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BULKLEY/MORICE STEELHEAD ASSESSMENT PROJECT 1998/99

Prepared for: Steelhead Society of BC, Bulkley Valley Branch

Funded by: Fisheries Renewal of British Columbia
Contract #: FSRBC-1998-SSBV

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1. Background

The status of Skeena steelhead (*Oncorhynchus mykiss*) has spawned much controversy both regionally and provincially in recent years with respect to conservation concerns, fisheries management implications and a host of related issues. These issues have proved to be very divisive for the sportfishing, commercial fishing and First Nations groups involved. The Skeena Watershed Committee, a much heralded, multi-sectoral board designed to deal with all salmon issues on the Skeena was dissolved due to the lack of resolution of the steelhead question and the conservation requirements that were implemented on the basis of limited information on steelhead. The questions remain as to the actual numbers of steelhead, what constitutes a conservation concern and what was historical abundance.

Steelhead are to this day thrown overboard from boats and nets and released dead by fishers from all sectors due to regulations forbidding possession of summer run Steelhead due to conservation concerns. In the early 1990's, regulations restricting possession of summer run steelhead were put into effect with very limited information as to the actual strength of the stocks prior to their arrival into the Skeena each year. Further to that approximately 75% of the streams in the Skeena watershed are closed to all angling for five and a half months of the year to protect Steelhead and their progeny from angling related mortalities.

While fishers and fisheries managers generally agree that to err on the side of conservation is prudent and necessary, a myriad of questions regarding the sustainability of all our fisheries due to bycatch issues and catch and release mortalities remain unanswered. Unfortunately, very little data is available for Steelhead in B.C. and the existing data on 43% of anadromous salmonid stocks in B.C. is inconclusive (MELP, Environmental Trends in BC, 1998). The lack of stock assessment information for the Skeena River and tributaries after 23 years of fisheries management for Steelhead has Regional Fisheries Manager R.S. Hooton asking the following questions in the International Journal of Salmon Conservation (Hooton, 1999):

- How do we account for the imperfect knowledge of the distribution of the aggregate Skeena summer run Steelhead stocks among the various tributaries? We abhor "mixed stock fisheries" within the commercial sector. When would we be satisfied we are not simply translocating a mixed stock fishery inland among anglers? Is the Bulkley a mixed stock situation? How do we know we are not disadvantaging sub-basin stocks such as those from the Suskwa, Telkwa and Morice if we endorse a consumptive fishery on the Bulkley?
- Does the angling-based community recognize that declaration of a conservation problem means no sport fishing?
- How do we deal with allocations to First Nations whose constitutional rights give them priority access to any fish that are subject to harvest?
- Do anglers understand First Nations are unconstrained in their constitutional right to harvest Steelhead in the absence of a proven conservation problem?

Questions such as above, and the need for better information for management decisions that have and will in future ultimately affect the viability and sustainability of our respective fisheries, demand answers. There must be some effort to provide credible estimates of relative abundance that is acceptable and can be utilized in determining what the future may hold with respect to all of the salmonid species present in the Skeena system.

In 1998 a coho (*Oncorhynchus kisutch*) tagging program was initiated by the Department of Fisheries & Oceans (DFO) at Moricetown Canyon on the Bulkley River and carried out by the Wet'Suwet'en Fisheries. In addition to coho, the program tagged in excess of 2000 steelhead in the Bulkley-Morice system which offered an excellent opportunity to collect much needed data on steelhead. Fisheries Renewal of British Columbia (FsRBC) funded a project which involved a cooperative effort among individuals and groups from all the sectors and at times the government agencies, to estimate the relative abundance of steelhead above Moricetown through comparative analysis of data collected and an angling based sampling program.

The angling based sampling program was cancelled by the Ministry of Environment prior to completion due to concerns regarding the scientific validity of the original tagging data. The following report therefore summarizes the information available to date from the sampling program and a number of sources in the Bulkley-Morice with respect to steelhead numbers in the 1998/99 season. A technical review of the angling component of the project by a consulting firm (LGL Limited Environmental Research Associates) commissioned by MELP recommends further assessment and verification of the tag release data prior to finalizing an estimate of the 1998 steelhead escapement past Moricetown, and suggests that information from a future (1999) tagging study at Moricetown would help to evaluate the validity of an estimate based on the data contained herein.

2. Introduction

The Bulkley/Morice system is home to a full range of the salmonids prevalent in the Skeena system including anadromous species of steelhead, chinook(*Oncorhynchus tchawytscha*), coho, pink (*Oncorhynchus gorbusscha*), sockeye (*Oncorhynchus nerka*) and a small number of chum (*Oncorhynchus keta*). As such it provides for a world renowned sport fishery through the communities of Houston, Telkwa, Smithers, and Hazelton and First Nations fisheries in Moricetown, Hagwilget and Gitanmax adjacent to the Bulkley River.

Declines in salmon stocks and habitat, and a subsequent decline in our respective fisheries resource industries through a variety of anthropogenic activities precipitated the formation of Fisheries Renewal of British Columbia (FsRBC). The objectives of FsRBC are to provide community based funding to partnerships of local non-profit societies, associations and agencies towards developing efficient, cooperative use of resources to

inventory, restore, enhance and protect fish and fish habitat in an economically sustainable and ecological fashion. The Bulkley-Morice Salmonid Preservation Group, as the offspring of FsRBC in the Bulkley/Morice watershed, has developed a process through which these objectives can be pursued.

In 1998, through the Wet'Suwet'en Aboriginal Fisheries Program and funding from Department of Fisheries and Oceans a tagging program was carried out at Moricetown Canyon for coho during August and September as fish migrated through the canyon. Through this program over two thousand steelhead were also tagged with numbered floy tags through seine and dipnet fisheries. This was the largest number of tagged steelhead on record in any Skeena tributary. It was acknowledged at the Northcoast Sportfish Advisory Board (NCSFAB) meeting on December 5, 1998 by members and agency representatives that this provided an excellent opportunity for stock assessment through a spring recapture program. The MELP representative indicated that due to staff and budget constraints it could not carry out this study. The NCSFAB then recommended that funding be sought through FsRBC to complete this study.

A proposal was subsequently developed and submitted through the Bulkley-Morice Salmonid Preservation Group (BMSPG) by the Bulkley Valley Branch of the Steelhead Society of BC (SSBC) and partners, including the Wet'Suwet'en Fisheries, Toboggan Creek Salmonid Enhancement Society (TCES), Nadina Community Futures (NCF) and the Department of Fisheries & Oceans. The Bulkley Valley Branch of the SSBC was designated as the lead proponent and funding was approved through the BMSPG for Contract #: FsRBC-1998-SSBV.

Following discussions with the Ministry of Environment, Lands & Parks (MELP) with respect to the study area, data collection requirements, methods and data analysis, a Scientific Collection Permit was applied for and issued and the project was initiated in early March of 1999.

The project consisted of two components, one to collect and collate data on steelhead in the study area from various sources, and the other to carry out a spring sampling program through angling to determine the ratio of tagged to untagged Steelhead in the river.

The spring sampling program was suspended and ultimately cancelled by the Ministry of Environment approximately 30% of the way through the program due to concerns about the scientific validity of the study and the original tagging data being used.

The following report details the findings of the project based on the best information available as the cancelled sampling program was not completed as proposed. It should be noted that the uncertainties surrounding the original tag data have yet to be resolved and as such the estimates generated cannot be considered completely accurate until such time as the concerns can be resolved through a more rigorous project design in 1999.

3. Study Area

The Bulkley River watershed is the largest of the Skeena tributaries and drains 12,173 square kilometers (Morten 1999). The Morice River is the largest tributary of the Bulkley contributing the majority of the water to the Bulkley River and for the purpose of this report both are considered the Bulkley/Morice. The current study is focused on that portion of the system above Moricetown as the canyon was the site of the tagging program carried out by the Wet'Suwet'en Fisheries in 1997 and 1998.

From Wet'Suwet'en Fisheries catch records, the steelhead migration into the Bulkley/Morice system begins in July with larger numbers being caught in late August and early September. Steelhead appear to continue to migrate into the system through September and October, although consistent catch records are not available into November to determine how late in the fall and early winter steelhead continue to move through. Steelhead are known to overwinter throughout the system, generally in the mainstem reaches (Koski, Link & English, 1995).

Freeze-up of many of the mainstem reaches of the Bulkley and lower Morice River generally occurs in December and January with ice out expected to occur in mid March to early April. At the Toboggan Creek counting fence near Smithers seven years of data collection has indicated that steelhead over wintering in the mainstem reaches begin their migration to tributaries and spawning areas following an increase in water temperatures in April and spawning is usually initiated when water temperatures have reached approximately five to six degrees Celsius in late April or early May (Mitchell, S.1999, O'Neill, M.1997, 1996, 1995, 1994). Spawning activity appears to continue through May and into June and it is assumed this is consistent throughout the other tributaries of the watershed. Following spawning, surviving steelhead move downstream out of the spawning areas and this movement from Toboggan Creek is generally complete by late June.

The Toboggan Creek counting fence is operated through the Toboggan Creek Salmon and Steelhead Enhancement Society (TCES) and has provided the only consistent estimate of steelhead migration into a Bulkley/Morice tributary for the past seven years.

While steelhead are known to utilize many of the tributaries and some mainstem areas for spawning, there exists little other information as to specific timing or run size relevant to this report on the Bulkley/Morice.

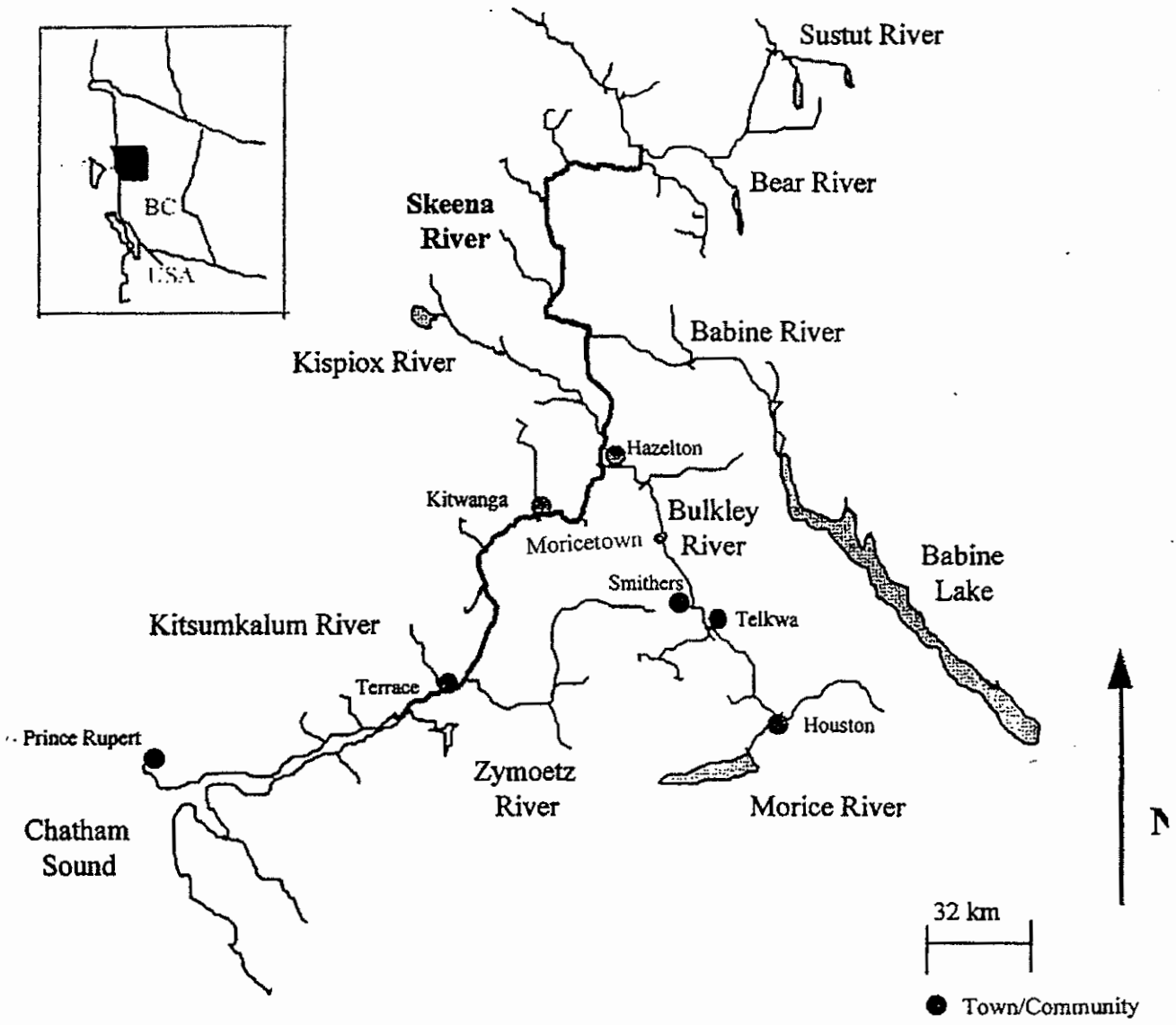

Figure 1. The Skeena River watershed.

4. Methods

4.1. Data Collection Component

Part of the project proposed to collect data from existing sources that were relevant to the steelhead stocks in the Bulkley/Morice in 1998/99. These included the 1998 Guardian Program Report, information from the Wet'Suwet'en Fisheries tagging program at Moricetown, tag and capture data from Bulkley/Morice fishing guides, 1998 tag recapture data from MELP from the fall sport fishery, data collected from the Toboggan Creek Enhancement Society's operation of a Steelhead counting fence on Toboggan Creek and a spring 1999 angling based sampling program carried out by the SSBC Bulkley Valley Branch.

The following is a summary of the data sources and the data we were able to assimilate from them.

4.2. The 1998 Guardian Program

The 1998 Guardian Program was carried out during the fall steelhead fishery on the Bulkley River from late August until mid November under contract from the Ministry of Environment, Lands and Parks (MELP) to Cascadia Natural Resource Consulting (Morten, 1999).

The program consisted of a creel survey which was conducted similar to the 1997 River Guardian Program and entailed aerial counts and on-site roving surveys of anglers on the Bulkley River (Morten 1999). The study area was from the Bymac campground on the lower Morice R. downstream to the confluence of the Bulkley R. and the Skeena R.

Objectives of the program were to:
1) Collect accurate catch and effort data in order to estimate the total catch and effort by Steelhead anglers on the Bulkley R. in the 1998 Steelhead angling season,
2) To collect representative demographic and angling methods data from 1998 Steelhead anglers on the Bulkley R., and
3) To provide a "presence" on the Bulkley R., evaluate compliance with regulations and encourage river stewardship.

(K.L.Morten 1999)

The total effort estimated for the study period in 1998 and area was 6,116 (±442) rod days. The total estimated catch was 8,956 (±1,466) steelhead. This information and other relevant data has been utilized in preparation of the analysis for this report.

4.3. Wet'Suwet'en Fisheries Tagging Program

The Wet'Suwet'en Fisheries Tagging Program was designed and funded by DFO in an attempt to tag coho stocks as they migrated through Moricetown canyon. While it was not designed as a steelhead tagging program, the incidental catch of steelhead in the coho capture operations offered an opportunity to collect information and tag steelhead encountered in the fisheries. MELP was approached to sanction the program and subsequently supplied tags at numerous times for steelhead tagging purposes.

The capture of fish was carried out in two distinct fisheries, one of which entailed the operation of a seine net by jet boat in the large pool below Moricetown canyon. The net is set from the jet boat and the crew pulls the net to the shore removing, tagging and releasing the target species as quickly as possible. One crew member is charged with the data collection component and required to record species, sex, length, tag and condition as fish are released. The number of sets, time of sets and catch were also recorded each day. A one-time monitor of the fish handling methods by MELP determined that standard fish handling techniques were being adequately employed (pers. com. Walter Joseph).

The dipnet fishery that is carried out in Moricetown canyon by First Nation fishers was also utilized as a capture method for the target species. The canyon tagging team employed proven dipnetters to capture coho and steelhead for tagging purposes. Coho and steelhead dipnetted by other food fishers during times when tagging teams were present in the canyon were also tagged, released and the data recorded as these species were not the primary target of food fishers. An incentive program to encourage fishers to provide their catch for tagging was successful in promoting release of these species.

Information from the steelhead tagging portion of the Wet'Suwet'en Fisheries tagging program at Moricetown was initially requested by MELP. Once provided with the Moricetown information they spent considerable time in trying to determine the number of valid tags on steelhead in the population (R. Hooton correspondence to G.Wadley, May 19/99). The SSBC requested this information from MELP but only received information on tagged fish which were recaptured in the sport fishery. Fortunately the Wet'Suwet'en Fisheries provided the SSBC the opportunity to review the field data. This data from the seine tagging and the canyon dipnet monitoring data was reviewed in depth to determine the number of steelhead tagged and handled in the respective fisheries. A copy of the database supplied to the Ministry was also made available.

As a result of the review of the field data we found, as did English and Link (1999), that the seine data was quite complete. However we determined 395 tags had been placed on steelhead by the seine crew with separate records of an additional four tags recovered that were from tag series and colors used by the seine tagging crew. This differs from the LGL report (English and Link 1999) where 371 separate records were identified.

The canyon tagging information was, as identified by LGL, incomplete in that the color of the tags used was not always recorded. Consistent with English and Link (1999) there was duplication of tag numbers, but it appears that it was the result of not recording the tag color that led to the confusion. The records clearly show that 1796 fish were tagged for release and in review of recapture information on specific fish it was possible in all except a few cases to determine which tag number the record corresponded to through the other data recorded such as sex and length. In essence there was little to suggest that those duplicate tags entries were not present as individually tagged fish in the population and subject to recapture through the fishery.

The canyon monitoring information provided another source of information for review of fish examined for marks. The monitoring program is separate from the tagging project and entails a paid observer placed on each side of the canyon to record fish captured by method (dipnet or gaff), by fishing site and whether taken for food fish or released. This has been an ongoing program for a number of years and monitors are trained to keep complete records and in most cases even included the time of capture by species, by site and by fisher. Monitors are present in the canyon from early morning hours until late evening through two shifts and record catch information even though tagging crews were not always present in the canyon.

Review of these records indicated that 2993 steelhead were captured and examined for tags in the canyon fishery of which 1796 were recorded as tagged and released. Steelhead captured when taggers were not available were generally released but records do show when fish were retained. In some cases tagged fish that were recaptured were not robust enough for release and were retained as food fish. These fish were recorded and it appears they were removed from the database during subsequent data entry of canyon monitoring forms.

Records were found for 41 + 4 tags recaptured in the dipnet fishery from the seine fishery tagging program. The + 4 tags are the four tags referred to above in the seine tagging totals that were tag color and series used in the seine fishery but not recorded in the seine tagging record.

While some of the information differs from the results of English and Link (1999) it is not clear if the same records were examined in both cases and in what detail. Therefore for the purposes of this report, the information gained from the our review of the Moricetown tagging has been used as we had the benefit of access to the field data and the database for comparison.

4.4. Guide Data

Fishing guides in the Bulkley/Morice were solicited for steelhead catch information on the basis that they are required to submit an annual angling guide report detailing the number of fish captured by date and river. While fish numbers are generally consistently reported, tag recaptures often are submitted by the individual angler in order to claim the

hat offered by MELP for participation in the tag information program. We found the records of three guides and one assistant guide that were complete in the aspects required for the purpose of this project in that the number of fish captured and examined for tags and the tag numbers were recorded. Two other guides operated primarily downstream of Moricetown and their information was therefore not included. Two guide operations above Moricetown did not always record tags as their anglers submitted those records individually. Another two guides we were not able to contact directly but we did manage to gain the records of one of their assistant guides that were complete.

We received permission from these guides to use their information and to compare their data with the MELP records of tag recaptures to confirm tags of Moricetown origin. The results of this component are included in the analysis. The guide data indicated that 907 steelhead were examined for tags with 48 confirmed tagged fish from the Moricetown tagging program in 1998.

4.5. Toboggan Creek Steelhead Fence Operations 1999

The Toboggan Creek counting fence was operated by the Toboggan Creek Salmon and Steelhead Enhancement Society under a FsRBC contract for the spring of 1999. This was the seventh consecutive year of operation for the fence which has been funded by a variety of sources over the years including the Skeena Green Plan through DFO, Habitat Conservation Fund, MELP, and for two years fund was provided by the TCES itself.

The Toboggan Creek fence operations for steelhead are currently the only consistent measure of the number of spawners entering a spawning tributary on the Skeena watershed. Only two other fences measure the number of steelhead migrating through them. One is the Sustut River fence which does not operate in spring when steelhead are moving into spawning areas. The Babine River counting fence is the other fence that documents steelhead passage during fall periods but again does not operate during spawning migration. As such, the Toboggan Creek fence operations can be considered the only current, viable source of information for determining numbers of steelhead spawning in a tributary of the Skeena Watershed.

The objectives of the fence operations are to:

- Estimate the size of the adult steelhead population utilizing Toboggan Creek above the counting fence by mark recapture procedure,
- Document run timing of steelhead to Toboggan Creek, and
- Collect information on size, sex ratio, age and life histories (via scales).

While the final report for the spring 1999 operations of the fence is not complete at the time of this report, the tag recapture information with respect to Moricetown tags and the number of steelhead examined for tags has been included in the analysis.

4.6. Spring Angling Based Sampling Program

The sampling program proposed for the Bulkley/Morice in the spring of 1999 was developed on the basis of discussion with MELP staff on January 19, 1999. A single pass system was proposed that entailed sampling twenty prescribed reaches of the study area through angling on a one time basis only. Consistent effort throughout the reaches was recommended, as was the use of a helicopter to sample areas of limited access. The objectives were to determine a random sample of tagged to untagged fish throughout the study area .

The use of roe for bait was suggested as the most effective method of sampling and use of other terminal tackle or flyfishing was not encouraged. Data collection and reporting requirements were conditions of permit and required the following information be submitted on a weekly basis: date, location, reach fished, anglers participating, species, sex, length, tag number, tag color and condition of the fish. Conservation Officers and Fisheries Officers were to be informed of the areas to be sampled on a timely basis and participants were required to have a copy of the permit in their possession while angling.

Local Steelhead Society members and interested anglers were solicited to volunteer their angling expertise for the sampling program and a workshop was held on March 3, 1999 with MELP present to review the conditions of permit and familiarize participants with the various aspects of the project. A project coordinator was designated and a number of technicians hired to ensure data was collected properly and all conditions of the permit were adhered to. All angling activity was to be strictly coordinated.

March 6, 1999 was the first day of sampling activity and there was eight days of directed angling between March 6 and March 24, 1999 which resulted in the capture of 281 steelhead, 24 of which were tagged at Moricetown. Sampling was carried out from Bymac on the lower Morice R. to Gosnell Creek which was equal to less than 1/3 of the total study area and was the only accessible area during that time due to ice conditions on the Bulkley R. above Moricetown.

The Scientific Collection Permit issued by MELP for the project was suspended on March 25, 1999 and ultimately cancelled two weeks later. In cancelling the permit Reid White, Regional Manager for MELP, Skeena Region determined that:

The Ministry's interest is in managing the fisheries resource and managing who has the opportunity to make use of the resource. I find that in the balance, the adverse effect on the resource and the general angling community's interest is greater than the BVSS (SSBC Bulkley Valley Branch) opportunity to continue this project where there is no valid scientific purpose. I have determined that there is sufficient cause for cancellation of this permit (R. White, letter to SSBC April 12, 1999).

5. 1999 Steelhead Evaluation – Morice/Bulkley

5.1. Data

Data used came from five sources (Table 1) and was divided into two groups – model building (angling) and validation. The objective was to build a model which would provide an estimate of fish "available for capture" based on the number of tagged fish, and to be able to validate it with independent data. Therefore, available information was split into two groups which would likely be internally quite similar 1) "experienced fishermen" (Guided anglers and the Morice spring fishery), and 2) "non-professional" fishers and non-angling data.

Table 1. Data used in developing model

Data		Total ST captured	Tagged ST captured	Tagged to Untagged Ratio	Proportion (p')	95 % Confidence Interval of p'	Source
Morice Spring Fishery		281	24	0.0933	0.0854	0.0330	1
Guide Data	Guide 1	280	23	0.0894	0.0821	0.0325	1
	Guide 2	192	17	0.0971	0.0885	0.0406	1
	Guide 3	111	4	0.0374	0.0360	0.0351	1
	Guide 4	324	4	0.0125	0.0123	0.0122	1
Toboggan Creek (1999)		255	12	0.0494	0.0471	0.0260	2
Toboggan Creek (1998)		266	5	0.0191	0.0188	0.0163	3
Moricetown Seining		2993	41	0.0139	0.0137	0.0042	1
Sport Fishing		8956*	329	0.0381	0.0367	0.0039	4,1

*Represents fish from Bulkley River only (does not include Morice River).
1 = Unpublished data
2 = Mitchell (1999b; *In Prep.*)
3 = Mitchell (1999a)
4 = Morten (1999)

5.2. Methodology

The mean proportion of tagged fish caught by anglers to total steelhead captured (tagged captured/total captured) was calculated for the results from the four guides and the Morice spring fishery. This resulted in a mean proportion of 0.0624 (SD = 0.0354; 95% confidence interval $\pm$ 0.0311; n=5) of tagged fish in the total captured population (Figure 1). The equations used to develop these estimates are:

$$p' = n_{(tagged)} / n_{(total)}$$
$$\text{Standard deviation} = [n_{(total)} * p' * (1-p')]^{0.5}$$
$$95\% \text{ confidence interval} = Z_{\alpha/2} * [(p'*(1-p')) / n_{(total)}]^{0.5}$$

Where p' = estimated proportion of tagged fish in total captured sample
$n_{(tagged)}$ = number of captured fish bearing tags
$n_{(total)}$ = total number of fish captured
$Z_{\alpha/2}$ = standard normal deviate for (1-α) level of confidence; 1.96 at α=0.05)

The developed model is one that estimates the total number of fish captured (n_{total}) based on the number of tagged fish caught (n_{tagged}). Since there exists an estimate of the number of tags applied at Moricetown (1950-2250; R. Hooten correspondence with G. Wadley, May 19, 1999), with an estimated proportion of tagged fish in a captured population, it should be possible to calculate how many fish are expected to be captured based on number of tagged fish caught. That is,

$$p' = n_{(tagged)} / n_{(total)}$$

$$\text{So: } n_{(total)} = n_{(tagged)} / p'$$

The model is:

$$\textbf{Expected total capture} = n_{(tagged)} / p'$$

This will give an estimate of the number of fish expected to be captured, not a population estimate which would be greater by some amount (depending upon what proportion of the total population is captured by anglers).

The number of valid tags recovered was adjusted in an attempt to account for tag loss with a tag loss of 2.5% being estimated (see Assumption 4 below).

5.3. Assumptions

There are a number of assumptions involved with any mark-recapture techniques, many of them unquantified (and largely unquantifiable without large outlays of time, manpower and money for which mark-recapture studies are not recognized). The important assumptions are discussed below and quantified to the degree possible but the philosophy of Krebs (1989) is followed in this analysis:

"The fourth and final strategy is to use the mark-recapture methods and recognize that the resulting estimates are biased (Jolly and Dickson, 1983). Biased estimates may be better than no estimates, but you should be careful to use these estimates only as indices of population size. If the bias is such as to be consistent over time, your biased estimates may be reliable indicators of changes in a population. (Krebs, 1989; p. 59)

Assumption 1) p' remains constant irrespective of population size

This assumption is obviously not strictly correct as increasing the number of marked animals within a fixed population will increase p'. The question becomes whether it is significantly changed in the range of concern. Figure 2 plots the proportion of a population which is tagged against population size for various values of tagged individuals (hypothetical population). At large population sizes (i.e., >25,000) the proportion tagged (p') converges to <0.10 whether there are 500 or 2,500 individuals tagged. In the second chart of Figure 2 proportions are plotted against population size for 1,500, 2,000 and 2,500 tagged individuals, along with the model proportion and 95% confidence intervals. It can be seen that for 1,500 marked fish, the proportion of marked fish enter the model 95% confidence intervals at a hypothetical population size of approximately 15,000, while 2,000 marked fish enter at 21,000 and 2,500 marked at 27,000. They then remain within the 95% confidence interval up past 41,000 fish.

Thus, while p' decreases with an increasing number of fish in the population, at relatively large population size (i.e., > approximately 25,000), it is reasonable to assume that the p' for the number of marked fish of concern here (between 1,500 and 2,500) are likely within the 95% confidence interval of the model. The proportion (p') does approach a linear relationship with population size irrespective of number of tagged fish between 500 and 2500 at large population sizes. Therefore, in general, it is suggested that this assumption is not significantly violated within this study provided the total population is greater than approximately 25,000 individuals.

Assumption 2) The marked fish suffer the same natural and fishing mortality as the unmarked fish.

Three years of data from Toboggan Creek provide indication that, at least in this area, tagged fish do not suffer greater mortality than untagged fish (Table 2). As well, information from the Sustut River (Saimoto, 1995) indicates a low mortality rate (4 of 254 [1.57%]) for tagged fish. Unfortunately total mortality was not included so it is unknown what the untagged mortality rate is, though it is extremely unlikely to be significantly less than the 1.57%. It is further interesting that the Sustut tag mortality value is similar to, though less than, Toboggan Creek.

Table 2: Dead recoveries of tagged and untagged fish relative to respective populations for Toboggan Creek, 1997-1999. Data from Mitchell (1999a,b) and M. O'Neill (unpublished data).

Year	Est. # of untagged fish*	Untagged Dead	Prop. of untagged fish dead	# tagged fish	Tagged dead	Prop. of tagged fish dead
1997	500	10	0.020	43	1	0.023
1998	226	6	0.026	155	4	0.025
1999	201	14	0.069	156	4	0.026

*Estimated number of untagged fish = Population estimate – Number of tagged fish

There is no reason to assume that survival for tagged fish would be greater than for untagged, the general concern is that the tagging may decrease survival, not enhance it. Thus, there is no evidence of significant violation of this assumption and it is concluded that differential mortality between marked and umarked fish is unlikely to be of concern.

Assumption 3) The marked fish are equally vulnerable to the recapture techniques as are the unmarked fish.

English and Link (1999) suggest that avoiding highly selective techniques such as gillnets and visual surveys can avoid violating this assumption. There is no reason to suspect differential recaptures for tagged versus untagged fish from angling; particularly considering that the tags were applied by a non-angling (i.e., seine, dip net) fishery. Since the fish were not exposed to anglers when the tags were applied the suggestion of avoidance behavior of hooks is unsupported. Further evidence against avoidance is that some fish are caught more than once. In the fall steelhead fishery, of 329 individual tagged fish captured, 33 (10%) were recaptured twice and 2 (0.6%) were recaptured three times. No recaptured tagged fish in the Spring Morice fishery were caught more than once. Unfortunately, there is no information for an untagged steelhead multiple recapture rate so it is not possible to compare the 10% of the tagged fish which were recaptured twice with the parent population. It provides evidence that these fish probably do not markedly avoid fishooks, but it remains unknown whether they may be more attracted to hooks than unmarked fish.

Assumption 4) The marked fish do not lose their marks.

English and Link (1999) suggest that spaghetti tag loss is less than 5% (though they don't provide specific studies to support this statement). Lough (1995) found a 0% tag loss of steelhead between fall and spring in the Morice River, and Parken and Atagi (1998) report one of 18 steelhead (5.6%) losing their [Floy] tags in the Cranberry River. Five years of tagging data (1994-96, 1998-99) from Toboggan Creek (O'Neill 1995, 1996, unpublished data; Mitchell, 1999a,b) show a range of tag loss from 0 to 18.75 % over short term periods (< 3 months). The Cranberry River result and the high estimates for Toboggan Creek are both based on very small sample sizes (18 and 32 fish tagged, respectively) and so, under these conditions, the loss of even single tags will be highly influential. Thus these two studies, while interesting, are not considered representative. In addition, the recapture technique used for model building (angling) is less likely to result in tag loss during recapture than other techniques such as seining. Therefore, tag loss is thought to be less than 5%, and for the purpose of this evaluation a tag loss rate of 2.5% is assumed.

Assumption 5) The marks are applied randomly over the entire run; and/or marked fish become randomly mixed with the unmarked fish; and/or the recovery effort is proportional to the number of fish present in different reaches of the system.

Tags were only applied to steelhead from July 30 to September 18 and so they were not applied over the entire run; the tagging program missed fish that moved through the canyon prior to July 30 and after September 18. It is not quantified what proportion of the total run this comprises though Hooten (1999) indicates 7% of the run occurred after September 10th at the Tyee test fishery. The assumption that marked and unmarked fish become randomly mixed, if they are part of the same run component (i.e., August-early September), has also not been quantified but is also a very reasonable assumption. There is no evidence that would suggest tagged fish would not mix with untagged if they are sampled randomly (i.e., no biases such as sex, size, etc.). The capture methods used at Moricetown (seine and dipnet) preclude any bias by the fisher (e.g., visibility or size bias) as he cannot see and so select fish. Whether seines and dip net sample a passing population randomly and representatively has not been assessed at Moricetown.

The assumption that recovery effort is proportional to the number of fish present appears reasonable for angling recovery. The guides have incentive to place their anglers where the greater number of fish are located, with less emphasis on areas of lower fish abundance. The same is true of the fall sportfishery, anglers will congregate where they are successful and avoid places where the fish are not located. Therefore, there is little reason to conclude that this assumption has been significantly violated.

Assumption 6) All marks are recognized and reported on recovery.

The spring Morice fishery was directed specifically to determining the ratio of marked to unmarked fish, and so this assumption has been met within this data; experienced anglers were conscientiously and consistently looking for tags. The data from the guides is also unlikely to have significantly violated this assumption. This is because the guides have a vested interest in reporting tags as their clients may want the reward, whether it is material (i.e., a hat) or informational (where the fish was tagged, etc). Angling guides are knowledgeable and observant fisherman and so are unlikely to miss a tag on a fish.

The Toboggan Creek data is also unlikely to have violated this assumption as every fish through the fence or captured passing downstream is closely examined, recorded and the data submitted to the Ministry of Environment, Lands and Parks. The Moricetown seining is likewise unlikely to miss significant numbers of tagged fish as these are specifically one of the components the are looking for (though the seining may result in lost tags and so a tagged fish appear as an untagged one). Finally, the sport fishery in which unguided fishermen are angling has an unknown component of unreported tags. This last data may violate this assumption, but it is unknown at this time. To mitigate this a worst-case scenario was run (see Validation) assuming 50% of the tags captured in

this fishery were not reported. Fifty percent was selected as a conservative approach and due to the lack of information indicating a greater or lesser value.

5.4. Validation

In order to validate the model, data from Toboggan Creek, the Moricetown seine fishery, and the Fall steelhead fishery were used. The 1998 Toboggan Creek results are based on 709 tags applied in Moricetown.

The model consistently underpredicts the total number of fish captured based on number of tagged fish caught (Figure 3). The difference between predicted and observed (predicted value/observed value) ranges from 0.24-0.94, suggesting that the values derived from the model can be viewed as conservative and probably considerably lower than true field values. In a Morice River population estimate in 1993/94, 23 recaptures were made out of a total of 310 fish caught ($p' = 0.074$) (Lough, 1995). This value is within the 95% confidence interval of the estimated mean proportion of the model.

The validation point using the sport fishing is very interesting. The number of fish caught (8,956 $\pm$ 1,466) comes from Morten (1999) and the number of tag recaptures is from reported tags reported to the Ministry of Environment for the Bulkley River (R. Hooten correspondence with G. Wadley, May 19, 1999). The predicted value is only 58% of the observed value; this is due to the difference in the proportions of tagged fish in the sample, 0.0381 for the fall fishery, 0.0624 for the spring angling program(Table 1). This, and Figure 4, suggest that at small sample sizes the proportion of tagged fish in the sample is higher than at larger sample sizes and since the angling data are a small sample size the derived mean value of 0.062 may significantly overestimate the true proportion. An overestimate in the proportion ($n_{(tagged)} / p'$) results in an underestimate in the expected number of fish to be caught.

A range of Petersen estimates (N=MC/R) were determined for the sportfishing data. The calculated values are not precise population estimates but are simply intended to provide order-of-magnitude estimates, to evaluate the reasonableness of the derived model values. Petersen estimates were calculated using two approaches, the first using the sportfishing data as it is presented (C=8,956, R= 337.225 after correction for tag loss) and using M of 1950 and 2250. Secondly, a worst case scenario was constructed in which the estimate of total steelhead captured was taken as the lower 95% confidence interval (7,490) and it was assumed that 50% of the tags were not reported (i.e., R = 674.45 after correction for tag loss). These calculations resulted in an estimated number of 51,700-59,600 fish under scenario one and 21,600-25,000 fish under worst-case conditions (scenario 2). The model estimates 10,800 fish to be captured under this assumption of worst case, further indicating conservative prediction.

In summary, the validation indicates that the developed model may be expected to significantly underestimate the expected number of fish to be caught. The derived numbers will be conservative.

5.5. Estimates

Applying the model to the estimated number of tagged fish at Moricetown of 1950 and 2250 yield the following estimates for predicted total captures (and see Figure 5).

# tagged fish	Est. total captures	Range of estimates*
1950	31,200	20,800 – 62,300
2250	36,000	24,100 – 71,800

* Using model 95% confidence interval in place of mean

Again, it must be emphasized that these are not population estimates, which will be greater, but are the expected number of total fish captured in a fishery given that all of the tags were to be recovered. Therefore if 60% of the total population was assumed to be captured by angling then these figures would have to be corrected by (1/0.6) = 1.666 times (i.e., 52,000 – 59,800) to arrive at population figures. Interestingly, if the total tag recaptures by angling (Fall, guides, and Morice combined), not correcting for multiple captures of the same fish, are examined, there are 401 tagged fish caught of a total of 1950 to 2250 tagged (17.8 – 20.6%). Lough (1995) captured 578 fish by angling of a total population estimated at 3,316 fish (17.4%) in the Morice River. Spence et al. (1990) reports capturing 628 fish from an population of 3,254-3,554 steelhead (17.7-19.2%) in the Sustut River. Even assuming dropback, lost tags, higher overwinter mortality for tagged fish it appears unlikely that anglers catch >50% of the total fish in the population.

6. Discussion

This analysis has resulted in an estimate of the number of fish that would be caught if all of the tagged fish could be recaptured based on a tagged-untagged ratio of approximately 6%. It is not a population estimate, though it strongly suggests that the steelhead population passing through Moricetown is considerably larger than 31,000-36,000 fish.

The approach is based on the extrapolation of a tagged-untagged ratio and, as with all extrapolation, the results must be interpreted with caution as it is unknown if the proportion remains the same at larger sample sizes. However, the validation data, which includes a sample size over 13 times larger than the model building sample, indicates that over this range the true proportion is likely to be less (and hence total estimated captures [n_{total}] greater) than at smaller sample sizes. Thus, the model, even if the extrapolation is not strictly correct, is likely to overestimate p' (i.e., underestimate n_{total}) and so the derived numbers should be viewed as approximations but also as minimum values.

As a prediction from this model it is suggested that a well conducted Petersen mark-recapture study, such as that proposed for 1999, will result in a population estimate in excess of 36,000 fish for the Bulkley/Morice system assuming the 1999 run is similar to 1998 as suggested by Hooton (1999).

7. Conclusions & Recommendations

The results of the analysis and validation strongly suggest that the steelhead population passing through Moricetown in 1998 is considerably larger than 31,000 - 36,000 fish. While the final results may vary should a more rigorous analysis of associated dropback and mortality of tagged fish be determined in 1999 as recommended, we do not anticipate substantial change in the results of the analysis.

We feel the Moricetown tagging program offers a unique opportunity for ongoing monitoring and tagging of salmonids. While some minor changes should be incorporated to ensure accurate data collection and to ensure assumptions are valid, we feel the effort and willingness to cooperate in data collection, conservation and information sharing exhibited by the Wet'Suwet'en Fisheries is commendable. We recommend that the Moricetown tagging program for steelhead be carried out again in 1999 with a single color and number series of tags being utilized for tagging. An effort towards determining mortality and dropback is recommended to deal with the past years concerns related to these issues. A cooperative effort with sportfishers and guides may assist in gaining the information required with regard to these issues.

Issues related to tag recovery by anglers during the fall steelhead fishery and possible removal of tags from the population should be dealt with through a public information program via sporting good stores, license vendors and posters placed in key locations to inform the public of the program.

While the spring angling based sampling program was cancelled prior to completion, it was on schedule to complete consistent sampling of the prescribed reaches prior to fish migration out of the study area. Projections of the number of fish that could have been captured and examined for tags are in excess of those required for an accurate estimate of population based on the prescribed methods by the Ministry of Environment, Lands & Parks. Considering the above, we recommend that a similar program be carried out in the spring of 2000 to provide a stand alone estimate of population that can be used to validate estimates based on the canyon program. A spring program in 2000 would also assist in validating the results of this report.

As identified by English & Link (1999) this program would provide information on stock specific run timing for steelhead as they move through Moricetown canyon and could be used with abundance based indices in the future to provide indications of stock specific run strength in-season.

The information gathered in a 1999/2000 program used in conjunction with detailed guide data and the Toboggan fence data would yield more accurate estimates of marked

to unmarked fish above Moricetown to evaluate population sizes in the Bulkley system. (Mitchell, 1999a)

A further comparison of the data collected in 19998/99 with the Tyee test fishery indices indicates the estimates from the Tyee index may be conservative. The estimated number of steelhead passing the test fishery and moving up the Skeena in 1998 was about 66,000 (Hooton, R.S., 1999). A radio telemetry program carried out on the Skeena and tributaries in 1994 determined that >35% of the tagged steelhead entering the Skeena were bound for the Bulkley/Morice system (Koski. W.R.,M.R. Link and K.K. English, 1995). On the basis of this information it could be assumed that in excess of 23,000 of the 66,000 steelhead passing Tyee would be bound for the Bulkley/Morice system. Based on the results of this study the Tyee estimates may be very conservative for 1998. A comprehensive program including the Moricetown tagging program and an spring angling based sampling program may assist in developing an index for one of the six major upriver sub-basins to validate future Tyee indices.

In conclusion, we recommend that the Moricetown tagging program for steelhead be continued through 1999 and that a spring-angling based sampling program be carried out consistent with the 1998 proposal. We further recommend that efforts be made to ensure MELP, DFO, Wet' Suwet'en Fisheries and other anglers in the Bulkley/Morice area are involved cooperatively to ensure completion of the project.

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8.1. Personal Communications

Hooton, R.S. Regional Biologist, Fisheries Branch, Ministry of Environment, Lands & Parks

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- The Steelhead Society of BC parent body and the Toboggan Creek Salmon & Steelhead Enhancement Society
- Nadina Community Futures and the Bulkley Morice Salmonid Preservation Group
- All of the anglers who volunteered their time to assist us in the spring sampling program and the guides who provided us with information.
- To the Bulkley Valley Branch of the Steelhead Society for the opportunity to work on this project. Special thanks to Gord Wolfe and Mary Lou Burleigh for the many hours of meetings, editing and constructive comment.
- Ron Tetreau and Bob Hooton of the Ministry of Environment, Lands & Parks for their assistance in determining the origin of tags recaptured through the various sources and the summary information provided from the Ministry data base.

10. Appendices

10.1 Figure 1: Proportion of tagged fish in sample from five angling sources used in model development.

10.2 Figure 2: Tagged proportion of fish as function of population size for various tag rates. Model proportion included (lower) for comparison

10.3 Figure 3: Validation chart

10.4 Figure 4: Proportion of total sample which are tagged as function of sample size for data sources used in analysis.

10.5 Figure 5: Projected number of recaptures as function of tags applied

10.6 Copy of all of the information supplied by R.S. Hooton, MELP

Source	Total ST	Tagged ST	Tagged-Ur	Proportion	Prop. 95%	95% CI	prop. est	95% CI	Mean	95%CI	95%CI
Morice Spring Fisl	281	24.6	0.095944	0.087544	0.033046	0.054498	0.087544	0.120591	0.062417	0.031317	0.093517
Guide 1	280	23.575	0.091937	0.084196	0.032526	0.051671	0.084196	0.116722	0.062417	0.031317	0.093517
Guide 2	192	17.425	0.099814	0.090755	0.040633	0.050122	0.090755	0.131388	0.062417	0.031317	0.093517
Guide 3	111	4.1	0.038354	0.036937	0.035087	0.001849	0.036937	0.072024	0.062417	0.031317	0.093517
Guide 4	324	4.1	0.012817	0.012654	0.012171	0.000483	0.012654	0.024826	0.062417	0.031317	0.093517
Guide Combined	907	49.2	0.057356	0.054245							
Total	1188	73.8	0.066236	0.062121	0.013726						
Mean				0.062417							
Stdev				0.035477							
95%CI				0.031097							
Median				0.084196							

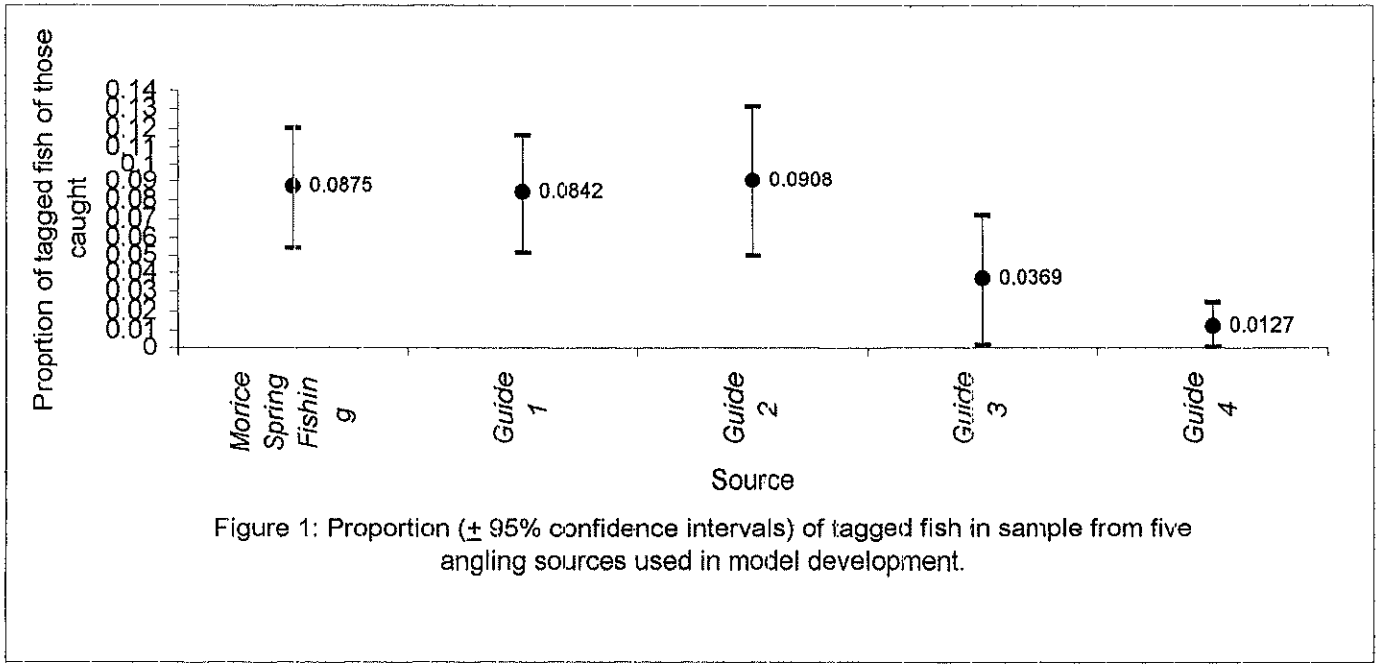

Figure 1: Proportion (± 95% confidence intervals) of tagged fish in sample from five angling sources used in model development.

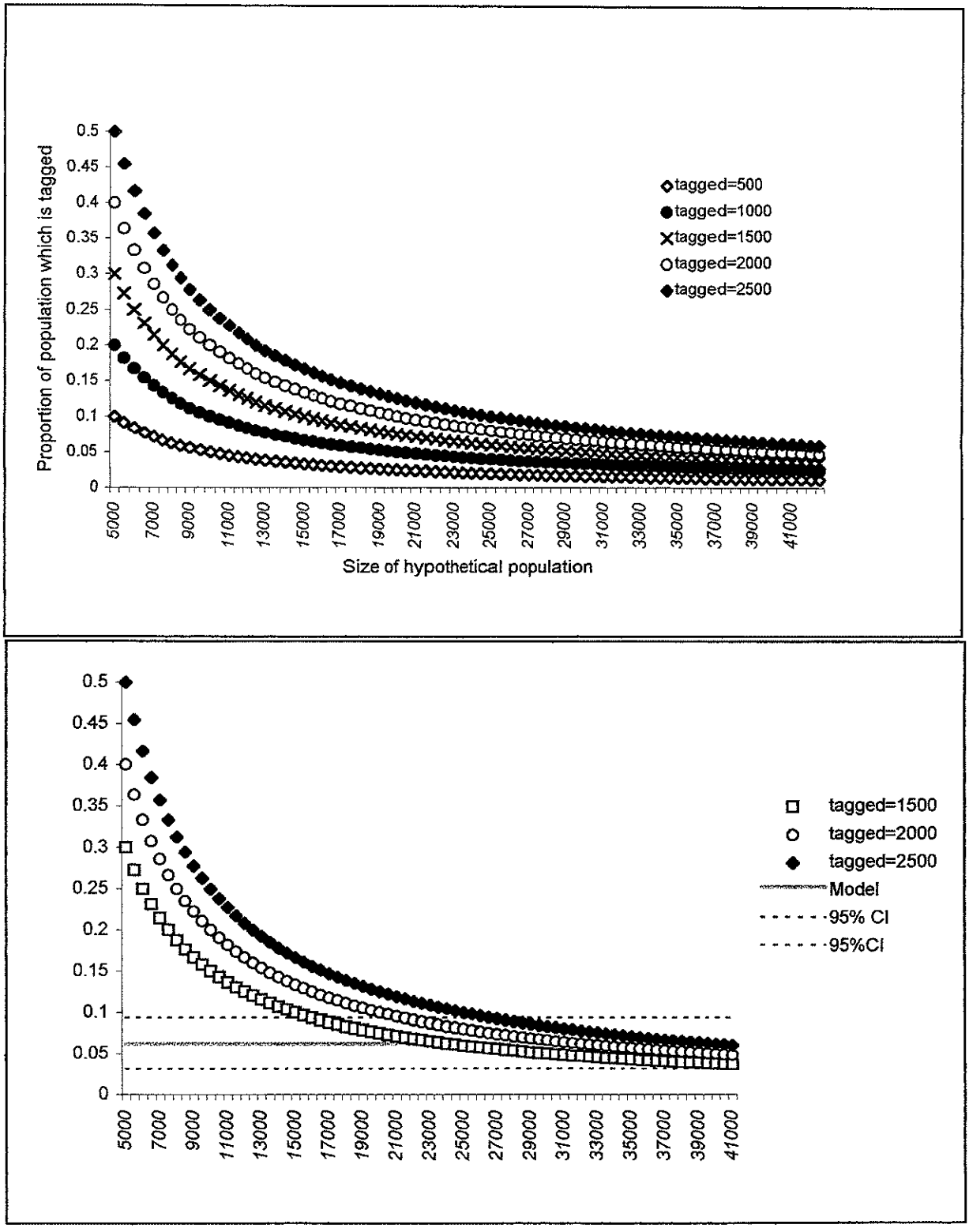

Figure 2: Tagged proportion of fish as function of population size for various tag rates. Model proportion included (lower) for comparison

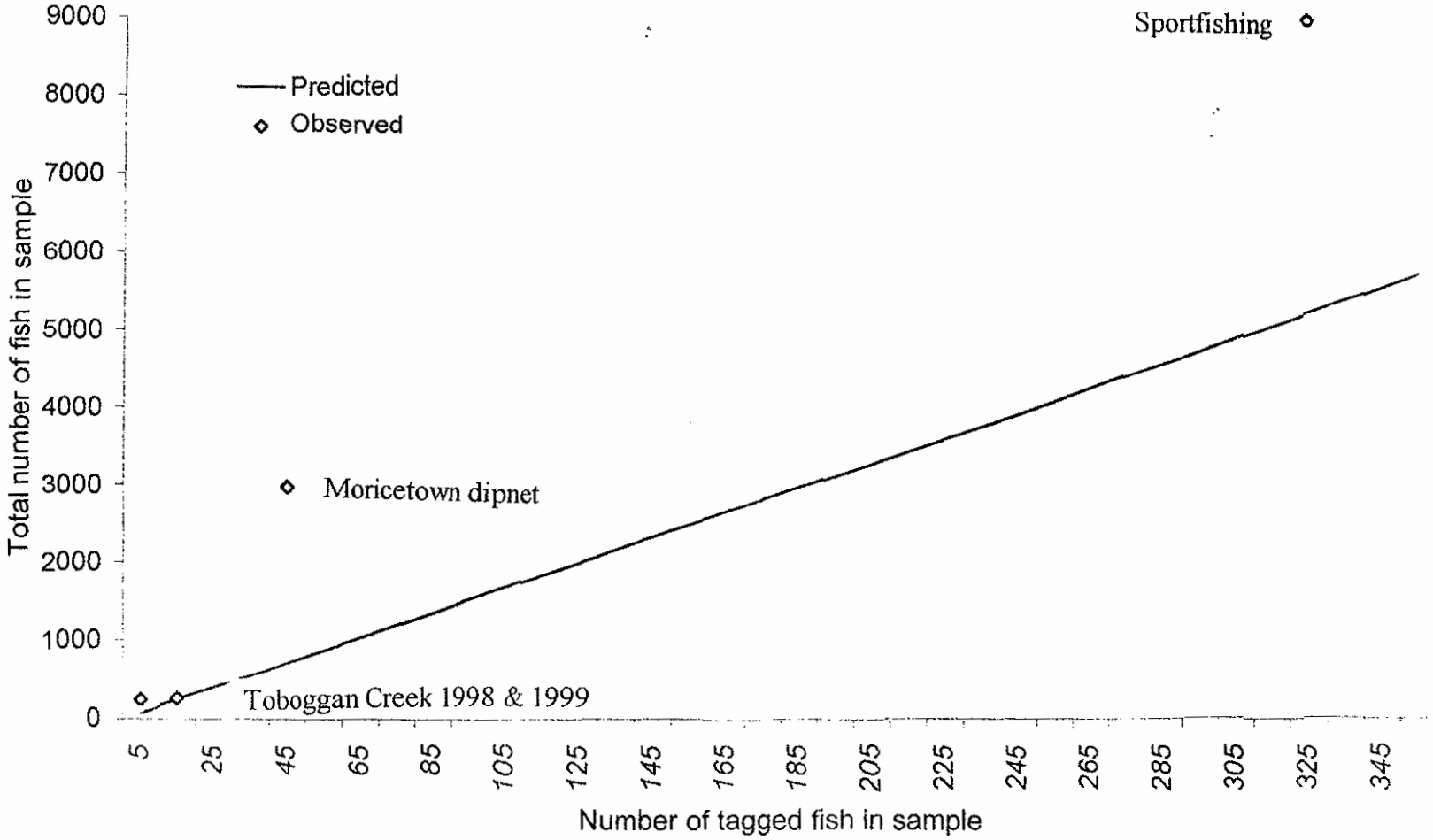

Figure 3: Validation chart. Four points are from Toboggan Creek, 1998 & 1999, Moricetown seining, and Sportfishing

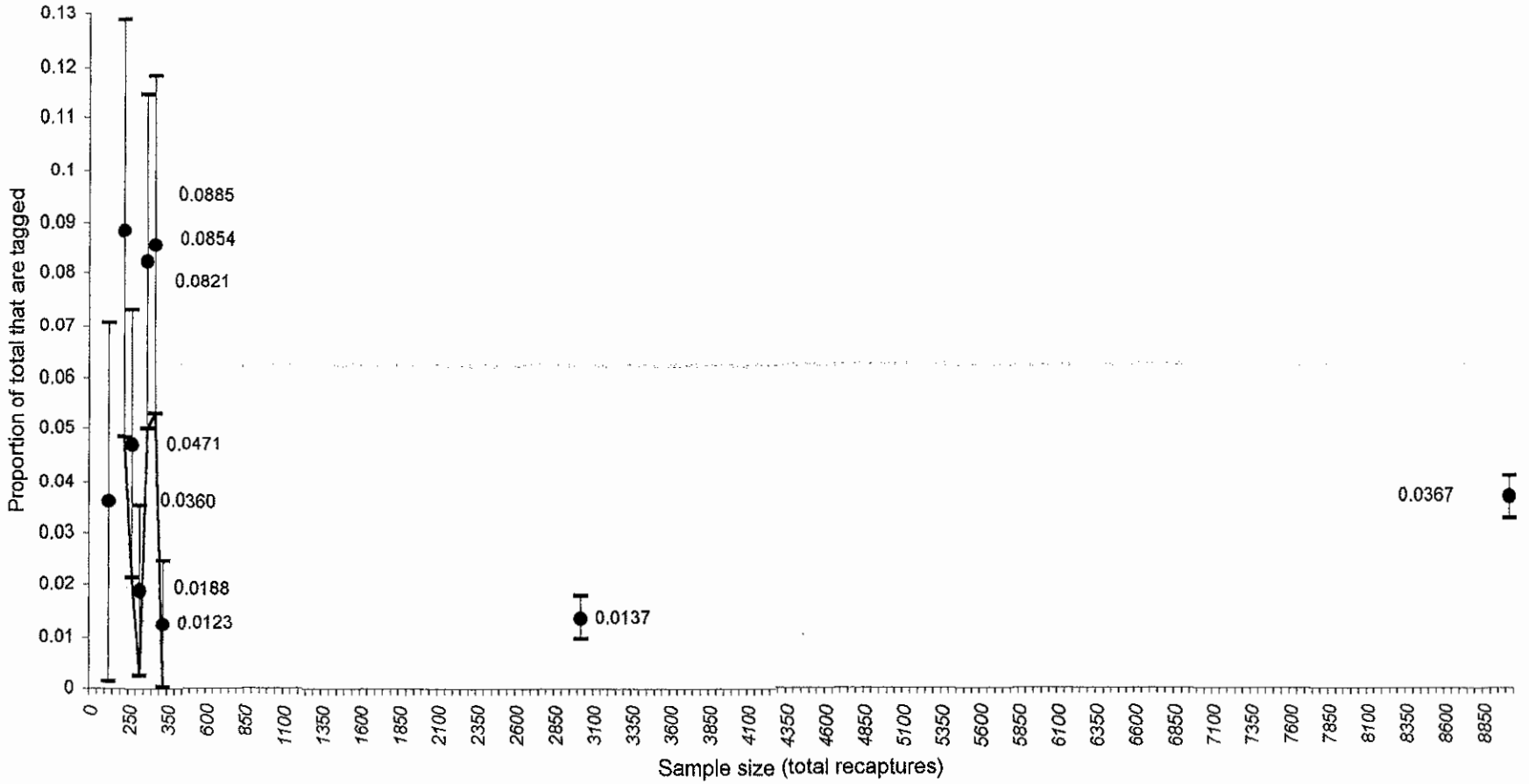

Figure 4: Proportion of total sample which are tagged as function of sample size for data sources used in analysis. Note great variability at small sample size with lower values at larger samples. Horizontal line is mean proportion used in model.

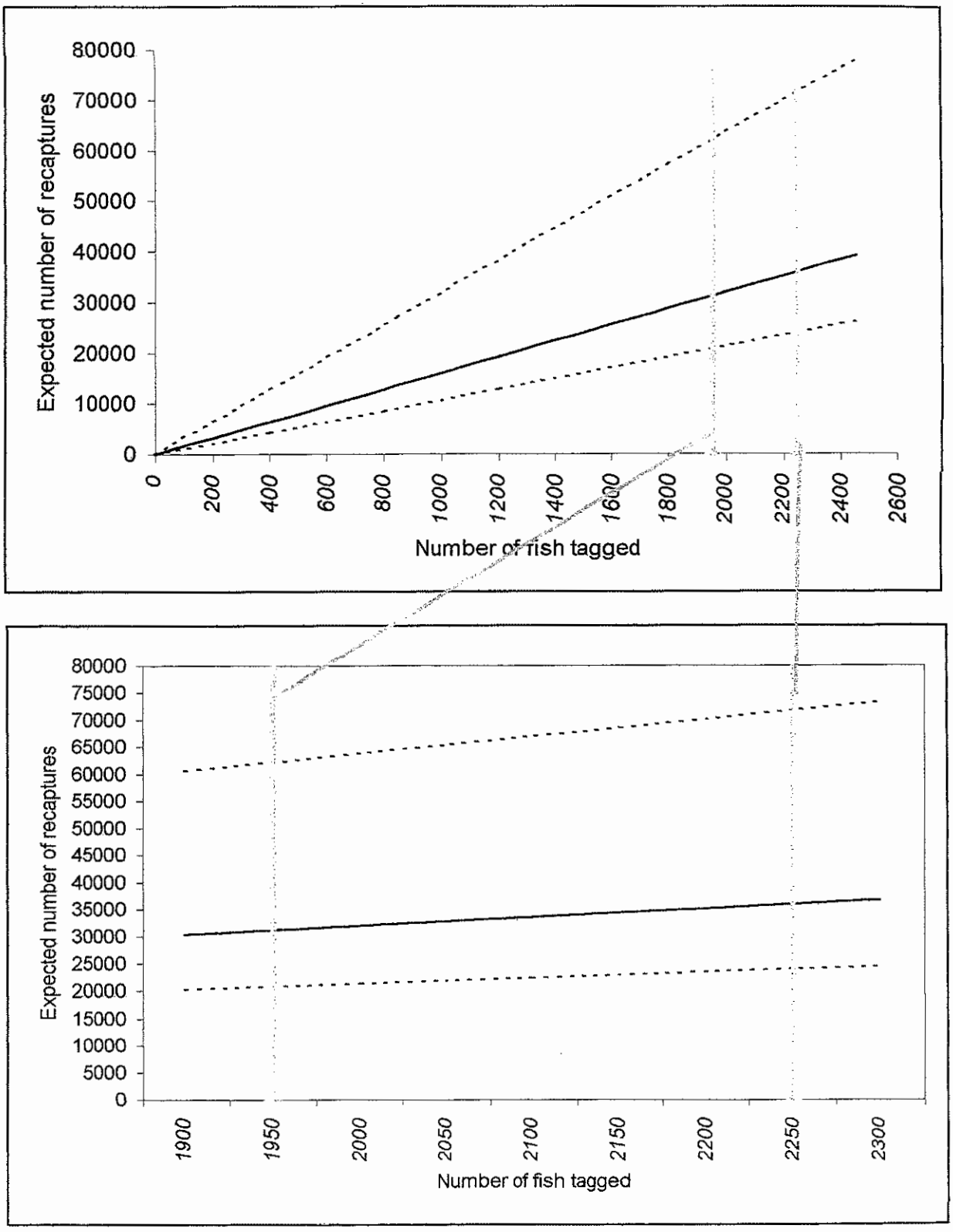

Figure 5: Projected number of recaptures as function of tags applied. Vertical lines indicate range of tags applied at Moricetown in 1998.

From: Hooton, Bob S ELP:EX <Bob.Hooton@gems1.gov.bc.ca>
To: 'Wadley, Gordon' <nortec@mail.bulkley.net>
Cc: White, Reid D ELP:EX <Reid.White@gems6.gov.bc.ca>
Subject: FW: Data Request
Date: May 20, 1999 5:02 PM

With respect to items 1 and 3 below there are some updates available based on further analyses over the past 24 hr. Please note the following.

* We have refined the range of the estimated number of tagged steelhead released at Moricetown. An exhaustive review of the data provided to us indicates there were 1866 different tag numbers recorded as applied to steelhead. Additionally there were 320 duplicate entries (i.e. the same tag number appeared twice) and 17 triplicate entries (i.e. the same number appeared three times). The low end of the range is therefore 1866 and the high end 2203 (1866+320+17). I emphasize again that on the basis of the data made available to us there is no way of determining how many of the duplicate and triplicate data entries should or shouldn't be included in the estimated number of tagged fish released. The number of tags at large during the recovery period in March is also speculative but certainly less than the number which may have been released at Moricetown 6-7 months previously.
* There was one additional Tyee test fishery origin tagged steelhead recovered in the Morice. The total number of Morice recoveries is now four, not three. Three were recaptured during the regular angling season and the fourth came during your March angling activity. To date there have been two recaptures of Tyee fish at the Toboggan fence. Detailed tagging records on these fish have already been sent to Mike O'Neill.

> -----Original Message-----
> From: Hooton, Bob S ELP:EX
> Sent: Wednesday, May 19, 1999 3:54 PM
> To: 'Wadley, Gordon'
> Cc: White, Reid D ELP:EX; Yardley, Jim R ELP:EX
> Subject: Data Request
>
> In response to the four questions posed in your e-mail of May 18 the
> following information is provided. The numbers correspond to the numbers
> in your message.
>
> 1. The tag data base from Moricetown does not provide certainty with
> respect to the number of individual tagged steelhead at large in the
> Bulkley system following the conclusion of that program. We have
> invested a man month or more in trying to determine "the valid number of
> tags" (your words), without success. LGL was similarly unsuccessful. The
> best estimate we can provide is that there were between 1950 and 2250
> steelhead tagged at Moricetown in 1998. How many of those fish may have
> been at large upstream from Moricetown during the period of the population
> estimation project is entirely speculative as has been noted on several
> previous occasions. No amount of reviewing the Moricetown tag data base
> is going to answer the question. The problems we have encountered with

> the data set imply the seine tagging records were accurate and complete.
> There were 389 steelhead tagged by the seine crews. Dip netting data
> presents numerous problems. On surface there appear to have been about
> 1875 steelhead tagged via that method. However as the recapture data was
> examined we discovered more than 300 duplicate tag numbers among the 1875.
> Whether this is related to different color tags bearing the same number,
> incorrect data entries or both cannot be determined from any information
> known to us.
>
> 2. To date we have had 336 Bulkley angler reports of tagged steelhead
> recaptures which we can trace to the 1998 Moricetown program. Please note
> these are the fall sport fishery recoveries and the total does not include
> the tags recovered by your crew during March. The 336 figure represents
> 294 individual fish recaptured once, 33 recaptured twice and 2 recaptured
> 3 times. There is no summary "print out" of this information, only
> individual pages on each tagged fish recovery for which matching tag data
> existed in the tagged fish data base which we maintain. We are not
> prepared to recall and print out the single page record of every tagged
> fish recovery due to the time and expense involved in that exercise. Such
> detail does not bear on population estimation in any event.
>
> 3. There were 520 tagged steelhead released at the Tyee test fishery in
> 1998. Recaptures in the Bulkley system by anglers numbered 11 of which 9
> were in the Bulkley and 2 in the Morice. Additionally there was one other
> Tyee origin tagged steelhead recaptured in the Morice during your project.
> Note that there are no data on the condition of the fish released at Tyee.
> It is not a given that 520 tagged steelhead arrived in upriver
> tributaries. In late January of this year I sent a written request for
> any data on test fishery origin tagged steelhead recovered at Moricetown.
> I have not received any response.
>
> 4. A copy of the data base printouts on the 25 Moricetown 1998 steelhead
> recaptured during your project in March of this year is available in our
> office. Twenty-two of the tag reports were readily traced to a single
> tagging record but the remaining three produced duplicate records. This
> is a good illustration of the problems we have encountered with the
> Moricetown records. Please make arrangements with our secretary Sharon
> Debruyne (847-7303) to pick up the envelope containing that material. You
> also reported five other tagged steelhead recaptures during March. Two of
> these do not match with any records in our electronic files, one was from
> Tyee, one courtesay of the Prince Rupert Fishing Vessel Owners Association
> (they do not provide records if they even have them) and one from the 1997
> Moricetown tagging. The Tyee and Moricetown 97 printouts are included in
> the package available from Ms. Debruyne. Note the significant differences
> in both length and sex when comparing those data recorded at the time of
> tagging with those same data recorded at recapture.
>
> The above information represents a large investment of Ministry time as
> well as reference to unique Ministry data bases. We trust any use of this
> information will be acknowledged and that no one will profit financially
> from it.
>
>
> Bob Hooton
> Head, Fisheries Section - Skeena Region