Habitat Use and Preliminary Conservation Status of the Mainstem Salmo River Rainbow Trout Population

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EXECUTIVE SUMMARY

- Prior to 2001, biologists have been unable to assess the conservation status of the rainbow trout population inhabiting the mainstem of the Salmo River due to limited information about trends or current levels of abundance, habitat use, and life history. To address these deficiencies, we initiated during 2001 a multi-year study of habitat use and population size employing radio telemetry as a primary investigative tool.

- Radio telemetry investigations of habitat use by adult and sub-adult trout (>30 cm) suggested that: (i) holding water during the summer low water period of 2001 and 2002 was limited to a few relatively large pools containing deep water and/or wood cover; (ii) overwintering habitat during the winters of 2001/2002 and 2002/2003 consisted of areas of deeper water and abundant wood or boulder cover; (iii) during springtime 2002, radio tagged fish utilized primarily mainstem areas for spawning, with only limited use of the bottom ends of tributaries and potentially little overlap with spawning areas of tributary-dwelling residents; and (iv) off-channel areas within the flood plain provided important refuge habitat during high water events for adult fish. A channelized section of the mainstem river extending from the town of Salmo downstream to Hellroaring Creek was conspicuously avoided by radio tagged trout, likely due to an absence of pool habitat and cover. The close association of rainbow trout elsewhere in the mainstem Salmo with deep water and cover suggests that habitat restoration work to create more area with depth and cover may be of benefit to the population.

- Although diver counts of trout in streams are commonly used to monitor trout abundance, few studies have directly investigated the relationships between diver observer efficiency and watershed physical conditions. We utilized diver observations of radio tagged trout, made during periodic surveys of a counting area located downstream of the town of Salmo, to estimate diver observer efficiency and its relationship with horizontal visibility and discharge during July 2001 and July 2002. Results from both years suggested that diver observations of radio tagged trout can be reliably used to estimate observer efficiency, but also that the relationships of observer efficiency to visibility and discharge may be affected by concealment behaviour associated with low flows. Changes in visibility and discharge, which were highly correlated, were good predictors of observer efficiency observations during July 2002, but observer efficiency did not change with changes in these variables during July 2001 (which had the lowest discharge levels observed for the Salmo River in the last decade). We recommend that a third year of the observer efficiency study be carried out under more typical flow conditions, to investigate whether results observed in 2001 were anomalous or they represent realistic interannual variability.

- Population estimates incorporating observer efficiency estimates and expectations for error were made for most of the swimmable length of the Salmo River extending from approximately Barrett Creek to a canyon reach located in the lower 5 km of the channel. Estimated adult (>40 cm) populations were 191 $\pm$ 22.4 and 145 $\pm$ 7.3 for July 2001 and July 2002, respectively. The estimates suggest that the population size may be approaching minimum levels considered adequate for conservation. Due to its small size and the possibility that it is to some degree demographically and genetically isolated, the Salmo River rainbow trout population may warrant additional study by biologists with respect to its conservation status. In the interim, special management actions to ensure the population's future viability and to maintain the quality of the fishery are needed. A change to a catch and release regulation on a portion of the Salmo mainstem, arising from the above results, has been implemented by MWLAP on an experimental basis beginning with the 2003/2004 angling season. Continued abundance monitoring, especially if it is accompanied with a willingness to experiment with alternative harvest regulations, is the key to learning about the population's status relative to meaningful conservation and management targets. We recommend that a program of diver counts in 2003 be expanded to take in the canyon reach in the lower 5 km of the channel, which was not surveyed during summer 2001 or summer 2002.

DEDICATION

This report is dedicated to Peter Neill. His enthusiasm for the rainbow trout of the Salmo River propelled our interest in this study. We all hope he can get out with us this summer to have some fun.

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The successful completion of this study was made possible only as a result of the co-operation of a large number of organizations and individuals within the following organizations.

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Bill Green, Les Brazier, and Kenton Andreashuk provided comments on the project, while Jaime Christales provided administrative assistance.

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BC Hydro supplied the radio tags that were utilized for the study and provided equipment and personnel. Specifically Ric Olmsted, Gary Birch and Dave Wilson were instrumental in providing funds and expertise for the project, with Ric providing assistance with fish capture. Dean den Biesen and Clint Tarala also assisted in the field.

BC Ministry of Water, Land and Air Protection

The BC Ministry of Water, Land and Air Protection provided tracking equipment and personnel to aid in the completion of the project. Specifically John Bell assisted with swims, fish capture, and tracking. Murray Pearson assisted with swims. Albert Chirico ensured collection permits were put in place to allow fish capture. Jay Hammond provided insight into project requirements and management issues.

Salmo Watershed Streamkeepers Society

Community volunteers that are members of the Salmo Watershed Streamkeepers Society assisted with various components of the project. Brian Henderson and Gerry Nellestijn assisted with swims, fish capture, and tracking.

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Jeremy Baxter provided technical assistance with all aspects of this project. Scott Decker also assisted with the project during swims, and through discussion. Aaron Shepard assisted with swims.

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Alice Nellestijn produced the fantastic poster for this project

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The club provided a letter of support for the project.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

INTRODUCTION

Background

Demand for quality trout stream fishing experiences is high in British Columbia, and this demand appears to be growing in the Kootenay Region particularly. The Salmo River, with its low flows, clear water, well-defined holding pools, and rainbow trout (*Oncorhynchus mykiss*) that can reach sizes of 50 cm or more, provides the highest quality small- to medium-sized stream fishery (currently open) in the Nelson area. Recreational use has not been measured but appears to have been relatively light in recent years, and an angler harvest has been permitted with a current daily limit of two rainbow trout over 30 cm. However, snorkel surveys of the system conducted in 2000, to investigate movements and abundance of other species, suggested that the rainbow trout population of the Salmo is currently small and may be depleted (Baxter and Nellestijn 2000). Concerned local residents and fisheries agency staff have also expressed the belief that the Salmo population was of small size, so we felt it possible that the population's status was of conservation concern.

Assessing the current status of the population from a data review was impossible, as no information existed about trends or current levels of adult trout abundance. This lack of information prevented regional fisheries staff at the BC Ministry of Water, Land and Air Protection (MWLAP) from making knowledgeable management decisions regarding the population. For this reason, MWLAP staff believed that a population estimate for the Salmo River, or at least an index of relative abundance, should be established as soon as possible (J. Hammond, fisheries biologist; formerly Regional Manager at MWLAP Nelson; pers. comm.). During spring, 2001, we initiated a study of the conservation status of the Salmo River's rainbow trout, which had the financial and/or in-kind support of MWLAP, BC Hydro, Beaumont Timber, the Columbia Basin Fish and Wildlife Compensation Program, the Columbia-Kootenay Fisheries Renewal Partnership/Columbia Basin Trust, and the Salmo Watershed Streamkeepers Society, and the West Kootenay Fly Fishing Club.

Conservation Biology

McElhany et al. (2000) introduced the 'viable salmonid population' (VSP) concept and defined it as an "independent population that has a negligible risk of extinction due to threats from demographic variation (random or directional), local environmental variation, and genetic diversity changes over a 100-year time frame." They identified four parameters for determining a population's conservation status relative to this definition:

1. *Abundance.* Population dynamics processes, including demographic stochasticity, genetic process (severe inbreeding and long-term genetic losses/genetic drift), and the effects of environmental stochasticity and catastrophes, work differently in small populations. It can be stated generally, however, that extinction risks posed by these forces are magnified greatly at very small population sizes (Simberloff 1988; Nunney and

Campbell 1993). Empirical studies of extinction in mammals and birds have generally suggested that an adult population size of $N < 50$ is clearly insufficient for a population's long-term persistence, populations of $50 < N < 200$ are marginally secure, and those of $N > 200$ are secure at least over time frames as limited as those used in the studies (reviewed in Boyce 1992).

2. *Population growth rate.* The population growth rate is the trend in the population’s abundance and is either positive (increasing population) or negative (declining). At small population sizes it appears that demographic and environmental stochasticity are more immediate and potent threats than are inbreeding and genetic drift. However, under a situation of negative population growth rate all of these can be likened to the final death throes of an organism that was already known to be dying (Caughley 1994). The anthropogenic external agents that forced the decline (negative population growth rate) to these population sizes in the first place - often overharvest and habitat destruction in salmonid populations - are far more important than any of the above, and extinction is likely unless these agents are identified and corrected and the negative population growth rate reversed.

3. *Population spatial structure*. A salmonid population's spatial structure affects extinction risk through processes increasing resilience to environmental stochasticity (variability in environmental conditions) and through evolutionary processes (genetic diversity) that affect a population's ability to respond to environmental change. A population consisting of multiple, connected sub-populations are generally thought to be more robust to extinction forces than is a single group (Simberloff 1988).

4. *Diversity*. Phenotypic and genetic diversity is an important part of salmonid population viability, for three general reasons. First, diversity allows a population to use a wider range of environmental conditions. Second, it protects a species against short-term spatial and temporal changes in the environment, and third it provides the raw material for surviving long-term environmental changes (McElhany et al. 2000). Gene flow via strays from other populations and sub-populations is one potential source of diversity that can be cut off by human actions such as dams (which have affected the Salmo River population). Conversely, stocking hatchery fish, which occurred in the Salmo River watershed between 1924 and 1953, can dilute important genetic adaptation of the population if a large degree of introgression (successful interbreeding) between the native and hatchery fish occurs.

Genetic and demographic mechanisms of extinction at small population sizes have received much attention by workers in conservation biology (reviewed in Simberloff 1988; Caughley 1994), and generally accepted theory and population size guidelines are emerging. However, Caughley (1994) has pointed out that the anthropogenic agents that force negative growth rates, critically low population sizes, unconnected relict populations, and insufficient or poorly adapted genetic diversity are not as easily generalized and quantitative investigations usually must be on a situation-specific basis. The goal is to get these agents within the reach of analytical methods. Towards this end Caughley (1994) recommended first studying the natural history of the population -

ecology, context, and abundance - in order to identify putative agents of population decline, then confirming the causal linkage via carefully monitored management experiments. The program of study initiated in the Salmo River watershed during spring, 2001 and continued through to the winter of 2002 was designed to gather the natural history information - habitat use, life history, and population spatial structure - required by regulatory agencies prior to undertaking adaptive management. This report presents results of the population monitoring studies conducted during July 2001 and July 2002, and the adult rainbow trout habitat use study for rainbow trout radio tagged during 2001. A limited amount of information on habitat use by rainbow trout radio tagged during 2002 is also presented – migration timing and spawning habitat use by these fish cannot be investigated until spring, 2003.

Study Design

Our principal objectives for this study of the Salmo River watershed's rainbow trout population were twofold:

1. To establish the relative importance of habitats throughout the Salmo River watershed for the rainbow trout population, for evaluation of protection, restoration, and enhancement priorities as well as population spatial structure.

2. To establish an index of abundance that could be related to the size of the adult rainbow trout population (and that incorporated estimates of uncertainty), and would be sufficiently cost-effective for the long-term monitoring required to investigate population abundance and growth rate.

We chose radio telemetry as a method for investigating habitat use by Salmo River rainbow trout, a technique that has been utilized frequently in British Columbia for these purposes. Our goal during the first year of the study (2001) was to distribute radio tags throughout the watershed in proportion to the relative abundance of taggable fish - if each fish had an equal chance of receiving a tag and then habitat use could be quantified from the telemetry record rather than merely described. A smaller number of fish were also radio tagged during 2002, although all of these were in one section of the river for use in the population estimation study.

The Salmo River is typically clear enough during early summer to permit the use of drift diving (snorkel surveys) as a technique to count larger trout (Northcote and Wilkie 1963; Slaney and Martin 1987; Zubik and Fraley 1988; Young and Hayes 2001). Drift diving is a quick, inexpensive, and non-destructive census technique that can be employed in relatively deep, swift water. However, it must not be assumed that all fish present are seen or counted accurately during diver surveys. Variability among counts of independent divers is small (Schill and Griffith 1984; Zubik and Fraley 1988; Hillman et al. 1992), but this is not a complete measure of the reliability of diver counts as indices of fish abundance. The proportion of the total number of fish present that is missed by divers (visibility bias) and variability in this proportion must also be considered. Individuals are missed because of imperfect visibility, fish behaviour, and stream channel complexity in addition to observer error. Evaluating the visibility bias of diver counts in streams, which requires that an independent estimate of the number of fish present in the survey area be available, is an important step because counts are frequently inaccurate. The proportion of fish present in survey sections actually seen by divers can be highly variable, ranging from 8-16% to 100% in published accounts (reviewed in Young and Hayes 2001).

Mark-resight techniques in combination with visual surveys (Slaney and Martin 1987; Zubik and Fraley 1988; Young and Hayes 2001) can be used to address the problem of unseen individuals. A number of assumptions are implicit in the method, however, including: (i) no emigration of marked individuals out of the study area; (ii) no mortality or harvest of tagged individuals; (iii) tagged and untagged individuals are equally likely to be seen; and (iv) tagged individuals will be always be recognized as tagged individuals (Young and Hayes 2001). Violations to these assumptions will presumably grow increasingly more serious as the amount of time between marking and resight surveys increases. The use of radio tagged individuals as marked fish (Korman et al. 2002) allows errors from violations to assumptions (i) and (ii) to be accounted for because the number of tagged fish in the survey area can be known with nearly exact certainty, which is of obvious benefit when multiple resight surveys are planned over a longer time period. Annual mark-resight studies would obviously be costly relative to diver counts alone, but would be required unless the ratio of diver counts to the real population size is consistent across years and viewing conditions. Few studies have investigated the variability of diver observer efficiency (ratio of fish seen: fish present) in standard snorkel survey practices and its relationship to changes in viewing conditions. However, in the Cheakamus River, BC, relatively precise relationships have been described between diver observer efficiency (derived from a mark-resight study using radio tags in marked fish) and underwater visibility and discharge for steelhead (Korman et al. 2002). If consistent among years, these relationships can be applied to standard diver count observations in the future to acquire population estimates for the counting section, precluding the need for costly annual mark-resight studies.

Our design for a mark-resight study to investigate diver efficiency in the Salmo River specified the use of fish radio tagged in 2001 and 2002 as the marked individuals, by deploying pairs of high visibility anchor tags in each fish in addition to the radio tag. Diver efficiency during periodic counts was to be estimated as the proportion of marked fish seen on each survey date as a ratio with the number known to be present. We also wished to develop a model for the relationship between observer efficiency and watershed conditions (discharge, visibility) to investigate whether future diver counts could be adjusted for interannual variability in these conditions, so stream discharge (Water Survey of Canada data) and horizontal visibility were to be recorded for each of the survey dates.

The designs for the population estimation procedures for 2001 and 2002 used the observer efficiency estimates in different ways. For 2001 the study design for the habitat use study specified that each taggable fish have an equal probability of receiving a tag. To achieve this, we were to first conduct diver counts over the entirety of the length of the Salmo River we considered surveyable, which we thought would correspond approximately to the distribution of fish >30 cm (Baxter 1999). Radio tags would then be allocated to various stream sections in proportion to the counts of trout. The necessary assumptions were that observer efficiency would be comparable along the length of the Salmo, and movements of the radio tagged fish would be representative of the untagged fish as well. After the completion of the observer efficiency study, the estimate of the population size for the swimmable section of the Salmo River could be calculated by expanding the average diver count in the index section during the observer efficiency study by two parameters: (i) the average value of the observer efficiency, and (ii) the average relative distribution of tags to the index section during the observer efficiency study. Wishing to avoid the reliance on the above untestable assumptions, we planned in 2002 to conduct diver surveys along the swimmable length of the mainstem during the same period covered by the 2002 observer efficiency study. Counts for each of the sections along the Salmo's swimmable length would then be expanded by observer efficiency estimates for each, based on results of the observer efficiency study, to generate population estimates for each section. The overall population estimate would then be the sum of the estimates for the sections.

Study Area

The Salmo River rises from the Selkirk Mountains 12 km southeast of Nelson, B.C. (Figure 1). The river flows in a southerly direction for approximately 60 km from its origin to the confluence with the Pend d'Oreille River (Seven Mile Reservoir). The system is a 5th order stream, and has a total drainage basin area of roughly 1,300 km^2. Elevation in the basin ranges from 564 meters at its confluence to 2,343 meters at the height of land. Within this elevation range, the system comprises two biogeoclimatic zones. At lower elevations, the valley lies within the Interior Cedar-Hemlock zone, while areas in the higher elevations are found within the Englemann Spruce-Subalpine Fir zone.

The Salmo River has a total of eight 2nd and 3rd order tributaries (including Apex Creek, Clearwater Creek, Hall Creek, Barrett Creek, Ymir Creek, Porcupine Creek, Erie Creek, and Hidden Creek) and two 4th order tributaries (Sheep Creek and the South Salmo River) (Figure 1). The Water Survey of Canada maintains a gauging station on the Salmo River downstream of the town of Salmo. Mean annual discharge in the Salmo River (1949-1976) was 32.5 $m^3 \cdot sec^{-1}$, with mean monthly minimum and maximum values of 7.5 and 128.5 $m^3 \cdot sec^{-1}$, respectively. Runoff reaches a peak in May, with the highest flows between April and July each year.

In addition to rainbow trout, many other fish species are distributed in the watershed. These include bull trout (*Salvelinus confluentus*), eastern brook trout (*S. fontinalis*), mountain whitefish (*Prosopium williamsoni*), largescale sucker (*Catostomus macrocheilus*), longnose sucker (*C. catastomus*), northern pikeminnow (*Ptychocheilus oregonensis*), longnose dace (*Rhinicthys cataractae*), redside shiner (*Richardsonius balteatus*), and slimy sculpin (*Cottus cognatus*). Natural populations of steelhead trout (*O. mykiss*) and chinook salmon (*O. tshawytscha*) have been extirpated from this system due to past hydroelectric development on the lower Columbia River.

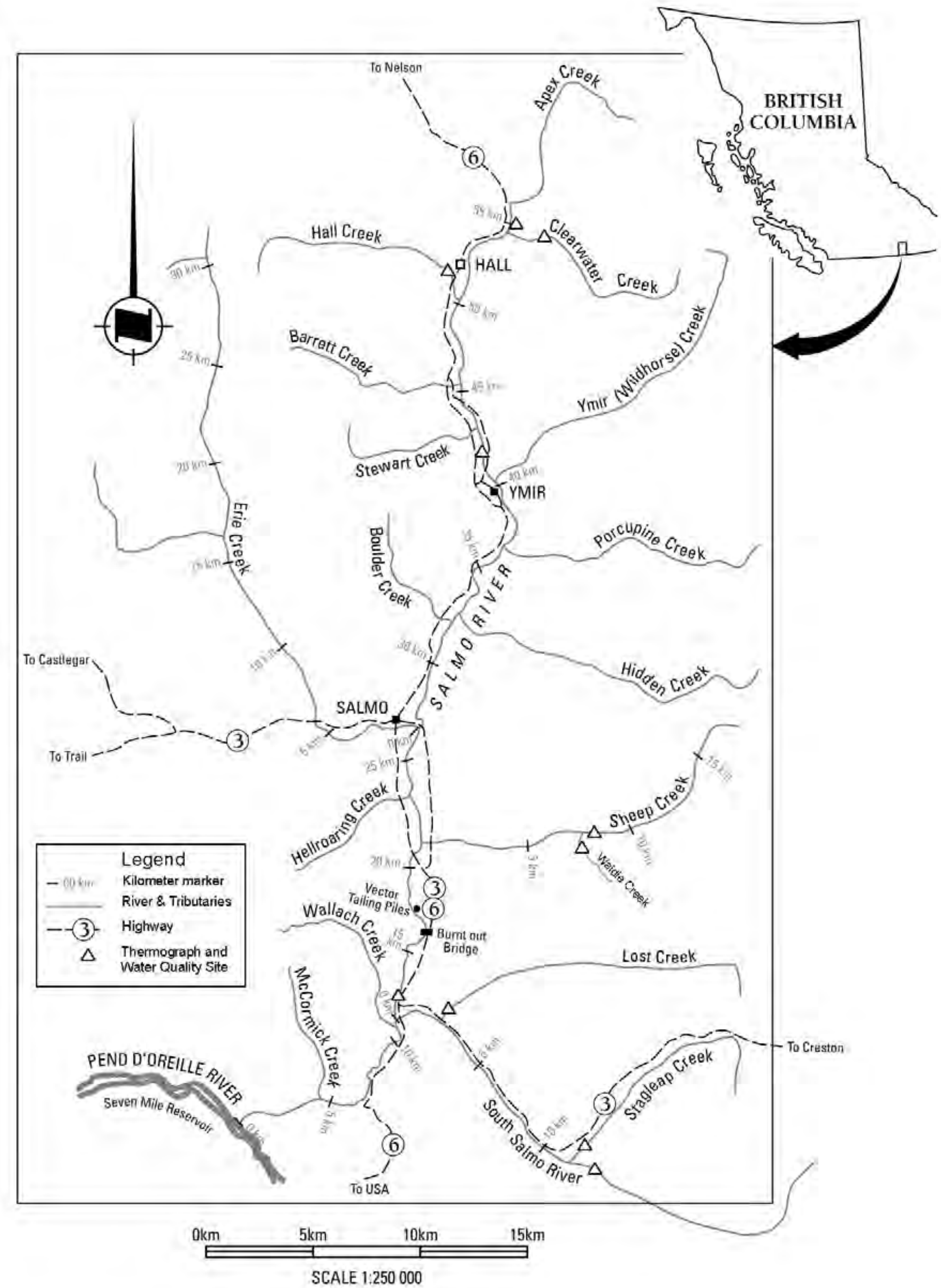

Figure 1. The Salmo River watershed study area.

METHODS

Fish Capture and Tagging

Of the 30 radio tags used for the study 2001, 29 tags were initially available and were allocated to the various stream sections in proportion to the relative abundance of catchable (>30 cm) rainbow trout in each section. This was determined at the outset of the project by diver counts conducted by two teams of divers on June 18 and June 19, 2001. The entirety of the swimmable watershed thought to contain taggable fish (Baxter 1999 and 2001) was surveyed, a section extending from the Hall Creek confluence downstream approximately 40 km to a point located 5.7 km from the Seven Mile Reservoir at the top of a steep canyon reach. All rainbow trout captures during spring, 2001 were made by angling in the mainstem Salmo River from June 1 to June 30 (one additional fish was captured and radio tagged on September 19). Angling therefore had been initiated prior to the diver counts, but effort and success were insufficient to exceed allocations for each stream section prior to their being established by the divers. Gear utilized included artificial lures and flies, as well as salmon egg bait. Freshet conditions lasted longer in 2002, delaying the onset of tagging and diver counts. Rainbow trout captures were made between June 10 and July 4, and all were in the section used for the observer efficiency study, located downstream of the town of Salmo (see below).

Methods for surgically implanting tags in suitable rainbow trout were the same for both years. To facilitate handling and reduce stress on the fish, trout were held prior to and after tagging in zippered tubes made from black, rubberized fabric with flow-through ends (Appendix I-Plate A). Fish selected for radio tagging were a minimum of 35 cm in fork length and 0.50 kg in weight so that the weight of the radio tag did not exceed 2% of the fish weight. Sterile conditions were maintained at the surgery site with the biologist using surgical scrub to sterilize his hands and donning sterile latex gloves. All operating instruments and radio tags were sterilized and disinfected in a container filled with 50% benzylkonium chloride diluted in distilled water at a concentration of 1000 PPM. A solution of Vidalife (Syndel International Inc., Vancouver, BC) at a concentration of 75 PPM was sprayed on all handling nets, the surgery trough and added to the anaesthetic bath to reduce the loss of the slime coating of the fish.

Radio tags utilized for this study were manufactured by Lotek Wireless Inc. (Newmarket, ON). Tags used were model MCFT-3EM (11 mm diameter, 49 mm length, 4.3 g weight in water, operational life >598 days). The tags were programmed to be operational for a total of 8 hours a day, and were digitally coded tags transmitting at a 2.5 or 5 second burst rate on one of four frequencies.

Once it had been decided that a captured trout would receive a radio transmitter, the field surgery station was set up (Appendix I-Plate B) while the fish was allowed to recover from capture (typically for a minimum of 10 minutes). The fish was then anaesthetized in water containing diluted clove oil (emulsified in 95% ethanol) at a concentration of 100 PPM (Prince and Powell 2000). When the trout had reached the stage of anaesthesia where it had lost its equilibrium and no longer responded to external stimuli, it was removed from the anaesthetic bath and placed on its back in a V-trough lined with foam (Appendix I-Plate C). Irrigation of the gills of the fish was started immediately upon removal from the bath (Appendix I-Plate C). A 3-4 cm incision was then made into the abdominal cavity (left hand body side wall about 3-5 cm anterior of the pelvic fins) using a scalpel fitted with a curved (No. 12) blade (Appendix I-Plate D).

After the incision was complete, a 16-gauge stainless steel needle was inserted through the abdominal wall posterior to the incision and back out the incision. The antenna of the radio tag was then threaded through the needle and the needle was pulled out, leaving the antenna protruding from the side wall of the fish. The radio tag was then inserted into the abdominal cavity, and the incision was closed with three interrupted sutures of braided silk on a cutting needle (Appendix I-Plate E). The antenna of the radio tag was then sutured to the body wall with one interrupted suture (Appendix I-Plate F) to prevent movement and irritation by the antenna at the exit point from the body wall. Finally the closed incision and exit point of the antennae were swabbed with Betadine (Syndel International, Inc., Vancouver, BC), and the fish was placed in a flow through tube for recovery for at least 10 minutes. During each surgery, the time in the anaesthetic, the time in surgery, and the recovery time were all recorded.

Biological sampling for rainbow trout captured in 2001 was more extensive than in 2002. First, a small section of the adipose fin was removed and stored, along with a label, in a vial of 95% ethanol for genetic analysis (Taylor 2002). Following this a sample of at least 10 scales was removed for aging analysis, and two orange T-anchor tags (Floy Tag, Seattle, WA) were inserted into punctures on either side of the fish's back at the posterior insertion of the dorsal fin. Sex (if mature), fork length (mm), girth (mm), mass (g) Floy tag numbers, radio tag frequency and code, genetic sample number, condition at time of release, and tagging location were recorded. Biological sampling during spring 2002 differed from 2001 in that fin and scale samples were not taken and fish mass was not measured. Radio tagged trout received white Floy tags in 2002 to distinguish them from fish tagged during 2001.

Radio Telemetry

All of the telemetry information used for the study's analyses was collected by mobile tracking, either by: i) boat along the counting section on the same day as diver counts; ii) helicopter during surveys of most of the watershed, frequently concurrent with bull trout telemetry surveys (Baxter 2002); or iii) a combination of foot, boat, and vehicle surveys (according to stream navigability and proximity of roads to the channel) over the whole stream length used by radio tagged fish. Helicopter flights occurred on August 13 and September 8, 2001, and January 11, April 22, May 2, May 31, and December 11, 2002. Tracking took place approximately bi-monthly between the completion of diver counts in late July 2001 and the onset of the spawning period in April 2002, when tracking was approximately weekly until mid-June. A single flight was the only tracking event after the completion of diver counts in late July 2002, primarily to identify overwintering areas and determine which of the radio tagged fish were likely still alive.

Radio reception for surveys on foot or by boat along the river channel was through a whip antenna attached directly to the receiver. During helicopter surveys a two-element antenna was attached to the base of one of the helicopter's skids, and was oriented with the elements perpendicular to the water surface. The two-element antenna was attached to the roof rack of a truck during vehicle-based surveys. During all surveys positions of tagged fish were recorded on prepared, 1:20,000 maps that showed distances from the mouth as marks located every 0.1 km. During telemetry surveys along river channels in spring 2002, potential spawning areas were surveyed for redds if discharge and visibility conditions were suitable.

Diver Counts

The counting section of the Salmo River used for estimating observer efficiency extended from the end of Carney Mill Road (26.2 km), near the town of Salmo, downstream approximately 9 km to an access point along Highway 3 at a former bridge crossing ("burned out bridge" – 17.3 km). Four divers were utilized for each survey, which was sufficient to cover the entire usable width for most of the surveyed length on each of the survey dates. Where possible a diver's 'lane' extended approximately 5 m toward shore from his swimming position, with the two offshore divers positioned back-to-back in the middle of the stream. When the usable wetted width exceeded 20 m one or more of the divers would extend his lane width and look both ways, with frequent stops required to discuss whether duplication had occurred. Observed fish were described as to species, and rainbow trout were classified into one of 5 size categories: 0-20 cm, 20-30 cm, 30-40 cm, 40-50 cm, and 50+ cm. Radio tagged fish were identified by their orange (2001-tagged) or white (2002-tagged) Floy tags, and observations were noted for comparison with telemetry results from that survey date. Size estimation was practiced on models suspended in the water column at the survey start point. Visibility (horizontal secchi disk distance) was recorded three times during each diver survey, at the beginning and completion of the survey and once at midday.

Data Analyses

Size and age at maturity

Estimating the abundance of adult rainbow trout in the Salmo River mainstem was a goal of the study, which required that the body size at maturity be reliably determined. To estimate the age and size that fish spawned for the first time, we recorded signs of recent spawning activity for rainbow trout captured in June of both years, and compared these to patterns of scale growth and resorption from scale samples taken from 2001 captures. As the first step in scale analysis one scale suitable for analysis was identified under 36X magnification on a microfiche reader-printer, and photograph was made. Cleaning of scales was not usually required. Regions of closely spaced circuli were identified as annuli. Each photographed scale was measured along the focus-anterior axis, the radius of each annulus and the outer scale margin being recorded. Spawning at a given age was suggested by, in order of reliability: (i) signs of recent spawning (worn tail, loose belly, dark coloration) recorded at time of capture (for last annulus); (ii) patterns of broken or resorbed circuli at the annulus; (iii) substantial reductions in the scale annual growth increment (signalling onset of maturity) following steady, large growth increments; and (iv) no plus growth since the most recent annulus.

We investigated the relationship between fish length and scale radius for 37 Salmo River rainbow trout using ordinary least-squares regression. Lengths at age were then back-calculated using the Fraser-Lee equation (Devries and Frie 1996):

$$l_k = c + (L - c)r_k/R$$

where: l_k is the length at age k,
- c is the constant of proportionality from the fish length/scale diameter regression
- L is the fish length at time of capture
- r_k is the radius of the annulus at age k
- R is the scale radius at the time of capture

Observer efficiency

We compared observer efficiency (radio tags seen / radio tags known to be present) with two variables representing physical conditions for the surveys, horizontal visibility (m) and discharge ($m^3 \cdot sec^{-1}$), using ordinary least squares regression (Zar 1996) for untransformed and log-transformed data, respectively. We also used regression analysis to evaluate the relationships between diver counts of untagged fish and physical conditions, the reliability of observer efficiency estimates as predictors of counts of untagged fish, and the relationships between discharge and visibility. Only radio tags deployed during the same year that each observer efficiency study was conducted in were used for estimates of observer efficiency, so that the estimate of the number of tags still functioning in live fish could be considered reliable.

Population estimates

For 2001, we generated the population estimates for Salmo River rainbow trout greater than 30 cm (available for harvest) and 40 cm from the estimated parameters C (average count in index section), λ (average diver observer efficiency), and r (average relative distribution of radio tags to the index section) utilizing stochastic simulations (Hilborn and Mangel 1997) within a Microsoft Excel spreadsheet. Each population estimate N was the average of 1,000 calculations of:

$$N = C / (\lambda * r)$$

where in every iteration each of the parameter values was generated stochastically from the error structure observed for that parameter during the 6 surveys of the counting section. The 95% confidence intervals for the population estimates were taken to be the 2.5% and 97.5% percentiles from the cumulative distribution of the Monte Carlo estimates.

In 2002 we conducted diver surveys along the swimmable length of the mainstem during the same time period covered by the 2002 observer efficiency study. The population estimates for the swimmable length were then:

$$N = \sum_{i=1}^{k} C_i / \lambda_i$$

where N is the population estimate (>30 or >40 cm), C_i is the diver count for section i, λ_i is the estimated observer efficiency for section i, derived from the observer efficiency study, and k is the total number of stream sections. We estimated confidence intervals from the cumulative distributions of 1000 estimates of N (for each of the two size distributions), where λ_I was simulated stochastically for each section based on the observer efficiency relationship for that year and error around the regression line.

RESULTS

Transmitter Distribution and Biological Sampling

In 2001 the diver counts of catchable rainbow trout (>30 cm) along the length of the Salmo River that were the basis for radio transmitter allocation took place on June 18 and June 19 2001, after tagging had already been initiated. Our goal was for tagging to be completed as shortly as possible after the distribution swims so that the relative distribution of tags was still representative. Very low densities of catchable rainbow trout were distributed upstream of the town of Ymir, located 43 stream kilometers from the mouth at the Wildhorse Creek confluence (Figure 1). Catchable fish were more prevalent between Ymir and the town of Salmo (located at 28.4 stream kilometers at the Erie Creek confluence), with abundances increasing downstream of Salmo until the sharp peak of relative abundance was reached between Sheep Creek (22.8 stream km) and a former bridge crossing located 17.3 stream kilometers from the mouth. Catchable rainbow trout were again less prevalent in habitats downstream, and were relatively rare downstream of the South Salmo River confluence (12.1 stream km).

Tag allocations (of 29 available) were 1, 3, 2, 5, 13, 3, and 2 for the Hall Creek (53.4 km) to Wildhorse Creek (43 km), Wildhorse Creek to Hidden Creek (34.7 km), Hidden Creek to Erie Creek (28.4 km), Erie Creek to Sheep Creek (22.8 km), Sheep Creek to former bridge (17.3 km), former bridge to South Salmo River (12.1 km), and South Salmo River to canyon (5.7 km) stream sections, respectively. Radio transmitters were distributed to rainbow trout angled over the period from June 1 to June 30, the earliest period suitable for both the distribution swims and relatively efficient fish capture (because of prior freshet conditions). Angling was terminated when the above goals for tag allocation were approximately met, with 0, 4, 2, 5, 13, 4, and 1 transmitters deployed, respectively, for the same stream sections mentioned above (Figure 2; Appendix II). It is important to note that some care was taken to ensure that the allocation goals were met exactly for the counting section, located between Carney Mill Rd. in Salmo (26.2 km) and the former bridge site (18 tags total - Erie C. to Sheep C. and Sheep C. to former bridge sections).

In 2002, all 10 radio tags available were deployed in the counting section between Carney Mill Road in Salmo and the former bridge site (Figure 2; Appendix II), as they were to be used primarily in the observer efficiency study.

Capture information and body size data for individual fish are presented in Appendix II, for both years. Salmo River rainbow trout are large. Fish sampled from the catch ranged in size from 25 cm to 60 cm, averaging an impressive 45 cm (n = 51; SE = 1.1 cm). Visual evidence of physical maturity or recent spawning was noted, as fish captured in June (both years) and early July (2002) presumably took place shortly after the completion of spawning activities. Of the 20 fish that showed evidence of spawning in spring 2001, and the 7 that showed evidence of spawning in spring 2002 (others showed no evidence or there was uncertainty), none were smaller than 39 cm in length, suggesting that this length was the best estimate of the threshold body size for adulthood.

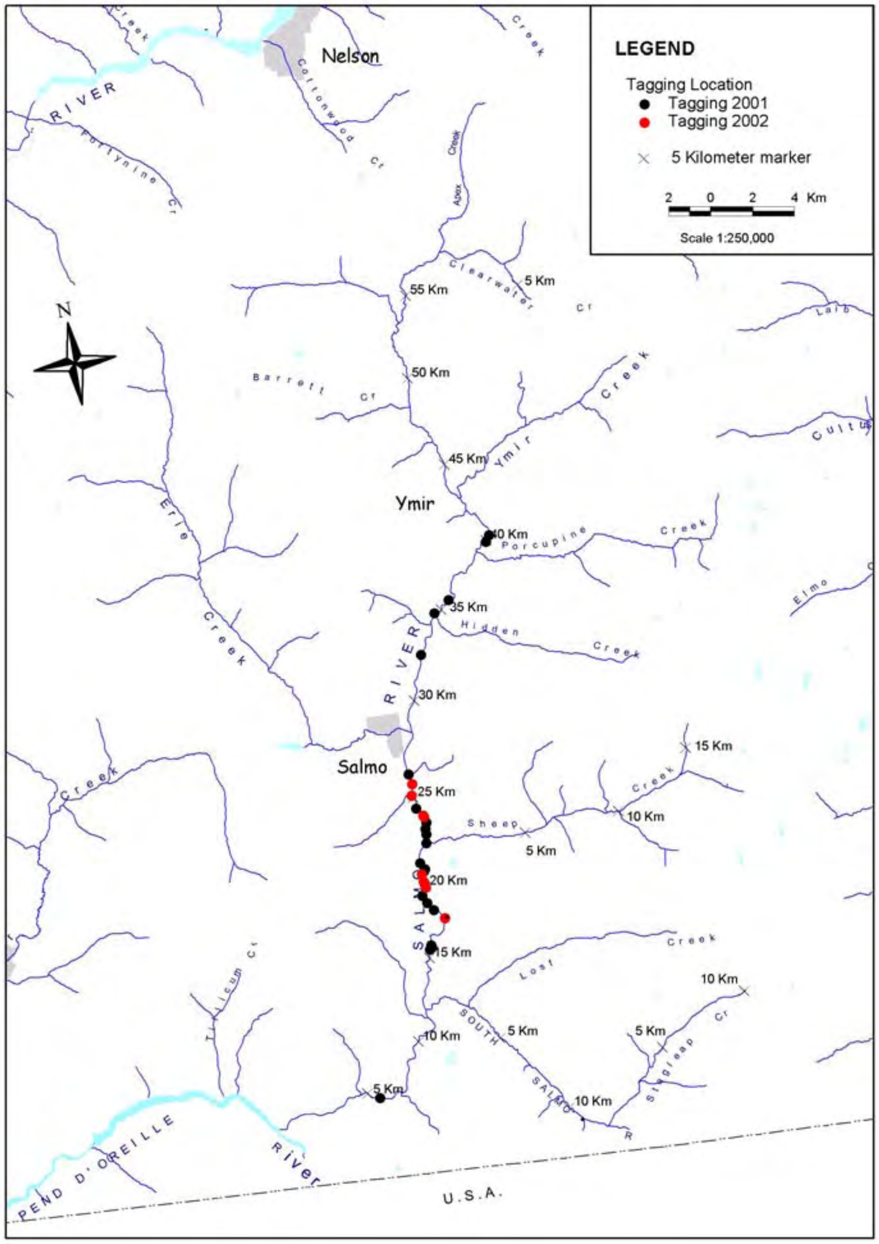

Figure 2. Capture locations of radio tagged rainbow trout in the Salmo River watershed in 2001and 2002.

Of the 43 fish sampled for scales in 2001, readable scales were available for 37 fish ranging from 25 to 60 cm fork length (Appendix III). Scale diameter was a relatively good predictor of rainbow trout fork length (Figure 3; $r^2 = 0.77$), allowing back-calculation of lengths-at-age for a scale radius corresponding to a preceding annulus. Back-calculated average lengths-at-age were 31 cm (*n* = 37; *SE* = 0.72), 39 cm (*n* = 34; *SE* = 0.76), 45 cm (*n* = 29; *SE* = 0.80), 48 cm (*n* = 14; *SE* = 1.4), and 50 cm (*n* = 2; *SE* = 7.0) for ages 3 (end of third winter) to 7, respectively (Table 1). Of 37 readable scales, 27 were considered to have come from mature fish. Evidence of spawning on the scales was often subtle, so we employed as many indications as possible (see methods) in assessing whether we should attribute a spawning event to a given annulus. Most Salmo River rainbow trout (82%; Table 1) appear to spawn for the first time at age 5s (after their fifth winter), with smaller numbers maturing at ages 4s (11%) and 6s (7%). Back-calculated lengths-at-first-maturity appear to agree well with the above visual observations of maturity status made during fish tagging, with the majority of fish appearing to have spawned for the first time at fork lengths between 37.5 and 47.5 cm (Figure 4). Back-calculated growth increments, which could only be estimated between ages covered by the regression equation, indicated growth is greatest in the fourth and fifth years of life and slows substantially after the fifth year, supporting the notion that Salmo River rainbow trout begin spawning predominantly at age 5s.

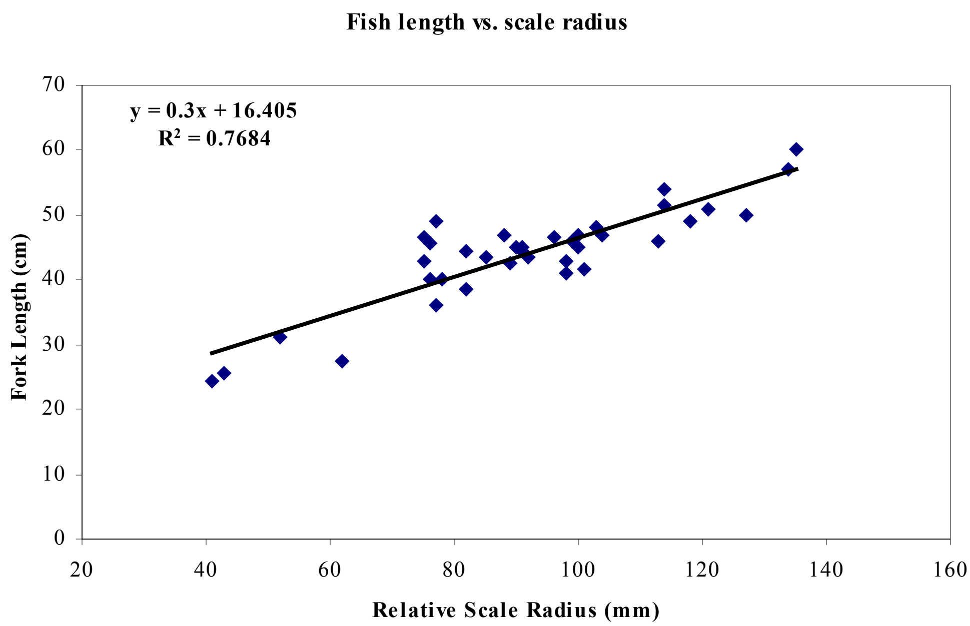

Figure 3. Relationship between fork length (cm) of sampled Salmo River rainbow trout and scale diameter (mm) measured from scale photographs.

Table 1. Age, life history, and growth from scales of Salmo River rainbow trout sampled during springtime of 2001 (standard errors in parentheses).

	Age				
	III	**IV**	**V**	**VI**	**VII**
Sample size *n*	37	34	29	13	2
Avg. fork length (cm)	31 (0.72)	39 (0.76)	45 (0.80)	48 (1.40)	50 (7.00)
Preceding year growth (cm)	N/A	7.6 (0.41)	5.7 (0.44)	2.8 (0.42)	1.6 (0.06)
% mature	0	11	81	100	100

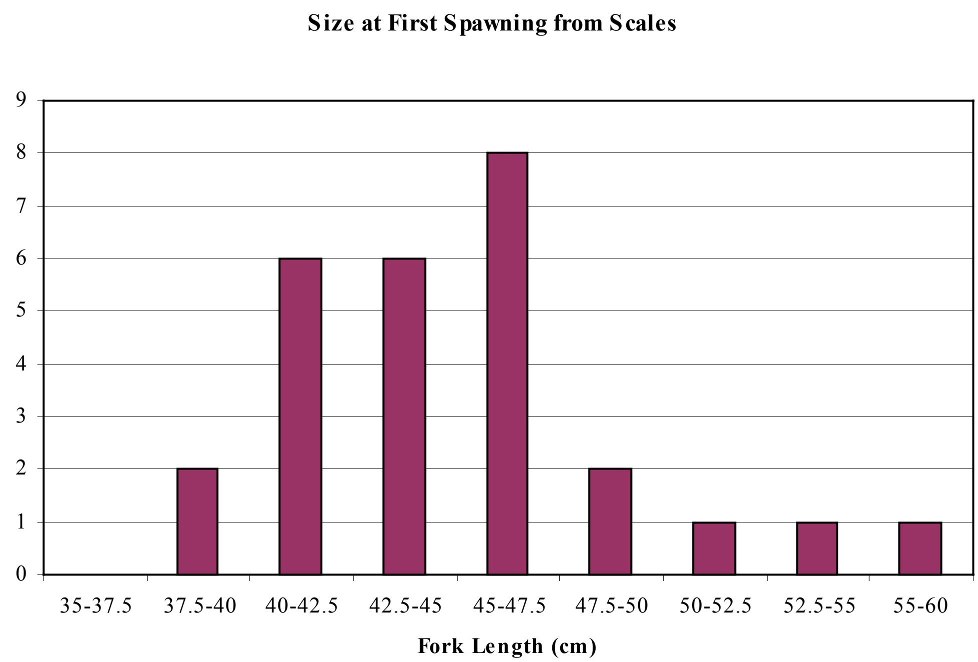

Figure 4. Size at first spawning (cm) for Salmo River rainbow trout from back-calculated from annulus diameter (regression) and from annulus diameter adjusted for ratio of total scale diameter relative to predicted scale diameter from regression (adjusted).

Survival of Salmo River rainbow trout spawners appears to be high. Repeat spawners made up 48% of the sample of mature fish, 11% appeared to have spawned three or more times, and one fish in its eighth year appeared to have been a four-time repeat spawner based on a spawning checks at ages 4s and 5s (Appendix III). The exploitation or retention rate for the population of adult fish, therefore, may be relatively low.

Genetic analyses were conducted by laboratory of Dr. E. B. Taylor, Dept. of Zoology, University of British Columbia, and were done concurrently with analyses of the genetic origins of wild-spawning rainbow trout in the Canadian portion of the Columbia River downstream of the Keenleyside Dam (Taylor 2002). Genetic samples from the Salmo watershed were available only from Clearwater Creek and the mainstem Salmo River. The Clearwater fish were the most divergent population in the study and exhibited a remarkable lack of genetic variation in the sample, which could be related to their headwater status or introduction with a small number of founders. Although the two populations (Clearwater and mainstem) were clearly genetically distinct from one another they did tend to share alleles to a large degree, but it was not clear that they were more closely related to each other than they were to other populations in the study (E.B. Taylor, University of British Columbia, pers. comm.). It should be noted that the Clearwater Creek sample was taken from upstream of a migration barrier, and genetic divergence between other tributary populations inhabiting reaches accessible to Salmo River spawners and the mainstem fish has not been investigated.

Habitat Use

In total, 63 tracking events were carried out during 2001 and 2002 (Appendix IV). Movement patterns of individual trout during this period are presented graphically in Appendix V.

Summer 2001, 2002

As water levels dropped during the summer of 2001 (Appendix VI), most movements of radio tagged rainbow trout were small migrations of less than 2 km. Some fish (n = 9) made movements of 5-15 km, however, mainly upstream into deep-water pool habitat (Figure 5). In general, fewer locations were used by holding trout as the water dropped – in many cases several radio tagged fish moved into the same pool. Large, deeper pools with abundant overhead or wood cover were particularly important. During summer 2002, which had higher river discharge (Appendix VI) relative to 200l (the lowest summer flows in the past decade), few longer migrations were observed (n = 2). Water temperature data was available only for 2001 (Appendix VII), and during the summer temperatures in the mainstem were well below upper limits of suitability for rainbow trout (21 °C: Scott and Crossman 1973). In both years, tributary streams were not used by radio tagged trout during the summer. For the most part, fish used pools and areas of cover along the entire length of the mainstem Salmo River downstream of Ymir where these habitats were available. There was, however, an obvious avoidance of the channelized section of low complexity extending from the town of Salmo downstream to Hellroaring Creek (28.3-25.4 km; Appendix IV and V; Figure 5). Fish that migrated during the summer frequently moved through this section, but only one fish ever held in this area for an extended period, during July of 2002 (Appendix IV and V).

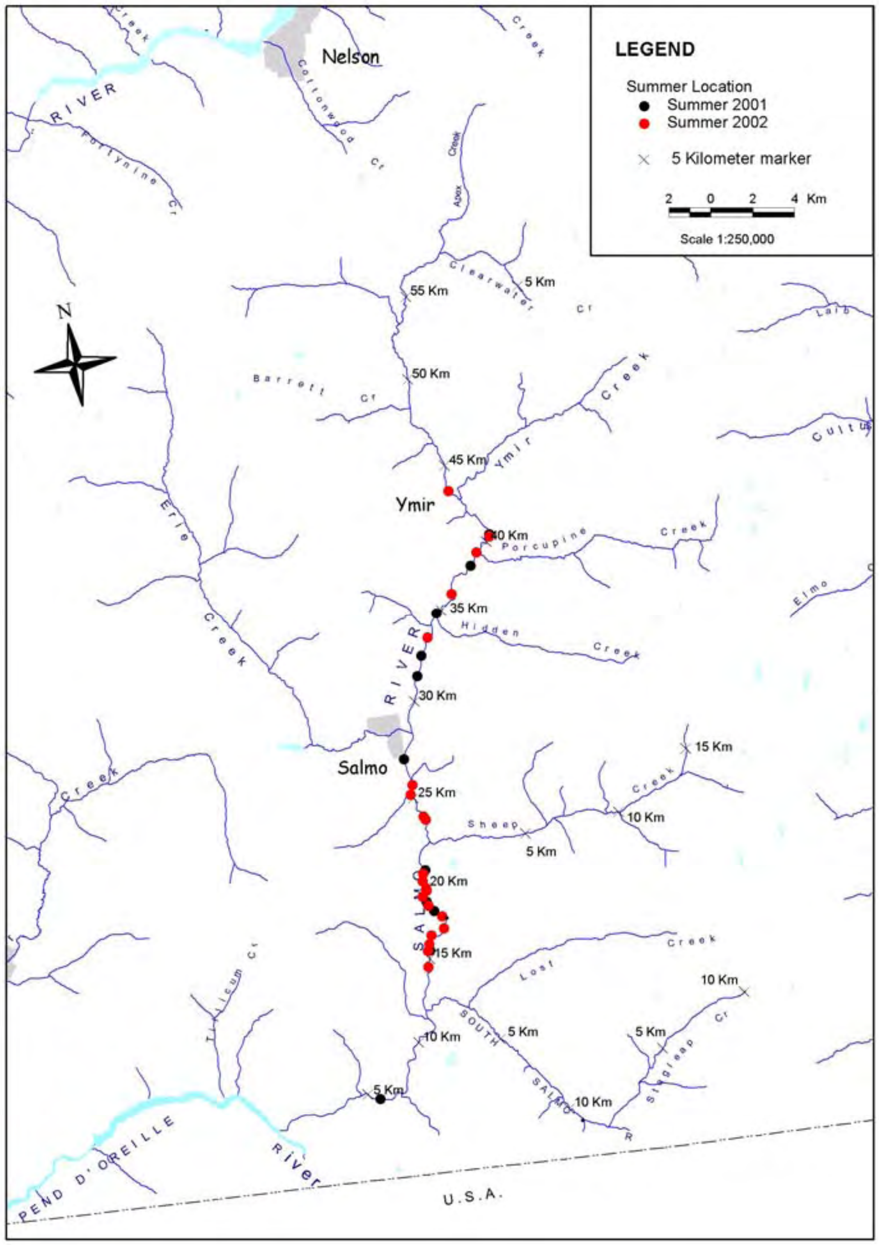

Figure 5. Summer locations of radio tagged rainbow trout in the Salmo River watershed in 2001and 2002.

Winter 2001/2002, 2002/2003

By the onset of winter in 2001 some redistribution of trout had taken place. In most cases these movements were small or non-existent from summer holding locations, but several fish did make downstream migrations of more than 10 km (Appendix IV and V; Figure 6). Suitable overwintering locations appeared to consist of mainstem areas of reduced flow having an abundance of cover in the form of woody debris, deep pool areas, or boulder substrates (Appendix I-Plates G and H). The mainstem river from Salmo to Hellroaring Creek was conspicuously avoided. One fish of note did migrate downstream to overwinter at the mouth of the Salmo River, and other significant overwintering areas were located at kms 16.0, 19.0, 19.9, 20.2, 32.3, and 35.7. Similar overwintering habitat use was observed on the only tracking event of winter 2002/2003, in December 2002, with some fish using the same pool in both years for overwintering (Appendix IV and V; Figure 6).

Spawning locations 2002

Of the original rainbow trout radio tagged in the summer of 2001 (n=30), we did not receive signals from six tags after January of 2002. One of these tags is one known to have malfunctioned (fish recaptured with radio tag in place), and one fish was assumed dead before the tag signal was lost. It is unknown what the fates of the additional four tags were. In addition, two tags are known to have been either expelled or removed from live fish (angling recaptures), and one fish was assumed to have died soon after capture based on a complete lack of movement after tag implantation. The remaining 21 radio tagged rainbow trout provide data for spawning movements and locations.

During the spring of 2002, weekly tracking events in May and June covered as much of the watershed that was feasible and that was thought to provide at least some opportunity for spawning. An initial tracking survey in the first week of March 2002, identified that no radio tagged trout had begun spawning migrations. Following this, three tracking events occurred in April, five tracking events occurred in May, and four tracking events occurred in June. The weekly tracking schedule was an attempt to ensure that the entire potential spawning period was surveyed, and that the resolution of the surveys was sufficient to detect spawning movements and locations.

The first movement that appeared to be associated with spawning took place in the third week of April, when two radio tagged trout began upstream migrations (Appendix IV and V). These movements occurred during an abrupt increase in discharge in early spring (Appendix VI). It appeared that the spawning period in 2002 extended from early May to mid-June (Appendix IV and V), with peak spawning occurring between the third week of May and early June (Appendix III). This period corresponded approximately with mainstem water temperatures of 5°C or greater, (Appendix VII), and with the ascending limb of the hydrograph (Appendix VI). Redds were identified during tracking surveys (Appendix I-Plates I and J) as early as May 9 (Table 2; Figure 7) but after mid-May it was virtually impossible to enumerate redds due to high water and poor visibility.

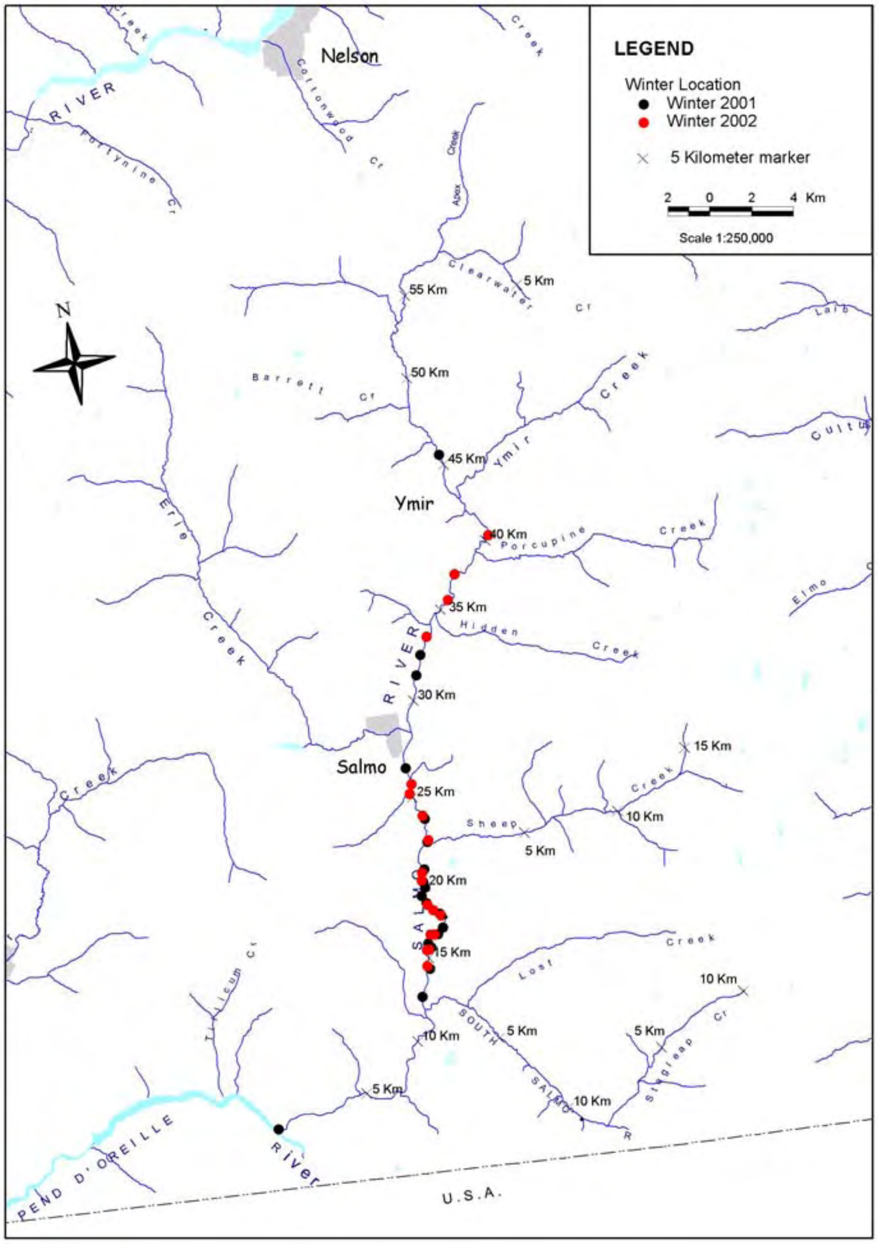

Figure 6. Winter locations of radio tagged rainbow trout in the Salmo River watershed in 2001and 2002.

Table 2. Known rainbow trout redd locations in the Salmo River in springtime of 2002.

Date	Mainstem Location (km)	Habitat	Number of Redds	Radio Tagged Fish Present in Area
05/09/02	26.2	Side Channel	1	Y
	23.8	Mainstem	2-3	Y
	20.7	Side Channel	2	Y
05/15/02	43-45	Mainstem	2	Y
	37	Mainstem	1	Y
	30.9	Mainstem	1	Y
	17.6	Mainstem	1	Y

In spring of 2002, radio tagged Salmo River rainbow trout appeared to use primarily mainstem areas for spawning (85.7%). Suspected spawning locations were distributed along the length of the mainstem Salmo River where there was suitable habitat, with concentrations being noted at km 18-21, 23-26, 31-32, and 34-37 (Figure 7). Within the mainstem Salmo River, redds visually identified during tracking were located in side channel areas and the near the margins of the mainstem channel. The only use of the channelized section downstream of Erie Creek that we observed was a redd constructed in a small side channel area near km 26.2. Spawning migrations were suspected in the telemetry record when a period of migration of radio tagged fish was followed by relatively brief period of holding at a new location that was followed by relatively rapid migration back in the direction from where the fish had come.

Of the 21 fish that were available to provide spawning data, nine (44%) made spawning migrations of greater than 5 km (Appendix IV and V), with three (14.3%) of these nine fish making movements into the lower reaches of tributaries (Sheep Creek and Erie Creek). No redds were identified in tributaries, but it appears likely that these fish spawned there. The greatest distance that a radio tagged fish was found upstream in a tributary was only 1.9 km, on May 24 (Appendix IV). We could not determine whether the remaining 12 trout did spawn, so the proportion of the adult population using tributaries for spawning may be actually be greater than estimated here. It is also possible that spawning movements are too limited for some fish to be clearly identified in the telemetry record. All of the 21 fish either made small migrations (0-2 km) within the suspected spawning period, made downstream migrations after the spawning period, or were located in proximity to known redd locations (Appendix IV and V; Figure 7).

Radio tagged trout also appeared to make non-spawning migrations into off-channel areas of refuge during high water runoff. From May 25-29, 2002 water discharge increased rapidly in the river from 122 to 273 $m^3 \cdot sec^{-1}$ (Appendix VI), and during this period we observed movements into side channel and off-channel habitats (Appendix I-

Plates K and L). One off-channel area in particular, located near the Salmo golf course (km 23.5-24.1), was used by five radio tagged fish. It was very unlikely these fish used this area for spawning as suitable gravel areas were not discovered during surveys of the area in summer 2002.

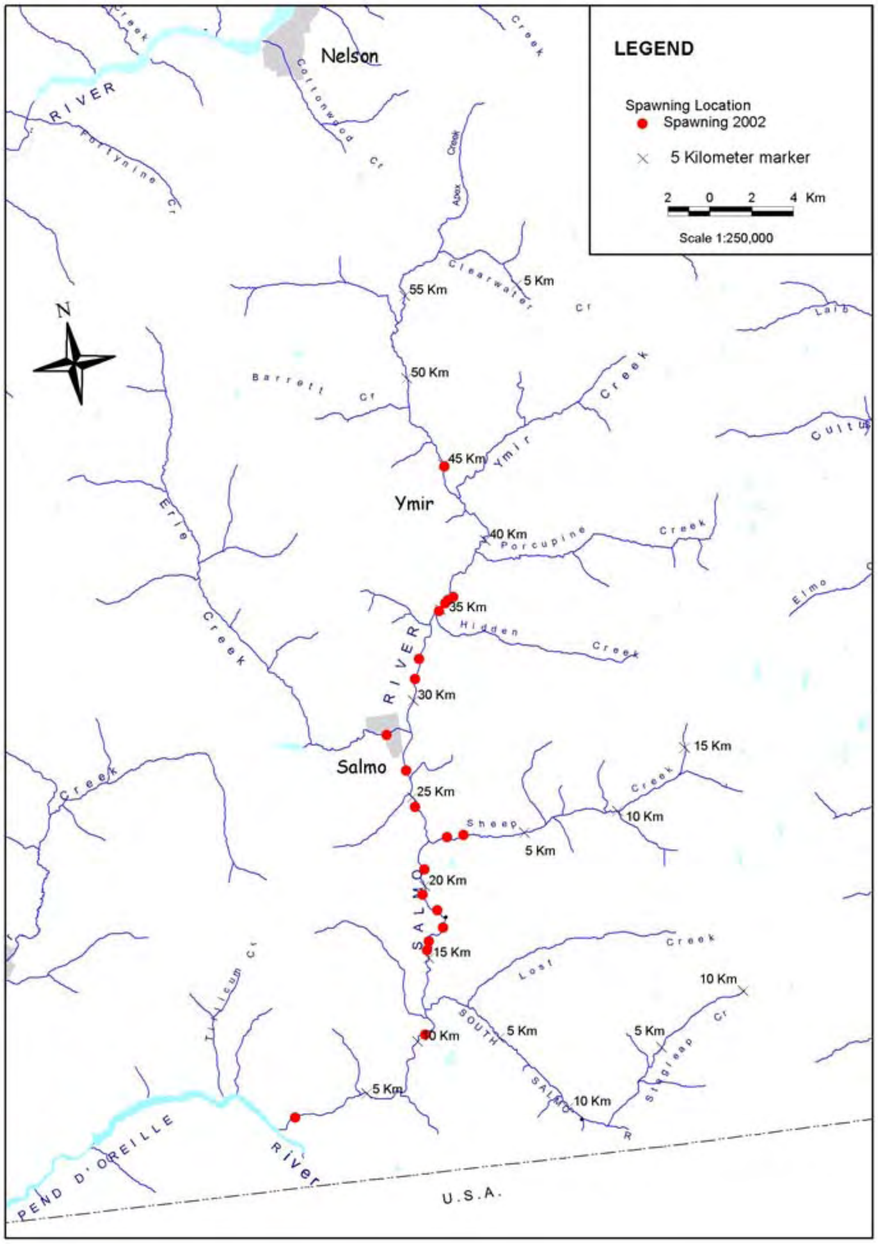

Figure 7. Spawning and redd locations of radio tagged rainbow trout in the Salmo River watershed in 2002.

Observer Efficiency Study

The two years of the observer efficiency study suggested that watershed physical conditions can be precise predictors of the proportion of fish in a counting section that are seen by divers, but that relationships may not be consistent among years. This suggested that other factors than those measured can affect fish visibility. Strong relationships between fish visibility and watershed conditions were evident only for 2002. Variability in horizontal visibility explained 94% and 93% of the variability in the counts of rainbow trout >30 cm and >40 cm, respectively, during July 2002 (Figure 8). The relationship between discharge and rainbow trout counts was curvilinear, but was also precise. Variability in log-transformed discharge explained 96% and 93% of the variability in the counts >30 cm and >40 cm (Figure 9), implying that visibility and discharge were highly correlated during the 2002 counting period.

In contrast, during 2001 counts were relatively stable across the survey period (see Appendix VIII for individual surveys), and poorly correlated with physical conditions. Variability in horizontal visibility explained only 15% and 1% of the variability in the July counts of rainbow trout >30 cm and >40 cm, respectively (Figure 10). Variability in log-transformed discharge explained 40% of the variability in counts >30 cm, but only 1% of the variability in the counts >40 cm, which were stable across the counting period (Figure 11) and better described by an average value than a regression relationship.

The above relationships do not allow us to estimate the number of fish present in the counting section, however, because the proportion of the total number of fish present in the counting section that are not seen cannot be determined. Observer efficiency estimates provided by observations of marked, radio tagged rainbow trout, which allow the number of unseen fish to be estimated, were relatively good predictors of counts of untagged rainbow trout in both size categories, suggesting that they are reliable. During July 2001 42% and 59%, respectively, of the variation in counts of rainbow trout >30 cm and >40 cm seen by divers was explained by variation in observer efficiency (Figure 12), which was increased to 68% for trout >30 cm if the outlier for July 6 (studentized residual = 2.07) is removed. During July 2002, 79% and 74% of the variation in counts of trout >30 cm and >40 cm, respectively, was explained by variation in observer efficiency (Figure 13), which rose to 85% and 82%, respectively if the outlier for July 30 (studentized residuals = 2.15, 2.26, respectively) for each regression is removed. Regressions for 2002 were highly significant for both size categories (>30: $P = 0.008$; >40: $P = 0.013$). Although regressions were not significant for 2001, this can be explained by the stability of both observer efficiency (*Mean* = 0.54; *SE* = 0.04) and counts of trout (>30: *Mean* = 129; *SE* = 6.1; >40: *Mean* = 52; *SE* = 3.5) across the survey period (Note: >40 mean calculated excluding data from 18 June, for which counts >40 cm not available).

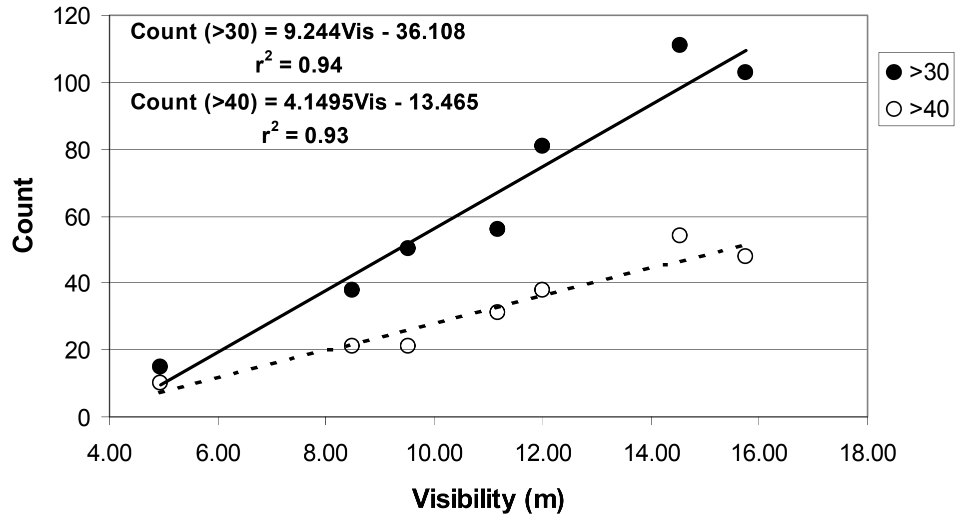

Figure 8. The relationship between counts of rainbow trout >30 cm (solid circles: P <0.001) and >40 cm (open circles: P <0.001) and horizontal visibility in the index section of the Salmo River, July 2002.

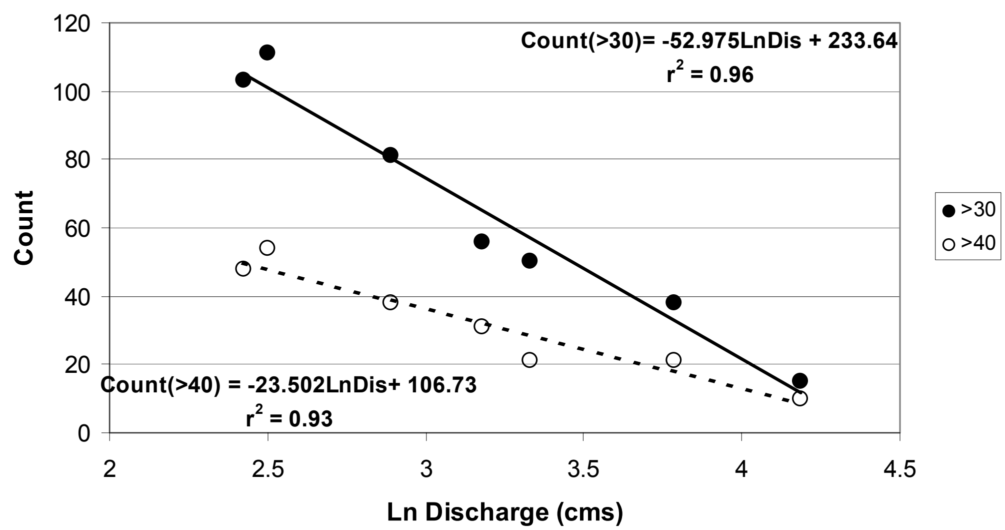

Figure 9. The relationship between counts of rainbow trout >30 cm (solid circles: P <0.001) and >40 cm (open circles: P =0.001) and log-transformed discharge in the index section of the Salmo River, July 2002.

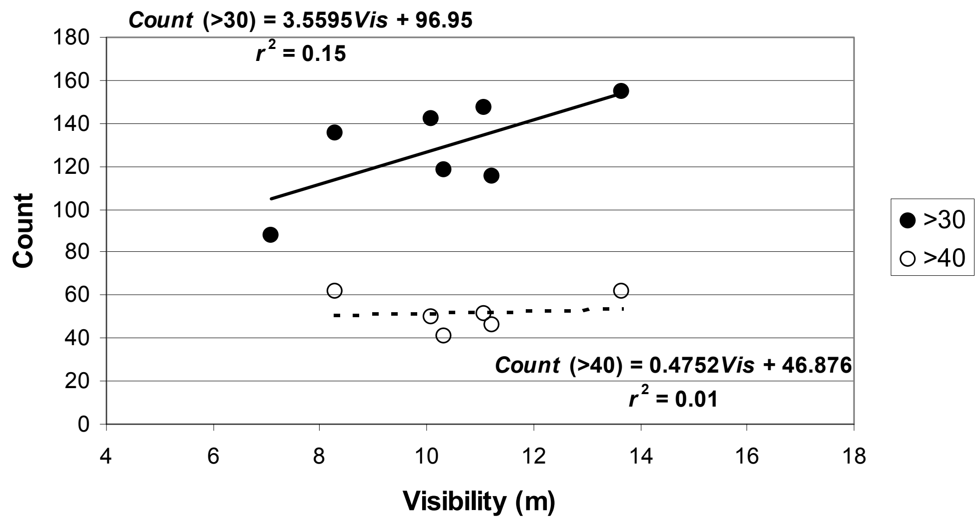

Figure 10. The relationships between counts of rainbow trout >30 cm (solid circles: P <0.083) and >40 cm (open circles: P >>0.05) and horizontal visibility in the index section of the Salmo River, July 2001.

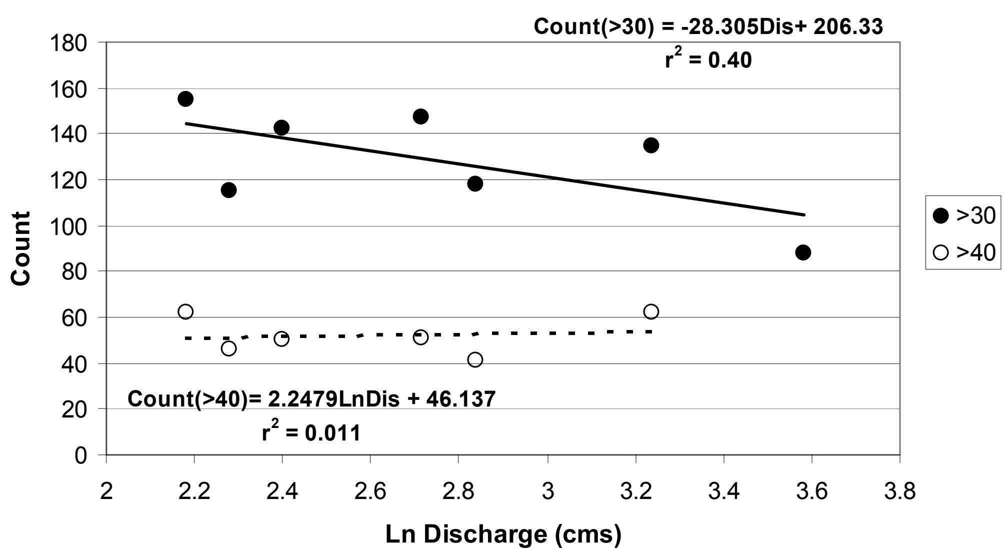

Figure 11. The relationships between counts of rainbow trout >30 cm (solid circles: P = 0.13) and >40 cm (open circles: P >>0.05) and log-transformed discharge in the index section of the Salmo River, July 2001.

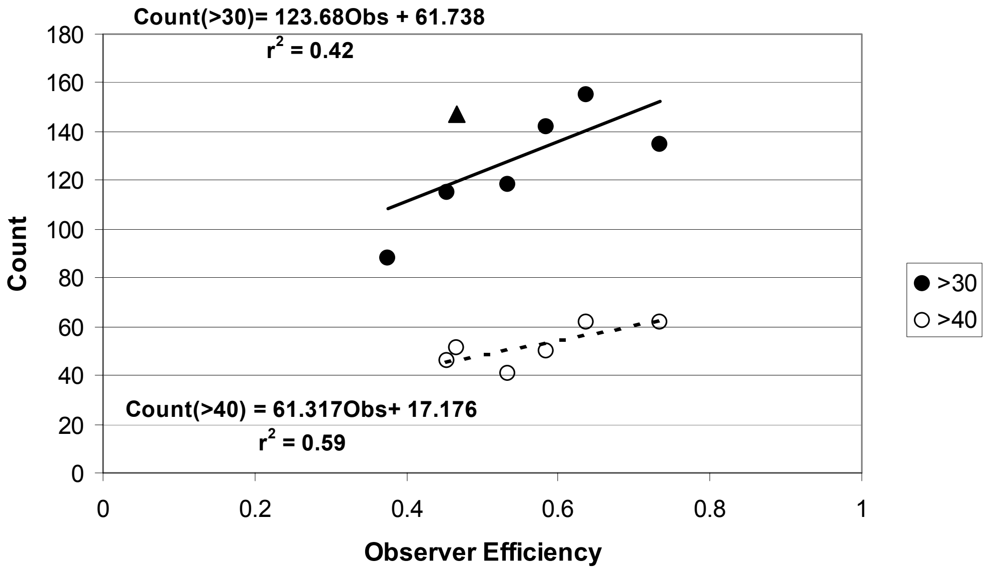

Figure 12. The relationships between counts of rainbow trout >30 cm (solid circles: *P* = 0.11) and >40 cm (open circles: *P* >>0.05) and observer efficiency in the index section of the Salmo River, July 2001. Note that the outlier (solid triangle; studentized residual = 2.065) was included in the regression analysis.

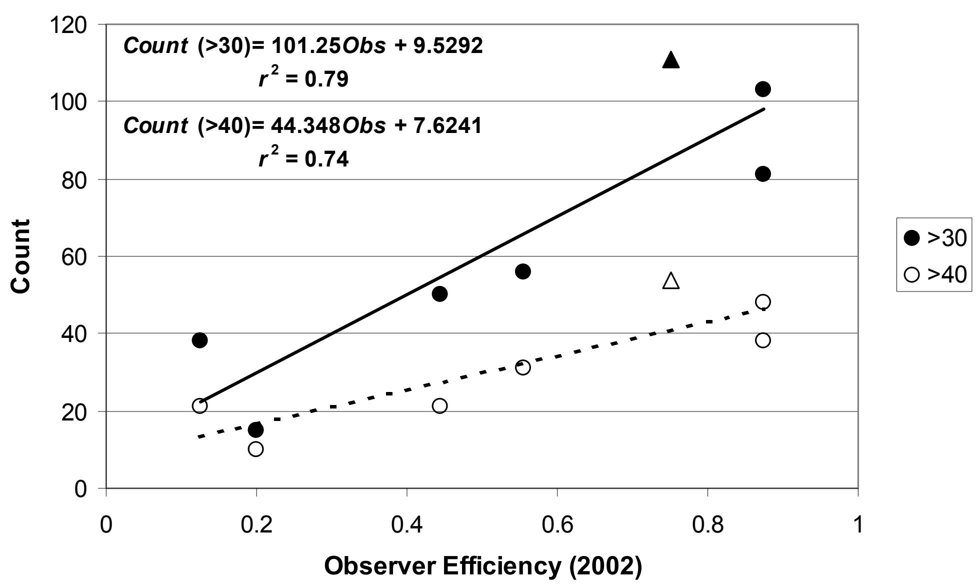

Figure 13. The relationships between counts of rainbow trout >30 cm (solid circles: *P* = 0.11) and >40 cm (open circles: *P* >>0.05) and log-transformed discharge in the index section of the Salmo River, July 2002. Outliers (triangles) for counts >30 cm (studentized residual = 2.146) and >40 cm (studentized residual = 2.263) were included in the regression analysis.

Mirroring the relationships of physical conditions to rainbow trout counts in 2001, horizontal visibility and discharge were poor predictors of observer efficiency for rainbow trout for that year, and regression relationships were not significant (visibility: $P = 0.65$; ln discharge: $P = 0.69$). Only 4.3% of the variability in observer efficiency was explained by variability in visibility (Figure 14), and only 3.5% by variability in discharge (Figure 15). During the survey period of 2002, however, visibility (Figure 16) and discharge (Figure 17) were good predictors of observer efficiency, explaining 76% and 85%, respectively, of its variability. Regression relationships for 2002 with respect to observer efficiency were highly significant for both the visibility ($P = 0.010$) and discharge ($P = 0.003$) variables.

It is possible that the limited range of visibility and discharge conditions during July 2001 contributed to the poor quality of the observer efficiency regressions. Combined 2001 and 2002 data sets result in significant regressions of observer efficiency on visibility (Figure 18; $P = 0.003$) and discharge (Figure 19; $P = 0.011$), but the relationships are imprecise relative to the 2002 regressions. Variability in visibility and discharge explained 54% and 43%, respectively, of the variability in observer efficiency in the pooled data set.

Discharge conditions were substantially different for the two years of the observer efficiency study. Flows in the Salmo River mainstem during the late spring and early summer of 2001 were the lowest seen in the past 10 years (Appendix VI), whereas flows in 2002 were higher than average in June and of approximately average magnitude during diver counts in July. Diver and telemetry observations during July 2001 suggested that the low values of observer efficiency even under apparently suitable conditions may have been in part due to concealment behaviour by trout. On several occasions, large fish were glimpsed in turbulent water in riffle areas at the head ends of pools, or in boulder rapids, locations at which it was difficult for divers to see them. Telemetry observations indicated radio tagged fish were also in these types of habitats during July 2001, but were frequently not seen by divers. Concealment in wood cover, undercut banks, and rip-rap /wood complexes was also apparent in the telemetry observations during 2001. While concealment and use of cover by tagged and untagged rainbow trout was also documented during July 2002, it did not appear to be as prevalent.

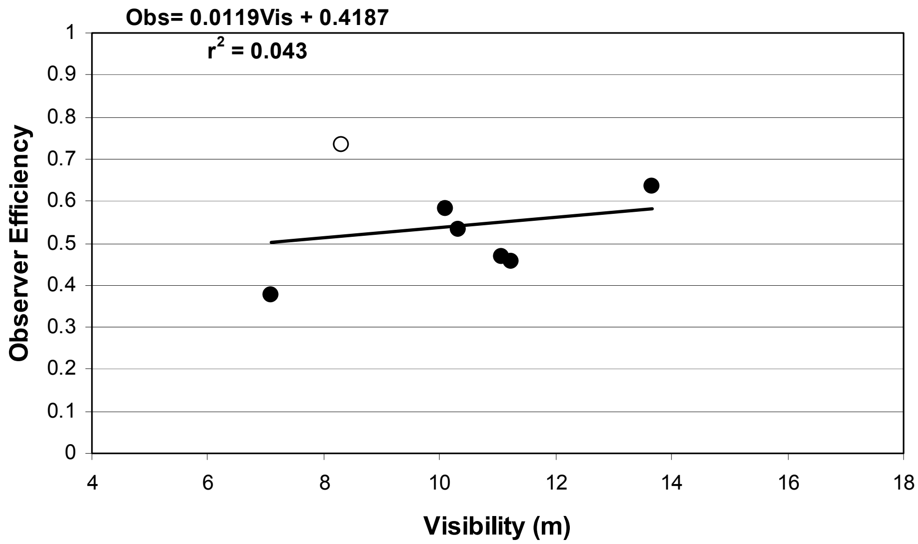

Figure 14. The relationship between observer efficiency (solid circles: $P = 0.66$) and horizontal visibility in the index section of the Salmo River, July 2001. Note that the outlier (open circle; studentized residual = 3.672) was included in the regression analysis.

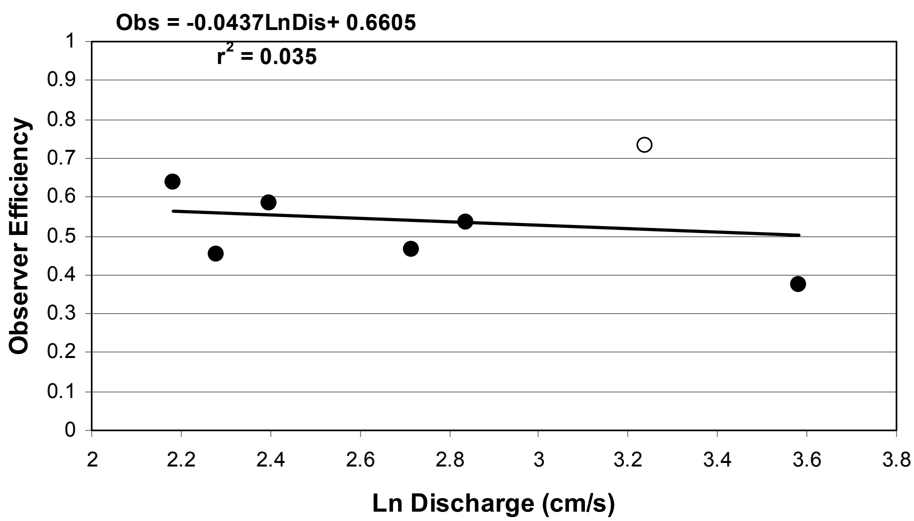

Figure 15. The relationship between observer efficiency (solid circles: $P = 0.69$) and horizontal visibility in the index section of the Salmo River, July 2001. Note that the outlier (open circle; studentized residual = 3.575) was included in the regression analysis.

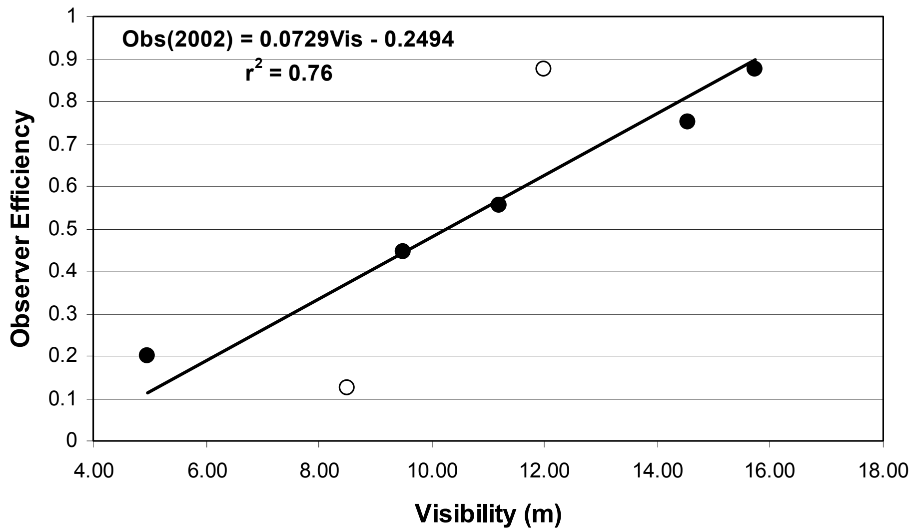

Figure 16. The relationship between observer efficiency (solid circles: $P = 0.010$) and horizontal visibility in the index section of the Salmo River, July 2002. Outliers (open circles; studentized residuals = -2.291, 2.215) were included in the regression analysis.

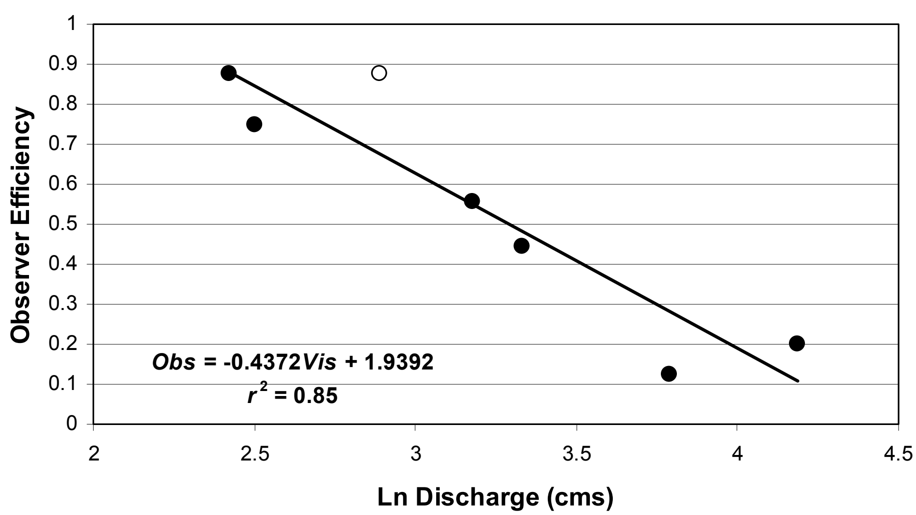

Figure 17. The relationship between observer efficiency (solid circles: $P = 0.003$) and log-transformed discharge in the index section of the Salmo River, July 2002. Note that the outlier (open circle; studentized residual = 2.339) was included in the regression analysis.

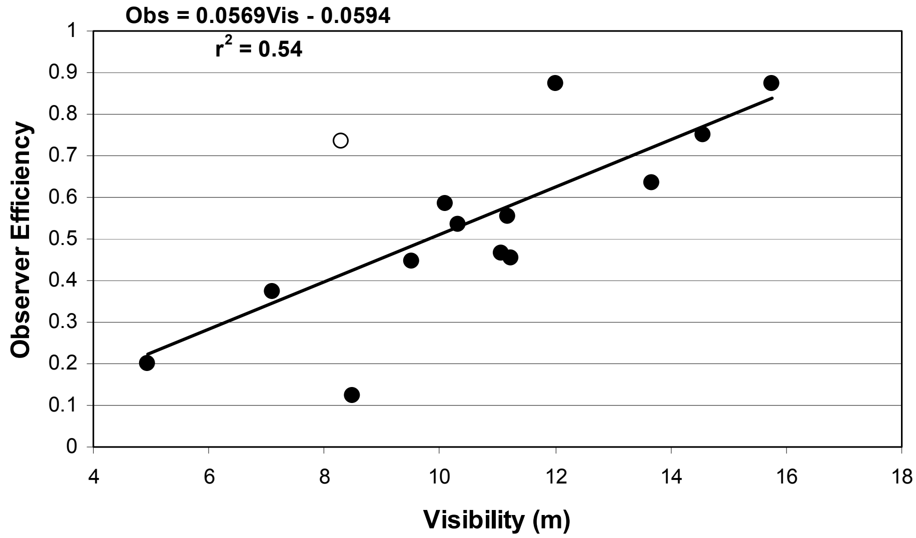

Figure 18. The relationship between observer efficiency (solid circles: *P* = 0.003) and horizontal visibility in the index section of the Salmo River for all surveys during July 2001 and July 2002 combined. Note that the outlier (open circle; studentized residual = 2.653) was included in the regression analysis.

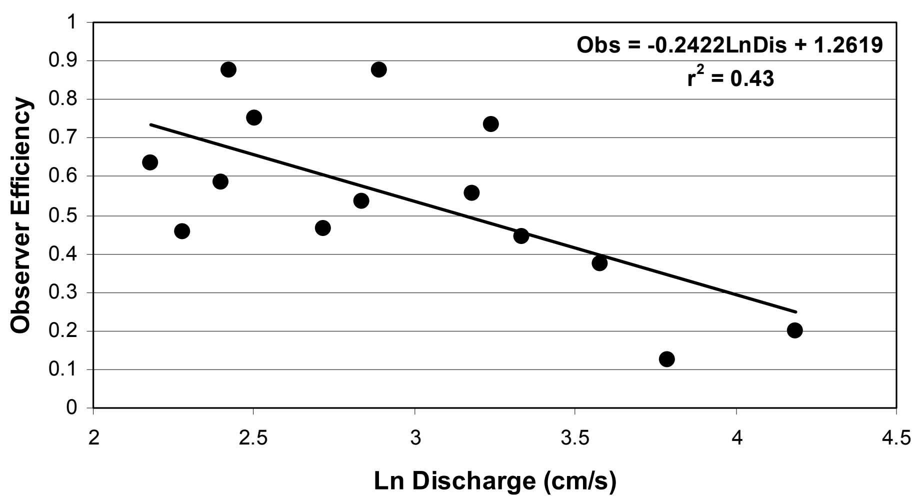

Figure 19. The relationship between observer efficiency (solid circles: *P* = 0.011) and log-transformed discharge in the index section of the Salmo River for all surveys during July 2001 and July 2002 combined.

2001 Population Size Estimates

Parameter estimation

Average diver counts (*C*) of rainbow trout in the index section between June 28 and July 30 were 306 (*SE* = 54.9), 130 (*SE* = 13.8), 83 (*SE* = 4.8), 43 (*SE* = 3.0), and 9 (*SE* = 0.99), for the size classes 0-20 cm, 20-30 cm, 30-40 cm, 40-50 cm, and >50 cm, respectively (Table 3; Appendix VIII). It is important to note that these estimates do not include the diver counts for June 18, which were made during the surveys along the swimmable length of the Salmo. These counts were only for the size category >30 cm in order to increase the distance divers could cover each day, and furthermore we were interested in the population estimate for July specifically, for comparison with future surveys. Either strong recruitment to the mainstem Salmo, marked behavioural shifts, or increased observer efficiency relative to larger fish was documented for parr less than 20 cm over the course of the study (Table 3; Appendix VIII). Strong patterns were not obvious for other size classes with the possible exception of the 20-30 cm fish, which increased to stable levels after a low initial count on June 30 (possibly indicating recruitment or observer efficiency changes). It is important to note, however, that the above comments are only speculative, as these topics were not investigated directly.

Table 3. Diver counts in the index section, July 2001.

Date	0-20 cm	20-30 cm	30-40 cm	40-50 cm	50+ cm
28-Jun-01	161	64	73	55	7
04-Jul-01	287	147	77	35	6
06-Jul-01	195	135	96	42	9
16-Jul-01	388	135	69	38	8
18-Jul-01	277	136	92	41	9
30-Jul-01	528	161	93	49	13
Average	**306**	**130**	**83**	**43**	**9**
SE	54.9	13.8	4.8	3.0	1.0

Observer efficiency (λ - radio tags seen/radio tags known to be present) for radio tagged, Salmo River rainbow trout averaged 0.57 and was relatively stable (*SE* = 0.043) over the counting period as described above. Again, this estimate does not include the observer efficiency estimate for June 18 because counts of rainbow trout on this date were not made for the size category >40 cm, and we were interested in population estimates for July for comparative purposes. It is also important to note the study's assumption that observer efficiency for all rainbow trout greater than 30 cm in length can be described by observations of tagged fish that were necessarily greater than 35 cm (minimum size requirement for the size of the implanted transmitter).

The relative distribution (*r*) of radio tagged fish to the counting area was relatively stable between June 28 and July 30, averaging 47% (*SE* = 3.0%) of the total. Because the allocation of radio tags was based on the relative distribution of fish >30 cm observed during the distribution swims, we assumed movements of radio tagged fish were representative of the untagged population as well. After the June distribution swims, 17 of 29 radio tags were allocated to the counting area - during the July diver counts 12-16 radio tagged rainbow trout were present depending on the survey. One of these tagged fish was assumed to have died shortly after tagging, as it never showed any movement from the tagging location and was never seen by divers. It was removed, therefore, from the calculation of the observer efficiency and relative distribution estimates.

Population estimates
The population estimates for Salmo River rainbow trout greater than 30 cm (available for harvest) and 40 cm (estimated breeding population) were made utilizing the average values for the parameters and were not based on the regressions with watershed physical conditions, which were not significant as described above. The relative consistency and good precision of each, however, suggested that reliable population estimates based on average values were feasible. Each population estimate *N* was the average of 1,000 calculations of:

$$N = C / (\lambda * r)$$

as described in the methods, where in every simulation each of the parameter values were generated stochastically from the observed error structure in its estimate. By this technique, then, the estimate for catchable rainbow trout (>30 cm) for the mainstem Salmo River, from Hall Creek to the canyon section 5.7 km from the mouth, during July, 2001 was 496 (SE = 54.2; 95% CI: $401 < N < 606$). The relative precision of this estimate, expressed as the average confidence interval as a proportion of the mean, was 0.207, within the 0.25 target recommended by Robson and Regier (1964) for management experiments. The estimated size of the population of rainbow trout >40 cm for the same section of the mainstem Salmo was 191 (SE = 22.4; 95% CI: $151 < N < 237$). The relative precision of this estimate was 0.225, also within the 0.25 threshold. We expect the accuracy of this latter estimate to be relatively high, as fish >40 cm were disproportionately represented in the radio tagged group.

2002 Population Size Estimates

Parameter estimation
To estimate the size of the Salmo River rainbow trout population we swam the mainstem from the town of Ymir downstream to the top of the canyon over a four-day period between July 22 and July 25 inclusive. Rainbow trout observations in all size categories were recorded, unlike the survey of the mainstem Salmo in June 2001 (Table 4; Appendix VIII). Counts among sections may not be directly comparable for smaller fish, as observer efficiencies are unknown, but apparently intensive use of the Swift Creek to Canyon section by juvenile trout (<20 cm), and their low abundance in the Hidden Creek to Carney Mill Road section are noteworthy.

Table 4. Diver counts of rainbow trout in the Salmo River watershed, July 22-25, 2002.

Section	**Date**	**Counts**				
		<20 cm	**20-30 cm**	**30-40 cm**	**40-50 cm**	**>50 cm**
Ymir-Porcupine C	25-Jul	135	26	7	6	0
Porcupine C-Hidden C	25-Jul	128	15	7	5	1
Hidden C-Erie C (Salmo)	24-Jul	39	27	14	7	2
Erie C to Carney Mill Rd.	24-Jul	21	4	1	1	0
Carney Mill-Sheep C	22-Jul	110	41	16	8	5
Sheep C-Bd Out Bridge	22-Jul	177	98	27	19	6
Burned Out Bridge-Swift C	23-Jul	166	48	29	18	4
Swift C-Canyon	23-Jul	478	135	23	6	0
Total		**1254**	**394**	**124**	**70**	**18**

Because this period was within that covered by the observer efficiency study, and observer efficiency during 2002 appeared to be strongly related to visibility conditions, we were able to estimate observer efficiency for each stream section surveyed. Horizontal visibility was recorded for each day, and that visibility measure was used to estimate observer efficiency using the regression equation presented above.

Population estimates

Population estimates for each section and their uncertainty were estimated by factoring counts together with stochastically simulated observer efficiency values, which were generated from the standard errors for each predicted value of observer efficiency from the regression relationship (Zar 1996). Confidence limits were based on 1000 simulations (in a Microsoft Excel spreadsheet) of N for each section, and the overall population estimate and its limits of 95% confidence were derived by summing the stochastically simulated section estimates (Table 5). The estimated size of the population of Salmo River rainbow trout >30 cm was 355 (SE = 17.3; limits of 95% confidence: 328-394), and the estimated size of the population >40 cm was 145 (SE = 7.3; limits of 95% confidence: 134-162) for July 2002. Average confidence intervals calculated in this manner as proportions of the estimates were 0.092 and 0.097 for the >30 cm and >40 cm size categories, respectively, within the 0.10 threshold recommended by Robson and Regier (1964) for research studies.

Table 5. Population estimates for rainbow trout in the Salmo River watershed, July 22-25, 2002.

Section	**Date**	**Avg. visibility**	**Obs. effic.**	**Count >30 cm**	**Estimate *N***	**Prop.**	**Count >40 cm**	**Estimate *N***	**Prop.**
Ymir-Porcupine C	25-Jul	13.8	0.76	13	17	0.05	6	8	0.05
Porcupine C-Hidden C	25-Jul	13.8	0.76	13	17	0.05	6	8	0.05
Hidden C-Erie C (Salmo)	24-Jul	11.7	0.60	23	38	0.11	9	15	0.10
Erie C to Carney Mill Rd.	24-Jul	11.7	0.60	2	3	0.01	1	2	0.01
Carney Mill-Sheep C	22-Jul	12.1	0.63	29	46	0.13	13	21	0.14
Sheep C-Bd Out Bridge	22-Jul	12.1	0.63	52	83	0.23	25	40	0.27
Bd Out Bridge-Swift C	23-Jul	10.7	0.53	51	96	0.27	22	41	0.28
Swift C-Canyon	23-Jul	10.7	0.53	29	55	0.15	6	11	0.08
Total				**212**	**355**		**88**	**145**	

DISCUSSION

Abundance and Population Growth Rate

The conservation in perpetuity of wild fish populations is the top management priority for the BC Ministry of Water, Land and Air Protection (MWLAP). The agency needs assurance that small populations, in particular, do not face an unacceptably high probability of extinction or severe depletion. Predicting the persistence or extinction of small populations has been a primary focus of the growing discipline of conservation biology. Because there are many causes of extinction for small populations in addition to anthropogenic agents forcing negative growth rates (those with some theoretical support include demographic stochasticity, environmental stochasticity, severe inbreeding, and long-term genetic losses - Simberloff 1988; Caughley 1994), predicting the extinction risk to a particular population is inexact at best. Speculation about the minimum population sizes necessary to reduce extinction risks to acceptable levels (MVP - minimum viable population size) has been primarily from two perspectives, one based on genetic processes and the other on stochastic population dynamics. In the genetics-based approach the conservation minimum is generally set by i) the risk of fixation of deleterious alleles (genetic drift), and/or ii) the requirement for some minimum amount of genetic variation that allows the population to evolve, which from this perspective is an essential buffer against environmental change. Conversely, from the perspective of the population dynamics-based approach the conservation minimum is determined according to the extinction probabilities set by stochastic demographic processes.

Genetics- and population dynamics-based models of extinction tend to reach similar conclusions about minimum viable population sizes. The importance of genetic drift in fixing deleterious alleles in a population is related to N_e, the effective population size, which is a measure of how many individuals are contributing their genes to the next generation (Nunney and Campbell, 1993). Franklin (1981, as cited in Nunney and Campbell 1993) argued that N_e must remain > 50 to for a population to avoid suffering inbreeding depression, and probably greater still to maintain the genetic diversity required for adaptation to a changing environment. Turning this N_e into an equivalent N (number of adults in the population) is not straightforward, because N will increase relative to N_e with increases in the magnitude of population fluctuations. A recommended minimum adult population size of at least five times the minimum N_e (N = 250) therefore, has been suggested if populations fluctuate significantly (Nunney and Campbell 1993). It is important to note, however, that the importance of genetics in extinction has not been demonstrated sufficiently well to allow specific management predictions (Boyce 1992).

Models of extinction due to demographic stochasticity alone (reviewed in Boyce 1992; Nunney and Campbell 1993) support a lower limit to the MVP of approximately N = 100, although the MVP can increase by up to an order of magnitude if populations are subject to a relatively high degree of environmental stochasticity. Neither genetics- nor population dynamics-based models of minimum viable population size are uncontroversial. However, empirical evidence does suggest that the above guidelines may be of the appropriate magnitude. Studies of extinction in mammals and birds have suggested that $N < 50$ is clearly insufficient for a population's long-term persistence, populations of $50 < N < 200$ are marginally secure, and those of $N > 200$ are secure at least over time frames as limited as those used in the studies (reviewed in Boyce 1992).

Aging analysis and visual observations of maturity status for captured fish (Table 1; Appendix III) suggested that the large majority of Salmo River rainbow trout spawn for the first time when they are five years old and greater than 40 cm in length. The estimates of the size of the Salmo River population that is >40 cm fork length, therefore, is the best estimate of the adult population size *N*. Estimates of rainbow trout *N* for the mainstem Salmo River between the Hall Creek canyon and the canyon at the river's lower end were 191 $\pm$ 22 and 145 $\pm$ 7for July 2001 and July 2002, respectively. Some adult fish will live outside of the surveyed length, particularly in the lowermost canyon reach. Low diver counts of larger fish below Swift Creek, however, in addition to poor angling success during tagging below Swift Creek and in the top section of the canyon (only 1 taggable specimen captured), suggest that this number may not be great and the above estimates may therefore be close to the total adult population size. According to the above criteria, the current abundance levels of Salmo River adult rainbow trout may therefore be close to minimum levels considered adequate for long-term conservation.

Two years of population estimates is not enough of a time series to investigate the population growth rate for the rainbow trout of the Salmo River mainstem, especially considering that the estimates were by two different methods and natural variability in the adult population size *N* is unknown. A reduced estimate of *N* for 2002, which was corroborated by lower counts of larger trout during the observer efficiency study (Appendix VIII), may therefore not be cause for concern. Anthropogenic factors forcing negative population growth rates are far more serious threats to a population's long-term persistence than are genetic and demographic factors associated with small population sizes (Caughley 1994). Although other anthropogenic agents capable of forcing decline in the Salmo population may exist, angling harvest is the most obvious and immediate threat. Given the current population size, even a small number of skilled anglers regularly harvesting their limit from the Salmo River could rapidly drive adult rainbow trout abundance to potentially dangerous levels. It is possible, of course, that the Salmo River rainbow trout population is stable under the management scenario in place to this point in time, and it may even be at the watershed's carrying capacity and therefore buffered to some extent from annual variability in recruitment and harvest. Regular abundance monitoring, especially if it is accompanied with a willingness to experiment with alternative harvest regulations, is the key to learning about the population's status relative to meaningful conservation and management targets.

Population Spatial Structure and Diversity

From one year's telemetry data (Appendix IV) it does not appear that larger trout inhabiting the Salmo River mainstem use tributaries extensively for spawning, or mainstem areas upstream of Barrett Creek. Only 14.7% of radio tagged rainbow trout appeared to have entered tributaries during springtime 2002, and none were detected more than 1.9 km upstream of the tributaries mouth (Appendix IV). However, it should be noted that this estimate may be low if not all of the radio tagged rainbow trout spawned. If the data are representative, and little spawning by mainstem-inhabiting trout takes place in tributaries to the Salmo, it is likely that tributary populations of smaller rainbow trout are primarily of the stream resident life history. Samples of rainbow trout from the South Salmo River and Sheep Creek include individuals up to age 4, also supporting the notion that these fish are residents (Decker et al. 2002).

The rainbow trout population spatial structure of the Salmo River watershed likely cannot be inferred without additional study, which would require at a minimum tissue sampling and genetic analysis for tributary populations for comparison with results from mainstem samples (Taylor 2002; E.B. Taylor, UBC Zoology, pers. comm.). Gene flow and migrants from tributary populations are likely, but whether these significantly increase genetic and demographic resilience (sensu Simberloff 1988) for the mainstem population would be difficult to infer. Hybrids could reasonably be produced from 'sneak' matings of resident males with fluvial females, but selection in alternative tributary and mainstem niches against intermediate hybrid phenotypes is possible. Residents make limited downstream movements and mature at smaller body sizes and younger ages than migrants (Elliott 1987; Hagen and Taylor 2001). Northcote (1981) found substantial differences in spawning timing for resident and migratory rainbow trout in a steep tributary to Kootenay Lake, and attributed them to strong selection in resident fish for emergence after freshet had abated so that they would not be swept downstream. The fluvial trout of the Salmo River mainstem appear to mature at an exceptionally large body size and advanced age, which may reflect adaptations to physical conditions during spawning in mainstem habitats. In Elliott's classic (1987) study he suggested adaptations by residents in 'fringe' habitats would be in response to density-independent mortality factors, whereas in highly suitable habitats inhabited by fluvial and migratory fish adaptations would reflect density-dependent population regulation. If selection for adaptations to alternative niches in the Salmo watershed is strong relative to gene flow (few hybrids and they fair poorly), tributary and mainstem populations may be genetically distinct and tributary phenotypes will not be able to replace mainstem phenotypes in habitats left open in a situation of severe population decline.

The genetic origins or relationships of Salmo watershed rainbow trout have not been determined (Taylor 2002). Stocking of rainbow trout into the Salmo River watershed took place sporadically between 1924 and 1953 (BC MWLAP data on file), but it may be more likely than not that widespread introgression of wild and hatchery genotypes did not occur. Wild-spawning, apparently native rainbow trout in the free-flowing portion of the Columbia River below the Keenleyside Dam in Canada show little genetic impact from Roosevelt Reservoir hatchery stocking programs (Taylor 2002), a result which is consistent with a growing number of studies addressing this issue (e.g. Moran et al. 1994; Hansen et al. 1995). Until it is established otherwise, we consider it prudent to manage the Salmo mainstem population as if it were genetically unique and native. With respect to other fluvial forms of rainbow trout the Salmo watershed is now genetically isolated, by the continuous impoundment of the Columbia and lower Pend d'Oreille Rivers, from populations downstream. Connectivity with populations upstream, each of which are separated from the Salmo River by at least one dam, is currently unknown.

Conclusions and Recommendations

The mainstem Salmo River rainbow trout population is of small size, unknown population growth rate, and possibly isolated demographically from other fluvial rainbow trout populations. Special management actions to ensure the population's future viability and to maintain the quality of the fishery, therefore, may be warranted. Catch and release regulations may be effective at increasing population size (e.g. Oliver 1990). We have recommended to MWLAP that this step be taken for a portion of the Salmo River watershed, to be applied on an experimental basis. Fishing pressure appears to be concentrated downstream of the town of Salmo, where approximately 80% of the harvestable and adult rainbow trout were located during July 2002 (Table 5). We recommended a catch and release zone that included all of the mainstem from the Sheep Creek confluence to the South Salmo River confluence, which encompassed 65% of the harvestable and adult trout, or an adult population of almost 100 individuals (July 2002), and two zones of the mainstem upstream and downstream of this section where a harvest would be allowed. High quality angling opportunities at numerous runs and pools, in locations with and without road access, are possible in both portions of the watershed. This recommendation has been implemented for the 2003/2004 angling season (J. Bell, Fisheries Biologist, MWLAP Nelson, pers. comm.).

We recommend that annual or at least periodic diver counts across all sections identified in Table 5 continue, so that the effects of the regulation change can be monitored closely. This is the science-based approach to conservation management recommended by recent authors (Walters and Hilborn 1976; Lande 1988; Caughley 1994), and that may generate research data that is of provincial significance. While a positive response to the regulation change is expected, population declines may signal the need for a basin-wide catch and release regulation. Declines of the adult population to levels approaching 50 adult individuals should be considered grounds for complete fishery closure, especially given the unknown genetic and demographic structure of the mainstem population relative to tributary populations and to other fluvial rainbow trout populations in the Pend d' Oreille basin.

It is worth considering whether it is feasible to investigate potential genetic and demographic relationships between rainbow trout in the Salmo mainstem and other locations, and whether the information would be of value in fishery management in the watershed. It may be possible to obtain this information from analyses of genetic samples from tributary or other lower Pend d'Oreille populations for comparison with the mainstem Salmo River sample, which has already been analyzed (E.B. Taylor, UBC Zoology, pers. comm.). A habitat use and life history study directed at the tributary residents would also benefit our understanding of their role in the overall rainbow trout population dynamics of the watershed, as well as point out potential conservation issues faced by these fish.

Although diver counts of trout in streams are commonly used to monitor population status, few studies have directly investigated the relationships between diver observer efficiency and watershed physical conditions. The results of the two years' observer efficiency studies reported on here have suggested that diver observations of radio tagged trout can be reliably used to estimate observer efficiency (Figures 12 and13). A precise relationship between observer efficiency and physical conditions such as visibility that can be easily measured could be utilized to calibrate diver counts without the need for concurrent mark-resight studies (Young and Hayes 2001), meaning that population estimates could be acquired in a highly cost-effective manner. Changes in visibility and discharge, which were highly correlated, were good predictors of observer efficiency observations during July 2002 (Figures 16, 17), but observer efficiency did not change with changes in these variables during July 2001 (Figures 14, 15). Concealment behaviour associated with low flows may have been a factor in the 2001 observer efficiency study. Whether or not this is a common occurrence cannot be determined from two years' data, but it is desirable that it be investigated, as the relationship of the combined observer efficiency data for both years to changes in visibility is of lower precision (Figure 18). The summer flows of the Salmo River during 2001 were the lowest recorded in the past decade (Appendix VI), suggesting the possibility that poor observer efficiency and concealment behaviour by trout recorded during 2001 were anomalous. We recommend highly that a third year of the observer efficiency study be conducted under more typical flow conditions so that this question can be addressed.

This report also documents the results of our investigation by radio telemetry of rainbow trout habitat use of in the mainstem Salmo River. Summer rearing habitat in 2001, which had the lowest summer flows of the past 10 years, was limited to a few relatively large pools where accumulations of fish were observed. A channelized section of the mainstem, which had limited areas of deeper water and cover, extending from the town of Salmo downstream to Hellroaring Creek was conspicuously avoided by radio tagged trout. A similar pattern was observed during the more normal flow conditions of 2002, but less movement to new holding locations was observed and concealment behaviour by larger trout did not appear to be as prevalent. Overwintering habitat in 2001 and 2002 consisted of areas of deeper water in association with cover, and was distributed along the length of the Salmo mainstem. Movements of radio tagged fish during the spawning period of springtime 2002 suggested that fluvial, mainstem-dwelling rainbow trout are not spatially segregated along the length of the Salmo River, that spawning takes place in side channels, along the margins of the mainstem, and in the lower reaches of some tributaries. Off-channel areas may be important to Salmo River rainbow trout during spring freshet.

The above observations suggest a close association between the population of larger rainbow trout in the Salmo River and areas of deeper water and cover. Efforts to increase rainbow trout habitat capability in the Salmo River watershed, through habitat complexing may be worth consideration, as a population's resilience to extinction threats increases with increases in carrying capacity (see Nunney and Campbell 1993 for review) provided anthropogenic agents forcing negative population growth rates have been addressed. However, the ability of any proposed habitat enhancement to increase rainbow trout habitat capability should be evaluated carefully, which likely would require additional study. Thorough monitoring is essential given the experimental nature of any such manipulation.

One final point of recommendation is for continued community involvement and education with regard to fisheries issues in the Salmo River watershed. We feel that student involvement (Appendix I-Plate M) and community education through a poster campaign (Appendix IX) increased community awareness in general of fisheries issues within the watershed. A workshop organized in the area to discuss rainbow trout biology and management, and oriented to the community, would also be of great benefit.

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Appendix I – Photographic Plates

Plate A. Rainbow trout in flow through fish tube following surgery.

Plate B. Field surgery station used during surgical radio tagging of rainbow trout.

Plate C. Anaesthetized rainbow trout on V-trough prior to incision, and irrigation of gills.

Plate D. Incision made into abdominal cavity through body wall of rainbow trout prior to insertion of radio tag.

Plate E. Sutures being used to close incision after radio tag is inserted into abdominal cavity of rainbow trout.

Plate F. Suture placed on antennae to prevent movement and irritation at exit point.

Plate G. Pool used for overwintering by rainbow trout in the Salmo River.

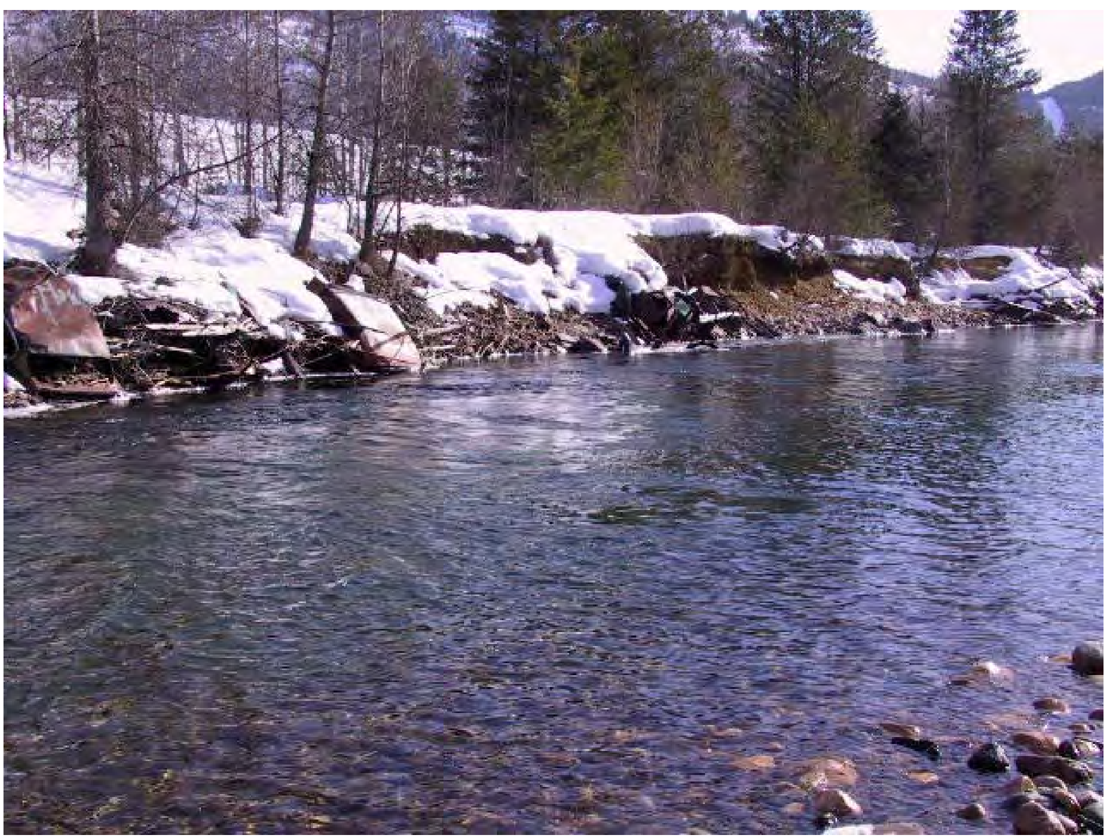


Plate H. Pool used for overwintering by rainbow trout in the Salmo River.

Plate I. Rainbow trout redd location in side channel of Salmo River.

Plate J. Rainbow trout redd location in side channel of Salmo River.

Plate K. Off-channel habitat used by rainbow trout in high flow of May 2002.

Plate L. Off-channel habitat used by rainbow trout in high flow of May 2002.

Plate M. Students observing a radio tag implant into rainbow trout.

Appendix II – 2001 and 2002 Salmo River Rainbow Trout Capture Data

Fish No.	Frequency	Code	Date	River Km	Length (mm)	Girth (mm)	Mass (g)	Sex	Scales	DNA	Floy Tag 1	Floy Tag 2	Maturity
A	380	9	06-06-2001	20.2	540	280	1700	F	A	A	6401	6402	Kelt
B			06-06-2001	19.1	415	230	800	F	B	B			?
C	420	4	06-06-2001	19	445	240	1000	F	C	C	6403	6404	Kelt
D	780	2	06-06-2001	15.5	475	245	1125	F	D	D	6405	6406	Kelt
E	380	2	06-06-2001	15.5	450	210	800	M	E	E	6407	6408	?
F	780	5	06-08-2001	40.5	450	230	1000	F	F	F	6449	6450	
G	780	10	06-08-2001	39.9	470	230	1100	M	G	G	6410	6411	Kelt
H	420	1	06-12-2001	32.3	570	275	1800	F	H	H	6391	6392	?
I			06-12-2001	24.4	245			?	I				IMM.
J			06-20-2001	23.9	310			F	J				IMM.
K	420	8	06-20-2001	23.5	400	195	600	F	K	K	6357	6358	Kelt
L	420	9	06-20-2001	23.2	400	200	650	?	L	L	6389	6390	Kelt
LO	780	1	09-19-2001	34.6	410	210	725	F	LO	LO	6301	6302	Kelt
M	420	10	06-20-2001	22.4	465	215	950	M	M	M	6359	6388	Kelt
N	380	5	06-20-2001	20.9	600	290	2100	F	N	N	6360	6361	Kelt
O			06-20-2001	20.9	370	180	550	?	O				?
P	380	4	06-21-2001	19.9	430	215	750	F	P	P	6424	6425	Kelt
Q			06-21-2001	19.9	490			M	Q	Q			?
R	380	6	06-22-2001	5.7	390	200		M	R	R	6362	6363	Kelt
U			06-21-2001	18.3	450			M	U	U			?
SARB-1	420	2	06-01-2001	26.2	465	250	1150	F	SARB-1	SARB-1	6351	6352	IMM.
SARB-10	420	3	06-12-2001	35.7	360	185	500	F	SARB-10	SARB-10	6414	6415	IMM.
SARB-11	420	7	06-20-2001	24.4	510	265	1450	F	SARB-11	SARB-11	6416	6417	?
SARB-12	780	7	06-20-2001	22.9	570	285	2000	F	SARB-12	SARB-12	6418	6419	?
SARB-13	780	9	06-20-2001	22.4	510	240	1300	M	SARB-13	SARB-13	6420	6421	?
SARB-14	380	8	06-20-2001	20.8	385	200	600	F	SARB-14	SARB-14	6422	6423	IMM.
SARB-15	380	1	06-21-2001	21.3	490	230	1100	F	SARB-15	SARB-15	6386	6387	Kelt
SARB-16	380	3	06-21-2001	19.4	445	195	700	M	SARB-16	SARB-16	6383	6385	Kelt
SARB-17			06-21-2001	19	435	220		F	SARB-17	SARB-17			?
SARB-18	380	10	06-30-2001	15.7	390	175	350	F	SARB-18	SARB-18	6381	6382	Kelt
SARB-2	780	3	06-06-2001	20.1	455	230	1100	F	SARB-2	SARB-2	6399	6400	Kelt
SARB-3			06-06-2001	20.1	275			?	SARB-3	SARB-3			IMM.

Fish No.	Frequency	Code	Date	River Km	Length (mm)	Girth (mm)	Mass (g)	Sex	Scales	DNA	Floy Tag 1	Floy Tag 2	Maturity
SARB-4	380	7	06-06-2001	18.5	480	235	700	F	SARB-4	SARB-4	6397	6398	Kelt
SARB-5	420	6	06-08-2001	20.2	435	225	850	F	SARB-5	SARB-5	6395	6396	Kelt
SARB-6	780	6	06-08-2001	20.1	425	210	750	M	SARB-6	SARB-6	6353	6354	Kelt
SARB-7	780	8	06-08-2001	15.8	445	220	1000	F	SARB-7	SARB-7	6355	6356	Kelt
SARB-8	420	5	06-08-2001	34.6	470	235		F	SARB-8	SARB-8	6393	6394	Kelt
SARB-9	780	4	06-12-2001	35.7	460	235		F	SARB-9	SARB-9	6412	6413	IMM.
1	580	10	06-10-2002	20.6	470	230		M	1	No	W7851/W7853	W7854/W7855	Kelt
2	580	2	06-10-2002	17.8	480	220		F	/	No	W7923/W7922	W7921/W7920	Kelt
3	580	4	07-04-2002	25.7	490	260		F	/	No	W7919/W7918	W7917/W7916	Kelt
4	580	1	07-04-2002	25.1	430	225		F	4	No	W7915/W7914	W7913/W7912	
5	580	3	07-04-2002	23.9	515	255		F	5	No	W7911/W7910	W7907/W7908	
6			07-04-2002	25.2	350	180		F	6	No	no tags	no tags	Maturing
JH-1	580	7	07-02-2002	23.8	460	215		F	JH-1	No	W7950/W7949	W7948/W7947	Kelt
JH-2	580	9	07-02-2002	20.2	500	255		F	JH-2	No	W7946/W7945	W7944/W7943	Kelt
JH-3	580	8	07-04-2002	19.9	380	205		Imm	/	No	no tags	no tags	Immature
JH-4	580	5	07-04-2002	19.5	600	280		F	/	No	6360	6361	Kelt given new radio tag
JH-5	580	6	07-05-2002	19.9	460	225		F	/	No	W7935/W7936	W7937/W7938	Kelt
JH-6			07-02-2002	23.5	255			?	JH-6	No	6419		
JH-7			07-02-2002	22.9	570			?	/	No	6418		Kelt

Appendix III – Scale Measurements, Salmo River Rainbow Trout, June 2001

Scale no.	Fork l.	Sex	Maturity	Age	Dia. Scale	Annulus 1	2	3	4	5	6	7	Fraser-Lee size-at-mat.	Comments
jh-6	25.5	I	I	3+	43	8	22	38						Plus growth at scale margin
4	43	F	na	5sss?	98		26	35	57	85	92	98	59	Poss. 3-time repeat spawner?
5	51.5	F	na	5ss	114	9	28	43	80	108	114		57	
1	47	M	kelt	5ss	100	15	25	34	47	80	100		70	Poor resolution for first 2-3 years
jh-2	50	F	kelt	5ss	127	13	30	47	91	116	127		60	
jh-1	46	F	kelt	5s	99	14	29	58	81	99			46	
sarb-17	43.5	F	na	6s	85		29	42	57	67	84		45	Resorption at scale margin
sarb-16	44.5	M	kelt	5ss	82	10	20	30	62	75	82		55	Resorption and spawning check p2
sarb-15	49	F	kelt	5ss	77	14	22	32	55	71	77		58	Classic spawning check
sarb-14	38.5	F	I	4+	82	13	30	58	77					Plus growth - immature
sarb-13		M	na											regenerated - repeat spawner
sarb-12		F	na											regenerated - poor scales
sarb-11	51	F	na	5s+	121	14	34	63	91	115	107		57	Plus growth
sarb-10	36	F	I	4+	77	13	30	44	71					
sarb-9	46	F	Imm?	5s?	113	15	30	65	95	113			46	No resorption or plus growth
sarb-8	47	F	kelt	5ss	88	15	32	62	79	88			47	Classic spawning check
sarb-7														V. poor scales
sarb-6	42.5	M	kelt	5s	89	14	29	48	74	89			43	Resorption at scale margin
sarb-5	43.5	F	kelt	5s	92	14	32	64	79	92			44	No resorption or plus growth
sarb-4	48	F	kelt	5s+	103	11	26	45	69	99			53	Plus growth although a kelt
sarb-3	27.5	I	I	3+	62	19	34	57						
sarb-2	45.5	F	kelt	4ss	76	21	33	60	71	76			53	May have spawned at age 4 also.
sarb-1	46.5	F	I?	4+	96	14	31	54	89					Substatial plus growth. Immature?
U	45	M	na	5s	90	13	31	52	76	90			45	Resorption
R														V. poor scales
Q	49	M	na	5+	118	15	28	47	75	112				Substatial plus growth. Immature?
P	43	F	kelt	5ss	75		22	34	56	71	75		49	
O														V. poor scales
N	60	F	kelt	5ss	135	12	35	66	102	128	135		65	Spawned at 600mm, 5sss in 2002
M	46.5	M	kelt	5s	75	14	26	41	63	75			47	Resorption at scale margin
L	40	na	kelt	4+	76	11	26	43	65	76				Substatial plus growth. Kelt?
LO	41	F	kelt	5s	98	12	24	39	85	98			41	Resorption at scale margin
K	40	F	kelt	5s	78	11	25	37	57	78			40	No plus growth
J	31	I	I	4+	52	10	29	41	52					
I	24.5	I	I	3+	41	11	23	35						
H	57	F	na	4ssss?	134	16	43	93	112	122	129	134	75	4-time repeat? - checks at 4s, 5s
G	47	M	kelt	5ss	104	17	32	45	71	99	104		53	good 5s check

					Dia.				Annulus				Fraser-Lee	
Scale no.	**Fork l.**	**Sex**	**Maturity**	**Age**	**Scale**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**size-at-mat.**	**Comments**
F	45	F	na	5s?	100	14	32	62	87	100			45	No plus growth
E	45	M	na	5s	91	15	28	41	70	91			45	Resorption at scale margin
D														regenerated - poor scales
C	44.5	F	kelt	4sss	91	15	29	57	78	85	91		62	Based on spawning check at 4s p.2
B	41.5	F	na	4+	101	15	39	67	96					Substatial plus growth.Imm?
A	54	F	kelt	6s	114	16	29	43	78	101	114		54	Resorption at scale margin

Appendix IV – Locations (Stream Kilometer from Mouth) of Radio Tagged Salmo River Rainbow Trout, 2001 and 2002 (Blue = Tagging Location, Green = Summering Location, Grey = Overwintering Location; Red = Spawning Location)

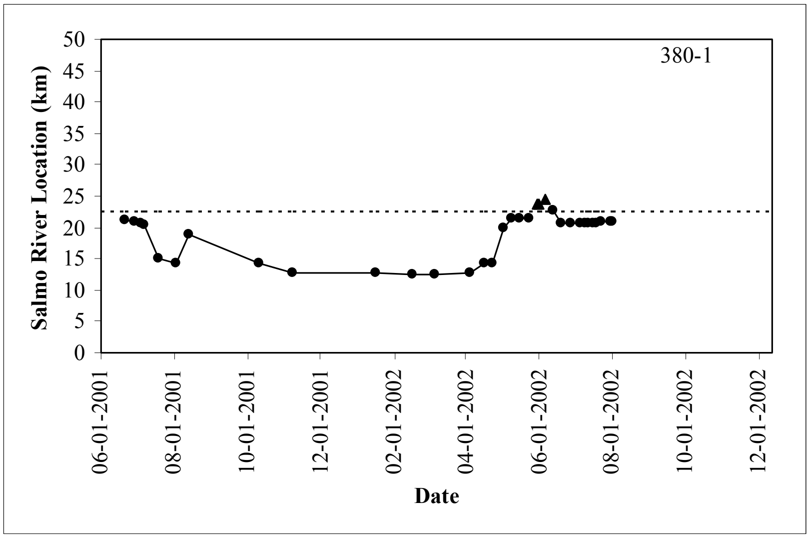
Tag no.	01-Jun-01	06-Jun-01	08-Jun-01	12-Jun-01	19-Jun-01	20-Jun-01	21-Jun-01	22-Jun-01	28-Jun-01	30-Jun-01	04-Jul-01	06-Jul-01	11-Jul-01	16-Jul-01	17-Jul-01	18-Jul-01	19-Jul-01	30-Jul-01	31-Jul-01	02-Aug-01	13-Aug-01	08-Sep-01	19-Sep-01	10-Oct-01	07-Nov-01	16-Dec-01	15-Jan-02
380-1							21.3		20.9		20.7	20.5					15.0			14.3	19.0			14.3	12.8		12.8
380-2		15.5					15.5			15.5							15.3			15.4	15.5	36.3					45.5
380-3							19.4		19.4		19.3	19.4				18.5		19.6		19.5	19.4	19.4			19.4		19.4
380-4							19.9		20.1		19.7	19.9		19.8		19.9	19.8			19.8	19.9	19.9			19.9		19.9
380-5						20.9	20.9		19.4		19.7	19.9		19.4		19.4		21.2		21.2	19.9	19.4			19.9		19.9
380-6								5.7									6.0			5.7	5.7	0.0			0.0		0.0
380-7		18.5					18.5		18.6		18.6	18.6		18.6		18.6		18.5		18.5		19.0			16.9		
380-8						20.8	20.8		20.8		20.5	20.4		20.4		20.4		20.4		20.4	19.0	18.1			20.2		19.9
380-9		20.2					19.0		19.0		19.0	19.0		19.0		19.0		19.1		19.0	19.0	19.0			21.8		20.9
380-10										16.0							16.1			16.1	15.5	15.8		16.0	16.0		16.0
420-1				32.3	32.3											32.3		32.3			32.3						14.3
420-2	26.2				26.0											32.3		32.3			32.3	32.3			32.3		32.3
420-3				35.7	37.0								36.3		36.3			37.6			38.3	38.3	37.0		37.0	35.7	35.7
420-4		19.0					19.0		19.0		19.0	18.9				33.5		33.3			33.3	33.3			33.3		33.3
420-5			34.6		34.6								34.6		34.6			34.7			34.7		34.7		34.7		16.9
420-6			20.2				20.2		20.2		20.3	20.2		25.2		25.2		25.2		25.2	25.2	25.2					15.4
420-7						24.4	24.4		24.4		24.4	24.4		24.4		24.4		19.1		19.1					19.0		19.0
420-8						23.5	23.5		23.6		23.4	22.9		22.9		22.9		24.1		23.8	27.0	21.6			22.5		23.7
420-9						23.2	23.2		23.3		23.3	23.3			36.0			36.0			36.3	35.8	35.8		22.5		22.5
420-10						22.4	22.0		22.0		22.0	22.0		18.5		18.5		18.5		18.5					18.1		18.1
780-1																							34.7				
780-2		15.5					14.5		15.5								15.0			14.4	14.5	14.5		17.3	19.0		15.4
780-3		20.1					20.1		20.1		19.8	20.0				31.3		31.3			31.3	31.3			31.3		31.3
780-4				35.7	35.7								36.3		36.3				36.3		36.3	36.3	36.3		36.3	35.7	35.7

Tag no.	01-Jun-01	06-Jun-01	08-Jun-01	12-Jun-01	19-Jun-01	20-Jun-01	21-Jun-01	22-Jun-01	28-Jun-01	30-Jun-01	04-Jul-01	06-Jul-01	11-Jul-01	16-Jul-01	17-Jul-01	18-Jul-01	19-Jul-01	30-Jul-01	31-Jul-01	02-Aug-01	13-Aug-01	08-Sep-01	19-Sep-01	10-Oct-01	07-Nov-01	16-Dec-01	15-Jan-02
780-5			40.5	40.5									40.5		40.5				40.8		40.6	40.7	40.7		24.5		17.3
780-6			20.1	20.2			20.2				19.9	20.0			20.1	18.0		20.1		20.1	20.9	19.9			19.0		20.2
780-7						22.9	22.9		25.2		25.1	25.2		25.2		25.2		25.2		25.2	25.2	25.2			25.2		19.9
780-8			15.8				15.8		15.8								15.8			15.7	15.5	14.5		15.7	15.7		15.7
780-9						22.4	26.2		26.2		26.2			18.5		18.5				14.4	14.5	25.2			26.5		26.5
780-10			39.9		40.5								40.4		40.5				40.6		40.6						
580-1																											
580-2																											
580-3																											
580-4																											
580-5																											
580-6																											
580-7																											
580-8																											
580-9																											
580-10																											

Tag no.	15-Jan-02	15-Feb-02	06-Mar-02	04-Apr-02	16-Apr-02	22-Apr-02	02-May-02	09-May-02	15-May-02	23-May-02	24-May-02	30-May-02	31-May-02	05-Jun-02	06-Jun-02	10-Jun-02	12-Jun-02	13-Jun-02	18-Jun-02	19-Jun-02	26-Jun-02	27-Jun-02	02-Jul-02	04-Jul-02	05-Jul-02	09-Jul-02	11-Jul-02	14-Jul-02	16-Jul-02	17-Jul-02	18-Jul-02	22-Jul-02	23-Jul-02	24-Jul-02	30-Jul-02	11-Dec-02
380-1	12.8	12.5	12.6	12.8	14.3	14.3	19.9	21.4	21.5	21.5		1-SC	1-SC		1.9-SC		22.6			20.7		20.7			20.7	20.7	20.7		20.7		20.7	20.9			20.9	
380-2	45.5				44.9	44.9	44.9	44.9	44.9	44.9		44.9	44.9	44.9			44.6		43.7		43.7									43.7						
380-3	19.4	19.4	19.4	19.5	19.5	19.5	19.5	19.5	19.5	19.5		19.5	19.5	19.0			19.4			19.5		19.5			19.4	19.4	19.4		19.4		19.4	19.4			19.4	19.4
380-4	19.9	19.9	19.9																																	
380-5	19.9	19.9	19.9	19.9	19.9	19.9	19.9	19.9	19.9	19.9		19.5	19.5		19.4		19.5			19.5		19.5		19.5	19.5	19.5	19.9		19.9		19.8	19.8			19.8	18.5
380-6	0.0					0.0	0.0	0.9		1.1			1.1		2.2			2.2																		
380-7																																				
380-8	19.9	19.9	19.9	19.9		19.9	19.9	19.9	19.9	20.2		21.4	21.4		24.5		26.2			25.2		28.3			20.7	25.4	20.2		20.7		20.7	20.2			19.9	
380-9	20.9		20.9	20.9	20.9	28.3	35.7	35.5	23.1	23.5		23.5	23.5		23.5		23.5			23.5		20.7			20.7	23.0	20.2	20.2	20.7		20.9	20.9			20.9	
380-10	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0		15.4	15.4		16.0		15.4			15.4		15.4											16.0			
420-1	14.3													32.3							32.3															
420-2	32.3	32.3	32.3	32.3	32.3	32.3	32.3	32.3	32.3	32.1		32.3	32.3	32.1			31.9		31.9			31.9														31.9
420-3	35.7	35.7	35.7	35.9	35.9	35.9	35.9	35.9	35.9	36.0		35.9	35.7	35.9			35.4		35.4		35.4									36.3						36.3
420-4	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3																											
420-5	16.9	16.9	16.9	16.9	16.9	16.9	16.9	16.9	23.9																											
420-6	15.4	15.4	15.4	15.4	15.4	15.4	15.4	15.3	25.2	25.2			31.1	31.1	23.5		15.4			15.4		15.4											15.4			15.4
420-7	19.0	19.0	19.0	19.0	19.0	19.0	19.0	19.0	19.0	18.5		17.3	16.6		16.6		16.6			16.6		16.5											16.5			16.5
420-8	23.7	23.7	23.7	23.7	23.7	23.7	23.7	23.7	23.7	23.7		23.7	23.7		23.7		23.7			23.7		23.7				23.7	23.7		23.7		23.7	23.7			23.7	23.7
420-9	22.5	22.5	22.5	22.5	22.2	22.2	22.2	22.3	22.3	22.3		24.5	24.5	34.9			38.6		38.6											39.0						37.3
420-10	18.1	18.1	18.1	18.1	18.1	18.1	18.1	18.1	18.1	18.1		18.1	18.1		18.3		18.0			18.0		18.0			18.0	18.0	18.0		18.0		18.0	18.0			18.0	18.0
780-1						15.4	17.3	17.3	24.4	24.4			25.2	34.9			36.3		30.7	24.4		24.4				24.4	24.4							33.3		33.3
780-2	15.4	15.4	15.4	15.4	15.4	25.2	1 EC	26.2	26.2	23.5		23.5	23.5		23.5		23.5			23.5		14.5											14.5			14.5
780-3	31.3	31.3	31.3	31.3	31.3	31.3	31.3	31.3	30.9	30.5		31.3	31.3	30.7			30.7		30.7		30.7							20.1						30.7		30.7
780-4	35.7	35.7	35.7	35.7	35.7	35.7	35.7	35.7	35.7	36.5		35.7	35.5	36.4			35.8		35.8		35.8									36.3						35.7

Tag no.	15-Jan-02	15-Feb-02	06-Mar-02	04-Apr-02	16-Apr-02	22-Apr-02	02-May-02	09-May-02	15-May-02	23-May-02	24-May-02	30-May-02	31-May-02	05-Jun-02	06-Jun-02	10-Jun-02	12-Jun-02	13-Jun-02	18-Jun-02	19-Jun-02	26-Jun-02	27-Jun-02	02-Jul-02	04-Jul-02	05-Jul-02	09-Jul-02	11-Jul-02	14-Jul-02	16-Jul-02	17-Jul-02	18-Jul-02	22-Jul-02	23-Jul-02	24-Jul-02	30-Jul-02	11-Dec-02
780-5	17.3					5.7	5.7	5.7	5.7	5.7		10.6	10.6		16.0		15.5			15.5		15.5								40.5						40.5
780-6	20.2	20.2	20.2	21.3	20.9	21.3	21.3	20.9	20.9	20.9		20.9			20.9		20.3			20.3		20.3			20.3	20.3	20.3		20.3		20.3	20.3			20.3	20.3
780-7	19.9	19.9	19.9	19.9	19.9	19.9	19.9	19.9			1.9-SC	23.5	23.5		23.5		23.5			23.5		23.5				25.1	25.2		25.2		25.2	25.2			25.2	25.2
780-8	15.7	15.7	15.7	15.7	15.4	15.4	15.4	15.7	15.7	16.0		16.1	16.1		16.4		17.7			15.5		15.5											16.0			15.5
780-9	26.5	26.5	26.5	26.5	26.5	26.5	26.5	26.4	26.4	26.4		26.4	26.4		26.4		26.4			26.4		26.4												26.4		26.4
780-10																																				
580-1																								25.1		23.1	22.9		22.9		24.4	25.2			25.2	22.6
580-2																17.8									19	18.9	19		18.9		18.9	18.9			18.9	18.9
580-3																								23.9		23.9	23.9		23.9		23.9	23.9			23.9	23.9
580-4																								25.7		25.7	25.7				25.7	25.7			25.7	25.7
580-5																																				
580-6																								19.9	19.9	17.7	20.2		19		19.8	19.8			19.8	18.5
580-7																							23.8			24								33.3		33.3
580-8																								19.9	19.4	19.4	19.4		19.4		19.4	19.4			19.4	
580-9																							20.2		20.2	20.2	20.2		20.2		19.9	19.9			19.9	20.7
580-10																20.6										20.6	20.6		20.6		20.7	17.1	17.3			16.7

Appendix V – Migration Patterns of Radio Tagged Salmo River Rainbow Trout, 2001 and 2002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Salmo River Location (km)
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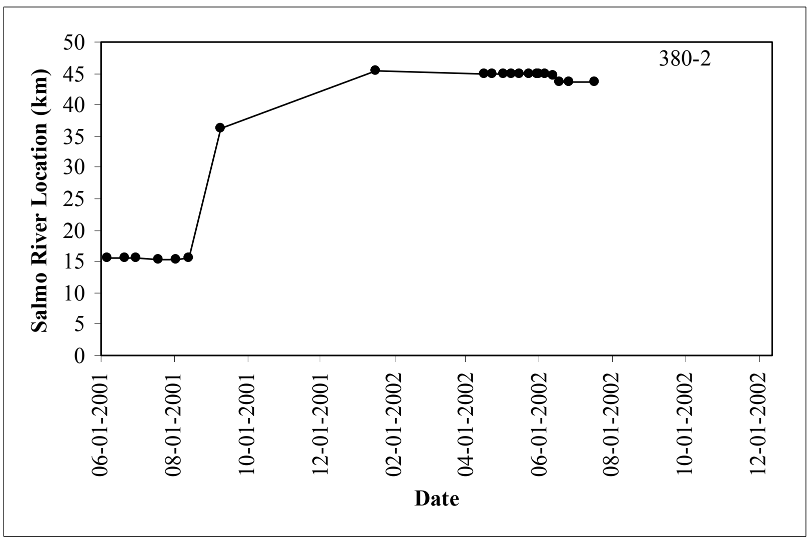
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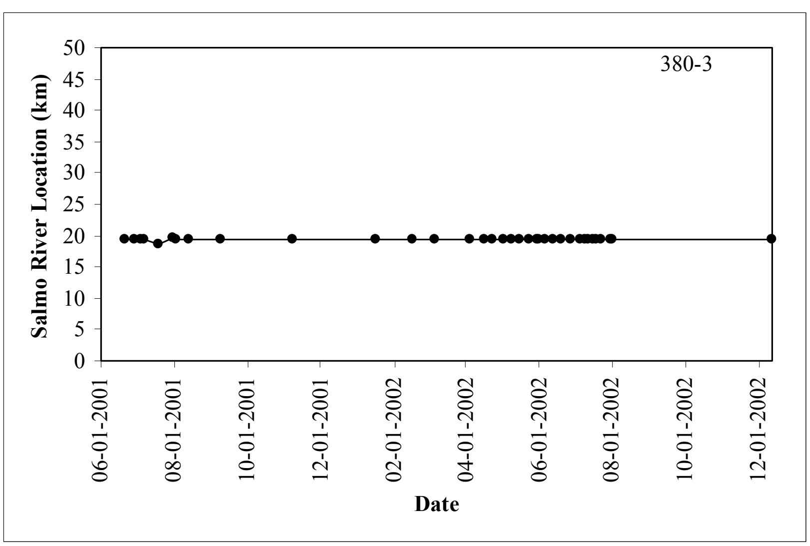
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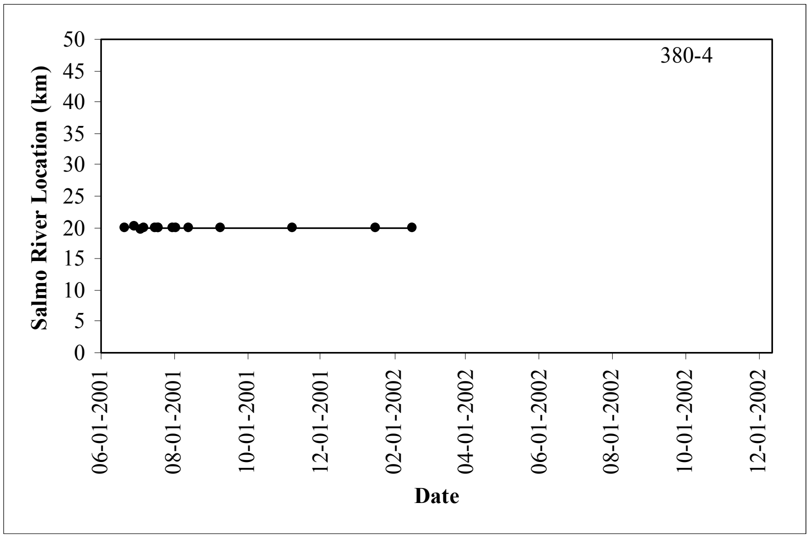
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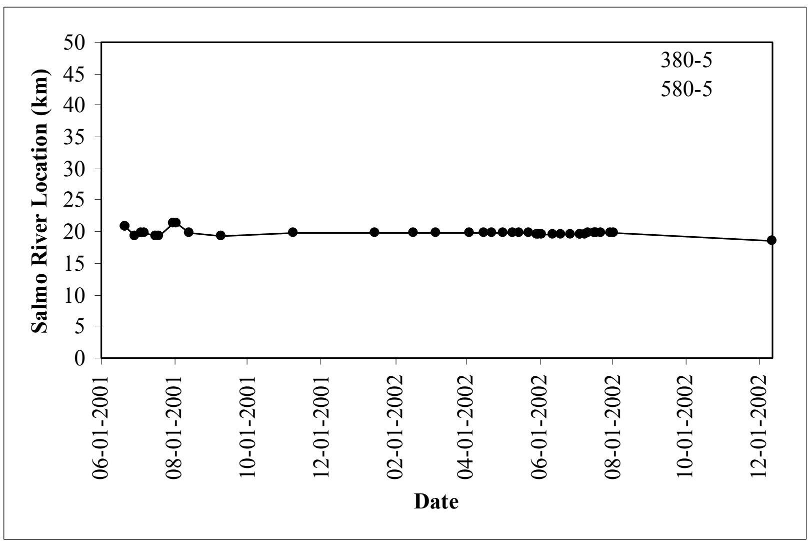
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08-01-2001
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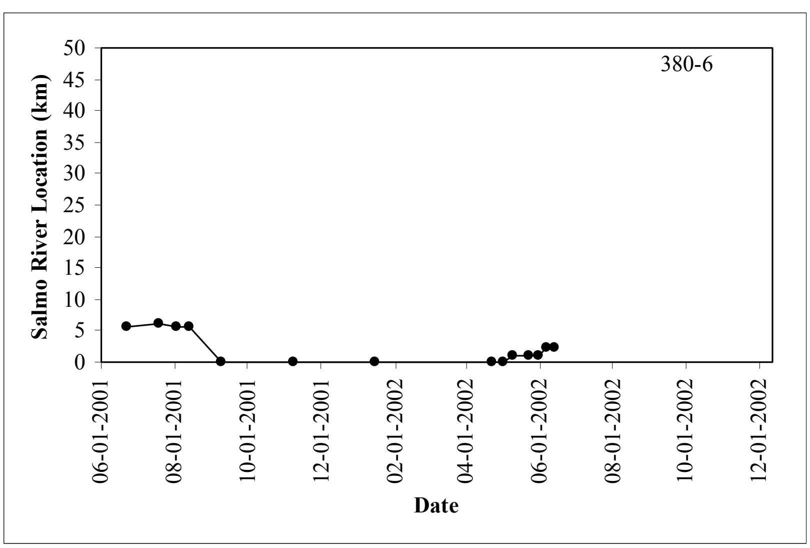
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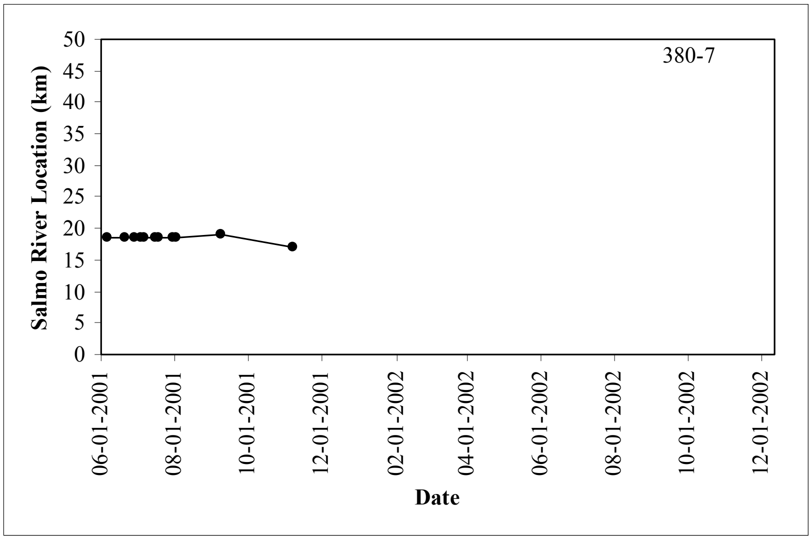
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Salmo River Location (km)
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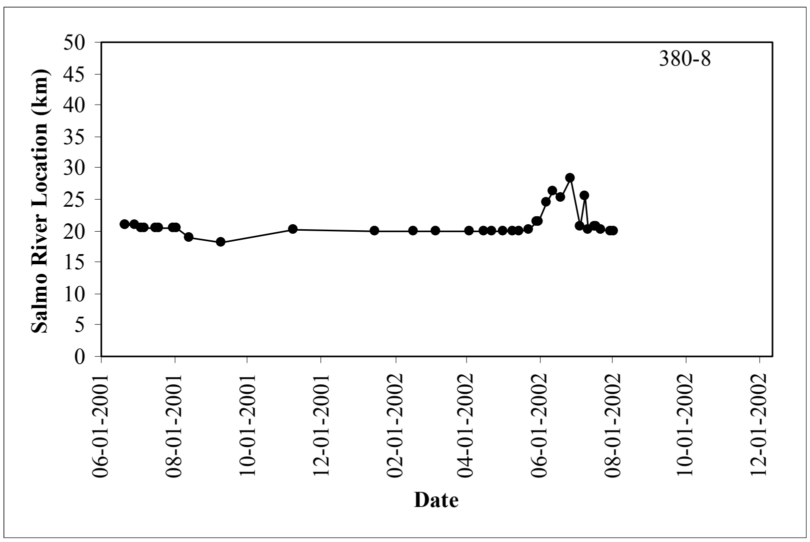
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40
45
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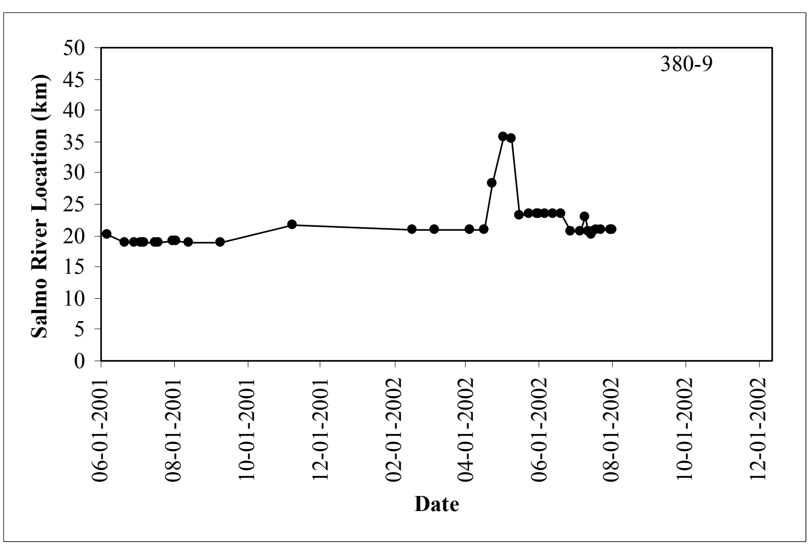
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Salmo River Location (km)
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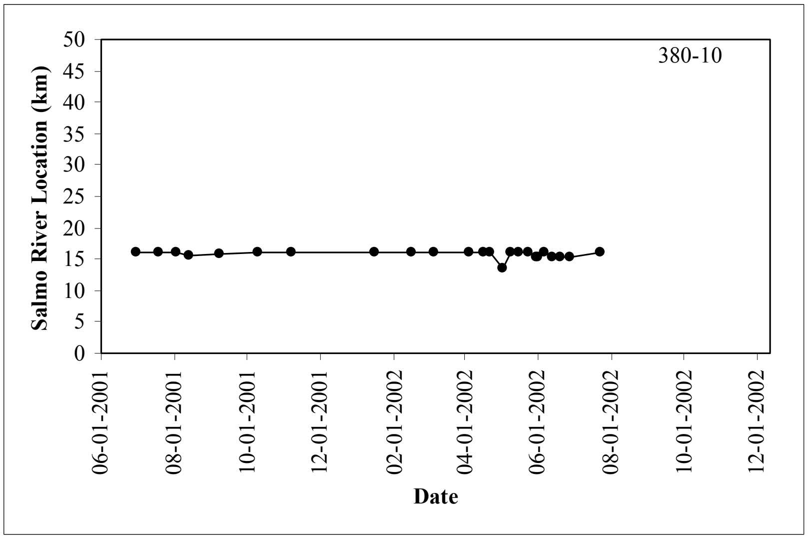
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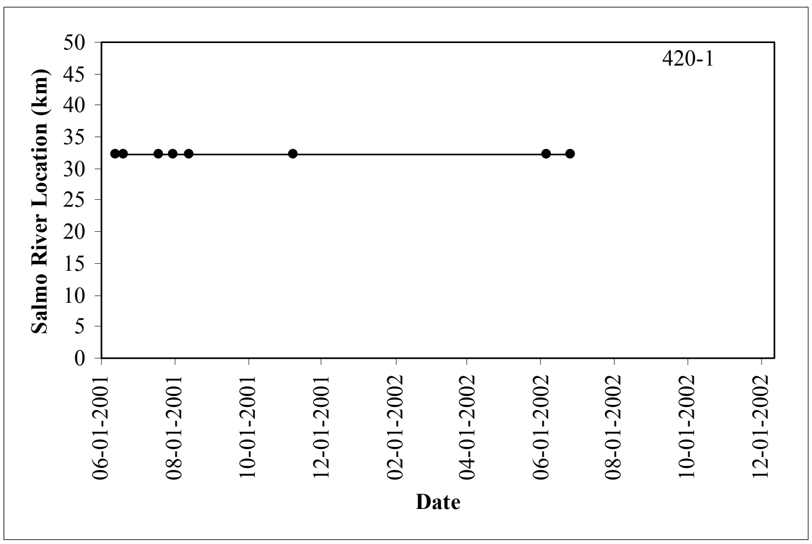
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Salmo River Location (km)
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40
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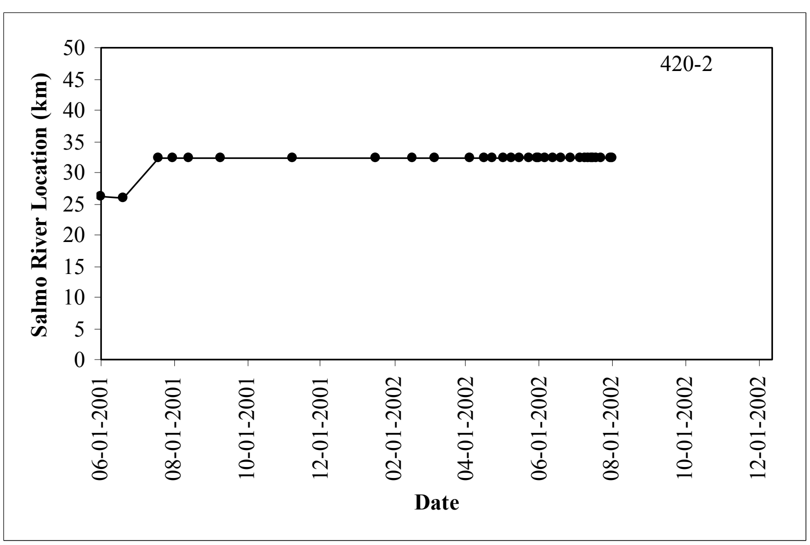
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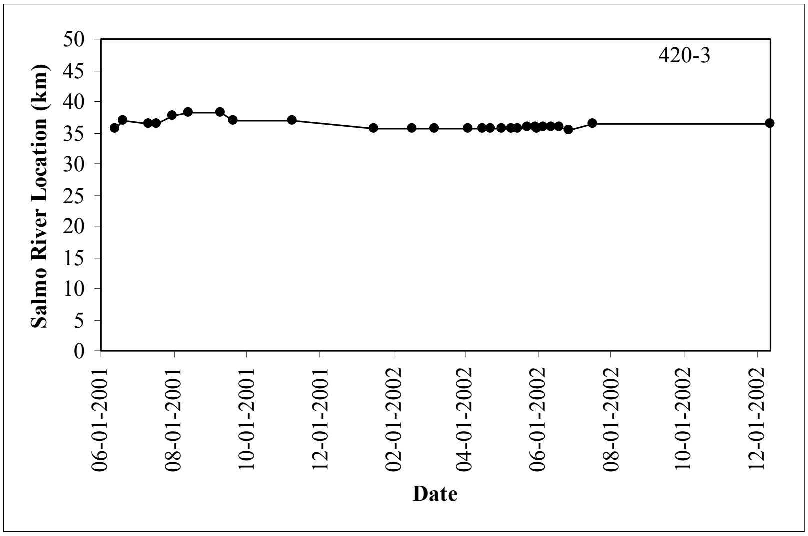
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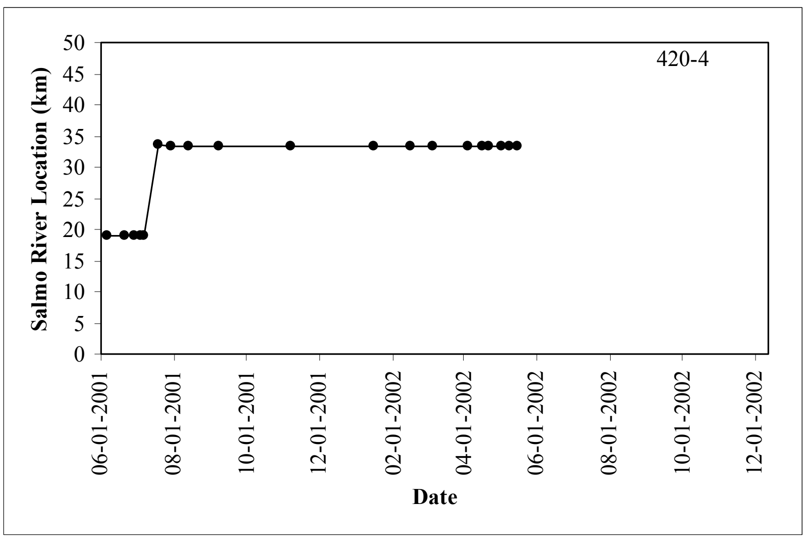
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Salmo River Location (km)
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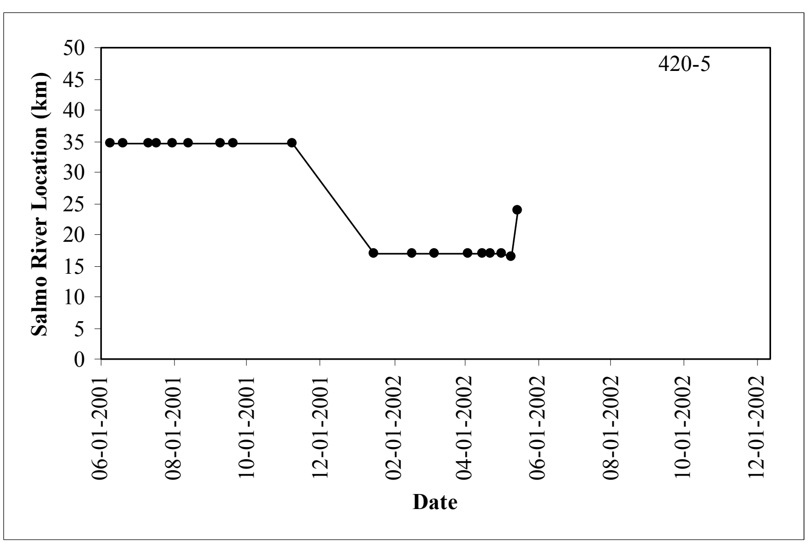
420-5
Salmo River Location (km)
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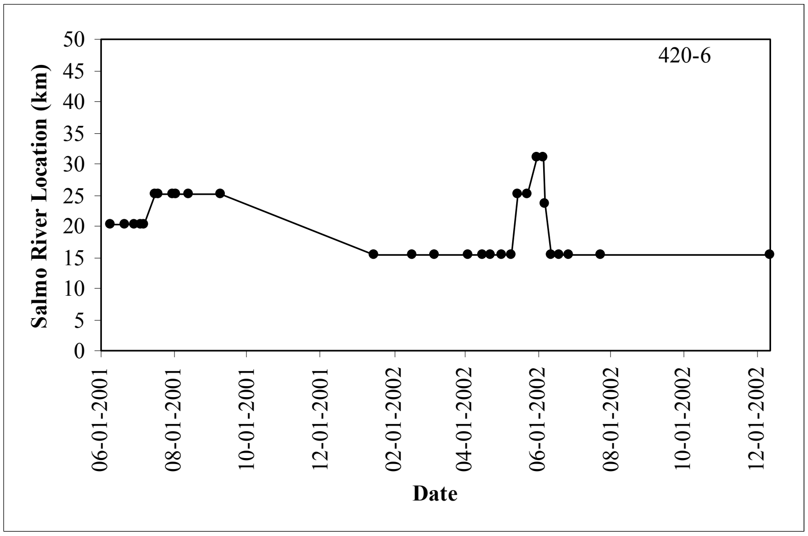
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Salmo River Location (km)
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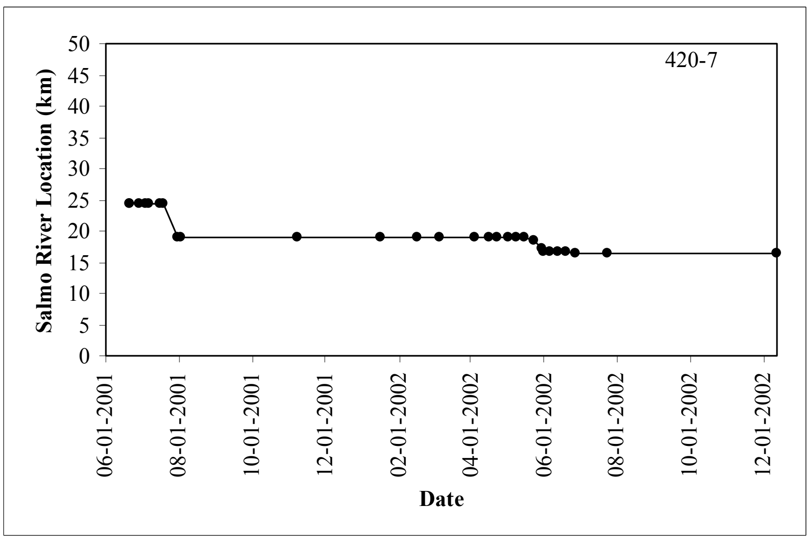
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Salmo River Location (km)
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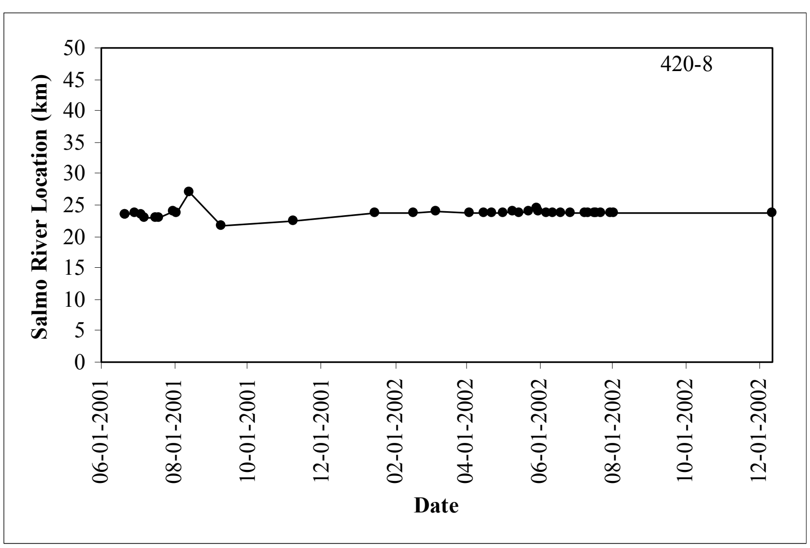
420-8
Salmo River Location (km)
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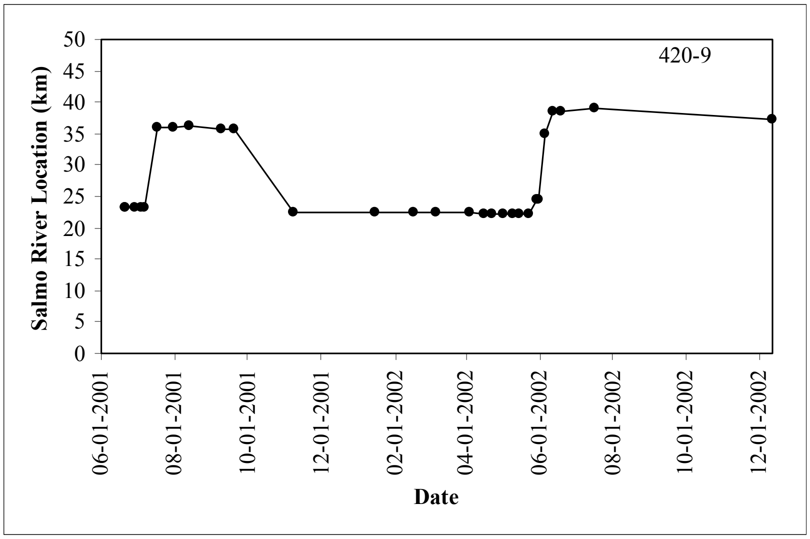
420-9
Salmo River Location (km)
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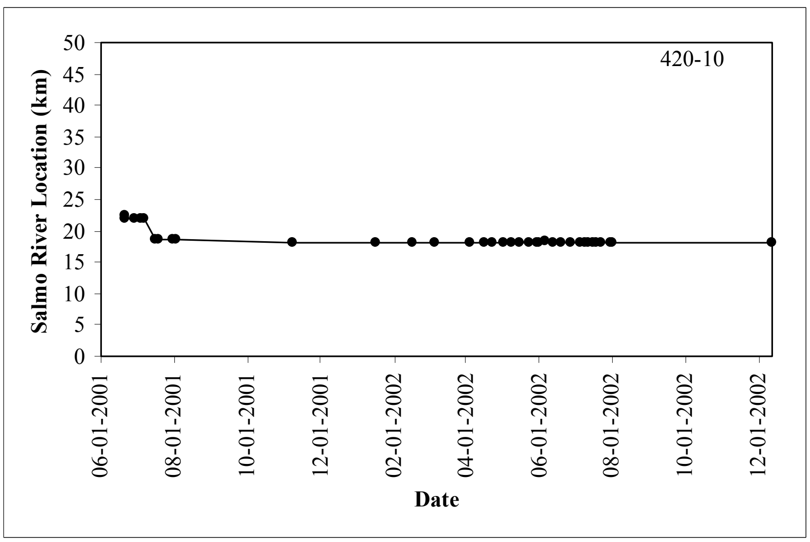
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Salmo River Location (km)
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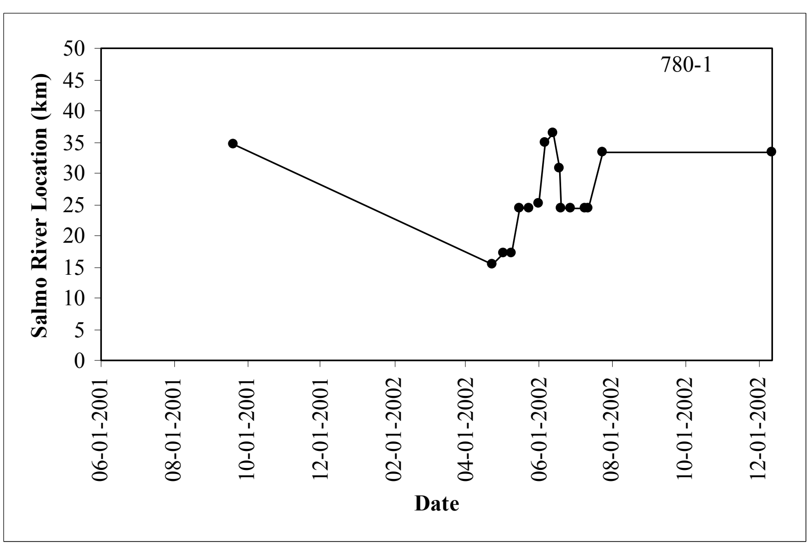
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Salmo River Location (km)
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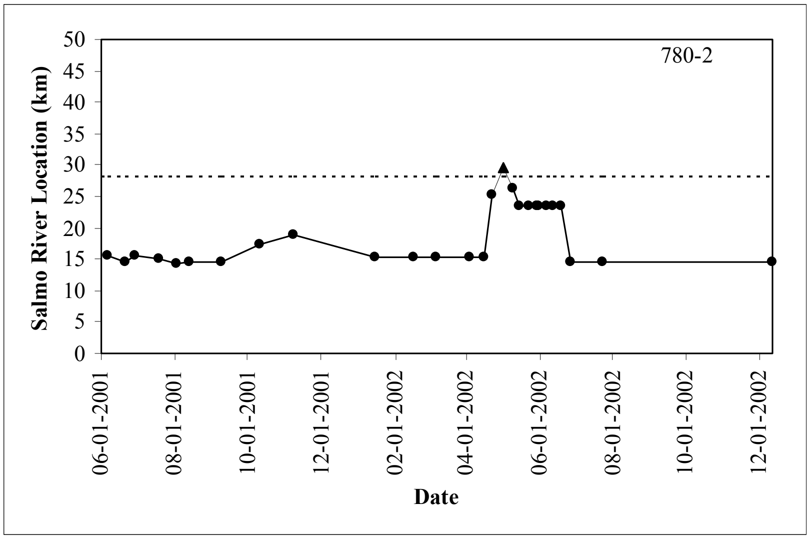
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Salmo River Location (km)
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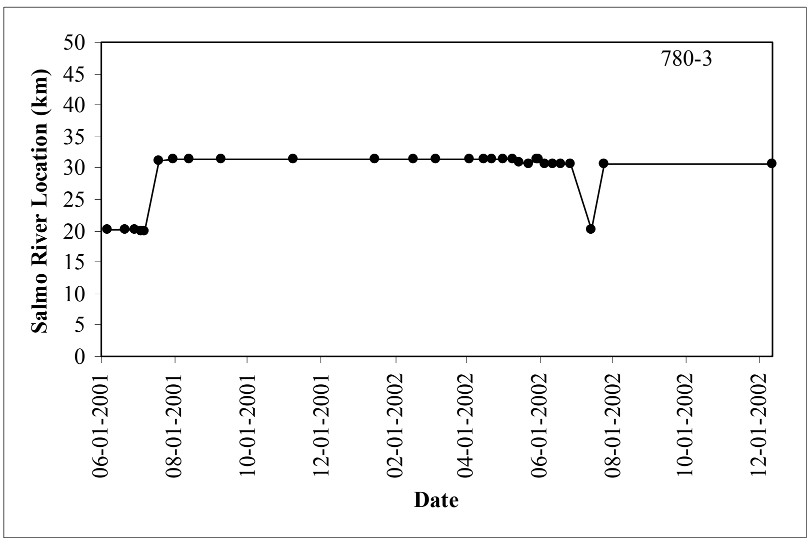
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Salmo River Location (km)
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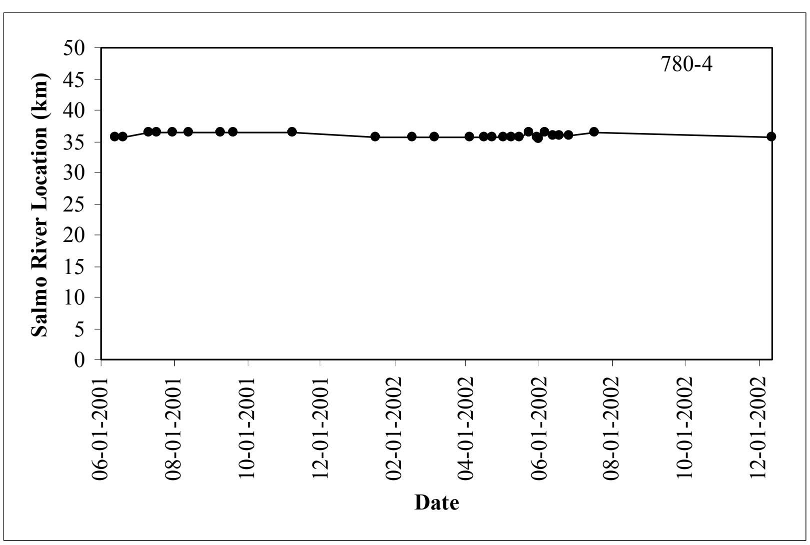
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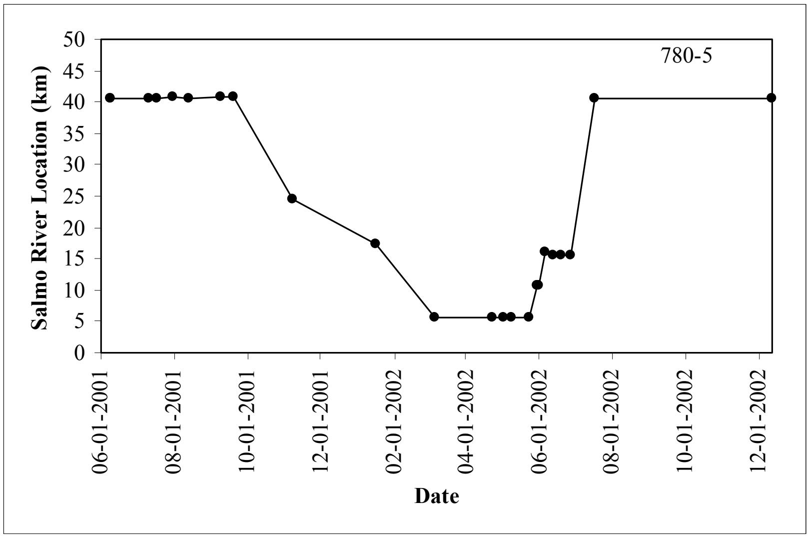
780-5
Salmo River Location (km)
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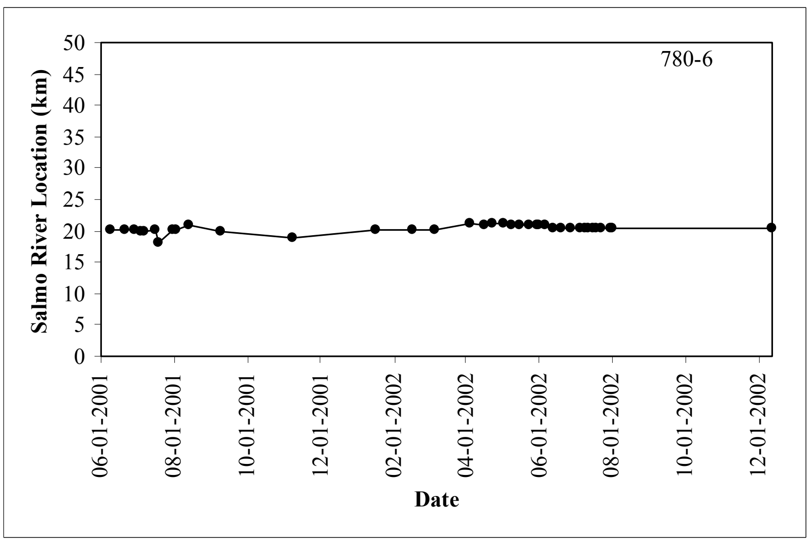
780-6
Salmo River Location (km)
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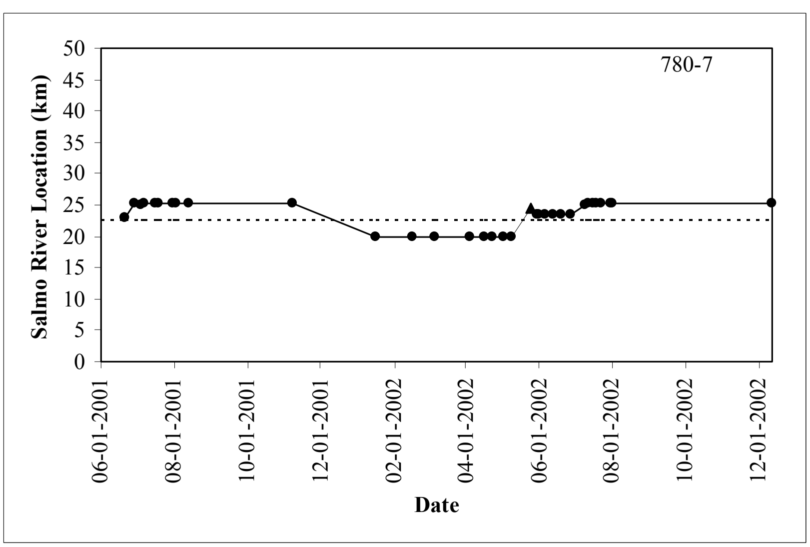
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Salmo River Location (km)
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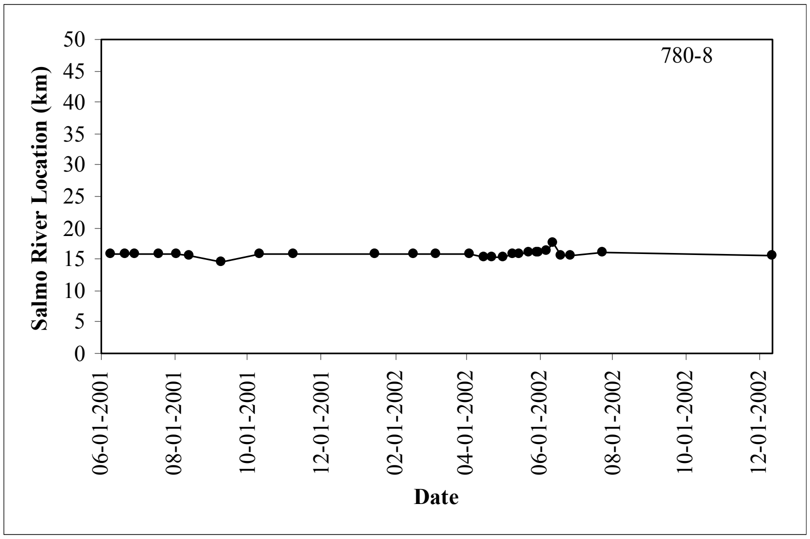
780-8
Salmo River Location (km)
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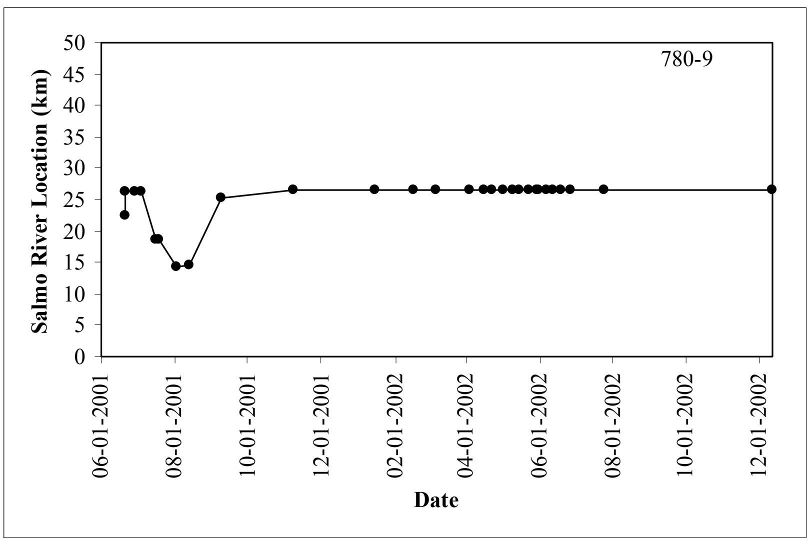
780-9
Salmo River Location (km)
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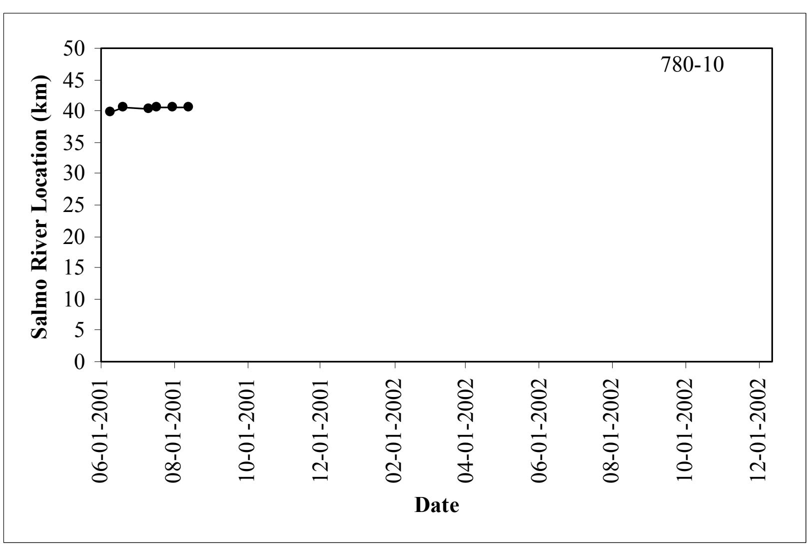
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Salmo River Location (km)
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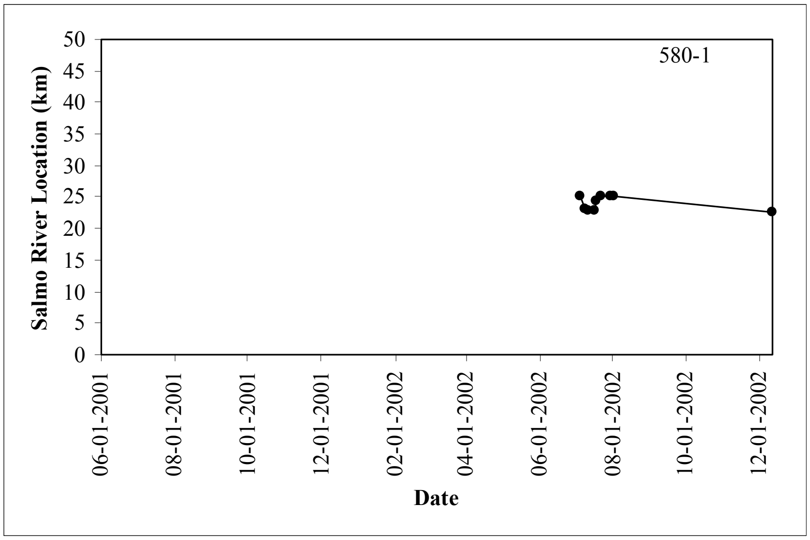
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Salmo River Location (km)
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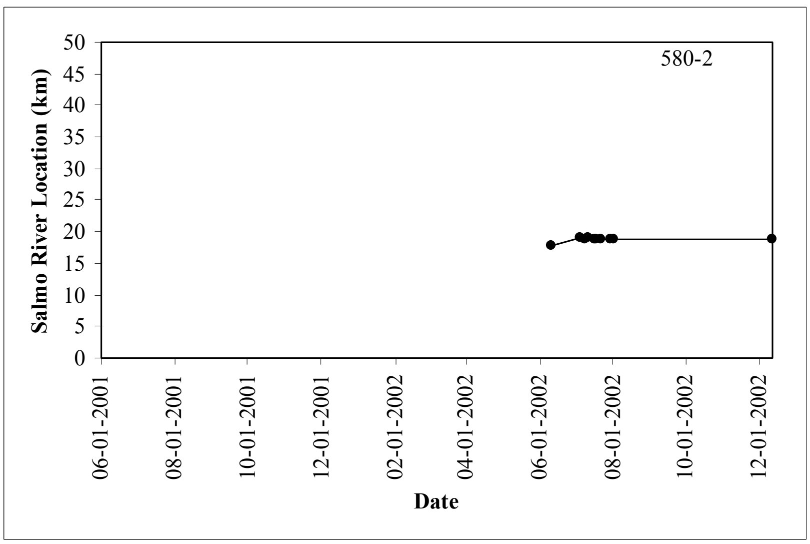
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Salmo River Location (km)
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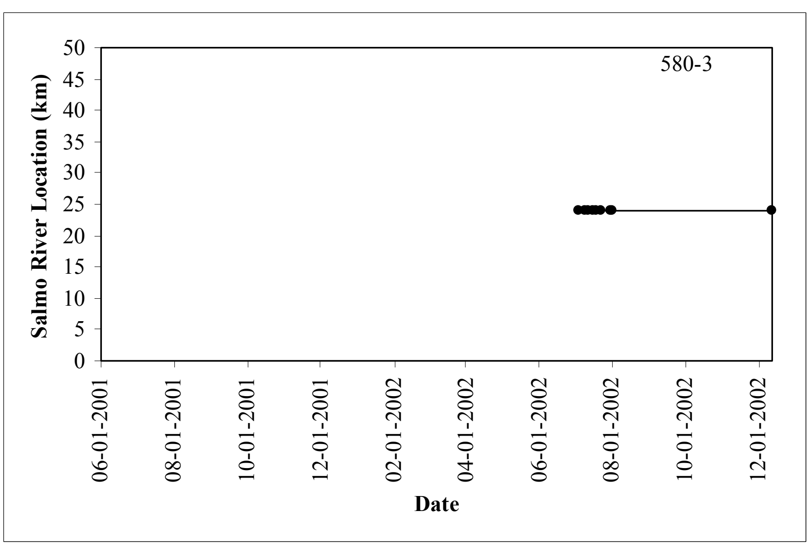
580-3
Salmo River Location (km)
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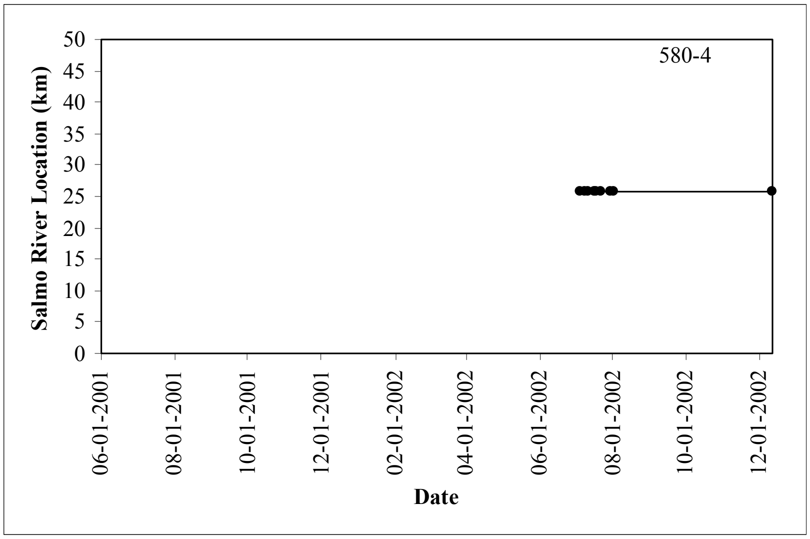
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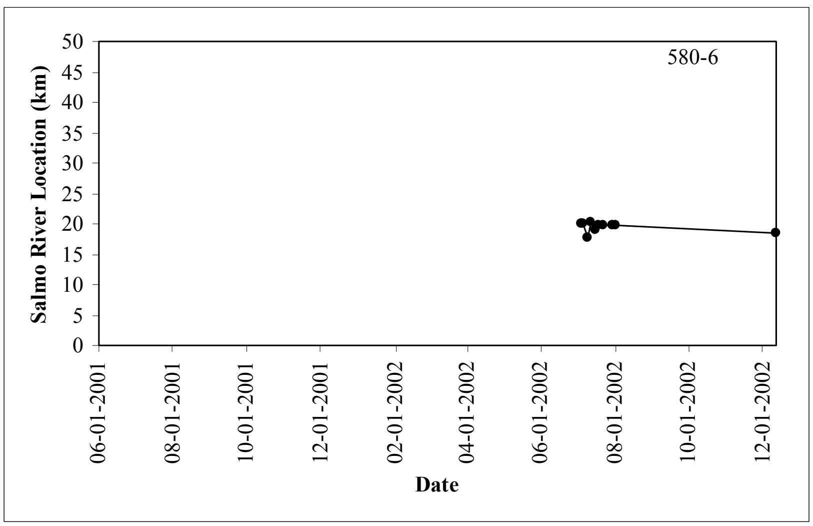
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Salmo River Location (km)
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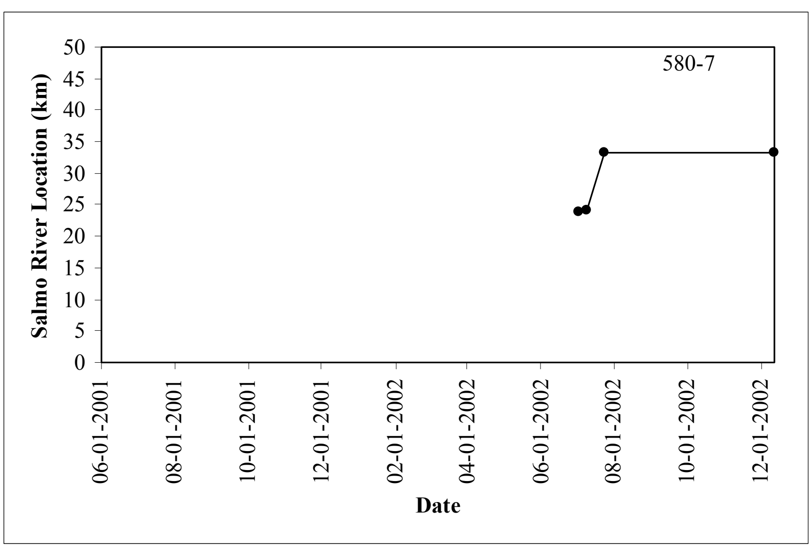
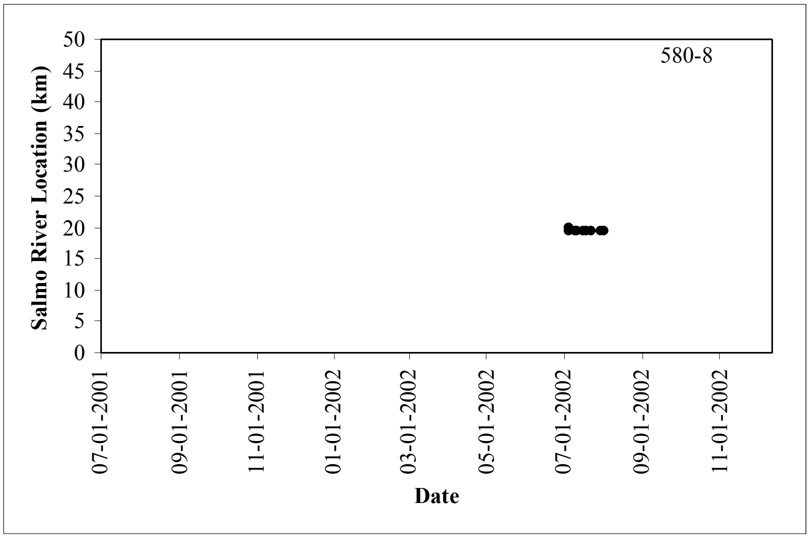
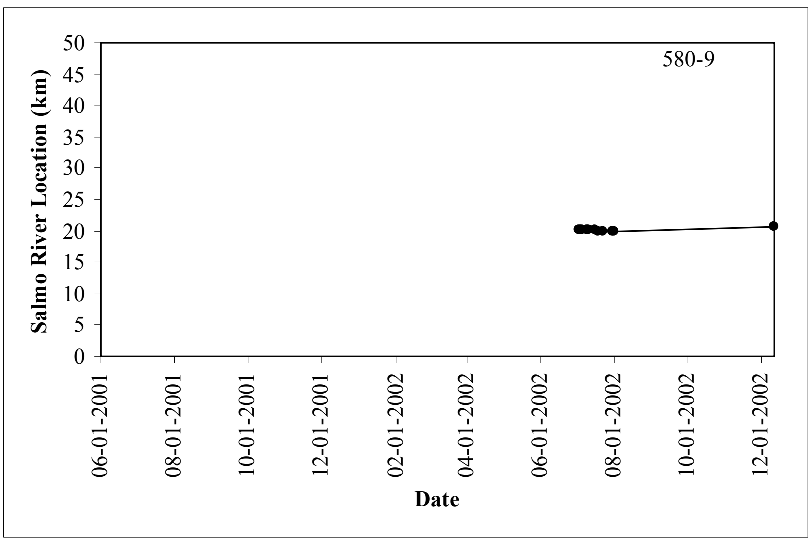
Date

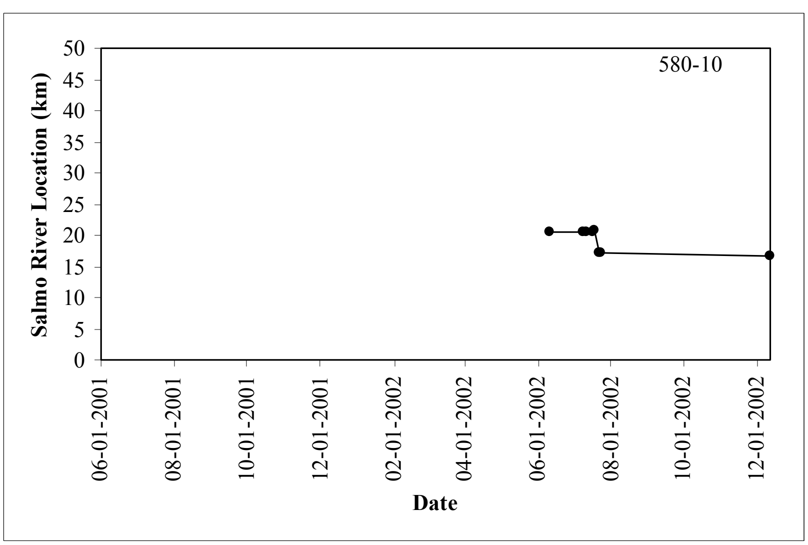

580-7
Salmo River Location (km)
50
45
40
35
30
25
20
15
10
5
0
06-01-2001
08-01-2001
10-01-2001
12-01-2001
02-01-2002
04-01-2002
06-01-2002
08-01-2002
10-01-2002
12-01-2002
Date



580-8
Salmo River Location (km)
50
45
40
35
30
25
20
15
10
5
0
07-01-2001
09-01-2001
11-01-2001
01-01-2002
03-01-2002
05-01-2002
07-01-2002
09-01-2002
11-01-2002
Date

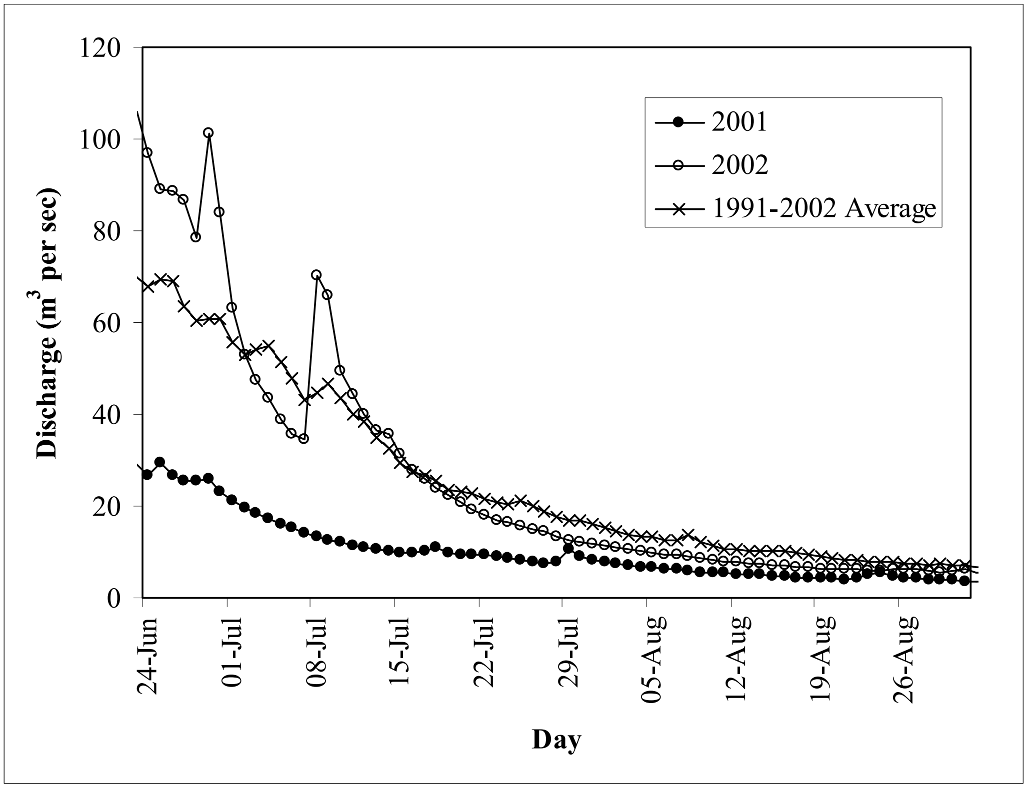


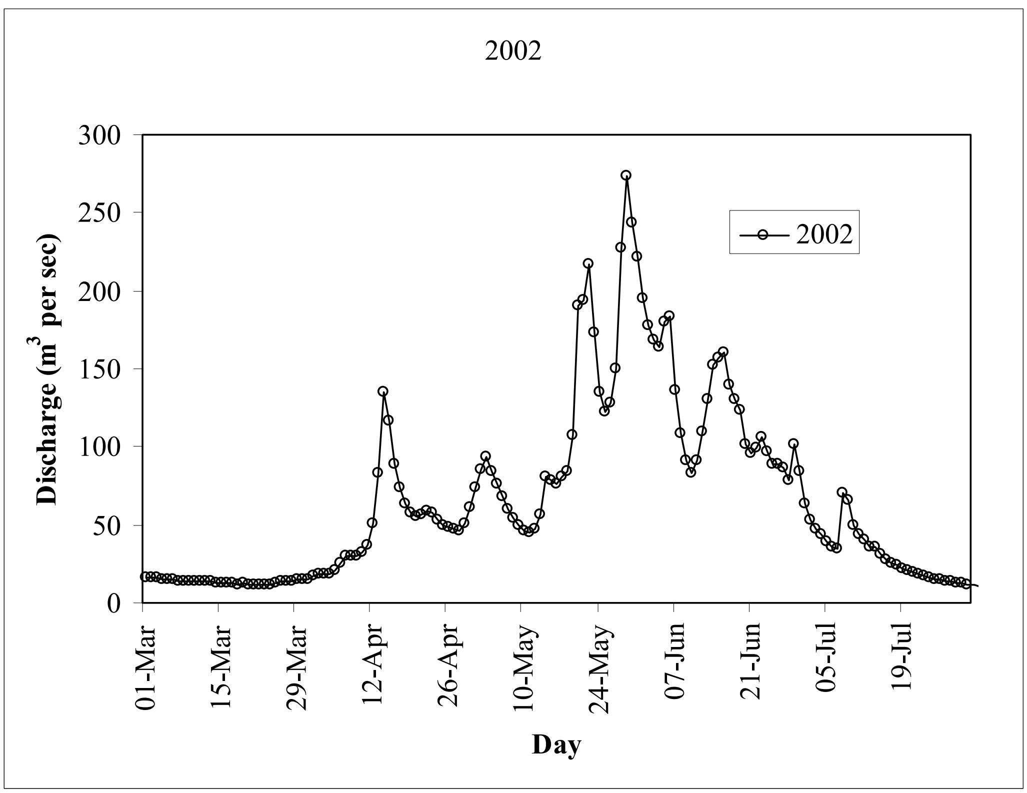
580-9
Salmo River Location (km)
50
45
40
35
30
25
20
15
10
5
0
06-01-2001
08-01-2001
10-01-2001
12-01-2001
02-01-2002
04-01-2002
06-01-2002
08-01-2002
10-01-2002
12-01-2002
Date



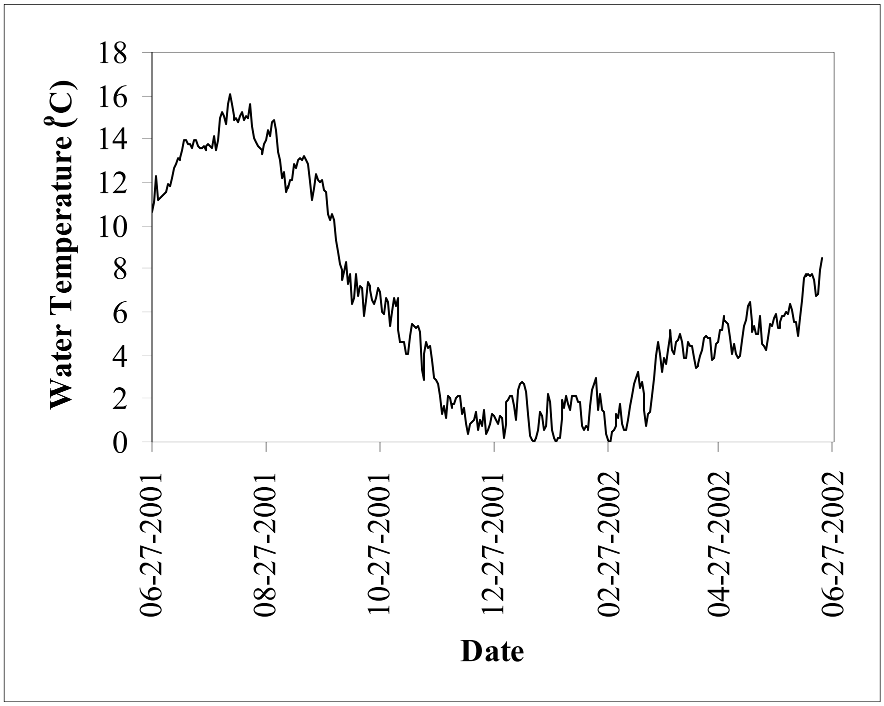
580-10
Salmo River Location (km)
50
45
40
35
30
25
20
15
10
5
0
06-01-2001
08-01-2001
10-01-2001
12-01-2001
02-01-2002
04-01-2002
06-01-2002
08-01-2002
10-01-2002
12-01-2002
Date

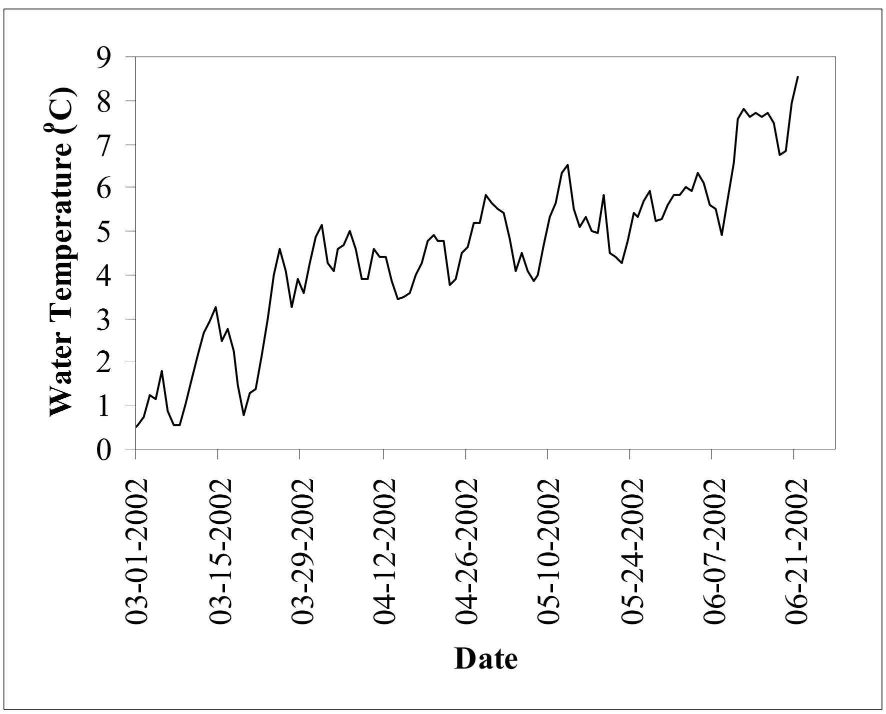
Appendix VI – Water Discharge in the Salmo River, 2001 and 2002


120
100
80
60
40
20
0
Discharge (m3 per sec)
2001
2002
1991-2002 Average
24-Jun
01-Jul
08-Jul
15-Jul
22-Jul
29-Jul
05-Aug
12-Aug
19-Aug
26-Aug
Day


2002
300
250
200
150
100
50
0
Discharge (m3 per sec)
2002
01-Mar
15-Mar
29-Mar
12-Apr
26-Apr
10-May
24-May
07-Jun
21-Jun
05-Jul
19-Jul
Day

Appendix VII – Water Temperature in the Salmo River, 2001 and 2002


Water Temperature (ºC)
18
16
14
12
10
8
6
4
2
0
06-27-2001
08-27-2001
10-27-2001
12-27-2001
02-27-2002
04-27-2002
06-27-2002
Date


Water Temperature (ºC)
9
8
7
6
5
4
3
2
1
0
03-01-2002
03-15-2002
03-29-2002
04-12-2002
04-26-2002
05-10-2002
05-24-2002
06-07-2002
06-21-2002
Date

Appendix VIII – Diver Survey Data Collected in the Salmo River, 2001 and 2002

Survey date	Section	Observer efficiency	RB observed 0-20cm	20-30cm	30-40cm	40-50cm	50+cm	Count >30	Count >40	BT	EB	MW	SU	NPM
28-Jun-01	upper	0.5	15	14	14	14	0			7	1	0	0	0
	lower	0.75	146	50	59	41	7			9		4	47	5
	total	**0.6875**	**161**	**64**	**73**	**55**	**7**	**135**	**62**	**16**	**1**	**4**	**47**	**5**
04-Jul-01	upper	0.5	51	32	30	12	3			0	0	0	0	0
	lower	0.5	236	115	47	23	3			18	12	6	62	0
	total	**0.5**	**287**	**147**	**77**	**35**	**6**	**118**	**41**	**18**	**12**	**6**	**62**	**0**
06-Jul-01	upper	0.75	21	25	36	9	5			6	2	0	0	0
	lower	0.333333	174	110	60	33	4			20	2	4	181	0
	total	**0.4375**	**195**	**135**	**96**	**42**	**9**	**147**	**51**	**26**	**4**	**4**	**181**	**0**
16-Jul-01	upper	0.5	150	47	15	13	4			4	5	1	0	1
	lower	0.375	238	88	54	25	4			6	0	2	169	27
	total	**0.416667**	**388**	**135**	**69**	**38**	**8**	**115**	**46**	**10**	**5**	**3**	**169**	**28**
18-Jul-01	upper	1	59	42	33	14	4			1	3	1	0	1
	lower	0.333333	218	94	59	27	5			0	0	1	180	24
	total	**0.538462**	**277**	**136**	**92**	**41**	**9**	**142**	**50**	**1**	**3**	**2**	**180**	**25**
30-Jul-01	upper	0.666667	88	42	27	8	4			2	4	1	0	0
	lower	0.555556	440	119	66	41	9			8	10	3	135	32
	total	**0.583333**	**528**	**161**	**93**	**49**	**13**	**155**	**62**	**10**	**14**	**4**	**135**	**32**

Survey date	Section	Observer Efficiency	RB observed 0-20cm	20-30cm	30-40cm	40-50cm	50+cm	Count >30	Count >40	BT<30	BT>30	EBT	MW
09-Jul	upper	0.25	4	1	0	1	0	1	1	0	6	1	0
	lower	0.166667	11	13	5	8	1	14	9	0	3	0	1
	total	**0.2**	**15**	**14**	**5**	**9**	**1**	**15**	**10**	**0**	**9**	**1**	**1**
11-Jul	upper	0	9	5	6	5	2	13	7	0	2	0	0
	lower	0.2	22	9	11	13	1	25	14	1	5	0	0
	total	**0.125**	**31**	**14**	**17**	**18**	**3**	**38**	**21**	**1**	**7**	**0**	**0**
16-Jul	upper	0.333333	63	19	11	2	1	14	3	0	3	8	0
	lower	0.5	56	31	18	14	4	36	18	1	8	0	0
	total	**0.444444**	**119**	**50**	**29**	**16**	**5**	**50**	**21**	**1**	**11**	**8**	**0**
18-Jul	upper	0.333333	92	37	4	9	1	14	10	0	5	5	0
	lower	0.666667	184	75	21	17	4	42	21	0	11	7	2
	total	**0.555556**	**276**	**112**	**25**	**26**	**5**	**56**	**31**	**0**	**16**	**12**	**2**
22-Jul	upper	0.666667	110	41	16	8	5	29	13	1	2	16	0
	lower	1	177	98	27	19	6	52	25	0	5	2	5
	total	**0.875**	**287**	**139**	**43**	**27**	**11**	**81**	**38**	**1**	**7**	**18**	**5**
30-Jul	upper	1	254	90	15	20	2	37	22	0	1	9	0
	lower	0.6	416	177	42	24	8	74	32	1	4	0	2
	total	**0.75**	**670**	**267**	**57**	**44**	**10**	**111**	**54**	**1**	**5**	**9**	**2**
01-Aug	upper	0.666667	152	72	15	11	2	28	13	0	1	17	0
	lower	1	189	86	40	31	4	75	35	0	3	0	1
	total	**0.875**	**341**	**158**	**55**	**42**	**6**	**103**	**48**	**0**	**4**	**17**	**1**

Appendix IX – Poster Used During Community Education

ATTENTION *anglers*

SALMO RIVER RAINBOW TROUT TELEMETRY PROJECT

PLEASE DO NOT KILL RADIO TAGGED FISH. RELEASE THEM UNHARMED.

Photo Credit: James Baxter

We are currently conducting a project to determine the status and life-history of rainbow trout in the Salmo River watershed. Rainbow trout have been tagged with a radio tag with antennae and an orange floy tag. If you capture a radio tagged fish, please record the tag numbers and release the fish. Report the tag numbers to James Baxter, by calling (250) 352.6096 or fax to (250) 352.6092. Thank you for your cooperation.

Should you have any technical questions regarding this project please contact James Baxter (250) 352.6096 or John Hagen (250) 505.5434.

Funding for this project is provided by BC Hydro, Ministry of Environment, Lands & Parks, Columbia Basin Fish & Wildlife Compensation Program, Columbia Kootenay Fisheries Renewal Partnership, Salmo Watershed Streamkeepers Society and Beaumont Timber

Poster design courtesy of Frank Communications Inc.

For your information: Bull Trout are a blue-listed species protected by Provincial Regulations. Please catch and release.