sport fishery from 2004 through 2015 (Gilk-Baumer et al. In prep[b]).
3. Bernard et al. (2014) investigated using genetic analysis in combination with CWTs to estimate terminal run size of Chinook salmon in 2011 from 4 large stock groups that are major contributors to SEAK troll and sport fisheries-West Coast Vancouver Island, Washington Coast, North Oregon Coast, and Upper Columbia River Falls. This driver stock method has proven successful for estimating the terminal run size of several of the stocks that are major contributors to the SEAK fishery and has resulted in an on-going annual effort.

**CONCLUSIONS**

1. The 7 driver stocks—SEAK/TBR, NCBC, South Thompson, West Vancouver, Washington Coast, Interior Columbia Su/F, and Oregon Coast—collectively contributed 91% to the regionwide troll harvest in AY 2015.

2. The fine-scale reporting groups that contributed the highest proportion of fish to the SEAK troll fisheries in AY 2015 were Interior Columbia Su/F, North Oregon Coast, Washington Coast, South Thompson, West Vancouver, and Andrew. Other reporting groups, such as S Southeast Alaska and BC Coast/Haida Gwaii, were also major contributors during some of the seasonal fisheries.

3. Stocks from Alaska and Transboundary reporting groups were the largest contributors to the spring troll fishery, though overall contributions decreased from previous years. These stock groups were most prevalent in the SI quadrant.

4. Summer- and fall-run Chinook salmon originating from the Upper Columbia River were the largest contributors overall to the regionwide harvest in AY 2015.

**ACKNOWLEDGEMENTS**

We thank the following current and former members of the Gene Conservation Laboratory team: Heather Hoyt, Zac Grauvogel, Judy Berger, Heather Liller, Wei Cheng, Erica Chenoweth, Paul Kuriscak, Hans Thompson, Christina Elmaleh, Zach Pechacek, Serena Rogers Olive, and the many seasonal and borrowed personnel who assisted with extractions. We wish to thank the Alaska Department of Fish and Game, Division of Commercial Fisheries Southeast Alaska port sampling staff, including Juneau/Hoonah/Yakutat Port Supervisor (Anne Reynolds-Manney), port sampling and Regional Scale Aging lab staff, Petersburg/Wrangell Port Supervisor (Jeff Rice) and port sampling staff, Ketchikan/Craig Port Supervisor (Anna Buettner) and port sampling staff, and the Sitka/Pelican/Elfin Cove Port Supervisors (Grant Hagerman, Craig Monaco, Brandi Adams, and Rhea Ehresmann) and port sampling staff. Many thanks to Pattie Skannes and Grant Hagerman for input concerning troll management, and to John H. Clark, Lowell Fair, Steve Heinl, and Randy Peterson for providing thoughtful review.
REFERENCES CITED


TABLES AND FIGURES
Table 1.—Relationship between populations and reporting groups for Chinook salmon used to report stock composition of SEAK troll fishery harvests.

<table>
<thead>
<tr>
<th>Population</th>
<th>Fine-scale</th>
<th>Driver stocks</th>
<th>Broad-scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>Situk</td>
<td>SEAK/TBR</td>
</tr>
<tr>
<td>2</td>
<td>2-5</td>
<td>Alsek</td>
<td>SEAK/TBR</td>
</tr>
<tr>
<td>3</td>
<td>6-10</td>
<td>N Southeast Alaska</td>
<td>SEAK/TBR</td>
</tr>
<tr>
<td>4</td>
<td>11-17</td>
<td>Taku</td>
<td>SEAK/TBR</td>
</tr>
<tr>
<td>5</td>
<td>18-21</td>
<td>Andrew</td>
<td>SEAK/TBR</td>
</tr>
<tr>
<td>6</td>
<td>22-28</td>
<td>Stikine</td>
<td>SEAK/TBR</td>
</tr>
<tr>
<td>7</td>
<td>29-42</td>
<td>S Southeast Alaska</td>
<td>SEAK/TBR</td>
</tr>
<tr>
<td>8</td>
<td>43-51</td>
<td>Nass</td>
<td>NCBC</td>
</tr>
<tr>
<td>9</td>
<td>52-78</td>
<td>Skeena</td>
<td>NCBC</td>
</tr>
<tr>
<td>10</td>
<td>79-97</td>
<td>BC Coast/Haida Gwaii</td>
<td>NCBC</td>
</tr>
<tr>
<td>11</td>
<td>98-113</td>
<td>West Vancouver</td>
<td>West Vancouver</td>
</tr>
<tr>
<td>12</td>
<td>114-123</td>
<td>East Vancouver</td>
<td>Other</td>
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<td>13</td>
<td>124-157</td>
<td>Fraser</td>
<td>Other</td>
</tr>
<tr>
<td>14</td>
<td>158-166</td>
<td>Lower Thompson</td>
<td>Other</td>
</tr>
<tr>
<td>15</td>
<td>167-172</td>
<td>North Thompson</td>
<td>Other</td>
</tr>
<tr>
<td>16</td>
<td>173-180</td>
<td>South Thompson</td>
<td>South Thompson</td>
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<td>181-212</td>
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<td>18</td>
<td>213-223</td>
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<td>224-226</td>
<td>West Cascades Sp</td>
<td>Other</td>
</tr>
<tr>
<td>20</td>
<td>227-240</td>
<td>Lower Columbia F</td>
<td>Other</td>
</tr>
<tr>
<td>21</td>
<td>241-246</td>
<td>Willamette Sp</td>
<td>Other</td>
</tr>
<tr>
<td>22</td>
<td>247-302</td>
<td>Columbia Sp</td>
<td>Other</td>
</tr>
<tr>
<td>23</td>
<td>303-320</td>
<td>Interior Columbia Su/F</td>
<td>Interior Columbia Su/F</td>
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<tr>
<td>24</td>
<td>321-331</td>
<td>North Oregon Coast</td>
<td>Oregon Coast</td>
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<td>25</td>
<td>332-339</td>
<td>Mid Oregon Coast</td>
<td>Oregon Coast</td>
</tr>
<tr>
<td>26</td>
<td>340-357</td>
<td>S Oregon/California</td>
<td>Other</td>
</tr>
</tbody>
</table>

Note: Population numbers are listed in Appendix A1. Populations were combined into (1) 26 fine-scale reporting groups, (2) 8 driver stock reporting groups, and (3) 4 broad-scale reporting groups.

Driver stocks are aggregate stocks that consistently make up a large proportion (>5%) of all Chinook salmon harvested annually in Southeast Alaska fisheries, and thus are important stocks that help drive catch allocations under the Pacific Salmon Treaty.
Table 2.—Sampling goals and numbers of fish sampled from troll-caught Chinook salmon landings at processors at ports in SEAK for mixed stock analysis, 2015.

<table>
<thead>
<tr>
<th>Fishery</th>
<th>Port</th>
<th>Quadrants Represented</th>
<th>AY 2015</th>
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<tbody>
<tr>
<td>Winter (October–April)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Early Winter</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Craig</td>
<td>SO, SI, NI</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Juneau</td>
<td>NI, NO</td>
<td>30</td>
<td>31</td>
</tr>
<tr>
<td>Ketchikan</td>
<td>SI</td>
<td>40</td>
<td>26</td>
</tr>
<tr>
<td>Petersburg</td>
<td>NI, SI</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>Sitka</td>
<td>NO</td>
<td>430</td>
<td>430</td>
</tr>
<tr>
<td></td>
<td></td>
<td>545</td>
<td>532</td>
</tr>
<tr>
<td>Late Winter</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Craig</td>
<td>SO, SI, NI</td>
<td>50</td>
<td>39</td>
</tr>
<tr>
<td>Juneau</td>
<td>NI, NO</td>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td>Ketchikan</td>
<td>SI</td>
<td>80</td>
<td>80</td>
</tr>
<tr>
<td>Petersburg</td>
<td>NI, SI</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td>Sitka</td>
<td>NO</td>
<td>350</td>
<td>350</td>
</tr>
<tr>
<td></td>
<td></td>
<td>580</td>
<td>569</td>
</tr>
<tr>
<td>Spring (May–June)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Craig</td>
<td>SO</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Juneau</td>
<td>NI, NO</td>
<td>200</td>
<td>206</td>
</tr>
<tr>
<td>Ketchikan</td>
<td>SI, NI</td>
<td>300</td>
<td>300</td>
</tr>
<tr>
<td>Petersburg</td>
<td>NI, SI</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Sitka</td>
<td>NO</td>
<td>300</td>
<td>300</td>
</tr>
<tr>
<td>Wrangell</td>
<td>SI, NI</td>
<td>300</td>
<td>300</td>
</tr>
<tr>
<td>Yakutat</td>
<td>NO</td>
<td>600</td>
<td>320</td>
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<tr>
<td></td>
<td></td>
<td>1,900</td>
<td>1,626</td>
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<tr>
<td>Summer (July–September)</td>
<td>Retention Period 1</td>
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<tr>
<td>Craig</td>
<td>SO</td>
<td>350</td>
<td>350</td>
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<tr>
<td>Elfin Cove</td>
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<td>0</td>
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<td>Hoonah</td>
<td>NO</td>
<td>40</td>
<td>40</td>
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<tr>
<td>Juneau</td>
<td>NO</td>
<td>0</td>
<td>0</td>
</tr>
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<td>Ketchikan</td>
<td>SI, SO</td>
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<td>Pelican</td>
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<td>60</td>
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<td>Petersburg</td>
<td>NI, SI</td>
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<td>150</td>
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<tr>
<td>Port Alexander</td>
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<td>100</td>
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</tr>
<tr>
<td>Sitka</td>
<td>NO</td>
<td>510</td>
<td>550</td>
</tr>
<tr>
<td>Wrangell</td>
<td>SI, NI</td>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td>Yakutat</td>
<td>NO</td>
<td>50</td>
<td>50</td>
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<tr>
<td></td>
<td></td>
<td>1,470</td>
<td>1,560</td>
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<tr>
<td>Retention Period 2</td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>No fishery</td>
<td></td>
</tr>
</tbody>
</table>

*Note:* No summer troll second retention period occurred in 2015.

* Quadrant names are abbreviated as follows: Northern Outside (NO), Northern Inside (NI), Southern Outside (SO), and Southern Inside (SI).
Table 3.—Samples collected by quadrant in SEAK for each seasonal troll fishery, 2015.

<table>
<thead>
<tr>
<th>Fishery</th>
<th>NO</th>
<th>SO</th>
<th>NI</th>
<th>SI</th>
<th>Total</th>
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<tbody>
<tr>
<td>Early Winter</td>
<td>442</td>
<td>20</td>
<td>31</td>
<td>39</td>
<td>532</td>
</tr>
<tr>
<td>Late Winter</td>
<td>402</td>
<td>39</td>
<td>26</td>
<td>102</td>
<td>569</td>
</tr>
<tr>
<td>Spring</td>
<td>770</td>
<td>100</td>
<td>190</td>
<td>566</td>
<td>1,626</td>
</tr>
<tr>
<td>Summer</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Retention Period 1</td>
<td>660</td>
<td>440</td>
<td>250</td>
<td>210</td>
<td>1,560</td>
</tr>
<tr>
<td>Retention Period 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>No fishery</td>
</tr>
</tbody>
</table>

*Note: No summer troll second retention period occurred in 2015.*
Table 4.—Selection criteria used to generate the Commercial Harvest Expansion Report on the ADF&G Mark, Tag, and Age Laboratory website.

<table>
<thead>
<tr>
<th>Criteria</th>
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<tr>
<td>Years</td>
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<tr>
<td>Species</td>
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</tr>
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<td>Gear Class Codes</td>
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</tr>
<tr>
<td>Harvest Codes</td>
<td>11, 13</td>
</tr>
<tr>
<td>Time Code</td>
<td>P</td>
</tr>
<tr>
<td>Time Value Range</td>
<td>1, 54</td>
</tr>
<tr>
<td>Area Code</td>
<td>Q- Quadrants</td>
</tr>
<tr>
<td>Districts</td>
<td>ALL</td>
</tr>
<tr>
<td>Quadrants</td>
<td>NE, NW, SE, SW (correspond to NI, NO, SI, and SO, respectively)</td>
</tr>
<tr>
<td>Stat Area Values</td>
<td>ALL</td>
</tr>
</tbody>
</table>

*Note: Data are available at https://mtalab.adfg.alaska.gov/CWT/reports/default.aspx*
Figure 1.—Location of Southeast Alaska troll fishing quadrants and ports.
Figure 2.—Mean estimated contributions of driver stock reporting groups of Chinook salmon to the troll fishery harvest in SEAK by quadrant and seasonal fishery, AY 2015.

Note: Reporting groups are described in Table 1. Driver stocks are aggregate stocks that consistently make up a large proportion (>5%) of all Chinook salmon harvested annually in Southeast Alaska fisheries, and thus are important stocks that help drive catch allocations under the Pacific Salmon Treaty.

Note: Quadrant names are abbreviated as follows: Northern Outside (NO) and Regionwide (All).

Note: Fishery names are abbreviated as follows: Early Winter (EW), Late Winter (LW), Spring (SP), and Summer retention period 1 (SU1).
Figure 3.—Estimated contributions and 90% credibility intervals of fine-scale reporting groups of Chinook salmon to the regionwide (upper) and Northern Outside quadrant (lower) early winter troll fishery harvest in SEAK, AY 2015.

Note: Reporting groups are described in Table 1. The Other group includes those reporting groups that do not contribute more than 5% in any seasonal fisheries.
Figure 4.—Estimated contributions and 90% credibility intervals of fine-scale reporting groups of Chinook salmon to the regionwide (upper) and Northern Outside quadrant (lower) late winter troll fishery harvest in SEAK, AY 2015.

Note: Reporting groups are described in Table 1. The Other group includes those reporting groups that do not contribute more than 5% in any seasonal fisheries.
Figure 7.–Mean contributions of driver stock reporting groups of Chinook salmon to the annual regionwide troll fishery harvest in SEAK, AY 2010–2015.

Note: Reporting groups are described in Table 1. Driver stocks are aggregate stocks that consistently make up a large proportion (>5%) of all Chinook salmon harvested annually in Southeast Alaska fisheries, and thus are important stocks that help drive catch allocations under the Pacific Salmon Treaty.
Figure 5.—Estimated contributions and 90% credibility intervals of fine-scale reporting groups of Chinook salmon to the spring troll fishery harvest in the Northern Outside and Southern Inside quadrants of SEAK, AY 2015.

Note: Reporting groups are described in Table 1. The Other group includes those reporting groups that do not contribute more than 5% in any seasonal fisheries.

Note: Inadequate sample sizes precluded estimating stock compositions for Spring troll Northern Inside quadrant for fine-scale reporting groups.
Figure 6.—Estimated contributions and 90% credibility intervals of fine-scale reporting groups of Chinook salmon to the regionwide (upper) and Northern Outside quadrant (lower) first retention period of the summer troll fishery harvest in SEAK, AY 2015.

Note: Reporting groups are described in Table 1. The Other group includes those reporting groups that do not contribute more than 5% in any seasonal fisheries.
APPENDIX A: BASELINE POPULATIONS
Appendix A1—Location and collection details for each population of Chinook salmon included in the coastwide baseline of microsatellite data (GAPS version 3.0).

<table>
<thead>
<tr>
<th>Fine-scale Reporting Group</th>
<th>Pop No.</th>
<th>Population</th>
<th>N</th>
<th>Run time</th>
<th>Origin</th>
<th>Life Stage</th>
<th>Collection Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 Goat Creek</td>
<td>3</td>
<td>Goat Creek</td>
<td>62</td>
<td>W</td>
<td></td>
<td>Adult</td>
<td>2007, 2008</td>
</tr>
<tr>
<td>3 N Southeast Alaska</td>
<td>6</td>
<td>Big Boulder Creek</td>
<td>138</td>
<td>W</td>
<td></td>
<td>Adult</td>
<td>1992, 1995, 2004</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>Tahini River–Macaulay Hatchery</td>
<td>77</td>
<td>H</td>
<td></td>
<td>Adult</td>
<td>2005</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>Tahini River</td>
<td>119</td>
<td>W</td>
<td></td>
<td>Adult</td>
<td>1992, 2004</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>Kelsall River</td>
<td>153</td>
<td>W</td>
<td></td>
<td>Adult</td>
<td>2004</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>King Salmon River</td>
<td>143</td>
<td>W</td>
<td></td>
<td>Adult</td>
<td>1989, 1990, 1993</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>Kowatua Creek</td>
<td>288</td>
<td>W</td>
<td></td>
<td>Adult</td>
<td>1989, 1990, 2005</td>
</tr>
<tr>
<td></td>
<td>14</td>
<td>Little Trapper River</td>
<td>74</td>
<td>W</td>
<td></td>
<td>Adult</td>
<td>1999</td>
</tr>
<tr>
<td></td>
<td>17</td>
<td>Tatsatua Creek</td>
<td>171</td>
<td>W</td>
<td></td>
<td>Adult</td>
<td>1989, 1990</td>
</tr>
<tr>
<td>5 Andrew</td>
<td>18</td>
<td>Andrew Creek</td>
<td>131</td>
<td>W</td>
<td></td>
<td>Adult</td>
<td>1989, 2004</td>
</tr>
<tr>
<td></td>
<td>19</td>
<td>Andrew Creek–Crystal Hatchery</td>
<td>207</td>
<td>H</td>
<td></td>
<td>Adult</td>
<td>2005</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>Andrew Creek–Macaulay Hatchery</td>
<td>135</td>
<td>H</td>
<td></td>
<td>Adult</td>
<td>2005</td>
</tr>
<tr>
<td></td>
<td>21</td>
<td>Andrew Creek–Medvejie Hatchery</td>
<td>177</td>
<td>H</td>
<td></td>
<td>Adult</td>
<td>2005</td>
</tr>
<tr>
<td></td>
<td>23</td>
<td>Craig River</td>
<td>96</td>
<td>W</td>
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<td>Adult</td>
<td>2001</td>
</tr>
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<td></td>
<td>25</td>
<td>Little Tatsamenie River</td>
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<td>W</td>
<td></td>
<td>Adult</td>
<td>2001, 2004</td>
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<tr>
<td></td>
<td>27</td>
<td>Tahltan River</td>
<td>80</td>
<td>W</td>
<td></td>
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<td>2008</td>
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<tr>
<td>7 S Southeast Alaska</td>
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<td>Chickamin River</td>
<td>126</td>
<td>W</td>
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<td>Adult</td>
<td>1990, 2003</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>King Creek</td>
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<td></td>
<td>Adult</td>
<td>2003</td>
</tr>
<tr>
<td></td>
<td>31</td>
<td>Butler Creek</td>
<td>190</td>
<td>W</td>
<td></td>
<td>Adult</td>
<td>2004</td>
</tr>
<tr>
<td></td>
<td>32</td>
<td>Leduc Creek</td>
<td>43</td>
<td>W</td>
<td></td>
<td>Adult</td>
<td>2004</td>
</tr>
<tr>
<td></td>
<td>33</td>
<td>Humpy Creek</td>
<td>124</td>
<td>W</td>
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<td>Adult</td>
<td>2003</td>
</tr>
<tr>
<td></td>
<td>34</td>
<td>Chickamin River–Little Port Walter H.</td>
<td>218</td>
<td>H</td>
<td>Adult</td>
<td>1993, 2005</td>
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<tr>
<td></td>
<td>35</td>
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<tr>
<td></td>
<td>36</td>
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<td>Adult</td>
<td>1989, 2003, 2004</td>
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<tr>
<td>Fine-scale Reporting Group</td>
<td>Pop No.</td>
<td>Population</td>
<td>N</td>
<td>Run time</td>
<td>Origin</td>
<td>Life Stage</td>
<td>Collection Date</td>
</tr>
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<td>---------</td>
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<td>----</td>
<td>----------</td>
<td>--------</td>
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<td>-----------------</td>
</tr>
<tr>
<td>7 Southeast Alaska (cont.)</td>
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<td>1988, 2003</td>
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<td>Gene's Lake</td>
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<td>1989, 2003, 2004</td>
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<tr>
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<td>Adult</td>
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<td>2005</td>
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*a Population numbers given correspond to the population numbers referenced in Table 1.

*b Run timing components are abbreviated as Sp (spring), Su (summer), F (fall), and W (winter).

*c Origin categories are abbreviated as H (hatchery), and W (wild).
APPENDIX B: ESTIMATED CONTRIBUTION
Appendix B1.—Estimated contributions of broad-scale reporting groups of Chinook salmon to the SEAK troll fishery harvest, AY 2015.

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Note: Standard deviation (SD) and 90% credibility intervals are provided.

<sup>a</sup> Quadrant names are abbreviated as follows: Northern Outside (NO), Northern Inside (NI), Southern Outside (SO), and Southern Inside (SI).
Appendix B2.—Estimated contributions of driver stock reporting groups of Chinook salmon to the SEAK troll fishery harvest by season and quadrant, AY 2015.

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<th>Summer 1 Regionwide (n = 842)</th>
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<td>0.000</td>
<td>0.011</td>
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</tr>
<tr>
<td>Interior Columbia Su/F</td>
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<td>0.443</td>
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<td>0.000</td>
<td>0.001</td>
<td>0.000</td>
</tr>
<tr>
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<td>0.173</td>
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<td>0.165</td>
<td>0.139</td>
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<td>0.184</td>
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<tr>
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<td>0.007</td>
<td>0.021</td>
<td>0.012</td>
<td>0.034</td>
<td>0.026</td>
</tr>
<tr>
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<td>0.015</td>
<td>0.006</td>
<td>0.014</td>
<td>0.006</td>
<td>0.025</td>
<td>0.018</td>
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<td>0.323</td>
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<td>0.387</td>
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<td>0.003</td>
<td>0.003</td>
<td>0.001</td>
<td>0.010</td>
<td>0.005</td>
</tr>
<tr>
<td>Other</td>
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<td>0.017</td>
<td>0.174</td>
<td>0.147</td>
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<td>0.014</td>
<td>0.156</td>
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<td>0.071</td>
</tr>
<tr>
<td>West Vancouver</td>
<td>0.072</td>
<td>0.009</td>
<td>0.072</td>
<td>0.057</td>
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<td>0.113</td>
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<td>0.027</td>
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<td>0.020</td>
<td>0.012</td>
<td>0.030</td>
<td>0.037</td>
</tr>
<tr>
<td>Interior Columbia Su/F</td>
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<td>0.013</td>
<td>0.144</td>
<td>0.124</td>
<td>0.165</td>
<td>0.235</td>
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<td>Oregon Coast</td>
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<td>0.003</td>
<td>0.001</td>
<td>0.009</td>
<td>0.000</td>
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<td>0.100</td>
<td>0.083</td>
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</tr>
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</table>

Note: Sample sizes (n), standard deviation (SD), and 90% credibility intervals are provided.

Note: Reporting groups are described in Table 1.
### Appendix B3.—Estimated contributions of fine-scale reporting groups of Chinook salmon to the harvest for the early winter troll fishery regionwide and in the Northern Outside quadrant of SEAK, AY 2015.

<table>
<thead>
<tr>
<th>Reporting Group</th>
<th>Regionwide ((n = 527))</th>
<th>Northern Outside Quadrant ((n = 437))</th>
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</thead>
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<td>0.000</td>
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<tr>
<td>2 Alsek</td>
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<td>0.000</td>
</tr>
<tr>
<td>3 N Southeast Alaska</td>
<td>0.006</td>
<td>0.004</td>
</tr>
<tr>
<td>4 Taku</td>
<td>0.002</td>
<td>0.003</td>
</tr>
<tr>
<td>5 Andrew</td>
<td>0.028</td>
<td>0.009</td>
</tr>
<tr>
<td>6 Stikine</td>
<td>0.002</td>
<td>0.004</td>
</tr>
<tr>
<td>7 S Southeast Alaska</td>
<td>0.085</td>
<td>0.013</td>
</tr>
<tr>
<td>8 Nass</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>9 Skeena</td>
<td>0.005</td>
<td>0.003</td>
</tr>
<tr>
<td>10 BC Coast/Haida Gwaii</td>
<td>0.220</td>
<td>0.019</td>
</tr>
<tr>
<td>11 West Vancouver</td>
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<tr>
<td>12 East Vancouver</td>
<td>0.054</td>
<td>0.010</td>
</tr>
<tr>
<td>13 Fraser</td>
<td>0.006</td>
<td>0.003</td>
</tr>
<tr>
<td>14 Lower Thompson</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>15 North Thompson</td>
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<td>0.002</td>
</tr>
<tr>
<td>16 South Thompson</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>17 Puget Sound</td>
<td>0.064</td>
<td>0.012</td>
</tr>
<tr>
<td>18 Washington Coast</td>
<td>0.005</td>
<td>0.003</td>
</tr>
<tr>
<td>19 West Cascades Sp</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>20 Lower Columbia F</td>
<td>0.019</td>
<td>0.006</td>
</tr>
<tr>
<td>21 Willamette Sp</td>
<td>0.013</td>
<td>0.005</td>
</tr>
<tr>
<td>22 Columbia Sp</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>23 Interior Columbia Su/F</td>
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<tr>
<td>24 North Oregon Coast</td>
<td>0.000</td>
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<tr>
<td>25 Mid Oregon Coast</td>
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<td>0.000</td>
</tr>
<tr>
<td>26 S Oregon/California</td>
<td>0.000</td>
<td>0.000</td>
</tr>
</tbody>
</table>

Note: Sample sizes \((n)\), standard deviation (SD), and 90% credibility intervals are provided.

\(^a\) Run timing components are abbreviated as Sp (spring), Su (summer), and F (fall).
Appendix B4.–Estimated contributions of fine-scale reporting groups of Chinook salmon to the harvest for the late winter troll fishery regionwide and in the Northern Outside quadrant of SEAK, AY 2015.

<table>
<thead>
<tr>
<th>Reporting Group</th>
<th>Regionwide (n = 563)</th>
<th>Northern Outside Quadrant (n = 402)</th>
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</thead>
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<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>1 Sitka</td>
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<td>0.000</td>
</tr>
<tr>
<td>2 Alsek</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>3 N Southeast Alaska</td>
<td>0.005</td>
<td>0.003</td>
</tr>
<tr>
<td>4 Taku</td>
<td>0.016</td>
<td>0.007</td>
</tr>
<tr>
<td>5 Andrew</td>
<td>0.044</td>
<td>0.011</td>
</tr>
<tr>
<td>6 Stikine</td>
<td>0.000</td>
<td>0.001</td>
</tr>
<tr>
<td>7 S Southeast Alaska</td>
<td>0.058</td>
<td>0.012</td>
</tr>
<tr>
<td>8 Niss</td>
<td>0.001</td>
<td>0.002</td>
</tr>
<tr>
<td>9 Skeena</td>
<td>0.020</td>
<td>0.006</td>
</tr>
<tr>
<td>10 BC Coast/Haida Gwaii</td>
<td>0.153</td>
<td>0.016</td>
</tr>
<tr>
<td>11 West Vancouver</td>
<td>0.165</td>
<td>0.016</td>
</tr>
<tr>
<td>12 East Vancouver</td>
<td>0.022</td>
<td>0.006</td>
</tr>
<tr>
<td>13 Fraser</td>
<td>0.005</td>
<td>0.003</td>
</tr>
<tr>
<td>14 Lower Thompson</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>15 North Thompson</td>
<td>0.000</td>
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<tr>
<td>16 South Thompson</td>
<td>0.022</td>
<td>0.007</td>
</tr>
<tr>
<td>17 Puget Sound</td>
<td>0.024</td>
<td>0.008</td>
</tr>
<tr>
<td>18 Washington Coast</td>
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<td>0.006</td>
</tr>
<tr>
<td>19 West Cascades Sp</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>20 Lower Columbia F</td>
<td>0.020</td>
<td>0.007</td>
</tr>
<tr>
<td>21 Willamette Sp</td>
<td>0.103</td>
<td>0.013</td>
</tr>
<tr>
<td>22 Columbia Sp</td>
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<td>0.000</td>
</tr>
<tr>
<td>23 Interior Columbia Su/F</td>
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<td>0.020</td>
</tr>
<tr>
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<tr>
<td>25 Mid Oregon Coast</td>
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<td>0.003</td>
</tr>
<tr>
<td>26 S Oregon/California</td>
<td>0.000</td>
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</tr>
</tbody>
</table>

Note: Sample sizes (n), standard deviation (SD), and 90% credibility intervals are provided.

Run timing components are abbreviated as Sp (spring), Su (summer), and F (fall).
Appendix B5.—Estimated contributions of fine-scale reporting groups of Chinook salmon to the harvest for the spring troll fishery regionwide and in the Northern Outside and Southern Inside quadrants of SEAK, AY 2015.

<table>
<thead>
<tr>
<th>Reporting Group^a</th>
<th>Regionwide (n = 884)</th>
<th>Northern Outside Quadrant (n = 301)</th>
<th>Southern Inside Quadrant (n = 299)</th>
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<td>Median</td>
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<td>0.000</td>
</tr>
<tr>
<td>2 Alsek</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>3 N Southeast Alaska</td>
<td>0.001</td>
<td>0.001</td>
<td>0.001</td>
</tr>
<tr>
<td>4 Taku</td>
<td>0.009</td>
<td>0.007</td>
<td>0.007</td>
</tr>
<tr>
<td>5 Andrew</td>
<td>0.269</td>
<td>0.018</td>
<td>0.269</td>
</tr>
<tr>
<td>6 Stikine</td>
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</tr>
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<td>0.015</td>
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<td>0.006</td>
</tr>
<tr>
<td>9 Skeena</td>
<td>0.011</td>
<td>0.004</td>
<td>0.010</td>
</tr>
<tr>
<td>10 BC Coast/Haida Gwaii</td>
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<td>0.013</td>
<td>0.139</td>
</tr>
<tr>
<td>11 West Vancouver</td>
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<td>0.009</td>
<td>0.072</td>
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<tr>
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<td>0.027</td>
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<td>13 Fraser</td>
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<td>14 Lower Thompson</td>
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<tr>
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<td>22 Columbia Sp</td>
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</table>

Note: Sample sizes (n), standard deviation (SD), and 90% credibility intervals are provided.

^a Run timing components are abbreviated as Sp (spring), Su (summer), and F (fall).
Appendix B6.—Estimated contributions of fine-scale reporting groups of Chinook salmon to the harvest for the first retention period of the summer troll fishery regionwide and in the Northern Outside quadrant of SEAK, AY 2015.

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<td>Mean</td>
<td>SD</td>
<td>Median</td>
<td>5%</td>
<td>95%</td>
<td></td>
<td></td>
<td></td>
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</tr>
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<td>0.01</td>
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<td>0.00</td>
<td>0.00</td>
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</tr>
<tr>
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<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
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</tr>
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<td>0.20</td>
<td>0.04</td>
<td>0.00</td>
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</tr>
<tr>
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</table>

Note: Sample sizes (n), standard deviation (SD), and 90% credibility intervals are provided.

a Run timing components are abbreviated as Sp (spring), Su (summer), and F (fall).
Appendix B7.–Estimated contributions of driver stock reporting groups of Chinook salmon to the annual SEAK troll fishery harvest, AY 2009–2015.

<table>
<thead>
<tr>
<th>Reporting Group</th>
<th>AY 2009 (n = 1,629)</th>
<th>AY 2010 (n = 3,197)</th>
<th>AY 2011 (n = 5,198)</th>
<th>AY 2012 (n = 3,288)</th>
<th>AY 2013 (n = 2,095)</th>
<th>AY 2014 (n = 3,465)</th>
<th>AY 2015 (n = 2,816)</th>
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</thead>
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<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Median</td>
<td>95% CI</td>
<td>Mean</td>
<td>SD</td>
<td>Median</td>
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</table>

Note: Sample sizes (n), standard deviation (SD), and 90% credibility intervals are provided.

Note: Reporting groups are described in Table 1.