Pacific Salmon Commission
Northern Fund

Northern Boundary Area Sockeye Salmon Genetic Stock Identification For Year 2006 and 2007 District 101 Gillnet and District 104 Purse Seine Fisheries

Final Report

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INTRODUCTION

Provisions outlined in Chapter 2 of the 1999 Pacific Salmon Treaty specify harvest sharing arrangements of Nass and Skeena River sockeye salmon returns between the United States and Canada. This treaty allows the United States to harvest a fixed percentage, averaged over ten years, of the annual allowable harvest (AAH) of Nass sockeye in the Alaskan District 101 gillnet fishery (GNF) and of Nass and Skeena sockeye in the District 104 purse seine fishery (PSF) prior to Statistical Week 31 (late July). There is also a District 101 purse seine fishery, but the catch in this fishery is not limited by the annex; it is used however in calculating the total return of Alaska, Nass and Skeena River stocks (along with Districts 102, 103 seine and 106 gillnet). Figure 1 illustrates the locations of the Alaska Department of Fish and Game (ADF&G) commercial fishing districts in the Northern Boundary area.

Accurate estimates of the stock composition of sockeye salmon caught in boundary area gillnet and purse seine fisheries (few are caught in troll fisheries) are required to estimate the total return (catch plus escapement) of stocks subject to harvest sharing agreements. The estimated total return is then used in calculating the percentage of the AAH caught in the Districts 101 gillnet and 104 purse seine fisheries. The AAH is calculated over the ten-year annex period. This approach allows for traditional fishing patterns based on stock abundance, recognizing that for some years more fish would be caught which would be compensated by other years in which less would be harvested.

It has been recognized for some time that U.S. and Canadian fishermen intercept salmon originating from the other country. Initial studies investigating the stock origins of pink and sockeye salmon caught in the Northern Boundary region between Alaska and British Columbia used mark-recapture techniques (Pella et al., 1993). These techniques involved tagging fish caught in boundary fisheries and re-capturing them at various weirs and through in-river escapement enumeration projects. This study found that a significant percent of the fish caught in Districts 101 and 104 fisheries originated from Canadian stocks (Pella et al., 1993). While informative, these tagging experiments were relatively expensive and labor intensive.

A study was undertaken in 1982 to evaluate scale pattern analysis as a means to discriminate particular stocks of fish (Marshall, 1984). This important study showed that sockeye salmon in the Alaska-British Columbia Northern Boundary area could be accurately discriminated using scales. Since then, scale pattern analysis (SPA) has been used by the ADF&G to determine stock proportions for sockeye salmon caught in the Districts 101 and 104 commercial sockeye fisheries.

While effective, scale pattern analysis requires yearly examination of source populations for each of the four major age classes (1.2, 1.3, 2.2 and 2.3) since the scale baseline patterns are strongly affected by varying environmental conditions. The requirement to reestablish or revalidate the scale pattern baseline can be expensive and burdensome. The use of more stable markers would eliminate this necessity. Like scale patterns, DNA patterns can also be used to discriminate stocks of salmon (Milner et al., 1985). Given that salmon return to their natal streams with high fidelity, they represent naturally occurring isolated populations in which genetic allele frequencies can change due to the isolation and adaptation of particular populations. These changes in allele frequencies can then be used to distinguish salmon stocks to a finer degree of resolution than SPA. For example, scale analysis can efficiently separate 4 large stock groups (Alaska, Nass, Skeena and Fraser) whereas genetic analysis can separate 14 stock groups, adding the ability of managing area fisheries to target surplus stocks.

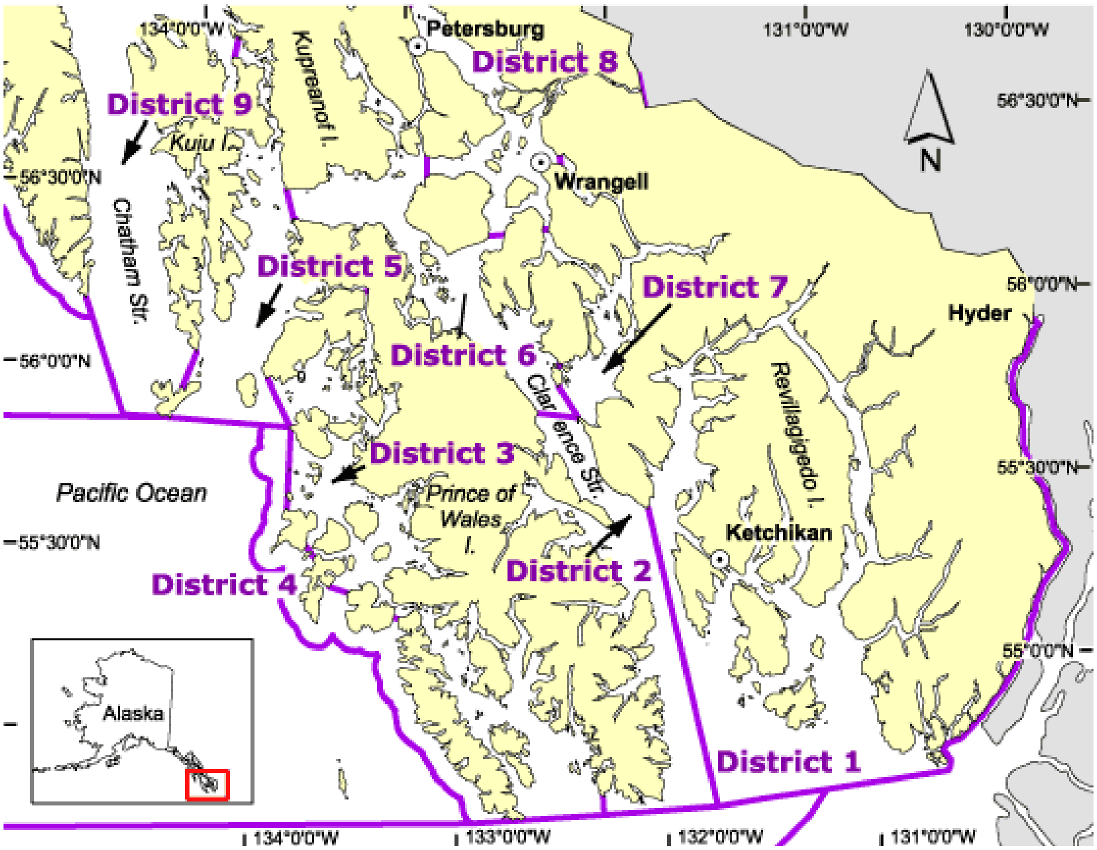

Figure 1. Geographic location of ADF&G Commercial Fishing Districts 101 (labeled District 1) and 104 (labeled District 4). Map obtained from the ADF&G web page (http://www.cf.adfg.state.ak.us/region1/finfish/salmon/maps/ketchikan.php).

Allozymes are naturally occurring protein size variants which have been used as genetic markers. As part of a study to estimate stock composition of sockeye salmon harvested in the 1987 Northern Boundary sockeye fisheries in ADF&G Districts 104 and 106 (Pella et al., 1998), four markers were used which included two unlinked allozyme markers (*PGM-1** and *PGM-2**), freshwater age, and brain-tissue parasitism (*Myxobolus arcticus*). Freshwater age and pathogen exposure are traits that, in combination with other markers, can be used to infer the stock composition of mixtures (Fournier et al., 1984; Pella and Milner, 1987). The 1987 study provided estimated proportions of 13 stock groups in the District 104 fisheries and confirmed that the majority of sockeye salmon caught were of Canadian origin, predominantly from the Nass and Skeena River systems (Pella et al., 1998). This analysis demonstrated that genetic markers could be effective in estimating the stock composition of sockeye salmon caught in Northern Boundary fisheries.

Although allozymes have been used in many genetic studies in salmon, it can be laborious to complete all the experiments necessary to score them. Since then, additional genetic markers have been evaluated including microsatellite DNA repeats and single nucleotide polymorphisms (SNPs). Like allozymes, both microsatellite and SNP markers can efficiently be used to separate stocks of salmon (Beacham et al., 2008; Smith et al., 2005b). While Canadian scientists use microsatellite markers for many of their Northern Boundary studies, ADF&G uses SNPs. Numerous studies have been completed outlining the advantages and disadvantages of each, although both have the resolving power necessary to accurately perform stock composition studies (Smith et al., 2007).

Over the last 6 years, the ADF&G has collaborated with numerous laboratories to develop a sockeye SNP baseline with 45 SNP markers (Habicht et al., 2007) This baseline has been used by the ADF&G to produce the 2004 and 2005 genetic stock composition analyses for Districts 101 and 104. As part of this process, the resolving power of the SNP baseline was evaluated using simulated mixture analyses, and this baseline was shown to be fully capable of distinguishing 14 Northern Boundary sockeye stock groups (Oliver 2009). Currently, 84 sockeye populations are part of the SNP baseline.

Problems in accurately estimating stock proportions of catches and total returns of sockeye salmon in the early years of the Pacific Salmon Treaty resulted in an extensive investigation by the bilateral Northern Boundary Technical Committee of run reconstruction modeling. The Committee concluded that improved stock identification techniques are needed for run reconstruction models. The most current method being evaluated is the use of SNP markers to genetically separate 14 stock groups of sockeye salmon caught in the Northern Boundary region. This technique has the advantage of a relatively stable baseline (does not change yearly) and can be highly automated. The purpose of this study is to provide the third and fourth years of genetic data using SNP markers to compare with the scale pattern analysis. If congruence between the two techniques is evident, it is likely that genetic analysis will replace scale pattern analysis for estimating stock composition of sockeye salmon caught in Northern Boundary fisheries.

Capture Location	***Date Collected***	***N***
Alecks Lake inlet creek	09/03/92	50
Auke Creek weir	07/--/97	40
Neckar Bay	07/23/91	88
Benzeman Lake outlet creek	08/15/93	99
Chunnk Mountain Slough (Taku Mainstem)	09/20/89	7
Crescent Lake weir-egg take	09/20/91	92
Ford Arm outlet creek weir	09/03/92	100
Kook Lake inlet creek	08/18/95	100
Kutlaku inlet creek	09/05/92	50
Lace River 15 miles from mouth	08/09/95	59
Lake Creek inlet creek of Auke Lake	09/02/97	50
Lake Eva inlet creek	08/14/95	100
Little Trapper Lake weir	09/14/91	25
Old Situk River	09/30/92	16
Old Situk River	09/20/95	90
Redoubt Lake inlet creek	10/05/91	8
Redoubt Lake inlet creek	08/26/93	27
Redoubt Lake inlet creek	08/19/94	76
Redoubt Lake Beach Spawners	10/10/91	60
Redoubt Lake Beach Spawners	10/04/91	32
Salmon Bay Lake inlet creek	09/09/92	40
Situk Lake near outlet of Situk River	09/19/95	99
South Fork Slough (Taku Mainstem)	09/27/89	19
Speel Lake weir-egg take	10/02/92	100
Steep Creek	08/04/91	50
Thoms Lake	09/08/92	50
Windfall Lake Inlet Creek	08/18/89	69
Yehring Creek	09/18/89	30
Yehring Creek	10/01/89	10
Yehring Creek	10/13/89	60
Yonakina Slough (Taku Mainstem)	09/27/89	17
Total		1713

Table 1. Newly genotyped sockeye salmon baseline populations.

OBJECTIVE

The purpose of this study was to genetically analyze axillary process samples from ~6,000 sockeye salmon harvested in the 2006 and 2007 Districts 101 gillnet and 104 purse seine sockeye fisheries to determine proportions of Canadian and U.S. fish. A SNP genetic baseline of 45 SNPs (41 markers as 3 groups of SNPs are linked) assayed in 84 sockeye populations from southeast Alaska and British Columbia was developed by the ADF&G. The 84 populations were grouped into 14 regions. With the exception of locus One_Serpin, which failed during genotyping, the same markers were evaluated in the baseline and mixtures. Stock proportions were estimated using a Bayesian mixture analysis. In addition to performing mixture analysis for the 2006 and 2007 fisheries, the sockeye baseline was also expanded as part of the 2007 project. Approximately 1700 fish from 21 locations (Table 1) were genotyped, which will be included in a future updated baseline.

Pop. #	Description	Region	Pop. #	Description	Region
1	East Alsek	**1**	43	Hetta Lake	**5**
2	Alsek - Klukshu River Weir late	**1**	44	Kanalku Lake	**5**
3	Alsek - Upper Tatshenshini	**1**	45	Klakas Lake	**5**
4	Berners Bay	**2**	46	Sarkar	**5**
5	Chilkat Lake early run	**2**	47	Shipley Lake	**5**
6	Chilkat River - Mule Meadows	**2**	48	Three Mile Creek - Klawock	**6**
7	Chilkoot Lake – beaches	**2**	49	Hatchery Creek – McDonald Lake	**7**
8	Chilkoot River - Chilkoot River	**2**	50	Hugh Smith - Cobb Creek	**8**
9	Crescent Lake	**2**	51	Hugh Smith Lake - Bushmann Creek	**8**
10	Falls Lake	**2**	52	Nass - Bowser Lake	**9**
11	Sitkoh Lake	**2**	53	Nass - Damdochax Creek	**9**
12	Snettisham Hatchery/Speel Lake	**2**	54	Nass - Hanna Creek	**9**
13	Steep Creek	**2**	55	Nass - Meziadin Lake	**9**
14	Windfall Lake	**2**	56	Nass - Tintina Creek	**9**
15	Redfish Lake Beaches	**2**	57	Skeena - Alastair Lake	**10**
16	Taku - Kuthai Lake	**3**	58	Skeena - Four Mile Creek	**10**
17	Taku - Little Tatsamenie	**3**	59	Skeena - Fulton River	**10**
18	Taku - Little Trapper Lake	**3**	60	Skeena - Kitsumkalum Lake	**10**
19	Taku - Taku River Mainstem	**3**	61	Skeena - Lakelse Lake (Williams)	**10**
20	Taku – Tatsamenie	**3**	62	Skeena - Lower Tahlo River	**10**
21	Taku - Tatsamenie Lake	**3**	63	Skeena - McDonell Lake (Zymoetz River)	**10**
22	Stikine - Iskut River	**4**	64	Skeena – Morrison	**10**
23	Stikine - Little Tahltan	**4**	65	Skeena - Nangeese River	**10**
24	Stikine - Scud River	**4**	66	Skeena - Nanika River	**10**
25	Stikine - Tahltan Lake	**4**	67	Skeena - Pierre Creek	**10**
26	Kutlaku Lake	**5**	68	Skeena - Pinkut Creek	**10**
27	Hatchery Creek - Sweetwater Lake	**5**	69	Skeena - Slamgeesh River	**10**
28	Heckman Lake	**5**	70	Skeena - Sustut (Johanson Lake)	**10**
29	Helm Lake	**5**	71	Skeena - Swan Lake	**10**
30	SI – Kah Sheets Lake	**5**	72	Skeena - Upper Babine River	**10**
31	Karta	**5**	73	QCI - Naden River	**11**
32	Kegan Lake	**5**	74	Central - Kitlope Lake	**12**
33	Kunk Lake - Etolin Island system	**5**	75	Fraser - Adams River (Shuswap late)	**13**
34	Luck Lake - P.O.W. Island	**5**	76	Fraser – Birkenhead	**13**
35	Mahoney Creek	**5**	77	Fraser - Chilko Lake	**13**
36	Mill Creek Weir - Virginia Lake	**5**	78	Fraser - Harrison River	**13**
37	Petersburg Lake	**5**	79	Fraser - Horsefly River	**13**
38	Red Bay Lake	**5**	80	Fraser - Raft River	**13**
39	Salmon Bay Lake	**5**	81	Fraser - Stellako River	**13**
40	Thoms Lake	**5**	82	Fraser - Weaver Creek	**13**
41	Unuk River - Gene's Lake	**5**	83	Baker Lake	**14**
42	Bar Creek - Essowah Lake	**5**	84	Cedar River	**14**

Table 2. Sockeye salmon baseline populations used in analysis.

METHODS

Genetic baseline and population grouping

Genetic samples from 84 baseline stocks (Table 2) were collated by ADF&G in collaboration with many other laboratories including NOAA's Auke Bay Laboratory and the Canadian Department of Fisheries and Oceans. The 84 populations were grouped into 14 regions (Table 3) based on manager needs to match the scale pattern analysis groupings, geographical location and historical knowledge.

Region	***Area***
1	Alsek
2	Northern southeast Alaska
3	Taku
4	Stikine
5	Southern southeast Alaska
6	Klawock
7	McDonald
8	Hugh Smith
9	Nass River
10	Skeena River
11	Queen Charlotte Island
12	Central Coast British Columbia
13	Fraser River
14	Washington

Table 3. Regional grouping designations.

Sample Collection

Matched genetic and scale samples were collected by port samplers from ADF&G. Samples were collected from the District 101 GNF and from the District 104 PSF. Genetic samples were clipped axillary processes that were stored in ethanol. The genetic samples were shipped to Auke Bay Laboratory for analysis and stored at room temperature. ADF&G collected genetic and scale samples from a maximum of 520 fish per statistical week for each district, of which up to 380 were analyzed.

DNA Extraction

DNA was isolated using a DNeasy Blood and Tissue Kit as described by the manufacturer (Qiagen, Inc.). In brief, small pieces of tissue (~20 mg) were excised from ethanol-stored axillary processes. The tissue pieces were digested in a proteinase solution for 3 hours and at 55ºC. Protease digestions were performed in 96 well plates. After digestion, the samples were centrifuged to remove undigested tissue fragments. Samples (with buffer) were centrifuged through a 96-well DNeasy plate. The samples on the plate were washed twice, each time followed by a centrifugation step. Following the final wash, the Qiagen plates were heated to 55 ºC for up to one hour to remove the residual ethanol. 200 *µl* of elution buffer was added to the sample plate, centrifuged and the eluate containing the DNA was stored at -20 ºC.

Single Nucleotide Polymorphism (SNP) Analysis

SNP genotyping was performed using Taqman chemistries (Applied Biosciences, Inc.) for 45 previously identified sockeye SNP probes. Of the 45 ADF&G sockeye SNP markers (Table 4) (Elfstrom et al., 2006; Smith et al., 2005a; Habicht et al., 2007), 44 were assayed in this analysis. The remaining assay, One_serpin was excluded from analyses due to poor resolution.

Taqman reactions were performed by transferring 1 *µl* of a 1:10 dilution of the eluted purified DNA (estimated final DNA concentration of *10 nl/µl*) to wells of a 384 well plate. Four wells were reserved for non-template controls. Each Taqman reaction was conducted in a 5 *µl* volume containing the template DNA, Taqman Universal PCR Mastermix, No AmpErase UNG (ABI), 900 nm of each PCR primer, and 200 nm probe. Thermal cycling was performed on a Dual 384-Well GeneAmp PCR System 9700 (Applied Biosystems, Inc.) using the protocol from Habicht et al. (2007).

Allele Scoring

After amplification, the Taqman genotyping reactions were assayed on an ABI PRISM 7900HT Sequence Detection System and scored using Sequence Detection Software 2.2 (Applied Biosciences, Inc.). Individual genotypes were imported into our genetic database developed with Progeny software (Progeny, Inc.).

Mixture Analysis

A mixture analysis using a Bayesian estimation method (Pella and Masuda, 2001) was implemented using Bayes software and was performed for each weekly mixture sample and each district. For every analysis, 14 Markov chain Monte Carlo chains were run for 10000 samples each. Priors for the 14 chains were established with diverse values for regional proportions: one chain for each region composing 95% of the stock mixture, with the other regions equally composed of the remaining 5%. Convergence of chains to posterior distributions of stock proportions was determined with Gelman and Rubin shrink factors (Gelman and Rubin 1992), and the first one-half of chains was discarded as burn-in before summarizing posterior distributions.

RESULTS

In 2006 and 2007, 62,770 and 66,822 sockeye salmon were harvested in District 101 GNF respectively which are less than the historical average of 87,345 (Table 5). In the District 104 PSF, 242,034 fish were harvested in 2006 which was approximately 100,000 fish less than the historical average (Table 6). The opposite occurred in 2007, when 770,666 fish were caught in district 104 PSF, which is more than double the historical average (Table 6).

Sockeye salmon DNA was isolated (Table 7) and genotyped for 44 SNP markers from 5,852 fish in 2006; and 5,267 fish in 2007. The data was imported into a Progeny database for analysis.

#	Name	Comments
1	*One_ACBP-79*	
2	*One_ALDOB-135*	
3	*One_CO1 (mitochondrial)*	*linked with 5&6*
4	*One_ctgf-301*	
5	*One_Cytb_17 (mitochondrial)*	*linked with 3&6*
6	*One_Cytb_26 (mitochondrial)*	*linked with 3&5*
7	*One_E2-65*	
8	*One_GHII-2165*	
9	*One_GPDH-201*	*linked with 10*
10	*One_GPDH2-187*	*linked with 9*
11	*One_GPH-414*	
12	*One_hsc71-220*	
13	*One_HGFA-49*	
14	*One_HpaI-71*	
15	*One_HpaI-99*	
16	*One_IL8r-362*	
17	*One_KPNA-422*	*ADF&G unpublished*
18	*One_LEI-87*	
19	*One_MARCKS-241*	*ADF&G unpublished*
20	*One_MHC2_190*	*linked with 21*
21	*One_MHC2_251*	*linked with 20*
22	*One_Ots213-181*	
23	*One_p53-534*	
24	*One_ins-107*	
25	*One_Prl2*	
26	*One_RAG1-103*	
27	*One_RAG3-93*	
28	*One_RFC2-102*	
29	*One_RFC2-285*	
30	*One_RH2op-395*	
31	*One_serpin-75*	*not resolved*
32	*One_STC-410*	
33	*One_STR07*	
34	*One_Tf_ex11-750*	
35	*One_Tf_in3-182*	
36	*One_U301-92*	
37	*One_U401-224*	*ADF&G unpublished*
38	*One_U404-229*	*ADF&G unpublished*
39	*One_U502-167*	*ADF&G unpublished*
40	*One_U503-170*	*ADF&G unpublished*
41	*One_U504-141*	*ADF&G unpublished*
42	*One_U508-533*	*ADF&G unpublished*
43	*One_VIM-569*	
44	*One_ZNF-61*	*ADF&G unpublished*
45	*One_Zp3b-49*	

Table 4. 45 SNP assays used to discriminate Northern Boundary sockeye populations.

Status of current SNP baseline

In comparison to SPA, genetic analysis has the potential for greatly increasing the precision and accuracy of stock composition estimates in the District 101 and 104 fisheries. An additional advantage of using DNA markers is that in-season results can theoretically be provided to fishery managers because, unlike SPA, it does not require annual baseline sampling. Importantly, a SNP baseline with good coverage has already been developed by the ADF&G for Southeast Alaska and British Columbia. ADF&G and NOAA's Auke Bay Laboratories are continuously updating the baseline by adding new populations and developing new markers. ADF&G made the most current sockeye baseline available to the ABL/TSMRI Genetics group for use in this analysis.

The ADF&G SNP baseline is comprised of 84 populations of fish characterized for 41 markers (38 individual SNPs and 3 groups of linked SNPs) (Oliver 2009; Habicht et al. 2007). The 84 populations of sockeye salmon are grouped into 14 regions. The original proposal called for Auke Bay Laboratories to analyze 25 SNPs for the 2006 genetic samples, although the proposal for analysis of the 2007 samples increased that number to 39. We have genotyped 5 additional markers for a total of 44 for the 2006 & 2007 samples.

District 101 Gillnet

Week	2006	2007	Historical Avg.
25	8,280	15,635	7,320
26	7,230	5,885	13,583
27	14,002	7,781	17,450
28	7,273	7,933	11,725
29	8,098	3,573	7,752
30	4,382	6,215	8,186
31	4,415	10,231	6,121
32	3,690	5,575	8,138
33	1,675	2,080	3,772
34	747	825	1,196
35	1,536	544	1,127
36	890	403	557
37	482	120	264
38	45	18	133
39	25	4	18
40	0	0	3
Total	62,770	66,822	87,345

Table 5. Numbers of sockeye salmon harvested in each statistical week in the District 101 gillnet fishery in 2006 and 2007 (http:// dungie.adfg .state.ak.us:8080 /CatchByMultiYear.po).

Stock Mixture Proportions

Because of the limited numbers of samples, fish from District 101 GNF weeks 34 and 35 in 2006 and weeks 34-37 in 2007 were combined into one mixture (Table 7). Likewise, fish from District 104 PSF weeks 27 and 28 in both years and weeks 34 and 35 in 2007 were also combined (Table 7). Weekly mixture samples were analyzed with Bayes software. In all analyses, the Gelman and Rubin shrink factors were less than 1.1, indicating convergence of the chains to posterior distributions.

District 104 Purse Seine

Week	2006	2007	Historical Avg.
27	1,000	7,406	2,245
28	3,898	17,547	14,397
29	18,564	21,619	22,925
30	66,153	65,563	31,259
31	82,770	206,860	88,050
32	43,878	205,054	73,559
33	13,028	170,051	46,660
34	12,743	47,428	51,409
36	0	0	5
Total	242,034	770,666	339,115

Table 6. Numbers of sockeye salmon harvested in each statistical week in the District 104 seine fishery in 2006 and 2007 (http://dungie.adfg .state.ak.us: 8080 /CatchByMultiYear.po).

Results from this analysis are presented in both graphical form (Figures 2-3) and Table form (Tables 8-11). Figures 2 and 3 graphically illustrate the estimated proportions of sockeye salmon endemic to each of the 14 regions that were harvested in each District and statistical week. Tables 8 and 9 provide the same data for the 2006 and 2007 101 gillnet fisheries, respectively, in numerical format showing the estimated stock group proportions, standard errors, and 95% probability intervals. Tables 9 and 10 illustrate results for the 104 purse seine fisheries in 2006 and 2007, respectively.

Analysis of the stock proportions of sockeye caught in Districts 101 GNF and 104 PSF over varying weeks shows interesting trends. For example, the sockeye commercial fishery in the 2006 District 101 GNF predominantly harvests Nass Region fish early in the season (89%), but over 10 weeks, this stock decreased to 22% of the catch. These fish were replaced with Skeena, Hugh Smith, and McDonald fish. Skeena stocks increased from 5% in week 25 to 23% in weeks 34/35. Hugh Smith stocks increased from 0% in week 25 to 23% in weeks 34/35. McDonald stocks increased from 2% in week 25 to 19% in weeks 34/35. In 2007, Nass harvests were at 85 % in week 25 declining to 7% in weeks 34-37. These fish were supplanted by Skeena, Hugh Smith, and McDonald fish. Skeena stocks rose from 7% in week 25 to a high of 48% in week 32. Hugh Smith peaked at 34% in week 29 from a low of 3% in week 25.McDonald was absent in week 25, and increased to 25% in weeks 34-37, with Skeena, Hugh Smith, and Stikine at 32%, 22%, and 12% respectively.

In the 2006 District 104 PSF, Skeena region stocks predominated throughout the entire fishery (43% in weeks 27/28 and 57% in week 34). In contrast, the proportion of Nass Region fish decreased during that same time period (24% starting and 4% ending) whereas the proportion of Fraser River fish increased (0% starting and 30% ending). Fraser fish surpassed Nass fish in weeks 32 and 33, 44% to 43%, and 54% to 30% respectively. McDonald fish was the predominate U. S. stock at 16% in week 25, decreasing to 5% in weeks 34 and 35. Skeena region stocks predominated again throughout the entire 2007 District 104 PSF: 63% in weeks 27/28 and decreasing slightly to 51% in weeks 34/35. Nass river numbers were low throughout ranging from 8% in weeks 27/28 to 2% in weeks 34/35, while SSE Alaska fish were higher in 2007 with 20% in weeks 27/28 dropping to 2% in weeks 34/35. The Fraser proportion increased from 0% to 42% during the same time period

The proportion estimates were used to estimate numbers of fish caught (Table 12). The small discrepancies between total numbers of fish in Tables 5, 6, and 12 were due to rounding errors in estimating numbers of fish caught from estimated stock group proportions; also table 5 totals include fish from weeks 36-40 in 2006, and weeks 38-40 from which no genetic samples were collected. Table 13 shows the estimated number of fish caught per region prior to statistical week 31. The Pacific Salmon Treaty allows for the harvest of a fixed percentage of Nass (for District 101) and Nass/Skeena (for District 104) sockeye prior to week 31.

2006 DNA Extracted			
Week	***104 Seine***	***101 Gillnet***	***Total***
25	0	377	377
26	0	380	380
27	147	380	527
28	75	305	380
29	280	379	659
30	379	380	759
31	379	378	757
32	380	379	759
33	260	380	640
34	353	101	454
35	0	160	160
Total	2,253	3,599	5,852

2007 DNA Extracted			
Week	***104 Seine***	***101 Gillnet***	***Total***
25	0	301	301
26	0	328	328
27	64	352	416
28	299	297	596
29	317	341	658
30	343	316	659
31	307	272	579
32	351	249	600
33	283	232	515
34	160	172	332
35	122	77	199
36	0	70	70
37	0	14	14
Total	2,246	3,021	5,267

Table 7. Numbers of sockeye samples from which DNA was extracted for genotyping for each District and statistical week.

DISCUSSION

Chapter 2 of the 1999 Pacific Salmon Treaty specifies U.S. and Canada harvest sharing arrangements of Nass and Skeena River sockeye salmon in Northern Boundary fisheries. In Alaska's District 101 and District 104 sockeye fisheries, the United States is allowed to harvest a fixed percentage of the annual allowable harvest (AAH) of Nass and Skeena River sockeye. Estimates of the stock-specific catch in these commercial fisheries are currently being provided by ADF&G using scale pattern analysis (SPA). This technique has been shown to be accurate, but requires the collection of yearly scale patterns to determine the year specific baseline for individual rivers. This is because annual fluctuations in environmental conditions can dramatically affect scale patterns.

Genetic markers are more stable than scale patterns and are not normally influenced by small environmental changes in short periods of time. Differences in allele frequencies in groups of genetic markers can be used to distinguish individual stocks of fish. These allele frequency differences can be reflective of evolutionary selective pressures that reflect the adaptive measures taken by unique stocks of fish to thrive in different environmental conditions, although these changes can often take many generations. Genetic stock identification is a powerful technique that takes advantage of these genetic differences to discriminate stocks of fish caught in a mixed stock fishery.

Auke Bay Laboratories has completed its genetic analysis of sockeye salmon caught in Districts 101 gillnet and 104 purse seine fisheries for 2006 and 2007. It should be recognized that while a total of 45 SNPs (41 markers) are currently used in the Southeast Alaska-British Columbia baseline, not all SNPs will be informative. For example, this same group of SNPs has been used by the ADF&G to separate stocks of fish in many regions of Alaska (Habicht et al., 2004; Habicht et al., 2007). SNPs that are effective at separating populations in one geographical location may not be effective at another location. A thorough analysis of the effectiveness of combinations of SNPs to resolve sockeye in southeast Alaska and British Columbia could help reduce the numbers of SNPs that need to be assayed to obtain the same resolution.

CONCLUSION

Our results indicate that a majority of sockeye salmon caught in the ADF&G District 101 gillnet and 104 purse seine fisheries originate from Canadian stocks in both 2006 and 2007. Our results are in general agreement with the mark-recapture studies completed in the early 1980's (Pella et al., 1993), scale pattern analyses completed since 1982 (Marshall, 1984), and allozyme/freshwater age/parasitism analyses completed in the late 1980's (Pella et al., 1998).   These correlations strongly suggest that all stock assessment methods have produced accurate and meaningful results in the management of these Northern Boundary fisheries. Compared with other methods, SNP genotyping is the most efficient method for stock assessment since it can be partially automated and the baseline does not require annual resampling. These advantages make it possible to use SNP markers to determine stock composition in a quicker time interval, allowing for improved management of the Northern Boundary fisheries.

The similarity between stock composition estimates produced using scale pattern analysis and genetic analysis helps validate both approaches for determining stock assessments. The similarity between the 2006 and 2007 stock composition estimates for Districts 101 GNF and 104 PSF and the 2004 and 2005 estimates for those same fisheries (Oliver 2009) suggest that the stock compositions are stable over a short interval. The finding that stock composition estimates have not changed by large measure since 1982 suggests a strong temporal stability in stock structure over long periods of time. Given that the large majority of fish (>75%) caught in the District 101 gillnet and 104 purse seine fisheries originate in 5 Canadian regions (mostly Nass, Skeena, and Fraser), it is likely that large changes in the escapements for those systems could have dramatic effects on the stock composition for these fisheries.

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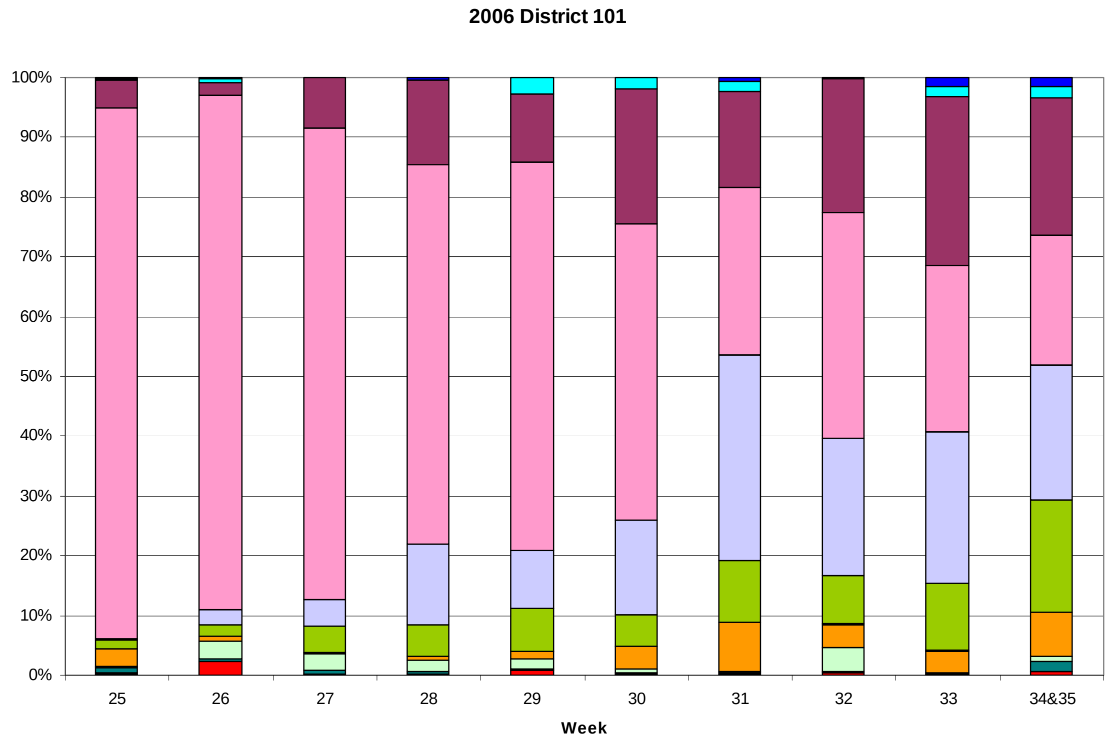
Figure 2. 2006 sockeye stock group proportions from the ADF&G District 101 gillnet (top panel) and 104 purse seine fisheries (lower panel).



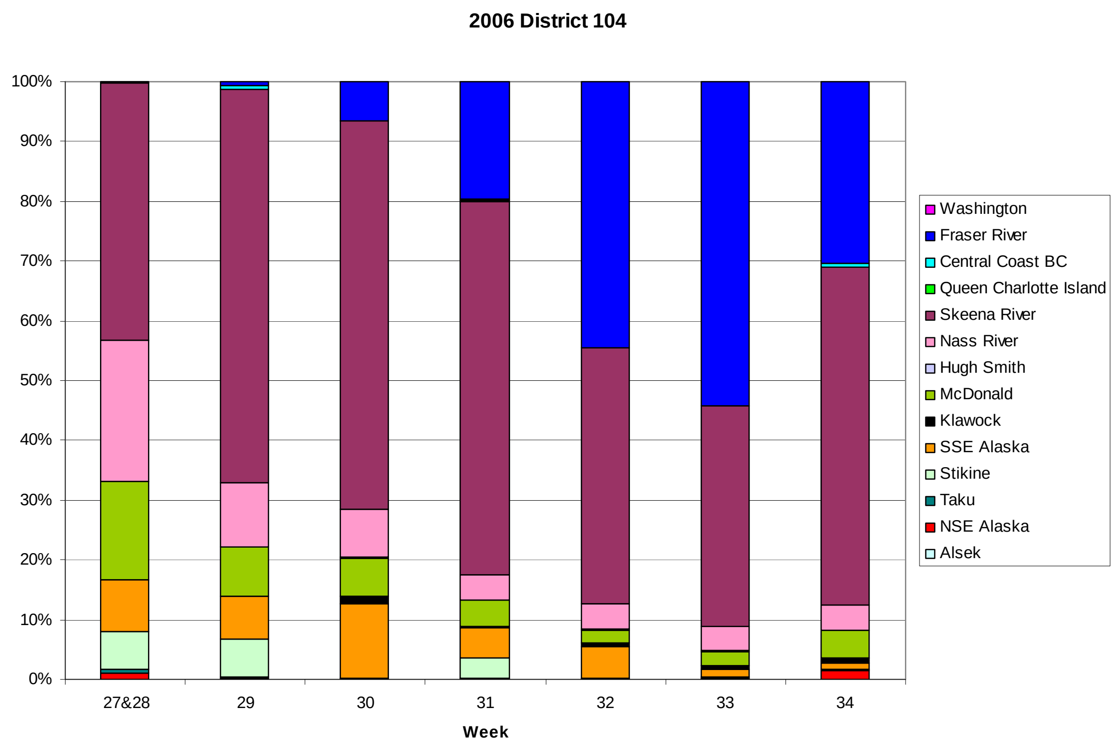
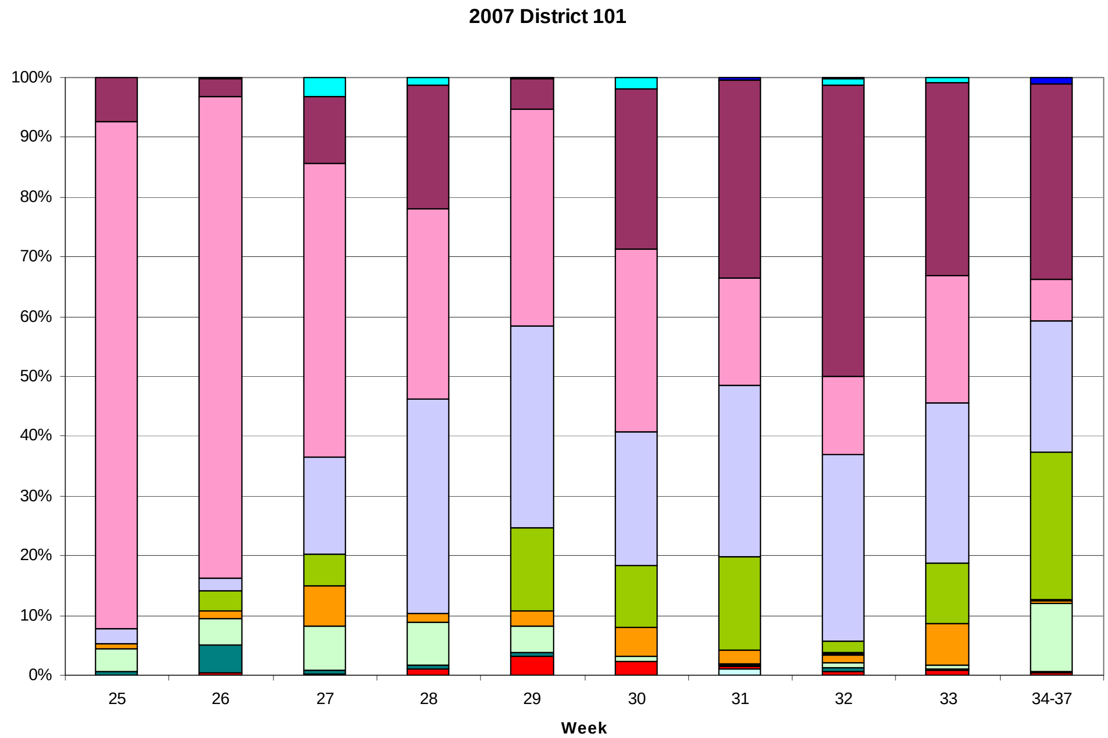
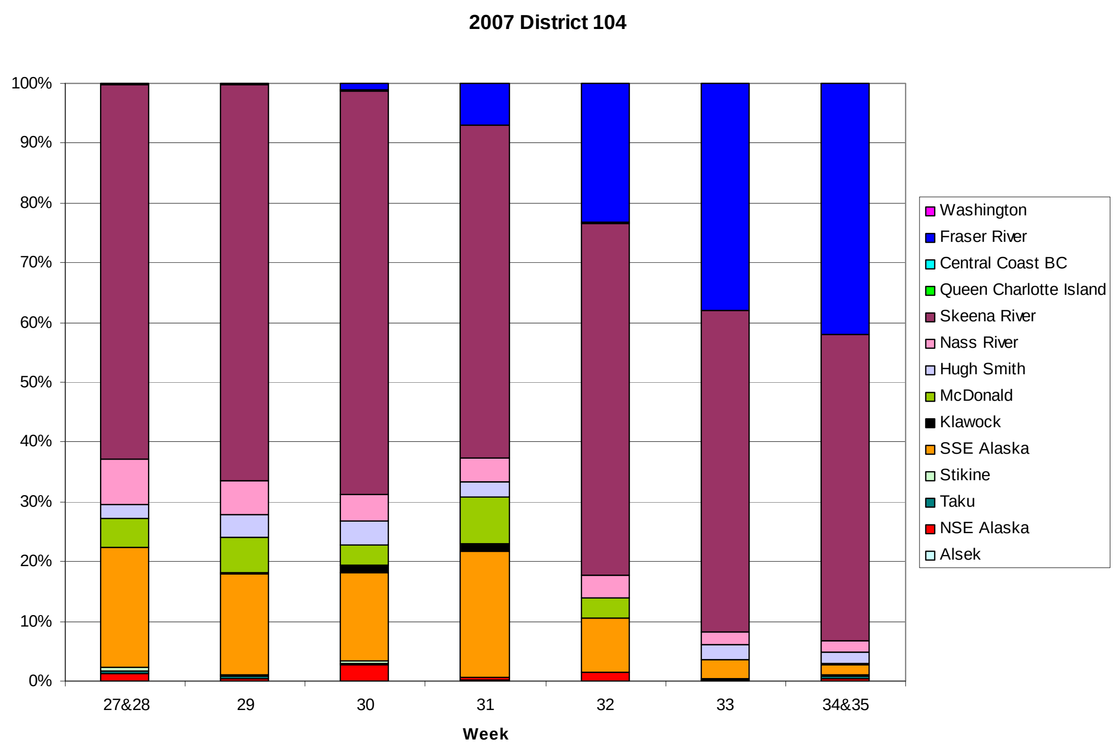


Figure 3. 2007 sockeye stock group proportions from the ADF&G District 101 gillnet (top panel) and 104 purse seine fisheries (lower panel).





	Week 25			Week 26			Week 27			Week 28		
	Mean	SD	95% PI	Mean	SD	95% PI	Mean	SD	95% PI	Mean	SD	95% PI
Alsek	0.2	0.34	(0.0,1.2)	0.0	0.11	(0.0,0.3)	0.0	0.15	(0.0,0.4)	0.0	0.15	(0.0,0.3)
NSE Alaska	0.1	0.32	(0.0,1.2)	2.4	1.29	(0.0,5.1)	0.2	0.39	(0.0,1.3)	0.2	0.46	(0.0,1.6)
Taku	1.0	1.04	(0.0,3.5)	0.3	0.67	(0.0,2.5)	0.8	1.39	(0.0,4.7)	0.4	1.00	(0.0,3.8)
Stikine	0.2	0.65	(0.0,2.4)	3.1	1.57	(1.1,7.1)	2.6	1.92	(0.0,6.5)	2.0	1.81	(0.0,5.9)
SSE Alaska	2.9	1.36	(0.4,5.8)	0.9	0.90	(0.0,3.1)	0.3	0.50	(0.0,1.8)	0.6	0.84	(0.0,3.0)
Klawock	0.0	0.07	(0.0,0.1)	0.0	0.06	(0.0,0.1)	0.0	0.08	(0.0,0.1)	0.0	0.16	(0.0,0.4)
McDonald	1.6	0.99	(0.0,3.9)	1.9	1.46	(0.0,5.2)	4.3	1.50	(1.7,7.6)	5.2	2.00	(1.8,9.6)
Hugh Smith	0.1	0.22	(0.0,0.6)	2.4	1.22	(0.0,5.0)	4.5	1.47	(2.0,7.7)	13.5	2.34	(9.2,18.3)
Nass River	88.8	1.79	(85.1,92.1)	86.0	2.01	(81.8,89.8)	78.9	3.01	(72.8,84.4)	63.4	3.57	(56.4,70.3)
Skeena River	4.8	1.37	(2.4,7.7)	2.1	1.09	(0.5,4.7)	8.4	2.67	(3.9,14.0)	14.2	3.41	(7.9,21.1)
Queen Charlotte I.	0.0	0.12	(0.0,0.3)	0.0	0.03	(0.0,0.0)	0.0	0.03	(0.0,0.0)	0.0	0.05	(0.0,0.0)
Central Coast BC	0.0	0.10	(0.0,0.1)	0.7	0.81	(0.0,2.7)	0.0	0.15	(0.0,0.2)	0.1	0.45	(0.0,1.6)
Fraser River	0.1	0.16	(0.0,0.5)	0.1	0.16	(0.0,0.6)	0.0	0.09	(0.0,0.3)	0.3	0.48	(0.0,1.7)
Washington	0.3	0.32	(0.0,1.1)	0.1	0.27	(0.0,0.9)	0.0	0.05	(0.0,0.1)	0.0	0.12	(0.0,0.3)

	Week 29			Week 30			Week 31			Week 32		
	Mean	SD	95% PI	Mean	SD	95% PI	Mean	SD	95% PI	Mean	SD	95% PI
Alsek	0.0	0.14	(0.0,0.3)	0.0	0.14	(0.0,0.3)	0.2	0.43	(0.0,1.5)	0.0	0.07	(0.0,0.1)
NSE Alaska	0.8	1.04	(0.0,3.5)	0.3	0.51	(0.0,1.8)	0.1	0.20	(0.0,0.7)	0.4	0.67	(0.0,2.3)
Taku	0.3	0.78	(0.0,2.9)	0.1	0.29	(0.0,0.9)	0.1	0.34	(0.0,0.9)	0.3	0.93	(0.0,3.8)
Stikine	1.5	1.38	(0.0,5.1)	0.6	0.97	(0.0,3.3)	0.2	0.69	(0.0,2.6)	4.1	1.73	(0.0,7.4)
SSE Alaska	1.4	1.09	(0.0,4.0)	3.8	1.72	(0.9,7.6)	8.2	2.55	(3.8,13.7)	3.7	1.75	(0.6,7.5)
Klawock	0.0	0.05	(0.0,0.0)	0.0	0.21	(0.0,0.6)	0.0	0.23	(0.0,0.6)	0.3	0.60	(0.0,2.1)
McDonald	7.1	2.12	(3.2,11.5)	5.2	1.99	(1.7,9.4)	10.4	3.17	(4.8,17.1)	8.0	2.39	(3.8,13.1)
Hugh Smith	9.7	2.05	(6.0,14.0)	15.9	2.40	(11.4,20.7)	34.4	3.75	(27.2,41.9)	23.0	3.09	(17.1,29.2)
Nass River	65.0	2.71	(59.5,70.2)	49.7	3.28	(43.0,55.9)	27.9	2.60	(23.0,33.2)	37.8	2.88	(32.2,43.4)
Skeena River	11.5	1.95	(8.0,15.6)	22.6	2.92	(17.5,29.0)	16.1	2.27	(11.9,20.8)	22.4	2.56	(17.7,27.7)
Queen Charlotte I.	0.0	0.03	(0.0,0.0)	0.0	0.03	(0.0,0.0)	0.0	0.03	(0.0,0.0)	0.0	0.05	(0.0,0.1)
Central Coast BC	2.6	1.35	(0.0,5.4)	1.8	1.06	(0.0,4.2)	1.7	0.90	(0.4,3.8)	0.1	0.45	(0.0,1.5)
Fraser River	0.0	0.10	(0.0,0.3)	0.1	0.17	(0.0,0.6)	0.6	0.53	(0.0,1.9)	0.0	0.13	(0.0,0.4)
Washington	0.0	0.04	(0.0,0.1)	0.0	0.07	(0.0,0.1)	0.0	0.13	(0.0,0.3)	0.0	0.05	(0.0,0.1)

	Week 33			Week 34&35		
	Mean	SD	95% PI	Mean	SD	95% PI
Alsek	0.0	0.12	(0.0,0.2)	0.1	0.30	(0.0,0.9)
NSE Alaska	0.1	0.23	(0.0,0.8)	0.5	0.70	(0.0,2.4)
Taku	0.1	0.22	(0.0,0.7)	1.7	1.54	(0.0,6.0)
Stikine	0.3	0.40	(0.0,1.4)	0.9	1.79	(0.0,6.1)
SSE Alaska	3.6	1.39	(1.3,6.7)	7.3	2.51	(3.0,12.8)
Klawock	0.0	0.15	(0.0,0.4)	0.1	0.35	(0.0,1.2)
McDonald	11.2	2.70	(6.3,16.8)	18.8	4.43	(10.4,27.8)
Hugh Smith	25.4	3.12	(19.4,31.7)	22.6	4.57	(14.1,32.0)
Nass River	27.9	2.54	(23.0,32.9)	21.8	2.60	(16.9,27.1)
Skeena River	28.2	2.53	(23.4,33.3)	22.9	2.69	(17.8,28.4)
Queen Charlotte I.	0.0	0.03	(0.0,0.0)	0.0	0.04	(0.0,0.0)
Central Coast BC	1.7	0.84	(0.5,3.7)	1.9	1.70	(0.0,5.6)
Fraser River	1.4	0.69	(0.4,3.0)	1.4	0.89	(0.1,3.6)
Washington	0.0	0.05	(0.0,0.1)	0.0	0.15	(0.0,0.2)

Table 8. Parameters of the posterior densities for population region proportions composing weekly mixtures of the 2006 District 101 commercial gillnet sockeye fishery.

	Week 25			Week 26			Week 27			Week 28		
	Mean	SD	95% PI	Mean	SD	95% PI	Mean	SD	95% PI	Mean	SD	95% PI
Alsek	0.0	0.11	(0.0,0.3)	0.0	0.10	(0.0,0.2)	0.1	0.26	(0.0,0.9)	0.0	0.11	(0.0,0.2)
NSE Alaska	0.1	0.21	(0.0,0.7)	0.5	0.82	(0.0,2.9)	0.2	0.43	(0.0,1.5)	1.1	0.83	(0.1,3.2)
Taku	0.6	0.88	(0.0,3.0)	4.6	1.94	(0.0,8.5)	0.6	0.82	(0.0,2.8)	0.5	0.53	(0.0,1.8)
Stikine	3.7	1.49	(1.4,7.1)	4.3	1.28	(2.3,7.2)	7.4	4.13	(1.9,18.8)	7.2	2.21	(3.1,11.8)
SSE Alaska	0.9	0.72	(0.0,2.6)	1.3	1.15	(0.0,4.0)	6.8	2.64	(0.1,11.4)	1.6	1.64	(0.0,5.7)
Klawock	0.0	0.04	(0.0,0.0)	0.0	0.04	(0.0,0.0)	0.0	0.09	(0.0,0.1)	0.0	0.04	(0.0,0.0)
McDonald	0.0	0.07	(0.0,0.1)	3.3	1.62	(0.5,6.9)	5.2	2.45	(0.0,10.0)	0.0	0.25	(0.0,0.1)
Hugh Smith	2.5	1.00	(0.9,4.8)	2.1	1.64	(0.0,5.7)	16.2	2.80	(11.2,22.2)	35.8	3.16	(29.6,42.1)
Nass River	84.8	2.47	(79.6,89.3)	80.8	2.40	(75.8,85.2)	49.2	3.10	(43.0,55.2)	31.9	3.35	(25.4,38.5)
Skeena River	7.4	2.03	(4.0,11.8)	2.9	1.14	(1.1,5.5)	11.2	2.07	(7.5,15.6)	20.6	3.06	(15.1,27.1)
Queen Charlotte I.	0.0	0.04	(0.0,0.0)	0.0	0.04	(0.0,0.0)	0.0	0.03	(0.0,0.0)	0.0	0.04	(0.0,0.0)
Central Coast BC	0.0	0.20	(0.0,0.4)	0.2	0.54	(0.0,2.0)	3.1	1.28	(0.9,5.9)	1.1	1.15	(0.0,3.8)
Fraser River	0.0	0.11	(0.0,0.3)	0.0	0.10	(0.0,0.3)	0.0	0.09	(0.0,0.3)	0.1	0.15	(0.0,0.5)
Washington	0.0	0.05	(0.0,0.1)	0.0	0.14	(0.0,0.4)	0.0	0.05	(0.0,0.1)	0.1	0.20	(0.0,0.6)

	Week 29			Week 30			Week 31			Week 32		
	Mean	SD	95% PI	Mean	SD	95% PI	Mean	SD	95% PI	Mean	SD	95% PI
Alsek	0.0	0.15	(0.0,0.3)	0.1	0.20	(0.0,0.6)	1.1	0.97	(0.0,3.4)	0.0	0.17	(0.0,0.4)
NSE Alaska	3.1	1.56	(0.6,6.7)	2.3	1.12	(0.5,4.9)	0.4	0.60	(0.0,2.1)	0.6	0.87	(0.0,3.0)
Taku	0.6	1.32	(0.0,4.7)	0.1	0.36	(0.0,1.2)	0.2	0.60	(0.0,2.1)	0.7	1.32	(0.0,4.5)
Stikine	4.5	2.12	(0.6,8.6)	0.8	0.54	(0.1,2.1)	0.3	0.77	(0.0,2.8)	0.9	1.36	(0.0,4.6)
SSE Alaska	2.6	1.96	(0.0,7.2)	4.8	1.98	(1.2,8.9)	2.4	1.89	(0.1,7.0)	1.2	1.25	(0.0,4.3)
Klawock	0.0	0.09	(0.0,0.1)	0.0	0.04	(0.0,0.0)	0.0	0.12	(0.0,0.1)	0.3	0.74	(0.0,2.6)
McDonald	14.0	3.76	(7.1,21.7)	10.4	3.09	(4.6,16.8)	15.5	4.22	(7.6,24.0)	1.9	3.31	(0.0,10.8)
Hugh Smith	33.7	4.35	(25.3,42.3)	22.5	3.61	(15.8,29.9)	28.7	4.74	(19.8,38.3)	31.3	4.58	(21.2,39.3)
Nass River	36.2	2.92	(30.4,41.9)	30.4	3.11	(24.5,36.7)	17.9	2.46	(13.3,23.0)	13.2	2.33	(8.9,18.0)
Skeena River	5.2	1.84	(2.4,9.6)	26.8	3.10	(20.8,33.0)	33.2	2.95	(27.6,39.1)	48.7	3.31	(42.2,55.2)
Queen Charlotte I.	0.0	0.04	(0.0,0.0)	0.0	0.03	(0.0,0.0)	0.0	0.04	(0.0,0.0)	0.0	0.04	(0.0,0.0)
Central Coast BC	0.0	0.21	(0.0,0.6)	1.9	0.96	(0.5,4.2)	0.0	0.11	(0.0,0.1)	1.0	1.14	(0.0,3.7)
Fraser River	0.1	0.15	(0.0,0.5)	0.0	0.13	(0.0,0.4)	0.4	0.39	(0.0,1.4)	0.1	0.26	(0.0,0.9)
Washington	0.0	0.09	(0.0,0.2)	0.0	0.05	(0.0,0.1)	0.0	0.07	(0.0,0.1)	0.2	0.47	(0.0,1.7)

	Week 33			Week 34,35,36&37		
	Mean	SD	95% PI	Mean	SD	95% PI
Alsek	0.0	0.13	(0.0,0.3)	0.0	0.12	(0.0,0.3)
NSE Alaska	0.8	0.94	(0.0,3.3)	0.3	0.63	(0.0,2.3)
Taku	0.3	0.77	(0.0,2.9)	0.2	0.61	(0.0,1.9)
Stikine	0.7	1.30	(0.0,4.4)	11.6	2.72	(6.5,17.1)
SSE Alaska	6.9	2.68	(2.3,12.7)	0.5	0.78	(0.0,2.8)
Klawock	0.1	0.30	(0.0,0.6)	0.0	0.19	(0.0,0.6)
McDonald	10.1	3.38	(4.1,17.3)	24.7	4.35	(16.7,33.7)
Hugh Smith	26.9	4.15	(18.9,35.2)	22.0	4.21	(13.9,30.3)
Nass River	21.1	2.80	(15.9,26.9)	6.9	1.64	(4.0,10.4)
Skeena River	32.4	3.25	(26.2,39.0)	32.8	2.80	(27.5,38.4)
Queen Charlotte I.	0.0	0.07	(0.0,0.1)	0.0	0.04	(0.0,0.0)
Central Coast BC	0.7	1.16	(0.0,3.9)	0.0	0.18	(0.0,0.3)
Fraser River	0.1	0.17	(0.0,0.5)	1.0	0.61	(0.1,2.5)
Washington	0.0	0.09	(0.0,0.2)	0.0	0.08	(0.0,0.1)

Table 9. Parameters of the posterior densities for population region proportions composing weekly mixtures of the 2007 District 101 commercial gillnet sockeye fishery.

	Week 27&28			Week 29			Week 30			Week 31		
	Mean	SD	95% PI	Mean	SD	95% PI	Mean	SD	95% PI	Mean	SD	95% PI
Alsek	0.1	0.29	(0.0,0.8)	0.0	0.14	(0.0,0.3)	0.0	0.09	(0.0,0.2)	0.0	0.12	(0.0,0.3)
NSE Alaska	0.9	1.39	(0.0,4.8)	0.2	0.53	(0.0,1.7)	0.1	0.20	(0.0,0.6)	0.2	0.36	(0.0,1.3)
Taku	0.7	1.87	(0.0,7.0)	0.1	0.53	(0.0,1.2)	0.0	0.14	(0.0,0.4)	0.1	0.53	(0.0,1.7)
Stikine	6.2	2.85	(0.5,11.8)	6.4	2.59	(0.4,11.5)	0.2	0.39	(0.0,1.4)	3.2	1.92	(0.0,7.1)
SSE Alaska	8.6	3.35	(3.6,16.1)	7.2	2.60	(2.5,12.7)	12.5	2.25	(8.4,17.2)	5.1	1.60	(2.2,8.5)
Klawock	0.0	0.13	(0.0,0.2)	0.0	0.20	(0.0,0.5)	1.2	0.79	(0.0,3.0)	0.3	0.54	(0.0,1.9)
McDonald	16.4	3.25	(10.2,22.9)	8.3	2.32	(4.1,13.2)	6.4	1.79	(3.1,10.1)	4.3	1.42	(1.9,7.4)
Hugh Smith	0.1	0.34	(0.0,0.8)	0.0	0.14	(0.0,0.3)	0.2	0.65	(0.0,2.4)	0.0	0.11	(0.0,0.2)
Nass River	23.6	3.07	(17.9,29.9)	10.8	2.01	(7.1,15.0)	8.0	1.61	(5.1,11.4)	4.3	1.14	(2.3,6.8)
Skeena River	43.2	3.51	(36.4,50.1)	65.7	3.00	(59.8,71.5)	64.9	2.69	(59.6,70.1)	62.6	2.65	(57.3,67.7)
Queen Charlotte I.	0.0	0.06	(0.0,0.0)	0.0	0.05	(0.0,0.0)	0.0	0.03	(0.0,0.0)	0.2	0.34	(0.0,1.2)
Central Coast BC	0.0	0.16	(0.0,0.2)	0.7	1.08	(0.0,3.6)	0.0	0.11	(0.0,0.2)	0.1	0.47	(0.0,1.8)
Fraser River	0.1	0.17	(0.0,0.5)	0.5	0.65	(0.0,2.3)	6.5	1.48	(3.9,9.6)	19.6	2.18	(15.5,24.0)
Washington	0.1	0.22	(0.0,0.7)	0.0	0.06	(0.0,0.1)	0.0	0.09	(0.0,0.2)	0.0	0.06	(0.0,0.1)

	Week 32			Week 33			Week 34&35		
	Mean	SD	95% PI	Mean	SD	95% PI	Mean	SD	95% PI
Alsek	0.0	0.08	(0.0,0.2)	0.2	0.39	(0.0,1.4)	0.0	0.16	(0.0,0.5)
NSE Alaska	0.1	0.23	(0.0,0.8)	0.1	0.19	(0.0,0.6)	1.5	1.38	(0.0,4.7)
Taku	0.0	0.10	(0.0,0.3)	0.1	0.23	(0.0,0.6)	0.0	0.16	(0.0,0.4)
Stikine	0.0	0.10	(0.0,0.3)	0.1	0.30	(0.0,0.8)	0.1	0.40	(0.0,1.2)
SSE Alaska	5.3	1.51	(2.7,8.6)	1.4	1.13	(0.0,4.0)	1.1	0.92	(0.0,3.3)
Klawock	0.7	0.64	(0.0,2.2)	0.5	0.60	(0.0,2.1)	0.9	0.60	(0.0,2.3)
McDonald	2.2	1.10	(0.0,4.5)	2.3	1.21	(0.0,4.9)	4.6	1.34	(2.2,7.4)
Hugh Smith	0.0	0.12	(0.0,0.3)	0.2	0.61	(0.0,2.2)	0.0	0.20	(0.0,0.5)
Nass River	4.3	1.26	(2.1,7.0)	4.0	1.29	(1.9,6.9)	4.3	1.35	(2.1,7.3)
Skeena River	42.9	2.73	(37.6,48.2)	37.0	3.16	(30.9,43.3)	56.5	2.83	(51.0,62.0)
Queen Charlotte I.	0.0	0.08	(0.0,0.2)	0.0	0.04	(0.0,0.0)	0.0	0.03	(0.0,0.0)
Central Coast BC	0.0	0.11	(0.0,0.2)	0.0	0.19	(0.0,0.6)	0.7	0.86	(0.0,2.9)
Fraser River	44.4	2.68	(39.2,49.7)	54.2	3.23	(47.8,60.5)	30.3	2.59	(25.3,35.4)
Washington	0.1	0.21	(0.0,0.7)	0.0	0.10	(0.0,0.2)	0.0	0.08	(0.0,0.1)

Table 10. Parameters of the posterior densities for population region proportions composing weekly mixtures of the 2006 District 104 commercial purse seine sockeye fishery.

	Week 27&28			Week 29			Week 30			Week 31		
	Mean	SD	95% PI	Mean	SD	95% PI	Mean	SD	95% PI	Mean	SD	95% PI
Alsek	0.0	0.10	(0.0,0.2)	0.03	0.1	(0.0,0.3)	0.01	0.1	(0.0,0.2)	0.22	0.5	(0.0,1.7)
NSE Alaska	1.2	1.17	(0.0,4.2)	0.44	0.9	(0.0,3.2)	2.66	1.6	(0.0,5.9)	0.35	0.7	(0.0,2.4)
Taku	0.5	0.76	(0.0,2.7)	0.33	0.4	(0.0,1.4)	0.36	0.7	(0.0,2.5)	0.1	0.4	(0.0,1.1)
Stikine	0.6	0.74	(0.0,2.5)	0.21	0.6	(0.0,2.3)	0.34	0.8	(0.0,2.7)	0.05	0.2	(0.0,0.6)
SSE Alaska	20.1	2.73	(14.9,25.6)	17	2.6	(12.2,22.2)	14.7	2.4	(10.2,19.7)	20.9	3	(15.3,26.9)
Klawock	0.1	0.29	(0.0,1.0)	0.1	0.3	(0.0,1.1)	1.29	1	(0.0,3.5)	1.36	1.1	(0.0,3.8)
McDonald	4.9	2.01	(1.0,9.1)	6.06	2.2	(2.3,10.9)	3.47	1.4	(1.2,6.6)	7.78	2.5	(3.1,12.9)
Hugh Smith	2.4	1.69	(0.0,5.9)	3.75	2.1	(0.0,7.9)	3.95	1.5	(1.2,7.2)	2.6	2.7	(0.0,8.6)
Nass River	7.6	1.59	(4.7,10.9)	5.67	1.5	(3.1,8.8)	4.43	1.2	(2.4,7.0)	4.07	1.3	(1.9,6.9)
Skeena River	62.7	2.67	(57.4,67.8)	66.3	2.8	(60.8,71.7)	67.4	2.6	(62.2,72.5)	55.6	2.9	(49.8,61.4)
Queen Charlotte I.	0.0	0.16	(0.0,0.6)	0.03	0.1	(0.0,0.4)	0	0	(0.0,0.0)	0.01	0.1	(0.0,0.1)
Central Coast BC	0.0	0.22	(0.0,0.5)	0.08	0.2	(0.0,0.8)	0.29	0.6	(0.0,2.2)	0.01	0.1	(0.0,0.1)
Fraser River	0.0	0.12	(0.0,0.4)	0.04	0.1	(0.0,0.4)	1.06	0.6	(0.2,2.6)	6.93	1.6	(4.2,10.3)
Washington	0.0	0.18	(0.0,0.6)	0.01	0.1	(0.0,0.1)	0.01	0.1	(0.0,0.1)	0.01	0.1	(0.0,0.1)

	Week 32			Week 33			Week 34&35		
	Mean	SD	95% PI	Mean	SD	95% PI	Mean	SD	95% PI
Alsek	0.1	0.2	(0.0,0.8)	0.1	0.3	(0.0,1.0)	0.05	0.2	(0.0,0.7)
NSE Alaska	1.38	1	(0.0,3.6)	0.18	0.4	(0.0,1.5)	0.36	0.6	(0.0,2.0)
Taku	0.05	0.2	(0.0,0.5)	0.05	0.2	(0.0,0.5)	0.42	0.5	(0.0,1.7)
Stikine	0.05	0.3	(0.0,0.6)	0.04	0.2	(0.0,0.5)	0.14	0.4	(0.0,1.5)
SSE Alaska	8.89	1.8	(5.6,12.7)	3.19	1.5	(0.7,6.5)	1.76	1.1	(0.0,4.2)
Klawock	0.01	0.1	(0.0,0.1)	0.01	0.1	(0.0,0.0)	0.01	0.1	(0.0,0.0)
McDonald	3.35	1.2	(1.3,6.0)	0.04	0.3	(0.0,0.4)	0.22	0.7	(0.0,2.4)
Hugh Smith	0.13	0.4	(0.0,1.5)	2.48	1.3	(0.3,5.3)	1.83	1.1	(0.0,4.2)
Nass River	3.85	1.3	(1.5,6.6)	2.2	0.9	(0.8,4.3)	1.88	0.8	(0.6,3.8)
Skeena River	58.8	2.9	(53.2,64.4)	53.8	3.2	(47.5,60.0)	51.4	3.1	(45.3,57.4)
Queen Charlotte I.	0	0	(0.0,0.0)	0.06	0.2	(0.0,0.7)	0	0	(0.0,0.0)
Central Coast BC	0.19	0.4	(0.0,1.5)	0.01	0.1	(0.0,0.1)	0.01	0.1	(0.0,0.0)
Fraser River	23.2	2.4	(18.6,28.1)	37.9	3.1	(31.9,44.1)	41.9	3.1	(35.9,48.1)
Washington	0.04	0.2	(0.0,0.6)	0.02	0.1	(0.0,0.3)	0.05	0.2	(0.0,0.6)

Table 11. Parameters of the posterior densities for population region proportions composing weekly mixtures of the 2007 District 104 commercial purse seine sockeye fishery.

		District 101 Gillnet		District 104 Seine	
Region	***Area***	***2006***	***2007***	***2006***	***2007***
1	Alsek	43	128	78	887
2	NSE Alaska	330	485	487	6,264
3	Taku	312	544	211	1,148
4	Stikine	1,087	2,393	4,276	789
5	SSE Alaska	1,391	1,709	16,868	86,573
6	Klawock	22	22	1,471	3,743
7	McDonald	3,419	3,913	12,006	27,997
8	Hugh Smith	6,578	12,712	219	15,263
9	Nass River	40,259	30,626	14,910	27,509
10	Skeena River	7,214	12,831	139,871	440,503
11	Queen Charlotte I.	3	1	170	139
12	Central Coast BC	509	537	358	652
13	Fraser River	123	70	51,042	159,032
14	Washington	36	19	61	194
	Totals	61,325	65,991	242,028	770,693

Table 12. Estimated numbers of sockeye salmon caught in the District 101 gillnet and 104 seine fisheries throughout all statistical weeks sampled.

	Prior to Week 31	District 101 Gillnet		District 104 Seine	
Region	***Area***	***2006***	***2007***	***2006***	***2007***
1	Alsek	31	16	22	18
2	NSE Alaska	299	395	129	2,129
3	Taku	258	474	77	432
4	Stikine	901	2,178	1,588	408
5	SSE Alaska	666	1,252	10,010	18,296
6	Klawock	8	1	767	885
7	McDonald	2,049	1,748	6,573	4,798
8	Hugh Smith	3,268	7,228	159	3,999
9	Nass River	36,671	27,546	8,444	6,014
10	Skeena River	4,680	5,689	57,276	74,182
11	Queen Charlotte I.	2	0	0	16
12	Central Coast BC	355	467	146	217
13	Fraser River	40	17	4,407	714
14	Washington	34	9	18	19
	Totals	49,264	47,022	89,618	112,128

Table 13. Estimated numbers of sockeye salmon caught in District 101 gillnet and 104 seine fisheries prior to statistical week 31