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National Environmental Science Program

Annotation guide: benthic composition and relief for horizontally facing imagery

Updated: July 2024

TransectMeasure: 2023-03_SwC_stereo-BRUVs_Forwards.TMObs: 39_1_01_L027_MAH00308.MP4_0028602.jpg

Program Picture Measurements About

Zoom 2 300

Measurements (32) NOT calibrated, Model = Length, Global

Image file	Fra...	Tim...
10_1_01_Left_MAH0035...	0	
12_1_01_L031_MAH0125...	0	
14_1_01_L031_14_MAH0...	0	
15_1_01_Left_MAH0037...	0	
16_1_01_L039_MAH0035...	0	
17_1_01_Left_MAH0037...	0	
19_1_01_L031_19_MAH0...	0	
21_1_01_Left_MAH0043...	0	
22_1_01_L035_MAH0036...	0	
23_1_01_Left_MAH0042...	0	
24_1_01_L035_MAH0035...	0	
26_1_01_Left_MAH0137...	0	
29_1_01_L035_MAH0034...	0	
2_1_01_Left_MAH00329...	0	
31_1_01_L029_MAH0033...	0	
32_1_01_L039_MAH0034...	0	
34_1_01_L027_34_MAH0...	0	
35_01_Left_MAH00294...	0	
36_1_01_L037_MAH0036...	0	
37_1_01_Left_MAH0037...	0	
39_1_01_L027_MAH0030...	0	
3_1_01_Left (2).MP4_00...	0	
40_1_01_Left_MAH0033...	0	
44_1_01_Left_MAH0043...	0	
45_1_01_Left_MAH0038...	0	
46_1_01_L041_MAH0038...	0	
47_1_01_L033_MAH0044...	0	
4_1_01_Left_MAH00360...	0	
5_1_01_Left_MAH00324...	0	
6_1_01_Left_MAH00375...	0	
7_1_01_L039_MAH00366...	0	
8_1_01_L039_MAH00361...	0	

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Introduction

We have developed a simple approach to characterise benthic composition and complexity from horizontally-facing imagery (including Baited Remote Underwater stereo-Video and Benthic Observation Survey System), adapting existing standardised schema for benthic composition ([CATAMI classification scheme](#)) and benthic complexity (Polunin and Roberts 1993).

The annotation approach is rapid and produces point annotation-level benthic composition and mean and standard deviation estimates of complexity, which enable flexible modelling of benthic class occurrence and fish-habitat relationships. A set of scripts to ensure quality assurance and quality control are also provided.

Brief explanation of the methodology

1. Classifying the benthos composition

Our recommended approach to characterise benthic composition utilises [TransectMeasure](#), a flexible software designed for the analysis of marine imagery. Benthic composition is classified using a random-point approach, wherein the biota directly under twenty randomly assigned points per image are analysed. To increase annotation efficiency, random points are only allocated to the lower 50% of the image, to avoid numerous unscorable or 'open water' annotation points in the top half of horizontal-facing benthic imagery. Benthic composition is classified using a hierarchical scheme that allows for standardised annotation labels which are consistent across different locations, over a wide range of depths, and in variable water visibility ([CATAMI classification scheme](#)).

2. Classifying the relief

Relief, or benthic complexity, is classified using a six point numeric scale adapted from Polunin and Roberts (1993). This scale provides a consistent method to score benthic complexity across a variety of habitat types, locations and water depths. The scale scores complexity from completely featureless and flat, up to highly complex benthos with For the benthic relief annotation, a 5 x 4 grid composing 20 rectangles across the entire image are assigned. During annotation, each grid-cell is analysed individually, and scores for mean and standard deviation across an image or deployment can be calculated.

Levels in annotation schema

The annotation schema we provide, adapted from the [CATAMI classification scheme](#), uses a hierarchical system to allow for accurate and consistent annotation labels. This schema uses 'levels' that increase in taxonomic and morphological resolution, with low levels representing coarse classifications (e.g. 'macroalgae', 'sponges') and high levels representing fine classifications (e.g. 'branching octocorals'). We also

provide a scientific name level, where some easily identifiable and ecologically meaningful species can be annotated to full taxonomic resolution (e.g. *Ecklonia radiata*).

The hierarchy of this annotation schema means that the level of detail can be decided by the custodians of the project, with annotators choosing to leave annotation labels at a lower level where high morphological or taxonomic resolution is not required. We recommend interrogating the required outcomes of a project and choosing the lowest annotation level required to meet the outcomes. This will increase annotation efficiency and allow for rapid data analysis.

TransectMeasure - Standard Operating Procedure

1. Load images and attribute file

- Open the program TransectMeasure and you will be welcomed with a blank screen ([Fig. 1](#)).

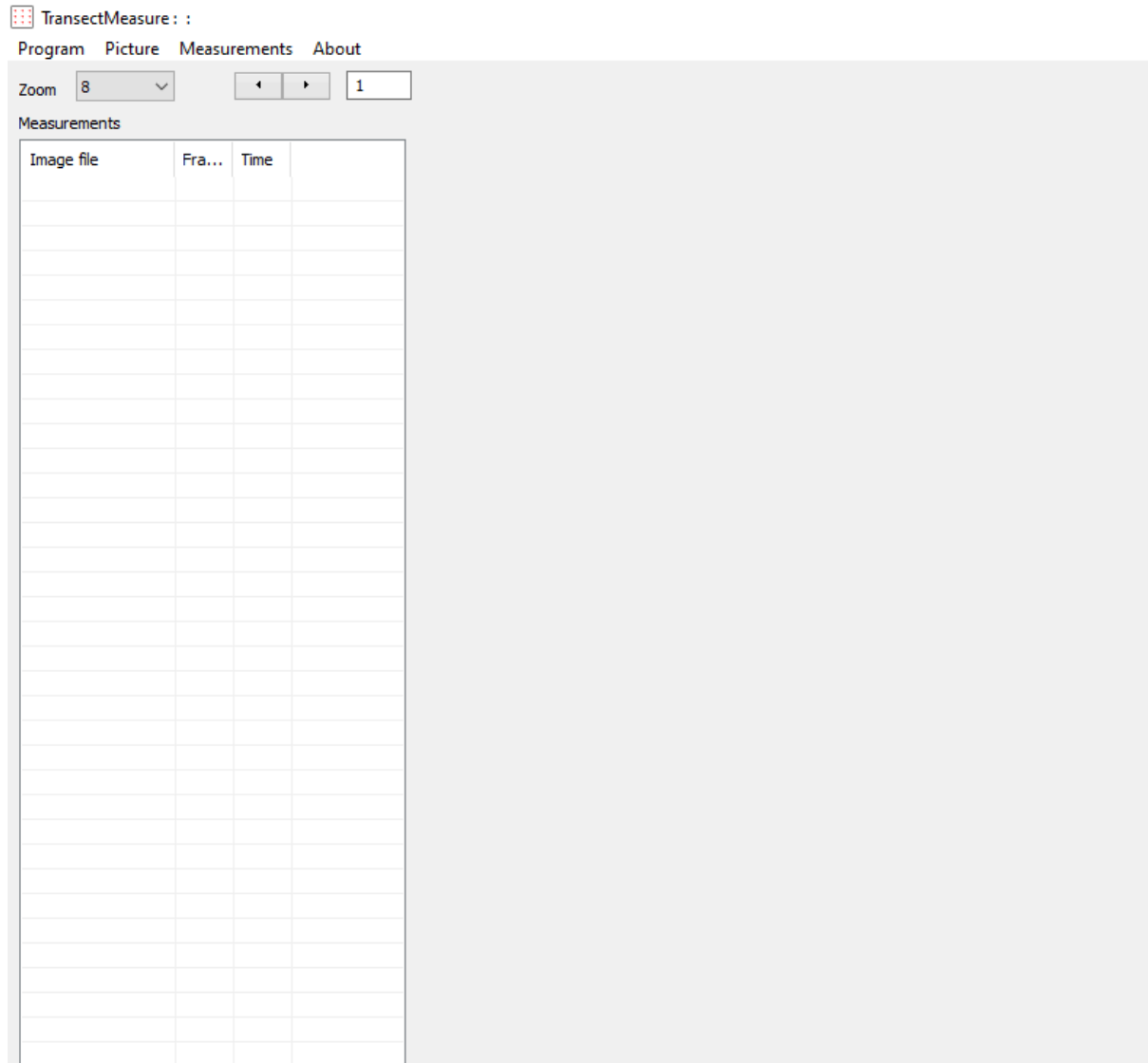


Figure 1: TransectMeasure initial opening screen.

- To start an analysis for a new set of images: Go to “Measurement” > “New measurement file” ([Fig. 2](#)).

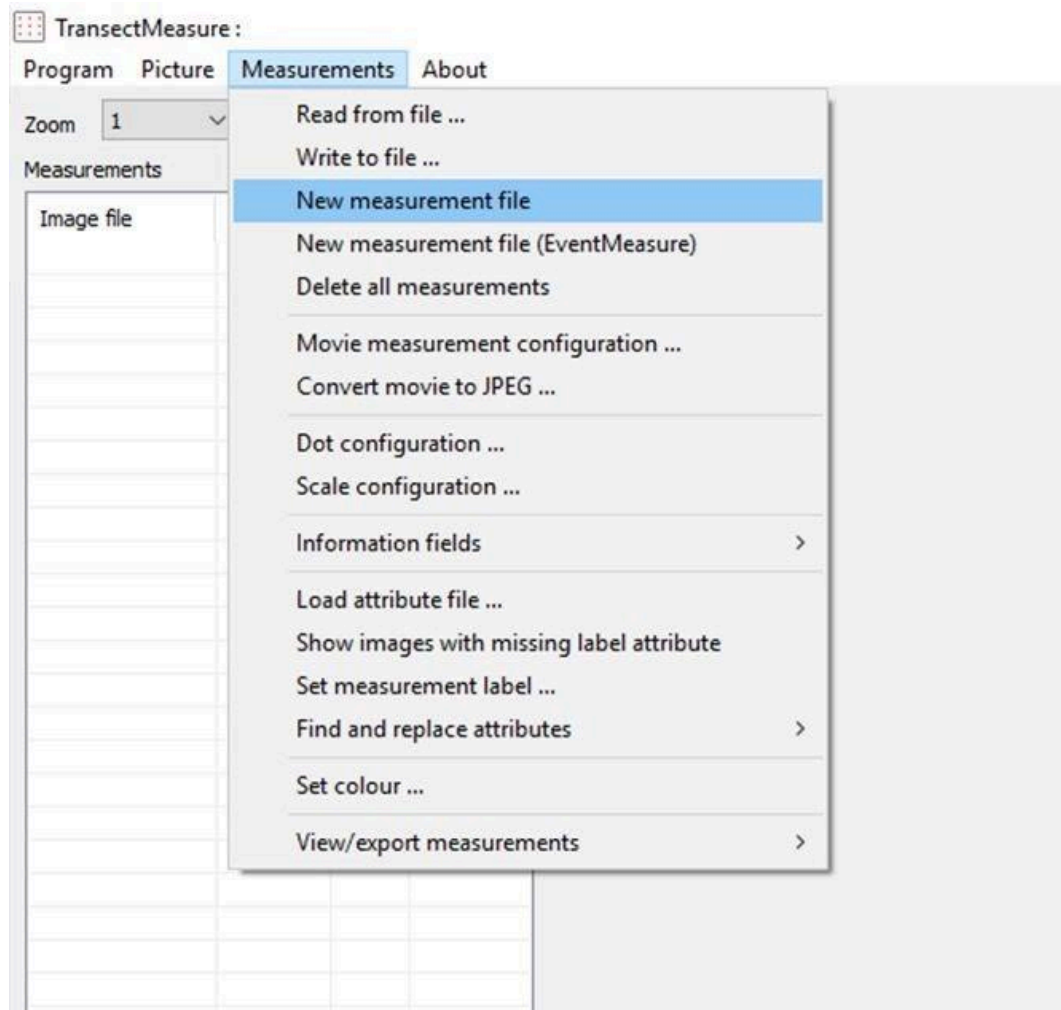


Figure 2: Creating a new measurement file in TransectMeasure.

- Locate the folder where your images have been stored: Go to “Picture” > “Set picture directory ...” ([Fig. 3](#)).

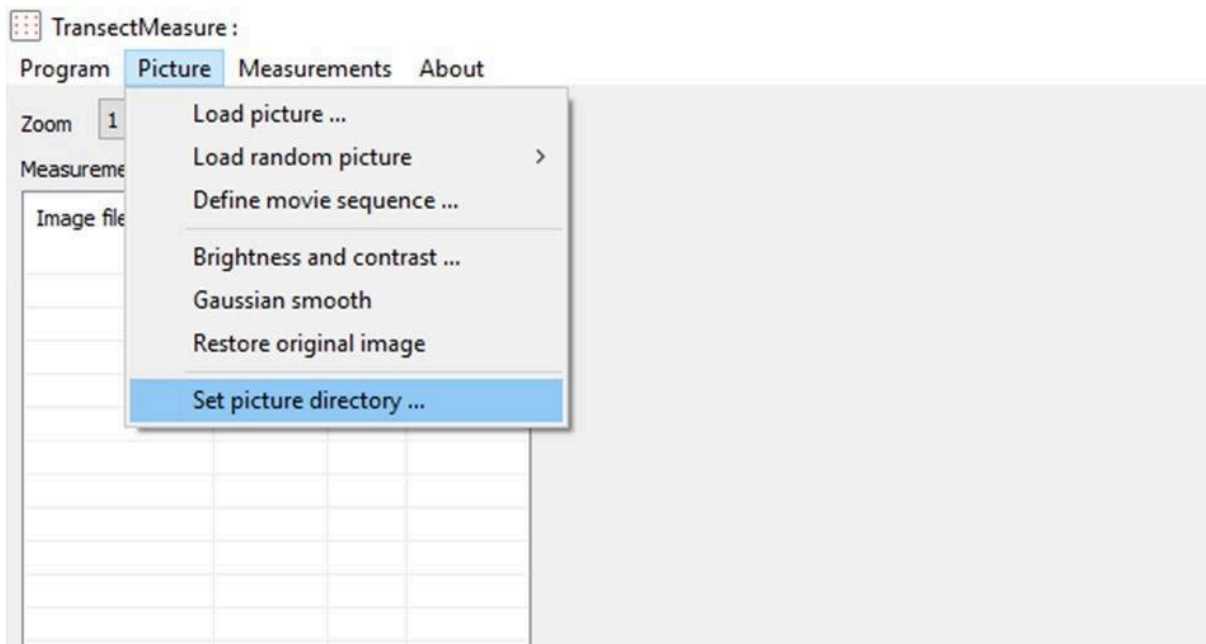


Figure 3: Setting the picture directory and loading the image in TransectMeasure.

- Load the first image to be analysed: Go to “Picture” > “Load picture ...” > click on the first image in the folder (Fig. 3).
 - *Note: It is important that the benthos is unobstructed by bubbles/fish/sediment plumes, retake any benthic images if they are unfocused/blurry or if visibility is low.*
 - For stereo-BRUV imagery, we recommend that left images are annotated, and for panoramic drop camera imagery, we recommend that top images are annotated.
- Press the left arrow key to make sure that you are actually at the first image in the sequence (TransectMeasure often orders image filenames in a different manner to the native Windows filename ordering).
- To load the attribute file containing all of the CATAMI habitat classifications: Go to “Measurements” > “Load attribute file ...” > The attribute file is a text file containing the information necessary for populating the drop down tabs when classifying your image (Fig. 4). This is available for download via [CheckEM](#) - ‘Schema downloads - benthic-habitat-annotation...’. See [Levels in annotation schema](#) for more information about choosing a schema.

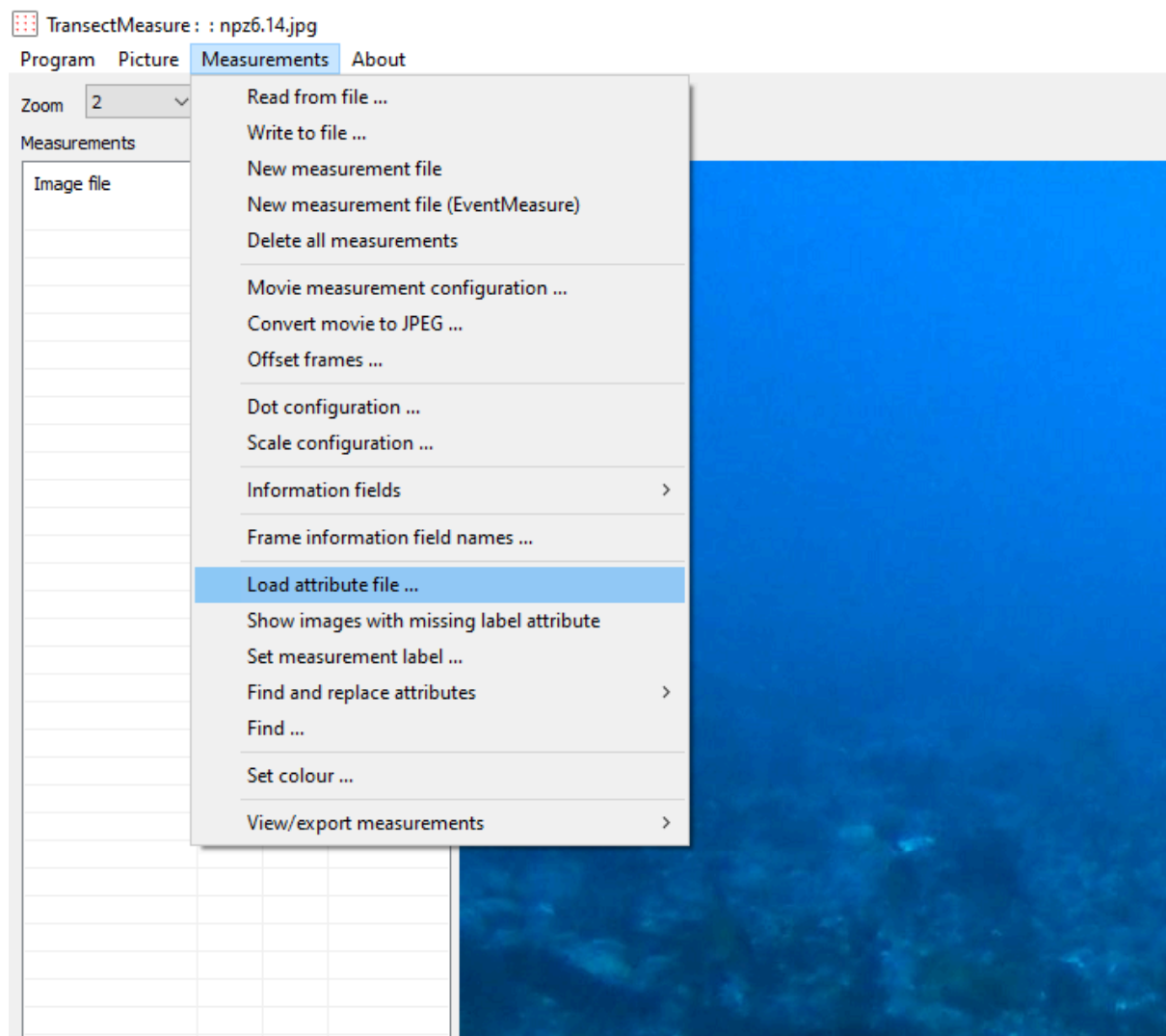


Figure 4: Loading the attribute file in TransectMeasure.

- Set the information field names: “Measurements” > “Information fields” > “Edit field names” (This only needs to be done once per user per computer).
 - Field heading 11 = “campaignid”
 - Field heading 12 = “relief_annotated”

[illegible]

Figure x: Setting the information field names.

- Save the observation file: “Measurements” > “Write to file” (Fig x). Our recommended file-naming convention is: ‘campaignid_forwards/backwards’ for BRUV imagery, and campaignid for BOSS imagery. We recommend saving your measurement files in a dedicated ‘TransectMeasure’ folder for each campaign, and periodically saving your work throughout the annotation process.

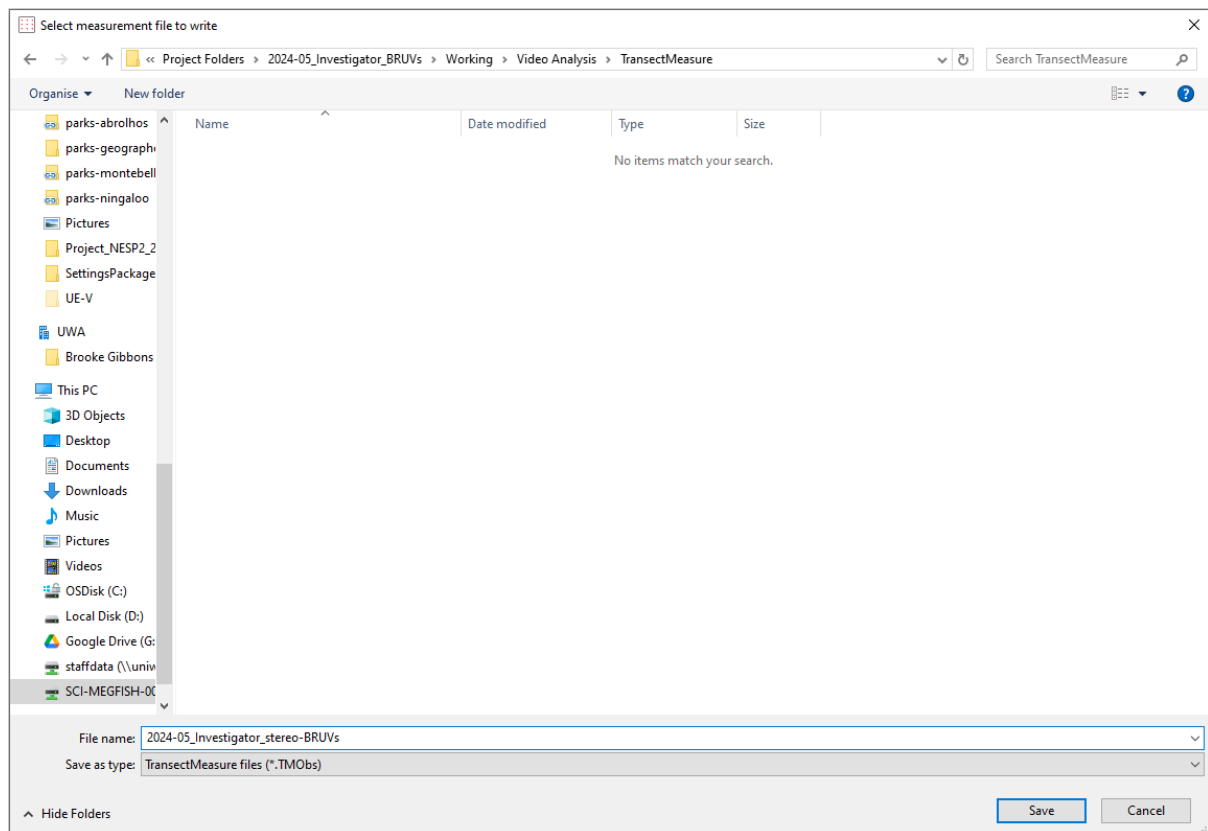


Figure x: Saving the measurement file.

2. Setting and overlaying the annotation points and adding frame information

This section is split into two sets of instructions for [single imagery approaches](#), such as Baited Remote Underwater stereo-Video (stereo-BRUVs), and [composite imagery approaches](#), such as stereo Benthic Observation Survey Systems (stereo-BOSS). Different procedures are required to overlay the annotation points, due to the multi-pane imagery used for the composite imagery.

Single imagery e.g. BRUV

- Enter the project information fields: “Measurements” > “Information fields” > “Edit field values” and enter the value for “campaignid” (e.g. 2024-05_Investigator_stereo-BRUVs) and “No” for “relief_annotated”.

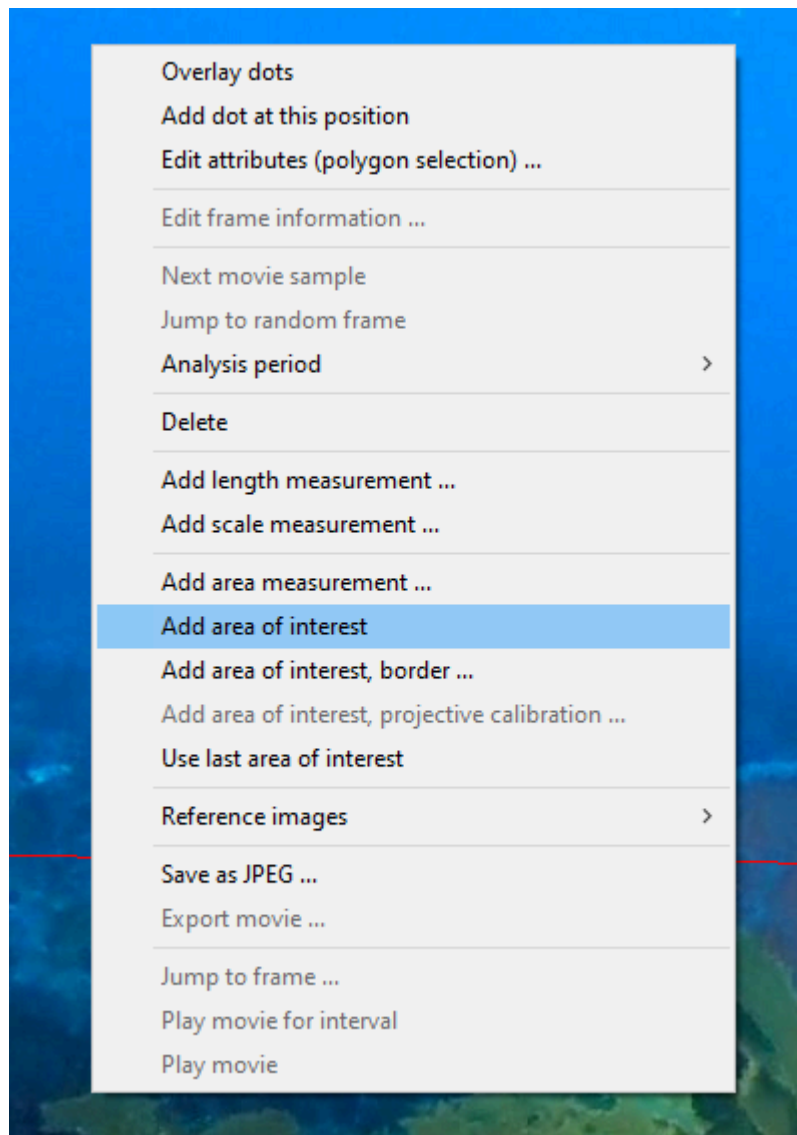
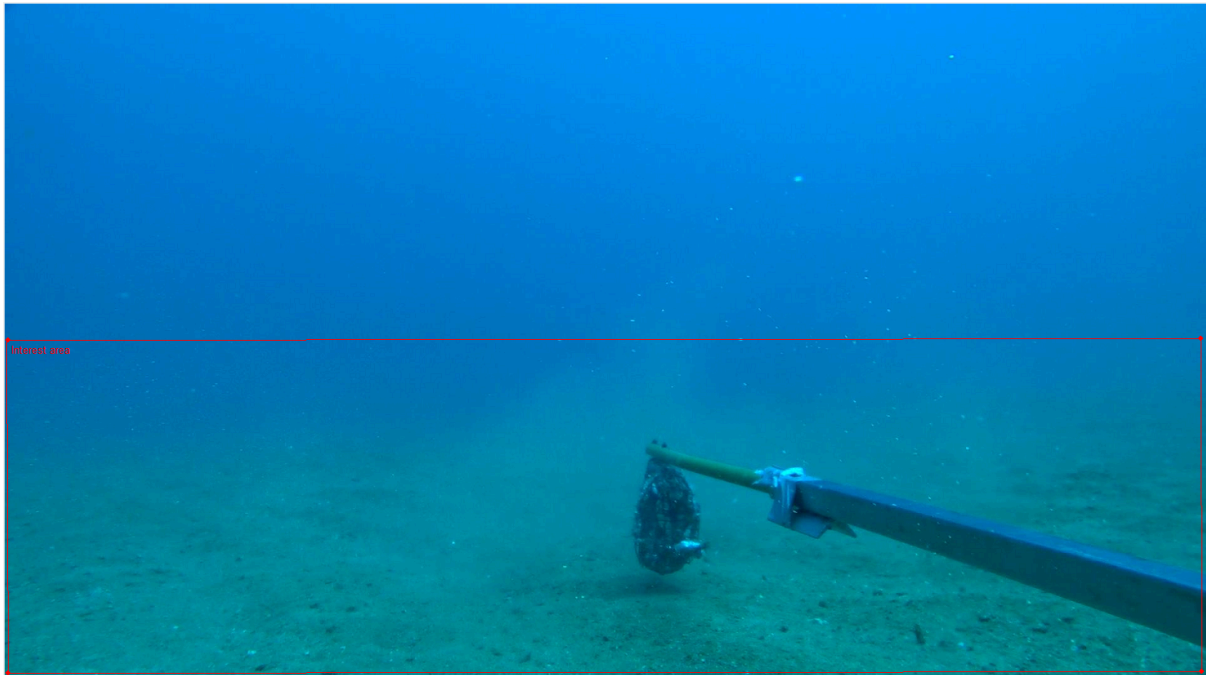


Figure 5: Adding a new area of interest in TransectMeasure.



- To set up the random points:
 - Go to “Measurements” > “Dot configuration ...”. And change the settings to: Random dots, ‘Number of dots’ = 20 (Fig. 6). This will allow you to classify the benthic composition according to 20 randomly generated points over the lower 50% of the screen.

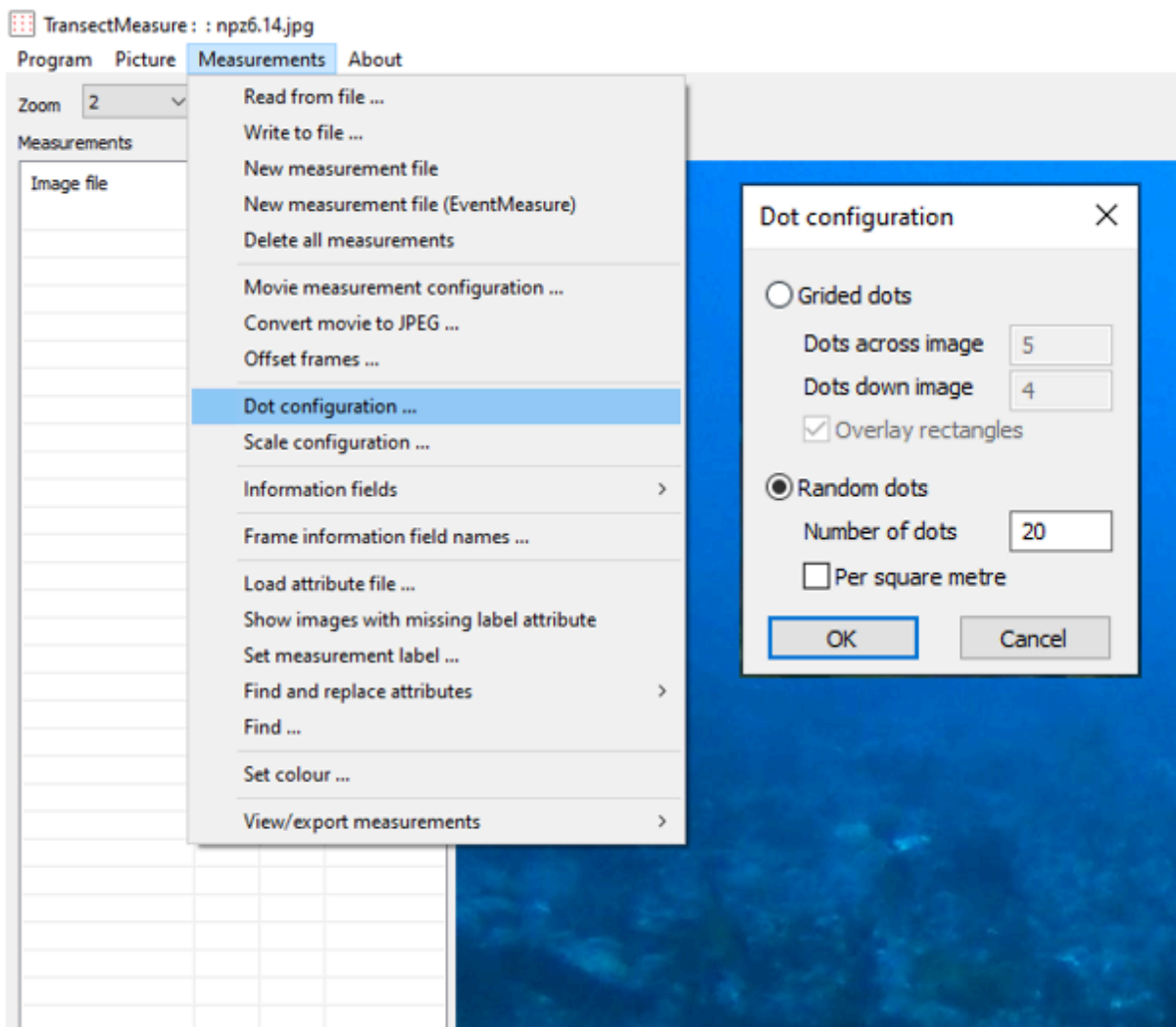


Figure 6: Setting the dot configuration in TransectMeasure.

- To overlay the points: Right click on an image and select “Overlay dots” (Fig. 7). The name of the image will then appear in the table to the left of the image.
- Press the right arrow key to move to the next picture in the picture directory. Use “ctrl + i” to add the last used area of interest and overlay random dots (Fig. 8). Repeat this step until all pictures in the picture directory have the dots overlaid.
 - NOTE: Check to see if the number of images with dots overlaid matches the total number of successful images recorded in your metadata (Fig XX).

Measurements (6)		NOT calibrated, Model = Length, Global	
Image file		Frame	
DM-BV-61_1_01_Left_MAH00358.MP4_0065493.jpg		0	
DM-BV-62_1_01_Left_MAH00500.MP4_0027433.jpg		0	
DM-BV-63_1_01_Left_1.MP4_0039316.jpg		0	
DM-BV-58_1_01_Left_MAH00393.MP4_0016619.jpg		0	
DM-BV-59_1_01_Left_1.MP4_0035987.jpg		0	
DM-BV-60_1_01_Left_MAH00363.MP4_0010371.jpg		0	

Figure XX. Total number of images/measurements in the TMobs file.

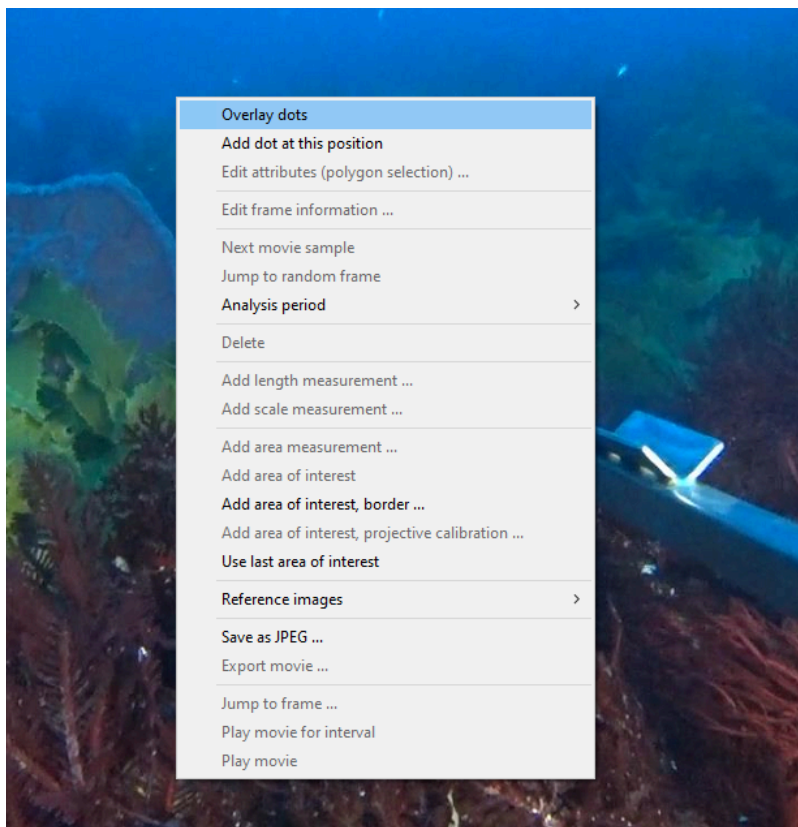


Figure 7: Adding dots in TransectMeasure.

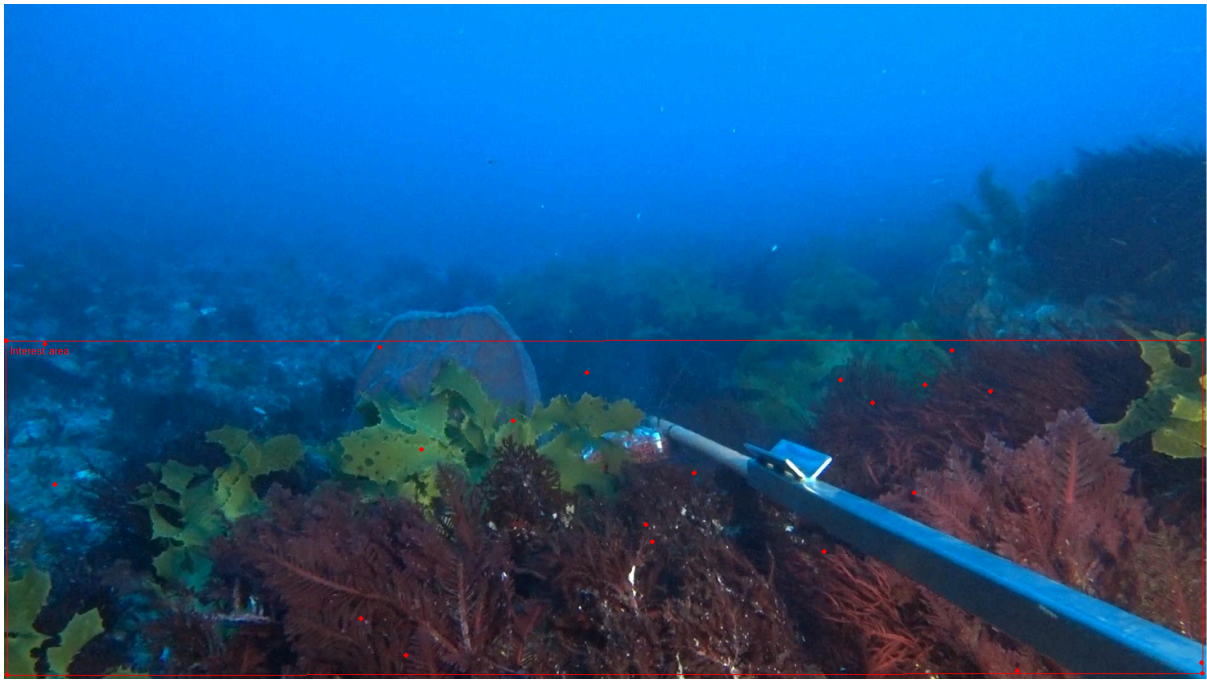


Figure 8: Example of a stereo-BRUV image with random points added to the lower 50% of the image ready for annotation.

- To set the frame information: After the image has had dots added, use **“ctrl + t”** to automatically fill information stored in the image filename into the **frame information fields** (when prompted *review the autofill information* and select “Yes”).

NOTE: *The frame information fields are important to match the benthic data to the sample metadata. The “ctrl + t” autofill information uses the filename structure that is automatically generated when exporting benthic images from EventMeasure (Right click > “Save as jpeg”. If you wish to use this feature, you must either export your images from EventMeasure, or name your images to match the following structure - ‘OpCode_Period_ImageName’. TransectMeasure will detect the first 2 underscores as separators and parse the information from these into the frame information fields.*

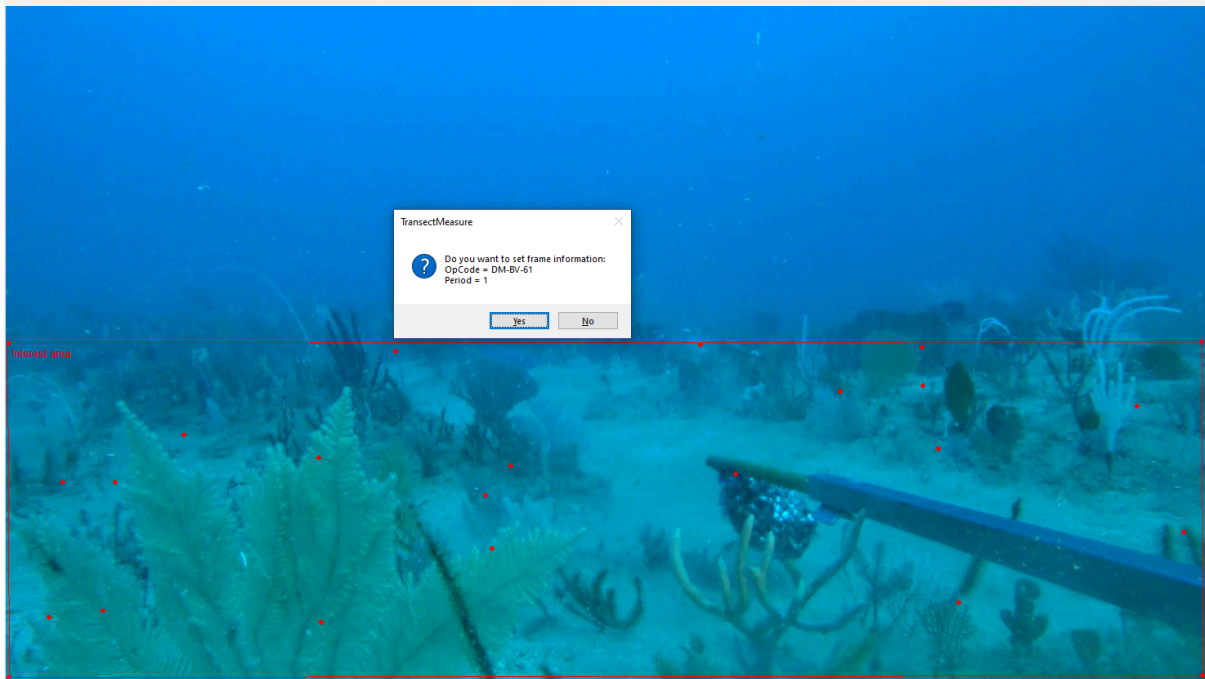


Figure 9: Example of adding frame information fields to a stereo-BRUV image using the “ctrl + t” shortcut.

Composite imagery e.g. BOSS

- Enter the project information fields: “Measurements” > “Information fields” > “Edit field values” and enter the value for “campaignid” (e.g. 2024-05_Investigator_stereo-BOSS) and “No” for “relief_annotated”.

Figure

- Go to “Measurements” > “Dot configuration” > Select “Gridded Dots” and change the settings to: Overlay gridded dots with rectangles (“Measurements” > “Dot configuration ...”). Set accordingly: Gridded dots, ‘Dots across image’ = 2, ‘Dots down image’ = 4 and check the “Overlay rectangles” box).

Figure

- Once you have added an area of interest you will not be able to overlay the grids again without overwriting any existing random point data. Our high-tech solution to this problem is to grab some sticky notes or another device to mark the corners of the rectangles on your screen (Fig. 10X). We have requested a

change to TransectMeasure and will update this guide once the changes have been made.

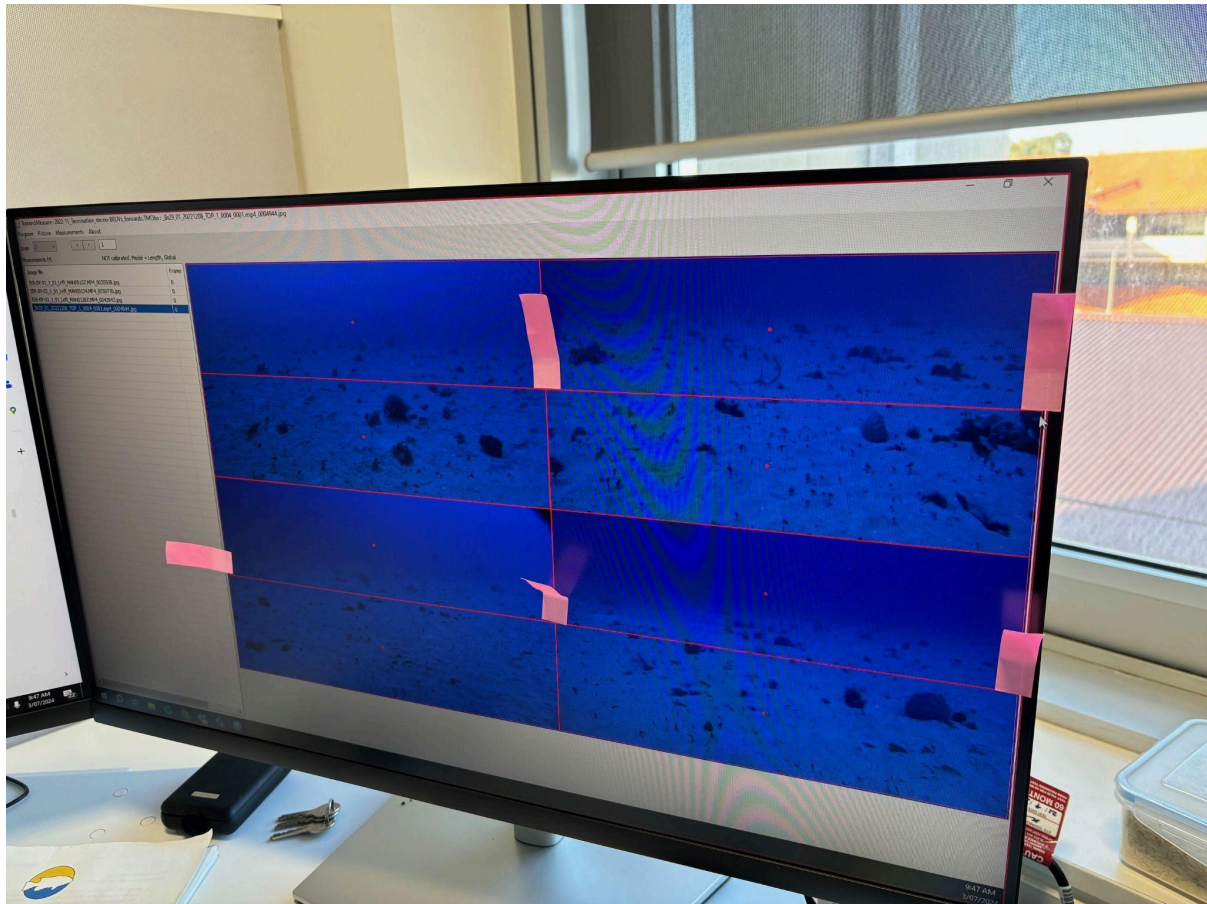


Figure 10X: Adding sticky notes to your monitor to accurately define the lower 50% of each of the panels.

- To set up the area of interest for the first pane of the image: Hold shift and left click on the four corners of the rectangle that forms the lower 50% of one pane of the composite image > Right click > “Add new area of interest” (Fig. 9).

Figure

- To add the random points: Go to “Measurements” > “Dot configuration ...”. Set accordingly: Random dots, ‘Number of dots’ = 20 (Fig. 6). This will allow you to classify the benthic composition according to 20 randomly generated points over the lower 50% of the screen.

Figure

- To overlay the points: Right click on an image and select “Overlay dots” (Fig. 10). The name of the image will then appear in the table to the left of the image.

Figure

- Press the right arrow key to load the next picture in the picture directory. Use “ctrl + i” to add the last used area of interest and overlay random dots (Fig. 8). Repeat this process until all pictures have the first area of interest and random points.

Figure

- Move back to the first image in the sequence (this will appear at the top of the list in the left hand side of TransectMeasure). Use the sticky notes or markings as a guide to set the second area of interest.

Figure

- To add points to the second pane of the image: “ctrl + right click + Add dots” > “Add to the existing points” (Fig. 9). For all subsequent images in the image directory, “ctrl + shift + i” will overlay the last area of interest and add additional random dots to the image.

Figure

- Repeat this process for the third and fourth panes.

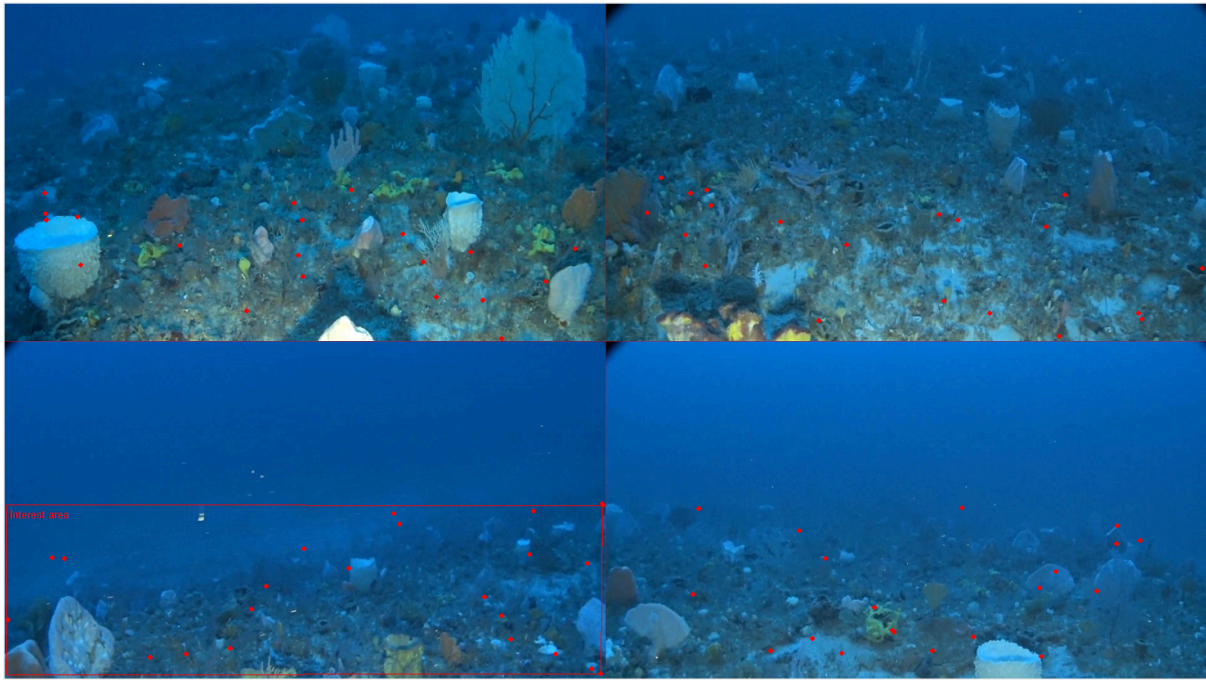


Figure 9: Example of a panoramic drop camera image with random points added to the lower 50% of each pane. The red box in the bottom right image denotes the custom area of interest used to overlay the annotation points in TransectMeasure.

- To set the frame information: After the image has had dots added, **use “ctrl + t” to automatically fill information stored in the image filename into the frame information fields** (when prompted *review the autofill information* and select “Yes”).

Figure

3. Classifying the benthic composition in an image

- Left click on a random point to display the “Attribute editor” (Fig. 10)
 - If the benthos is not obscured
 - Then select the biota that lies directly underneath the point in the “level_2” dropdown (Cnidaria, Sponges etc.).
 - Continue to populate each level drop down (i.e. “level_3” > “level_4” > “level_5” > “scientific” > “qualifiers”) until you reach the highest level you have decided to annotate to (See [Levels in](#)

[annotation schema](#)). Available selections will change depending on the value selected in the previous level.

- If you can not determine a level e.g. you know the level_2 category is Macroalgae but you are not sure of the level_3 category then leave the level you are unsure of blank.
- Select “Clear” to reset the dropdowns for all of the categories (Fig. 10).
 - If the benthos is obscured (e.g. point lands on a bait arm, bait bag, part of a frame) or not visible (e.g. point lands on open water or the benthos is not distinguishable due to bad visibility), you should select “Unscorable” in the “level_2” dropdown (Fig. 8).
- Repeat for all other points to annotate.

[illegible]

Figure 10: The 'attribute editor' window within TransectMeasure.

Tips & annotation approaches:

- To zoom into an image, you can either hold “ctrl” and move the mouse towards the area you want to zoom to, or, you can use the scroll wheel on the mouse to zoom into an area of the image.
- In the attribute editor, points from the history can be quickly assigned to an annotation point using ‘hot keys’, which are called using the ‘function’ keys on the keyboard (e.g. f2, f3 etc...). The keyboard shortcuts for the history items are dynamic, and care must be taken when using them to ensure that incorrect annotations are not accidentally assigned.

Figure

- To assign the same label to multiple points, a polygon selection can be made: hold shift + left click around the desired points (Fig. x) > right click and “Edit attributes (polygon selection)” (Fig. x).



Fig xx. An example polygon selection made around multiple annotation points. This selection allows multiple points to be assigned the same attribute.

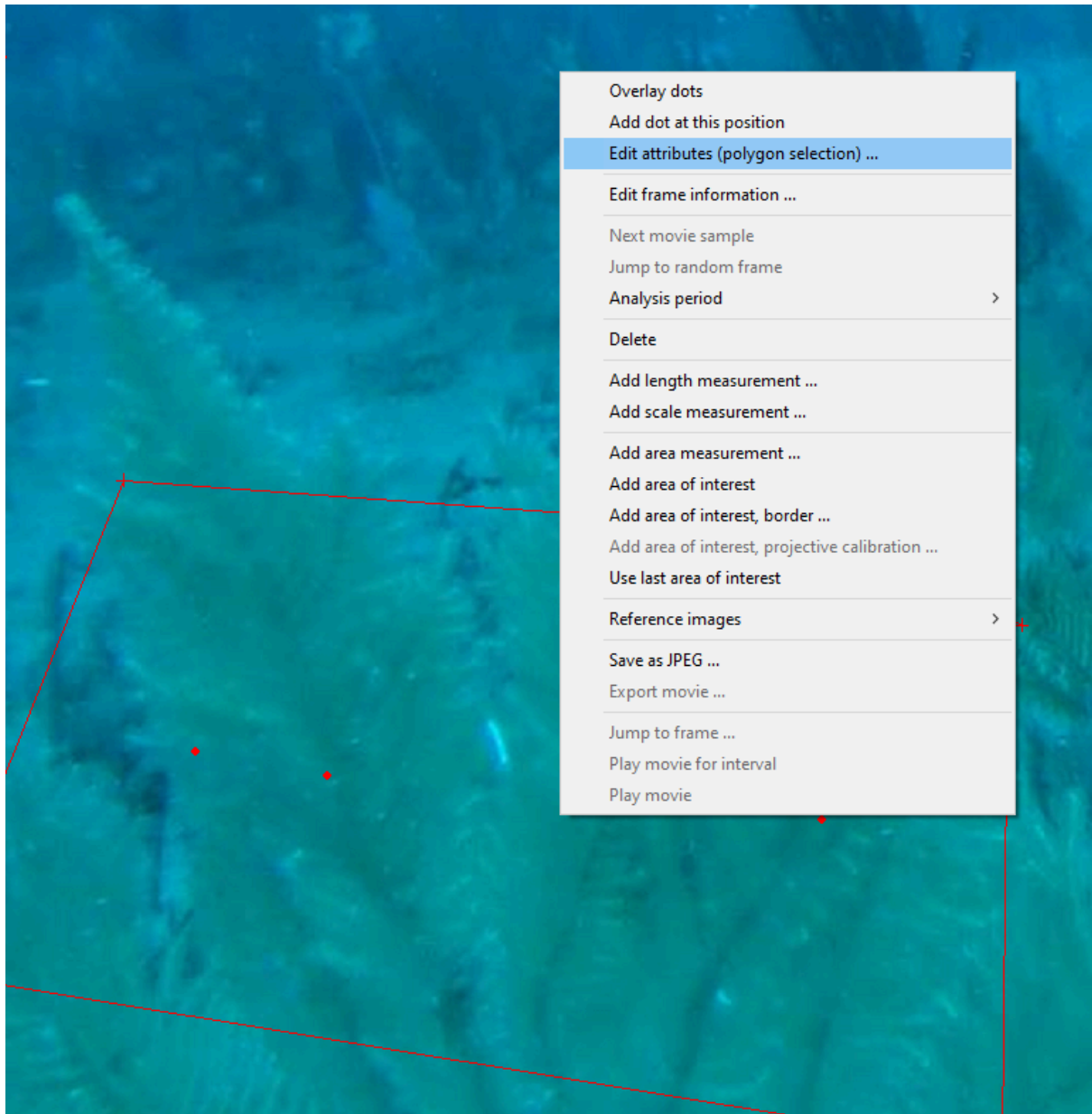


Fig xx. Editing a polygon selection to assign multiple annotation points the same attribute selection from the schema.

- How to change level of schema

4. Classifying the relief of an image

A separate schema for relief is available for download via [CheckEM](#) - 'Schema downloads'.

[Here](#) are some examples of relief annotations.

This section is split into a set of instructions for [single imagery approaches](#), such as stereo-BRUVs, and a set of instructions for [composite imagery approaches](#), such as stereo-BOSS. Different procedures are required to overlay the annotation points, due to the multi-pane imagery used for the composite imagery.

Single imagery e.g. BRUV

- Annotation of relief will need to be annotated in a separate TransectMeasure file (.TMObs), which can be set up by following the same steps defined in '[1. Load images and attribute file](#)'.
 - A separate attribute file is required for annotation of benthic relief, which is available for download via [CheckEM](#) - 'Schema downloads - benthic-relief-annotation...'.
- Enter the project information fields: "Measurements" > "Information fields" > "Edit field values" and enter the value for "campaignid" (e.g. 2024-05_Investigator_stereo-BRUVs) and "Yes" for "relief_annotated".

Figure

- To set up the grid: "Measurements" > "Dot configuration ...". Set accordingly: Gridded dots, 'Dots across image' = 5, 'Dots down image' = 4 and check the "Overlay rectangles" box (Fig. 11). This will allow you to classify the relief according to 20 gridded rectangles.

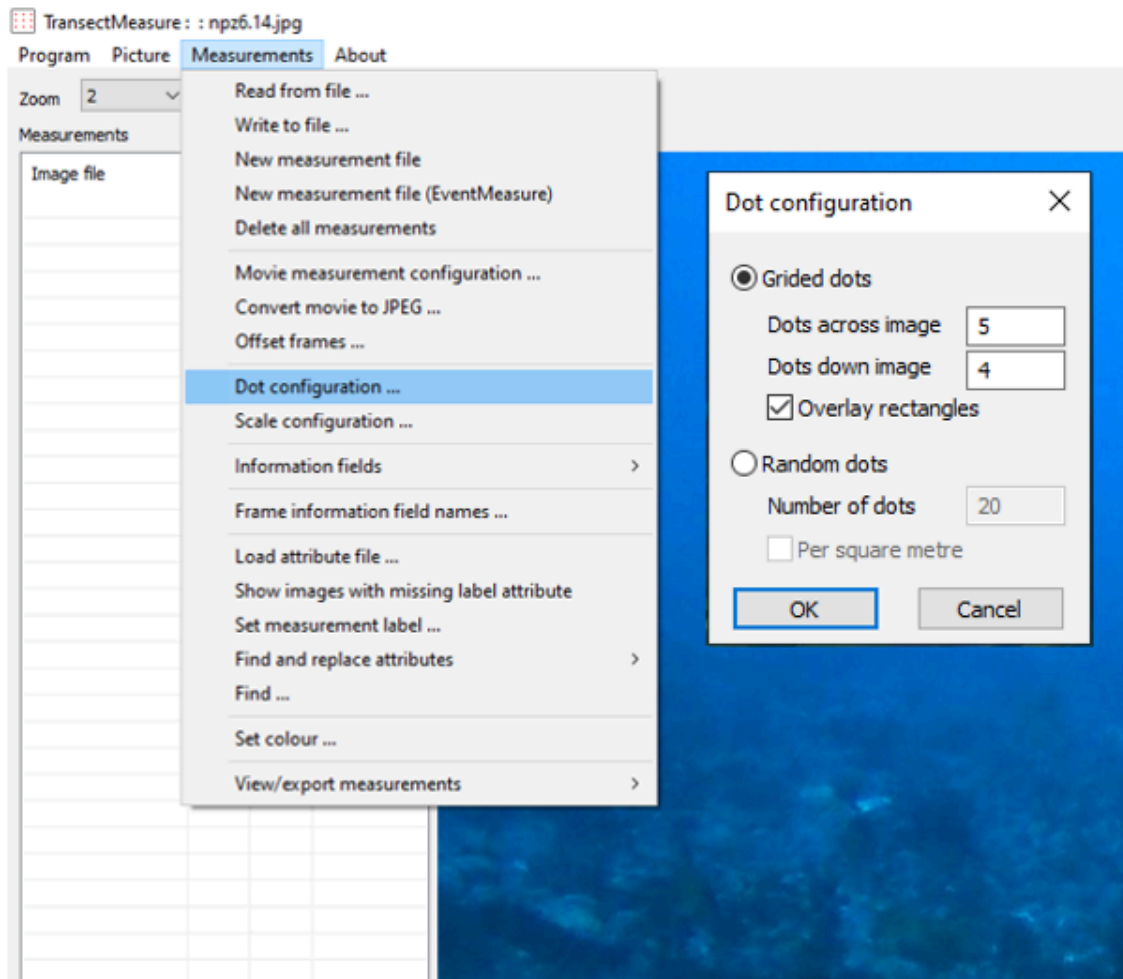


Figure 11: Setting the dot configuration in TransectMeasure.

- To overlay the grid: Right click on an image and select "Overlay dots" (Fig. 12). The name of the image will then appear in the table to the left of the image.

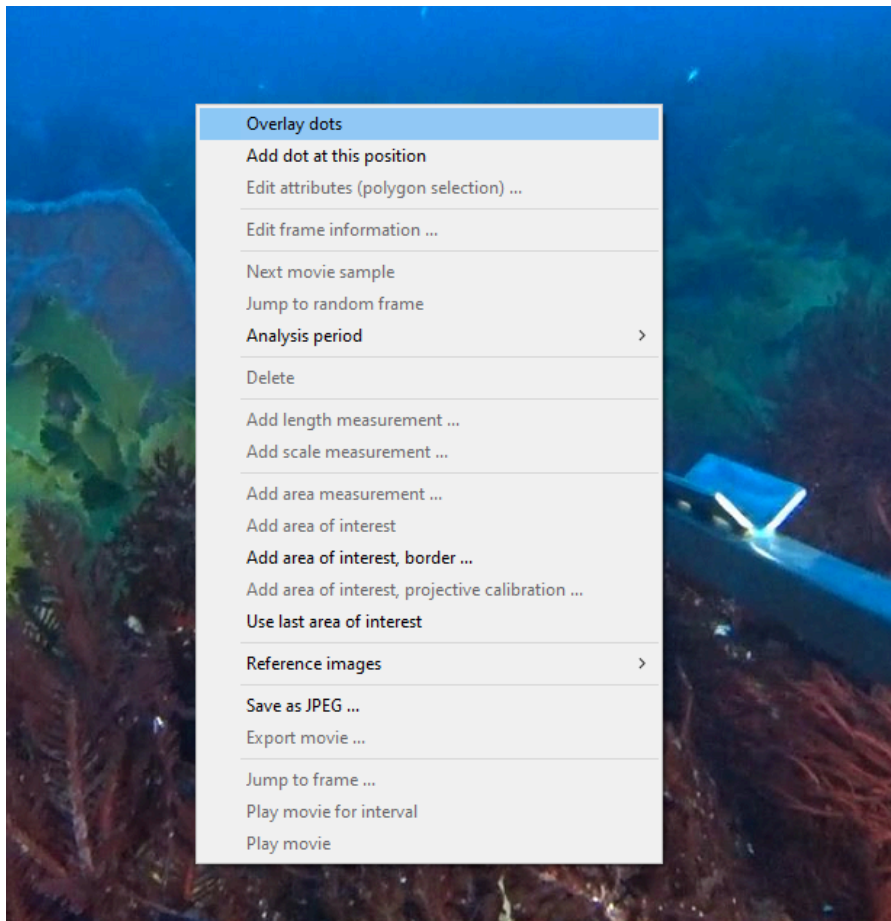


Figure 12: Adding dots to an image in TransectMeasure.

Composite imagery e.g. BOSS

- Annotation of relief will need to be annotated in a separate TransectMeasure file (.TMObs), which can be set up by following the same steps defined in '[1. Load images and attribute file](#)'.
 - A separate attribute file is required for annotation of benthic relief, which is available for download via [CheckEM](#) - 'Schema downloads - benthic-relief-annotation...'.
- Enter the project information fields: "Measurements" > "Information fields" > "Edit field values" and enter the value for "campaignid" (e.g. 2024-05_Investigator_stereo-BOSS) and "Yes" for "relief_annotated".

Figure

- To set up the grid: “Measurements” > “Dot configuration ...”. Set accordingly: Gridded dots, ‘Dots across image’ = 10, ‘Dots down image’ = 8 and check the “Overlay rectangles” box (Fig. 11). This will allow you to classify the relief according to 80 gridded points. You should only need to change these settings the first time you use the program on your computer.

Figure

- To overlay the grid: Right click on an image and select “Overlay dots” (Fig. 12). The name of the image will then appear in the table to the left of the image.

Figure

To annotate relief for all methods

- Left click on a point to display the “Attribute editor” (Fig. 13)

Figure

- Select the relevant relief score for the whole rectangle from the “level_5” dropdown (Figs. 14 & 15). The remaining drop downs will populate after you select the appropriate value in “level_5”.

Figure

- The dropdown for “level_5” indicates the structural complexity of the substrate and associated benthos. This dropdown includes six distinct categories adapted from Polunin and Roberts (1993), which are;
 - **0.** Flat substrate, sandy, rubble with few features. ~0 substrate slope
 - **1.** Some relief features amongst mostly flat substrate/sand/rubble. <45 degree substrate slope
 - **2.** Mostly relief features amongst some flat substrate or rubble. ~45 substrate slope
 - **3.** Good relief structure with some overhangs. >45 substrate slope

- **4.** High structural complexity, fissures and caves. Vertical wall. ~90 substrate slope.
- **5.** Exceptional structural complexity, numerous large holes and caves. Vertical wall. ~90 substrate slope.

NOTE: Any 'rectangle' that has more than 50% benthos/substrate visible should be classified for *Relief*. Any rectangle with less than 50% benthos/substrate visible (e.g. more than 50% open water) should not be annotated. The relief score for rectangles that are entirely composed of open water should also be left blank.

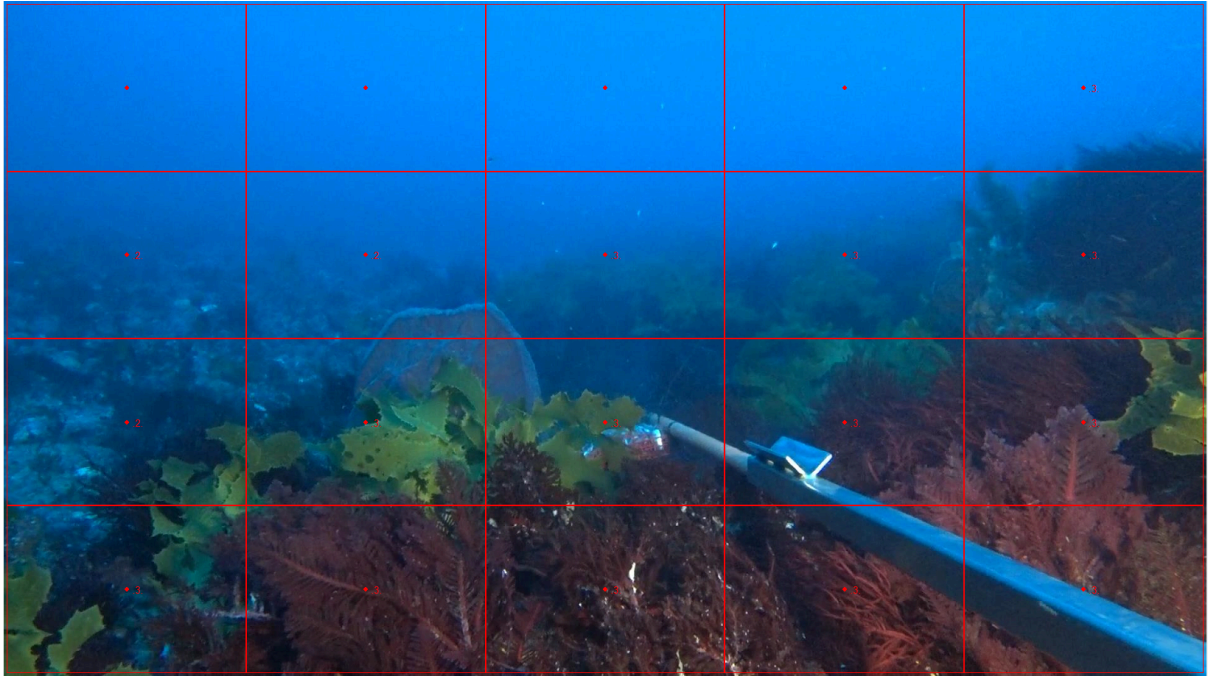


Figure 14: Example of a stereo-BRUV image annotated for relief.

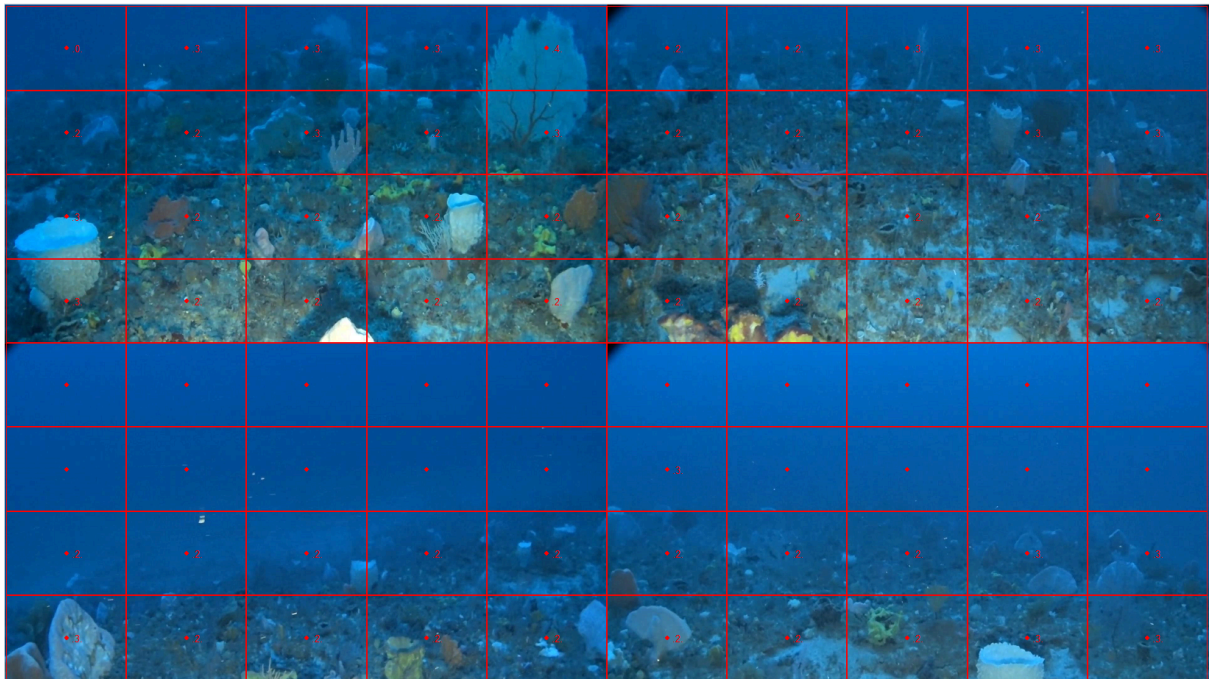


Figure 15: Example of a panoramic drop camera composite image annotated for relief.

5. Exporting from TransectMeasure

- To include frame information fields in the data output: “Program” > “Current settings” > “Include frame information fields in text reports” = “True” . You will only need to do this once per computer.

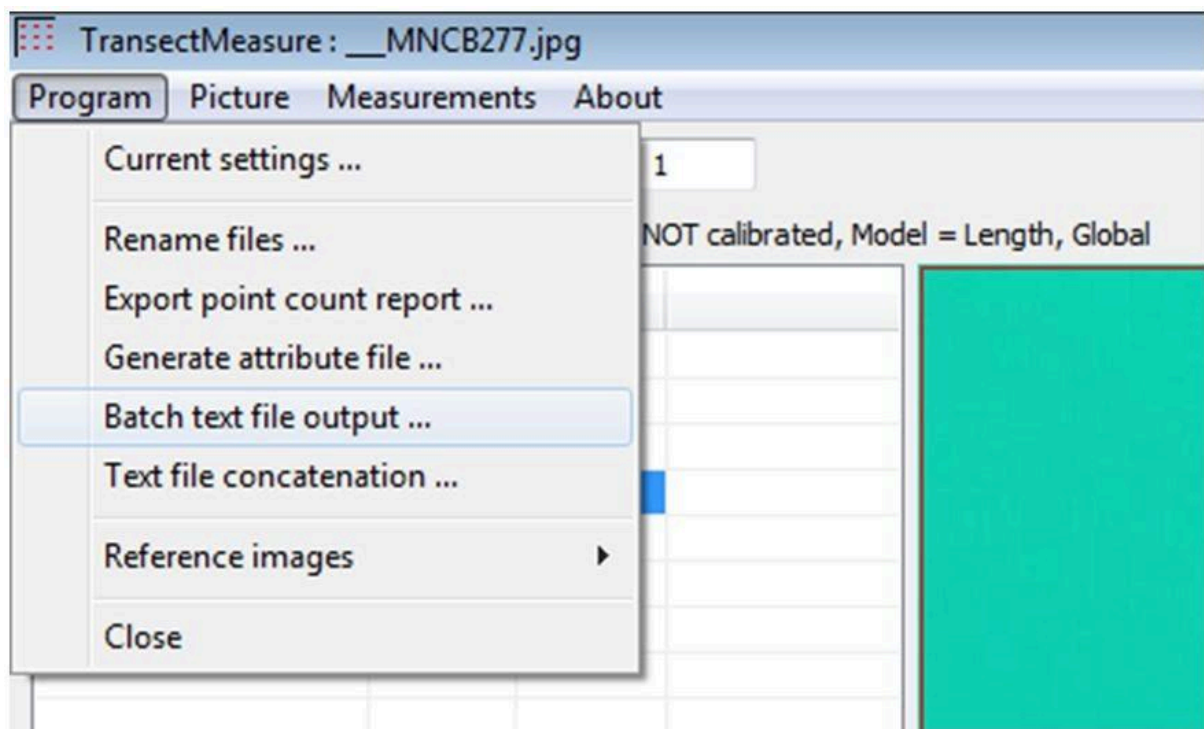


Figure 18: The 'batch text file output' option in TransectMeasure.

- The following box should appear: Double click to the right of the ✓ (under "Data") in the "Input file directory" row, then locate the folder where your *.TMObs files have been saved, do the same for the "output file directory" to specify the folder location for saving your text file (Fig. 19). Now select "Process". This will generate an output text file that can be processed using the scripts included in the GitHub repository (see '[Annotation summary and quality control](#)').

- Visually assess data for trends, outliers and potential errors (Figs 19-20).
- Spatially visualise the data for patterns in the distribution of key benthic classes (Fig. 21).

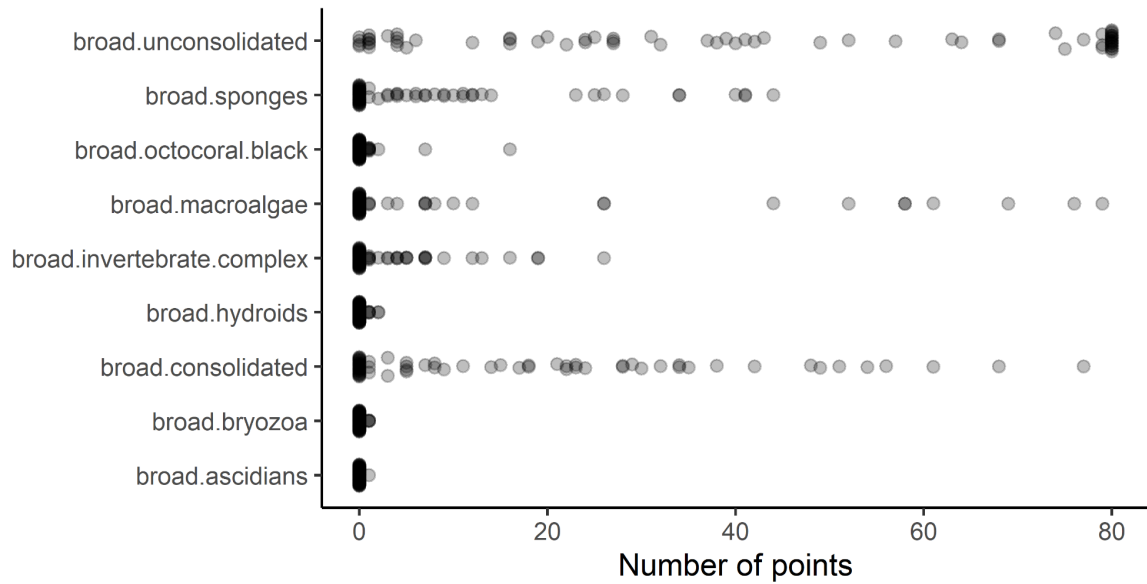


Figure 19: Quality control visualisation of the benthic annotations.

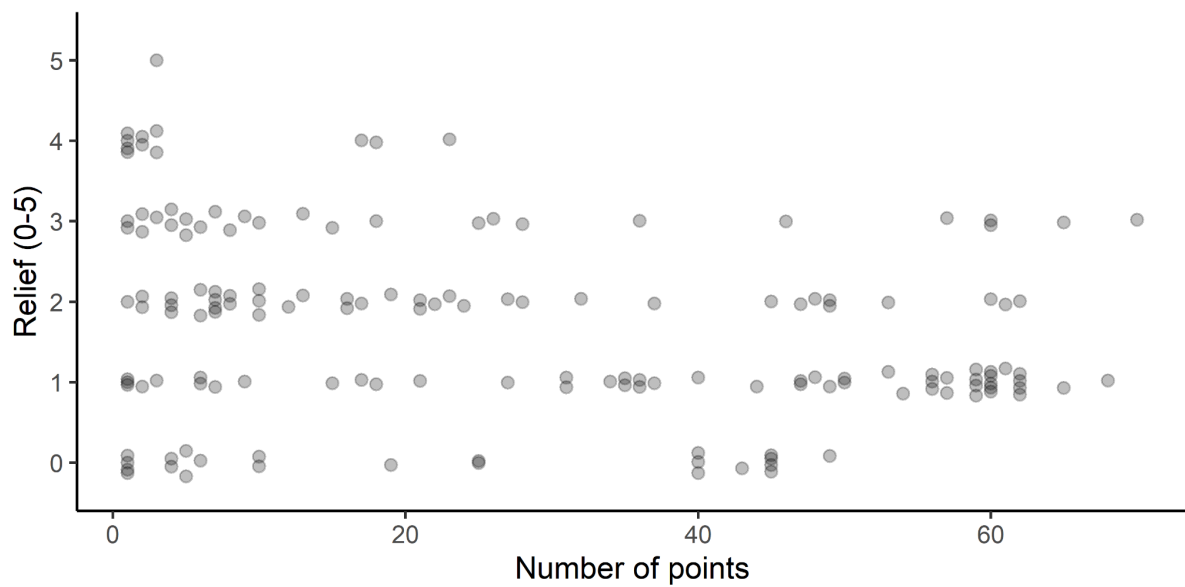


Figure 20: Quality control visualisation of the relief annotations.

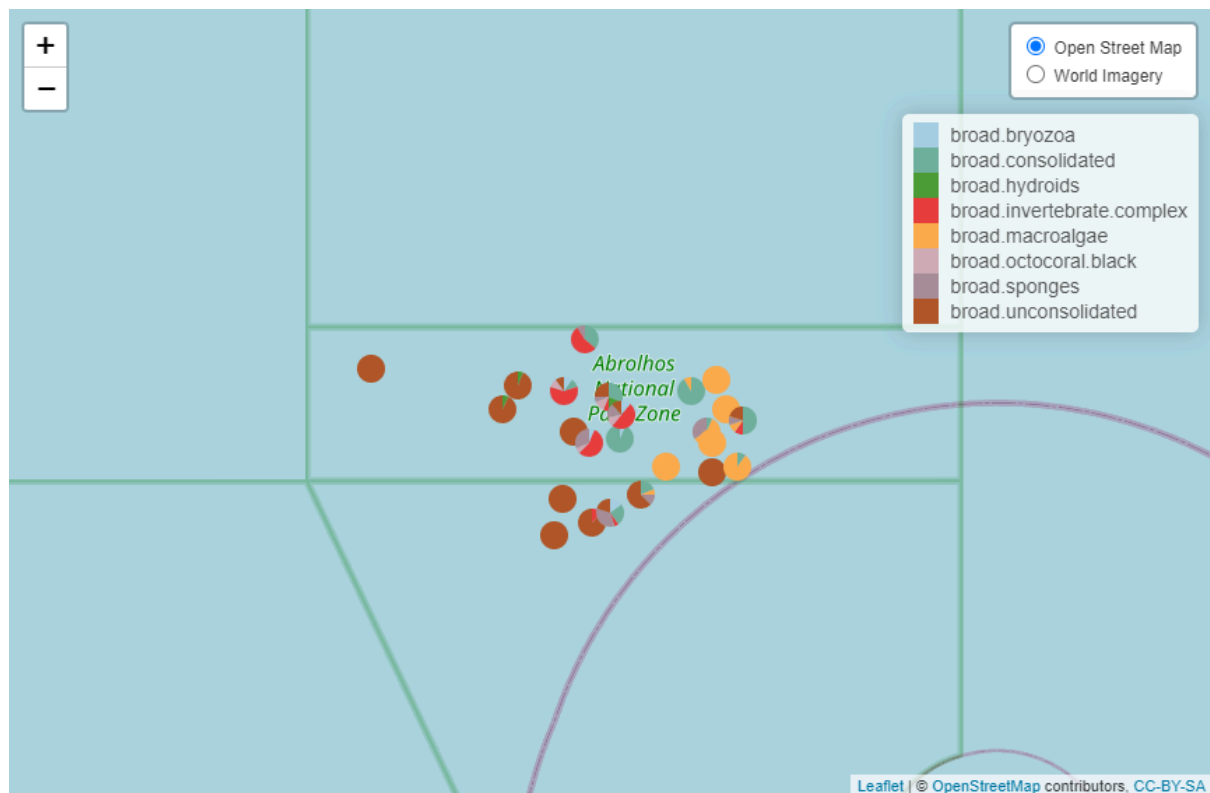


Figure 21: Quality control spatial visualisation of broad benthic classes annotated.

Examples of publications that have used this or earlier versions of this SOP

1. McLean, D. L. *et al.* Distribution, abundance, diversity and habitat associations of fishes across a bioregion experiencing rapid coastal development. *Estuarine, Coastal and Shelf Science* **178**, 36–47 (2016).
2. McLean, D. L. *et al.* Using industry ROV videos to assess fish associations with subsea pipelines. *Cont. Shelf Res.* **141**, 76–97 (2017).
3. Bond, T., Partridge, J. C., Taylor, M. D., Cooper, T. F. & McLean, D. L. The influence of depth and a subsea pipeline on fish assemblages and commercially fished species. *PLoS One* **13**, e0207703 (2018).
4. Bond, T. *et al.* Fish associated with a subsea pipeline and adjacent seafloor of

- the North West Shelf of Western Australia. *Mar. Environ. Res.* (2018)
doi:10.1016/j.marenvres.2018.08.003.
5. Bond, T. *et al.* Diel shifts and habitat associations of fish assemblages on a subsea pipeline. *Fish. Res.* **206**, 220–234 (2018).
 6. Lester, E. *et al.* Drivers of variation in occurrence, abundance, and behaviour of sharks on coral reefs. *Sci. Rep.* **12**, 728 (2022).
 7. Lester, E. K. *et al.* Relative influence of predators, competitors and seascape heterogeneity on behaviour and abundance of coral reef mesopredators. *Oikos* **130**, 2239–2249 (2021).
 8. Rolim, F. A. *et al.* Network of small no-take marine reserves reveals greater abundance and body size of fisheries target species. *PLoS One* **14**, e0204970 (2019).
 9. Rolim, F. A., Rodrigues, P. F. C. & Gadig, O. B. F. Baited videos to assess semi-aquatic mammals: occurrence of the neotropical otter *Lontra longicaudis* (Carnivora: Mustelidae) in a marine coastal island in São Paulo, Southeast Brazil. *Mar. Biodivers.* (2018) doi:10.1007/s12526-018-0868-7.
 10. Haberstroh, A. J., McLean, D., Holmes, T. H. & Langlois, T. Baited video, but not diver video, detects a greater contrast in the abundance of two legal-size target species between no-take and fished zones. *Mar. Biol.* **169**, (2022).
 11. Piggott, C. V. H., Depczynski, M., Gagliano, M. & Langlois, T. J. Remote video methods for studying juvenile fish populations in challenging environments. *J. Exp. Mar. Bio. Ecol.* **532**, 151454 (2020).
 12. MacNeil, M. A. *et al.* Global status and conservation potential of reef sharks. *Nature* **583**, 801–806 (2020).
 13. Goetze, J. S. *et al.* Drivers of reef shark abundance and biomass in the

Solomon Islands. *PLoS One* **13**, e0200960 (2018).

14. Wilson, S. K., Graham, N. A. J., Pratchett, M. S., Jones, G. P. & Polunin, N. V.

C. Multiple disturbances and the global degradation of coral reefs: are reef fishes at risk or resilient? *Glob. Chang. Biol.* **12**, 2220–2234 (2006).