Skeena Sockeye In-river Run Reconstruction Analysis Model

and

Preliminary Analysis Results for 1982-2009

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1.0 INTRODUCTION

The Fraser, Skeena and Nass watersheds are the three largest sockeye producing watersheds in British Columbia. Exploitation rate estimates for the Nass and Skeena Sockeye stock aggregates are estimated annually using the Northern Boundary Sockeye Run Reconstruction (NBSRR) Model (English et al. 2004b; 2005; Alexander et al. 2010). English et al. (2011) provided estimates of marine exploitation rates for each Nass and Skeena sockeye Conservation Unit (CU) using estimates of the migration timing for each CU. These analyses have not included the details on the location and timing of in-river fisheries needed to estimate harvests for the various sockeye CUs or sub-stocks within each watershed. In some years, in-river harvest account for a large portion of the Canadian harvest of sockeye returning to these rivers. Run reconstruction analyses have been used to estimate CU specific harvest rates for in-river fisheries targeting Fraser sockeye and Chinook salmon (English et al. 2007; Noble 2011). This report provides a brief outline of a Skeena Sockeye In-River (SSIR) run reconstruction model built to combine information on run timing and escapements for Skeena sockeye sub-stocks with catch estimates for each sockeye fishery within the Skeena watershed. The model is similar to those developed for the Fraser River sockeye fisheries within the Fraser watershed except that the Skeena model moves fish forward (upstream) through the fisheries and subtracts sockeye catches from estimates of the number of sockeye entering the Skeena River each day. The Fraser sockeye reconstructs the run entering the Fraser River by adding catches to daily estimates of escapement for each sub-stock.

1.1 Analysis Objectives

Estimates of in-river harvest by sub-stock are needed to be combined with those for marine fisheries to estimate total exploitation rates for Skeena sockeye. The SSIR model provides a systematic process for combining information on catch, fishery timing, stock specific migration rates through fisheries, escapement and river entry run timing by sub-stock. The results from these run reconstruction analyses will be combined with the marine harvest rates from NBSRR model to provide estimates of the total exploitation rate for each Skeena sockeye sub-stock and the biological basis for the forward looking model needed to evaluate alternative fisheries and fisheries management options for Skeena sockeye sub-stocks.

2.0 DATA SOURCES AND PREPARATION

2.1 Sockeye Stocks and Stock Aggregates

The model has the capacity to accommodate details for as many sockeye sub-stocks or run-timing groups as can be defined using the available data and combine these stocks into any number of management groups. Initial analyses of available run-timing data resulted in the definition of 20 sub-stocks for the Skeena watershed (English et al. 2011).

2.2 Fishery Definitions

The SSIR model includes two types of fisheries (FSC and ESSR) and 12 fishing areas: 3 Tsimshian fishery strata in the lower Skeena and 9 fishing areas used by other Skeena First Nations above Fiddler Creek (Table 1). All of the fisheries on the Skeena River (mainstem) harvest multiple stocks and stock composition estimates are not available for these fisheries. Consequently, run reconstruction analysis is required to distribute the reported weekly catches between the stocks vulnerable to each fishery. Some FSC and most ESSR fisheries occur in locations where only a single stock is affected. The harvest rate estimates for these fisheries were computed by dividing the catch by the sum of the annual catch and escapement for these stocks.

2.3 Escapement and Entering Run Size

Annual escapement estimates for each Skeena sockeye CU were combined with daily Tyee test fishery data and stock-specific run timing parameters to produce estimates of daily escapement past the Tyee test fishery for each CU. Annual estimates of spawning escapement for the 20 Skeena CU-run timing groups were derived from three sources: 1) nuSEDS data for 11 non-Babine sockeye CUs; 2) DFO Prince Rupert historical databases for the 5 Babine sockeye stock groups; and 3) assumed fixed values for the remaining 4 non-Babine sockeye CUs without escapement monitoring programs. Each of the non-Babine sockeye stocks had one or more years of missing escapement estimates and these were filled in by using the average of the estimates for adjacent years or interpolating between the available estimates. The filled in values are highlighted in yellow in Table 2. The annual escapement estimates for sub-stocks with terminal fisheries (i.e. Pinkut, Fulton, Sustut and Bulkley-Morice) were increased to account for catches in these terminal fisheries prior to determining the portions that each sub-stock proportions represents of the total return of Skeena sockeye in a given year. These sub-stock proportions were combined with annual estimates of the total sockeye abundance passing Tyee and run-timing parameters derived from analysis of 2000-10 Tyee DNA samples (Cox-Rogers, DFO Rupert, pers. comm.) to compute the daily abundance passing Tyee for each sub-stock.

2.4 Run Timing

Estimates of river entry timing for 20 sub-stocks of Skeena sockeye were obtained from information reported in a memorandum entitled “SKEENA SOCKEYE SUB-STOCK RUN-TIMING AND ABUNDANCE EVALUATED USING TYEE TEST FISHERY DNA: 2000-2010” prepared by Steve Cox-Rogers dated 23 February 2012. The relative timing for each sub-stock was used to determine the offset difference between the average annual timing for all Skeena sockeye and that for a specific sub-stock. For example: Lakelse sockeye were estimated to have a timing 3 weeks earlier than the median timing for Skeena sockeye, therefore, the offset parameter was set at -21 days for Lakelse sockeye. The duration of the run for each sub-stock was also derived from the 2000-2010 DNA stock composition estimates. The parameter used to define the duration was the standard deviation (SD) measured in number of days. Table 3 provides the offset and SD parameters for each sub-stock. The run timing curve for each sub-stock was defined by a normal curve where the mid-point was defined by combining the stock-specific offset with the median date of sockeye migration past the Tyee test fishery and the start

and end points for each timing curve were 3 SD units each side of the mid-point. Therefore, the SD of 13.3 d for Lakelse sockeye results in a total duration of 80 days for this stock. For our initial analysis we used the same offset and SD parameters for each year except 2006, when the duration of the run (SD) for the two large enhanced stocks (Pinkut and Fulton) was increased from 14 to 17.5 days (total duration increased from 84 to 105 days) in order to reflect the notably longer duration of the Skeena sockeye run observed in 2006.

2.5 Fishery Residence Time

Residency time was defined as the number of days (to the nearest day) a stock resides within the boundaries of a single fishery. These residence times were derived from historical tagging studies, the differences between peak abundances estimated at Tyee and the Babine fence, and information on the size (river kms) and location of each fishery (English et al 1985, Steve Cox-Rogers, pers. comm.).

2.6 Catch

Estimates of annual harvest by Skeena River First Nations for each fishery location and type from 1982-2009 were obtained from DFO records (Table 4, Steve Cox-Rogers, pers. comm.). Estimates of the annual harvests were available for most FSC fisheries from 1996-2009. FSC catch estimates were not available for two FSC fisheries (Kitsegass and Sustut) prior to 1993 and there were notable missing estimates for a large portion of the Tsimshian fisheries in 1992 and 2001, Lake Babine FN fisheries in 1987 and the Bulkley River (Wet'suwet'en) fisheries in 1984 and 1990. ESSR commercial fisheries were first conducted on the Skeen River in 1993. These fisheries are only permitted at specific locations within the Skeena watershed when managers determine that Escapements Surplus to Spawning Requirements (ESSR) can be harvested for some Skeena sockeye stocks. In recent years, additional commercial fishing opportunities have been provided to Skeena River First Nations through the transfer of sockeye allocations for Area 4 seine and gillnet licences to in-land "demonstration" fisheries. From 1993-2009, there have been 10 years when ESSR and/or demonstration fisheries have been conducted within the Skeena watershed and total harvests in these fisheries have ranged from 13,700 to over 780,000 sockeye (Table 5).

The breakdown of these annual harvest estimates to weekly harvests was not available for the analyses conducted to date (15 October 2012), so the available annual harvest estimates were prorated to weekly harvest estimates using the year specific estimates of the number of sockeye passing Tyee each week adjusted for the time required for sockeye to migrate from Tyee to each fishery. Ideally, these initial estimates of weekly catch will be replaced with the best available estimates from Skeena First Nations. If weekly estimates are not available of some in-river fisheries, additional information on the timing and duration of these fisheries could be used to improve the estimate of weekly catches. Adjustments to the timing of FSC harvests are not expected to have a significant impact on the harvest rate estimates because of the small relative magnitude and protracted nature of these fisheries. The timing of the more substantial ESSR fisheries along the Skeena mainstem from Fiddler Creek to the Babine fence could have a significant impact on harvest rates for sockeye stocks migrating through these fisheries.

2.7 Fishing Patterns

Detailed information on fishing patterns (number of fishing days per week) for Skeena First Nation fisheries have not been obtained so the SSIR model currently runs on the assumption that weekly First Nation catches are distributed equally across all days in a week.

3.0 RUN RECONSTRUCTION MODEL

The theoretical basis of run reconstruction analysis for salmon stocks and fisheries are described in Starr and Hilborn (1988), Gazey et al. (1989), Cave and Gazey (1994), Gazey and English (2000) and English et al. (2007). The proposed analytical model will use essentially the same algorithms as those described in our 2007 PSARC approved report for Fraser Chinook (English et al. 2007). The sequential steps in the run reconstruction are described below:

1. read all catch, escapement, run-timing parameters and total daily abundance estimates derived from Tyee test fishery data;

2. estimate the daily escapement past the Tyee test fishery for each sub-stock;

3. starting with the first fishery in the lower Skeena, assign portions of the weekly catch to each sub-stock present in the fishery using the estimated constant daily harvest rate for all days in a week based on the assumption of equal vulnerability for all sub-stocks present during the week;

4. subtract the catch for each stock from the abundance of that stock that entered the fishery;

5. repeat steps 3 and 4 for each fishery moving upstream along the Skeena mainstem and into the tributaries;

6. total the catch and escapement estimates for each sub-stock and calculate annual estimates for the in-river harvest rates for each sockeye sub-stock and management group.

The model control worksheet has locations where the user can define the start and end years for the analysis and input files to be used for the run reconstruction analyses.

A more mathematically rigorous description of the above methods can be found in English et al. (2007).

3.1 Model Assumptions

The assumptions associated with the SSIR run reconstruction analyses model include:

a. The sockeye sub-stocks included in the models adequately represent the run timing and total escapement for Skeena sockeye;

b. The daily sockeye CPUE estimates from Tyee test fishery provides a reliable indication of the relative abundance sockeye entering the Skeena River;
c. The escapement estimates and run-timing parameters available for Skeena sub-stocks can be used with the assumption of normal distributions for each stock to derive daily stock composition estimates for the run at Tyee;
d. The fisheries and catch data included in the model adequately represent the timing and location of fisheries that harvest sockeye within the Skeena watershed; and
e. All stocks are equally vulnerable to harvesting when present in a fishery, such that harvests of a stock are proportional to the relative abundance of that stock in that fishery during the fishing period.

3.2 Model Structure

In order to expedite these run reconstruction analyses, we have used a model structure that is very similar to that used for the Fraser Chinook run reconstruction model (i.e. a MS Excel model prepared using the Visual Basic programming language). The model contains a series of sub-routines and function calls to read input data from MS Excel worksheets, conduct the analyses and output results to MS Excel files.

The model includes the following sub-routines and functions:

Sub Reconstruction() - main program where public variables are defined and all other sub-routines are called.

Sub Init() – prompts for input from the user, opens the input files, creates the output files and writes the initial column headings into each output file.

Sub FishResSpawn() – reads the fishery residence times for each stock and determines the cumulative number of days between each fishery and the escapement area for each stock.

Sub Calc_Escape() – calculates the daily escapement for each stock for a specific year.

Sub Reconstruct() - conducts the run reconstruction analysis working backward through the fisheries building on the daily escapement estimates.

Function CalcHarvestRate() - calculates the weekly harvest rate for a given fishery based on the size of the reported catch, number of fishing days per week and the number of sockeye that escaped from that fishery.

Function gs() – calculates the weekly catch for a given harvest rate. This function is used in the bisection algorithm to determine the weekly harvest rate that would result in the reported catch.

Sub-OutputData() – writes the run reconstruction results to the various output files.

The internally documented source code for the current version of the SSIR model will be provided as an Appendix to the report for this project.

4.0 PRELIMINARY RESULTS

Figures 1-3 provide a sample of the run-timing and abundance of sockeye passing the Tyee test fishery in the lower Skeena River for 2006-08. These figures also show the normally distributed run-timing curves for each of the major sub-stock groups and the resulting breakdown of the total Tyee abundance for each of the major sub-stocks. These years were selected because 2006 is an example of one of the latest run-timing years, 2007 run-timing is close to the multi-year mean and 2008 is one of the earliest run-timing years. As indicated above, 2006 was the only year where we increased the duration of two sub-stocks (Pinkut and Fulton) to reflect the protracted nature of the sockeye return in that year and ensure that the stock composition estimates for Tyee were consistent with the best available escapement estimates.

These figures clearly show the substantial overlap in the run-timing and long durations estimated for most Skeena sockeye stocks. These long durations are likely the result of having to use multiple years of DNA samples to obtain an adequate sample size for the relatively small non-Babine sockeye stocks. Steve Cox-Rogers 23 February 2012 memorandum included the following conclusion:

> *"The estimated peak dates of run entry for most Skeena sockeye sub-stocks, based on updated 2000-2010 DNA analysis, are not substantially different from past tagging assessments and the peak dates currently being used to assess stock impacts. The DNA data does suggest slightly wider "spreads" about the peaks for most stocks than currently assumed, and some apparent skewness/bi-modal variability to the timings may not be appropriately captured with the current practice of fitting normal curve approximations to the data. However, it is not clear how much of the shape variation is real or simply an artefact of sample size issues given the small number of DNA samples actually analyzed for some stocks in certain weeks (e.g. the tails of the test fishery). This, coupled with the fact that many non-Babine stocks are present in small proportions at Tyee in the first place, means the derived timings for the larger stocks are probably ok, but will always be uncertain for the smaller ones."*

While it is likely that the run duration for a single year would be shorter than the duration derived from samples collected over multiple years, the harvest rate estimates derived from these longer run durations will be less sensitive to uncertainties in the run and harvest timing for a given year. In the absence of more reliable year specific data on run-timing and duration, a conservative approach for estimating harvest rates for in-river fisheries is to use these longer durations.

Two model inputs that are critical for deriving reliable estimates of in-river harvest rates are catch estimates for all major fisheries and relative escapement estimates for each sub-stock. The preliminary estimates of the stock-specific harvest rates show the results of deficiencies in the available catch and escapement estimates (Table 6). Harvest rates estimated for lower Skeena

stocks in 1992 and 2001 are underestimated due to missing catch estimates for all Skeena fisheries below Terrace. Underestimation of escapements to the Bulkley-Morice watershed prior to 1989, have resulted in substantial overestimates of the harvest rates for the Moricetown fishery for 1982-1988. In years when catch estimates are available for all major fisheries and escapement estimates reflect the relative abundance of each stock, the SSIR model produces harvest rates the difference in the magnitude and location of fisheries and run-timing and geographic distribution of the sockeye sub-stocks. For example: in 2000 when ESSR fisheries were permitted to target surplus escapements for enhanced Babine stocks, in-river harvest rates were 45% for Pinkut and Fulton, 20-32% for the three run-timing groups of wild Babine sockeye, 23-27% for upper Skeena sockeye stocks and 1-4% for the early run lower Skeena sockeye stocks. In years without ESSR fisheries (e.g. 2002 and 2005), in-river harvest rates are similar (15-20%) for all Babine sockeye sub-stocks, 10-16% for upper Skeena stocks and 2-6% for lower Skeena stocks. The two lower Skeena stocks with notably shorter durations and least overlap with the Babine enhanced stocks are Lakelse and Zymoetz. The in-river harvest rates for these stocks are typically in the 2-4% range.

5.0 NEXT STEPS

The tasks remaining to complete the estimation of in-river harvest rates for 1982-2009 include:

1. Circulate this report for review and discussion with Skeena River First Nations during the week of 29 October 2012;

2. Obtain additional information on in-river fisheries and fill in any missing catch estimates;

3. Discuss any necessary adjustments to the relative escapement estimates for Skeena sockeye sub-stock;

4. Discuss the model assumptions regarding run-timing and obtain additional information that could be used to improve the run-timing estimates;

5. Finalize the estimates of in-river harvest rates for each Skeena sub-stock and combine these with the marine harvest rates to compute total exploitation rates for each sub-stock from 1982-2009.

6.0 LITERATURE CITED

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Table 1. Fisheries, stocks and estimates residence time in days for the Skeena sockeye in-river run reconstruction analyses.

						Fisheries											
Stocks (Geographic CUs)	Short Name	Order	Aggregate	Data Quality[1]	CUs in Group	Coastal to Kasiks	Kasiks-Terrace	Terrace-Fiddler	Fiddler-Hazelton	Hazelton-L Babine	Babine below Fence	Babine Fence	Babine Lake	Pinkut Terminal	Fulton Terminal	Bulkley-Morice	Sustut
Kluatantan/Kluayaz	Kluatan+	1	1	W	2	3	4	3	4	7							
Motase	Motase	2	1	W	1	3	4	3	4	7							
Sustut/Johanson/Spawning	Sustut+	3	1	G	3	3	4	3	4	7							1
Bear/Azuklotz/Asitka	Bear+	4	1	G	3	3	4	3	4	7							
Slamgeesh/Damshilgwit	Slamgeesh	5	1	G	2	3	4	3	4	7							
Sicintine	Sicintine	6	1	W	1	3	4	3	4	7							
Babine W Early	Babine-WE	7	2	G	1	3	4	3	4	7	4	1	3				
Babine W Middle	Babine-WM	8	2	G	1	3	4	3	4	7	4	1	3				
Babine W Late	Babine-WL	9	2	G	1	3	4	3	4	7	4	1	3				
Babine Pinkut	Babine-P	10	2	G	1	3	4	3	4	7	4	1	3	1			
Babine Fulton	Babine-F	11	2	G	1	3	4	3	4	7	4	1	3		1		
Swan/Stephans/Club	Swan+	12	1	G	3	3	4	3	4								
Bulkley/Maxan	Bulkley+	13	1	W	2	3	4	3	4							1	
Morice/Atna	Morice+	14	1	G	2	3	4	3	4							1	
Kitwanga	Kitwanga	15	1	G	1	3	4	3	2								
Zymoetz	Zymoetz	16	1	W	3	3	4	1									
Kalum	Kalum	17	1	W	1	3	4										
Lakelse	Lakelse	18	1	G	1	3	4										
Alastair	Alastair	19	1	G	1	3											
Johnston	Johnston	20	1	W	1	1											

[1] G= Good, W=Weak

Table 2. Escapement estimates for each sub-stock of Skeena sockeye salmon 1980-2010.

	Kluatan+	Motase	Sustut+	Bear+	Slamgeesh	Sicintine	Babine-WE	Babine-WM	Babine-WL	Babine-P	Babine-F	Swan+	Bulkley+	Morice+	Kitwanga	Zymoetz	Kalum	Lakelse	Alastair	Johnston	Skeena Agg.
1980	1,000	500	4,000	1,980	1,000	1,000	31,679	11,166	197,031	85,017	178,731	3,166	1,000	850	200	280	620	29,620	30,000	504	579,344
1981	1,000	500	4,000	997	1,000	1,000	46,466	7,178	113,332	453,885	781,574	8,443	1,000	2,125	1,040	3,000	482	16,064	1,800	504	1,445,389
1982	1,000	500	4,000	947	1,000	1,000	93,630	4,827	159,595	231,341	605,442	8,443	1,000	6,375	1,880	2,000	758	30,296	9,500	504	1,164,037
1983	1,000	500	4,000	922	1,000	1,000	26,965	8,904	103,027	191,903	535,594	9,498	1,000	8,500	2,720	10,000	606	19,365	13,000	705	940,210
1984	1,000	500	4,000	897	1,000	1,000	26,503	8,065	204,447	357,780	435,090	10,553	1,000	6,375	3,560	1,000	785	9,573	8,000	705	1,081,833
1985	1,000	500	4,000	2,709	1,000	1,000	75,649	17,229	623,637	590,887	823,141	9,287	1,000	4,250	4,400	1,200	1,570	36,530	8,000	907	2,207,896
1986	1,000	500	4,000	2,992	1,000	1,000	26,865	3,874	167,437	213,745	266,086	10,553	1,000	6,375	3,720	6,000	1,570	9,022	21,000	353	748,092
1987	1,000	1,500	4,000	10,917	1,000	1,000	38,206	15,786	237,400	665,019	331,145	21,107	1,000	8,500	3,040	6,000	3,139	5,336	10,000	604	1,365,699
1988	1,000	100	4,000	7,221	1,000	1,000	42,435	23,459	241,974	376,474	699,538	25,328	1,000	2,125	2,360	4,000	1,884	10,508	13,000	705	1,459,109
1989	1,000	400	4,000	1,667	1,000	1,000	18,412	7,701	132,563	233,680	717,960	8,443	1,000	11,900	1,680	3,500	2,825	7,724	14,932	302	1,171,690
1990	1,000	60	4,000	2,279	1,000	1,000	21,328	7,395	198,864	202,042	527,016	10,553	1,000	12,750	1,000	3,000	4,133	2,707	10,000	458	1,011,586
1991	1,000	300	4,000	7,551	1,000	1,000	58,719	24,980	432,582	437,123	202,114	14,775	1,000	85,001	1,000	1,200	4,133	13,534	22,000	613	1,313,624
1992	1,000	500	4,000	5,097	1,000	1,000	55,071	8,863	613,114	457,238	734,513	21,107	1,000	57,376	1,000	10,000	11,022	10,453	16,000	1,992	2,011,346
1993	1,000	400	4,000	5,599	1,000	1,000	16,646	21,962	595,377	455,190	470,660	16,885	1,000	46,751	1,000	15,000	9,645	13,754	15,000	3,371	1,695,240
1994	1,000	250	4,000	8,057	1,000	1,000	25,124	7,560	132,299	202,916	636,540	12,453	1,000	60,563	1,000	10,295	15,156	3,136	13,000	4,750	1,141,100
1995	1,000	250	4,000	10,516	1,000	1,000	79,679	6,555	69,506	565,722	916,955	8,020	1,000	74,376	500	10,295	13,434	27,618	17,000	6,129	1,814,554
1996	1,000	100	4,000	6,308	1,000	1,000	60,909	7,975	143,305	518,865	917,303	7,598	1,000	87,126	250	10,295	5,236	23,822	25,000	5,108	1,827,198
1997	1,000	220	4,000	3,816	1,000	1,000	92,245	34,660	129,975	184,561	488,761	5,910	1,000	51,001	250	10,295	10,058	3,466	24,000	4,086	1,051,303
1998	1,000	500	4,000	1,578	1,000	1,000	43,130	16,545	97,880	97,149	244,797	5,910	1,000	12,750	250	10,295	10,747	5,409	11,000	6,129	572,070
1999	1,000	500	4,000	9,195	1,000	1,000	63,692	22,946	155,040	132,582	208,657	4,221	1,000	31,875	250	10,295	12,318	7,235	2,000	8,172	676,977
2000	1,000	400	4,000	5,297	949	1,000	84,558	19,982	185,020	197,387	888,911	5,823	1,000	6,375	231	10,295	13,888	7,235	6,200	1,500	1,441,050
2001	1,000	200	4,000	4,348	855	1,000	232,802	47,818	617,401	114,385	462,095	7,425	1,000	8,500	221	10,295	8,292	9,061	10,800	4,500	1,545,997
2002	1,000	100	4,000	897	398	1,000	37,049	31,046	165,162	83,236	253,749	2,533	1,000	14,875	978	7,072	11,072	7,468	4,000	2,000	628,635
2003	1,000	2,000	4,992	11,253	430	1,000	55,028	83,151	99,284	218,006	682,889	5,070	1,000	21,250	3,377	9,106	28,383	7,468	27,000	5,050	1,266,738
2004	1,000	600	1,604	2,998	293	1,000	45,849	59,994	288,950	92,033	401,164	5,538	1,000	16,469	1,317	6,332	13,968	5,875	20,074	2,395	968,453
2005	1,000	290	1,175	2,499	216	1,000	27,153	33,882	176,235	123,965	314,847	2,550	1,000	17,002	937	6,888	8,939	6,305	13,147	2,395	741,425
2006	1,000	120	808	2,849	331	1,000	40,874	12,515	137,660	258,670	684,130	4,529	1,000	17,536	5,139	6,116	9,521	3,632	4,800	2,395	1,194,625
2007	1,000	300	2,469	3,199	366	1,000	52,862	12,595	100,762	226,528	607,886	2,090	1,000	28,475	245	3,800	12,455	6,624	22,000	2,395	1,088,052
2008	1,000	100	212	8,577	150	1,000	28,667	12,744	93,158	197,787	507,968	4,475	1,000	19,125	1,200	280	15,349	5,513	1,119	2,395	901,819
2009	1,000	410	540	6,787	161	1,000	20,503	18,341	93,791	140,515	340,254	3,466	1,000	24,342	3,047	3,400	19,521	7,574	21,500	2,395	709,548
2010	1,000	592	426	12,210	740	1,000	20,455	6,065	74,126	133,695	361,259	266	1,000	7,831	20,804	2,980	30,496	14,720	33,700	2,395	725,760
After Fill																					
Average	1,000	442	3,362	4,908	1,000	1,000	51,263	19,541	218,708	272,236	523,444	8,581	1,000	24,475	2,213	6,275	9,097	11,827	14,470	2,465	1,177,110
Portion	0.001	0.000	0.003	0.004	0.001	0.001	0.044	0.017	0.186	0.231	0.445	0.007	0.001	0.021	0.002	0.005	0.008	0.010	0.012	0.002	
Before Fill																					
Average	0	441	1,528	5,080	444	0	51,263	19,541	218,708	272,236	523,444	8,709	0	23,796	3,078	4,939	8,990	12,490	14,283	2,395	1,171,365
Portion	0.001	0.000	0.003	0.004	0.001	0.001	0.044	0.017	0.187	0.232	0.447	0.007	0.001	0.020	0.003	0.004	0.008	0.011	0.012	0.002	

Table 3. Run-timing parameters used for each Skeena sockeye sub-stock group.

#	Stocks (Geographic CUs)	CUs in Group	Offset (days)	Duration (days)	Default SD (days)	2006 SD (days)	Source: Cox-Rogers (2012) Group Name	Peak Week	Offset (days)	SD (weeks)
1	Kluatantan/Kluayaz	2	-10.5	105	17.5	17.5	Bulkley-Morice	72	-10.5	2.5
2	Motase	1	3.5	92	15.4	15.4	Motase	74	3.5	2.2
3	Sustut/Johanson/Spawning	3	-3.5	84	14.0	14.0	Sustut	73	-3.5	2.0
4	Bear/Azuklotz/Asitka	3	-3.5	84	14.0	14.0	Sustut	73	-3.5	2.0
5	Slamgeesh/Damshilgwit	2	-3.5	84	14.0	14.0	Sustut	73	-3.5	2.0
6	Sicintine	1	-3.5	84	14.0	14.0	Sustut	73	-3.5	2.0
7	Babine W Early	1	-10.5	84	14.0	14.0	Babine WE	72	-10.5	2.0
8	Babine W Middle	1	-3.5	84	14.0	14.0	Babine WM	73	-3.5	2.0
9	Babine W Late	1	10.5	84	14.0	14.0	Babine WL	75	10.5	2.0
10	Babine Pinkut	1	-3.5	84	14.0	17.5	Pinkut	73	-3.5	2.0
11	Babine Fulton	1	3.5	84	14.0	17.5	Fulton	73	3.5	2.0
12	Swan/Stephans/Club	3	-10.5	76	12.6	12.6	Swan+	72	-10.5	1.8
13	Bulkley/Maxan	2	-10.5	105	17.5	17.5	Bulkley-Morice	72	-10.5	2.5
14	Morice/Atna	2	-10.5	105	17.5	17.5	Bulkley-Morice	72	-10.5	2.5
15	Kitwanga	1	3.5	118	19.6	19.6	Kitwanga+	74	3.5	2.8
16	Zymoetz	3	-17.5	59	9.8	9.8	Zymoetz	71	-17.5	1.4
17	Kalum	1	-3.5	105	17.5	17.5	Kalum-Bear	73	-3.5	2.5
18	Lakelse	1	-21.0	80	13.3	13.3	Lakelse+	64	-21	1.9
19	Alastair	1	-14.0	109	18.2	18.2	Alastair	71	-14	2.6
20	Johnston	1	-21.0	80	13.3	13.3	Lakelse+	64	-21	1.9

Table 4. Annual estimates of the harvest of Skeena River sockeye by First Nations in FSC fisheries, 1982-2009.

Fishery	Group	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Coastal	TTC	12,770	7,232	7,630	10,655	8,284	9,431	7,334	8,553	10,197	5,420		16,926	8,423	11,821
Marine to Kasiks	TTC	23,816	13,489	14,230	19,872	15,450	17,590	13,678	15,951	19,017	10,108		27,809	26,409	14,905
Coastal to Kasiks	TTC	36,586	20,721	21,860	30,526	23,734	27,021	21,012	24,504	29,214	15,528		44,735	34,832	26,726
Kasiks to Terrace	TTC	4,582	2,595	2,738	3,823	2,972	3,384	2,631	3,069	3,658	1,945		14,274	3,665	5,177
Terrace to Fiddler	TTC	11,653	6,600	6,963	9,723	7,560	8,606	6,693	7,805	9,305	4,946		9,019	14,418	9,757
Fiddler to Hazelton	GWWA	102,600	79,420	128,250	114,000	85,500	76,000	71,250	85,500	83,600	83,600	66,500	27,221	35,307	42,668
Hazelton to L. Babine	GWWA	5,400	4,180	6,750	6,000	4,500	4,000	3,750	4,500	4,400	4,400	3,500		1,858	2,246
Babine below Fence	GWWA												13,448		6,439
Babine Fence	LBN														
Babine Lake	LB/YECH	42,000	20,000	12,100	16,000	4,050		25,000	22,000	27,008	15,650	33,093	68,250	32,300	18,491
Pinkut Terminal	LBN														
Fulton Terminal	LBN														
Bulkley-Morice	GWWA	4,500	6,450		4,000	22,450	20,296	4,250	1,450		13,000	15,138	11,408	12,629	23,912
Sustut	TAKLA													1,302	
Total		207,320	139,966	178,660	184,072	150,766	139,307	134,586	148,828	157,185	139,069	118,231	188,355	136,311	135,416

Fishery	Group	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Coastal	TTC	7,444	4,090	21,124	3,073	37,157		29,000	3,123	4,356	10,376	9,607	21,685	27,134	9,100
Marine to Kasiks	TTC	31,951	37,839	24,105	14,644	27,600		20,000		4,840	2,507		17,022	5,428	
Coastal to Kasiks	TTC	39,395	41,929	45,229	17,717	64,757		49,000	3,123	9,196	12,883	9,607	38,707	32,562	9,100
Kasiks to Terrace	TTC	5,927	4,656	1,951	2,294	1,544		4,905	6,075	7,056	4,360	5,803	4,168	5,966	10,763
Terrace to Fiddler	TTC	15,744	12,909	15,209	10,131	13,245	13,479	13,680	11,337	12,550	9,098	9,749	9,338	8,535	9,465
Fiddler to Hazelton	GWWA	21,058	32,880	50,369	51,854	58,444	49,531	56,258	60,876	66,295	64,144	68,859	26,306	63,494	35,946
Hazelton to L. Babine	GWWA	1,109	1,731	2,651	2,730	3,076	2,487	2,879	3,204	3,489	3,376	3,624	1,385	3,342	1,892
Babine below Fence	GWWA	2,802	1,637	195	3,366	2,658	5,000	1,091	533	333	1,273		16,643		107
Babine Fence	LBN														
Babine Lake	LB/YECH	39,422	13,699	9,744	23,220	23,300	24,080	24,785	32,000	31,441	33,117	38,600	36,070	48,901	43,957
Pinkut Terminal	LBN														
Fulton Terminal	LBN														
Bulkley-Morice	GWWA	14,453	15,512	3,674	675	1,905	1,289	331	456	278	197	2,085	219	2,391	1,644
Sustut	TAKLA	559	513	768	868	1,050	470	811	1,954	567	862	632	419	526	992
Total		140,469	125,466	129,790	112,855	169,979	96,336	153,740	119,558	131,205	129,310	138,959	133,254	165,717	113,866

1) Coastal = LaxKwalaams+Metlakatla (No Kitkatla+Hartley Bay) catch data
2) Marine to Kasiks = Prince Rupert catch data
3) Kasiks to Terrace = Kitsumkalum catch data
4) Terrace to Fiddler = Kitselas catch data
5) Fiddler to Hazelton = 0.95 * Skeena (e.g. Hazelton) catch data based on comments provided by J. Steward regarding location of catch + Gitanyow
6) Hazelton to Lower Babine = 0.05 * Skeena (e.g. Hazelton) catch data based on comments provided by J.Steward regrading location of catch
7) Kitsegass (L. Babine) = Babine catch data
8) All Babine Lake = sum of Nat'oo'ten catch data
9) Sustut = Takla catch data
10) 1982-1992 GWWA Kitsegass catch data are included in the Hazelton to Lower Babine catch estimates
11) 1982-2000 Moricetown data are the actual reported catch figures
12) Note: Some missing 1992-1982 catch by fishery calculated as area-specific IFF total catch*Prop. IFF catch for 1993-2000
These numbers are of unknown accuracy: all have been interpolated from Kerra Hoyseth's (2000) DFO review.USE WITH CAUTION

Table 5. Annual estimates of the harvest of Skeena River sockeye by First Nations in ESSR and in-land “Demonstration” fisheries, 1993-2009.

Fishery	Group	1993	1994	1995	1996	1997	2000	2001	2006	2007	2008
Kasiks to Terrace	TTC	3,919	4,009	14,720	60,016	5,093	14,998				
Terrace to Fiddler	TTC			2,878			7,770		81,790		
Fiddler to Hazelton	GWWA	24,202	21,249	79,943	165,551	91,554	139,345	38,957			67,289
Hazelton to L. Babine	GWWA	1,274	1,118		8,713	4,819	180,140	26,112			
Babine below Fence	GWWA			31,880			9,995	152,230	92,347		41,715
Babine Fence	LBN	104,340	15,900	45,000	150,000	18,750	56,203	138,240	138,180	13,777	104,585
Babine Lake	TTC					48,432					
Pinkut Terminal	LBN					36,982	65,821	32,220			37,388
Fulton Terminal	LBN			35,000		19,268	310,132	315,220	80,820		50,506
Bulkley-Morice	GWWA					1,208					
Total		133,735	42,276	209,421	384,280	226,106	784,404	702,979	393,137	13,777	301,483

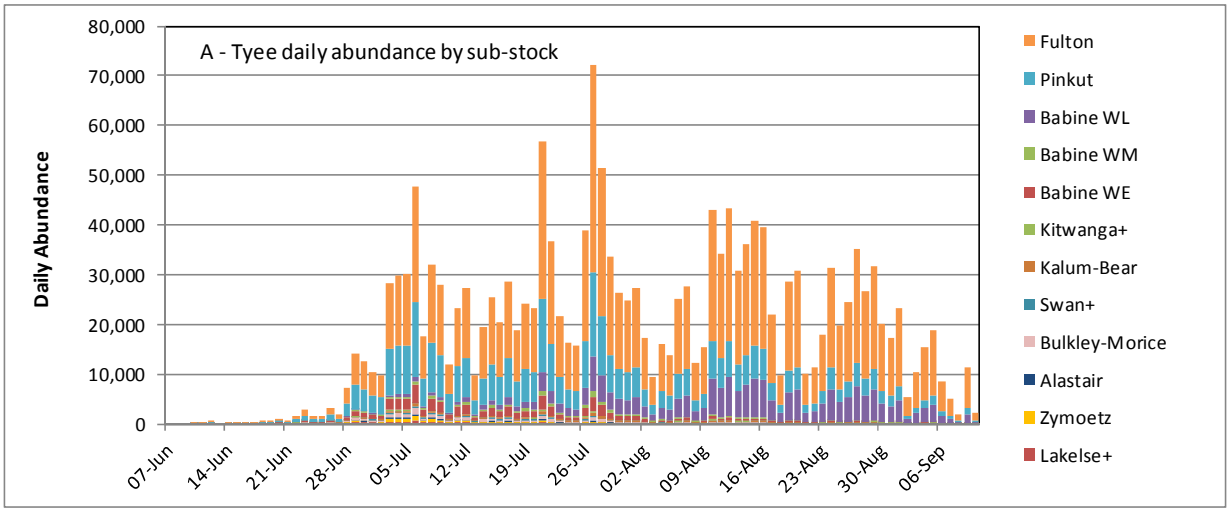
1) Terrace to Fiddler ESSR for 2006 is the DEMO fishery catch

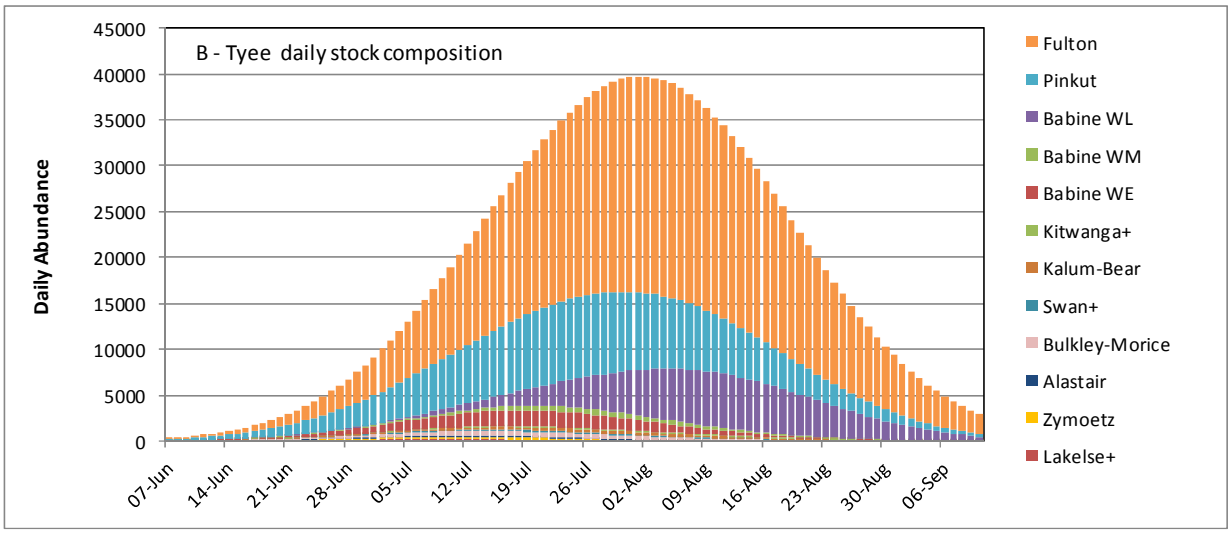
2) Fiddler to Hazelton ESSR = 67289 Econ + 41715 ESSR

Table 6. Preliminary estimates of harvest rates for each Skeena sub-stock group in First Nation fisheries conducted in and adjacent to the Skeena watershed.

Sub-Stock	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Kluatan+	13.1	17.4	12.4	7.1	14.3	8.1	8.8	12.7	10.3	7.6	3.5	6.9	10.6	10.6
Motase	11.2	10.0	13.0	6.8	13.3	7.6	6.4	9.2	10.9	7.4	3.2	6.0	8.8	7.8
Sustut+	12.0	12.6	12.6	6.8	13.6	7.8	7.2	10.6	10.5	7.4	3.3	6.4	31.8	9.1
Bear+	12.0	12.6	12.6	6.8	13.6	7.8	7.2	10.6	10.5	7.4	3.3	6.4	9.6	9.1
Slamgeesh	12.0	12.6	12.6	6.8	13.6	7.8	7.2	10.6	10.5	7.4	3.3	6.4	9.6	9.1
Sicintine	12.0	12.6	12.6	6.8	13.6	7.8	7.2	10.6	10.5	7.4	3.3	6.4	9.6	9.1
Babine-WE	17.1	19.7	13.3	7.8	14.7	8.1	10.6	15.1	12.8	8.9	5.5	19.9	16.7	17.2
Babine-WM	15.4	14.9	13.6	7.5	14.1	7.8	9.0	12.7	13.0	8.7	5.1	17.6	14.5	14.7
Babine-WL	12.9	8.7	14.2	7.4	13.5	7.4	6.8	9.1	13.7	8.4	4.4	14.2	11.2	10.9
Babine-P	15.4	14.9	13.6	7.5	14.1	7.8	9.0	12.7	13.0	8.7	5.1	17.6	14.5	14.7
Babine-F	14.0	11.3	13.9	7.4	13.8	7.5	7.8	10.7	13.3	8.5	4.7	15.7	12.7	15.8
Swan+	12.6	15.8	11.7	6.7	13.5	7.8	7.7	11.8	9.8	7.2	3.4	6.7	10.2	10.2
Bulkley+	44.7	50.4	11.9	45.4	77.8	70.0	60.8	21.0	10.0	19.1	22.7	24.4	25.2	31.7
Morice+	44.7	50.4	11.9	45.4	77.8	70.0	60.8	21.0	10.0	19.1	22.7	24.4	25.2	31.7
Kitwanga	7.5	7.4	7.6	4.3	8.5	5.0	4.4	6.2	7.1	4.4	1.5	4.8	6.5	5.2
Zymoetz	3.2	2.8	1.4	1.3	2.7	2.0	1.8	2.8	2.1	1.1	0.0	3.4	4.1	2.8
Kalum	2.9	2.2	1.8	1.3	2.7	1.9	1.5	2.2	2.5	1.1	0.0	3.1	3.3	2.2
Lakelse	2.9	2.4	1.3	1.2	2.4	1.8	1.7	2.6	1.9	1.0	0.0	3.3	3.8	2.8
Alastair	2.5	2.0	1.4	1.0	2.2	1.6	1.4	2.1	1.8	0.9	0.0	2.1	2.8	1.3
Johnston	0.9	0.7	0.4	0.3	0.7	0.5	0.5	0.8	0.5	0.3	0.0	0.7	1.0	0.5
Total	14.3	12.4	13.6	7.4	15.6	8.7	8.3	10.9	12.9	9.0	5.2	15.4	13.4	15.5

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Kluatan+	12.8	15.3	18.9	11.8	27.4	5.8	15.9	6.5	11.3	14.3	11.7	5.8	13.6	8.4
Motase	12.4	14.4	16.9	10.3	20.5	5.9	16.5	5.9	9.1	10.7	9.9	6.5	13.0	7.4
Sustut+	23.1	24.5	30.9	26.8	39.0	15.7	30.3	32.5	33.4	49.2	49.9	19.6	75.1	67.5
Bear+	12.5	14.9	17.6	11.0	23.0	5.8	16.2	6.1	9.9	12.0	10.7	6.0	13.3	7.9
Slamgeesh	12.5	14.9	17.6	11.0	23.0	5.8	16.2	6.1	9.9	12.0	10.7	6.0	13.3	7.9
Sicintine	12.5	14.9	17.6	11.0	23.0	5.8	16.2	6.1	9.9	12.0	10.7	6.0	13.3	7.9
Babine-WE	22.1	23.6	20.9	16.6	31.7	19.9	20.0	9.4	15.4	20.2	30.3	11.4	29.5	15.5
Babine-WM	21.0	22.2	19.5	15.0	27.5	20.1	20.0	8.7	13.5	17.1	27.5	11.6	28.4	13.9
Babine-WL	19.9	19.8	17.4	12.7	20.6	21.0	20.1	7.8	10.7	12.9	23.0	12.5	26.8	11.5
Babine-P	21.0	35.2	19.5	15.0	45.7	37.6	20.0	8.7	13.5	17.1	28.0	11.6	39.8	13.9
Babine-F	20.3	23.8	18.3	13.7	43.5	52.7	20.0	8.2	12.0	14.7	33.2	12.0	34.1	12.6
Swan+	12.3	14.8	18.1	11.4	16.1	4.6	15.5	6.2	10.4	12.9	11.1	5.5	13.4	8.1
Bulkley+	23.2	34.5	35.1	13.2	34.2	15.1	17.2	8.1	12.2	14.6	20.4	6.2	22.2	13.7
Morice+	23.2	34.5	35.1	13.2	34.2	15.1	17.2	8.1	12.2	14.6	20.4	6.2	22.2	13.7
Kitwanga	8.5	9.6	13.1	7.0	9.6	2.6	12.5	3.7	6.1	7.0	8.0	5.3	8.3	5.4
Zymoetz	4.1	3.8	7.3	2.9	4.4	0.2	6.0	0.9	2.0	2.6	3.0	2.5	2.5	2.7
Kalum	4.0	3.7	6.6	2.4	3.7	0.0	6.4	0.6	1.5	2.0	0.9	3.1	2.7	2.2
Lakelse	3.9	3.4	6.4	2.5	4.4	0.0	5.4	0.7	1.7	2.3	1.1	2.4	2.4	2.4
Alastair	1.3	2.8	6.2	2.1	3.2	0.0	5.3	0.2	0.8	1.5	0.6	2.4	2.1	0.9
Johnston	0.4	0.8	2.0	0.7	1.2	0.0	1.5	0.1	0.3	0.5	0.2	0.7	0.6	0.3
Total	19.9	25.1	18.2	13.5	39.7	34.0	19.2	8.0	11.5	14.3	29.7	11.3	33.2	12.1





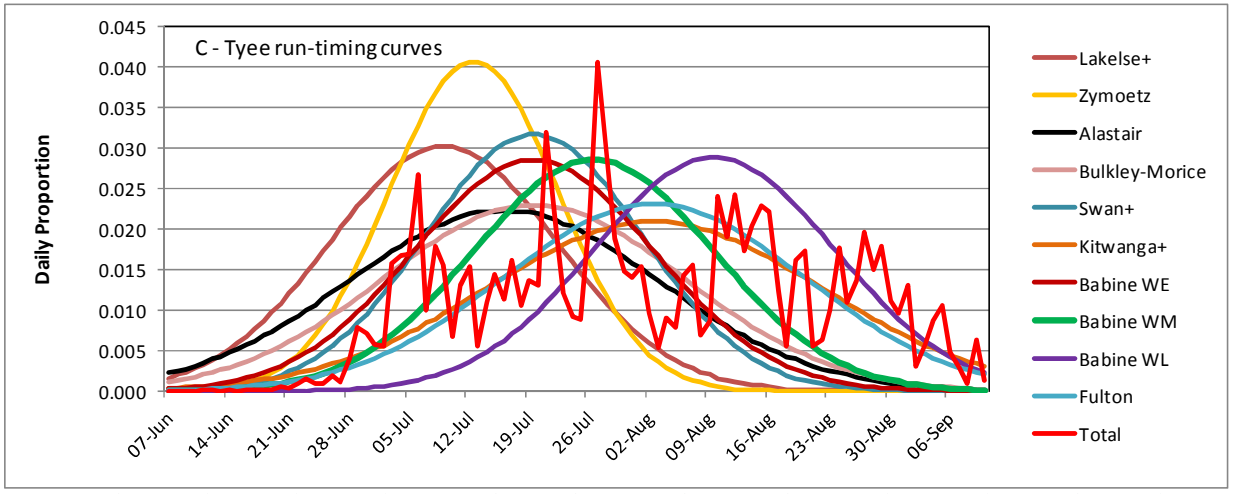


Figure 1. Estimated Tyee daily abundance, stock composition and run-timing curves for Skeena sockeye stocks in 2006 (late run-timing year).

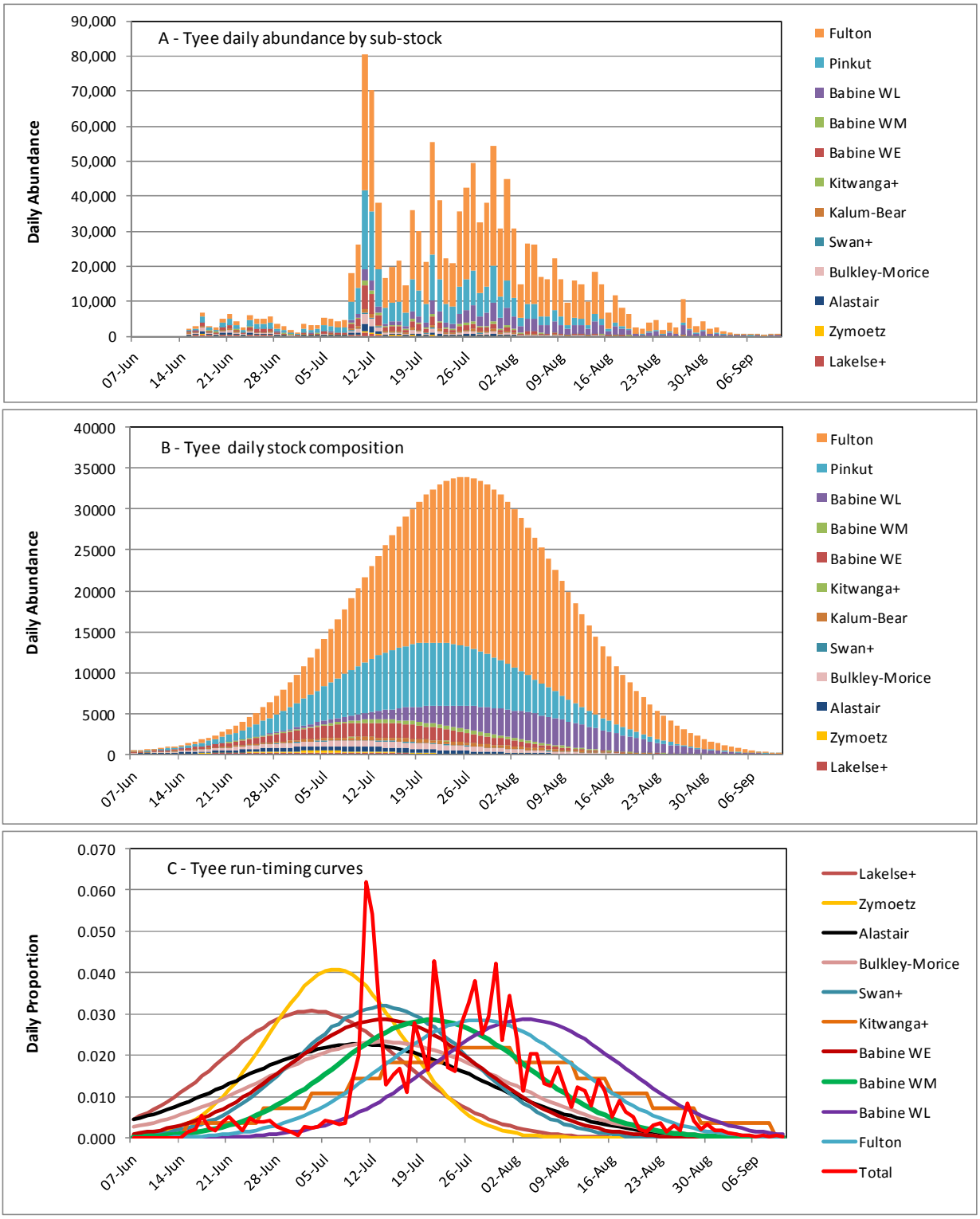


Figure 2. Estimated Tyee daily abundance, stock composition and run-timing curves for Skeena sockeye stocks in 2007 (average run-timing year).

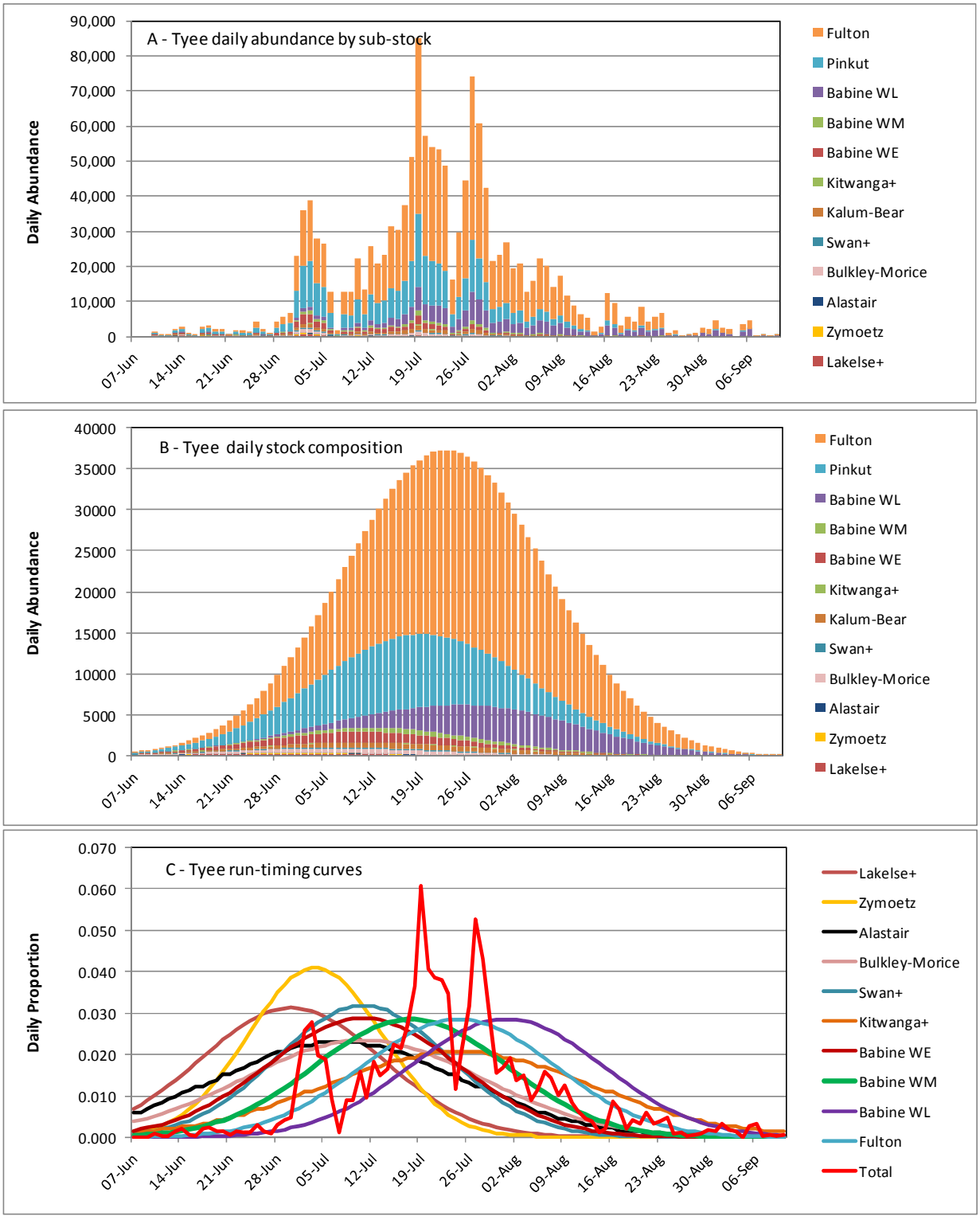


Figure 3. Estimated Tyee daily abundance, stock composition and run-timing curves for Skeena sockeye stocks in 2008 (early run-timing year)