Extension Note

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Goat River bull trout (*Salvelinus confluentus*) biotelemetry and spawning assessments 2002–03

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Abstract

In 2002, the British Columbia Ministry of Water, Land and Air Protection radio-tagged and tracked 16 sexually mature bull trout in the Goat River to determine the river's status as a bull trout spawning system, to identify and rank important spawning areas for habitat protection considerations, and to develop index sites to monitor population trends.

Five tagged bull trout spawned in the Upper Goat River, eight spawned in Macleod Creek, one remained near Northstar Creek, and two moved downstream after tagging. Goat River bull trout travelled up to 500 km to and from spawning areas, highlighting the importance of the Goat River as a bull trout spawning stream. Ground-based redd (gravel nest) surveys undertaken in 2003 resulted in 73 (4.3 redds per kilometre) and 90 (9.0 redds per kilometre) redds for Upper Goat River and Macleod Creek, respectively. In 2003, the Goat River bull trout spawning population was estimated at approximately 326. The high-quality spawning habitat, water quality, and bull trout detection qualities of the Upper Goat River watershed provide ideal index sites for monitoring population trends in the upper Fraser River drainage. Proposed measures aimed at protecting important spawning habitat include "wildlife habitat area" (WHA) designations and adaptive resource management strategies involving stakeholder participation. Effective April 1, 2004, seasonal angling closures at spawning areas will serve to protect spawning bull trout. Future management direction will involve site monitoring and meta-population analysis.

KEYWORDS: *bull trout, Robson Valley, "wildlife habitat area," redd counts, monitoring, Goat River.*

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Introduction

Throughout their range, bull trout (*Salvelinus confluentus*) populations are generally in decline and have become a species of concern. Bull trout are "blue listed" by the Canadian Conservation Data Centre and are presently "Identified Wildlife" in the *British Columbia Forest Practices Code*. The species is also a candidate for "wildlife habitat area" (WHA) designations (B.C. Environment, Lands and Parks 1999). Adult and juvenile bull trout densities are often very low relative to other salmonids (Baxter and McPhail 1996; Bonar *et al.* 1997) and the species can be extremely sensitive to over-fishing, habitat degradation, and competition with introduced species (McPhail and Baxter 1995). Within British Columbia, the primary concerns are angler exploitation as a result of uncontrolled access, and physical and thermal habitat degradation.

Bull trout exhibit various life-history patterns, including large adfluvial (lake-run), fluvial (large river), and small-stream resident types. Each of these forms reside in cold, headwater streams for at least the early juvenile portion of their lives (Rieman and McIntyre 1993). Bull trout distributions are often limited to cold clean water; they are uncommon in aquatic environments where temperatures exceed 15 ℃ (Donald and Alger 1993; Rieman and McIntyre 1993; Selong *et al.* 2001).

Within the Robson Valley, the Goat River watershed (Figure 1) generally supports high-quality wildlife and fisheries values. Excellent water quality, cold water temperatures (e.g., maximum temperatures of 8.3 ℃ were recorded in the Goat main stem during 2000) (Rex and Lheidli T'enneh Band 2001), and anecdotal evidence indicating seasonal presence of large adult bull trout established this system as a high priority for investigation. However, before 2002, with the exception of chinook salmon (*Oncorhynchus tshawytscha*) stock assessments by Fisheries and Ocean Canada, other fisheries values in the Goat River watershed had not been formally assessed. This study, initiated in 2002, seeks to understand the importance of the Goat River bull trout population relative to other local populations. The main goal of the study is to identify and protect important bull trout spawning habitat in the Goat River watershed, and to collect baseline information that will help determine what effects forest development activities proposed by McBride Forest Industries might have on bull trout populations. The long-term objectives are to provide science-based management recommendations to stakeholders such as McBride Forest Industries, and to develop suitable index sites in the Upper Fraser to monitor long-term population and habitat trends, ensuring the protection of bull trout habitat in the Robson Valley.

Bull trout can be extremely sensitive to over-fishing, habitat degradation, and competition with introduced species.

The specific objectives of this study were to:

- confirm the presence and general distribution of bull trout in the Goat River;
- determine the status of the Goat River as a spawning stream for bull trout;
- determine the spatial and temporal extent of spawning activities and locations;
- rank bull trout spawning habitat according to relative abundance of spawning fish and the quality of habitat used;
- identify locations and time periods of greatest risk to exploitation of bull trout in the Goat River; and
- characterize habitat variables, such as substrate type, cover, stream temperature and inter-gravel temperature, at the spawning sites.

Data collected will be used to provide clear management direction for road development and timber extraction; it will also ensure that the risks of bull trout over-exploitation and habitat degradation are minimized or eliminated.

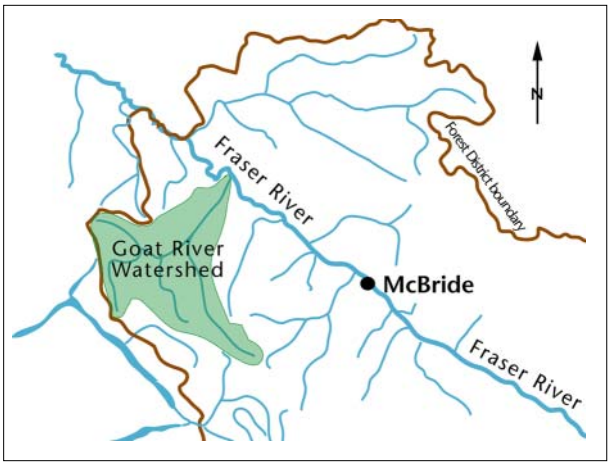

FIGURE 1. Overview of Goat River study area.

Study Area

The Goat River, located 144 km southeast of Prince George in the Robson Valley Forest District (53°31'54" N, 120°33'54" W), is a sixth-order watershed (1:20 000 trim watershed atlas) with an area of 346 km^2 (Figure 1). Biogeoclimatic zones within the watershed include the Interior Cedar–Hemlock wet cool variant (ICHwk3) in the lower reaches, the Engelmann Spruce–Sub-Alpine Fir wet cool variant (ESSFwk1) through the majority of the drainage, and the ESSFwc3 and Alpine Tundra (AT) in the upper elevations. The Goat River is a relatively pristine watershed with little forestry development. It does not have any glacial meltwater input upstream of the Milk River. Water quality in the Goat River watershed above the confluence of the glacially fed Milk River is very high (i.e., turbidity and suspended sediment levels are exceptionally low for Robson Valley rivers) (Rex and Lheidli T'enneh Band 2001). One forestry road provides access to the eastern side of the watershed including the Milk River basin; however, ground access above the Milk River confluence is presently limited to a hiking trail that follows the Goat River into Bowron Provincial Park. Forest harvesting activities, including road construction, are currently proposed for the upper portions of the Goat River watershed.

Methods

During July 2002, reconnaissance surveys were conducted in the Goat River watershed to assess the general abundance and habitat use by bull trout. Road-accessible pools were angled to evaluate project feasibility by obtaining estimates of catch per unit effort (CPUE), to determine run timing, and to determine whether Goat River bull trout would meet the tag–body weight ratios of less than 2% [Winter 1996] required for surgical implantation of radio transmitters.

For the surgery component of the project, road and helicopter-accessible sites (typically pool habitat) upstream of the Milk River confluence were fished using salmon rods until bull trout catch rates declined. Initially, owing to the ease of identification, only male bull trout were selected for radio-tracking. Females were selected later to increase the sample size. All bull trout caught by angling were weighed, measured, visually assessed for sexual maturity, and tagged with uniquely numbered Floy™ (t-bar anchor) tags. Bull trout selected for radio-tracking were anaesthetized (Anderson *et al.* 1997) until they reached total loss of reflex reactivity (Schreck and Moyle 1990). Lotek™ coded microprocessor transmitters were inserted through a ventral and medial incision, with the antenna exiting the left abdominal wall. Incisions were closed with poly-propylene swage sutures and passive integrated transponder (PIT) tags were inserted in the left operculum; when fully recovered, the fish were released. Sample locations were geo-referenced with a global positioning (GPS) unit to allow for the analysis and mapping of fine-scale movement patterns.

Starting on August 16, 2002, tracking flights were completed on a weekly basis through the expected spawning migration period. Helicopter flights were increased to a twice-weekly schedule during the period when bull trout adults were expected on their spawning grounds. During emigration, bull trout were tracked out of the Goat River watershed on a twice-weekly basis and then monthly through the winter. During the spawning period, higher use (i.e., extended residence by tagged fish) sites were visually inspected for obvious signs of reproductive activity, such as adult bull trout on redds (gravel nests excavated by spawning fish) and exhibition of spawning behaviours (e.g., digging, pairing of brightly coloured mature fish), or cleared patches of substrate with adults in nearby pools, glides, or other habitat cover. Geographic (UTM) co-ordinates and habitat data were recorded for each obvious redd site for future assessment of redd distributions.

Immediately following the spawning period, temperature data loggers were placed at selected redd sites to assess stream and inter-gravel temperatures. At selected redd sites, one temperature logger was buried in the gravel adjacent to the mounded portion of the redd containing the eggs and a second logger was left unburied on the stream bottom.

To assess the distribution and frequency of bull trout habitat types, and to monitor potential changes within these habitats, a videographic aerial survey was completed in early October 2002. With the exception of the Milk River, the entire Goat watershed was flown by helicopter at approximately 300 m above the channel while a geo-referenced video record of the stream network was filmed with an externally mounted digital video recorder. Geo-referencing will allow for future mapping of habitat features.

During the spawning period in 2003, ground-based redd surveys were completed in the Macleod and Upper Goat drainages. Redds were visually enumerated and geo-referenced. Site attributes, such as distance from large woody debris (LWD), site gradient, redd location

(i.e., open vs. against stream banks or under LWD), and distance from pools, were recorded and coded to allow for the analysis of detection functions and to investigate any correlations between redd locations and habitat types. Dispersion of redds throughout the survey area were evaluated using the negative binomial parameter "*k*" (Krebs 1999). This data will serve to identify and monitor important habitat attributes, and to ensure that the level of redd detection is sufficient to identify changes within an appropriate time period.

Preliminary Results

Sixteen adult bull trout were radio-tagged and 12 sub-adults were tagged with t-bar anchors between July 11 and August 23, 2002 (Figure 2, Table 1). All radio-tagged fish were caught on August 8th, 9th, and 23rd. Fourteen of sixteen fish in the Goat River were located at least once following radio-tagging. Based on the movements of fish we were able to track, survival was 100% through the spawning period.

The Goat River watershed provides important spawning habitat for large fluvial forms of bull trout. The average length and weight of the radio-tagged bull trout (n = 16) was 617.5 mm (range: 505–780 mm) and 2613 g (range: 1300–5100 g), respectively. The average length of all bull trout sampled was 519 mm (n = 28).

Of 16 radio-tagged bull trout, five were tracked to spawning sites in the Upper Goat River, eight were tracked to spawning sites in the mid-to-upper reaches of Macleod Creek, one remained near the confluence of Northstar Creek during the peak spawning period, and two moved downstream after tagging. The presence of bull trout in the upper reaches of Northstar Creek was visually confirmed during spawning site investigations

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FIGURE 2. Large male bull trout being released after surgical implantation of radio transmitter.

in September. In 2003, one large redd was recorded in the upper reaches of Northstar Creek, indicating that during ideal flows, fluvial bull trout are able to navigate a small set of falls located in the first reach.

A preliminary assessment of bull trout movements showed that immigration into the Goat River began in late July and continued through to the third week of August. Bull trout arrived at spawning locations between the end of August and the first week of September. Spawning activities began around the first week of September and continued over a 3-week period, with the majority of tagged bull trout emigrating from the Goat River into the Fraser River by September 22 (Figure 3). Two radio-tagged and a few untagged adult fish were observed at potential redd locations after most tagged fish had left the Goat River.

TABLE 1. Summary of Goat River bull trout capture statistics and angling effort (2002)

Date	Location	Type	Effort (hours)	Bull trout captured	Radio tagged	CPUE	Mean fork length (mm)
July 11	5 km/15 km	Angling	0.77	3	0	0.257	413
July 18	Milk Confluence	Angling	1.33	4	0	0.333	393
August 8	Mid-Goat	Angling	1.67	11	10	0.152	607
August 9	u/s Milk Confluence	Angling	0.92	4	4	0.23	660
August 23	u/s Milk Confluence	Angling	2.5	6	2	0.417	401
			7.19	28	16	0.278	519

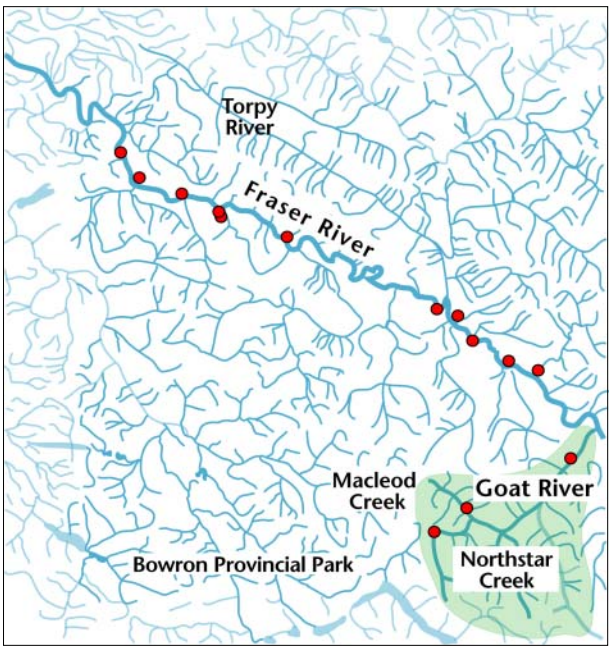

FIGURE 3. Bull trout distribution along the Fraser River four days after spawning (September 22, 2002).

The pre-spawning migration up the Goat River to the spawning areas was relatively slow (weeks). In contrast, emigration to the Fraser River following spawning was rapid, with most fish vacating the Goat River within a few days after spawning. Downstream migration rates within the Fraser River were also rapid. For example, one fish moved over 30 km within a 6–7 hour period in late September. As a result of this rapid downstream migration and budget limitations, 10 of the 16 bull trout were not relocated despite attempts to relocate all fish. Tracking flights were completed throughout all major tributaries in the Upper Fraser. Biologists from Williams Lake, B.C., have assisted this search by scanning for Goat River bull trout as far downstream as the Chilcotin River. Of the bull trout located, one fish was found just upstream of Quesnel, three moved into the Nechako, and two remained in the Fraser River near Penny, B.C.

On September 19 and 22, 2002, ground surveys were completed to determine whether future redd counts would be feasible. A total of 24 redds were counted in the Upper Goat in a 1000 m long section, four redds were counted in a section over 600 m long in the lower portion of the upper Goat, and 11 redds were counted in Macleod Creek over a 1000-m distance (Figure 4).

Redd surveys completed in 2003 resulted in 73 (4.3 redds per kilometre) and 90 (9.0 redds per kilometre) redds in Upper Goat River and Macleod Creek, respectively; this is consistent with the Davis River, which had approximately 4.5 redds per kilometre in 2003. The Davis is considered to be one of the highest-value bull trout spawning streams on the Williston Reservoir and a benchmark system for comparative purposes. The Goat River population estimate for 2003 is approximately 326 bull trout, but on a few occasions there were more bull trout present than the redd numbers would indicate. This emphasizes the need to accurately determine residence time at each site, as well as spawner sex ratios and redd detection functions, to provide better confidence in the estimates.

Habitat utilization results were similar to findings in previous studies (Rieman and McIntyre 1993; Baxter 1996; Baxter and McPhail 1996; Baxter *et al.* 1999; Hauer *et al.* 1999; Baxter and Hauer 2000). The highest densities of spawning fish were found in areas with an abundance of instream LWD or overhead cover, and with side-channel habitat in the vicinity (Figure 5). Spawning areas were also characterized by meandering, low-gradient sites with accumulations of medium-sized gravel.

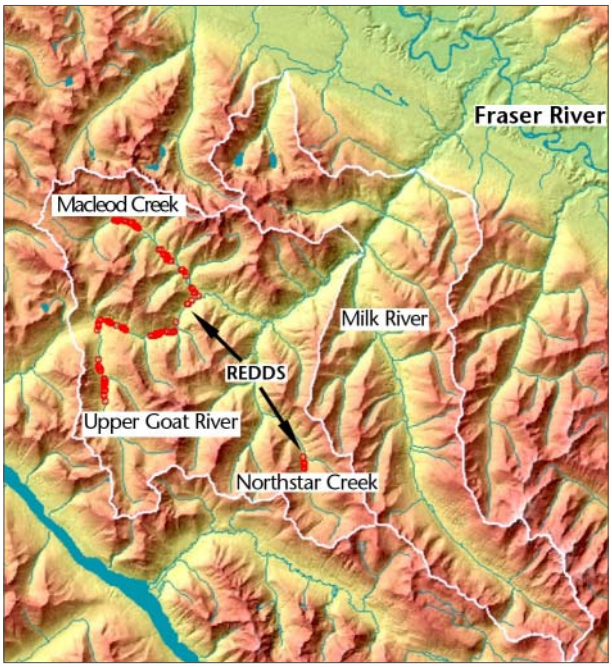

FIGURE 4. Distribution of bull trout redds (open red circles) in Macleod Creek and the Upper Goat River as determined by surveys completed during 2003.

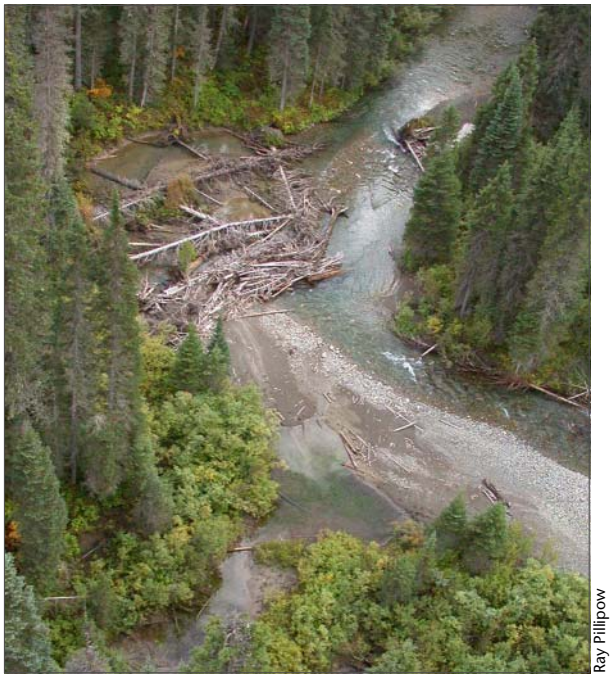

FIGURE 5. High-use spawning habitat located in the Macleod Creek.

Summary and Management Implications

The Goat River lies within the traditional territory of the Lheidli T'enneh and North Thompson Bands. The Lheidli T'enneh's interest and involvement in the Goat watershed stems from several factors.

- The river is the largest intact watershed for its ecotype in the upper Fraser.
- The river lies within the Band's statement of intent area for treaty negotiations.
- The desire exists to collect and provide accurate information to feed into resource development plans that are submitted to Chief of Council.
- The river has been identified as a traditional char and salmon sustenance site (Brian Toth, Resource Manager, Lheidli T'enneh First Nation Natural Resource Department, pers. comm., 2003).

These interests have resulted in partnerships between the Lheidli T'enneh, McBride Forest Industries, and the B.C. Ministry of Water, Land and Air Protection.

As a function of the initial water quality work (Rex and Lheidli T'enneh Band 2001), watershed assessments (Aquatic Resources Ltd. 2000; Integrated Wood Services 2001, Fisheries and Oceans Canada Web site), and an array of local knowledge from the Robson Valley, the Goat River was identified as a watershed with a high potential for bull trout habitat.

The primary objectives of the telemetry project were:

- to determine bull trout presence and distribution within the Goat River watershed and investigate the movements of adult fish;
- to determine the location of important spawning habitats within the watershed; and
- to identify key spawning and rearing habitat features.

Investigations of bull trout use in the Goat River during this project will provide the basis for a full understanding of Goat River bull trout habitat requirements and a framework for monitoring long-term population trends.

We have been able to confirm the presence of a substantial spawning population of large fluvial bull trout in the Goat River. The maximum length of bull trout observed in our study (780 mm) was much larger than that observed in other study programs within the Upper Fraser River (e.g., 620 mm, Dome Creek Fish Fence; Williamson and Zimmerman 2000; Williamson and Pillipow 2002). A comparison of length–weight regression models (Figure 6) indicates that the Goat River bull trout have similar growth functions to fluvial bull trout previously studied in British Columbia (e.g., Duncan River [O' Brien 1999]; Chowade River [Baxter 1996]; Davis River [O'Brien and Zimmerman 2001]).

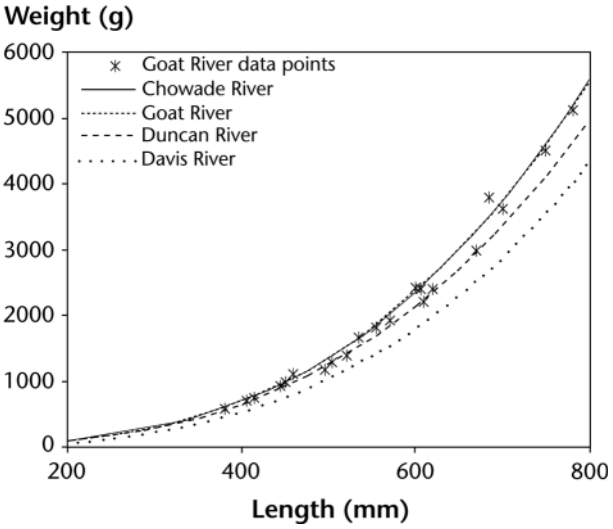

FIGURE 6. Comparison of log-transformed mass–length relationships for various bull trout studies.

Based on the regression models, Goat River fish were most similar to bull trout from the Chowade River (fluvial) and were approximately 25% heavier than Davis River (Williston Reservoir) fish at a length of 700 mm. The relatively high condition (fatness) of Goat River bull trout may have been influenced by their late stage of maturity, or by the high productivity of the Fraser River. Juveniles from all populations demonstrated similar length–weight relationships, providing evidence that the Fraser River plays an important role in bull trout growth rates, but does not explain the difference in size between Upper Fraser River bull trout stocks. Until age-structure or genetic comparisons of bull trout among watersheds in the Upper Fraser have been made, we cannot speculate as to why Goat River bull trout are larger than those in neighbouring streams.

The migratory behaviour of bull trout spawning in the Goat River provides further evidence to suggest that the Goat River is an important watershed for bull trout spawning. Our post-spawning (emigration) results show that bull trout spawners in the Goat River rapidly migrate long distances to the Fraser and Nechako rivers. Goat River bull trout were tracked downstream in the Fraser River as far as Quesnel, and into the Nechako River as far upstream as Fraser Lake (approximately 450–500 km). It is unclear whether Goat River bull trout are a distinct stock that home to specific spawning sites (spawning-site fidelity), or whether their migrations result in spawning fish straying into other watersheds. Further investigations into the behavioural patterns of bull trout in the Fraser are required to better understand how the Goat River contributes to the broader bull trout population of the Upper Fraser drainage.

Our preliminary results suggest that the vulnerability of spawning bull trout during their migration up the Goat River, and when they are on the spawning sites, is a management concern. The Goat River is a moderately high gradient stream with low sinuosity and, consequently, it has a relatively low number of holding pools for migrating fish. The upstream migration of mature bull trout was fairly slow. During this period, bull trout congregated in a limited number of pools and were highly susceptible to angling. The vulnerability of large fluvial bull trout migrating to spawning grounds in the Goat River has been addressed through the application of seasonal angling closures in the watershed upstream of the Macleod Creek confluence. Regulatory measures will serve to protect fish at spawning sites.

Our preliminary results suggest that the vulnerability of spawning bull trout during their migration up the Goat River, and when they are on the spawning sites, is a management concern.

Although low numbers of spawning bull trout were dispersed throughout the Upper Goat River and McLeod Creek where spawning habitat conditions appear suitable, most fish were concentrated at key locations (Figure 4). All high density spawning areas were characterized by abundant LWD, medium-sized gravel, undercut banks, pool cover, and overhead cover, with side channel habitat nearby (Figure 5). Abundant instream LWD creates holding pools and cover, accumulates gravel, and creates local gradient reductions, which in turn affects hyphoreic (ground water) exchange through the gravel (Hauer *et al*. 1999; Baxter and Hauer 2000). These attributes working in concert create high-quality spawning habitat for bull trout.

Bull trout redd numbers were found to be negatively correlated with watershed road density and positively correlated with the extent of bounded (i.e., segments confined by bedrock nick points or valley confinement) alluvial valley segments (Baxter *et al*. 1999). Spawning locations in the Goat River will require special management considerations to ensure that all habitat characteristics remain intact and that access is managed effectively. Presently, the B.C. Ministry of Water, Land and Air Protection is exploring management options such as "wildlife habitat areas" as a tool to protect important spawning areas. This process will involve further identification of spawning habitat, and ranking and delineating boundaries around key areas. With stakeholder involvement, adaptive management criteria will be developed that are designed to protect the biological and structural elements important for spawning habitat, while limiting economic impacts on timber resource activities. Because of the steep-walled valleys in the area, restricting access into the upper watershed by gates is another viable option that will be investigated.

This study has shown that the Goat River is an ideal bull trout index watershed. Intact habitat, coupled with excellent redd visibility, will allow the establishment of redd index sites to monitor populations trends within the watershed. Identification of two or three comparison watersheds is being proposed to provide an effective monitoring tool for the overall health and trends of bull trout in the upper Fraser basin. By monitoring several watersheds, we hope to differentiate the local effects on habitat change from the cyclical trends that may occur at a larger scale.

The large-scale migrations exhibited by Goat River bull trout have raised questions about meta-population structure of the species in the upper Fraser. These questions will be highlighted as "action items" in the development of higher-level bull trout management plans, which will drive future management activities in the upper Fraser.

In addition to using Goat River data for the development of regional bull trout management criteria, the B.C. Ministry of Water, Land and Air Protection, in partnership with FORREX, is using Goat River and other bull trout data along with information on other "identified wildlife" to develop a species "summary and procedures" guide for managing identified wildlife. This document will assist forest companies and the general public by providing criteria to identify which species and associated habitat features qualify for potential "wildlife habitat area" and "wildlife habitat feature" designation proposals. Where knowledge of significant fish and wildlife features for identified species are known to exist, forest companies and the general public should have increased opportunities to bring forward WHA proposals using this guide.

Currently, proposals are being developed to determine stock structure using recent advances in geosciences. This process will look for distinct watershed chemistry signatures (i.e., trace element:calcium ratios). These will be compared to calcified growth structures (e.g., otoliths) to determine origin and life-history patterns of fluvial bull trout.

If these applications (coupled with changes in regulations and proposed measures to protect and monitor spawning bull trout in Goat River) prove effective, the Upper Fraser and the Goat River will be more effectively managed, ensuring that population structures are properly identified and managed at the appropriate scale.

Acknowledgements

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