

# Semi-automated DIDSON Data Analysis for the Assessment of Kenai Chinook Salmon



Field Manual

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# 1. Introduction

The goal of the method described here is to obtain length estimates of Chinook and sockeye salmon from DIDSON data, faster and with fewer user interactions than manual measurements, while producing comparable estimates of Chinook salmon abundance when used in a mixture model.

Over the course of its development this method has been tested with DIDSON data (long-range system with high resolution lens) collected in 2008 and 2009 at the Kenai River sonar site (Mile 8.6). We derived auto length estimates for a total of 1,988 fish in 84 x 20-minute periods and 72 x 10-minute periods. The resulting point estimates of Chinook salmon abundance, as well as the precision of these estimates, agreed very well with estimates obtained with manual length measurements made with Sound Metrics *DIDSON Control and Display Software*. The results are summarized in Figure 21 in the Appendix.

This method is semi-automated, which means that it requires a moderate amount of user interaction. The goal has been to automate the process as much as possible, while allowing for enough human supervision to ensure a high accuracy of the results. To make the most of existing software it uses a combination of two software packages: *DIDSON Control and Display Software Version 5.24* (Sound Metrics Corp.) and *Echoview Version 4.80* (Myriax, Pty.). The *DIDSON Control and Display Software* pre-processes DIDSON ddf files to remove the image background and empty frames from the file. *Echoview* is used to track the fish images and estimate fish length. Part of the *Echoview* process is automated through the *Kenai EV Auto Processor*, a Visual Basic program developed by Aquacoustics, Inc., specifically for the Kenai River Chinook Assessment Project.

The manual is accompanied by three video tutorials and the dataset that has been used for the development. We recommend you first review the video demonstrations and then work through the manual using some of the test data. A description of the test data can be found in *Description of data files.xls*.

The following diagram gives an overview of the processing steps involved in deriving estimates of Chinook salmon from DIDSON data. Processing times refer to the time it takes to process 1 day of 1 stratum, based on 10 minutes of data collected per hour. The manual covers the process up to the summarization of the fish.



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## 2. *Pre-process ddf data files* (*DIDSON Software*)

The original DIDSON ddf data files are pre-processed to remove the background, like the river bottom, from the image. Background removal is combined with a second step that eliminates frames where no motion has been detected. Pre-processing is executed as a batch process that processes all ddf files within a folder. If you want to do a quick test work with a folder that contains only a couple of ddf files.

Open the first file of the batch in the *DIDSON Control and Display Software* and check the following settings. The software will keep the same settings until they are changed again by the user.

In the menu ***Image... Capture... Record Options...*** the settings should read:

***N > Threshold*** = 500

***Threshold*** = 4.9

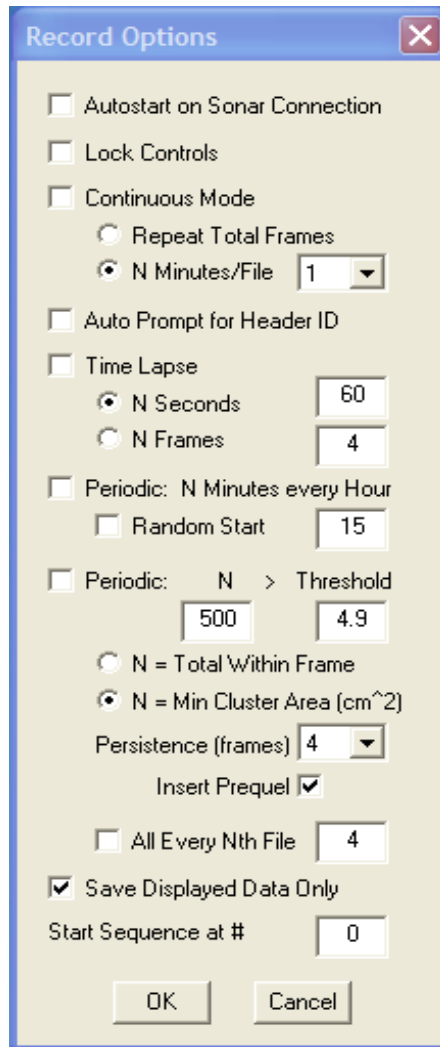
***N*** = Min Cluster Area (cm<sup>2</sup>)

***Persistence (frames)***: 4

***Insert Prequil*** checked

***Save Displayed Data Only*** checked

A screen shot of the Record Option settings is shown on the next page.



In the menu **Processing... Background...** make sure:

- Detect Empty Frames** is unchecked
- Background Subtraction** is checked

In the menu **Processing...** make sure:

- Batch Mode** is checked

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When you are ready to start the batch go to **Processing... CSOT...** and check **Export CSOT Frames**. This will immediately start the batch process, which takes approximately 15 minutes per 10-minute stratum per day. Once started the batch process cannot be stopped. If the entire day is divided into 4 6-hour batches, each batch will run less than 5 minutes. The BS/CSOT process creates a set of new files, one for each original file. The new files have the prefix "CSOT\_" and are here referred to as "CSOT files".

Do not mix files from different strata. If files from different strata are processed in the same batch there will be brief periods of noise at the beginning of each file as the background removal adjusts to a different image background.

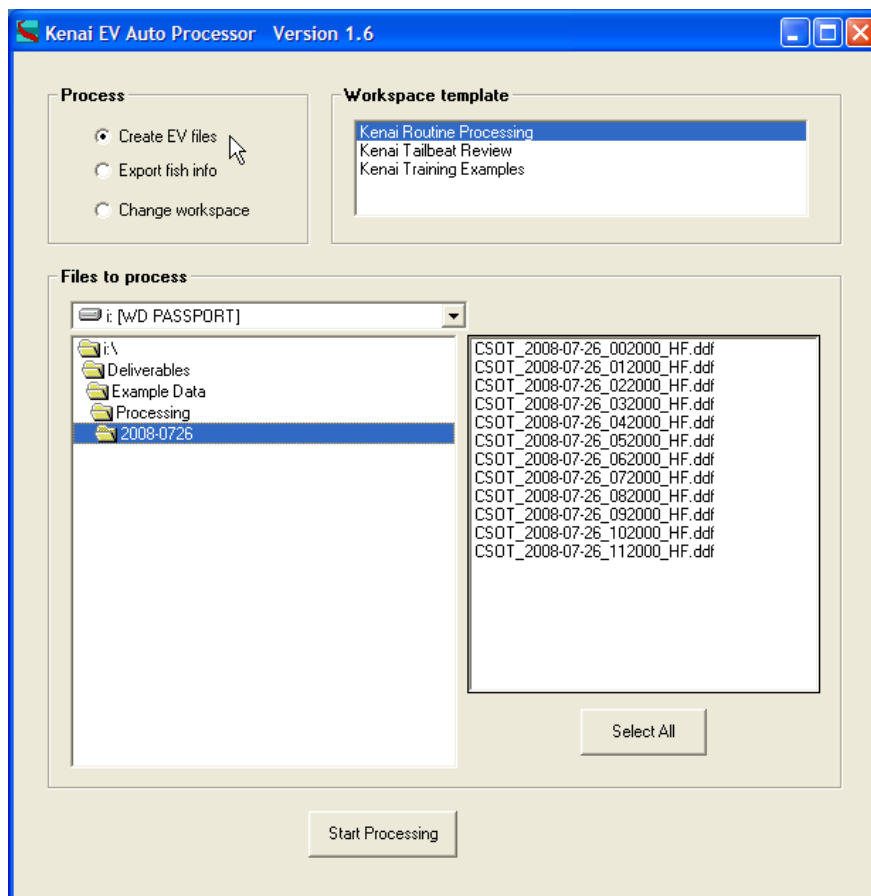
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### 3. Create EV files (Kenai EV Auto-Processor)

Make sure the Echoview auxiliary files listed in Section 11.3 have been copied to their respective locations.

The images contained in the CSOT files will be further processed with an algorithm that detects clusters of high intensity (“bright”) samples that are formed by the echoes of fish and other moving objects. To compensate for transmission loss, differential thresholds are applied to data from different strata. This process is integrated with the creation of Echoview EV files in a format that is ready for fast review and interactive fish tracking, which are described in the next section.

To create the EV files open the *Kenai EV Auto-Processor*.



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Select the **Process** *Create EV Files*.

Select the **Workspace template** *Kenai Routine Processing*.

Select **Files to process**. Make sure the selected files all belong to the same stratum. This is best done by creating a directory structure that sorts the files by stratum.

Click **Start Processing**.

This process takes approximately 2 minutes per 10-minute stratum per day. It creates 1 EV file that loads all CSOT ddf files that have been selected. The name of the EV file is constructed from the first and the last file in the set of selected files. For example, if you select the files for the first 6 hours of the day the EV file will be named YYYY-MM-DD\_00mm-05mm.EV. In addition, there will be two more files with the same name, one with the extension .evw and one with the extension .target.csv. The evw file is the workspace file that saves the window configuration of the display. The target.csv file contains the information of all clusters that have been detected in the images.

**Tip:** When you run the *Kenai EV Auto-Processor* for the first time start by opening Echoview manually and turn on its *Message* window (see page 17) before you press Start Processing in the Auto-Processor. The *Message* window will give you feedback on the processes that are being executed.

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## 4. Track fish (Echoview)

### 4.1. Echoview workspace

An Echoview workspace defines the types of windows displayed and how they are arranged within the main window. Most of the time you will be working in the *Kenai Routine Processing* workspace, which tiles four windows:

- **DIDSON image:** This is the background subtracted DIDSON image. Since it can be replayed it is sometimes referred to as the video display. Superimposed on the DIDSON image are the outlines of clusters that have been detected. The goal of the clusters is to capture the outlines of the fish images. In addition to the cluster outlines you will see small circles, which mark the cluster centroids.
- **Echograms:** These are plots of echoes (more specifically: cluster centroids) over range and time. By default range increases from the top to the bottom. However, new in Echoview 4.90, the echogram can be flipped so the range increases from the bottom to the top. To be consistent with the default view in the *DIDSON Control and Display Software* the *Kenai Routine Processing* template is now set to display range from the bottom to the top. Time increases from left to right. Each echo corresponds to a cluster that has been detected on the DIDSON image. Even though they may at first be more difficult to interpret than the more intuitive DIDSON image, echograms offer the advantage of a faster review and form the basis for semi-automated fish tracking. The colors of the echogram can represent any echo (= "target") properties. The two echograms used for this project are:
  - **Length echogram:** Here the color represents target length. The longer the target the warmer the color.

- 
- **Angle echogram:** Here the color represents the angle at which the target has been detected. As a target moves through the beam it will be seen from different angles. For data collected on the right side of the river, upstream swimming fish will leave traces that run from blue to red. Downstream moving fish or objects can be recognized by their traces changing color in reverse order. In addition to angle the angle echogram shows target thickness, which corresponds to the “height” of each echo. The target thickness is the maximum range interval covered by the corresponding cluster on any given beam of the DIDSON image.
  - **Regions window:** This is a table that lists all regions. The most common type of region you will be dealing with are “fish track regions”. Each fish track region represents a fish. More on tracks in Section 4.5. The second type of region that may at times be useful are marker regions, which can be used to add notes to the echogram that are independent of fish track regions. The Regions window will mostly be used during quality control.

The figures on the next two pages show the display of the *Kenai Routine Processing* workspace and highlight some of the elements of the interface that you will be using. (Note the figures in this manual and the video tutorial have been created with Echoview 4.80. Therefore, the DIDSON image and the two echograms are displayed with range increasing from the top to the bottom.) Review the video tutorial *Echoview Basics and Routine Processing Workspace.avi* to see a demonstration and a more detailed description. For a description of other Echoview functionality see the Echoview Help file. See Section 8.1 to learn how to customize the *Kenai Routine Processing* workspace template.

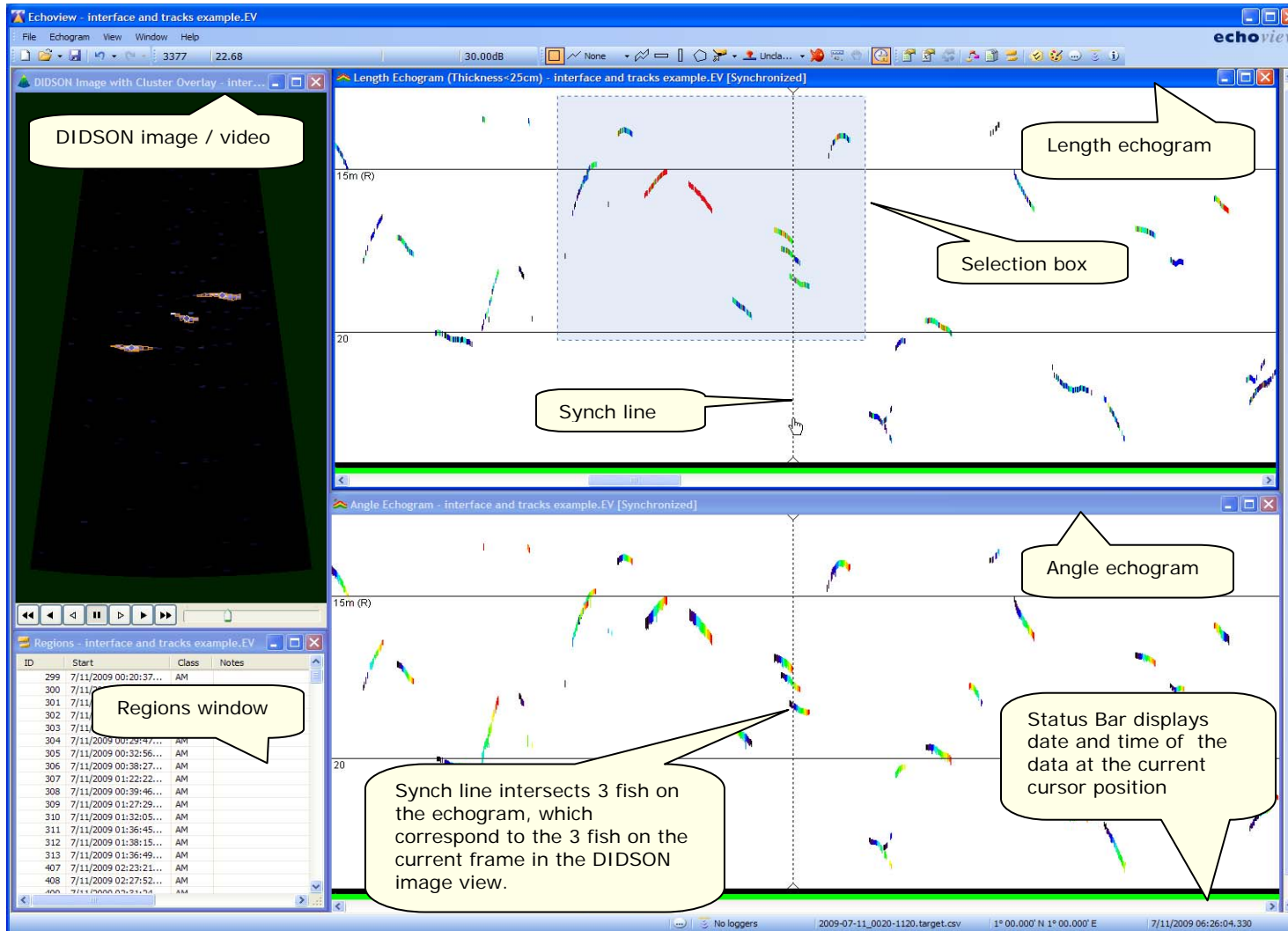


Figure 1. The four windows of the Kenai Routine Processing workspace. Also shown are the synch line, which is displayed as a vertical dashed line on both echograms, and an area that has been selected on the length echogram. A zoom view of the selected area is shown in the next Figure.

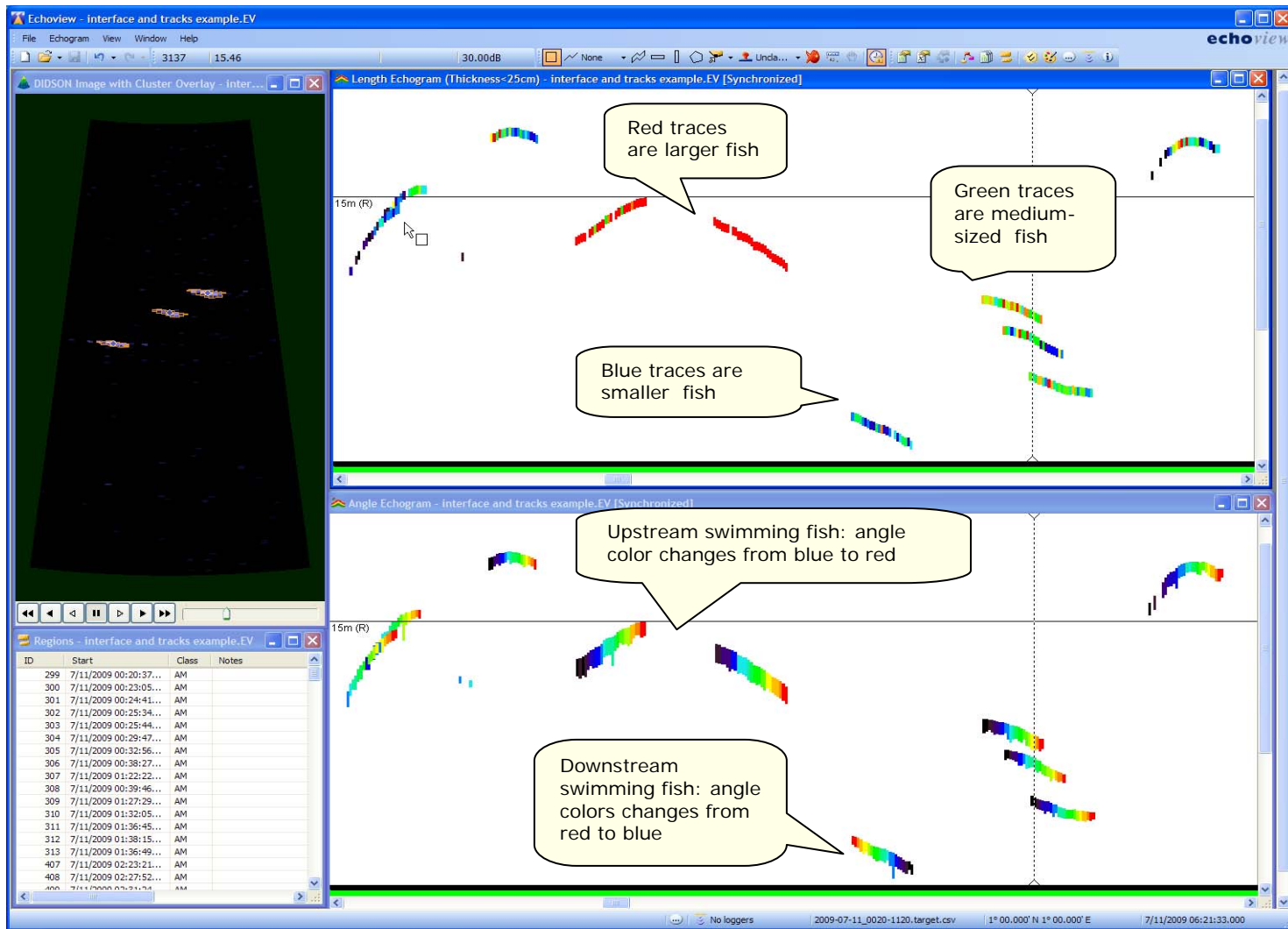
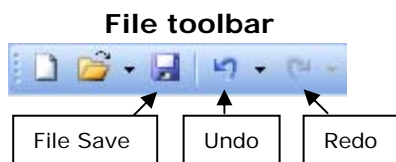


Figure 2. Display after zooming in on the selected area shown in the previous Figure. Note the different meaning of the colors in the length echogram and the angle echogram. To better understand the angle colors, move the cursor over the synch line until it turns into a hand symbol. Then click, hold down the mouse and move it left to right (= time axis), and watch the corresponding frames in the DIDSON image.

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## 4.2. Echoview toolbars

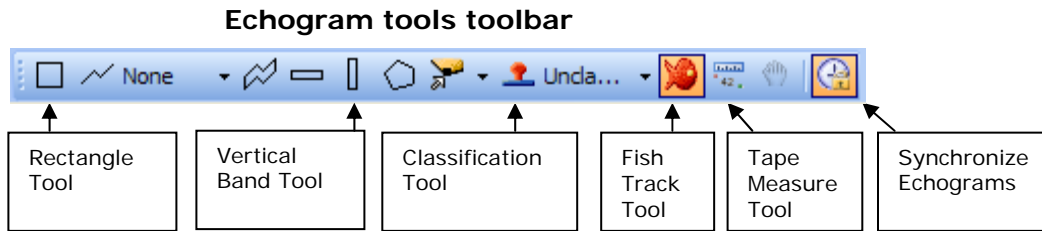
The following gives a description of the tools used for this project. For a complete description of all tools available see the Echoview Help. Many tools have shortcut keys assigned. Hovering with the mouse over a tool icon will display its shortcut.



File Save	save the EV File to disk
Undo	undo the previous action
Redo	reinstate last undo action



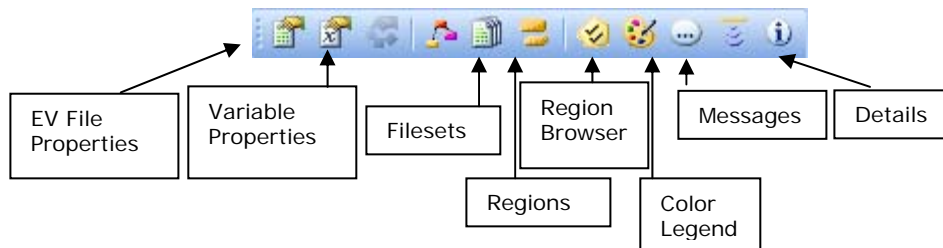
Frame Number	number of current frame (at cursor position); frames are numbered consecutively over the series of files loaded
Range	range at the cursor position
Value	value at the cursor position; depending on the active window this will be length in cm (Length Echogram), or angle in degrees (Angle Echogram) (disregard that it says "dB")
Threshold	minimum display limit (do not change)



- |                       |  |
|-----------------------|--|
| Rectangle tool (1)    | draw a rectangular selection on the echogram, used to zoom in (press S key)  |
| Vertical band tool    | use to select entire range sampled over time period defined by click and drag (can be stretched over multiple pages) |
| Classification tool   | use to classify cluster as frame pick  |
| Fish track tool (9)   | use to create and edit fish tracks   |
| Tape Measure tool     | use to measure distance on the DIDSON image  |
| Synchronize echograms | add or remove echogram or DIDSON image from auto-synchronization group   |

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### Windows and dialog boxes toolbar



EV file properties	Open the EV File Properties dialog box. Potentially use for trouble-shooting.
Variable properties	Open the Variable Properties dialog box. Potentially use for trouble-shooting.
Filesets	Open Filesets window. The Filesets window lists the data files that have been loaded. Use for quality control.
Regions	Open Regions window. Automatically opened in <i>Kenai Routine Processing</i> workspace template. Lists fish that have been tracked and additional notes if any exist. Use for quality control. Unfortunately, the <i>Regions</i> window is read-only. To edit, e.g. change the class (user initials) of a region, or to add notes you have to open the <i>Region Browser</i> .
Region browser (F4)	Open Region Browser dialog box, which displays the currently active region. Use to change the class (user initials) of a region, or to add notes.
Color Legend	Open Color Legend.
Messages	Open Messages window. This is useful for getting feedback on the processes that are initiated by the <i>Kenai EV Auto-Processor</i> .
Details	Open Details window.

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### 4.3. Echoview keyboard shortcuts

The following gives a description of the shortcut keys used in this project. Keyboard shortcuts are defined in the file *Shortcuts.cfg* (see Section 11.3) and can be customized. See the Echoview Help for more details. Many tools are context specific, i.e. require that the active window is of a particular type. A window is active when its title bar is bright blue (as opposed to faded blue). To make a window active click anywhere in it. The *Shortcuts.cfg* provided with this manual assigns the following keys:

When the Length or Angle Echogram are active

F	page forward 80% of the window length, holding the key down will page forward until you release
R	page reverse 80% of the window length, holding the key down will page reverse until you release
Home	scroll echogram to the beginning of the data files loaded
End	scroll echogram to the end of the data files loaded
S	zoom the echogram to a selected area
W	zoom out to previous extent
U	unzoom
A	synchronize zoom of echograms (may have to unzoom DIDSON image)
9	activate track editing tool
1	activate rectangle tool (default tool)
K	track fish with current settings (first select area to be tracked)
Shift+K	open fish track dialog (allows assignment of region class, - this can be used to assign user initials) (first select area to be tracked)
Q	use with the track editing tool active to merge tracks
Ctrl+X	delete track after having drawn a box that encompasses the beginning of the track
Delete	delete active track (first make track active by clicking within its border, - border will become animated)
G	use with the track editing tool active to add echo to track (first activate track by clicking within its border, - border will become animated -, then box the top of the echo you want to add and press G)

- 
- H use with the track editing tool active to remove echo from track (first activate track by clicking within its border, - border will become animated, then box the top of the echo you want to remove and press H)
  - Z use with the track editing tool active to create fish track from targets ("force track")
  - F4 open and close *Region Browser* dialog to assign class (user initials) or to add notes to track

When the DIDSON image is active

- Spacebar toggles play/pause
- Right Arrow play 1 frame forward, pressing down the Right Arrow key plays forward until you release the key
- Left Arrow plays 1 frame reverse, pressing down the Left Arrow key plays reverse until you release the key
- D toggles the display of the cluster outlines, turn cluster outlines off and on to see how well they correspond to what you visually perceive to be the fish image
- Ctrl+M toggles between the frame rate at which the data were collected and the maximum replay rate

#### 4.4. Echogram patterns to look for

The following figures show the echogram patterns to look for in Kenai River data. In each figure you see the date and time of the data in the status bar in the lower right corner:

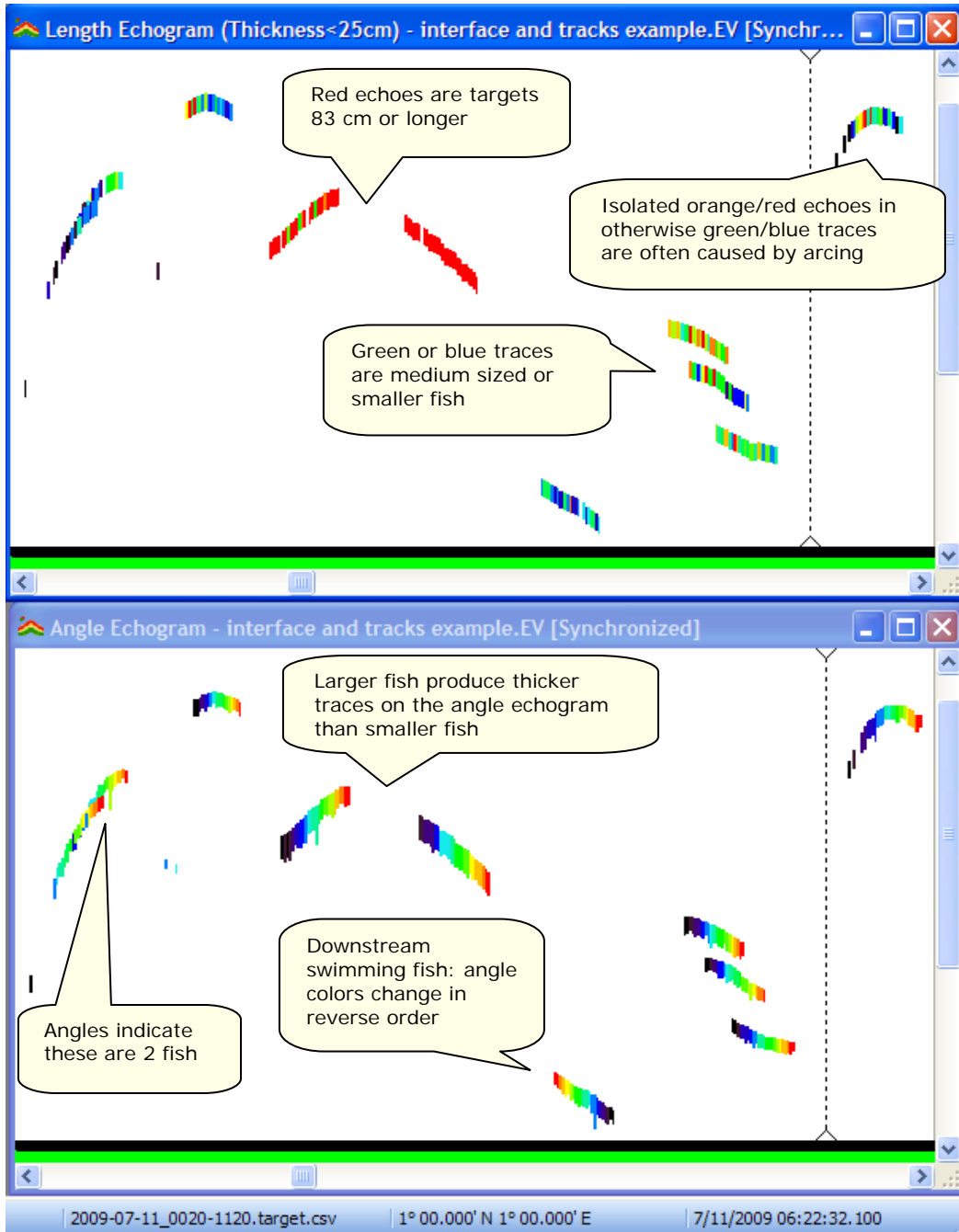


Figure 3. Fish of different size, upstream versus downstream, one closely spaced pair, and the typical appearance of arcing echoes on the length echogram.



Figure 4. Not all fish traces are as clean and solid as those shown in the previous figure. Depending on the tidal stage and fish behavior the traces may be disrupted. This happens especially when the fish change range rapidly. Note on the Length Echogram it is impossible to tell whether the two traces at the top belong to one fish or two. Looking at the progression of the colors on the Angle Echogram it is obvious that it is the disrupted trace of one fish. In total, this echogram snippet shows the disrupted traces of 3 fish. To determine whether a group of echoes belongs to one or multiple fish one can also review the DIDSON video. However, usually it is immediately obvious on the Angle Echogram, which can save a considerable amount of time.

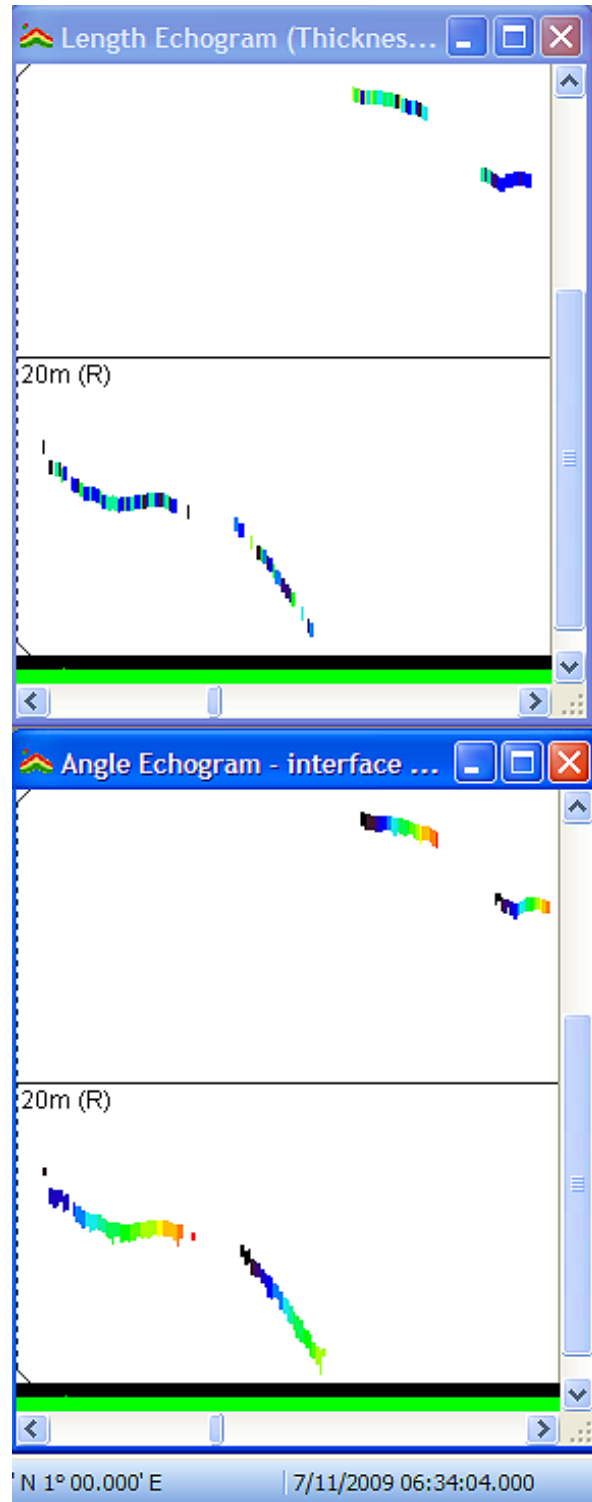


Figure 5. Multiple fish passing head to tail, not to be confused with the disrupted traces of single fish shown in the previous Figure. Here the colors of each trace start at the opposite end of the color spectrum compared to the color at the end of the preceding trace. In total, this echogram snippet shows the traces of 4 fish.

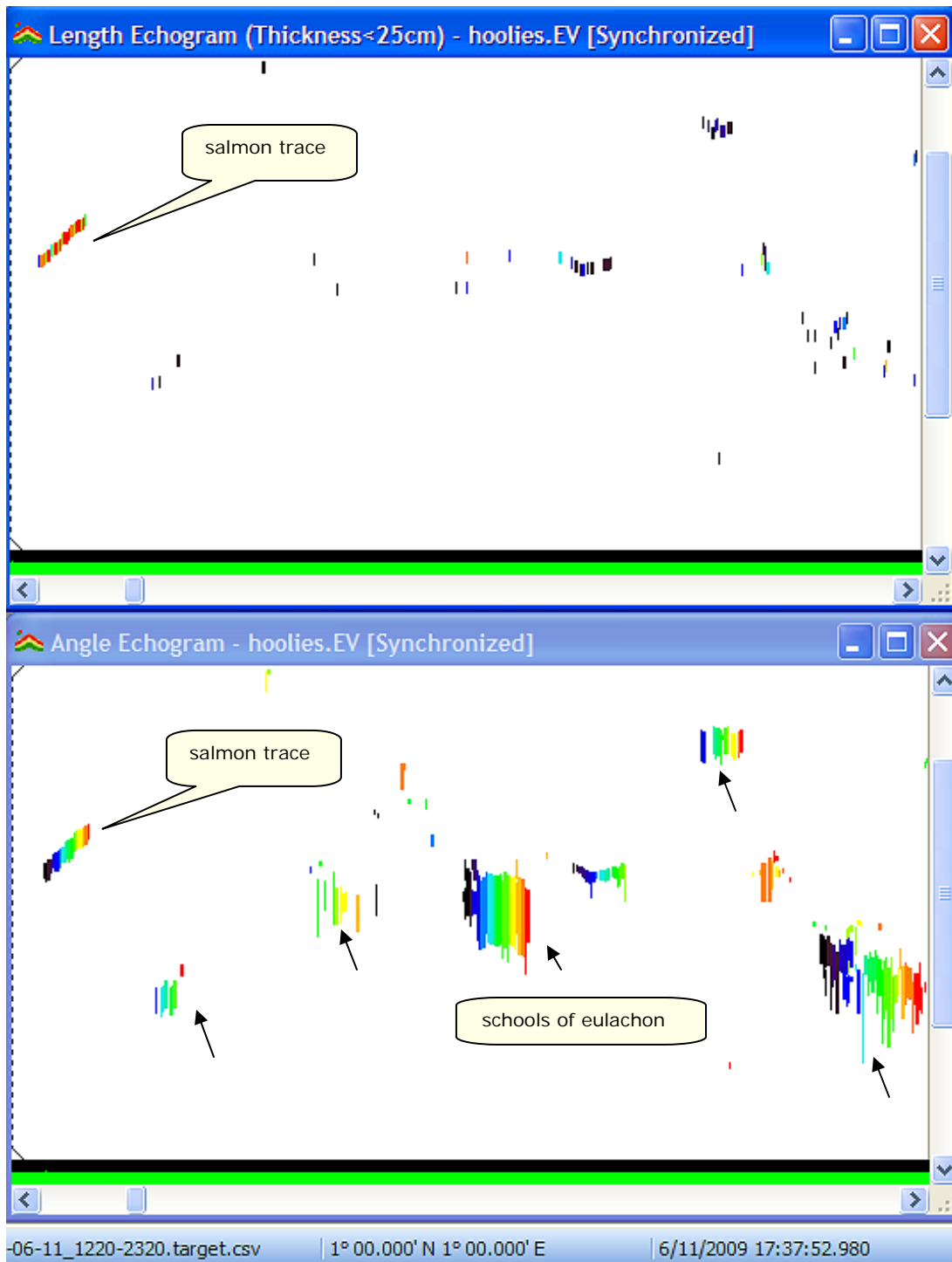
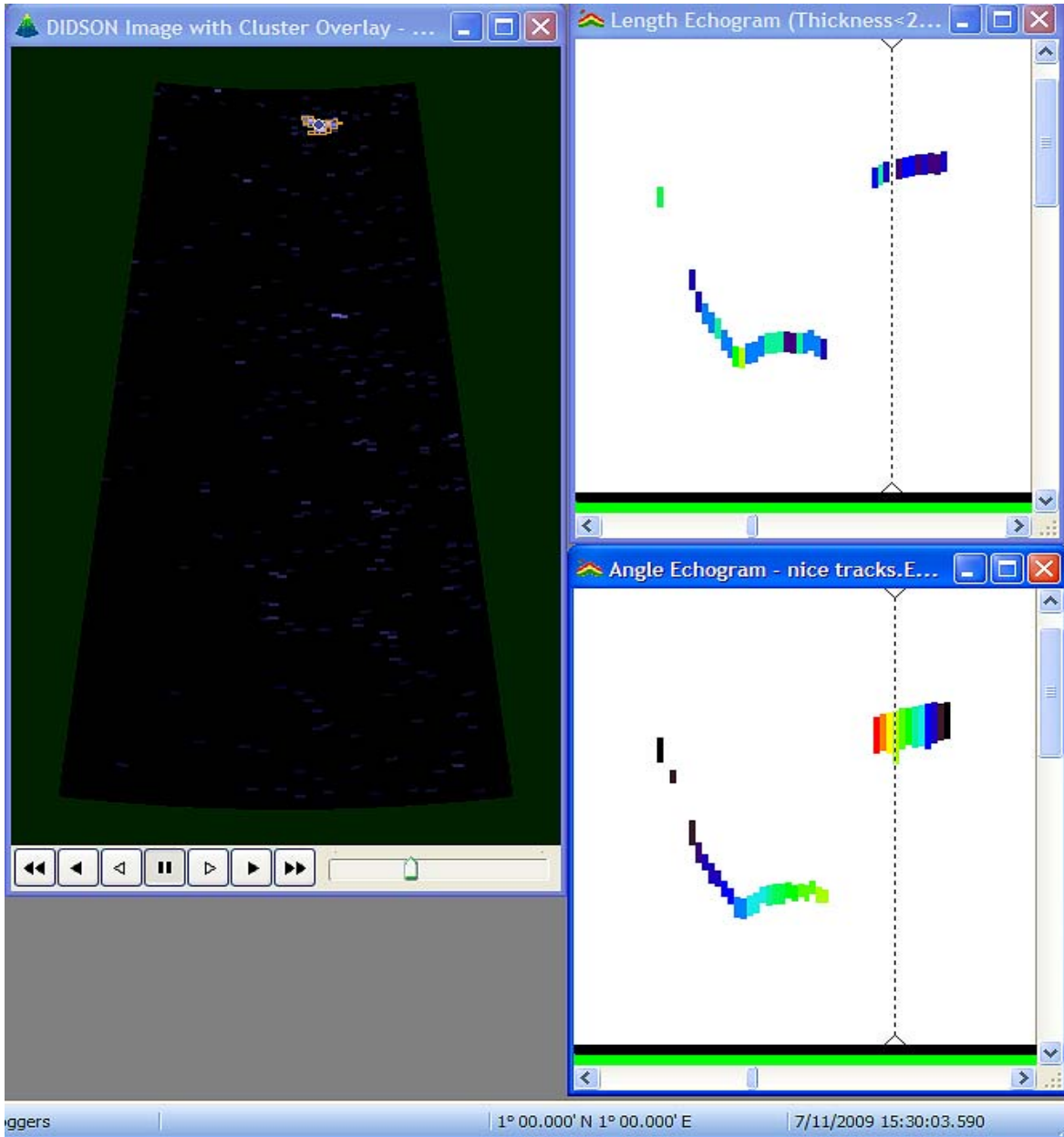
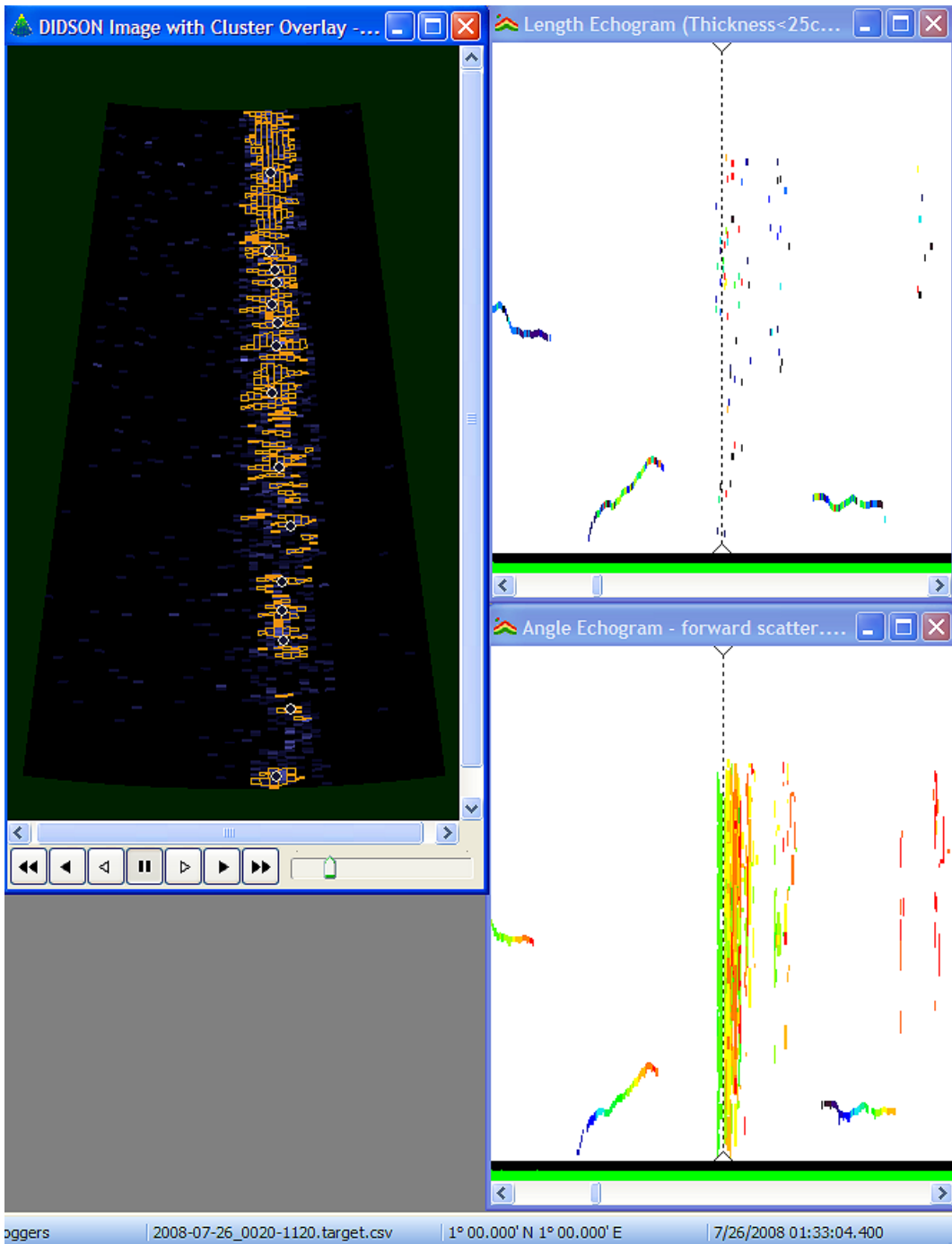


Figure 6. The trace of a salmon compared to schools of eulachon. The cluster detection algorithm joins closely spaced fish. This transforms dense schools of eulachon into large clusters that produce striking patterns on the Angle Echogram. On the Length Echogram echoes are filtered by thickness. This removes most echoes produced by the eulachon schools, which now show up only as faint speckles.



**Figure 7.** Downstream moving target other than salmon. The angle echogram clearly shows that its echoes are thicker and that its angles change in reverse order, compared to the fish that passed before. Be aware that the appearance of thickness depends on the zoom level. Look at the thickness of traces relative to each other. Also note compact shape of corresponding cluster in DIDSON image. Press the D key to toggle the outline off so you can better see the underlying image. This is obviously not a live salmon.



**Figure 8. Forward scatter. Sometimes targets that pass close to the transducer scatter sound towards the river bottom which then lights up temporarily. Similar to the schools of eulachon the echoes are merged into one giant cluster which is very obvious on the Angle Echogram.**

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## 4.5. Tracking procedure

Make sure you are familiar with the basics of echogram interpretation (see previous section) before you start tracking fish. Fish tracking refers to the process of grouping echoes that belong to the same fish into one track. This is necessary for two reasons: First, the number of tracks tells us how many fish have been detected. And secondly, grouping echoes into tracks is key to the automated estimation of fish length. As the fish passes through the beam its image is recorded over a series of frames. On some frames the detected cluster is a poor representation of the fish, on others it is better. Over the course of the development of this semi-automated approach, we have found that using an algorithm that takes the mean (or in some cases the maximum) length observed within a given track provides a good estimate of the length that a person would measure manually on a chosen DIDSON image of the fish. However, keep in mind that the success of this auto-measure depends on the accuracy of the tracks.

Echoview has a tracking algorithm (“auto-tracker”) that performs very well with clean data. Overall, Kenai River DIDSON data are very clean. However, some tide stages and erratic fish behavior can create challenges for the auto-tracker. It will make mistakes. We have found the results improve significantly if the auto-tracking algorithm executes under human guidance, hence the term “semi-automatic”. The goal of the human “supervisor” is to improve the performance of the auto-tracker with a minimum amount of effort. Before you read on we recommend you watch the video demonstration.

Start the tracking session by opening a newly created EV file. With the Length Echogram active, draw a box encompassing the entire range sampled but only approximately two thirds of the page width and press S to zoom in. The idea is to adjust the zoom level such that you can see the colors of the individual echoes fairly well while fitting as long a time period on the page as possible. At the beginning you may want to restrict the display to a shorter time period (i.e. make the zoom box narrower), which stretches the echoes more and makes the colors easier to see. After you have gained more experience you may be able to work with larger sections at a time.

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With the Length Echogram active, click the *Variable Properties* button to open the Variable Properties and go to the *Regions* tab. Make sure your class (user initials) is checked so tracks with your initials will be displayed on the echogram.

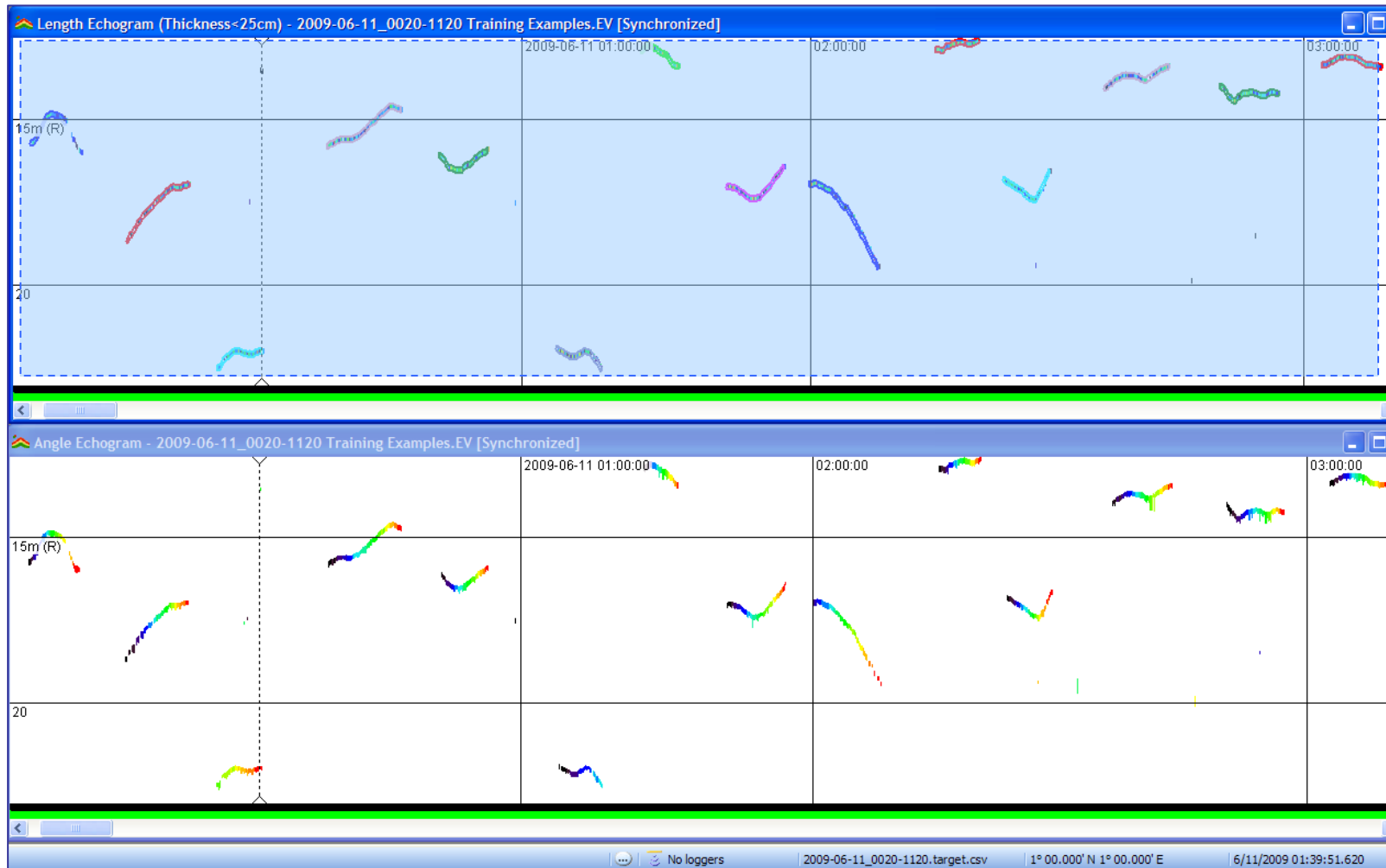
Figure 9 shows an example of very clean data, which the auto-tracker can track perfectly. Here all you have to do is draw one box over the entire page and hit K. If you are at the beginning of a new EV file hit Shift+K instead. This opens a dialog box that allows you to assign your initials (in the *Assign class* drop-down box) to the tracks. After assigning a class press *Detect*. The selected class will be assigned to each new track for the remainder of the file, i.e. from here on you only need to hit K. One exception are manually created tracks (“forced tracks”) which we will discuss on page 34. Press F to page forward.

If the echogram stays very clean you can stretch the selection box over multiple pages. Start drawing either a box or a vertical band (see vertical band tool) and — without releasing the mouse button — press F to page forward. When you release the mouse button the selection will stop expanding.

It will not take you long to get a sense of what the auto-tracker does well and where it runs into problems. Sometimes the amount of manual editing required can be reduced by anticipating the errors the auto-tracker is likely to make and preventing them from occurring in the first place.

There are four types of problems to look for:

- Disrupted traces producing fragmented tracks
- Joined clusters producing significant overestimates of length
- Missed short traces
- Convolved traces that cannot be tracked



**Figure 9. Very clean traces are tracked perfectly by the auto-tracker. Entire page (14 fish) can be tracked with 1 box. No edits or video review are necessary.**

---

**Disrupted traces** are common under conditions that make the fish change range rapidly. Not only do these traces show gaps that need to be bridged by the tracker but the gaps are often accompanied by changes in the trajectory. Imagine trying to keep track of a dodging rabbit that keeps disappearing behind trees. The following four figures show examples of when this error occurs and how to solve or avoid it.

Sometimes the easiest solution is to restrict the auto-tracker to portions of the trace that do not have these problems. This is done by drawing boxes on the echogram that exclude the problem areas. Overall, this is still considerably faster than measuring each fish manually. The important point is that in the end there is one track per fish. The track does not need to contain every echo of the fish.

An alternative option is to join broken track fragments or delete fragments that are not needed. This requires one more step but, depending on how many good tracks can be captured with one big tracking box, it may be preferable over the “prevention strategy” of drawing multiple smaller boxes. Some of it may also be personal preference. Experiment with both options and see what you prefer.

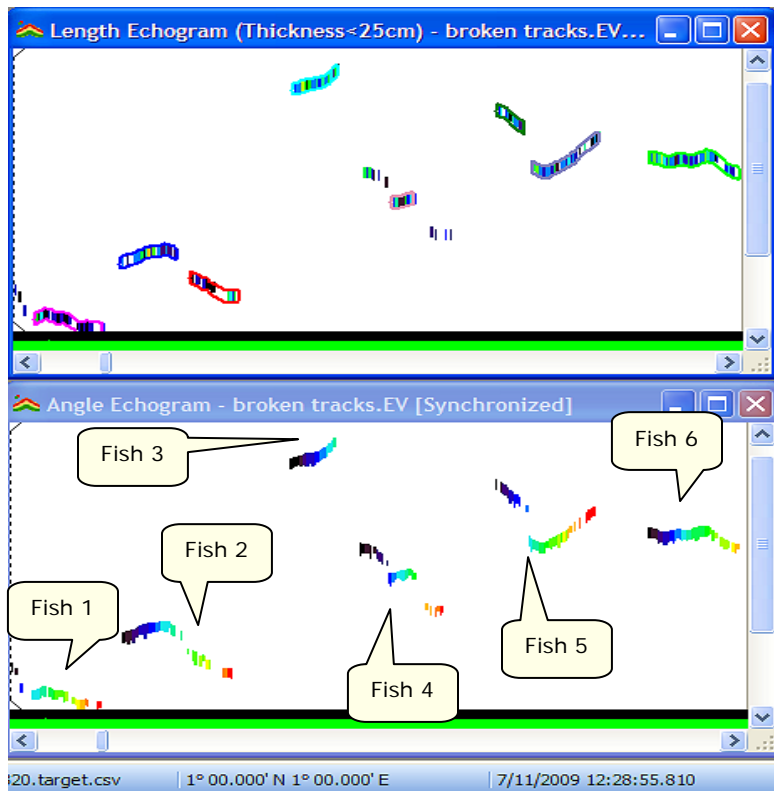


Figure 10. Disrupted traces. If these 6 fish are tracked with 1 box 2 errors will occur that need to be corrected: Fish 2 and 5 are split into 2 track fragments each. Three possible solutions are shown in the next figures. (Note there is no need to add the missed echoes to the track of fish 4.)

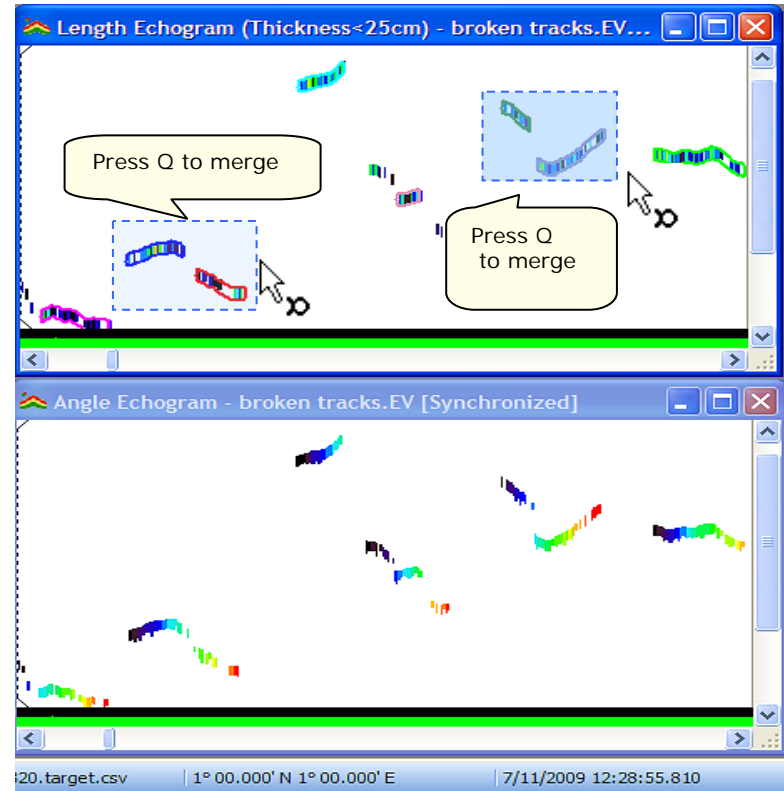


Figure 11. Disrupted traces — Solution 1. With the fish track editing tool active, draw a box around track fragments and hit Q to merge. Alternatively, click in one track fragment to make it active, move mouse over second track fragment and hit Q.

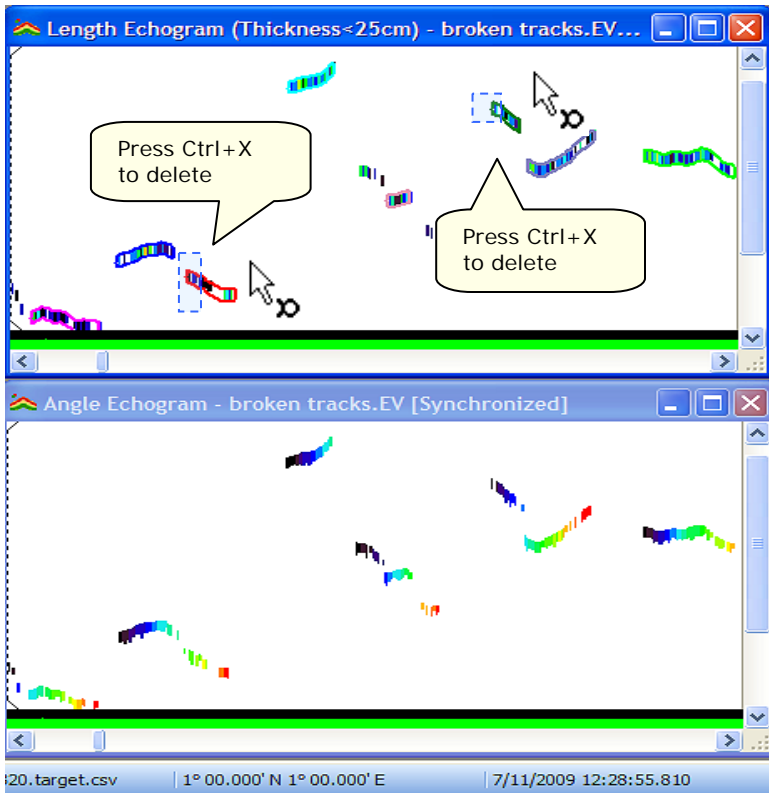


Figure 12. Disrupted traces — Solution 2. Draw a box that encompasses the beginning of track fragments that are not needed and hit Ctrl+X to delete. Keep the fragment that shows better clusters. As a rule of thumb keep the fragment that looks more “solid”.

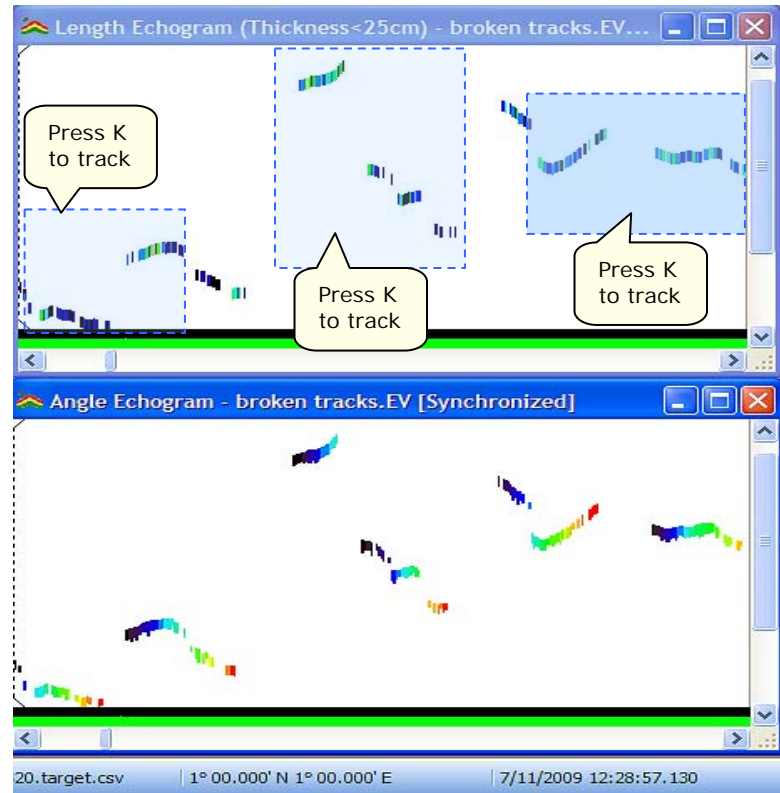
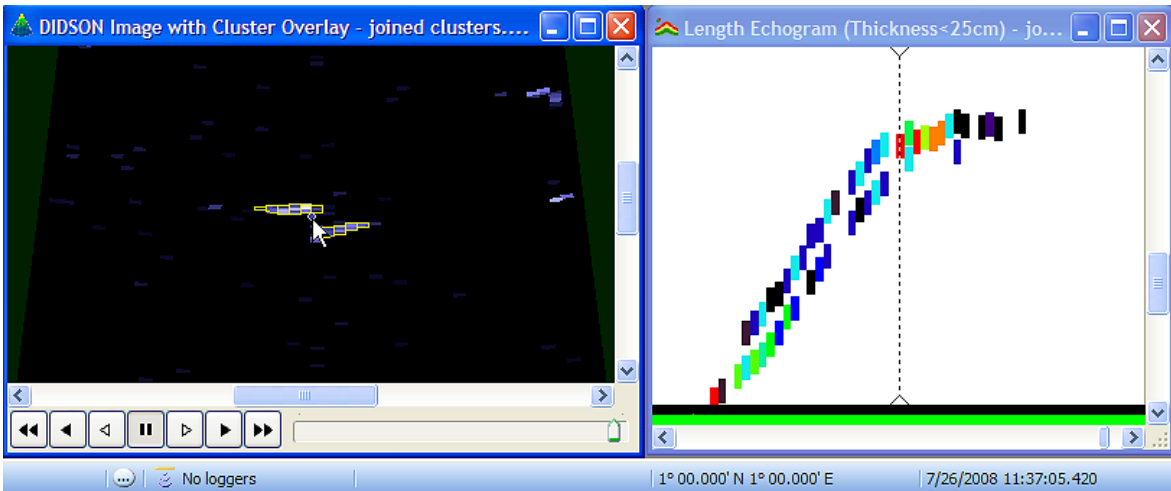


Figure 13. Disrupted traces — Solution 3. With some experience you can anticipate where the tracks will fragment and draw the tracking boxes such that only 1 fragment per fish gets tracked. No editing is required if the auto-tracker is restricted to the 3 boxes shown.

**Joined clusters** typically occur with very closely spaced sockeye salmon. This typically shows as intertwining blue to blue-green traces that turn red as two or more traces merge. To confirm that this is what is happening review the video. If you are reasonably certain that the fish in question are sockeye, because of the way they behave and their uniform size, simply skip the entire group of fish. Keep in mind the goal is to estimate the number of Chinook salmon. This means track every potential Chinook salmon plus a good number of sockeye salmon. Since there are usually plenty of easy sockeye traces in each file, it is acceptable to skip groups of closely spaced sockeye which would otherwise be difficult to track. If you still want to include at least some of the fish restrict the tracking box to portions of the traces that show no sign of merged clusters (Figure 14).

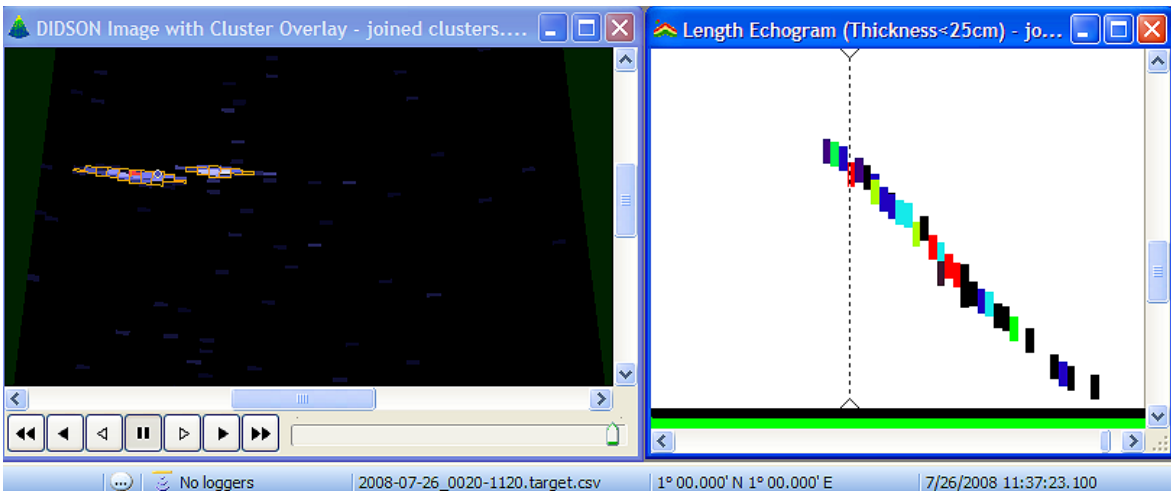


Figure 14. With closely spaced fish make sure the tracks do not include joined clusters.



**Figure 15.** Clusters are joined when their centroids are within 20 cm of each other. (The intention is to join tails to their bodies when they become separated.) If it is not obvious whether two clusters are joined or not run the mouse over the circle that marks the cluster centroid. The outline of the entire cluster will turn yellow. With the DIDSON window active press D to toggle the outline on and off to see how many fish images are underneath.

Occasionally, you may see pairs of fish that swim so closely head to tail that their clusters as well as their traces merge. When this happens you will see a trace that has a conspicuously large variation in its length colors, e.g. red echoes next to dark blue or black.



**Figure 16.** Very closely spaced pair of fish traveling head to tail. If at least one of them is a potential Chinook salmon you may have to pick a frame (see page 35).

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Note, aside from joined clusters, overestimates of cluster length also occur when the target arcs. This is an artifact most often seen when a fish is at relatively close range and broadside to a beam's center axis. The reflected echo can then be so strong that it causes interference on adjacent beams, creating a bright arc. While this causes the length of the cluster on that given frame to be overestimated it has little effect on the results because these echoes are filtered out after the data have been tracked. The arc filter is applied before the echoes of each fish are summarized to produce a fish length estimate. It is based on the fact that arcing clusters span a very narrow range extent, compared to their overall length. This is usually not true for joined clusters of two or more fish. Because joined cluster are not easily detected by the arc filter, it is important that they are not included in the tracks.

**Missed short traces.** The auto-tracker requires a minimum of 10 echoes to accept a track. Occasionally the auto-tracker skips traces because they are too short. This typically happens at close range, especially when a fish cuts across one of the corners. A fish passing at close range will spend less time in the beam, and thus be seen on fewer frames, than a similarly sized fish swimming through at the same speed but at a farther range where the beam is wider and therefore takes longer to traverse. If the missed trace is clearly a sockeye you may ignore it. If there is any doubt make sure to include it. Figure 17 shows how to create a track on short traces. This is also called "forcing a track" because it overrides the track acceptance criteria of the tracking algorithm. When the track is created the *Region Browser* dialog box will pop up. It can be dismissed (and called back) with *F4*. The first time you force the creation of a track in your session make sure the *Region Browser* shows the correct class (user initials) assignment. If it is not correct select your initials from the drop-down box at the top of the *Region Browser* window.

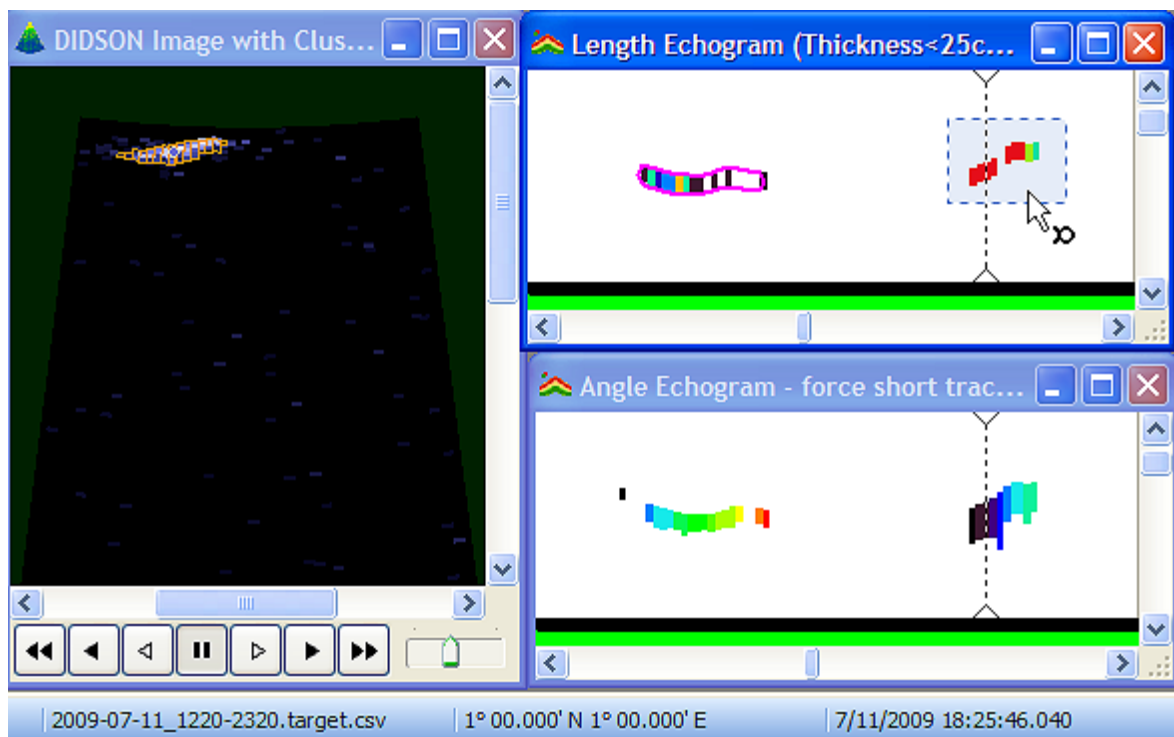


Figure 17. The auto-tracker skips the large fish because its image was captured on fewer than 10 frames. With the track editing tool active, force the track by drawing a box around its echoes and then press Z (or alternatively, click with the right mouse button and select *Create fish track from targets*).

**Convolut ed traces that are difficult to track.** On rare occasions you may encounter fish that mill or chase one another. This creates convolut ed traces that are difficult to follow by eye, let alone track. This situation requires a careful review of the DIDSON video. Not only are these traces difficult to track but, because of the steep (i.e. oblique) aspect angle of the fish, the cluster length tends to underestimate the length of the fish. If the fish are deemed potential Chinook salmon select a frame where the fish image is represented reasonably well by the outline of its corresponding cluster. After you have found a suitable frame make the DIDSON image window the active window, select the Classification tool, move the cursor over the cluster until it turns yellow and click. This will classify the cluster as a “Frame Pick” and mark the cluster with a label. Now, in order to get this information carried over into the data export you have to make sure that the echo corresponding to the marked cluster is part of a track. If there are more echoes adjacent to the chosen one you can simply let the auto-tracker create a track. If the auto-tracker cannot create the track because there are not enough echoes, force the track as described on the previous page. A track can be forced on a single echo. It does not matter

whether other echoes in the track are “good” clusters or not. If one of the echoes is marked as a “Frame Pick” then its length will override all other echoes in the same track.

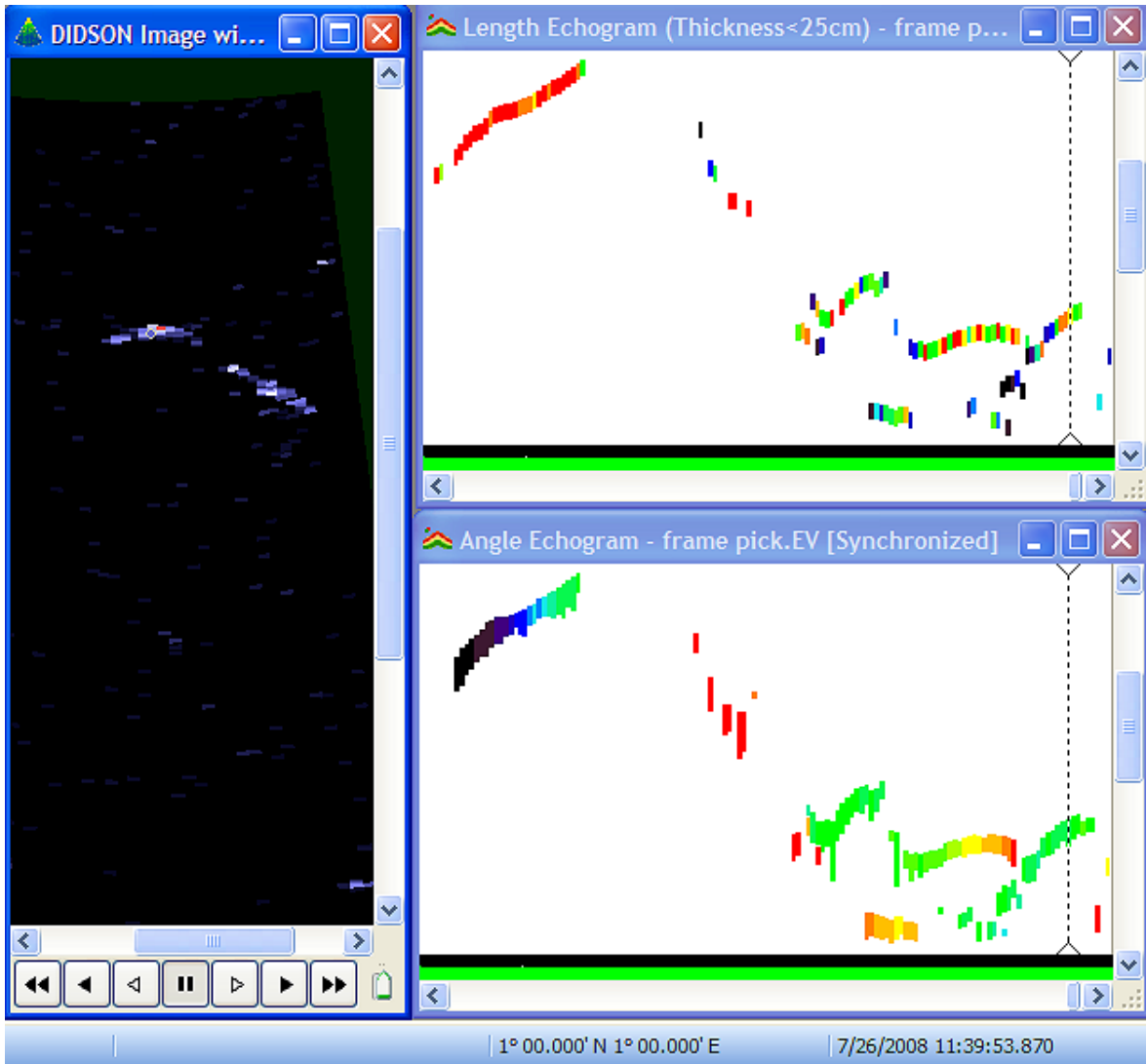


Figure 18. Complex swimming behavior of two large fish that are probably Chinook salmon. The first fish cuts the top left corner of the DIDSON image (therefore the angle colors of its trace do not progress through the entire color spectrum). It leaves a good trace of echoes that are easy to track. After it disappears, two fish reappear close to the exit point of the first fish (one of them is presumably the same fish). The second fish has few echoes whose corresponding clusters show its full length. With the DIDSON image and the classification tool active, select the best cluster and mark it as “Frame Pick”. Then switch to the Length Echogram and create a track that includes the corresponding echo.

---

Don't track fish or objects that are obviously not salmon (see Figures 6 and 7 for examples). When you review the result of the auto-tracker look for downstream moving traces and traces that have a thickness pattern that is conspicuously different from those of salmon. If tracks have been created for traces you are sure are not salmon delete them.

As you are working through the EV file, periodically click the *File Save* button (or press Ctrl+S) to save your work. Fish tracks are saved to the EV file where the *Kenai Auto Processor* will retrieve them in the *Export Fish Info* routine (see next section).

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## Tracking Guidelines – Summary

- When traces are very clean track entire page or stretch tracking box across multiple pages
- When traces are broken, look at angle echogram to see which echoes belong together, -either adjust the tracking box to avoid fragmented tracks or edit after tracking
- Be careful with closely spaced groups of sockeye. Make sure you do not include echoes where the clusters of adjacent fish have been joined. If it is obvious that the fish are sockeye skip them, otherwise draw smaller tracking boxes over portions of the trace.
- Review traces that have conspicuously large variation of length colors (e.g., reds mixed with blues). If it is obvious that the fish are sockeye skip them, otherwise draw smaller tracking boxes over portions of the trace or create a frame pick.
- At close range look for traces that have been skipped by the auto-tracker because they are too short. Skip if obvious sockeye, else force track.
- When trajectories are convoluted and not easily interpreted on the angle echogram review the DIDSON video.
- When fish pass through at a very oblique angle review the DIDSON video. If very few clusters give a reasonable representation of the fish length, mark one as frame pick. Make sure you create a track that includes the corresponding echo.
- Skip fish or objects that are obviously not salmon (e.g. eulachon, fillets, flounders, debris)
- Remember, the goal is to estimate the number of Chinook salmon. This means track every potential Chinook salmon plus a good number of sockeye salmon. Since there are usually plenty of easy sockeye traces in each file, trying to resolve closely spaced groups of obvious sockeye salmon is not worth the time.

---

## 5. *Export fish information (Kenai EV Auto-Processor)*

After you have tracked a batch of EV files export the fish information with the *Kenai EV Auto-Processor*:

Select the ***Process Export fish info.***

Select ***Files to process.*** Select all the EV files you want to process.

Click ***Start Processing.***

This process takes approximately 1 minute per 10-minute stratum per day. It creates a series of files, one for each EV file, with the same base name of the EV file added to the extension (targets).csv, which is not to be confused with the file .targets.csv (no parentheses in the name) generated for the detected clusters (see Section 3).

---

## 6. Summarize fish information

After the fish information has been exported as (targets).csv files it has to be summarized to calculate a length estimate for each fish and its direction of travel. This process can be automated in SAS or Access. In the interim, for testing purposes you can also do it manually in Excel.

In the csv files each record represents an echo (= fish image) on a given frame. The field *Region\_ID* is the ID of the fish. Each series of records that share the same *Region\_ID* corresponds to one fish track.

The following fields are pertinent:

*Region\_ID* (column A)

*Ping\_date* (column G)

*Ping\_time* (column H)

*Target\_range* (column I)

*Angle\_major\_axis* (column M)

*Target\_length* (column U)

*Target\_area* (column X)

*Target\_length\_across\_beams* (column AC)

*Target\_class* (column AE)

Summarize each fish as follows:

ID = First of *Region\_ID*

Date = First of *Ping\_date*

Time = First of *Ping\_time*

Range = Mean of *Target\_range*

---

## Direction

For data collected on the right side of the river:

If First of *Angle\_major\_axis* < Last of *Angle\_major\_axis*

Direction = "upstream"

Else

Direction = "downstream"

EndIf

For data collected on the left side of the river use the opposite.

## AutoLength

Apply logic in the following order:

1. For fish tracks that contain an echo marked as frame pick (*Target\_class* = "Frame Pick")

AutoLength = *Target\_length* of the echo marked as frame pick

2. For the echoes of all remaining fish create 2 calculated fields:

ArcIndicator

= [*Target\_length*] / ([*Target\_area*] / [*Target\_length\_across\_beams*])

High ArcIndicator values indicate clusters that are long relative to their thickness.

FillsBeam

If [*Target\_length\_across\_beams*] > ([*Target\_range*]\*25 – 30)

FillsBeam = 1

Else

FillsBeam = 0

EndIf

Note FillsBeam = 1 flags fish that are large relative to the beam diameter.

3. Remove echoes for which ArcIndicator > 12

This step removes fish images that are likely to have suffered artificial

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elongation due to arcing. The cutoff value of 12 has been chosen empirically based on a visual assessment of the relationship between the ArcIndicator value and the occurrence of the arcing artifact.

4. Calculate AutoLength:

If (Sum of *FillsBeam* > 0) And (*Target\_range* < 7)

    AutoLength = Max of *Target\_Length*

Else

    AutoLength = Mean of *Target\_Length*

EndIf

The idea behind this step is that for large fish at close range there will be many frames where the fish is only partially in the beam (even when its centroid is within 4 degrees of the center). When this is likely to be the case estimate fish length as the maximum of the lengths of its images. Otherwise use the mean of the lengths of its images.

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## 7. *Quality assurance*

### 7.1. **Are the filesets complete?**

Check whether the EV files contain complete filesets. Open the EV file and press F10 to display the filesets window. Look at the tab *DIDSON CSOT BS*, which lists all the data files that have been loaded. Check whether they are a complete series, i.e. there are no missing hours. If hours are missing check whether a corresponding CSOT file exists. If CSOT files have been overlooked see the troubleshooting guide. Occasionally it may happen that an original ddf file does not contain a single fish. In this case the CSOT process will not detect any moving targets and therefore not generate a CSOT file. That is fine.

Check whether for each stratum you have a complete set of EV files. It is probably best to create EV files for regular intervals. For example, if you process the files in 4 batches per day you will have the following series of EV files:

YYYY-MM-DD\_00mm-05mm.EV

YYYY-MM-DD\_06mm-11mm.EV

YYYY-MM-DD\_12mm-17mm.EV

YYYY-MM-DD\_18mm-23mm.EV

### 7.2. **Check background subtraction**

If the echograms show unusual amounts of noise (other than forward scatter), or tracking is very difficult see the troubleshooting tips on background subtraction.

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### **7.3. Do detected clusters match fish images?**

Is the average quality of the clusters, i.e. the degree to which they capture what we perceive to be the fish image, similar to that of the test data? If not contact [am@aquacoustics.com](mailto:am@aquacoustics.com) for support.

### **7.4. Check notes**

If you are checking an EV file that has been tracked by somebody else check whether the previous person made any notes. In the Regions Table click the Notes field (clicking the field header a second time will reverse the sort order). This will sort the table and put those records at the top that have notes associated with them. If there are tracks with notes step through them. When you double-click an entry the echogram will scroll to the corresponding time. Drag the synch line over the sequence in question and review.

### **7.5. Check fish tracks**

Check the fish tracks following the guide lines on page 38. Look for tracking errors and missed fish. Be especially watchful for short traces of large fish at close range that may have been missed. If a trace is yellow, orange or red on the Length Echogram it is likely to be a large fish even when the trace is short. Review the video and force the track if necessary (see page 34).

### **7.6. Have frame picks been made? If so are they incorporated in a track?**

To check whether Frame Picks have been made go to the menu item *View... Open Target Metadata...* If the table is empty there are no Frame Picks in the current EV file. If you see records in the *Target Metadata* Table make sure their class is "Frame Pick". Double click the record to view the associated cluster. Make sure the cluster marked as Frame Pick is part of a track.

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## 8. *Miscellaneous and advanced topics*

### 8.1. **How to customize an Echoview workspace template**

To customize the Routine Processing workspace open an EV file that has been created with the Kenai EV Auto Processor. After you have rearranged the windows as desired save the EV file under a new name (this will be the name of your new template) in

C:\Program Files\Myriax\Echoview\Echoview4\Templates

The next time you open the Kenai EV Auto Processor you will see your new template added to the list of available workspace templates.

### 8.2. **How to quickly change the workspace of existing EV files**

To quickly change the workspace of existing EV files open the Kenai EV Auto Processor. Select the Process *Change workspace*. From the list of workspace templates select the template you wish to apply. Select the files to process and click Start Processing. This process is very fast.

### 8.3. **How to add notes to the echogram or individual tracks**

To add notes to an individual track make it active, either by clicking on it on the echogram or double-clicking its record in the *Regions* Table. Then press F4 to open the *Region Browser* window and enter notes in the text box.

To add notes to a particular time in the echogram press Ctrl+J. This will insert a marker region at the time of the current cursor position. In the Region Browser window select the Class Notes. To make the new marker region visible on the echogram open the *Variable Properties* window and check the Notes Class in the *Regions* Tab. See Echoview Help for more information on region types and classes.

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## 8.4. How to customize shortcut keys

See Echoview Help on user-defined keyboard shortcuts.

## 8.5. How to add a region class

If you want to create a new region class for fish tracks press Shift+K to open the *Detect Tracks* dialog box and press Edit. Alternatively, open the *EV File Properties* and go to the Classes tab. See Echoview Help for more information on regions.

## 8.6. How to turn the display of track outlines and other regions on and off

The display of track outlines and other regions is set individually for each echogram by opening its *Variable Properties* and checking or unchecking the box for each class. See Echoview Help for more information on region types and classes.

## 8.7. Tail beat echograms

There is a type of echogram that often reveals patterns that are related to the tail beat of the fish. This echogram is generated from samples (as opposed to the Length and Angle Echograms, which are cluster-based), by a process that summarizes each range sample over all beams and determines its maximum intensity on the given frame. The significance of tail beat patterns is that they may be used to determine tail beat frequency, which in turn may provide clues for species identification and may also be used in bioenergetics studies. For more see:

Mueller, A. M., D. Burwen, K. Boswell, and T. Mulligan. 2010. Tail Beat Patterns in DIDSON Echograms and their Potential Use for Species Identification and Bioenergetics Studies. *Transactions of the American Fisheries Society* 139:900-910

To view the tail beat echogram in EV files that have been created with the Kenai EV Auto Processor change the workspace to Kenai Tailbeat Review. After you have applied the change in workspace open the EV file. The tail beat echogram should open automatically.

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## 9. Troubleshooting tips

### 9.1. Echoview windows do not fit screen

If the Echoview windows do not fit your screen you can resize them and save the new window arrangement as a workspace template. See 8.1.

### 9.2. Echograms appear blank

If the echograms appear blank when you first open a newly generated EV file click in one of the two echograms and press U to unzoom.

### 9.3. Echograms are very noisy

Check the background subtraction and CSOT frame removal that is done during pre-processing. Make sure the settings are as described in Section 2. You can test the process with some of the original files used during development. See folder */Semi-automated DIDSON data analysis/Test data/Processing/BS-CSOT Test/ddf*

This folder contains 3 original ddf files. Pre-process them as described in Section 2. Then open the *Compare BS-CSOT Results.EV* (in the */Solutions* folder). In the *Test Files* tab of the *Filesets* window press *Add...* and add the CSOT files you just created. After you have loaded the files press *Echogram* in the lower right of the *Filesets* window. You should now see two DIDSON image views: the Solution File and the Test File. Scroll until you find a fish. Draw a box around the fish, press S to zoom in and A to synchronize. Now run the cursor over one of samples in the Solution File and read its dB value in the Information toolbar. Do the same for the corresponding sample in the Test File. The values should be the same. Repeat for a couple more frames in the middle and towards the end of the fileset.

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## 9.4. Synch line not visible on echograms

There appears to be a bug in Echoview 4.90.44. When you first open an EV file that has been newly created by the Kenai EV Auto-Processor, the DIDSON image is at its end position even though it is auto-synchronized with the echograms which are set to the beginning of the fileset. As a workaround solution manually move the frame slider of the DIDSON image to the beginning of the fileset. As soon as you move the slider the synch line will appear on the echograms.

## 9.5. I pressed K but don't see any tracks appear on the echogram

Look in the *Regions* table to see which class the last tracks were assigned. If the tracks had the wrong class assigned, select them in the *Regions* table and delete them. (Alternatively, you may reassign the class of selected tracks. See Echoview Help on *Regions*.) Redraw your tracking box and press Shift+K to assign the correct class. If the tracks are not visible even though they had the correct class assigned open the *Variable Properties* for the Length Echogram, go to the *Regions* tab and make sure the correct class is turned on.

The auto-tracker may not detect all traces. This is relatively common at close range where the traces are very short. To force the creation of a track, make the fish track editing tool active, box the echoes you want to include and press Z or alternatively, right-click and select *Create Fish Track from Targets* (see page 34).

## 9.6. Tracks are overlaid on the Angle Echogram

When a new region class is created (e.g., when you add one to mark the tracks created by a new person) it will by default be turned on every echogram, including the *Angle Echogram*. To turn the track outlines off go to the *Regions* tab in the *Variable Properties* and uncheck their class.

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## 9.7. Cannot create or edit track

Make sure the fish track editing tool is active. When active the cursor is accompanied by a fish symbol. The quickest way to do so is to press 9 on the keyboard.

## 9.8. Track editing becomes time consuming

If track editing becomes difficult because of a noisy background or because the traces are fragmented check the original ddf files. If the image quality of the original ddf files is poor the lens may have to be cleaned or the aim corrected. If the original ddf files look okay make sure the background subtraction process is working correctly. Test the background subtraction with the procedure described in 9.3.

If track editing is time consuming because the fish swim in tight groups and with fast changes in range, review the video. If the group is made up of obvious sockeye salmon skip them. If there are fish that are potentially Chinook salmon consider using the Frame Pick method (see page 35).

## 9.9. Cluster centroid or frame pick label makes it difficult to see fish image

Sometimes you may not be able to judge how well a cluster matches the fish image because the circle representing the centroid of the cluster or a frame pick label may cover the fish image. The centroid circles and labels cannot be toggled on and off. To see the image without any of the cluster detection elements press F7 to open the *Variables and Geometry Window* and double click the flow chart element (= *Variable*) labeled *Data Type Conversion*. Click the *Synchronize Echogram* button to add the new window to the current synchronization pool.

---

## 9.10. What can I do if a CSOT file has been missed?

If you discover during quality control checks that an EV file that has already been tracked misses a CSOT file in its filesets do the following: Open the EV file. Make the Length Echogram active. Make sure the tracks are displayed. Go to the menu *Echogram... Export...* and select *Region Definitions*. Specify a file name and location. Close the EV file. Now move the complete set of CSOT files that belongs to the EV file into a new folder and rerun the *Create EV files* routine (see Section 3). In the newly created EV file go to *File... Import...* and navigate to the evr file you just exported from the old EV file. In the *Variable Properties* of the Length Echogram make sure the appropriate region class is turned on. You should now see the tracks that have been created previously. Now scroll to the time period that has been overlooked and complete tracking.

## 9.11. Shortcut keys do not work as described in the manual

Overwrite the file *shortcuts.cfg* with the file provided with the manual. See section 11.3 for the correct file location. Make sure the window that is supposed to receive the keystroke is active, e.g., in order to toggle the cluster outlines (D) the DIDSON image window has to be the active window. You can click anywhere within a window to make it active.

## 9.12. Technical support

For technical support contact Anna-Maria Mueller (Aquacoustics, Inc.) at [am@aquacoustics.com](mailto:am@aquacoustics.com) or call during office hours 907-260-6341. Please let us know ahead of time if you may require assistance outside office hours.

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## 10. Glossary

**Angle Echogram** is an echogram where the colors of the echoes represent the angle at which they have been received. This is a useful visual feedback for determining direction of movement.

**Cluster** refers to the cluster of bright samples within a DIDSON image that have been detected by the Cluster Detection algorithm as a potential fish image. Cluster Detection plays a key role in the Sound Metrics CSOT process, where it is used to detect empty frames (so they can be removed), and again in the Echoview processing chain, where it is used to convert the data into a form that can be tracked. A “good cluster” is a cluster whose outline matches what we visually perceive to be a fish image. The echogram equivalent of cluster is “echo”. Echoview uses the term “target” synonymous to the echo on the echogram and “multibeam target” synonymous to the cluster on the DIDSON image.

**CSOT (Convolved samples over threshold)** is a function provided by the Sound Metrics software. It removes frames where no moving object has been detected. The name refers to the type of image processing technique used.

**CSOT file** is a file generated by the Sound Metrics CSOT process. Here we use the term to refer to ddf files that have been pre-processed, i.e. files that have empty frames removed and the background subtracted. Note: the Echoview process relies on the background having been subtracted before the data files are loaded.

**Echo** is the echogram equivalent of cluster. Used synonymously with the Echoview term “target”. (The latter tends to create confusion because the target is arguably the object in the water, as opposed to the echoes it generates. Following this logic, one target produces a series of echoes over a series of pings.)

**EV file** is an Echoview file that serves as a container for data files. It defines the type of processing that is applied to the data (it never alters the data files) and stores fish tracks and notes.

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**Evw file** is an Echoview file that stores the workspace of a given EV file. The workspace defines the types of windows that are open and how they are arranged within the main Echoview window.

**Frame Pick** refers to the method of manually marking a cluster as a “good cluster” (you “pick the frame” where the cluster gives a good representation of what you perceive to be the fish image, in particular with respect to its length). The length of a “frame picked” cluster is used as the final length estimate for this fish, i.e. the lengths of all other clusters within the track are ignored. This method is to be used on the rare occasions when a fish shows very few clusters with reasonable lengths. This typically occurs when large fish are oriented at a very steep angle towards or away from the transducer.

**Length Echogram** is an echogram where the colors of the echoes represent the length of the corresponding cluster. This is a useful visual feedback for determining the general size of fish and as a flag for artifacts that may bias the length estimates, e.g. joined clusters or fragmented clusters.

**Region** is an Echoview term for a polygon displayed on the echogram that is defined in time and range coordinates. In the context of this project we are working with fish track regions, which are used to define the group of echoes that belong to 1 fish, and marker regions that can be used to annotate the echogram. See Echoview Help for more information on region types and classes.

**Regions Window** is a table that lists all regions in the EV file. It can be used to search for notes and, with a double-click on an entry, it can be used to quickly find tracks on the echogram. It can also be used to delete regions. It cannot be used to edit region notes or change the class.

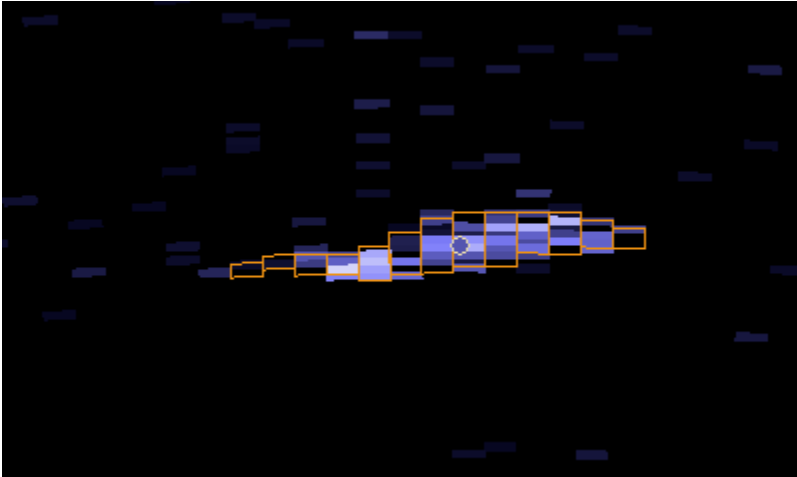
**Region Browser** is a dialog box that can be used to edit the region class and notes. It is automatically displayed when a new region is created by a process other than auto-tracking. It can also be displayed and dismissed with F4.

**Target** see Cluster and Echo.

**Target thickness** is the maximum range interval covered by the outline of samples per beam in the target. In the context of this project target refers to the Echoview “multibeam target”, which is synonymous with cluster. This property is used to filter

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echoes on the length echogram. Target thickness is an important visual clue on the angle echogram. Unusually thick traces are produced by schools of eulachon, some debris and forward scatter. See Echoview Help for more information on target thickness and how it differs from target range extent.



**Figure 19.** Target thickness. This cluster or “multibeam target” spans 13 beams. On any of these 13 beams it is 2 – 8 range samples “thick”. The target thickness is the maximum range interval covered on any individual beam, - here: 8 range samples, which translates into 15.6 cm.

**Trace** For the purpose of this manual we distinguish between trace and track. Each trace consists of a series of echoes returned by the same object or fish. The trace may or may not be tracked correctly. (In practice, the use of the terms trace and track is not very consistent. People often use them interchangeably.)

**Track** For the purpose of this manual we distinguish between trace and track. Track refers to a track region. (but see above..)

**Variable** refers to different types of data that can be derived from the source data. The source data themselves are Raw Variables. Each element shown in the *Variables and Geometry* window of the Kenai Routine Processing template represents a *Variable* or step in the processing chain.

**Workspace** defines the types of windows that are open and how they are arranged within the main Echoview window. It is saved to the .evw file that accompanies each EV File.

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# 11. Appendix

## 11.1. Echoview data processing chain

The *Kenai Routine Processing* template defines the series of Echoview processing steps that the data run through to generate the Length and Angle Echograms. Figure 20 shows the processing chain, which can be viewed in any of the EV files that are created with this template by pressing F7. This opens the so called *Variables and Geometry* window. Each step in the processing chain is also referred to by the Echoview term *Variable*. See the Echoview Help file to learn more about each type of *Variable* and the *Variables and Geometry* window. Here we will describe the general purpose and relevant settings of the 13 *Variables* of the *Kenai Routine Processing* template. For a complete documentation of all settings see the *Variable Properties* in the *Kenai Routine Processing.EV* file. During routine processing the user interacts with only three of the 13 Variables shown: the DIDSON image (Variable 7), the Length Echogram (Variable 11) and Angle Echogram (Variable 12).

**Variable 1: DIDSON CSOT BS** This is the starting point and represents the data that is loaded into the EV file, i.e. the data that has been pre-processed with the Sound Metrics CSOT empty frames removal and background subtraction routine. No threshold has been applied. Also, no transmission loss correction has been applied. During the development phase of this project we experimented with several forms of transmission loss correction but found that none of the reasonable choices (absorption coefficient based on an extrapolated function of frequency and temperature, geometric spreading term between  $N = 20$  and  $N = 40$ ) leveled the intensity over range to an extent that would allow us to work with the same intensity over the entire range sampled (30 m). We therefore decided to work with the images without transmission loss correction, as has been done for the manual measurements, which had been shown in experiments with tethered fish to correlate well with the physical length, and that over a range interval similar to that used during routine data collection.

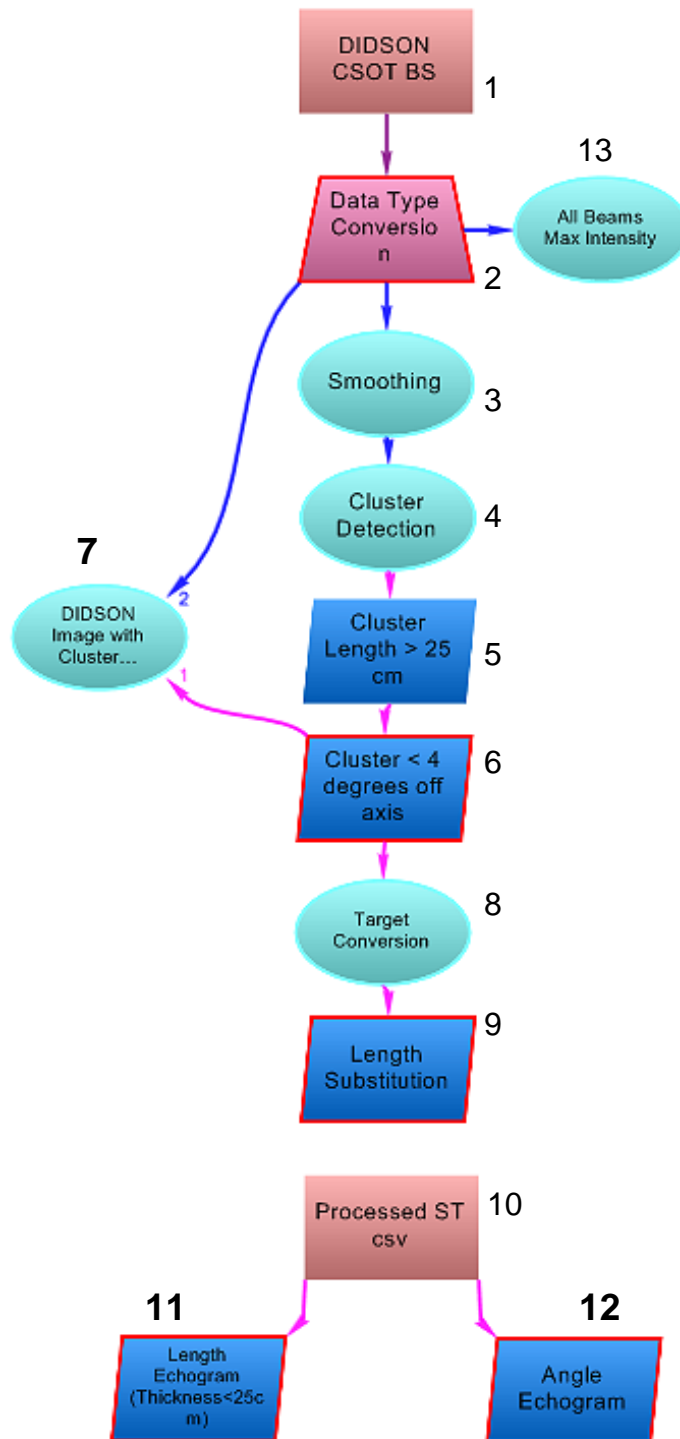


Figure 20. Data processing chain of the *Kenai Routine Processing* template. The DIDSON image and the two echograms displayed in the *Kenai Routine Processing* workspace represent the output from steps 7, 11 and 12, respectively. A brief description of each processing step is given in the text. For further information see Echoview Help on the *Variables and Geometry* window.

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**Variable 2: Data Type Conversion** Converts Variable 1 from the type “Unspecified dB” to “Multibeam Sv”. This is only necessary because the Echoview Multibeam target overlay operator (Variable 7) requires a “Multibeam Sv” type Variable as input.

**Variable 3: Smoothing** This processing step applies a 3x3 Median convolution, which is a commonly used image processing technique. The goal is to smooth the image to help join samples that are part of a given fish image into a contiguous cluster, while at the same time preserving the shape of the fish image and preventing adjacent fish from being merged into one cluster. A key parameter is the intensity data threshold applied to this Variable. Only data samples that are above this threshold are passed on to the next processing step, which is the Cluster Detection. If the threshold is lowered the clusters detected in a given range stratum will generally increase in size, if the threshold is raised the clusters will become smaller. The threshold applied to the Median Filter is therefore one of the most important parameters in the entire processing chain. The Kenai Routine Processing template uses a default threshold of 8. The Kenai EV Auto-Processor will raise the threshold to 10 for range strata starting at less than 10 m range, and lower it to 7 for range strata starting at more than 15 m. This provides an (empirically derived) approximate compensation for the transmission loss of intensity of the transmitted signal.

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**Variable 4: Cluster Detection** In Echoview this operation is called “Multibeam Target Detection”. The goal is to detect the clusters of high intensity (“bright”) samples that form the image of individual fish. The clusters are defined by the threshold that is applied to the preceding variable (i.e. operand) and the values of the target linking parameters, which are:

Link target clusters	on
Seed threshold (cm <sup>2</sup> )	350
Satellite threshold (cm <sup>2</sup> )	5
Link distance (m)	0.20
Link satellite clusters	on
Retain unlinked satellites	off

The goal of the linking procedure is to solve the problem of fragmented clusters, i.e. where the image of one fish generates several smaller clusters. This typically happens when fish are oriented at an oblique angle, which reduces the amount of energy reflected and causes the intensity of some samples within the fish image to drop below the threshold. Another scenario where linking can improve the formation of clusters (i.e. form clusters that represent what we visually perceive to be the fish image) are situations where the tail becomes separated from the fish body.

**Variable 5: Cluster Length > 25 cm** This variable filters the clusters that have been detected in the previous step by length. Only clusters that are longer than 25 cm are retained.

**Variable 6: Cluster < 4 degrees off axis** This variable filters the clusters by the angle of the cluster centroid relative to the center of the fan beam. Only clusters that have been detected within 4 degrees of the center are retained. The goal is to get rid of clusters that represent fish close to the left and right edge of the fan beam, where they are likely to be only partially in the beam, i.e. where the length of the fish would be underestimated.

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**Variable 7: DIDSON image with cluster overlay** This is the variable whose output you see in the DIDSON image window of the Kenai Routine Processing workspace. It overlays the detected (and filtered) clusters on the DIDSON image. This step provides important visual feedback on how well the detected clusters match what we visually perceive to be the image of the fish.

**Variable 8: Target conversion** converts the format of the data from clusters that can be displayed on top of DIDSON images to a format that can be plotted on echograms. On the echogram the equivalent of the clusters are referred to as “echoes” or by the Echoview term “target”. (The latter is arguably confusing because “target” is generally interpreted as the object in the water, as opposed to the echoes it reflects.) The conversion from DIDSON image to echogram collapses each frame into a single vertical column of data. Plotted on the echogram these columns are also referred to as pings because that is what they represent with traditional single beam or split beam data. Strictly speaking, this is incorrect with DIDSON data since each DIDSON frame is a composite of the data returned from a series of pings, but since the meaning seems reasonably clear from the context you may find that here the terms “frame” and “ping” are used interchangeably.

**Variable 9: Length Substitution** replaces the intensity related “TS values” of each cluster with a value that represents length in cm. This variable was used during development to provide live-linked feedback on the effect of changes in the preceding variables on length estimates. Since the generation of these data requires time intensive computations the results are now written to the target.csv files during the Create EV Files process (Kenai EV Auto-Processor), which then reloads the saved data into the next variable.

**Variable 10: Processed ST csv** represents the data that have been written to file in the previous step. The echogram of this variable and those of its two descendants (Variables 11 and 12) draw very quickly because the data no longer need to be calculated on the fly.

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**Variable 11: Length Echogram (thickness < 25 cm)** is the Length Echogram shown in the Kenai Routine Processing workspace template. It filters echoes by the thickness of their corresponding clusters. The thickness filter removes echoes generated by some types of noise (e.g., forward scatter) and schools of eulachon (which are merged into giant clusters by the target linking algorithm in Variable 4).

Display settings:

Color display minimum:	30
Color display range:	57
Color scheme:	DT4
Upper display limit:	set by EV Auto-Processor to the start range of the data
Lower display limit:	set by EV Auto-Processor to the stop range of the data
Upper detection range:	3
Lower detection range:	30.5
Thickness factor:	0.2

Calibration:

ST thickness source: transmitted pulse length

Note: The values for color display minimum, color display range and color scheme have been chosen to provide a good visual contrast between large Chinook salmon (red) and average sockeye salmon (blue/green). The calibration setting ST thickness source has been set to transmitted pulse length to display the traces with uniform thickness. That makes it easier to see the track outlines and (together with the small thickness factor) reduces the likelihood of overlapping track regions, which may otherwise create problems.

**Variable 12: Angle Echogram** is the Angle Echogram shown in the Kenai Routine Processing workspace template. It shows the same data as the previous variable, except it has no thickness filter imposed and the colors of its echogram reflect target angle, rather than length.

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Display settings:

Color display minimum:	-4
Color display range:	8
Color scheme:	DT4
Upper display limit:	set by EV Auto Processor to the start range of the data
Lower display limit:	set by EV Auto Processor to the stop range of the data
Upper detection range:	3
Lower detection range:	30.5
Thickness factor:	1.6

Calibration:

ST thickness source: multibeam target thickness

Note: The values for color display minimum, color display range and color scheme have been chosen such that fish that move through the entire center 8 degrees of the fan beam produce traces that span the full color spectrum. The ST thickness source has been set to multibeam target thickness to provide a visual clue for thickness, which plays an important role in echogram interpretation.

**Variable 13: All Beams Max Intensity** generates a sample (rather than cluster) based echogram by summarizing each range sample over all beams and determining its maximum intensity on the given frame. This type of echogram often reveals patterns that are related to the tail beat of the fish. The significance of this finding is that these patterns may be used to determine tail beat frequency, which in turn may provide clues for species identification and may also be used in bioenergetics studies. For more see:

Mueller, A. M., D. Burwen, K. Boswell, and T. Mulligan. 2010. Tail Beat Patterns in DIDSON Echograms and their Potential Use for Species Identification and Bioenergetics Studies. Transactions of the American Fisheries Society 139:900-910

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## 11.2. Track detection properties

The *Kenai Routine Processing* template uses the following *Track Detection Properties* (*Track Detection Properties* are part of the *EV File Properties*). See the Echoview Help for information on each parameter and a detailed description of the algorithm.

### Algorithm

Data used	4D (range, angles, time)
Track detection	
Alpha	
Major axis	0.5
Minor axis	0.5
Range	0.7
Beta	
Major axis	0.2
Minor axis	0.2
Range	0.4
Target gates	
Exclusion distance (m)	
Major axis	0.4
Minor axis	0.1
Range	0.2
Missed ping expansion (%)	
Major axis	0.0
Minor axis	0.0
Range	0.0



**Weights**

Major axis	1.0
Minor axis	0.0
Range	1.5
TS	0.0
Ping gap	0.0

**Track Acceptance**

Minimum number of single targets in a track	10
Minimum number of pings in track (pings)	10
Maximum gap between single targets (pings)	10

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### 11.3. Files provided with the manual

The following files are provided with the manual:

**Auxiliary Echoview files** located in the folder

*/Semi-automated DIDSON data analysis/Auxiliary Echoview files/*

<i>shortcuts.cfg</i>	(Definition of keyboard shortcuts)
<i>Kenai Routine Processing.EV</i>	(Template for processing chain)
<i>Kenai Routine Processing.evwm</i>	(Workspace template)
<i>Kenai Tail Beat Review.evwm</i>	(Workspace template)

<p><b>Note:</b> Before you begin working make sure all auxiliary files have been copied to their respective locations!</p>
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Depending on the operating system copy *shortcuts.cfg* either to

Microsoft Windows XP operating system:

*C:\Documents and Settings\\Application Data\Myriax\Echoview*

or

Microsoft Windows Vista operating system:

*C:\Users\\AppData\Roaming\Myriax\Echoview*

The files *Kenai Routine Processing.EV*, *Kenai Routine Processing.evwm*, and *Kenai Tail Beat Review.evwm* need to be copied to

*C:\Program Files\Myriax\Echoview\Echoview4\Templates*

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**Documentation and training files** located in the folder

*/Semi-automated DIDSON data analysis/Documentation and training/*

*Semi-automated DIDSON Data Analysis – Field Manual.doc* (this manual)

Three video tutorials:

*Echoview Basics and Routine Processing Workspace.avi*

*Echogram Interpretation.avi*

*Fish Tracking - Basics.avi*

*Fish Tracking Editing.avi*

The subfolder */Tutorial data* contains the EV files and copies of the data used in the video tutorials.

**Data files** used in the development of this method are located in the folder

*/Semi-automated DIDSON data analysis/test data/*

The subfolder */Original ddfs* contains the original ddf files.

The subfolder */Processing* contains the corresponding CSOT files.

The subfolder */Processing/BS-CSOT Test* contains an EV file that can be used to test the results of the BS-CSOT process (see Troubleshooting Tips).

The subfolder */Results* contains the Echoview export (target).csv files and *Estimates of Chinook abundance.xls* which summarizes the results.

**Kenai EV Auto Processor executable** located in the folder

*/Semi-automated DIDSON data analysis/Kenai EV Auto Processor/*

*Kenai EV Auto Processor Version 2.0.exe*

This executable does not require any install procedures. You can simply copy the exe file to a convenient location. Its file browser will open in the folder where the exe is located. So it may be convenient to place it directly in or close to the folder that contains the files that need to be processed.

## 11.4. Test data results

The method described in this manual has been tested with DIDSON data (long-range system with high resolution lens) collected in 2008 and 2009 at the Kenai River sonar site (Mile 8.6). We derived length estimates for a total of 1,988 fish in 84 x 20-minute periods and 72 x 10-minute periods. Figure 21 shows a comparison of Chinook salmon abundance estimates in seven pooled (half or full day) samples, based on auto length estimates and manual length measurements made with Sound Metrics *DIDSON Control and Display Software*. The estimates of Chinook salmon abundance made based on the auto length estimates agreed very well with those based on the manual length measurements, as did their precision.

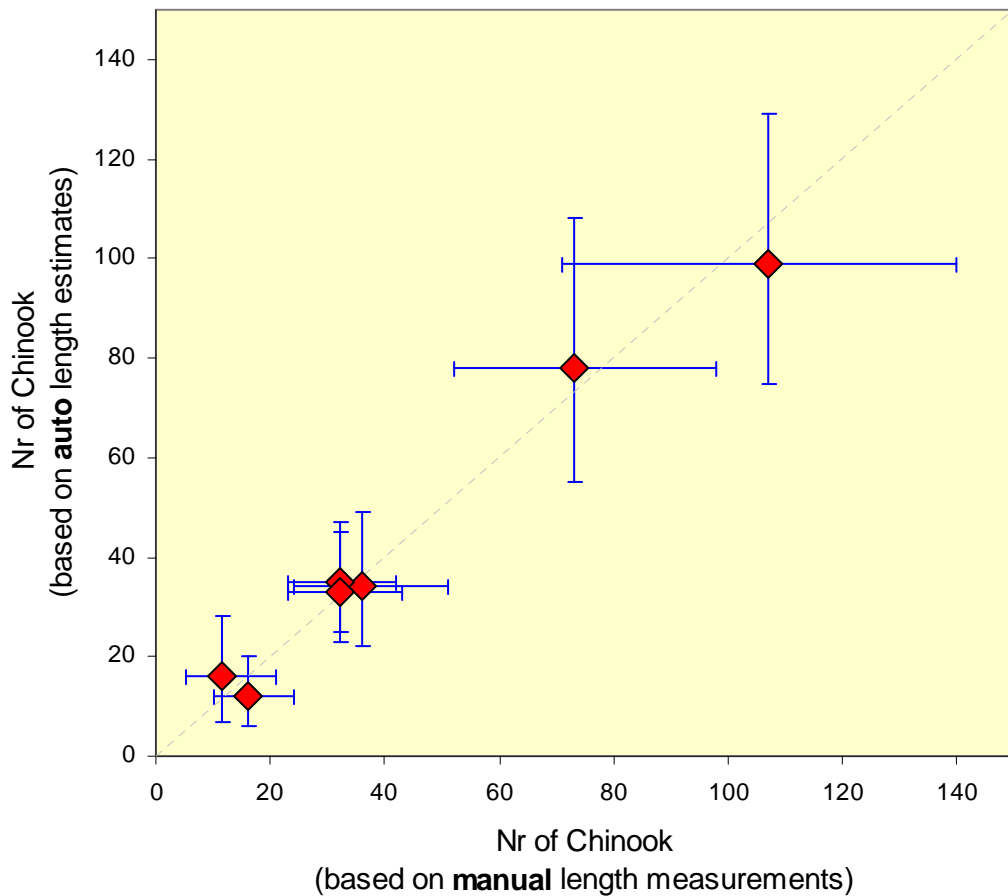


Figure 21. Estimates of Chinook salmon abundance based on auto length estimates versus manual length measurements (red diamonds) and their confidence intervals (blue bars).