Steelhead Tagging Project
at
Moricetown Canyon

JULY TO OCTOBER 2008

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.

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Executive Summary

During the summer and fall of 2008, 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 July to October 2008 are summarized in this report in conjunction catch per unit effort information summarized in a separate report prepared 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 returns of steelhead migrating upstream of Moricetown Canyon.

Between June 23rd and October 20th, 2008, 777 steelhead were tagged by beach seining and 1820 steelhead were tagged in the dipnet fishery. Tagging at the beach seine fishery ceased on October 6th, and tagging effort was reduced by one crew between October 6th and October 20th in the dipnet fishery. Steelhead catch rates obtained from dipnet and beach seine samples exhibited less temporal differences in 2008 than in the initial two years of the study (1999 and 2000), when capture rates by dipnetting decreased notably after September 1st (Labour Day). Catch rates indicate that the tagging program encompassed the fall steelhead migration through Moricetown Canyon. No comparisons of sex ratios was 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 were compared between dipnet and beach seine catches, and were found to be significantly different. Steelhead captured in the dipnet fishery were significantly smaller than those captured in the beachseine fishery in 2008, indicating a bias in capture techniques, and/or inconsistencies in recording fork length at the dipnet fishery where some fork lengths measurements were recorded in inches.

The number of steelhead tagged in 2008 is second highest among the number of steelhead tagged since 1999, and is within the targeted number (600-1,000) for a mark-recapture estimate, assuming a population size between 10,000 and 30,000 steelhead. The number of recaptures in 2008 was similar to recaptures in previous years of the study, with 2.8% of the steelhead examined in the dipnet fishery having been tagged by beach seining (54 of 1923). Since 1999, the highest proportion of recaptures in the dipnet fishery was achieved in 2003, where 5.5% of the steelhead sampled by dipnetting were recaptures initially tagged in the beach seine fishery (100 of 1805). The lowest proportion of recaptures was in 1999, where only eight steelhead were recaptured in a sampled 1555 steelhead examined in the dipnet fishery. The varying proportions of recaptured steelhead in the dipnet fishery is in large part due to the varying number of tags applied in the beach seine fishery, with a low of 164 (in 1999) and a high of 834 (in 2002). The third highest number of tags applied in the beach seine fishery (656 tags) was in 2003, which corresponds to the highest proportion of recaptures. In 2008, 777 steelhead were tagged in the beach seine fishery downstream of Moricetown Canyon, and resulted in the recapture of 54 of these steelhead in the dipnet fishery.

Fifty-four of the 777 steelhead tagged downstream of the canyon were recaptured in a sample of 1,923 steelhead examined for tags at the canyon. A 5% tag loss was assumed, based on tag loss estimates for beach seine and dipnet capture steelhead in 2008, and in previous years of the study. The adjusted Petersen estimate for steelhead moving through Moricetown Canyon between June 23rd and October 20th, 2008 determined for this mark-recapture data is 25,865 steelhead (95% confidence interval = 19,441-32,288). In addition, a Schaeffer estimate was calculated for steelhead migrating through Moricetown Canyon for the duration of the tagging project. The Schaeffer estimate for the tagging project was 19,039 steelhead. The ML Darroch estimate for the Moricetown tagging project was 27,474 steelhead (95% confidence interval = 15,487-39,461). These estimates should be viewed in light of constraints of the study, including low recapture rates (2.8%), and non-random sampling at the beach seine and dipnet locations. The estimated number of steelhead moving through Moricetown Canyon in the study period is the highest estimate since 2001, when the numbers of recaptures increased from very low initial recapture rates in 1999 and 2000.

Table of Contents

List of Tables

List of Figures

List of Appendices

Acknowledgements

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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 2008 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, 2009c). 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). This report summarizes steelhead data collected from June 23rd, 2008 to October 20th, 2008.

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 2008.

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 June to October 2008, 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 2000, 2001, 2002, 2003, 2006, 2007, 2009a, 2009b, 2009c). 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 June 23rd and October 20th, 2008 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 June 23rd and October 6th, 2008. Beach seining efforts were reduced to one crew from October 6th, 2008 to the end of the tagging study on October 20th, 2008 due to decreased day length. 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 2007, 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 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 used to tag 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, tangeling or snagging during individual sets.

In conjunction with tagging at the beach seine location, a steelhead sonic tagging project was implemented in 2008. A total of 50 steelhead were fitted with sonic tags between August 12th and September 3rd, 2008. Results for the sonic tagging project are reported elsewhere.

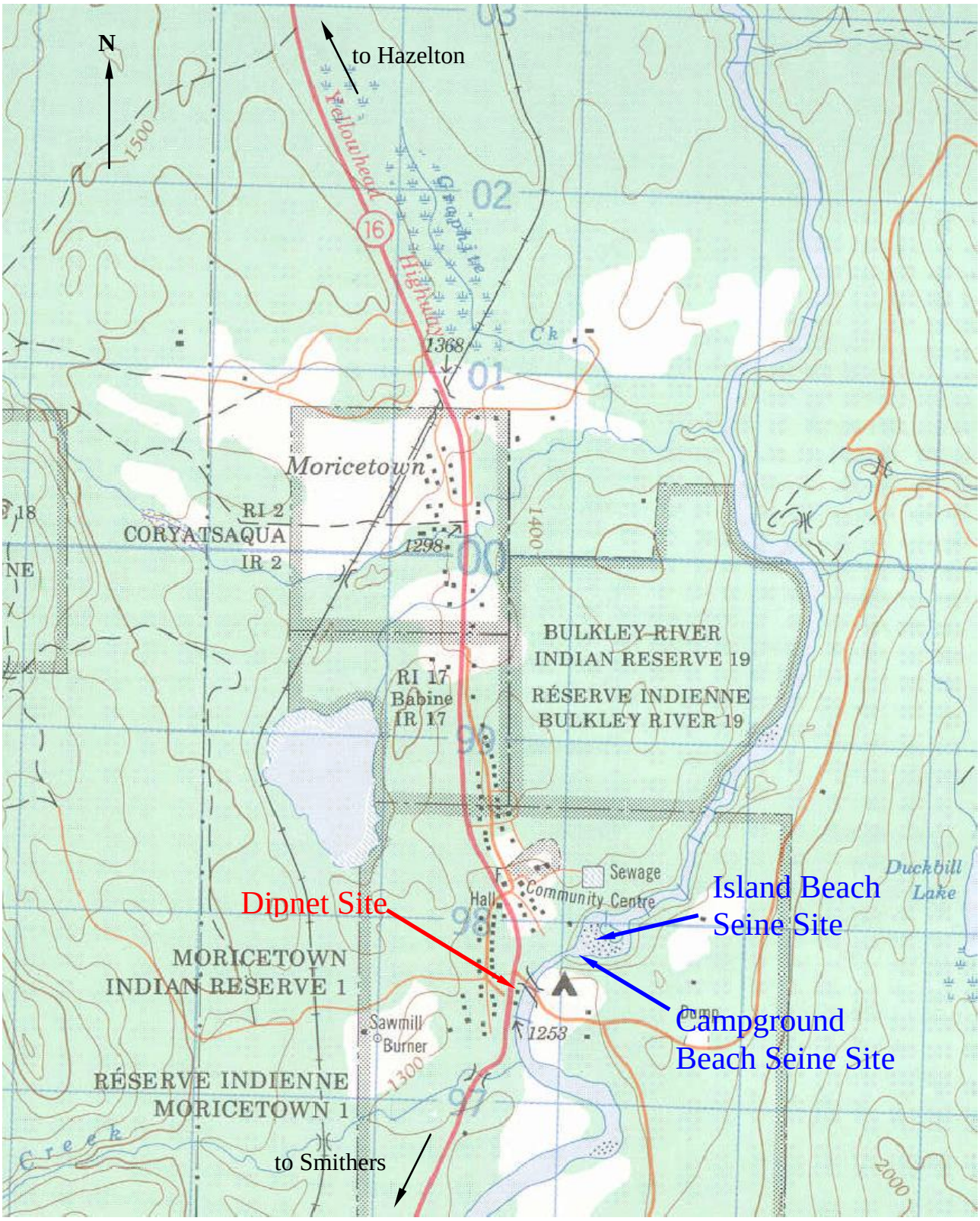

Figure 1. Locations of beach seine and dipnetting operations in the Moricetown Canyon. The map is an excerpt of 093M/03 NTS map (scale is 1:50,000).

Table 1. Tag colours and numbers applied by beach seine crews from June to October 2008, Moricetown tagging program.

Species	Tag colour	Tag Numbers
Steelhead	Green	30881, 38002-38450
Steelhead	White	957-974, 14502-14590, 15811-15997, 38011-38022, 40676-41111, 45100
Chinook	Red	Unnumbered, 2589-2999
Chinook	White	29, 701-977, 2999
Chinook	Yellow	2653-2856
Coho	Green[1]	3344, 22517, 30201-31000, 32022-38030
Coho	Orange	32630-32634, 63301-68329
Coho	White	32490
Sockeye	Unknown	2008, 2233, 70135-72091
Sockeye	Orange	7074, 32085, 62001-67030, 70001-72452
Sockeye	Pink	2003-2398

[1] some green tags were entered as "lime green"

2.1.2 Canyon Dip Net Census

Two crews captured, tagged and released steelhead, sockeye and coho at the fishway in Moricetown Canyon between June 23rd and October 6th, 2008, and one crew continued to the completion of the tagging project on October 20th, 2008. 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 colour and number of recaptured fish were recorded.

Table 2. Tag colours and numbers applied by canyon crews from July to October 2008, Moricetown tagging program.

Species	Tag colour	Tag Numbers
Steelhead	Brown	22575-30224
Steelhead	Green[1]	3993, 19420, 19499, 30744-30749, 30800-30832, 35254-35909, 37901-37925, 38034-38525, 39376-39997
Steelhead	Grey[1]	30550-30999, 32737, 32951-32992, 38028-39513, 41201-41450
Steelhead	Orange	16711, 35976-35991, 48001-48499
Steelhead	White	16177, 35958-36189, 39451-39454, 41229-41375
Steelhead	Yellow	1285-1375, 35910-37000, 41355
Coho	Blue	3489-3494, 10701-10900, 13001-13850, 14821-14829, 15002-16735, 23230, 33901-34000
Sockeye	Blue	1222-1223
Sockeye	Green[2]	38020-38205
Sockeye	Pink	2002, 2352-2473
Sockeye	Purple	2475-2500
Sockeye	Yellow	1-1382, 2351, 96333-97000

[1] some data records did no distinguish between green and grey tags, [2] some green tags were entered as "lime green"

2.1.3 Quality Assurance/Quality Control

Quality assurance checks were conducted opportunistically in conjunction with Sonic tagging at the beginning of the 2008 field season, with additional field checks of tagging crews on a biweekly basis after completion of Sonic tagging. Field checks consisted of unscheduled visits to the beach seine and dipnet tagging sites, observation of species identifications, handling, tagging and record keeping activities. Field data sheets were copied and reviewed upon their submission to the Wet'suwet'en Fisheries Office, and were used for a detailed review of data entry to ensure data accuracy and fidelity.

2.2 Data Entry

Wet'suwet'en Fisheries entered all data collected in the 2008 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 for this report.

2.3 Data Analysis

Wet'suwet'en Fisheries conducted some data analysis for catch per unit effort and daily run timing for their final summary report (Wet'suwet'en Fisheries in prep.). Data provided to SKR did not included 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 daily 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 population size of fish migrating upstream through Moricetown Canyon from June 23rd to October 20th, 2008 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, starting with the initial capture data for steelhead (July 23rd, 2008) (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), and thus population estimates for the sample are biased.

Table 3. Temporal stratification for the Moricetown steelhead data.

Week Number	Start Date	End Date
Week 1	July 23	August 1
Week 2	August 2	August 8
Week 3	August 9	August 15
Week 4	August 16	August 22
Week 5	August 23	August 29
Week 6	August 30	September 5
Week 7	September 6	September 12
Week 8	September 13	September 19
Week 9	September 20	September 26
Week 10	September 27	October 3
Week 11[1]	October 4	October 20

[1] Week 11 includes steelhead data from October 4th to the end of the study due to low sample size and reduced sampling effort in both, beach seine and dipnet fisheries.

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. Few records had incomplete tag numbers, or incomplete information (e.g. gender, FL, date). Some inconsistencies in the recording of tag colour was noted especially for green and grey tags. Tag colour for both of these tag types were abbreviated as GR, making it difficult to distinguish tags of different colour during data entry and data analysis.

3.1.1 Beach Seine Tagging

A total of 776 steelhead were marked during beach seining (763 on the campground side, and 13 on the island side). In addition, one steelhead tagged in previous years was recaptured during beach seining, and while this fish was not re-tagged, tag number was recorded, and was included in the total number of steelhead marked by beach seining in 2008 (total marked is 777). This is the second highest number of steelhead tagged in the beach seine fishery since the start of the steelhead tagging project, second to 2002 when 835 steelhead were tagged (Table 4). The number of steelhead tagged in 2008 falls within 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, 2009c).

Year	Number of steelhead		
	Beach seine[1]	Dipnet[3]	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[2]	1568	n.a.
2005	526[2]	1636	n.a.
2006	556[2]	1700	n.a.
2007	208[2]	1101	n.a.
2008	777[2]	1925	n.a.

[1] excludes recaptures from this study
[2] includes 3 steelhead for 2004, 5 steelhead for 2005, 7 steelhead for 2006, 4 steelhead for 2007, and 1 steelhead for 2008 tagged in previous years of the study
[3] excludes recaptures initially tagged at dipnet location; includes steelhead originally tagged by beach seine

The increased number of tags applied in 2008 when compared to 1999 and 2000 is in part attributable to more consistent tagging effort due to the availability of back up equipment (jet boat and beach seine). In the initial three years of the study, no back up equipment was available, resulting in the reduction of tagging effort due to equipment failure. The new boat used by Wet'suwet'en Fisheries beach seine crews handled much better, and was more maneuverable than the boat used previously, resulting in better seine

sets, and higher catches. In addition, the increased number of steelhead tagged in 2008 compared to all years except 2002 may be a result of an extended season. In 2008, the field season was extended to October 20th, whereas in most previous years the tagging project ceased in mid to end September. Physical changes in the river (e.g. shifting gravel bars), fewer steelhead in the river, and abundance of other species in the catch are possible factors resulting in fewer steelhead captured than in 2002. Data provided are insufficient to investigate these potential causes of the annual changes in steelhead catch.

No logistical problems for the beach seine fishery were recorded in the datasheets provided.

Beach seine crews were generally diligent and careful in handling fish, and examining fish for marks. Beach seine crews were aware of, and implemented, handling techniques to reduce stress on fish, and were thus efficient at tagging, measuring and examining fish prior to their release. Beach seine crews were instructed to hold the fish in their natural position, and support visceral organs of the fish on release rather than holding fish by their caudal peduncle, and crews generally complied with this suggestion. Beach seine crews were generally receptive and cooperative with suggestions made during site visits.

In 2008, the Skeena steelhead sonic tagging project was initiated, and included the tagging of 50 steelhead captured in the beachseine fishery at Moricetown canyon with sonic tags. The results of the sonic tagging study are summarized elsewhere. All sonic tagging was conducted between August 12th and September 3rd, 2008, and resulted in minor delays during processing of fish at the beach seine site.

3.1.2 Canyon Dip Net Census

A total of 1,987 steelhead were captured by the dipnet crews between June 23rd and October 20th, 2008. Sixty-two of these steelhead were originally tagged by dipnetting and recaptured by dipnetting (62 tagged steelhead and 0 steelhead that lost their tags). These repeat recaptures were excluded from the number of steelhead examined since they represent the same fish. Therefore, the number of steelhead examined for tags by dipnetting was reduced to 1,925. This is the second highest number of steelhead examined in the dipnet fishery, next to 2002 when 1,933 steelhead were examined (Table 4). 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). The number of steelhead examined 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 few data entry problems were present. The number of duplicate tags in the raw data and database was lower in 2008 (8 of 2863; 0.28%) than for most previous years (0.67% in 2006, 2.3% in 2005, 0.35% in 2004, 1.6% in 2003 and 1.2% in 2001), but was higher than in 2000 (0.13%) or 2007 (0%). The number of tags applied in 2000 and in 2007 was significantly lower than in 2008, and accounts for the lower number of duplicate records in the raw data and the database in those years. Some of the duplicate could be resolved after comparison of the digital data with field datasheets, but four duplicate records remain in the dataset (0.13%).

The QA process found problems with an additional 468 records (16.3%), excluding simple spelling mistakes or inconsistent coding for tag colours, and identified 356 missing records (340 records applied tags, 16 recaptures) from the original submission of the database. Wet'suwet'en Fisheries updated the database by adding the missing tagging and recapture records. Common errors included incorrect data (377 records), tag status (3 records), tag numbers (12 records), tag colour (5 records), length and sex data (12 records), and species (2 records).

3.3 Data Analysis

Wet'suwet'en Fisheries handled a total 2,702 steelhead in June to October 2008. The majority of these steelhead (1,925) were captured at Moricetown Canyon in the dipnet fishery, 1,820 of which were tagged at the canyon, 81 were recaptures from this or other studies (including one fish initially identified as a coho), 1 was a recapture that had lost its tag, and 23 were harvested. The 777 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 777 steelhead tagged by beach seining, 54 were recaptured in the canyon dipnet fishery (Table 5).

Table 5. Applied and recaptured steelhead tags for the 2006 Moricetown steelhead tagging program.

	Beach Seine Tags (d/s of the canyon)	**Dipnet Tags (in canyon)**
Applied	777[1]	1925[3]
Recaptured by Dipnet (in canyon)	54[2] (excl. 1 steelhead that lost tag)	62 (excl. 0 steelhead that lost tags)
Recaptured by beach seine (d/s of canyon)	22 (excl. 3 steelhead that lost tag)	58 (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 2 recaptured steelhead had lost their tags; 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 23 steelhead not tagged at the dipnet location, all of which were harvested

In addition to recaptures used for population estimates (Table 5), 33 other tagged steelhead were recaptured in this study. Some of these steelhead originated from other tagging studies, including 14from previous years of the project (Appendix 3). Tag number from 19 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. In addition, one recapture was identified as steelhead on recapture, but as a coho at initial capture. These records were deleted from the population estimate calculations. Of the 200 steelhead recaptured in the study, four steelhead had lost their tags, but the initial capture location could be identified by the secondary mark (caudal punch) for all of these steelhead. This indicates that approximately 2% of the tagged steelhead lost their tags. Tags from other studies, or tags with incomplete initial tagging data or recapture data were not used in the calculation of the population estimate.

In total, 24 steelhead were harvested during the 2008 Moricetown steelhead tagging project. Most of these steelhead were harvested at the dipnet fishery (23, 95.8%), and only one untagged steelhead was harvested in the beach seine fishery (4.2%). All harvested steelhead were untagged steelhead.

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 2). The first steelhead was captured on July 23rd in the dipnet fishery, and the first steelhead in the beachseine fishery was captured on July 24th, 2008. The tagging program started well in advance of these dates, with the first Pacific salmon captured on June 23rd for beach seine fishery, and July 16th for dipnet fishery. This indicates that the timing of the mark-recapture study at Moricetown canyon encompassed the start of the steelhead migration period.

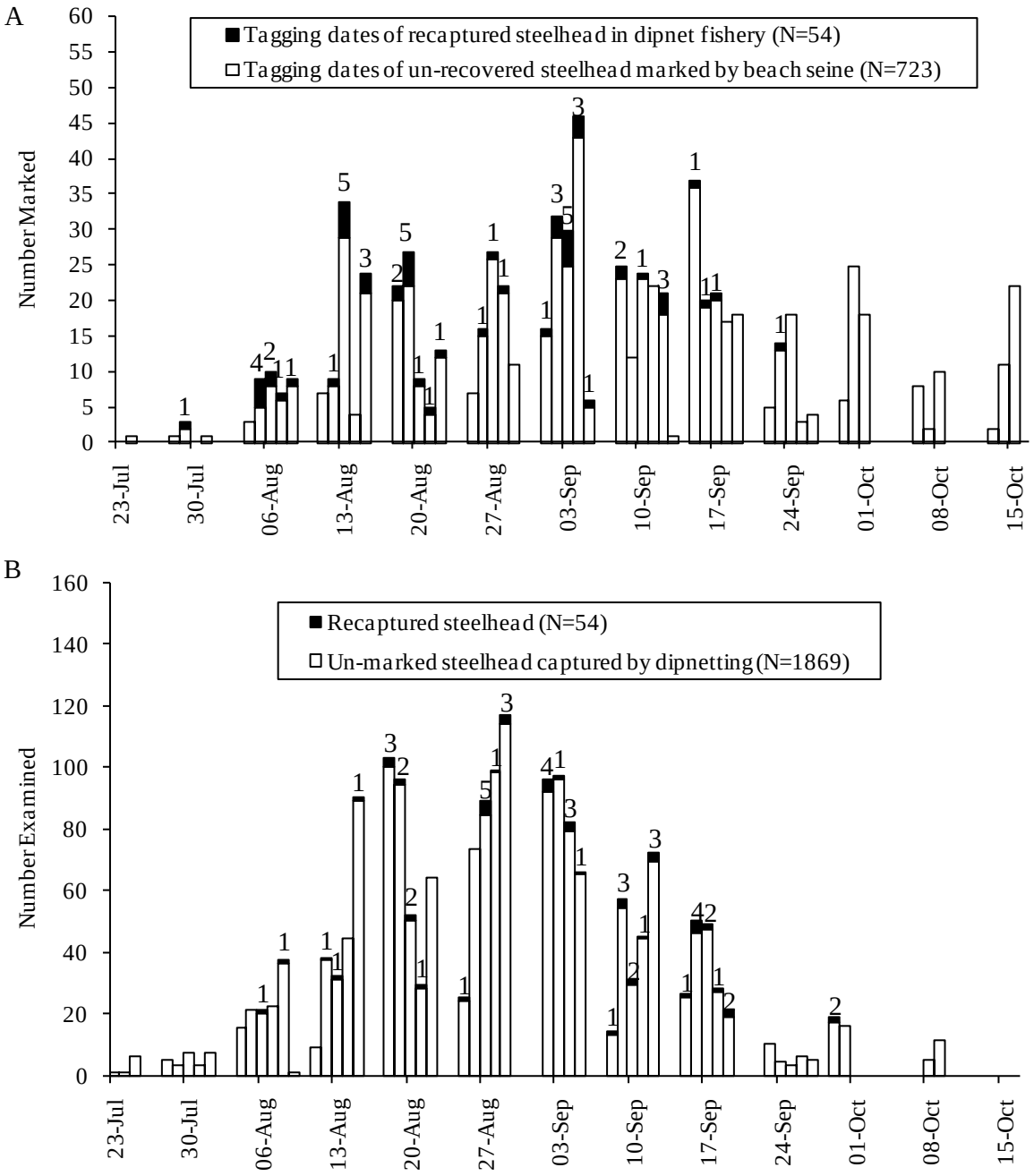

Figure 2. Temporal distribution of tag application during beach seining (A), and of examination for tags during dipnetting (B) during the 2008 steelhead population estimate study. Data labels in the graphs indicate the number of recaptured steelhead. The recaptured steelhead that lost its tag, and the recaptured steelhead initially identified as a coho are excluded from the graph.

Capture dates for steelhead at the start of the migration season in 2008 coincide with 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 at the end of July and the beginning of August, to a peak of 46 on September 4th, then fluctuated between 1 and 37 until October 15th, when catch rates dropped off to no steelhead. Even though only one beachseine crew operated after October 6th, 2008, steelhead catch from October 6th did not decline drastically after that date. This is likely due to the fact that the number of hours spent beachseining was not reduced drastically since work shifts were increased in duration to encompass available daylight hours. Fluctuating catch rates throughout the tagging project 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), capture locations (sampling on the island as well as the campground site on some days), or they may be indicative of fluctuating migration rates or travel routes.

Steelhead catch in the canyon peaked on August 29th (117 steelhead). This is similar to peak daily catches in 2005 (August 17th and August 19th) (SKR 2008a), 2004 (August 18th and August 19th) (SKR 2006), and 2003 (August 23rd and 28th) (SKR 2005). In previous years, steelhead catch at the dipnet location showed a distinct peak in late August, with a distinct second peak in late September, and a reduced catch rate for the remainder of the tagging season. The 2008 daily dipnet catch for steelhead showed a much broader peak, with continued high daily catch until the second week of September, followed by a significant reduction in daily catch in the last week of September and early October to the completion of the study. Reduced daily catch at the end of the tagging season may be a result of varying catch efficiencies due to environmental factors (e.g. water levels, water clarity), efforts by individual crews (contingent on day length, catch of other species, temperature, motivation), or they may be indicative of fluctuating migration rates or travel routes.

Overall, the low daily catch for steelhead in both the beach seine and the dipnet fishery at the start and end of the study suggests that the sampling protocol was successful in encompassing the fall steelhead migration period. However, the continued capture of steelhead in the beachseine fishery in to mid-October, and the lack of steelhead at the dipnet fishery subsequent to that date indicates that steelhead either migrate upstream in October and later but fail to be captured by dipnetting, or overwinter downstream of the canyon.

A greater proportion of steelhead tagged early in the beach seine fishery were recaptured in the dipnet fishery (Figure 3). 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 positive bias to the population estimate.

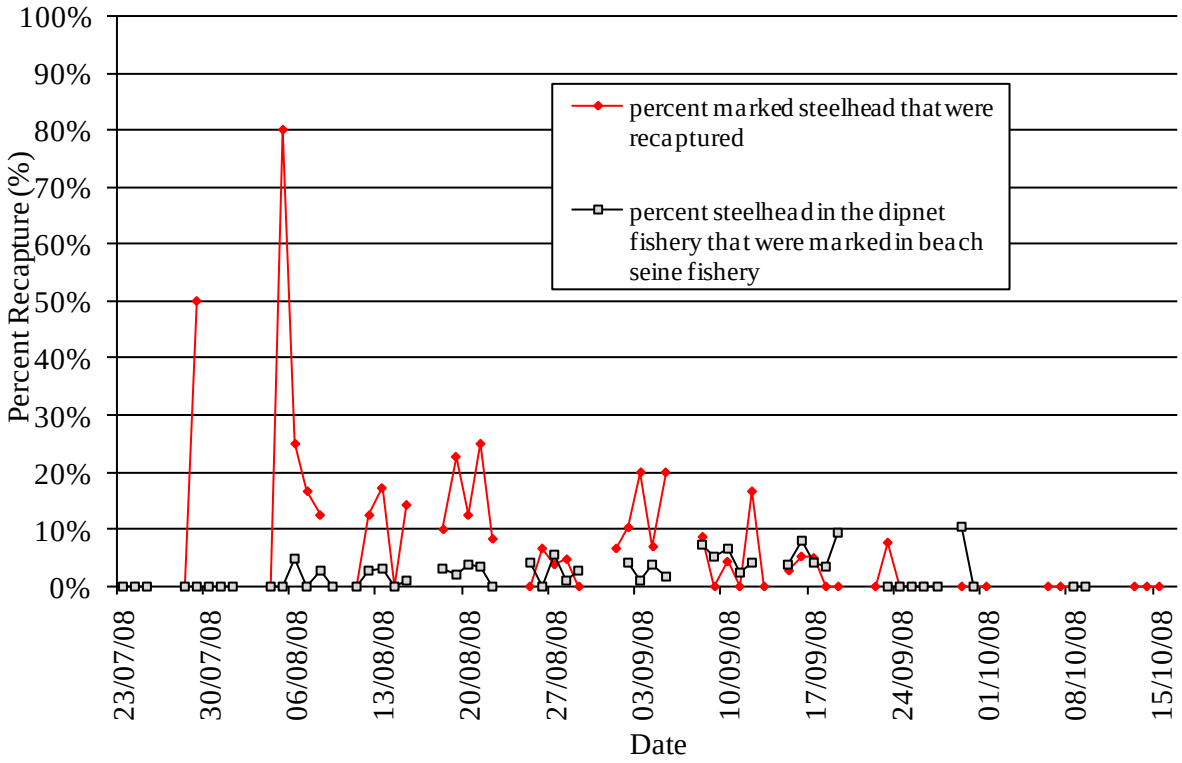

Figure 3. Percent recapture rate for steelhead tagged in the beach seine fishery (♦) and for steelhead examined in the dipnet fishery (+).

Of the 1925 steelhead captured by dipnet crews, tags were applied to 1820, while 55 steelhead were recaptures from the beach seine fishery (including 1 that had lost its tag), 13 were recaptures from previous years of the study, 13 were unknown recaptures (tag number could not be cross-references to applied tagging record), one was a recapture initially identified as a coho, and 23 were harvested. Recaptures in the dipnet fishery and the beach seine fishery resulted in the capture of 62 and 58 steelhead originally tagged in the dipnet fishery, respectively. This indicates that some steelhead drop back after handling and tagging. The 2008 recapture rate of drop backs (6.6%) is higher than the recapture rate of drop backs in 2006 (5.2%), 2004 (5.6%), 2003 (6.1%), 2002 (4.3%), 2001 (5.4%) and 2000 (4.4%), but is lower than the recapture rates of drop backs for 2005 (7.2%) (SKR 2001a, 2002a, 2003a, 2004, 2005, 2009a, 2009b). The actual drop back rate is higher than the recapture rate since catchability must be taken into account. Catchability of tagged steelhead in the dipnet fishery is estimated as 7.1% (55 recaptures of 777 tagged fish from beach seine fishery), and the actual drop back rate for 2008 is likely around 48.0%. Steelhead tagged during dipnetting and falling back, were recaptured within 0 to 54 days by beach seining (mean = 10.29 days, SD = 13.263), while steelhead tagged during dipnetting were recaptured by dipnetting within 0 to 43 days (mean = 14.37 days; SD = 10.015). Steelhead tagged in the beach seine fishery were recaptured between 0 and 35 days in the dipnet fishery (mean = 9.70 days, SD = 7.715), and between 0 and 23 days in the beachseine fishery (mean = 8.53, SD = 8.362). 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, was calculated for this study (Ricker 1975). In addition, an ML Darroch estimate was computed, since confidence intervals can be determined for the ML Darroch estimate, while no confidence intervals are associated with the Schaeffer estimate (Arnason *et al* 1996). For these estimates, the study was broken into weekly intervals, with tagging and recovery determined for each week (Appendix 4). A 5% tag loss was applied to the estimate to compensate for steelhead that had lost their tags, as in previous years of the study. Tag loss of tags applied in the beach seine fishery in 2008 was estimated as 2%, however tag loss in previous years of the study fluctuate around 5%, and this has historically been the standard correction for tag loss applied to mark-recapture data for this project.

To arrive at the Schaeffer and ML Darroch estimates, some pooling of data was required. Data for the last four tag weeks were combined as the proportion of recaptured steelhead in that time period was low. In addition, the first two weeks of the study were pooled since few steelhead were tagged in weeks 1 and 2 (total marked in beachseine fishery = 44). To allow for the calculation of an ML Darroch estimate, tagging weeks 4 and 5 were pooled, and tagging week 7 was pooled with weeks 1 and 2 to provide a more equal distribution of tagged and recaptured steelhead for those weeks. This resulted in five weeks of steelhead data for the beachseine fishery and seven weeks of data for the dipnet fishery. The Schaeffer estimate was calculated as 19,039 steelhead moving through Moricetown Canyon between June 23rd and October 20th, 2008. The ML Darroch estimate was 27,474 (SE = 6116) with a 95% confidence interval ranging between 15,487 and 39,461 steelhead upstream of Moricetown Canyon. The broad confidence interval, could not be reduced by further pooling of the data. The ML Darroch estimate is higher than the Schaeffer estimate, and the confidence interval for the ML Darroch estimate brackets the Schaeffer estimate. Unlike previous years of the study where the tagging project was terminated earlier, the 2008 tagging project appears to encompass the majority of the fall steelhead run, as indicated by the significantly reduced capture rates of steelhead after October 15th, 2008, and both the ML Darroch (27,474; 95% CI = 15,487-39,461) and the Schaeffer estimate (19,039) are assumed to represent the fall steelhead run migrating through Moricetown Canyon in 2008.

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 June 23rd and October 20th, 2008. Two sets of tags (anchor tags and caudal punch) were used to evaluate the proportion of tag loss. Since steelhead captured in the beach seine fishery were both anchor tagged and lower caudal punched, tag loss for steelhead tagged downstream of the dip net location could be evaluated. As for the ML Darroch and Schaeffer estimates, a 5% tag loss was assumed, which is higher than the 2% tag loss estimated from secondary tags applied at the beach seine fishery, but is consistent with historical estimates of tag loss for this project. The pooled Petersen estimate was calculated as 25,865 steelhead (SE = 3278, 95% confidence interval = 19,441-32,288), which moved through Moricetown Canyon during the fall tagging program. Petersen estimates for the number of steelhead moving through Moricetown Canyon in 1999 to 2006 are summarized in Table 6. The sample size is a notable improvement from the 1999, 2000 and 2001 field seasons, and is similar to the sample size in the 2003 field seasons.

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[5]	
	marked	examined	recaptured		Lower	Upper
Moricetown tagging 1999 [1]	164	1555	8	28,527	16,250	58,350
Sport fish estimate spring 2000[2]				27,005	22,261	35,479
Moricetown tagging 2000[3]	225	734	3	41,428	18,876	103,819
Sport fish estimate fall 2000[2]	1161	831	42	22,627	17,200	32,135
Moricetown tagging 2001[4]	323	1182	18	20,173	13,820	31,477
Moricetown tagging 2002[6]	834	1998	65	25,289	20,596	33,941
Moricetown tagging 2003[6]	656	1805	100	14,963	12,390	17,535
Moricetown tagging 2004[5,6]	321	1568	32	14,581[8]	11,054	23,228
Moricetown tagging 2005	527	1636	54	14,912[8]	11,289	18,535
Moricetown tagging 2006	556	1700	64	13,685[8]	10,647	16,703
Moricetown tagging 2007	208	1101	8	24,316	13,746	51,075
Adjusted Moricetown 2007[7]	208	1101	13	15,633[8]	9,786	28,475
Moricetown tagging 2008	777	1923	54	25,865[8]	19,441	32,288

[1] (SKR 2000) based on 8 recaptures; [2] (Mitchell 2001), [3] (SKR 2001a) based on 3 recaptures, [4] SKR 2002a
[5] Confidence intervals (CI) for the sport fish estimates and the Moricetown 2002, 2003, 2005, 2006, and 2008 estimate are based on the normal approximation; all other CI calculations were determined using the Poisson Frequency distribution (Krebs 1999)
[6] 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.
[7] the adjusted Petersen estimate for 2007 includes 5 beach seine recaptures in the canyon fishery for which tag information was incomplete.
[8] estimates include 5% tag loss.

In previous years, mis-identification of steelhead that were recaptured accounted for up to 2.2% 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. In 2003 and 2004, only one fish was identified inconsistently. In 2003, the fish was initially tagged as a steelhead, but recorded as a sockeye upon recapture, and in 2004 a fish was initially tagged as a coho but identified as a steelhead upon recapture. In 2005, two recaptures were initially identified as a coho, but were identified as a steelhead upon recapture. In 2006, a marked increase in the number of inconsistent species identification was noted. A total of seven recaptures were identified as either coho (4 fish) or sockeye (3 fish) on initial capture, and as a steelhead on recapture, accounting for 4.2% of recaptured steelhead. Few steelhead were tagged in 2007, and no estimate of the proportion of fish identified inconsistently could be generated for that year. In 2008, only one fish was identified inconsistently, with the fish being recorded as a coho by beachseine crews upon tagging, and a steelhead by the dipnet crews upon recapture. As in the previous three years, the fish that was identified as a coho and then a steelhead, was excluded from the data analysis.

When compared to steelhead population estimates resulting from the adult tagging project at Moricetown canyon since 1999, the 2008 population estimate is the third highest estimate, with only the estimates for 1999 (28,527) and 2000 (41,428) being higher. The estimates for 1999 and 2000 were based on very few recaptures, and are associated with very broad confidence intervals. The 2008 estimate is higher than any of the estimates where more than 10 recaptures were recorded (Table 6). The generally higher population

estimate for 2008 may in part be attributable to the later extent of the tagging season (well into October), especially compared to the lower population estimates for steelhead at Moricetown Canyon in 2003, 2004 and 2006, when the tagging project terminated earlier. Trends in estimated steelhead population size from the Moricetown tagging study are similar to those of the tyee test index for steelhead (Figure 4). Years with a higher tyee test index generally correspond to years with a higher mark-recapture estimate. However, the slight decline in the tyee 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 Moricetown, which is speculated to be in part due to a longer tagging season in 2005 compensating for lower steelhead numbers. 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 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 Tyee 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 (2.8% of censused fish) 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 2008 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 2008, 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 secondary 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.

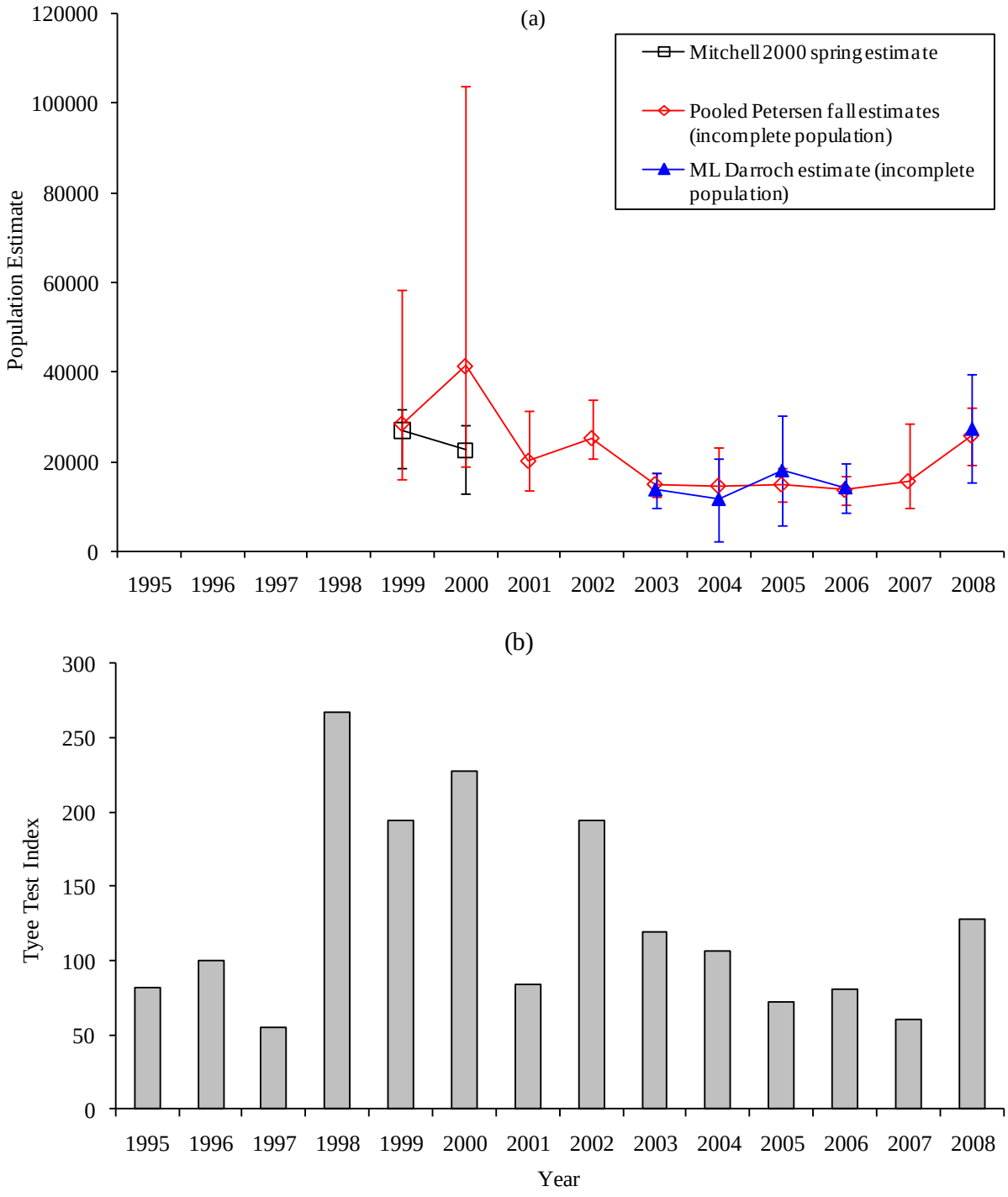

Figure 4. Estimated population size for steelhead upstream of Moricetown Canyon (a), and Tyee test fishery index (b). Error bars in (a) indicate 95% confidence intervals. Please note that the tagging project in 2002, 2003, 2004 and 2006 was terminated earlier than in other years of the study, with the last date of sampling September 27th, 2002, September 19th, 2003, September 13th, 2004, and September 26th, 2006 respectively. The tagging project in 2008 continued well into October (October 20th, 2008).

Fork lengths of steelhead captured in the beachseine fishery (Mean = 71.26, SE = 0.303) was significantly larger than the fork lengths of steelhead captured in the dipnet fishery (Mean = 69.07, SE=69.20, SE=0.210; Mann Whitney U statistics = 1009412.5, p=0.000) in 2008. This is contrary to findings in 2007, 2006 and 2004 where steelhead were significantly larger at the dipnet site when compared to the beach seine site (U=105860.55, p=0.000; U=511074.00, p=0.001 and U=265386, p=0.005 respectively) (SKR 2006, 2009b, 2009c), and to findings in 2005, 2003 and 2001, where fork lengths did not differ significantly between gear types (SKR 2002a, 2004a, 2009a). The inconsistent result of smaller average fork length at the dipnet site compared to the beach seine site in 2008 may be due to a greater number of fork lengths recorded in inches rather than centimeters at the beachseine location in 2008. While efforts were made to correct fork length recorded in inches, fork lengths recorded between 40 and 50 could either represent small steelhead (40 – 50 cm), or large steelhead (40-50 inches), and could not be converted. This introduces a potential size bias into the data record. The fact that, historically, several years have indicated size biases between gear types with average fork lengths of steelhead captured in the dipnet fishery significantly greater than those captured in the beachseine fishery indicates that gear bias is a potential factor in the validity of the population estimate.

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 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. Survival of captured and tagged fish could be evaluated to some degree by retaining a sub-sample of fish overnight, and determining their survival within 24 hours of capture and tagging. In addition, mark-recapture ratios could be evaluated upstream through angling, snorkel counts, fence counts (e.g. Toboggan Creek) or other methods to determine if the mark-recapture ratio changes. A change in mark-recapture ratio would indicate that differential mortality may be occurring between the un-marked and marked group of steelhead.

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 Increasing Beach Seine Steelhead Catch

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 2008, the number of steelhead tagged in the beach seine fishery fell within 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

In 2002 to 2007, 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

A large number of steelhead are tagged at Moricetown Canyon each year. The value of tagging such a large number of fish is primarily for estimation of population sizes. Indices of population sizes can be developed through comparisons of catch per unit effort data to estimated population size. Currently, the mark recapture data and the catch per unit effort data are analysed separately. A comprehensive report summarizing the last five years of mark recapture and CPUE data should be prepared to evaluate if a CPUE index can be derived for the Moricetown Canyon project.

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.

The steelhead tags applied at Moricetown canyon are not utilized for further studies on steelhead life history and population dynamics. Until the spring of 2003, an adult steelhead fence was operated on Toboggan Creek. Marked to unmarked ratios of steelhead tagged at Moricetown and captured at Toboggan Creek could be used to estimate population size, and resulted in the ability to compare population estimates in more than one location. In addition, data collected was used to estimate the contribution of the Toboggan Creek steelhead population to the number of steelhead upstream of Moricetown Canyon. Other studies, such as marked to unmarked ratios at spawning locations, which could be determined using a variety of methods (e.g. angling, snorkel counts) have not been developed, but could be valuable in increasing our understanding of steelhead population dynamics in the Bulkley River and tributaries.

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.

5.0 References

Arnason, A.N., C.W. Kirby, C.J. Schwarz, and J.R. Irvine. 1996. Computer analysis of data from stratified mark-recovery experiments for estimation of salmon escapements and other populations. Can. Tech. Rep. Fish. Aquat. Sci. 2106: vi+37p.

Bagenal, T. 1978. Methods of Assessment of Fish Production in Fresh Waters. 3rd ed. Blackwell Scientific Publications, Oxford, IBP Handbook No. 3.

Department of Fisheries and Oceans Canada. 2004. Tyee Test Fishery data. http:/ www.pac.dfo-mpo.gc.ca/ops/northfm/skeena/steelhead.

Joseph, W. Personal Communications. Wet'suwet'en Fisheries, Moricetown, B.C.

Krebs, C.J. 1999. Ecological Methodology. 2nd ed. Addison – Wesley, New York.

Michell, B. 2009. Personal Communications. Wet'suwet'en Fisheries, Moricetown, BC.

Mitchell, S. 2000. A Petersen Mark-Recapture Estimate of the Steelhead Population of the Bulkley/Morice River Systems Upstream of Moricetown Canyon. Unpublished report prepared for the Steelhead Society of British Columbia, Bulkley Valley Branch and Fisheries Renewal BC.

Mitchell, S. 2001. A Petersen Mark-Recapture Estimate of the Steelhead Population of the Bulkley/Morice River Systems Upstream of Moricetown Canyon During Autumn 2000, Including Synthesis with 1998 and 1999 Results. Unpublished report prepared for the Steelhead Society of British Columbia, Bulkley Valley Branch and Fisheries Renewal BC.

Ricker, W.E. 1975. Computation and Interpretation of Biological Statistics of Fish Populations. Bull. Fish. Res. Bd. Can. No. 191.

SKR Consultants Ltd. 2000a. 1999 Steelhead Tagging Project at Moricetown Canyon by Wet'suwet'en Fisheries. Unpublished report prepared for Wet'suwet'en Fisheries, Moricetown, BC.

SKR Consultants Ltd. 2000b. Letter to Walter Joseph regarding Moricetown adult coho and steelhead tagging program – late summer and fall 2000, dated August 23rd, 2000. Letter to Wet'suwet'en Fisheries, Moricetown, B.C..

SKR Consultants Ltd. 2000c. Letter to Walter Joseph regarding Moricetown adult coho and steelhead tagging program – late summer and fall 2000, dated September 18th, 2000. Letter to Wet'suwet'en Fisheries, Moricetown, BC.

SKR Consultants Ltd. 2001a. 2000 Steelhead Tagging Project at Moricetown Canyon by Wet'suwet'en Fisheries. Unpublished report prepared for Wet'suwet'en Fisheries, Moricetown, BC.

SKR Consultants Ltd. 2001b. Letter to Walter Joseph regarding Moricetown adult coho and steelhead tagging program – late summer and fall 2000, dated January 31st, 2001. Letter to Wet'suwet'en Fisheries, Moricetown, BC.

SKR Consultants Ltd. 2002a. 2001 Steelhead Tagging Project at Moricetown Canyon by Wet'suwet'en Fisheries. Unpublished report prepared for Wet'suwet'en Fisheries, Moricetown, BC.

SKR Consultants Ltd. 2002b. Letter to Walter Joseph regarding Moricetown adult coho and steelhead tagging program – late summer and fall 2001, dated March 31st, 2002. Letter to Wet'suwet'en Fisheries, Moricetown, BC.

SKR Consultants Ltd. 2003a. 2002 Steelhead Tagging Project at Moricetown Canyon by Wet'suwet'en Fisheries. Unpublished report prepared for Wet'suwet'en Fisheries, Moricetown, BC.

SKR Consultants Ltd. 2003b. Letter to Walter Joseph regarding Moricetown adult coho and steelhead tagging program – late summer and fall 2001, dated March 31st, 2003. Letter to Wet'suwet'en Fisheries, Moricetown, BC.

SKR Consultants Ltd. 2004. 2003 Steelhead Tagging Project at Moricetown Canyon by Wet'suwet'en Fisheries. Unpublished report prepared for Wet'suwet'en Fisheries, Moricetown, BC.

SKR Consultants Ltd. 2006. 2004 Steelhead Tagging Project at Moricetown Canyon by Wet'suwet'en Fisheries. Data Analysis and Recommendations. Unpublished report prepared for Ministry of Environment, Smithers, BC.

SKR Consultants Ltd. 2009a. 2005 Steelhead Tagging Project at Moricetown Canyon by Wet'suwet'en Fisheries. Data Analysis and Recommendations. Unpublished report prepared for the Pacific Salmon Foundation Vancouver, BC and the Ministry of Environment, Smithers, BC.

SKR Consultants Ltd. 2009b. 2006 Steelhead Tagging Project at Moricetown Canyon by Wet'suwet'en Fisheries. Data Analysis and Recommendations. Unpublished report prepared for the Pacific Salmon Foundation Vancouver, BC and the Ministry of Environment, Smithers, BC.

SKR Consultants Ltd. 2009c. 2007 Steelhead Tagging Project at Moricetown Canyon by Wet'suwet'en Fisheries. Data Analysis and Recommendations. Unpublished report prepared for the Pacific Salmon Foundation Vancouver, BC and the Ministry of Environment, Smithers, BC.

Walters, C.J., J.A. Lichatowich, P.M. Peterman and J.D. Reynolds. 2008. Report of the Skeena Independent Science Review Panel. A report to the Canadian Department of Fisheries and Oceans and British Columbia Ministry of Environment. May 2008. 144p.

Wet'suwet'en Fisheries. 2000. 1999 Steelhead Tagging Project Conducted in Moricetown. Final Report. Moricetown, BC.

Wet'suwet'en Fisheries. 2001. 2000 Steelhead Tagging Project Conducted in Moricetown. Final Report. Moricetown, BC.

Wet'suwet'en Fisheries. 2002. 2001 Steelhead Tagging Project Conducted in Moricetown. Final Report. Moricetown, BC.

Wet'suwet'en Fisheries. 2003. 2002 Steelhead Tagging Project Conducted in Moricetown. Final Report. Moricetown, BC.

Wet'suwet'en Fisheries. 2006. Office of the Wet'suwet'en Aboriginal Fisheries Strategy 2005-2006 Final Report. Moricetown, BC.

Wet'suwet'en Fisheries. 2007. Office of the Wet'suwet'en Aboriginal Fisheries Strategy 2006-2007 Final Report. Moricetown, BC.

Zar, J.H. 1984. Biostatistical Analysis. 2nd ed. Prentice-Hall Inc. Englewood Cliffs, N.J.

Appendix 1. Steelhead data obtained by beach seining.

Appendix 2. Steelhead data obtained by dipnetting.

Appendix 3. Steelhead Recaptures obtained during the 2008 Moricetown tagging program.

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