USE OF RADIO TELEMETRY TO CALIBRATE OBSERVER EFFICIENCY AND MONITOR RECOVERY OF CHEAKAMUS RIVER CHAR (SALVELINUS SP.) USING PRE AND POST SPILL SNORKEL SURVEYS

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FINAL

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Char Adult Enumeration Study – Post Spill Abundance Assessment

Introduction

The following document outlines a proposed study to calibrate existing information from previous snorkel survey data by developing an observer efficiency index, which would allow for the development of recovery targets and be used to monitor recovery of char in the Cheakamus River.

Rationale

A number of juvenile and adult char were recorded as mortalities in the Cheakamus River due to the August 2005 sodium hydroxide spill (McCubbing et al. 2006). The lack of pre-spill quantitative abundance information on char in the Cheakamus River has made the development of a defensible recovery target difficult.

The number of adult char in the Cheakamus River from the confluence of the Cheekeye River to the anadromous boundary approximately 14 km upstream has been enumerated by snorkel surveys since 1996. Counts are auxiliary data collected as part of a snorkel and radio telemetry program to estimate steelhead escapement for BC Hydro. On average nine swims have been conducted per year between February and May. The char counts provide information on the distribution of char over the 14 km survey area as well as relative abundance. The data are therefore potentially useful to develop a recovery target for this species in the Cheakamus River. Abundance and distribution of char from nine pre-spill years can be compared to similar data from ongoing BC Hydro steelhead enumerations to allow for a continued assessment of recovery.

Unlike the Cheakamus River steelhead escapement program, no radio telemetry information is available for char. This information is critical for determining the proportion of fish seen by divers and the survey life or residence time of fish in the survey area. These data are required to translate counts of fish across multiple surveys within a year into an annual population estimate. Variation in survey life or diver efficiency across years that is not accounted for in the estimation procedure can lead to spurious interannual trends in abundance. Differences in diver observer efficiency in the upper and lower portions of the river (Korman et al. 2005 and 2002) will influence the assessment about the distribution of different components of the char population (see Appendix 1).

It is proposed that the most effective method of evaluating stock recovery for char is by utilizing existing swim count data for char collected during steelhead adult monitoring. These data would be used to develop an annual adult char population estimate, to calculate historical abundance using archived count data (BC Hydro data on file) and to determine pre-spill levels of abundance, and develop a defensible recovery target. Additional information on the geographical movement of fish within the Cheakamus and Squamish basins would also be collected to provide important life history information about char in the Cheakamus River system. There are anecdotal data to indicate the majority of char may leave the Cheakamus River in May following fry and smolt outmigration, but little is known of their subsequent movements.

Timescale

The project will be undertaken over three years with annual reporting in 2007 and 2008 and a summary and analysis of all data to be completed in 2009. Fish will be captured and tagged in the winter/spring (December through April) in the first two years and swims conducted January through May as conditions permit. Radio telemetry will be continued throughout the first two years to assess fish movement in the period following snorkel surveys. In the third year telemetry will be conducted until June 30th when all snorkel surveys will be completed and the majority of tags utilized will have limited available battery life. The length of the study has been determined based on many factors including: replication required to ensure that observer efficiency, survey life, departure schedule, and upper and lower-river use. Movements of fish are likely representative of various conditions and life histories that will be encountered during the study period. Based on the size of fish available in this study, tag technology limits the length of study as each tag only has a guaranteed lifespan of 678 days (1.9 years). Thus, tag life ensures all fish tagged in Year 1 will be available for detection in Year 1 and Year 2, those tagged in Year 2 will be "live" during Year 2 and Year 3 (when no new fish will be tagged).

Methods

A limited group of experienced volunteer anglers will be used to assist in the capture of 40 to 50 char annually for two years within the Cheakamus River. These fish will be tagged with internal radio tags using surgical methods and an external spaghetti Floy tag for visual identification, during snorkel surveys. Floy tags will be different colours in each year of tagging in order to try and discern potential dead tags in year 3 of the study.

All fish captured and tagged will be sampled for fork length (mm), sex (if able to determine), and scales and fin ray samples for ageing and genetic analysis will be collected and provided to Ministry of Environment (MoE) for archiving and future analysis in the event funding becomes available.

Based on anecdotal life history of char in the Cheakamus (see Appendix 1), fish will be tagged from throughout the anadromous section of the Cheakamus between December and April and tags will be distributed, spatially, temporally and stratified based on size in an effort to ensure all size ranges of presumed migratory or resident "adults" and "sub-adults" are represented in the sample.

The following tagging plan has been developed primarily to meet the study objective of observer efficiency and development of robust population estimates of char and will be adaptive in nature:

I. Spatial distribution of tags is based on observations of char abundance in various sections of the river during past snorkel surveys and logistical constraints such as the success of the anglers through time and angling conditions in various parts of the river. As observations on fish behaviour are collected from telemetry data, and angler success in various sections is quantified, targets for each section may be revised in season (example: fish tagged below Cheekye confluence may not migrate into swim zone and thus would have limited value to the primary study objective of developing population estimates, and tagging effort may be moved elsewhere). Decisions to revise tag distribution and timing targets will be made by the study team based on field observations and ongoing examination of telemetry data in consultation with the contract monitor and CN.

Proposed tag application scenario -Year 1:

- **Section 1:** Squamish confluence to the Cheekye; **10 tags.**

Target: Potentially migratory and resident fish, as well they will give strong residency time data (exit and entry to swim zone) necessary for population estimation.

- **Section 2:** Cheekye to Bailey Bridge; **25 tags.**

Target: Assumed to be primarily migratory fish but may also include a resident component. Area of highest historical abundance based on previous snorkel surveys.

- **Section 3:** Upstream of Bailey Bridge; **15 tags**.

Target: Assumed to be primarily resident component of the population and will also distribute tags into this area for observer efficiency data to the upper river (Appendix 1). Fish will be captured a minimum of 1.5km upstream of the Bailey Bridge.

II. Tag application will be distributed temporally through the tagging period with an attempt to apply approximately 60% of the tags prior to February 1st. Tagging effort will then be reduced through April 1st but will attempt to add tags based on snorkel survey schedule (Table 1).There is a need to have as many tagged fish as possible during snorkel surveys, and based on the assumption that char are not leaving the system between January and late April, fish tagged in December and January should be available until the majority of snorkel surveys are completed in early May. The tagging schedule is adaptive in nature and may change depending on angler success, angler conditions, and fish behaviour. The tagging schedule will be reviewed in Year 2 and will be refined based on Year 1 results.

III. Distribution of fish size will be based on observed distribution of sizes during snorkel surveys. Stratifying tagging effort over the size distribution of char will partially be limited by the fish captured by anglers and will be adaptive based on capture success of various sizes of char.

In Year 3 two options exist and a decision of how to proceed will be determined at the conclusion of Year 2. At this time it is not anticipated tags will be deployed in the watershed in Year 3 as tag life (1.9 years) makes tagging in Year 3 a confounding factor to developing observer efficiency[1].

- **Option 1**: The continuation of fixed station data logging on the Cheakamus at Sites 1 to 3 in Year 3, to corroborate entry and exit time based on Year 2 tagged fish returning to the Cheakamus in December (see Appendix 1).

- **Option 2:** The continuation of all components of the study except for tagging. This option would be chosen if we saw a high proportion of Year 1 tagged fish returned in Year 2. Additional swims in Year 3 would be added to develop observer efficiencies.

Mobile tracking and observed tags would be recorded during BC Hydro steelhead swims in Year 3 regardless of which of the above options was selected and data from those swims in Year 3 may be included in the resulting model (or not) depending on whether different coloured Floy tags (identifying Year 1 fish with dead radio tags) could easily be discerned from Year 2 tagged fish that contained live radio tags.

1. If Floy tag colour can easily be detected by swimmers radio tags could be added in Year 3 if deemed necessary upon review of Year 1 & 2 data.

Swim crews undertaking steelhead enumeration for BC Hydro will collect visual data on char abundance as in previous survey years (1996 to 2006, Korman et al., 2005), in addition this same swim crew will conduct the extra swims within this study in order to maintain consistency in data collection. The survey area is limited to the upper 14.5 km of the anadromous portion of the river that extends from approximately 500 m below the natural barrier to the confluence with the Cheekye River.

On each survey, a team of three divers floats the entire study area (14.5 km of river) in about six hours. A safety raft accompanies just behind the swimmers on each survey. Divers float side-by-side in lanes spaced equidistant along the channel cross-section. The number of tagged and untagged steelhead, char (bull trout or Dolly Varden), and resident rainbow trout (i.e. rainbow trout greater then 20 cm in fork length) are recorded by river section (Table 2) on each survey. Diver horizontal visibility (HV) is estimated by measuring the maximum distance from which a diver can detect a dark object held underwater at 1 m depth. Horizontal visibility will be measured in sections 4 and 21 to index conditions in the upper and lower survey areas, respectively (Table 2).

In addition to the average ten swims normally conducted during the BC Hydro steelhead enumeration program, five additional swims will be completed prior to the normal steelhead survey period, in an effort to determine early char abundance and run timing. A further five swims will be added during the normal survey period (March through May) to provide a population estimate with increased confidence. As well snorkellers will record tag observations, horizontal visibility and discharge. During each swim (Hydro and additional char study swims), the safety raft will also conduct manual tracking as undertaken during the steelhead telemetry study. Mobile tracking during the swim will assess the location of all radio tagged fish within the swim zone. These data will be compared with fixed station output (from three sites, Cheakamus/Squamish confluence, Cheekye confluence and Culliton Creek confluence).

Fixed station logging with three directional aerials at each station will be installed and run from late December when tagging commences throughout the year in Year 1 & 2. During the tagging and swim portion of the study (December to June) the three fixed stations will remain at the following sites with the configuration of aerials as follows;

a. **Squamish confluence (Site 1)**: UP & DOWN Squamish and UP Cheakamus,

b. **Cheekye confluence (Site 2):** UP & DOWN Cheakamus, and UP Cheekye,

c. **Culliton confluence (Site 3):** UP & DOWN Cheakamus and UP Culliton.

Fixed station data will be used to corroborate fish location (during mobile tracking), identify entry and exit timing of each fish into the swim zone, and build a picture of typical char behaviour in the Cheakamus River.

An adaptive process will be utilized to determine locations for fixed receivers throughout the rest of the year (July to November) based on examination of telemetry data from each station, and in particular Site 1. If the majority of char are observed to leave the Cheakamus in late spring and summer, Site 2 and Site 3 fixed stations could be moved to locations such as the Squamish Estuary, and/or the upper Squamish/Elaho area, depending on observed direction of travel at

Site 1. This may assist in evaluating typical char feeding/spawning migrations in the Squamish watershed and corroborate the suppositions about life history of char in the Squamish Watershed (Appendix 1). In Year 3 fixed stations will be removed at the end of June as tag life will limit the collection of useful data.

The information collected will be modeled to provide an annual escapement estimate based on visual abundance and observer efficiency using the methods described in Korman et al 2005. After three years the combined data will be utilized to reconstruct historic abundance estimates for the river, the distribution of abundance in upper and lower river sections, and to assess pre and post spill variations. Additional data on fish movement will be collected through fixed station telemetry to assess and describe the annual migration patterns of char within the Cheakamus River.

Sampling of Fish

The following information will be recorded or collected for all char captured and tagged during this study:

- Date, time and location of capture (UTM coordinate, and river km);
- Name of angler, and gear used;
- Radio tag ID and frequency;
- Colour of floy tag;
- Fork length (mm);
- Sex (if it can be visually determined);
- Fin rays and scales to archive for potential future ageing and genetic analysis and,
- Observations or general comments about fish condition.

Analysis

The historic trend in char population size will be developed based on historical count data, the telemetry information collected as part of this project, and a modified version of the Cheakamus River steelhead assessment model (Korman et al. 2005). This model estimates annual escapement based on count and telemetry data in a maximum likelihood framework and provides relatively robust estimates of uncertainty. The steelhead estimation model requires a few significant modifications to be used for this char application:

1. The time frame of the model must be expanded to cover the period of char residency (currently unknown but may be as long as Nov-June).
2. A spatial component must be added to the model to try and estimate upstream-resident and downstream-migratory components of the population.
3. A functional relationship between diver efficiency and river conditions (what variables, what structural form) must be developed.
4. A functional relationship relating survey life with date of entry and the departure schedule must be determined; and
5. The revised model must be tested using simulated data (to check for errors).

The model structure, simulation testing, and application to the char data must be documented in a report. The report will also document the data in a general format to describe fish migration patterns and spatial distribution.

Deliverables

Key deliverables include:

- Abundance estimates for each survey year,
- Description of general movement patterns, and spatial distribution, and
- Reconstructed abundance of historic abundance and distribution for years which data are available (1996-2006 except 1998),

Reporting:

Monthly: A brief report will be submitted at the end of each month summarizing such things as number of snorkel surveys, fish tagged, observations of behaviour etc.

Annual: At the conclusion of Year 1 & 2 (December 2007 and December 2008). Data will be analysed and modeled to provide an annual escapement estimate, and describe observed migration patterns from telemetry data. (Draft delivery date March 31, 2008 and March 31, 2009).

Final: At the conclusion of Year 3 (June 2009) the combined data will be utilized to provide historic abundances, the distribution of abundance in upper and lower river sections, assess pre and post spill variations, and report on life history and behaviour characteristics (Final Report delivery date November 30, 2009).

References

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Table 1. Proposed schedule of tag application in Year 1.

Week Ending	Tagging Target			Weekly	Cumulative
	Section 1	Section 2	Section 3	Total	Total
23-Dec	1	2	1	4	4
30-Dec	1	2	1	4	8
06-Jan	1	2	1	4	12
13-Jan	1	3	2	6	18
20-Jan	1	3	2	6	24
27-Jan	1	3	2	6	30
03-Feb		1	1	2	32
10-Feb		1		1	33
17-Feb		1	1	2	35
24-Feb		1		1	36
03-Mar	1	2	1	4	40
10-Mar	1	2	1	4	44
17-Mar	1	1	1	3	47
24-Mar	1	1	1	3	50
Total	**10**	**25**	**15**	**50**	

Table2. List of river sections in the Cheakamus River used in the analysis of snorkel count and telemetry data.

2004+ Section	Upstream Boundary Description	Survey Area	1997-2001 Section	2003 Section
-1	Above swimmer put-in			-1
0	Swimmer put-In to raft put-in	Upper	CYER	0
1	Raft put-n	Upper	ERCU	1
2	Large rock/powerlines	Upper	ERCU	2
3	Huge boulder at Start of Pool	Upper	ERCU	3
4	End of pool/rock on RR; Small pool	Upper	ERCU	4
5	Suspension bridge to sweepers on RL at start of riffle	Upper	ERCU	5
6	Sweepers to u/s of Culliton confluence	Upper	ERCU	6
7	Pool starting just u/s of Culliton	Upper	CUCA	7-8
8	Long boulder rapid	Upper	CUCA	9
9	Big rock on RR (orange tape)	Upper	CUCA	10
10	Above upper Campground; Logjam on RR	Upper	CUCA	11
11	Below giant gravel dump on RL	Upper	CAHB	12
12	Below split channels	Upper	CAHB	13
13	Original lunch spot at old cableway	Upper	CAHB	14
14	First pool above tree-fort (new lunch spot)	Upper	CAHB	15
15	First pool below wife wanted (Don's Pool, includes riffle d/s of new wood on RR)	Upper	CAHB	16
16	Right corner (orange tape)	Upper	CAHB	17-18
17	End of pool (orange tape)	Upper	CAHB	19
18	Boil in pool (orange tape)	Upper	CAHB	20
19	Lower Campground (orange tape)	Upper	CAHB	21
20	Orange tape on River Left above Bailey Bridge	Upper	CAHB	22
21	Bailey Bridge	Lower	HBCC	23
22	Riffle above side channel that is now gone	Lower	HBCC	24
23	Tenderfoot Confluence	Lower	HBCC	25
24	Riffle just below Al's Rock	Lower	HBCC	26
25	NVOS pool	Lower	HBCC	27
26	NVOS Tailout	Lower	HBCC	28
27	Gauge pool (warning sign on RR at start of pool)	Lower	HBCC	29
28	RST pool to below longhouse	Lower	HBCC	30
29	Top of riffle; Woody pool below longhouse	Lower	HBCC	31
30	Start of Dry section where most flow goes RR into trees	Lower	HBCC	32
31	Start at confluence with new channel. Log sticking out of water on RR	Lower	HBCC	33-34
32	Tree lying along RL	Lower	HBCC	35
33	Start of gravel bar (RL); Hydro lines above	Lower	HBCC	36
34	Frog pond; Ends at Cheekeye	Lower	HBCC	37
35	Below Cheekeye confluence			38

APPENDIX 1: Anecdotal life history of char in the Cheakamus from swim data and angler observations.

It is assumed that adult and sub-adult char are making in-river migrations within the Squamish Watershed, to opportunistically feed in the productive Cheakamus River. These fish are thought to enter the river with chum adults in late October through December, remaining resident through the winter months feeding on chum eggs and carcass material. In the spring the fish likely feed on fry as they begin to emerge in late January (chinook and on year pink fry) and then leave the Cheakamus River as the chum fry emergence and outmigration diminishes in late April. It is possible that these fish follow the fry into the estuary to continue to feed as chum rear in the inner coastal area of Howe Sound. Subsequently all char are likely to make a spawning migration to some unknown locale in the Squamish Watershed with potentially some spawning in the Cheakamus watershed in September-October, before returning to the Cheakamus in November/December. (8 large char >9cm were captured in a test electroshock survey in the Elaho on Oct 12 1999, van Dischoeck, 2000).

Examination of recent (post spill) raw count data suggests there may be a resident population of char that uses the upper portion of the Cheakamus river (upstream of Tenderfoot confluence) and a migratory/resident population that utilizes the lower river over the winter and spring. An assumption that a resident population resides principally above the Bailey Bridge (RK7) in the Cheakamus comes from swim data observations of rates of decline and increase in abundance in the different areas of the river post spill. Raw count data indicates that the mid and lower river (assumed) migratory population is similar in abundance to pre-spill years, but that the (assumed) resident population in the upper river has been very much reduced. Telemetry information will allow us to determine if these hypothesized populations exist and the relative size of these two populations. It may also assist in assessing the extent to which fish from the migratory component might help recolonize the upstream river area.