# DIDSON Chum Enumeration, East Coast Vancouver Island


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Project #SF2019-SP-21
2019

**Abstract**

Dual Frequency Identification Sonar (DIDSON) technology has been the primary method of Chum Salmon enumeration on the Cowichan River since 2007. This enumeration method has also been implemented on the Nanaimo and Chemainus Rivers in more recent years. DIDSON counts provide in-season escapement estimates which are used to manage Chum Salmon stocks in these rivers. Manual review of DIDSON data is labour intensive, can be influenced by reviewer experience, and is open to subjectivity. In order to investigate the feasibility of automating fish counts, a review trial was conducted using Echoview software. A selection of DIDSON data collected from the Cowichan and Chemainus rivers during the 2018 and 2019 Chum migration was processed and compared to manual counts. Results from the Cowichan River were most promising with similar correlation between manual and automated counts ($r^2$= 0.86 in 2018 and 0.94 in 2019) as between independent manual counts ($r^2$= 0.76 and 0.96, respectively). However, the slope of the lines suggested Echoview consistently under-counted in both years (m= 0.63 in 2018 and 0.38 in 2019) relative to a comparison between manual reviewers (m= 0.83 in 2018 and 0.94 in 2019). A calibration between manual and Echoview counts should therefore be generated for each system and year. After correcting for manual comparisons to automated counts and time spent setting up automated data processing runs, it was found that the Echoview-based review was nearly 79% faster than manual counting methods. Further work is required to refine software settings and data collection techniques in order to achieve a stronger correlation between automated and manual counting methods.

# Contents

**Acknowledgements**

Funding for this project was provided by the Pacific Salmon Commission Southern Boundary Restoration and Enhancement Fund. We thank the staff at DFO West Coast Region (Kevin Pellet, Andrew Campbell) for supplying project equipment as well as assistance with Echoview software and analysis. Thank you to Patricia Halinowski (BCCF) for assisting with manual review of Cowichan and Chemainus DIDSON files.

# Introduction

Dual Frequency Identification Sonar (DIDSON) technology is used to provide in-season escapement estimates for Chum Salmon stocks in the Cowichan, Nanaimo, and Chemainus rivers on East Coast Vancouver Island (ECVI). DIDSON software produces video-like imagery which allows viewers to count individual fish as they move up or downstream. However, review of DIDSON data is time-consuming (i.e., costly) and subjective, causing counts to vary between reviewers depending on factors such as viewer experience, attentiveness, fish quantity and behavior.

Echoview® software is used for hydroacoustic data processing and has potential to improve accuracy/consistency and reduce manual time required for reviewing DIDSON data. Using a processing template within the Echoview software, specific data corrections can be applied to raw DIDSON data to detect individual fish tracks. The direction of fish track movement is calculated using the start and end positions of targets. A spreadsheet output file summarizes hourly counts and direction of movement for individual fish tracks.

The primary objective of this project was to investigate the feasibility of using Echoview software to improve the speed and accuracy of reviewing DIDSON data. During winter 2019/20, BCCF used Echoview software provided by DFO staff to process the 2018 DIDSON data from the Cowichan (Oct 12 – Nov 18) and Chemainus (Oct 6 – Nov 26) rivers. A manual review of select hours during those dates was performed concurrently by BCCF to allow for a comparative analysis between past reviewer counts, BCCF reviewer counts, and the Echoview software output. Additionally, during spring 2020, BCCF used Echoview to process the 2019 DIDSON data from the Cowichan River (Oct 11 – Nov 18), and performed a manual review of select hours during the peak migration time (Oct 27 - Nov 9). A full manual review was not completed due to time constraints.

A comparison between manual and Echoview counts was performed in the spring of 2020. The strengths and weaknesses of using Echoview software to process and review DIDSON Chum escapement data is summarized below.

# Methods

## Materials and Software

DIDSON sonars (Sound Metrics Corp., Bellevue WA) were installed during the 2018/2019 field seasons. The Chemainus River DIDSON was mounted to a modified step ladder approximately 1.3 km upstream from the estuary, in the Bald Eagle Campground. The Cowichan River DIDSON was mounted to a permanent structure on the right bank approximately 3 km upstream from the estuary. Both DIDSON units were installed in early October and removed in mid- to late- November at the end of the Chum migration.

A customized laptop computer[1] was employed for data processing and DIDSON file viewing. DIDSON Control and Display Software (Sound Metrics Corp., Version 5.26.26, 2018) was used for viewing DIDSON files and performing manual fish counts. Echoview (Echoview Software Pty Ltd., Version 10.0.257, Aug 2019) was used for automated data processing.

[1] HP ZBook (15u-G6) with 32.0 GB RAM and Intel Core i7-8565U @ 1.80GHz processor

## Manual review

DIDSON data was manually reviewed by BCCF staff using the DIDSON Control and Display Software (V5.26). A subset of three hours per day (usually a night, early morning, and early afternoon hour each day) were viewed to attempt to capture relatively high, moderate, and low fish traffic. Fish behavior was classified as swimming upstream, downstream, or milling. Behaviours such as schooling or redd building were noted. Total counts of upstream and downstream migrants were summarized in a spreadsheet to calculate the net upstream movement for each hour reviewed.

The 2018 and 2019 Cowichan DIDSON files were broken up by fifteen-minute intervals (00, 15, 30, and 45), therefore four files were viewed for each hour of data. The 2018 Chemainus DIDSON files were broken up by ten-minute intervals (00, 10, 20, 30, 40, 50), therefore six files were viewed for each hour of data.

Time spent viewing a file varied depending on total file length, resolution (high or low), number of fish, and fish movement behaviors. For example, files at a high resolution with few fish moving mainly upstream or downstream could be accurately viewed at a rate of 30-50 frames per second (fps); files at a low resolution (or a high resolution with noise) and many fish moving at once in bursts, schools, or milling on-screen had to be viewed at much slower rates of 10-30fps to accurately record fish movement. The average amount of time spent to view one file varied between five and fifteen minutes.

## Data processing

DIDSON data was processed with Echoview using the Strait of Georgia (SOG) Chum DIDSON processing template provided by DFO staff, with the following settings:

Beam subset
- Beam range: 20-29

Multibeam background removal
- Input data window size (pings): 21
- Minimum SNR threshold: 7.00 dB

Multibeam target detection
- Target linking seed threshold: 200.00 $cm^2$
- Target linking satellite threshold: 100.00 $cm^2$
- Target link distance: 0.20 m

Target property threshold
- Length, minimum threshold: 15.00
- No maximum threshold

Data were processed and exported in intervals of approximately 1 – 10 days. The processing interval varied mainly due to staff availability and timing within the office. The total time required to complete processing varied between 4 – 20 hours, and export time varied between 0.5 – 8 hours, depending on the size of the files within the processing interval. Total review, processing and export time was tracked and recorded for the 2018 Chemainus and 2019 Cowichan data. Manual review effort was estimated based on the average amount of time spent viewing a single data file. This value was multiplied by the number of files reviewed and summarized in units of hours.

Echoview software summarizes the number of hours used to run Detect Fish Tracks and File Export processes; this value was noted for each group of data analyzed for 2018 Chemainus and 2019 Cowichan. Additionally, the manual time required to copy/load files into Echoview as well as to create pivot tables and copy/paste Echoview outputs into a master spreadsheet was approximated and added to the total time requirement for Echoview effort.

BCCF staff also performed additional data processing to try to improve Echoview outputs in certain cases where Echoview outputs did not align with manual counts (e.g., due to high volumes of milling, schools, and/or river debris). The time required for computer processing and human review to complete these Echoview trials is summarized in the results below.

## Data analysis

For the data analysis we compared the Echoview generated counts to the in-season manual counts conducted by Cowichan Tribes (Cowichan River) and the Q'ul-lhanumutsun Aquatic Resource Society (QARS; Chemainus River), and the subset counts performed by BCCF. Where possible, we also compared manual counts from multiple different viewers who reviewed the same data.

# Results

## Comparative analysis

**2019 Cowichan River**

Cowichan DIDSON data was reviewed multiple times in-season by different reviewers, with the average of the counts being used for the escapement estimate. The average count was used to compare the manual daily counts and the daily count generated from the Echoview software (Figure 1).

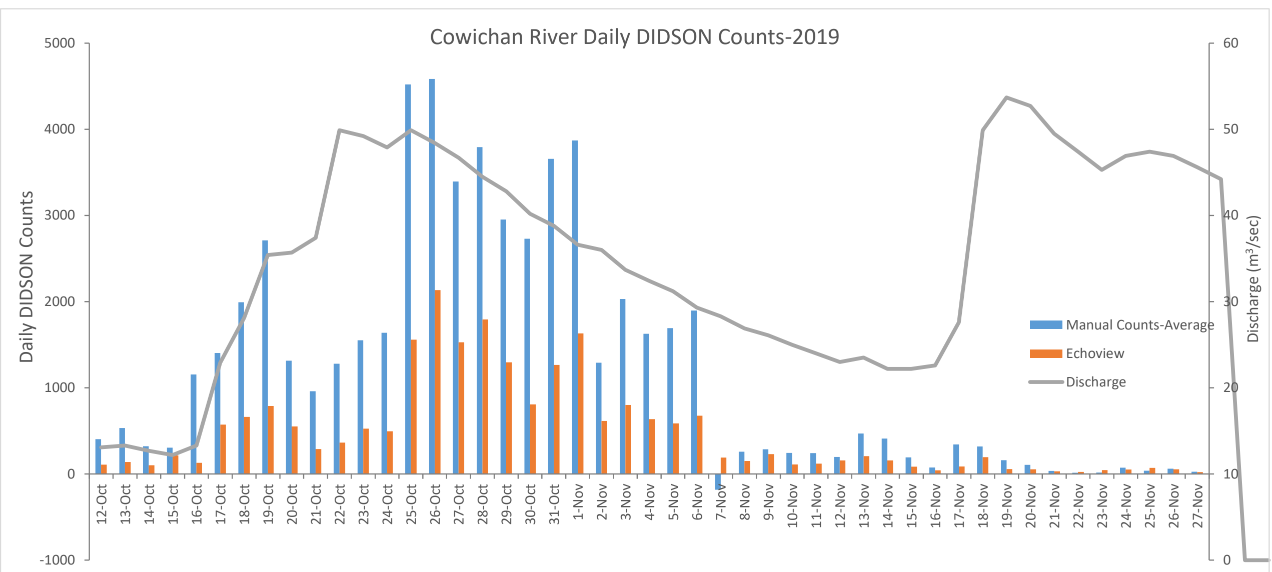


**Figure 1.** *2019 Cowichan River Daily DIDSON counts (net upstream) relative to mainstem discharge.*

Additionally, BCCF provided a subset of manual counts. We used scatter plots to compare the relationship between the various counting methods; we compared the average of the Cowichan Tribes counts to the counts from Echoview (Figure 2), the two viewers from Cowichan Tribes to each other (Figure 3), and the average of the Cowichan Tribes viewer counts to the BCCF counts (Figure 4).

**Comparing Manual Counts to Echoview Counts**

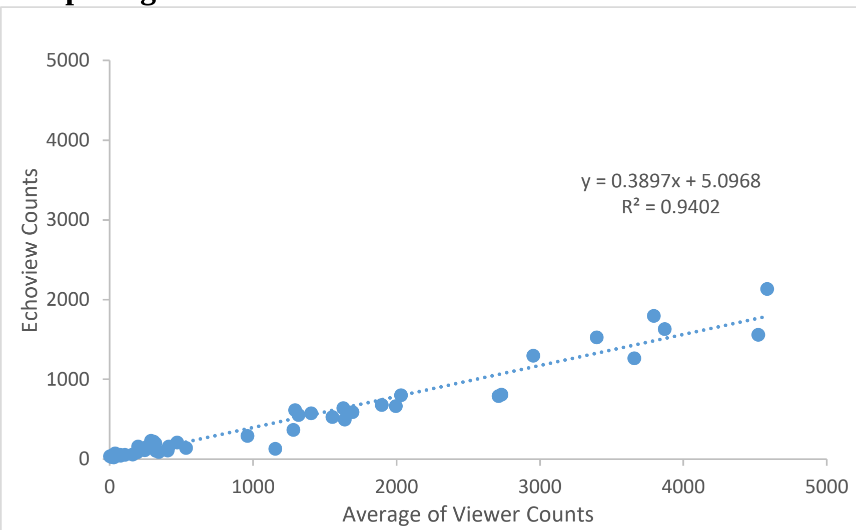


***Figure 2.*** *Comparison of the Average of manual counts and Echoview counts from the 2019 Cowichan River DIDSON project.*

These results show a strong positive relationship between the average of the viewer counts and the Echoview counts ($R^2$ = .9402), though the Echoview software was undercounting (when compared to the manual review) by approximately 60%. There was a significant difference between the average of the viewer counts (M=1187.5, SD=1343.2, Range=4675), and the Echoview counts (M=467.9, SD=539.8, Range=2112), t(62)=3.4, p= .001.

**Comparing Manual Counts from Multiple Viewers**

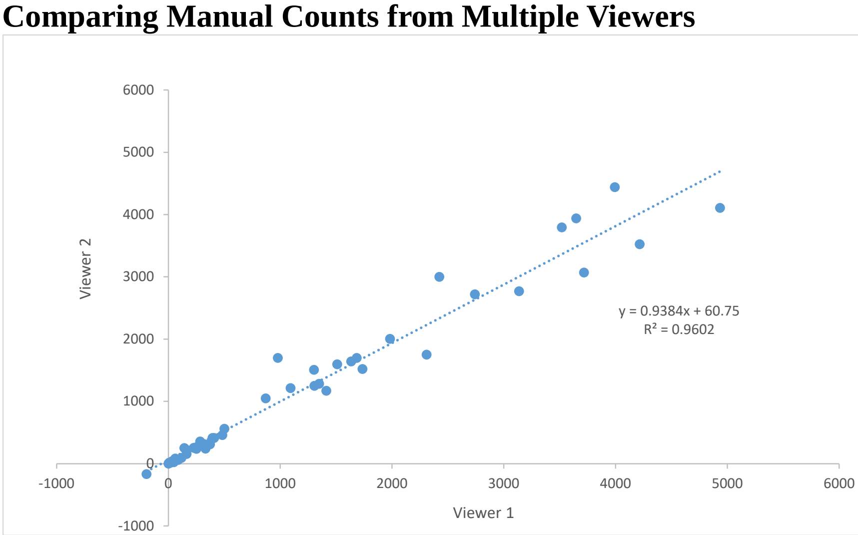


***Figure 3.*** *Comparison of the 2019 Cowichan River DIDSON counts from two Cowichan Tribes viewers.*

The comparison of reviewer 1 to reviewer 2 daily counts showed a strong correlation ($R^2$= 0.96) with a slope of approximately 1:1 (Figure 3). There was no significant difference between the means of viewer 1 counts (M=1162.5, SD=1298.4, Range=4616), and the viewer 2 counts (M=1174.1, SD=1355.8, Range=5192), at the 95% confidence level t(94)=-0.04, p= .97

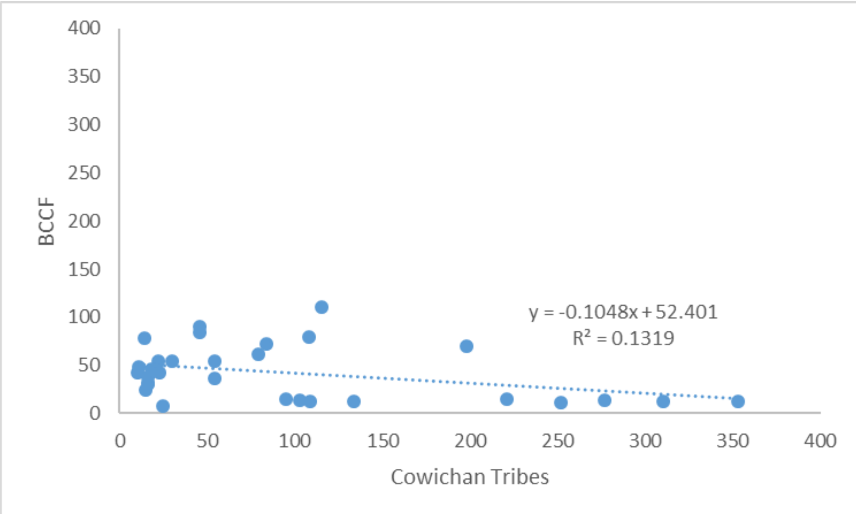


***Figure 4.*** *Comparison of 2019 Cowichan River DIDSON counts from Cowichan Tribes and BCCF.*

The comparison of the subset of the BCCF hourly counts to the average of the Cowichan Tribes viewers was poorly correlated ($R^2$= 0.13), and there was a significant difference between the mean Cowichan Tribes counts (M=95.1, SD=98.1, Range=343) and the BCCF counts (M=42.4, SD=28.3, Range=103) at the 95% confidence level, t(34)=-2.8, p= 0.01.

**2018 Cowichan River**

Similar to 2019, an average of the manual daily counts from Cowichan Tribes reviewers was compared to the daily count generated from the Echoview software (Figure 5).

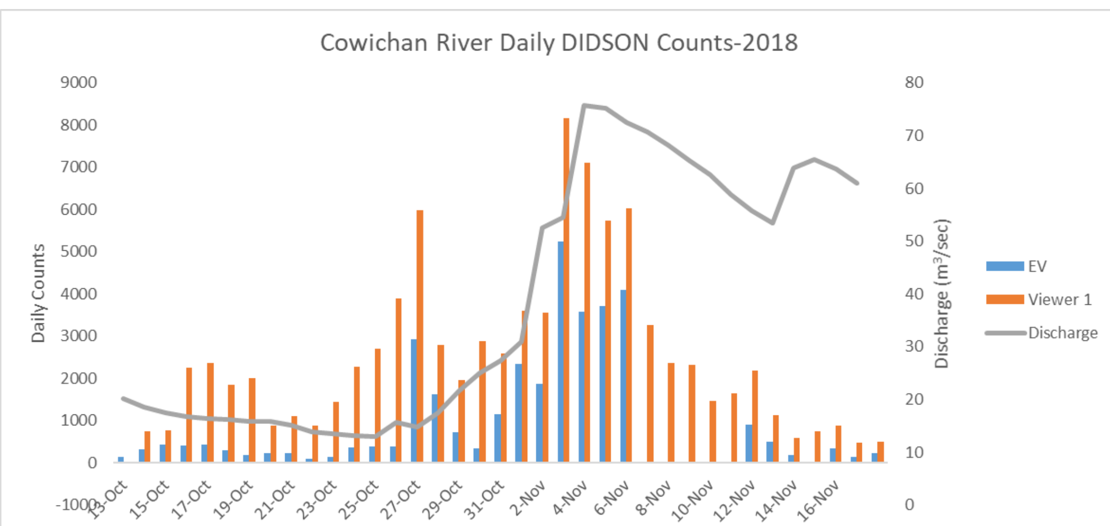


***Figure 5.*** *2018 Cowichan River Daily DIDSON counts and Discharge.*

Additionally, BCCF provided a subset of manual counts. We used scatter plots to compare the relationship between the counting methods; we compared the average of the Cowichan Tribes counts to the counts from Echoview (Figure 6), the two viewers from Cowichan Tribes to each other (Figure 7), and the average of the Cowichan Tribes viewer counts to the BCCF counts (Figure 8).

**Comparing Manual Counts to Echoview Counts**

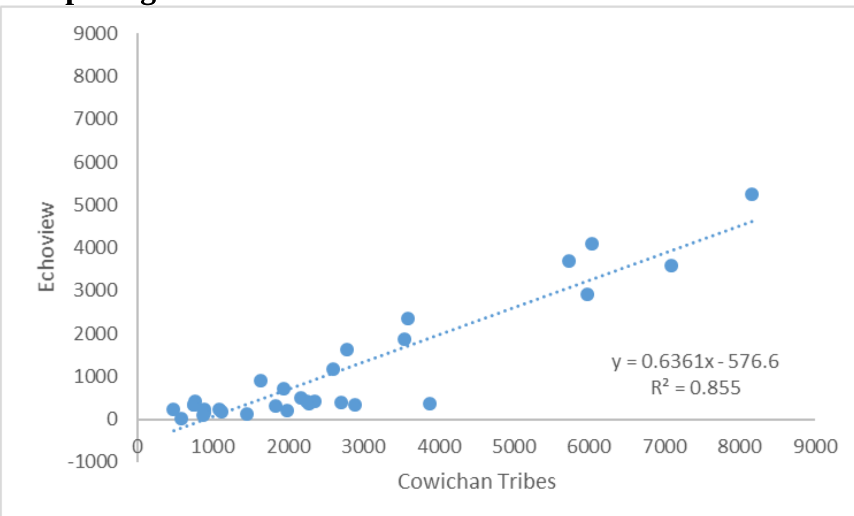


***Figure 6.*** *Comparison of 2018 Cowichan River DIDSON counts from Cowichan Tribes and Echoview.*

There was a positive relationship between the average of the two viewer counts in 2018 and the Echoview counts ($R^2$ = .855), though the Echoview software was undercounting (when compared to the manual review) by approximately 35% (Figure 6). There was a significant difference between the means of the average of the viewer counts (M=2551.7, SD=2035.6, Range=7682), and the Echoview counts (M=1026.7, SD=1377.4, Range=5258) at the 95% confidence level, t(54)=-3.5, p= .001.

**Comparing Manual Counts from Multiple Viewers**

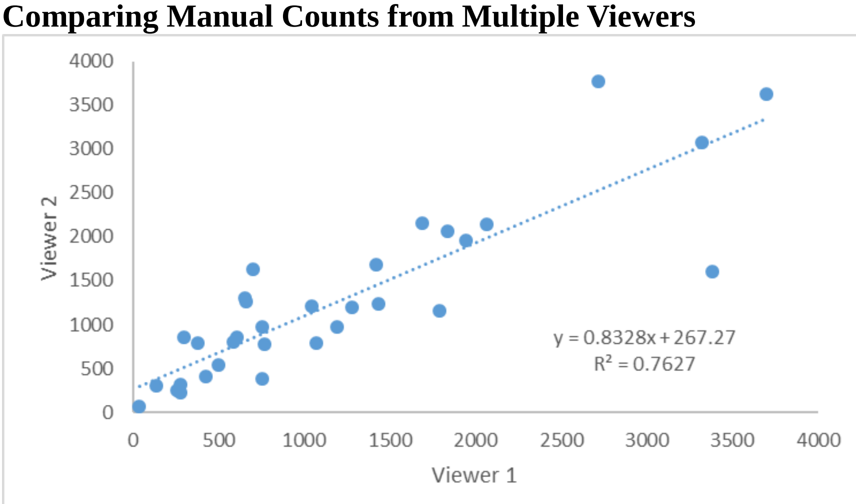


***Figure 7.*** *Comparison of 2018 DIDSON counts from two Cowichan Tribes viewers.*

There was also a positive relationship between the average of the viewer counts ($R^2$ = .7627, Figure 7). There was no significant difference between the average of the first viewer count (M=1159, SD=982.4, Range=3654), and the second viewer counts (M=1232.5, SD=936.8, Range=3706) at the 95% confidence level, t(64)=-0.31, p= .76.

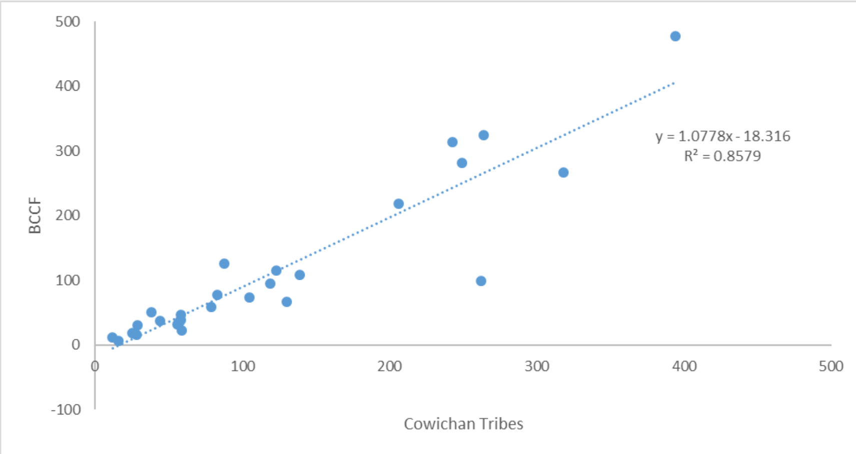


***Figure 8.*** *Comparison of 2018 DIDSON counts from Cowichan Tribes and BCCF.*

There was a positive relationship between the average of the BCCF viewer counts and the Cowichan Tribes counts ($R^2$ = .8579, Figure 8). There was no significant difference between the average of the Cowichan Tribes count (M=132.2, SD=102.4, Range=425), and the BCCF counts (M=147.8, SD=119.2, Range=472) at the 95% confidence level, t(53)=-0.3, p= .76.

**2019 Chemainus River**

The 2019 Chemainus River DIDSON data was reviewed by QARS fisheries staff. The first 30 minutes of each hour was reviewed and counts expanded to generate an estimate of escapement. Unlike the Cowichan data, the Chemainus data was manually reviewed once. This count was used to compare the manual daily count and the daily count generated from the Echoview software (Figure 9). There were no secondary manual counts to compare to the counts provided by QARS. A scatter plot was used to compare the QARS manual counts to the counts from Echoview (Figure 10)

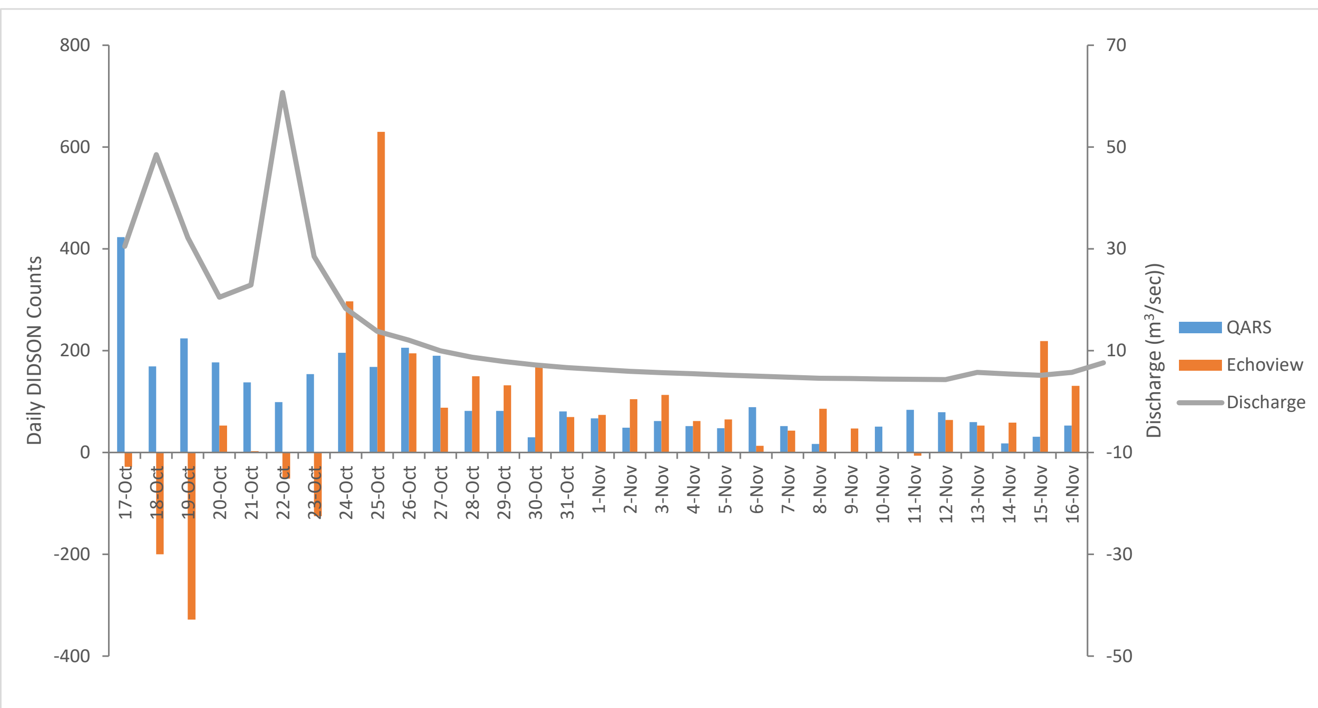


***Figure 9.*** *2019 Chemainus River Daily DIDSON counts and Discharge.*

### Comparing Manual Counts to Echoview Counts

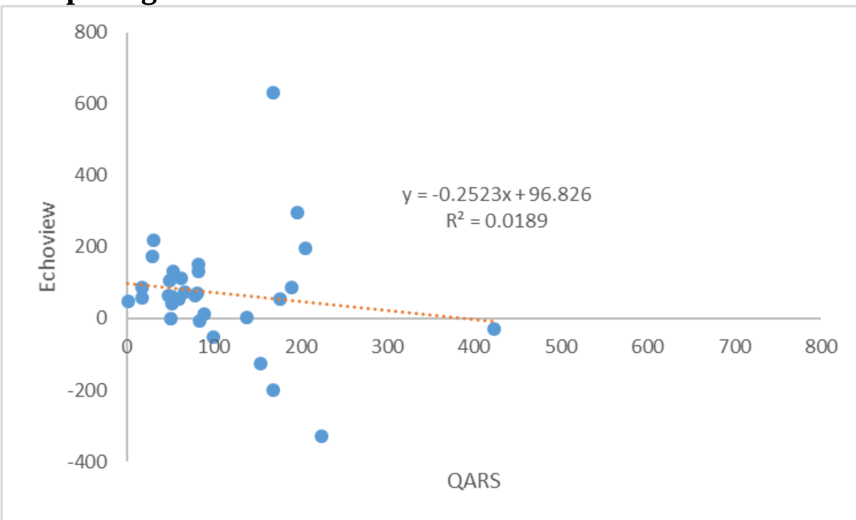


***Figure 10.*** *Comparison of the Manual counts and Echoview counts from the 2019 Chemainus River DIDSON project.*

The comparison of the QARS counts to the Echoview count shows a poor correlation ($R^2$= 0.0189, Figure 10). However, there was no significant difference between the means of the QARS count (M=104.2, SD=89.8, Range=422) and the Echoview counts (M=70.5, SD=157.6, Range=958) at the 95% confidence level, t(46)=1.04, p=0.3.

### 2018 Chemainus River Data

The 2018 Chemainus River DIDSON data was reviewed by QARS fisheries staff. Unlike the Cowichan data, the Chemainus data was only reviewed once, although a subset of the data was also reviewed by BCCF for this project. The QARS count was compared to the daily count generated from the Echoview software (Figure 11).

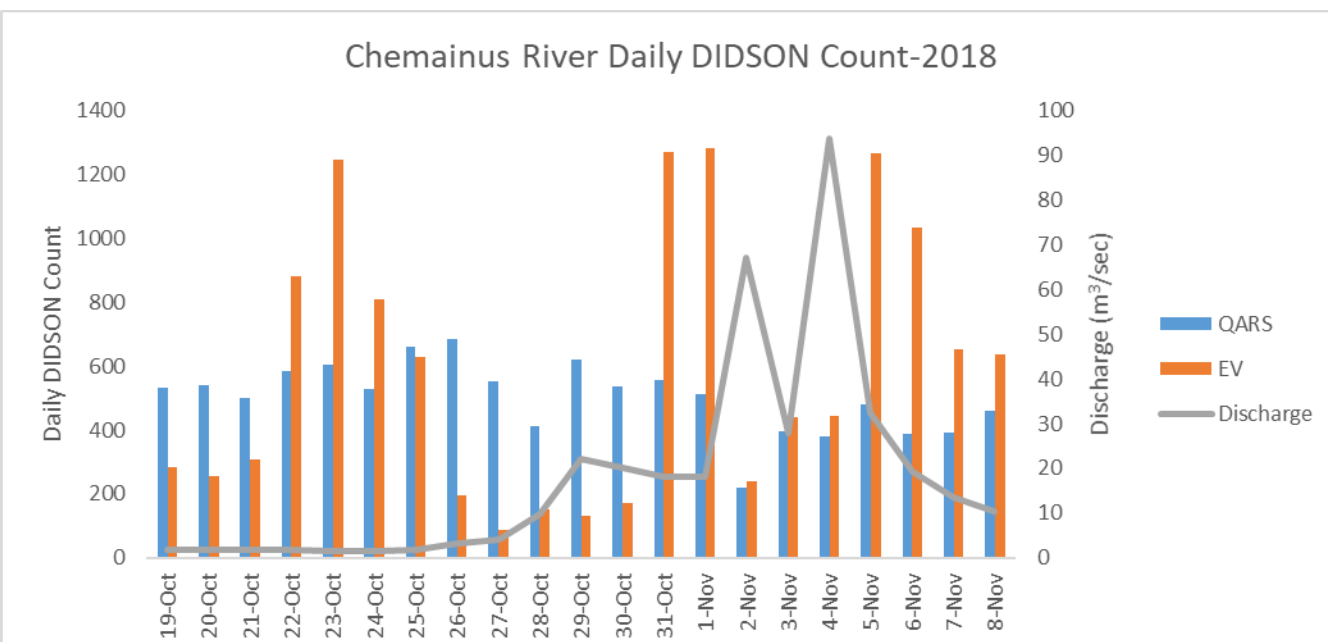


***Figure 11.*** *2018 Chemainus River Daily DIDSON counts and Discharge.*

In addition to the QARS manual count, a subset of the data was manually reviewed by BCCF. Scatter plots were used to compare data between the different counting methods. For this data we compared the daily counts from QARS to the daily counts from Echoview (Figure 12), and the BCCF subset counts to the corresponding QARS counts (Figure 13).

**Comparing Manual Counts to Echoview Counts**

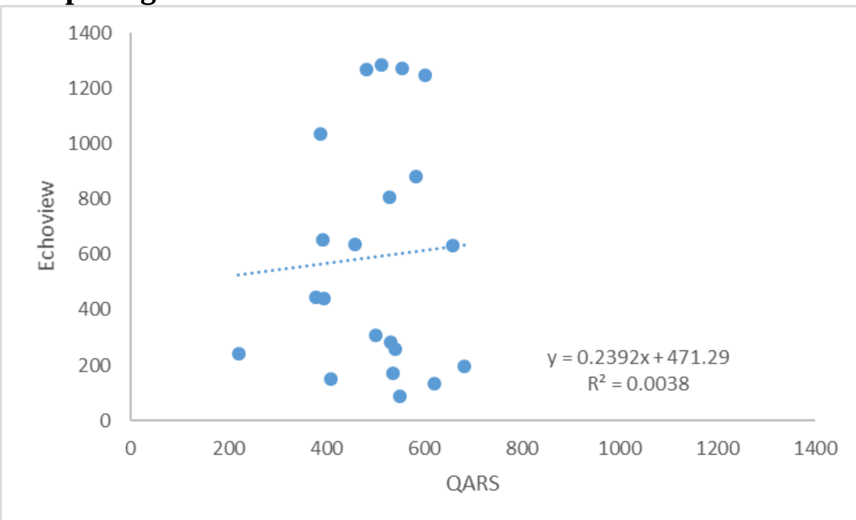


***Figure 12.*** *Comparison of the Manual counts and Echoview counts from the 2018 Chemainus River DIDSON project.*

The comparison of the QARS counts to the Echoview count shows a weak correlation ($R^2$= 0.0038, Figure 12). However, there was no significant difference between the means of the QARS count (M=501.6, SD=109.5, Range=463), and the Echoview counts (M=591.3, SD=429.9, Range=1196) at the 95% confidence level, t(23)=9.3, p= 0.4.

**Comparing Manual Counts from Multiple Viewers**

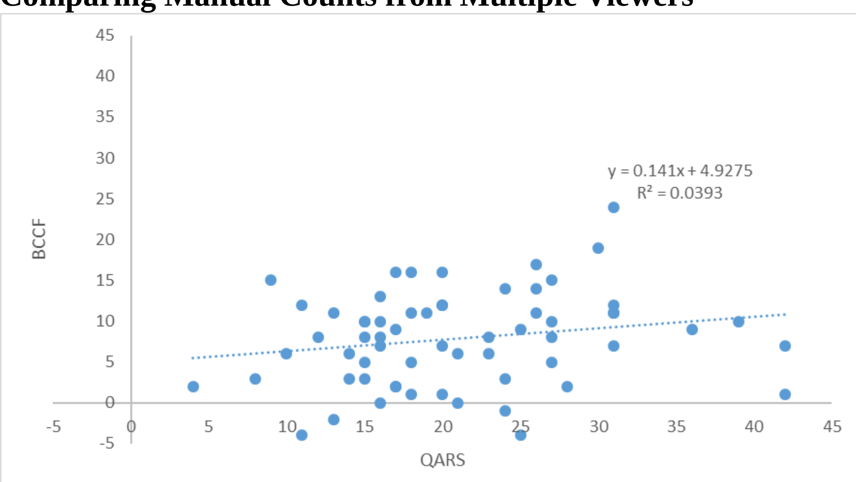


***Figure 13.*** *Comparison of the Manual counts from 2018 Chemainus River DIDSON project*

The comparison of the QARS counts to the BCCF manual count indicated very weak correlation ($R^2$= 0.0393, Figure 13). There was a significant difference between the means of the QARS count (M=21.0, SD=8.1, Range=38), and the Echoview counts (M=7.9, SD=5.8, Range=28), t(110)=1.6, p= 5.01E-18.

## Effort summary

BCCF's manual review time required was approximately 158 hours (~20 work days) for 2018 Chemainus, and 42 hours (~5.5 work days) for 2019 Cowichan. Note that the manual review of 2019 Cowichan data only covered a 14-day period during peak run timing (Oct 27 – Nov 9); the effort that would have been required to analyze the entire dataset is estimated at approximately 112.5 hours (~14 work days). The manual review time for 2018 Cowichan data was not recorded, but is estimated to have been approximately 120 hours (~15 work days).

The total Echoview processing time (*i.e.* computer run-time) required was 116.5 hours for 2018 Chemainus and 52.5 hours for 2019 Cowichan. Additional person-hours were required to load & export files from Echoview, which amounted to approximately 30 minutes per "round" of data reviewed. Running of Echoview trials and data comparisons amounted to an additional 176 hours of computer run-time, and 30 hours of person-hours. Comparison of effort is summarized in Table 1.

***Table 1.*** *Comparison of time required for manual review vs. Echoview analysis for the 2018 Chemainus and 2018/2019 Cowichan datasets.*

| | BCCF Manual Review | | Echoview | |
|---|---|---|---|---|
| | **File viewing hours** (3 hours viewed per 24 hours of data) | **Additional file processing time** | **Echoview run time (computer)** | **Additional file processing time (manual)** |
| **Cowichan 2018** | ~120 | Not recorded | Not recorded | Not recorded |
| **Chemainus 2018** | 156 | 2 | 116.5 | 3 |
| **Cowichan 2019** | 111 | 1.5 | 52.5 | 2.5 |
| **Echoview trials & data comparisons** | | | 176 | 30 |

While effort was not tracked for the exporting of 2018 Cowichan data, it was greater than the effort required for the 2019 Cowichan data as reviewers were learning how to use the Echoview program, and figuring out the best in-house system for running large amounts of data through Echoview.

## Echoview trials

Several different Echoview trials were run to try to improve the settings beyond those provided by DFO staff (SOG Chum template) using a subset of data that included different fish behaviours (e.g. milling, schooling). The best output settings achieved were as follows:

Beam subset
  Beam range: **10-37**
Multibeam background removal
  Input data window size (pings): 21
  Minimum SNR threshold: **11.00 dB**
Multibeam target detection
  Target linking seed threshold: 200.00 $cm^2$

Target linking satellite threshold: **150.00 cm$^2$**
Target link distance: **0.10 m**
Target property threshold
Length, minimum threshold: 15.00
No maximum threshold

These settings resulted in the closest fish counts to manual review; however, this result was not consistent, and occasionally the SOG Chum template was still closer to the manual results despite over- or under-estimating fish numbers compared to manual review.

Unfortunately, there was no clear pattern as to how the Echoview trial changes improved the accuracy of Echoview outputs. An excerpt of Cowichan vs Chemainus and manual vs Echoview results using the SOG Chum template settings and the template adjustments is presented in Table 2.

***Table 2:*** *Comparison of Manual vs Echoview results (SOG Chum template and template adjustments) for one hour of data in the 2018 Cowichan and 2018 Chemainus datasets.*

<table>
<tr><td rowspan="3">Cowichan River 2018</td><td colspan="3">BCCF counts</td><td colspan="3">Echoview counts</td></tr>
<tr><td rowspan="2">Manual Up</td><td rowspan="2">Manual Down</td><td rowspan="2">Manual Net Up</td><td colspan="3">SOG Chum template</td></tr>
<tr><td>Echoview Up (270)</td><td>Echoview Down (90)</td><td>Echoview Net Up</td></tr>
<tr><td rowspan="4">Oct 14, 200-300 h</td><td rowspan="4">66</td><td rowspan="4">9</td><td rowspan="4">57</td><td>78</td><td>44</td><td>34</td></tr>
<tr><td colspan="3">Template adjustments</td></tr>
<tr><td>Echoview Up (270)</td><td>Echoview Down (90)</td><td>Echoview Net Up</td></tr>
<tr><td>13</td><td>12</td><td>1</td></tr>
<tr><td rowspan="3">Chemainus River 2018</td><td colspan="3">BCCF counts</td><td colspan="3">Echoview counts</td></tr>
<tr><td rowspan="2">Manual Up</td><td rowspan="2">Manual Down</td><td rowspan="2">Manual Net Up</td><td colspan="3">SOG Chum template</td></tr>
<tr><td>Echoview Up (90)</td><td>Echoview Down (270)</td><td>Echoview Net Up</td></tr>
<tr><td rowspan="4">Oct 14, 300-400 h</td><td rowspan="4">43</td><td rowspan="4">11</td><td rowspan="4">32</td><td>315</td><td>399</td><td>- 84</td></tr>
<tr><td colspan="3">Template adjustments</td></tr>
<tr><td>Echoview Up (90)</td><td>Echoview Down (270)</td><td>Echoview Net Up</td></tr>
<tr><td>26</td><td>42</td><td>-16</td></tr>
</table>

## Fish counts

BCCF's manual counts were highest for the Cowichan River in 2018. The highest Net Up count in 2018 was 1,199 fish between 3:00 – 4:00pm on Nov 2, 2018; this involved several large schools of fish. The highest Net Up count for the Cowichan River in 2019 was 111 fish between 10:00 – 11:00am on Oct 28, 2019.
Conversely, the highest Net Up count for the Chemainus River in 2018 was 60 fish between 10:00 – 11:00am on Oct 11, 2018.

# Discussion

## Comparative analysis

Results from the Cowichan River shows a high degree of correlation between the manual counts and the Echoview counts for both years; however, the Echoview software consistently counted fewer fish (60% in 2019, 35% in 2018) than the manual counts. We suspect this is attributed to the apparent inability of Echoview to differentiate large schools as individual fish resulting in an artificially low count. When comparing counts between different reviewers in both 2018 and 2019 we found no statistical difference; whereas BCCF counts were only similar to Cowichan Tribes counts for 2018.

In the Chemainus River, we found a poor correlation between the manual counts and the Echoview counts in both years. This is likely due to the placement of the DIDSON unit near spawning habitat which resulted in milling behavior making both manual and software based counts challenging. Alternatively, the Cowichan DIDSON captured a more regular upstream flow of fish which was easier for both the reviewers and software to interpret.

## Manual review

The major disadvantage of manual review is that it is time-consuming, and therefore difficult for reviewers to remain attentive when viewing files. The DIDSON records in both high- (1.8 MHz) and low-frequency (1.0 MHz) modes. High-frequency mode is the most effective for manual review, as it provides better resolution images to distinguish individual fish (especially when there is milling or schooling behaviour). Low-resolution imagery can be incredibly difficult to interpret, especially when there is interference (e.g., camera noise, shadows from fish swimming in front of beam, fish "fading" in and out of view behind boulders, debris floating downstream). Low-resolution files that were recorded at distances greater than approximately 15-20m from the DIDSON had increased noise, shadow effects, and blurriness, all of which degraded the quality of data files for viewing.

## Echoview

The use of Echoview software has potential to greatly reduce manual reviewing effort for the DIDSON Chum Salmon escapement data by automating fish detection and summarizing movement in-river. Specific advantages of using the software over manual review include a more rapid processing time, less viewer fatigue, and greater consistency/less subjectivity between files. The average reviewer effort for 2018 Chemainus and 2019 Cowichan data decreased by approximately 98% when using Echoview as compared to manual review (Table 1); although, when adding in the extra time spent running Echoview trials and comparing data, this drops to approximately 79% less time. While this difference is promising, there are still some shortcomings to using Echoview, as described below:

**Schooling Behaviour**

The Fish Track Detection feature in Echoview is used to identify groups of single targets (echoes) that show a pattern of systematic movement (Echoview 2019). The targets grouped into a fish track are assumed to have been generated by a single object moving through space. Echoview consistently under-reported fish tracks when fish moved upstream or downstream in large schools, which is likely due to Echoview amalgamating individual fish within the school into one single track. Manual reviewers have an advantage of being able to distinguish individual fish movements within a school with experience and when viewing DIDSON files at a slow frame rate.

It was thought that changing Echoview settings to increase sensitivity of track detection may improve the software's ability to pick up individual fish within a school. However, in practice, when sensitivity was increased (using alpha and beta settings within the Detect Fish Tracks properties menu, and/or decreasing the SNR (signal-to-noise) ratio within the Multibeam Target Detection properties) it did not improve results. Milling behavior and random noise caused the program to over-estimate counts of individual fish when there was no schooling, but the software still consistently under-estimated the number of fish when there was schooling.

A recommendation to address this issue is to further investigate the SOG Chum template settings to improve accuracy of school detection using Echoview as well as experiment with additional modules available through Echoview.

**Milling Behaviour**

Echoview consistently over-reported total fish counts in cases where fish were milling (*i.e.*, displaying random movement within the DIDSON beam). Echoview interpreted milling movement from one fish as several individual fish when a fish crossed the beam threshold multiple times; this often occurred when a fish was holding or redd building at the edge of the field of view.

Milling behaviour was corrected for during the analysis by subtracting downstream moving fish from upstream moving fish, in order to get a Net Upstream movement. Theoretically, this should correct for milling behaviour when running files through Echoview. In practice, however, there was often discrepancy between Echoview counts and manual reviewer counts when milling behaviour was observed. The reason for this discrepancy is not immediately clear, however it is suspected to be linked to Echoview picking up noise and debris and interpreting this as fish movement. Additionally, fish exhibiting holding behaviour (remaining in place for extended periods) can appear to “drop” out of view of the beam, to reappear after a moment. When the fish returns, it is interpreted as a second fish. Manual reviewers have the advantage of interpreting this as a single fish, whereas Echoview results may lead to an overestimation of fish track detections.

The alpha and beta settings in the Detect Fish Tracks menu were adjusted, as these account for unpredicted changes in position and velocity of the target; a highly predictable target may use low alpha and beta settings, whereas an erratic target may use high alpha and beta settings (Echoview 2019). Unfortunately, several trials with different variations of alpha and beta settings and combinations with other template adjustments did not consistently improve Echoview outputs during milling. Additionally, fish were observed to mill in different locations of the river and at different times and days in the dataset, therefore there was no blanket solution that could be applied to the SOG Chum template in order to improve fish track detections. Until an improved understanding of how to correct for milling behaviour can be achieved, files with milling must still be reviewed manually as verification for Echoview outputs.

A potential solution to this issue would be to restrict fish milling behaviour within the section of river that the DIDSON is recording. An example is the installation of a fish fence or removal of woody debris within the beam of where the DIDSON is recording (Brennan 2013). If milling behaviour could be discouraged and strict upstream or downstream movement encouraged, it could potentially make Echoview counts more efficient by removing the need for manual review of milling behaviours.

**Noise and River Debris**

River debris and noise were noted to occasionally be interpreted by Echoview as fish movements downstream. This was noted by BCCF manual reviewers particularly in the 2018 Chemainus data, and appears to have accounted for many artificial fish track detections. This is particularly noticeable during the high flow periods in early October that saw a spike in downstream movement (Figure 9).

Link distance and satellite threshold were adjusted to reduce the incidence of Echoview linking noise into a fish track. Increasing the SNR from 7.0 to 11.0 during Echoview trials also helped reduce the incidence of false fish track detections due to noise in the 2018 Chemainus data. However, this was noted to also decrease the incidences of Echoview correctly interpreting fish tracks during schooling. Further investigation into the Echoview settings is required to determine how best to prevent Echoview from classifying noise and larger pieces of debris as fish tracks, while still allowing for proper fish track detection during schooling.

### Feasibility of using Echoview in-season

It would be feasible to use Echoview in-season to speed up processing time; however, Echoview processing adjustments to account for inaccuracies during periods of high fish traffic (schooling, milling) as well as manual oversight and verification especially during peak run times will still be required. Further adjustments to the SOG Chum template, and creating condition-specific templates to account for periods of high fish traffic or periods of high flow, are strongly recommended.

## Summary and Conclusions

A satisfactory level of agreement between the Echoview outputs and manual review results was not achieved for the 2018 Chemainus data. Results from the Cowichan River were more promising with relatively strong correlation between manual and automated counts ($r^2$= 0.86 in 2018 and 0.94 in 2019). The correlation between different manual reviewers was similarly strong in 2018 ($r^2$= 0.76) and 2019 ($r^2$= 0.96). However, the slope of the lines suggested Echoview consistently under-counted in both years (m= 0.63 in 2018 and 0.38 in 2019) relative to a comparison between manual reviewers (m= 0.83 in 2018 and 0.94 in 2019).

Both manual review as well as the use of Echoview software for processing DIDSON data would be best applied in a scenario where fish movement is confined to a relatively narrow section of river (e.g., 0 – 15 m) to allow for strictly high-frequency file capture at close range; this would hopefully reduce the incidence of noise in data files and improve image quality to expedite manual viewing as well as Echoview processing. Additionally, conditions that discourage milling, holding, or hiding behaviours could help improve the quality of DISON imagery by encouraging uniformity of flow and in turn, fish movement.

Manual verification of DIDSON imagery is strongly recommended during periods of high fish traffic, until greater confidence in the accuracy of the Echoview software can be achieved. Further work to determine the best settings for detection of schooling and milling fish while not being overly sensitive to noise and debris, and vice-versa, is strongly recommended before field implementation.

These results suggest the precision between Echoview and manual counts is similar to manual review of the same data but the accuracy requires calibration. It is recommended that a calibration between manual and Echoview counts be generated for each system and year in order to correct automated counts. At this time it appears automated processing software for review of DIDSON data should be further explored where the conditions on calibration, fish movement and video quality can be met.

# References


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