Stock-specific distribution of juvenile Chinook salmon (*Oncorhynchus tshawytscha*) in the Skeena River, British Columbia 2007-2008

Dec-2008

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Abstract

We surveyed microsatellite variation at 12 loci in approximately 1,360 juvenile Chinook salmon in the Skeena River drainage in northwestern British Columbia; this variation was used to estimate stock composition at five discrete geographic locations from June-November 2007 and May 2008. The distribution of juvenile Chinook salmon stocks was broadly consistent with that of the largest adult stocks. Bear River stocks comprised the highest percentage of stocks in the upper Skeena River (37%). Morice River stocks comprised nearly approximately 94% of the stocks in the Bulkley River and about 71% of juvenile Chinook salmon stocks sampled in the middle Skeena River. Stocks from the Kitsumkalum River comprised about 60% of the juvenile fish sampled in the lower Skeena River where all juvenile Chinooks salmon stocks could potentially mix. Despite an incomplete baseline and relatively small sample sizes, the pattern of distribution determined by the microsatellite analysis is generally consistent with known stock distributions. However some additional genetic samples from upriver stocks are needed to improve assignment of individual fish to discrete geographic locations in the Skeena River drainage.

Introduction

Large numbers of Chinook salmon (*Oncorhynchus tshawytscha*) return to the Skeena River basin to spawn. The annual terminal run size of Skeena Chinook salmon is approximately 100,000, spread among about 75 to 100 widely distributed spawning areas. These fish support important ocean fisheries in both Canada and the U.S. as well as in-river commercial, First Nations, and sport fisheries. Most of the commercial catch is taken in troll fisheries which are divided according to provisions of the Pacific Salmon Treaty (Annex IV Chapter 3).

There are about seven large Chinook salmon populations in the Skeena River basin: Lower Kitsumkalum, Kitwanga, Morice, Slamgeesh, Kispiox, Babine, and Bear Rivers. Most Skeena River Chinook salmon are stream type (Healey 1991). Typically, adult Chinook salmon enter the Skeena River in late spring and summer, ascending the river and major tributaries during June and July; spawning typically occurs in during August and September. Juvenile Chinook salmon typically emerge from the gravel in April and May and leave these natal streams within a month or two after emergence (Healey 1991, Shepard 1975, 1979, Williams *et al.* 1985). Scale samples from returning adults indicate that juvenile fish spend one year in fresh water (Healey 1991, Peacock *et al.* 1997) before migrating to the ocean, but it is unclear where they spend their first year of life.

Factors stimulating movement of juvenile Chinook salmon to downstream habitat, the utilization of that habitat, and possible genetically determined differences in habitat use are complex and not well understood. The rate of downstream migration of juvenile Chinook salmon may be time and size dependent, as well as positively correlated to seasonal river discharge and the presence of other juvenile fish.

Juvenile Chinook salmon rearing in the main stem Skeena River likely come from a heterogeneous mix of stocks. Microsatellite variation has been useful in discriminating among stocks of adult Chinook salmon in mixed stock fisheries (Beacham et al. 2003; Beacham et al. 2008) and can also be useful for separation of migratory juvenile Chinook into their natal stocks and can provide insight into downstream movement timing relative to the time of fry emergence, and other factors such as migration to suitable overwintering habitat. This information may provide support for planning habitat protection and conservation, habitat restoration, and for modeling spawning escapement.

In this paper we surveyed variation at 12 microsatellite loci to (1) determine the stock of origin of juvenile Chinook salmon sampled at six locations in the Skeena River and (2) characterize the space-time variability in stock composition among sampling locations. We also report on catch-per-unit effort of juvenile Chinook salmon at the six reaches we sampled.

Methods

Study area

The Skeena River watershed is the second largest watershed in British Columbia and drains 54,432 km^2 (Gottesfeld and Rabnett 2008). The Skeena River is in the northwest quarter of the province and flows for 570 km before entering Chatham Sound and Ogden Channel in the Pacific Ocean (Figure 1). The study area included six locations in the Skeena River (Figure 2). The localities measured in river distance are: (1) Kuldo, 24 km upstream from the confluence of the Babine River, (2) Anlaw, 8 km downstream from the confluence with the Kispiox River, (3) the lower Bulkley River at Hagwilget 2 km above the Skeena confluence, (4) Coyote Creek 23 km downstream from the confluence with the Kitwanga River, (5) Shames about 27 km below the Kitsumkalum River and (6) Salvus about 61 km below the Kitsumkalum River near the limit of tidal influence.

River conditions during the late spring and summer of 2007 were characterized by high flows. The peak flow was the highest since 1974, a flood return interval of about 20 years (HYDAT 2007). The peak discharge at Usk above Terrace was 7625 m^3sec^{-1}. Water temperatures measured at the study sites were about 10-12 °C at most sites from June-September then declined to 2-5 °C in October and November (Table 1). Water temperatures in May 2008 ranged from approximately 6 to 8 °C.

Fish collections

We used beach seines to collect juvenile Chinook salmon at six sampling locations in the Skeena River drainage from June through November 2007 and May 2008. This collection pattern follows a single cohort as fry that emerged from spawning gravels in May and June 2007 and left as smolts in June of 2008. The beach seine was approximately 8.8 m in length, 2.0 m deep, constructed of 5.0 mm mesh webbing with an approximately 25 kg lead line. Beach seining was conducted at sites characterized by relatively low-velocity water with cobble bed material, often with sandy flood deposits along the shorelines. We also used minnow traps to capture juvenile fish in June and November 2007 and May 2008. The number of sets and length of shoreline fished by beach seine was recorded. Due to the difficulty of distinguishing between juvenile Chinook and coho salmon, fish were placed in a 30 cm × 22 cm × 8 cm tray containing a lethal dose (approximately 100 mg/L; see Summerfelt and Smith 1990) of MS 222 (Tricaine methamnesulfonate). Juvenile Chinook and coho salmon were then placed in bottles containing 95% ethanol. Other fish captured in beach seines and minnow traps were visually identified (see McPhail 2007), enumerated and released. We used meristic characteristics (e.g. pyloric caeca and brachiostegal rays) to validate species identification in the laboratory (McPhail 2007). Fish were also measured for fork length (FL) and an operculum clip was taken for DNA determinations Tissue samples were stored in ethanol.

Analysis of relative abundance

We used an aligned ranks procedure (Lehman and D'Abrera 1983) and analysis of variance (ANOVA) at the $P = 0.05$ level to compare catch per unit effort (CPUE, catch/set) statistically among the sampling locations. We used months as a blocking variable, river locations as treatments, and CPUE of the juvenile Chinook salmon as dependent variables. Due to the monthly variation in river conditions, such as temperature, turbidity and flow, blocked comparison of treatments was not meaningful. However, the aligned ranks procedure makes the blocks more comparable by subtracting some estimate of location, such as the block mean or median, from each observation in the block (Lehman and D' Abrera 1983). The procedure works as follows: (1) data are aligned for each block, (2) a block mean is subtracted from each observation (CPUE) in the block, and then (3) observations are ranked simultaneously across all blocks and treatments. We then subjected the rank of CPUEs to analysis of variance (Conover and Iman 1983) for a randomized block design. We used linear contrasts at the p=0.05 level to determine which treatments differed from each other if the ANOVA for the overall treatment effect was significant.

Collection of DNA samples and laboratory analysis

Analysis of DNA samples was performed in the DFO salmon genetics Laboratory at the Pacific biological station using procedures described in Beacham *et al.* 2003, and Beacham *et al.* 2006. Genomic DNA was extracted from operculum punches. The DFO laboratory evaluated diversity at 12 microsatellite loci: Ots100, Ots101, Ots102, Ots104, Ots107 (Nelson and Beacham 1999), Ssa197 (O'Reilly et al. 1996), Ogo2, Ogo4 (Olsen et al. 1998), Oke4 (Buchholz et al. 2001), Omy325 O'Connell et al. 1997), Oki100 (K. M. Miller, DFO, unpublished data), Ots2, and Ots9 (Banks et al. 1999). Allele sizes were determined with the aid of Genescan 3.1 and Genotyper 2.5 software (Applied Biosystems, Foster City, California) with an internal lane sizing standard. Maximum missing loci were set to 5.

Estimation of stock composition

Stock composition was estimated by comparison to a baseline of 19 Skeena watershed populations. Eight of the populations are newly added to the baseline. The sample size of the baseline populations ranged from 19 to 447. All but 5 of the samples have more than 50 specimens. Several of the small samples are of newly added populations.

Weir and Cockerham's (1984) genetic differentiation index (FST) estimates were calculated for each locus over all populations with FSTAT version 2.9.3 (Goudet 1995). Single-population samples were simulated for each of the 19 populations in the baseline, and the 19-population baseline was used to estimate the stock composition of each mixture. Genotypic frequencies were determined for each locus in each population, and the Statistical Package for the Analysis of mixtures (SPAM, version 3.7; Debevec et al. 2000) was used to estimate stock composition of simulated mixture samples. When mixtures are generated in SPAM, the proportion of fish in the mixture from which the sample is being drawn is fixed, but the proportion of fish in the sample iteration varies to account for sampling variability. All loci were assumed to be in Hardy–Weinberg equilibrium. Reported stock compositions for the simulated mixtures are mean estimates derived from 1,000 parametric bootstrap simulations. Each baseline population and simulated fishery sample were resampled during each bootstrap iteration to simulate random variation involved in the collection of the baseline and fishery. Regional reporting groups for estimated stock composition were defined as outlined in Table 1, and the regional groups were based on observed population structure (Beacham et al. 2006, 2008). We evaluated two measures of genetic diversity, FST and number of alleles, which may be predictive of the value of individual loci for stock identification. Mean accuracy of estimated stock compositions for 19 single population samples was compared with both FST and the number of alleles observed at each microsatellite locus. The effect of the number of loci used in estimation of accuracy of stock compositions for single-population samples was also evaluated by sequentially adding microsatellite loci to the analysis of the 19 single-population samples beginning with the locus with the highest accuracy of estimated stock composition. The analysis was concluded when additional loci provided only minimal increases in accuracy and precision of estimated stock compositions.

Analysis of simulated mixtures provided the initial evaluation of baseline utility for stock composition analysis. The key assumption in the simulations is that the baseline used will be representative of populations present when it is applied to mixed-stock fishery samples. In the analysis, 10 20,000-iteration Monte Carlo–Markov chains of estimated stock compositions were produced. The initial starting values for each chain were set at 0.90 for a particular population that was different for each chain. Estimated stock compositions were considered to have converged when the shrink factor was less than 1.2 for the 10 chains (Pella and Masuda 2001), and thus the starting values were considered to be irrelevant. Stock composition estimates converged before 20,000 iterations, and no further improvements in the estimates were observed in excess of 20,000 iterations. Therefore, 20,000 iterations were set as the standard in the analysis. The last 1,000 iterations from each of the eight chains were then combined, and for each fish the probability of originating from each population in the baseline was determined.

These individual probabilities were summed over all fish in the sample and divided by the number of fish sampled (n = 1,364) to provide the point estimate of stock composition.

Standard deviations of estimated stock compositions were determined from the last 1,000 iterations from each of the eight chains incorporated into the analysis.

We used ANOVA to determine if proportions of juvenile Chinook salmon stocks differed among months at the five sampling locations. We used month and stocks as independent variables and also tested for a stock × month interaction effect. Because proportions form a binomial (0, 1) rather than normal distribution, we used an arcsine square-root to transform proportions and normalize the data (Zar 1999). All analyses were conducted using the general linear model (GLM) option in Systat 11.0 (Steinberg and Colla 1997).

Results

Fish collections and relative abundance of juvenile Chinook salmon

Based on visual field identification, we captured approximately 3,100 Chinook salmon with beach seines and gee traps (Table 2). Most Chinook salmon were caught at the Kitwanga site, followed by Salvus, and Anlaw. We also captured juvenile coho salmon (*O. kisutch*), sockeye (*O. nerka*), chum (*O. keta*), pink *(O. gorbuscha*), rainbow trout (*O. mykiss*), Dolly Varden *(Salvelinus malma*) and several other species (Table 2).

Overall, CPUE (catch/set) of Chinook salmon was highest (13.6 fish/set) at Kitwanga and lowest at Kuldo (2.3 fish/set) (Table 3). Although substantial variation existed in CPUE among sites and months, the aligned ranks ANOVA results were not statistically different among sample sites (df = 4, MS = 126.7, F = 1.4, P = 0.270).

Distribution of juvenile Chinook salmon stocks

Percent contribution of juvenile Chinook salmon stocks among the major geographic regions within the Skeena River watershed was consistent with patterns observed at individual locations (Figure 3, Table 5). Upper Skeena River stocks comprised about 85% of the stocks at Kuldo and 50% at Anlaw. Babine River stocks comprised about 5% of the juveniles collected at Anlaw but <1% of at the other locations. Not surprisingly, Bulkley River stocks were dominant at Bulkley River locations where they comprised approximately

97% of samples. Bulkley River juvenile Chinook salmon stocks also made up the highest percentage (72%) of juvenile fish collected at the Kitwanga.   Stocks from the lower Skeena River were dominant (68%) at Salvus (Table 5).

The ANOVA revealed that the percentages of individual juvenile Chinook salmon stocks at the five locations were not significantly different ($P > 0.05$) among months. Therefore, we combined monthly samples to characterize the distribution of Chinook salmon stocks at each location (see Appendix for percentage of juvenile stocks by month for each location). Bear River stocks comprised the highest proportion of juvenile Chinook salmon stocks at Kuldo (37%) followed by Slamgeesh River stocks (Table 4). Bear River stocks also comprised the highest percentage of juvenile Chinook salmon stocks at Anlaw (32%), followed by Kispiox River stocks. Juvenile stocks from the Morice River were dominant at Bulkley River (94%) and Kitwanga (71%) sites. Kitsumkalum River stocks composed >50% of juvenile Chinook salmon stocks collected at the Salvus site (Table 4).

Discussion

Relative abundance of juvenile Chinook salmon

Overall, catch-per-unit effort of juvenile Chinook salmon was highly variable among months at most sampling locations in 2007. Variability in CPUE was lowest at Salvus perhaps because the abundance of juvenile stocks is highest or most stable from relatively constant infusion from upstream sources. Low catches at Kuldo can be partly attributed to the predominance of large cobble substrate which is difficult habitat to effectively beach seine and might be suboptimal rearing habitat for juvenile salmonids. Beach seining was also relatively ineffective at all location during November and April. Perhaps this was because Chinook like other northern and boreal salmonids seek shelter in interstitial spaces in the winter (Cunjak 1996, Huusko *et al.* 2007). In May 2008, CPUE was highest at Salvus which may be related to higher densities of over-wintering juvenile fish. Although we lack firm quantitative data on Chinook abundance, the CPUE pattern is consistent with a general downstream movement of Chinook fry in the autumn to the extensive habitat downstream of Terrace. This area has a considerably milder winter climate, with extensive unfrozen reaches in most winters.

Distribution of juvenile salmon stocks

Stocks identified by microsatellite DNA were derived from a broad geographic distribution including all the major drainages in the Skeena River basin. The mixture analysis indicated that proportions of juvenile stocks were consistent with the known distribution of the largest adult Chinook stocks (Figure 3); Bear River stocks were dominant at upstream sites, Morice River stocks comprised > 97% of stocks in the Bulkley River and a large part of juvenile Chinook sampled in the middle Skeena River (Coyote Creek). Stocks from the Kitsumkalum River comprised on the average more than 59% of the juvenile fish sampled in the lower Skeena River, where all stocks could potentially mix. Thus there is a general pattern of dominance of local stocks. Nevertheless the Kalum River stock appears the largest in the Skeena samples year-round with the highest proportion of Kitsumkalum Chinook occurring in the May 2008 sample when most Skeena Chinook fry are likely in the lower river.

In the upper river samples from Kuldo, stocks from the Slamgeesh River were found in abundance second only to the Bear River, generally accepted as the largest stock in the upper Skeena River. The Slamgeesh River is a glacier derived river that is frequently turbid and clearly hosts abundant Chinook. But the proportion suggested by this analysis is unexpectedly high. It is possible that the Slamgeesh stock is over represented in the DNA composition because it includes Chinook fry from other as of yet uncollected upper Skeena spawning localities.

The occurrence of Chinook in the Kuldo samples that are genetically assigned to Kitwanga and Kispiox localities requires comment. Clearly Chinook fry are unlikely to have moved either 50 or 120 km upstream from their natal streams through the high velocity areas below and above the Babine River confluence. The most likely cause of this observation is the occurrence of one or more unknown stocks in the upper Skeena with a genetic makeup similar to that of the Kispiox and Kitwanga Rivers. Likely candidates are the Kuldo River, which shares a drainage divide with the Kispiox River, the Sicintine River on the eastern side of the Skeena near the Kuldo River, and the Squingula River about 100 km upstream. All three of these rivers have Chinook spawners and we have begun collection of samples for new baseline additions.

The analysis of the Tyee Test fishery Chinook for 2003 (I. Winter, unpublished data), evaluated against a smaller Skeena baseline set, suggested an unexpectedly high abundance of Kitwanga River Chinook returns, about 21%. This is inconsistent with the 2003 count at the Kitwanga River Weir of about 1800, with an overall Skeena escapement estimated at 54,000 (DFO SEDS 2005). Probably re-evaluation with the current larger baseline would reduce but not eliminate this discrepancy.

While the distribution of juvenile Chinook stocks was broadly consistent with that of the largest adult stocks, the use of some baseline samples with small samples sizes likely led the misallocation of some stocks, particularly upstream stocks. Beacham et al. (2006) found that in simulated mixtures that 90% accuracy of estimated stock composition was observed for sample sizes of up to about 75 individuals. Six of the nineteen populations in the upper Skeena River have baseline samples of less than 75 individuals. These small samples likely resulted in some misallocation of Chinook fry. On the other hand, the addition of five spawning sites to the pre-existing Skeena baseline resulted in a pattern of allocation that is consistent with the topology of the Skeena Watershed.

Seasonal variability in stock composition

In general, at all localities a higher percentage of local fish were present in June and sometimes July. Upstream stocks tended to accumulate later in the season in the lower Skeena River with upstream stocks (e.g. Morice and Slamgeesh rivers) not reaching high proportions until October and to some extent September. It is unclear whether Kitsumkalum River fish left or if new arrivals changed the proportions.

In conclusion, microsatellite analysis enabled us to successfully identify individual fish collected in the main stem Skeena and Bulkley rivers to specific natal tributaries. We believe our estimates are reliable particularly for the larger stocks (e.g. Bear River, Morice River, Kitsumkalum River) with large baseline samples. However, there is potential for inaccurate estimate of stock composition because several Skeena River Chinook populations are inadequately represented in the baseline, particularly stocks in the upper Skeena River. Additional genetic samples from upriver stocks are needed to provide accurate estimates of the origin of individual fish to discrete geographic locations in the Skeena River drainage.

The freshwater habitat of Skeena Chinook

These data make it clear that the Chinook fry that have been observed to leave their spawning areas shortly after emerging (Healey 1991, Shepard 1975, 1979, Williams *et al.* 1985), and rear on gravel bars downstream. At the most general level they may be characterized as being widely distributed along all gravel bars as far as tidewater. The Skeena River is notable among rivers worldwide for the abundance of wandering gravel-bed reaches (Gottesfeld & Gottesfeld 1990) and for the presence of cobble bars throughout. These cobble dominated bars have low amounts of sand and finer constituents in their surface layers. That is to say they are characterized by a coarse pavement layer that results in sufficient roughness to create a boundary layer thick enough to provide juvenile salmonid habitat.

Acknowledgements

Many people provided time and assistance during the course of this study. Angus Gowa, Richard Harris, Rodney Harris, Terry Howard, James McCrae, Ken Rabnett, Gord Ridley, George Sampare, Bill Squires, and Tim Wilson of the Gitxsan Watershed Authority helped with the field operations and data collection. Special thanks to Peter Hall, Alicia Hooper and Scott Swift of the Gitxsan Watershed Authority for field and logistical support. Russell Bolton, Richard Roberts, and Steve Roberts, Kitsumkalum Fisheries, provided field and logistical support in the lower Skeena River. We thank Jim Allen, Kispiox Fisheries, for boat operation and field assistance. Tom Bansak, University of Montana, provided samples of juvenile Chinook and coho salmon and assistance with field identification of fish species. Bea and Paul Rabocz graciously provided access to the Kuldo site from their property. This project was funded by the Pacific Salmon Commission, Northern Fund.

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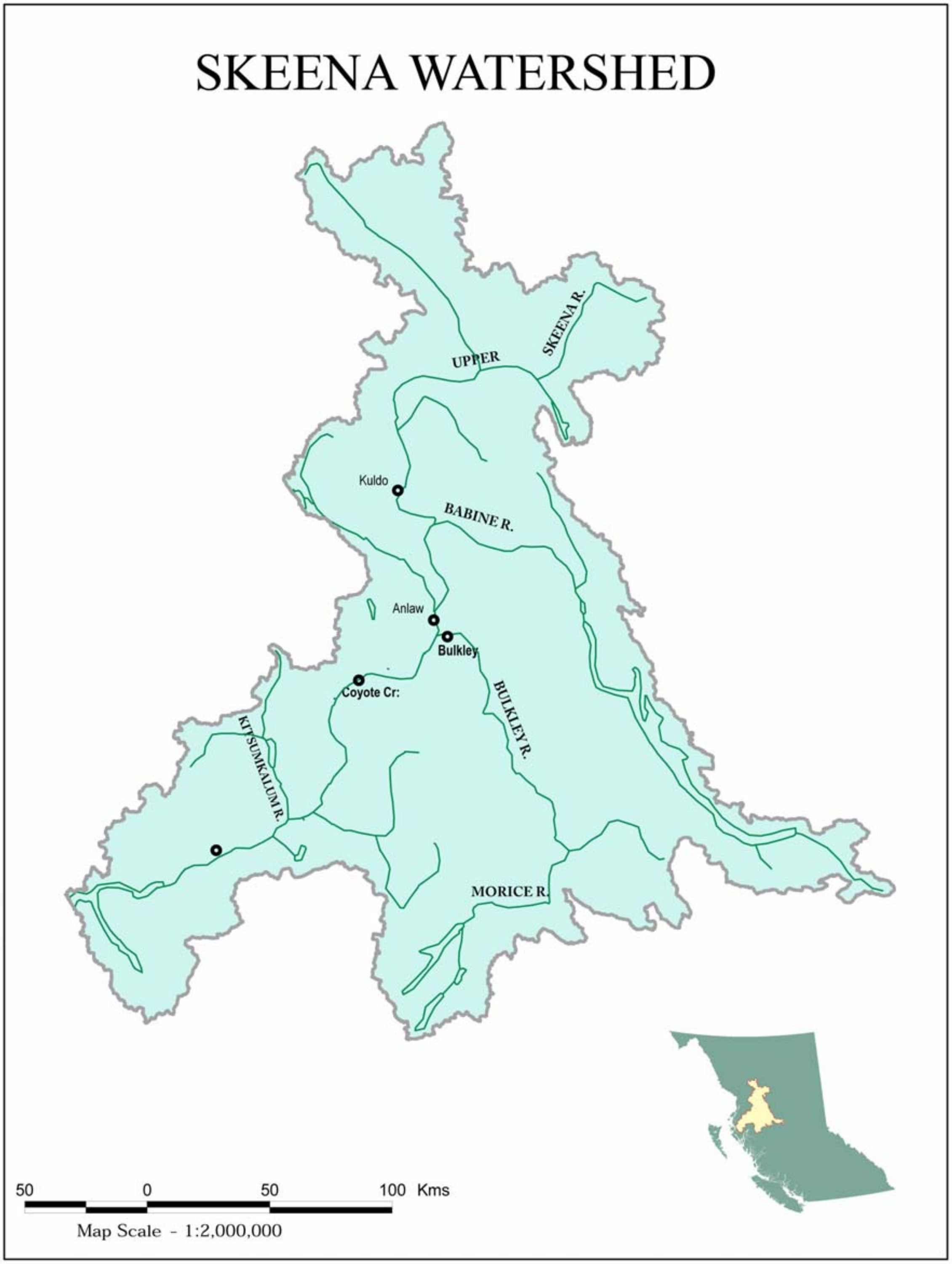

Figure 1. Map of Skeena River basin including location of sampling sites in 2007-2008.

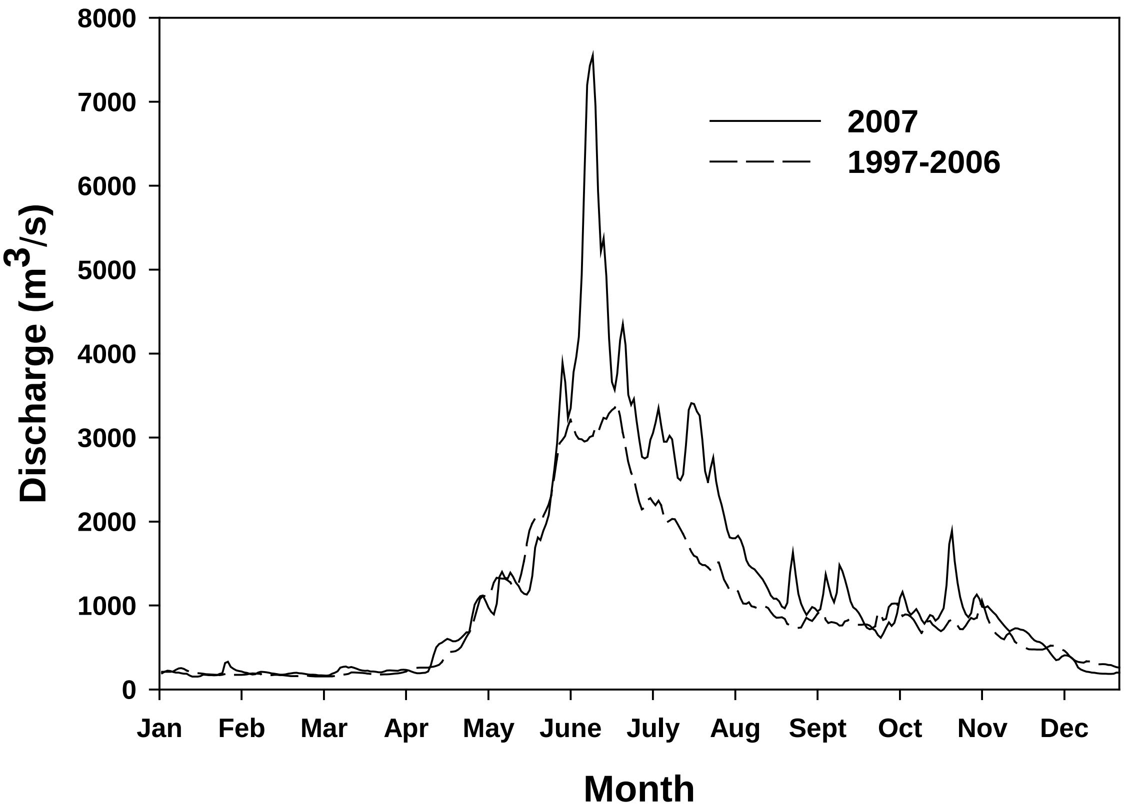

Figure 2. Mean Skeena River discharge in 2007 and 10-year average (1997-2006) recorded at Usk, British Columbia (approximately 150 km from the river mouth). Data from Water Survey of Canada HYDAT.

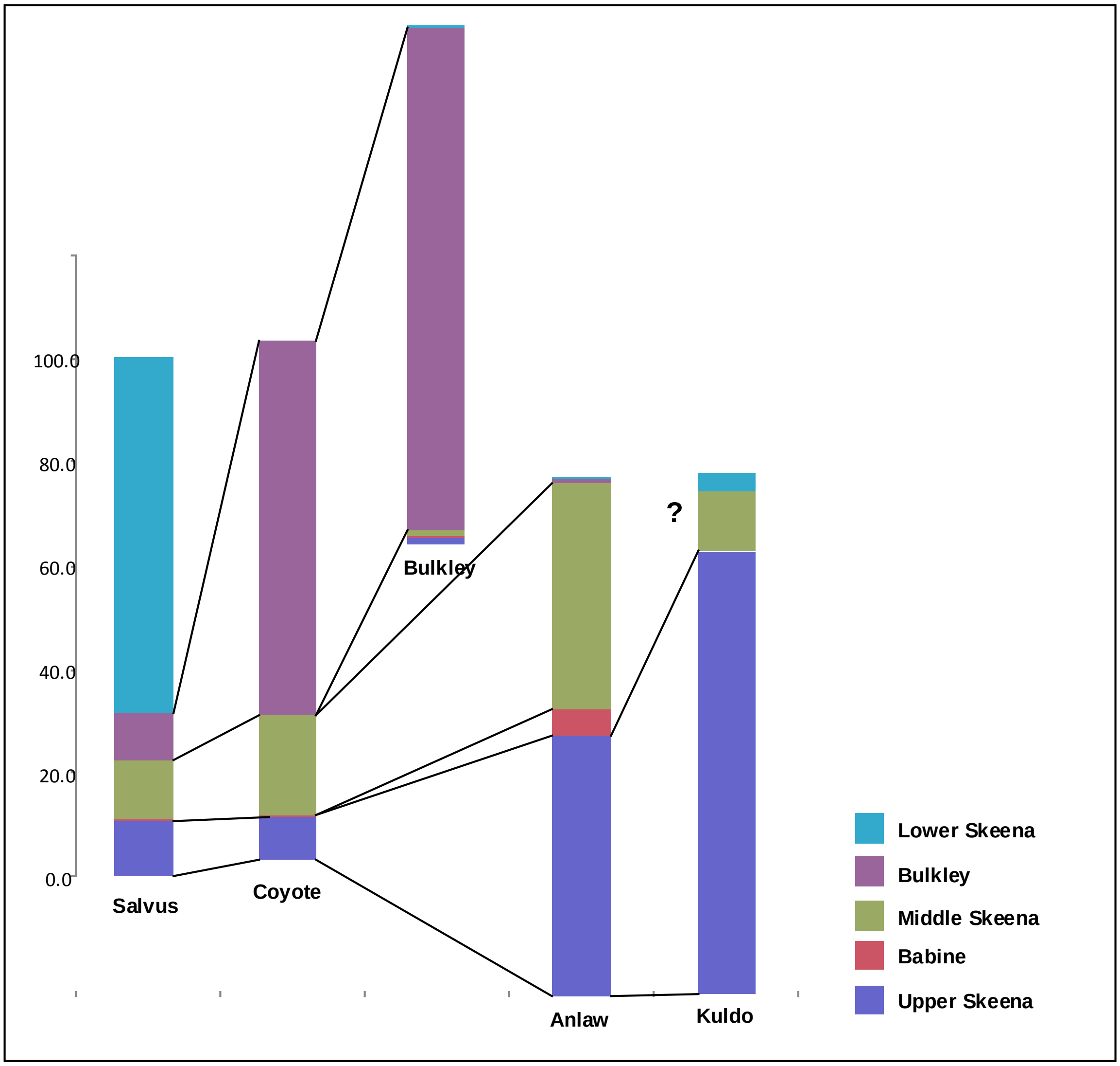

Figure 3. Juvenile Chinook stock composition by region at six Skeena river localities 2007-2008.

Table 1. Mean water temperatures measured during sampling for juvenile Chinook salmon at six locations in the Skeena and Bulkley rivers June-November 2007 and May 2008. Sample sizes are in parentheses.

	Month						
Species	June	July	Aug	Sept	Oct	Nov	May
Kuldo	7.0 (1)	10.0 (1)	10.0 (1)	11.0 (2)	6.0 (2)		8.0 (1)
Anlaw	12.0 (2)	12.0 (1)	10.8 (3)	6.3 (3)	2.5 (2)	2.5 (2)	5.7 (3)
Bulkley	9.5 (2)	11.3 (2)	12.0 (1)	10.8 (5)	7.0 (2)	2.4 (6)	6.9 (4)
Kitwanga			13.0 (1)	11.0 (2)	5.7 (3)	3.6 (4)	7.3 (3)
Shames				9.0 (1)		4.0 (1)	
Salvus		11.0 (2)	12.0 (3)	11.0 (3)	8.3 (2)	5.5 (1)	8.0 (1)

Table 2. Cumulative catches of fish captured by beach seining and minnow traps at six locations in the Skeena and Bulkley rivers June-November 2007 and May 2008.

	Location						
Species	Kuldo	Anlaw	Bulkey	Kitwanga	Shames	Salvus	Total
Chinook salmon	203	646	509	993	121	641	3113
Coho salmon	25	98	56	212	0	302	693
Sockeye salmon	0	13	4	11	0	5	33
Pink salmon	0	35	6	1	0	6	48
Chum salmon	22	37	0	6	0	56	121
Rainbow trout	13	30	101	39	11	149	343
Dolly Varden	4	4	1	2	0	70	81
Mountain whitefish	177	62	442	101	6	248	1036
Pacific lamprey	0	3	10	5	0	1	19
Stickleback	0	0	0	0	0	2	2
Sculpin (*Cottus* spp)	0	18	0	15	3	247	283
Sucker (*Catastomas* spp)	0	0	0	0	0	1	1
Redside shiner	0	0	1	2	1	2	6
Cutthroat trout	0	0	1	0	0	4	5
Bull trout	0	4	1	4	0	0	9
Longnose dace	0	3	0	1	0	2	6
Unidentified salmonid	0	0	0	1	0	0	1

Table 3. Catch-per-unit-effort (set) of juvenile Chinook salmon captured by beach seining at six locations in the Skeena and Bulkley rivers June-November 2007 and May 2008. The number of sets is in parentheses. Samples from Shames were not included in the statistical analysis because only sampling only occurred in September and October.

	Month							
Species	June	July	Aug	Sept	Oct	Nov	May	Total
Kuldo		1.2 (6)	4.4 (14)	3.3 (36)	0.5 (30)		0.3 (4)	2.3 (90)
Anlaw	9.2 (11)	11.6 (5)	36.0 (3)	3.8 (28)	3.4 (38)	0.2 (5)	1.2 (9)	5.2 (99)
Bulkley	0.0 (3)	5.7 (9)	50.0 (2)	8.9 (23)	2.0 (49)	0.1 (9)	1.7 (10)	4.7 (105)
Kitwanga	12.5 (11)		1.7 (6)	18.7 (6)	23.4 (29)	0.0 (8)	1.4 (10)	13.6 (70)
Shames				28.4 (4)	0.5 (12)			7.6 (16)
Salvus		5.5 (13)	6.9 (13)	4.0 (47)	5.2 (42)	0.3 (18)	13.0 (4)	4.6 (137)

Table 4. Percentages of juvenile salmon stocks by month in samples collected from five locations in the Skeena and Bulkley rivers, British Columbia, June-November 2007 and May 2008.

Sample size and stock	Location				
	Kuldo	Anlaw	Bulkley	Kitwanga	Salvus
Sample size	106	336	215	330	377
Bear River	36.8	32.4	0.3	0.2	2.2
Kluayaz Creek	13.6	2.8	0.1	0.2	0.2
Kluakaz Creek	0.8	0.8	0.5	0.0	0.9
Slamgeesh River	28.6	12.0	0.5	7.1	7.0
Sustut River	5.3	1.9	0.0	0.7	0.0
Babine River	0.1	5.3	0.2	0.3	0.6
Bulkley River	0.0	0.0	1.1	1.0	0.0
Harold Price Creek	0.0	0.6	2.0	0.1	0.1
Morice River	0.1	0.2	93.7	71.1	9.4
Kispiox River	0.3	22.0	0.7	6.4	1.3
Kitwanga	7.6	10.0	0.2	12.0	6.0
Skeena River -Terrace	0.7	0.4	0.0	0.5	3.5
Sweetin River	3.1	11.2	0.4	0.3	0.2
Cedar River	0.0	0.0	0.0	0.0	0.0
Ecstall River	0.0	0.0	0.0	0.0	0.0
Gitnadoix	0.6	0.0	0.1	0.0	4.3
L._Kalum	0.5	0.2	0.1	0.1	53.7
L._Kalum - AC	1.5	0.1	0.0	0.0	5.1
Thomas Creek	0.4	0.0	0.0	0.1	5.4

Table 5. Percentages of juvenile salmon stocks by region in the Skeena and Bulkley rivers, British Columbia, June-November 2007 and May 2008.

Sample size and stock	Location				
	Kuldo	Anlaw	Bulkley	Kitwanga	Salvus
Sample size	106	336	215	330	377
Upper Skeena River	85.1	49.9	1.4	8.1	10.4
Babine River	0.1	5.3	0.2	0.3	0.6
Bulkley River	0.2	0.8	96.7	72.2	9.5
Middle Skeena River	11.7	43.6	1.4	19.2	11.0
Lower Skeena River	3.0	0.4	0.3	0.2	68.5

Appendices

Table A.1. Percentages of juvenile salmon stocks by month in samples collected from five locations in the Skeena and Bulkley rivers, British Columbia, June-November 2007 and May 2008.

	Month			
Sample size and stock	July	Aug	Sept	Oct
		Kuldo		
Sample size	20	40	32	14
Bear River	63.8	33.6	10.0	12.9
Kluayaz Creek	4.2	10.3	1.3	49.6
Skeena River - Kluakaz Creek	11.4	2.5	0.1	1.6
Slamgeesh River	15.2	16.7	42.9	9.0
Sustut River	0.1	0.1	18.4	0.1
Babine River	0.1	0.6	0.2	0.7
Bulkley River	0.0	0.0	0.0	0.1
Harold Price Creek	0.7	0.1	0.3	0.2
Morice River	0.0	0.1	2.5	0.2
Kispiox River	0.1	5.3	0.7	2.0
Kitwanga	1.6	1.6	12.5	0.9
Skeena River -Terrace	0.1	5.7	1.5	0.3
Sweetin River	0.6	19.5	0.2	0.3
Cedar River	0.0	0.0	0.0	0.0
Ecstall River	0.0	0.0	0.0	0.0
Gitnadoix	0.1	0.5	1.3	6.7
L._Kalum	1.7	0.6	1.0	4.0
L._Kalum - AC	0.2	0.4	6.7	10.7
Thomas Creek	0.0	1.7	0.2	0.1

Table A. 2. Percentages of juvenile salmon stocks by month in samples collected from five locations in the Skeena and Bulkley rivers, British Columbia, June-November 2007 and May 2008.

	Month						
Sample size and stock	June	July	Aug	Sept	Oct	Nov	May
			Bulkley				
Sample size		32	67	25	50	31	10
Bear River		1.1	0.1	0.8	0.2	0.6	0.2
Kluayaz Creek		0.1	0.0	0.3	0.1	2.5	0.3
Skeena River - Kluakaz Creek		0.3	0.2	0.3	0.0	2.9	0.0
Slamgeesh River		1.6	3.8	0.2	0.1	1.8	0.1
Sustut River		0.0	0.0	0.0	0.0	0.0	0.0
Babine River		0.3	0.4	0.1	0.0	0.8	0.0
Bulkley River		0.0	0.0	0.0	2.0	0.0	10.0
Harold Price Creek		1.3	0.0	1.8	3.9	0.1	10.3
Morice River		83.8	94.5	76.4	89.4	83.6	78.5
Kispiox River		0.3	0.2	10.7	3.1	1.0	0.4
Kitwanga		0.6	0.4	4.7	0.3	0.5	0.1
Skeena River -Terrace		1.9	0.0	0.0	0.1	0.1	0.0
Sweetin River		3.1	0.1	4.0	0.3	3.7	0.0
Cedar River		0.0	0.0	0.0	0.0	0.0	0.0
Ecstall River		0.0	0.0	0.0	0.0	0.0	0.0
Gitnadoix		2.5	0.0	0.1	0.2	0.0	0.0
L._Kalum		0.7	0.0	0.2	0.1	0.0	0.0
L._Kalum - AC		0.2	0.0	0.1	0.0	0.0	0.0
Thomas Creek		0.9	0.0	0.0	0.1	2.0	0.0

Table A. 3. Percentages of juvenile salmon stocks by month in samples collected from five locations in the Skeena and Bulkley rivers, British Columbia, June-November 2007 and May 2008.

	Month						
Sample size and stock	June	July	Aug	Sept	Oct	Nov	May
			Anlaw				
Sample size	25	45	87	76	17	78	8
Shakes Creek	1.5	0.1	0.0	1.0	0.4	0.1	0.1
Bear River	9.0	21.9	33.4	27.1	52.4	38.2	0.3
Kluayaz Creek	0.3	4.7	0.3	5.7	0.6	3.5	18.4
Skeena River - Kluakaz Creek	0.4	8.8	0.2	3.0	0.8	1.9	1.2
Slamgeesh River	10.7	10.5	9.4	5.1	3.5	6.4	0.3
Sustut River	3.2	0.0	1.4	0.8	0.0	0.2	36.4
Babine River	0.8	6.6	9.4	14.4	2.6	0.1	1.7
Bulkley River	0.0	0.0	0.0	0.0	0.0	0.1	0.4
Harold Price Creek	17.6	0.2	0.0	0.7	1.3	1.5	0.1
Morice River	0.3	0.2	0.4	0.1	0.2	4.7	0.0
Kispiox River	35.4	4.4	19.2	33.9	23.1	24.6	24.3
Kitwanga	12.1	39.7	5.5	1.9	7.6	8.4	0.8
Skeena River -Terrace	2.0	2.0	0.1	4.4	1.9	0.2	0.0
Sweetin River	5.4	0.3	19.8	0.4	0.9	9.8	6.7
Cedar River	0.0	0.0	0.0	0.0	0.1	0.0	0.0
Ecstall River	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gitnadoix	0.2	0.0	0.0	0.0	1.8	0.0	0.1
L._Kalum	0.2	0.2	0.5	0.4	0.9	0.2	0.2
L._Kalum - AC	0.7	0.4	0.3	0.3	1.7	0.0	8.9
Thomas Creek	0.1	0.0	0.0	0.6	0.2	0.0	0.2

Table A.4. Percentages of juvenile salmon stocks by month in samples collected from five locations in the Skeena and Bulkley rivers, British Columbia, June-October 2007 and April 2008.

	Month						
Sample size and stock	June	July	Aug	Sept	Oct	Nov	May
			Coyote				
Sample size	20		92	87	54	34	13
Shakes Creek	0.0		0.2	0.1	0.1	0.0	4.8
Bear River	0.9		0.0	0.1	0.4	30.3	10.6
Kluayaz Creek	0.1		0.2	0.2	2.9	1.7	0.2
Skeena River - Kluakaz Creek	0.0		0.1	0.6	0.1	0.1	0.7
Slamgeesh River	0.1		6.8	10.0	7.6	13.4	7.9
Sustut River	0.0		0.0	0.2	1.1	0.0	4.0
Babine River	0.5		0.1	1.5	0.0	0.1	0.1
Bulkley River	2.9		2.4	0.0	0.5	0.0	0.0
Harold Price Creek	0.1		0.3	0.6	1.6	0.1	2.3
Morice River	23.0		81.2	64.5	50.8	49.8	22.8
Kispiox River	2.4		1.0	8.6	26.5	0.2	22.2
Kitwanga	64.4		7.1	7.9	3.3	1.2	14.3
Skeena River -Terrace	0.3		0.2	2.8	2.3	0.4	0.5
Sweetin River	1.1		0.1	1.4	2.1	0.4	5.5
Cedar River	0.0		0.0	0.0	0.0	0.0	0.0
Ecstall River	0.0		0.0	0.0	0.0	0.0	0.0
Gitnadoix	3.3		0.0	0.0	0.1	0.4	0.3
L._Kalum	0.2		0.0	1.2	0.3	0.5	2.3
L._Kalum - AC	0.1		0.0	0.0	0.1	1.0	0.2
Thomas Creek	0.7		0.1	0.0	0.0	0.3	1.3

Table A.5. Percentages of juvenile salmon stocks by month in samples collected from five locations in the Skeena and Bulkley rivers, British Columbia, June-October 2007 and April 2008.

	Month						
Sample size and stock	June	July	Aug	Sept	Oct	Nov	May
			Salvus				
Sample size	30	85	92	24	91	11	44
Shakes Creek	1.0	0.2	2.1	0.1	0.0	23.1	0.0
Bear River	0.4	1.7	1.2	0.7	3.8	1.8	1.4
Kluayaz Creek	0.0	0.0	0.1	2.5	1.4	0.2	0.2
Skeena River - Kluakaz Creek	0.0	0.3	0.3	0.9	6.5	0.5	0.1
Slamgeesh River	0.2	0.3	7.8	0.3	19.3	1.4	0.9
Sustut River	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Babine River	0.5	0.6	0.1	0.4	1.2	0.2	0.5
Bulkley River	0.0	0.0	0.0	0.0	0.3	0.0	0.0
Harold Price Creek	0.4	0.1	0.1	0.9	0.4	5.4	0.5
Morice River	1.6	0.6	1.0	11.3	17.4	47.8	8.9
Kispiox River	1.9	0.4	1.3	0.2	6.3	3.6	1.1
Kitwanga	2.2	0.6	0.7	0.3	7.1	3.4	10.0
Skeena River -Terrace	0.2	0.4	7.8	4.0	1.0	0.2	0.2
Sweetin River	5.7	0.2	0.3	0.1	0.6	2.7	0.5
Cedar River	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Ecstall River	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gitnadoix	8.5	0.9	6.2	0.0	0.1	9.1	5.3
L._Kalum	66.4	77.0	54.9	68.0	22.9	0.6	56.4
L._Kalum - AC	10.7	2.8	14.2	2.2	1.5	0.1	5.7
Thomas Creek	0.2	13.9	1.8	8.1	10.1	0.0	8.3

Table A. 6. Percentages of juvenile salmon stocks by region in samples collected from five locations in the Skeena and Bulkley rivers, British Columbia, June-October 2007 and Mayl 2008. Percentages in bold italics represent the highest percent for each month.

		Month						
Location	Sample size and stock	June	July	Aug	Sept	Oct	Nov	May
Kuldo	*Sample size*		20	40	32	14		
	Stikine River		0.0	0.7	0.1	0.4		
	Skeena - upper		***94.7***	***63.2***	***72.7***	***73.2***		
	Skeena- Babine		0.1	0.6	0.2	0.7		
	Bulkley River		0.8	0.2	2.9	0.5		
	Skeena - mid		2.4	32.1	14.9	3.6		
	Skeena - lower		2.0	3.1	9.1	21.6		
Anlaw	*Sample size*	25	45	87	76	17	78	8
	Stikine River	1.5	0.1	0.0	1.0	0.4	0.1	0.1
	Skeena - upper	23.6	45.9	***44.7***	***41.7***	***57.3***	***50.3***	***56.5***
	Skeena- Babine	0.8	6.6	9.4	14.4	2.6	0.1	1.7
	Bulkley River	17.9	0.4	0.4	0.9	1.5	6.3	0.5
	Skeena - mid	***54.9***	***46.4***	***44.7***	40.6	33.6	43.0	31.8
	Skeena - lower	1.3	0.6	0.8	1.3	4.6	0.3	9.4
Bulkley River	*Sample size*		32	67	25	50	31	10
	Stikine River		1.3	0.1	0.2	0.1	0.1	0.0
	Skeena - upper		3.1	4.1	1.6	0.4	7.8	0.6
	Skeena- Babine		0.3	0.4	0.1	0.0	0.8	0.0
	Bulkley River		***85.2***	***94.5***	***78.2***	***95.4***	***83.8***	***98.8***
	Skeena - mid		5.9	0.7	19.4	3.7	5.4	0.6
	Skeena - lower		4.3	0.1	0.4	0.4	2.1	0.0
Coyote Creek	*Sample size*	20		92	87	84	34	13
	Stikine River	0.0		0.2	0.1	0.1	0.0	4.8
	Skeena - upper	1.1		7.2	11.1	12.1	45.5	23.4
	Skeena- Babine	0.5		0.1	1.5	0.0	0.1	0.1
	Bulkley River	26.0		***83.9***	***65.2***	***52.9***	***50.0***	25.2
	Skeena - mid	***68.1***		8.4	20.7	34.3	2.2	***42.5***
	Skeena - lower	4.2		0.2	1.3	0.5	2.2	4.0
Salvus	*Sample size*	30	85	92	24	91	11	44
	Stikine River	1.0	0.2	2.1	0.1	0.0	23.1	0.0
	Skeena - upper	0.8	2.4	9.4	4.4	31.0	3.8	2.5
	Skeena- Babine	0.5	0.6	0.1	0.4	1.2	0.2	0.5
	Bulkley River	2.0	0.7	1.1	12.2	18.0	***53.2***	9.4
	Skeena - mid	10.0	1.5	10.1	4.6	15.1	9.8	11.8
	Skeena - lower	***85.8***	***94.5***	***77.1***	***78.3***	***34.7***	10.0	***75.7***