INTERIM REPORT

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MULTI-SPECIES MIGRATION AND IMPROVED ESCAPEMENT ENUMERATION

COWICHAN RIVER DIDSON PROJECT

by

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INTRODUCTION

Background

In the fall of 1988, a study was implemented on Cowichan River chinook with additional information collected from the Squamish and Nanaimo River stocks. These three stocks within the framework of the Pacific Salmon Treaty between Canada and the United States were identified as exploitation and escapement indicators and deemed to represent the status of all lower Georgia Strait chinook stocks. Since then, due to logistical reasons the Squamish River system was dropped as an indicator and in 2002 the Nanaimo River system was dropped as well (Nagtegaal et al., 2004). Chinook assessment activities are ongoing on the Cowichan River.

Chinook escapement is assessed using a fixed point counting fence which is located approximately 8.3 kilometres upstream of the estuary. This location is below all known chinook spawning areas. The fence can be operated at summer low flows but must be removed when flows reach 22 cubic metres per second. This generally coincides with fall storm events and if this occurs earlier than normal then not all chinook spawners will be enumerated. In these situations the population would be estimated using a mark-recapture method.

Estimates for coho and chum salmon cannot be obtained with this fence. Generally, most chum and coho have not entered the system before the fence is removed and must be estimated using difference methods. Coho salmon are estimated by obtaining Area-under-the-curve estimates on selected spawning areas and expanding that data to the whole system. Chum salmon are estimated from one to two aerial surveys. In the last three years these surveys have not been feasible due to very high sediment loads in the river from Stoltz slide upstream of Duncan.

DIDSON systems have been used since the late 1990's on a number of river systems in the Pacific Northwest and have proved to be an effective tool for obtaining escapement counts on river systems that are difficult to assess using any of the more established enumeration techniques such as stream surveys, counting fences and mark recapture.

The application of DIDSON technology provides a possible solution to the on going problem of obtaining reliable escapement estimates for salmon returning to the Cowichan River, especially chum for which no estimate has been possible for several years.

Project Goals

The goal of this project was to obtain an estimate of the number of each species of salmon returning to the Cowichan River system and attempt to identify the species composition of the targets enumerated by the DIDSON. These estimates will be compared to those obtained by more conventional/traditional stock assessment techniques such as the chinook enumeration fence, chum aerial surveys, and coho spawning ground surveys. This will provide an assessment of the feasibility/applicability in using DIDSON technology to obtain escapement estimates of salmon returning to the Cowichan River.

Study Area

The Cowichan River watershed is located on the Southeast coast of Vancouver Island and drains an area totalling 826 km^2 (Figure 1). The Cowichan River system includes Cowichan, Bear, Mesachie, Somenos, and Quamichan lakes. Cowichan Lake (62 km^2), the largest of the five lakes, is situated approximately 50 km west of the Cowichan Bay estuary. Discharge from a flow control dam situated at the outlet of Cowichan Lake ranges from 7 to 326 m^3/s, and averages 44.9 m^3/s (Fielden and Holtby 1987). A total of 26 tributaries drain into the Cowichan River. The largest of these is the Koksilah River, which intersects the mainstem of the Cowichan River approximately 2.5 km upstream of the estuary. The Cowichan River watershed system is a typical Vancouver Island and coastal British Columbia stream in which maximum flows occur during winter months due to heavy rainfall (McDougall 1985).

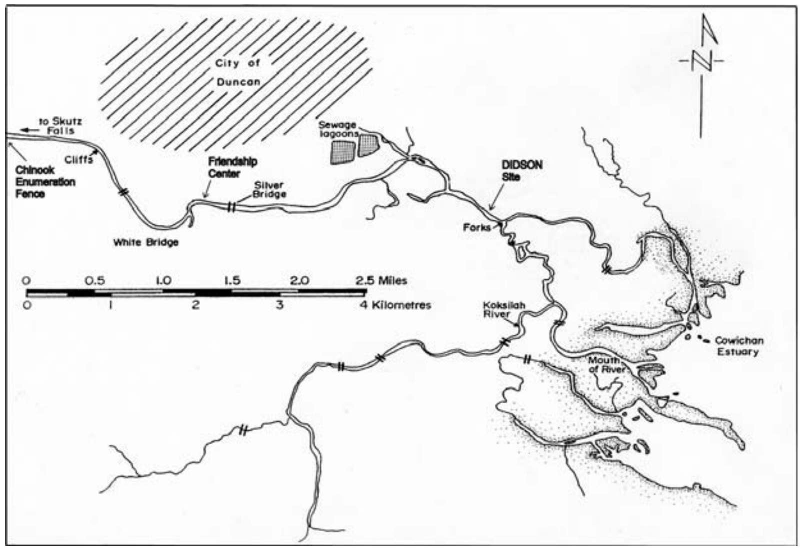

Figure 1. Lower Cowichan River

The Cowichan River supports many salmonid species including chinook (*Oncorhynchus tshawytscha*), coho (*Oncorhynchus kisutch*), chum (*Oncorhynchus keta*), sockeye (*Oncorhynchus nerka*), and pink (*Oncorhynchus gorbuscha*) salmon; as well as cutthroat trout (*Oncorhynchus clarki*), steelhead trout (*Oncorhynchus mykiss*), kokanee salmon (*Oncorhynchus nerka*), and Dolly Varden char (*Salvelinus malma*). Attempts have been made to introduce several other species including: atlantic salmon (*Salmo salar*), brown trout (*Salmo trutta*), and brook trout (*Salvelinus fontinalis*) (Perrin et al. 1988). The salmonids of the Cowichan River support several vital fisheries, which include a First Nations food fishery, tidal sport fishery, and a commercial ocean fishery.

METHODS

Equipment

The sonar unit used in this study is a dual-frequency identification sonar (DIDSON) model Unibody Standard with 1.1 and 1.8 MHz operating frequency settings, manufactured by Sound Metrics Corporation (2810 Hudson St., Chesapeake, VA). This technology was originally developed for the US Navy by the Applied Physics Laboratory at the University of Washington.

The DIDSON uses multiple beams of sound scanning across the river to form a near video quality real time image of all underwater features (Cronkite et al. 2006). The standard model used in this project can be set to high frequency (1.8 MHz) or low frequency (1.1MHz) and has a field of view 29^{o} wide and 12^{o} in height. The high frequency mode uses 96 separate sonar beams with an adjustable horizontal "window" length of 10m. It can image targets out to 15 m if the window is set to start at 5 m from the transducer. In this mode the resolution ranges from 3 mm close to the transducer up to 30 mm at the maximum range of 15 m. This is sufficient resolution to easily differentiate targets such as small fish and moving debris within the field of view. The low frequency mode use only 48 beams but has a greater horizontal window length of 20m and a maximum range of 40m. However, the lower resolution of this setting reduces the accuracy of target identification and smaller fish can be lost in the background noise.

The image built from the sonar returns can be displayed at frame rates ranging from 1 to 12 per second and shows a top down view of the segment of river covered by the field of view. Fish moving through this area can be counted in real time, and the data files can be saved and reviewed at a later time. The image forming capabilities are generally not affected to any great extent by varying sediment loads or turbulence in the water column although at the low frequency setting a reduction in target definition can be noted at longer range.

The DIDSON was controlled with a Toshiba Satellite 1900 laptop computer. It was connected to the sonar unit via a 60m waterproof cable that provided a network link and power to the sonar unit. The operating software used to control the sonar, display real time images, record and playback the data is provided with the DIDSON by Sound Metrics Corporation. The sonar could generate up to 19 GB of data a day, depending on settings such as frame rate, range etc. This data was continually recorded to an external 1 Terabyte hard drive networked to the laptop. Separate hard drives were also used so that data could be periodically transferred to longer term storage at the Nanaimo DFO office. A second laptop was networked to the 1 terabyte drive and used by site personnel to review data on a daily basis. The use of a second computer was necessary as recorded data could not be reviewed with the primary laptop while it was controlling the DIDSON.

Figure 2. DIDSON ladder mount

A 2 m by 3 m cargo trailer (Interstate) was used as a field office for the duration of the project. This provided a heated work space for the personnel who were required to be on site at all times for system monitoring, security and data review. A power line was installed to the site prior to the program start up date in September.

The DIDSON unit was mounted on a pole attached to a modified aluminium step-ladder (Enzenhofer and Cronkite, 2005)(Figure 2). The ladder was placed in the river at a depth of about 0.5 m approximately 6 m from the waters edge. It was anchored in place with six stainless steel pins hammered into the substrate and clamped to the ladder (Figure 3). This left a gap of approximately 12 m to the far bank that could be adequately covered by the sonar beam. There was sufficient height and angle adjustment in the attachment mechanism to compensate for moderate daily fluctuations in water level.

Figure 3. DIDSON ladder and diversion weir

A diversion fence was constructed on the downstream side of the unit to direct salmon into the field of view (Figure 3). The fence was built with four sections constructed with 2 by 4 frames 2 m long by 1 m high. The frames were braced on the corners with plywood gussets and covered with plastic Vexar fencing (2 cm mesh). The fence sections were anchored to the river substrate with re-bar pins and wood back braces.

The advantage of using this design of fence and DIDSON mount was the flexibility it allowed for rapidly repositioning the sonar in the event of rising water levels.

Site Selection

This is the second year of operation for the DIDSON unit on the Lower Cowichan River and the site chosen last year proved its suitability over a range of water flow conditions. Consisting primarily of a wide gradually slopping gravel bar, it was relatively simple to reposition the DIDSON unit assembly as water levels fluctuated during September water releases and storm events. By the first week in October water flows had increased to 50 cubic meters per second (m^3/s) or more and the DIDSON was relocated to a bulkhead built into the bank 30 meters upstream from the low water site (Figure 4). This allowed for continued safe operation of the DIDSON unit during the considerably higher flows experienced during October and November.

Figure 4. High water redeployment of DIDSON unit to bulkhead.

Data Collection

The objective was to record sonar data 24 hours a day, seven days a week, The DIDSON unit operating system was set to record data in 15 minute files making it easier to manage the 19 GB of data generated each day. The files are automatically named with the date, time and type (low or high frequency) of data they contain. Actual file size was dependent on the frequency setting and the number of frames per second (fps) being used. Most of the Cowichan data was recorded at 5 fps as this gave the best compromise of sufficient detail for any faster moving fish, especially in the close range narrow part of the sonar beam, but limited the individual file sizes to manageable 240 MB.

Water flows in the Cowichan River were maintained at 8 to14 m^3/s through September with several scheduled water release of up to 21 m^3/s to assist chinook migration (Figure 5). During this period the DIDSON unit was moved several times during the higher flows, however, data collection continued on the high frequency setting with a 10 meter field of view covering the majority of the channel open to fish passage. this setting was changed to low frequency and 20 meter range on 2nd October when the sonar was moved

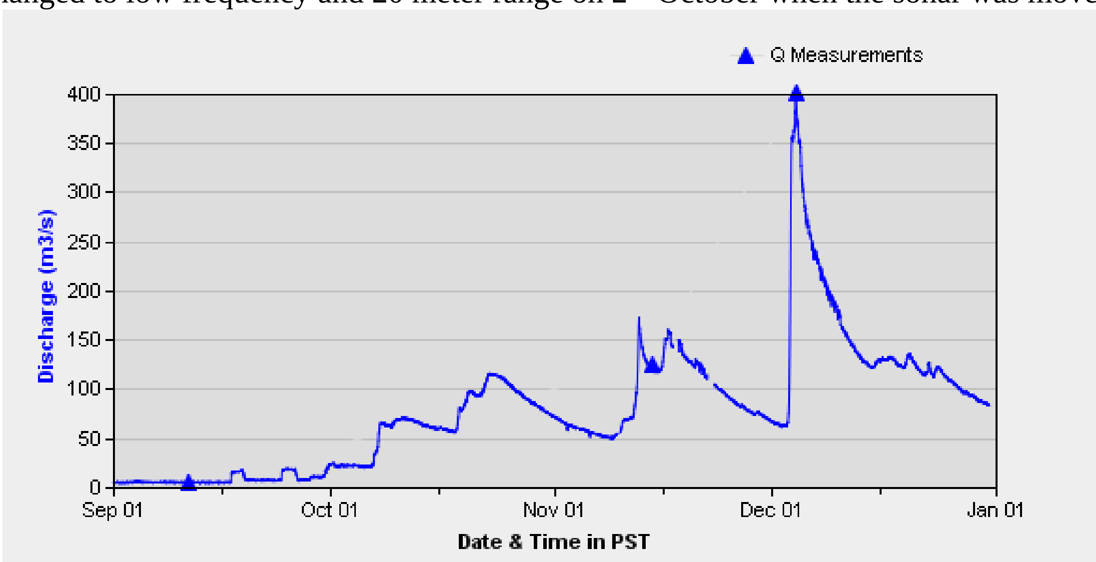

Figure 5. Cowichan River water flow during DIDSON project, 2007. The peaks in September indicate the timed water releases to aid chinook migration.

further up the gravel bay with rising water levels. On the 9th October the DIDSON unit was moved to the bank as flows had increased to 65 m^3/s with the first of several Fall storms moving through the region. At his time frequency switching was initiated with the first 15 minutes of each hour recording on high frequency with a 10 meter window covering 1.7 m to 11. 7 m. For the next 15 minutes the DIDSON unit switched to low frequency and a 20 meter field of view starting at 11 m and going out to 31 m. This cycle was repeated giving two 15 minute files with short range data and two with longer range data for every hour. These setting provided the best combination of high resolution close to the bank where the majority of the fish activity occurred but with adequate coverage of over 75% of the river to monitor for any future changes in fish migration behaviour.

Target Enumeration

Recorded data was reviewed seven days a week by field staff using the second laptop computer. Eight hours of recorded data generally took one to two hours to review. As expected more time was required to review data as increasing numbers of salmon moved into the river and from mid October onwards. Target counts were recorded on data sheets and later entered into a spreadsheet for further analysis and compilation.

Data files were usually replayed at 20 to 50 fps, or three to ten times faster than the recorded speed. In the later half of the project selected files were recounted to assess the precision of this counting methodology. Recounts for the low frequency data recorded from mid October onwards had very poor correlation with the original counts. During this period there were 20 to 30 spawning chum holding within the field of view with newly arriving fish migrating upstream through them resulting in a higher level of activity that was difficult too accurately count in a single pass. This resulted in an under estimate of fish migration. To rectify this bias most of the chum period data was sub-sampled after the field season. The low frequency files were reviewed twice using the zoom function to display only half of the 20 m window length at a time. This method provided numbers with good correlation when individual files were counted repeatedly. The low bias of the original numbers was then corrected using these sub-sample recounts.

Target Count Expansions

At the start of the project all of the recorded data was reviewed as chinook migration tended to be random through the day with small groups and individual moving up an at times back downstream. As the numbers of migrating salmon increased with the arrival of the chum, the target review procedure was changed to reviewing only the first thirty minutes of each hour. The resulting data were expanded to provide full hour estimates. Previous work by Cronkite et al. 2006, indicated that reviewing 10 minutes and 20 minutes per hour varied ± 10% and 5% respectively from a full hour count.

When the DIDSON unit was re-located to the river bank on 9th November it was switched to low frequency giving the sonar a window length of 20 m with a field of view out to 22 m, providing coverage for half of the river width. We assumed that similar numbers of salmon would be migrating upstream along the far bank therefore target counts were doubled to provide a full river estimate.

On 10th November range switching was initiated on the DIDSON unit providing sonar coverage out to approximately 35 meters. The first two 15 minute files being reviewed now covered different sections of the river channel. Therefore each of the 15 minute target counts was expanded by four times to provide full hour estimates of fish migration. This pattern of recording and data analysis was maintained for the remainder of the project.

Target Size

Only targets that were 39 cm or larger were used in the DIDSON escapement estimates. Targets less than 39 cm in length were considered to be species other than chinook adults, chinook jacks, coho adults or chum. This lower limit was derived from aged chinook jack broodstock sampled at Cowichan Hatchery.

Species Composition

Species composition for September and early October was estimated from observations at the chinook enumeration fence. The initial intention had been to use data collected by the broodstock crew however, higher than usual water levels hampered these efforts and very few fish were caught with the beach seining in the lower river. The species composition was summarized by stat week and applied to the total target count. Target numbers started to increase rapidly with the first storm event on 7th October indicating the onset of the chum migration. Determination of species composition was not possible after early October as the enumeration fence was removed and flood water conditions precluded any further attempts at beach seining. It was assumed that chum comprised the majority of targets for the remainder of the project.

Escapement Estimates

The final escapement number from the DIDSON data was estimated by taking the target count by stat week and applying the species composition to that number. The results were summed over the entire season to provide an estimate. The 95% confidence interval for each stat week estimate was calculated using the formula (from Fowler et al.1999):

$$1.96 * \sqrt{\frac{p(1-p)}{(n-1)}}$$

where p is the proportion of each species and n is the number of individuals used in the calculation. The confidence interval for the total is the summation of the stat week intervals. This represents the error associated with apportioning the count into species. This CI formula cannot be used after mid- October when species composition estimates are no longer available and the composition was assumed. For this period we also assumed a 3% error in the chum proportion. The resulting error was used for the other species.

The DIDSON estimates will be compared to the escapement estimates that are derived using standard DFO escapement models and formulae. The chinook escapement is estimated using the counting fence and carcass mark recapture projects. Broodstock collection and First Nations catch are added to this total to estimate the freshwater escapement. Coho are estimated using Area-Under-the-Curve (AUC) estimates from stream surveys of standard reaches in the watershed, then expanding those counts using a distributional model based on data from Lister et al. 1981. The chum salmon escapement is estimated using periodic aerial surveys but due to the turbid conditions of the river this method has not been feasible for the last four years and of questionable accuracy for a number of years prior to this.

RESULTS

Weather and water levels

Summer water level in the Cowichan River is normally maintained at 7 m^3/s. This is augmented by weekly water releases in September to aid the migration of chinook. Fall storm events had filled Cowichan Lake to minimum capacity by 8 October and the river system came off water control at this time. Water flows fluctuated between 55 and 170 m^3/s for the remainder of the project.

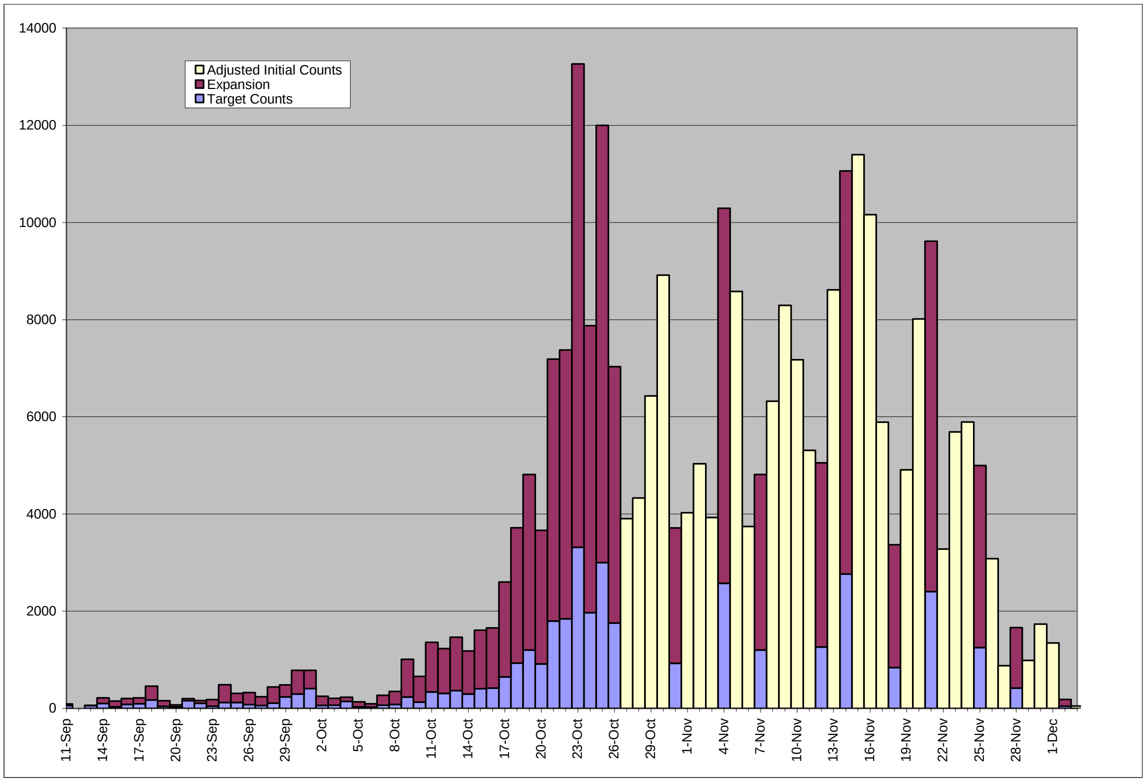

Figure 6. Estimate of daily net upstream targets.

Target Counts

The final estimate for expanded net upstream targets from the DIDSON data is 290,000 (Figure 6, Table 1). This final number was derived from an expansion of the original in-season estimate when it was realised that much of the chum period counts (9th October to 3rd December) were biased low. Post season sub-sampling of the data indicated that an increase of 50.3% was required to provide an accurate estimate of actual numbers of targets moving upstream past the DIDSON unit.

On 9th October (stat week 10-2) daily DIDSON target estimates started to increase indicating the beginning of the chum migration. This was corroborated by observation of chum in the river and catches in the FN food fishery. Average daily targets had been around 350 for the two weeks prior to this point (Table 2). This daily average increased to 869 for stat week 10-2 and then to 2,790 for week 10-3. Average daily targets by stat week remained substantially above this value until the end of November. The peak daily count of 13,264 was on 23rd October.

Target Size

No significant upstream migration of small (less than 39cm) fish was observed this year. Approximately 17 targets in this size range were observed during September and were not included in the total target estimate. Everything 39cm or larger was counted and therefore assumed to be a salmonid.

Species Composition

Species composition estimates are presented by stat week in Table 2 and Figure 7. Chinook jacks and adults comprised 100% of the fish observed during the first two weeks of the enumeration fence operation. Coho were first observed at the beginning of statistical week 9-3, comprising 0.65% of the fence count for this period. This had increased to 6.3% by stat week 10-1, the last week for which species composition data was available. Chum were first observed at the fence in stat week 10-1, and by week 10-2 a rapid increase in upstream targets indicated the commencement of the chum migration.

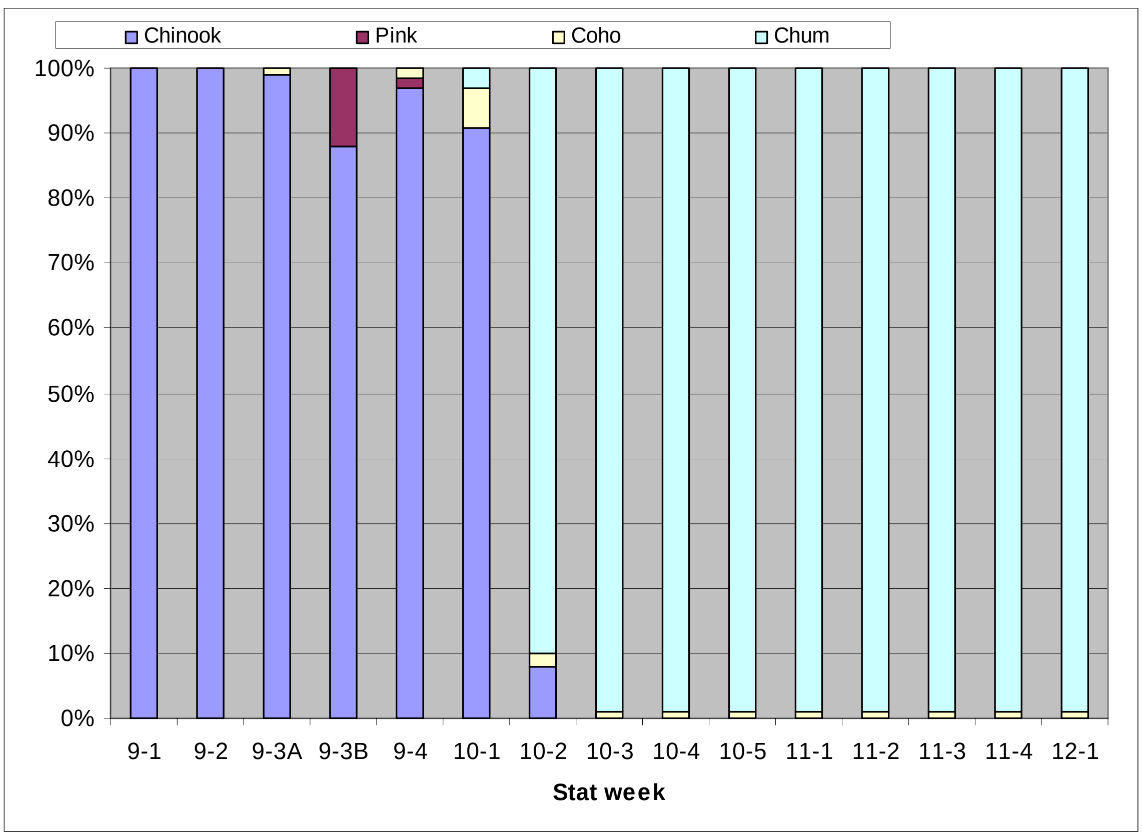

Figure 7. Species Composition by Stat Week from enumeration fence observations.

Increasing water levels in early October resulted in the enumeration fence being removed on 5th October, three weeks earlier than planned. Consequently we were unable to examine the species composition for the remainder of the migration season. By

9 October daily target counts began climbing indicating commencement of the chum migration to numbers that were substantially higher than coho and chinook levels. Therefore, with no further species composition data available from the enumeration fence, we made the following assumptions:

Chinook: migration had ended during Stat week 10-3 and the species composition was considered to be 0% thereafter.

Coho: migration continued until the end of the sample period with an increase in numbers with the rising river levels in mid-October. Two percent was assumed for Stat week 10-2 and 1% thereafter.

Chum: migration continued until the end of the sample period and comprised the remnant of the species composition. 90% was assumed for Stat week 10-2 and 99% thereafter.

DIDSON Escapement Estimates

Table 2 shows the escapement estimate and the process from target count through species composition and the final estimates, rounded to two significant digits.

The chinook escapement estimate produced by the DIDSON unit is 6,800 with a 95% confidence interval of $\pm$ 700.

It was not possible to provide a coho escapement estimate with the DIDSON unit as there was insufficient species composition data available this year and their run timing coincides with the arrival of the chum.

The chum escapement estimate produced by the DIDSON unit is 280,000 with a 95% confidence interval of $\pm$ 8,500.

Comparison to Standard DFO Estimates

The chinook freshwater escapement estimate for the Cowichan using standard DFO stock assessment techniques is 2,413 adults and 1,450 jacks. These numbers are derived from the carcass deadpitch mark recapture program, broodstock collection and First Nations in-river fishery. An estimated 238 adult and 132 jack chinook were caught by fishers from below the DIDSON site and therefore have to be subtracted from the standard estimate before it can be compared to the DIDSON data. Therefore the comparable standard estimate for total chinook is 3,493.

The standard estimate for coho escapement is 3,200 adults. In 2007 we were unable to use the upper Cowichan River mainstem reach as part of the estimate as high water prevented any swim surveys from being performed. As a result this escapement estimate is based only on results from Lake Cowichan tributary surveys which are estimated to represent 14.9% of the spawning population. Freshwater removals from the river occurred prior to the enumeration so they do not have to be factored in.

There is no standard estimate to compare the DIDSON chum result to as aerial surveys have not been possible for the last four years due to the turbid water conditions. The chinook enumeration fence cannot provide any kind of estimate as it is generally removed before the majority of the chum have entered the system and it is upstream of the primary spawning areas. Therefore, no comparison with escapement estimates from conventional DFO stock assessment methods is possible. Conversely the application of the DIDSON technology has provided an estimate that would normally not have been possible to obtain.

DISCUSSION

Results Comparison

There is significant discrepancy between the DIDSON escapement estimate of chinook compared to those derived from standard estimate methods. This discrepancy could be attributed to a number of different factors causing error in the standard methods, the DIDSON estimate or both.

Possible Errors with Traditional Enumeration

<u>Incomplete mark recapture coverage:</u> The mark recapture program covers the upper Cowichan River from the lake downstream for 10.5 km. In previous years some chinook spawning activity has been observed in sections of the river immediately above and below Skutz Falls which is downstream of the area covered by the mark recapture program. It is therefore likely that escapement estimates from the mark recapture will be lower than the actual spawning population. This estimate of 3,863 chinook cannot be corroborated by the fence count as it was removed three weeks earlier than usual due to rapidly rising water levels.

<u>Species composition estimate:</u> There were some errors in the chinook broodstock collection data when beach seining took place, but again it is extremely unlikely that it could contribute to any significant underestimate of numbers of fish handled. Broodstock numbers are definitive by the end of gamete collection when all salmon are noted.

<u>Freshwater fishery estimate:</u> Chinook and coho creel survey data is collected by the First Nations Fisheries Guardians who also perform regular patrols for regulation enforcement. These personnel do an excellent job with good coverage of the lower river and although the final estimates of First Nation catch could have some error it is not likely to be significant. It is unlikely that any significant levels of poaching occurred in 2007 as reports of individuals caught fishing during closures from both the Cowichan Tribes Fisheries Guardians and DFO C&P staff was lower than in previous years.

<u>Coho Escapement model:</u> We were unable to obtain an estimate of the coho spawners in the upper Cowichan mainstem reach, which represents 45% of the escapement. The reaches that were used represent 14.9% of the escapement. There are a number of assumptions in the spawner distributional model that is used to expand the reach estimates that could affect the true number of coho spawners. There has been no evidence, however, that major shifts to the spawning ground preferences that would significantly alter the model.

<u>Pre-spawn mortality:</u> Finally, no significant occurrences of pre-spawn mortality in river sections below the enumeration fence were observed by the beach seine crews, Fisheries Guardians or DIDSON personnel.

Possible Errors with the DIDSON Estimates

<u>Target Counting Errors:</u> Recounts of files reviewed earlier in the project brought to light a number of issues with the accuracy of these initial upstream estimates. The primary reason for this error appears to be the technique used to review the data in that attempting to count the low frequency 20 meter widow length files in a single pass led to under estimate of actual numbers of targets. This was especially so during the chum spawning period when 20 to 30 salmon were holding in the field of view. This heightened level of

activity in conjunction with the longer window length meant that targets migrating through the actively spawning chum were often missed. It was possible to obtain consistent counts if only half of the field of view was counted at a time and replay frame rates were slowed to 10 to 20 fps (2 to 4 times faster than recorded speed).

A secondary issue with target counting accuracy is observer inattention. Reviewing DIDSON data is a monotonous task. Regular breaks need to be taken and review sessions should be limited to an hour or so at a time. During the busier periods of 200 or more migrants an hour, it is not possible to exactly reproduce the same total count. There will always be some ambiguity with (some migrants being lost in the constant background spawning activity) the exact numbers of individuals in a school of fish moving upstream through the spawning groups holding in the field of view. However, repeat counts should be within ±5% of the original if sufficient care is taken with review procedure.

Data Expansion: Several types of expansion were applied to the raw counts.

- First, expansions to full hour estimates were made based on the reviews of 15 or 30 minutes of each hour.
- Second, When the DIDSON was first relocated to the bank on 9th October the low frequency 20 meter window length only covered half of the river channel. Therefore hourly counts were doubled to provide a total estimate.
- Third, when frequency switching was initiated on 10th October only 15 minutes of data for each range was counted. These counts were therefore expanded to provide full hour estimates for the ten and 20 meter fields of view.
- Fourth, there were short periods when no data was recorded due to computer lockup, loss of power or other technical issues. Data recorded before and after these events were used to interpolate an estimated target count.
- Finally there was expansion of the original chum migration counts using the post season recount data. This covered the period from 27th October to 1st December.

Target size: Very few small targets (<39cm) were observed in 2007. Most targets from the first 15 minutes of each hour throughout September were measured using the measure tool incorporated into the DIDSON software. Of the 1,983 lengths obtained only 17 (0.85%) were less than 39cm. As the nature of the DIDSON data creates limitations with accuracy (±2cm in the short range and increasing for targets farther out in the 10 meter field of view), it was decided to use the total target count for the escapement estimates.

Species Composition: Another source of error is with the species composition ratios derived from the fence observations. The fence is located approximately 5 km upstream of the DIDSON site and above the majority of the chum spawning habitat. Consequently the species composition observed at the fence will likely not accurately represent composition in the lower river closer to the DIDSON site. In 2007 the higher water levels precluded any beach seining for broodstock in the lower river so the fence observations is the only composition information available. There would also be a timing difference between targets moving past the sonar and the fish being observed at the fence. Finally, the fence had to be removed on 5th October, three weeks earlier than planned, due to rising water levels. This leaves one week during which no species composition data was available before daily target counts passing the DIDSON unit started to rapidly increase indicating the start of the chum migration. From this point onwards the vast majority of targets can be assumed to be chum with some unknown but small (likely <1%, based on the traditional coho estimate of 3,200) proportion of coho. Errors in the species composition assumptions after Stat week 10-2 would only have a minor effect on the final chum estimate.

No comparison with a traditional estimate is possible for chum because aerial surveys have not been possible for the last four years. However, this project has demonstrated that the DIDSON is capable of provided an estimate under flood conditions when very poor visibility precludes any other escapement estimate methodology.

Recommended Improvements

The problems associated with accuracy of in-season data review are primarily an issue of training. An important part of the post season recounts, other than confirmation of total targets, was an attempt to understand the major causes of error in the initial counts. This resulted in a number of recommendations for changes to data review procedures:

1. Count half of the view at a time when replaying low frequency 20 meter range data. This is critical during the busy chum spawning period in October and November.
2. Reduce replay speed to 15 - 20 frames per second during periods of high activity. It can be very tempting to review the data as quickly as possible, but fish will be missed at higher replay speeds.
3. Take frequent breaks to prevent eye fatigue and inattention.
4. Recount at least one file per shift, preferably the busiest one, for quality control.
5. During the chinook migration period when isolated groups of fish are moving upstream, replay the clip at least twice to ensure an accurate count. Individual fish in the background can be intermittently hidden in the shadow of foreground fish.
6. Take extra care to ensure that the correct file is being reviewed. It is easy to confuse the date and or time in the data file names.
7. Pay careful attention to perceived behaviour of downstream targets as image flicker can sometimes cause debris to resemble swimming fish.

A secondary issue with count estimate accuracy is the ability of the individuals reviewing the recordings. Reviewing DIDSON files is a tedious job and some people are more suited than others to this type of task. Part of the early season training for any new staff should be a realistic assessment of an individual's ability to handle the monotony of the review work and to be able to stay focused. Reducing the amount of DIDSON data to be processed will help this situation. This can be achieved by reviewing only 30 minutes in every hour once recording is switched to long range/low frequency around the time that target activity increases with the arrival of the chum. It is important, if time permits, to continue reading all of the data during the chinook migrations as periods of upstream movement are irregular and expansions of partial counts would introduce a greater degree of error in the estimates. However, the higher resolution recording and 10 meter window length in conjunction with lower numbers of targets makes this data less onerous to review.

Target species separation for all sizes was a major focus of this project and is still an issue. We believe that the beach seining can be sufficient to determine species composition of the larger groups of salmon. However, during years of higher water flows such as 2007 it is not possible to sample fish in the lower river pools above and below the DIDSON site. An alternative would be to perform regular snorkel surveys of these pools during the chinook migration when water visibility is generally better. Species separation will likely never be practical during the higher water flows of the later half of the program making it unlikely that the DIDSON can be used for coho escapement estimates. The unknown but very small coho component during this elevated water period will have very little effect on the final chum escapement estimate.

CONCLUSION

The purpose of this project was to examine whether a DIDSON unit could be used to obtain escapement estimates for multiple salmon species. The approach we took was to compare the results obtained from this project to the results from standard estimates techniques. For chinook the DIDSON estimates were not consistent with the standard estimates although this may in part be due to inaccuracy with the traditional estimate as the fence had to be removed prior to run completion. For chum salmon there was no standard estimate for comparison.

On the positive side, the system continued to work under extreme conditions and we were able to maintain a target count at times when traditional fixed point enumeration is impossible. We were able to provide daily in-season estimates of run strength and timing which were very useful for managing local and associated fisheries.

The chosen site worked well for the DIDSON with good river profile, continued access through flood conditions and no major issues with maintaining counts of fish. Addition of electrical power to the site and construction of a bulkhead on the river bank increased the efficiency and safety of the DIDSON program.

Next Steps

If the recommended changes and improvements are undertaken then escapement estimates using the DIDSON technology can be improved and at the very least should provide reasonable estimates for chinook and chum. It may continue to be a problem obtaining reliable coho estimates due to the time of year and the likelihood of flood water conditions hampering beach seining for species composition. The relatively small numbers of coho will always be overwhelmed by higher numbers of chum migrating at the same time.

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TABLES

Stat Week	Date	Daily Count	Stat Wk Avg.	Comments
9-2	10-Sep-07			Didson set-up
	11-Sep-07	93		- High Frequency setting with 10m range
	12-Sep-07	0		
	13-Sep-07	58		
	14-Sep-07	69		
	15-Sep-07	136	71	
9-3A	16-Sep-07	187		
	17-Sep-07	163		
	18-Sep-07	457		
	19-Sep-07	160		
9-3B	20-Sep-07	48		
	21-Sep-07	114		
	22-Sep-07	163	185	
9-4	23-Sep-07	180		
	24-Sep-07	488		
	25-Sep-07	307		
	26-Sep-07	324		
	27-Sep-07	240		
	28-Sep-07	440		
	29-Sep-07	484	352	
10-1	30-Sep-07	781		
	1-Oct-07	784		
	2-Oct-07	248		Didson switched to low frequency - 20m range
	3-Oct-07	206		
	4-Oct-07	229		
	5-Oct-07	132		Chinook counting fence removed
	6-Oct-07	96	354	
10-2	7-Oct-07	272		
	8-Oct-07	328		
	9-Oct-07	924		Didson moved to river bank - 20m range used
	10-Oct-07	520		Frequency switching initiated - 30 minutes at high
	11-Oct-07	1344		frequency with 2 to 12m field of view
	12-Oct-07	1232		and 30 minutes of low frequency with
	13-Oct-07	1464	869	12 to 32m field of view.
10-3	14-Oct-07	1180		
	15-Oct-07	1608		
	16-Oct-07	1656		
	17-Oct-07	2600		
	18-Oct-07	3724		
	19-Oct-07	5096		
	20-Oct-07	3664	2790	
10-4	21-Oct-07	7188		
	22-Oct-07	7376		
	23-Oct-07	13264		
	24-Oct-07	7876		

	25-Oct-07	12000		
	26-Oct-07	7032		
	27-Oct-07	3907	8378	
10-5	28-Oct-07	4331		
	29-Oct-07	6429		
	30-Oct-07	8918		
	31-Oct-07	3716		
	1-Nov-07	4024		
	2-Nov-07	5031		
	3-Nov-07	3928	5197	
11-1	4-Nov-07	10296		
	5-Nov-07	8581		
	6-Nov-07	3745		
	7-Nov-07	4812		
	8-Nov-07	6324		
	9-Nov-07	8295		
	10-Nov-07	7174	7033	
11-2	11-Nov-07	5311		
	12-Nov-07	5052		
	13-Nov-07	8614		
	14-Nov-07	11060		
	15-Nov-07	11396		
	16-Nov-07	10160		
	17-Nov-07	5888	8212	
11-3	18-Nov-07	3368		
	19-Nov-07	4908		
	20-Nov-07	8014		
	21-Nov-07	9616		
	22-Nov-07	3279		
	23-Nov-07	5688		
	24-Nov-07	5895	5824	
11-4	25-Nov-07	5000		
	26-Nov-07	3082		
	27-Nov-07	879		
	28-Nov-07	1664		
	29-Nov-07	987		
	30-Nov-07	1734		
	1-Dec-07	1348	2099	
12-1	2-Dec-07	184		
	3-Dec-07	48		
	4-Dec-07			Didson removed
	5-Dec-07			
	6-Dec-07			
	7-Dec-07			
	8-Dec-07			

Table 1. Daily net upstream target count

Stat Week	Daily Avg.	Total Targets	Percentage				Estimated Escapement			
			CN	PK	CO	CM	CN	PK	CO	CM
9-1			100.0%	0.0%	0.0%	0.0%				
9-2	71	356	100.0%	0.0%	0.0%	0.0%	356	0	0	0
9-3A	242	967	98.9%	0.0%	1.1%	0.0%	956	0	11	0
9-3B	108	325	87.9%	12.1%	0.0%	0.0%	286	39	0	0
9-4	352	2,463	97.0%	1.5%	1.5%	0.0%	2,389	37	37	0
10-1	354	2,476	92.4%	0.0%	6.3%	3.0%	2,288	0	156	74
10-2	869	6,084	8.0%	0.0%	2.0%	90.0%	487	0	122	5,476
10-3	2790	19,528	0.1%	0.0%	0.9%	99.0%	20	0	176	19,333
10-4	8376	58,643	0.0%	0.0%	1.0%	99.0%	0	0	586	58,057
10-5	5197	36,378	0.0%	0.0%	1.0%	99.0%	0	0	364	36,014
11-1	7033	49,228	0.0%	0.0%	1.0%	99.0%	0	0	492	48,735
11-2	8212	57,481	0.0%	0.0%	1.0%	99.0%	0	0	575	56,906
11-3	5824	40,769	0.0%	0.0%	1.0%	99.0%	0	0	408	40,362
11-4	2099	14,695	0.0%	0.0%	1.0%	99.0%	0	0	147	14,548
12-1	116	232	0.0%	0.0%	1.0%	99.0%	0	0	2	230
		289,625								
					Final Totals		**6,781**	**76**	**3,075**	**279,734**
					FINAL Esc. Est.		**6,800**	**100**	**3,200**	**280,000**

Table 2. Estimate of salmon escapement by species from the weekly DIDSON target counts.

Red font indicates assumed species composition

APPENDICES

Appendix 1. Financial Statement

	BUDGET			ACTUAL			
ELIGIBLE COSTS	**OTHER FUNDING**	**CONTRIBUTION FUNDING**	**TOTAL**	**IN-KIND[1]**	**OTHER FUNDING[2]**	**CONTRIBUTION FUNDING**	**TOTAL**
Wages & Salaries							
DFO Biologist	6,750.00		6,750.00	6,750.00			6,750.00
DFO Technicians	12,600.00		12,600.00	12,600.00			12,600.00
DIDSON technician[3]		14,688.00	14,688.00			25,252.52	25,252.52
security technicians		27,300.00	27,300.00				
sub total	19,350.00	41,988.00	61,338.00	19,350.00		25,252.52	44,602.52
Labour - Employer Costs							
sub total	2,515.50	5,461.44	7,976.94	2,516.00		2,575.26	5,091.26
Subcontractors & Consultants							
					600.00[4]	5,000.00[4]	5,600.00
sub total	0.00	0.00	0.00		600.00	5,000.00	5,600.00
Volunteer Labour							
Skilled	8,160.00		8,160.00	8,160.00			8,160.00
Un-skilled							
sub total	8,160.00	0.00	8,160.00	8,160.00			8,160.00
Total Labour Costs	30,025.50	47,449.44	77,474.94	30,026.00	600.00	32,827.78	63,453.78
Site / Project Costs							
Travel (do not include to & from work)	3,000.00	1,000.00	4,000.00	3,000.00		0.00[5]	3,000.00
Small Tools & Equipment	2,000.00	1,000.00	3,000.00	2,000.00		460.07	2,460.07
Site Supplies & Materials		6,000.00	6,000.00		66.48	2,525.56	2,592.04
Work & Safety Gear		800.00	800.00			1,475.97	1,475.97
Other site costs	5,000.00	7,000.00	12,000.00		5,000.00	11,105.62[6]	16,105.62
Total Site / Project Costs	10,000.00	15,800.00	25,800.00	5,000.00	5,066.48	15,567.22	25,633.70
Training							
Swiftwater Rescue	700.00	700.00	1,400.00			3,192.00[7]	3,192.00
Total Training Costs	700.00	700.00	1,400.00			3,192.00	3,192.00
Overhead / Indirect Costs							
Office space (trailer); including utilities, etc.	10,000.00	2,000.00	12,000.00	10,000.00		3,533.02	13,533.02
Insurance		800.00	800.00			[8]	
Office supplies	700.00	800.00	1,500.00	700.00		239.37	939.37
Telephone & long Distance	300.00	500.00	800.00	300.00		710.01	1,010.01
Photocopies & printing	500.00	500.00	1,000.00	500.00		[9]	500.00
Other overhead costs						1,340.89	1,340.89
Total Overhead Costs	11,500.00	4,600.00	16,100.00	11,500.00		5,823.29	17,323.29
Capital Costs / Assets							
computer, for reviewing data		2,000.00	2,000.00	1,000.00		[10]	1,000.00

Total Capital Costs		2,000.00	2,000.00	1,000.00			1,000.00
Project Total Costs	52,225.50	70,549.44	122,774.94	47,526.00	5,666.48	57,410.29	110,602.77
Funds returned to PSC						6,083.71	

Budget Summary							
(PSC + in-kind + cash)							
Total Labour Costs			77,474.94				63,453.78
Total Site / Project Costs			25,800.00				25,633.70
Total Training Costs			1,400.00				3,192.00
Total Overhead Costs			16,100.00				17,323.29
Total Capital Costs			2,000.00				1,000.00
		Project Total	122,774.94				110,602.77

Notes

[1] In-kind contribution was not estimated for Actual Costs. Budgeted amounts were carried forward.

[2] Other Funding line items were actual expenditures by DFO.

[3] Budget items DIDSON technicians and security technicians were combined into one line for actual costs. The contract with Cowichan Tribes was for $42817.63 however only $28327.78 was invoiced (includes $500 for power use and $2575.26 for overhead). There is no explanation for this discrepancy. Attempts were made with Cowichan Tribes to identify all associated costs with this contract but no additional amounts were identified.

[4] A consultant was hired after the field season to assist with data review and analysis. Other Funding amount was used to hire swimmers to enumerate migrants.

[5] There were no travel costs charged against this project.

[6] Costs for power installation exceeded estimate

[7] Costs for Swiftwater Rescue exceeded budgeted amount

[8] Insurance cost was included in Contract Overhead line item

[9] Copying cost was included in Contracting Overhead

[10] A surplus computer was used instead of purchasing a new one for this project.