Summary of Summer-Run Steelhead Enumeration Activities on the Kitwanga River 2003-2011

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Executive Summary

Electronic fish counting technologies are desirable methods to enumerate aquatic species when traditional methods like fish fences are not practical. The Ministry of Environment (MoE) has experimented with a Logie 2100C resistivity counter (*Aquantic Ltd. Scotland*) and a Dual Frequency Identification Sonar (DIDSON) *(Soundmetrics Ltd. Lake Forest Park Wa.)* to enumerate Kitwanga River summer-run steelhead between 2003 and 2011.

Hybrid crump weir resistivity panels were incorporated in to the design and construction of the adult salmon fence on the Kitwanga River. The first year of operation was 2003. The number of fish migrating upstream of the resistivity counter between April 17 and June 6 is estimated to be 1027. Peak daily upstream migration occurred on May 11. Based on peak signal strength (P.S.S.), and visual observations, it was determined that there were other non-target species migrating at the same time as steelhead. Therefore, it is not certain what proportion of the 1027 count is represented by steelhead. Days of resistivity counter operation ranged between April 17 and June 6 in 2003 (716 upstream migrants) to April 29 to May 17 in 2006 (468 upstream migrants. In 2006 flat panels, located upstream of the hybrid crump weirs, were utilized in an attempt to improve results. Sensor operation and count validation continued to be problematic. During high flows several panels became separated from the substrate compromising the results and it was decided to discontinue the resistivity counter project after the 2006 season.

The Kitwanga River DIDSON project experiment began in 2009. The DISDON was installed at the Kitwanga River adult salmon fence on May 4. Attempts to esonify the entire water column horizontally and vertically at this location were unsuccessful. Approximate width at this site is 20 meters. The best range achieved at this site was estimated to be 9 meters. In 2010, a consultant was retained to assist with site selection and operations for the DIDSON project. The DIDSON was repositioned upstream of the Gitanyow Fisheries Authority (GFA) fence site where the wetted width was approximately 13 meters. For protection, the DIDSON was placed behind a boulder located two meters from the wetted edge on river right. At the time of installation this left approximately two meters on river left not esonofied. The DIDSON was operational on April 7 and was shut down on June 20. Power loss and sediment infiltration resulted in a significant amount of data loss in 2010. A total of 3,020 ten minute files were recorded in 2010. Overall, 1,716 files (53%) did not contain any images of fish. There were 32 files (1%) that contained images of fish that were between 0.45m and 0.60m in length, and 982 files (30%) that contained images of fish below 0.45m. 215 files (6%) contained images of steelhead moving across the field of view. There were a total of thirteen steelhead observed migrating downstream during the project, resulting in a net upstream count of 202 steelhead captured in the field of view during the project. The proportion of steelhead that migrated on outside of the field of view is unknown. Several changes were made to the project in 2011. Range improvement was minimal and the coverage in the water column remained incomplete, therefore, it was decided to halt the project until a time when all steelhead passing the site could be enumerated with certainty.

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1.0 Introduction

Stock assessment data for Kitwanga River steelhead has been historically limited. The Kitwanga River is a fifth order stream that flows into the Skeena River. It supports all five species of Pacific salmon including pink salmon (*Oncorhynchus gorbuscha*), chum salmon (*O. keta*), chinook salmon (*O. tshawytscha*), coho salmon (*O. kisutch*) and sockeye salmon (*O. nerka*). This system is also known to support populations of steelhead trout (*O. mykiss*), resident rainbow trout (O. mykiss), cutthroat trout (*O. clarkii*), bull trout (*Salvelinus confluentus*), mountain whitefish (*Prosopium williamsoni*) and various other species.

The Provincial Fisheries Section has a significant interest in developing a summer-run steelhead stock assessment program on this river for several reasons. These reasons include:

- Lack of annual steelhead abundance information on any lower/mid Skeena tributaries
- Existing partnership with the Gitanyow Fisheries Authority.
- The majority of adult Kitwanga River steelhead over winter in the Skeena River and make their spawning migration into the Kitwanga River in the spring. This attribute mitigating the complication of multiple salmonid species migrating at the same time.
- Existing infrastructure i.e. Gitanyow adult fence, access, security.
- Close relative proximity to the Smithers Regional office.

Under the auspices of the Habitat Conservation Foundation (HCTF) resistivity counter panels were incorporated into the construction of the GFA adult salmon fence in 2003. The resistivity counter was in operation during spring 2003, 2004 and 2006. In 2006, flat pad sensor panels were installed upstream of the original "Crump" type sensor panels due to gravel accumulations on the original units in an effort to achieve better results. After 2006, the decision was made to discontinue the resistivity counter project due to inconsistent results and the inability to successfully validate counts.

A DIDSON was purchased in April of 2009 to implement the method that had been experimented with in 2008 in the Kitwanga River. This purchase was funded by the Living Rivers Trust Fund. The DIDSON was utilized in 2009, 2010 and part of 2011. The DIDSON was not able to detect migrating steelhead throughout the entire water column, neither vertically nor horizontally, and the decision was made to discontinue the project. This report describes the technologies utilized to count migrating adult steelhead on the Kitwanga River, the information recorded, and the reasons the technologies did not achieve the desired project goals and objectives.

2.0 Study Area

The confluence of the Kitwanga and Skeena rivers is located approximately 90 kilometers northeast of Terrace, B.C. (Figure1). The drainage encompasses an area of approximately 83,000 hectares and has a total main stem length of 59 kilometers. The river can be divided into two sections, the Upper and the Lower Kitwanga River. The Upper Kitwanga is located directly north and upstream of Kitwancool Lake and the Lower Kitwanga runs south from Kitwancool Lake to the Skeena River. The Lower Kitwanga River has four major tributaries Tea Creek, Deuce Creek, Kitwancool Creek and Moonlit Creek (Figure 2). The Upper Kitwanga River has no major tributaries and exhibits a multi-channel meandering configuration with numerous beaver dams along its lower reaches.

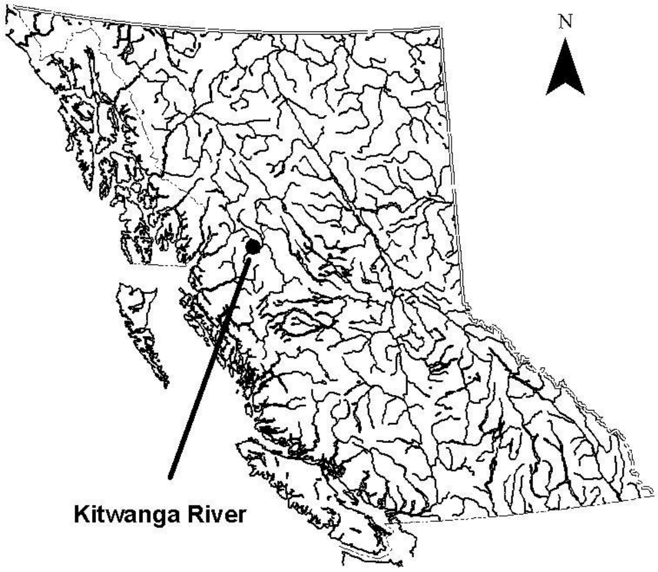


Figure 1. Kitwanga River

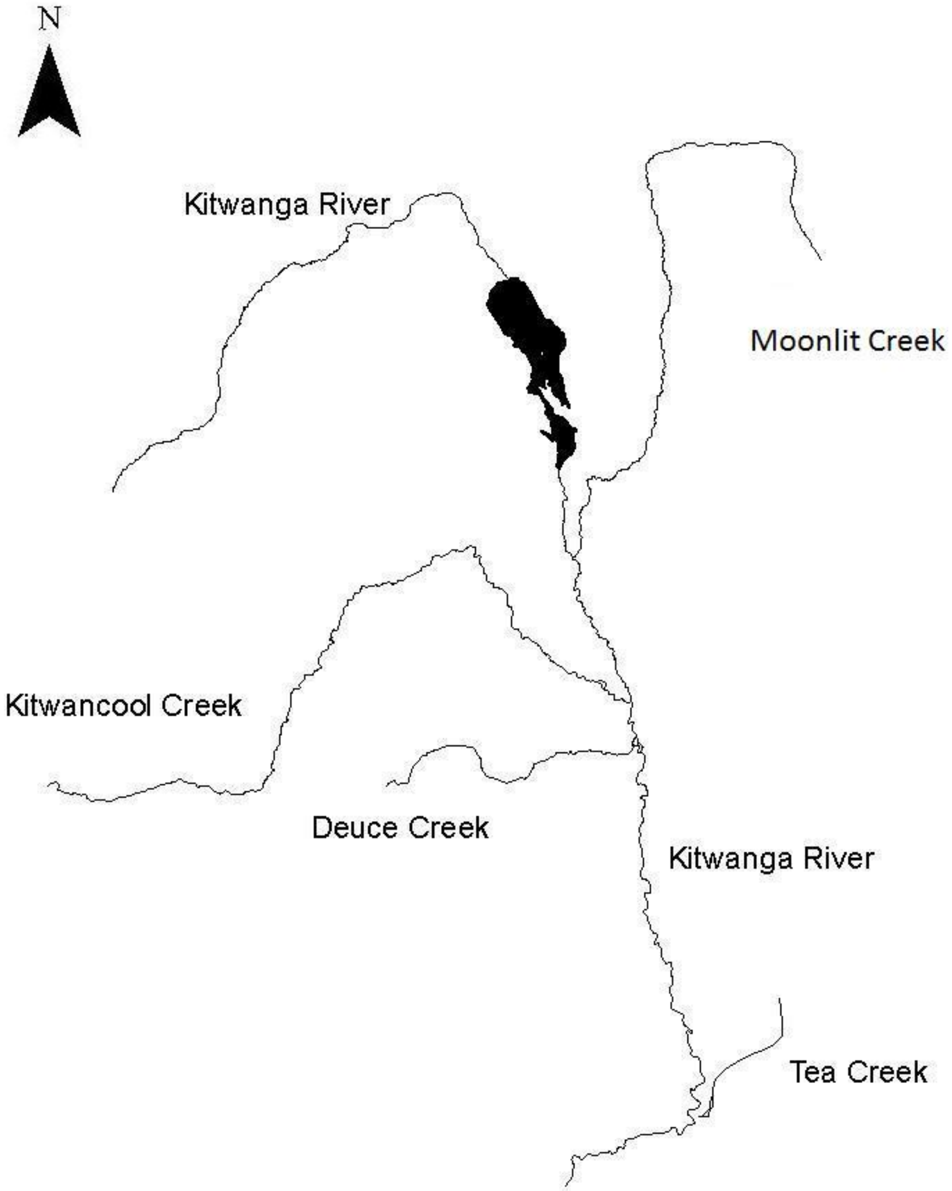


Figure 2 Kitwanga River and Tributaries

3.0 Methods

3.1 Resistivity Technology

Resistivity counters are used to enumerate steelhead in several locations in British Columbia. Long term steelhead enumeration projects, using resistivity technology, have been established on tributaries to the Thompson River (*McCubbing 2000*) and the Keogh River on Northern Vancouver Island (*McCubbing, et al. 1999*).

A resistivity counter detects the passage of fish across an array of three electrodes, placed across the river, or in a channel, in an insulated base (Picture 1). The electrodes can be organized on a flat pad, within a tube or on a crump weir. The counter electronics continually monitors the resistance of the water above the counting array (bulk resistance) and calibrates for changes in this resistance every 30 minutes. When a fish passes over the three electrodes, a change in resistance occurs, as a fish is more conductive than the water it displaces. This change of resistance is recorded and analyzed by the counter using a firmware algorithm to determine if it fits a typical fish pattern. Should the counter assess that a fish has passed over the array (based on this comparison), the time, direction of travel and peak signal size (maximum change of resistance measurement) of the fish event, is recorded and stored for later downloading and analysis (*see Aprahamian et al. 1996)* for more details of counter design and operation).

Picture 1. Counter site on the Kitwanga River.

In 2003, a full span salmon enumeration fence was constructed by the Gitanyow Fisheries Authority and Fisheries and Oceans Canada for the purposes of enumerating annual salmon escapements (Figure 3). While salmon enumeration was assessed to be feasible using a floating fish fence and trap facility during typical summer flows, high water events during adult steelhead migration precluded the operation of such a structure for steelhead enumeration purposes. However, this facility development did offer the potential opportunity to construct a full span resistivity electronic counter on the concrete sill which formed part of the fish fence with significantly lower costs than a purpose built site would incur. Therefore, a Logie 2100C resistivity counter was purchased by the Provincial Fisheries Branch.

In the fall of 2002, InStream Fisheries Research staff assisted Don Hjorth (DFO North Coast) in the design of a hybrid crump weir resistivity counter (Figure 4). This counter departed from traditional crump weirs (*McCubbing and Ignace 2000, McCubbing et al. 1999 and Nicholson et al. 1995)* in that it was an equal height over the complete river span to facilitate the operation of floating fish fence panels during summer and fall (plans on file). Counter sensors were split into four units, separated by insulated iron cut-waters, with electrodes set into HDPE plastic on the downstream face of a 1:6 gradient weir. While no such weir was operating in North America at this time, the relatively low costs of development (circa 40-60k) were deemed acceptable for the risks evaluated.

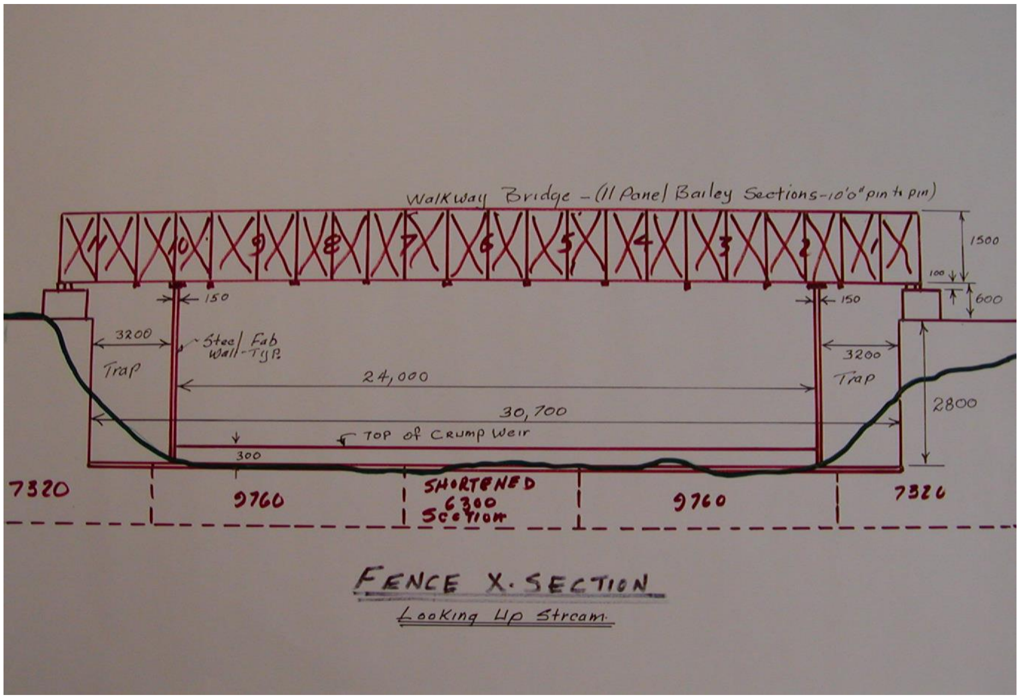


Figure 3. Fence construction diagram

During the first year of operation it became apparent that maintaining wire connectivity to the panels and gravel accumulation on the sensors, during freshet flows, was going to be problematic. After similar problems with the panels during the second year the counter was not operated in 2005 and an alternative panel arrangement was installed in 2006. The original sensor units were abandoned and flat pads were placed across the river, above the weir, in a method similar to that reported for the Chilcotin River (*McCubbing and Espinoza 2009*).

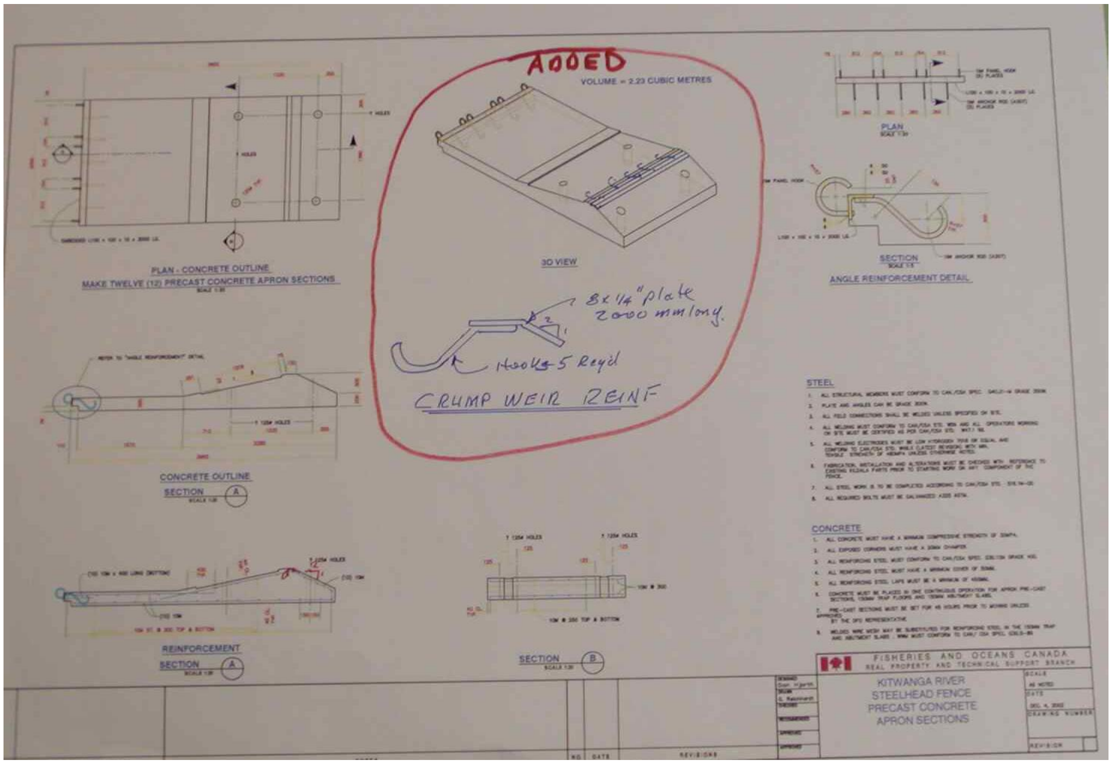


Figure 4. Hybrid crump weir

3.2 DIDSON Technology

DIDSON technology has been utilized to enumerate adult migrating salmon in several rivers in Alaska and British Columbia *(Holmes et al. 2005) (Burwen et al. 2007).* DIDSON technology utilizes sound to record images that can be near video quality by utilizing short acoustic pulses that contain 96 total beams in the high frequency mode and 48 total beams in the low frequency mode. In the high frequency mode the 96 beams are separated by 0.3° to 0.6° in the horizontal and 14° in the vertical (*Anonymous 2007*). Overall, the standard DIDSON provides a field of view that covers 29° in the horizontal and 14° in the vertical (*Anonymous 2007*). The maximum practical range for the standard version DIDSON is approximately 10 meters (*Peter Johnson LGL U.S.A. pers. comm.*).

The DIDSON’s field of view requires the unit to be angled down approximately 15° so the beams reflect off the bottom and returns to the sonar *(Anonymous 2007)*. If the angle is too steep then the DIDSON will be covering a very small portion of the bottom. In contrast, if the angle is too shallow then the DIDSON field of view will not include the bottom close to the unit and may also be emitting sound waves that terminate in the surface of the water column.

4.0 Results

4.1 Resistivity counter

Data collected in 2003, 2004 and 2006 was stored as buffer files (on the counter) and downloaded on a regular basis by field staff. The data contains the date of download, settings of the counter, and dummy fish data, followed by fish records. The fish records contain a date, time, conductivity, channel of count, direction of travel (up or down) and estimated Peak Signal Strength (PSS)

Example fish record:

Date	Time	Conductivity.	Channel.	Direction	PSS
04/23/2006	19:44:24	100	1	U	93

In addition to the text data graphical records were collected for migrating fish through much of the migration period. This data was logged directly to a portable PC for storage, as the counter memory is insufficient for this purpose (Figure 5). Graphical data was used for post data analysis and assisted in the assessment of fish behaviour and counter performance and efficiency. This type of data, which can be collected in addition to standard counter output, allows for increased confidence in fish counter performance. Many graphical traces were recorded on multiple channels which conformed to typical upstream counts *(Galesloot and McCubbing 2003, McCubbing et al. 1999)*. This indicates the potential for accurate validated counts utilizing this application of resistivity technology at the site under study. In addition, all variations in peak signal size above threshold values were recorded by the counter and in trace form for later analysis.

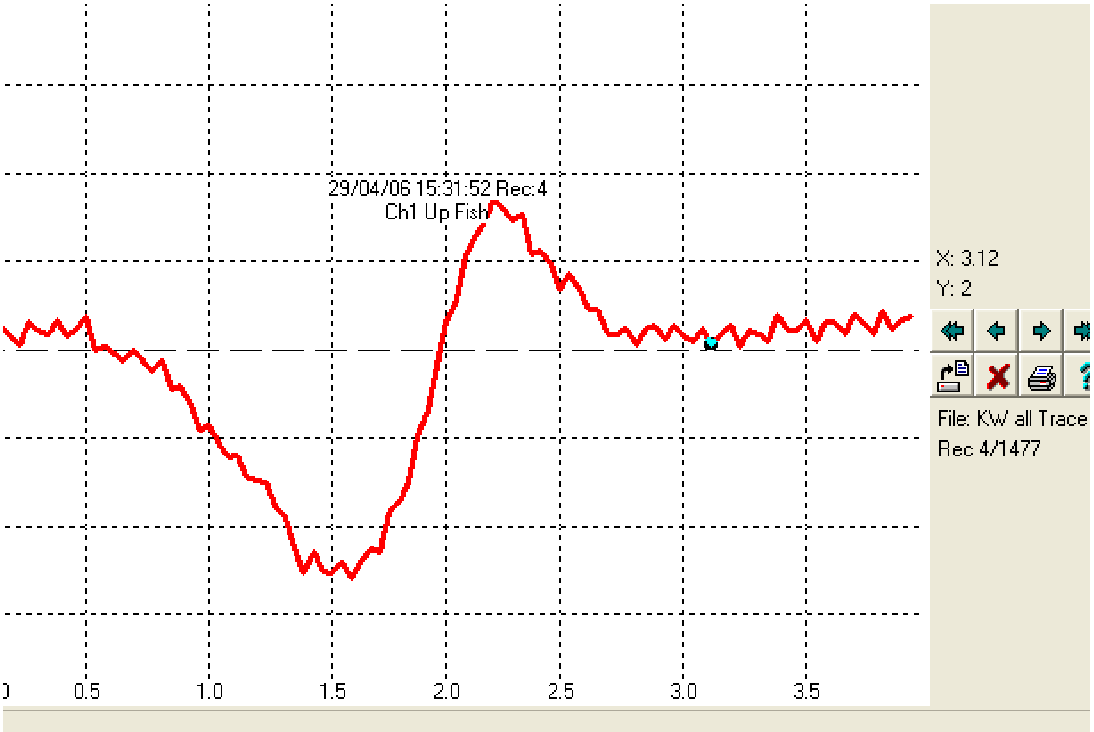


Figure 5. Typical counter fish trace of upstream large signal size upstream migrant recorded on Channel 1, Kitwanga River 2006**.**

Fish counter estimates of fish escapement on the Kitwanga River were based on methods used on the Deadman River in 1999 (*McCubbing 1999*). In summary they were calculated by the following process:

1) All obvious spurious debris or wave action data was removed from the raw data set. These are characterized by large numbers of events on a single channel over a short period of time.

2) All trace data was examined and any ghost events were removed (*see McCubbing and Ignace 2000).*

3) A frequency histogram of "peak signal sizes" was examined to determine if all fish were enumerated. A truncated normal distribution curve may indicate this occurrence.

4) A daily summary of up and down counts was examined to determine, at what time during the migration window kelted fish began dropping back over the counter.

5) A value for net up counts was determined for trout passage based on peak signal size distributions and the pattern of downstream counts.

6) All upstream raw escapement counts were raised by a factor of 21% to accommodate counter efficiency data while downstream counts were raised by a factor of 31% (graphics analysis 2006 data).

Observation calculations are thus:

Calculate adjusted up count, $Ue = U_r/E_a * 100$

Where
Ue = up count estimate
Ur = the sum of all daily up counts
Ea = average count efficiency (from video validation)

Calculate adjusted down count, $De = D_r/D_a * 100$

Where
De = down count estimate
Dr = the sum of all daily down counts (excluding kelts)
Da = average count efficiency (from video validation)

Calculate escapement, E = Ue - De - Ghost counts

4.1.1 2003

In 2003, operation of the counter began on April 17. Data collected between April 17 and April 19 appeared unreliable with many events recorded on all channels and close to threshold values. This appeared to relate to noise from standing waves which had formed on the sensor units at low flows. As river discharge increased counter reliability improved. During the first night of improved operation, on April 23, a total of three upstream fish were counted indicating fish migration was now underway although daily counts remained low (<10 fish per day) through May 5. Final counts were recorded on June 6. Up counts were recorded almost daily, between April 17 and June 6 with peak daily count on May 11. Down counts were recorded from May 6, with peak count recorded on May 24 (Figure 6).

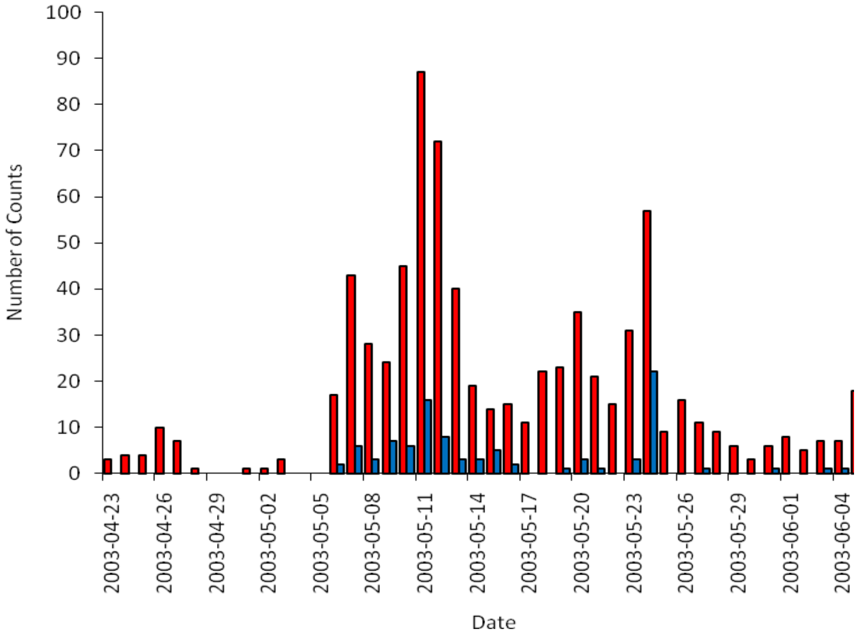


Figure 6. Uncorrected (for efficiency) upstream (red) and downstream (blue) fish counts recorded at Kitwanga counter, spring 2003.

Peak signal size analysis indicated that for upstream counts there was a normal distribution of data (Figure 7). This histogram was produced from data combined from all three operational channels. The observed histogram is possibly truncated at lower signal sizes (30 to 40), with a mode 40 to 50 for upstream counts. This indicates some fish may have passed the counter without being enumerated correctly, a risk particularly high at elevated stream discharges. Counts were recorded during the survey period over three of the four sensor channels. One channel was not functional due to damaged wiring and none of the channels functioned from April 19 to 23 due to power supply issues. Peak signal strength can be affected by swim height over the electrodes. The potential error with sizing can be greater with the flat pad design since fish can travel anywhere from the top to the bottom of the water column during upstream and downstream migrations. For example, a large fish swimming high in the water column may give a comparable PSS to a small fish swimming low in the water column. To attempt to separate steelhead from non-target species a PSS threshold value of 30 was calculated. Anything greater than a PSS of 30 was determined to be a steelhead, or target species, and a change in resistance with a PSS less than 30 was determined to be a non- target species.

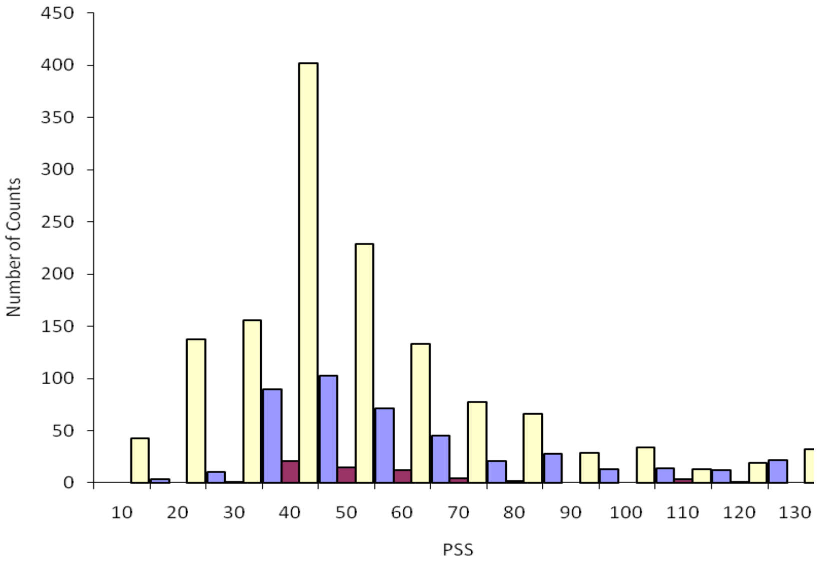


Figure 7. Peak Signal Size (PSS) data from the Kitwanga counter in 2003. Up counts, blue bar, red bar down counts, yellow bar, events (count threshold = 30).

Examination of peak signal sizes through time (Figure 8) indicated that there was a large range in peak signal sizes detected by the counter throughout the sample period. These observations may be related to the large range of fish sizes within the steelhead population, the presence of relatively smaller non-target species (whitefish, rainbow trout were visually observed) and/ or variation in fish swim height over the electrodes. The large range might have also resulted from programmed changes to the counter sensitivity. Prior to May 5, the resistivity counters gain setting was set to vary with conductivity and ranged from 100 to 150. Post May 5, a fixed gain of 200 was used, which generated larger signal sizes. In general signal sizes recorded in late May and June were smaller than those in April and early May. These observations may indicate fish swim height increased above the sensors as water depth increased but may also indicate a shift from larger steelhead migrants to smaller rainbow trout and whitefish migrants.

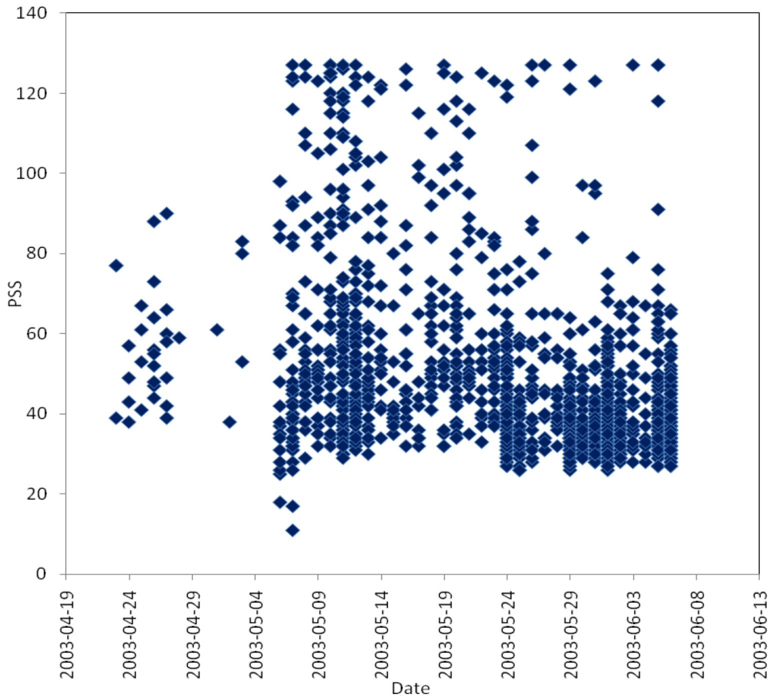


Figure 8. Analysis of Peak Signal Size (PSS) data through time (daily) from the Kitwanga counter in 2003.

Further examination of average daily peak signal size for up counts (Figure 9) indicates changes in peak signal size through time and differences between channels. In general channel one provided the largest signal size while channel three provided the smallest. Post May 22, a change in daily average signal size was observed on channel 2 resulting in reduced PSS. The reasons for this change are unclear, but might be related to a deterioration of sensor sensitivity as the change is sudden and persistent and not observed across all channels.

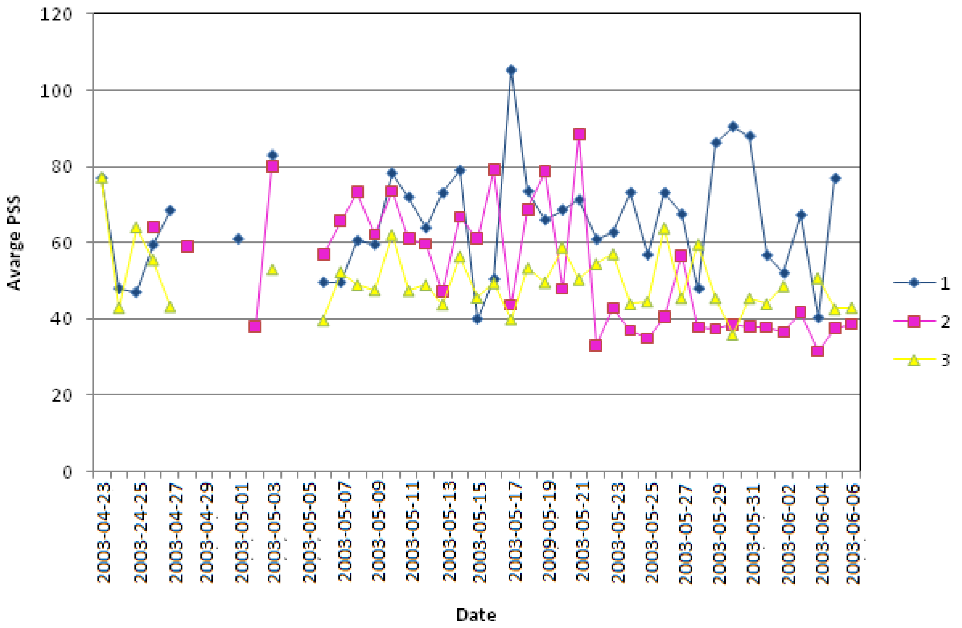


Figure 9. Analysis of average daily up count Peak Signal Size (PSS) data through time from the Kitwanga counter in 2003, compared with channel sensor (m).

Evaluation of graphics data has been undertaken periodically to establish if trace data for up and down counts are consistent with those observed by fish passage at other resistivity counter sensor units. In general this has been the case based on professional judgement (data on file), although some evidence of misclassification of trace data at lower peak signal sizes (where one peak failed to reach threshold) was observed.

In 2003 a total of 99 events were examined for correct classification. A total of 74% of up counts (n=43) and 100% of down counts (n=3) were assessed as correct. Of the misclassified up counts, the majority were close to the preset threshold size of 30, while the remaining traces indicated a large fish which altered its swim height over the electrodes, between electrode pairs.

Without adjustment for variables like counter efficiency and the counter threshold for target species and without the benefit of visual validation it is estimated that 1027 fish migrated upstream of the GFA fence site between April 17 and June 6, 2003. It is unknown at this time as to what proportion of these fish may have been steelhead.

4.1.2 2004

In 2004, operation of the counter was started on April 2, 2004. The counter start date was two weeks earlier than 2003. During the first night of operation a total of one upstream migrant was counted indicating fish migration was limited. Final counts were recorded on May 9 when the counter was turned off due to sensor failure. This is almost four weeks earlier than the end date in 2003. Up counts were recorded almost daily, between April 16 and May 9 with peak daily count on April 17 and again on May 4 (62 migrants). The counter powered down between April 22 and April 25 and no data is available for this time period. Down counts were recorded from April 16 with peak upstream count recorded on May 4 (Figure 10).

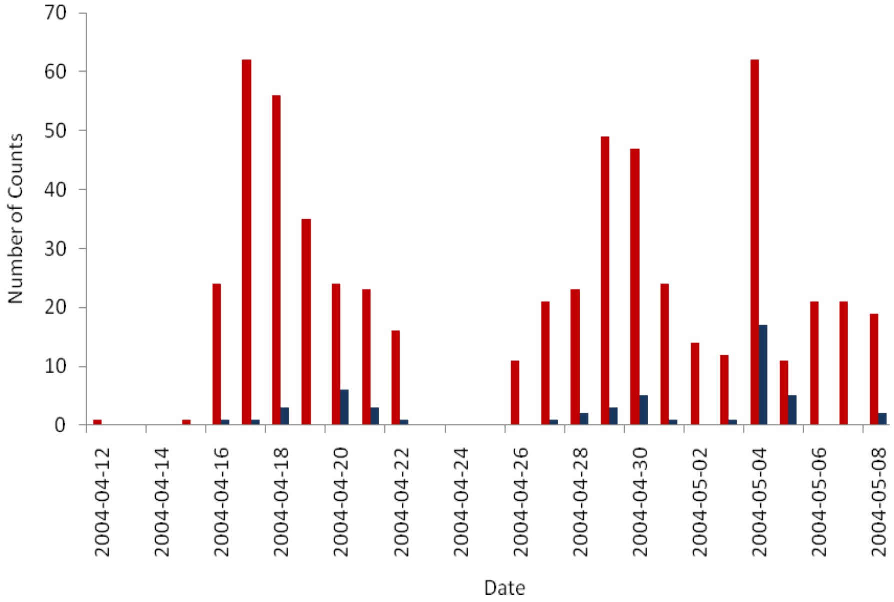


Figure 10. Uncorrected (for efficiency) upstream (red) and downstream (blue) fish counts recorded at Kitwanga counter, spring 2004.

Recorded peak signal sizes, in 2004, were comparable to 2003. The 2004 data indicated that for upstream counts there was a normal distribution of data (Figure 11). This histogram was produced from data combined from all three operational channels. Similar to 2003, the observed histogram is possibly truncated at lower signal sizes (30 to 40), with a mode 50 to 60 for upstream counts.

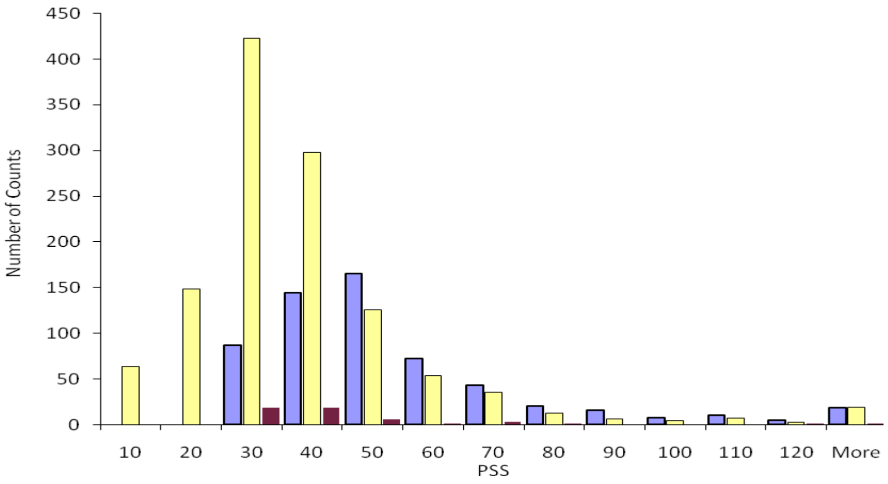


Figure 11. Analysis of Peak Signal Size (PSS) data from the Kitwanga counter in 2004. Up counts, blue bar, down counts red bar, yellow bar, events (count threshold = 30).

Examination of peak signal sizes through time (Figure 12) indicated that there was a large range in peak signal sizes detected by the counter throughout the sample period as in 2003. Once again smaller signal sizes were generally generated during the later part of the survey season as water levels increased possibly due to changes in swim height over the electrodes during this time period.

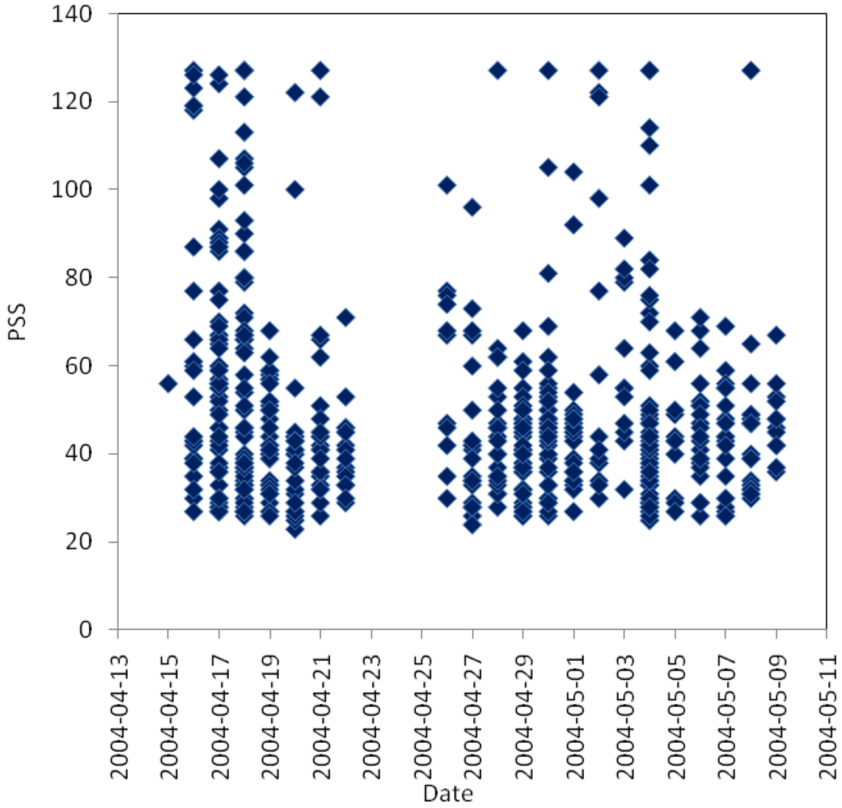


Figure 12. Analysis of Peak Signal Size (PSS) data through time (daily) from the Kitwanga counter in 2004.

Further examination of average daily peak signal size for up counts (Figure 13) indicates a relatively stable average daily peak signal size through time unlike that observed in 2003. Differences between channels persisted with channel one providing the largest signal average signal sizes while channel two provided the smallest as observed in the later part of 2003 data collection.

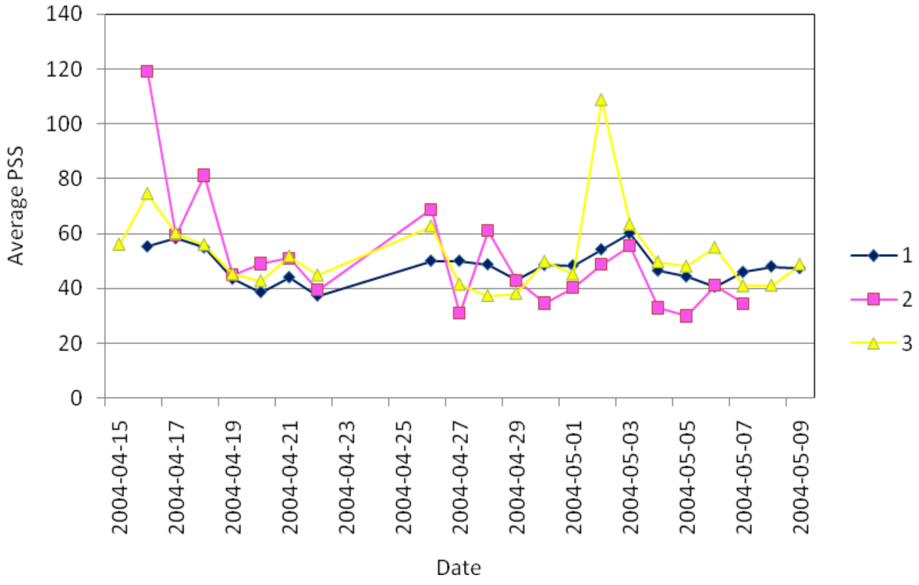
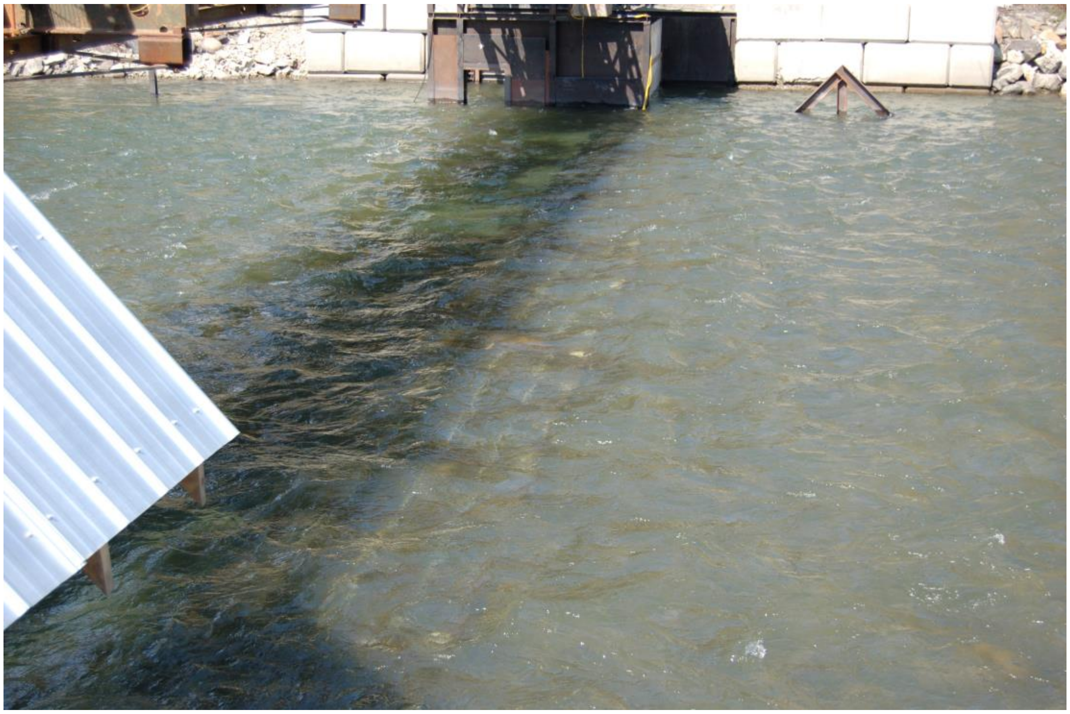


Figure 13. Analysis of average daily up count Peak Signal Size (PSS) data through time from the Kitwanga counter in 2004, compared with channel sensor (m).

In 2004, it is estimated that 716 upstream migrants passed the GFA adult salmon fence site between April 2 and May 9, 2009. It is unknown at this time as to what proportion of these fish may have been steelhead. The counter was shut down early in 2004 when problems were experienced with the sensors. Therefore, the 2004 steelhead run estimate does not include the time period when peak upstream steelhead migration was recorded in 2003 although migration timing may have been earlier based on results prior to May 9. Direct comparisons between the 2003 and 2004 total estimated escapement results cannot thus be made.

In the early spring of 2005 the leading edge of the cut-waters were removed so that floating fence panels for fence operation could be moved to the forward part of the weir as gravel/cobble accumulation was resulting in difficulties when mounting the panels to the downstream end of the weir. At this time, problems were encountered with electrode wiring that may or may not have been the result of these changes. The removal of part of the cut-waters further compromised operation of the counter in its original configuration, although trap operations were much improved (*Derek Kingston, pers. comm*.) As a result of these changes and with further problems to crump sensor unit operation perceived, a new approach was taken. Sensor units of a similar type to those installed and operated on McKinley Creek (*McCubbing and Burroughs 2002)* and on the Lardeau River (*McCubbing 2005, Andrusak and McCubbing 2006*) were installed in 2006, upstream of the weir sill, where a stable area of gravel had accumulated and mounts were now in place to attach the fish fence panels (Picture 2). Existing knowledge gained locally on counter operation, download and power/site infrastructure would thus be maintained and utilized.



Picture 2. Counter site on the Kitwanga River, 2006 indicating open array panel set up upstream of original sensors.

4.1.3 2006

Operation of the counter was started on April 29, 2006. During the first night of operation a total of 15 upstream fish were counted indicating fish migration was well underway. Final counts were recorded on May 17 when high water dislodged several of the open array panels. Up counts were recorded almost daily, between April 29 and May 17 with peak daily count on May 5. Down counts were recorded from April 29, with peak down count recorded on May 16 (Figure 14).

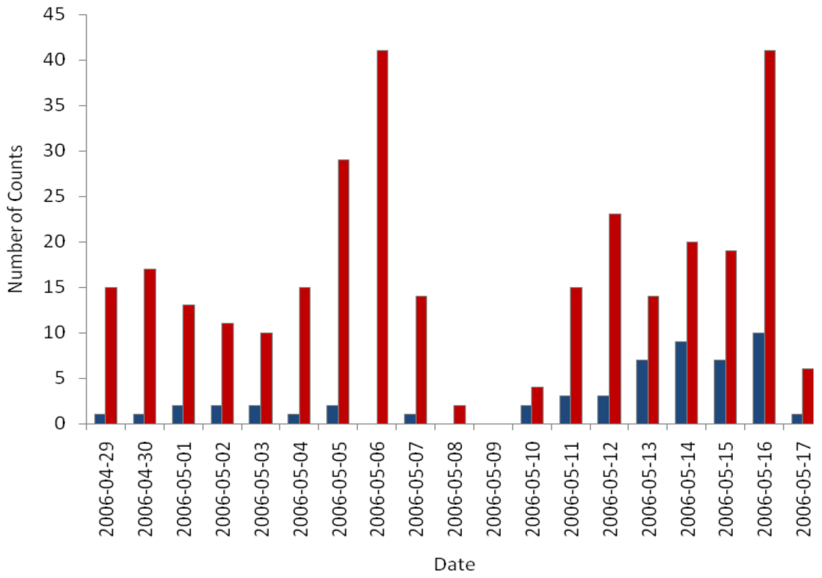


Figure 14. Uncorrected (for efficiency) upstream (red) and downstream (blue) fish counts recorded at Kitwanga counter, spring 2006.

Peak signal size analysis indicated that for upstream counts there was a normal distribution of data (Figure 15). This histogram was produced from data combined from all four channels. The observed histogram does not appear to be significantly truncated at lower signal sizes unlike in 2003 and 2004. A PSS mode of 60 to 70 for upstream counts was observed. This likely indicates either swim height of fish was closer to the electrodes as would be expected given the topography of the site and/or the relative absence of smaller non target species.

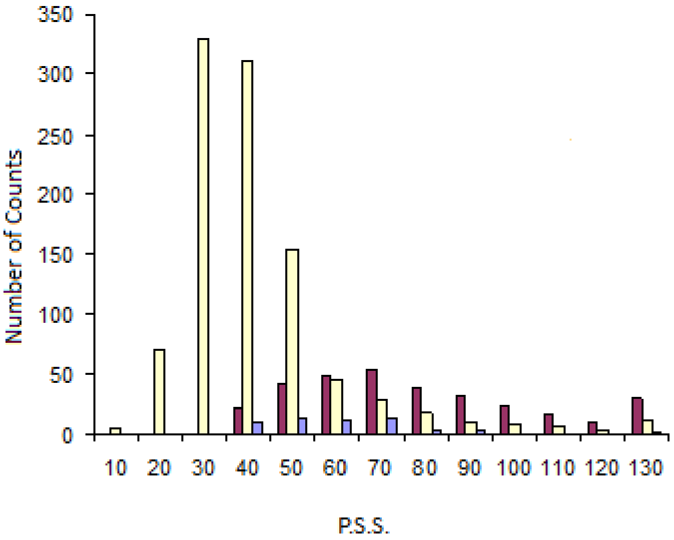


Figure 15. Analysis of Peak Signal Size (PSS) data from the Kitwanga counter in 2006. Up counts, red bar, blue bar down counts, yellow bar, events (count threshold = 30).

Examination of peak signal sizes through time (Figure 16) indicated that there was a large range in peak signal sizes detected by the counter throughout the sample period. No obvious trend was observed over time unlike in previous years with fixed sensor units despite observed variance in river depth.

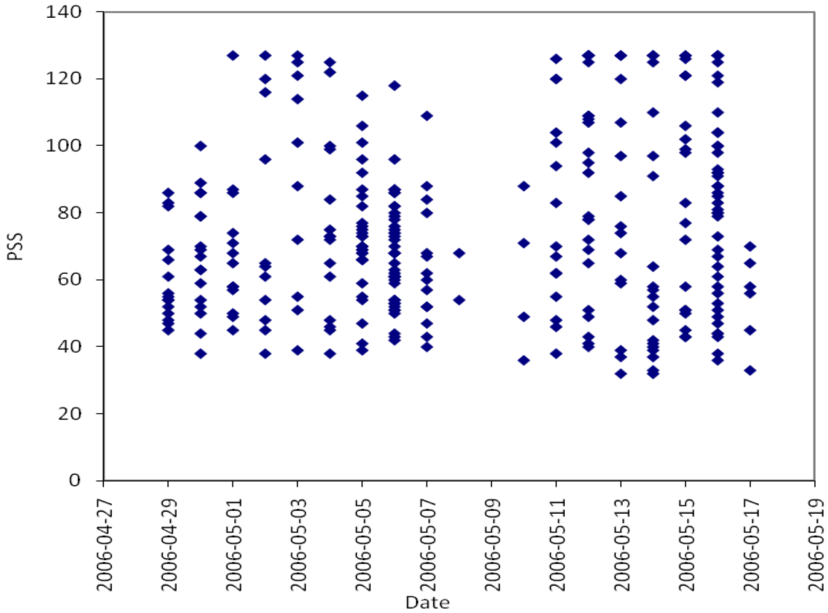


Figure 16. Analysis of Peak Signal Size (PSS) data through time (daily) from the Kitwanga counter in 2006.

Further examination of average daily peak signal size for up counts (Figure 17) indicates changes in peak signal size through time and differences between channels during the same time period. This might be explained by different sizes of fish passing over different electrode channels at varying swim heights, or variances in the assemblages of fish passing over the sensors on a day to day and channel to channel basis.

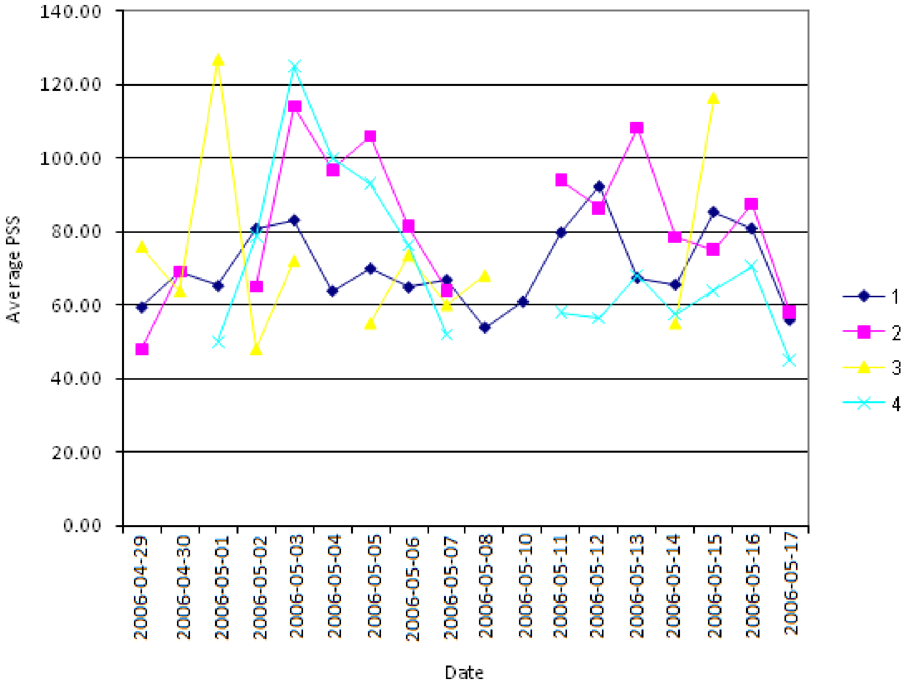


Figure 17. Analysis of average daily up count Peak Signal Size (PSS) data through time from the Kitwanga counter in 2006, compared with channel sensor (m).

Similar to 2003, a graphical analysis was completed for a portion of the trace data collected during the project.

In 2006, a total of 60 events were examined for correct classification. A total of 64% of up counts (n=36) and 66% of down counts (n=3) were assessed as correct. This represents a decrease in the counter efficiencies recorded in 2003 and may be the result of the different sensor arrays used in 2003 and 2006. Of the misclassified up counts, 8 of 13 were close to the threshold size of 30, while the remaining traces indicated a large fish which altered its swim height over the electrodes, between electrode pairs.

With corrections for counter efficiency and threshold values it is estimated that 468 upstream migrants passed the fish fence site between April 29 and May 16. It is unknown at this time as to what proportion of these fish may have been steelhead. It is likely that a significant portion of the adult steelhead immigration occurred before April 29 and after May 16. The variability in the temporal operation of the counter makes it difficult to make inter-annual comparisons. After 2006, the decision was made to discontinue the project due to the problems with the sensor arrays and the uncertainty about the over or under counting non-target species migrating during the same time period as adult steelhead.

4.2 DIDSON

In 2008, the fisheries branch of the MoE began investigating the potential for using DIDSON technology to enumerate summer-run steelhead in the Kitwanga River. Indications from users and suppliers were that the DIDSON is a useful tool for counting migrating fish in freshet conditions, and in rivers that contain a high amount of suspended sediments. Experiments with a borrowed DIDSON unit began in November of 2008. The DIDSON was installed on river left at the GFA adult salmon fence site, on a support modified for that location, where the wetted width was approximately 20 meters. The field of view was perpendicular to flow and was “shooting” across the river. It became apparent that the maximum range to be achieved at that site, in low flow conditions, was not going to be greater than nine meters. Water depth at this time ranged between 0.30m and 0.50m. No data was collected during this week since no fish were expected to be migrating in November during low flow and cold water temperatures. It was expected that greater depths and the addition of a concentrator lens would extend the field of view and improve the range. A concentrator lens changes the 14° vertical field of view and concentrates the beams, in this case, to a 3° vertical field of view. It was expected that the concentrator lens would extend the range and field of view as well as prevent some of the image distortion that can occur when the beams reflect off the waters surface.

4.2.1 2009

A DIDSON unit was purchased in 2009 and placed into the Kitwanga River at the GFA adult salmon fence, on May 4, 2009 (Picture 3). Despite the addition of the concentrator lens, and a general increase in water depth, the operational range of the DIDSON did not significantly improve. To maximize range it was necessary to increase the height of the DIDSON relative to the substrate. This created another field of view that was no longer able to cover the area close to the DIDSON. A significant amount of time was spent experimenting with different frequencies and window end and start distances. The DIDSON experiment was stopped on May 29, 2009 when it was determined that the DIDSON was not going to be able to cover the wetted width at that specific site. A total of 605 20 minute files were recorded in this time period. A comprehensive review of these files was not completed on these files due to the poor imagery and range achieved in this project year.

Picture 3. DIDSON April, 2010 GFA fence site

4.2.2 2010

In April 2010, a consultant with significant DIDSON experience was contracted to assist with site selection and data collection for the Kitwanga River DIDSON steelhead enumeration project. The primary objectives were to evaluate potential sites downstream of Tea Creek, and determine if there was a site that would provide a reasonable probability of enumerating all steelhead passing a certain point.

Potential sites were evaluated downstream of the Tea Creek confluence (Figure 2). The consultant produced a matrix evaluating the sites (Table.1). The scale used was from one to three with one being non-desirable and three being desirable. Using these criteria it was decided to place the DIDSON approximately 100 meters upstream of the adult fence. The DIDSON was operational on April 7 and small fish were immediately observed in the field of view. The DIDSON was placed behind a boulder to protect it from debris and increased water velocity during freshet.

Sites Evaluated	Access to Site	Security	Channel Morphology	Protection from Debris	Channel Width Variation	Location Relative to Spawning Areas	Total Score
GFA Counting Bridge	3	3	1	1	2	3	**13**
100 m upstream Counting Bridge	3	3	2	3	2	3	**16**
Gravel Pit Rd	3	1	2	1	1	3	**11**
Ellsworth Rd above Tea Creek	3	1	2	1	2	2	**11**
Ellsworth Rd at Big Bend	3	1	1	1	1	2	**9**

Table 1. Matrix for evaluating site suitability for using DIDSON to enumerate steelhead spawners on the Kitwanga River (Produced by Peter Johnson LGL Limited)

Picture 4. DIDSON unit behind boulder April, 2010.

Picture 5. Photo of Kitwanga River DIDSON site April, 2010 (photo courtesy of Peter Johnson LGL)

At the time of installation it was estimated that the distance from the DIDSON to the far shore was 12.5 meters. On the computer substrate was observed out between 8.5 and 9 meters leavening portions of river left outside of the DIDSON field of view. The DIDSON stand was attached to the substrate using rebar and sandbags. Electrical power was supplied by a generator *(Honda Motor Corporation Minato, Japan)* and battery charger located on a bench above the river. Fuel supply to the generator was augmented by plumbing in two 20 liter fuel cans to increase capacity. Data collection began on April 7, 2010 and concluded on June 20, 2010. No data was collected between May 18, 2010 and June 17, 2010 due to the unit becoming saturated with silt (Picture 6). Problems with power loss earlier in the season due to generator issues were mitigated with the purchase of a new generator. Access to the DIDSON to install a silt box during this time was precluded by the height and condition of the river. The river had receded enough by June 17, 2010 to clean the unit and install the silt box and redeploy.

Recording parameters included a window length of 10 meters and a window start length of 0.83 meters. Files were recorded in 10 minute segments and stored in a external hard drive (*Maxtor One Touch 4 Plus, Thailand*) located at the site.

Recorded files were analyzed using the CSOT (*convolved samples over threshold*) software feature. A total of 3,202 10 minute files (22.2 days) were recorded between April 7, 2010 and June 20, 2010. Data collected in June represents approximately 11% of the data collected during the project. Overall the DIDSON was operational for 50% of the time between April 7, 2010 and June 20, 2010 and 47% of the time between April 7, 2010 and May 18, 2010. The time period when the DIDSON was down due to siltation was not defined as operational time. There were 1,716 files that contained no images of fish, and 1,280 files that contained images of fish.

Picture 6. Accumulated silt in DIDSON June, 2010

Files containing fish were separated into three different criteria after reviewed for fish presence and length was determined by the coarse measuring tool provided in the DIDSON software. Files containing fish over 0.60m migrating upstream or downstream were placed in a steelhead folder (n=215). Files containing fish between 0.45m and 0.59m were placed in a folder titled 0.45m to 0.59m (n=32), and files containing images of fish smaller than 0.45m were placed in a folder titled less than 0.45m (n=982). These thresholds were based on a small amount of steelhead length data reported by Grieve and Webb in 1997. A small sample of female steelhead measured in the Kitwanga River ranged from 0.45m to 0.81m (*Grieve and Webb 1997).* Cutthroat trout sampled at the GFA smolt fence, in 2009, ranged from 0.17m to 0.42m in length. The mean length was 0.31m (*Derek Kingston pers. comm.*). Therefore, any potential misclassification of a cutthroat trout as a steelhead is believed to be minimal. Bull trout in the Kitwanga River are known to reach lengths greater than 0.45m so the potential for species overlap between steelhead and bull trout is recognized. Bull trout sampled at the GFA smolt fence in 2009 ranged in length from 0.12m to 0.68m. The mean length for bull trout sampled was 0.43m (*Derek Kingston pers. comm.*). Overall, 72% of the bull trout sampled were less than 0.60m meters in length (n=101). Therefore, the potential for misclassification still exists. All fish below 45cm are classified as non-target species. To be included as an up count or a down count a steelhead had to pass from left to right (down) or right to left (up) across the entire field of view. In a limited number of cases a fish greater than 0.60m entered the field of view from one direction and left the field of view in the same direction. In another case one steelhead remained in the field of view for several consecutive files. Although these files were placed in the steelhead folder the observations were not included in the spreadsheet which is used to generate the net up count.

Information collected from steelhead observations (fish over 0.60m) included date, time, direction of travel, length (m) and distance from DIDSON (m) (Appendix 1). A total of 215 steelhead were observed between April 7, 2010 and June 20, 2010. The first steelhead was observed on April 7 and the last on June 20. Down counts represented 6% (n=13) of the steelhead migrants, and up counts represented 94% (n=202) of the observations. The peak upstream count occurred on May 12 when 32 steelhead were observed migrating upstream (Figure 18). The highest observed daily down count was two. This value was recorded on multiple dates April 21, May 6, May 7 and May 13 (Figure 19).

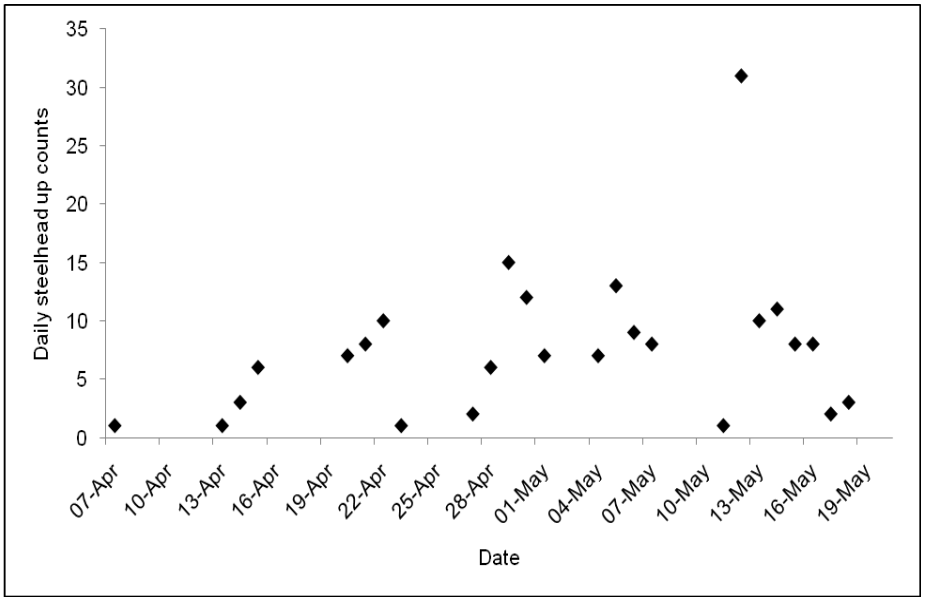


Figure 18. Daily upstream steelhead migrants 2010.

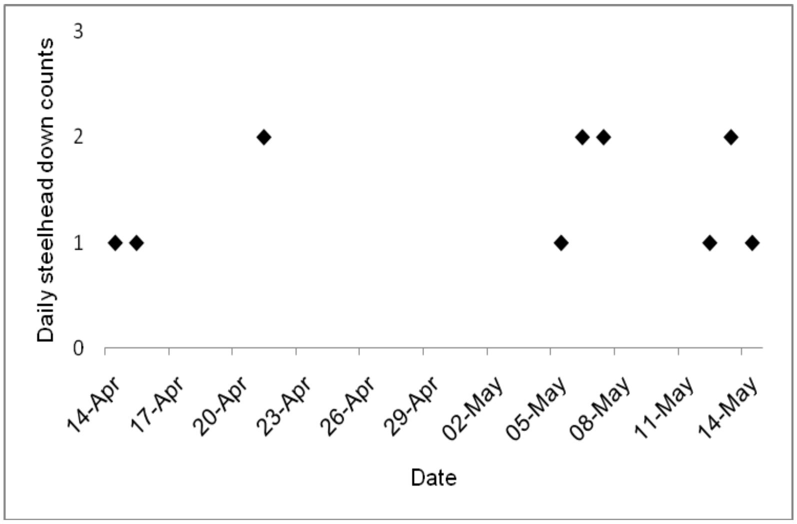


Figure 19. Daily downstream steelhead migrants 2010

The coarse measuring tool in the DIDSON software provides an approximate length (meters) for all fish within the field of view. The mean length for all steelhead recorded is 0.80 meters (n=215). Mean length for steelhead captured in 1979 was 0.69m (n=15) (*Grieve and Webb 1997*).

One of the concerns about the Kitwanga River DIDSON project was the uncertainty about whether all fish migrating upstream of the site would be captured by the DIDSON. The DIDSON field of view also contains a grid showing distance (meters) from the unit. When the DIDSON was installed it was estimated that the effective range of the DIDSON was between 8.5 meters and 9 meters. It was also estimated that the distance between the DIDSON and the far shore (river left) was 12.5 meters. The distance that steelhead migrated from the DIDSON was measured and recorded for all upstream and downstream migrants. It was determined that 38% (n=81) of all steelhead passed the DIDSON at a range between 3 meters to 4 meters, and 32% (n=69) passed at a range between 2 meters and 3 meters (Table 2). The shape of the collective sound waves emitted from the DIDSON is essentially a cone. Therefore, to cover as much of the substrate as possible the DIDSON is angled down to extend the top of the cone so that it is returning an image of the substrate. As a result fish migrating either upstream or downstream may not be recorded by the DIDSON if they are not close to the substrate and therefore not within the cone of emitted sound waves. As an example, you could have a steelhead migrating upstream, six meters away from the DIDSON, that would be recorded if it was close to the substrate. While another fish that is migrating half way between the substrate and the surface the same distance away from the DIDSON may not be recorded because it is outside the cone of sound. This despite the fact they are within the same distance from the DIDSON. This created more uncertainty about the 2010 results and what they mean since the results are biased by the number of unknown migrants on river left, and the unknown number of migrants missed due to their swim height in the water column.

meters	frequency	percent
0 to 1	6	3
1 to 2	69	32
2 to 3	81	38
3 to 4	12	6
4 to 5	18	8
5 to 6	13	6
6 to 7	14	7
7 to 8	2	1
8 to 9	0	0

Table 2. Range (M) from DIDSON to steelhead recorded.

The mean range for steelhead was 2.82 meters (minimum=0.68m) (maximum =7.60m). These data suggest that the effective range of the DIDSON was out to eight meters although it is not certain the number of fish that may not have been recorded due to their swim height within the eight meter range. It is uncertain what proportion of the annual run migrates on either river left or river right.

To calculate the net upstream migrants recorded passing the site was done by subtracting the downstream migrants from the upstream migrants during the time period the DIDSON was operational. Therefore, it is calculated that 202 steelhead migrated upstream of the site that were recorded while the unit was operational.

4.2.3 2011

In 2011, attempts to increase the effective range of the DIDSON did not produce the desired results. Modifications to the DIDSON stand resulted in a modest improvement, however, the improvement did not include reaching all the way to river left. An attempt to move the DIDSON further out from river right, and mitigate any steelhead migration behind the unit by utilizing gabions increased the coverage, but it was determined in high water the DIDSON would not be accessible for maintenance or re positioning as required. In 2010, the DIDSON was able to achieve a partial count but the uncertainty about migration outside of the field of view created uncertainty about how the number of steelhead migrating outside of the field of view would bias the steelhead escapement estimate. Therefore, it was decided to discontinue DIDSON operations in the Kitwanga River in 2011.

5.0 Discussion

Many methods have been experimented with to find an appropriate application to successfully enumerate aquatic species in various watersheds across British Columbia. One of the challenges of enumerating summer-run steelhead is the fact that their final spawning migrations and spawning activities coincide with high water and turbid conditions. These conditions preclude traditional enumeration methods like fish fences, aerial surveys snorkel surveys. The iteroparous lifehistory of steelhead also precludes other methods like a dead pitch survey.

The Kitwanga River has several attributes that made it a desirable location to conduct steelhead stock assessment activities. It is a relatively small river in the Skeena watershed with a steelhead population that is likely between 500-1000. It's location in the lower Skeena watershed also makes it a desirable location to develop a long-term stock assessment project since there are no abundance estimates generated for any summer-run steelhead population in the lower Skeena River watershed. Radio-tracking information and data collected during the summer at the GFA salmon fence also indicate that a large proportion of Kitwanga River steelhead also over-winter in the mainstem Skeena River and migrate into the Kitwanga River in the spring immediately prior to spawning. This mitigates the problem of trying to differentiate between multiple species, of a comparable size, migrating together at the same time.

Electronic fish counters have been successful in meeting the goals and objectives of other management agencies across North America. In some cases these technologies have also been successful in freshet conditions. Attempts to apply these technologies were unsuccessful for several reasons. However, the common theme was the difficulties of operation in freshet conditions at this location. For the resistivity fish counter, freshet flows affected fish swim height over the sensor units as a typical “Crump” weir was not utilized (*McCubbing and Ignace 2000*) and subsequently sensor operation was compromised by bed load movement. In addition large numbers of whitefish may have complicated data analysis as they could mimic steelhead counts under the described circumstances. These factors made it difficult to compare the results on an inter annual basis using resistivity counter technology in that location. For the DIDSON it was the inability to narrow the river to a width that could be covered by the unit in high flows and the uncertainty about coverage in the water column in general. The equipment used to narrow the river could be damaged or altered plus the unit would not be accessible for regular maintenance or repositioning during the project and it would be exposed to debris.

DIDSON users have identified that the technology is better than traditional hydro-acoustic equipment due to its increased field of view and is robust and easy to use. Users also indicate that the DIDSON images are more user friendly to work with, and that suspended silt does not have significant negative impact on the recorded images.

DIDSON users have also identified that the range limitations at certain sites is problematic if target species are not swimming close to shore. The significant number of files collected during DIDSON projects require large amounts of storage, and the data analysis is very time consuming and requires significant resources.

The software that interfaces with the DIDSON to record and analyze data has many different functions and parameters to facilitate data collection and analysis. It is important to note that Soundmetrics is continually releasing new versions of the software that can be downloaded from the Soundmetrics ftp site at no cost.

The two methodologies attempted for enumeration of summer-run steelhead on the Kitwanga River indicate that enumerating steelhead in this system is a priority for the provincial fisheries branch. New methods and technologies to electronically count aquatic species are continually being developed and tested (i.e. Coldwater river combined DIDSON/resistivity flat pad research being conducted by Nicola Band and DFO). Eventually, a method applicable to the successful enumeration of summer-run steelhead in the Kitwanga River will likely be developed. It is important to continue to monitor these new technologies as they emerge, so that a successful long term monitoring program can be developed sooner rather than later.

Much has been learned about the Kitwanga River and these technologies during duration of these projects. It is important to note that both of these technologies have appropriate applications. The Province has since applied the resistivity counter to a small coastal steelhead stream, in Northern B.C., where it has been successfully counting steelhead moving through a fishway. In time, an appropriate location will be found for the DIDSON and it will provide long term datasets for fisheries managers.

6.0 Recommendations

- It is important to secure a source of electrical power down to the GFA adult salmon fence. This will facilitate the testing of new electronic technologies in the future.

- Continue experimenting with electronic counters as new technologies emerge. This location will eventually support an important steelhead monitoring program once the appropriate technology is found.

7.0 Acknowledgments

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9.0 Appendices

Appendix 1. Steelhead observed on DIDSON 2010.

Number	File Name	Date	Time	Direction	Length (M)	Distance from DIDSON (M)
1	2010-04-7_0400	April 7,2010	0403	U	0.84	5.77
2	2010-04-13_2100	April 13,2010	2115	U	0.7	6.9
3	2010-04-14_02400	April 14,2010	0243	U	0.67	1.1
4	2010-04-14_0330	April 14,2010	0337	D	0.74	4.74
5	2010-04-14_2150	April 14,2010	2150	U	0.61	6.11
6	2010-04-14_23100	April 14,2010	2318	U	0.72	5.15
7	2010-04-15_0040	April 15,2010	0480	U	0.66	3.44
8	2010-04-15_01200	April 15,2010	0123	U	0.92	1.6
9	2010-04-15_0240	April 15,2010	0240	U	0.66	1.61
10	2010-04-15_0320	April 15,2010	0325	U	0.88	5.69
11	2010-04-15_0340	April 15,2010	0346	U	0.66	7.37
12	2010-04-15_0430	April 15,2010	0431	U	0.94	5.99
13	2010-04-15_0910	April 15,2010	0918	D	0.61	5.83
14	2010-04-20_173250	April 20,2010	1735	U	0.65	0.95
15	2010-04-20_17400	April 20,2010	1742	U	0.96	2.24
16	2010-04-20_18300	April 20,2010	1835	U	0.8	1.03
17	2010-04-20_18400	April 20,2010	1845	U	0.76	2.91
18	2010-04-20_18500	April 20,2010	1854	U	0.84	2.46
19	2010-04-20_19300	April 20,2010	1938	U	0.85	4.7
20	2010-04-20_19400	April 20,2010	1940	U	0.82	1.55
21	2010-04-21_06100	April 21,2010	0619	D	0.64	4.54
22	2010-04-21_08500	April 21,2010	0858	U	0.66	1.05
23	2010-04-21_1201	April 21,2010	1201	U	1	4.38
24	2010-04-21_1230	April 21,2010	1234	U	0.82	1.45
25	2010-04-21_1301	April 21,2010	1302	U	0.65	1.24
26	2010-04-21_1310	April 21,2010	1319	U	0.72	1.23
27	2010-04-21_1320	April 21,2010	1328	D	0.84	1.73
28	2010-04-21_1600	April 21,2010	1609	U	0.8	2.8
29	2010-04-21_1820	April 21,2010	1826	U	0.65	2.23
30	2010-04-21_1850	April 21,2010	1859	U	0.86	3
31	2010-04-22_1110	April 22,2010	1119	U	0.62	1.27
32	2010-04-22_1130	April 22,2010	1135	U	0.65	0.83
33	2010-04-22_1140	April 22,2010	1141	U	0.61	1.1
34	2010-04-22_1140	April 22,2010	1142	U	0.7	1.15
35	2010-04-22_1220	April 22,2010	1221	U	1.06	2.71
36	2010-04-22_1330	April 22,2010	1338	U	0.9	1.38
37	2010-04-22_1400	April 22,2010	1407	U	0.84	3.3
38	2010-04-22_1430	April 22,2010	1430	U	0.62	1.11

39	2010-04-22_1520	April 22,2010	1521	U	0.66	4.06
40	2010-04-22_1520	April 22,2010	1526	U	0.61	1.49
41	2010-04-23_1950	April 23,2010	1952	U	0.78	1.39
42	2010-04-27_1501	April 27,2010	1508	U	0.8	1.69
43	2010-04-27_2310	April 27,2010	2315	U	1.07	2.7
44	2010-04-28_0350	April 28,2010	0351	U	0.94	2.65
45	2010-04-28_1250	April 28,2010	1252	U	0.86	2.04
46	2010-04-28_1250	April 28,2010	1256	U	0.66	2.21
47	2010-04-28_1530	April 28,2010	1534	U	1	1.6
48	2010-04-28_1600	April 28,2010	1605	U	1	2.62
49	2010-04-28_1308	April 28,2010	1309	U	0.94	2.92
50	2010-04-29_1400	April 29,2010	1405	U	0.7	2.71
51	2010-04-29_1430	April 29,2010	1439	U	0.74	1.12
52	2010-04-29_1510	April 29,2010	1516	U	0.75	1.37
53	2010-04-29_1620	April 29,2010	1620	U	0.84	4.79
54	2010-04-29_1630	April 29,2010	1639	U	0.68	6.34
55	2010-04-29_1640	April 29,2010	1640	U	0.9	1.43
56	2010-04-29_1800	April 29,2010	1801	U	0.75	1.26
57	2010-04-29_1810	April 29,2010	1817	U	0.88	2.67
58	2010-04-29_1820	April 29,2010	1820	U	0.8	4.41
59	2010-04-29_1820	April 29,2010	1826	U	0.65	1.46
60	2010-04-29_1830	April 29,2010	1831	U	0.76	4.31
61	2010-04-29_1830	April 29,2010	1837	U	0.88	1.17
62	2010-04-29_2000	April 29,2010	2000	U	0.78	1.46
63	2010-04-29_2150	April 29,2010	2152	U	0.63	2.09
64	2010-04-29_2220	April 29,2010	2227	U	0.6	1.07
65	2010-04-30_0001	April 30,2010	0002	U	1.04	2.28
66	2010-04-30_0240	April 30,2010	0243	U	0.84	1.02
67	2010-04-30_0730	April 30,2010	0735	U	1.07	2.57
68	2010-04-30_1220	April 30,2010	1228	U	0.8	1.47
69	2010-04-30_1230	April 30,2010	1230	U	1.06	2.59
70	2010-04-30_1340	April 30,2010	1343	U	0.94	1.75
71	2010-04-30_1440	April 30,2010	1444	U	0.76	1.56
72	2010-04-30_1618	April 30,2010	1618	U	0.64	1.24
73	2010-04-30_1710	April 30,2010	1710	U	0.76	1.12
74	2010-04-30_1730	April 30,2010	1730	U	0.74	1.44
75	2010-04-30_1850	April 30,2010	1853	U	0.61	2.83
76	2010-04-30_1910	April 30,2010	1917	U	0.9	2.71
77	2010-05-1_0840	May 1,2010	0849	U	1.04	2.5
78	2010-05-1_1010	May 1,2010	1013	U	0.82	1.53
79	2010-05-1_1400	May 1,2010	1400	U	0.8	2.58
80	2010-05-1_1420	May 1,2010	1425	U	0.92	2.71
81	2010-05-1_1450	May 1,2010	1458	U	0.68	0.97

82	2010-05-1_1510	May 1,2010	1516	U	0.61	0.95
83	2010-05-1_1510	May 1,2010	1519	U	0.63	0.91
84	2010-05-4_1350	May 4,2010	1351	U	0.7	1.98
85	2010-05-4_1450	May 4,2010	1450	U	0.88	1.99
86	2010-05-4_1620	May 4,2010	1626	U	0.8	6.59
87	2010-05-4_2020	May 4,2010	2029	U	0.84	5.99
88	2010-05-4_2120	May 4,2010	2128	U	0.7	3.18
89	2010-05-4_2120	May 4,2010	2128	U	1.02	2.25
90	2010-05-4_2210	May 4,2010	2216	U	0.84	4.62
91	2010-05-5_0010	May 5,2010	0019	U	0.63	4.39
92	2010-05-5_0050	May 5,2010	0058	U	0.74	1.25
93	2010-05-5_0110	May 5,2010	0111	U	0.61	1.23
94	2010-05-5_0120	May 5,2010	0123	U	0.96	2.45
95	2010-05-5_0120	May 5,2010	0127	U	0.94	0.68
96	2010-05-5_0700	May 5,2010	0705	U	0.84	2.61
97	2010-05-5_0930	May 5,2010	0938	U	0.82	6.26
98	2010-05-5_1030	May 5,2010	1039	U	0.72	4.7
99	2010-05-5_1220	May 5,2010	1224	U	0.92	4.55
100	2010-05-5_1220	May 5,2010	1224	U	0.84	2.74
101	2010-05-5_1220	May 5,2010	1224	U	0.9	2.57
102	2010-05-5_1250	May 5,2010	1254	D	1.17	2.61
103	2010-05-5_1250	May 5,2010	1259	U	0.84	5.25
104	2010-05-5_1650	May 5,2010	1650	U	0.82	2.53
105	2010-05-6_1310	May 6,2010	1314	U	0.9	6.72
106	2010-05-6_1410	May 6,2010	1417	U	0.7	2.33
107	2010-05-6_1510	May 6,2010	1517	U	0.84	6.45
108	2010-05-6_1550	May 6,2010	1559	U	0.8	6.35
109	2010-05-6_1630	May 6,2010	1636	U	1	5.81
110	2010-05-6_1640	May 6,2010	1640	D	0.92	5.83
111	2010-05-6_1950	May 6,2010	1951	U	0.74	3.47
112	2010-05-6_1950	May 6,2010	1951	D	1	5.55
113	2010-05-6_2240	May 6,2010	2247	U	0.61	2.75
114	2010-05-6_2250	May 6,2010	2255	U	0.78	1.41
115	2010-05-6_2250	May 6,2010	2258	U	0.94	2.53
116	2010-05-7_0120	May 7,2010	0127	U	0.72	1.44
117	2010-05-7_0700	May 7,2010	0726	U	0.74	7.6
118	2010-05-7_1129	May 7,2010	1129	U	0.76	6.38
119	2010-05-7_1630	May 7,2010	1635	U	0.64	6.34
120	2010-05-7_1630	May 7,2010	1635	U	0.68	6.63
121	2010-05-7_1630	May 7,2010	1635	U	0.7	5.62
122	2010-05-7_1630	May 7,2010	1635	U	0.8	6.32
123	2010-05-7_1730	May 7,2010	1733	D	1	3.07
124	2010-05-7_1950	May 7,2010	1953	D	0.78	2.92

125	2010-05-7_2240	May 7,2010	2246	U	0.82	2.74
126	2010-05-11_1800	May 11,2010	1800	U	0.98	6.18
127	2010-05-12_0030	May 12,2010	0030	U	0.61	1.97
128	2010-05-12_0040	May 12,2010	0043	U	0.84	2.25
129	2010-05-12_0040	May 12,2010	0049	U	0.9	2.57
130	2010-05-12_0050	May 12,2010	0053	U	0.64	1.77
131	2010-05-12_0120	May 12,2010	0122	U	0.72	1.18
132	2010-05-12_0120	May 12,2010	0124	U	0.61	2.08
133	2010-05-12_0120	May 12,2010	0147	U	0.76	3.43
134	2010-05-12_0200	May 12,2010	0204	U	1	2.41
135	2010-05-12_0210	May 12,2010	0213	U	0.84	4.12
136	2010-05-12_0220	May 12,2010	0221	U	0.86	2.11
137	2010-05-12_0220	May 12,2010	0223	U	1	1.72
138	2010-05-12_0250	May 12,2010	0285	U	0.82	2.63
139	2010-05-12_0300	May 12,2010	0304	U	1.02	2.53
140	2010-05-12_0300	May 12,2010	0305	U	0.88	2.75
141	2010-05-12_0330	May 12,2010	0306	U	0.8	2.06
142	2010-05-12_0340	May 12,2010	0342	U	0.89	2.51
143	2010-05-12_0340	May 12,2010	0349	U	0.72	1.66
144	2010-05-12_0350	May 12,2010	0352	U	0.8	2.69
145	2010-05-12_0430	May 12,2010	0432	U	0.9	3.24
146	2010-05-12_0740	May 12,2010	0740	U	0.66	3.99
147	2010-05-12_1030	May 12,2010	1034	U	0.7	1.76
148	2010-05-12_1040	May 12,2010	1049	U	0.8	2.32
149	2010-05-12_1100	May 12,2010	1118	U	0.76	2.61
150	2010-05-12_1140	May 12,2010	1146	U	0.96	2.36
151	2010-05-12_1140	May 12,2010	1146	U	0.61	1.67
152	2010-05-12_1320	May 12,2010	1322	U	0.66	5.96
153	2010-05-12_1450	May 12,2010	1454	U	0.8	2.63
154	2010-05-12_1720	May 12,2010	1726	U	0.78	1.92
155	2010-05-12_1720	May 12,2010	1928	U	0.72	1.58
156	2010-05-12_2020	May 12,2010	2017	U	0.72	2.04
157	2010-05-12_2030	May 12,2010	2035	D	0.78	3.27
158	2010-05-12_2201	May 12,2010	2205	U	0.64	1.87
159	2010-05-13_0110	May 13,2010	0116	U	0.8	2.74
160	2010-05-13_0210	May 13,2010	0218	U	0.92	4.32
161	2010-05-13_0250	May 13,2010	0258	U	1	2.06
162	2010-05-13_0410	May 13,2010	0415	U	0.63	2.19
163	2010-05-13_0650	May 13,2010	0657	U	1	1.34
164	2010-05-13_1130	May 13,2010	1136	U	0.82	6.76
165	2010-05-13_1500	May 13,2010	1501	U	1.06	2.79
166	2010-05-13_1500	May 13,2010	1505	U	0.66	2.08
167	2010-05-13_1850	May 13,2010	1856	D	0.8	2.99

168	2010-05-13_2230	May 13,2010	2234	D	0.8	2.22
169	2010-05-13_2300	May 13,2010	2300	U	0.84	1.91
170	2010-05-13_2330	May 13,2010	2332	U	0.76	2.01
171	2010-05-14_0010	May 14,2010	0018	U	0.85	2.93
172	2010-05-14_0120	May 14,2010	0126	U	0.7	1.42
173	2010-05-14_0200	May 14,2010	0201	U	1.04	2.18
174	2010-05-14_0220	May 14,2010	0228	D	0.74	3.07
175	2010-05-14_0230	May 14,2010	0233	U	0.63	1.39
176	2010-05-14_0240	May 14,2010	0249	U	0.96	1.46
177	2010-05-14_0400	May 14,2010	0401	U	0.78	2.13
178	2010-05-14_0410	May 14,2010	0411	U	0.76	2.71
179	2010-05-14_2030	May 14,2010	2030	U	0.9	5.81
180	2010-05-14_2210	May 14,2010	2218	U	0.64	2.63
181	2010-05-14_2220	May 14,2010	2222	U	0.63	2.2
182	2010-05-14_2350	May 14,2010	2352	U	0.64	3.35
183	2010-05-15_2350	May 15,2010	0021	U	0.74	2.25
184	2010-05-15_0110	May 15,2010	0111	U	1	2.64
185	2010-05-15_0140	May 15,2010	0149	U	0.92	2.32
186	2010-05-15_0210	May 15,2010	0211	U	0.8	1.45
187	2010-05-15_0250	May 15,2010	0250	U	0.64	1.79
188	2010-05-15_0350	May 15,2010	0353	U	0.88	2.71
189	2010-05-15_2010	May 15,2010	2013	U	0.63	2.13
190	2010-05-15_2330	May 15,2010	2336	U	0.88	4.29
191	2010-05-16_0010	May 16,2010	0016	U	0.94	2.34
192	2010-05-16_0230	May 16,2010	0238	U	0.76	1.62
193	2010-05-16_0310	May 16,2010	0310	U	1.02	2.38
194	2010-05-16_0550	May 16,2010	0552	U	0.92	2.47
195	2010-05-16_1230	May 16,2010	1235	U	0.76	2.52
196	2010-05-16_1330	May 16,2010	1335	U	0.92	4.52
197	2010-05-16_1940	May 16,2010	1948	U	0.7	4.04
198	2010-05-16_2350	May 16,2010	2356	U	0.68	1.7
199	2010-05-17_0440	May 17,2010	0448	U	0.76	2.53
200	2010-05-17_0810	May 17,2010	0815	U	0.78	1.79
201	2010-05-18_1130	May 18,2010	1130	U	1.06	2.66
202	2010-05-18_1210	May 18,2010	1218	U	0.63	1.22
203	2010-05-18_1940	May 18,2010	1945	U	0.86	1.56
204	2010-06-17_1900	June 17,2010	1903	U	0.8	1.07
205	2010-06-18_0630	June 18,2010	0631	U	0.78	2.71
206	2010-06-18_0730	June 18,2010	0732	U	0.64	2.88
207	2010-06-18_1900	June 18,2010	1900	U	0.61	1.19
208	2010-06-19_0520	June 19,2010	0521	U	0.9	1.56
209	2010-06-19_0600	June 19,2010	0607	U	0.64	1.07
210	2010-06-19_0930	June 19,2010	0937	U	1	2.47

211	2010-06-19_1500	June 19,2010	1500	U	0.66	4.34
212	2010-06-19_1710	June 19,2010	1710	U	0.94	2.82
213	2010-06-19_2010	June 19,2010	2017	U	0.74	3.08
214	2010-06-19_2140	June 19,2010	2148	U	0.76	1.24
215	2010-06-20_0100	June 20,2010	0108	U	0.88	1.45