

**Steelhead Tagging Project  
at  
Moricetown Canyon**

**AUGUST TO SEPTEMBER 2007**

by  
Wet'suwet'en Fisheries

**Data Analysis and Recommendations**

by  
SKR Consultants Ltd.  
Smithers, B.C.

for  
Pacific Salmon Foundation  
Vancouver, B.C.  
And  
Ministry of Environment  
Smithers, B.C.

July 2009

## Executive Summary

During the summer and fall of 2007, Wet'suwet'en Fisheries continued the Moricetown Canyon steelhead tagging program that was initiated in 1999, in coordination with an ongoing coho, sockeye and chinook tagging program. Coho, sockeye and chinook data were analysed separately by Fisheries and Oceans Canada. The data collected for steelhead migration from August to September 2007 are summarized in this report in conjunction with catch per unit effort information summarized by Wet'suwet'en Fisheries. The continued objectives of this steelhead tagging program have been to standardize the sampling methodologies, to evaluate in-season population estimates or indices and to monitor the run timing and relative annual returns of steelhead migrating upstream of Moricetown Canyon.

In 2007, 208 steelhead were tagged by beach seining, and 1101 steelhead were captured by dipnetting. The onset of the fishing season in 2007 was delayed substantially due to high water levels. Catch rates indicate that the tagging program encompassed the beginning and peak time of steelhead migration through Moricetown Canyon. However, run timing information from previous years of the study indicate that an early portion of the steelhead run may not have been sampled due to high water levels and consequent late onset of the fishing season. In addition, the late part of the run was not sampled as indicated by the continued catch of steelhead to the last day of fishing on the 29<sup>th</sup> of September, 2007. A comparison of sex ratios was not conducted because gender identification of steelhead in the fall is notoriously difficult, and has been found to be inconsistent during previous years of the study (1999, 2000 and 2001). Fork lengths for steelhead captured in the beach seine fishery were significantly smaller than for lengths for steelhead captured in the dipnet fishery, similar to findings in 2004 and 2006. The significant difference between fork lengths of fish captured with different gear types this year indicates bias in capture techniques, which further draw the population estimates into question.

The number of steelhead tagged in 2007 is considerably lower than the targeted number (600-1,000) for a mark-recapture estimate, assuming a population size between 10,000 and 30,000 steelhead, and recapture rates in 2007 were lower than previous years of the study, with only 0.7 % of the steelhead examined in the dipnet fishery having been tagged by beach seining (8 of 1,101). An additional five recaptures with lower caudal punches but incomplete tag information may have been recaptured from the beach seine fishery in the dipnet fishery, bringing the recaptured rate in 2007 up to 1.2% (13 of 1101). This is the third lowest recapture rate since the initiation of the study, with only 1999 and 2000 having lower recapture rates (0.5% and 0.4% respectively), and is much lower than the highest recapture rate recorded in 2003 at 5.5%. The lower proportion of steelhead recaptures in 2007 is in large part due to the low number of tags applied in the beach seine fishery. In 2007, only 208 tags were applied in the beach seine fishery, the second lower number of tags applied since the initiation of the study, with only 1999 having fewer tags applied by beach seining (165).

Eight of the 208 steelhead tagged downstream of the canyon were recaptured in a sample of 1,101 steelhead examined for tags at the canyon. A 5% tag loss was assumed, based on tag loss estimates for beach seine captured steelhead in 2007, and in previous years of the study. The adjusted Petersen estimate for steelhead moving through Moricetown Canyon between August 3<sup>rd</sup> and September 27<sup>th</sup>, 2007 based on eight recaptures is 24,316 steelhead (95% confidence interval = 13,746-51,075). It is likely that the five steelhead with lower caudal punches and incomplete tag information, which were captured in the dipnet fishery, are also beach seine recaptures. An alternate Petersen estimate, using 13 recaptures in the sample of 1,101 was calculated as 15,554 (95% CI 9,786-28,475). The 2007 estimates should be viewed in light of constraints of the study, including low recapture rates, incomplete sampling of the steelhead run, non-random sampling at the beach seine and dipnet locations, and uncertainties around the number of recaptures in the census sample obtained by dipnetting.

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## **Acknowledgements**

We wish to thank Wet'suwet'en Fisheries, in particular Walter Joseph and the Wet'suwet'en Rangers for providing the databases, information, clarification, and input for this report. Thanks go to Brian Michelle for his help in gathering historical hardcopy and digital data. Walter Joseph (Wet'suwet'en Fisheries) and Mark Beere (Ministry of Environment) reviewed a draft version of the report. Funding for data analysis and reporting was provided by the Pacific Salmon Foundation, Vancouver BC.

## 1.0 Introduction

Wet'suwet'en Fisheries conducted a steelhead tagging program on the Bulkley River at Moricetown Canyon (about 30 km north of Smithers, B.C.) in 2007 to monitor run timing and abundance of steelhead (*Oncorhynchus mykiss*) moving through Moricetown Canyon. This study is a continuation of previous tagging efforts at Moricetown Canyon since 1999 (SKR 2000a, 2001a, 2002a, 2003, 2004, 2006, 2009a, 2009b). Steelhead tagging at Moricetown Canyon is conducted in conjunction with an extensive adult coho (*Oncorhynchus kisutch*) tagging program, and an adult sockeye salmon (*Oncorhynchus nerka*) tagging program; data for these species are analysed separately by the Department of Fisheries and Oceans Canada (Joseph pers. comm.). In addition, chinook salmon have been tagged at Moricetown since 2002 (SKR 2003a, 2004, 2006, 2008). The steelhead tagging program at Moricetown Canyon was designed by Wet'suwet'en Fisheries, incorporating input from B.C. Environment (MoE) and the Department of Fisheries and Oceans (FOC). The initial three years of the program were jointly funded by Fisheries Renewal B.C. and the FOC. The fourth, fifth, sixth and seventh years of the project were funded by FOC. SKR Consultants Ltd. was retained by Wet'suwet'en Fisheries to monitor data collection, summarize steelhead data obtained in the study and to provide recommendations for future efforts toward collecting data related to steelhead migration through Moricetown Canyon between 1999 and 2004. Budgetary constraints in 2005, 2006 and 2007 prevented Wet'suwet'en Fisheries to fund data analysis and reporting for steelhead data collected in these years, and additional constraints prevented funding of independent QA assessments in 2006 and 2007. The Ministry of Environment retained SKR Consultants Ltd. to conduct cursory data analysis and reporting of data collected after 2005 to follow recommendation number 15 of the Independent Science Panel (Walters et al 2008). This report summarizes steelhead data collected from August 3<sup>rd</sup>, 2007 to September 29<sup>th</sup>, 2007. The results for the 2005 and 2006 tagging project are summarized in separate reports (SKR 2009a and 2009b respectively).

The main objectives of this project were:

- to monitor timing of steelhead migrations through Moricetown Canyon;
- to review, check, and summarize steelhead data collected at Moricetown Canyon; and
- to estimate the number of steelhead in the Bulkley River upstream of Moricetown Canyon in the fall/winter 2007.

## 2.0 Materials and Methods

The adult steelhead tagging program at Moricetown was designed by Wet'suwet'en Fisheries, MoE and FOC, and was conducted in conjunction with an extensive adult coho and sockeye tagging program, and a coincidental chinook tagging program. Methodologies employed in August to September 2007, were generally similar to those employed in previous years.

### 2.1 Data Collection

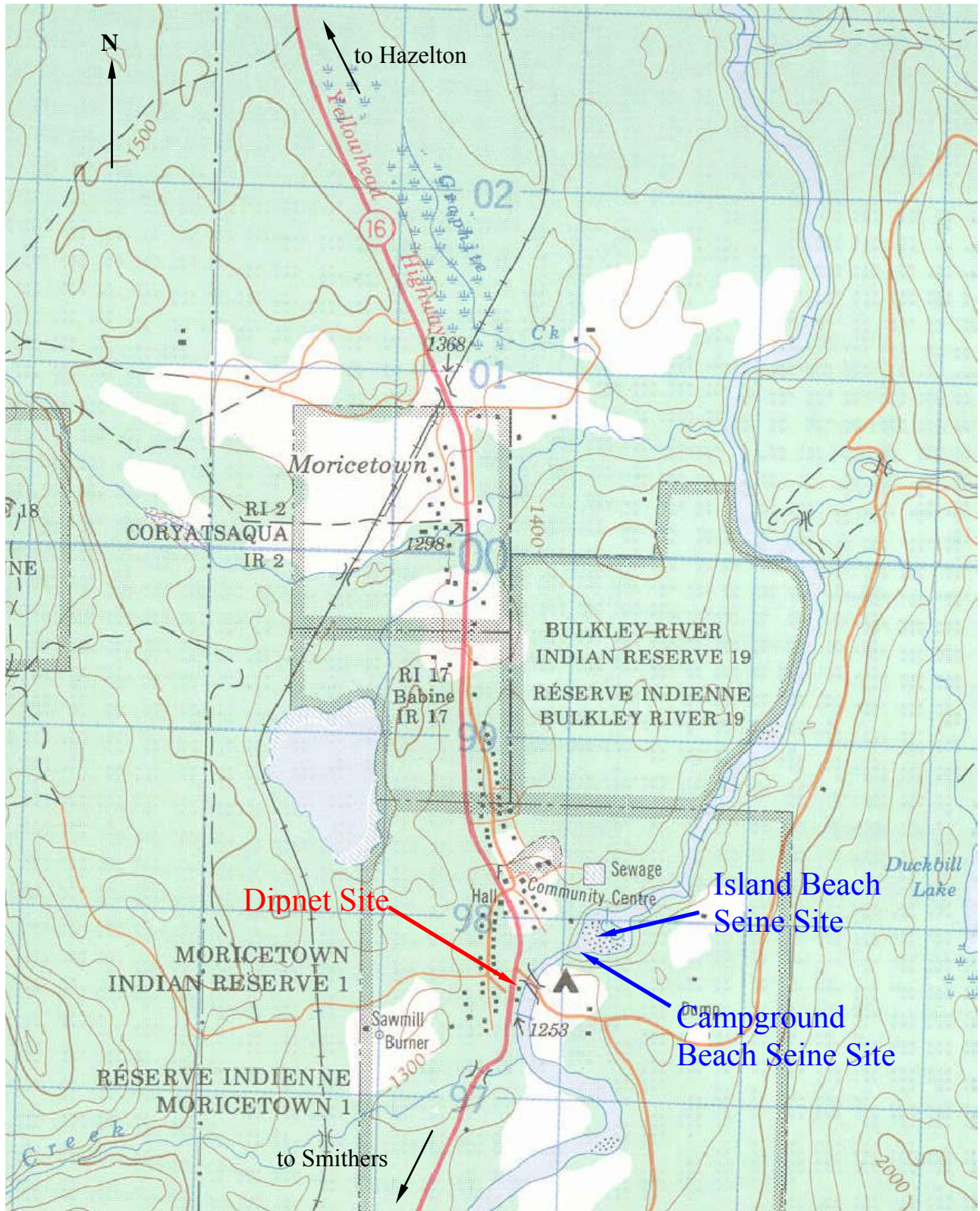
Steelhead were captured using beach seines and dip nets. Beach seining was conducted just downstream of the Moricetown Canyon, while sampling by dipnet was conducted in Moricetown Canyon (Figure 1), using similar methods to those employed since 1999 (Wet'suwet'en Fisheries 1999, 2001, 2002, 2003, 2006, 2009a, 2009b). Steelhead captured by beach seining and by dipnetting at the fishway were tagged using a combination of anchor tags and hole punches of the caudal fin. Methodologies employed for tagging and data collection between August 3<sup>rd</sup> (Wet'suwet'en 2008) and September 29<sup>th</sup>, 2007 are described in detail below.

#### 2.1.1 Beach Seine Tagging

Two beach seine crews tagged steelhead captured at the island or shore side immediately downstream of "Idiot Rock", located directly below the campground in Moricetown between August 3<sup>rd</sup> and September 29<sup>th</sup>, 2007. Beach seine crews generally consisted of five individuals, and the two crews captured and tagged fish from sunrise to sunset. A trail leading from the campground to the beach was used to access the beach seine area on foot. A boat launch located downstream of the campground was utilized to access the beach seine area by boat. The beach seine was set at the campground side on most days (river right), and a beach on the island was used on some days as water levels changed the efficiency of each capture location. A 90 m long by 8 m deep net with a 5 cm (2") diagonal mesh size was used for beach seining purposes (Wet'suwet'en 2008, Michell pers. comm.). The upstream side of the net was tied off to shore, and the net was spread out in a semicircle along the beach shore, and pulled into shore. A jet boat was used to set the net. The net was pulled into shore, ensuring that the lead and float lines did not tangle. Captured fish were identified to species. Steelhead, coho, chinook and sockeye were measured (fork length), checked for tags (anchor tags, fin clips or punches), and their condition and gender was recorded. Tags applied to steelhead, coho, Chinook and sockeye are summarized in Table 1. A secondary tag consisting of a lower caudal punch was also applied to assess tag loss. Tag colour and number of all recaptured fish were recorded. The beach seine location was allowed to rest for a minimum of 15 minutes between consecutive sets. The daily number of successful beach seine sets varied, and depended on several factors including day length, weather conditions, number of species caught (i.e. handling time), mending requirements, and potential twisting, tangling or snagging during individual sets.

**Table 1.** Tag colours and numbers applied by beach seine crews from August to September 2007, Moricetown tagging program.

Species	Tag colour	Tag Numbers
Steelhead	Grey	8413
Steelhead	White	41001-41765
Chinook	Red	No numbers
Chinook	White	No numbers
Coho	Blue	10851-10858
Coho	Lime Green	28001-3200
Sockeye	Orange	67001-67291



**Figure 1.** Locations of beach seine and dipnetting operations in the Moricetown Canyon. The map is an excerpt of 093M/03 NTS map (scale is 1:50,000).



### 2.1.2 Canyon Dip Net Census

Two crews captured, tagged and released steelhead, sockeye and coho at the fishway in Moricetown Canyon between August 3<sup>rd</sup> and September 29<sup>th</sup>, 2007. Canyon crews consisted of five individuals, including two fishermen, a runner, a tagger and a recorder. Fish were captured by dipnetting in the canyon, and were transported to a tagging trough for processing. Fish were identified to species, measured, sexed and examined for marks (anchor tags, fin clips and punches) and condition. Captured steelhead, coho and sockeye were anchor tagged and upper caudal punched. Chinook were either harvested or released untagged. Anchor tags applied by canyon crews are summarized in Table 2. Tag number and colour of recaptured fish were recorded.

**Table 2.** Tag colours and numbers applied by canyon crews from August to September 2007, Moricetown tagging program.

<b>Species</b>	<b>Tag colour</b>	<b>Tag Numbers</b>
Steelhead	Grey	30530-30539, 53536-53537
Steelhead	Blue	9165
Coho	Blue	4400-4514, 5966-9279, 1101-13000
Sockeye	Yellow	96001-96332

### 2.1.3 Quality Assurance/Quality Control

No independent Quality Assurance checks were conducted in the 2007 field season.

## **2.2 Data Entry**

Wet'suwet'en Fisheries entered all data collected in the 2007 field season into a Microsoft Access 2000 data entry tool designed by Walter Joseph (Wet'suwet'en Fisheries). Newly marked fish and recaptured fish were differentiated in the database. "Applied tag" was the tag status entered for all newly tagged fish, "recaptured" was the tag status entered for recaptured fish. Recaptured fish that had lost their tag, as identified by the presence of a caudal punch, were identified in the database with "lost" entered as the tag status. Entered data was compared to original field data where possible prior to data analysis.

## **2.3 Data Analysis**

Wet'suwet'en Fisheries conducted some data analysis for catch per unit effort and daily run timing for their final report (Wet'suwet'en Fisheries 2007). Data provided to SKR did not include effort information, and we therefore limited this analysis to mark-recapture estimates.

### 2.3.1 Migration

While effort data was not available from the data set provided, the number of steelhead captured by beach seine and dipnet on each day could be determined. The number of fish captured by beach seine and dipnetting was compared graphically. In addition, the distribution of recaptured steelhead among the marked and censused sample was compared. These comparisons allowed for a subjective assessment of temporal biases in sampling. If the number of fish captured over time is similar between the two capture methods, temporal biases or differences in temporal biases between capture gears are likely small. Conversely, differences in capture rates over time between the two sampling methods may indicate temporal biases between capture methods in the data, and provide insight into which capture method is a better indicator of migration rates, for future development as a catch per unit effort index of population size.

### 2.3.2 Population Estimates

The number of fish migrating upstream through Moricetown Canyon from August 3<sup>rd</sup> to September 29<sup>th</sup>, 2007 was determined using a Schaeffer estimate and an ML Darroch estimate, which are suitable for open populations. A computer program designed by Arnason *et al.* (1996) for population analysis was used to calculate the Schaeffer estimate. To calculate the Schaeffer and the ML Darroch estimate, the study period was divided into weeks (Table 3). A pooled Petersen estimate was also calculated for comparison. If the marking sample or the census sample is random, a Petersen estimate can provide an unbiased estimate of the population size. However, both the mark sample (beach seine), and the census sample (dipnet) were obtained in a non-random fashion (sampling days and times were not determined randomly, sampling period did not encompass entire migration period), thus the population estimates for this sample are biased.

**Table 3.** Temporal stratification for the Moricetown steelhead data.

Week Number	Start Date	End Date
Week 1	July 30 <sup>th</sup> , 2007	August 5 <sup>th</sup> , 2007
Week 2	August 6 <sup>th</sup> , 2007	August 12 <sup>th</sup> , 2007
Week 3	August 13 <sup>th</sup> , 2007	August 19 <sup>th</sup> , 2007
Week 4	August 20 <sup>th</sup> , 2007	August 26 <sup>th</sup> , 2007
Week 5	August 27 <sup>th</sup> , 2007	September 2 <sup>nd</sup> , 2007
Week 6	September 3 <sup>rd</sup> , 2007	September 9 <sup>th</sup> , 2007
Week 7	September 10 <sup>th</sup> , 2007	September 16 <sup>th</sup> , 2007
Week 8	September 17 <sup>th</sup> , 2007	September 23 <sup>rd</sup> , 2007
Week 9	September 24 <sup>th</sup> , 2007	September 30 <sup>th</sup> , 2007

### 3.0 Results and Discussion

#### 3.1 Data Collection

Data sheets obtained from the Wet'suwet'en Fisheries office appeared generally complete, and contained most of the digital data provided by the Wet'suwet'en Fisheries staff. Review of the field data forms and revealed that significant data collection problems were present in the 2007 dataset. Most importantly, recapture tag information was incomplete at the dipnet fishery, where tag number, or tag colour and number were not recorded for some recaptures (17 of 34 (50%)). This did not allow for the matching of original tag information to the recapture information, which is required for the calculation of some estimates (Schaeffer and ML Darroch), and which introduced uncertainty as to the tag origin of these recaptures. It is likely that most of the recaptures originated in the beach seine fishery since only 10 steelhead were marked in the dipnet fishery, however it is uncertain if these recaptures are from previous years of the study, or if they are from the 2007 field season.

##### 3.1.1 Beach Seine Tagging

A total of 203 steelhead were marked during beach seining. In addition, five steelhead tagged in previous years were recaptured during beach seining, and while these fish were not re-tagged, tag numbers were recorded, and were included in the total number of steelhead marked by beach seining in 2007 (total marked is 208). This is a marked decrease from the number of tags applied in 2006 (556 steelhead), 2005 (526 steelhead), 2004 (321 steelhead), 2003 (656 steelhead), 2002 (835 steelhead), and 2001 (323 steelhead) (Table 4). It is the second lowest number of tags applied since the initial year of steelhead tagging efforts at Moricetown Canyon in 1999 when 164 steelhead were tagged, and is similar to the number of steelhead tagged in the second year of the study (225 steelhead tagged in 2000). The number of steelhead tagged in 2007 falls well below the recommended number of steelhead to be tagged, following the 1999 and 2000 seasons of the project (SKR 2000, 2001a). The minimum number of steelhead recommended for tagging at the start of the 2001 field season was 600 to 1000, assuming a steelhead population size of between 10,000 and 30,000. These numbers are the minimum number of steelhead required to be marked to arrive at a Peterson estimate with an error of 25% of the true population (Ricker 1975).

**Table 4.** Comparisons of sample sized obtained at the beach seine, dipnet and fishwheel locations during the steelhead tagging program conducted at Moricetown Canyon in 1999-2007 (see SKR 2000a, 2001a, 2002a, 2003a, 2004, 2006, 2009a, 2009b).

Year	Number of steelhead		
	Beach seine <sup>1</sup>	Dipnet <sup>3</sup>	Fishwheel
1999	164	1555	n.a.
2000	225	1010	11
2001	323	1183	18
2002	835	1933 (incl. 3 steelhead with lost tags)	None reported
2003	656	1805	n.a.
2004	321 <sup>2</sup>	1568	n.a.
2005	526 <sup>2</sup>	1636	n.a.
2006	556 <sup>2</sup>	1700	n.a.
2007	208 <sup>2</sup>	1101	n.a.

<sup>1</sup> excludes recaptures from this study

<sup>2</sup> includes 3 steelhead for 2004, 5 steelhead for 2005, 7 steelhead for 2006, and 4 steelhead for 2007 tagged in previous years of the study

<sup>3</sup> excludes recaptures initially tagged at dipnet location; includes steelhead originally tagged by beach seine



**Figure 2.** Photograph taken on June 4, 2007 illustrating high water level at Moricetown Canyon, resulting in lower steelhead catch (courtesy of Walter Joseph).

The decrease in the number of tags applied in 2007 when compared to 2001 to 2006 is in part attributable to unusually high water in the canyon during the 2007 field season (Walter personal communications; Figure 2). The high water level resulted in decreased fishing effort (e.g. delayed start of the fishing season), and in physical changes in the river (e.g. shifting gravel bars). In addition to water level and physical changes in the river, overall steelhead catch may also be lower in 2007 compared to previous years as a result of fewer steelhead in the river, decreased catchability of fish due to high water, and abundance of other species in the catch are possible factors resulting in fewer steelhead captured than in 2002 or 2003. Data provided was insufficient to investigate these potential causes of the overall reduced steelhead catch.

### 3.1.2 Canyon Dip Net Census

A total of 1,114 steelhead were captured by the dipnet crews between August 3<sup>rd</sup> and September 29<sup>th</sup>, 2007. Thirty-four of these steelhead were identified as recaptures, one of which was originally tagged by dipnetting, and 17 of which had incomplete tag information recorded. The original tag location for these 17 steelhead could not be ascertained. Caudal punches for five of these 17 steelhead indicate that they were recaptures from the beach seine fishery. Eight of the 34 recaptures were tagged in previous years of the study, and eight were recaptures from the beach seine fishery. The recaptured steelhead originally tagged in the dipnet fishery (1), and the 12 steelhead for which neither tag information nor caudal punches were recorded were deleted from the population estimates. Therefore, the number of steelhead examined for tags by dipnetting was reduced to 1101. This is the second lowest number of steelhead examined in the dipnet fishery; only the 2000 field season recorded a lower number of steelhead examined in the dipnet fishery (1010). The number of steelhead examined in the dipnet fishery is 9.0% higher than for

2000 (1010). However, the number of steelhead captured by dipnetting is 29.2% lower than in 1999 (1555), 6.9% lower than in 2001 (1183), 43.0% lower than in 2002 (1933), 39.0% lower than in 2003 (1,805), 29.8 % lower than in 2004 (1568), 32.7 % lower than in 2005 (1636) and 35.2% lower than in 2006 (1700) (Table 4). The relatively low number of steelhead captured in the dipnet fishery is likely attributable to the high water in the canyon, delaying the onset of the dipnet fishery. The first steelhead in the dipnet fishery was not caught until August 10<sup>th</sup>, 2007, where as in previous years, the first steelhead was captured around the 25<sup>th</sup> of July (e.g. July 25<sup>th</sup> in 2006, and July 27<sup>th</sup> in 2005; SKR 2009a, b). The minimum number of steelhead that should be examined for tags to arrive at a Petersen estimate with a 25% error from the true population size is 1,000 to 2,000 with an expected population size between 10,000 to 30,000 steelhead (SKR 1999, 2000, Ricker 1975). Thus, the number of steelhead examined, despite logistical difficulties in this sampling year, falls within the range recommended if the actual population size is between 10,000 and 30,000 steelhead.

### 3.2 Data Entry

Data entry conducted by Wet’suwet’en Fisheries staff were submitted digitally for QA. Comparisons of field data forms and digital data revealed that some data entry problems were present in the 2007 dataset. There were no duplicate tags in the database, which is partly attributable to the low number of tags applied (203 in the beach seine and 10 in the dipnet fishery). The QA process found problems with an additional 70 records (5.2%), excluding simple spelling mistakes or inconsistent coding for tag colours. Common errors included date (14 records), location (13 records), tag status (16 records), tag numbers (4 records), tag colour (7 records), length and sex data (11 records), and missing records (5 records). However, significant omissions in the data collection, especially for recapture tag colour and/or number (17 of 34 (50%)) could not be rectified in the digital data, and introduces significant additional uncertainties around mark-recapture estimates for 2007.

### 3.3 Data Analysis

Wet’suwet’en Fisheries handled a total 1,309 steelhead in August to September 2007. The majority of these steelhead (1,101) were captured at Moricetown Canyon in the dipnet fishery, but only 10 of these fish were tagged prior to their release. The remainder were released untagged (1019), harvested (50) or were recaptures from this or other studies (32). The 208 steelhead that were tagged just downstream of Moricetown Canyon were considered to be the number of marked fish (M) for the calculation of the adjusted Petersen estimate. Of the 208 steelhead tagged by beach seining, eight were recaptured in the canyon dipnet fishery (Table 5).

**Table 5.** Applied and recaptured steelhead tags for the 2007 Moricetown steelhead tagging program.

	<b>Beach Seine Tags (d/s of the canyon)</b>	<b>Dipnet Tags (in canyon)</b>
Applied	208 <sup>1</sup>	1101 <sup>3</sup>
Recaptured by Dipnet (in canyon)	8 <sup>2</sup> (excl. 6 steelhead with lower caudal punch but no tag information)	1 (excl. 0 steelhead that lost tags)
Recaptured by beach seine (d/s of canyon)	14 (excl. 1 steelhead that lost tag)	0 (excl. 0 steelhead that lost tags)

- 1 The number of tags applied by beach seine equals M in equation 1
- 2 The number of beach seine tagged steelhead recaptured by dipnetting equals R in equation 1 (note 1 recaptured steelhead had lost its tag, and 5 recaptured steelhead did not have tag information; these fish were excluded from “R” because it could not be determined if the these fish were repeat recaptures or not)
- 3 This number includes 1069 steelhead not tagged at the dipnet location, of which 50 were harvested

In addition to recaptures used for population estimates (Table 5), 30 other tagged steelhead were recaptured in this study. Some of these steelhead originated from other tagging studies, including 12 from previous years of the project (Appendix 3). Tag number from 18 recaptured steelhead could not be matched to applied tag records of this or previous years of the study, and it is unclear when these tags were applied. All of the recaptured steelhead for which original tag information could be ascertained had consistent species identification (i.e. the fish were identified as steelhead on both captured occasions). Because of incomplete tag information of recaptures, and because most fish caught in the dipnet fishery received a top caudal punch even though they were not tagged, tag loss estimates for the 2007 season are less accurate than for previous years of the study. Only beach seine data was used to estimate tag loss because recapture information and tag status were more consistently recorded by beach seine crews than by dipnet crews in 2007. Fourteen steelhead originally tagged by beach seining were recaptured in the beach seine fishery. In addition, one steelhead with a lower bottom punch was recaptured, but had lost the tag. Thirteen additional steelhead with a top caudal punch but no tag were captured in the dipnet fishery, and it is speculated that these fish were not tagged with an anchor tag. One steelhead captured in the dipnet fishery was recorded with “lost” tag status, but no caudal punch or tag information was provided in the original data sheets. Based on these data, one or two of the 23 recaptured steelhead had lost their tag, resulting in an estimated tag loss of 4.3% to 8.6%, which is similar to tag loss rates estimated in previous years of the study. Tags with incomplete initial tagging data or recapture data were not used in the calculation of the population estimate.

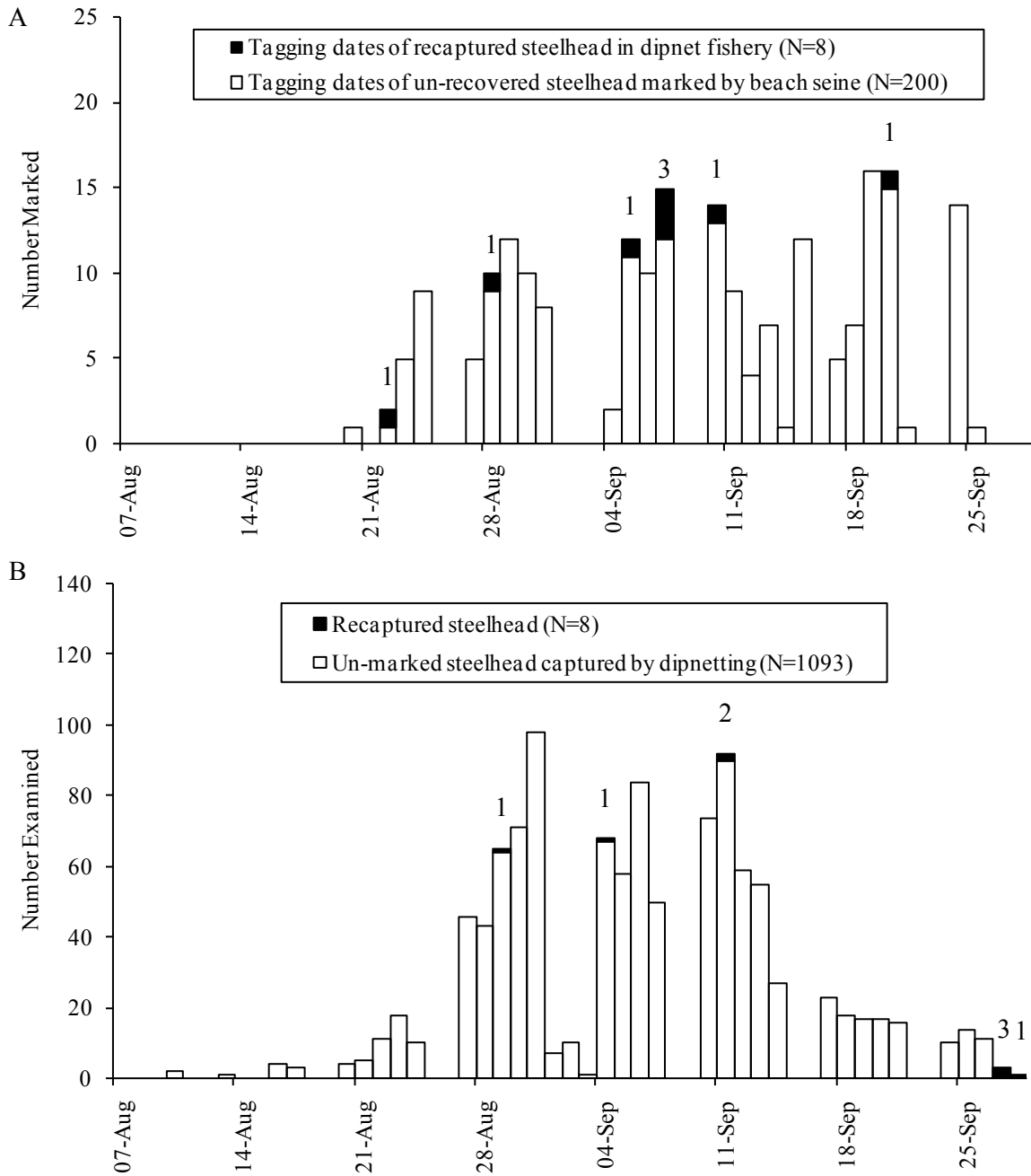
In total, 51 steelhead were harvested during the 2007 Moricetown steelhead tagging project. All of these steelhead were harvested at the dipnet fishery, including one recaptured steelhead originally tagged on August 16, 2005 (Green tag Number 38837).

### 3.3.1 Timing of Migration

The number of steelhead captured by beach seine and dip netting throughout the study period were compared graphically (Figure 3). The first steelhead was captured on August 10<sup>th</sup> in the dipnet fishery, and the first steelhead in the beach seine fishery was captured on August 20<sup>th</sup>, 2007. The tagging program started in advance of these dates, with the first Pacific salmon captured on August 6<sup>th</sup> for both, the dipnet and the beach seine fisheries. This indicates that the timing of the mark-recapture study at Moricetown canyon likely encompassed the start of the steelhead migration period, however, the first day of steelhead catch in 2007 (August 10<sup>th</sup>) is later than in previous years (e.g. July 27<sup>th</sup>, 2006, July 25<sup>th</sup>, 2005, July 14<sup>th</sup>, 2004), and the sampling may have missed the early part of the run.

Capture dates for steelhead at the start of the migration season in 2007 were later than capture dates in previous years of the study (usually the last week of July or first week of August). Daily beach seine catch increased gradually in August, to a peak of 15 steelhead on September 7<sup>th</sup>, then fluctuated between 1 and 14 until a second peak of 16 steelhead on September 19<sup>th</sup> and 20<sup>th</sup>. Fluctuating catch rates may be due to varying catch efficiencies due to environmental factors (e.g. water level, water clarity), effort by individual crews (contingent on day length, catch of other species etc), or they may be indicative of fluctuating migration rates or travel routes. Overall steelhead catch rates were much lower in 2007 than in 2005 or 2006, which may be attributable to higher water levels reducing catch efficiency.

Steelhead catch in the canyon peaked on August 31<sup>st</sup> (97 steelhead), with a second peak in steelhead catch rates in the beginning to mid September (84 steelhead on September 6<sup>th</sup>, 87 steelhead on September 11<sup>th</sup>). This is considerably later than peak capture rates in 2005 (August 17<sup>th</sup> and August 19<sup>th</sup>) (SKR 2009a), 2004 (August 18<sup>th</sup> and August 19<sup>th</sup>) (SKR 2006), and 2003 (August 23<sup>rd</sup> and 28<sup>th</sup>) (SKR 2005), and the timing of the second peak capture rates in 2007 is earlier than a second, minor peak in daily steelhead catch rate on September 19<sup>th</sup> and 22<sup>nd</sup>, 2005 (SKR 2009a), and September 16<sup>th</sup> and 18<sup>th</sup>, 2002 (SKR 2003), as well as the timing of peak steelhead migration in 2006 (September 25<sup>th</sup>, SKR 2009b). Differences in

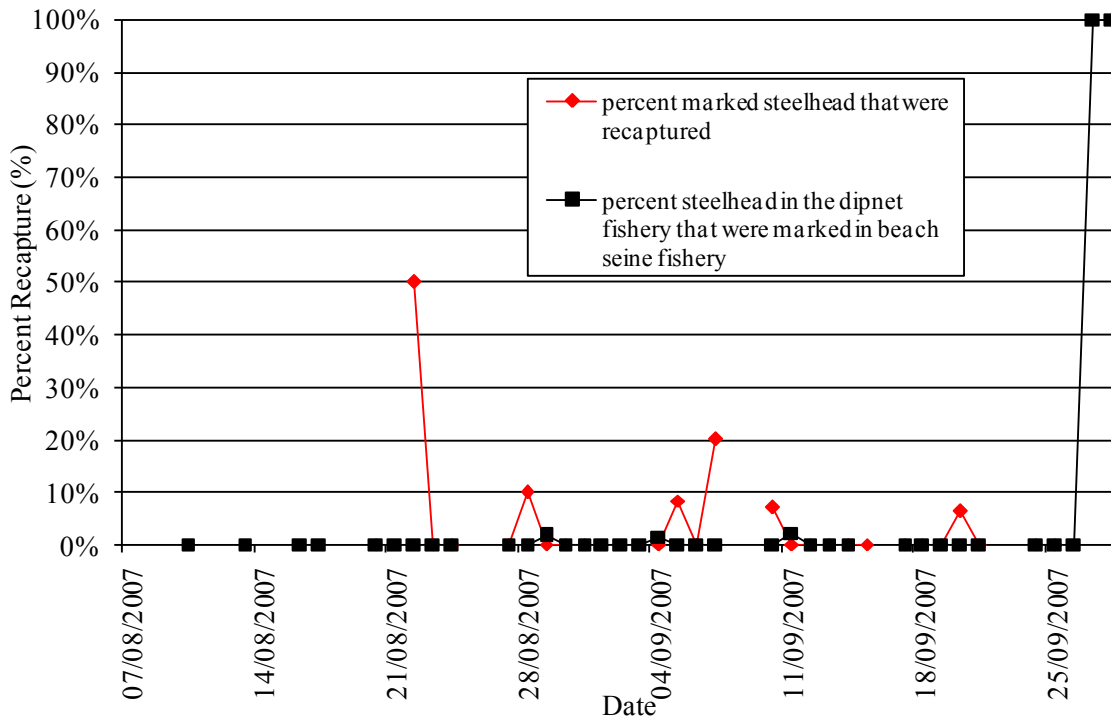


**Figure 3.** Temporal distribution of tag application during beach seining (A), and of examination for tags during dipnetting (B) during the 2007 steelhead population estimate study. Data labels in the graphs indicate the number of recaptured steelhead. The recaptured steelhead for which original tag data could not be determined are excluded from the graph.

timing of peak steelhead capture rates in the dipnet fishery may be attributable to different physical conditions in the canyon (e.g. higher water levels in 2007), varying levels of effort for steelhead fishing, and/or differences in migration rates.

Overall, the low capture rates for steelhead in both the beach seine and the dipnet fishery at the start of the study suggests that the sampling protocol was successful in encompassing the early part of the steelhead migration period though the first capture date of steelhead in 2007 is later than for previous years of the study. Low capture rates at the start of the tagging project may also be due to high water levels reducing sampling efficiency. The low capture rate in early to mid August may be due to continued high water levels rather and/or a delayed migration of steelhead in 2007. The continued capture of steelhead to the termination of the study implies that the late part of the run was not sampled during the tagging study.

The early termination of the study resulted in incomplete sampling of the steelhead run. Only eight of the steelhead tagged in the beach seine fishery were recaptured by dipnetting, however, despite the small sample size trends in different recapture probabilities found in previous years of the study are also illustrated in the 2007 steelhead tagging data. A greater proportion of steelhead tagged early in the beach seine fishery were recaptured in the dipnet fishery (Figure 4). The percent of recaptures in the dipnet fishery was generally greater towards the end of the study than at the beginning. These two trends are speculated to reflect the lag time between mark dates and recapture dates as steelhead move upstream through Moricetown Canyon. The different proportions of recaptures in the study indicates that steelhead tagged earlier in the study are more likely to be recaptured than steelhead tagged later in the study, which introduces bias to the population estimate.



**Figure 4.** Percent recapture rate for steelhead tagged in the beach seine fishery (♦) and for steelhead examined in the dipnet fishery (+) ■



Of the 1101 steelhead captured by dipnet crews, tags were applied to only ten steelhead, while thirteen steelhead were recaptures from the beach seine fishery (including 5 that had no record of recapture tag information but were bottom caudal punched), eight were recaptures from previous years of the study, 51 were harvested (including 1 recapture) and 1019 were released untagged (steelhead escaped prior to tagging, insufficient tags available on some tagging dates). Recaptures in the dipnet fishery and the beach seine fishery resulted in the capture of one and zero steelhead originally tagged in the dipnet fishery, respectively. This indicates that some steelhead drop back after handling and tagging. The 2007 recapture rates of drop backs (10%) is higher than for 2006 (5.2%), 2005 (7.2%), 2004 (5.6%), 2003 (6.1%), 2002 (4.3%), 2001 (5.4%), or 2000 (4.4%) (SKR 2001a, 2002a, 2003a, 2004, 2005, 2009a, 2009b). The actual drop back rate is higher than the recapture rate since catchability must be taken in to account, and was estimated as 37.1% for 2005 and 29.8% for 2006. Steelhead tagged in the beach seine fishery were recaptured between 4 and 23 days in the dipnet fishery (mean 11.3 days, SD = 7.624), and between 0 and 8 days in the beach seine fishery (mean = 0.6, SD = 2.13). Since it is unknown what the natural frequency of drop backs at Moricetown Canyon is, it is difficult to speculate on how much of the observed drop back is due to tagging and handling of the fish. Increased drop back of steelhead tagged in the beach seine fishery compared to natural drop back rates can affect the population estimates since steelhead that drop back are less likely to be recaptured in the dipnet fishery, thus resulting in a lower recapture rate, and a higher population estimate.

### 3.3.2 Schaeffer and ML Darroch Estimates

The Moricetown mark-recapture study takes advantage of the fact that steelhead are moving through Moricetown Canyon. Therefore, the levels of immigration and emigration are significant, and a Petersen estimate may not be the most appropriate mark-recapture estimate. A Schaeffer estimate, suitable for migrating fish (Ricker 1975), was not calculated for this study however, because in addition to the eight recaptures for which original tag information was available, another 5 recaptures had incomplete or no tag information recorded, and could not be included in the Schaeffer estimate. This accounts for a significant proportion of recaptures (5 of 13 = 38.5%). The five steelhead did not lose their tags since tag colour, and/or comments indicated that tags were present (e.g. ``MoE tag``), but tag number was not recorded in the datasheets.

### 3.3.3 Petersen Estimate

Due to low proportions of recaptures in the initial three years of the study, an adjusted Petersen estimate was used to estimate the number of steelhead migrating through Moricetown canyon in 1999, 2000 and 2001. For comparisons to previous years, an adjusted Petersen estimate was generated for steelhead migrating through Moricetown Canyon between July and September 26<sup>th</sup>. 2007. Two sets of tags (anchor tags and caudal punch) were used to evaluate the proportion of tag loss. A 5% tag loss was assumed based on previous years of the study.

The pooled Petersen estimate was calculated as 24,316 steelhead (SE = 7,483, 95% confidence interval = 13,746-51,075), which moved through Moricetown Canyon during the fall tagging program based on eight recaptures for which initial and recapture tag information was known. There is potential for significant errors associated with the 2007 estimate since up to an additional five beach seine recaptures were recorded in the dipnet fishery based on caudal punches, but tag information for these steelhead were not recorded. These steelhead did not lose their tags, since recorded for these fish include ``MoE tag`` or a tag colour. While there is a chance that these steelhead were tagged in previous years of the study, the potential for them to have been tagged in the beach seine fishery in 2007 is much greater, and we assumed that these recaptures were tagged in 2007 for the Petersen estimate. Including these five recaptures in the estimate results in a much smaller Petersen estimate of 15,554 (95% CI = 9,786 – 28,475), and this

estimate is assumed to be more representative because of the inclusion of the additional recaptures of steelhead initially tagged in the beach seine fishery. These Petersen estimates for the number of steelhead moving through Moricetown Canyon since 1999 are summarized in Table 6. The sample size is similar to the sample size in earlier years of the study (e.g. 1999 and 2001), and notably lower than sample sizes in more recent years (e.g. 2002, 2003), at least in part due to high water levels decreasing sampling effort and sampling efficiency in 2007.

In previous years, mis-identification of steelhead that were recaptured accounted for up to 4.2% of the recaptured steelhead in the study. These fish were identified as steelhead by one crew (either beach seine or dipnet crews), but they were identified as a different species (usually coho) by another crew. None of the recaptured steelhead in 2007 were identified as a different species on initial capture, and the proportion of misidentified fish in the recapture data is therefore 0% for the 2007 field season.

**Table 6.** Comparisons of adjusted Petersen Population estimates calculated for steelhead migrating upstream of Moricetown Canyon in 1999, 2000, 2001 (Mitchell 2001, SKR 2000, 2001a), 2002 (SKR 2003a), 2003 (SKR 2004), 2004 (SKR 2005), 2005 (SKR 2009a), 2006 (SKR 2009b) and 2007. For studies with multiple estimates, the most conservative estimate is summarized here.

Study	Sample size (N)			Adjusted Petersen Estimate	95% Confidence Interval <sup>5</sup>	
	marked	examined	recaptured		Lower	Upper
Moricetown tagging 1999 <sup>1</sup>	164	1555	8	28,527	16,250	58,350
Sport fish estimate spring 2000 <sup>2</sup>				27,005	22,261	35,479
Moricetown tagging 2000 <sup>3</sup>	225	734	3	41,428	18,876	103,819
Sport fish estimate fall 2000 <sup>2</sup>	1161	831	42	22,627	17,200	32,135
Moricetown tagging 2001 <sup>4</sup>	323	1182	18	20,173	13,820	31,477
Moricetown tagging 2002 <sup>6</sup>	834	1998	65	25,289	20,596	33,941
Moricetown tagging 2003 <sup>6</sup>	656	1805	100	14,963	12,390	17,535
Moricetown tagging 2004 <sup>5,6</sup>	321	1568	32	14,581	11,054	23,228
Moricetown tagging 2005	527	1636	54	14,912	11,289	18,535
Moricetown tagging 2006	556	1700	64	13,685	10,647	16,703
Moricetown tagging 2007	208	1101	8	24,316	13,746	51,075
Adjusted Moricetown 2007 <sup>7</sup>	208	1101	13	15,633	9,786	28,475

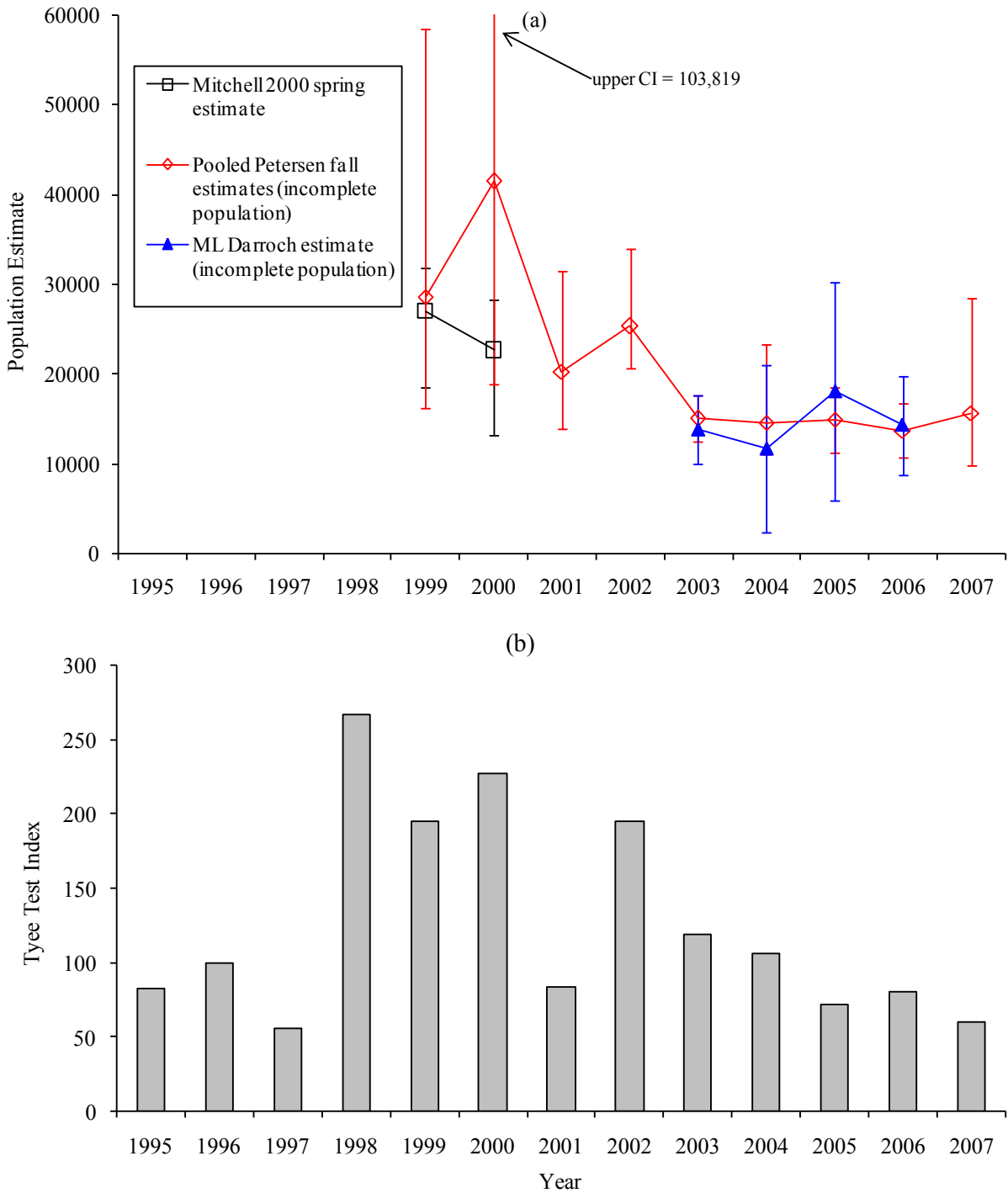
<sup>1</sup> (SKR 2000) based on 8 recaptures; <sup>2</sup> (Mitchell 2001), <sup>3</sup> (SKR 2001a) based on 3 recaptures, <sup>4</sup> SKR 2002a

<sup>5</sup> Confidence intervals (CI) for the sport fish estimates and the Moricetown 2002, 2003, 2005 and 2006 estimate are based on the normal approximation; all other CI calculations were determined using the Poisson Frequency distribution (Krebs 1999)

<sup>6</sup> the 2002 (SKR 2003a), 2003 (SKR 2004a) and 2004 tagging projects did not encompass the entire steelhead migration period, since the studies were terminated earlier than previous years of the study, and did not sample the later portion of the steelhead migration.

<sup>7</sup> the adjusted Petersen estimate for 2007 includes 5 beach seine recaptures in the canyon fishery for which tag information was incomplete.

When compared to the steelhead adult tagging project at Moricetown Canyon conducted since 1999, the steelhead population estimate is similar to the estimates for 2003 to 2006, although the confidence interval associated with the estimate is much larger. The lower population estimates for steelhead at Moricetown Canyon in 2003, 2004, 2006 and 2007 are partly attributable to the earlier termination of the study than in any of other years. In addition, for the 2007 field season, the capture efforts were hampered by high water levels in the canyon early in the field season. Generally, trends in estimated steelhead population size from the Moricetown tagging study are similar to those of the tye test index for steelhead (Figure 5). Years with a higher tye test index generally correspond to years with a higher mark-recapture estimate. However, the slight decline in the tye test index from 2003 to 2005, and the marginal increase in the index from 2005 to 2006 were not observed in the mark-recapture estimates at



**Figure 5.** Estimated population size for steelhead upstream of Moricetown Canyon (a), and Tyee test fishery index (b). Error bars in (a) indicate 95% confidence intervals. Please note that the tagging project in 2002, 2003, 2004, 2006 and 2007 was terminated earlier than in other years of the study, with the last date of sampling September 27<sup>th</sup>, 2002, September 19<sup>th</sup>, 2003, September 13<sup>th</sup>, 2004, September 26<sup>th</sup>, 2006, and September 29<sup>th</sup>, 2007 respectively.

Moricetown, which is speculated to be in part due to a longer tagging season in 2005 compensating for lower steelhead numbers. Similarly, the decline in the tye test index in 2007 was not observed in the Moricetown tagging project, though this is at least in part attributable to the significantly lower sample size, due to high water levels at the canyon. Catch rate data were not available for Moricetown to collaborate this hypothesis. While the confidence intervals around the estimated steelhead population sizes at Moricetown Canyon in 1999 and 2000, as well as uncertainties around recaptures in 2007, make comparisons difficult, the trends in estimated population sizes for steelhead at Moricetown Canyon correspond to trends in the cumulative steelhead escapement index observed in the Tye Test Fishery (FOC 2008).

### *3.3.3.1 Assumptions of the Petersen Estimate*

Mark-recapture estimates assume random samples of marked or unmarked fish, or that marked fish mix randomly with unmarked fish, that immigration, emigration, mortality and natality are negligible during the study, that marked fish are in every way the same as un-marked fish, and that marked fish do not lose their marks (Bagenal 1978, Krebs 1999). Almost all mark recapture studies violate at least some of these assumptions to some degree, which results in decreased accuracy of the estimate. If violations are severe, resulting estimates can be misleading. Therefore, it is important to evaluate to what extent the underlying assumptions of the mark-recapture study are violated, and if adjustments can be made to compensate for these violations. The potential presence of sampling biases and low recapture ratios, as well as uncertainties around a significant proportion of recaptures affects the accuracy and precision of the Petersen Estimate, and must be taken into consideration when refining this study.

Differences in capture rates of sampling gear over time, fork length and sex ratio comparisons can indicate selectivity in capture methods, which influence the validity of population estimates (Ricker 1975, Bagenal 1978, Krebs 1999). As in previous years, some temporal and gear biases may exist in the data obtained for the 2007 Moricetown tagging program, but these biases were less severe than in the initial two years of the study. While temporal biases in capture rates between dip net and beach seine sampling observed in 1999 and 2000 were reduced in 2001 to 2007, systematic sampling on weekdays for dipnet crews and beach seine crews results in non-random sampling, which violates assumptions for the Petersen estimate. Sampling on weekends can be achieved by adding one extra beach seine crew, and rotating crews on work schedules that would cover weekday and weekend days (e.g. 4 days on, 2 days off). Alternatively, sampling times could be selected by randomly choosing sampling blocks during the study period. Gender biases were observed between steelhead data collected in the beach seine and dipnet fishery in previous years (SKR 2000, 2001a, 2002a), but these are speculated to be due to difficulties in sex determination due to the lack of clear sexual characteristics, and are assumed to stem from biases between crews rather than biases between gear. Because gender was not consistently and accurately assigned, fork length of steelhead captured at the dipnet and beach seine location for both males and females were grouped together.

Fork lengths of steelhead captured in the beach seine fishery (Mean = 61.8, SE = 0.698) was significantly smaller than fork lengths of steelhead captured in the dipnet fishery (Mean = 65.4, SE = 0.327; Mann Whitney U statistic = 105860.55,  $p = 0.000$ ). The significant difference in fork length between capture locations is similar to findings in 2006 and 20-04, where steelhead were significantly larger at the dipnet site when compared to the beach seine site ( $U=511074.00$ ,  $p=0.001$  and  $U=265386$ ,  $p =0.005$  respectively) (SKR 2006, 2009b), but is contrary to findings in 2005, 2003 and 2001, where fork lengths did not differ significantly between gear type (SKR 2002a, 2009a).

The use of multiple tags during the Moricetown steelhead tagging study allowed for an assessment of the frequency of tag loss. The low tag loss rate determined in previous years of the study, where more tags were applied, indicates that tagging methods are adequate for mark-recapture studies in the canyon. However, the study was not designed to determine the extent of mortality during the study period. Mortality, resulting from predation, unknown harvest levels, or other causes, was not accounted for in the data. In addition, the effect of capture and tagging on survival rates or behaviour of steelhead was not determined in the study. Some reduction in the survival of steelhead after capture and tagging may exist, and if this reduction is significant, the population size would be overestimated.

## **4.0 Recommendations**

Detailed recommendations for this study were provided in the previous years' reports (SKR 2000, 2001a, 2002a, 2003a, 2004), and only recommendations found in addition to those mentioned previously are listed below. For a complete set of recommendations, the reader should also consult the 1999 summary report (SKR 2000) as well as communications regarding the QA portion of the project (SKR 2001b, 2002b) and the summary report for the 2002 Moricetown tagging project (SKR 2003a).

### **4.1 Quality Assurance Monitoring**

Reviewing the 2007 datasheets indicate a need for a consistent quality assurance (QA) program that is implemented in each field season. A significant proportion of recaptures at the dipnet fishery had incomplete tag information, and this severely limited the analysis of the data for the 2007 field season. Taking into account the cost of labour, the cost of tags, and the cost to the fish, it is essential that data collected in the field is of high quality and consistency. A QA program can be simple and cost-effective to implement. For example, data entry concurrent with data collection can quickly reveal chronic errors in record keeping. Internal or independent QA monitoring can be achieved by allocating a few hours a week to this process, particularly in the beginning of the study. Encouraging crews to double check each datasheet, and initialing each sheet can reinforce the need for consistent and complete record keeping. An education session at the beginning of field seasons (e.g. each field season, field seasons with significant crew turn overs) can facilitate the collection of good, consistent data. Future field seasons should consider the implementation of a QA program during the field season to ensure that data collected is of high quality, and is complete, accurate and legible.

### **4.1 Increasing Beach Seine Steelhead Catch and Recapture**

If the true steelhead population is assumed to range between 10,000 and 30,000, the minimum number of steelhead tagged in the beach seine fishery should be between 600 and 1,000. In 2007, the number of steelhead tagged in the beach seine fishery fell short of this target. To increase the number of steelhead tagged, the following should be attempted:

- Extend the study to encompass the main portion of the steelhead migration period. Early termination of the study will not provide a complete population estimate.
- Investigate other potential sites that could be used for beach seining where steelhead capture rates may increase. Physical changes to the river bottom may render previously productive steelhead fishing areas less productive. Other potentially suitable beach seine locations may exist between the boat launch and the canyon. These sites should be investigated using a sounder, and the older beach seine.
- Crews may need to shift to various beach seine locations as river levels change during the tagging period.
- Add an additional crew to allow for sampling on weekends and statutory holidays, and/or to let crews work additional hours during peak migration times.

To increase the potential recapture of steelhead tagged late in the season on the beach seine fishery, consideration should be given to extending the dipnet fishery one week past the end of the beach seine fishery. This would provide steelhead tagged on the last few days in the project a higher probability of being recaptured and decrease some of the bias in the population estimate.

## **4.2 Record Keeping for Sport Fish Recaptures**

Since 2002, Wet'suwet'en Fisheries used their own tags, which were labeled with the Wet'suwet'en Fisheries address. It is strongly suggested the Wet'suwet'en Fisheries continues the collection of steelhead recapture information from the sport fishery.

## **4.3 Future Studies**

In-season estimation of population sizes is valuable for management decision-making in season. Currently, data collected during the field season are not entered until the winter, when more time is available for Wet'suwet'en Fisheries staff. It would be valuable to try to enter data in-season so that periodic estimates on run status can be conducted.

A large number of steelhead are captured during the Moricetown tagging project, and the study can be used as a site for other studies on steelhead in the Skeena Region. For example, DNA, fish health sampling, and age structure projects could build on the Moricetown tagging project.

Since steelhead have been tagged since 1999, and because of the relatively large number of steelhead sampled at Moricetown, this study can provide useful data on the proportion of steelhead that are repeat spawners in consecutive as opposed to alternate years, and on the proportion of spawners that are repeat spawners.

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**Appendix 1. Steelhead data obtained by beach seining.**

**Appendix 2. Steelhead data obtained by dipnetting.**

**Appendix 3. Steelhead Recaptures obtained during the 2007 Moricetown tagging program.**

**Appendix 4. Breakdown of mark-recapture data for calculation of the Schaeffer estimate**

