

# MATECHO USER MANUAL

Laboratory: UMR LEMAR

User manual

Implantation : Plouzané

Version 01

## Summary

1. Installation and software required .....	1
1.1. Ifremer Movies3D software .....	1
1.2. Matecho .....	1
1.3. Note on biological groups separation (bifrequency method) .....	2
2. General methodology .....	3
3. Matecho utilization and description.....	4
3.1. Interface description and functionalities .....	5
3.2. HAC conversion to MATLAB format.....	7
3.2.1. Input files .....	7
3.2.2. Run the Matlab conversion of input files .....	7
3.2.3. Setup and run hac conversion of raw EK60 or BI500 input files.....	8
3.2.4. Setup and run Matlab HDF5 conversion of hac files .....	9
3.2.5. Output file of the Matlab HDF5 conversion.....	13
3.3. Interface visualization setup.....	14
3.4. Manual cleaning .....	20
3.4.1. Bottom correction .....	21
3.4.2. Water column correction.....	22
3.4.3. Output file for manual cleaning.....	22
3.5. Filtering, Echointegration, Shoal Extraction, Bifrequency .....	22
3.5.1. Filtering .....	23
3.5.1.1. Filtering intermittent parasites.....	24
3.5.1.2. Background noise reduction .....	25
3.5.1.3. Filtering pings .....	28
3.5.1.3.1. Low ship speed ping removing .....	29
3.5.1.3.2. Empty ping removing.....	30

# MATECHO USER MANUAL

Laboratory: UMR LEMAR

User manual

Implantation : Plouzané

Version 01

---

3.5.1.3.3. Deep spikes removing .....	33
3.5.1.4. Output file for filtering .....	37
3.5.2. Clean hac files .....	38
3.5.3. Echointegration (EI) .....	38
3.5.3.1. EI setup and run .....	39
3.5.3.2. EI cleaning .....	40
3.5.3.3. EI output files .....	41
3.5.3.3.1. EI Matlab HDF5 file .....	41
3.5.3.3.2. EI figures .....	42
3.5.3.3.3. EI Excel files .....	42
3.5.3.3.4. EI NetCDF files at ICES/IMOS standard format.....	44
3.5.3.4. Layer extraction on echointegration data .....	47
3.5.4. Fish shoal extraction (SE).....	48
3.5.4.1. SE setup and run .....	48
3.5.4.2. SE extracted fish shoal removing .....	50
3.5.4.3. SE output files .....	50
3.5.4.3.1. SE Matlab HDF5 file .....	50
3.5.4.3.2. SE Excel files .....	51
3.5.4.4. Apply shoals from a frequency to others.....	52
3.5.5. How to make a new echointegration or shoal extraction.....	53
3.6. Add hac files to a cruise .....	54
3.7. Matecho result folders displacement or rename .....	55
3.8. Re-initialization of data results.....	55
4. Matlab and R scripts examples .....	56
4.1. Matlab script example .....	56
4.2. R script example.....	57

# MATECHO USER MANUAL

Laboratory: UMR LEMAR

User manual

Implantation : Plouzané

Version 01

---

5. Contacts .....	58
6. Bibliography .....	58
7. Suivi des versions de ce document .....	59
Annex 1: Matecho HDF5 data results.....	60
1. Read and write HDF5 data file results .....	60
2. Description HDF5 file 'Echogram.mat' containing hac file data echograms.....	62
3. Description HDF5 file 'Filtering.mat' containing filtering data for echograms.....	65
4. Description HDF5 file 'Echointegration.mat' containing echointegration data .....	69
5. Description HDF5 file 'ShoalExtraction.mat' containing shoal extraction data .....	71
Annex 2: Matecho layer extraction from echointegration .....	74
Annex 3: Procedure for Matlab/Movies3D interfacing .....	87
Annex 4: Description of bifrequency processing from Matecho .....	89

# MATECHO USER MANUAL

Laboratory: UMR LEMAR

User manual

Implantation : Plouzané

Version 01

Page 1/96

## 1. Installation and software required

Recommended operating system configuration:

- Windows 7 or 10, 64 bits
- RAM  $\geq$  4 Go

Software:

- Matlab 64 bits (version  $\geq$  2013b, tested until 2016b for Matecho)
- Movies3D Ifremer software 64 bits (version  $\geq$  1125, tested until 1278 for Matecho)

Matlab and Movies3D must be installed on your computer. For the standalone version of Matecho (which run without Matlab), only Movies3D must be installed on PC.

### 1.1. Ifremer Movies3D software

Ifremer gives free of charge Movies3D software by simply registering on their web site:

<http://flotte.ifremer.fr/Presentation-de-la-flotte/Logiciels-embarques/HERMES-MOVIES3D/Telechargement>

During the installation of Movies3D, keep the installation path proposed by default, which must be: C:\Program Files\Ifremer\Movies3d\

Before to run Matecho, Matlab and Movies3D must be interfaced by following the procedure describes in [Annex 3: Procedure for Matlab/Movies3D interfacing](#).

### 1.2. Matecho

This document was written from the version Matecho20170518V1 (from May 18th, 2017) available online from <https://svn.mpl.ird.fr/echopen/MATECHO/> (login: userecho, password: echopen).

The folder **Matecho20170518V1** or **Matecho20170518V1\_StandAlone** (which run without Matlab soft) and its content (i.e. the main program "Matecho.m" or "Matecho.exe" and their corresponding subfolder "**privat**" containing all the Matecho functions) do not be modified (also avoid adding something else in these folders).

## MATECHO USER MANUAL

---

Laboratory: UMR LEMAR

User manual

Implantation : Plouzané

Version 01

Page 2/96

---

Matecho folder can be positioned everywhere on your PC, **except in the windows system folder C:\Program Files\**.

Installation of the Matecho standalone version which run without Matlab software:

Before the first run of Matecho standalone version, user has to install on his PC (which must be under MS Windows 64 bits) the Matlab Component Runtime (MCR) by double-clicking on '**MyAppInstaller\_web**' available in folder:

**'..\Matecho20170518V1\_StandAlone\Installation\_Matecho\_StandAlone\'**

When the MCR installation is terminated, user can run Matecho by double-clicking on the application '**Matecho.exe**' available in:

**'..\Matecho20170518V1\_StandAlone\ Matecho\_StandAlone\'**

Important note: keep the integrity of the content of the folder **Matecho\_StandAlone** by never separating the application 'Matecho.exe' and the folder '**privat**', which must be always in a same folder.

### 1.3. Note on biological groups separation (bifrequency method)

Bifrequency algorithm to separate biological groups is not activated by default in Matecho.

To activate it, open the file "Matecho.m" in Matlab m-file editor (by double clicking on Matecho.m). At the line 10 of the m-file program, put the variable `ActivateBifreq=1` and in Matlab menu "EDITOR", click on Save.

Then, run Matecho as described in [section 3: Matecho utilization and description](#). The bifrequency treatment will then be available in menu Setup and run (see Fig. 9).

See [annex 4](#) for a synthetic description of the bifrequency processing in Matecho.

# MATECHO USER MANUAL

Laboratory: UMR LEMAR

User manual

Implantation : Plouzané

Version 01

Page 3/96

## 2. General methodology

Matecho is an integrated and supervised Matlab processing chain which allows realizing scientific echo-sounder data treatments. It allows applying, under user control, recent echo-sounder data processing methods needed to prepare and present acoustic data to their analysis and interpretation in the field of fisheries acoustics researches.

The processing chain consists in:

- [Step 0: Conversion of the Simrad raw EK60 or Simrad BI500](#) data files into the ICES *hac* format (standard format for the exchange of fisheries acoustics raw and edited data).
- [Step 1: Conversion of the hac files in HDF5 format](#) (corresponding to the –V7 Matlab file format, <https://www.hdfgroup.org/>).
- [Step 2: Manual corrections of bottom line and echogram water column](#) from Matecho interface functionalities.
- [Step 3 : Echogram filtering](#):
  - [Deep spikes removing](#), called "Transient Noise (TN) in Ryan and al. (2015).
  - [Empty ping removing](#), called "Attenuated Signal (AS)" in Ryan and al. (2015).
  - [Echogram parasites removing](#) (Naïg Le Bouffant, Ifremer) called "Impulsive Noise (IN)" in Ryan and al. (2015).
  - [Background noise reduction](#) by using the algorithm described in De Robertis and al. (2007) called Background Noise (BN) in Ryan and al. (2015).

→ Note: if all filters are used, the default order of their application is in Matecho TN, AS, IN, BN. To change this order, run each filter one by one in your own order.
- [Step 4: Echointegration](#) and/or [fish shoal extraction](#) processes by using Ifremer Movies3D libraries (Trenkel et al, 2009).
  - Note: see also [How to modify user cleaning and/or filtering](#). When echointegration and/or Shoal extraction was done, the user cleaning (Step 2) and filtering (Step 3) are then no more applicable (disable in Matecho).
  - Note: see also [How to make a new echointegration or shoal extraction](#).

# MATECHO USER MANUAL

Laboratory: UMR LEMAR

User manual

Implantation : Plouzané

Version 01

Page 4/96

- Step 5: [Echointegration data cleaning](#) and/or [Extracted fish shoals data cleaning](#).
- Step 6: [Post-treatments on echointegration and/or shoal extraction data](#):
  - [Layer extraction on echointegration data](#).
  - [Apply shoal from a frequency to other](#).
  - [Plot the frequency response curves](#).

**Important note:** According to the realized steps in the processing chain, one or several menus or action buttons can be in disable (buttons are grayed).

For example, when echointegration was realized and knowing that echointegration depend to the filtering and the user cleaning, the buttons for raw echogram cleaning are then in disable and the filters cannot be applied any more (except by following the procedure described in the first note of Step 4: [How to modify user cleaning and/or filtering](#)).

For all processing types (Matlab conversion, cleaning, filtering, echointegration and shoal extraction), treatment can be stopped at any moment and continued later from the stop, even if Matecho, Matlab or your PC were stopped in the meantime.

## 3. Matecho utilization and description

- Open Matlab (see Fig. 1 below).
- Find from "Matlab Current Folder" (Matlab left panel), the program Matecho.m.
- Drag and drop the program Matecho.m from the "Matlab Current Folder" to the "Matlab Command Windows" (Matlab right panel) to run Matecho (\*).

The empty interface of Matecho is then opened (see Fig. 2 below).

# MATECHO USER MANUAL

Laboratory: UMR LEMAR

User manual

Implantation : Plouzané

Version 01

Page 5/96

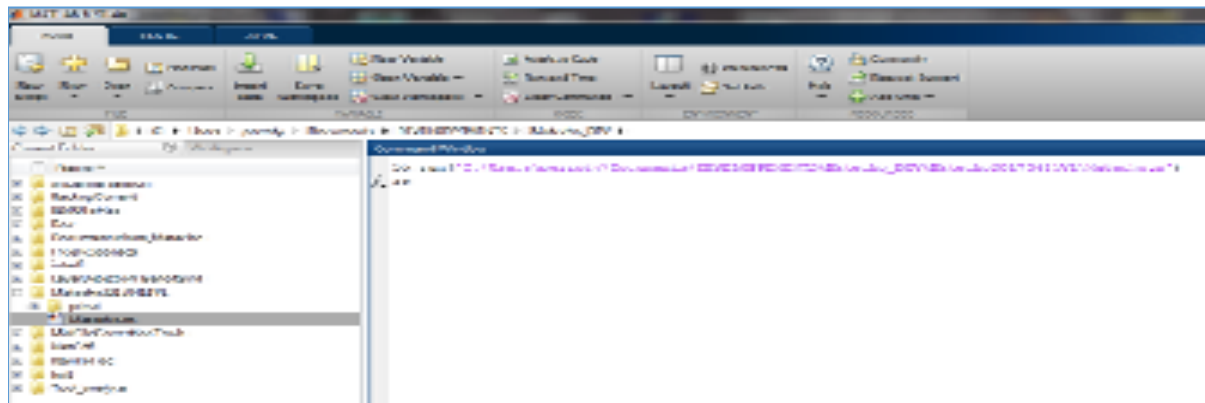


Fig. 1: Matlab panel with the "Matlab Current Folder" panel on the left side and the "Matlab Command Windows" on the right side to run Matlab programs (\*.m) or commands

(\*): Note that, after a first run of Matecho, the Matlab command to run Matecho – as for example: `run('C:\Users\...\Documents\Matecho20170411V1\Matecho.m')` – is recorded in your Matlab command history with its complete path on your PC.

Subsequently, this allows, in future session, to run quickly Matecho from any position of the Matlab current folder by using the command history. You will just have to tape in Matlab Command Windows: `run` and, before to press Enter, to press the arrow  $\uparrow$  on keyboard to find again the Matecho run command with its complete PC path.

## 3.1. Interface description and functionalities



## MATECHO USER MANUAL

Laboratory: UMR LEMAR

User manual

Implantation : Plouzané

Version 01

Page 6/96

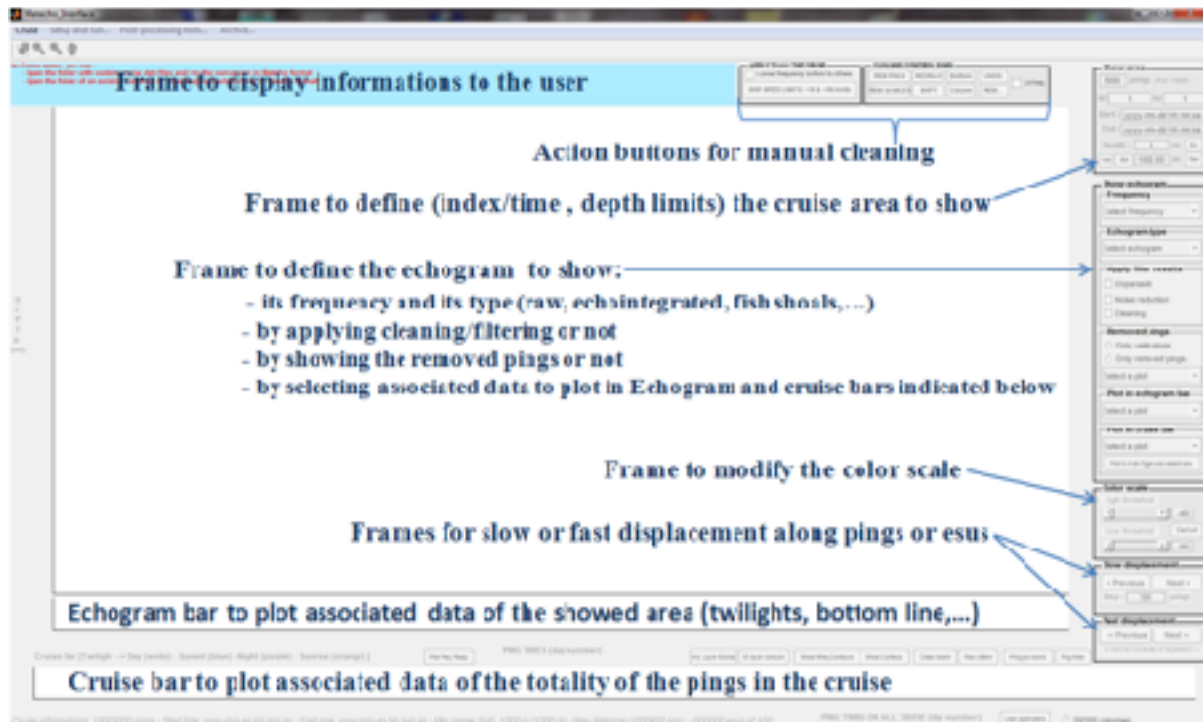


Fig.2: Empty Matecho interface when data are not loaded and description of the main frames

In this empty Matecho interface when no data are loaded yet, only the menu "Cruise" is available (see Fig.3 below). At this step, you have then three possibilities:

- Menu **"Cruise > Open new cruise..."** to run the echo-sounder data files conversion in Matlab HDF5 format (see [section 3.2: HAC conversion to MATLAB format](#)).
- Menu **"Cruise > Open an existing cruise treatment..."** to open a cruise completely or partially treated. Select an existing folder `Cruise_YourCruiseName` produced before by Matecho during [hac file Matlab conversion](#).
- Menu **"Cruise > Open only an echointegration file..."** to open only Matlab HDF5 echointegration file without initial data. Select an existing file called 'Echointegration.mat' produced before by Matecho during [echointegration process](#).

# MATECHO USER MANUAL

Laboratory: UMR LEMAR

User manual

Implantation : Plouzané

Version 01

Page 7/96

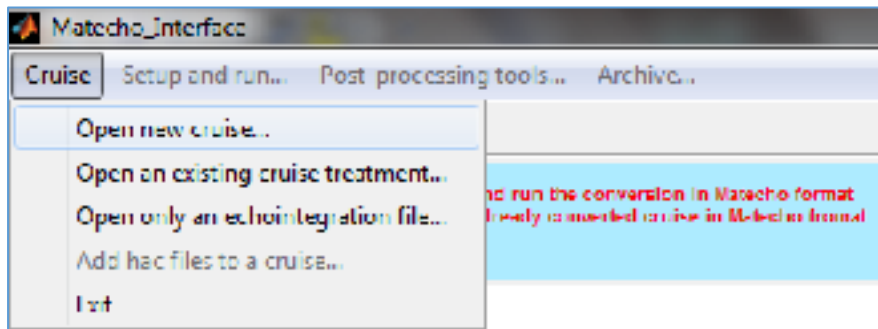


Fig. 3: Menu Cruise > Open new cruise...

## 3.2. HAC conversion to MATLAB format

### 3.2.1. Input files

Input format: HAC EK60, HAC EK80 CW (narrowband)

Conversion to HAC format possible for:

- RAW EK60
- BI500

### 3.2.2. Run the Matlab conversion of input files

- Menu "**Cruise > Open new cruise...**" (Fig. 3) allow to run the conversion of echosounder data files (hac, Simrad raw ek60 or Simrad BI500) in HDF5 Matlab format
- Select the parent directory which contains cruise data files (whatever the input file format hac, raw EK60 or BI500).
- Choose to consider (or not) the subdirectories of the previous selected parent directory from:

## MATECHO USER MANUAL

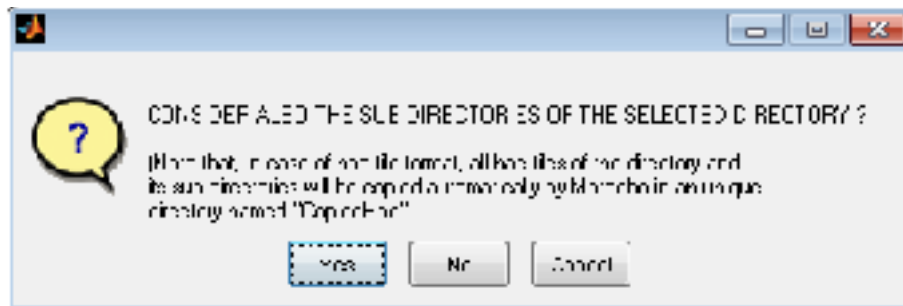
Laboratory: UMR LEMAR

User manual

Implantation : Plouzané

Version 01

Page 8/96



*Note that hac files (including those resulting from the hac conversion of the raw EK60 or BI500) must be gathered in a single folder (not in subfolders) in a chronological order. Then, if echo-sounder data files are in subdirectories, they will be copied by Matecho in a unique directory named "CopiedHAC" (or "ConvertedHac" if initial input files were raw ek60 or BI500 formats).*

Matecho detects the presence of the input files (hac, raw ek60 and/or BI500). If several formats are detected, a dialog box allows selecting the format to open.

If the input files are ever in hac format, the popup to run the HDF5 conversion is then directly opened ([see section 3.2.4: Popup to define and run Matlab HDF5 format conversion](#)).

### 3.2.3. Setup and run hac conversion of raw EK60 or BI500 input files

If the input file format is raw ek60 or BI500, before to open the HDF5 conversion popup of Fig. 4, Matecho run the conversion of the input files in hac format by asking you:

- To select a directory to save converted hac files.
- To define a maximum range for each frequency containing in the input files.
- To define (or not) the sounder calibration parameters in case of BI500 files. This information is asked only in the case of BI500 files conversion knowing that sounder calibration parameters are not available in BI500 files. If the user chooses to ignore calibration parameters, it is some default calibration parameters which are encoded in resultant hac files according to each frequency (not recommended).

At the end of the input file conversion in hac format, the popup to run the HDF5 conversion is then opened (described just below)

# MATECHO USER MANUAL

Laboratory: UMR LEMAR

User manual

Implantation : Plouzané

Version 01

Page 9/96

## 3.2.4. Setup and run Matlab HDF5 conversion of hac files

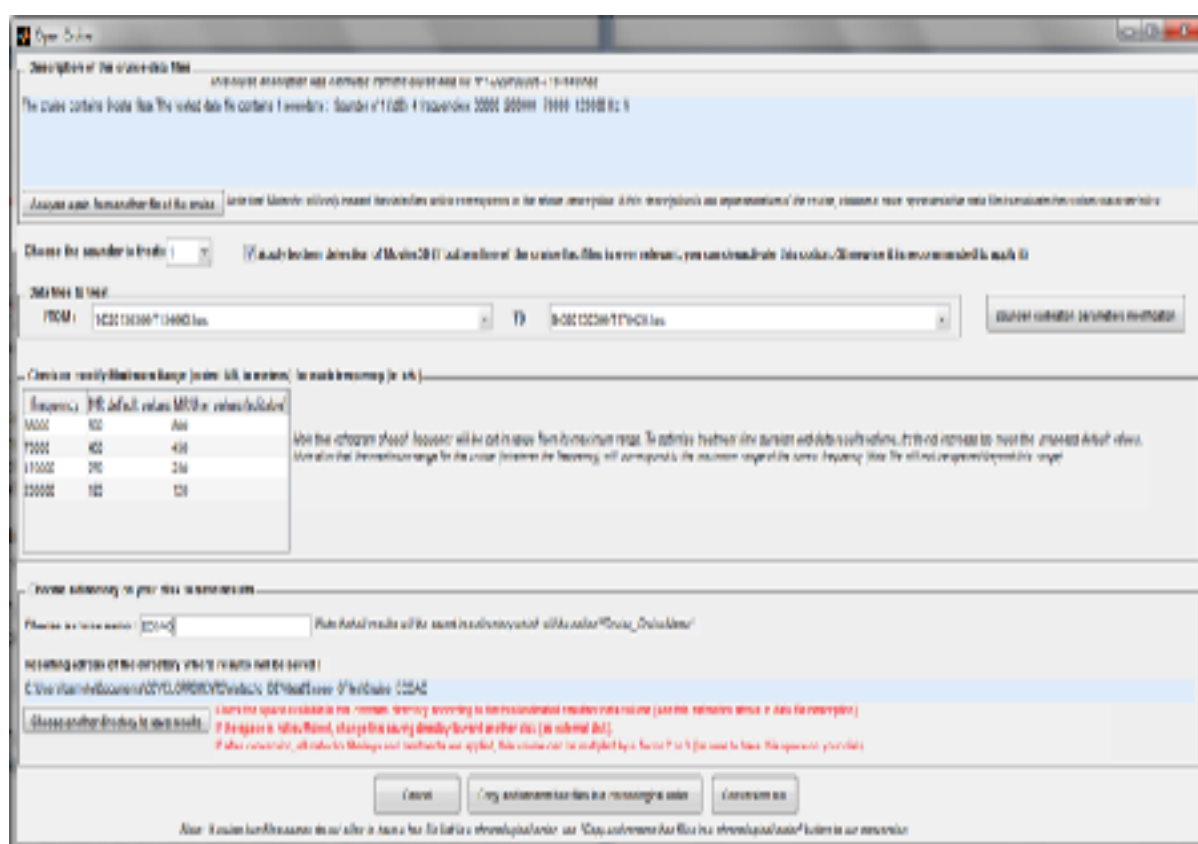


Fig. 4: Pop up to run the conversion in Matlab HDF5 format

From the Matlab conversion popup (Fig. 4), the needed actions before to run the Matlab conversion are:

- Check the content of the hac files display in the blue panel "**Description of the cruise data files**" (number of sounder, frequencies).
  - This content must reflect the echo-sounders characteristics (sounder, frequencies) using in the cruise. It was extracted from the first hac file of the hac file list. If this first hac file is not representative of your cruise echo-

## MATECHO USER MANUAL

---

Laboratory: UMR LEMAR

User manual

Implantation : Plouzané

Version 01

Page 10/96

---

sounders, click on the button "**Analyze again from another file of the cruise**" and select another hac file more representative than the first.

- **Choose the sounder to treat** if hac files contain several sounders.
  - Note that multibeam sounders are automatically ignored by Matecho.
- Check the hac file list in panel "**Data file to treat > FROM or TO**" by being sure that:
  - The hac file list is in a chronological order.  
If it is not the case (due to hac file name typologies which would not allow a chronological arrangement of the hac file list), you have to click on button "**Copy and rename hac files in a chronological order**" to copy and rename the hac files before to run the Matlab conversion.
- Select the first hac file of the hac list to treat in "**Data file to treat > FROM**" and the last in "**Data file to treat > TO**". By default, all hac files are selected.
- Choose to apply or not the Movies3D bottom detection.
  - It is recommended to turn off this option in case of hac files converted from BI500 data files for which bottom line was ever corrected during the acquisition.
  - Except for BI500 file, it is recommended to activate the Movies3D bottom detection.
- Check or modify the maximum depth range for each frequency from the table of the panel "**Check or modify Maximum Range**".
  - If needed, set your modifications, in the table column "**MR User values (editable)**" by knowing that the greater maximum range (among ranges for each frequency) will be the maximum range of the echograms saving in Matlab resultant HDF5 file. More this maximum range is important, more resultant data volume and processing time durations will be important.
- Enter a cruise name in the field "**Choose a cruise name**" (press enter on keyboard to validate it)

## MATECHO USER MANUAL

---

Laboratory: UMR LEMAR

User manual

Implantation : Plouzané

Version 01

Page 11/96

---

- Matecho will then create a cruise folder which will be called "Cruise\_XXX" with XXX: the cruise name which you entered. All resultant Matlab HDF5 files of this cruise will then be saved in this cruise folder (see for more details, [section 3.2.5: Output file directory tree](#))
- Check the address of the cruise folder in the field "**Resulting address of the directory where results will be saved**".
  - By default, the cruise folder is created in the folder of the hac file list.
  - Check the amount of free space on the selected disk by planning at least a space equivalent to the total volume of the hac file list.

*Note that Matecho will refuse to run a processing or will stop the current processing as soon as the free space on the selected disk is lower than 750 Mo. In this case, before to continue the processing, make free space on the disk or displace the entire cruise folder (with all its content) on another disk with enough free space and run again the processing which will take back from its stop.*
- Modify, if needed, the cruise folder address by clicking on button "**Choose another directory to save results**" and select another address on your PC, an external disk or a network disk.
- If needed, modify the sounder calibration parameters for each frequency from the button "**Sounder calibration parameters modification**".

## MATECHO USER MANUAL

Laboratory: UMR LEMAR

User manual

Implantation : Plouzané

Version 01

Page 12/96



Enter for each echo-sounder frequency, the new measured calibration parameters:

- TS gain (G0) in dB.
- Sacorr in dB.

These two parameters correspond to the results obtain from Simrad ER60 software calibration. If you have only the Sv gain, put this gain (in dB) in the TS gain field and the Sacorr field at zero (knowing that  $Svgain = TSgain + Sacorr$ ).

- Click on button "**Conversion run**" to run the conversion.



A popup called "ProcessingState" allow following and checking the processing progress.

Note that, you can stop the processing at any moment by clicking on button **STOP** (click on STOP just one time and wait few seconds the end of current hac file processing).

To continue after an interrupted conversion (even if Matecho or Matlab was closed in the meantime), use the menu "**Cruise > Open an existing file treatment...**". Matecho will then detect that the conversion was not terminated and will continue it from the stop.

When the entire hac file list was converted, Matecho complete the resultant Matlab HDF5 file by:

- Detecting the non-chronological ping times and the inconsistent geographical positions due to possible missing or errors in GPS telegrams.



## MATECHO USER MANUAL

Laboratory: UMR LEMAR

User manual

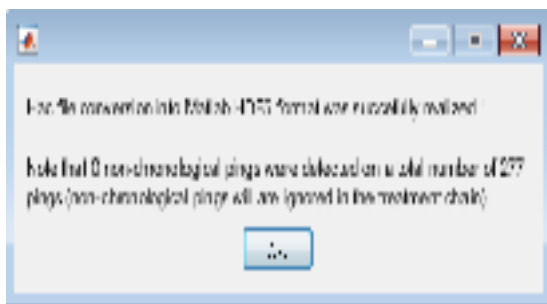
Implantation : Plouzané

Version 01

Page 13/96

- Estimating the ping distances and the ping twilights (night, sunrise, day, sunset) from time and geographical position of each ping by using a proven Matlab script of University of California, San-Diego :  
[http://mooring.ucsd.edu/software/matlab/doc/toolbox/geo/suncycle.html#\\_sub1](http://mooring.ucsd.edu/software/matlab/doc/toolbox/geo/suncycle.html#_sub1)
- Initializing the HDF5 file 'filtering.mat' where manual cleaning and automatic filtering data will be saved.

At the end of the conversion, the Matecho interface ([see section 3.3: Interface visualization setup](#)) coming back with the echograms and their associated information resulting from the hac file conversion.



The pop-up on the left also appears by mentioning the detected number of non-chronological ping times which are flagged to be ignored by Matecho in the following steps of the treatment chain.

If a lot of non-chronological ping time was detected, your hac file list contains certainly one or several hac files in a non-chronological position in hac files list (or redundant hac files).

In this case, you can redone the conversion but, this time, by using before the button **"Copy and rename hac files in a chronological order"**.

### 3.2.5. Output file of the Matlab HDF5 conversion

Matlab conversion data results are saved in the Matlab HDF5 file named **'Echogram.mat'**.

If, for example, the saving address of data results chosen by user in previous popup (see Fig. 4) was C:\DataEemple\ and the name given to the cruise was XXX, this HDF5 file will be located in C:\DataEemple\Cruise\_XXX\MatData\Echogram.mat as below:



## MATECHO USER MANUAL

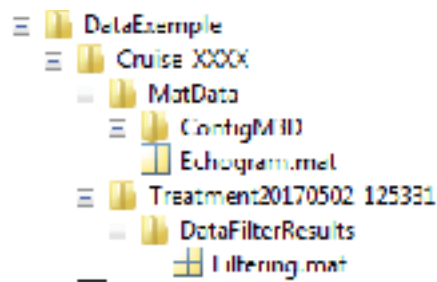
Laboratory: UMR LEMAR

User manual

Implantation : Plouzané

Version 01

Page 14/96



Otherwise, if the Matlab conversion of the hac file list was run the 02/05/2017 at 12:53:21, the initialized HDF5 file 'filtering.mat' (where manual cleaning and automatic filtering data will be saved) will be located in as showed in the directory tree above:

'C:\DataExemple\Cruise\_XXX\Treatment20170502\_125321\DataFilterResults\Filtering.mat'.

When the cruise named XXX is loaded into Matecho, you can access:

- to the content of **Echogram.mat** by taping **m** in Matlab Command Windows.
- to the content of **Filtering.mat** by taping **fi** in Matlab Command Windows.

As these HDF5 file can be very big, [see the Annex 1 for more details about the HDF5 files](#) to know how to open these files safely to preserve the PC ram.

Note that the Movies3D configuration which was generated automatically by Matecho to read hac files is also recorded in C:\DataExemple\Cruise\_XXX\MatData\ConfigM3D\ . If needed, this Movies3D configuration directory can be loaded in Movies3D to visualize hac files from Movies3D with the configuration used by Matecho.

### 3.3. Interface visualization setup

## MATECHO USER MANUAL

Laboratory: UMR LEMAR

User manual

Implantation : Plouzané

Version 01

Page 15/96

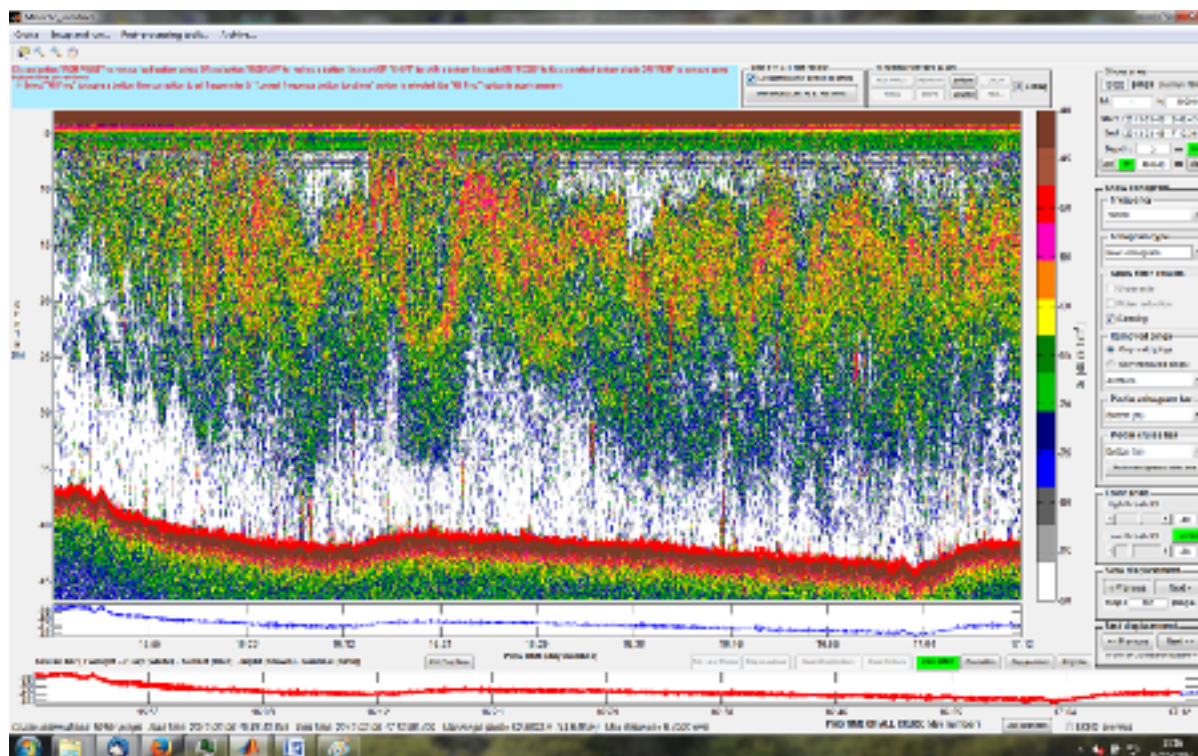


Fig. 5: Matecho main interface when a cruise is loaded

The frames of **right side of the interface** allow to setup the visualization of the cruise data:

- **Frame 'Show area'** : allow to choose or edit accurately the number of pings (with a maximum of 10000 pings), the start-end pings indexes or times and/or the start-end depth with following options for the setup of the depth:
  - Select '**Min**' to setup the minimum depth at the first depth sample in data.
  - Select '**Max**' to setup the maximum depth at the last depth sample in data.
  - Select '**Bot**' to setup the maximum depth at 5 meters below the maximum bottom depth of the current showed ping bloc.
  - Select '**Valid**' to setup the maximum depth at the last valid depth sample of the current showed ping bloc.

For a linear displacements from a ping bloc to another, rather use:

## MATECHO USER MANUAL

Laboratory: UMR LEMAR

User manual

Implantation : Plouzané

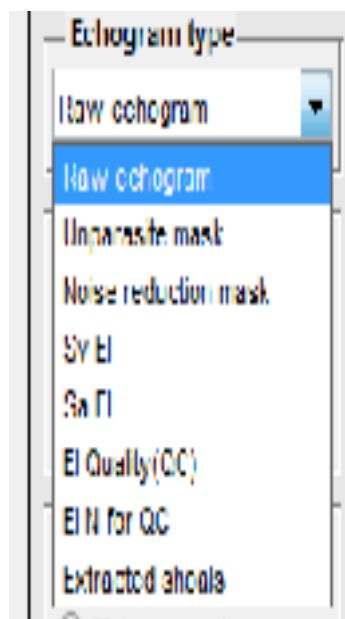
Version 01

Page 16/96

- Buttons '**Previous**' and '**Next**' in frame '**Slow displacement**' (where the ping step is adjustable in 'Step' field) or in frame '**Fast displacement**' to go to the previous or next ping bloc according to the current ping position. The keyboard arrow left and right also corresponds to the button 'Previous' and 'Next' of the frame 'Fast displacement'.

**By clicking on the cruise bar (which correspond to all the pings of the cruise), you can go to any ping part of the cruise in one click.**

- Frame '**Show echogram**' allow to choose the echogram to show:
  - Select the frequency in **Frequency frame**
  - Select the echogram type in **Echogram type frame**:



- **Raw echogram** show initial echogram (extracted from hac files)
- **Unparasite mask** to show the Unparasite mask define as  $\text{mask} = \text{Sv} - \text{Svunparasited}$
- **Noise reduction mask** to show the noise reduction mask define as  $\text{mask} = \text{Sv} - \text{Svdenoised}$  if unparasite filter mask was not run and  $\text{mask} = \text{Svunparasited} - \text{Svdenoised}$  otherwise.
- **Sv EI** to show echointegration Sv results,
- **Sa EI** to show echointegration Sa results,
- **EI quality (QC)** to show echointegration quality factor define as the ratio for each echointegration cell of the number of integrated sample on the total number of sample
- **EI N for QC** to show the total number of sample on each echointegration cell.
- **Extracted shoals** to show the fish shoal echoes extracted by Movies3D.

## MATECHO USER MANUAL

Laboratory: UMR LEMAR

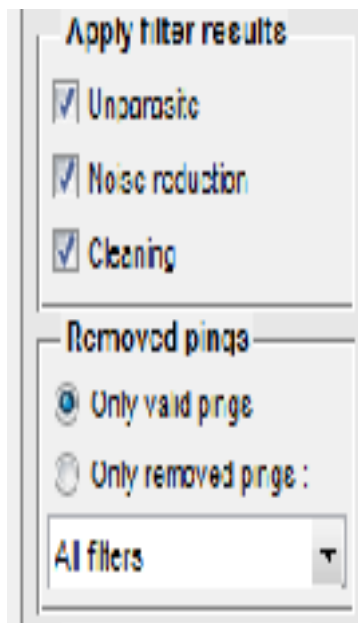
User manual

Implantation : Plouzané

Version 01

Page 17/96

- Frames '**Apply filter results**' and '**Removed pings**':



In '**Apply filter results**' (only if Raw Echogram is selected in Echogram Type):

- check '**Unparasite**' to show unparasited raw echogram
- check '**Noise reduction**' to show denoised raw echogram
- check '**Cleaning**' to show raw echogram with manual water column cleaning (realized by user)

In '**Removed pings**' (only if Raw Echogram or unparasite or noise reduction mask are selected in Echogram Type):

- check '**Only valid ping**' to mask all the removed pings.
- check '**Only removed ping**' to show only the removed. pings (valid pings are then masked).
- if '**Only removed ping**' is selected, choose the removed ping type to show (all filter, empty pings, deep spike pings, low ship speed, ...) by selecting the type in the pop-up menu just below the radio button '**Only removed ping**'.
- if the radio buttons 'Only valid ping' and 'Only removed pings' are both in the unchecked position, all cruise ping are then showed.

- Frames '**Plot in echogram bar**' and '**Plot in cruise bar**':

## MATECHO USER MANUAL

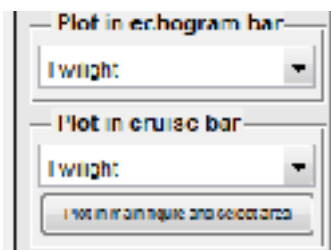
Laboratory: UMR LEMAR

User manual

Implantation : Plouzané

Version 01

Page 18/96



In '**Plot in echogram bar**', select the associated data to plot in the echogram bar just below the echogram (which corresponds to the echogram showed part). The associated data are twilights, times, bottom depths, latitude, ...

In '**Plot in cruise bar**', select the associated information to plot in the cruise bar at the bottom of the interface (which corresponds to all the cruise pings). The associated data are the same than above for echogram bar.

Click on **button 'Plot in main figure and select area'** to plot associated data in the main figure instead of the echogram data (see Fig. 5 below). When this button is activated, you can also make displacement in the cruise from the plotted associated data chosen in the frame 'Plot in cruise bar'.

For example, in Fig. 5 below, a specific ping bloc can be selected from the associated data plotted in Matecho main figure:

- Click on button '**Plot in main figure and select area**'.
- Choose an associated data type, as for example 'Position map' (like in Fig. 5).
- Clicking on the button '**Select Area**' (at the top of the interface) to activate the user selection.
- Click twice on the map to select a ping bloc from a rectangular area. The selected pings are then plotted in red color. To come back to the echogram view corresponding to the selected pings, click again on the button '**Plot in main figure and select area**' to disable this view mode.



# MATECHO USER MANUAL

Laboratory: UMR LEMAR

User manual

Implantation : Plouzané

Version 01

Page 19/96

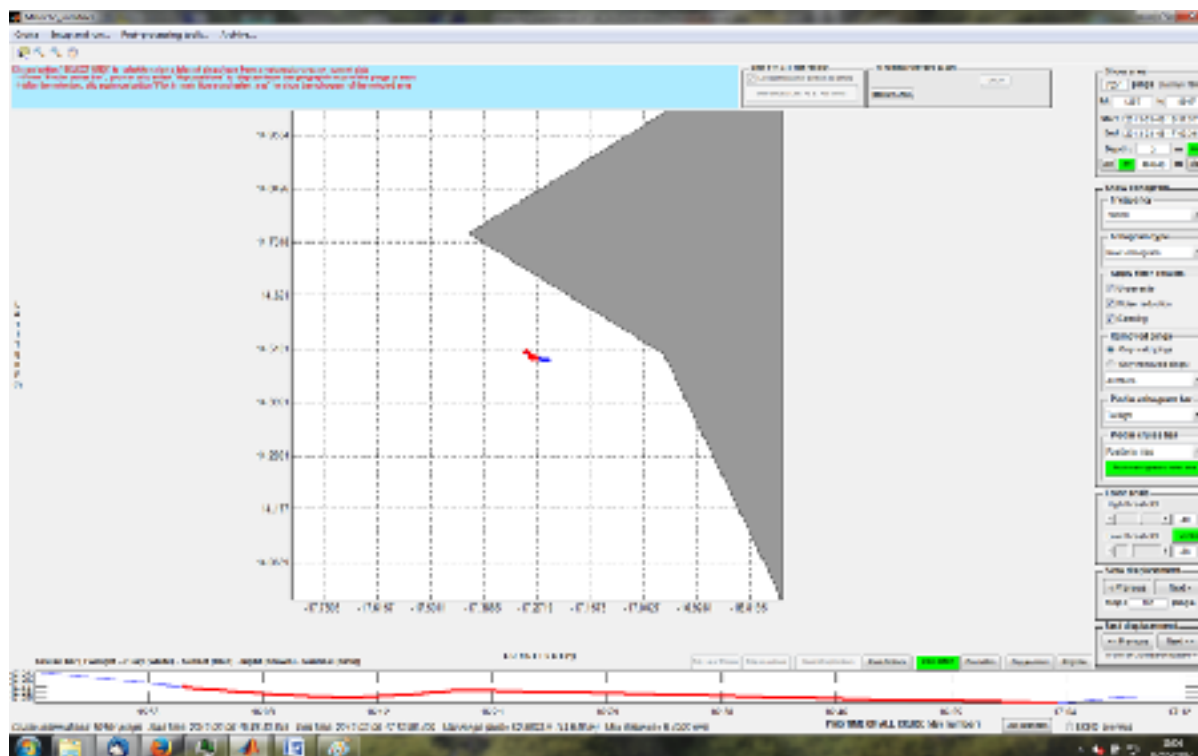


Fig. 5: Matecho main interface when button 'Plot in main figure and select area' is activated

The other buttons at the **bottom of the interface** are described below (Fig.6).

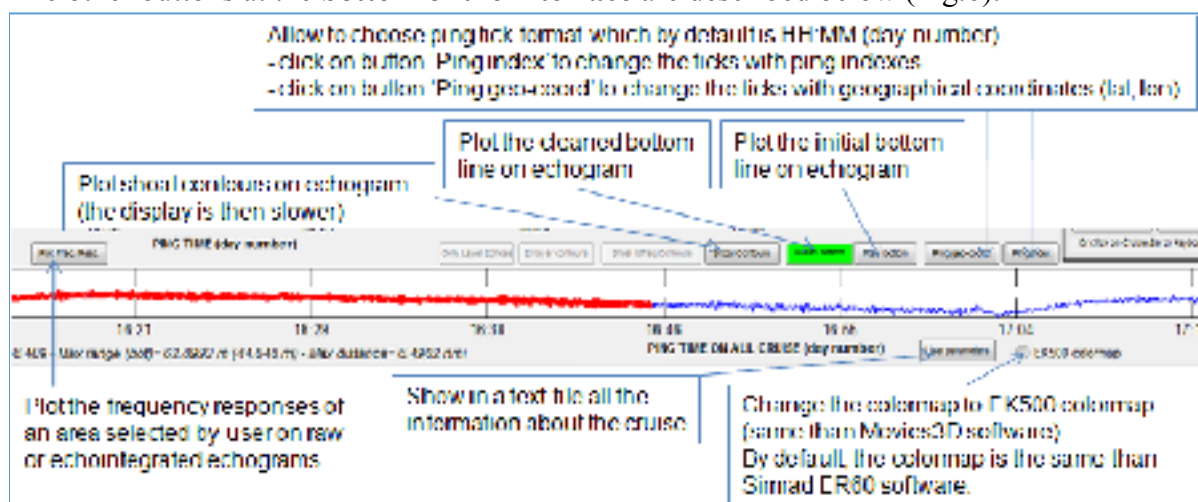


Fig. 6: Buttons to plot additional information with echogram

## MATECHO USER MANUAL

Laboratory: UMR LEMAR

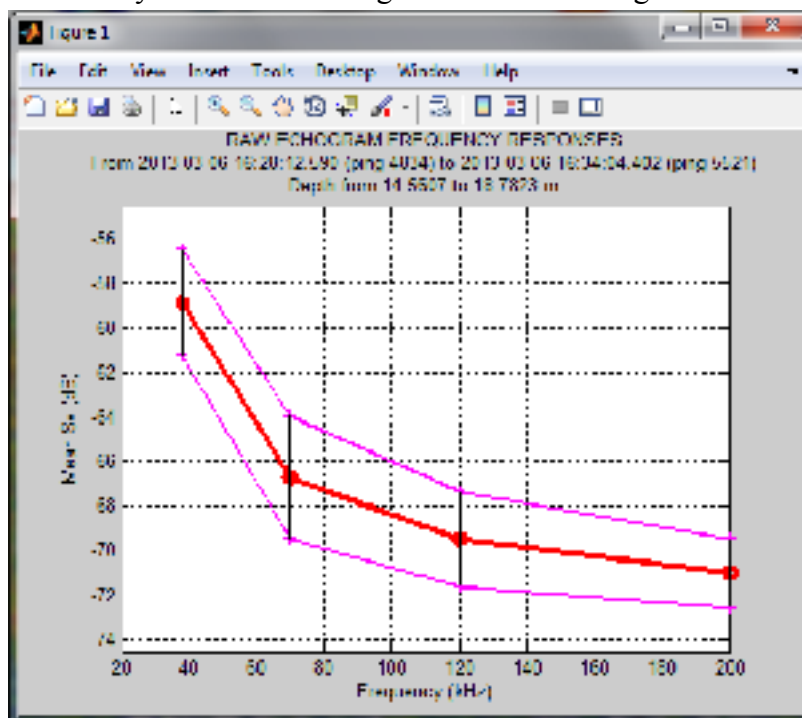
User manual

Implantation : Plouzané

Version 01

Page 20/96

Button '**PlotFreqResp**' allows plotting the frequency responses corresponding to an area selected by user on raw echogram or on echointegration results.



### 3.4. Manual cleaning

Manual cleaning on echogram bottom line and water column are realized from buttons located at the top of the Matecho interface in frames '**APPLY TO ALL THE CRUISE**' and '**CLEANING CONTROL PANEL**' (see Fig. 7 and 8 below).



Fig. 7: Cleaning buttons in mode bottom line correction describe in 3.4.1

## MATECHO USER MANUAL

Laboratory: UMR LEMAR

User manual

Implantation : Plouzané

Version 01

Page 21/96



Fig. 8: Cleaning buttons in mode water column cleaning describe in 3.4.2

If '**All Freq**' is checked, each cleaning applying on showed echogram is also reported on the echograms of all the other frequencies.

The blue information panel (located at the left of the cleaning buttons) display information about the possible actions that user can realized according to the button selected.

An activated cleaning button is presented in green color. Each button contains several options of use. All the options are described in the blue information panel and can be activated by pressed on keyboard the key '**'z','s' or 'x'**'. For example, in mode 'Column', if the button 'REM SAMPLES' is activated, user can:

- Select by default a rectangular area on echogram to remove echoes inside it.
- Press 'z' key to remove echoes sample by sample.
- Press 's' key to remove echoes inside a polynomial area (area defined with multiple points as a contour).

As available options can be different from a cleaning button to another, user has to read step by step the indications display in the blue information panel.

Button '**UNDO**' allow to cancel the last action realized by user.

Button '**REM**' allow to delete corrections (on bottom line or on water column) on a rectangular area selected by user.

### 3.4.1. Bottom correction

By selecting '**Lowest frequency bottom to others**', the lowest frequency bottom line (and its correction) is applied to other bottom lines (recommended). This option allow to correct only the lowest frequency bottom line and is activated by default.



## MATECHO USER MANUAL

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Laboratory: UMR LEMAR

User manual

Implantation : Plouzané

Version 01

Page 22/96

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In the cleaning control panel:

- Click on button '**Bottom**' to correct bottom line
- Click on button '**REM PINGS**' to remove bad bottom pings
- Click on button '**REDRAW**' to redraw a bottom line section ()
- Click on button '**SHIFT**' to shift a bottom line section
- Click on button '**FIXED**' to fix a bottom line section at a constant depth
- Click on button '**REM**' to remove some bottom line corrections

### 3.4.2. Water column correction

In the cleaning control panel:

- Click on button '**Column**' to correct echogram water column
- Click on button '**REM PINGS**' to remove bad pings
- Click on button '**REM SAMPLES**' to remove bad samples
- Click on button '**REM**' to remove some water column cleanings

### 3.4.3. Output file for manual cleaning

All manual cleanings are saved at once by Matecho in the HDF5 file '**Filtering.mat**' located in the subfolder '**DataFilterResults**' of the Cruise folder. This file corresponds to the variable **fi** when Matecho is open.

In this HDF5 file, the cleaned bottom line is saved in the field 'CleanBottom' and the water column cleaning is saved in the fields 'Mask\_Cleaning' for each available frequency.

See Annex 1 for more details about Matecho HDF5 files.

## 3.5. Filtering, Echointegration, Shoal Extraction, Bifrequency

# MATECHO USER MANUAL

Laboratory: UMR LEMAR

User manual

## Implantation : Plouzané

Version 01

Page 23/96

**Note that as soon as one of filter or echointegration or shoal extraction were run, the manual cleaning cannot be modified and the cleaning buttons are not any more accessible.**

Then, when manual cleaning described above is realized, user can run filtering, echointegration and/or shoal extraction from:

- **Menu Setup and run > Setup and run...**

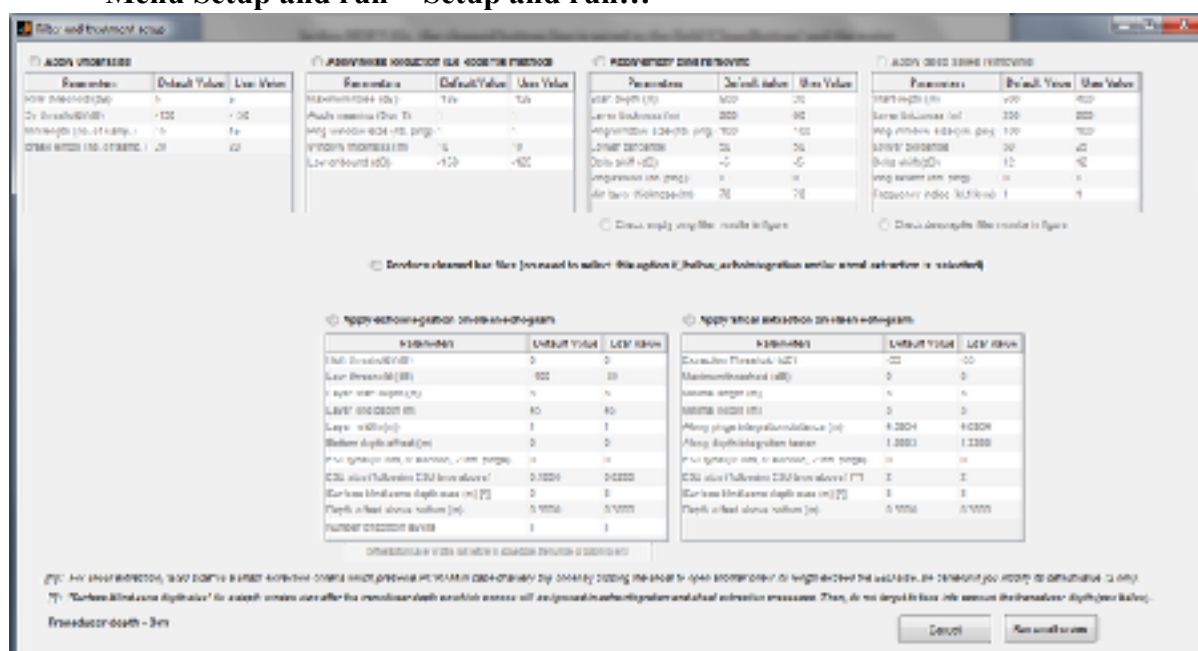


Fig. 9: Popup to setup and run filtering, echointegration and/or shoal extraction

### 3.5.1. Filtering

When you select all available filters from the setup (Fig. 9), their application order filter is:

1. [Deep spikes removing](#), called "Transient Noise (TN) in Ryan and al. (2015).
2. [Empty ping removing](#), called "Attenuated Signal (AS)" in Ryan and al. (2015).
3. [Echogram parasites removing](#) (Naïg Le Bouffant, Ifremer) called "Impulsive Noise (IN)" in Ryan and al. (2015).
4. [Background noise reduction](#) by using the algorithm described in De Robertis and al. (2007) called Background Noise (BN) in Ryan and al. (2015).

To change this default order, run each filter one by one in your own order.

## MATECHO USER MANUAL

Laboratory: UMR LEMAR

User manual

Implantation : Plouzané

Version 01

Page 24/96

### 3.5.1.1. Filtering intermittent parasites

Method is based on codes developed by N. Le Bouffant (Ifremer).

Domain of application: use this filter to replace intermittent parasites on echogram (such as ADCP or Scanmar artefact). This filter will not detect parasites if they are present at same range of two neighbor pings.

For each frequency and each ping, samples are compared to pings before and after. At a same depth, if Sv differences (with ping before and ping after) are greater than a threshold, samples are replaced by the average of corresponding Sv of the ping before and after.

Apply Unparasite		
Parameters	Default Value	User Value
RSB threshold (dB)	5	5
Sv threshold (dB)	-150	-150
Min length (nb. of samp.)	15	15
Erase length (nb. of samp.)	20	20

RSB threshold (dB): Minimum threshold of Sv difference between samples in one ping comparing to ping before and after.

Sv threshold (dB): all Sv under this limit will not be used in the parasite detection.

Minimum length (number of samples): Minimum length, in number of vertical samples, used to detect parasite. NOTE: never use a value below number of samples in a pulse duration. To avoid single target removing, use 2 or 3 times the number of samples in pulse duration.

Erase length (number of samples): number of samples replaced by the average of samples from ping before and after.

# MATECHO USER MANUAL

Laboratory: UMR LEMAR

User manual

Implantation : Plouzané

Version 01

Page 25/96

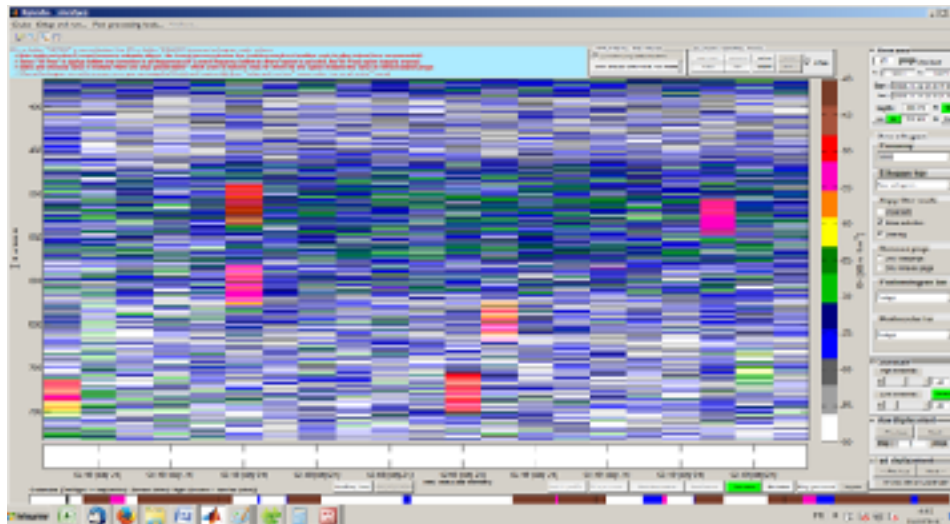


Fig. 10: zoom on raw echogram with parasites (Scanmar).

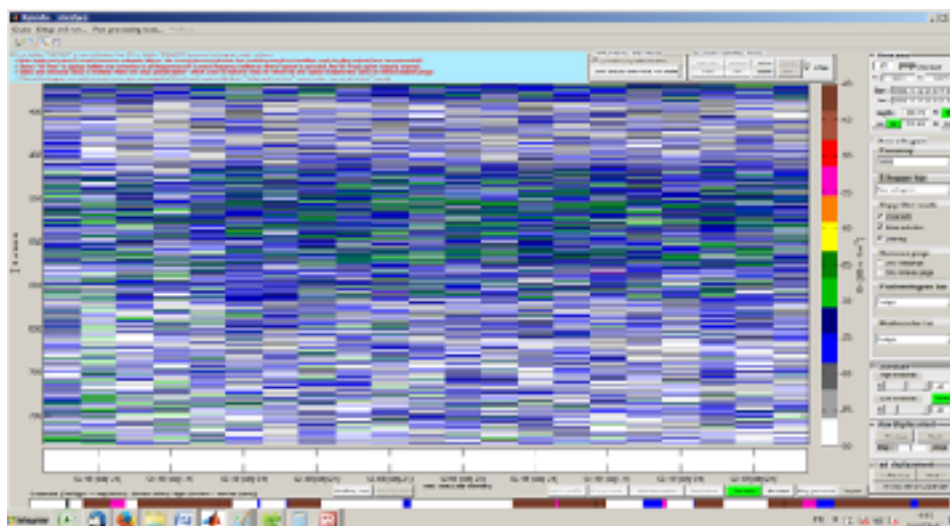


Fig. 11: zoom on echogram after parasites filtering.

## 3.5.1.2. Background noise reduction

Method is based on De Robertis and Higginbottom, 2007.

## MATECHO USER MANUAL

Laboratory: UMR LEMAR

User manual

Implantation : Plouzané

Version 01

Page 26/96

For each frequency and for a block of pings, Time Variation Gain (TVG) is removed and resampled in ping and vertical dimension. The minimum value of this resampled set of data is attributed to back ground noise corresponding to the block of ping. This back ground noise value is subtracted to all vertical samples in the block of ping. If noise is greater than samples, a lower bound value is attributed. TVG is then applied to get Sv corrected from background noise.

☒ Apply Noise Reduction (De Robertis method)

Parameters	Default Value	User Value
Maximum noise (dB)	-135	-125
Apply meaning (0 or 1)	1	1
Ping window size (nb. ping)	1	1
Window thickness (m)	10	10
Lower bound (dB)	-150	-125

Parameters to apply this filter :

Maximum Noise (dB) : upper limit of noise estimation in dB for all frequencies (estimation in passive mode).

Apply meaning (0 or 1) : in the block of ping, do user want to apply an horizontal meaning (use 0 for no meaning, use 1 to apply meaning). If “Ping Window size” is set to 1, this parameter is useless.

Ping window size (number of pings) : number of pings in the block. NOTE : set this parameter to 1 in order to estimate ping to ping background noise (recommended if back ground noise is highly fluctuating).

Window thickness (m) : vertical resampling size to estimate noise. Greater is this value, better is the noise estimation. But keep this value much smaller than the vertical distance inbetween two scattering layers.

Lower bound (dB) : if signal is smaller than noise estimation, samples will be set to this value.



# MATECHO USER MANUAL

Laboratory: UMR LEMAR

User manual

Implantation : Plouzané

Version 01

Page 27/96

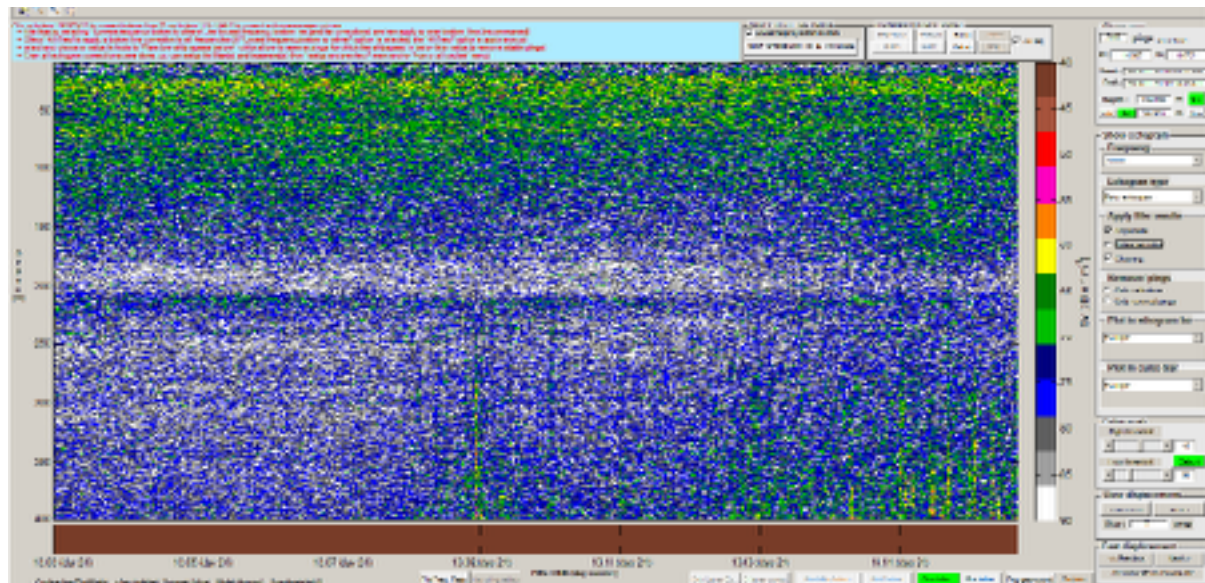


Fig. 12: Raw echogram at 70 kHz with background noise at depth >250 m

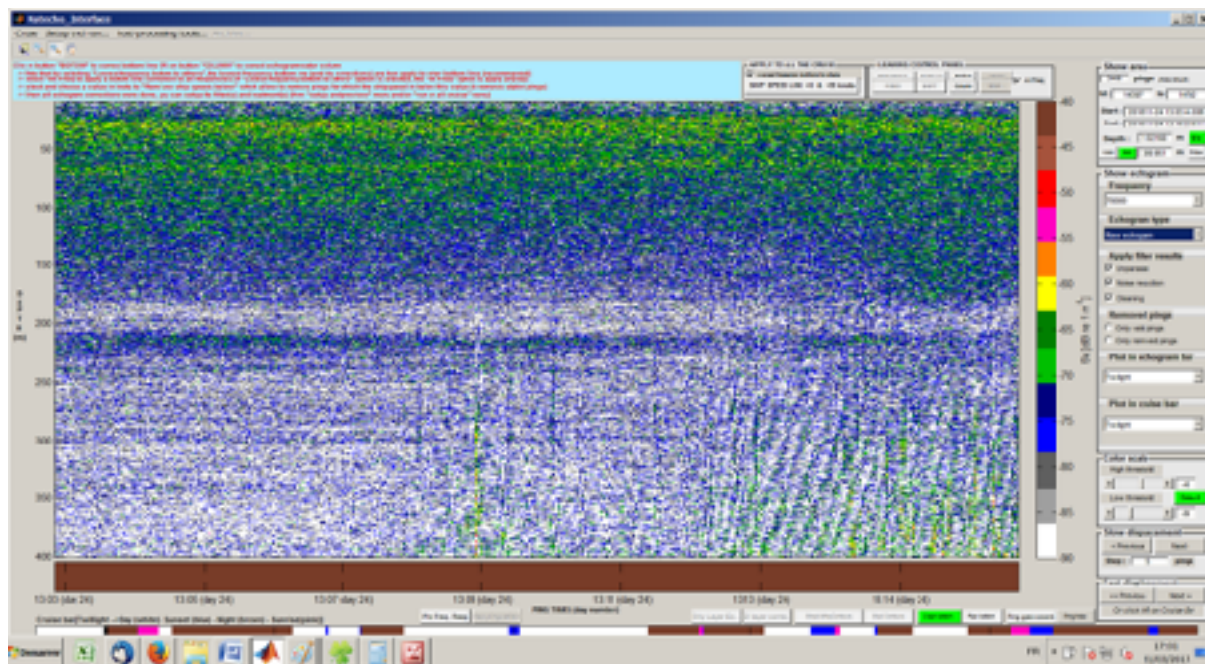


Fig. 13: Same echogram at 70 kHz with background noise reduction

# MATECHO USER MANUAL

Laboratory: UMR LEMAR

User manual

Implantation : Plouzané

Version 01

Page 28/96

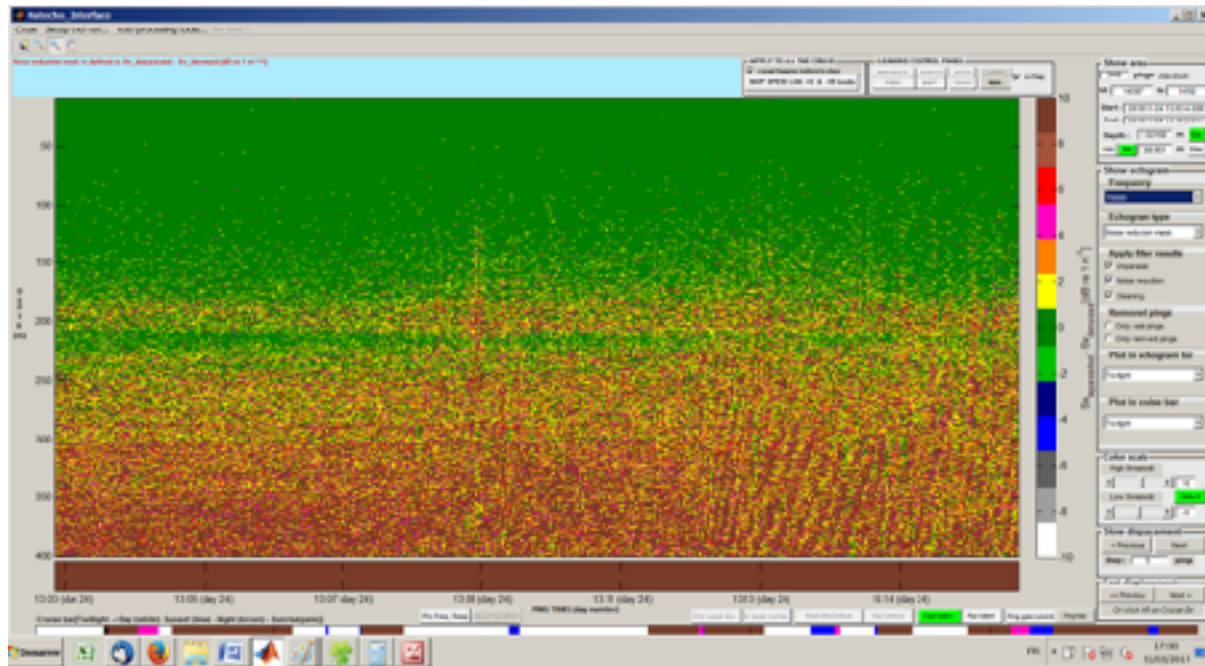


Fig. 14: noise reduction mask applied on raw echogram.

## 3.5.1.3. Filtering pings

**NOTE: testing filter parameters on a set of “bad and good data” is highly recommended before applying those filters to whole cruise.**

Raw echogram:



## MATECHO USER MANUAL

Laboratory: UMR LEMAR

User manual

Implantation : Plouzané

Version 01

Page 29/96

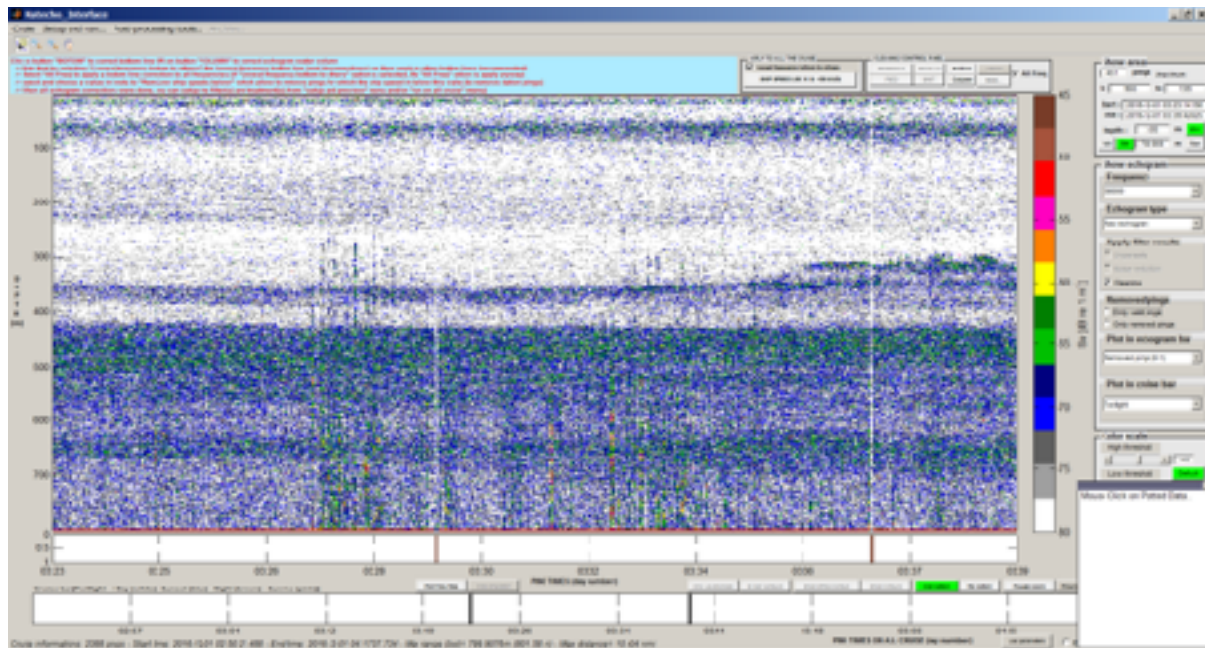
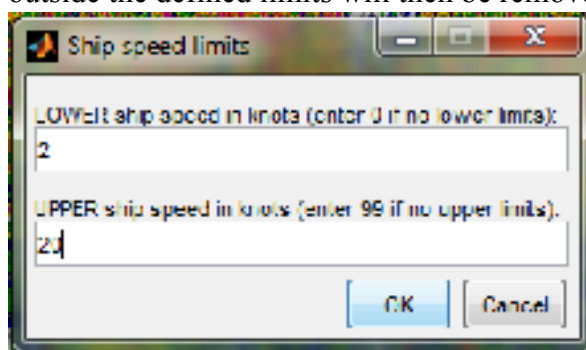


Fig. 15: raw echogram at 38 kHz. Deep spikes and empty pings are visible and need to be filtered.

### 3.5.1.3.1. Low ship speed ping removing

In the frame 'Apply to all the cruise':

To remove the pings according to the ship speed, click on button '**SHIP SPEED LIM**' and define the lower and upper limit values of the ship speed in knots. Pings with ship speed outside the defined limits will then be removed.





## MATECHO USER MANUAL

Laboratory: UMR LEMAR

User manual

Implantation : Plouzané

Version 01

Page 30/96

When Ship speed limits were fixed, the button 'SHIP SPEED LIM' appear in green with a callback of the defined limit values

### 3.5.1.3.2.Empty ping removing

An “empty ping” is a void ping due generally to surface bubbles with low Sv values in whole water column compared to pings before and after (Fig. 16).

This filter will be applied frequency by frequency with sufficient acquisition range. Filtering results will be applied on all frequencies. It means that empty pings on one frequency will be remove on all frequencies. Method is based on Ryan et al., 2015.

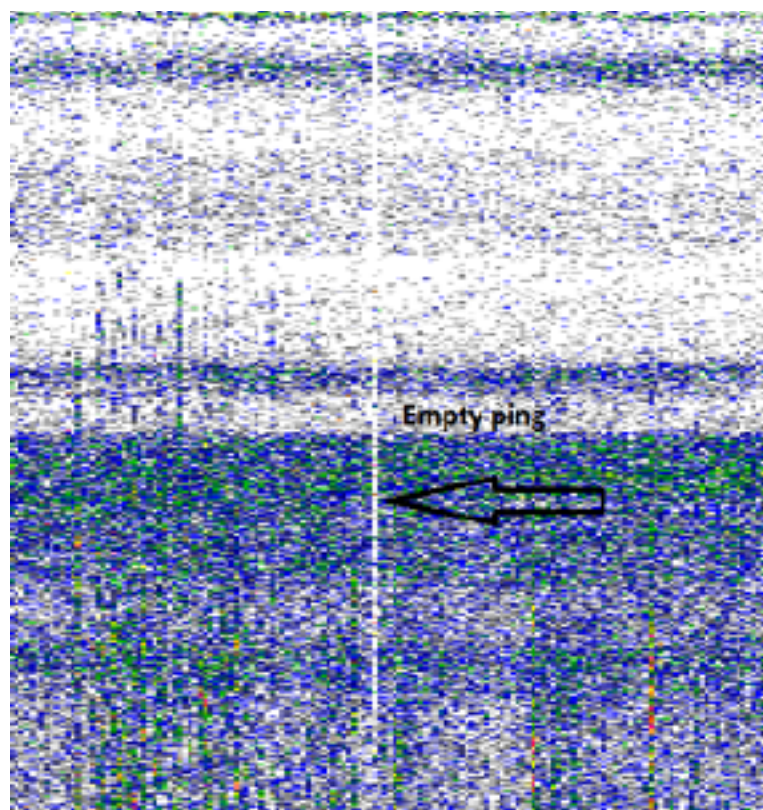


Fig. 16: example of an empty ping shown by the arrow on a zoom of 38 kHz raw echogram.

In order to filter (remove the ping) for all frequencies, user can apply the “empty ping removing option” in menu “Setup and run”.

## MATECHO USER MANUAL


Laboratory: UMR LEMAR

User manual

Implantation : Plouzané

Version 01

Page 31/96

 **Apply empty ping removing**

Parameters	Default Value	User Value
Start depth (m)	500	20
Layer thickness (m)	200	80
Ping Window size (nb. ping)	100	100
Lower percentile	50	50
Depth shift (dB)	-5	-5
Ping extend (nb. ping)	0	0
Min layer thickness (m)	70	70

☐ Check empty ping filter results in figure

Parameters to apply this filter :

Start depth (m) : layer starting depth (in meter) to consider. Deeper is this layer, better is robustness of the method due to beam overlapping at high range.

Layer thickness (m): thickness of the layer in meter

Ping window size (number of ping): length (in ping) of the sliding window to compute the Sv percentile in the layer. See figure below.

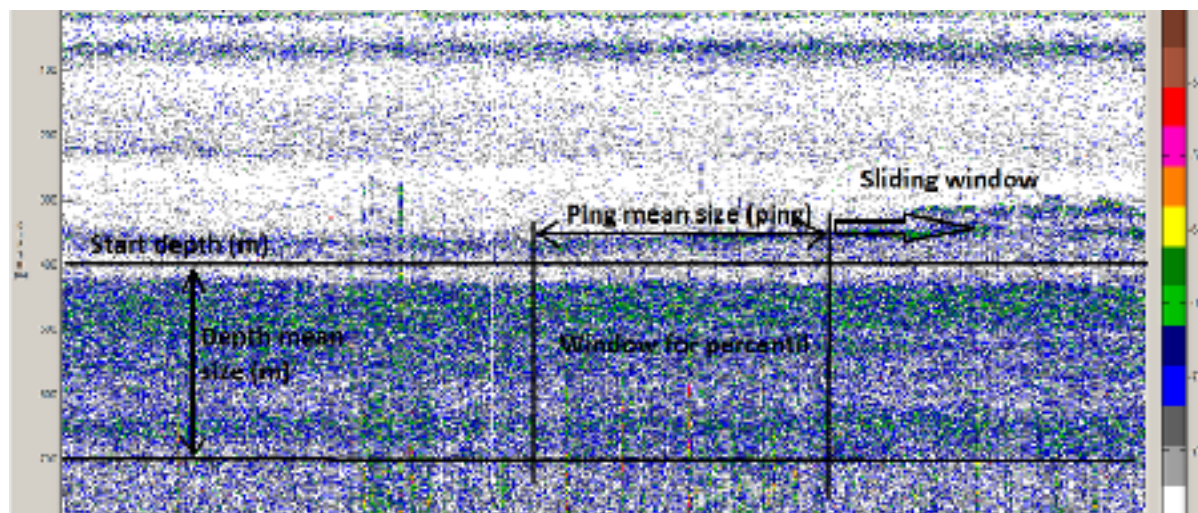


Fig. 17: layer parameters for empty ping filter

Lower percentile : percentile computed in the sliding window

## MATECHO USER MANUAL

Laboratory: UMR LEMAR

User manual

Implantation : Plouzané

Version 01

Page 32/96

Delta shift (dB) : for each ping, the percentil in the sliding window is shifted by this value (negative value) (Fig. 18).

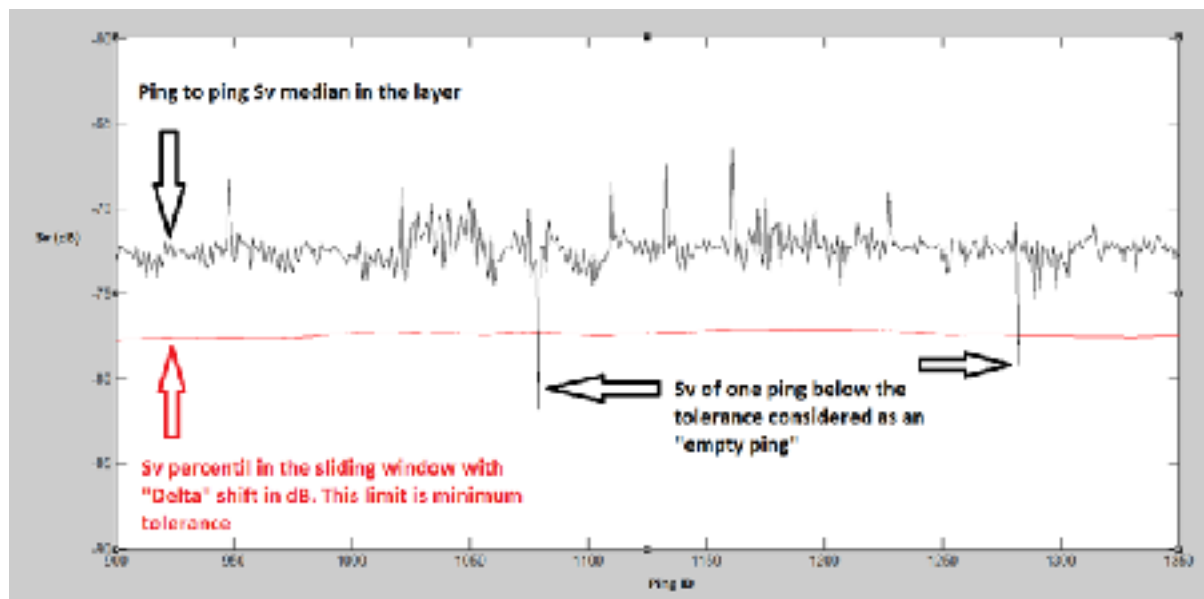


Fig. 18 : Method : if the ping to ping Sv median in the layer (black line) is below the minimum tolerance (Sv percentil in the window + “ping delta value”, the ping is considered as an empty ping

Additional parameters :

Ping extend (number of pings) : for each empty ping detected, neighbor ping can be also removed. If this value is set to 1, one ping before and one ping after will be removed.

Minimum layer thickness (meters) : Minimum thickness (in meters) of the layer to apply the empty ping filter. Filtering will not be applied if layer thickness is under this value.

Once filtering is done, empty pings are shown in the echogram with a white line. Select “Removed pings (0-1)” option in the “Plot echogram bar” scrolling menu (Fig. 19).

Additional option: User can activate the radio button '**Check empty ping filter results in figure**' to have a synthesis of the empty removed ping.



## MATECHO USER MANUAL

Laboratory: UMR LEMAR

User manual

Implantation : Plouzané

Version 01

Page 33/96

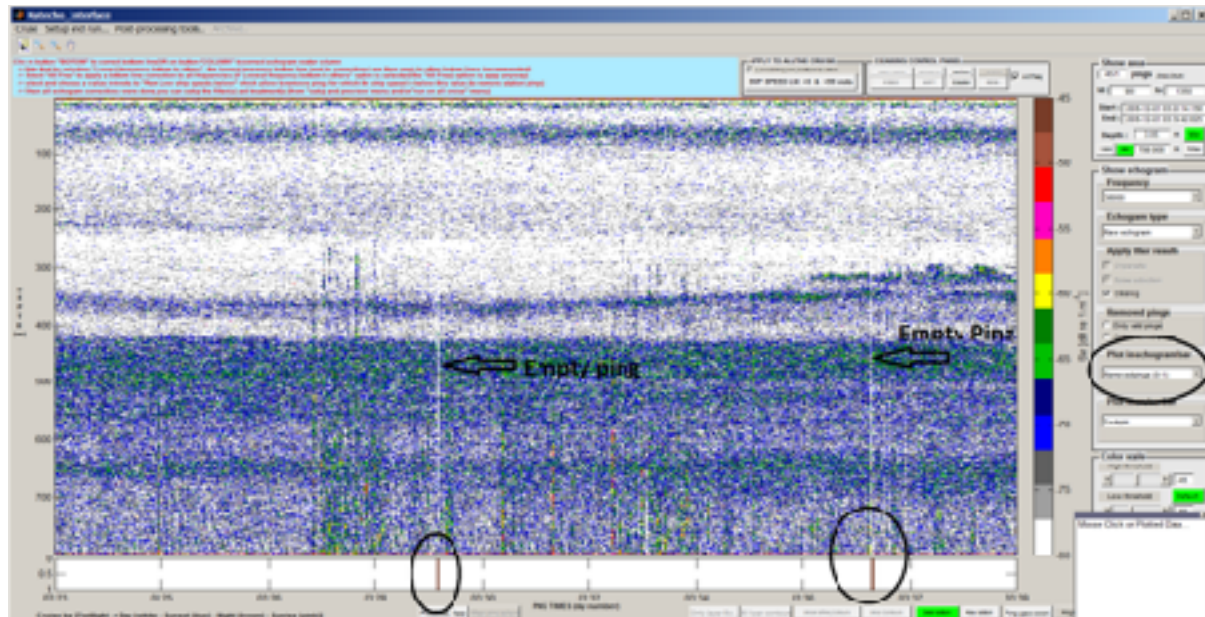


Fig. 19 : empty pings are white on the echogram. Select “removed pings” to plot them in the echogram bar.

### 3.5.1.3.3. Deep spikes removing

A “deep spike” on a ping is abnormal high Sv values at range where signal to noise ratio is low (Fig. 20). Pings with deep spikes (on frequency chose by user) will be remove on all frequencies. Method is based on Ryan et al., 2015.

**Note that this filter is available if the depth maximum range in the cruise is more than 400 m.**

## MATECHO USER MANUAL

Laboratory: UMR LEMAR

User manual

Implantation : Plouzané

Version 01

Page 34/96

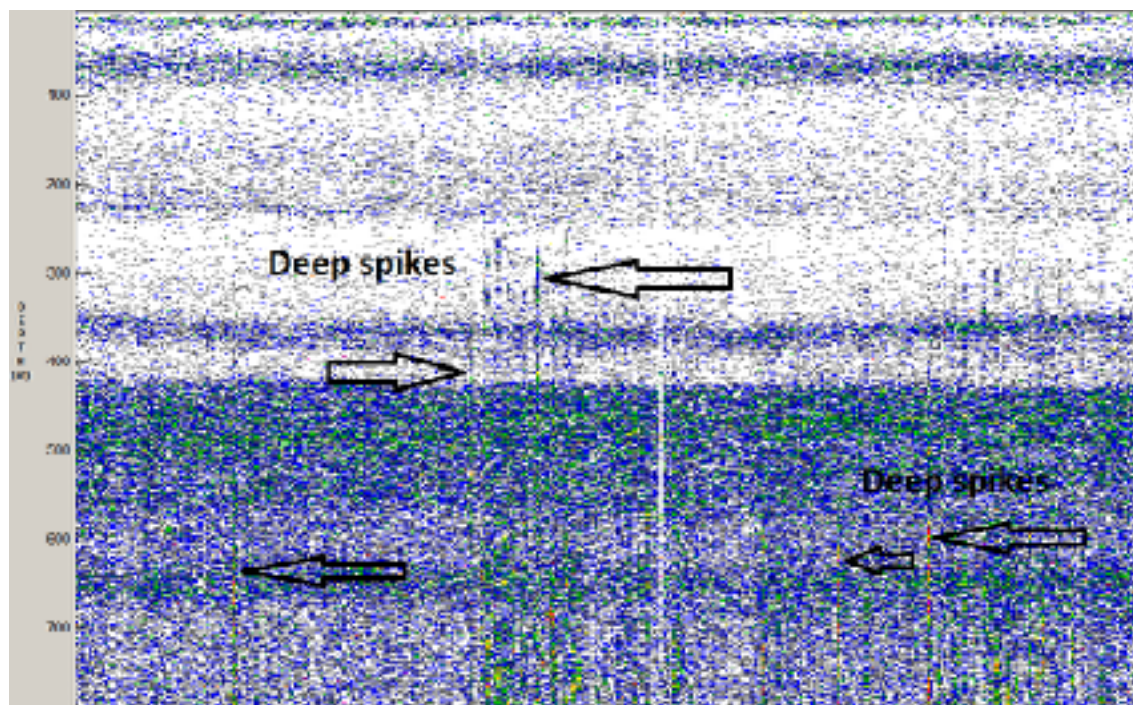


Fig. 20: “Deep spikes” visible on 38 kHz echogram

To remove the ping on all frequencies, user select the “deep spike removing option” in menu “Setup and run”.

☐ Apply deep spike removing

Parameters	Default Value	User Value
Start depth (m)	500	400
Layer thickness (m)	200	200
Ping Window size (nb ping)	100	100
Lower percentile	50	25
Delta shift (dB)	12	12
Ping extend (nb ping)	0	0
Frequency Index (0, 1, low)	1	1

☐ Check deep spike filter results in figure

Parameters to apply this filter :

Start depth (m) : layer starting depth (in meter) to consider. Deeper is this layer, better is robustness of the method due to beam overlapping at high range.



## MATECHO USER MANUAL

Laboratory: UMR LEMAR

User manual

Implantation : Plouzané

Version 01

Page 35/96

Layer thickness (m): thickness of the layer in meter.

Ping window size (number of pings): length (in ping) of the sliding window to compute the Sv percentil in the layer. See figure below.

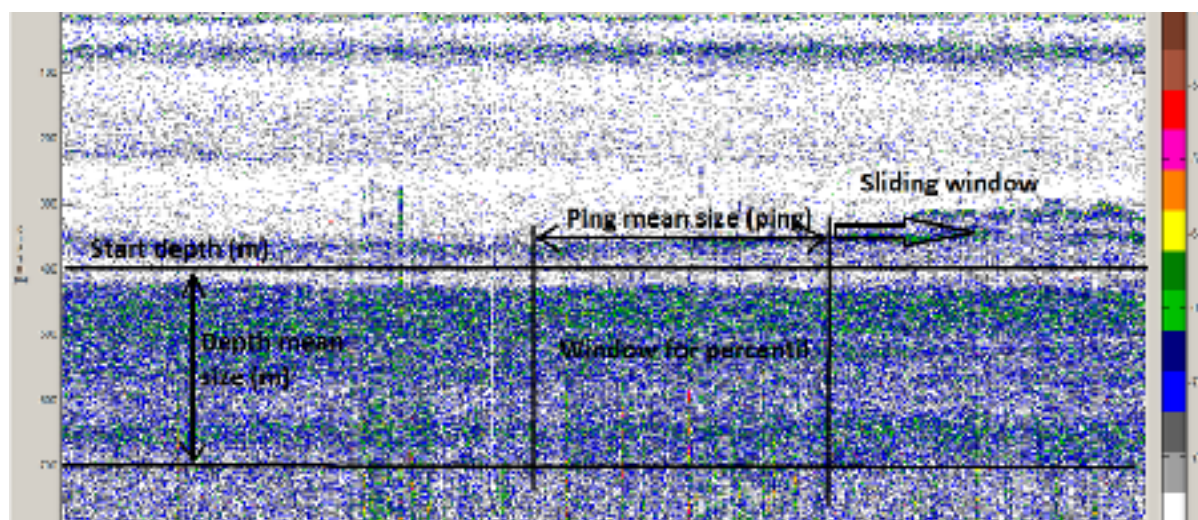


Fig. 21 : layer parameters for empty ping filter

Lower percentil: percentil computed in the sliding window

Delta shift (dB): for each ping, the percentil in the sliding window is shifted by this value (positive value). See figure below.

## MATECHO USER MANUAL

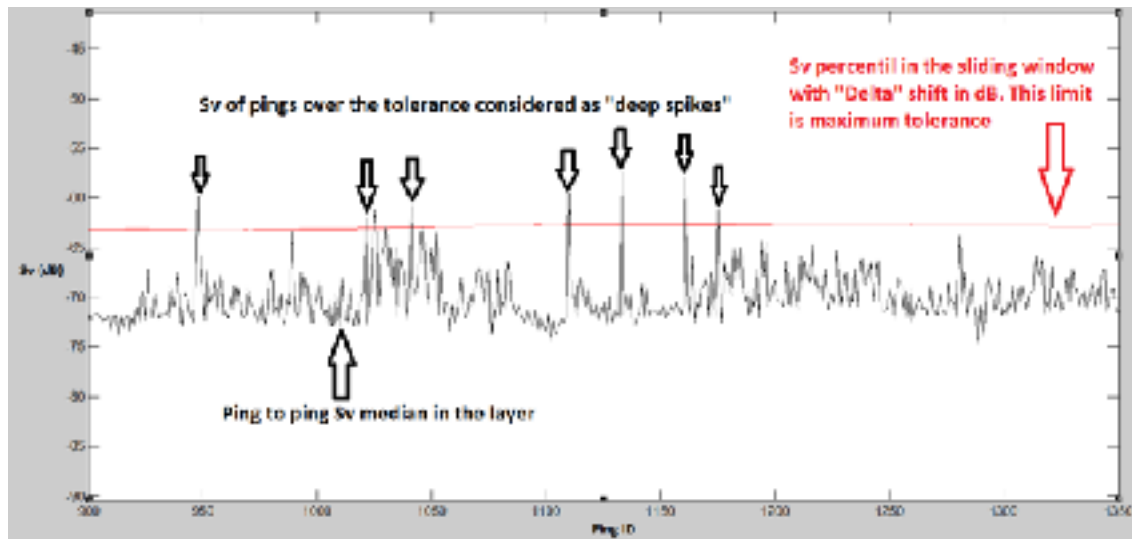
Laboratory: UMR LEMAR

User manual

Implantation : Plouzané

Version 01

Page 36/96



Additional parameters :

Ping extend (number of pings) : for each ping detected with deep spikes, neighbor ping can be also removed. If this value is set to 1, one ping before and one ping after will be removed.

Frequency indice (id) : frequency indice to apply deep spike filtering. Only one frequency is used for this filter but “bad” pings are removed on all frequencies.

Additional option: User can activate the radio button '**Check deep spike filter results in figure**' to have a synthesis of the deep spike removed ping.

Once filtering is done, pings with deep spikes are shown in the echogram with a white line. Select “Removed pings (0-1)” option in the “Plot echogram bar” scrolling menu. See figure below.

## MATECHO USER MANUAL

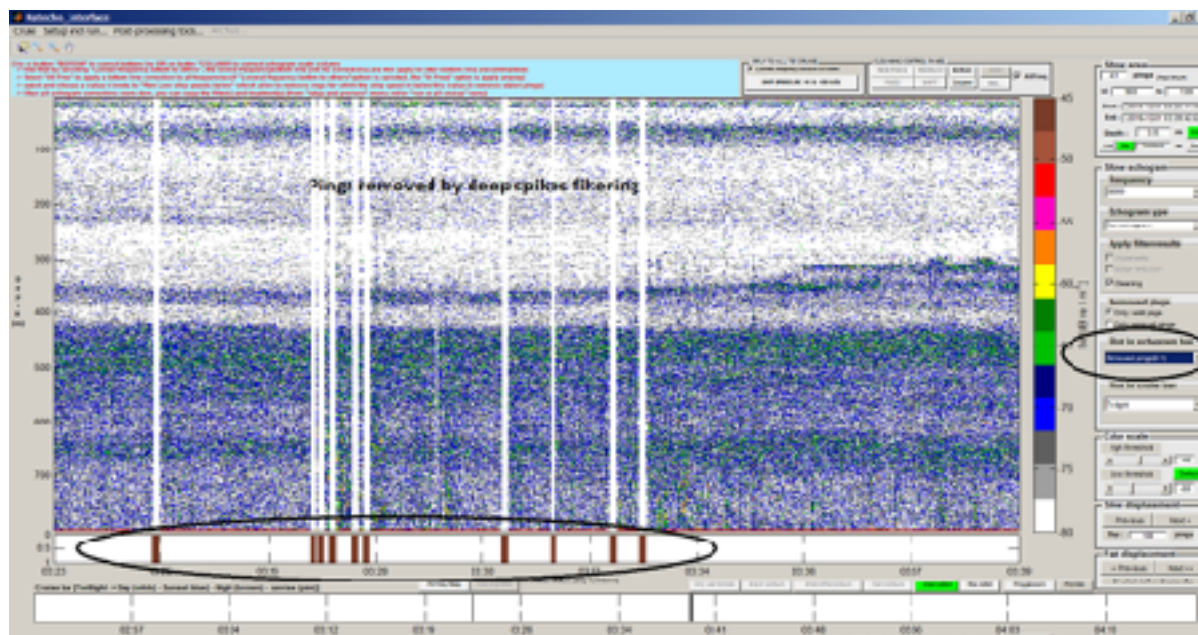
Laboratory: UMR LEMAR

User manual

Implantation : Plouzané

Version 01

Page 37/96



### 3.5.1.4. Output file for filtering

All filter results are saved by Matecho in the HDF5 file '**Filtering.mat**' located in the subfolder '**DataFilterResults**' of the Cruise folder. This file corresponds to the variable **fi** when Matecho is open.

In this HDF5 file, the unparasite and noise reduction filter results are saved in the fields 'Mask\_Unparasite' and 'Mask\_NoiseReduction' for each available frequency. For example, you can find for the 38 kHz, the matrix (with the same dimension than the raw echogram) called 'Mask\_Unparasite38' and 'Mask\_NoiseReduction38'.

The removed ping filter results (low ship speed, empty ping and deep spike filters) are saved in the fields 'TimePingRemove', 'IndexPingRemove', 'IdPingRemove', 'IdHacPingRemove' for each filter type. For example, 'IndexPingRemove\_DeepSpike' gather all the indexes (in all the cruise) of the pings removed by the Deep spike filter.

See Annex 1 for more details about Matecho HDF5 files.



## MATECHO USER MANUAL

Laboratory: UMR LEMAR

User manual

Implantation : Plouzané

Version 01

Page 38/96

### 3.5.2. Clean hac files

Before to run echointegration and/or Shoal extraction treatment, Matecho has to generate, from initial hac files, the clean hac files which take into account all the manual cleaning and the computed filtering.

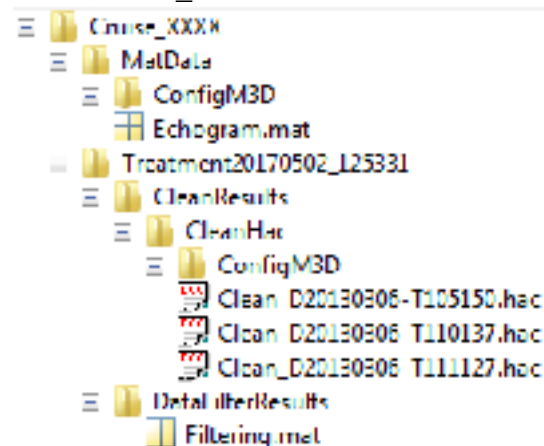
**Note that as soon as the clean hac files are produced, it is not any more possible to apply manual cleaning and/or filters which would not have been applied yet.**

The radio button '**Produce cleaned hac files**' available in the popup setup and run (Fig. 9) allow to produce clean hac files without to run echointegration and/or shoal extraction. But, if you run echointegration and/or shoal extraction, clean hac files are then produced automatically and it is unnecessary to activate this option.

Directory tree where the clean hac files are saved by Matecho:

If the name of the initial hac file was 'YYYY.hac', its corresponding clean hac file will be named as 'Clean\_YYYY.hac'.

If, for example, the name given to the cruise was XXX and the Matlab conversion of the initial hac file list was realized the 02/05/2017 at 12:53:31, the clean hac files will be located in '...\Cruise\_XXXX\Treatment20170502\_125331\CleanResults\CleanHac\' as below:



### 3.5.3. Echointegration (EI)

## MATECHO USER MANUAL

Laboratory: UMR LEMAR

User manual

Implantation : Plouzané

Version 01

Page 39/96

### 3.5.3.1. EI setup and run

#### Menu Setup and run > Setup and run...

☒ Apply echointegration on clean echoqram

Parameters	Default Value	User Value
High threshold (dB)	0	0
Low threshold (dB)	-100	-80
Layer start depth (m)	3	3
Layer end depth (m)	45	45
Layer width (m)	1	1
Bottom depth offset (m)	0	0
ESU type (0. nmi, 1. second, 2. nb. pings)	0	0
ESU size (following ESU type above)	0.1000	0.0200
Surface blind zone depth size (m) [°]	0	3
Depth offset above bottom (m)	0.3000	0.3000
Number of bottom layers	1	1

Define Bottom Layer Widths (set before. In above table, the number of bottom layers)

The EI parameters are:

**High threshold (dB):** echointegration high threshold in dB. *Default value: 0.*

**Low threshold (dB):** echointegration low threshold in dB. *Default value: -100.*

**Layer start depth (m):** start depth of the first EI layer in meter. *Default value: 3.*

**Layer end depth (m):** end depth of the last EI in meter. *Default value calculated by Matecho corresponds to the maximum bottom depth in the cruise.*

**Layer width (m):** width of EI layers in meter. *Default value: 1.*

**Bottom depth offset (m):** offset in meter above first bottom layer. It is recommended to keep this parameter to the default value zero and to rather use the parameter '**Depth offset above bottom**' (described below) to fix an offset above bottom depth. *Default value: 0.*

**ESU type:** enter 0, 1 or 2 to define the ESU size (just below) in nautical miles, in seconds or in number of pings. *Default value: 0.*

**ESU size:** enter the ESU size in the format of ESU type just above. *Default value: 0.1.*

## MATECHO USER MANUAL

Laboratory: UMR LEMAR

User manual

Implantation : Plouzané

Version 01

Page 40/96

**Surface blind zone depth size (m):** offset in meter from the surface to avoid taking into account the sounder blind zone (echo saturation in surface) and/or bubble effect. 'Surface blind zone size' fix a depth window after the transducer depth. So if the transducer depth is for example 3 m, sample echoes above 3 + 'Surface blind zone size' in depth will be ignored. So, fix this parameter according to the transducer depth, which is callback at the bottom of the setup and run popup (Fig. 9). *Default value: 0.*

**Depth offset above bottom (m):** offset in meter above bottom depth (the EI is then done from the transducer depth to the bottom depth minus the 'Depth offset above bottom'). *Default value: 0.3.*

**Number of bottom layers:** number of EI bottom layers. *Default value: 1.*

Option: If you are interested by the bottom layers for a specific study on bottom echoes, the button **'Define Bottom Layers Widths'** allow to define EI bottom layer widths for each bottom layer. Otherwise, keep **'Number of bottom layers'** to 1 and simply ignore this option button.

### 3.5.3.2. Ei cleaning

In panel **'Echogram type'**, select **'Sv EI'** or **'Sa EI'** or **'EI quality (QC)'** or **'EI N for QC'** to clean echointegration results.

In the cleaning control panel:

- Select **'All Freq'** if you want to apply the corrections to all frequencies.
- Click on button **'Column'** to correct echointegrated echogram.
- Click on button **'REM ESUS'** to remove bad ESUS.
- Click on button **'REM SAMPLES'** to remove bad samples.
- Click on button **'REM'** to remove corrections on echointegrated echogram.

Read information about the different cleaning options for each cleaning button in the blue information panel at the top on the interface.

## MATECHO USER MANUAL

Laboratory: UMR LEMAR

User manual

Implantation : Plouzané

Version 01

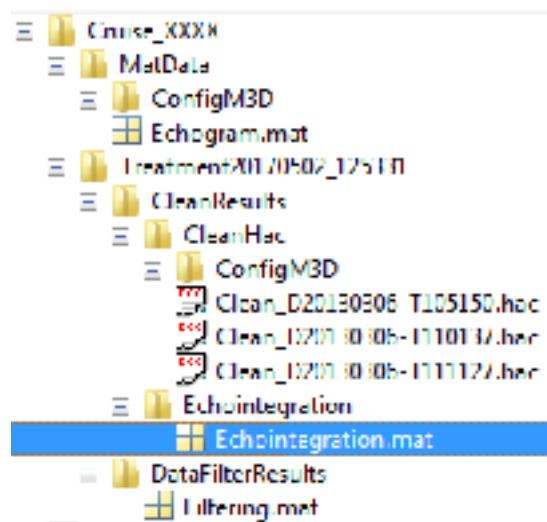
Page 41/96

### 3.5.3.3. *EI output files*

#### 3.5.3.3.1. EI Matlab HDF5 file

Echointegration results are saved in the Matlab HDF5 file named '**Echointegration.mat**'.

If, for example, the name given to the cruise was XXX and the Matlab conversion of the initial hac file list was realized the 02/05/2017 at 12:53:31, the file 'Echointegration.mat' will be located in '...\Cruise\_XXXX\Treatment20170502\_125331\CleanResults\Echointegration\' as below:



When the cruise\_XXX is loaded into Matecho, you can access to the content of Echointegration.mat by tapping **ei** in Matlab Command Windows.

As these HDF5 file can be very big, [see the Annex 1 for more details about the HDF5 files](#) to know how to open these files safely to preserve the PC ram.

Note that the Movies3D configuration which was generated automatically by Matecho to produce the echointegration is recorded in:

'...\Cruise\_XXXX\Treatment20170502\_125331\CleanResults\CleanHac\ConfigM3D\'.

If needed, this Movies3D configuration directory can be loaded in Movies3D to visualize hac files from Movies3D with the configuration used by Matecho to perform echointegration.

## MATECHO USER MANUAL

Laboratory: UMR LEMAR

User manual

Implantation : Plouzané

Version 01

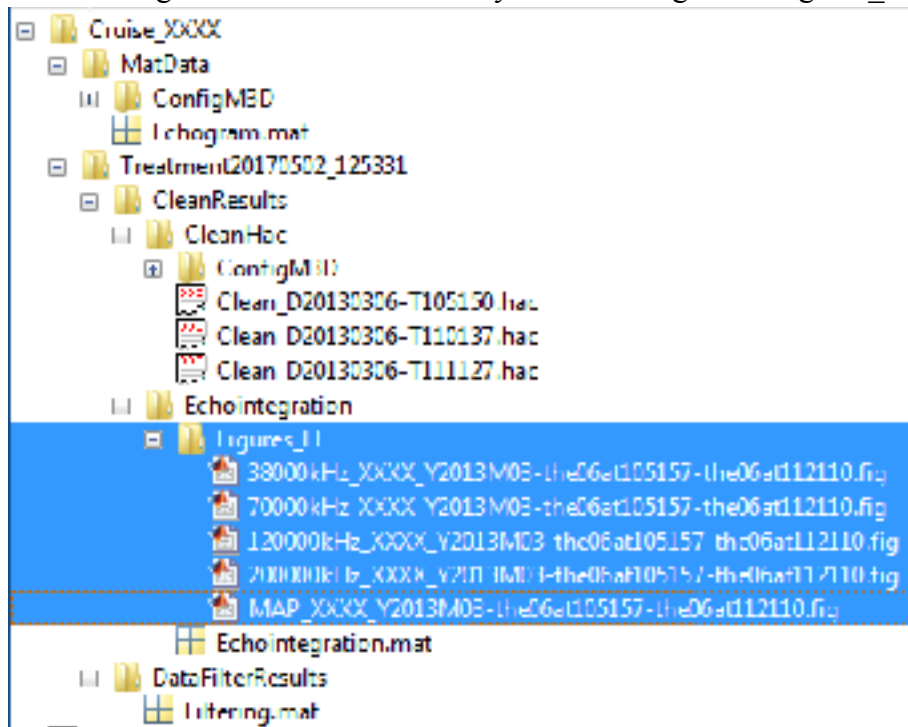
Page 42/96

### 3.5.3.3.2.EI figures

Use Matecho menu '**Archive...>Echointegration results...>Save echointegration results in figures...**' to produce figures of the echointegration results at the Matlab format '.fig'.

These format (.fig) can be easily re-open from Matlab and then saving in any classical formats for figure (as .png, .jpeg, etc.).

Produced figures are saved in directory ...>Echointegration>Figures\_EI\ as below:



### 3.5.3.3.3.EI Excel files

To produce Excel file of the echointegration results at the Matlab **format '.csv'**:

- Use Matecho menu '**Archive...>Echointegration results...>Write echointegration in Excel file...**'
- Choose to make the Excel conversion for one frequency or all frequencies

## MATECHO USER MANUAL

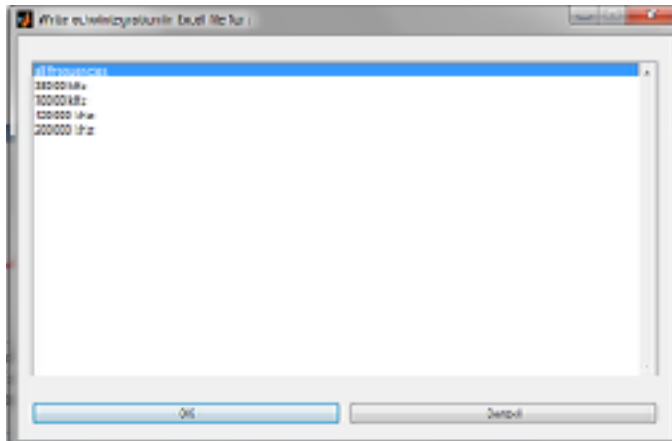
Laboratory: UMR LEMAR

User manual

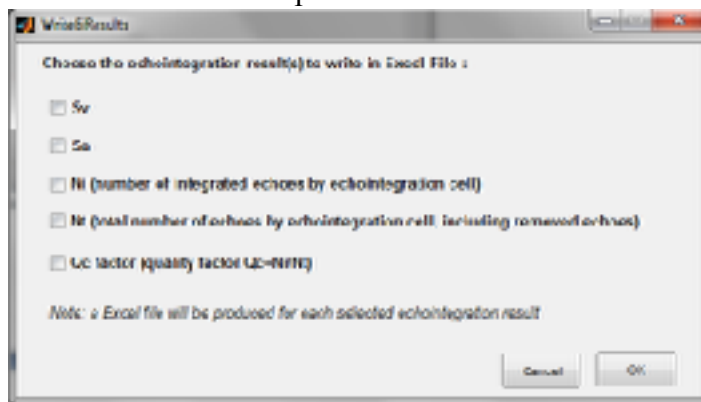
Implantation : Plouzané

Version 01

Page 43/96



- Choose to produce an Excel file for one or many result types (Sv, Sa, Ni, Nt, Qc) and click on OK button to perform the Excel conversion



Produced Excel files are saved in directory ...\\Echointegration\\EchointegrationXLS\\ as below:



## MATECHO USER MANUAL

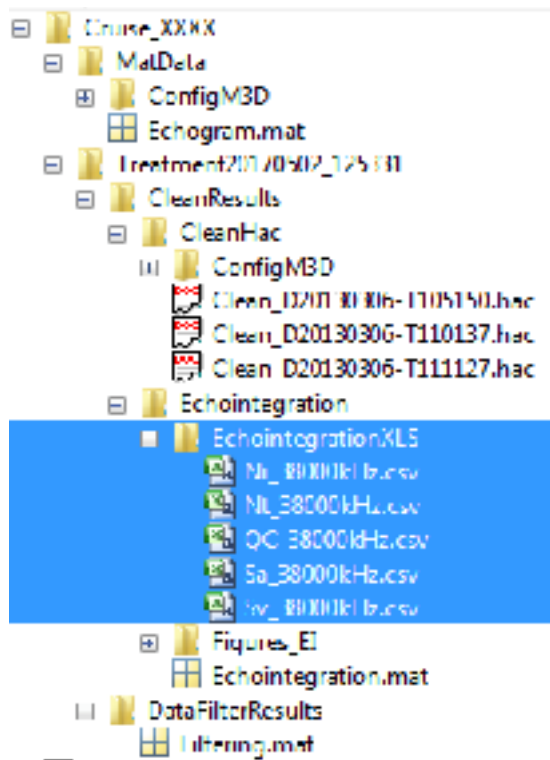
Laboratory: UMR LEMAR

User manual

Implantation : Plouzané

Version 01

Page 44/96



### 3.5.3.3.4.EI NetCDF files at ICES/IMOS standard format

To produce NetCDF file of the echointegration results at the Matlab **format '.nc'**:

- Use Matecho menu "**Archive...\Echointegration results...\Write echointegration in NetCDF file...**"
- Choose to make the Excel conversion for one frequency or all frequencies

## MATECHO USER MANUAL

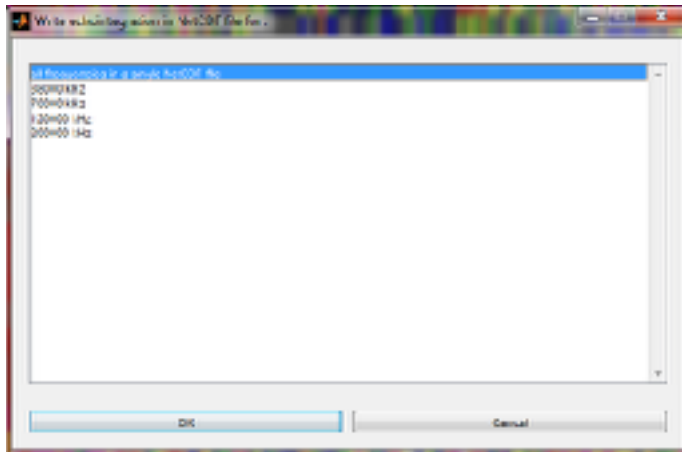
Laboratory: UMR LEMAR

User manual

Implantation : Plouzané

Version 01

Page 45/96



- Choose to Load or Edit the dataset metadata. If user have ever edited and filled with his own information a dataset metadata (from another cruise for example), he can use it for the current cruise by loading it from 'Load', otherwise user has to edit one from 'Edit' button and fill the dataset metadata.

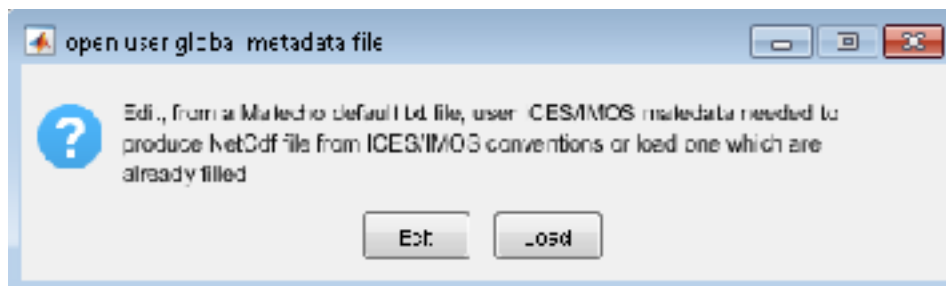


Fig. 22: Opening mode of the global metadata file

- The two popups displayed below ('UserNetCdfMetadata.txt' and 'User global Attribute filling') are then opened simultaneously by Matecho. User has to realize the 3 following actions in this order:
  - First of all, consider the text file named '**UserNetCdfMetadata.txt**' that user must fill by reading previously with attention the methodology described at the beginning of the txt file. The fields to fill by user are not preceded by a % character. All lines preceded by a % character are just the comments which describe the parameter to fill (just a help in fact).

## Laboratory: UMR LEMAR

User manual

## Implantation : Plouzané

Version 01

Page 46/96

- User Global Attribute Filing**

1- FILL or CHECK is to be filled by the user ICES/IMOS metadata needed to produce NetCDF file from ICES/IMOS conventions (read all instructions to fill it)

2- Save and close the file when it is filled

3- Click on one option writing below to write NetCDF file

☐ FILL or CHECK is to be filled by the user ICES/IMOS metadata needed to produce NetCDF file from ICES/IMOS conventions (read all instructions to fill it)

☐ Save and close the file when it is filled

☐ Click on one option writing below to write NetCDF file

**Important note:**

MS Windows (seven or 10) do not accept file path which excess 250 characters. As the IMOS name of the NetCDF file is often very long and if your cruise folder is very far of the root folder (C:\) of your PC, it is possible that Matecho cannot save the NetCDF file in the cruise folder. In this case, Matecho open an additional popup to select another location on the PC

## MATECHO USER MANUAL

Laboratory: UMR LEMAR

User manual

Implantation : Plouzané

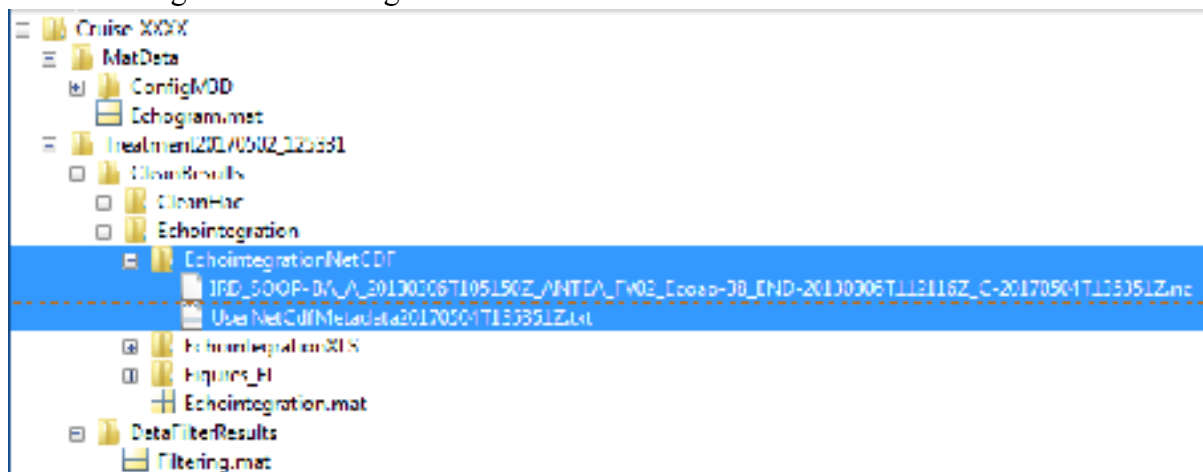
Version 01

Page 47/96

where the NetCDF file can be saved. In this case, select from this popup a folder near the root directory (C:\) on your PC. The NetCDF file will then be saved in this folder.

If you are not in the case of the note just above, produced NetCDF files are saved in directory:

...\Echointegration\EchointegrationNetCDF\ as below:



Note that, in the tree directory above, the file 'UserNetCdfMetadata20170504T135351Z.txt' (which is saved with the NetCDF file, .nc) corresponds to the metadata filled by user. If, later, user has to convert another echointegration into NetCDF, this txt metadata file (ever filled by user) can be use again by clicking on the button 'Load' (instead of 'Edit') of the popup called **'open user global metadata file'** described above (see Fig. 22).

### 3.5.3.4. Layer extraction on echointegration data

By using Matecho menu '**Post-processing tools...\Layer extraction on echointegration\**', Matecho performs a segmentation, on each zone of a cruise with a constant twilight (night, sunrise, day, sunset), of the echointegrated echogram from an echo level threshold fixed by user to extract plankton layers.

This post-processing tool and its implementation from Matecho is described in detail [in annex 2](#).

## MATECHO USER MANUAL

Laboratory: UMR LEMAR

User manual

Implantation : Plouzané

Version 01

Page 48/96

### 3.5.4. Fish shoal extraction (SE)

For accurate details about the Movies3D algorithm allowing realizing fish shoal extraction, see in Matecho documentation the IFREMER document called:

**'Movies3D\_ShoalExtraction\_IFREMER.pdf'**

#### 3.5.4.1. SE setup and run

Apply Shoal extraction on clean echogram		
Parameters	Default Value	User Value
Extraction Threshold (dB)	-55	-55
Maximum threshold (dB)	0	0
Minimal length (m)	3	3
Minimal height (m)	3	3
Along pings integration distance (m)	4.0904	4.0904
Along depth integration factor	1.3333	1.3333
ESU type (0: nm, 1: second, 2: nh pings)	0	0
ESU size (following ESU type above) [**]	2	2
Surface blind zone depth size (m) [°]	3	3
Depth offset above bottom (m)	0.3000	0.3000

The SE parameters are:

**Extraction threshold (dB):** fish shoal extraction threshold in dB. *Default value: -55.*

**Maximum threshold (dB):** fish shoal extraction maximum threshold in dB (echo levels beyond this maximum threshold will be ignored and not be integrated in fish shoal). This parameter allows avoiding to take into account very the high echo levels which could be outliers. *Default value: 0.*

**Minimal length (m):** minimal length (along ping axe) of fish shoal in meter. Fish shoal length, smaller than this minimal length, are not extracted. *Default value: 3.*

**Minimal height (m):** minimal height (along depth axe) of fish shoal in meter. Fish shoal height, smaller than this minimal height, are not extracted. *Default value: 3.*

## MATECHO USER MANUAL

Laboratory: UMR LEMAR

User manual

Implantation : Plouzané

Version 01

Page 49/96

**Along ping integration distance (m):** maximum distance along ping axe to integrate a sample in fish shoal. For a given fish shoal, if the distance along ping axe between the last integrated sample in the fish shoal and the current sample is bigger than the parameter 'Along ping integration distance', the current sample is not integrated in the fish shoal and another fish shoal is then opened with this current sample integrated in it. *Default value is calculated by Matecho as the mean of ship speed \* mean of time increments \* 4 allowing to have an integration distance of four times the mean distance between 2 consecutive pings.*

**Along depth integration factor (m):** factor of the sounder depth resolution cell size (sound speed \* pulse duration / 2) to fix the maximum distance along depth axe to integrate a sample in fish shoal. For a given fish shoal, if the distance along depth axe between the last integrated sample in the fish shoal and the current sample is bigger than the parameter 'Along depth integration distance', the current sample is not integrated in the fish shoal and another fish shoal is then opened with this current sample integrated in it.

*Default value is calculated by Matecho as:*

- *Mean size of depth resolution cell = mean of sound speed \* mean of pulse duration / 2*
- *Maximum integration distance along depth = 3 \* mean of beam spacing to have a vertical integration distance containing at mean 3 samples.*
- ***Along depth integration factor** = Maximum integration distance along depth / Mean size of depth resolution cell*

**ESU type:** enter 0, 1 or 2 to define the ESU size (just below) in nautical miles, in seconds or in number of pings. *Default value: 0.*

**ESU size:** enter the ESU size in the format of ESU type just above. For fish shoal extraction, the ESU size is used by Movies3D as additional criteria to close a shoal to avoid having too much big shoal which could saturate the PC ram. Indeed, if the shoal length (along ping axe) exceeds the ESU size, the fish shoal is then closed and another fish shoal is opened. It is recommended to keep the ESU size default value proposed by Matecho (2 nmi). Otherwise, if the PC ram is higher than 8 Go, this value can be increasing. *Default value: 2.*

**Surface blind zone depth size (m):** offset in meter from the surface to avoid taking into account the sounder blind zone (echo saturation in surface) and/or bubble effect. 'Surface blind zone size' fix a depth window after the transducer depth. So if the transducer depth is for example 3 m, sample echoes above 3 + 'Surface blind zone size' in depth will be ignored.



## MATECHO USER MANUAL

---

Laboratory: UMR LEMAR

User manual

Implantation : Plouzané

Version 01

Page 50/96

---

So, fix this parameter according to the transducer depth, which is callback at the bottom of the setup and run popup (Fig. 9). *Default value: 3.*

**Depth offset above bottom (m):** offset in meter above bottom depth (the shoal extraction is then done from the transducer depth to the bottom depth minus the 'Depth offset above bottom'). *Default value: 0.3.*

### 3.5.4.2. SE extracted fish shoal removing

In panel '**Echogram type**', select '**Extracted shoals**' to remove bad fish shoal extractions.

Click on button '**Shoal contours**' to display contours of each fish shoal. Note that, when fish shoal contours are displayed, the display is slower.

In the cleaning control panel:

- Select '**All Freq**' if you want to apply the shoal removing to all frequencies.
- Click on button '**REM SHOALS**' to remove bad extraction of fish shoals. Note that fish shoal contours are displayed in black color when the fish shoal is considered as valid. When a shoal is flagged as removed by user, its contour is then displayed in red color.
- Click on button '**REM**' to remove shoal removing.

Read information about the different cleaning options for button 'REM SHOALS' in the blue information panel at the top on the Matecho interface.

### 3.5.4.3. SE output files

#### 3.5.4.3.1. SE Matlab HDF5 file

Fish shoal results are saved in the Matlab HDF5 file named '**ShoalExtraction.mat**'.

If, for example, the name given to the cruise was XXX and the Matlab conversion of the initial hac file list was realized the 02/05/2017 at 12:53:31, the file 'ShoalExtraction.mat' will

## MATECHO USER MANUAL

Laboratory: UMR LEMAR

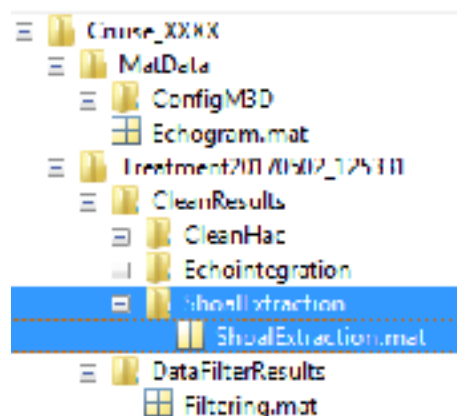
User manual

Implantation : Plouzané

Version 01

Page 51/96

be located in '...\Cruise\_XXXX\Treatment20170502\_125331\CleanResults\ShoalExtraction\' as below:



When the cruise\_XXX is loaded into Matecho, you can access to the content of Echointegration.mat by tapping **se** in Matlab Command Windows.

As these HDF5 file can be very big, [see the Annex 1 for more details about the HDF5 files](#) to know how to open these files safely to preserve the PC ram.

Note that the Movies3D configuration which was generated automatically by Matecho to produce the fish shoal extraction is recorded in:

'...\Cruise\_XXXX\Treatment20170502\_125331\CleanResults\CleanHac\ConfigM3D\'.

If needed, this Movies3D configuration directory can be loaded in Movies3D to visualize hac files from Movies3D with the configuration used by Matecho to perform fish shoal extraction.

### 3.5.4.3.2.SE Excel files

To produce Excel file of the extracted fish shoal descriptors at the Matlab **format '.csv'**:

- Use Matecho menu "**Archive...\Shoal extraction results...\Write shoal descriptors in Excel file...\**

Produced Excel files are saved in directory ...\ShoalExtraction\ShoalDescriptorsXLS\ as below:

## MATECHO USER MANUAL

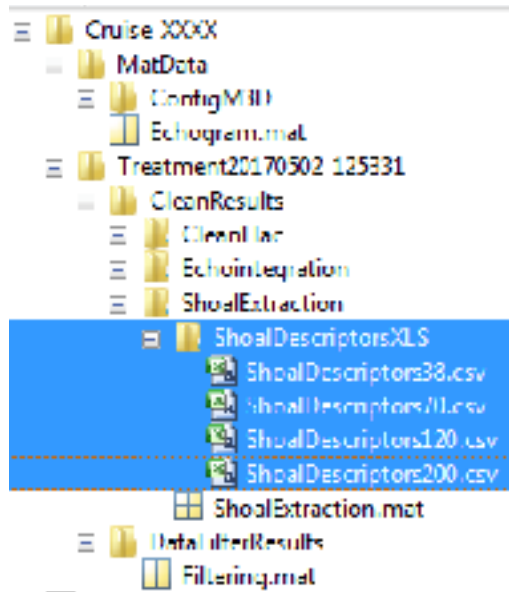
Laboratory: UMR LEMAR

User manual

Implantation : Plouzané

Version 01

Page 52/96



### 3.5.4.4. Apply shoals from a frequency to others

The contours of fish shoals extracted from the echogram of one frequency are used to extract the corresponding echoes of the echograms of others frequencies. This allows to study the frequency responses of each extracted fish shoal

- Use Matecho menu '**Archive...\Post-processing tools...\Apply shoals from a frequency to others...**'
- Choose the reference frequency for which the extracted fish shoal contours will be apply to the other frequencies

## MATECHO USER MANUAL

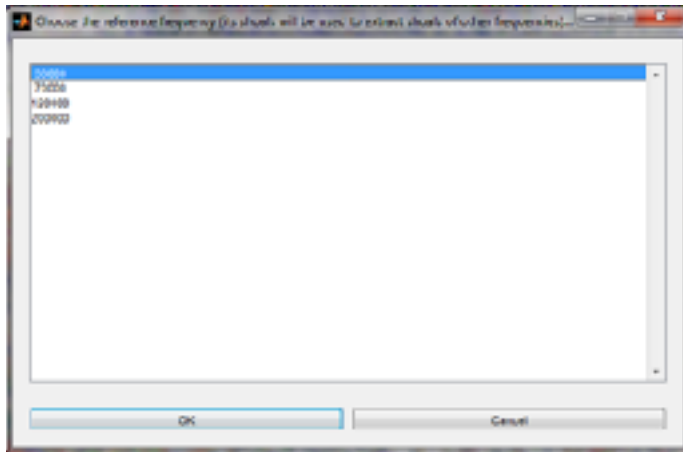
Laboratory: UMR LEMAR

User manual

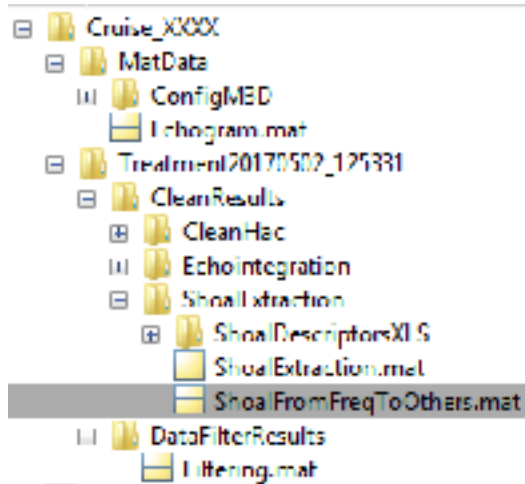
Implantation : Plouzané

Version 01

Page 53/96



The results are saved in the HDF5 file 'ShoalFromFreqToOthers.mat' in directory '...\ShoalExtraction\' as below:



### 3.5.5. How to make a new echointegration or shoal extraction

- **Cruise > Open an existing cruise treatment...**
- **Setup and run > Open a new echointegration and/or shoal extraction...**
- Valid or enter the subdirectory name where new results will be stored

## MATECHO USER MANUAL

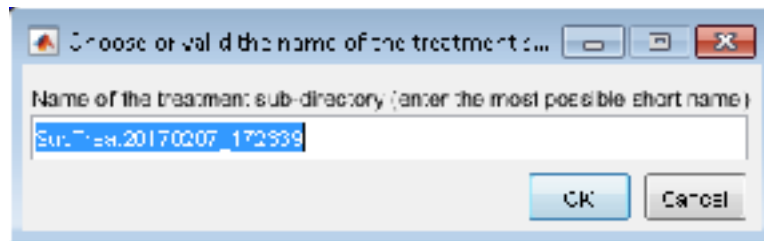
Laboratory: UMR LEMAR

User manual

Implantation : Plouzané

Version 01

Page 54/96



- **Setup and run** > to run a new echo integration and/or fish shoal extraction which will be saved in the created subfolder (SubTreat20170207\_172339 in the example just above).

### 3.6. Add hac files to a cruise

This option allows adding hac file in a cruise (which is useful at sea when data are saved each day). Obviously, this option is available when a first hac file conversion (hac files of day n°1 for example) was ever done with the method described above ([see § 3.2](#)). To add a hac file set to a cruise:

- **Cruise > Add hac files to a cruise...**
- Select the folder which contains the hac file to add (hac file set of day n°2 for example) to the cruise.  
Matecho will then copy and rename (to be sure of the hac file chronological order) the added hac files in the hac file initial folder of the cruise (created for day n°1) before to run the Matlab conversion of the added hac files with the same setup than the previous Matlab conversion for day n°1. At the end of the Matlab conversion, Matecho display the popup below:

## MATECHO USER MANUAL

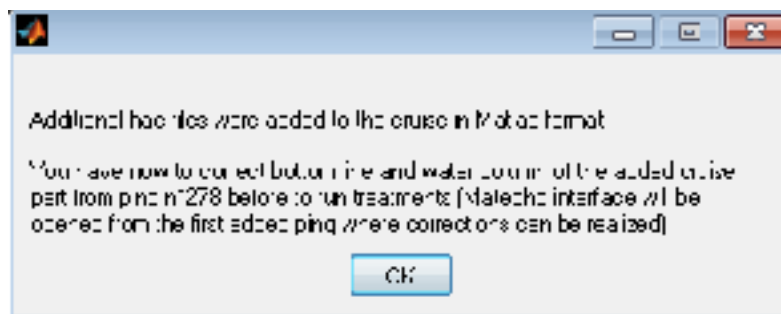
Laboratory: UMR LEMAR

User manual

Implantation : Plouzané

Version 01

Page 55/96



- At the end of the Matlab conversion of hac file set of day n°1, if manual cleaning, filtering, EI and/or SE were done for hac file set of day n°1, Matecho ask to the user to make manual cleaning for the ping bloc corresponding to the day n°2.
- Then, at this step, if user run the treatments for day n°2 from menu Run and setup... \Run and setup\), Matecho do not display the popup (see Fig. 9) but run automatically the same filter(s) and treatment(s) (with the same setup) than for the day n°1.

**Never add, for example, hac file set of day n°3 before hac file set of day n°2 !**

### 3.7. Matecho result folders displacement or rename

For Matecho cruise folders, only the following directories can be renamed as the user want:

'Cruise\_YourCruiseName'

'Treatment\_YYYYMMDD\_HHMMSS'

'SubTreat\_\_YYYYMMDD\_HHMMSS'

Don't rename the others directories as 'MatData', 'CleanResults', 'Echointegration', 'ShoalExtraction', etc.

Only the complete directory 'Cruise\_YourCruiseName' with all his content can be moved.

Never move 'Treatment\_YYYYMMDD\_HHMMSS' outside 'Cruise\_YourCruiseName' for example.

### 3.8. Re-initialization of data results



## MATECHO USER MANUAL

Laboratory: UMR LEMAR

User manual

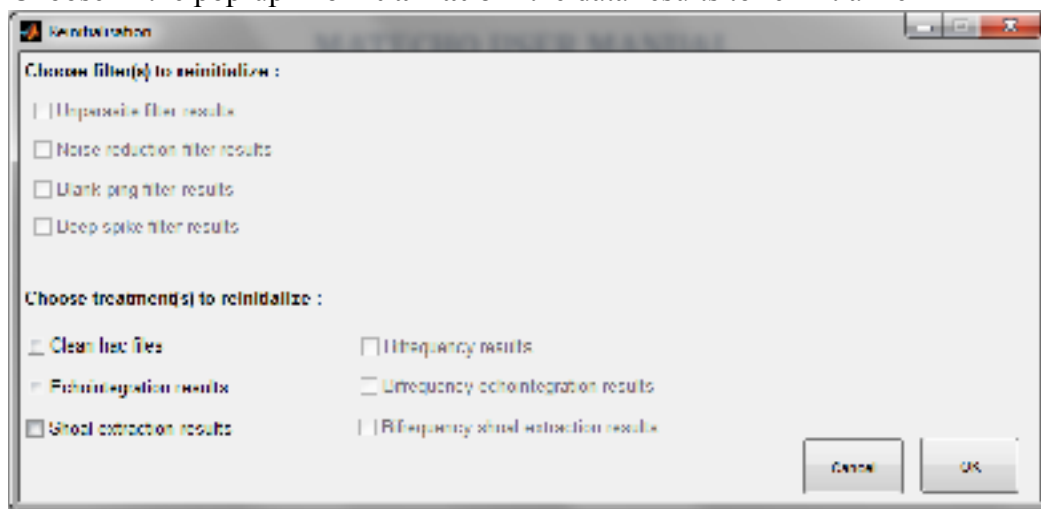
Implantation : Plouzané

Version 01

Page 56/96

Data results (i.e. filters, echointegration and shoal extraction) can be re-initialized by:

- Matecho menu **.\Setup and run...\Reinitialization of filterings and/or treatments...\**
- Choose in the pop-up **'Reinitialization'** the data results to re-initialize



Important note: If clean hac files or treatments (echointegration and/or shoal extraction) were produced whereas the user choose to delete one or several filters (as unparasite filter for example), the clean hac files and the treatment results must also be deleting (because clean hac files and treatments depend to the filter results). In this case, Matecho display a popup to ask to the user the confirmation of this action.

Note: If a filter or a treatment was not run, its re-initialization is in disable (grayed radio button).

## 4. Matlab and R scripts examples

### 4.1. Matlab script example

# MATECHO USER MANUAL

Laboratory: UMR LEMAR

User manual

Implantation : Plouzané

Version 01

Page 57/96

```
echogram = matfile('F:\...\Cruise_PIRATA_FR26\Treatment...  
\CleanResults\Echointegration\Echointegration.mat','Writable',true);  
  
Time = (echogram.Time / (24*3600))+datenum('01-Jan-1970');  
Longitude = echogram.Longitude;  
Latitude = echogram.Latitude;  
depth_surface = echogram.depth_surface;  
depth_bottom = echogram.depth_bottom(1,:,1);  
Night1Sunrise2Day3Sunset4 = echogram.Night1Sunrise2Day3Sunset4;  
Sv_surface = echogram.Sv_surface;  
Sa_surface = echogram.Sa_surface;  
SolarAltitude = echogram.SolarAltitude;  
SolarElevationAngleLim = echogram.SolarElevationAngleLim;  
CumulatedGPSDistanceMeter = echogram.CumulatedGPSDistanceMeter;  
Mask_clean = echogram.Mask_clean;  
DateTime =echogram.DateTime;  
  
% EI parameters  
EIParameters = echogram.EIParameters;  
UserParam = echogram.UserParam;  
FrequencySort = echogram.FrequencySort;
```

## 4.2. R script example

```
library(rhdf5)  
  
library(ggplot2)  
library(scales)  
library(reshape2)  
library(data.table)  
library(gridExtra)  
  
##### use of rhdf5 library to read echointegration results  
file <- 'C:/aurore/these/EI.mat'  
Sv <- h5read(file,"Sv_surface")  
dep <- h5read(file,"depth_surface")  
night <- h5read(file,"Night1Sunrise2Day3Sunset4")  
date <- as.data.frame(h5read(file,"DateTime"))  
date2 <- data.frame(date = apply(date, 1, switch.datetime))  
time_incr <- data.frame(t_inc = h5read(file,"Time")[1,]/31557600 + 1970  
+ 36000/31557600)
```

## MATECHO USER MANUAL

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Laboratory: UMR LEMAR

User manual

Implantation : Plouzané

Version 01

Page 58/96

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### 5. Contacts

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[yannick.perrot@ird.fr](mailto:yannick.perrot@ird.fr)

### 6. Bibliography

Ballón Soto, R. M. (2010). Acoustic study of macrozooplankton off Peru: biomass estimation, spatial patterns, impact of physical forcing and effect on forage fish distribution. Thesis. Montpellier II university.

De Robertis, A., and Higginbottom, I. (2007). A post-processing technique to estimate the signal-to-noise ratio and remove echosounder background noise. *ICES Journal of Marine Science* 64, 1282–1291.

Ryan, T., Downie, R.A., Kloser, R., and Keith, G. (2015). Reducing bias due to noise and attenuation in open-ocean echo integration data. *ICES Journal of Marine Science* 72, 2482–2493.

Trenkel, V., Berger, L., Bourguignon, S., Doray, M., Fablet, R., Massé, J., Mazauric, V., Poncelet, C., Quemener, G., Scalabrin, C., and Villalobos, H. (2009). Overview of recent progress in fisheries acoustics made by Ifremer with examples from the Bay of Biscay. *Aquat. Living Resour.* 22, 433–445.

## MATECHO USER MANUAL

Laboratory: UMR LEMAR

User manual

Implantation : Plouzané

Version 01

Page 59/96

### 7. Suivi des versions de ce document

Rédacteur		Approbateur	
Nom :	Habasque Jérémie	Nom :	
Fonction:	IE	Fonction :	
Nom :	Roudaut Gildas		
Fonction:	AI		
Nom :	Perrot Yannick		
Fonction:	IE		

Date	Version	Commentaires et modifications
05/05/2017	01	

Relecteur	Date





## MATECHO USER MANUAL

---

Laboratory: UMR LEMAR

User manual

Implantation : Plouzané

Version 01

Page 61/96

---

To load in PC ram, for example, the echogram of the 38 kHz echosounder between sample depths 1 to 200 and the ping indexes 1 to 5000, you type on Matlab command windows:

`Echo=m.Echogram38(1:200,1:5000);` The echogram part is then loaded in variable `Echo`.

**Be careful to not load data which excess you PC ram.** See the link below to have more details on the Matlab 'matfile' function:

<https://fr.mathworks.com/help/matlab/ref/matfile.html?requestedDomain=www.mathworks.com>

The main HDF5 data file produced by Matecho are:

- **'Echogram.mat'** containing hac file data echograms, readable from object **m** in Matecho.
- **'Filtering.mat'** containing filtering data for echograms, readable from object **fi** in Matecho.
- **'Echointegration.mat'** containing echointegration data, readable from object **ei** in Matecho.
- **'ShoalExtraction.mat'** containing fish shoal extraction data, readable from object **se** in Matecho.

Note that when a cruise is open in Matecho, user can also access to the content these files (at any moment except when Matecho is in processing) by tapping from the Matlab command window: **m**, **fi**, **ei** or **se** (and **b**, **bei** or **bse** to access to bifrequency data, bifrequency echointegration or bifrequency fish shoal extraction). In parallel of Matecho, user can then load, plot and study in Matlab any data of the cruise.

When a cruise is open in Matecho, the user parameters for this cruise are available from Matlab command windows by tapping **UserParam**:

## Laboratory: UMR LEMAR

User manual

## Implantation : Plouzané

Version 01

Page 62/96

```

#? UserParam
UserParam =

INDEXFILEPATH: "C:\Users\BETH01\Documents\DEVELOPMENTS\Win4GDO_DEV\Win4GDO40_6Files\"
CPUIDNUMBER: "5003E"
ResultSavePath: "C:\Users\garnov\Documents\DEVELOPMENTS\Win4GDO_DEV\Win4GDO40_6Files\Cruise_SubData\"
IndexSavePath: "C:\Users\garnov\Documents\DEVELOPMENTS\Win4GDO_DEV\Win4GDO40_6Files\Cruise_SubData\Treatment20170102_12700\"
IndexSavePath: "C:\Users\garnov\Documents\DEVELOPMENTS\Win4GDO_DEV\Win4GDO40_6Files\Cruise_SubData\Treatment20170102_12700\"
SubSiteFlag: 0
PACCODEPATH: "C:\Users\BETH01\Documents\DEVELOPMENTS\Win4GDO_DEV\Win4GDO40V1\SUBDIV\"
InputFileRead: [1x1 struct]
Depressure: [1x1 struct]
Filtering: [1x1 struct]
Treatment: [1x1 struct]
SOLARINVESTIGATIONDATE: 0-10 10
LONG: [1x1 struct]
BEACON: [1x1 struct]
InputFileList: [0x1 struct]
RFFrequency: [1x1 struct]

```

User can find in this structure `UserParam`, all paths to the data files and user setup for filtering and treatments. For example, the user setup for echointegration is in:

```

30 UserParams.Treatment = 21
end

      Apply: 0
      BifreqApply: 0
      HeightThreshold: 0
      LowThreshold: -80
      LayerStartDepth: 5
      LayerEndDepth: 45
      LayerWidth: 1
      LayerBottomOffset: 1
      ObjectBottom: 0
      KNTType: 0
      ESISeed: 0.0000
      BlindZoneFilter: 0
      FloodFillTolerance: 0.0000

```

**Never try to write in an HDF5 file if you have not enough space disk because the HDF5 file will be then corrupted. So, check your space disk before to write in HDF5 file from Matlab.**

2. Description HDF5 file 'Echogram.mat' containing hac file data echograms

An example of the content of the HDF5 file '**Echogram.mat**' containing hac file data echograms is described in the table below. The content of this file is accessible in Matecho from object **m**.

## MATECHO USER MANUAL

---

Laboratory: UMR LEMAR

User manual

Implantation : Plouzané

Version 01

Page 63/96

---

The presented field names are always the same from a cruise to another.

Dimensions of each field are given for an example of a cruise containing 4 echo-sounder frequencies (38, 70, 120, 200 kHz) and 10161 pings.

The frequencies data are always saved in the increasing order of frequencies (for example, for the field `Bottom`: [4x10161 double] (matrix with 4 lines for each frequency and 10161 columns for each ping), the bottom lines are `m.bottom(1,:)` for the 38 kHz, `m.bottom(2,:)` for the 70 kHz, `m.bottom(3,:)` for the 120 kHz, `m.bottom(4,:)` for the 200 kHz.

## MATECHO USER MANUAL

Laboratory: UMR LEMAR

User manual

Implantation : Plouzané

Version 01

Page 64/96

A b s o r p t i o n C o e f f i c i e n t :	Sound absorption coefficient in dB/m
[4x10161 double]	
B e a m A t h w a r t S t e e r i n g A n g l e R a d :	Beam athwart ship steering angle in Rad
[4x10161 double]	
B e a m S a C o r r e c t i o n I n i t :	Sacorr calibration parameter in hac files in dB
[4x1 double]	User Sacorr calibration parameter in dB
B e a m S a C o r r e c t i o n U s e r :	Beam spacing in meter
[4x1 double]	Initial bottom line depths in m
B e a m S p a c i n g :	Common beam spacing in m [*]
[4x10161 double]	Cumulated GPS Distance in meter
B o t t o m :	Ping date times in YYYY-MM-DD HH:MM:SS
[4x10161 double]	
C o m m o n B e a m S p a c i n g :	Sample depths for 120 kHz
[4x1 double]	Sample depths for 200 kHz
C u m u l a t e d G P S D i s t a n c e M e t e r :	Sample depths for 38 kHz
[1x10161 double]	Sample depths for 70 kHz
D a t e T i m e :	Time duration in min used for hac conversion
[10161x23 char]	
D e p t h 1 2 0 :	Echogram data of 120 kHz
[1236x1 double]	Echogram data of 200 kHz
D e p t h 2 0 0 :	Echogram data of 38 kHz
[2472x1 double]	Echogram data of 70 kHz
D e p t h 3 8 :	Sorted sounder frequencies in hac files in Hz
[618x1 double]	
D e p t h 7 0 :	First and last ping indexes of each hac files
[1236x1 double]	
D u r a t i o n C o n v e r s i o n I n M i n :	Heave in meter
[1x1 double]	
E c h o g r a m 1 2 0 :	Indexes of hac files for each ping
[1236x10161 single]	
E c h o g r a m 2 0 0 :	Ping indexes in hac files for each ping
[2472x10161 single]	Frequency order index recording in hac files
E c h o g r a m 3 8 :	Latitude in deg
[618x10161 single]	Longitude in deg
E c h o g r a m 7 0 :	=1 if ping bottom was detected, 0 otherwise
[1236x10161 single]	Maximum range in meter
F r e q u e n c y S o r t :	Twilights: Night=1/ Sunrise=2/Day=3/ Sunset=4
[4x10161 double]	
H a c P i n g S t a r t E n d :	
[2x10161 double]	

## Laboratory: UMR LEMAR

## Implantation : Plouzané

Version 01

Page 65/96

[\*\*]: see below the detailed description of the sounder with an example for the first echosounder of the frequency list recorded in hac files (38 kHz):

3. Description HDF5 file 'Filtering.mat' containing filtering data for echograms

An example of the content of the HDF5 file '**Filtering.mat**' containing cleaning and filtering data is described in the table below. The content of this file is accessible in Matecho from object **fi**.

The presented field names are always the same from a cruise to another.

## MATECHO USER MANUAL

Laboratory: UMR LEMAR

User manual

Implantation : Plouzané

Version 01

Page 66/96

Dimensions of each field are given for an example of a cruise containing 4 echo-sounder frequencies (38, 70, 120, 200 kHz) and 10161 pings.

C l e a n B o t t o m : [4x10161 double]		User corrected bottom line depths in meter
DurationApplyFiltersInMin:	[0x0 double]	Time duration in min used for apply filtering
IdHacPingRemove_BadBottom:	[0x0 double]	<u>Removed Pings:</u> Index of the hac file in hac file list for each removed pings corresponding to each automatic filter type and manual cleaning.
IdHacPingRemove_Blank:	[0x0 double]	
IdHacPingRemove_Cleaning:	[0x0 double]	
IdHacPingRemove_DeepSpike:	[0x0 double]	
IdHacPingRemove_LowShipSpeed:	[0x0 double]	
IdPingRemove_BadBottom:	[0x0 double]	<u>Removed Pings:</u> Indexes in the hac file of the removed pings for each automatic filter type and manual cleaning.
IdPingRemove_Blank:	[0x0 double]	
IdPingRemove_Cleaning:	[0x0 double]	
IdPingRemove_DeepSpike:	[0x0 double]	
IdPingRemove_LowShipSpeed:	[0x0 double]	



## MATECHO USER MANUAL

Laboratory: UMR LEMAR

User manual

Implantation : Plouzané

Version 01

Page 67/96

IndexPingRemove_BadBottom: [0x0 double] IndexPingRemove_Blank: [0x0 double] IndexPingRemove_Cleaning: [0x0 double] IndexPingRemove_DeepSpike: [0x0 double] IndexPingRemove_LowShipSpeed: [0x0 double]	<p><u>Removed Pings:</u> Global indexes in the cruise of the removed pings for each automatic filter type and manual cleaning.</p>
L a s t C l e a n H a c : [1x2 double]	Index of the last produced clean hac file
M a s k _ C l e a n i n g 1 2 0 : [1236x10161 single] M a s k _ C l e a n i n g 2 0 0 : [2472x10161 single] M a s k _ C l e a n i n g 3 8 : [618x10161 single] M a s k _ C l e a n i n g 7 0 : [1236x10161 single]	<p>Echogram cleaning mask where manual cleaning in water column are saved. Each Mask has the same dimensions than its corresponding echogram in 'Echogram.mat'</p>
M a s k _ N o i s e R e d u c t i o n 1 2 0 : [1236x10161 single] M a s k _ N o i s e R e d u c t i o n 2 0 0 : [2472x10161 single] Mask_NoiseReduction38: [618x10161 single] M a s k _ N o i s e R e d u c t i o n 7 0 : [1236x10161 single]	<p>Echogram noise reduction data results. Each field has the same dimensions than its corresponding echogram in file 'Echogram.mat' [*]</p>
M a s k _ U n p a r a s i t e 1 2 0 : [1236x10161 single] M a s k _ U n p a r a s i t e 2 0 0 : [2472x10161 single] M a s k _ U n p a r a s i t e 3 8 : [618x10161 single] M a s k _ U n p a r a s i t e 7 0 : [1236x10161 single]	<p>Echogram unparasited data results. Each field has the same dimensions than its corresponding echogram in file 'Echogram.mat' [*]</p>

## MATECHO USER MANUAL

Laboratory: UMR LEMAR

User manual

Implantation : Plouzané

Version 01

Page 68/96

TimePingRemove_BadBottom: double]	[0x0	<u>Removed Pings:</u> Times (in second since 1970) in the cruise of the removed pings for each automatic filter type and manual cleaning.
TimePingRemove_Blank: double]	[0x0	
TimePingRemove_Cleaning: double]	[0x0	
TimePingRemove_DeepSpike: double]	[0x0	
TimePingRemove_LowShipSpeed: double]	[0x0	
U s e r P a r a m F : [1x1 struct]		User parameters in Matecho [see 1.1 above]

[\*] :

A - How to re-construct cleaned and filtered echogram from the raw echogram (i.e. not cleaned and unfiltered echogram) saved in file 'Echogram.mat' (objet m in Matecho) and knowing that the cleaning and filtering data are saved in HDF5 file 'Filtering.mat' (objet fi in Matecho)

For example, construct the 38 kHz echo-sounder cleaned and filtered echogram between ping indexes 1 to 10000 and between depth indexes 1 to 500 (Matlab commands, to tape in Matlab command windows or in a m-file, are in bold below):

% Define the ping and depth indexes:

**PingIndex=[1:10000]; DepthIndex=[1:500];**

% Load the 38 kHz raw echogram by taping in Matlab command window:

**UnfilteredEchogram38 = m.Echogram38(DepthIndex,PingIndex);**

% Load the corresponding part of the unparasite mask for 38 kHz:

**Clean = fi.Mask\_Unparasite38(DepthIndex,PingIndex);**

% Load the corresponding part of the noise reduction mask for 38 kHz and add his contribution:

**Clean = Clean + fi.Mask\_NoiseReduction38(DepthIndex,PingIndex);**

% Load the corresponding part of the cleaning mask for 38 kHz and apply his contribution:

**Clean = Clean .\* fi.Mask\_Cleaning38(DepthIndex,PingIndex);**

% The cleaned and filtered echogram for 38 kHz is then:

**FilteredEchogram38 = UnfilteredEchogram38-clean;**

B- How to remove the pings flagged as removed pings in Matecho:

User can copy and paste in Matlab command windows the generic code below when a cruise is loaded in Matecho:

**% Compilation of all removed ping indexes saved in 'Filtering.mat'**

**if(~isempty(m.TimePingRemove))**

## MATECHO USER MANUAL

Laboratory: UMR LEMAR

User manual

Implantation : Plouzané

Version 01

Page 69/96

```
IdPingRem=[fi.IndexPingRemove_BadBottom,fi.IndexPingRemove_Cleaning,fi.IndexPingRemove_LowShipSpeed,fi.IndexPingRemove_DeepSpike,fi.IndexPingRemove_Blank,m.TimePingRemove(1,:)];
```

```
else
```

```
IdPingRem=[fi.IndexPingRemove_BadBottom,fi.IndexPingRemove_Cleaning,fi.IndexPingRemove_LowShipSpeed,fi.IndexPingRemove_DeepSpike,fi.IndexPingRemove_Blank];
```

```
End
```

**% Keep only the removed ping indexes included in the loaded echogram part**

```
tmp=find(IdPingRem>=Index(1) & IdPingRem<=Index(end)); idping=IdPingRem(tmp); clear tmp; idping=idping-Index(1)+1;
```

**% Remove pings in FilteredEchogram38**

```
FilteredEchogram38(:,idping)=[];
```

#### 4. Description HDF5 file 'Echointegration.mat' containing echointegration data

An example of the content of the HDF5 file '**Echointegration.mat**' containing cleaning and filtering data is described in the table below. The content of this file is accessible in Matecho from object **ei**.

The presented field names are always the same from a cruise to another.

Dimensions of each field are given for an example of a cruise containing 4 echo-sounder frequencies (38, 70, 120, 200 kHz) and 334 esus.

In the 3-D dimensions field, indicate by [3-D single]:

- the first dimension is the number of depth samples,
- the second is the number of esus,
- the third dimension is the number of frequencies

## MATECHO USER MANUAL

Laboratory: UMR LEMAR

User manual

Implantation : Plouzané

Version 01

Page 70/96

Bottom:	[4x334 double]	Bottom depth for each esu in meter
BottomShift:	[1x1 double]	Bottom shift in meter setup by user
CumulatedGPSDistanceMeter:	[1x334 double]	Cumulated GPS distance in meter for each esu
DateTime:	[334x23 char]	Esu date times in YYYY-MM-DD HH:MM:SS
DurationApplyTreatmentInMin:	[1x1 double]	Time duration in min used for echointegration
EILowThreshold:	[1x1 double]	Echointegration low threshold in dB
EIParameters:	[1x1 struct]	Echointegration high threshold in dB
EsuPingStartEnd:	[2x334 double]	Start and end ping indexes for each esu
FrequencySort:	[4x1 double]	Sorted frequencies in Hz
LastHac:	[1x2 double]	Last clean hac file which has been echointegrated Last valid sample depth for each esu
LastValidSampleDepth:	[1x334 double]	Esu latitude in deg
Latitude:	[1x334 double]	Layer width setup by user
LayerWidth:	[1x1 double]	Esu longitude in deg
Longitude:	[1x334 double]	User cleaning mask for echointegration [*]
Mask_clean:	[3-D double]	Initial total number of samples for each EI cell
N_surface:	[3-D single]	Twilights: Night=1/ Sunrise=2/Day=3/ Sunset=4
Night1Sunrise2Day3Sunset4:	[1x334 double]	QC=Ni/N_surface, Ni=number integrated sample
QC_surface:	[3-D single]	Vertical sum of Sa for each esu
		Sa of bottom layers (NASC, m2/nmi-2)
		Sa echointegrated echogram (NASC, m2/ nmi-2)
		Solar altitude in deg for each esu
		Solar altitude limit angles for sunset/sunrise
		Sv of bottom layers (dB re 1 m-1)
		Sv echointegrated echogram (dB re 1 m-1)
		Esu time in second since 1970
		Transducer depth from surface in meter
		User parameters in Matecho [see 1.1 above]
		Depth(s) of the bottom layer(s)

## MATECHO USER MANUAL

Laboratory: UMR LEMAR

User manual

Implantation : Plouzané

Version 01

Page 71/96

[\*]: How to obtain the cleaned Sv echointegrated echogram from the raw echointegrated echogram. Copy/paste in Matlab command window (or in a Matlab m-file):

% Define the ping, depth and frequency indexes:

**PingId=[1:10000]; DepthId=[1:500]; FreqId=1;**

% Apply the echointegration cleaning mask to the echointegrated echogram

**CleanedSv = ei.Sv\_surface(DepthId,PingId,FreqId) .\* ei.Mask\_clean(DepthId,PingId,FreqId);**

### 5. Description HDF5 file 'ShoalExtraction.mat' containing shoal extraction data

An example of the content of the HDF5 file '**ShoalExtraction.mat**' containing hac file data echograms is described in the table below. The content of this file is accessible in Matecho from object **se**.

The presented field names are always the same from a cruise to another.

Dimensions of each field are given for an example of a cruise containing 4 echo-sounder frequencies (38, 70, 120, 200 kHz) and 10161 pings.

ContourDepth120: [34x691 double] ContourDepth200: [28x691 double] ContourDepth38: [112x691 double] ContourDepth70: [38x691 double]	Depth of each fish shoal contour points in meter. For example, for 120 kHz, there is 34 extracted fish shoals with 691 contour points for each one.
ContourIndPing120: [34x691 double] ContourIndPing200: [28x691 double] ContourIndPing38: [112x691 double] ContourIndPing70: [38x691 double]	Global indexes in the cruise of each fish shoal contour points

## MATECHO USER MANUAL

Laboratory: UMR LEMAR

User manual

Implantation : Plouzané

Version 01

Page 72/96

DurationApplyTreatmentInMin: [1x1 double] FrequencySort: [4x1 double] LastHac: [1x2 double]	Time duration in min used for fish shoal extraction Sorted frequency in Hz Last clean hac file where fish shoals were extracted
RemovedShoal120: [0x0 double] RemovedShoal200: [0x0 double] RemovedShoal38: [0x0 double] RemovedShoal70: [0x0 double]	Removed Fish shoal Indexes corresponding to fish shoal indexes recording in field 'ShoalEchogramMask' (see just below)
ShoalDescription120: [34x33 double] ShoalDescription200: [28x33 double] ShoalDescription38: [112x33 double] ShoalDescription70: [38x33 double]	Fish shoal descriptors
ShoalDescriptionHeader: [33x1 cell]	Names of Fish shoal descriptor [*]
ShoalEchogram120: [1236x10161 single] ShoalEchogram200: [2472x10161 single] ShoalEchogram38: [618x10161 single] ShoalEchogram70: [1236x10161 single]	Fish shoal echograms with the same dimensions than raw echograms in 'Echogram.mat'
ShoalEchogramMask120: [1236x10161 single] ShoalEchogramMask200: [2472x10161 single] ShoalEchogramMask38: [618x10161 single] ShoalEchogramMask70: [1236x10161 single]	Fish shoal echogram masks (same dimensions than raw echograms in 'Echogram.mat'). It is also the same matrix than in field 'ShoalEchogram' but with fish shoal indexes instead of shoal echoes
ShoalExtractionParameters: [1x1 struct]	User parameters used for fish shoal extraction



## MATECHO USER MANUAL

Laboratory: UMR LEMAR

User manual

Implantation : Plouzané

Version 01

Page 73/96

TimeEnd120: [34x23 char] TimeEnd200: [28x23 char] TimeEnd38: [112x23 char] TimeEnd70: [38x23 char]	Fish Shoal end times (in YYYY-MM-DD HH:MM:SS)
TimeMean120: [34x23 char] TimeMean200: [28x23 char] TimeMean38: [112x23 char] TimeMean70: [38x23 char]	Fish shoal mean times (in YYYY-MM-DD HH:MM:SS)
TimeStart120: [34x23 char] TimeStart200: [28x23 char] TimeStart38: [112x23 char] TimeStart70: [38x23 char]	Fish shoal start times (in YYYY-MM-DD HH:MM:SS)
UserParam: [1x1 struct]	User parameters in Matecho [see 1.1 above]

[\*]: Fish shoal descriptor names can be display as below from Matlab command window when a cruise is open from Matecho:

# MATECHO USER MANUAL

Laboratory: UMR LEMAR

User manual

Implantation : Plouzané

Version 01

Page 74/96

```
>> ME.ChosDescriptionHeader
ans =

    'Frequency (kHz)'
    'Number of echoes'
    'Cv mean (dB)'
    'Cv mean weighted (dB)'
    'Start time'
    'End time'
    'Scan time'
    'Twilight (Twilight, Sunrise, Day, Sunset)'
    'Minimum depth (m)'
    'Maximum depth (m)'
    'Minimum depth above bottom (m)'
    'Maximum depth above bottom (m)'
    'Length (m)'
    'Width (m)'
    'Height (m)'
    'Volume (m3)'
    'Energy center latitude (°)'
    'Energy center longitude (°)'
    'Energy center depth (m)'
    'Geographical center latitude (°)'
    'Geographical center longitude (°)'
    'Geographical center depth (m)'
    'First point latitude (°)'
    'First point longitude (°)'
    'First point depth (m)'
    'Last point latitude (°)'
    'Last point longitude (°)'
    'Last point depth (m)'
    'Minimum angle (°)'
    'Maximum angle (°)'
    'Signal'
    'Number of holes'
    'Surface (m2)'
```

## Annex 2: Matecho layer extraction from echointegration

Before to run the layer extraction, you have to clean the echointegration results ([as described above in section 3.5.3.2](#)) to delete residual echoes of bottom or saturation in surface.

This process performs a segmentation (from Matlab function `contourf.m`) of the echointegration from a given threshold on echo levels to extract layers. The process contains 4 steps:

1. From Matecho menu:

## MATECHO USER MANUAL

---

Laboratory: UMR LEMAR

User manual

Implantation : Plouzané

Version 01

Page 75/96

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**'Post-processing tools.../Layer extraction from echointegration/Step 1: Layer contour level adjustment/'**, adjust the echo level threshold in dB. For each frequency, contours are calculated on 2 zone types: day and night. This adjustment can be tested several times to find the optimal level. The calculation is not long duration.

2. When the threshold is defined, run the menu **'Post-processing tools.../Layer extraction from echointegration/Step 2: Layer echo extraction from contours/'**. This second step consists in the extraction of the echoes inside each contours and the calculation of the layer descriptors. This step can be longer in term of calculation duration.
3. When layers echoes are extracted, you can correct the extraction by adding or deleting echoes from layers. When all the correction are done, you have to update the extraction and the layers descriptors from menu **'Post-processing tools.../Layer extraction from echointegration/Step 3: Update layers from new layer correction/'**.
4. Use menu **'Post-processing tools.../Layer extraction from echointegration/Step 4: Write layer descriptors in Excel file/'** to write layer descriptor in an excel file.

### 1- Adjustment of the extraction threshold dB

For example, by considering the echointegrated echogram below:

# MATECHO USER MANUAL

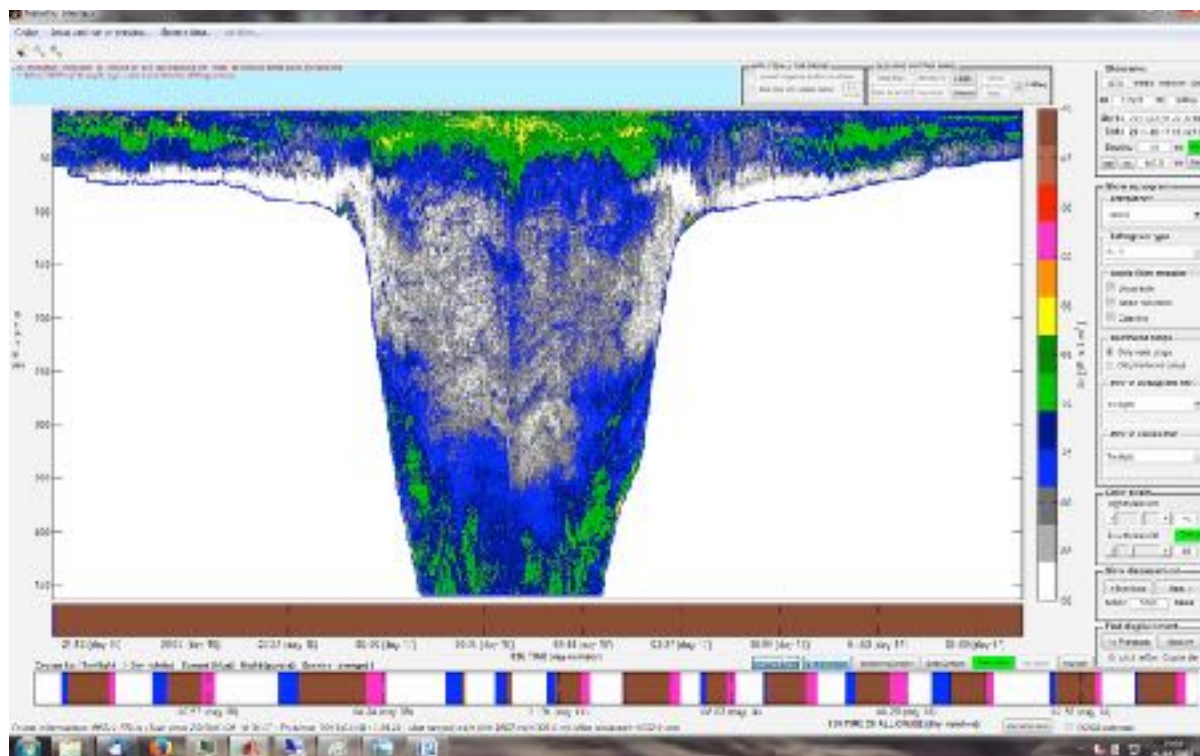
Laboratory: UMR LEMAR

User manual

Implantation : Plouzané

Version 01

Page 76/96



Use menu « Layer contour level adjustment » :



The results for an extraction level to -76 dB are presented below:

- click on button « **EI layer contours** » at the bottom of Matecho interface to show layer contours on echogram) :

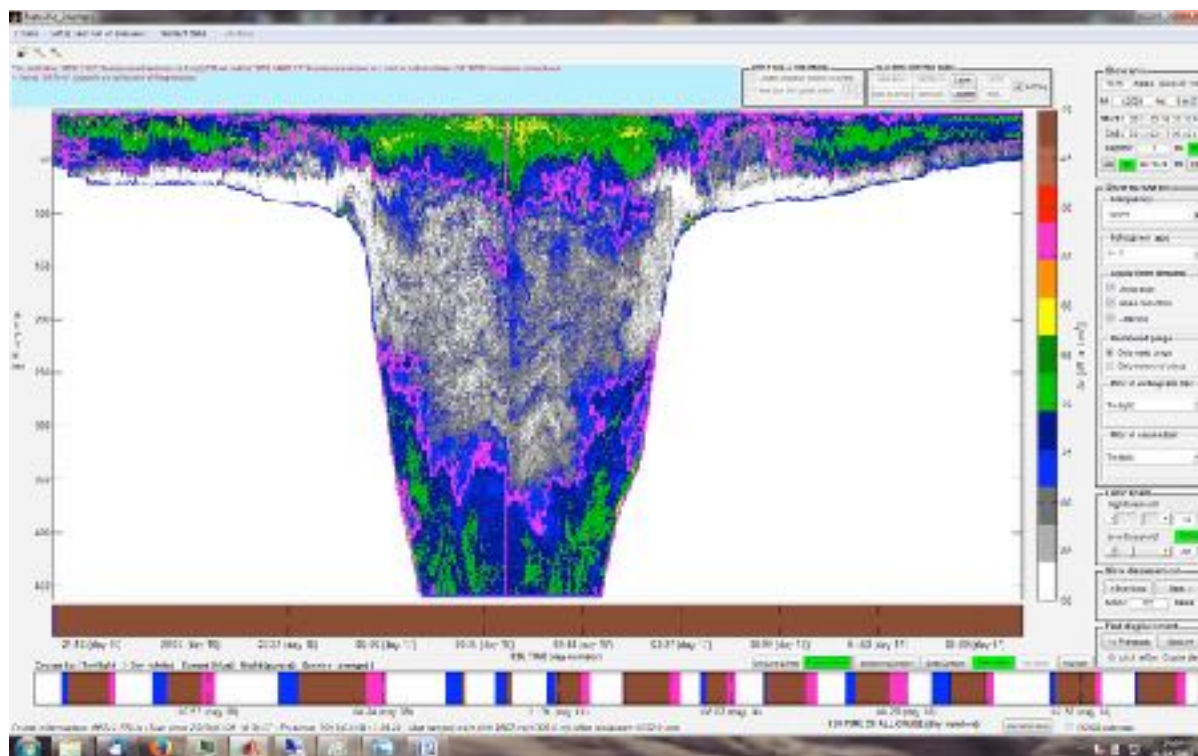
Laboratory: UMR LEMAR

User manual

Implantation : Plouzané

Version 01

Page 77/96



## 2- Echo extraction and layers descriptor calculation

When contouring is relevant, the echo extraction is run from menu « **Layer Echo extraction from contours** »:



# MATECHO USER MANUAL

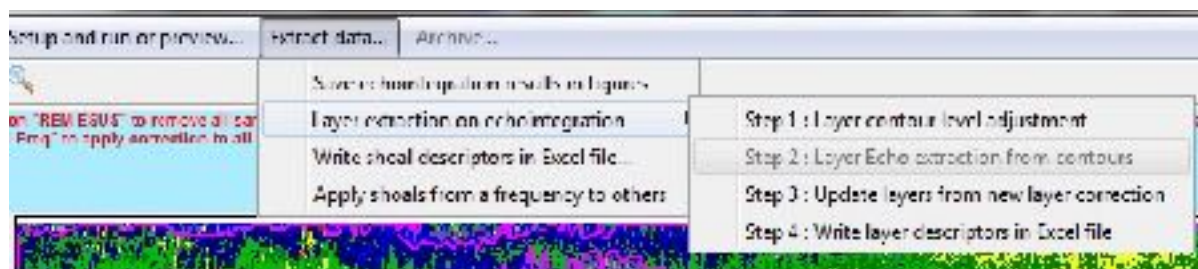
Laboratory: UMR LEMAR

User manual

Implantation : Plouzané

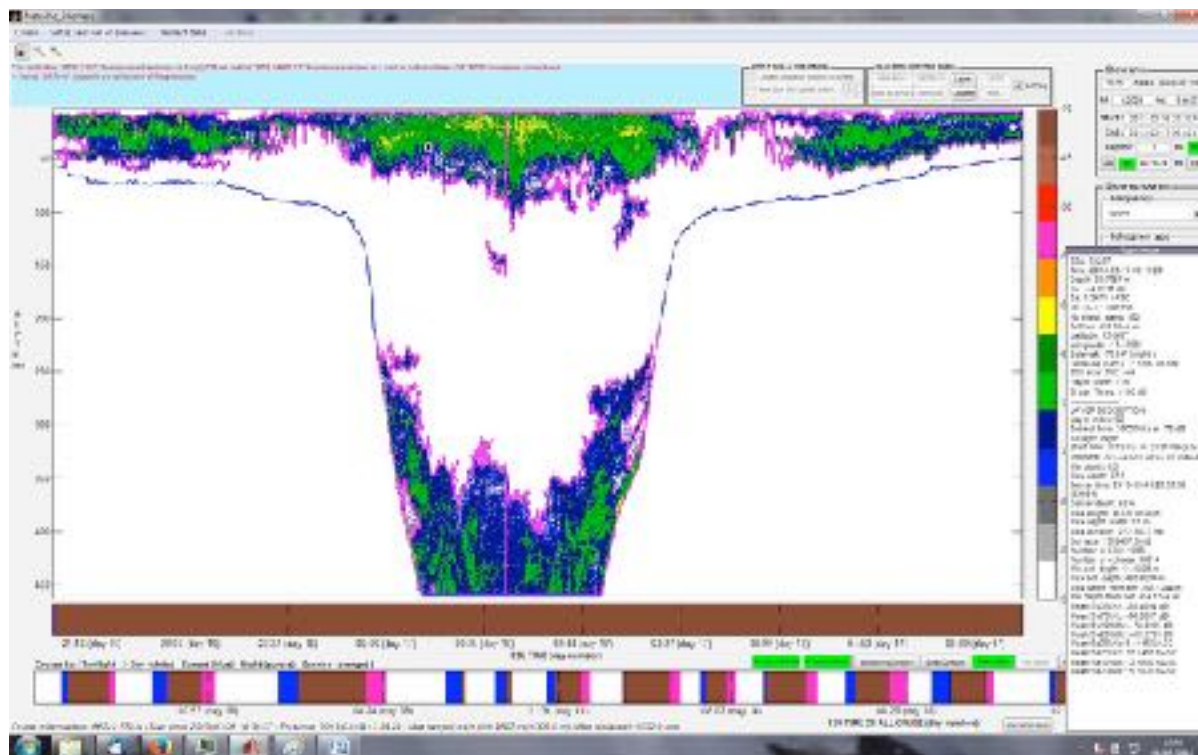
Version 01

Page 78/96



To obtain the following results:

- click on button « **Only Layer Echoes** » at the bottom of Matecho interface to show only layer echoes :



Layer descriptor can be visualized by using the yellow button at the left-top of Matecho interface (just below the menu Cruise) and by clicking on a layer.

## 3- Echo layer corrections by adding or removing echoes and layer updating



## MATECHO USER MANUAL

Laboratory: UMR LEMAR

User manual

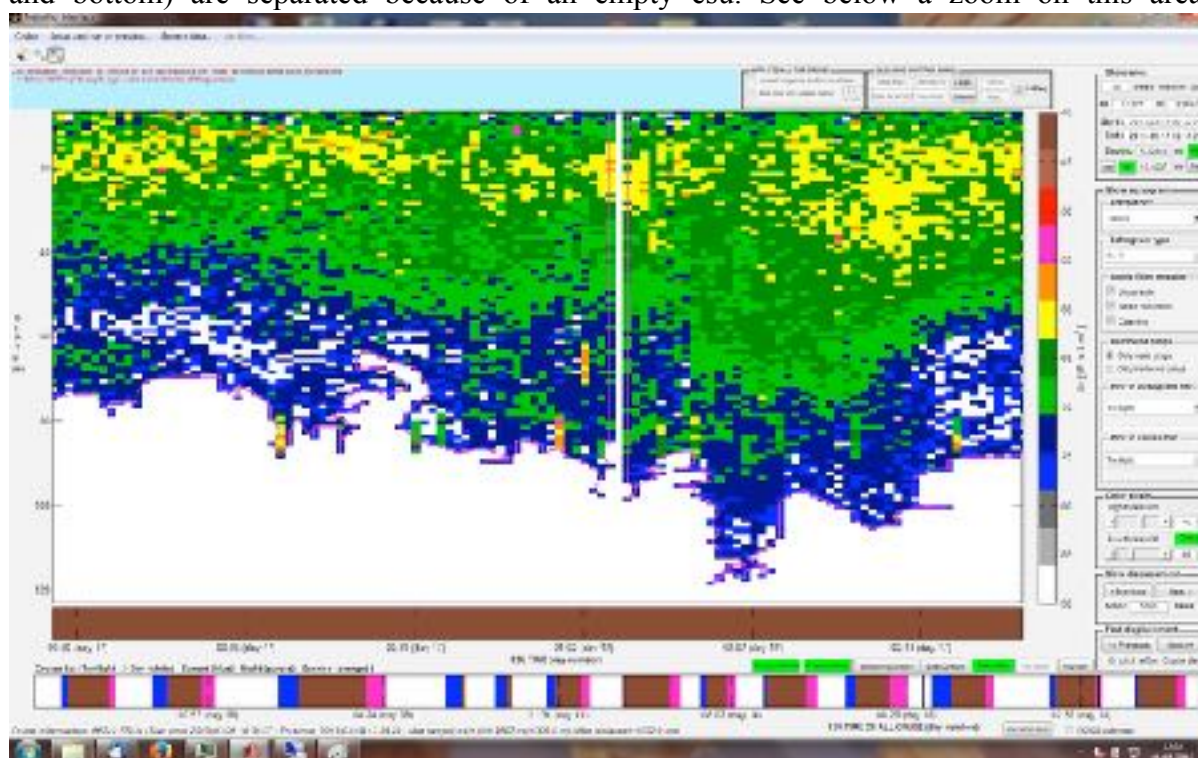
Implantation : Plouzané

Version 01

Page 79/96

If needed, it is possible to add virtual echoes between contours to link them (after updating) or to remove echoes inside a contour. Virtual echoes are only use to link contours but are not considered in the layer descriptor calculation.

By considering again the example above, you can see that both extracted layers (in surface and bottom) are separated because of an empty esu. See below a zoom on this area:



To link both contours, click on button '**Layers**' of the frame '**Cleaning control panel**' (at the top of the Matecho interface) to activate the manual layer correction option.

Then click on button '**Rem/Add**' and select the area (by reading in blue panel of user information, the different selection options. Rectangular or polynomial selections are possible) between both contours, as in the example below from a polynomial selection:

## MATECHO USER MANUAL

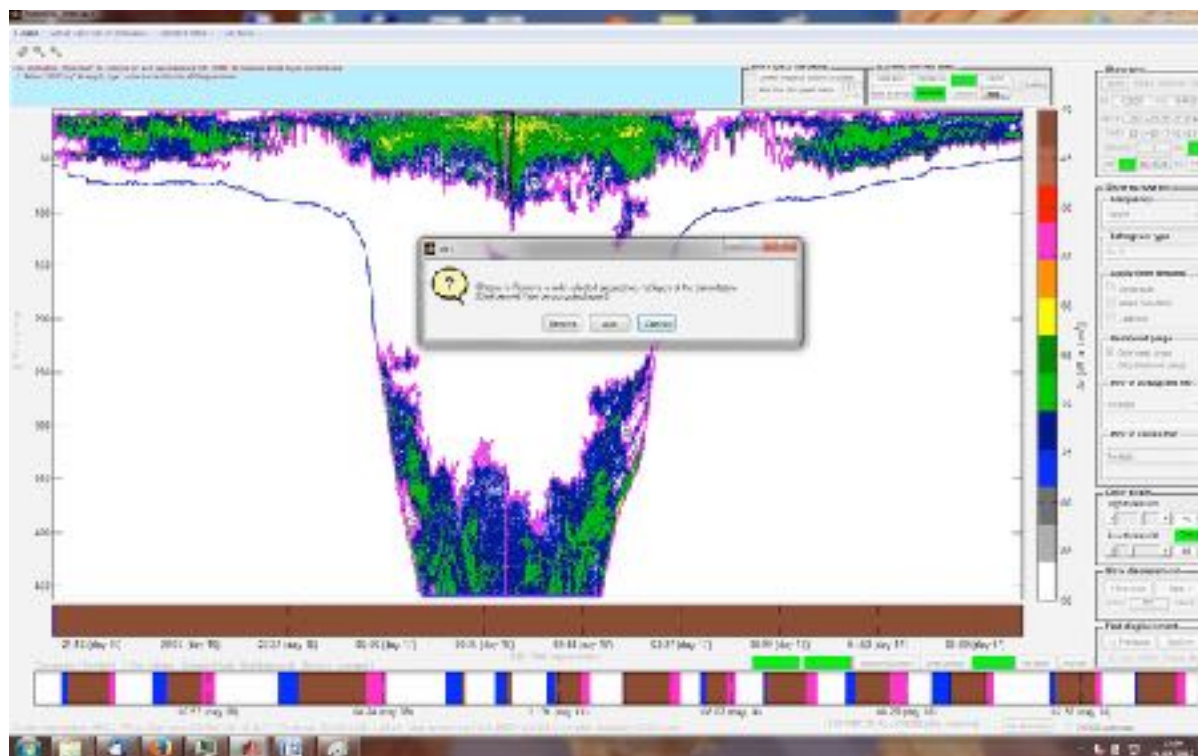
Laboratory: UMR LEMAR

User manual

Implantation : Plouzané

Version 01

Page 80/96



When the selection was done, a popup is opened. The button '**Add**' allows adding virtual echoes on selected zone to link contours and the button '**Remove**' allows removing echoes inside the selected area.

The example below shows the result when user choose to add virtual echoes to link both contours. Red patch indicate where virtual echoes have been added. Otherwise, when echoes are removed, they are not any more showed

Note that button '**REM**' in '**Cleaning control panel**' allows removing the layer correction(s) in a selected rectangular area.

# MATECHO USER MANUAL

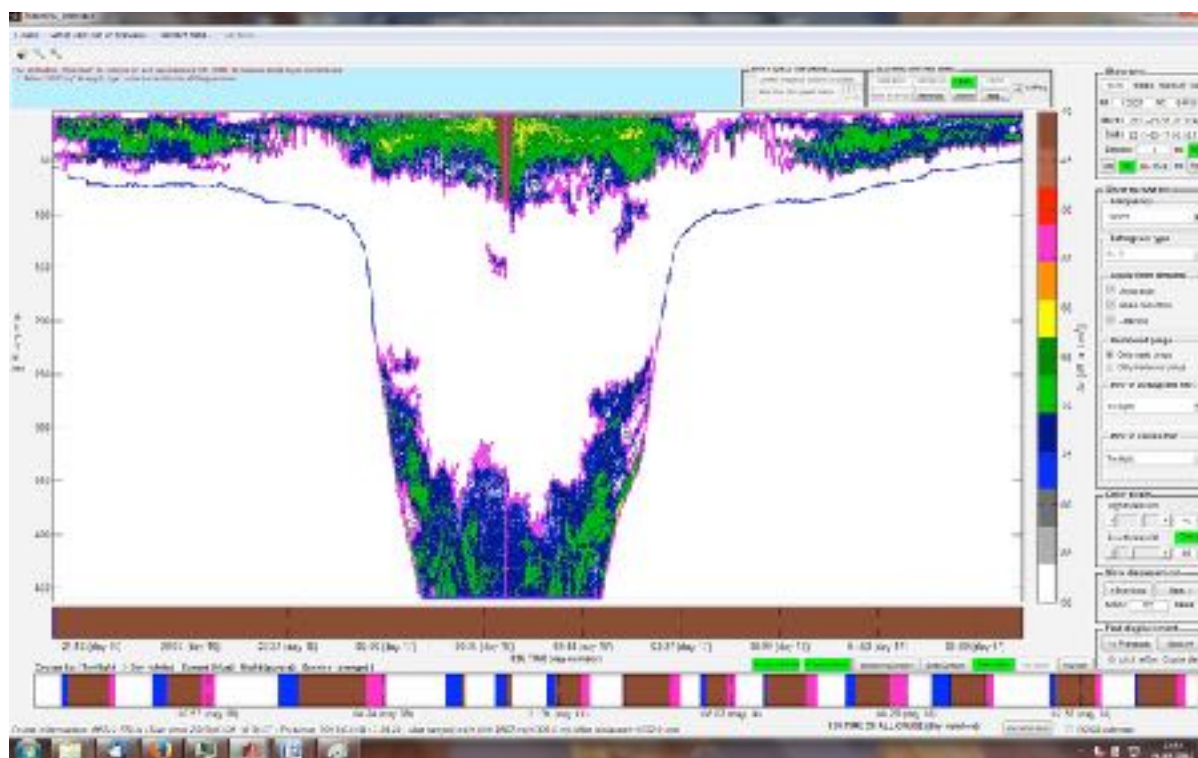
Laboratory: UMR LEMAR

User manual

Implantation : Plouzané

Version 01

Page 81/96



## 4- Layer updating after user correction:

The layer updating after user correction can be realized at any moment from menu '**Update layers from new layer correction**':



NB: User can choose to correct all layers (by adding or removing layer echoes) and to run the layer updating or to run the updating after each or few correction(s). **Important: Contours**



# MATECHO USER MANUAL

Laboratory: UMR LEMAR

User manual

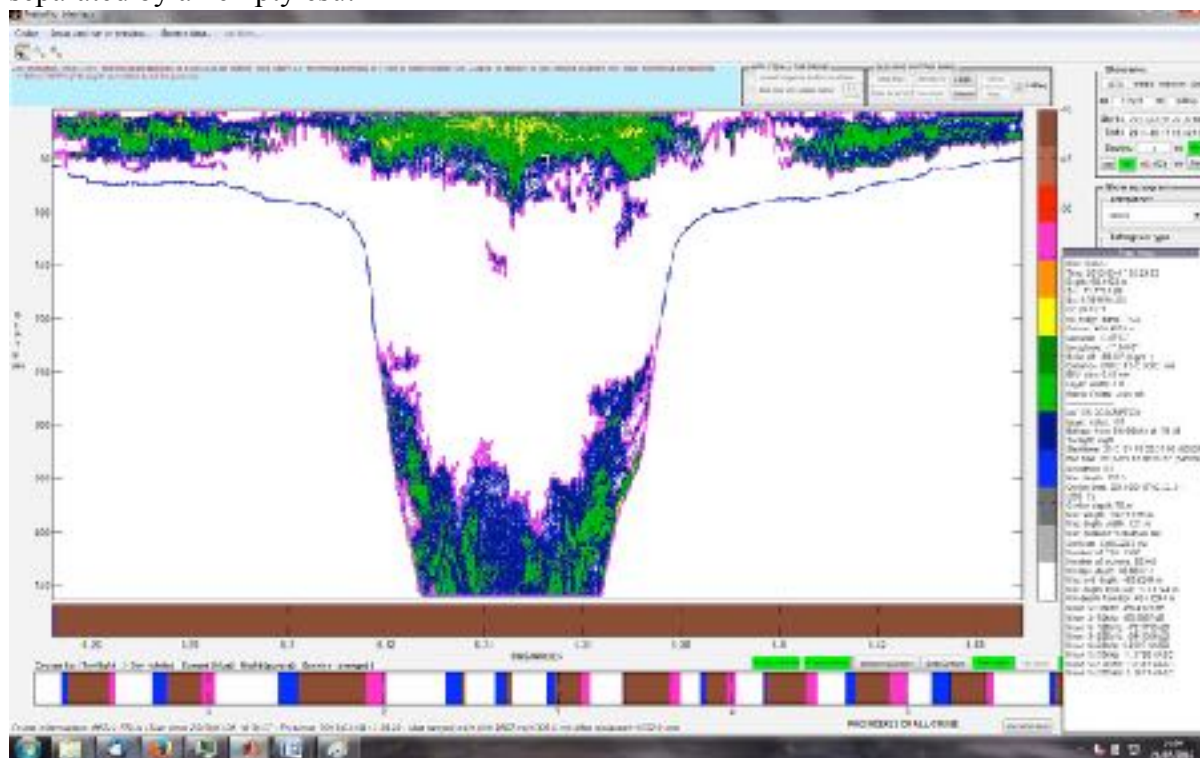
Implantation : Plouzané

Version 01

Page 82/96

are calculated independently on each zone with constant twilight (day, night). So, do not try to link contours which contain different twilights.

After the layer updating, we then obtain a single contour in surface instead of two contours separated by an empty esu:



## 4- Write layer descriptors in Excel

When all correction and updating have been done, layer descriptors for each twilight zones can be gathered in an Excel file from menu '**Write layer descriptors in Excel file**':

## MATECHO USER MANUAL

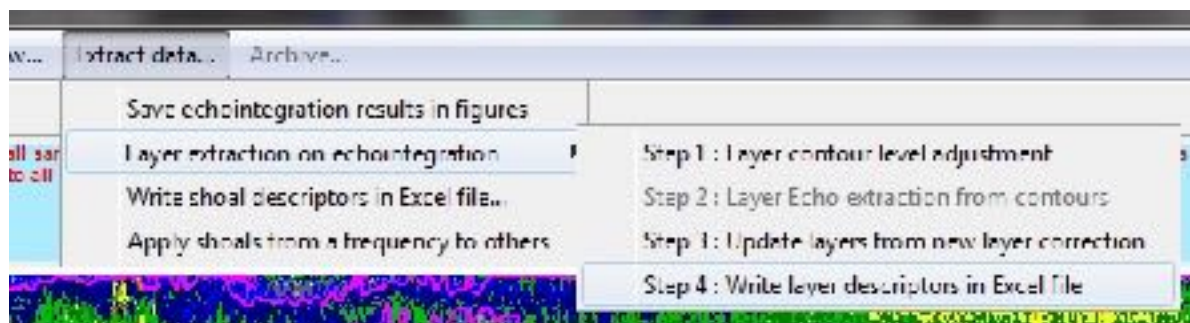
Laboratory: UMR LEMAR

User manual

Implantation : Plouzané

Version 01

Page 83/96



Layer extraction results are saved in HDF5 file '**Layer.mat**' at the same location than its corresponding HDF5 echointegration file '**Echointegration.mat**' (see above the location of this kind of file). See below, the directory and file tree for layer extraction:

# MATECHO USER MANUAL

Laboratory: UMR LEMAR

User manual

## Implantation : Plouzané

Version 01

Page 84/96

→ Excel files with layer descriptors

→ HDF5 file '**Layer.mat**' containing layer extraction results realized on the HDF5 file '**Echointegration.mat**' saved just above

When a cruise is opened in Matecho, you can access to the content of the HDF5 file **'Layers.mat'** by taping in Matlab commands windows **lay**. The content of this file is:



## MATECHO USER MANUAL

Laboratory: UMR LEMAR

User manual

Implantation : Plouzané

Version 01

Page 85/96

Layer.mal (MAT-file)	
Name	Value
CleanLayerMask	<28x231x4 single>
ContourDepth120	<1x696 double>
ContourDepth200	<1x729 double>
ContourDepth38	<1x137 double>
ContourDepth70	<1x511 double>
ContourIndPing120	<1x696 double>
ContourIndPing200	<1x729 double>
ContourIndPing38	<1x137 double>
ContourIndPing70	<1x511 double>
ExtractLevelB	-75
IdEsuZone	[1 231 3]
LayerDescription120	<1x31 single>
LayerDescription200	<1x31 single>
LayerDescription38	<1x31 single>
LayerDescription70	<1x31 single>
LayerDescriptionHeader	<31x1 cell>
LayerMask	<28x231x4 single>
TimeEnd120	'2013-03-06 11:21:10.763'
TimeEnd200	'2013-03-06 11:21:10.763'
TimeEnd38	'2013-03-06 11:21:10.763'
TimeEnd70	'2013-03-06 11:21:10.763'
TimeMean120	'2013-03-06 11:07:08.254'
TimeMean200	'2013-03-06 11:07:08.254'
TimeMean38	'2013-03-06 11:07:08.254'
TimeMean70	'2013-03-06 11:07:08.254'
TimeStart120	'2013-03-06 10:51:57.603'
TimeStart200	'2013-03-06 10:51:57.603'
TimeStart38	'2013-03-06 10:51:57.603'
TimeStart70	'2013-03-06 10:51:57.603'
UserCurrentCorrectionFreq	[]
UserCurrentCorrectionZone	[]
UserMask	<28x231x4 single>
UserParam	<1x1 struct>

Calculated descriptors for a given layer:

## MATECHO USER MANUAL

---

Laboratory: UMR LEMAR

User manual

Implantation : Plouzané

Version 01

Page 86/96

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**'1-Layer index'**: layer index allowing to find its position and its corresponding echoes in matrix 'CleanLayMask' (which is the mask to apply to the echointegrated echogram to only have the echoes included in the layer)

**'2-Zone index'**: zone index (day, night, sunset or sunrise) in the cruise

**'3-Layer extracted from frequency (Hz)'**: Frequency for which the layer was extracted

**'4-Twilight (1:night, 2:sunrise, 3:day, 4:sunset)'**: Twilight of the layer

**'5-Start ESU index'**: Esu index of the layer start

**'6-End ESU index'**: Esu index of the layer end

**'7-Number of ESU'**: Number of esu covered by the layer

**'8-Number of echoes'**: Number of echoes in the layer

**'9-Start time (s from 1970)'**

**'10-End time (s from 1970)'**

**'11-Minimum depth (m)'**

**'12-Maximum depth (m)'**

**'13-Center point time (s from 1970)'**: time at the layer central point

**'14-Center point time index'**

**'15-Center point depth (m)'**

**'16-Maximum length (m)'**

**'17-Maximum depth width (m)'**

**'18-Maximum duration (s)'**: Maximum duration of the layer

**'19-Surface (m2)'**: surface covered by the layer

**'20-Minimum bottom depth (m)'**: minimal bottom depth for the layer

**'21-Maximum Bottom depth (m)'**: maximal bottom depth for the layer

## MATECHO USER MANUAL

---

Laboratory: UMR LEMAR

User manual

Implantation : Plouzané

Version 01

Page 87/96

---

'22-Minimum depth from bottom (m)'

'23-Maximum depth from bottom (m)'

'24-Latitude ESU début de la couche (°)'

'25-Longitude ESU début de la couche (°)'

'26-Latitude ESU point central de la couche (°)'

'27-Longitude ESU point central de la couche (°)'

'28-Latitude ESU fin de la couche (°)'

'29-Longitude ESU fin de la couche (°)'

'30-Mean Sv Freq1 kHz (dB re 1 m-1)': mean Sv for frequency n°1

'31-Mean Sv Freq2 kHz (dB re 1 m-1)': mean Sv for frequency n°2

'32-Mean Sv Freq3kHz (dB re 1 m-1)'

'33-etc... according to all available frequencies....

'34-Mean Sa Freq1 kHz (NASC m2 nmi-2)': mean Sa for frequency n°1

'35-Mean Sa Freq2 kHz (NASC m2 nmi-2)': mean Sa for frequency n°2

'36- etc. according to all available frequencies ....

### Annex 3: Procedure for Matlab/Movies3D interfacing

Install Movies3D with setup file: **setup.exe** (to be sure to have needed windows framework)  
Otherwise, if your PC frameworks are ever updated, rather use **Setup\_x64.msi** for a fast installation.

For Matlab/Movies3D interfacing, there is two paths to add (a Matlab path and a windows path):

- Matlab path to add (not needed if you use the standalone version of Matecho):

## MATECHO USER MANUAL

Laboratory: UMR LEMAR

User manual

Implantation : Plouzané

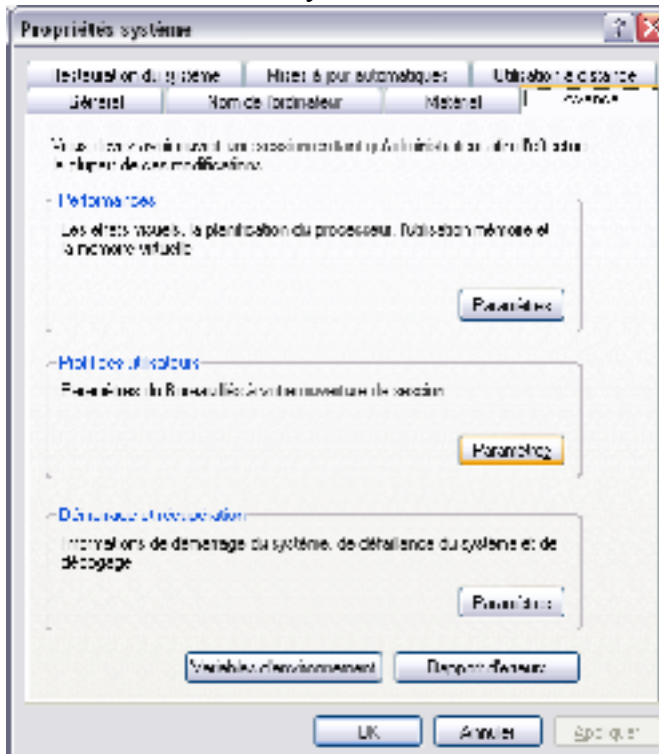
Version 01

Page 88/96

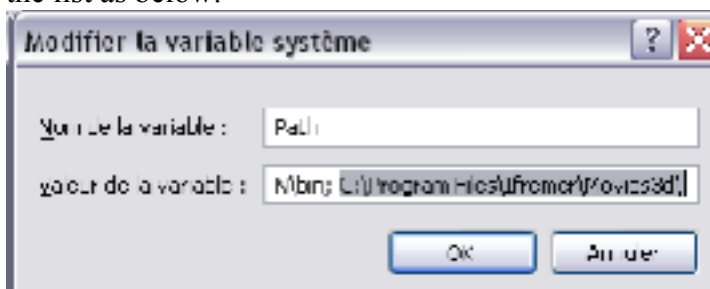
In Matlab menu: **Home**, click on button '**Set Path**' and then click on button '**Add with subfolders...**' to select the Movies3D folder '**MATLABLINK**' which must be located on your PC in the folder '**C:\Program Files\Ifremer\Movies3d\**'. To finish, click on Save and Close.

- Windows path to add (needed for all versions of Matecho):

Go to Control Panel / System / Advanced / Environment variables / to have:



- Modify variable '**path**' and add **C:\Program Files\Ifremer\Movies3d\** at the end of the list as below:



## MATECHO USER MANUAL

Laboratory: UMR LEMAR

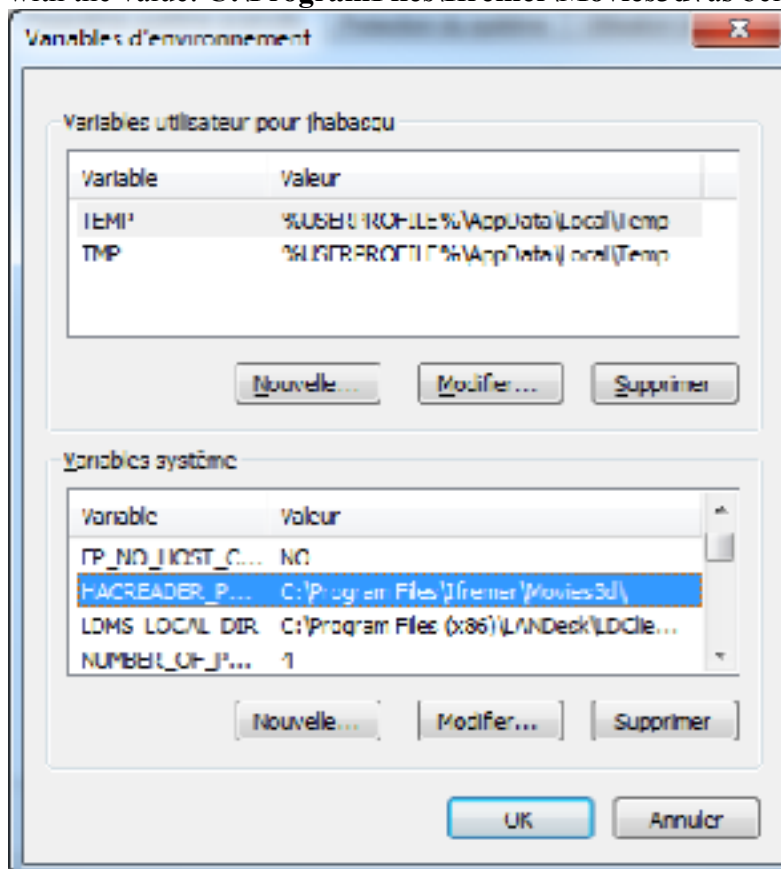
User manual

Implantation : Plouzané

Version 01

Page 89/96

- Add a variable **HACREADER\_PATH** with the value: **C:\Program Files\Ifremer\Movies3d\** as below:



- Close and open Matlab (sometimes you also have to restart the computer) to finish the interfacing
- Run Matecho and try to open a cruise (from Matecho menu, 'Cruise/Open a new cruise...'). If the popup of Fig. 4 appear without any error (as, for example, 'invalid mex-file'), the interfacing is then ok.

### Annex 4: Description of bifrequency processing from Matecho

## MATECHO USER MANUAL

Laboratory: UMR LEMAR

User manual

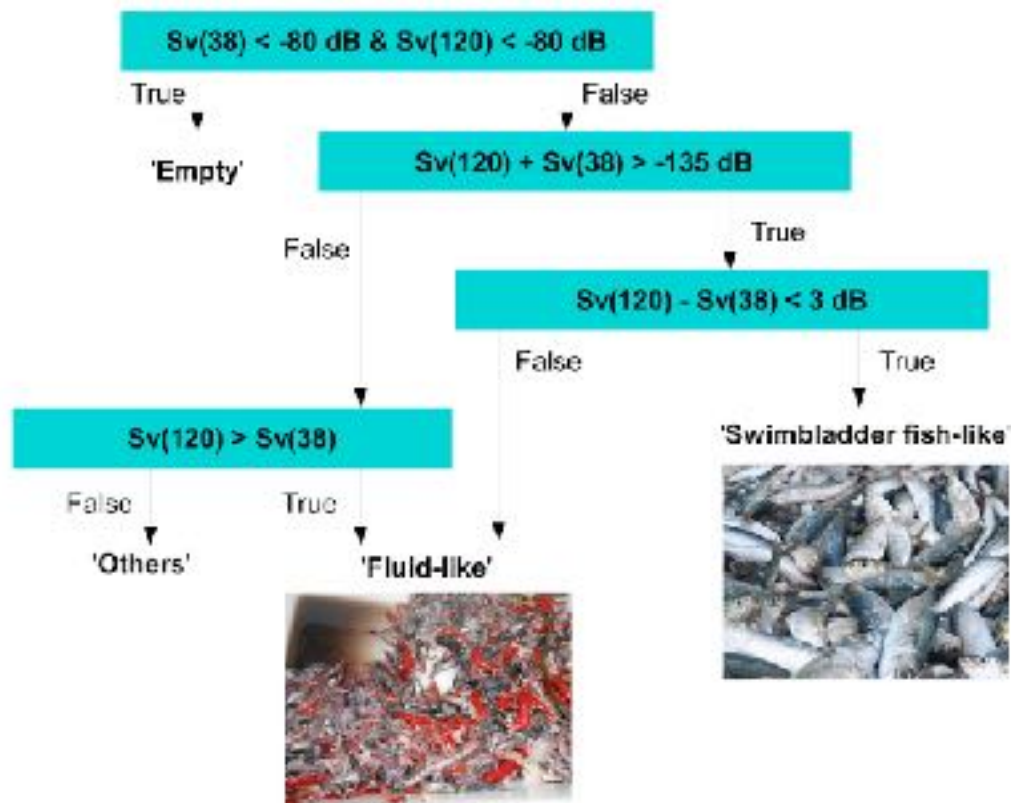
Implantation : Plouzané

Version 01

Page 90/96

**Bifrequency treatment is not activated by default in Matecho, [see section 1.3](#) to activate it.**

The bifrequency method implemented in Matecho, based on Ballon (2010), is synthetically described on figure below:



To run bifrequency treatment (when cruise echograms data were previously cleaned) use:

- Matecho menu /Setup and run.../Setup and run.../



# MATECHO USER MANUAL

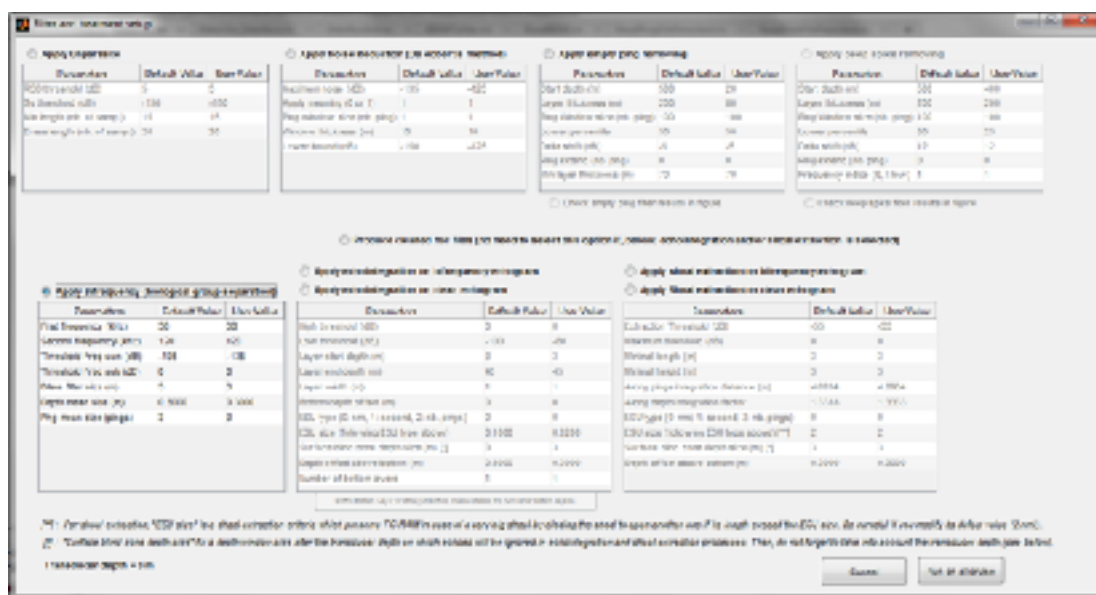
Laboratory: UMR LEMAR

User manual

Implantation : Plouzané

Version 01

Page 91/96



- Setup the bifrequency process:

Apply Bifrequency (biological group separation)		
Parameters	Default Value	User Value
First frequency (kHz)	00	00
Second frequency (kHz)	120	120
Threshold Freq sum (dB)	-135	-135
Threshold Freq sub (dB)	0	0
Wave filter size (m)	0	0
Depth mean size (m)	0.0000	0.0000
Ping mean size (pings)	5	5

First frequency of the bifrequency process (in kHz)  
 First frequency of the bifrequency process (in kHz)  
 Threshold to apply on the sum on both frequencies (in dB)  
 Threshold to apply on the frequency subtraction (in dB)  
 Size of the dilatation filter (in meter)  
 Size of the meaning window along depth (in meter)  
 Size of the meaning window along pings (number of pings)

Note that bifrequency thresholds (for frequency sum and subtraction) need an expertise according to the geographical area and the types of biological presence. It is the reason why the bifrequency process is not activated by default in Matecho.

Note that theses thresholds have been studied (by comparison and validation from zooplankton trawls) in the zone of Peru (Humboldt current) and Morocco for which the Threshold freq sum at -135 dB seems to be relevant to separate biological groups on these area.

## MATECHO USER MANUAL

Laboratory: UMR LEMAR

User manual

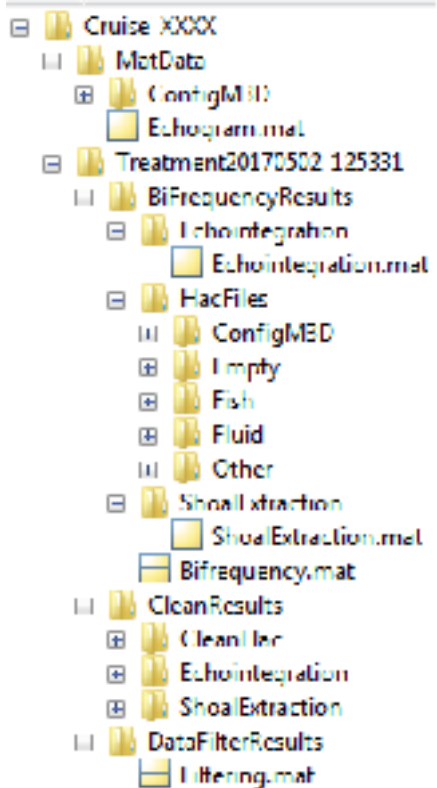
Implantation : Plouzané

Version 01

Page 92/96

- To apply echointegration on bifrequency results, check the radio button '**Apply echointegration on bifrequency echogram**'. The echointegration is then realized on Fish, Fluid and Others biological group echograms, obtain from bifrequency process.
- To apply fish shoal extraction on bifrequency results, check the radio button '**Apply shoal extraction on bifrequency echogram**'. The shoal extraction is then realized on Fish biological group echograms, obtain from bifrequency process.

All Data results for bifrequency process are saved by Matecho in folder '...\BiFrequencyResults\'. The resulting bifrequency echograms are saved in HDF5 file '...\BiFrequencyResults\Bifrequency.mat':

	<p>→ Saving folder for bifrequency results</p> <ul style="list-style-type: none"> <li>→ Bifrequency echointegration results</li> <li>→ Folder where bifrequency clean hac files are saved (for groups: Empty, Fish, Fluid and Others)</li> </ul> <ul style="list-style-type: none"> <li>→ Bifrequency fish shoal extraction results</li> <li>→ Bifrequency echograms</li> </ul>
---	--

When a cruise is loaded in Matecho, the content of bifrequency HDF5 files is available:

- In object **b** for bifrequency echograms saved in HDF5 file:

## MATECHO USER MANUAL

Laboratory: UMR LEMAR

User manual

Implantation : Plouzané

Version 01

Page 93/96

'...\BiFrequencyResults\Bifrequency.mat'. See below the content of this file for a cruise of 4 frequencies (38, 70, 120, 200 kHz) and 3387 pings

Bifrequency.mat (MAT-file)

Name	Value
Depth120	<824x1 double>
Depth200	<1648x1 double>
Depth38	<412x1 double>
Depth70	<824x1 double>
DurationApplyBifrequ...	0.2056
Empty120	<824x3387 single>
Empty200	<1648x3387 single>
Empty38	<412x3387 single>
Empty70	<824x3387 single>
Fish120	<824x3387 single>
Fish200	<1648x3387 single>
Fish38	<412x3387 single>
Fish70	<824x3387 single>
Fluid120	<824x3387 single>
Fluid200	<1648x3387 single>
Fluid38	<412x3387 single>
Fluid70	<824x3387 single>
Other120	<824x3387 single>
Other200	<1648x3387 single>
Other38	<412x3387 single>
Other70	<824x3387 single>
UserParamB	<1x1 struct>
dur	1.7347e-05

- in object **bei** for bifrequency echointegration saved in HDF5 file:  
'...\BiFrequencyResults\Echointegration\Echointegration.mat'. See below the content of this file for each biological groups:

## MATECHO USER MANUAL

Laboratory: UMR LEMAR

User manual

Implantation : Plouzané

Version 01

Page 94/96

Name	Value
Bottom	<4x231 double>
BottomShift	0
CumulatedGPSDistan...	<1x231 double>
DateTime	<231x23 char>
DurationApply Freslm...	0.5177
FlowThreshold	-100
EPParameters	<1x1 struct>
EsuPingStartEnd	<2x231 double>
FrequencySort	[38000;70000;120000;...
LastFile	[1.13626e+09;1.1352...
LastValidSampleDepth	<1x231 double>
Latitude	<1x231 double>
LayerWidth	1
Longitude	<1x231 double>
Mask_clean	<28x231x4 double>
N_surface_Empty	<28x1x4 single>
N_surface_Fish	<28x231x1 single>
N_surface_Fluid	<28x231x4 single>
N_surface_Other	<28x231x4 single>
NightSunrise?Day35...	<1x231 double>
QC_surface_Empty	<28x1x1 single>
QC_surface_Fish	<28x231x1 single>
QC_surface_Fluid	<28x231x4 single>
QC_surface_Other	<28x231x4 single>
Sa_bottom_Empty	<1x1x4 single>
Sa_bottom_Fish	<1x231x1 single>
Sa_bottom_Fluid	<1x231x4 single>
Sa_bottom_Other	<1x231x4 single>
Sa_surface_Empty	<28x1x4 single>
Sa_surface_Fish	<28x231x1 single>
Sa_surface_Fluid	<28x231x4 single>
Sa_surface_Other	<28x231x4 single>
SolarAltitude	<1x231 double>
SolarElevationAngleLim	[-18 18]
Sw_bottom_Empty	<1x1x1 single>
Sw_bottom_Fish	<1x231x4 single>
Sw_bottom_Fluid	<1x231x4 single>
Sw_bottom_Other	<1x231x4 single>
Sw_surface_Empty	<28x1x1 single>
Sw_surface_Fish	<28x231x4 single>
Sw_surface_Fluid	<28x231x4 single>
Sw_surface_Other	<28x231x4 single>
Time	<1x231 double>

## MATECHO USER MANUAL

Laboratory: UMR LEMAR

User manual

Implantation : Plouzané

Version 01

Page 95/96

- in object **bse** for bifrequency shoal extraction saved in HDF5 file:  
'...\BiFrequencyResults\ShoalExtraction\ShoalExtraction.mat'. See below the content of this file for Fish groups:

ShoalExtraction.mat (MAT-file)

Name	Value
ContourDepth120	<79x125 double>
ContourDepth200	<37x125 double>
ContourDepth38	<96x125 double>
ContourDepth70	<71x125 double>
ContourIndFreq120	<79x474 double>
ContourIndFreq200	<37x474 double>
ContourIndFreq38	<96x474 double>
ContourIndFreq70	<71x474 double>
DurationApplyTreatmentInMin	1.0000
FrequencySort	[38000;20000;120000;200000]
LastHar	[3 1.3625e+09]
RemovedShoal120	[]
RemovedShoal200	[]
RemovedShoal38	[]
RemovedShoal70	[]
ShoalDescription120	<79x23 double>
ShoalDescription200	<37x23 double>
ShoalDescription38	<96x23 double>
ShoalDescription70	<71x23 double>
ShoalDescriptionHeader	<33x1 cell>
ShoalEchogram120	<824x3387 single>
ShoalEchogram200	<1648x3387 single>
ShoalEchogram38	<4112x3387 single>
ShoalEchogram70	<8224x3387 single>
ShoalEchogramMask120	<824x3387 single>
ShoalEchogramMask200	<1648x3387 single>
ShoalEchogramMask38	<4112x3387 single>
ShoalEchogramMask70	<8224x3387 single>
ShoalExtractionParameters	<1x1 struct>
TimeEnd120	<79x23 char>
TimeEnd200	<37x23 char>
TimeEnd38	<96x23 char>
TimeEnd70	<71x23 char>
TimeMean120	<79x23 char>
TimeMean200	<37x23 char>
TimeMean38	<96x23 char>
TimeMean70	<71x23 char>
TimeStart120	<79x23 char>
TimeStart200	<37x23 char>
TimeStart38	<96x23 char>
TimeStart70	<71x23 char>
UserParam	<1x1 struct>



## MATECHO USER MANUAL

Laboratory: UMR LEMAR

User manual

Implantation : Plouzané

Version 01

Page 96/96

See below an illustration of the bifrequency biological group separation results:

