Calibration of 2007 Chinook Salmon Escapements to Two Clear Rivers in Northern B.C.

Ivan Winther

Fisheries & Oceans Canada
Science Branch, Pacific Region

417-2nd Avenue West
Prince Rupert, British Columbia
V8J-1G8

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ABSTRACT

Chinook salmon (*Oncorhynchus tshawytscha*) escapements were estimated in two clear rivers in Northern British Columbia. Run size indices from visual peak count surveys were calibrated against abundance estimates provided from mark re-sight techniques applied in the Kateen River and against a fence count in the Kitwanga River. The expansion factors for the visual survey indices were found to be 1.72 in the Kateen River and 1.57 in the Kitwanga River.

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INTRODUCTION

Funding for this project was provided by the Northern Boundary and Transboundary Rivers Restoration and Enhancement Fund for the calibration of visual indices of Chinook salmon (*Oncorhynchus tshawytscha*) abundance. The relationships between visual indices and estimates of total spawners were examined and expansion factors were developed. This report presents the expansion factors for the third year of study in the Kitwanga and Khutzeymateen Rivers.

The primary objective of this study was to generate expansion factors for visual escapement indices at two sites, a coastal stream and a tributary of the Skeena River. On the Khutzeymateen River, a mark-recapture program was used to provide escapement estimates with a reasonable level of accuracy to allow for the development of expansion factors for existing visual indices of escapement. These results compliment previous work completed on a second coastal stream, the Kwinamass River, where factors were measured over 5 years. The Skeena River tributary selected for the program was the Kitwanga River. At this site the project was the inverse; we generated visual indices of Chinook salmon escapement for a system where a true estimate of escapement was derived from a counting fence.

The Gitanyow Fisheries Authority has operated a fish counting weir on the Kitwanga River since 2003. Recent escapements of Chinook salmon to the Kitwanga River ranged from 1500 to 3200. Historic estimates of Chinook salmon escapements are available but the series of stream inspection logs is not complete. However, replicating the procedures and collecting additional visual survey data applicable to other visual indices was possible for comparison to the true estimate. In this system an individual engaged in generating many of the Fishery Officer estimates over the past two decades was available to assist in the flight data collections.

Interest in validating Chinook salmon escapement estimates in the Kwinamass and Khutzeymateen Rivers extends beyond the development of expansion factors for visual methods. These systems didn't respond to Pacific Salmon Treaty initiatives in 1985 as observed in many other systems in the North Coast of British Columbia. Visual escapement estimates in the 1960's and early 1970's varied between 750 and 5000 Chinook salmon in each river. These systems appear to epitomize the mixed stock problem as two small and apparently weak Chinook salmon populations located between the two large and relatively healthy populations of the Nass and Skeena Rivers.

A significant time series of visual escapement indices exist for Chinook salmon stocks the Kwinamass and Khutzeymateen watersheds (Appendix 1). Estimates of Chinook salmon in the Khutzeymateen apply primarily to the Kateen River tributary and the area downstream of the Khutzeymateen – Kateen confluence. The estimates are extrapolations and essentially the same methods have been used for 20 years. They are similar to peak count extrapolations. These systems also present a fortunate scenario where the personnel conducting stream inspections have remained static over the past decade and the primary individual engaged in estimation of Chinook salmon in these systems has been involved since 1985.

Stream inspection logs for the Kwinamass and Khutzeymateen River systems have been prepared since 1985. The logs provide information on live and dead Chinook salmon observed and stream conditions during each inspection. These raw data allow for comparison of the existing indices (commonly referred to as Fishery Officer estimates) to other methods of generating escapement estimates using the same data (e.g. area under the curve or peak count estimates).

Mark-recapture experiments were conducted on the Kwinamass River for 5 years, 2002 to 2006 inclusive (Appendix 2). Fishery Officer estimates continued over this time, independent

of the mark-recapture estimates. Recoveries of Chinook salmon carcasses from the Kwinamass and Khutzeymateen Rivers are limited due to the predators that inhabit the area (bears and wolves). To make up for the inability to sample a representative portion of the carcasses the recapture portion of the study also consists of observations of marked and unmarked live Chinook salmon during swim and boat surveys. Swim surveys observe most Chinook salmon if they are timed just before spawning when the fish are holding in pools. The boat surveys observe most Chinook salmon as they are spawning.

METHODS

Kitwanga River

The Gitanyow Fisheries Authority operated a fish counting weir on the Kitwanga River in 2007 and Chinook salmon were counted through the weir daily after July 25, 2007. The fish weir was installed late in 2007 due to flood conditions so the beginning of the Chinook salmon run had to be estimated from counts in previous years. The mean proportion of the run counted through the weir before July 25 in years 2003 to 2006 was applied to the 2007 count to provide an estimate of the total number of Chinook salmon in the Kitwanga River. This estimate of large Chinook salmon that passed the weir site was compared with the visual index.

The visual index was developed from counts of large Chinook salmon collected during three helicopter flights of the Kitwanga River. Live and fresh dead carcasses were included in each count. In areas of dense spawning the fish were counted in 10's by picturing a grid pattern over the spawning area.

No biological data (size, sex, age) were collected from Kitwanga River Chinook salmon in 2007.

Kateen River

The total number of large Chinook salmon spawning in the Kateen River was estimated using a mark re-sight procedure. Chinook salmon were caught by angling and marked with a Petersen disc. The marked ratio was determined by swimming the river with snorkel gear. The mark re-sight estimate was compared with the abundance index developed from visual counts of spawning Chinook salmon made while floating and walking the river.

The mark re-sight estimate of large Chinook salmon was generated using Schnabel's method for multiple censuses:

$$N = \frac{\Sigma (C_t M_t)}{(R+1)}$$

where N was the estimate of large Chinook salmon, M was the number of large Chinook salmon marked at time t, C was the total number of large Chinook salmon observed in the snorkel surveys at time t and R was the number of marked large Chinook salmon observed in the snorkel surveys. Approximate confidence limits were obtained by considering R as a Poisson variable (Ricker, 1975).

The process of marking Chinook salmon occurred in the lower portions of the river. Chinook salmon were caught by angling to minimize capture related mortalities (angling mortality was less than 5%). The primary mark consisted of uniquely numbered, vinyl, Petersen discs applied 2 cm below the dorsal fin. The discs were attached with 7 cm stainless steel pins passed through a disc, through the skin, between the dorsal rays, through the skin on the far side of the fish and through a second disc. A loop was twisted into the end of the pin to secure the disc in place. The discs were brightly colored and 26 or 32 mm in diameter to provide a visible mark to the snorkel or float crews. Males less than 65 cm fork length were not marked. Females

were marked with a different color. Secondary marks were applied by punching a hole through the left operculum with a 6 mm paper punch. Fish judged to be unhealthy after capture were sampled for biological attributes and released without marks.

Chinook salmon caught in the mark application procedure were sampled for fork length, sex, and scales. Sex was determined from external appearance. Scale samples were collected on to scale books as described by MacLellan (1999). Scales were forwarded to the Fisheries & Oceans Canada, Fish Ageing Laboratory at the Pacific Biological Station for ageing.

The re-sight procedure was to swim the river with snorkel gear and count the number of marked and unmarked Chinook salmon. When schools of fish were encountered it was often necessary to swim over the school several times in order to break it up such that individual fish could be counted. In these cases the "best pass" consisting of the largest number of marked and unmarked Chinook salmon counted was used for the final estimate.

RESULTS

Kitwanga River

A total of 3225 large Chinook salmon were counted through the Kitwanga River weir between July 25 and the end of October 2006. The first Chinook salmon was counted through the weir on July 25 and the last was on September 17. Daily counts are presented in Table 1. A total of 116 jacks were counted through the weir in 2007 (unpublished data, Gitanyow Fisheries Authority, P.O. Box 148, Kitwanga, BC, V0J 2A0). Data from 2003 to 2006 provide an estimate of 93% (SD = 11%) of the run passed the fence site after July 25. The total estimated run size in 2007 was 3500 with 95% confidence limits of 3225 and 4239. (Note that the lower bound is the known fence count after July 25 as the calculated value was less than the fence count.)

Helicopter flights of the Kitwanga River were made on 14 August, 25 August and 13 September, 2007. Counts of Chinook salmon from each flight appear in Table 2. The peak count was 2200 and the index for the system was 2300 Chinook salmon. Counting conditions were relatively poor for all flights and no Chinook were observed during the flight on 25 August due to recent rains. The number of fish observed below the counting fence while generating the visual index was estimated at 70 Chinook salmon.

The expansion factor for the visual index to the estimate of large Chinook salmon spawning above the weir in the Kitwanga River in 2006 was 1.57 (Table 5).

Kateen River

The visual index for the Kateen River was based on float counts made on 15 and 25 August and a helicopter count on 20 August 2007. Counts appear in Table 3. The index for 2006 was 550 large Chinook salmon in the Kateen River. The visual index was separated into fish observed above and below the canyon. Typically counts are made below the canyon only. The index was 550, 350 below the canyon and 200 above the canyon.

Marking of Kateen River Chinook salmon occurred over 6 days from 20 July to 1 August 2006. A total of 180 Chinook were caught and 153 large Chinook salmon were tagged and released. Only 2 jacks were caught. Tags were not applied to jacks in 2007.

Swims of the Kateen River occurred on 9 and 10 August 2006. The majority of the spawning area was covered each day. Conditions were good on both days and over 200 large Chinook salmon were observed each day (Table 4).

No fish were observed to have lost tags so no correction was applied for tag loss. The Schnabel estimate of large Chinook salmon spawning in the Kateen River was 605 with 95% confidence limits of 503 and 728 (Table 4).

The expansion factor for the visual index to the mark re-sight estimate of large Chinook salmon spawning in the Kateen River in 2007 was 1.72 (Table 5).

DISCUSSION

Water levels, turbidity, light, wind and other conditions greatly affect attempts to enumerate spawning salmon. Conditions experienced in 2007 were often exceptional due to high water conditions, a situation opposite to extreme low waters experienced in 2006. High water conditions prevented the Kitwanga River fence from being installed until July 25, 2007. An unknown number of Chinook salmon had entered the river prior to July 25. It's probable that the high water conditions changed the behavior of Chinook salmon with respect to the timing of their migration past the fence site. Examination of the Chinook salmon runs past the fence site before July 25 in years 2003, 2004 and 2005 indicate relatively small proportions of 1%, 2% and 4% respectively. However, in 2006 the proportion of the run past the fence by 25 July represented 24% of the total annual count. This complicated the calibration procedure because although we knew there were more than 3225 Chinook salmon in the Kitwanga River in 2007 there was significant uncertainty around the true estimate. Large variations in the data from previous years provided little predictive capacity. The uncertainty around an estimate of the front tail of the run was so significant that the standard deviation of the annual proportion past the fence before 25 July was greater than the mean. It's unlikely that the range of run proportions past the fence site experienced from 2003 to 2006 (1% to 24%) represents the upper bounds for Chinook salmon, especially considering the water conditions experienced in 2007. Thus the confidence limits around the estimated number of Chinook salmon that escaped to the Kitwanga River in 2007 expressed by the data are broad, 21%, but the actual uncertainty is probably greater.

The lack of a known estimate of the Chinook salmon escapement to the Kitwanga River essentially violates one of the basic assumptions defined in the calibration proposal: The project assumed that the fence on the Kitwanga River would operate in 2007 to provide a count of Chinook salmon into the system for comparison with the visual index.

Variations in water conditions also affected the accuracy of visual counts; ultimately affecting the indices derived from those counts. Rain and turbidity made it impossible to count Chinook salmon during the second flight of the Kitwanga River, 25 August.

The mark re-sight procedure used on the Kateen River only estimated the return for the portion of the Chinook salmon over 65 cm long. Few jack Chinook salmon (age 3_2) were available to the capture and mark application processes and they could not be readily distinguished from pink salmon during the swim or boat surveys. Marked and unmarked jack Chinook salmon were observed within schools of pink salmon but an accurate count of unmarked jacks could not be obtained. The mark re-sight estimates of large Chinook salmon were consistent with the visual indices which also only measured large Chinook salmon.

The Khutzeymateen River has a significant pink salmon population with visual escapement indices up to 230,000. This river has not exhibited large variations between odd and even year pink returns. Pink salmon returns to the Khutzeymateen River were modest in 2007 with a visual index of 70,000.

The Khutzeymateen Chinook salmon population has been assessed with visual indices between 100 and 750 Chinook since 1985. The index for 2007 was 350 but an additional 200 fish were estimated for the portion of the Kateen River above the canyon. This area was not surveyed for the visual index in 2006 (Table 5).

None of the Chinook salmon marked in 2007 were observed to have lost their Petersen disc tags and no corrections were made to account for tag loss.

The mark rate for large Chinook salmon in the Kateen River in 2007 was 25%. Mark rates for studies conducted in 2005 and 2006 were 22% and 15% respectively. The 2007 Schnabel estimate of 605 large Kateen Chinook salmon was within 20% of the true value 19 times out of 20. In comparison, the 2005 and 2006 estimates were within 27% and 21% of the true value 19 times out of 20 respectively.

The Pacific Salmon Treaty outlines tasks for the Chinook Technical Committee (CTC), which include establishing MSY or other biologically-based escapement goals. Chinook escapement goals are used in the management Chinook salmon fisheries. Typically MSY escapement goals are calculated from stock-recruitment analyses of several years of spawner escapements and subsequent production. The approach can take 15-20 years to acquire sufficient data and often requires considerable resources. Many stocks do not have sufficient spawner and production data to estimate optimal spawning escapements. Consequently, habitat-based methods were developed to estimate optimal spawning escapements for Chinook salmon based on the size of the watershed used by the stock (Parken et. al. 2006). The habitat model predicts the spawners required for maximum sustainable yield and replacement, but most data limited stocks only have indices of abundance and additional information is required to convert the indices to total numbers of spawning fish. This project estimated total escapement by mark re-sight and direct count methods while performing the index methods to establish the relationship between the indices and the total escapement estimates.

The CTC has considered data standards for factors used to expand escapement indices. The draft recommendations include the criteria that expansion factors be based on a minimum of 3 years data and that the coefficient of variation (CV) for the point estimates should not exceed 20% across years. The CTC guidelines include the criteria that the contrast in escapements (largest escapement / smallest escapement) used to generate factors should exceed 4.

The CV for the average expansion factor measured on the Kwinamass River from 2002 to 2006 was 23%, outside of the CTC guidelines (Appendix 2). Contrast in the escapements used to generate the Kwinamass expansion factor was 1.96. Generating an expansion factor for the Kwinamass River that falls within the CTC guidelines will require additional work on the system, especially for escapements that are above or below those currently used to generate the average expansion factor.

The CV for the average expansion factor measured on the Kateen and Kitwanga Rivers from 2005 to 2007 was 29% and 22% respectively (Table 5). The contrast in the escapements used to generate the expansion factors was 1.5 for both rivers. Expansion factors for both rivers remain outside of the draft standards recommended by the CTC. Two additional years of study are proposed to refine the expansion factors used for the Kateen River and the Kitwanga River.

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TABLES

Table 1. Kitwanga River weir counts of large Chinook salmon 2007.

(Unpublished data, Gitanyow Fisheries Authority, P.O. Box 148, Kitwanga, BC, V0J 2A0.)

Date	Daily Count	Cumulative Count
Jul-25	15	15
Jul-26	182	197
Jul-27	160	357
Jul-28	110	467
Jul-29	211	678
Jul-30	23	701
Jul-31	126	827
Aug-01	214	1041
Aug-02	153	1194
Aug-03	47	1241
Aug-04	89	1330
Aug-05	12	1342
Aug-06	47	1389
Aug-07	276	1665
Aug-08	362	2027
Aug-09	146	2173
Aug-10	63	2236
Aug-11	198	2434
Aug-12	130	2564
Aug-13	43	2607
Aug-14	35	2642
Aug-15	96	2738
Aug-16	113	2851
Aug-17	88	2939
Aug-18	0	2939
Aug-19	0	2939
Aug-20	4	2943
Aug-21	14	2957
Aug-22	140	3097
Aug-23	56	3153
Aug-24	18	3171
Aug-25	19	3190
Aug-26	5	3195
Aug-27	0	3195
Aug-28	2	3197
Aug-29	6	3203
Aug-30	8	3211
Aug-31	1	3212
Sep-01	2	3214
Sep-02	2	3216
Sep-03	5	3221
Sep-04	2	3223
Sep-05	0	3223
Sep-06	1	3224
Sep 6-16	0	3224
Sep-17	1	3225

No Chinook salmon were counted between September 6 and 16 or after September 17, 2007. A total of 116 jacks were counted through the fence in 2007, they are not part of the counts presented.

Table 2. Chinook salmon counts during helicopter overflights of the Kitwanga River 2007.

Date	# Chinook	Comment
August 14	1160	Conditions fair, spawning areas visible but pools were glacial. Count includes 60 below the fence.
August 25	unknown	Water conditions very poor, Chinook not visible.
September 11	1770 live, 500 dead	Water conditions moderate. Count includes 70 below the fence.

Table 3. Visual counts of spawning Chinook salmon in the Kateen River in 2007.

River	Date	Method	Unmarked large Chinook	Marked large Chinook	Total large Chinook
Kateen	August 15	float	118	12	130
Kateen	August 20	helicopter	116	uk	116
Kateen	August 25	float	186	31	217

Table 4. Mark re-sight data summary and 2007 population estimate for the Kateen River.

Date	C	R	Schnabel estimate	lower CL	upper CL
M = 153					
9 Aug	232	60			
10 Aug	207	50	605	503	728

M = the number of large Chinook salmon marked and released
C = the total number of large Chinook salmon observed in the snorkel surveys
R = the number of marked large Chinook salmon observed in the snorkel surveys
CL = confidence limit

Table 5. Comparisons of visual indices of Chinook salmon escapement with mark re-sight estimates and fence estimates for the Kateen and Kitwanga Rivers, 2005 to 2007.

Year	River System	Visual Index	Mark re-sight or Fence Estimate	Factor
	Kateen	below canyon / total		below canyon / total
2005	Kateen	200 / 350	579	2.90 / 1.65
2006	Kateen	450 / uk	847	1.88 / uk
2007	Kateen	350 / 550	605	1.72 / 1.1
2005	Kitwanga	1600	2408	1.51
2006	Kitwanga	2915	3014	1.03
2007	Kitwanga	2230	3500	1.57

FIGURES

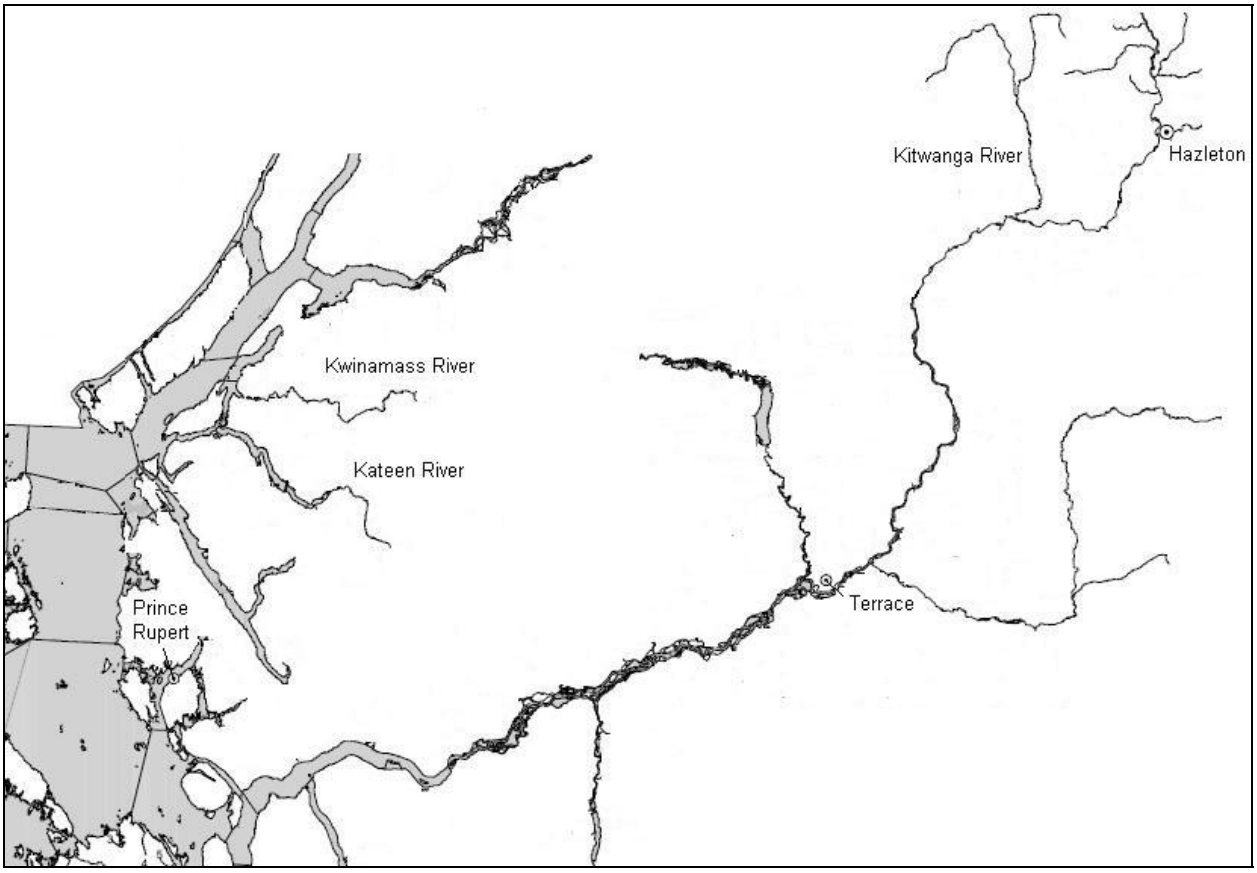

Figure 1. Location of the Kateen River and the Kitwanga River in northern British Columbia.

APPENDICES

Appendix 1. Chinook salmon escapements to Kwinamass, Khutzeymateen and Kitwanga Rivers from Fishery Officer records.

Year	Kwinamass	Khutzeymateen	Kitwanga
1962	1500		25
1963	3500		
1964	1500	3500	
1965	3000	800	25
1966	5000	1000	25
1967	3500	800	
1968	5000	5000	25
1969	1000	750	75
1970	1200	750	75
1971	2500	750	75
1972	1000	2000	75
1973	300		200
1974	1200		200
1975	1000		200
1976	500	500	75
1977	600	1000	200
1978	700	700	200
1979	300	800	25
1980	300	300	25
1981	300	300	
1982	500	500	
1983	150	200	
1984	300	300	15
1985	200	300	700
1986	600	500	1000
1987	300	750	1000
1988	300	300	1000
1989	200	200	1000
1990	350	325	2000
1991	300	300	1200
1992	295	275	2500
1993	200	200	975
1994	100	100	1000
1995	100	100	600
1996	300		2000
1997	300	150	1600
1998	400	100	2500
1999	200	100	1000
2000	300	300	
2001	700	600	2500
2002	600	300	
2003	450	150	1776*
2004	400		1542*
2005	400	350	2408*
2006	500	450	3014*

* fence counts

Appendix 2. Comparisons of visual indices of Chinook salmon escapement with mark re-sight estimates for the Kwinamass River, 2002 to 2006.

Year	River System	Visual Index	MR or fence Estimate	Factor
2002	Kwinamass	600	1176	1.96
2003	Kwinamass	450	771	1.71
2004	Kwinamass	400	813	2.03
2005	Kwinamass	400	957	2.39
2006	Kwinamass	500	1512	3.02