Echoview Tutorial:

Introduction to Bottom Classification

Contents

Overview

This tutorial is optimized for Echoview 15 and provides an introduction to bottom classification.

This tutorial is not intended as a comprehensive user manual.

Further information on Echoview tools and topics can be found in the latest version of the Echoview help file. This can be viewed online and is installed with Echoview. Press F1 when using Echoview to open the help file and read context-sensitive information.

Throughout this tutorial further reading is referred to the Echoview help file or other Echoview learning materials: https://www.echoview.com/support

Prerequisites

This tutorial assumes you have Echoview installed, and the following skills and knowledge:

- Familiarity with the basic operation of Echoview. We strongly recommend that you complete the "Getting Started with Echoview" tutorial before beginning this tutorial.

- Familiarity with a supported Microsoft Windows™ operating system. For more information refer to the Echoview Help file page: Computer requirements.

- A basic understanding of echosounding techniques and hydroacoustic surveying. For more information, see texts such as *Fisheries Acoustics* (Simmonds and MacLennan, 2005, Blackwell Science, Oxford.).

Echoview modules

This tutorial requires a license with the Habitat Classification module.

Use of the Background noise removal operator requires the Advanced Operators module.

If you do not yet have access to an Echoview license with these modules, please contact info@echoview.com to request an evaluation license. Solution files are also included in the tutorial package to allow you to see the results of module-protected capabilities.

Contacting Echoview

For assistance with this tutorial please contact support@echoview.com.

Set up

We recommend extracting or copying the tutorial files to `C:\Echoview Software\Tutorials\`. If the files are not in this folder, use Windows Explorer to search for them. If they are not loaded on your machine, download and reinstall the tutorial from www.echoview.com or from the Echoview USB drive.

Troubleshooting

If you receive a message saying that the version of Echoview you are running cannot read the file you have opened, you may be running an old version of Echoview. You can download the latest version of Echoview from www.echoview.com.

Acknowledgements

Thanks to Milne Technologies (Canada) for permission to use their Scott Lake survey data.

Topic 1: Overview of Bottom Classification

Acoustic bottom classification

The successful management of aquatic ecosystems requires an understanding of the interactions between the life forms that inhabit its regions, and the structure and processes of the constituent physical regions.

The collection of hydroacoustic data can provide information from both areas. Echo returns in the water column determine biomass, and the use of bottom echo returns differentiate changes in the bottom.

Acoustic bottom classification is the process and partitioning of acoustic bottom returns into discrete classes that may represent bottom types, such as rock or sand. The classification becomes powerful when calibrated hydroacoustic data and ground-truth data are used together. Calibration offers qualitative and reproducible data, while ground-truth data offers a mapping for the classes. As a result, acoustic bottom classification is more cost-effective than the collection of extensive grab samples or comprehensive visual verification[1].
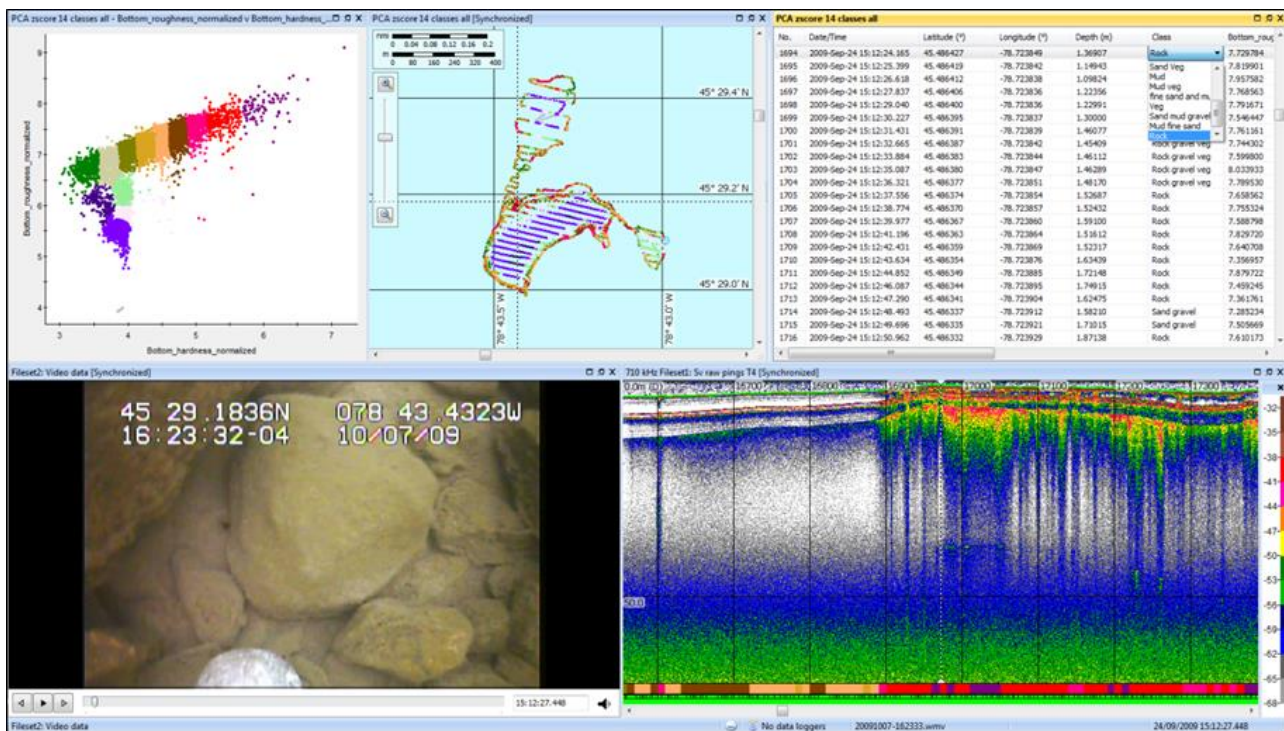

Figure 1. Scott Lake bottom classification displayed through various Echoview windows.

Figure 1 shows Echoview after a complete bottom classification of Scott Lake, Canada. The figure includes a bottom classification graph, bottom points cruise track, bottom points table, Video window, and a Sv echogram with a bottom classification integram.

Echoview bottom classification

Echoview bottom classification is suitable for single, split and dual beam S_v data which may contain only a first-bottom echo trace, or S_v data containing both a first-bottom echo trace and a second-bottom echo trace.

Bottom_roughness_normalized and other bottom features are determined from the first-bottom echo trace. Bottom_hardness_normalized and Second_bottom_length_normalized are determined from the second-bottom echo trace. Bottom classification using an echogram containing only a first-bottom echo trace is possible but will be limited due to having fewer bottom features calculated, resulting in the clustering algorithm having fewer features to process.

Echoview's bottom classification algorithms are based on bottom classification techniques published in the research literature[2].

The main aspects of the algorithms include:

- specifiable depth normalization
- bottom feature Z-score used with automatic Principal Component Analysis (five dimension) or manual specification with specified dimensions
- automatically or manually specified *k*-Means based clustering, with *k*-Means++ cluster initialization and two clustering algorithms.

For further information, refer to the Echoview Help file pages About bottom classification and Bottom classification algorithms.

Topic 2: Introducing a Bottom Classification Survey and Dataflow

Data files

This tutorial will use seven Simrad ES70 data files logged during an extensive hydroacoustic survey of Scott Lake, Canada (for more information see the Acknowledgements). The complete survey consisting of 70,000 pings was logged over a three-hour period, and traversed Scott Lake. From the full dataset, Echoview can determine 14 classes of bottom type that correlate well to ground truth provided by substrate grabs and video data as seen in Figure 2.
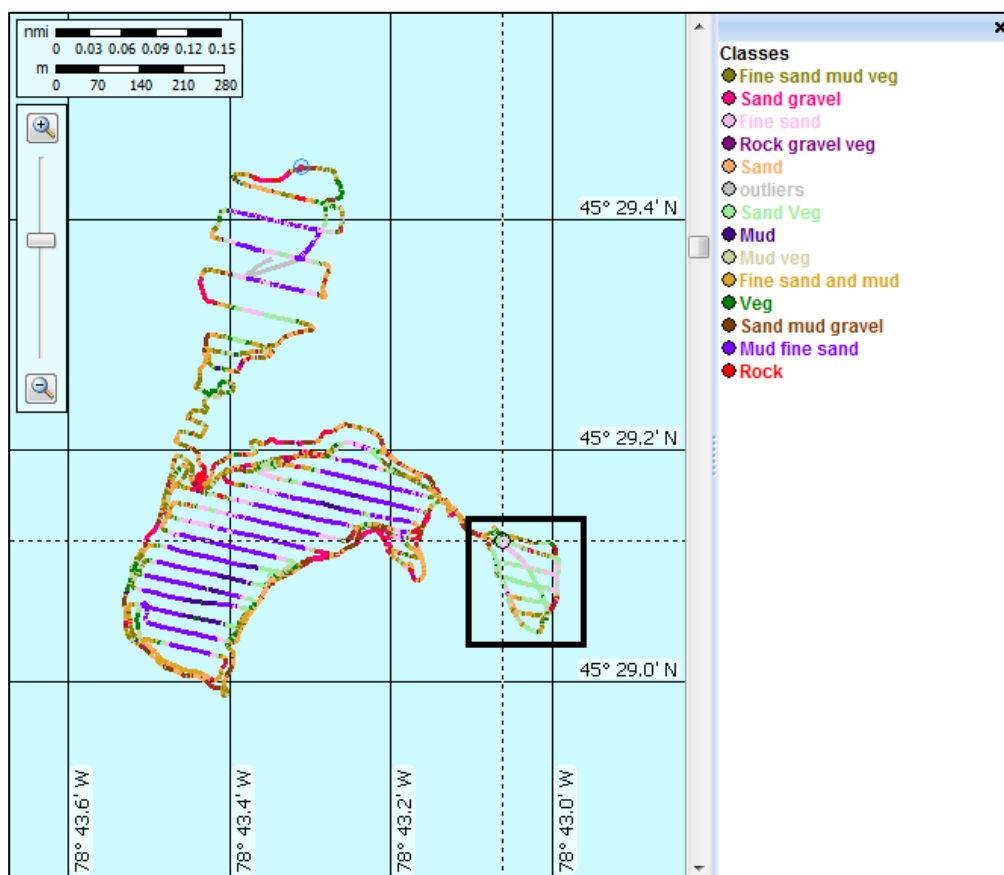

Figure 2. Cruise track showing bottom classification results of the entire survey. The 14 class colors and class names reflect the characterization of substrates from substrate sampling. The files used in this tutorial cover the area inside the black rectangle.

A factor that can affect the quality of a bottom classification is the number of pings used. Generally, more pings result in better (more stable) statistics for class allocation, as the sample mean may better approximate the population mean[3].

The data files used in the following steps of this tutorial will cover a 20-minute, 8000-ping subset from the survey. When using a feature extraction interval of 10 pings, the classification algorithms will work with 800 intervals.

To achieve a good correlation with bottom classification of the large survey, this tutorial will create nine classes within the data. The tutorial solution EV file class colors have been edited to match the class colors from the large survey classification. While the correlation between bottom classifications from the 70,000-ping and 8000-ping datasets are close, they are not a match.
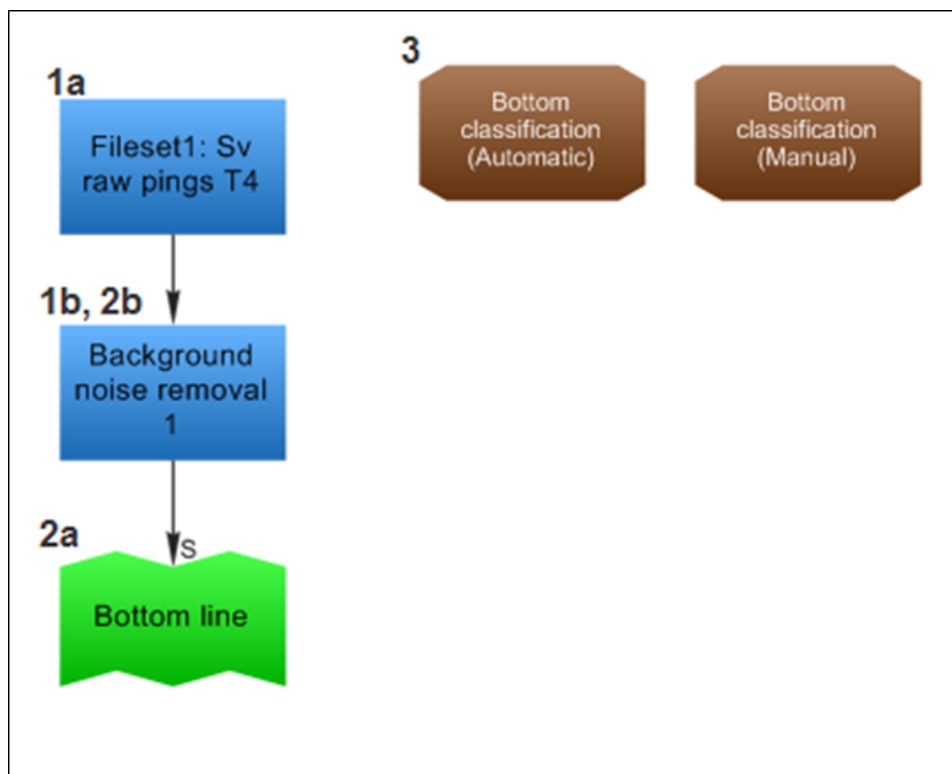
Dataflow

Figure 3. The numbered dataflow stages show the steps required for a simple bottom classification. The table following provides information about each stage.

Stage	Aim	Echoview features or operators used
1a	Prepare Sv data	Select a variable (frequency)
1b	Remove background noise	Create a **Background noise removal** variable
2a	Identify the bottom	Detect a bottom line using the **Best bottom candidate** line-pick algorithm Edit the line pick (quality control)
2b	Configure settings for bottom classification, and undertake a bottom classification	Configure the variables bottom classification settings and configure the bottom-classification algorithm On the **Echogram** menu, click **Classify Bottom**
3	Analyze bottom classification results, and reclassify the bottom	Display bottom classification results as an integram, as a graph, as a cruise track, and as a table Run a new bottom classification Export results

Topic 3: Getting Started

Preparing data

The general preparation of Sv echogram data prior to bottom classification preparation includes verifying and using calibration settings; identifying and dealing with unsuitable echogram data such as intermittent noise, bad samples, and unwanted data from the water column. For further information on these topics refer to the Getting Started tutorial and Help file topics on calibration and ECS files, creating regions and region types

More specific bottom classification preparation includes the removal of background noise, line pick/editing and the specification of bottom classification settings.

1. Start **Echoview**.

2. On the **File** menu, click **New.** The Dataflow window and Filesets window are displayed.

3. Click **Add** in the **Filesets** window.

4. Browse to the location of these tutorial data files and select all 7 files:

   - `D20090924-T152516.raw`

   - `D20090924-T152744.raw`

   - `D20090924-T153013.raw`

   - `D20090924-T153243.raw`

   - `D20090924-T153513.raw`

   - `D20090924-T153742.raw`

   - `D20090924-T154012.raw`

5. Click **Open**. The selected data files are displayed in the **Data files** section of the **Filesets** window. The data files contain 23 raw variables that are listed in the **Raw variables** section of the **Filesets** window.

6. In the **Raw variables** section of the **Filesets** window, click **Sv raw pings T4**.

7. Click . The echogram of **Sv raw pings T4** variable is displayed.

8. Right-click on the echogram, select **Variable Properties** (F8), then click **Echogram Display**. Select **Manually set the display limits** and enter 30.00 as the **Lower display limit (m)**. Click **OK**.

The **Sv raw pings T4** variable, which has a frequency of 710 kHz, shows a clearly visible first-bottom echo trace and second-bottom echo trace. Both these traits make this data ideal for use in bottom classification.
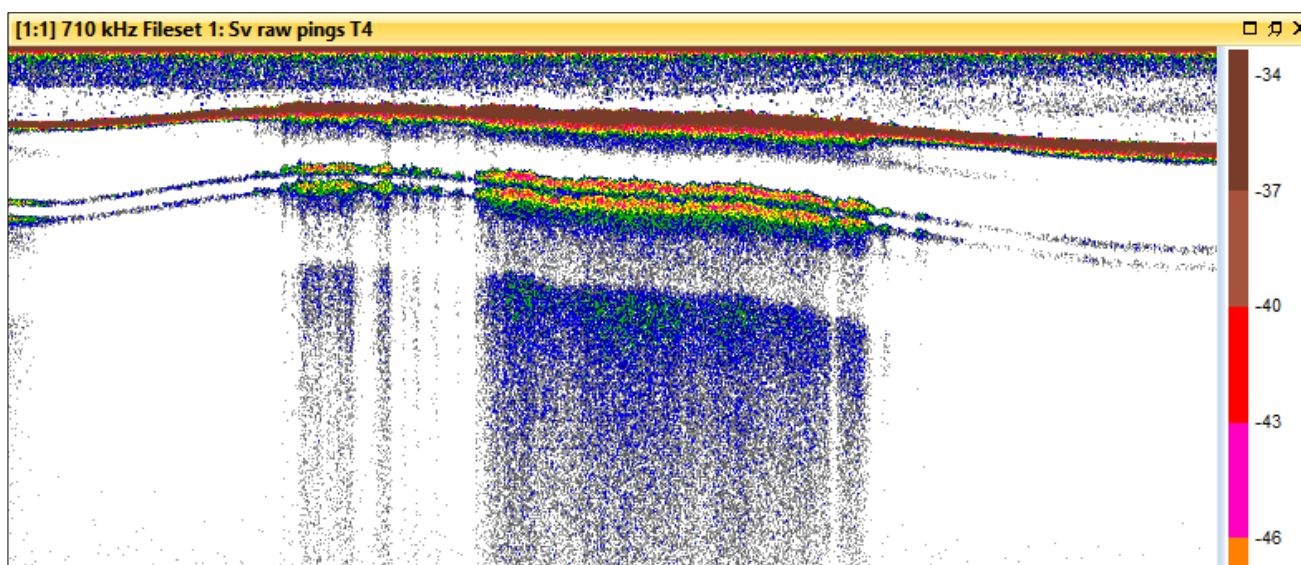

Figure 4. Sv raw pings T4 echogram with first and second bottom echo.

![echoview logo]

Removing background noise

Bottom classification uses the **Bottom echo threshold at 1 m** setting on the Analysis page of the Variable Properties dialog box to separate samples and noise. Two methods are described for this estimate.

One method uses the Background Noise Removal virtual variable that is licensed by the Advanced Operators module. The value for **Bottom echo threshold at 1 m** on the Background noise removal variable includes all valid samples and excludes samples close to the noise and is relatively simple to specify.

The other method doesn't require a licensed Advanced Operators module. An approximate value is estimated from the raw variable ping graph and is then applied to the raw Sv variable.

Notes

- The bottom classification algorithm requires that data samples of the bottom echo traces describe a complete echo. Missing data samples or an incomplete echo can result in the output of no-data bottom points during a classification.

- For further information refer to the Help file topics: About the integram and Using the integram.

Ping Graph method Background noise removal method

The Background Noise Removal operator estimates the background noise level and subtracts it from the value of each sample and also allows a simple way to set the **Bottom echo threshold at 1 m** before running a bottom classification.

9. On the **View** menu click **Dataflow**.

10. Within the Dataflow window, on the **Shortcut** (right-click) menu, point to **New**, then click **Variable…**. The New Variable dialog box is displayed.

11. Select the **Background noise removal** operator. Click **OK**. The Variable Properties dialog box will automatically open at the **Operands** page.

12. In the **Operand 1** list, select **Sv raw pings T4**.

13. View **the Background Noise Removal** page of the Variable Properties dialog box. Take a moment to review the available settings. The **Maximum noise (dB)** box has the default value of -125 dB. In this case, the default provides a good balance between noise removal and the minimization of no-data bottom points in a bottom classification. The settings can be adjusted to suit other data sets, use F1 to display information from the Help file.

14. Click **OK**.

15. On the **Dataflow** window select **Background noise removal 1**.

16. On the Shortcut (right-click) menu, click **Echogram**. The echogram of the **Background noise removal 1** variable is displayed.

17. Point at a ping on the **Background noise removal 1** echogram. On the Shortcut (right-click) menu, click **Graph Ping**. As a diagnostic tool, you can use a ping graph (with keyboard shortcuts F and R) to check the data samples in the first-bottom echo trace and second-bottom echo trace. For more information refer to the Echoview help file page Configuring a bottom classification.

Identify the start of the bottom

Set up the line-pick algorithm.

18. On the **View** menu click **EV File Properties** (or press F6) to open the **EV File Properties** dialog box.

19. Click on **Line and Surfaces** and then view the **Single beam** tab.

In the **Line picking algorithm** list, select Best bottom candidate and enter the following values:

Start depth (m): 0.50

Stop depth (m): 30.00

Minimum Sv for good pick (dB): -70.00

Select **Use Backstep**

Discrimination level (dB): -60.00

Backstep range (m): -0.05

Peak threshold (dB): -55.00

Click **OK**.

Pick the bottom line

20. Display **the Background noise removal 1** echogram.

21. On the toolbar, click on the ▼ icon on the **Line and Surface** ⟋ None ▾ button to open the menu, and then click **New Editable Line**.

    Into the **Create a new line** box, type: Bottom line.

    Select **Pick from current variable**.

    Select **Span gaps**.

    Click **OK.**

A line will be picked from the echogram data. The line will be visible on the echogram and as an object on the **Dataflow** window (Figure 5).
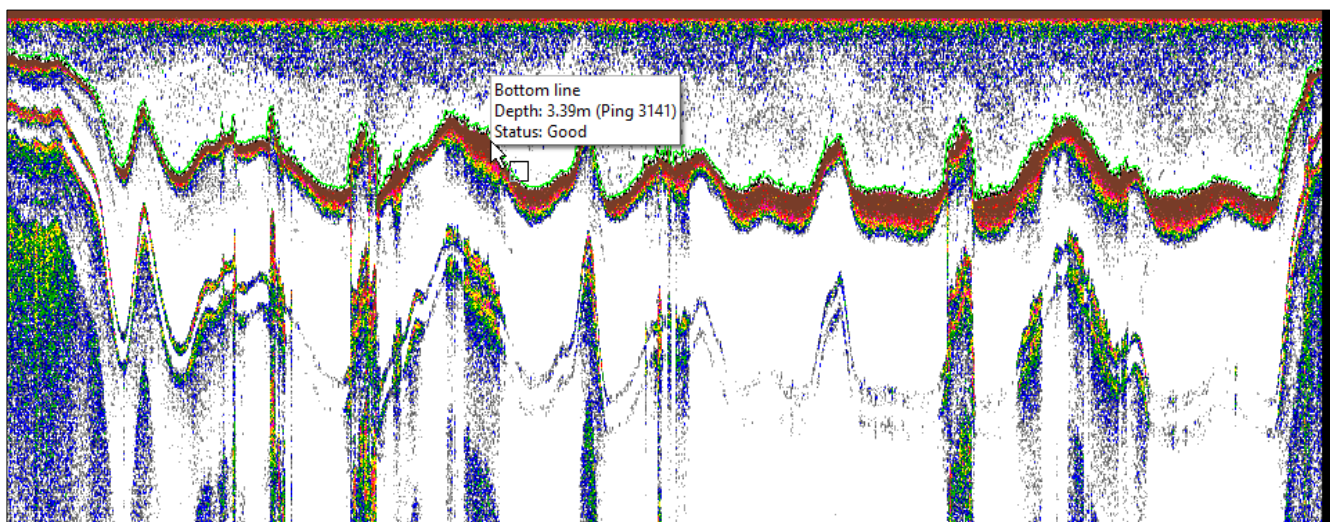

Figure 5. Background noise removal 1 echogram with Bottom line in green.

The samples immediately below the **Bottom line** will represent the first-bottom echo trace. Samples detected at twice the bottom line depth will represent a second-bottom echo trace. Be aware that any samples from the water column that occur below the bottom line will distort bottom echo trace calculations and in turn the bottom-classification results. For this reason, it is good practice to inspect line picks and manually line edit unsatisfactory sections. In this tutorial, the line pick is largely satisfactory however, there is a section around ping 6260 that requires a manual line edit with the Line edit tool. The Line tool is discussed in the Getting Started tutorial.

Settings for bottom classification

View the **Dataflow** window .

22. Select the Bottom line variable.

23. Display a line graph of **Bottom line**. Double-click the dataflow object, or on the **Shortcut** (right-click) menu, click **Graph** (Figure 6). Estimate the average depth of the line: approximately 3.5 meters (this number does not need to be precise).
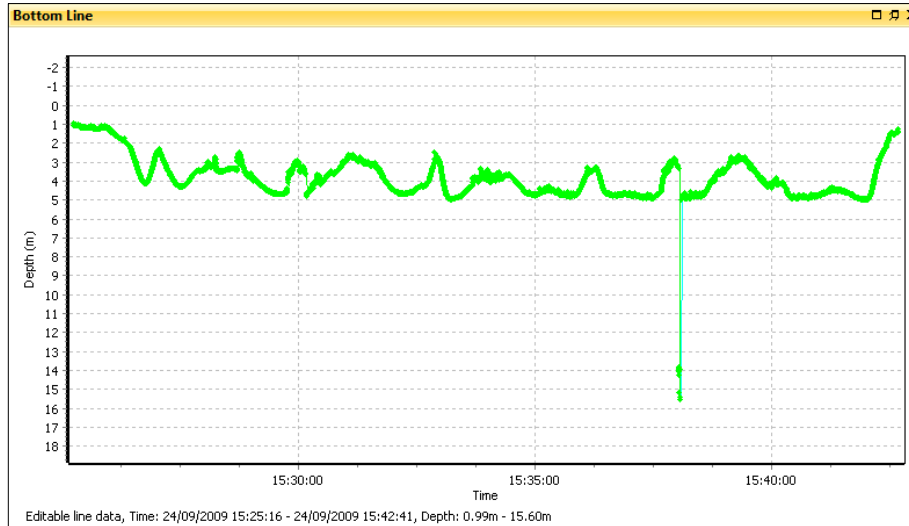
Figure 6. Line graph for Bottom line shows an estimated average depth of 3.5 meters.

24. Display the **Background noise removal 1** echogram.

25. On the **Shortcut** (right-click) menu, click **Variable Properties** (or press F8).

26. View the **Analysis** page of the **Variable Properties** dialog box.

    Under Bottom Settings, in the **Bottom line** list, select Bottom line.

    Into the **Bottom echo threshold at 1m (dB)** box, type: -500.

    Into the **Depth normalization reference depth (m)** box, type: 3.5.

    Click **OK**.

The **Background noise removal** operator sets identified noise samples to -999 dB. Setting **Bottom echo threshold at 1m (dB)** to -500 ensures that bottom classification will include all valid samples in the echo trace but excludes samples that are close to the noise.

Topic 4: Initial Bottom Classification and Subsequent Tuning

Automatic bottom classification

Undertaking a bottom classification using various automatic settings is useful to get an initial understanding of the potential bottom classes of the echogram.

View the **EV File Properties** dialog box (press F6).

1. View the **Bottom Classification** page of the EV File Properties dialog box.

   Under **Features to Extract**, ensure all features are selected.

   Under **Cluster Dimension Selection**, ensure **Automatic (Principal component analysis)** is selected.

   Under **Bottom Class Allocation**, ensure **Automatic detection** is selected.

   In the **Method** list, ensure **Calinski-Harabasz** is selected.

   Into the **Clustering iterations** box, type: 30.

   Click **OK**.

   Display the Background noise removal 1 echogram.

   On the Echogram menu click **Classify Bottom**.

   The **Classify Bottom** dialog box is displayed.

   Into the **Variable name** box, type: Bottom classification (Automatic).

   Ensure **Show bottom classes on integram** is selected.

   Click **Classify**.

When processing is complete, an object named **Bottom classification (Automatic)** will be available on the **Dataflow** window. The **Bottom classification (Automatic)** variable contains the bottom-classification results. Saving the EV file will save the variable and the bottom classification results.

Note: If you do not have a licensed Habitat Classification module, or an Echoview evaluation license, please open the solution EV file found in the data file folder to view the classification results.

2. Review the integram for the **Background noise removal 1** echogram (Figure 7). As **Show bottom classification on integram** was selected on the **Classify Bottom** dialog box, the echogram displays the resulting bottom classification result class colors in the echogram integram area.
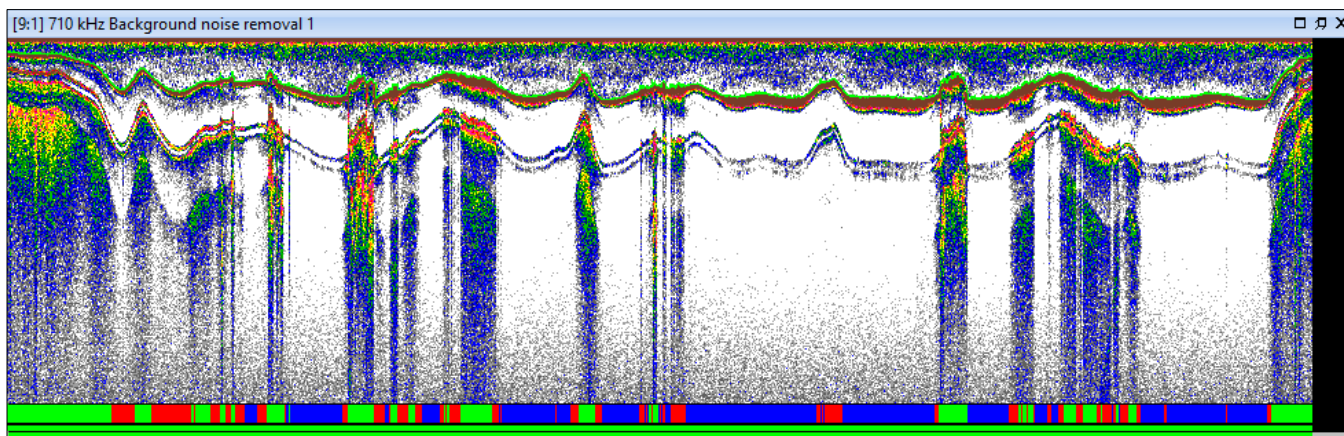

Figure 7. Echogram with bottom classification result integram shown along the bottom.

Viewing bottom classification results as a cruise track

3. On the Dataflow window select Bottom classification (Automatic).

4. On the **Shortcut** (right-click) menu, click **Cruise Track**. The bottom classification results will be shown as a cruise track.

Note: The use of automatic settings determines a set of classes based on the characteristics of the data set analyzed. The random initialization of clustering can lead to slight variations in the final number of classes.

Viewing bottom classification results as a graph

5. On the Dataflow window select Bottom classification (Automatic).

6. On the **Shortcut** (right-click) menu, click **Graph**. A Bottom roughness normalized versus Bottom hardness normalized graph is displayed.

7. On the Dataflow window, again select Bottom classification (Automatic).

8. While holding **Ctrl** on the **Shortcut** (right-click) menu, click **Graph**. A second Bottom roughness normalized versus Bottom hardness normalized graph is displayed.

9. Point at the second graph. On the **Shortcut** (right-click) menu, click **Graph Properties**.

   Select Override variable settings.

   In the X-Axis data list, select Bottom_roughness_normalized.

   In the Y-Axis data list, select Bottom_rise_time_normalized.

   Click **OK**.

Review the Bottom classification result graphs docked side by side (Figure 8). The two graphs show a clustering of points and a clear separation of class. Graph axis features that result in separated point clusters may be useful when used as cluster dimensions when tuning the bottom classification settings while undertaking manual bottom classification.

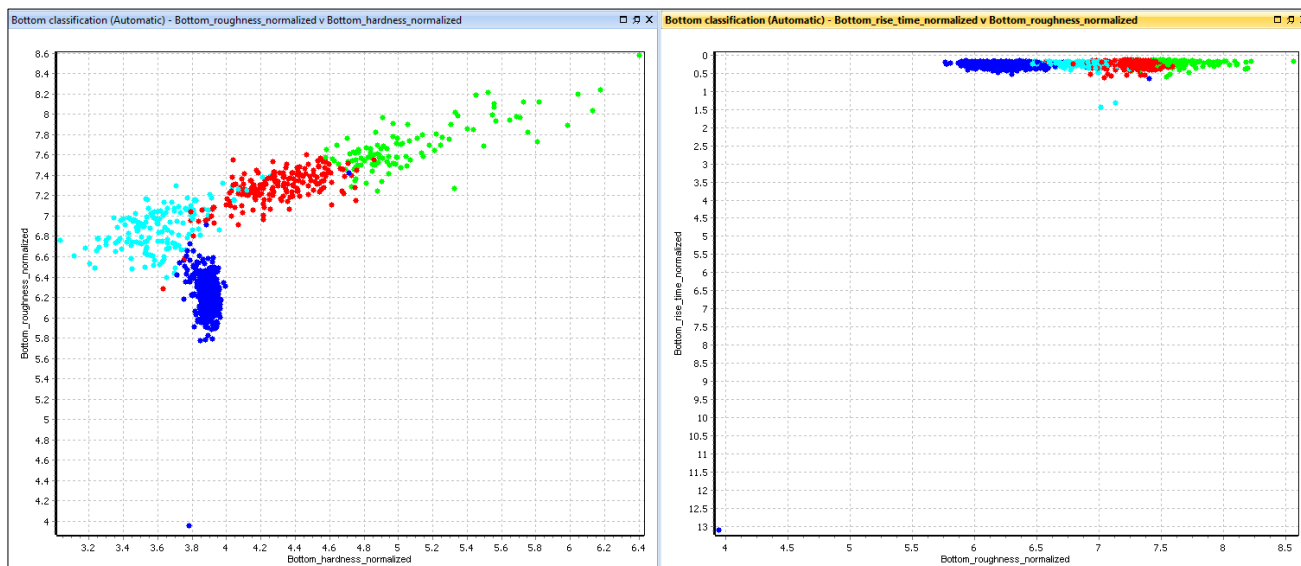*Figure 8. Side-by-side comparison of Bottom classification result graphs.*

Note: Any number of bottom classification graphs can be displayed, each with any feature-to-axis combination. You may need to plot a number of graphs to find features that may be useful as cluster dimensions.

Manual bottom classification

10. View the **EV File Properties** dialog box (press F6).

11. View the Bottom Classification page.

Under **Features to Extract**, ensure all features are selected.

Under **Cluster Dimension Selection**, select **Manual**.

Click the **Dimension Properties** button.

12. The **Manual Dimensions** dialog box is shown.

Leave Bottom_roughness_normalized selected.

Leave Bottom_hardness_normalized selected.

Select Bottom_rise_time_normalized.

Click **OK**.

13. Under **Bottom Class Allocation**, select **Manual**.

Into the **Class count** box, type: 9.

In the **Cluster measure** list, ensure **Calinski-Harabasz** is selected.

Into the **Clustering iterations** box, type: 30.

Click **OK**.

Information from the analysis of the complete survey and site sampling indicate that nine clusters with 30 iterations are suitable for the data in this tutorial.

14. Display the Background noise removal 1 echogram.

15. On the Echogram menu click **Classify Bottom**. The **Classify Bottom** dialog box is displayed.

Into the **Variable name** box, type: Bottom classification (Manual).

Click **Classify**.

When processing is complete an object named **Bottom classification (Manual)** will be available on the **Dataflow** window.

Topic 5: Viewing and Using Bottom-Classification Results

Viewing manual bottom-classification results as a cruise track

16. On the Dataflow window select Bottom classification (Manual).

17. On the Shortcut (right-click) menu, click Cruise Track (Figure 9).
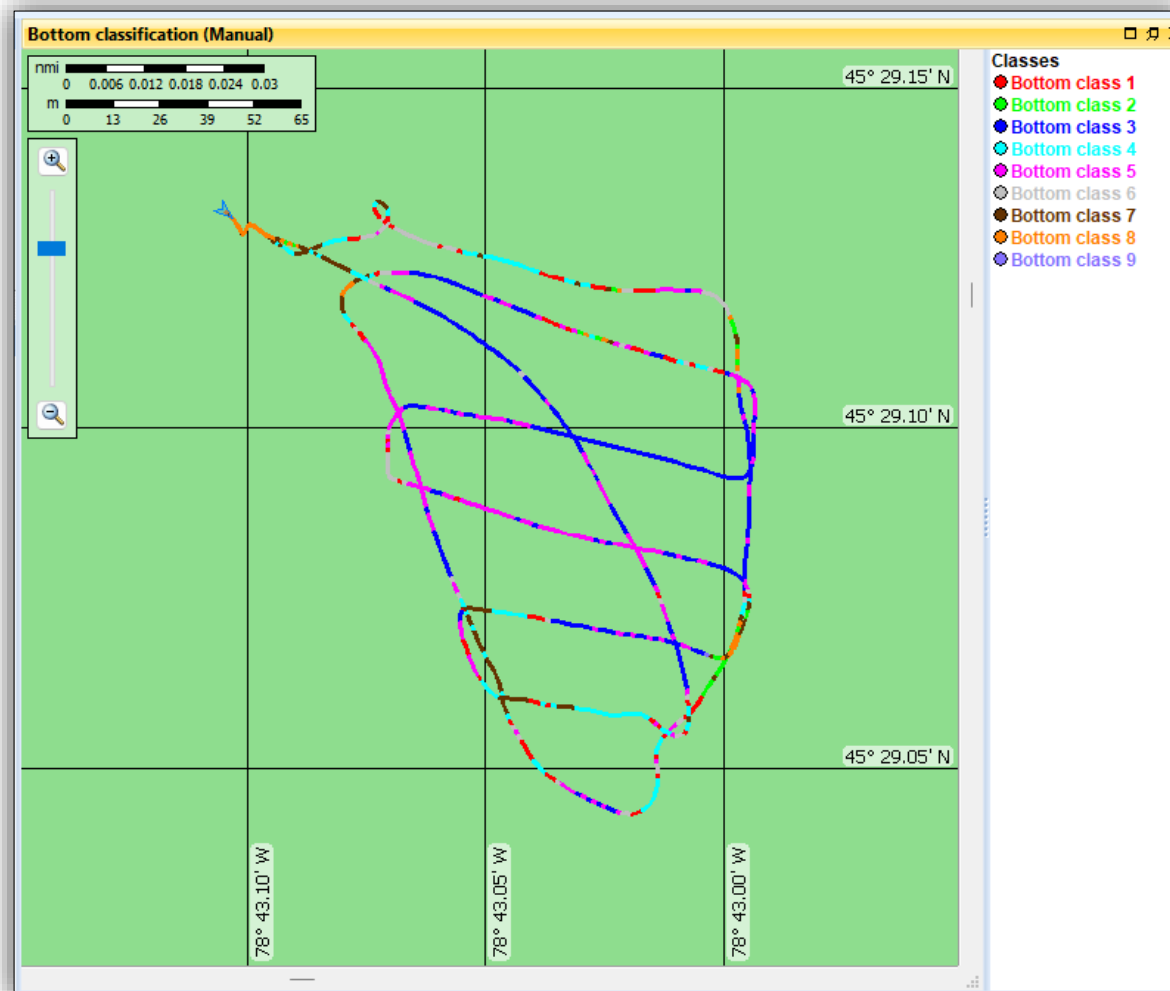
Figure 9. Bottom classification displayed as a cruise track.

Initial bottom classification result, class colors and class names are assigned automatically. The class colors and names can be manually edited after their creation.

18. On the Dataflow window select Bottom classification (Manual).

19. On the **Shortcut** (right-click) menu, click **Variable Properties**.

20. View the **Classes** page of the **Variable Properties** dialog box.

21. Under Bottom Classes select **Bottom class 1**.

    Into the **Name** box, type *Renamed class.*

    Click the color swatch. The **Color** dialog box is displayed.

    Select a color.

    Click **OK**.

On the **Variable Properties** dialog box, click **OK**. The class name will be updated in the cruise track window. The color of the class will be updated in the cruise track window and in graph windows.

The colors of classes in Figure 9 have been manually edited to represent those of the colors assigned in the extensive hydroacoustic survey of Scott Lake (see Figure 2).

Viewing bottom classification results as a table

22. On the Dataflow window select Bottom classification (Manual).

23. On the **Shortcut** (right-click) menu, click **Table**. Bottom classification results will be shown as a table (Figure 8).

No.	Date/Time	Latitude (°)	Longitude (°)	Altitude (m)	Depth (m)	Class	Bottom_roughn...	Bottom_hardne...	First_bottom_le...	Second_bo
0	2009-Sep-24 15:25:16.7355	45.485532	-78.718409	-1.1056	1.1056	Bottom class 8	7.556822	4.786741	23.578403	22.152529
1	2009-Sep-24 15:25:17.9385	45.485528	-78.718403	-1.1038	1.1038	Bottom class 8	7.644602	4.771770	22.948796	21.532340
2	2009-Sep-24 15:25:19.1645	45.485524	-78.718397	-1.1193	1.1193	Bottom class 7	7.501967	4.654995	20.737049	19.331245
3	2009-Sep-24 15:25:20.3760	45.485521	-78.718392	-1.1336	1.1336	Bottom class 8	7.568852	4.840059	22.219015	20.778959
4	2009-Sep-24 15:25:21.5865	45.485517	-78.718387	-1.1178	1.1178	Bottom class 8	7.654541	4.842828	21.875556	20.455297
5	2009-Sep-24 15:25:22.8135	45.485513	-78.718383	-1.1134	1.1134	Bottom class 8	7.451482	4.748600	20.517289	19.120521
6	2009-Sep-24 15:25:24.0320	45.485509	-78.718379	-1.1567	1.1567	Bottom class 8	7.532056	4.806332	22.205679	20.734643
7	2009-Sep-24 15:25:25.2510	45.485506	-78.718375	-1.1987	1.1987	Bottom class 8	7.579084	4.945563	20.584494	19.079908
8	2009-Sep-24 15:25:26.4855	45.485502	-78.718371	-1.2352	1.2352	Bottom class 8	7.812832	4.872361	20.596849	19.049298
9	2009-Sep-24 15:25:27.6805	45.485500	-78.718368	-1.2122	1.2122	Bottom class 8	7.623736	4.743160	20.785787	19.266259
10	2009-Sep-24 15:25:28.8995	45.485497	-78.718366	-1.2202	1.2202	Bottom class 8	7.602431	4.723288	22.148802	20.598884
11	2009-Sep-24 15:25:30.1185	45.485494	-78.718364	-1.2031	1.2031	Bottom class 8	7.567864	4.824879	23.787355	22.234757
12	2009-Sep-24 15:25:31.3445	45.485492	-78.718362	-1.2506	1.2506	Bottom class 8	7.490156	4.789327	21.990886	20.405880
13	2009-Sep-24 15:25:32.5475	45.485489	-78.718360	-1.2251	1.2251	Bottom class 8	7.539402	4.759474	23.488537	21.915988
14	2009-Sep-24 15:25:33.7745	45.485487	-78.718358	-1.2430	1.2430	Bottom class 8	7.594508	4.863951	20.404879	18.851594
15	2009-Sep-24 15:25:35.0010	45.485485	-78.718357	-1.2322	1.2322	Bottom class 8	7.474040	4.756639	21.807942	20.250791

Figure 10. Bottom classification results table.

24. Double-click a row of the table. Displayed echogram windows and cruise track windows will synchronize to the date and time of the row.

When double-clicking on the bottom classification results within the cruise track window, table and echogram windows will synchronize. Synchronization is also useful when video data and/or substrate sampling data is available to correlate with the bottom classification result classes.

Exporting bottom classification results

Bottom classification results can be exported from the Dataflow window, from the table window and from the cruise track window.

25. On the Dataflow window select Bottom classification (Manual).

26. On the **Shortcut** (right-click) menu, click **Export** then **Data Values…**.

27. Under **Select range to export** ensure **All measurements** is selected.

28. Click **Export**.

29. Into the **File name** box, type: Bottom_classification_results

30. Click **Save**.

Using the csv file format, calculated bottom features and bottom classification results can be further examined in third-party statistical packages.

Note: If you do not have a licensed Habitat Classification module, or an Echoview evaluation license, please examine the provided file:
`Bottom_classification_results(solution).bottom.points.csv`

Select the **File** menu and click **Close**. Click **Yes** when prompted if you want to save changes to the EV file.

Further information

Help file topic title	Description
About bottom classification	Overview of bottom classification.
Configuring a bottom classification	Discussion of factors that affect bottom classification settings and bottom classification algorithms.
Bottom classification analysis options	Discussion of techniques for the examination of bottom classification results: auto-synchronization, video footage, reclassify with the same features but different cluster settings and exporting data.
Bottom classification algorithms	Discussion of algorithms and references.
Bottom classification – practical notes	Practical excerpts on bottom classification from reference papers.
Habitat Classification module	Overview of the functionality offered by the Habitat Classification module. Alongside bottom classification, the module enables the use of the Threshold offset line operator (used to detect the boundary of features like vegetation, transducer ring down, bubbles around the transducer, shadow zones or dead zones) and vegetation analysis export.

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For further information on Echoview bottom classification algorithms see the Echoview help file.

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