PSC Northern Fund
Final Report

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Project Title: Origins of Chinook Salmon Harvested in Southeast Alaska Fisheries, 2018

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Abstract:
U.S. fisheries in Southeast Alaska (SEAK) harvest stocks of Chinook salmon bound for river systems in Alaska, Canada, and the continental U.S. Thus, fisheries in SEAK are managed under the purview of the Pacific Salmon Treaty (PST), in which an aggregate abundance-based management (AABM) framework is used for Chinook fisheries. This requires management to have access to reliable information on stock-specific catch, escapement, and recruitment to forecast indices of abundance in PST fisheries. This project aimed to improve fishery management and provide estimates of stock composition in commercial troll and sport Chinook salmon fisheries in Southeast Alaska, independent of coded wire tag (CWT) recoveries. We extended genetic mixed stock analysis of Chinook salmon harvested or encountered in the commercial troll and sport fisheries in Southeast Alaska until the close of the summer fisheries in September 2018. A total of 12,016 fish were sampled and 5,637 fish were genotyped from sport and commercial fisheries in 2018. Results indicate considerable temporal and spatial variation in the compositions of troll and sport harvests within years and across years. The largest contributor to the Southeast Alaska troll fisheries were more diverse than previous years with *Southeast Alaska/TBR*, *Washington Coast*, *Oregon Coast*, *West Vancouver Island, Interior Columbia River Su/Fa*, and *South Thompson* reporting groups each contributing >10% to the annual harvest. The largest contributors to the Southeast Alaska sport fisheries were the *Southeast Alaska/TBR* and *West Vancouver Island* reporting groups, which accounted for over half of the annual harvest. These stock composition estimates provide important information for Chinook salmon fisheries managed under the Pacific Salmon Treaty.

Introduction:
Chinook salmon are harvested throughout the year by commercial and sport fishers in the waters of Southeast Alaska, including in commercial troll fisheries and sport fisheries throughout the region. In these fisheries mixed stocks of Chinook salmon are harvested, including salmon originating from Alaska, British Columbia, and the Lower 48. Thus, these fisheries are under the jurisdiction of the Pacific Salmon Treaty (PST) which established a framework for aggregate abundance-based management (AABM) of the Chinook salmon harvest in Southeast Alaska. Allowable catches are specified by the PSC and rely on catch, escapement, recruitment information, and stock composition estimates to forecast indices of abundance in Treaty fisheries. Since 1999, genetic stock identification has been used to estimate the composition of the commercial troll fishery harvest (Crane et al. 2000; Templin et al. 2011; Gilk-Baumer et al. 2013,

2017a, 2017b, 2018), gillnet and seine harvest (e.g. Gilk-Baumer and Carlile 2012), and sport fishery harvests (Gilk-Baumer et al. 2017c, 2018).

This project aimed to take the analysis beyond basic estimation of stock composition by combining genetic assignment of individuals from selected stocks and fisheries with their associated age and mark information to provide additional information about Chinook salmon in SEAK fisheries for CTC needs. This type of information has been used to measure the effectiveness of management actions in SEAK as well as to contribute to applications outside of SEAK (e.g. estimating age-specific terminal returns of stock groups and forecasting returning run sizes). This program had particularly important benefits in 2018, given that domestic management of Chinook harvest in SEAK during the winter and spring commercial troll and sport fisheries were altered to avoid harvesting wild-origin SEAK stocks that were recently declared stocks of concern by the Alaska Board of Fisheries (Hagerman, Ehresmann, and Shaul 2019). This project is an integral part of a larger SEAK GSI program, which includes comprehensive coverage of major gillnet, troll, and sport fisheries for Chinook salmon.

Objectives:

The objective of this project is to identify the origins—stock, age, and hatchery or natural origin—of fish harvested in the Southeast Alaska (SEAK) Chinook salmon fisheries in Accounting Year 2017. Project tasks to accomplish this objective are as follows:

1. Estimate the relative stock composition of seasonal fishery harvests in SEAK using genetic mixed stock analysis such that the estimated stock composition is within 5% of the true value 90% of the time:
    a. Troll fishery – seasonal troll fishery harvests from October 2017 through September 2018 (<u>early winter</u>: October to December, <u>late winter</u>: January to March, <u>spring</u>: April to June, <u>summer</u>: July to September).
    b. Sport fishery – harvests between April and September 2018.
2. Estimate the stock composition and number of Chinook salmon harvested annually in the SEAK fisheries by ages such that the estimated stock composition is within 7% of the true value 90% of the time for stocks representing more than 5% of the harvest.
3. Combine information from mixed stock analysis, individual assignment, otolith marks, coded wire tags, adipose clips, age, and harvest to identify Pacific Salmon Commission (PSC) Chinook Model stocks captured in the SEAK fisheries,
4. Provide age-specific estimates of the catch for stocks of interest to the Chinook Technical Committee (CTC), and to allow a comparison between PSC Chinook Model estimates and genetic stock identification (GSI) estimates.

Approach:

The origins of Chinook salmon harvested in SEAK fisheries were estimated using a combination of GSI and recovery of marked salmon. Chinook salmon samples were collected from commercial troll landings at processors in SEAK, and in the sport fishery by onboard participants and by creel census samplers.

Chinook salmon were selected for sampling without regard to size, sex, adipose fin-clip, or position in the hold. Axillary process tissue was dissected from sampled fish and placed on Whatman paper grid cards for dry tissue preservation. Along with each individual sampled, basic information was recorded such as size, sex, date, vessel, and age (from scale samples). Scale and tissue samples were taken from each sampled fish in a manner that allows specimens to be tracked to individual fish. In recreational fisheries in Sitka and Craig, heads (for otoliths) were taken from each sampled fish to provide a means to identify hatchery origin versus natural origin for those Chinook salmon determined by genetic means to be of WCVI origin. Each individual fish sampled was assigned a unique sample number and all associated data were maintained in the ADF&G database. At the end of the fishery, genetic samples were transported back to the ADF&G Gene Conservation Laboratory, Anchorage, for analysis.

Representative sets of individuals for mixture analysis were created by subsampling from the collected samples in proportion to the harvest in quadrants comprising the stratum to be estimated. Target mixture sizes were 200, 300, or 400 individuals to achieve acceptable levels of accuracy and precision. Due to the vagaries of fisheries and fishery sampling, target sample sizes were not available for every time and space stratum. Sample sizes smaller than the target were analyzed, but strata represented by fewer than 100 individuals were pooled into larger groups for analysis.

Samples were assayed for DNA loci developed by the Genetic Analysis of Pacific Salmon (GAPS) group funded by the PSC for use in PST fisheries (Seeb et al. 2007). Laboratory methods are well established and have been described in previous proposals and reports. Briefly, DNA were extracted from tissue and the polymerase chain reaction (PCR) was used to amplify DNA fragments at specified locations in the genome. PCR fragment analysis was done on an AB 3730 capillary DNA sequencer and PCR bands were visualized and separated into bin sets using *AB GeneMapper* software v4.0. All laboratory analyses followed protocols accepted by the CTC. The genetic data collected were individual genotypes for each locus. Genotype data are stored in an *Oracle* database (LOKI) maintained by ADF&G.

Errors which can occur in tissue handling, laboratory processes, genotyping, and data recording can have an effect on the accuracy and precision of stock composition estimates and individual assignments. Several measures were implemented to ensure the quality of data produced, including reanalysis of approximately 8% of the individuals for all loci and genotyping by two observers. Details on quality control methods can be found in Gilk-Baumer et al. (2013).

The stock composition of fishery mixtures was estimated using the program BAYES (Pella and Masuda 2001). Proof tests indicate that a minimum of 21 reporting groups are identifiable at a correct allocation of 90% or better (Table 1). We defined prior parameters for each stock group equal to results from the corresponding estimates generated for the 2017 fisheries, with the prior for each stock group subsequently divided equally to populations within that stock group. We ran five independent Markov Chain Monte Carlo (MCMC) chains of 40,000 iterations with different starting values, and then discarded the first 20,000 iterations to remove the influence of the initial start values. Convergence was tested both within and among chains. The mean and 90% credibility intervals were tabulated from the combined set of the second half of the five chains. This procedure was repeated for each fishery mixture, with the goal of estimating the proportions in the mixtures within 7% of the true value 90% of the time (Thompson 1987).

Stock group origin of each sampled fish was identified through GSI using ONCOR (Kalinowski et al. 2008). Individuals were determined to be of particular stock of origin if they had a cumulative probability of >0.80 of having originated from the populations representing that stock group in the baseline based on the posterior probability distribution from the mixture analysis.

Individuals identified as originating from one of the stocks of interest were used for the remaining analyses. First, otoliths were extracted from the heads of individuals identified as being of WCVI origin (by their genotype) collected in recreational fisheries in Sitka and Craig. Otoliths were inspected for thermal bands by the ADF&G Mark, Tag and Age Laboratory. Existence of thermal marks indicated that the WCVI individual was of hatchery origin, while lack of thermal marks indicated the individual was of natural origin. For remaining stocks of interest, Chinook salmon containing CWTs were expanded by the sampling percentage and the mark fraction to estimate the fish of hatchery origin. Within each stock group, the natural origin Chinook salmon was estimated by calculating the difference between the estimated stock total and the estimate of hatchery origin fish. In addition, the individual’s scales were inspected to determine age. Personnel from Fisheries and Oceans Canada (DFO), Oregon Department of Fish and Wildlife (ODFW), Columbia River Inter-Tribal Fish Commission (CRITFC), and Washington Department of Fish and Wildlife (WDFW) examined scales from their respective areas (determined by their genotype) to determine age. This information was used to estimate stock compositions by age.

Table 1. Reporting groups and corresponding CTC model stocks (where applicable) for the coast-wide Chinook salmon baseline. Collection details are available in Seeb et al. 2007 and Moran et al. 2005.

	Reporting Group	CTC Model Stock(s)	No. Pops	N
1	Yakutat	None	5	972
2	Northern Southeast AK	None	4	487
3	Transboundary	None	14	3,184
4	Southern Southeast AK	Alaska South Southeast	19	2,880
5	North/Central BC	North/Central BC	49	6,662
6	Lower Strait of Georgia	Lower Strait of Georgia Hatchery	6	1,082
		Lower Strait of Georgia Wild	8	1,172
7	Upper Strait of Georgia	Upper Strait of Georgia	2	211
8	West Vancouver Island	West Vancouver Island	16	2,508
9	Fraser Late	Fraser Late	1	216
10	Fraser Early	Fraser Early	48	5,761
11	South Thompson	Fraser Early	8	871
12	Puget Sound	Nooksack Fall	1	74
		Nooksack Spring	1	137
		Puget Sound Fingerling	9	977
		Puget Sound Natural Fingerling	5	686
		Puget Sound Yearling	1	146
		Skagit Wild	3	247
		Snohomish Wild	4	517
		Stillaguamish Wild	1	290
		None	4	376
13	Juan de Fuca	None	4	544
14	Washington Coast	Washington Coastal Hatchery	5	504
		Washington Coastal Wild	5	412
15	Lower Columbia Fall	Fall Cowlitz Hatchery	1	116
		Lewis River Wild	3	290
		Lower Bonneville Hatchery	3	280
		Spring Creek Hatchery	1	194
		None	6	555
16	Willamette Spring	Willamette River Hatchery	6	550
17	Columbia Spring	Spring Cowlitz Hatchery	3	373
		None	56	5,534
18	Interior Columbia Su/Fa	Columbia River Summers	4	434
		Columbia Upriver Brights	10	1,206
		Spring Creek Hatchery	1	94
		Lyons Ferry	3	396
19	North Oregon Coast	Oregon Coast	11	1,103
20	Mid Oregon Coast	None	8	790
21	Southern Oregon/California	None	18	1,922

In addition to making raw data available for outside analyses, summarization of data will be completed through stock composition estimates. This work will assess different parts of the model that currently use CWT information and will provide additional information on stocks or components of stocks not included in the model. In addition, the above analyses could be used in a number of ways including: assessment of differential vulnerabilities of components of different stocks (e.g. different mortality rates between separate age groups for a particular stock); real-time forecasting of Chinook salmon runs (e.g. Hyun et al. 2013); and estimation of terminal run sizes of certain stocks (e.g. Korman et al. 2012, Bernard et al. 2014). This data has already been used to look at the origins of Chinook salmon harvested in SEAK troll and sport fisheries to provide independent estimates of stock composition of wild- versus hatchery-origin stocks.

Results/Findings:

Sampling of harvests of Chinook salmon in Southeast Alaska troll and sport fisheries began in October 2017 and continued until September 30, 2018. Samples from fisheries were returned to the laboratory in May – October 2018, and laboratory analysis was completed in December 2018 (Tables 2–3). Data analysis was completed in 2019 to estimate the relative stock composition of CTC Model stocks of interest in Southeast Alaska fisheries using genetic stock identification, and applied these estimates to harvest numbers (Figures 1–4). Ageing and otolith inspection is still pending for most stocks as of September 2020 due to limited staff capacity at collaborating agencies (Table 4).

Table 2. Number of Chinook salmon sampled in the Southeast Alaska troll fisheries between October 2017 and September 2018 (AY 2018).

Fishery	Port	Goal	Sampled
Early Winter (October – December)	Craig	50	31
	Juneau	30	56
	Ketchikan	60	35
	Petersburg	25	35
	Sitka	400	508
	Wrangell	0	33
	Yakutat	30	0
Late Winter (January – March)	Craig	50	498
	Juneau	30	45
	Ketchikan	80	35
	Petersburg	40	131
	Sitka	350	176
	Yakutat	30	0
Spring (April – June)	Craig	300	554
	Juneau	200	0
	Ketchikan	300	1786
	Petersburg	200	0
	Sitka	600	1608
	Wrangell	100	0
	Yakutat	50	161
Summer (July – September)	Craig	500	767
	Elfin Cove	100	0
	Hoonah/Juneau	80	90
	Ketchikan	300	495
	Pelican	60	143
	Petersburg	120	334
	Port Alexander	120	0
	Sitka	700	1,066
	Wrangell	60	122
	Yakutat	50	0
	Observer	0	631
	Total	5,015	9,340

Table 3. Number of Chinook salmon sampled from Southeast Alaska sport fisheries during the spring and summer of 2018.

Fishery	Port	Goal	Sampled
Sport	Juneau	600	267
	Haines	15	0
	Skagway	20	0
	Glacier Bay	65	55
	Sitka	1,500	1,069
	Yakutat	75	109
	Elfin Cove	50	98
	Craig	500	461
	Petersburg	450	66
	Wrangell	200	56
	Ketchikan	600	495
	Total	4,075	2,676

Table 4. Matched information available by CTC stock of interest for Chinook salmon sampled in the AY2018 sport and troll fisheries in SEAK.

Stock of Interest	Assigned with genotype	Aged	Otolith	CWT[1]
South SEAK	1,667	1,598	0	124
North Cent BC	325	pending	0	12
WCVI	1,190	pending	394	59
Wash. Coast	309	in progress	0	63
Int. Columbia Su/F	448	pending	0	68
N. Oregon Coast	178	162	0	7

[1]Does not include ad clipped fish that did not have a CWT.

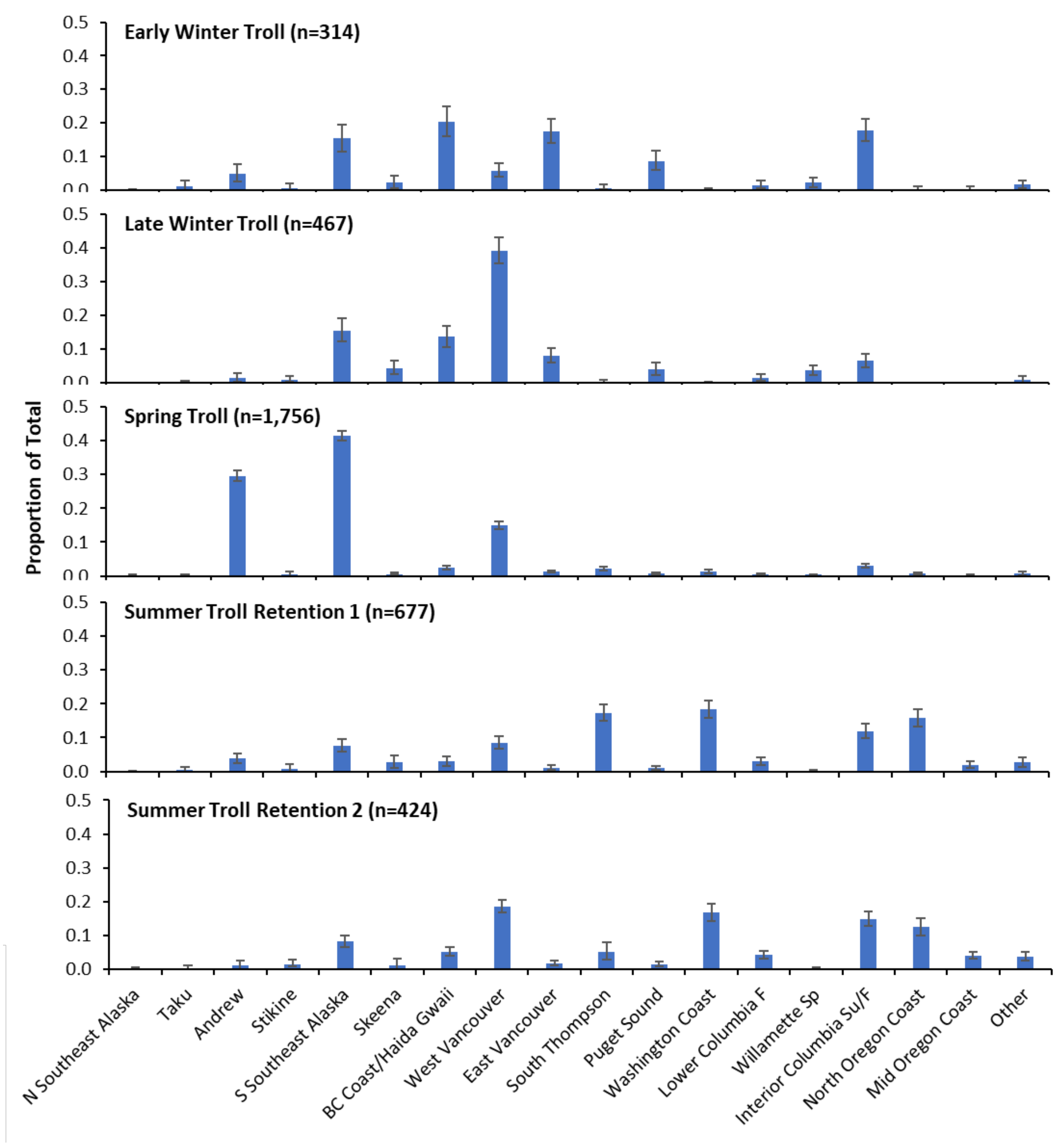

Figure 1. Estimated proportional contributions of a subset of 18 reporting groups of Chinook salmon to the harvest during the Southeast Alaska troll fisheries in AY 2018. Minor contributing reporting groups are combined into an *Other* group for ease of interpretation. Estimates are given for all quadrants combined for each fishery.

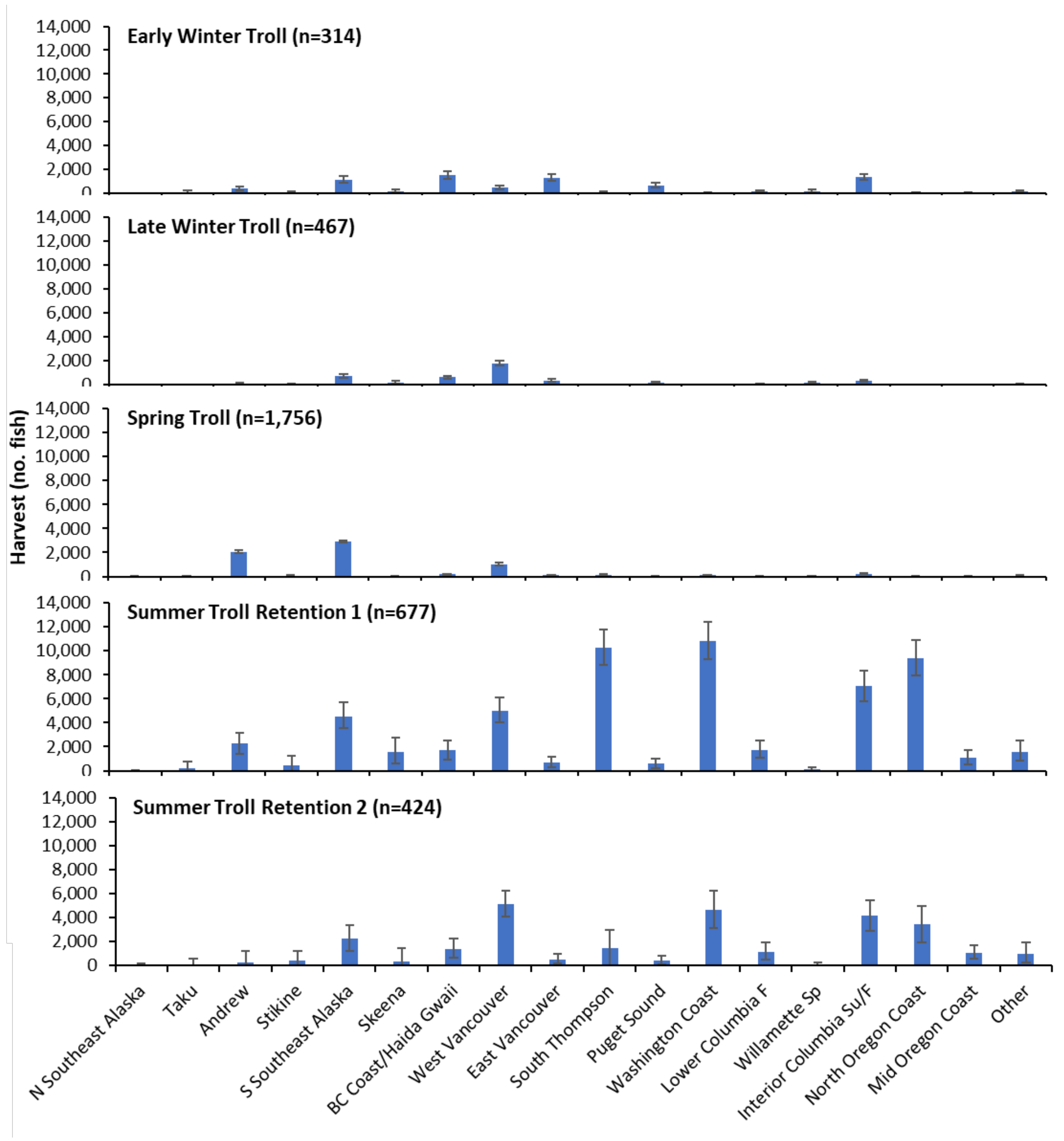

Figure 2. Harvest numbers of a subset of 18 reporting groups of Chinook salmon to the harvest during the Southeast Alaska troll fisheries in AY 2018. Minor contributing reporting groups are combined into an *Other* group for ease of interpretation. Estimates are given for all quadrants combined for each fishery.

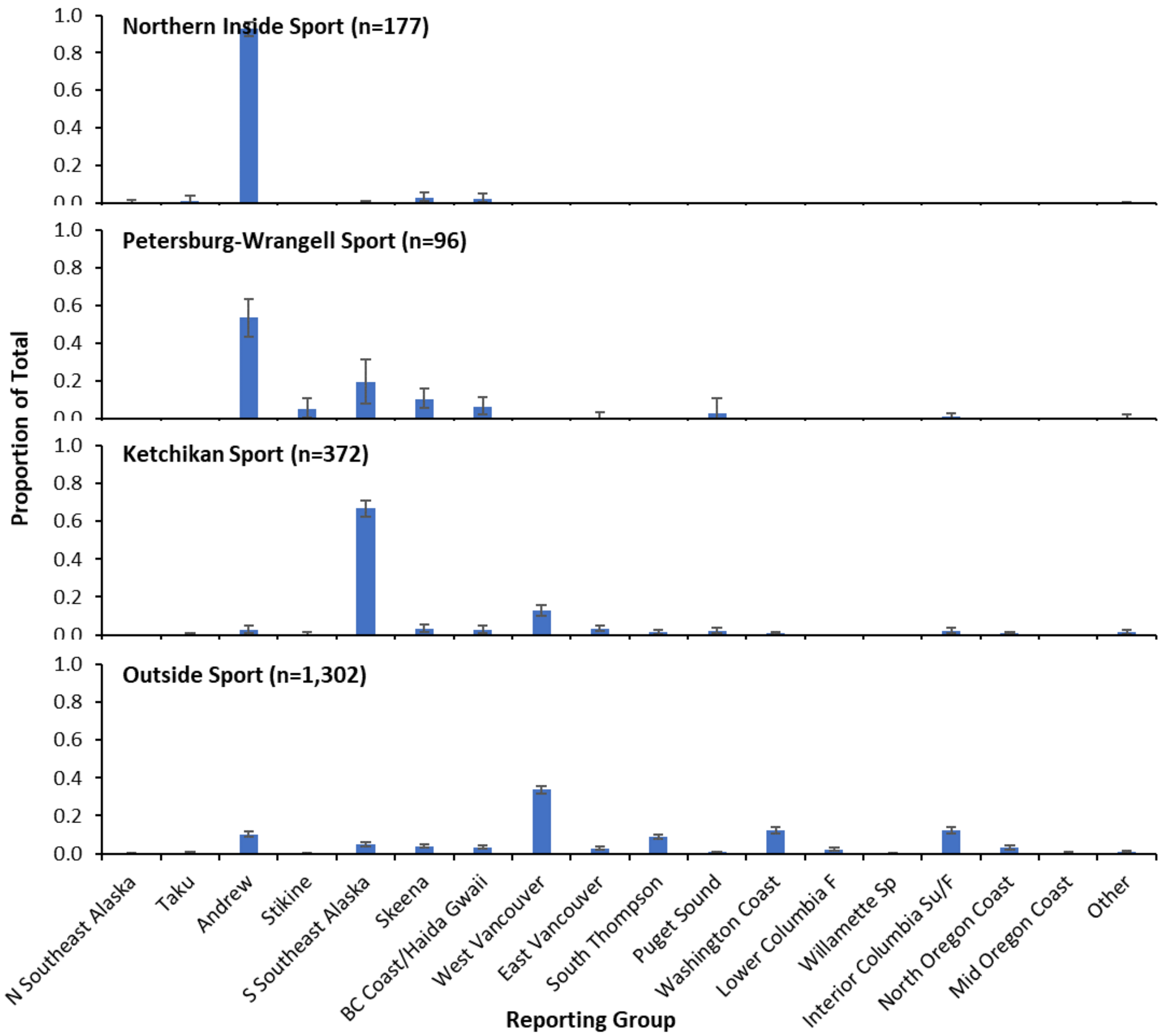

Figure 3. Estimated proportional contributions of a subset of 18 reporting groups of Chinook salmon to the harvest during the Southeast Alaska sport fisheries in AY 2018. Minor contributing reporting groups are combined into an *Other* group for ease of interpretation.

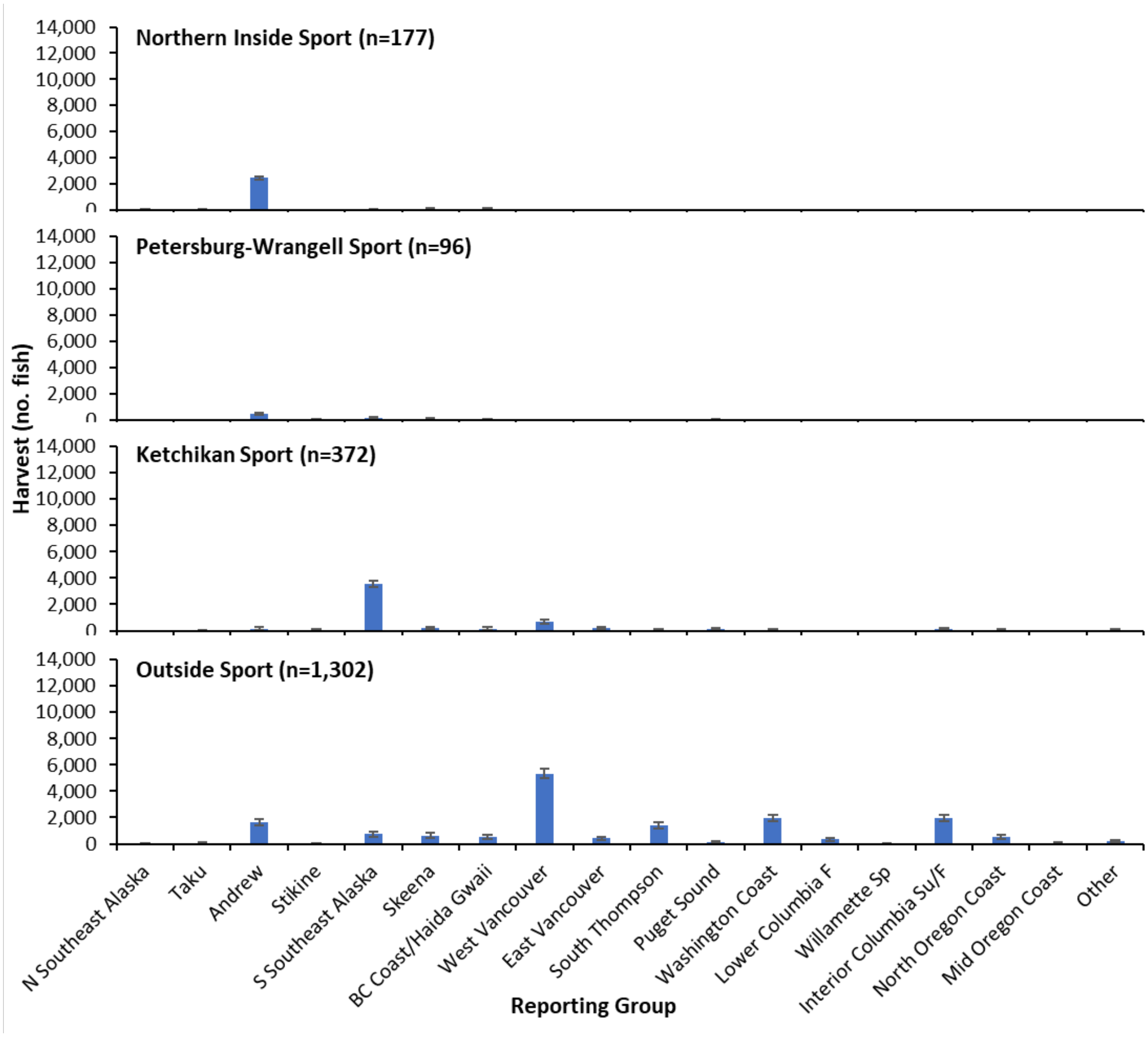

Figure 4. Harvest numbers of a subset of 18 reporting groups of Chinook salmon to the harvest during the Southeast Alaska sport fisheries in AY 2018. Minor contributing reporting groups are combined into an *Other* group for ease of interpretation.

Evaluation:

We accomplished the following:

- A total of 12,016 fish were sampled and 5,637 fish were genotyped from Southeast Alaska sport and commercial Chinook fisheries in 2018.
- All samples from were assayed for genotypes for the 13 microsatellite loci and quality control procedures revealed a low rate of inconsistencies.
- Mixture analyses estimated the contributions of 18 reporting groups of CTC interest.
- Mixture analyses indicate considerable temporal and spatial variation in the compositions of troll and sport harvests within years and across years. As opposed to previous years, largest contributors to the Southeast Alaska troll fisheries were from a very diverse and equally weighted group of driver stocks with *Southeast Alaska/TBR*, *Washington Coast*, *Oregon Coast*, *West Vancouver Island*, *Interior Columbia River Su/Fa*, and *South*

Thompson reporting groups each contributing >10% to the annual harvest. The largest contributors to the Southeast Alaska sport fisheries were the *Southeast Alaska/TBR* and *West Vancouver Island* reporting groups, which accounted for over half of the annual harvest. These large changes in stock composition in 2018 were in part due to the reshaping of SEAK troll and sport fisheries to avoid wild-origin SEAK fish due to stocks of concern

- Ageing was completed for two stocks, in progress for one stock, and pending for remaining stocks.
- Otolith work is ongoing.

The following results are still pending:

- Ageing labs at CRTFC, DFO, and WDFW have experienced capacity issues and have been unable to age scales associated with this project. The DFO ageing lab does not currently have the capacity to age Canadian-origin samples associated with this project, given shifting domestic priorities. No other scale ageing lab has yet been identified with the expertise to age *WCVI* or *North Central BC Coast* stocks, so this result is listed as "pending".
- Full implementation of objectives 3 and 4 are expected to continue and evolve as analysis needs are discussed with CTC model users.

Project Products:

Results from this project have been presented to ADF&G management staff and have been made available to bilateral PSC committees and panels. A multi-year report published in the ADF&G Fishery Data Series is expected in 2021.

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