# Implementation of a Conservation Plan for Gerrard Rainbow Trout:

## STOCK ASSESSMENT OF JUVENILE GERRARD RAINBOW TROUT IN THE LARDEAU RIVER

## FINAL REPORT

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**Cover Photo**: 'Lee Williston releases a 715 mm tagged rainbow trout on Kootenay Lake.' Photograph taken on the 29th of April 2010 by Greg Andrusak.

HABITAT CONSERVATION TRUST FOUNDATION

This project is primarily funded by the Habitat Conservation Trust Foundation. The Habitat Conservation Trust Foundation was created by an act of the legislature to preserve, restore and enhance key areas of habitat for fish and wildlife throughout British Columbia.

Anglers, hunters, trappers and guides contribute to the projects of the Foundation through licence surcharges. Tax deductible donations to assist in the work of the Foundation are also welcomed.

Suggested Citation: Andrusak G.F. (2010) Implementation of a Conservation Plan for Gerrard Rainbow Trout: Stock Assessment of Juvenile Gerrard Rainbow Trout in the Lardeau River.. A Redfish Consulting Ltd. Report prepared for the Habitat Conservation Trust Foundation.

## EXECUTIVE SUMMARY

This report provides a summary of five years (2005-2010) of juvenile rainbow trout density and abundance estimates in the Lardeau River. Habitat surveys were conducted and four categories of habitat were summarized for the entire river. Night time snorkel surveys were conducted in the fall (2005-2007) and spring (2006-2010) to estimate fry and parr densities by habitat type based on sub sampling of randomly selected sites. Over the five year period 428 sites were assessed with each site between 20-50 m. These estimates were then extrapolated for the entire river by habitat type. Fry utilized shallow water side channels and main stem river margins in the fall moving to deeper water as winter advanced. Unfortunately the density and abundance estimates were highly variable owing to insufficient number of sampling sites. The same sampling problems occurred for the parr but the data clearly points to strong reliance by parr on deep water in side channels as well as in the main river. The density and abundance estimates are considered low in comparison to other nursery streams tributary to similar large lakes. Additional sampling in future years is recommended in an effort to reduce the variability.

A small number of acoustic tags were inserted into parr captured in the river in the fall 2007-2008 to determine timing of out-migration. A total of 49 fish have been acoustically tagged with V7 tags in the fall of 2007, spring and fall of 2008. Results from the fall 2007 tagging suggest there is some late fall migration of juvenile rainbow trout from the Lardeau River following the kokanee spawn. Results from the spring 2008 tagging indicate that there is a pronounced spring migration of juvenile rainbow trout from the Lardeau River during the freshet. Results indicate that the majority of out migration occurs in the spring during or following freshet similar to that observed by Irvine (1978).

**ACKNOWLEDGEMENTS**

The authors would like to thank Harvey Andrusak, Steve Arndt, James Baxter, John Bell, Jeff Burrows, and Colin Spence for their support and valuable input. Jeremy Baxter, Stephen Himmer, Gerry Nellestijn, Jim Renn, Jody Schick, and Joseph Thorley assisted with the field work.

The British Columbia Habitat Conservation Trust Foundation provided primary financial support for this study. BC Hydro also contributed financial and logistical support. Logistical support was also contributed by British Columbia Ministry of Environment, Nelson and by the Fish and Wildlife Compensation Program – Columbia Basin.

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## INTRODUCTION

The Gerrard rainbow trout of Kootenay Lake constitute a distinct population (Keeley et al. 2007) of large piscivorous rainbow trout (*Oncorhynchus mykiss*). These remarkable, and sometimes "trophy" size rainbow trout which can often attain ~7 kg, are highly sought after by recreational anglers. While this unique ecotype provides an excellent fishery on the lake, most of their natural production (spawning and rearing) is entirely dependent upon the Lardeau River (Irvine 1978; Redfish Consulting Ltd. 2002). Assessing and determining a stock's reproductive capacity and productivity is essential for managing this highly exploited population. Assessment and estimations of the in-river juvenile abundance provides important information for determining the stock-recruitment relationship that is used to determine useable biological reference points for management of this unique stock.

Understanding how fishing influences the status of these piscivorous rainbow trout on Kootenay Lake and determining whether the current rates of harvest are sustainable is considered to be a high priority for management (Andrusak 2005). Currently, a study is underway on Kootenay Lake to assess the natural and fishing mortality rates of this population (Andrusak and Thorley 2010). During the last five years work has been underway on the Lardeau River to determine the stock's reproductive productivity, an essential piece of information when managing a highly exploited stock. The data obtained from the exploitation study will compliment information collected from the work on the Lardeau River (spawner escapement and juvenile recruitment) thus providing fisheries management with a sound foundation for future management of this highly prized rainbow trout population.

Utilization of a stock recruitment relationship relies on having or obtaining relatively precise indices of adult spawners and subsequent recruitment. Spawner counts have been conducted at the Gerrard spawning grounds and provide an excellent time series extending from 1961 to the present (Hartman and Galbraith 1970; Hagen et al. 2007). More recently, in river work utilizing nighttime snorkel methods have focused on obtaining estimates of juvenile Gerrard rainbow trout in the Lardeau River (Decker and Hagen 2009). Understanding juvenile distribution, habitat use, age structure and standing stock in relation to spawner abundance is required to address several critical issues related to the conservation and management of this population.

Data from the juvenile assessment work also provided the necessary support for implanting acoustic tags in a proportion of age 1+and 2+ juvenile Gerrard rainbow trout within mainstem of the Lardeau River (Decker and Hagen 2009). The tagging provided necessary information on out-migration timing of lake entry juveniles. It is believed that juvenile rainbow trout, as with many other species, are highly dependent upon kokanee spawning within the river and that there is a substantial migration of larger juveniles (>120 mm) entering the lake after completion of kokanee spawning in the fall. Specifically, acoustically tagging parr will assist in determining which factors of mortality or emigration are responsible for the observed age proportions of 1+ to 2+ within the river. Importantly, information from the proportion of lake entry juveniles will assist in determining the population "bottlenecks" within the Lardeau River. If mortality is high determined from the tagging study then indications would point to an in river limitation whereas if emigration rates were high the population would be limited by in-lake factors.

Use of stock recruitment relationships provide the ability to assess stock productivity and define important biological reference points for management. However, these relationships are often based on relatively few and temporally autocorrelated data with substantive measurement errors that can lead to non-interpretative and indistinguishable information. To overcome this collection of more years of data and increasing the precision of the measured variables in the stock-recruit relationship can be addressed with increased sampling at additional cost. This report analyses and summarizes estimates of juvenile abundance data collected from 2006 to 2008 (Decker and Hagen 2009) and more recent data from 2009-2010 on the Lardeau River utilizing nightime snorkel methods to assess recruitment of Gerrard rainbow trout. The study was designed to obtain estimates of juvenile abundance, juvenile distribution, habitat use by age class for the ability to be used in defining a stock recruitment relationship for management purposes.

The original HCTF project objectives were as follows:

**Project objectives:**

The goal of determining the Gerrard population size to more effectively manage this trout population can be achieved by accomplishing the following objectives listed in order of implementation over a five year period**:**

1. Develop a conservation Plan for Gerrard rainbow trout (completed in 2005);
2. Obtain key data on age and growth for model use;
3. Estimate fry/parr densities by habitat type;
4. Initiate and develop a population model;
5. Initiate restoration work for fry and parr habitat at select sites.
6. Assess juvenile out-migration from the Lardeau River

The conservation plan was completed (Andrusak 2005) and restoration work was initiated in 2007 at 28 km (Andrusak 2006) . This summary report addresses objectives

2-4.

**BACKGROUND**

The Lardeau River and the surrounding valley have endured over a century of extractive resource development. There has been over one hundred years of mining and logging and these resource activities were the primary reason why the CPR built a railway into the valley in 1902 (Irvine 1978). Logging activities initially commenced in the early 1900s in the Lardeau Valley (Alexander 1998). In response to gold and silver discoveries in the valley the CPR railroad grade was started at the town site of Lardeau in 1898 and reached Gerrard in 1902 and thereafter, a mill at Trout Lake City was moved down the lake to Gerrard (Alexander 1998). Mining activity was quite brief and by 1942, the CPR rails were lifted and the rail-bed was converted to a road (Highway 31 north). By the 1950s, logging was moving into the side valleys via roads including Meadow Creek and other important fish bearing streams such as Poplar and Healy creeks. Evidence of old mines and old growth logging is apparent throughout the valley bottom, but while no mining activity exists today, there is still a considerable amount of logging on the valley walls but mainly in the side tributary valleys.

The Lardeau River supports a number of fluvial and adfluvial fish populations but only the Gerrard rainbow trout population is believed to be entirely reliant on the Duncan/Lardeau River system. Substantial research has been conducted on the Gerrard rainbow trout life history over the past 50 years. These fish spawn in late April and early May and their progeny emerge in early July (Hartman 1969, Irvine 1978). Most of the young fish move down the Lardeau River a few weeks after emerging from the spawning grounds saturating available rearing habitat along the river margins and side channels with some fry entering the lake presumably because all available rearing habitat is utilized. It is believed that most surplus fry entering Kootenay Lake do not survive to adult size fish (Burrows 1993; Redfish Consulting Ltd. 2002). Based on this knowledge and in consideration of their value there has been some recent effort made to identify rainbow trout rearing habitat and to assess potential habitat restoration opportunities (Andrusak and Baxter 2000, Redfish Consulting Ltd. 2001; 2002; 2003, Slaney and Andrusak 2003).

Diverse and complex habitat is an essential part of free flowing rivers that support juvenile salmonid production. The Lardeau River is no exception; many side channels and small feeder streams throughout the Lardeau River are known to provide habitat for juvenile Gerrard rainbow trout, bull trout, and kokanee. Research by Irvine (1978) suggested that Gerrard rainbow trout juveniles rely much more heavily on the mainstem and side channels compared to other species. In 2002, Lardeau River habitat used by rainbow trout fry and parr was assessed by Slaney and Andrusak (2003). Their assessment generally concurred with Irvine's work but suggested that the mainstem river provided 2.5 times more parr than fry habitat while the side-channels provided about 1.5 times more fry than parr habitat in late summer to fall and winter. They also indicated their 2002 assessment underestimated the amount of fry habitat. Sampling by Redfish Consulting Ltd. (2002) indicated that side channels were highly important to Gerrard rainbow trout fry and that small feeder streams not assessed by Slaney and Andrusak (2003) were probably quite important to Gerrard rainbow trout fry.

As mentioned, a comprehensive management plan was designed that outlined management goals and objectives specifically for the conservation of Gerrard rainbow trout (Andrusak 2005). One task emanating from the plan was to obtain a better understanding of juvenile rainbow trout habitat preferences and requirements in the Lardeau River. As a result, this study was initiated to ascertain juvenile production estimates for the Lardeau River (Decker and Hagen 2009). Their estimates can be used in relationship to adult escapement data to identify the stocks' overall productivity, carry capacity and population limitations or "bottlenecks".

**STUDY AREA**

Kootenay Lake is positioned in a north-south axis between the Selkirk and Purcell mountain ranges in the southeast corner of British Columbia. The Duncan River, the major tributary entering the north end of the lake, receives the Lardeau River 10 km upstream of Kootenay Lake, at the town of Meadow Creek. The confluence is located approximately one kilometer downstream of the Duncan Dam, which is not operated to allow passage of adult rainbow trout. The Lardeau River, which is paralleled by Highway 31, originates at the outlet of Trout Lake, and flows approximately 45 km in a southeastern direction to its confluence with the regulated Duncan River. The Lardeau valley is quite narrow, often less than 2 km across the valley floor. After joining the Duncan the valley widens to about 4 km at the north end of Kootenay Lake at the Duncan River delta. The Lardeau River is a relatively low gradient system varying from <1% to 2%. Trout Lake serves as a settling basin, providing very clear water at the lake outlet. However, each tributary downstream from Trout Lake contributes substantial amounts of sediments to the Lardeau River during spring freshet and periods of heavy rainfall. As a result, the river is usually turbid from mid-May until early July. The system is fairly active geomorphologically, with a broad floodplain, large wood accumulations (log jams), bar development, and extensive bank erosion (Slaney and Andrusak 2003).

The Lardeau River was the primary area of focus for this study. Juvenile rainbow trout also rear in the lower Duncan River downstream of the Lardeau River confluence (AMEC 2003; Golder 2003; Hagen and Decker 2006), but there are two reasons why this reach was not included as part of the study. First, it is possible that some of these fish are progeny of a rainbow trout population in the Duncan River below Duncan Dam (Hagen et al. 2007). Including these fish in standing stock estimates may confound stock-recruitment relationships for the Lardeau River population. Secondly, recent stocking of the Duncan Reservoir with yearling trout and potential entrainment to the lower Duncan River could confound the parr estimates. Thirdly, the lower Duncan River is accessible by boat only, which creates considerable logistical challenges and safety concerns for a long-term monitoring program. To provide a cursory assessment of the potential contribution of the lower Duncan River to overall juvenile rainbow trout abundance, data from a separate study of juvenile production in side channel and braid habitat in the lower Duncan River was relied on (Hagen and Decker 2006), which employed sampling methods similar to those used in this study. It should be noted the only survey of side channel/braid habitat in the Duncan River occurred in April 2005, while this study's first spring survey of the Lardeau River occurred in April 2006. The fall survey in September 2005 of side channel/braid habitat in the Duncan River was conducted concurrently with the Lardeau River survey. Juvenile rainbow trout abundance data were not available from previous studies for mainstem habitats in the Duncan River. Consequently, limited snorkeling surveys along the mainstem of the lower Duncan River were conducted during fall 2005 and spring 2006. No juvenile sampling occurred in the Duncan River during the second (2006-07) and third (2007-08) years of this study.

## METHODS

### Study Design

The project design and implementation was undertaken by John Hagen and Scott Decker beginning in 2006 (Decker and Hagen 2009). The design implemented 6 important methods in an effort to obtain relatively precise and unbiased estimates of juvenile distribution, habitat use, age structure and abundance within the river. These methods are discussed briefly here, but for further detail see Decker and Hagen (2009).

1. Stratification of sampling effort
2. Total amount of habitat based throughout the river (Lardeau only)
3. Nightime snorkel surveys (fish counts)
4. Estimated observer efficiency using a mark recapture
5. Age structure (length at age)
6. Juvenile abundance estimates by age class

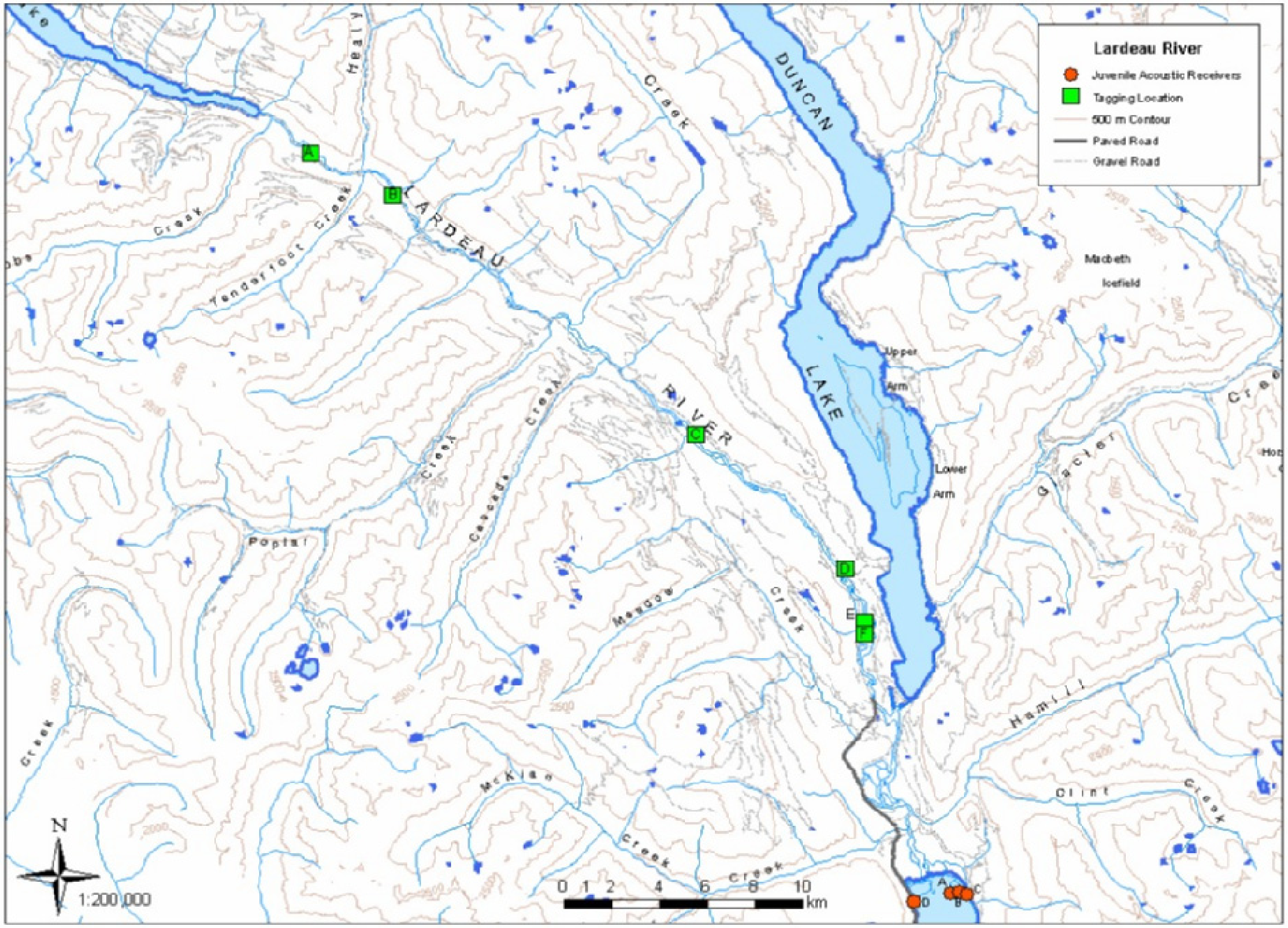



**Figure 1.** Acoustic tagging locations (green boxes) along the Lardeau River and receiver locations within Kootenay Lake (orange dots) in fall 2007 & 2008.

*Stratification of sampling effort*

Stratification of habitat for fish population sampling in the Lardeau River defined three general habitat types: 1) deep mainstem shoreline (average depth >40 cm within 2 m of the stream margin), 2) shallow mainstem shoreline (average depth <40 cm within 2 m of stream margin), and 3) side channels and braids.

The sampling design implemented a systematic and random selection within each stratum. Sampling locations (access permitting) were selected systematically at uniform intervals (approximately every 2 km). This accounted for the potential effects of incremental changes along the length of the Lardeau River in abundance, stream discharge, and ecological conditions. At each designated sampling location, habitat units of the appropriate type were selected randomly from those immediately available (i.e., in cases where several habitat units of the same type occurred at a designated sampling location). Whenever possible, mainstem and side channel/braid habitat units were sampled in their entirety, but sub-sampling was often employed in habitat units longer than 50 m. If sub-sampling was necessary, the length of the site was predetermined and the location of downstream boundary was randomly selected. At sites in side channel/braid habitat, snorkelers surveyed the entire wetted width. At sites in mainstem habitats, however, snorkelers surveyed only one shore. Shoreline habitat types often differed on opposite sides of the mainstem channel, and furthermore the Lardeau River is too large at most locations to cross safely at night. Further physical attributes at individual sites were measured, for further detail see Decker and Hagen (2009).

*Stream-wide habitat survey*

In order to convert an estimate of mean fish density to an estimate of standing stock for a particular sampling stratum, an estimate of the total amount of habitat for that stratum was required. In April 2006, a survey of all wetted habitats in the Lardeau River was initiated and continued until completion during August 2006 and April 2007 sampling periods, respectively. Conducting a complete survey of the study area was important for reducing uncertainty in the expanded population estimates, and for determining whether the stratification scheme for fish sampling adequately represented the diversity of habitats in the system (Fausch et al. 2006). For further detail see Decker and Hagen (2009).

*Nightime snorkel surveys*

Calibrated night snorkeling methodology was utilized to obtain estimates of juvenile trout abundance in the Lardeau system (note: see following section re: estimated observer efficiency using mark recapture method). Besides being more visible at night compared to during the day, most salmonids in larger streams are also found closer to shore (Edmundson et al. 1968; Campbell and Neuner 1985) and are less active (Bonneau et al. 1995), making them easier to count. Snorkel surveys commenced 0.5 hours after dusk, and did not exceed 4 hours in duration, based on Bradford and Higgins (2000).

Two-person crews conducted the snorkeling surveys. To illuminate the sampling sites at night, snorkelers used handheld dive lights. In side channels and braid sites, snorkelers surveyed the stream's entire wetted width, with each snorkeler entering the site at its downstream end and systematically sweeping in an upstream direction the area between his bank and the agreed upon mid-point of the site. Regular communication between snorkelers was essential to avoid duplicating counts, particularly in the instances where fish were present in mid-channel areas. In mainstem shoreline sites, snorkelers surveyed out as far as was physically possible from stream margin or until no fish were observed. Snorkelers found that they could consistently observe well beyond the nighttime offshore distribution of juvenile trout.

Some studies have shown that snorkeler counts are not effective for estimating the abundance of age-0+ salmonids (Griffith 1981; Campbell and Neuner 1985; Hillman et al. 1992), principally because they occupy shallow (< 30 cm deep) nearshore habitats that are difficult for snorkelers to survey from an underwater, offshore position. To address this, at shallow sites, the snorkeling methodology was modified such that one of the snorkelers performed a shoreline search on foot in order to count fry in shallow water. It was observed that at night small rainbow trout along the stream margin were stationary enough that their length could easily be identified. For further detail see Decker and Hagen (2009).

*Estimated observer efficiency using mark recapture methodology*

Mark-recapture methodology was implemented to estimate snorkeling capture efficiency (the proportion of a fish population in a site that snorkelers detect). A sub-sample of the total number of sites surveyed was selected for the mark-recapture study, with each of the major habitat strata (deep and shallow shorelines and side channel/braids) represented. One night prior to the regular snorkeling survey, trout were captured and marked throughout the site by a snorkeler using one or two large aquarium nets affixed to handles of approximately 80 cm in length. The snorkeler captured encountered fish during thorough searches at locations selected systematically throughout the site. The snorkeler captured fish in deeper water from an underwater, offshore position, while fish in shallow water were captured by dip net by a second crew member using a light while walking slowly along the stream margin. Minimizing site disturbance was a primary goal of the marking methodology. Captured fish were handed to a second crew member on the shore, who immediately measured the fish (fork length to nearest 5 mm), tagged it, removed a scale sample if required for aging analysis, and returned it the location where it was originally captured. Anticipating that snorkeling efficiency would differ for smaller and larger trout (Decker and Hagen 2007; Hagen et al. 2005), color-coded tags were used to mark fish according to three length categories (September: <60 mm, 60-100 mm, and >100 mm; April: <70 mm, 70-100 mm, and >100 mm). The length categories were intended to coincide with the expected median for age-0+ trout length in September and April (60 mm and 70 mm, respectively), and to delineate age-0+ and age-1+ fish (100 mm). At the mark-resighting sites used to estimate observer efficiency, the river immediately above and below the site were also swum and any marked fish that had left the site recorded. For the purpose of estimating the observer efficiency these fish were subtracted from the number of tagged fish as they were no longer available to count within the site. Fish densities are expressed in terms of the number of individuals per lineal meter of river bank. For further detail see Decker and Hagen (2009).

*Age determination*

Based on Decker and Hagen (2009) methods, fish with a fork length ≤ 100 mm were considered to by young of the year (age-0) while fish with a fork length (FL) between 101 and 150 mm were considered to be one year olds (age-1) and all other fish were classified as age-2+ where the + indicates three or more summers growth. To be consistent with Decker and Hagen (2009) the 2009 and 2010 fish were considered to be one year old on the 1st of June - their theoretical emergence date. A total of four habitat types were recognized corresponding to main shallow, main deep, side shallow and side deep with side habitats representing both side channels and braids. Alcove habitat, especially important for parr, were noted separately in 2009 and 2010. This habitat typically supported high fish densities and were characterized by deep, slow-moving water formed by aggregations of large woody debris that occur where side channels leave or join the main channel. In Decker and Hagen (2009) this habitat was included in the side deep habitat.

**Data analysis**

The analysis of the data used a hierarchical Bayesian assessment of juvenile rainbow trout densities and abundance on the Lardeau River. The data was obtained over a five year period by the snorkel surveys that provided information on densities as well as mark-recapture data at selected sites required to estimate observer efficiencies. The first three years of the dataset were previously analyzed using bootstrapping by Decker and Hagen (2009).

*Data analysis using models*

Models were implemented using R scripts (R Development Core Team 2010) which interfaced with WinBUGS 1.4.3 (Gilks et al. 1994) using the R2WinBUGS library (Sturtz et al. 2005). All plots were produced using ggplot2 (Wickham 2009). The model parameters are defined in Table 1 and the relationships between them listed in Table 2 in WinBUGS syntax (Ntzoufras 2009). The model assumed low information priors *sensu* Nztoufras (2009). Together Table 1 and Table 2 provide a description of the model.

**Table 1.** Definitions of the parameters in the hierarchical Bayesian model

| Parameter | Definition |
|---|---|
| $\alpha_0$ | The intercept for the log mean fish density |
| $\alpha_y$ | The fixed difference in the log mean fish density in year $y$ |
| $\alpha_h$ | The fixed difference in the log mean fish density at habitat $h$ |
| $\alpha_s$ | The random difference in the log mean fish density at site $s$ |
| $\alpha_{y,h}$ | The random difference in the log mean fish density due to an interaction between habitat $h$ during year $y$ |
| $\log(\mu_1(d_1(y,h,s)))$ | The log mean fish density site $s$ in habitat $h$ during year $y$ |
| $\tau_d$ | The precision of the fish density |
| $d_{y,h,s}$ | The density of fish at site $s$ in habitat $h$ during year $y$ |
| $L_{y,h,s}$ | The snorkelled length of site $s$ in habitat $h$ during year $y$ |
| $n_{y,h,s}$ | The number of fish at site $s$ in habitat $h$ during year $y$ |
| $\mu_p$ | The mean observer efficiency |
| $\tau_p$ | The precision of the observer efficiency |
| $p_{y,h,s}$ | The observer efficiency at site $s$ in habitat $h$ during year $y$ |
| $C_{y,h,s}$ | The total number of fish counted at site $s$ in habitat $h$ during year $y$ |
| $T_{y,h,s}$ | The number of fish tagged at site $s$ in habitat $h$ during year $y$ |
| $M_{y,h,s}$ | The number of marked fish counted at site $s$ in habitat $h$ during year $y$ |

**Table 2.** Equations in WinBUGs syntax representing the relationships in the hierarchical Bayesian model

| Number | Equation |
|---|---|
| (1.1) | $\log(\mu_{d_{y,h,s}}) \sim \alpha_0 + \alpha_y + \alpha_h + \alpha_s + \alpha_{y,h}$ |
| (1.2) | $d_{y,h,s} \sim dlnorm\left(\log(\mu_{d_{y,h,s}}), \tau_d\right)$ |
| (1.3) | $n_{y,h,s} \sim dpois(d_{y,h,s} * L_{y,h,s})$ |
| (1.4) | $logit(p_{y,h,s}) \sim dnorm(\mu_p, \tau_p)$ |
| (1.5) | $C_{y,h,s} \sim dbin(p_{y,h,s}, n_{y,h,s})$ |
| (1.6) | $M_{y,h,s} \sim dbin(p_{y,h,s}, T_{y,h,s})$ |

Convergence was monitored using the Gelman and Rubin (1992) $\hat{R}$ statistic as modified by Brooks and Gelman (1998). Following a burn in period of 10,000 iterations, the posterior probabilities were derived from 1,000 Markov Chain Monte Carlo (MCMC) simulations thinned from three MCMC chains of 100,000 iterations in length.

In summary, the model allows the mean fish density, which following Wyatt (2003) is assumed to be log-normally distributed, to vary with year, habitat and site. The model was fitted by season separately to each age-class of fish. The total abundance in the Lardeau River was then calculated by multiplying the mean densities for each habitat type in each year by the lineal bank length of each habitat type.

**Out-Migration Assessment**

The study implanted V7-2L and V7-1L acoustic tags in individuals >140 mm in length and detect their passage into Kootenay Lake using VR2W receivers. Surgical procedures detailed in Welch et al. (2007).

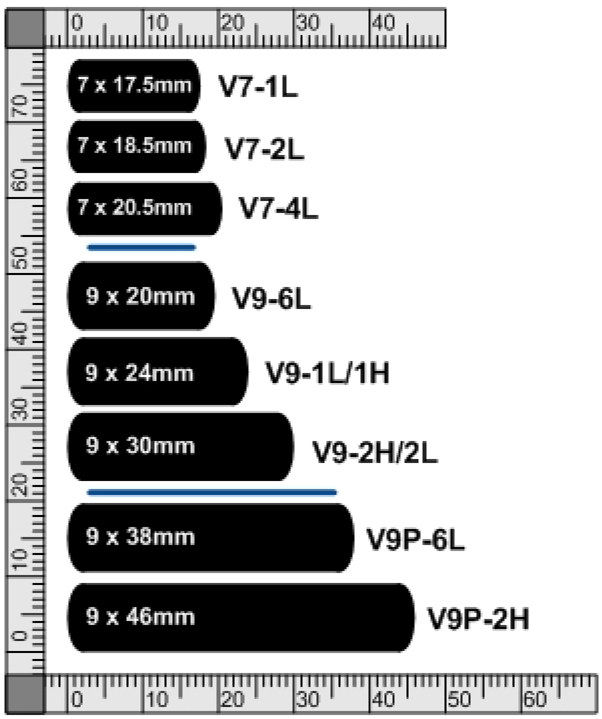
Upon out-migration from the Lardeau River, tags are detected by 4 Vemco VR2W receivers deployed off the mouth of the Lardeau/Duncan Rivers in Kootenay Lake (Fig. 1; Photo 1). Tags with varying detection rates and sizes (V7-1L and V7-2L), pertaining to battery life, were selected to be implanted within samples collected in the spring and fall (Appendix 1, Photo 2). In our study, all V7 tags deployed ~ 17.5 mm in length by 7 mm in diameter (Table 3 and 4). These implanted tags were well below the critical value of 8% and 16% for the weight and length of the fish, respectively (Brown et al. 1999 and Lacroix et al. 2004). In fact, our study did not exceed 5% or 3% for the weight of the fish in air or water, respectively. As well, our study did not exceed 12.3% of the length of the fish. Welch et al. (2007) reported combined rates of tag loss (mortality plus tag shedding) for surgically implanted tags dropped to <15% and growth following surgery was close to that of the controls for fish > 140 mm. However, these results were reported on a tag size was 24 x 8 mm.

**Table 3.** Physical characteristics of the V7-1L and V7-2L acoustic tags from Vemco deployed on the Lardeau River in 2007.

Physical Specifications

| Model: | V7-1L | V7-2L |
|---|---|---|
| Length (mm) | 17.5 | 18.5 |
| Diameter (mm) | 7 | 7 |
| Power Output (dB re 1 uPa @ 1m) | 136 | 136 |
| Weight in air (g) | 1.4 | 1.6 |
| Weight in water (g) | 0.7 | 0.75 |

**Table 4.** The comparative sizes for Vemco acoustic transmitters.



# RESULTS

## Stratification of sampling effort

Seasonal juvenile trout survey data was collected on the Lardeau River over a five year period 2005-2010. Fall surveys were conducted in 2005-2007 before being discontinued. Meanwhile spring surveys were conducted from 2006-2010. Over the five year period, a total of 428 sites have been surveyed on the Lardeau River (Fall surveys from 2005-2007 averaged 50 sites per season compared to an average of 55 sites surveyed in the spring).

The more recent surveys conducted in the spring of 2009 and 2010, not included in the Decker and Hagen (2009) report, surveyed a total of 58 sites per yea (Table 3)r. The 2009 survey was conducted March 30 to April 2 dictated by river conditions. The 2010 survey was conducted during March 17-19, 2010, two weeks prior to the 2009 surveys, due to inclement weather .e. spring runoff commenced.

**Table 5.** Number of sites using nightime snorkel surveys by season and year from 2005-2010.

| Survey Year | Survey Season | Total |
|---|---|---|
| 2005 | Fall | 46 |
| 2006 | Spring | 44 |
| 2006 | Fall | 48 |
| 2007 | Spring | 55 |
| 2007 | Fall | 58 |
| 2008 | Spring | 61 |
| 2009 | Spring | 58 |
| 2010 | Spring | 58 |
| Total | | 428 |

## River-wide habitat survey

Total amount of river habitat was stratified into the four habitat categories in the fall 2006 and spring(s) of 2006 and 2007. In general, the mainstem habitat strata (deep and shallow) comprised over half of the habitat within the Lardeau River. Deep shoreline (mainstem and side channel) was the dominant mainstem habitat type within the Lardeau River Shallow shoreline (mainstem and side channel) made up about one third of the total length of the Lardeau). It should be noted that braided habitat was included in the side channel category.. For further detail see Decker and Hagen (2009).

**Table 6.** The length of each habitat expressed in terms of lineal meters of bank type in the Lardeau River.

| Habitat | Length (m) |
|---|---|
| Main Shallow | 13,473 |
| Main Deep | 25,289 |
| Side Shallow | 16,200 |
| Side Deep | 20,085 |
| Total | 75,047 |

**Nightime snorkel surveys**

Overall, the combined data (2005-2010) provide good and reliable insight into the age structure of juvenile rainbow trout rearing in the Lardeau River. Length-frequency histograms showed a clear separation in fork length between age-0+ and age-1+ Gerrard rainbow trout and to a lesser extent between age-1+ and age-2+ (Figure 1). In the latter case, information from scale-age analysis was needed to reliably separate age-1+ and 2+ parr. Nevertheless, the data suggests that age 0 (fry) are ≤ 100 mm, ranging from 25-100 mm, age 1 fish had a fork length between 101 and 150 mm and age-2+ fish had a fork length >150 mm (Figure 1). Relatively few trout greater than 220 mm were observed during the study and it is uncertain if this is limitation of snorkeler visibility or absence of larger trout.

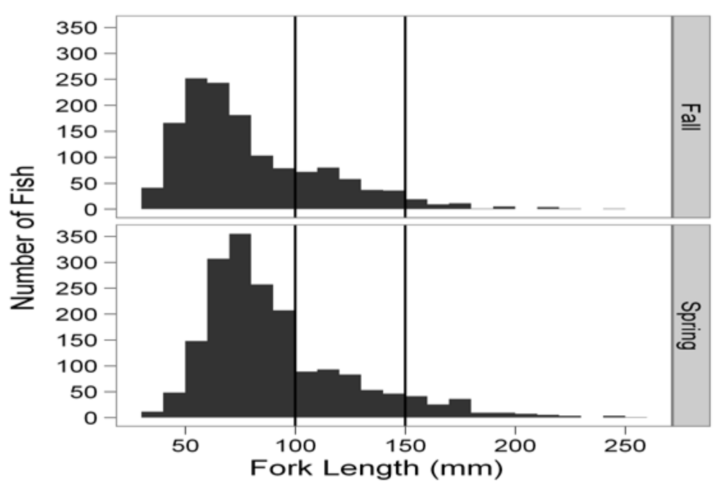



**Figure 2**. Length-frequency histogram for rainbow trout in the Lardeau River by season. The vertical lines indicate the divisions between age-classes. Age-0 fish had a fork length ≤ 100 mm, age-1 fish had a fork length between 101 and 150 mm and age-2+ fish had a fork length >150 mm.

**Estimated observer efficiency using mark recapture methodology**

The mark-recapture information was used to determine observer efficiency of the snorkelers.. The data was collected at various sites and strata to obtain unbiased estimates of observer efficiency. The assumption that trout populations in unenclosed sampling sites could be considered closed during the 24 to 36 hour mark-recapture period was reasonably well met, particularly during the spring sampling periods. During the mark-recapture snorkeler surveys, relatively few marked fish moved from the marking site to adjacent upstream and downstream sections that were also surveyed.

Snorkeling observer efficiency was higher for the spring sampling period than for the fall period across all length classes despite considerably lower temperatures and, in some cases, lower underwater visibility during the April survey (Table 5). The relationship between fish length and snorkeling efficiency also differed between fall and spring. Fall mark-recapture data suggested a capture efficiency of 57% for fish 60-100 mm in length compared to that 24% for fish under 60 mm and 40% for fish between 101 and 150 mm. Spring data suggested a positive linear relationship between fish length and snorkeling efficiency, with snorkeling efficiency ranging from 49% for fish less than 70 mm, to 71% for fish greater than 150 mm.

Observer efficiency estimates for age 2+ fish were considered unreliable during the fall surveys due to the interaction amongst spawning kokanee. Regardless, the spring time observer efficiencies were also highly variable that can only be overcome through increased sampling.

**Table 7**. The estimated observer efficiencies by season and age class. The values in brackets represents 95% confidence intervals.

| Season | Age-class | Observer Efficiency |
|---|---|---|
| Fall | age-0 | 0.36 (0.29-0.43) |
| Spring | age-0 | 0.49 (0.34-0.65) |
| Fall | age-1 | 0.29 (0.18-10.45) |
| Spring | age-1 | 0.31 (0.14-0.59) |
| Fall | age-2+ | 0.00 (0.00-0.05) |
| Spring | age-2+ | 0.28 (0.07-0.71) |

In deriving standard deviation values for mean snorkeling efficiency estimates, which was necessary for developing 95% confidence intervals for standing stocks estimates , the sampling site was determined to be the appropriate unit of replication. However, at some sites, the number of marked trout in individual length categories was very low (i.e., < 5) and binomial error resulted in highly unlikely estimates of snorkeling efficiency (e.g., 0 or 1). This problem was even more pronounced for the larger length categories corresponding to age-1+ and 2+ parr (101-150 mm and > 150 mm, respectively).

**Standing Stock Estimates**

Estimates of density and abundance are provided by age class by season and habitat for the surveys conducted from 2006-2010. These estimates were derived from data compiled over the five period and the results are somewhat different from that reported in Decker and Hagen (2009). The differences are discussed below.

*Age 0+ fry*

Density estimates of young of the year (age 0+) indicate they were primarily distributed within shallow mainstem or shallow side channel habitat in the fall and spring surveys (Figures 2, 3). Age 0+ were also distributed in deep side channel habitat in the fall and spring but the estimates were highly variable., During the fall sampling period, densities of age-0+ fry were several-fold higher in shallow mainstem shoreline and side channel/braid habitats than in deep mainstem shoreline habitat (Figure 2). Fall densities estimates ranged from 0.16-6.92 fish/m compared to spring densities of 0.16-1.72 fish/m for all habitats from 2005-2010.

Fall abundance estimates of age 0+ suggest a decline in numbers from 2005-2007 (Figure 4). Spring abundance estimates of age 0+ also indicated a decline from 2006 to 2007 (Figure 3). However, mean estimates of abundance of fall age 0+ for the three years (2005-2007) are considered highly variable. Much of the variability around these estimates are attributed to the confounding problem of enumerating fry during the fall kokanee spawning period. In comparison, spring estimates of age 0+ indicated relatively consistent numbers of < 20,000 from 2007 to 2010.

Across years, side channel/braid habitat in the Lardeau River contributed an average of 55% of total fall standing stock of fry in the Lardeau River and 44% of the total spring standing stock (Decker and Hagen 2009). By comparison, the proportion of the total length of habitat in the Lardeau River represented by this stratum was 48% (Table 4). Shallow mainstem habitat in the Lardeau River contributes, on average, 33% of the fall and spring fry standing stocks (Decker and Hagen 2009). This was disproportionately high considering this shallow mainstem habitat represents only 18% of total stream length in the system. Deep mainstem habitat in the Lardeau River represent 34% of total stream length, but contributed an average of only 12% of the fall fry standing stock. This anomaly is explained through either higher survival in deep mainstem habitats and or an overwinter redistribution of fry to this habitat from the other strata. These possibilities are supported by the increased contribution (31%) of deep mainstem habitats to fry standing stock in the spring data.

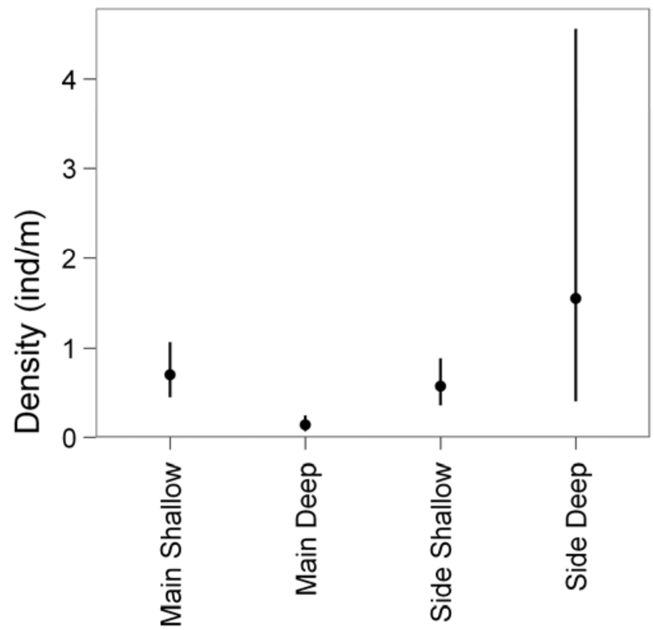



**Figure 3.** Fall age-0 rainbow trout mean densities by habitat stratum 2005-2007. The vertical lines indicate 95% confidence intervals

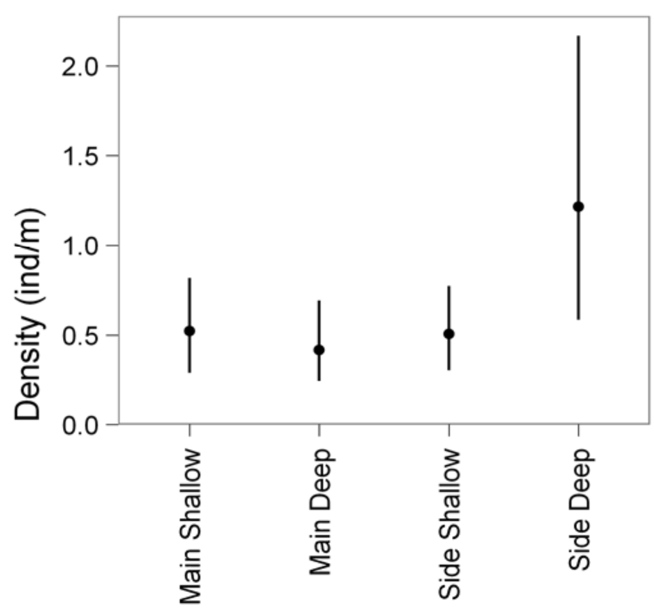



**Figure 4.** Spring age-0 rainbow trout mean densities by habitat stratum 2006-2010. The vertical lines indicate 95% confidence intervals

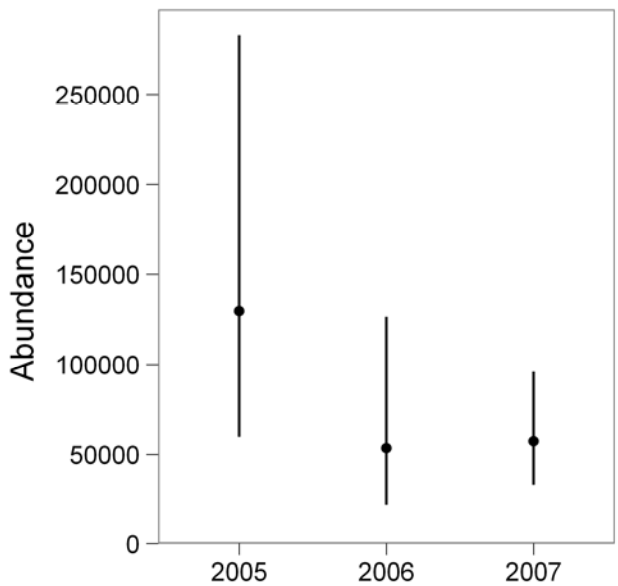



**Figure 5.** Fall age-0 rainbow trout abundance by year. The vertical lines indicate 95% confidence intervals

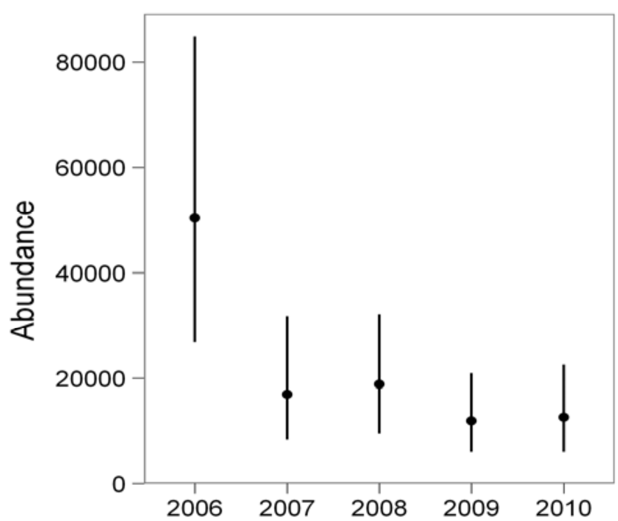



**Figure 6.** Spring age-0 rainbow trout abundance by year. The vertical lines indicate 95% confidence intervals

*Age 1+ parr*

Densities of parr (age 1+) indicate they were primarily distributed within deep mainstem or deep side channel habitat in both the fall and spring surveys from 2005-2010 (Figure 6 and Figure 7). Unfortunately, the data displays considerable variability but does suggest a preference for this habitat based on increasing size . Spring data indicates age 1+ densities are several-fold lower compared to estimates derived in the fall, likely indicating factors related to emigration or mortality (Figure 6 and Figure 7). Fall densities estimates ranged from 0.15-0.21 fish/m compared to spring densities of 0.04-0.13 fish/m for all habitat from 2005-2010.

Abundance estimates of age 1+ indicate considerable variability around the estimates each year for fall and spring from 2005-2010 (Figure 6 and Figure 7). Fall estimates range between 5,000 to 30,000 age 1+ compared to spring estimates between 2,000 to 20,000, demonstrating a substantial decline during over wintering. (Figures 6, 7). The decline in overwintering numbers likely point to factors related to emigration or mortality. The surveys do demonstrate the ability to detect a strong year class or cohort, exhibited in the estimates from the fall of 2006 and subsequent spring of 2007 for age 1+.

Across years, deep mainstem habitat in the Duncan River contributed to the majority of parr numbers in the Lardeau River. This habitat accounted for an average of 40% and 49% of the total parr (age1+) numbers in the fall and spring from 2005-2010, respectively (Decker and Hagen 2009). Deep side channel habitat, especially the alcoves, was an important habitat unit for age 1+ parr in the Lardeau River. This stratum accounted for an average of 40% and 35% of the total parr (age1+) numbers in the fall and spring from 2005-2010, respectively (Decker and Hagen 2009). Of note, while not typed as a separate stratum, alcove habitat usually was located where a side channel or a braid left or rejoined the mainstem. This habitat feature usually consisted of silt bottoms and often contained abundant large woody debris (LWD), and supported high densities of older juveniles throughout the study from 2005-2010. Mainstem shallow habitat consistently demonstrated that it was not the preferred habitat for older juvenile rainbow trout within the Lardeau River. Similar to age 0+, the increase in the average density from fall to spring into the deep habitat suggests a re-distribution into overwintering habitat on the Lardeau River. As a result, fall survey timing is quite important in observing the re-distribution of age 1+ rainbow trout into this habitat.

*Age 2+ parr*

The abundance and density estimates for the age-2+ fish were too variable to have any utility and are not presented. This is likely a result of too few recaptures during the mark-recapture surveys to estimate observer efficiency for this age group. As well, it is believed that many of these older juveniles are distributed in water in wood structures beyond the ability/visibility of snorkel surveys.

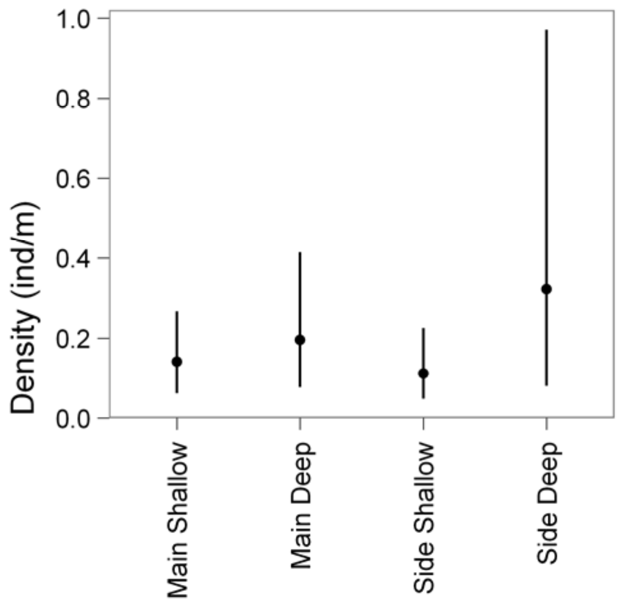



**Figure 7.** Fall age-1 rainbow trout mean densities by habitat type 2005-2007. The vertical lines indicate 95% confidence intervals.

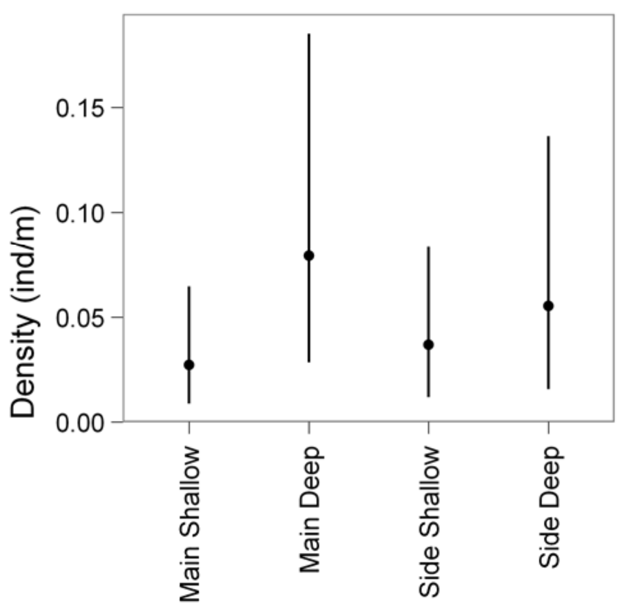



**Figure 8.** Spring age-1 rainbow trout mean densities by habitat type 2006-2010. The vertical lines indicate 95% confidence intervals

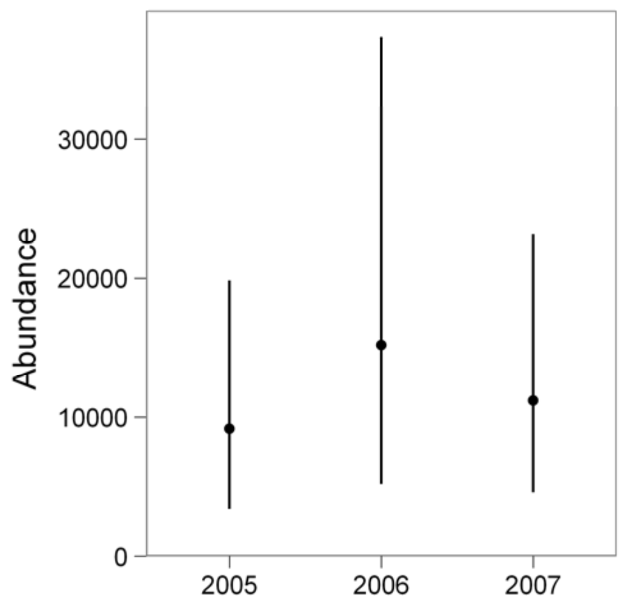



**Figure 9.** Fall age-1 rainbow trout abundance by year. The vertical lines indicate 95% confidence intervals

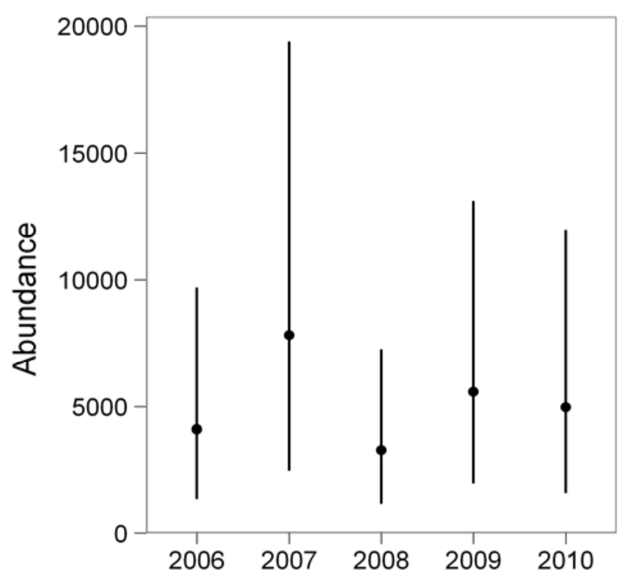



**Figure 10.** Spring age-1 rainbow trout abundance by year. The vertical lines indicate 95% confidence intervals.

**Out-Migration Assessment**

A total of 49 fish have been acoustically tagged with V7 tags in the fall of 2007, spring and fall of 2008 (Appendix 1). A total of 30 (10 in spring 2008 and 20 in fall 2008) Vemco V7 acoustic tags were deployed in juvenile rainbow trout at various sites in the Lardeau River in 2008, which compliment another 19 Vemco V7 acoustic tag deployed in 2007.

Results from the fall 2007 tagging suggest there is some late fall migration of juvenile rainbow trout from the Lardeau River following the kokanee spawn. Of the 19 acoustic tags released, 3 juvenile rainbow trout were detected entering Kootenay Lake in mid-November. While the majority of the juvenile fish sampled (n=19) were of age 2+, the three individuals that migrated to Kootenay Lake were comprised of ages 1+, 2+ and 3+. As well, juvenile acoustically tagged (n=19) individuals had a mean length of 173 mm (SD±34), ranging from 150-293 mm (Appendix 1). With the exception of the largest fish, mean weight was 55 g (SD±27), ranging from 35.1-150.8 g.

Results from the spring 2008 tagging indicate that there is a pronounced spring migration of juvenile rainbow trout from the Lardeau River during the freshet. Of the 10 acoustic tags released, 7 juvenile rainbow trout were detected entering Kootenay Lake in late May and early June. As well, juvenile acoustically tagged (n=10) individuals had a mean length of 184 mm (SD±12.6), ranging from 168-205 mm (Appendix 1). Mean weight was 65 g (SD±13.9), ranging from 47.3-82.3 g. Of the 20 juvenile rainbow trout collected in the fall of 2008, mean length was 157 (SD±10.5) ranging from 145-180mm. Mean weight was 43 g (SD±10.5), ranging from 28.8-59.8 g.

In summary a total of 49 fish have been acoustically tagged with V7 tags in the fall of 2007, spring and fall of 2008. Of these, fish mean size was estimated at 169 mm for all years combined, ranging from 145-293 mm (Fig. 2). Length vs. weight followed a linear relationship on a log scale for fish captured for tagging, for all years combined (Fig. 3).

Results from the fall 2008 tagging were hampered by the ability to recover the receivers at the mouth of the Lardeau River. Two of the three receivers were successfully recovered but with only limited information on detections. Only two tags were recovered in the spring of 2009 from the 20 deployed in the fall of 2008.

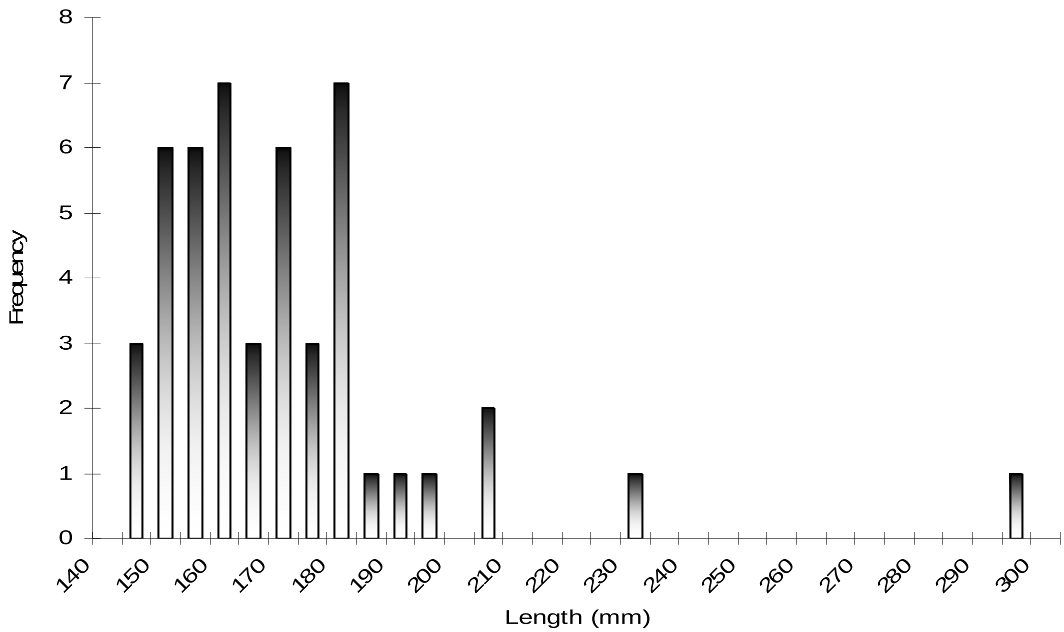



**Figure 11.** Length frequency distribution of fish implanted with acoustic tags (n=49) on the Lardeau River from fall 2007, spring and fall 2008.

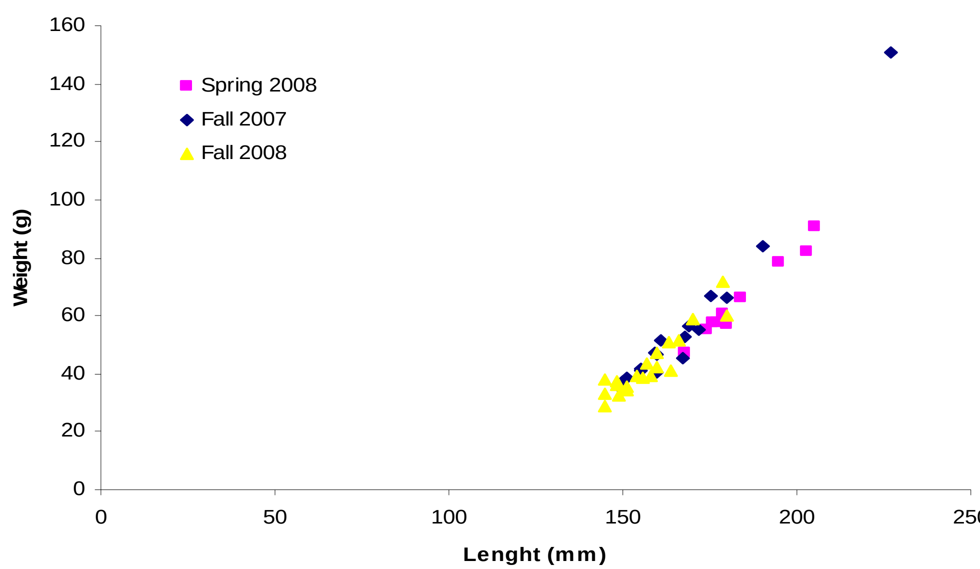



**Figure 12.** Length-weight relationship of fish implanted with acoustic tags (n=49) on the Lardeau River in the fall 2007, spring and fall 2008**.**

## DISCUSSION

The Gerrard rainbow trout of Kootenay Lake constitute a distinct population (Keeley et al. 2007) of large piscivorous rainbow trout (*Oncorhynchus mykiss*) that are highly sought after by anglers. While this unique ecotype provides an excellent fishery on the lake, most of their natural production (spawning and rearing) is entirely dependent upon the Lardeau River (Irvine 1978; Redfish Consulting Ltd. 2002). Assessing and determining a stock's reproductive capacity and productivity is essential in managing this exploited population. Obtaining precise and accurate data on the juvenile recruitment and habitat requirements were primary objectives of this study since they are an essential priority in managing this unique ecotype. Assessment of the in river juvenile abundance and in unison with adult escapement data provides important information for defining a stock-recruitment relationship used in determining useable biological reference points for stock management.

Juvenile Gerrard rainbow trout recruitment data was collected over a 5 year period (2005-2010) from the Lardeau River (Decker and Hagen 2009). This data was collected to obtain standing stock estimates by age class utilizing and rearing in the river before lake entry. A combined systematic and stratified randomized survey was implemented on the river to effectively assess the juvenile abundance rearing in the river. One of the core objectives of the study was to employ nightime swim surveys at the site level to extrapolate juvenile densities to a whole river abundance by age class. In addition, another objective was to identify if this methodology was feasible on a large interior river such as the Lardeau. While the methodology proved to be an invaluable tool for assessment of juvenile rainbow trout on the Lardeau River, the study fell short of obtaining the relatively precise and unbiased estimates of their numbers.

While data collected over the 5 year period indicated the methodology was feasible, the study did not achieve the level of precision and accuracy that could provide informative data for management purposes. Based on the results of the data from 2005-2010, estimates by age class indicate considerable variability. The age 0+ estimates are considered more reliable than the older age groups. As a result, further refinement and far more sampling is required to obtain more precision to obtain unbiased estimates of juvenile rainbow trout in the river. This is not to say that the data is not valuable. At the very least a far greater understanding of juvenile trout habitat preference and the seasonal changes have been better defined and adds to the original work by Irvine (1978).

Reducing the uncertainty in the juvenile data set can be obtained through a number of steps. One of the easiest and least costly way of reducing uncertainty is to increase the site replication on the Lardeau River. This would likely entail doubling the number of sites from ~55 sites to 110 sites along the 44 km of the Lardeau River. Although fairly time consuming, additional mark-recapture information by age class will also assist in reducing the variability in the estimates of abundance. This is especially the case for the age 2+ parr, in which, no observer efficiency was estimated and the overall estimates are deemed unreliable. The ability to detect larger trout at night in either deep water or in heavy cover such as wood accumulations is suspect.

By most standards the estimates of juvenile trout standing stock in the Lardeau River are low. Andrusak et al. (2005) summarized some juvenile trout densities from a number of studies on large lake rainbow trout piscivores and the 2005-2010 density estimates from the 2005-2010 study are generally lower than other systems. Even if this study's estimates are low due to insufficient sample size the "take home" message is that juvenile population in this river is quite small. An experimental fertilization project in a section of the river would be a useful means of determining if it sampling problems or habitat limitation. Acoustic tagging information also confirmed that the majority of the out-migration occurs in the spring but can be protracted into the fall following the kokanee spawning in the Lardeau River.

The importance of obtaining better information is fundamental to effective stock assessment for this unique ecotype. It will allow fisheries management to make informed decisions whether current regulations are appropriate especially in light of the popular fishery on the lake. Assessing and determining a stock's reproductive productivity is essential in managing exploited populations. Currently, a study is underway on Kootenay Lake to assess the natural and fishing mortality rates of this population (Andrusak and Thorley 2010). The information obtained from this exploitation study will compliment information collected from the work on the Lardeau River (spawner escapement and juvenile recruitment) to formulate biological reference points based on a stock recruitment relationship.

In summary, while the data collected to date on the Gerrard juvenile data set (2005-2010) has proved informative the data to date falls short of what is required for developing a stock-recruitment relationship. The methodology is effective for measuring fry standing crop but the high variability in the data, especially for ages 1+ and older points to the need for increased sampling sites. A considerable investment has been made in assessing Lardeau River rainbow trout juvenile densities and further refinement of these estimates is easily justified

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**Photo 1.** Deploying a Vemco VR2W receiver near the mouth of the Lardeau/Duncan Rivers in August 2007.

**Photo 2.** V7 acoustic tag (left) transmitter and a VR2W receiver (right) used on the Lardeau River in 2007

**Photo 3.** Surgical implant of an acoustic tag in the fall 2008 on the Lardeau River

## **APPENDIX 1.** Acoustically tagged juvenile rainbow trout in the Lardeau River in 2007 and 2008.

| # | Caught | Tagged | Released | Site | Capture Method | Length (mm) | Weight (g) | Age | Serial | ID | Tag Type | Hz | Tag Diameter (mm) | Tag Length (mm) | Pulse (sec) | Surgeon | Weight in Air (g) | Weight in water (g) | % of Weight in Air | % of Weight in Water | % Length |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 17/09/07 | 20/09/07 | 21/09/07 | 45km | EF | 161 | 51.5 | 2+ | 1038746 | 4516 | V7-1L | 69 | 7 | 17.5 | 225 | JL | 1.4 | 0.7 | 2.7% | 1.4% | 10.9% |
| 2 | 19/09/07 | 20/09/07 | 21/09/07 | 27km | DN | 155 | 41.2 | 2+ | 1043001 | 6510 | V7-2L | 69 | 7 | 18.5 | 60 | JL | 1.6 | 0.75 | 3.9% | 1.8% | 11.9% |
| 3 | 19/09/07 | 20/09/07 | 21/09/07 | 27km | DN | 155 | 41.6 | 2+ | 1042996 | 6505 | V7-2L | 69 | 7 | 18.5 | 60 | JT | 1.6 | 0.75 | 3.8% | 1.8% | 11.9% |
| 4 | 19/09/07 | 20/09/07 | 21/09/07 | 27km | DN | 150 | 34.2 | 1+ | 1043002 | 6511 | V7-2L | 69 | 7 | 18.5 | 60 | JT | 1.6 | 0.75 | 4.7% | 2.2% | 12.3% |
| 5 | 19/09/07 | 20/09/07 | 21/09/07 | 27km | DN | 150 | 35.1 | 2+ | 1042997 | 6506 | V7-2L | 69 | 7 | 18.5 | 60 | JT | 1.6 | 0.75 | 4.6% | 2.1% | 12.3% |
| 6 | 23/09/07 | 24/09/07 | 25/09/07 | 19km | DN | 159 | 47.2 | 2+ | 1043000 | 6509 | V7-2L | 69 | 7 | 18.5 | 60 | JT | 1.6 | 0.75 | 3.4% | 1.6% | 11.6% |
| 7 | 23/09/07 | 24/09/07 | 25/09/07 | 17km | DN | 168 | 52.8 | 2+ | 1038751 | 4521 | V7-2L | 69 | 7 | 18.5 | 225 | JT | 1.6 | 0.75 | 3.0% | 1.4% | 11.0% |
| 8 | 23/09/07 | 24/09/07 | 25/09/07 | 17km | DN | 150 | 37.1 | 2+ | 1043004 | 6513 | V7-2L | 69 | 7 | 18.5 | 60 | JT | 1.6 | 0.75 | 4.3% | 2.0% | 12.3% |
| 9 | 23/09/07 | 24/09/07 | 25/09/07 | 17km | DN | 180 | 66.1 | 2+ | 1038752 | 4522 | V7-2L | 69 | 7 | 18.5 | 225 | GA | 1.6 | 0.75 | 2.4% | 1.1% | 10.3% |
| 10 | 23/09/07 | 24/09/07 | 25/09/07 | 17km | DN | 172 | 55.3 | 2+ | 1038750 | 4520 | V7-2L | 69 | 7 | 18.5 | 225 | GA | 1.6 | 0.75 | 2.9% | 1.4% | 10.8% |
| 11 | 23/09/07 | 24/09/07 | 25/09/07 | 17km | DN | 160 | 40.3 | 2+ | 1043005 | 6514 | V7-2L | 69 | 7 | 18.5 | 60 | GA | 1.6 | 0.75 | 4.0% | 1.9% | 11.6% |
| 12 | 3/10/07 | 4/10/07 | 4/10/07 | 48km | DN | 293 | NA | 3+ | 1043003 | 6512 | V7-2L | 69 | 7 | 18.5 | 60 | JT | 1.6 | 0.75 | | | 6.3% |
| 13 | 3/10/07 | 4/10/07 | 4/10/07 | 48km | DN | 227 | 150.8 | 3+ | 1042998 | 6507 | V7-2L | 69 | 7 | 18.5 | 60 | JT | 1.6 | 0.75 | 1.1% | 0.5% | 8.1% |
| 14 | 3/10/07 | 4/10/07 | 4/10/07 | 48km | DN | 175 | 66.6 | 3+ | 1042999 | 6508 | V7-2L | 69 | 7 | 18.5 | 60 | JT | 1.6 | 0.75 | 2.4% | 1.1% | 10.6% |
| 15 | 3/10/07 | 4/10/07 | 4/10/07 | 48km | DN | 190 | 83.8 | 2+ | 1038745 | 4515 | V7-1L | 69 | 7 | 17.5 | 225 | JT | 1.4 | 0.7 | 1.7% | 0.8% | 9.2% |
| 16 | 3/10/07 | 4/10/07 | 4/10/07 | 48km | DN | 160 | 46.4 | 2+ | 1038749 | 4519 | V7-2L | 69 | 7 | 18.5 | 225 | JT | 1.6 | 0.75 | 3.4% | 1.6% | 11.6% |
| 17 | 4/10/07 | 4/10/07 | 5/10/07 | 16km | DN | 169 | 56.2 | 2+ | 1038743 | 4513 | V7-1L | 69 | 7 | 17.5 | 225 | GA | 1.4 | 0.7 | 2.5% | 1.2% | 10.4% |
| 18 | 4/10/07 | 4/10/07 | 5/10/07 | 16km | DN | 167 | 45.3 | 2+ | 1038744 | 4514 | V7-1L | 69 | 7 | 17.5 | 225 | GA | 1.4 | 0.7 | 3.1% | 1.5% | 10.5% |
| 19 | 4/10/07 | 4/10/07 | 5/10/07 | 16km | DN | 151 | 38.5 | 2+ | 1038748 | 4518 | V7-2L | 69 | 7 | 18.5 | 225 | GA | 1.6 | 0.75 | 4.2% | 1.9% | 12.3% |
| 20 | 4/2/08 | 4/3/08 | 4/3/08 | 27km | DN | 203 | 82.3 | 2+ | 1053354 | 11708 | V7-2L | 69 | 7 | 18.5 | 60 | JT | 1.6 | 0.75 | 1.9% | 0.9% | 9.1% |
| 21 | 4/2/08 | 4/3/08 | 4/3/08 | 27km | DN | 176 | 57.6 | 3+ | 1053355 | 11709 | V7-2L | 69 | 7 | 18.5 | 60 | JT | 1.6 | 0.75 | 2.8% | 1.3% | 10.5% |
| 22 | 4/10/08 | 4/10/08 | 4/11/08 | 15km | DN | 180 | 57 | 2+ | 1053356 | 11710 | V7-2L | 69 | 7 | 18.5 | 60 | JT | 1.6 | 0.75 | 2.8% | 1.3% | 10.3% |
| 23 | 4/10/08 | 4/10/08 | 4/11/08 | 15km | DN | 184 | 66.4 | 2+ | 1053357 | 11711 | V7-2L | 69 | 7 | 18.5 | 60 | JT | 1.6 | 0.75 | 2.4% | 1.1% | 10.1% |
| 24 | 4/10/08 | 4/10/08 | 4/11/08 | 15km | DN | 174 | 55.2 | 2+ | 1053358 | 11712 | V7-2L | 69 | 7 | 18.5 | 60 | JT | 1.6 | 0.75 | 2.9% | 1.4% | 10.6% |
| 25 | 4/11/08 | 4/11/08 | 4/12/08 | 39km | DN | 168 | 47.3 | 2+ | 1053359 | 11713 | V7-2L | 69 | 7 | 18.5 | 60 | GA | 1.6 | 0.75 | 3.4% | 1.6% | 11.0% |
| 26 | 4/11/08 | 4/11/08 | 4/12/08 | 39km | DN | 177 | 57.6 | 2+ | 1053360 | 11714 | V7-2L | 69 | 7 | 18.5 | 60 | GA | 1.6 | 0.75 | 2.8% | 1.3% | 10.5% |
| 27 | 4/11/08 | 4/11/08 | 4/12/08 | 39km | DN | 179 | 60.8 | 2+ | 1053361 | 11715 | V7-2L | 69 | 7 | 18.5 | 60 | GA | 1.6 | 0.75 | 2.6% | 1.2% | 10.3% |
| 28 | 4/11/08 | 4/11/08 | 4/12/08 | 39km | DN | 195 | 78.5 | 2+ | 1053362 | 11716 | V7-2L | 69 | 7 | 18.5 | 60 | GA | 1.6 | 0.75 | 2.0% | 1.0% | 9.5% |
| 29 | 4/11/08 | 4/11/08 | 4/12/08 | 39km | DN | 205 | 90.9 | 2+ | 1053363 | 11717 | V7-2L | 69 | 7 | 18.5 | 60 | GA | 1.6 | 0.75 | 1.8% | 0.8% | 9.0% |
| 34 | 10/8/08 | 10/9/08 | 10/9/08 | 17km | DN | 154 | 39.5 | 1+ | 1059611 | 51079 | V7-2L | 69 | 7 | 18.5 | 140 | GA | 1.6 | 0.75 | 4.1% | 1.9% | 12.0% |
| 35 | 10/8/08 | 10/9/08 | 10/9/08 | 42km | DN | 160 | 47.3 | 1+ | 1059612 | 51080 | V7-2L | 69 | 7 | 18.5 | 140 | GA | 1.6 | 0.75 | 3.4% | 1.6% | 11.6% |
| 36 | 10/8/08 | 10/9/08 | 10/9/08 | 16km | DN | 179 | 71.6 | 1+ | 1059613 | 51081 | V7-2L | 69 | 7 | 18.5 | 140 | GA | 1.6 | 0.75 | 2.2% | 1.0% | 10.3% |
| 37 | 10/8/08 | 10/9/08 | 10/9/08 | 27km | DN | 163 | 50.9 | 2+ | 1059614 | 51082 | V7-2L | 69 | 7 | 18.5 | 140 | GA | 1.6 | 0.75 | 3.1% | 1.5% | 11.3% |
| 38 | 10/8/08 | 10/9/08 | 10/9/08 | 27km | DN | 148 | 37.1 | 1+ | 1059615 | 51083 | V7-2L | 69 | 7 | 18.5 | 140 | GA | 1.6 | 0.75 | 4.3% | 2.0% | 12.5% |
| 39 | 10/8/08 | 10/9/08 | 10/9/08 | 27km | DN | 145 | 37.9 | 3 | 1059616 | 51084 | V7-2L | 69 | 7 | 18.5 | 140 | GA | 1.6 | 0.75 | 4.2% | 2.0% | 12.8% |
| 40 | 10/8/08 | 10/9/08 | 10/9/08 | 27km | DN | 166 | 51.4 | 2+ | 1059617 | 51085 | V7-2L | 69 | 7 | 18.5 | 140 | GA | 1.6 | 0.75 | 3.1% | 1.5% | 11.1% |
| 41 | 10/8/08 | 10/9/08 | 10/9/08 | 42km | DN | 156 | 38.4 | 2+ | 1059618 | 51086 | V7-2L | 69 | 7 | 18.5 | 140 | GA | 1.6 | 0.75 | 4.2% | 2.0% | 11.9% |
| 42 | 10/8/08 | 10/9/08 | 10/9/08 | 16km | DN | 170 | 58.9 | 2+ | 1059619 | 51087 | V7-2L | 69 | 7 | 18.5 | 140 | GA | 1.6 | 0.75 | 2.7% | 1.3% | 10.9% |
| 43 | 10/8/08 | 10/9/08 | 10/9/08 | 16km | DN | 180 | 59.8 | 1+ | 1059620 | 51088 | V7-2L | 69 | 7 | 18.5 | 140 | GA | 1.6 | 0.75 | 2.7% | 1.3% | 10.3% |
| 44 | 10/8/08 | 10/9/08 | 10/9/08 | 27km | DN | 160 | 42.2 | 2+ | 1059621 | 51089 | V7-2L | 69 | 7 | 18.5 | 140 | GA | 1.6 | 0.75 | 3.8% | 1.8% | 11.6% |
| 45 | 10/8/08 | 10/9/08 | 10/9/08 | 27km | DN | 145 | 33.3 | 1+ | 1059622 | 51090 | V7-2L | 69 | 7 | 18.5 | 140 | GA | 1.6 | 0.75 | 4.8% | 2.3% | 12.8% |
| 46 | 10/8/08 | 10/9/08 | 10/9/08 | 17km | DN | 151 | 35.5 | 2+ | 1059623 | 51091 | V7-2L | 69 | 7 | 18.5 | 140 | GA | 1.6 | 0.75 | 4.5% | 2.1% | 12.3% |
| 47 | 10/8/08 | 10/9/08 | 10/9/08 | 42km | DN | 157 | 43.5 | 2+ | 1059624 | 51092 | V7-2L | 69 | 7 | 18.5 | 140 | GA | 1.6 | 0.75 | 3.7% | 1.7% | 11.8% |
| 48 | 10/9/08 | 10/9/08 | 10/9/08 | 16km | DN | 164 | 41.2 | 1+ | 1059625 | 51093 | V7-2L | 69 | 7 | 18.5 | 140 | GA | 1.6 | 0.75 | 3.9% | 1.8% | 11.3% |
| 32 | 10/8/08 | 10/9/08 | 10/9/08 | 16km | DN | 151 | 34.6 | 1+ | 1059626 | 51094 | V7-2L | 69 | 7 | 18.5 | 140 | GA | 1.6 | 0.75 | 4.6% | 2.2% | 12.3% |
| 31 | 10/8/08 | 10/9/08 | 10/9/08 | 27km | DN | 149 | 32.3 | 1+ | 1059627 | 51095 | V7-2L | 69 | 7 | 18.5 | 140 | GA | 1.6 | 0.75 | 5.0% | 2.3% | 12.4% |
| 30 | 10/8/08 | 10/9/08 | 10/9/08 | 27km | DN | 145 | 28.8 | 2+ | 1059628 | 51096 | V7-2L | 69 | 7 | 18.5 | 140 | GA | 1.6 | 0.75 | 5.6% | 2.6% | 12.8% |
| 33 | 10/8/08 | 10/9/08 | 10/9/08 | 17km | DN | 158 | 39.5 | 1+ | 1059629 | 51097 | V7-2L | 69 | 7 | 18.5 | 140 | GA | 1.6 | 0.75 | 4.1% | 1.9% | 11.7% |
| 49 | 10/8/08 | 10/9/08 | 10/9/08 | 17km | DN | 148 | 36.3 | 1+ | 1059630 | 51098 | V7-2L | 69 | 7 | 18.5 | 140 | GA | 1.6 | 0.75 | 4.4% | 2.1% | 12.5% |

tags detected in lake