Steelhead Tagging Project
at
Moricetown Canyon

JULY TO OCTOBER 2005

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 2005, the Wet'suwet'en Fisheries continued the Moricetown Canyon steelhead tagging program that was initiated in 1999, in conjunction 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 migrating from June to October 2005 are summarized in this report. Catch per unit effort information was summarized in a separate report prepared by Wet'suwet'en Fisheries. The continued objectives of this steelhead tagging program have been to standardize sampling methodologies, develop and evaluate in-season population estimates or indices and to monitor the run-timing and relative annual returns of steelhead migrating upstream of Moricetown Canyon.

Between July 7th and October 3rd, 2005, 527 steelhead were tagged by beach seining and 1426 steelhead were tagged in the dipnet fishery. Steelhead catch rates obtained from dipnet and beach seine samples exhibited less temporal differences in 2005 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 beginning and peak time of steelhead migration through Moricetown Canyon, but that a later portion of the migration period may not have been sampled. A comparison of sex ratios was not conducted because gender identification of steelhead in the fall is notoriously difficult, and was found to be inconsistent during previous years of the study (1999, 2000 and 2001). Fork lengths were compared between dipnet and beach seine catches to investigate potential size biases in sampling gear. Fork lengths were not found to be significantly different, similar to previous years of the study except 2004 where steelhead captured in the dipnet fishery were significantly larger than the steelhead captured by beach seining.

The number of steelhead tagged in 2005 is 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 the recapture rates in 2005 were intermediate to recapture rates in previous years of the study, with 3.3% the steelhead examined in the dipnet fishery having been tagged by beach seining (54 of 1,636). 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 0.5% in 1999, where only eight steelhead were recaptured in a sample of 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 second highest number of tags applied in the beach seine fishery (656 tags) was in 2003, which corresponds to the highest proportion of recaptures. In 2005, 527 steelhead were tagged in the beach seine fishery downstream of Moricetown Canyon. The number of steelhead tagged in the beach seine fishery in 2005 was lower than the number tagged in 2003, and 2002, but was higher than the number of steelhead tagged in the beach seine fishery in 1999, 2000, 2001 and 2004.

Fifty-four of the 527 steelhead tagged downstream of the canyon were recaptured in a sample of 1700 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 2005, and in previous years of the study. The adjusted Petersen estimate for steelhead moving through Moricetown Canyon between July 7th and October 3th, 2005 determined for this mark-recapture data is 14,912 steelhead (95% confidence interval = 11,289-18,535). 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 15,567 steelhead. The ML Darroch estimate for the Moricetown tagging project was 18,126 steelhead (95% confidence interval = 5,696-30,284). These estimates should be viewed in light of constraints of the study, including low recapture rates (3.3%), incomplete sampling of the steelhead run, 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 similar to the estimate for the same period in 2003 and 2004, and appears lower than the population estimates determined in 1999 to 2002. The population estimates for 2000 (Petersen estimate = 43,428; 95% confidence interval = 18,876-103,819) and 2001 (25,289; 95% confidence interval = 20,596-33,941) are significantly higher than the steelhead population estimates for 2003 (14,963; 95% = 12,390-17,535) and 2005 (14,912, 95% confidence interval = 11,289-18,535) as indicated by the lack of overlap in the confidence intervals. No further studies (e.g. snorkel counts) were conducted upstream of Moricetown Canyon in 2005.

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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 2005 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). 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). 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 for 2005. Budgetary constraints in 2005, 2006 and 2007 prevented Wet'suwet'en Fisheries to fund quality assurance monitoring in 2006 and 2007, as well as data analysis and reporting for steelhead data collected in 2005 to 2007. The Ministry of Environment retained SKR Consultants Ltd. to conduct cursory data analysis and reporting of data collected after 2005 to follow recommendations number 15 of the Independent Science Panel (Walters et al 2008). This report summarizes steelhead data collected from July 7th, 2005 to October 3rd, 2005. Subsequent reports will summarize data collected for 2006 and 2007 (SKR 2009a, 2009b).

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 2005.

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 July to October 2005, 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). 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 July 7th and October 3rd, 2005 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 July 7th and October 3rd, 2005. 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. 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 2006, Michell pers. com.). 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. Steelhead, coho, Chinook and sockeye were tagged using tag numbers 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.

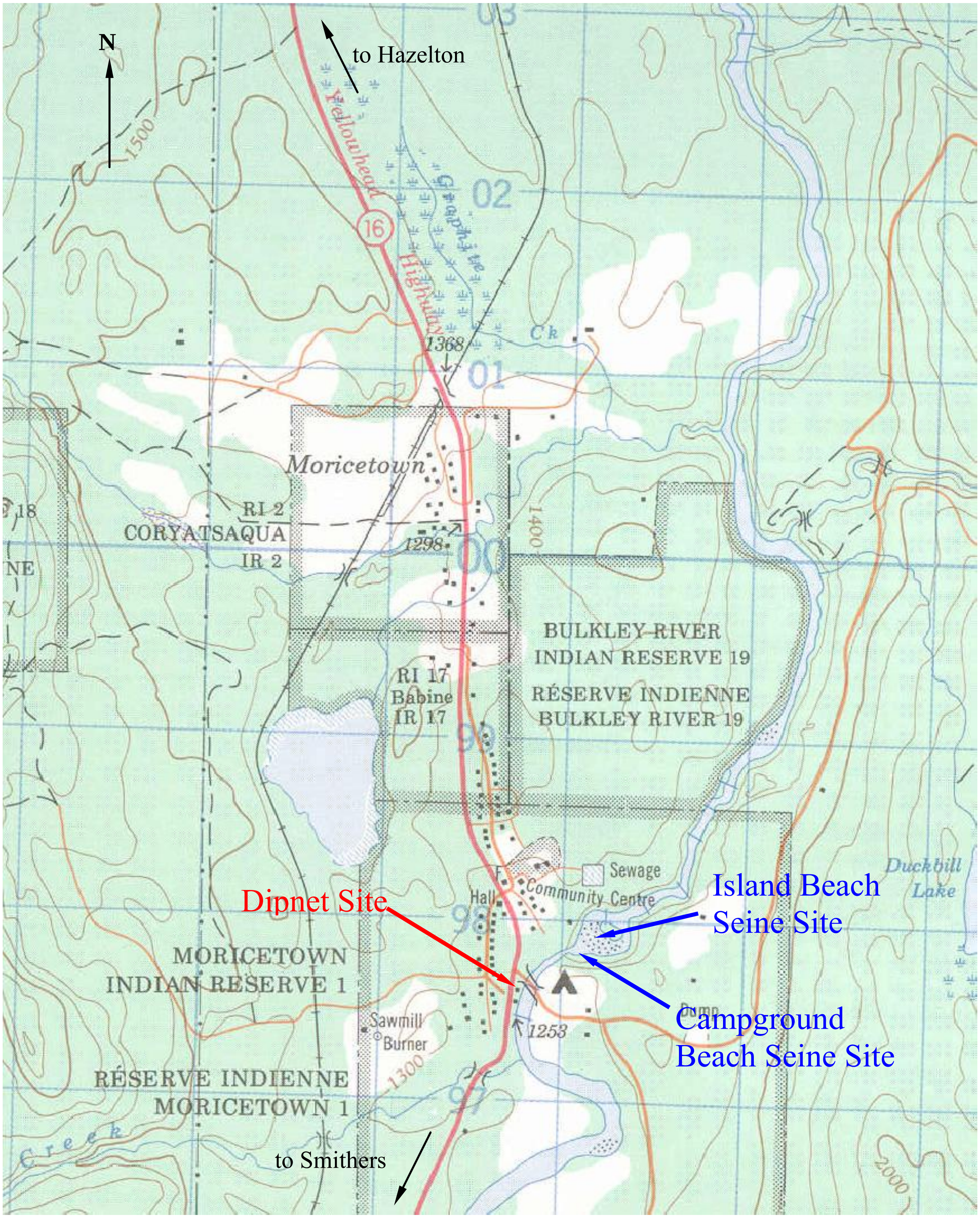

Figure 1. Locations of beach seine and dipnetting operations in the Moricetown Canyon. The map is an excerpt of 093M/03 NTS map (scale is 1:50,000).

Table 1. Summary of tag colours and numbers applied by beach seine crews from July to October 2005, Moricetown tagging program.

Species	Tag colour	Tag Numbers
Steelhead	Brown	22550-22649, 22850-22875, 23828-23949, 24800-24932
Steelhead	Grey	33600-33749, 33800-33997
Chinook	Dark Green	No numbers
Chinook	Grey	No numbers; 8330-8412, 32993-32999
Chinook	Pink	608-825, 1801-2000
Chinook	Purple	1388-1996
Chinook	Red	No numbers
Chinook	White	No numbers; 3138-3150
Chinook	Yellow	No numbers; 1399-1400, 4376-4500
Chinook	Blue	6641, 6642
Coho	Blue	3065-3123, 32159-32161
Coho	Lime Green	1301-1500, 4951-5000, 20001-24000, 40004-44499
Coho	Orange	61301-61800
Coho	Pink	1640-1800
Coho	Red	2601-2650
Coho	Yellow	1101-2000
Sockeye	Orange	60019, 61001-61818
Sockeye	Pink	501-1000
Sockeye	Purple	1701, 1702

2.1.2 Canyon Dip Net Census

Two crews captured, tagged and released steelhead, sockeye and coho at the fishway in Moricetown Canyon between July 7th and October 3rd, 2005. 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. Summary of tag colours and numbers applied by canyon crews from July to September 2005 Moricetown tagging program.

Species	Tag colour	Tag Numbers
Steelhead	Grey[1]	22100-22124, 22200-22223, 22250-22399, 22451-22498, 24450-24499, 24550-24798, 38101-38106, 38503-38554, 38694-38709, 39629-39643, 40390-40648
Steelhead	Green[1]	38107-38145, 38501-38509, 38526-38999, 39626-39628, 34013, 37760
Steelhead	White	40251-40661
Coho	Blue	2953-7000, 30145-34481
Sockeye	Yellow	90001-90450

2.1.3 Quality Assurance/Quality Control

SKR Consultants Ltd. was retained by Wet'suwet'en Fisheries to monitor the field portion of the project. Dipnet and beach seine crews were visited at least once per week in July and August, and at least biweekly in September. Regina Saimoto (SKR Consultants Ltd.) conducted all of the site visits. Field data was submitted to SKR on a weekly basis for review. A training session developed and provided for both beach seine and dipnet crews in previous years was not provided for tagging crews in 2005.

2.2 Data Entry

Wet'suwet'en Fisheries entered all data collected in the 2005 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 during the QA/QC portion of the project conducted by Regina Saimoto of SKR Consultants Ltd.

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 2006). 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 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 July 7th to October 3rd 2005 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 4	July 10
Week 2	July 11	July 17
Week 3	July 18	July 24
Week 4	July 25	July 31
Week 5	August 1	August 7
Week 6	August 8	August 14
Week 7	August 15	August 21
Week 8	August 22	August 28
Week 9	August 29	September 4
Week 10	September 5	September 11
Week 11	September 12	September 18
Week 12	September 19	September 25
Week 13	September 26	October 3

3.0 Results and Discussion

3.1 Data Collection

Data collection generally proceeded with few problems during the 2005 field season. The field staff were generally aware of the objectives of the study, data collection procedures, and transfer of information due to their participation in previous years of the study and in the training session conducted in 2001 (SKR 2002a), 2002 (SKR 2003a), and 2004 as well as on site training conducted in 2003 and 2004 (SKR 2004, 2006). As in the 2003 and 2004, capture methods used in 2005 were limited to dipnetting and beach seining. In some previous years (2001 and 2002), a fishwheel was installed downstream of the Telkwa High Road Bridge, but capture efficiency of the fishwheel was low, and the fishwheel was not installed in subsequent years. Logistical problems encountered during the field season are summarized for each of the capture methods used during the study.

3.1.1 Beach Seine Tagging

A total of 522 steelhead were marked during beach seining. In addition, one steelhead died in the beach seine fishery (not included in totals), and 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 2005 (total marked is 527). This is an increase from the number of tags applied in 2004 (321 steelhead), 2001 (323 steelhead), 2000 (225 steelhead) and 1999 (164 steelhead), but a decrease of the number of tags applied in 2003 (656 steelhead) or 2002 (835 steelhead) (Table 4). The number of steelhead tagged in 2005 falls 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 1999-2005 (see SKR 2000a, 2001a, 2002a, 2003a, 2004, 2006).

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	527[2]	1634	n.a.

[1] excludes recaptures from this study
[2] includes 3 steelhead for 2004, and 5 steelhead for 2005 tagged in previous years of the study
[3] excludes recaptures initially tagged at dipnet location; includes 32 steelhead originally tagged by beach seine

The increased number of tags applied in 2005 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. Fewer steelhead were tagged in the beach seine fishery in 2005 when compared to 2002, and 2003, despite a longer duration of the tagging project in 2005 (July 7 – October 3; 89 days) when compared to 2002 (August 2 – September 27; 57 days) and 2003 (July 17 – September 19; 65 days). 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 and 2003. Data provided was insufficient to investigate these potential causes of the overall reduced 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 the 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 QA visits, which facilitated the QA process.

3.1.2 Canyon Dip Net Census

A total of 1694 steelhead were captured by the dipnet crews between July 7th and October 3rd, 2005. Fifty-eight of these steelhead were originally tagged by dipnetting and recaptured by dipnetting. 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 1636. This number is 10.3% lower than for 2003 (1805), and 18.1% lower than for 2002 (1,933), despite a longer field season in 2005. However, the number of steelhead captured by dipnetting in 2005 is 5.0% higher than in 1999 (1555), 38.3% higher than in 2000 (1010), 27.7% higher than in 2001 (1183), and 4.2% higher than in 2004 (1,568) (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.

3.1.3 Quality Assurance/Quality Control

Wet'suwet'en staff were cooperative during Quality Assurance (QA) visits, which greatly facilitated the QA process. A work schedule for different crews was not readily available, which resulted in a disproportionate number of visits with some crews relative to other crews. However, the work schedule was more consistent, and the QA visits were more even between crews than in the two initial years of the study (SKR 2001a). Cursory review of hardcopy data sheets during the field portion of the project, and detailed comparison of field data sheets with digital data is important in ensuring data accuracy and fidelity. Field forms available for QA were generally complete, legible, and provided few problems in terms of duplicate records. The training session in previous years, QA process, and frequent communications between field crews and the QA monitor stressed the importance of diligent record keeping, and demonstrated that the data sheets and data entry were checked by an independent monitor. The QA process was valuable in ensuring accurate and complete data collection in the field, and can work well in conjunction with the project manager toward ensuring that the project proceeds smoothly throughout the field season.

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 higher in 2005 (54 of 2298; 2.3%) than in 2004 (0.35%), 2003 (1.6%), 2001 (1.2%), or 2000 (0.13%). Most of the duplicate could be resolved after comparison of the digital data with field datasheets, but 12 duplicate records remain in the dataset (0.5%).

The QA process found problems with an additional 93 records (4.05%), excluding simple spelling mistakes or inconsistent coding for tag colours. Common errors included wrongly entered dates (56 records), tag status (3 records), tag numbers (7 records), tag colour (24 records), length and sex data (1 record), and missing records (2 records). The success of the QA process may have resulted from field crews and data entry staff being more diligent in data collection and data entry simply because a QA process was in place. In addition, the training session and field visits by the QA stressed the importance of accurate record keeping.

3.3 Data Analysis

Wet'suwet'en Fisheries handled a total 2,163 steelhead in July to October 2005. The majority of these steelhead (1,636) were captured at Moricetown Canyon in the dipnet fishery, and included 1,426 that were tagged by dipnet crews, 88 were recaptures from this or previous years of the study, 2 were recaptures that had lost their tags, 50 were harvested, and 70 were released untagged. The 527 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 527 steelhead tagged by beach seining, 54 were recaptured in the canyon dipnet fishery (Table 5).

In addition to recaptures used for population estimates (Table 5), 41 other tagged steelhead were recaptured in this study. Most of these steelhead originated from other tagging studies, including 36 from previous years of the project (Appendix 3). Tag number from five 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. Of the 193 steelhead recaptured in the study, 11 steelhead had lost their tags, but the initial capture location could be identified by the secondary mark (caudal punch). This indicates that approximately 5.6% 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.

Table 5. Applied and recaptured steelhead tags for the 2005 Moricetown steelhead tagging program.

	Beach Seine Tags (d/s of the canyon)	Dipnet Tags (in canyon)
Applied	527[1]	1634[3]
Recaptured by Dipnet (in canyon)	54[2] (excl. 2 steelhead that lost tag)	58 (excl. 0 steelhead that lost tags)
Recaptured by beach seine (d/s of canyon)	25 (excl. 1 steelhead that lost tag)	45 (excl. 8 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 120 steelhead not tagged at the dipnet location, of which 50 were harvested, and excludes 2 recaptured steelhead that had lost their tags

In total, 59 steelhead were harvested during the 2005 Moricetown steelhead tagging project. Most of these steelhead were harvested at the dipnet fishery (58, 98.3%), and only one untagged steelhead was harvested in the beach seine fishery (1.7%). Of the 58 steelhead harvested in the dipnet fishery, eight (13.8%) were recaptures initially tagged in the beach seine or the dipnet fishery, and 50 (1.2%) 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 25th in the beach seine fishery, and the first steelhead in the canyon was captured by on the same day in the dipnet fishery. The tagging program started well in advance of these dates, with the first Pacific salmon captured in early July (July 7th for beach seine fishery, and July 12th for dipnet fishery). This indicates that the timing of the mark-recapture study at Moricetown canyon encompassed the start of the steelhead migration period.

Capture dates for steelhead at the start of the migration season in 2005 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 first week in August, to a peak of 17 on August 5th, then fluctuated between 9 and 21 until a second peak of 38 steelhead on August 22nd. Daily steelhead capture rates gradually declined to less than ten steelhead per day in the first week in September, then increased again to a third peak on September 20th, 2005 of 27 steelhead. Fluctuating catch rates may be due to varying catch efficiencies due to environmental factors (e.g. water level, water clarity), or 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.

Steelhead catch in the canyon peaked on August 17th and 19th (108 and 124 steelhead respectively). This is similar to the timing of peak capture rates for 2004 (August 18th and August 19th) (SKR 2006), and 2003 (August 23rd and 28th) (SKR 2005). A second, minor peak in daily steelhead catch rate was noted on September 19th and 22nd, 2005 (47 steelhead and 40 steelhead respectively), similarly to a second, minor peak in steelhead captured rates noted between September 16th and 18th, 2002. The pattern in the number of steelhead caught in the dipnet are similar to the beach seine fishery for July and August 2007, however, the second peak in steelhead catch observed in mid to late September in the beach seine fishery was not observed in the dipnet fishery in 2007.

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, but 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.

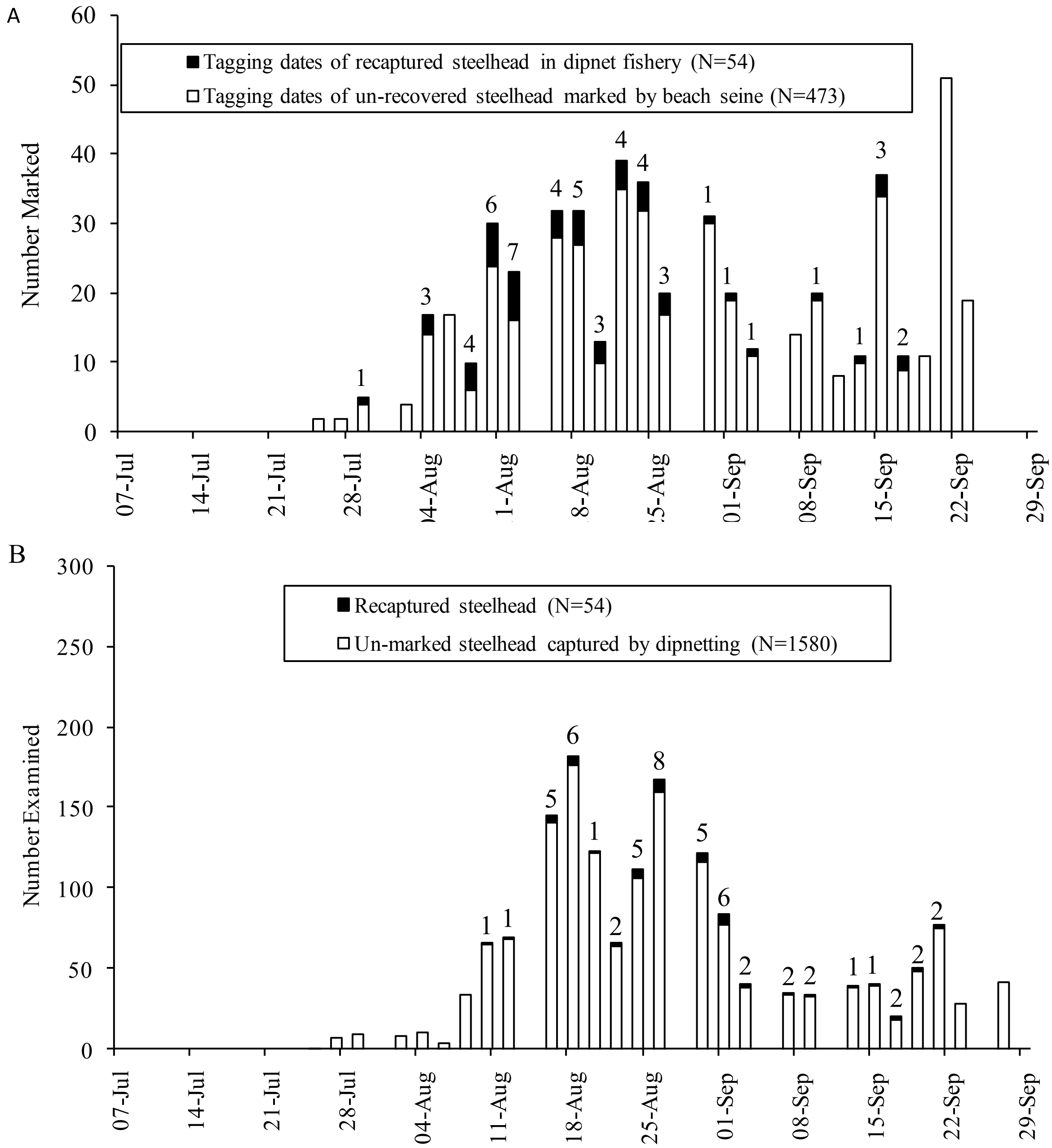

Figure 2. Temporal distribution of tag application during beach seining (A), and of examination for tags during dipnetting (B) during the 2005 steelhead population estimate study. Data labels in the graphs indicate the number of recaptured steelhead.

The early termination of the study resulted in incomplete sampling of the steelhead run. 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 bias to the population estimate.

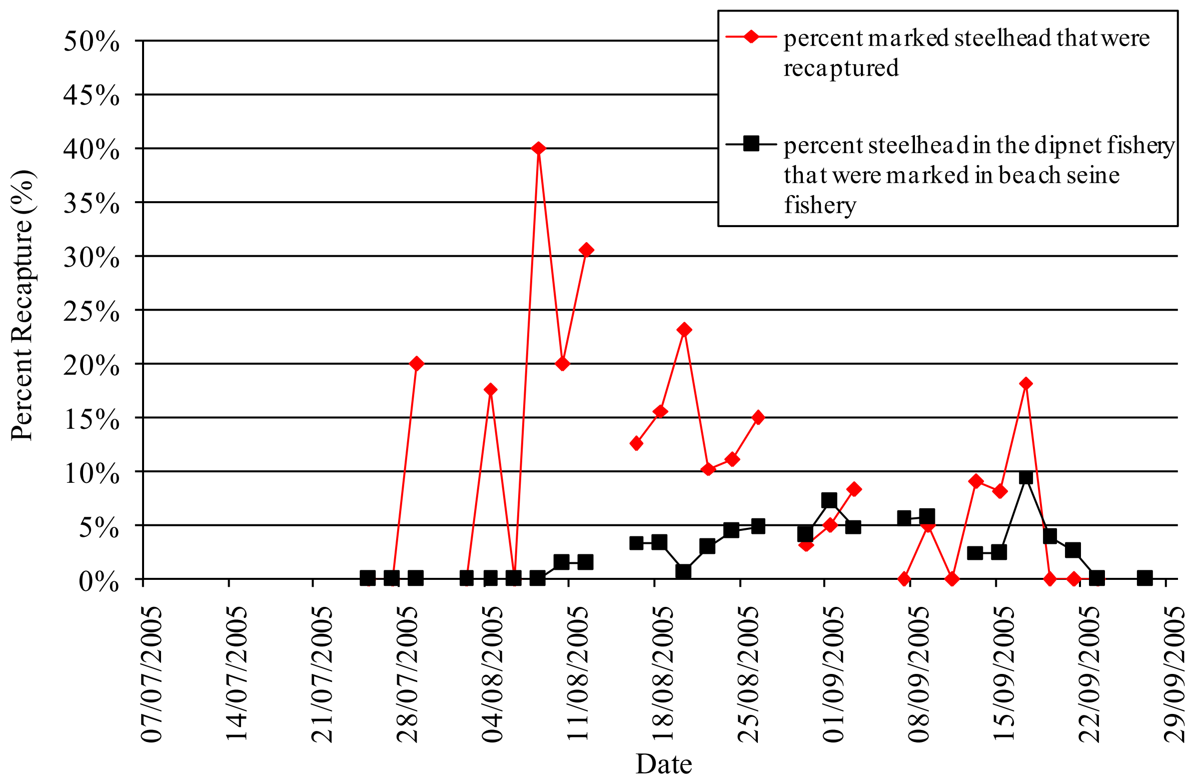

Figure 3. Percent recapture rate for steelhead tagged in the beach seine fishery (♦) and for steelhead examined in the dipnet fishery (■).

Of the 1634 steelhead captured by dipnet crews, tags were applied to 1426, while 54 steelhead were recaptures from the beach seine fishery (excluding 2 that had lost their tags), 34 were recaptures from previous years of the study, 50 were harvested and 70 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 58 and 45 steelhead originally tagged in the dipnet fishery, respectively. This indicates that some steelhead drop back after handling and tagging. The 2005 recapture rate of drop backs (7.2%) is higher than the recapture rates of drop back rate estimates for 2004 (5.6%), 2003 (6.1%), 2002 (4.3%), 2001 (5.4%) or 2000 (4.4%) (SKR 2001a, 2002a, 2003a, 2004, 2005). 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 10.2% (54 recaptures of 527 tagged fish from beach seine fishery), and the actual drop back rate for 2005 is likely around 37.1%. Steelhead tagged during dipnetting and falling back, were recaptured within 0 to 35 days by beach seining (mean = 8.1 days, SD = 7.813), while steelhead tagged during dipnetting were recaptured by dipnetting within 0 to 29 days (mean = 10.6 days; SD = 8.379). Steelhead tagged in the beach seine fishery were recaptured between 1 and 36 days in the dipnet fishery (mean 8.6 days, SD = 6.834), and between 0 and 20 days in the beach seine fishery (mean = 6.3, SD = 6.490). 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). Due to low sample sizes in the initial three weeks of tagging at the beach seine location, the data for the initial three weeks were pooled. 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 may be slightly lower than 5% in 2005, as indicated by the estimate of 3.6% tag loss from recaptured steelhead initially tagged in the beach seine fishery, however overall tag loss for steelhead tagged in the beach seine and dipnet fishery is higher than 5% (6.0%). Three of the 72 recaptured steelhead initially tagged by beach seine had lost their tag (3.7%). Eight of the 111steelhead initially tagged in the dipnet fishery and recaptured in either the beach seine or the dipnet fishery had lost their tag (7.2% tag loss). Tag loss estimates in this study may be overestimates of true tag loss because steelhead handled in previous years, which were also identified by both, an anchor tag and a secondary tag (lower or upper caudal punch), may be mistaken for steelhead tagged in this season that have lost their tags. It is possible that some of the three steelhead with lower caudal punches are repeat spawners, and not steelhead tagged in the beach seine fishery in 2005.

To arrive at the Schaeffer estimate, data for tag weeks 1 and 2 were pooled as none of the steelhead tagged in week 1 were recaptured. Similarly, tag week 8 was pooled with tag week 7 because none of the fish tagged in week 8 were recaptured. In addition, data for recapture weeks 6 and 8 were pooled as none of the steelhead sampled in week 8 were marked. Recapture week 8 was pooled with week 6 rather than week 7 because the proportion of marked fish in the sample was more similar between weeks 6 and 8 than between weeks 7 and 8. The Schaeffer estimate was calculated as 15,567 steelhead moving through Moricetown Canyon between July 7th and October 3rd, 2005. The ML Darroch estimate was 18,126 (SE = 6,203) with a 95% confidence interval ranging between 5,969 and 30,284 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. Since the study was terminated on October 3rd, 2005, the rate or proportion of steelhead migrating through Moricetown Canyon after October 3rd, 2005 is unknown. Because the tagging project did not encompass the entire migration period for steelhead, both the ML Darroch (18,126; 95% CI = 5,969-30,284) and the Schaeffer estimate (15,567) exclude the number of steelhead moving through Moricetown Canyon after October 3rd, 2005.

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 7th, 2005 and October 3rd, 2005. 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 slightly higher than the 3.6% tag loss estimated from secondary tags applied at the beach seine fishery. The pooled Petersen estimate was calculated as 14,912 steelhead (SE = 1,848, 95% confidence interval = 11,289-18,535), which moved through Moricetown Canyon during the fall tagging program. Petersen estimates for the number of steelhead moving through Moricetown Canyon in 1999 to 2005 are summarized in Table 6. The number of marked and recaptured steelhead is a notable improvement from the 1999, 2000, 2001 and 2004 field seasons, but is lower than the sample size in the 2002 or 2003 field seasons (Table 4). The lower number of recaptures in 2005 when compared to 2003 is largely attributable a lower number of steelhead marked in the beach seine fishery, and results in a larger confidence interval around the population estimate for 2005.

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 2006) and 2005. For studies with multiple estimates, the most conservative estimate is summarized here.

Study	Sample size			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 autumn 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	11,054	23,228
Moricetown tagging 2005	527	1636	54	14,912	11,289	18,535

[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 and 2005 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.

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 the last three years, these records were excluded from the data analysis.

When compared to the steelhead adult tagging project at Moricetown Canyon conducted in 1999 (SKR 2000, Mitchell 2000, 2001), 2000 (SKR 2001a), 2001 (SKR 2002a), and 2002 (SKR 2003a), the steelhead population estimates for 2003 to 2005 are lower than any of the other estimates, though these annual differences are largely not statistically significant due to the large confidence intervals. Estimates for 2003, 2004 and 2005 are relatively similar, with the 2004 estimate being slightly smaller than the 2003 or 2005 estimates, however, overlapping confidence intervals indicate that the estimates are not statistically different. The lower population estimates for steelhead at Moricetown Canyon in 2003 and 2004 is partly attributable to the earlier termination of the study than in any of the other years. The population estimate for 2005 is slightly higher than those for 2003 and 2004, which is likely in part due to the longer duration of the study in 2005, encompassing more of the steelhead run, but the estimate for 2005 is also associated with a broad confidence interval for the ML Darroch estimate. By comparison, the confidence interval of the pooled Petersen estimate is relatively narrow. The 2005 Petersen estimate is significantly smaller than the Petersen estimates for 2000 and 2002, as indicated by the lack of overlap in the confidence intervals of those years.

Trends in estimated steelhead population size from the Moricetown tagging study are similar to those of the tyee test index for steelhead. Years with a higher tyee test index correspond to years with a higher mark-recapture estimate. However, the slight decline in the tyee test index from 2003 to 2005 was 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 2004).

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 (3.3% of censused fish) affects the accuracy and precision of the Petersen Estimate, and must be taken into consideration when refining this study.

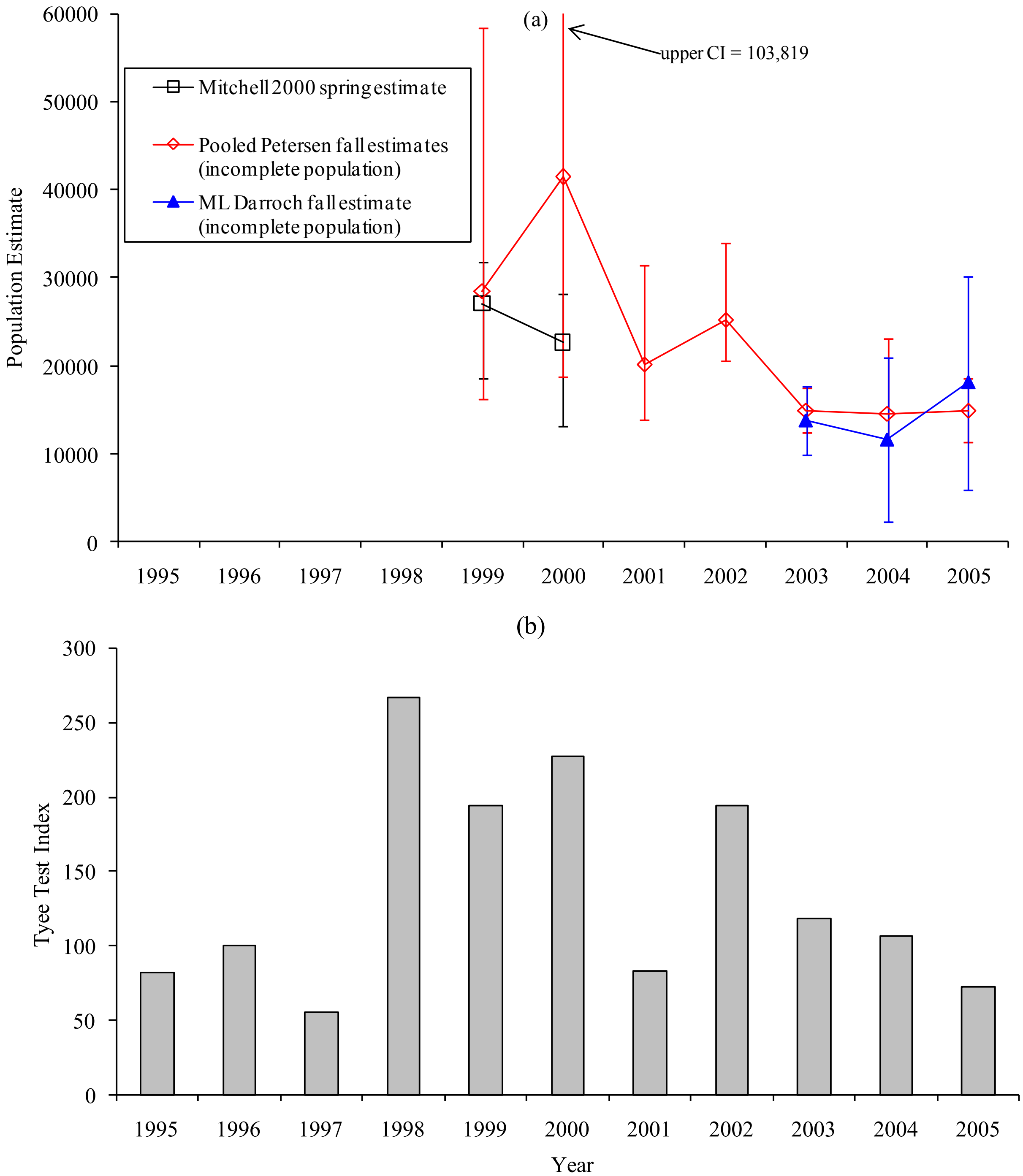

Figure 4. Estimated population size for steelhead upstream of Moricetown Canyon (a), and Tyee test fishery index (b). Error bars in (a) indicate 95% confidence intervals. Please note that the tagging project in 2002, 2003 and 2004 was terminated earlier than in previous years of the study, with the last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

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 2005 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 2005, 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. Fork lengths of steelhead captured in the beach seine fishery (Mean = 64.6, SE = 0.407) did not differ significantly from fork lengths of steelhead captured in the dipnet fishery (Mean = 64.6, SE = 0.245; Mann Whitney U statistic = 508791.5, p=0.935). The lack of significant difference in fork length between capture locations is contrary to findings in 2004, where steelhead were significantly larger at the dipnet site when compared to the beach seine site (U=265386, p =0.005) (SKR 2006), but is similar to findings in 2003 and 2001, where fork lengths did not differ significantly between gear type (SKR 2002a).

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 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 2005, the number of steelhead tagged in the beach seine fishery fell slightly 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

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 sizes 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.

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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 2005 Moricetown tagging program.

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