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Final Report

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Project Title: Genetic stock identification of Districts 106 and 108 sockeye, 2015

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Abstract:
The Stikine River in Southeast Alaska supports sockeye salmon runs important for various commercial and aboriginal fisheries in both Alaska and Canada. This project continues the use of mark- and age-enhanced genetic stock identification (GSI) of sockeye salmon harvested in the 2015 gillnet fishery in Districts 106 and 108 by screening 96 single nucleotide polymorphic genetic markers in 4,031 salmon. Advances in mixed stock analysis methodologies allowed the incorporation of hatchery-marked fish and age composition into genetic-based fishery estimates. The mixed stock analysis model indicated that the *Non-Stikine* reporting group was the largest contributor in the District 106 fisheries in 2015. In the District 108 fisheries, the *Stikine/Taku Mainstem* and *Non-Stikine* reporting groups were the largest contributors. *Enhanced Tahltan*, *Enhanced Tuya*, and *Tahltan Wild* reporting groups were important contributors only early in the season for District 108. The most common age group over all fisheries was age-1.3.

Introduction:
The Stikine River in Southeast Alaska (SEAK) supports sockeye salmon runs important for various commercial and aboriginal fisheries in both the United States (U.S.) and Canada. Stikine River sockeye salmon are harvested in commercial gillnet fisheries in U.S. Districts 106 and 108, by U.S. subsistence fisheries in the lower river, by Canadian commercial gillnet in the lower and upper river, and by Canadian aboriginal fisheries in the upper river.

The gillnet fisheries in U.S. Districts 106 and 108 harvest wild stocks of sockeye salmon bound for Southeast Alaska (SEAK) island and mainland lakes, and for lakes and tributaries in the Stikine, Nass, and Skeena River drainages. Significant numbers of enhanced sockeye bound for release sites in the Stikine River are also caught in the fisheries. Catches of Stikine River sockeye salmon stocks in Districts 106 and 108 gillnet fisheries and the U.S. Stikine subsistence fishery are subject to a harvest sharing agreement under the Pacific Salmon Treaty (PST), in which the U.S. is allowed 50% of the Total Allowable Catch of Stikine River sockeye. Stock contribution estimates are used to document compliance with the harvest sharing agreements, reconstruct runs of wild stocks, estimate the return of enhanced fish, forecast upcoming returns, and support sustainable management.

This project completed mark- and age-enhanced GSI analysis on sockeye salmon tissue samples collected from commercial gillnet fisheries in areas near the Stikine River in 2015. The analysis focused on tissue samples collected in U.S. Districts 106 and 108. For Subdistricts 106-30 and 106-41, estimates are provided over the entire season for all age groups, for 10 time strata for all age groups, and over the entire season for 6 age groups. For District 108, estimates are provided over the entire season for all age groups, for 9 time strata for all age groups, and over the entire season for 6 age groups. Estimates are reported as proportions of 5 reporting groups consisting of 2 groups of Stikine wild fish (*Stikine/Taku Mainstem* and *Tahltan Wild*), 2 groups of Stikine hatchery-origin fish (*Enhanced Tahltan* and *Enhanced Tuya*), and one group that includes all other non-Stikine wild- and hatchery-origin fish in the baseline (*Non-Stikine*).

Objectives:
The objective of this project is to estimate the stock composition of Southeast Alaska sockeye fisheries near the Stikine River in 2015 using genetic stock identification for 5 reporting groups including: 2 reporting groups of Stikine wild fish (*Stikine/Taku Mainstem* and *Tahltan Wild*), 2 reporting groups of Stikine hatchery-origin fish (*Enhanced Tahltan* and *Enhanced Tuya*), and one reporting group that includes all other non-Stikine wild- and hatchery-origin fish in the baseline (*Non-Stikine*) such that the estimates are within 10% of the true value 90% of the time. This will be accomplished through the following tasks:

- Determine the stock composition of sockeye harvests from the District 106 drift gillnet fishery. For 2015, provide estimates for:
  - Subdistrict 106-30
    - Total season, all age groups combined;
    - Total season, by age groups including ages-1.2, -1.3, -2.2, -2.3, 0-checks, and other;
    - At least 5 time strata, all age groups combined;
  - Subdistrict 106-41
    - Total season, all age groups combined;
    - Total season, by age groups including ages-1.2, -1.3, -2.2, -2.3, 0-checks, and other;
    - At least 5 time strata, all age groups combined.
- Determine the stock composition of sockeye harvests from the District 108 drift gillnet fishery. For 2015, provide estimates for:
  - District 108
    - Total season, all age groups combined;
    - Total season, by age groups including ages-1.2, -1.3, -2.2, -2.3, 0-checks, and other;
    - At least 5 time strata, all age groups combined.

Approach:
Fishery Sampling
Landings from drift gillnet fisheries in Subdistricts 106-30 and 106-41 (District 106) and in District 108 were sampled by ADF&G at fish processing facilities in Wrangell and Petersburg and by observers on tenders. Sampling protocols ensured that the fish sampled were as representative of catches as possible. Axillary processes were excised and placed into individually labeled vials and preserved in ethanol. Associated data for each sample including fishery and capture date were recorded, and the tissue sample for each fish was paired with age, sex, and length (ASL) information and with otolith samples.

Laboratory Analysis

A single nucleotide polymorphism (SNP) baseline for SEAK and British Columbia (BC) including 45 markers was first completed in 2007. The baseline included all major sockeye salmon-producing systems in SEAK and in BC north of and including the Skeena River and from representative sockeye salmon-producing systems in BC south of the Skeena River. A cooperative project between ADF&G and DFO in 2007-2009 added several collections to the baseline for transboundary rivers (Northern Fund project no. NF-2008-I-15A). In addition, these and existing collections have been analyzed at a total of 96 SNP markers in order to further enhance the baseline for fishery applications. The current genetic baseline includes 171 populations and 96 markers (Table 1; Rogers Olive et al. *in review*).

Samples were analyzed for 96 SNP loci. Genomic DNA was extracted using a DNeasy® 96 Tissue Kit by QIAGEN®, (Valencia, CA). All SNPs were detected using a TaqMAN SNP Genotyping Assay (Life Technologies). SNP assays were generally performed using the BioMark 96.96 Dynamic Array (Fluidigm). Re-analyses of failed assays was performed on the QuantStudio™ 12K Flex Real-Time PCR System (Life Technologies). Genotype data are stored in an *Oracle* database (*LOKI*) on a network drive maintained by ADF&G computer services. Quality control measures included reanalysis from DNA extraction forward of 8% of each collection for all markers to ensure that genotypes are reproducible and to identify laboratory errors and measure rates of inconsistencies during repeated analyses.

Mixture Analysis

Mixture analyses included additional available data to help inform the genetic estimates; specifically, ages from matched scales and hatchery marks on matched otoliths. In this method (“mark- and age-enhanced GSI”), two sets of parameters are required: 1) a vector of stock compositions, summing to one, with a proportion for each of the wild and hatchery stocks weighted by harvest per stratum; and 2) a matrix of age composition, with a row for each of the wild and hatchery stocks (summing to one), and a column for each age class. This information is “completed” iteratively by stochastically assigning each wild fish to a population, then estimating the stock proportions based on summaries of assignments from each iteration. In this process, all available information is used to assign individuals to stock of origin based on age, genotype, and/or otolith information. For this method, only genotypes from wild fish are necessary to complete stock composition estimates; thus only wild fish were genotyped for 2015 fisheries.

This algorithm was run for 40,000 repetitions, discarding the first 20,000 repetitions to eliminate the effect of the initial state. The point estimates and credibility intervals for the stock proportions and age composition are simple summary statistics of the output.

Results are given for 5 reporting groups consisting of 2 groups of Stikine wild fish (*Stikine/Taku Mainstem* and *Tahltan Wild*), 2 groups of Stikine hatchery-origin fish (*Enhanced Tahltan* and *Enhanced Tuya*), and one group that includes all other non-Stikine wild- and hatchery-origin fish in the baseline (*Non-Stikine*). A total of 48 separate estimates were made for the 2015 fisheries.

Results/Findings:

Fishery sampling

A total of 4,964 sockeye salmon were sampled in the gillnet fisheries in District 106 and 3,404 sockeye salmon were sampled in District 108 during 2015 (Table 2 and 3). Fish were sampled from statistical weeks 25 through 34 for both District 106 and 108. In District 106, Subdistrict 30, 2,781 fish were sampled and in Subdistrict 41, 2,185 fish were sampled (Table 2).

Laboratory analyses

Of the samples collected in District 106, 2,923 samples were genotyped at 96 SNP genetic markers. During quality control procedures a total of 246 fish were reanalyzed at all 96 markers for a total of 23,616 comparisons. The average failure rate for District 106 was 3%. Few inconsistencies were found (1% across all comparisons).

Of the samples collected in District 108, 1,108 samples were genotyped at 96 SNP genetic markers. During quality control procedures a total of 91 fish were reanalyzed at all 96 markers for a total of 8,736 comparisons. The average failure rate for District 108 was low at 1.2%. Few inconsistencies were found (0.4% across all comparisons).

Mixture analysis

Mixtures of fish representing catches by statistical week, age group, and subdistrict from U.S. Districts 106 and 108 gillnet fisheries were analyzed. Of the samples extracted and genotyped, genotypes from 3,912 wild fish (no otolith mark present) were used for the genetic analyses in the mark- and age-enhanced GSI method. Stock composition estimates can be found in Figures 1–10. Total season estimates were made for each subdistrict or district by age class and over all ages, and were weighted by harvest in each stratum. In addition, results are given for fish of all age classes over every time stratum sampled, regardless of sample size. The estimate for District 108, statistical week 25, did not meet the minimum criteria for precision and accuracy accepted by the Pacific Salmon Commission (PSC) Transboundary Technical Committee (within 10% of the true mixture 90% of the time) and thus was not reported.

The largest component of the Subdistrict 106-30 fishery sample in 2015 was non-Stikine-origin fish, 98% over the entire season (Figure 1). This reporting group dominated catches in every statistical week (Figure 2). All other stocks were present at low proportions (<5%) over all statistical weeks. The most common age group in Subdistrict 106-30 for the *Non-Stikine* group was age-1.3 (64% of total), followed by age-2.2 and -2.3 (each at 12%; Figures 3 and 4).

Similar to Subdistrict 106-30, the harvests in Subdistrict 106-41 were dominated by the *Non-Stikine* reporting group (81% over the entire season; Figure 1). This reporting group was the largest contributor in each statistical week, though other stocks were important contributors especially early in the season (Figure 5). The *Enhanced Tuya* reporting group contributed the most early in the season (statistical weeks 25 through 30) with the highest proportion observed in statistical week 27 (16%). The *Stikine/Taku Mainstem* reporting group contributed at least 5% in 5 statistical weeks with the highest proportion in week 25 (9%), while the *Tahltan Wild* reporting group contributed at least 5% in statistical weeks 26–28 and *Enhanced Tahltan* contributed at least 5% in weeks 27 and 29. The most common age group in Subdistrict 106-41 was age-1.3 (52% of total), followed by age-2.2 (17%), age-2.3 (14%) and age-1.2 (13%; Figure 6). The *Enhanced Tahltan*, *Tahltan Wild*, *Non-Stikine* and *Stikine/Taku Mainstem* reporting groups were primarily age-1.3 fish, while the *Enhanced Tuya* group was primary age-2.2 (Figure 7).

Stock compositions in District 108 were quite different from District 106, with no single stock dominating every week. The largest contributor over the entire season was the *Stikine/Taku Mainstem* reporting group (28%), followed by the *Non-Stikine*, and *Tahltan Wild* (27% and 17% respectively; Figure 1). The total contribution over the entire season for both the *Enhanced Tahltan* and *Enhanced Tuya* reporting groups was 14% each. The *Stikine/Taku Mainstem* reporting group was an important contributor throughout the season ranging from 11–50%, with the largest contributions from statistical week 29 through 34. The largest contributions from the *Tahltan Wild*, *Enhanced Tahltan,* and *Enhanced Tuya* reporting were from weeks 26 through 30. The most common age group in District 108 was age-1.3 (54%), followed by age-2.2 (14%) and age-1.2 (12%; Figure 9). Similar to District 106 fisheries, the *Enhanced Tahltan*, *Tahltan Wild*, and *Stikine/Taku Mainstem* reporting groups were primarily age-1.3 fish, while the *Enhanced Tuya* reporting group was comprised of larger percentages of ages-2.2 and other. The *Non-Stikine* reporting group was primarily comprised of ages-1.3, 2.2, and 2.3 (Figure 10).

Evaluation:

We accomplished the following:

- A total of 4,964 sockeye salmon were sampled from District 106 gillnet fisheries and 3,404 sockeye salmon were sampled from District 108 gillnet fisheries during the 2015 season.
- A total of 2,923 samples from District 106 and 1,108 samples of sockeye salmon from District 108 were assayed for genotypes for the 96 SNP loci in the sockeye salmon baseline, and quality control procedures revealed a low rate of inconsistencies. The genotypes for 2,831 samples were used in analysis for District 106 and 1,081 for District 108.
- Mixture analyses estimated the contributions of 5 reporting groups including Stikine wild and enhanced sockeye salmon to 10 temporal strata in Subdistrict 106-30 and Subdistrict 106-41, and 9 temporal strata in District 108.
- Mixture analyses estimated the age compositions of harvests over the entire season in Subdistrict 106-30, Subdistrict 106-41, and District 108 for 5 reporting groups.
- Mixture analyses estimate the seasonal stock composition over all ages for Subdistrict 106-30, Subdistrict 106-41, and District 108 for 5 reporting groups.
- In total, 41 separate estimates are provided for Stikine area fisheries in 2015.
- The improved methodology (mark- and age-enhanced GSI) has allowed us to combine several sources of data when estimating stock composition in Districts 106 and 108 for Pacific Salmon Treaty (PST) purposes. In the past, GSI was conducted on only wild fish, and stock composition estimates for enhanced fish were conducted in a separate analysis using otolith and other data. This approach allows us to combine these analyses to provide the most accurate and efficient estimates possible for Stikine area fisheries. Work is currently underway to continue to improve this methodology to provide reliable estimates for statistical weeks where low sample sizes are an issue.
- Results will be incorporated into harvest estimates for PST purposes by the Transboundary Technical Committee (TTC *in prep*).

Project Products:

Results from this project have been presented both to ADF&G Commercial Fisheries management staff and to the bilateral PSC Transboundary Technical Committee. A report published in the ADF&G Fishery Data Series is expected in 2016.

Date Prepared: July 11, 2016

References:

Rogers Olive, S. D., S. E. Gilk-Baumer, E. K. C. Fox, and C. Habicht. *In review*. Genetic baseline of Southeast Alaska sockeye salmon for mixed stock analyses, 2014. Alaska Department of Fish and Game, Fishery Data Series No. YY-XX, Anchorage.

TTC (Transboundary Technical Committee). *In prep*. Estimates of Transboundary River salmon production, harvest and escapement, and a review of joint enhancement activities in 2015. Pacific Salmon Commission Report TCTR, Vancouver.

Table 1. Reporting groups and collection locations defined for use in genetic stock identification of sockeye salmon caught in gillnet fisheries in Districts 106 and 108 in 2015. Wild collections are ordered north to south and followed by enhanced collections.

Reporting Group	Collection Location	Reporting Group	Collection Location
Non-Stikine	Bainbridge Lake	*Non-Stikine (cont.)*	Chilkat River - Mule Meadows
	Coghill Lake		Chilkoot Lake - Beaches
	Eshamy Lake		Chilkoot Lake - Bear Creek
	Main Bay		Chilkoot River
	Miners Lake		Berners Bay
	Bering Lake		Lace River
	Clear Creek at 40 Mile		Steep Creek
	Eyak - Hatchery Creek		Windfall Lake
	Eyak - Middle Arm		Lake Creek - Auke Creek Weir
	Eyak - South beaches		Crescent Lake
	Gulkana - Fish Creek		Speel Lake
	Gulkana - East Fork		Snettisham
	Klutina Lake - inlet		Vivid Lake
	Klutina - Mainstem		Bartlett River - Creel survey
	Klutina - Banana Lake		North Berg Bay Inlet
	Klutina - Bear Hole		Hoktaheen Lake
	Kushtaka Lake		Neva Lake
	Long Lake weir		Sitkoh Lake
	Mahlo River		Lake Eva
	Martin Lake		Kook Lake
	Martin River Slough		Pavlof Lake
	McKinley Lake 2007		Hasselborg Lake
	McKinley Lake 2008		Kanalku Lake[1]
	McKinley Lake 1991		Kutlaku Lake
	Salmon Creek - Bremner		Falls Lake
	Mendeltna Creek		Ford Arm Creek
	Mentasta Lake		Klag Bay Stream outlet
	Paxson Lake - outlet		Redfish Lake Beaches
	St. Anne Creek		Salmon Lake weir
	Steamboat Lake - Bremner		Redoubt Lake - outlet
	Swede Lake		Benzeman Lake
	Tanada Creek weir		King Salmon Lake
	Tanada Lk - lower outlet		Little Tatsamenie
	Tanada Lk - shore		Little Trapper Lake
	Tebay River - Outlet		Kuthai Lake
	Tokun Lake		Tatsamenie Lake
	Tonsina Lake	*Stikine/Taku Mainstem*	Hackett River
	Ahrnklin River		Nahlin River
	Akwe River		Tulsequah River
	Dangerous River		Yellow Bluff Slough
	East Alsek River		Sustahine Slough
	Lost/Tahwah Rivers		Taku River
	Old Situk River		Takwahoni/Sinwa Creek
	Mountain Stream		Tuskwa/Chunk/Bear Slough
	Situk Lake		Fish Creek
	Blanchard River		Yehring Creek
	Border Slough		Shakes Slough
	Klukshu River		Iskut River
	Upper Tatshenshini/Kudwat		Verrett River
	Tatshenshini - Kwatini River		Scud River
	Neskataheen Lake		Andy Smith/Porcupine/Fowler
	Tweedsmuir River		Devil's Elbow
	Vern Ritchie		Chutine River
	Chilkat Lake		Chutine Lake
	Chilkat River - Mosquito Lake		Christina Lake
	Chilkat River - Bear Flats	*Tahltan Wild*	Little Tahltan River

-continued-

Table 1 (cont.)

Reporting Group	Collection Location	Reporting Group	Collection Location
Tahltan Wild (cont.)	Tahltan Lake	*Non-Stikine (cont.)*	Alastair Lake
Non-Stikine (cont.)	Hugh Smith Lake		Four Mile Creek/Pierre Creek
	McDonald Lake		Fulton River/Morrison Creek
	Hatchery Creek - Sweetwater		Kitsumkalum Lake
	Kah Sheets Lake		Lower Tahlo River
	Kunk Lake		McDonell Lake - Zymoetz R
	Luck Lake		Nangeese River
	Big Lake		Nanika River
	Mill Creek Weir		Slamgeesh River
	Petersburg Lake		Sustut River - Johanson Lake
	Red Bay Lake		Swan Lake
	Salmon Bay Lake		Upper Babine River
	Shipley Lake		Naden River
	Thoms Lake		Kitlope Lake
	Sarkar Lakes		Baker Lake
	Heckman Lake		Issaquah Creek
	Helm Lake		Cedar River
	Karta River/McGilvery Creek		Adams R - Shuswap Lake
	Kegan Lake		Birkenhead River
	Mahoney Creek		Chilko Lake
	Unuk River - Gene's Lake		Gates Creek
	Fillmore Lake - Hoffman Creek		Harrison River
	Klakas Lake		Horsefly River
	Bar Creek - Essowah Lake		Raft River
	Eek Creek		Stellako River
	Hetta Creek - Middle run		Enhanced - Burnett Inlet
	Hetta Creek - Early run		Enhanced - Main Bay
	Hetta Lake		Enhanced - McDonald
	Klawock River		Enhanced - Sweetheart
	Bowser Lake		Enhanced - Tatsamenie
	Damdochax Creek		Enhanced - Speel Arm
	Meziadin Lake	*Enhanced Tahltan*	Enhanced - Tahltan
	Tintina Creek	*Enhanced Tuya*	Enhanced - Tuya
	Weaver Creek		

Table 2. Number of sockeye salmon sampled from Subdistricts 106-30 and 106-41 gillnet harvests during each statistical week in 2015, total genotyped samples used in analysis, and otolith-marked or aged samples not genotyped (or failed genotyping) for each statistical week.

District	Subdistrict	Statistical Week	Total Samples Collected	Genotypes Used in Analysis	Not Genotyped (otolith-marked or aged or both)
106	30	25	200	30	170
		26	300	57	243
		27	300	109	191
		28	300	238	62
		29	300	172	128
		30	180	137	43
		31	300	253	47
		32	300	288	12
		33	300	137	163
		34	300	64	236
	41	25	200	45	155
		26	300	132	168
		27	300	180	120
		28	300	237	63
		29	200	159	41
		30	300	185	115
		31	60	60	0
		32	200	182	18
		33	300	142	158
Totals			4,964	2,831	2,133

Table 3. Number of sockeye salmon sampled from gillnet harvests in the sockeye salmon fisheries in District 108 during 2015 by statistical week, total genotyped samples used in analysis, and otolith-marked or aged samples not genotyped.

District	Statistical Week	Total Samples Collected	Genotypes Used in Analysis	Not Genotyped (otolith-marked or aged or both)
108	25	37	20	17
	26	360	53	307
	27	511	121	390
	28	480	205	275
	29	510	211	299
	30	338	192	146
	31	412	90	322
	32	257	65	192
	33	324	82	242
	34	174	42	132
Totals		3,403	1,081	2,322

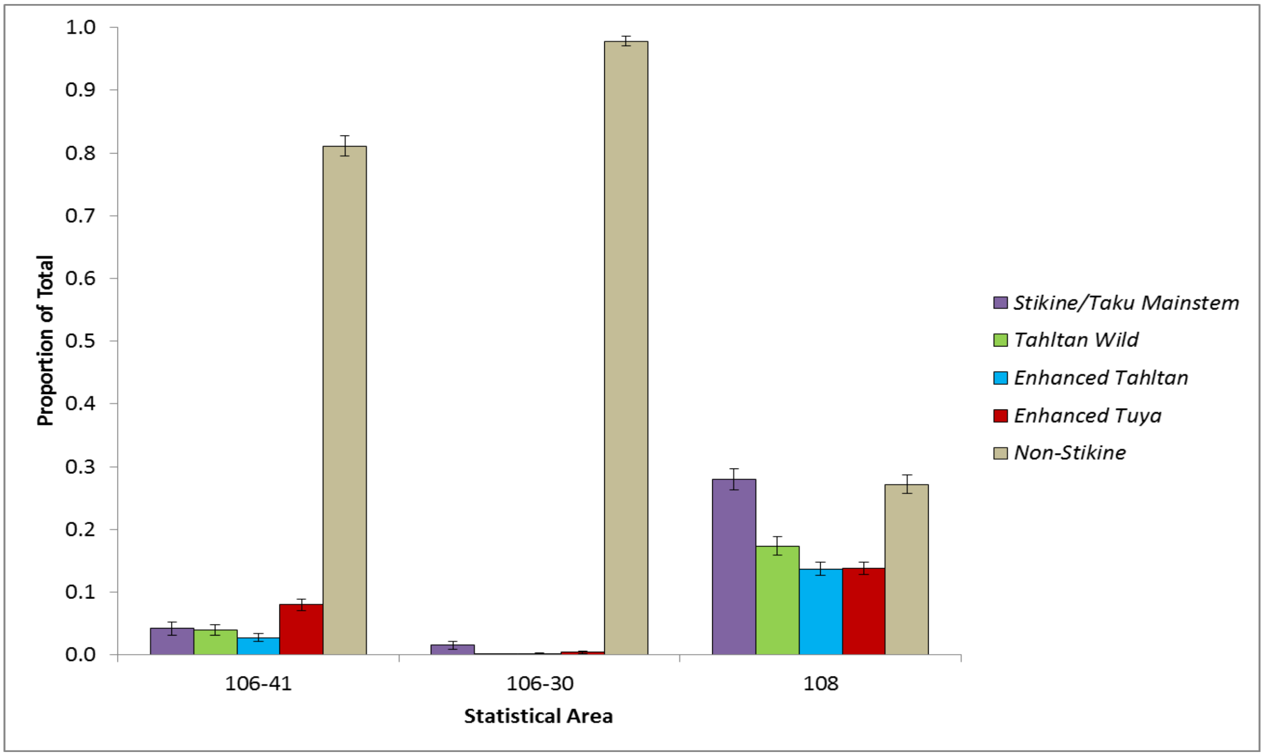

Figure 1. Total season stock composition estimates for Stikine River area fisheries 2015. Estimates were weighted by harvest per stratum. Error bars are upper and lower bounds of 90% credibility intervals.

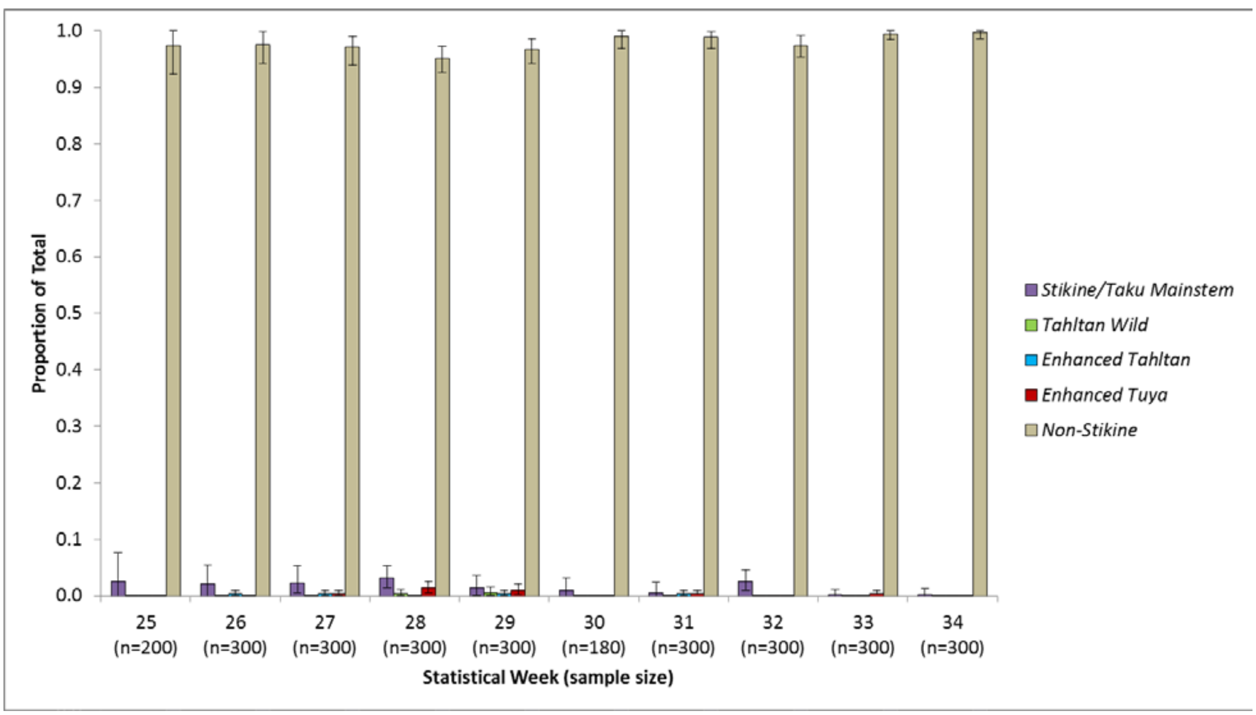

Figure 2. Stock composition estimates of sockeye salmon caught in the District 106-30 gillnet fishery in 2015. Sample size (n) includes genotyped, aged, and otolith-marked fish. Error bars are upper and lower bounds of 90% credibility intervals.

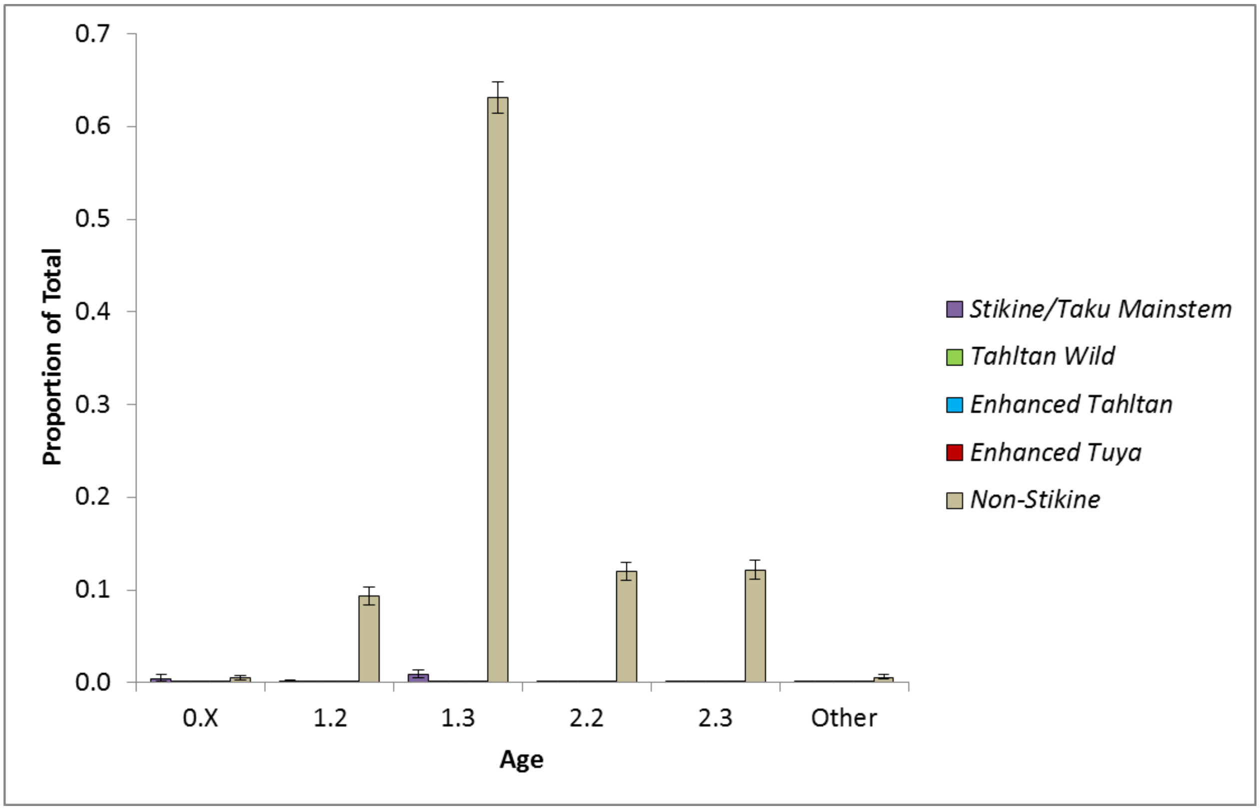

Figure 3. Age composition of sockeye salmon caught in the District 106-30 gillnet fishery in 2015 over the entire season. Error bars are upper and lower bounds of 90% credibility intervals.

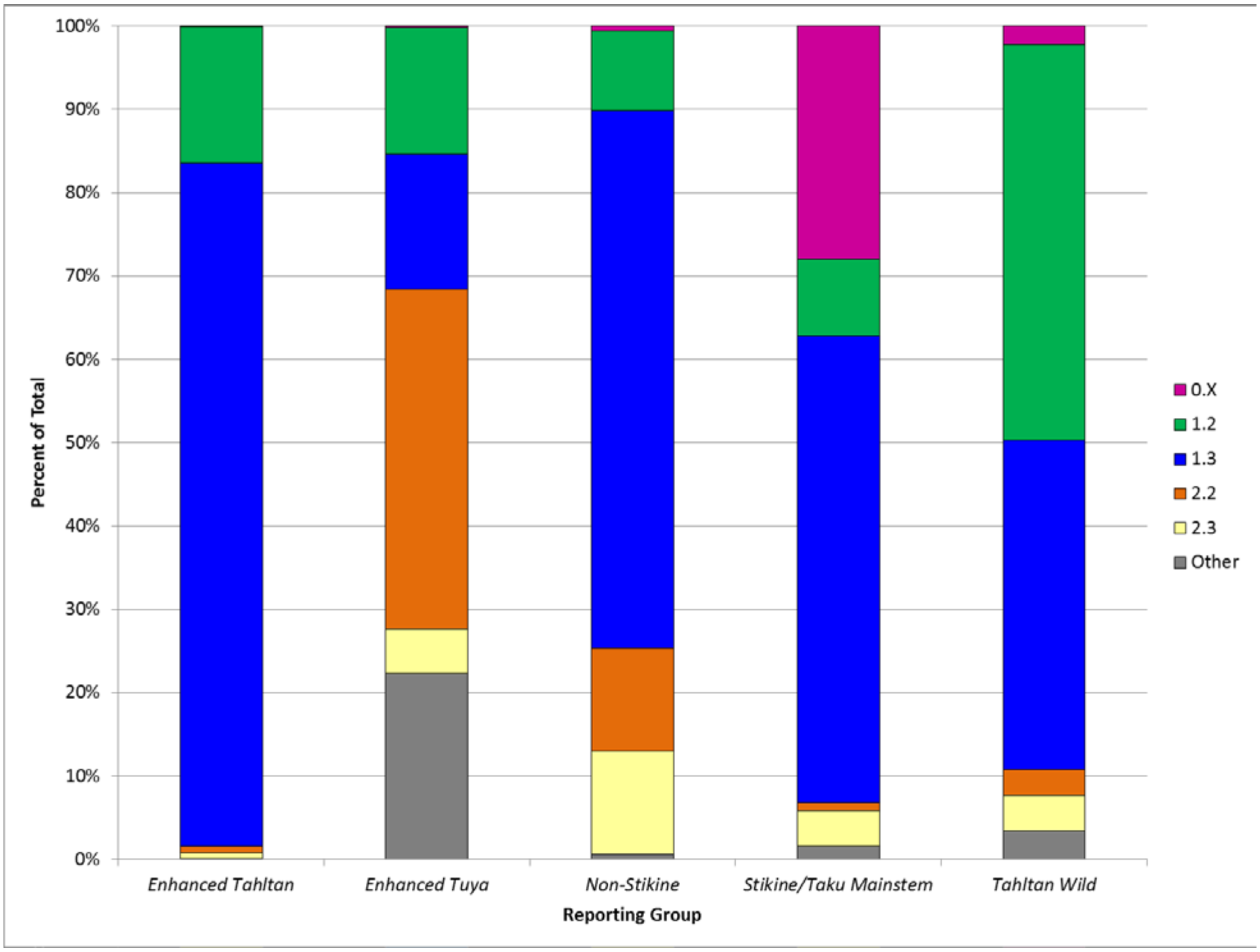

Figure 4. Age composition by reporting group of sockeye salmon caught in the District 106-30 gillnet fishery in 2015.

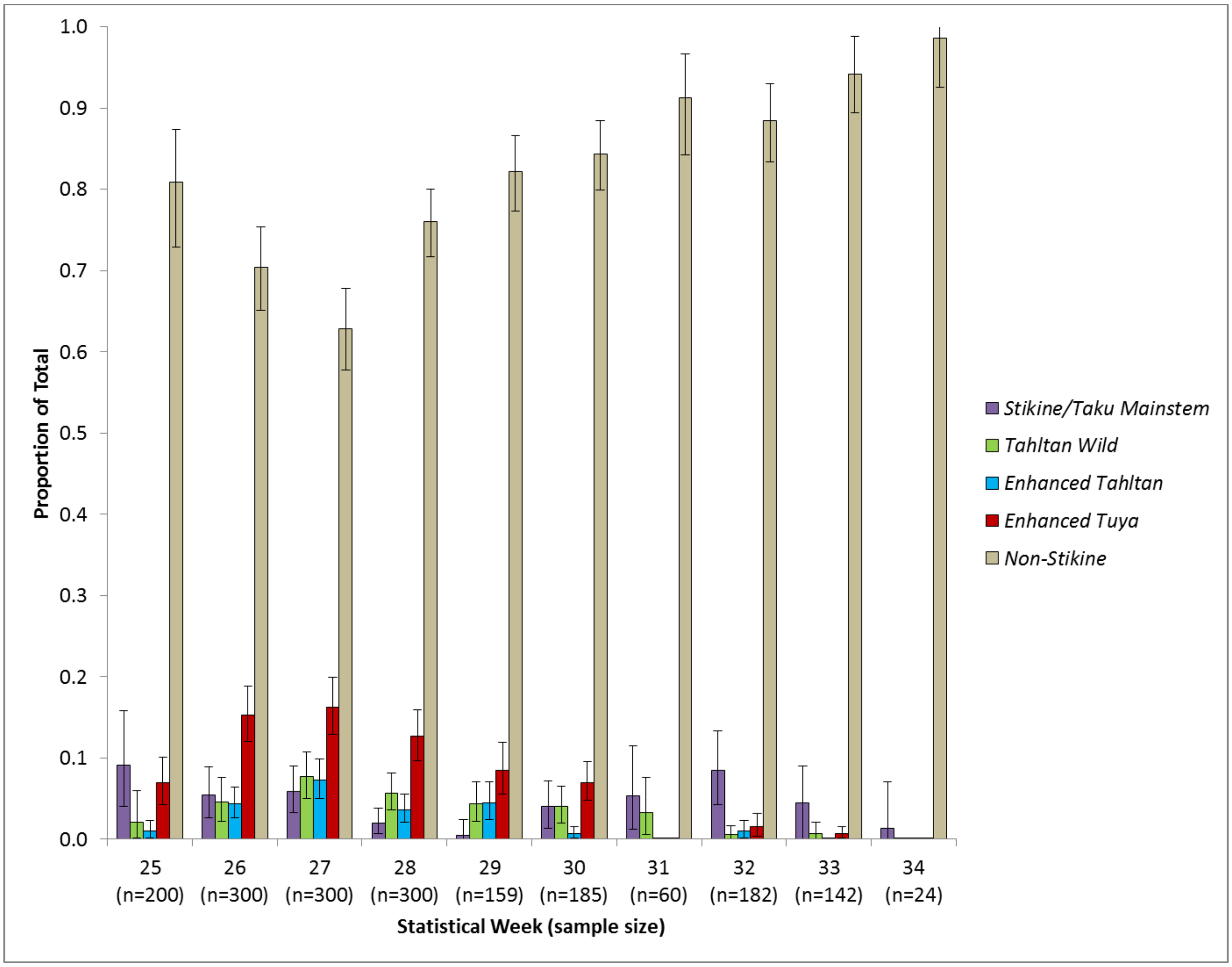

Figure 5. Stock composition estimates of sockeye salmon caught in the District 106-41 gillnet fishery in 2015. Sample size (n) includes genotyped, aged, and otolith-marked fish. Error bars are upper and lower bounds of 90% credibility intervals.

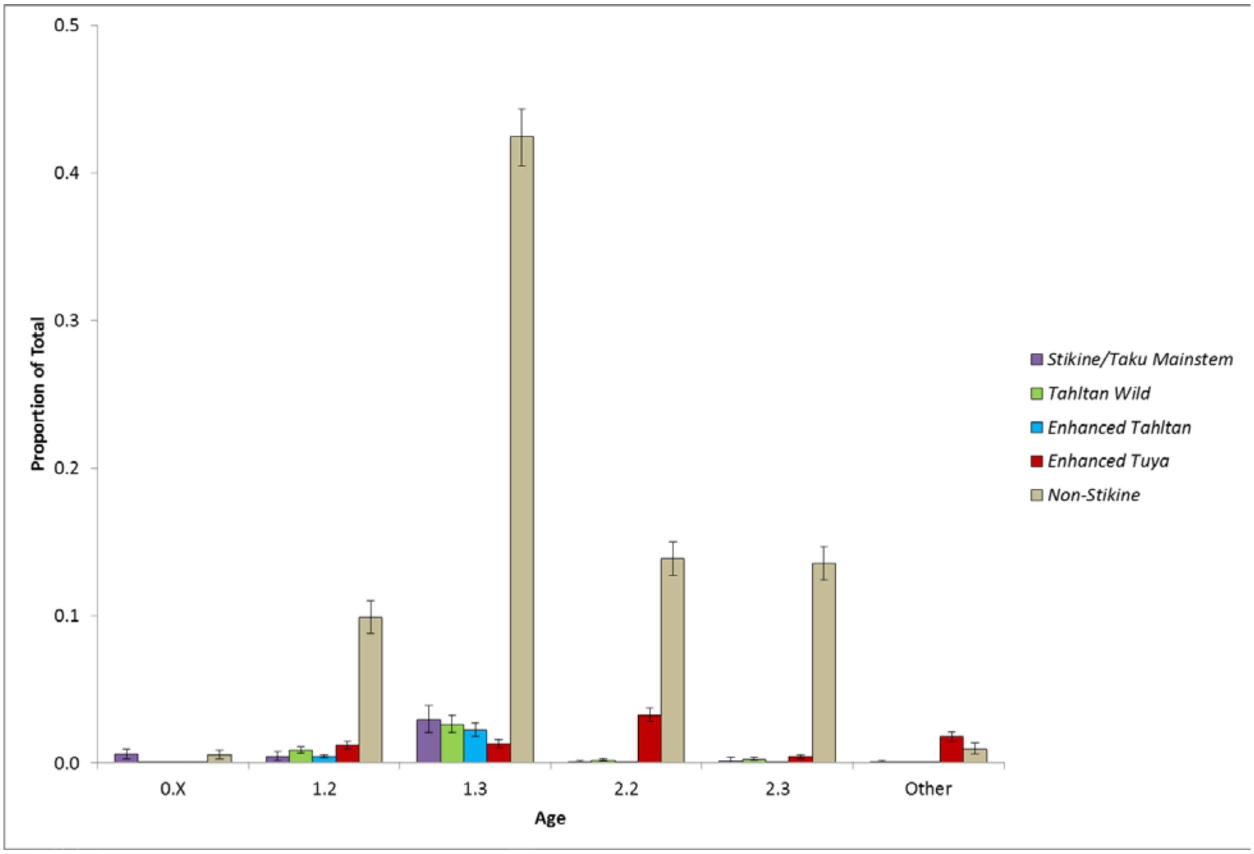

Figure 6. Total age composition of sockeye salmon caught in the District 106-41 gillnet fishery in 2015 over the entire season. Error bars are upper and lower bounds of 90% credibility intervals.

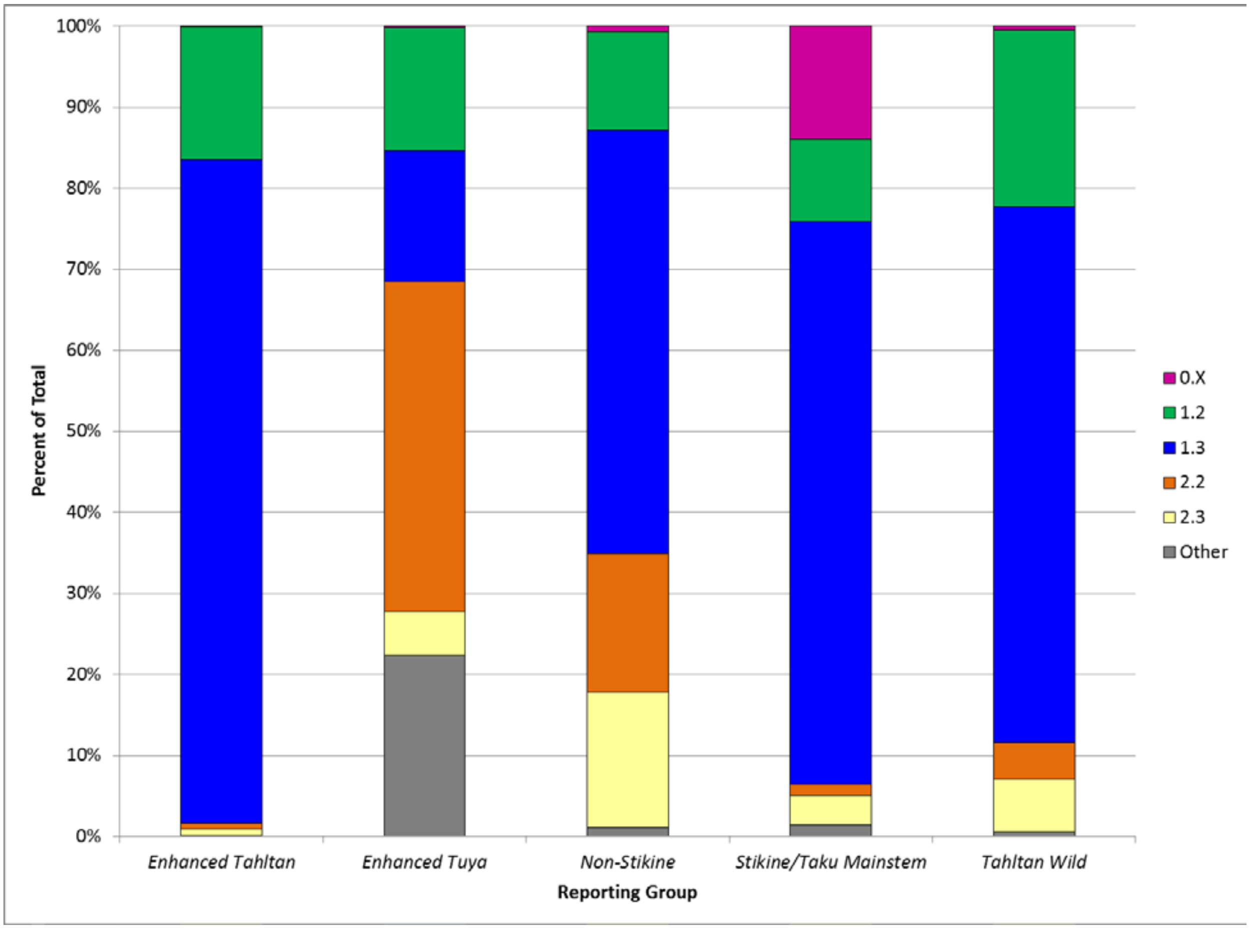

Figure 7. Age composition by reporting group of sockeye salmon caught in the District 106-41 gillnet fishery in 2015.

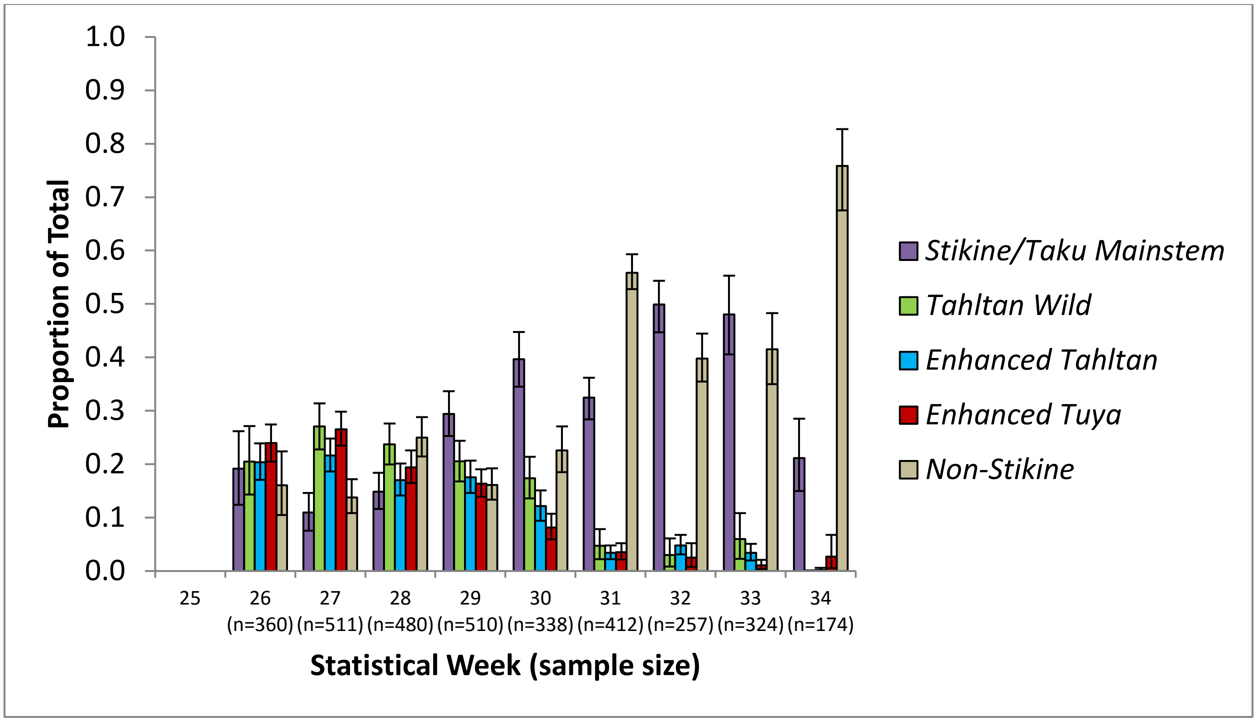

Figure 8. Stock composition estimates of sockeye salmon caught in the District 108 gillnet fishery in 2015. Sample size (n) includes genotyped, aged, and otolith-marked fish. Estimates in week 25 did not meet precision and accuracy goals identified by the TTC and thus are not reported. Error bars are upper and lower bounds of 90% credibility intervals.

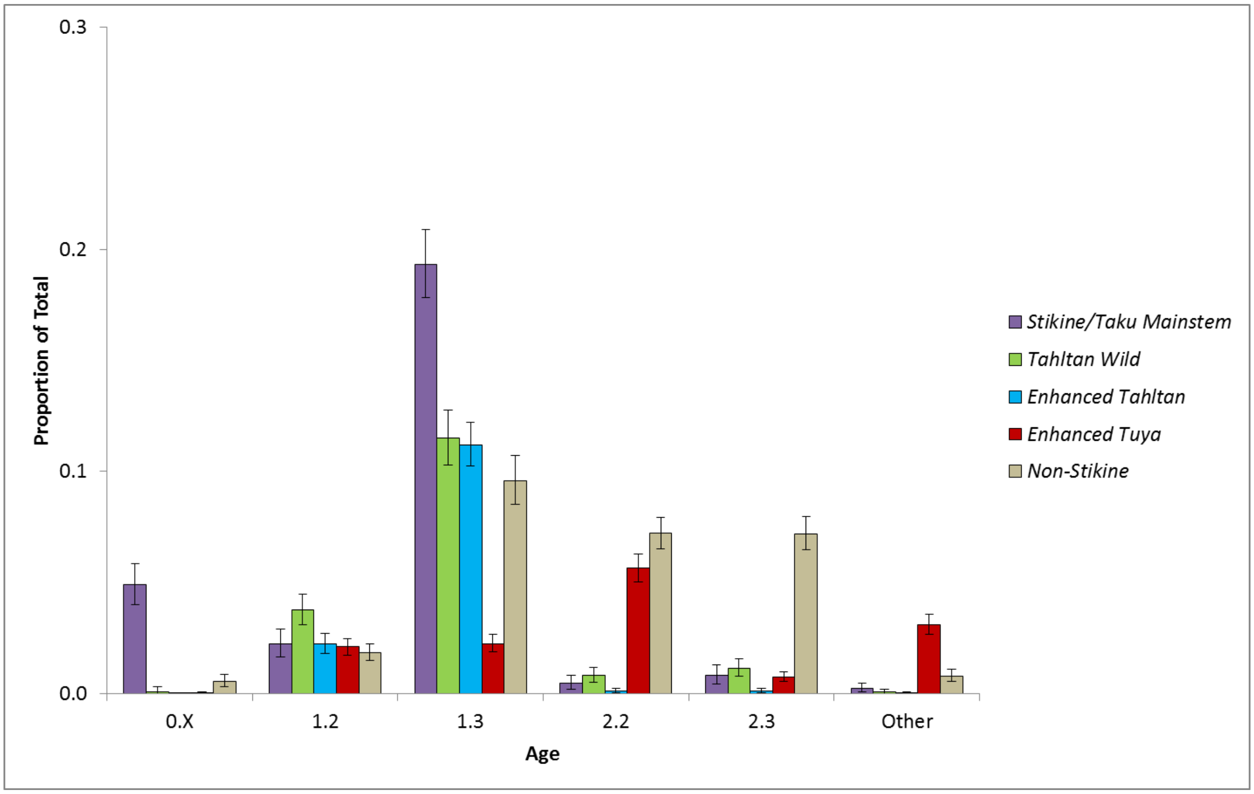

Figure 9. Total age composition of sockeye salmon caught in the District 108 gillnet fishery in 2015 over the entire season. Error bars are upper and lower bounds of 90% credibility intervals.

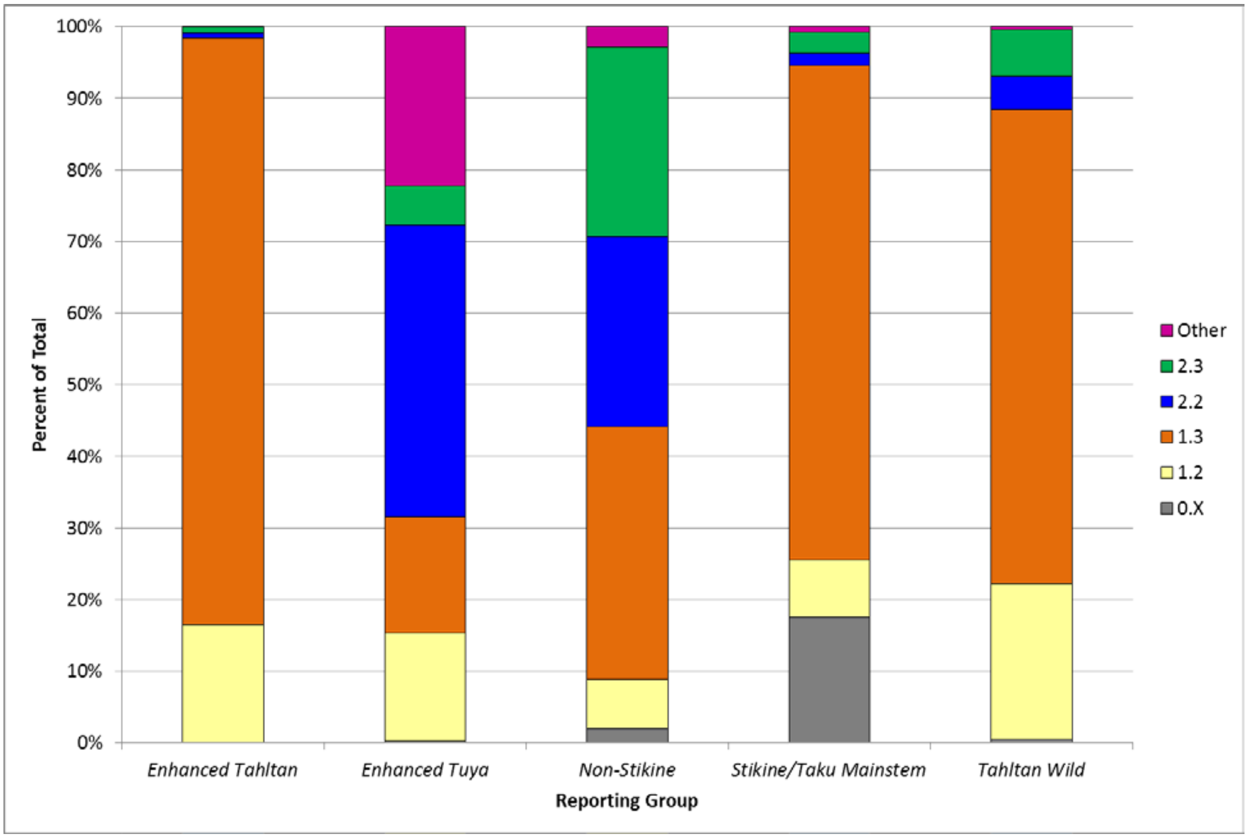

Figure 10. Age composition by reporting group of sockeye salmon caught in the District 108 gillnet fishery in 2015.