Australian Government
Geoscience Australia

International Seabed Geomorphology Mapping Working Group - ISGM Seabed Geomorphology Classifier (ISGM-SGC)

Tutorials and User Guide

Zhi Huang, Rachel Nanson, Mardi McNeil, Jasmin Wells

Oceans, Reefs, Coasts and Antarctic Branch, Geoscience Australia

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1 Introduction

Seabed geomorphology maps provide critical baseline information for a wide range of Ocean Economy stakeholders. To bring greater consistency and value to diverse mapping efforts, it is essential to standardise the terminology used to classify seabed features. To address this need, geoscience agencies from the United Kingdom (British Geological Survey), Norway (Geological Survey of Norway), Ireland (Geological Survey Ireland and University College Cork), and Australia (Geoscience Australia) collaborated to develop a standardised, two-part approach to seabed geomorphology mapping. Part 1 of this approach (Dove et al., 2020) is used to map and define the seabed shape using bathymetry and derivative data; Part 2 (Nanson et al., 2023) classifies these shapes with their geomorphic interpretation (Figure 1).

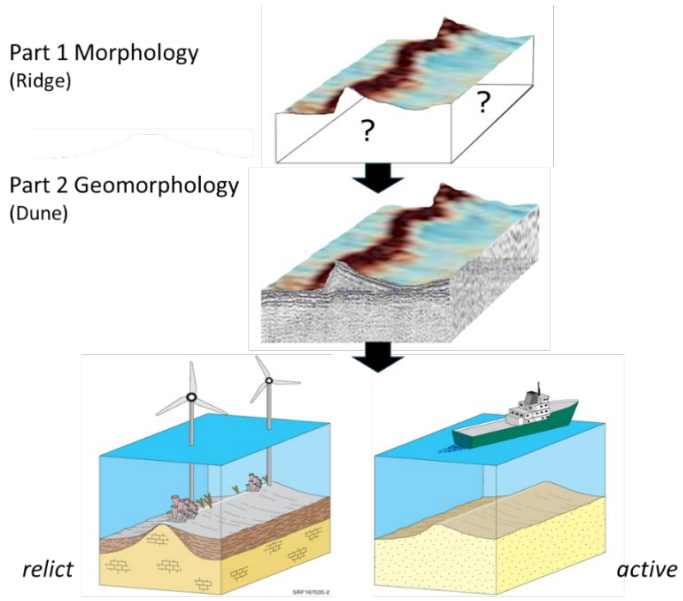


Figure 1: In this example of a bathymetric Ridge (Part 1 Morphology,) sub-surface data can help to differentiate it as either a stationary and lithified (hard) relict dune, or a mobile sand dune. These alternative interpretations indicate distinctly different geotechnical and habitat characteristics. Modified from Nanson et al (2023).

1. **Part 1 (Morphology).** An illustrated, open access Part 1 report and glossary (Dove et al., 2020) presents terms and definitions derived primarily from the International Hydrographic Organization standardisation of undersea feature names (IHO 2019; see Figure 2). The Dove et al. (2020) morphology terms and the Nanson et al (2023) geomorphology terms are also available as a suite of W3C web standard digital vocabularies (Wells et al., 2025a-d). To support users to implement this step, Geoscience Australia has developed the Geoscience Australia's Semi-automated Morphological Mapping Tools (GA-SaMMT: Huang et al., 2022; 2023). The tools and accompanying tutorials (e.g., user-guide) can be downloaded from Huang et al. (2022).

2. **Part 2 (Geomorphology).** An open access Part 2 report and glossary groups over 400 geomorphic feature terms, sourced from peer reviewed literature, within 11 high-level Process and Setting categories (Nanson et al., 2023; Figure 2). To maintain consistency across a wide variety of geomorphologies, and to support their implementation in a GIS interface, a standardised hierarchical database design is used to structure terms within each of these categories (Figure 3). All feature terms are also available as a suite of W3C web standard digital vocabularies (Wells et al., 2025a-d). The application of this second mapping step requires additional seabed data and/or contextual information to infer a geomorphic interpretation and classification. Implementation of the geomorphology classification in GIS software is supported by an Esri Python toolbox named International Seabed

Geomorphology Mapping Working Group - ISGM Seabed Geomorphology Classifier (ISGM-SGC: Huang et al., in prep; these tutorials). A case study is provided in Section 3 of these tutorials.

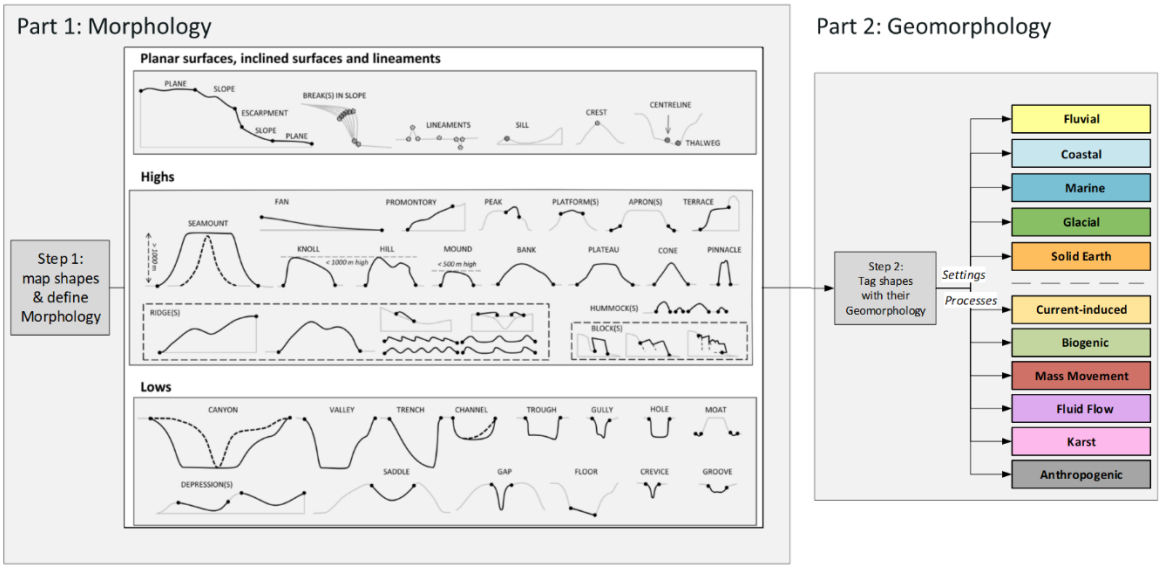


Figure 2: A glossary of Part 1 Morphology terms are used to classify the shape of the seabed, and Part 2 glossary supports the consistent classification of the geomorphology of these shapes (Nanson et al., 2023).

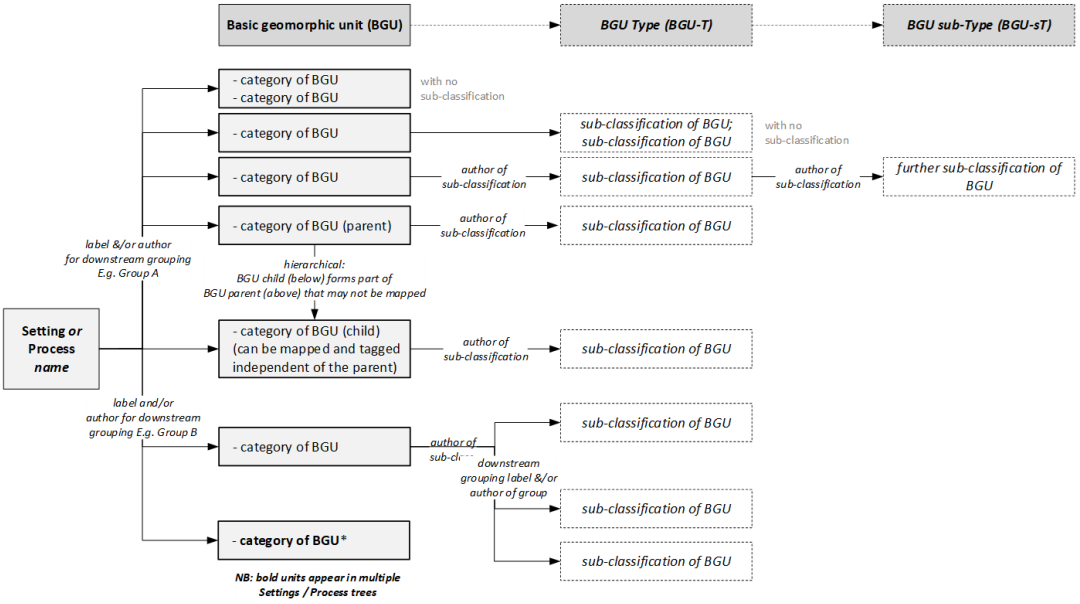


Figure 3: A standardised hierarchical database design is used to structure terms for classifying geomorphology. This part 2 framework can be implemented for terms representing 11 different Process and Setting categories, using the ISGM Seabed Geomorphology Classifier *(ISGM-SGC: Huang et al., in press; this tutorial). Nanson et al (2023).*

1.1 ISGM-SGC description

The remainder of this document supports the user to implement the Part 2 geomorphology classification system using an Esri Python tool for a sample dataset. The International Seabed Geomorphology Mapping Working Group - ISGM Seabed Geomorphology Classifier (ISGM-SGC) assigns a number of geomorphology attributes for selected seabed features. The tool is composed of a series of drop-down lists and several free text entries. Depending on the user choices at the drop-down lists of higher classification levels, options at the drop-down list of lower classification levels are updated accordingly. In total, 21 attributes can be

assigned to describe the geomorphology of the selected features according to the Nanson et al. (2023) scheme.

1.2 ISGM-SGC system and data requirements

The ISGM-SGC is developed as an Esri ArcGIS Pro Python tool using Python 3+. As a result, the tool can only currently be applied in ArcGIS Pro. Additionally, the tool only accepts input vector data in an Esri File Geodatabase (.gdb).

Please use this link to download the files package. It is recommended to save the files package in a location with the path that does not contain space and special characters. The tool, sample data and this tutorials/user guide document are contained in the ISGM-SGC_v1p0 folder. The tool subfolder contains one Python toolbox:

- ISGMSeabedGeomorphologyClassifier.pyt: This toolset contains a tool to assign a number of geomorphology attributes for selected seabed features.

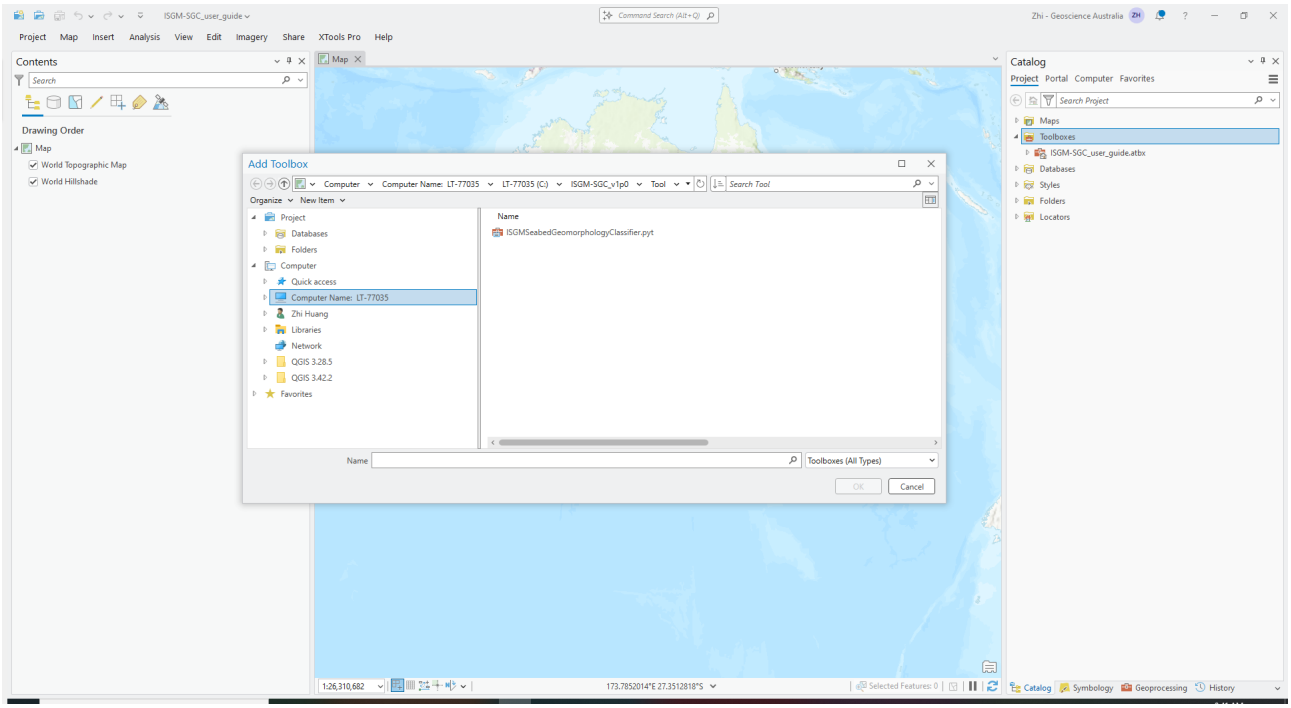
The sample data are contained in one File Geodatabase:

- Tutorials.gdb

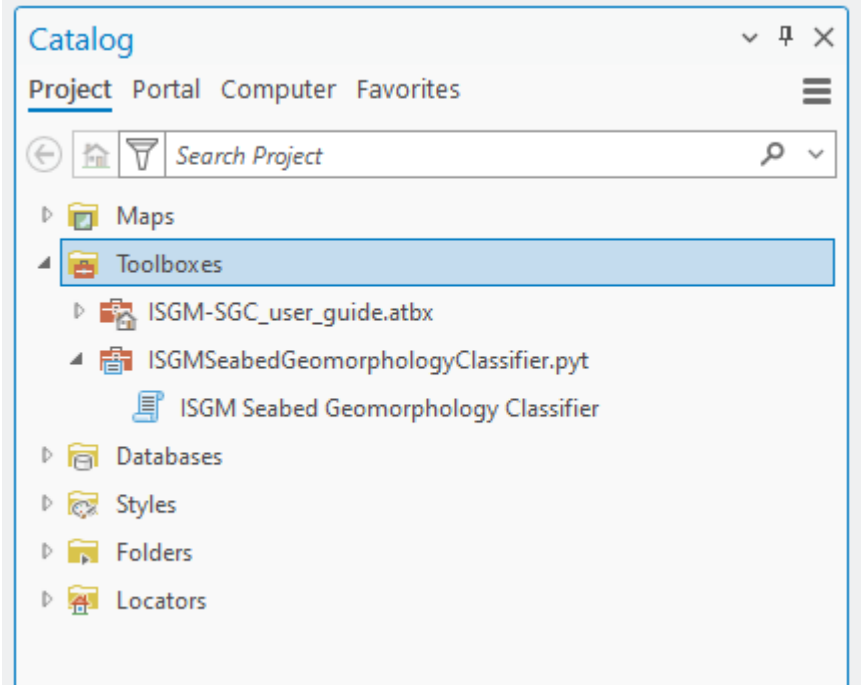
The current version (v1.0) of the ISGM-SGC is developed and tested in ArcGIS Pro 3.4.3. Earlier versions of ArcGIS Pro have not been tested and may generate errors. It is recommended to use ArcGIS Pro 3.4.3 or higher versions for these tutorials.

2 Add Data and GIS Tool to ArcGIS Pro

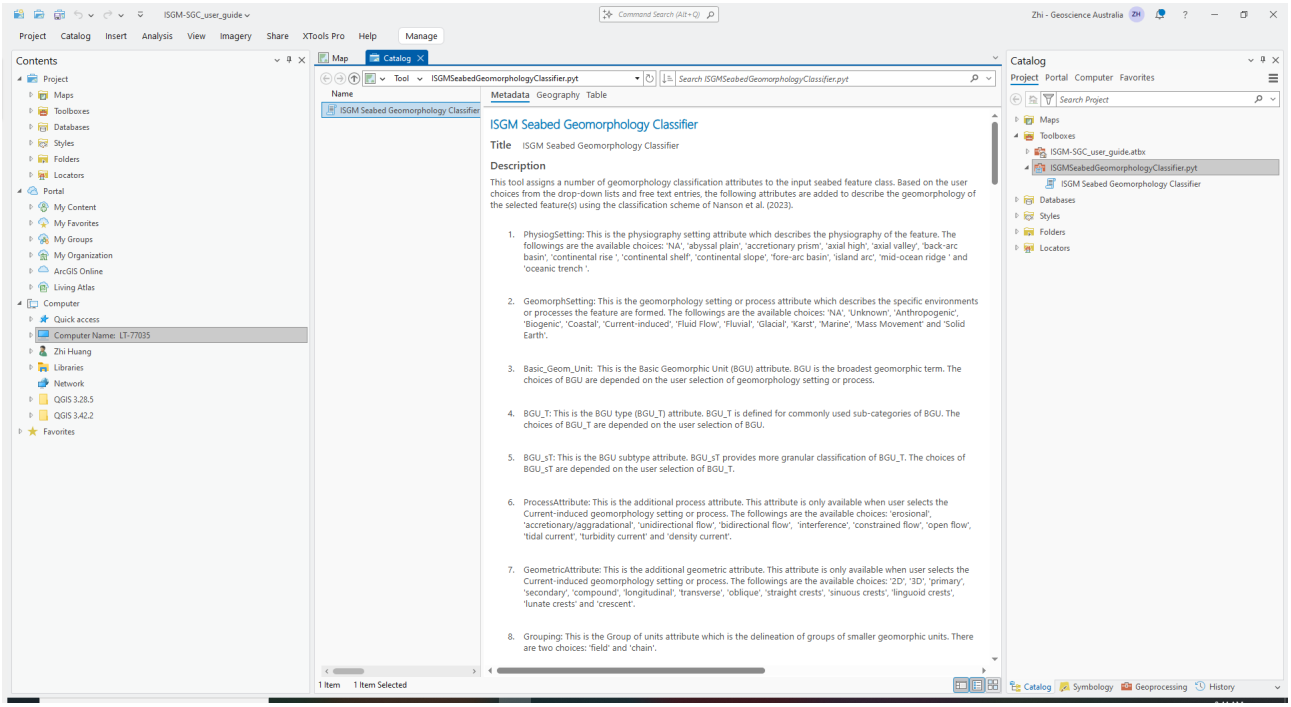
1. Check that the ISGM-SGC_v1p0 folder you downloaded contains the following sub-folders: Tool, which contains the GIS tool; Tutorials.gdb, which contains the datasets; and User_Guide which contains this document.
2. Open ArcGIS Pro and create a new map project.
3. Under the Catalog Pane, Right-Click Toolboxes, Click Add Toolbox



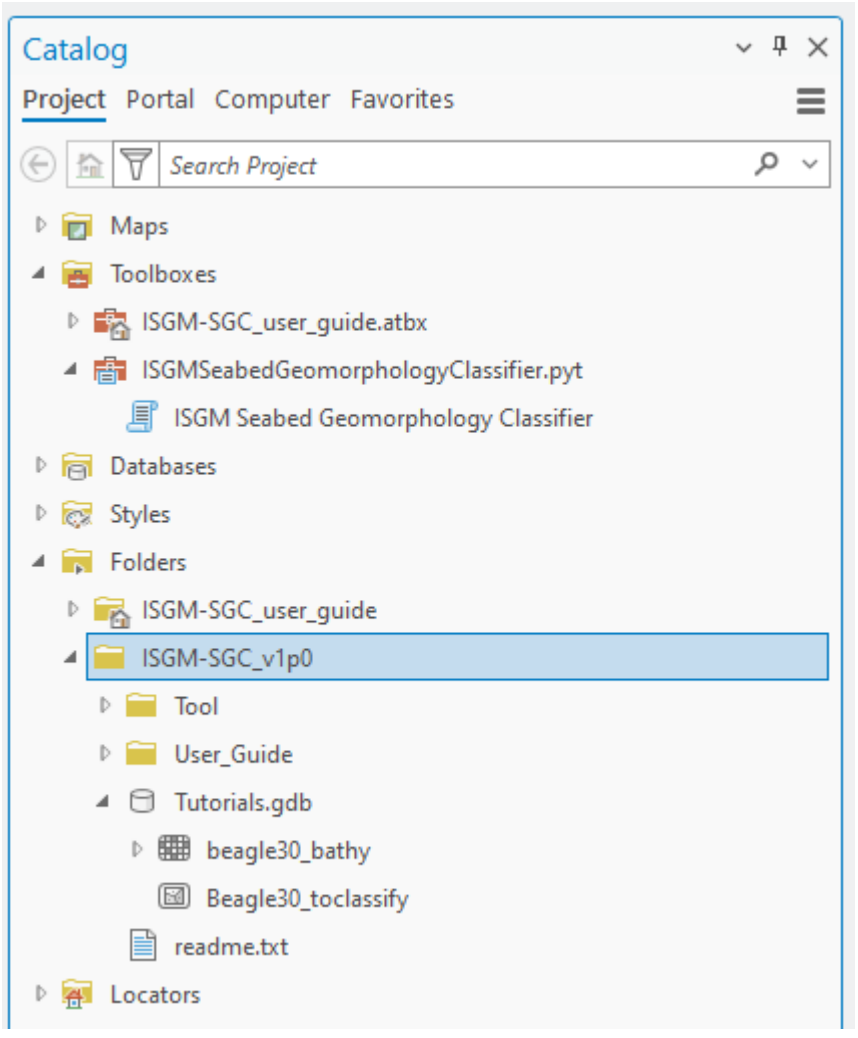
4. Navigate to …\ISGM-SGC_v1p0\Tool folder, Add the ISGMSeabedGeomorphologyClassifier.pyt Python toolbox which contains the ISGM Seabed Geomorphology Classifier tool.



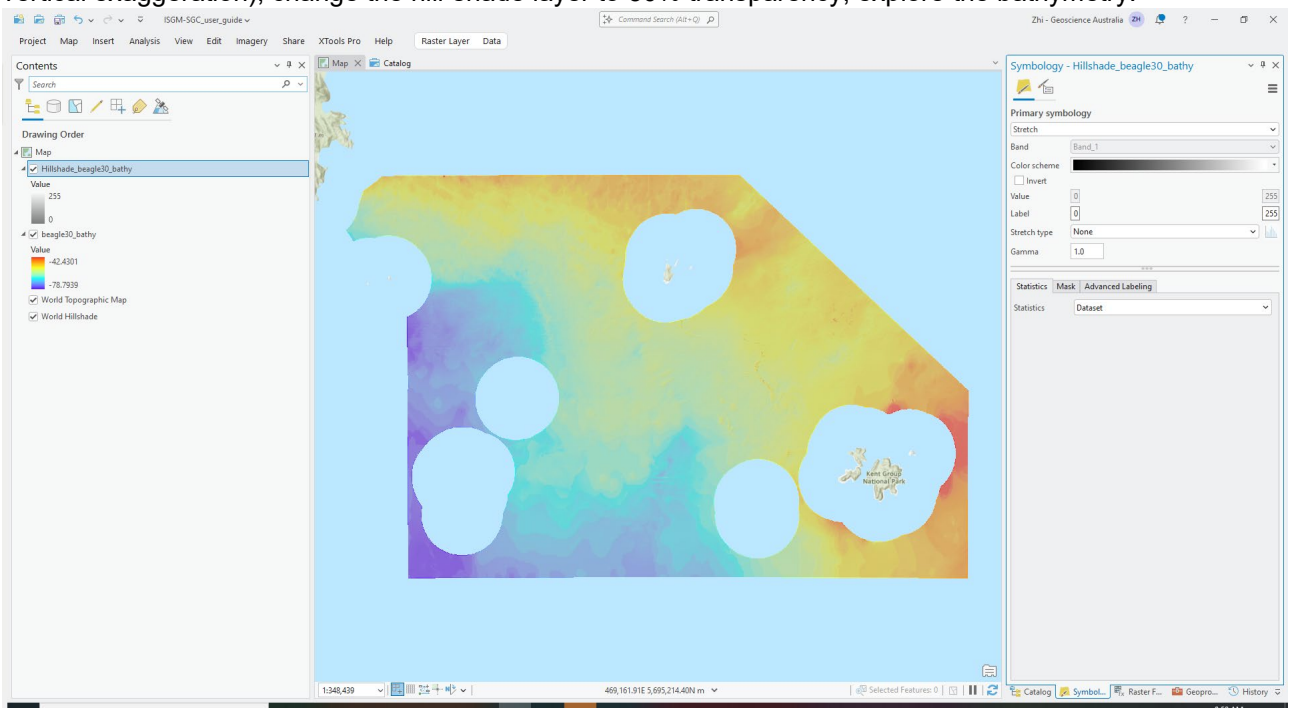
5. Right-Click the ISGM Seabed Geomorphology Classifier, Click View Metadata menu to examine the metadata of the tool. Note that the metadata provides detailed descriptions, graphic illustrations, and usages of this tool.

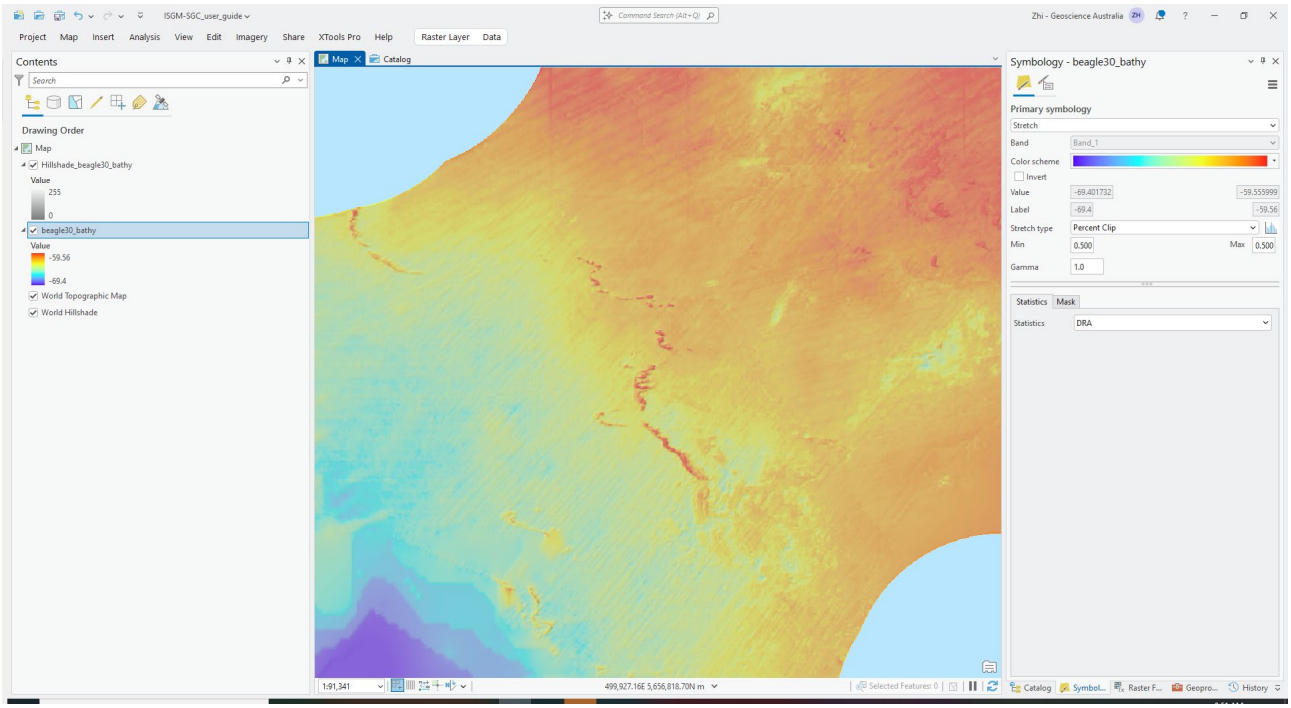


6. In the Catalog Pane, Right-Click Folders, then Click Add Folder Connection. Navigate to and Add the ISGM-SGC_v1p0 folder. The sub-folders will appear under the folder.

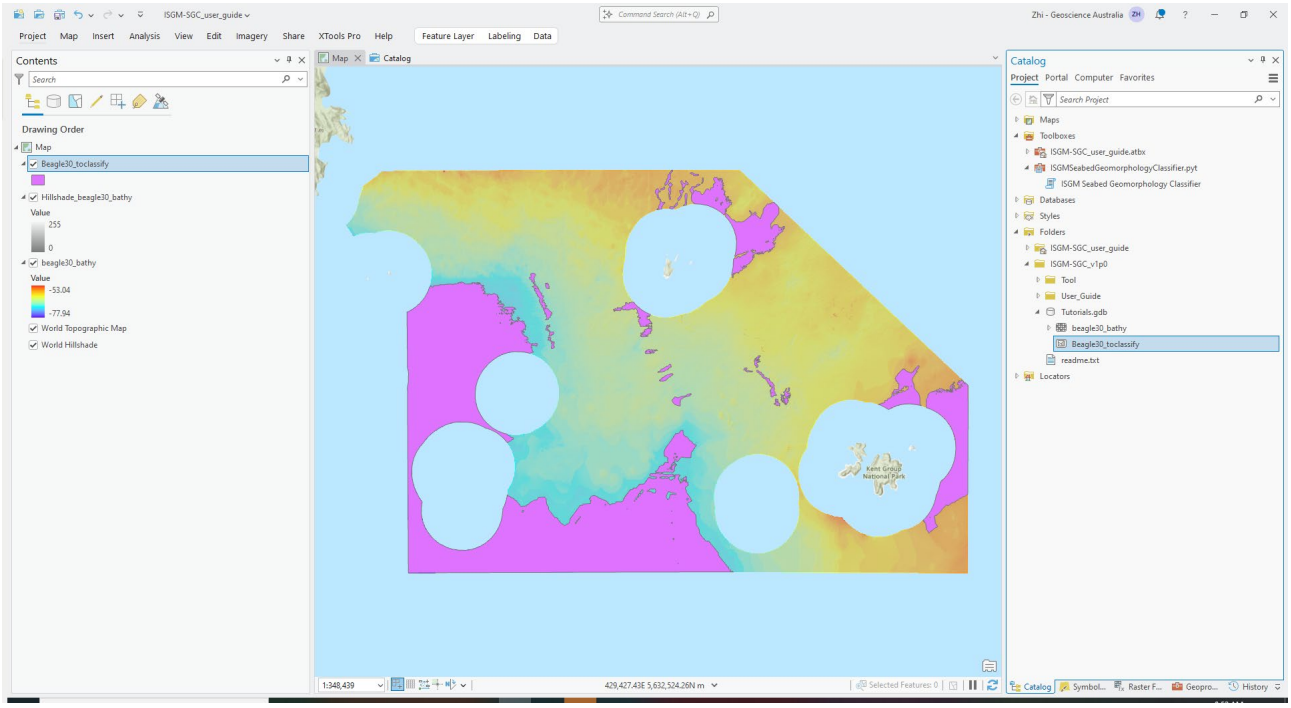


7. Under the Catalog Pane, Navigate to the Tutorials.gdb. This File Geodatabase contains the datasets needed for these tutorials.
8. Select the beagle30_bathy dataset, which is the bathymetry grid of the Beagle Marine Park. Add the bathymetry dataset to the Map display. Change the displaying symbology if necessary, generate a hill-shade layer using Raster Functions -> Surface -> HillShade (you can change the Z-factor for vertical exaggeration), change the hill-shade layer to 50% transparency, explore the bathymetry.

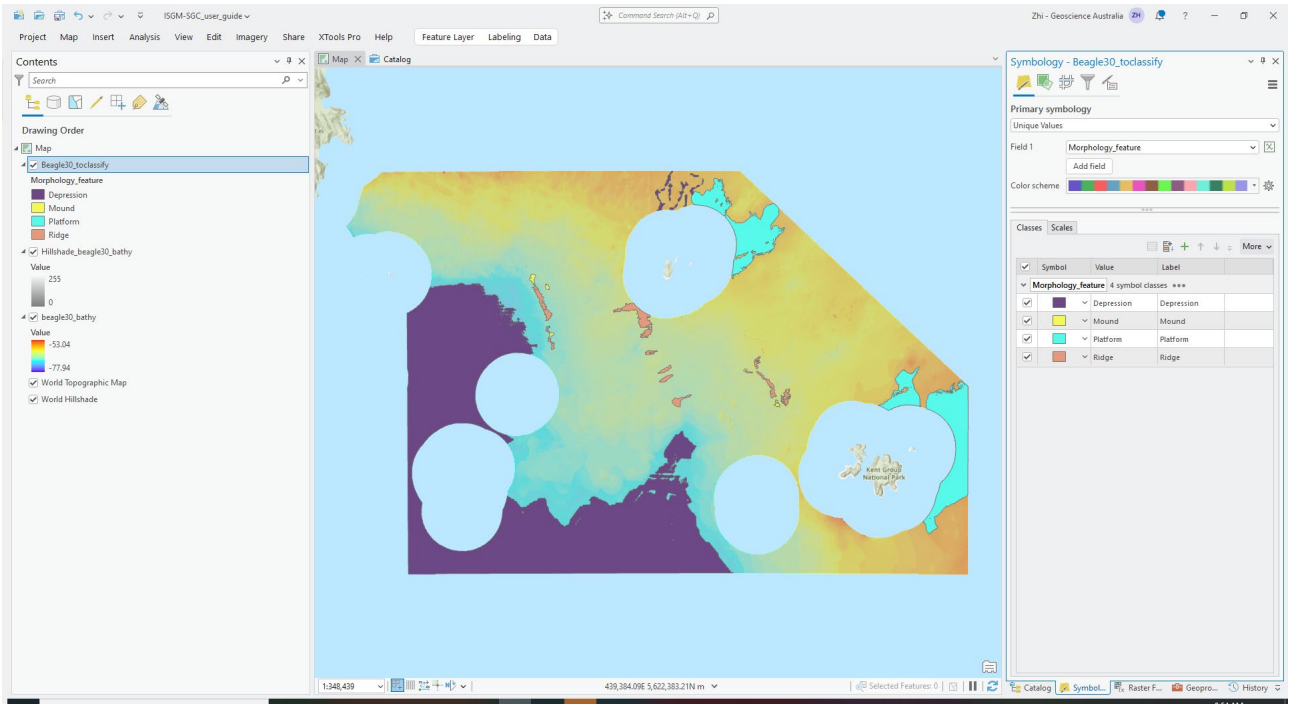




9. Right click the bathymetry dataset on the Contents pane, select the Zoom To Layer option to display the dataset at its full extent.
10. Add the Beagle30_toclassify dataset to the map. This is a polygon dataset displaying morphology features within the study area. Their morphology classifications (Part 1) have already been assigned under the “Morphology_feature” field.

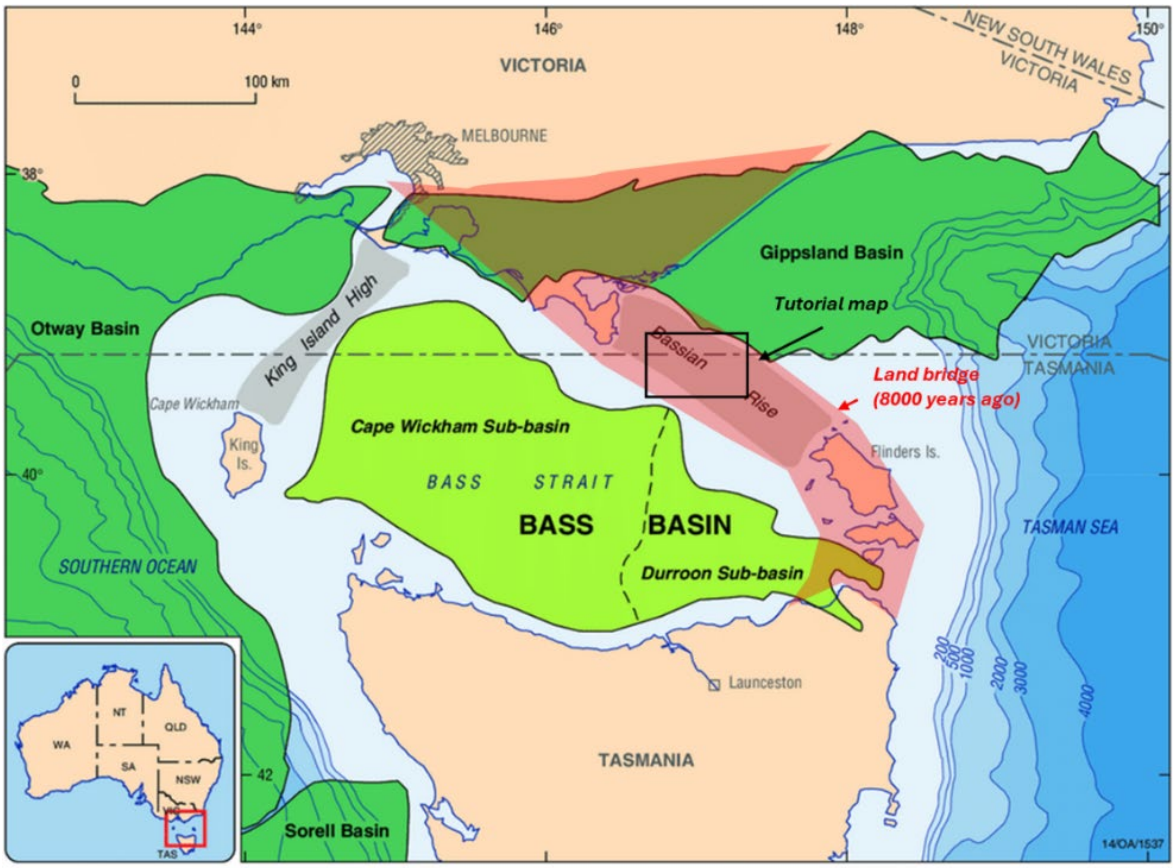


11. Activate the Symbology pane for this dataset. Select the Unique Values option for the Primary symbology, Select the “Morphology_feature” under Field 1, Select a suitable colour scheme from the list, and add all four Morphology Feature types (Depression, Mound, Platform and Ridge) to the symbology by using the Add all values button. This will colour the polygons on the map depending upon the category of Morphology Feature the polygon represents.

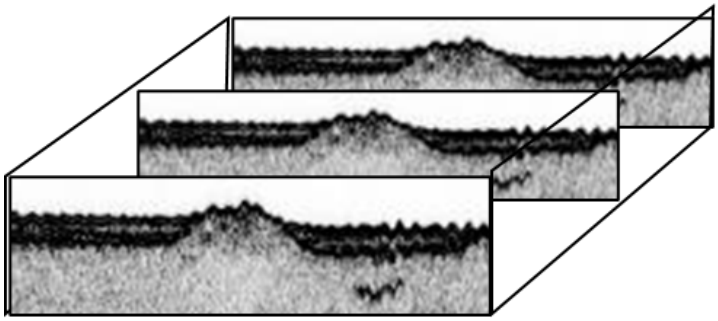


3 Case study geomorphology

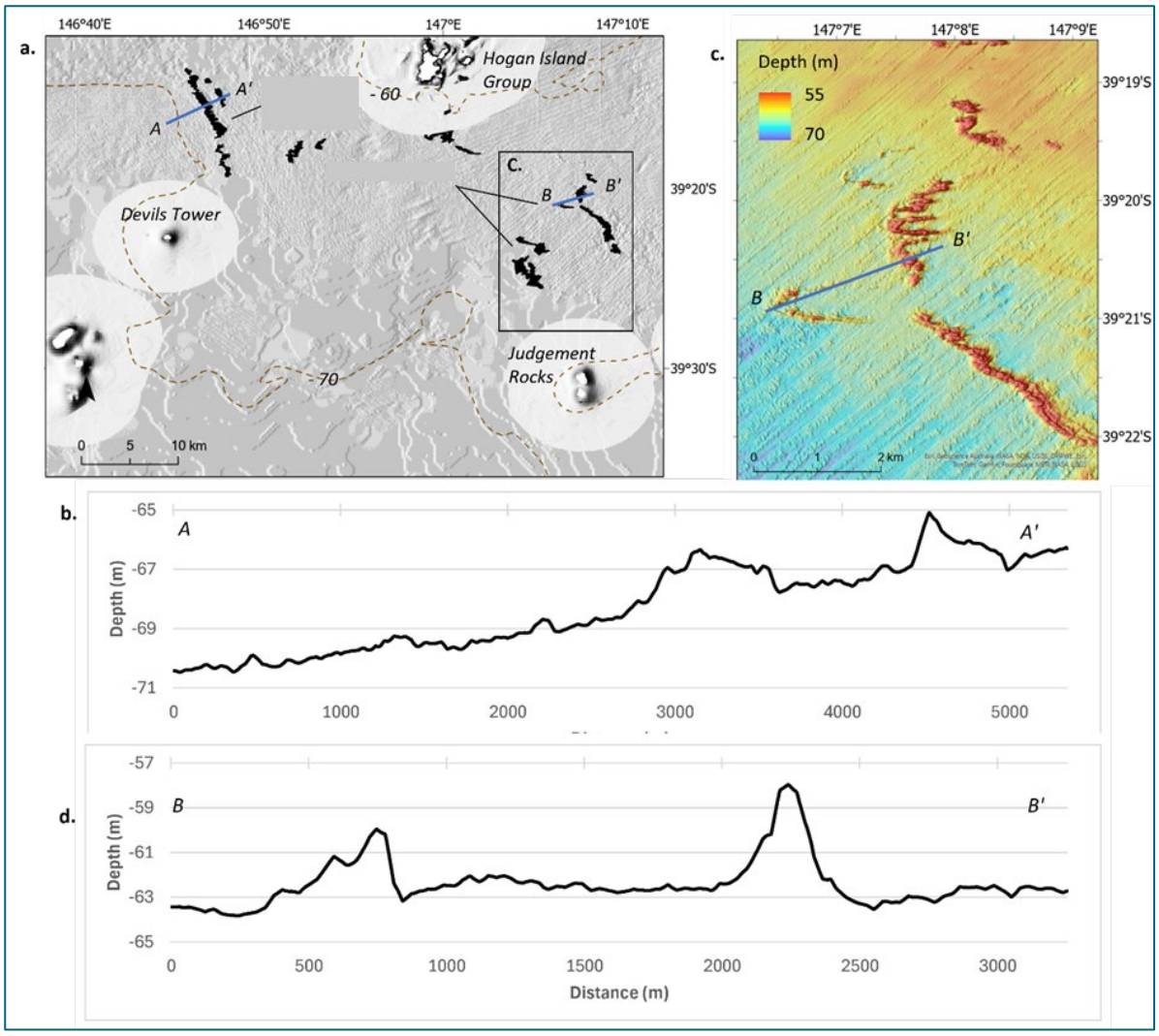
Now that you have your GIS project set up you can use regional geoscience datasets to understand the types of geomorphic units that are on your map, before attempting to classify their Part 2 Geomorphology using the ISGM Seabed Geomorphology Classifier tool. The figures below provide example regional geoscience context.



Regional geology and palaeogeography (modified from Boreham et al., 2003).



Sub-bottom profile data (proxy data to represent A-A' in next image).

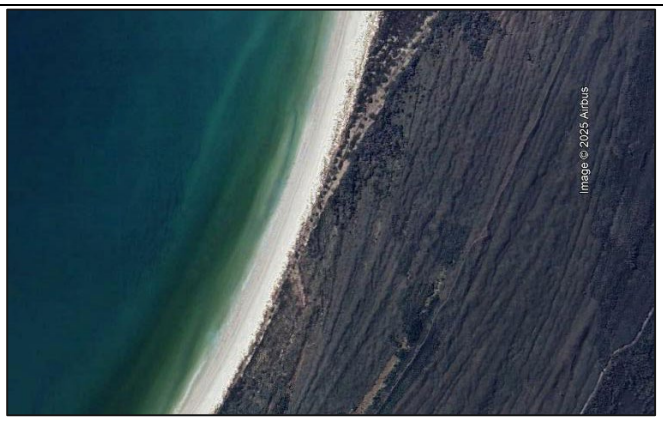
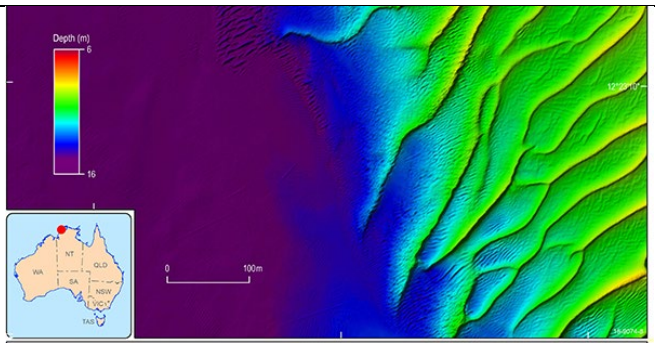


Example bathymetric profiles over representative seabed units (Brooke et al., accepted)

Geomorphic analogues

Morphological Ridges that can form via different processes and in different Settings.

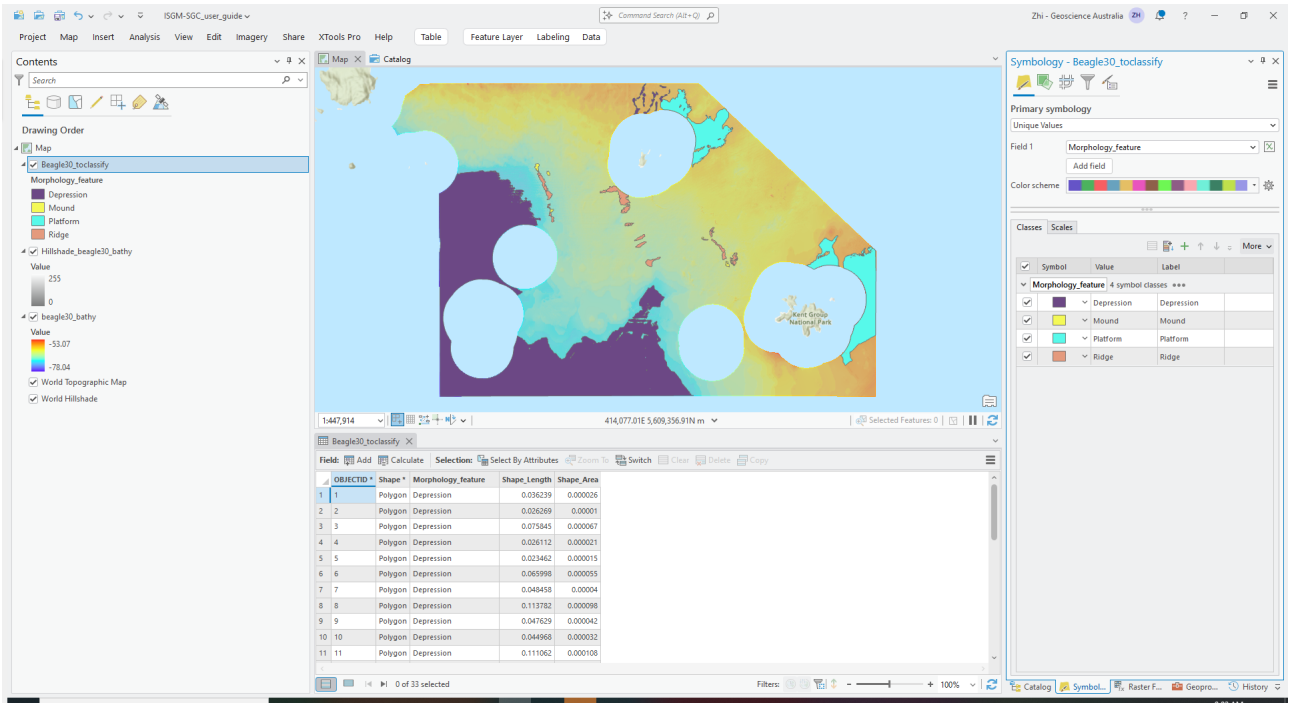
Setting	Geomorphology	Image
Coastal	Dune (aeolian – wind)	 (George Steinmetz)

Coastal	beach ridges	 (Google Earth, n.d.)
Marine	dune (sand waves)	 (www.ga.gov.au/news)

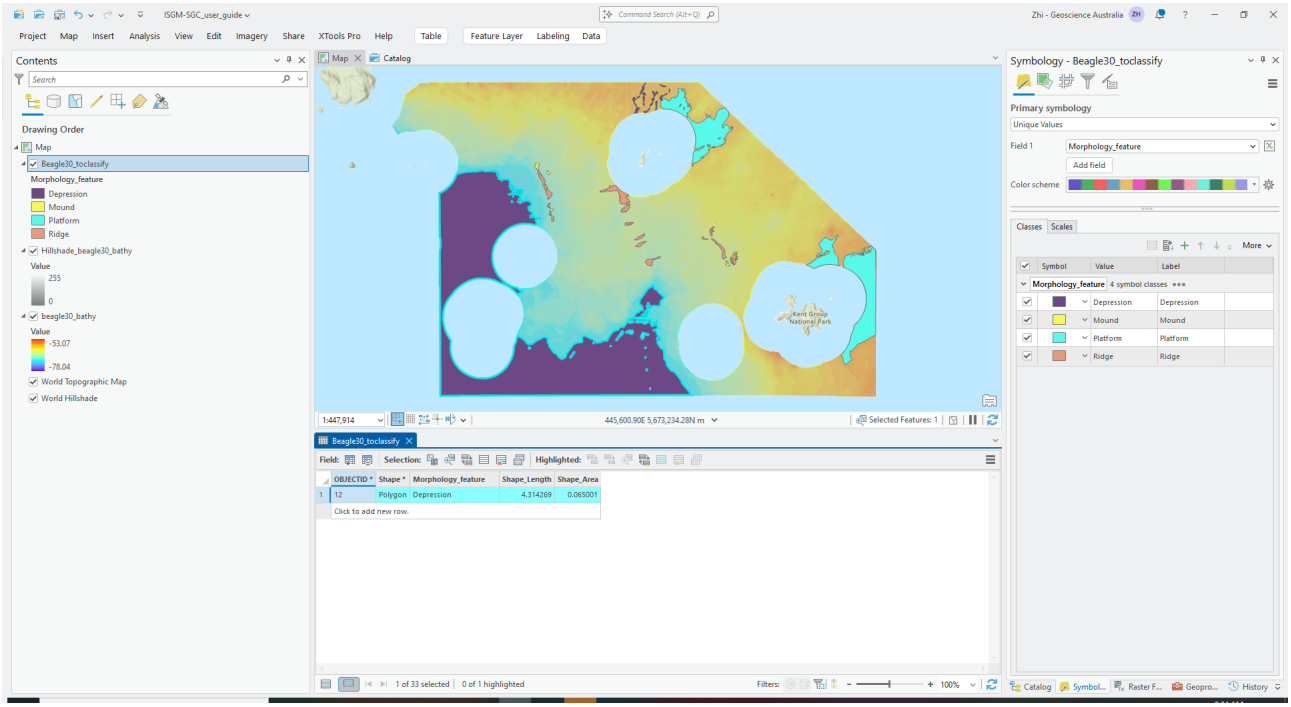
4 Use the ISGM Seabed Geomorphology Classifier to add geomorphology attributes

The ISGM Seabed Geomorphology Classifier will assign geomorphology attributes to selected morphology feature(s). Therefore, the first step is to select morphology feature(s) on the map. There are two ways of selecting morphology feature. One is through manual selection; the other is through the Select By Attributes Tool. We will illustrate both ways below.

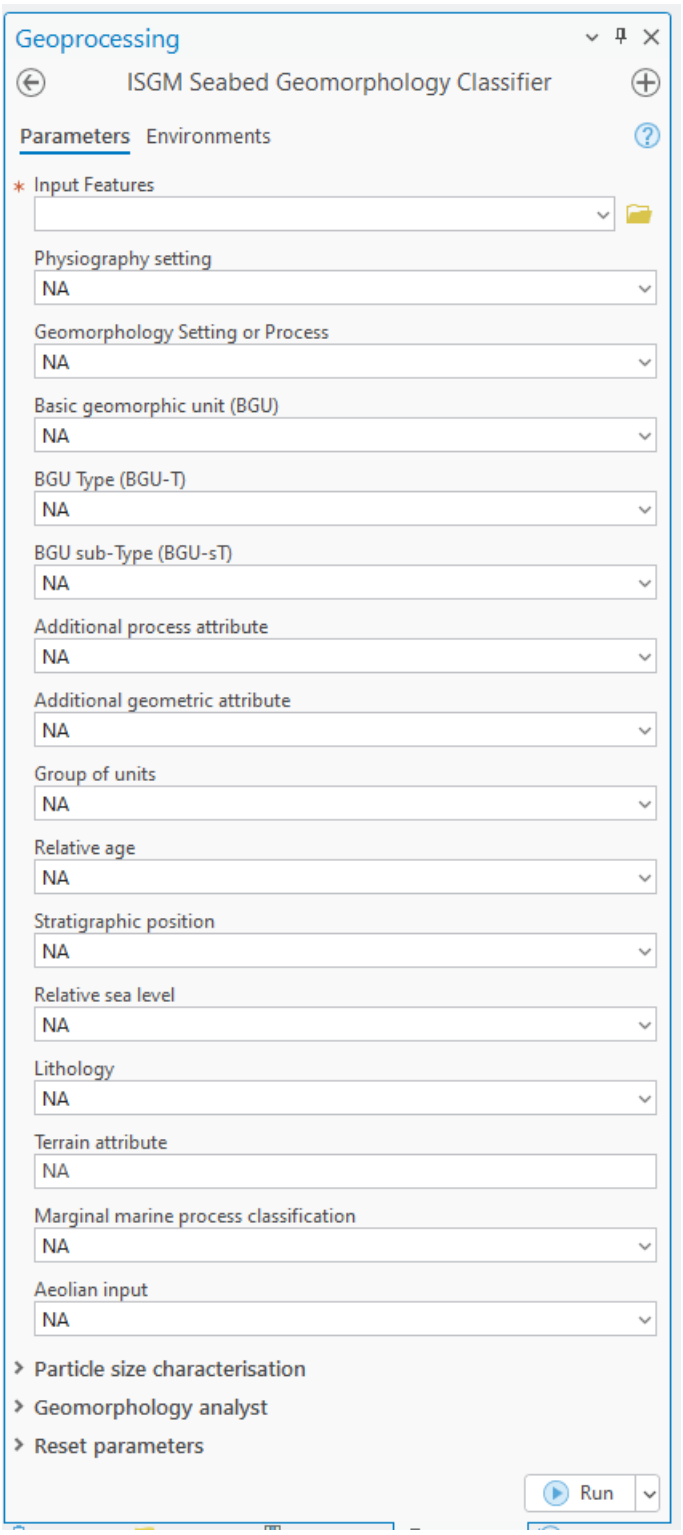
1. Select the Beagle30_toclassify dataset from the Contents pane. Open and view the attribute table of the dataset.



2. On the top menu bar, Activate the Map menu bar, then in the Selection group, select the Select button to activate it. Manually select the largest Depression feature on the bottom-left corner of the dataset. The selected feature is highlighted with a blue outline.



3. From the attribute table, you can see that there is 1 (out of 33) feature selected. Show only the selected record by clicking the Show Selected Records button on the bottom of the table.
4. With this feature selected, Double click the ISGM Seabed Geomorphology Classifier on the Catalog pane to open the tool interface.

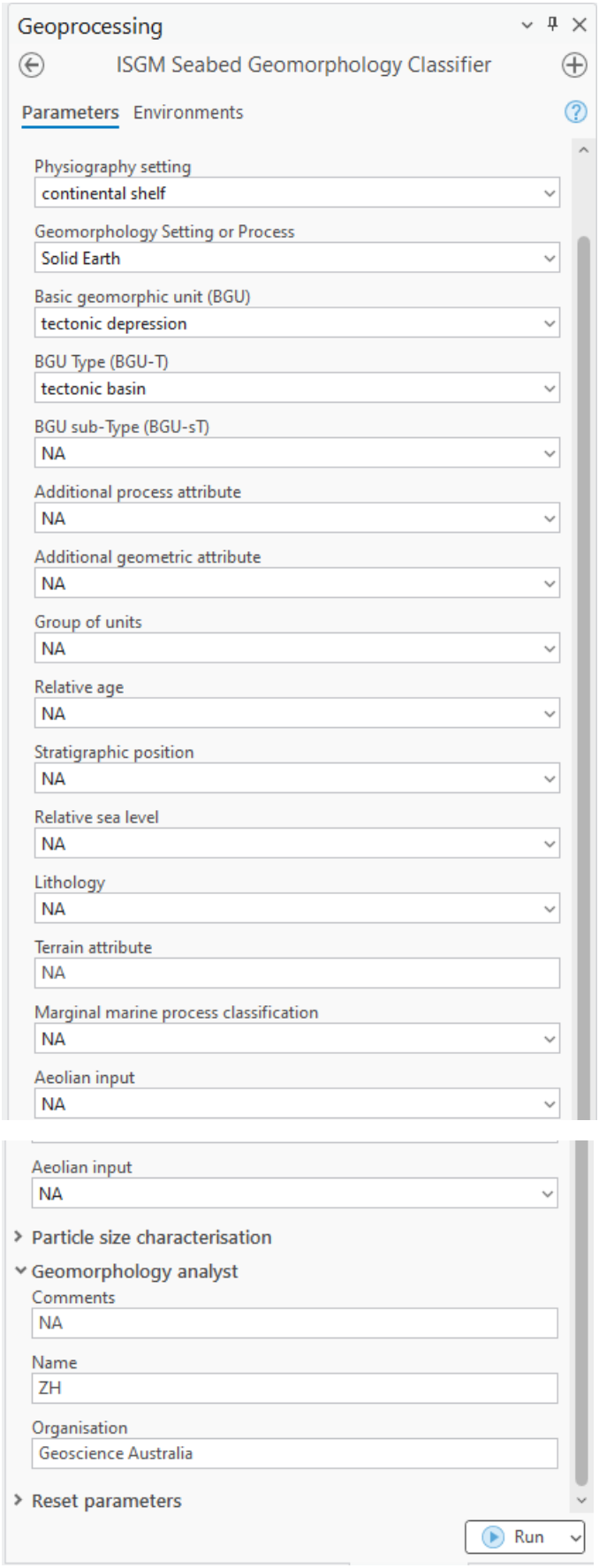


5. This tool allows you to either select an option from a drop-down list or enter free text for each parameter. For this exercise, use the following table as a guide. Note that, if necessary, you need to open the Particle size charcterisation group to enter three particle size parameters and open the Geomorphology analyst group to enter the Comments, the Geomorphology analyst name and the Geomorphology analyst organisation parameters.

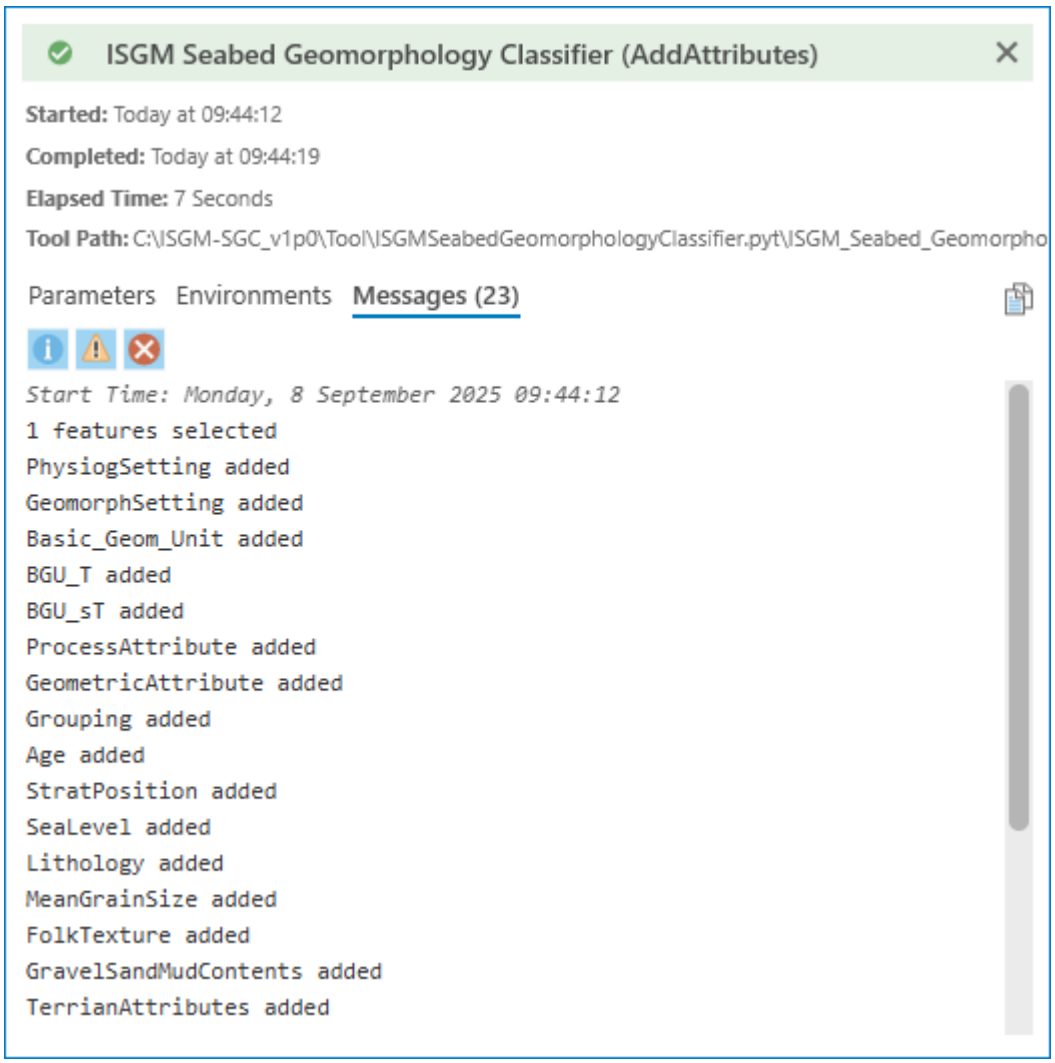
Tool Parameter	**Drop-down selection and Free text entry**

Input Features	Beagle30_toclassify
Physiography Setting	continental shelf
Geomorphology Setting or Process	Solid Earth
Basic Geomorphic Unit (BGU)	tectonic depression
BGU Type (BGU-T)	tectonic basin
Geomorphology analyst name	Your name
Geomorphology analyst organisation	Your organisation name

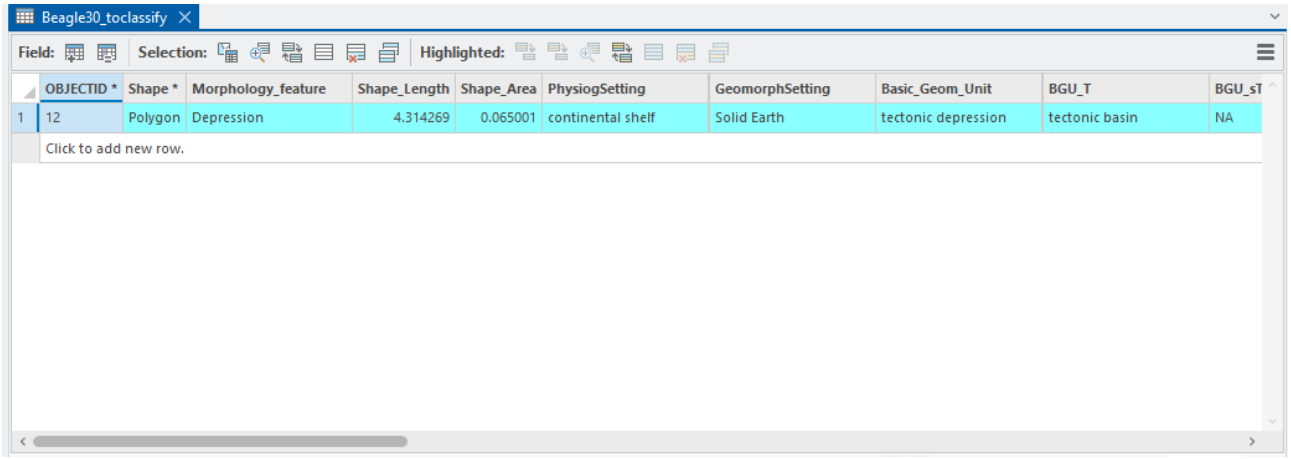
All other tool parameters can be left as default. Once you have done this, your tool pane will appear similar to the image below. When it does, click the Run button.



6. Open the View Details tab to display the geoprocessing messages.

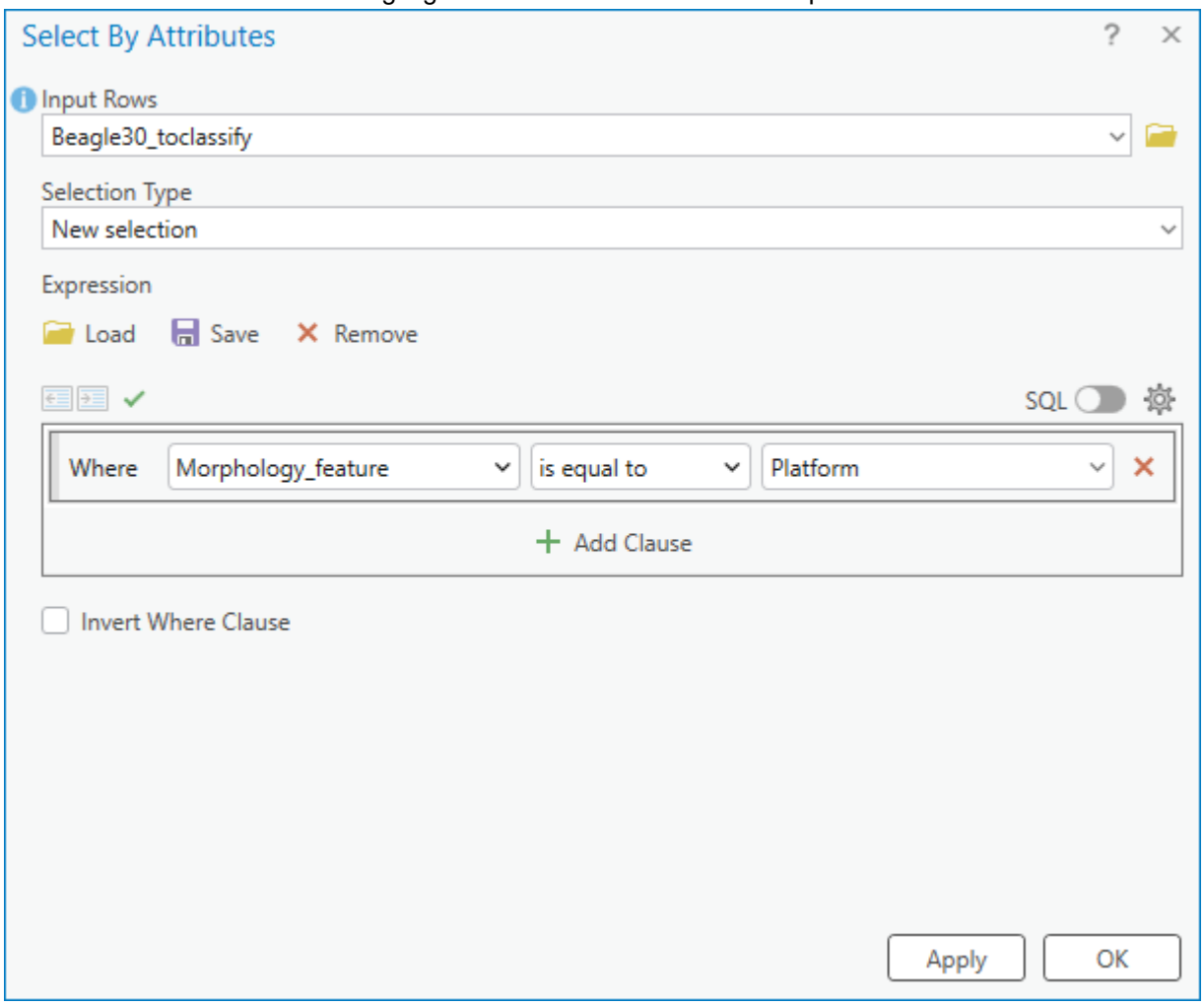


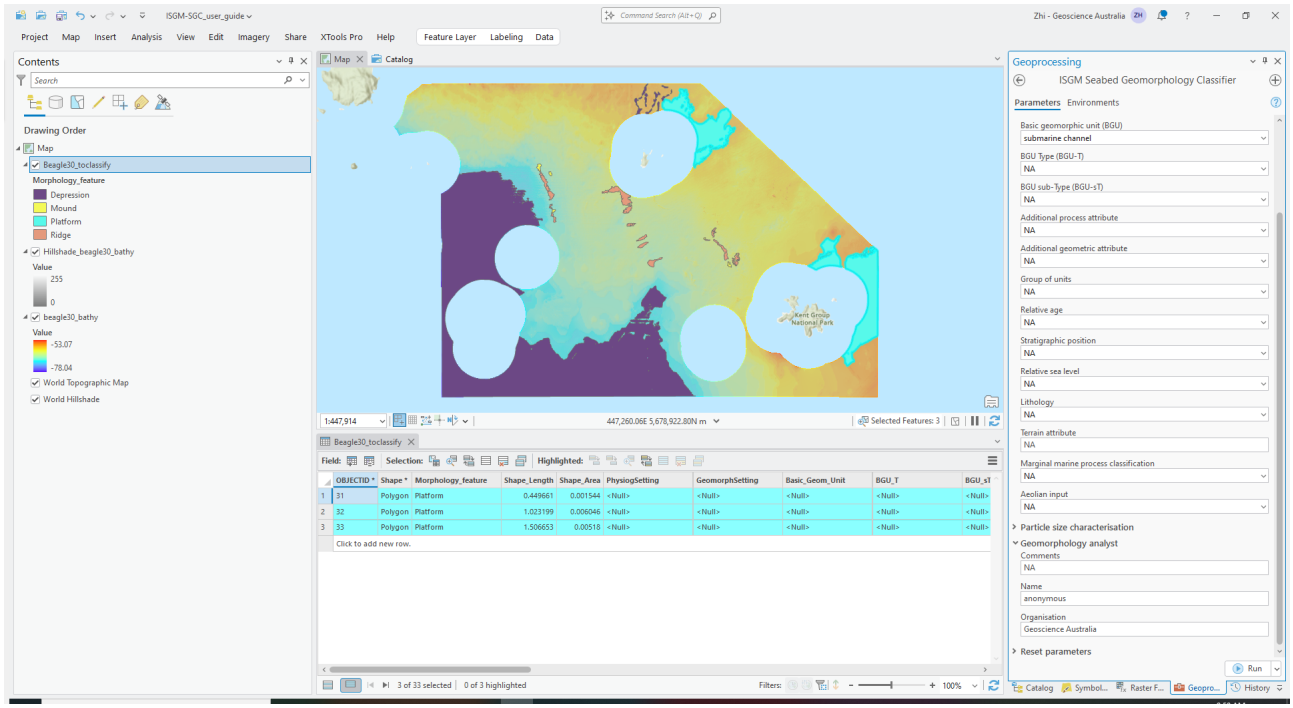
7. Once the tool has finished running, check the attribute table for the Morphology Features polygon layer. You should see that columns for geomorphology attributes have been added to the table with the values you selected in the tool. For the selected Depression feature, check that the values of the geomorphology attributes have been correctly added.



8. Congratulations! You have just used the GIS tool to assign geomorphology attributes to the selected feature.
9. Use similar steps to a) select some small Depression features on the top of the datasets; b) use the tool to assign “Marine” as the Geomorphology Setting and Process parameter and “Submarine channel” as the Basic geomorphic unit (BGU) parameter. Feel free to select other geomorphology attributes as you see fit (or leave them as default), using the regional geology information provided at the Section 3 of this tutorial and your own expert knowledge.

10. On the top menu bar, Click on Map then in the Selection part of the menu, select the Select By Attributes button to open a pop-up box. For Input Rows, Select the Beagle30_toclassify dataset from the drop-down list. In the SQL section, Build a SQL expression like “Where Morphology_feature is equal to Platform” using the three drop-down lists; Click the OK button to execute the selection. The selected Platform features are highlighted with blue outline on the map and in the attribute table.



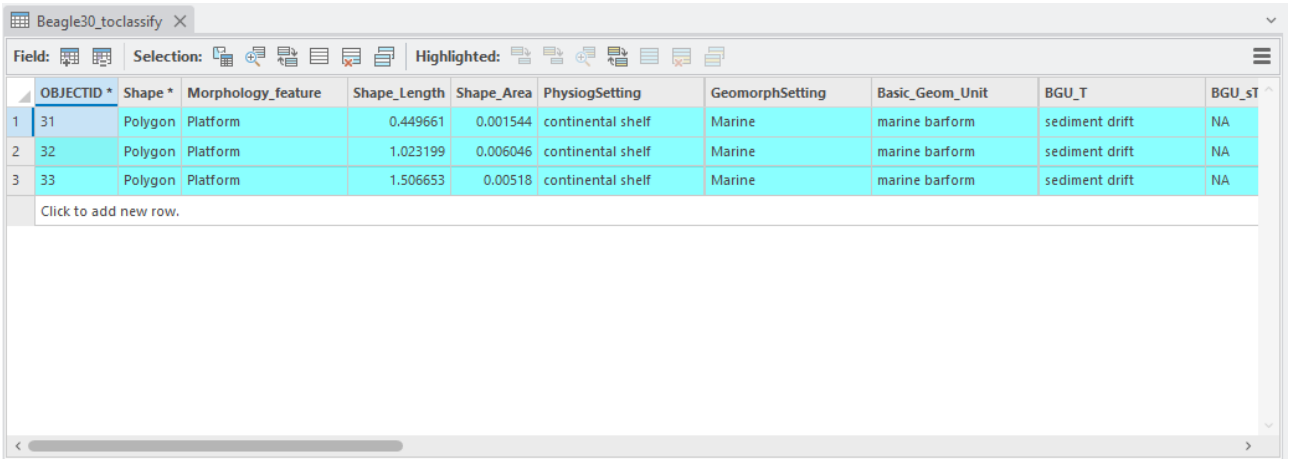


11. Update the tool inputs as follows:

Tool Parameter	**Drop-down selection**
Input Features	Beagle30_toclassify
Physiography Setting	continental shelf
Geomorphology Setting or Process	Marine
Basic Geomorphic Unit (BGU)	marine barform
BGU Type (BGU-T)	sediment drift
Geomorphology analyst name	Your name
Geomorphology analyst organisation	Your organisation name

Click the Run button to execute the tool.

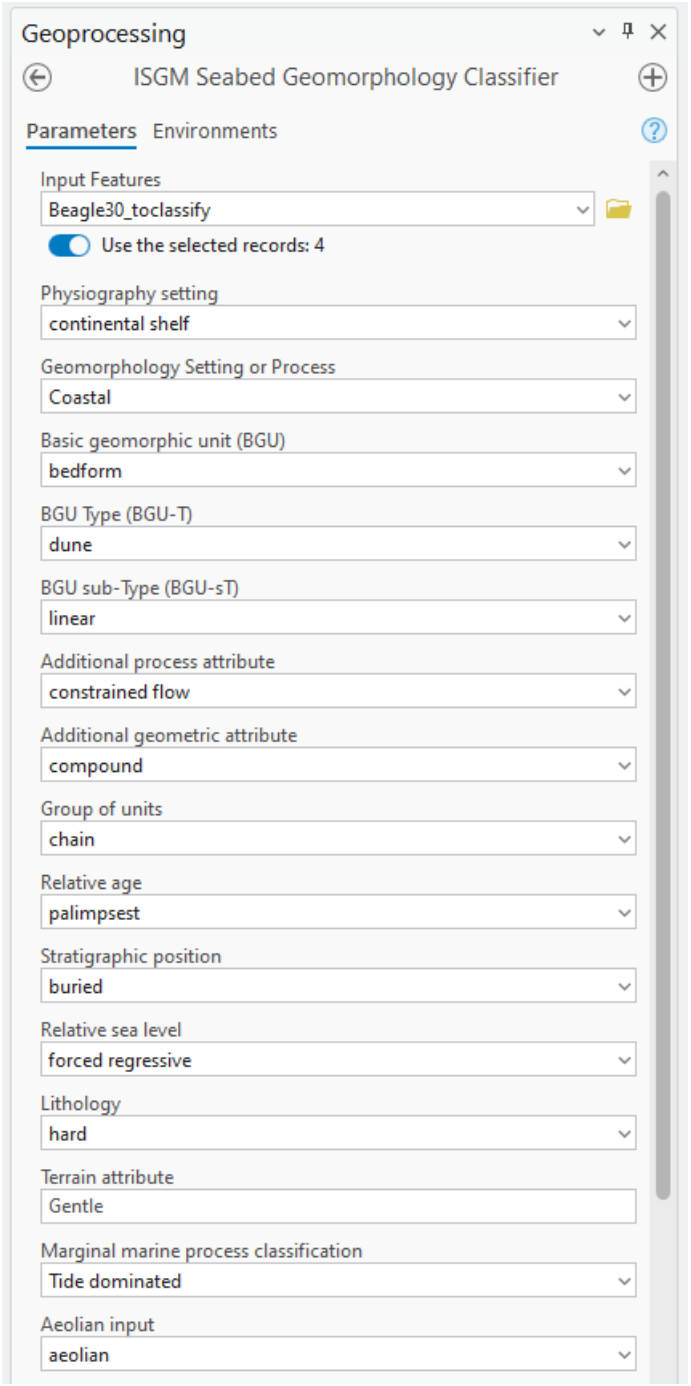
12. For the selected Platform features, check that the values of the geomorphology attributes have been correctly added.

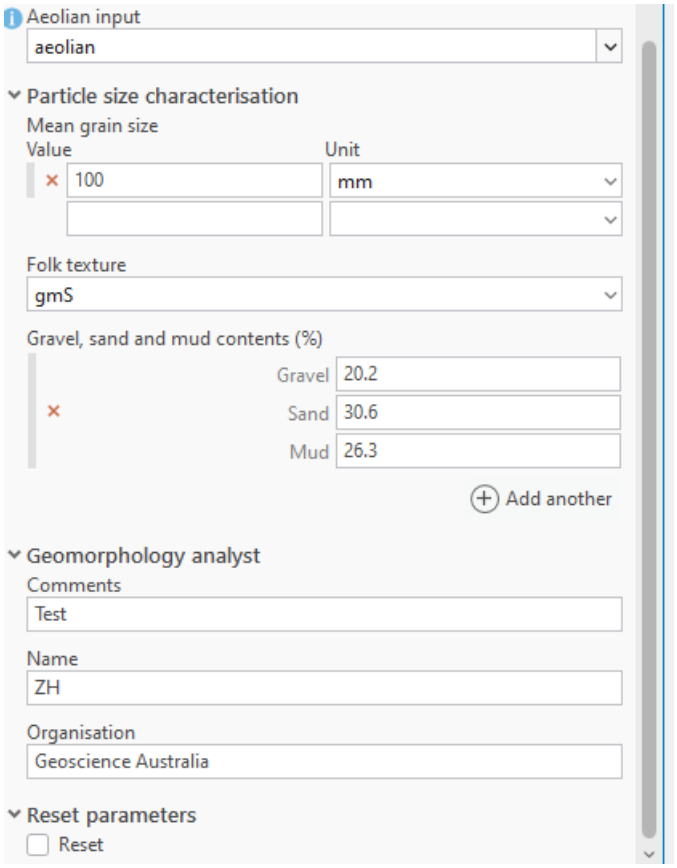


13. Use the table below to add geomorphology attributes to the Ridge features. Feel free to select other geomorphology attributes as you see fit, using your own expert knowledge.

Morphology feature	**Physiography Setting**	**Geomorphology Setting or Process**	**BGU**	**BGU-T**	**BGU-sT**
Ridge	continental shelf	Coastal	bedform	dune	coastal dune
Ridge	continental shelf	Coastal	bedform	dune	barchan
Ridge	continental shelf	Coastal	bedform	NA	NA

14. Now, we want to demonstrate how to clean up the current tool parameters using the Reset parameter.
15. On the current selected Ridge features, freely select different options and enter free texts as you wish (below is just an example).

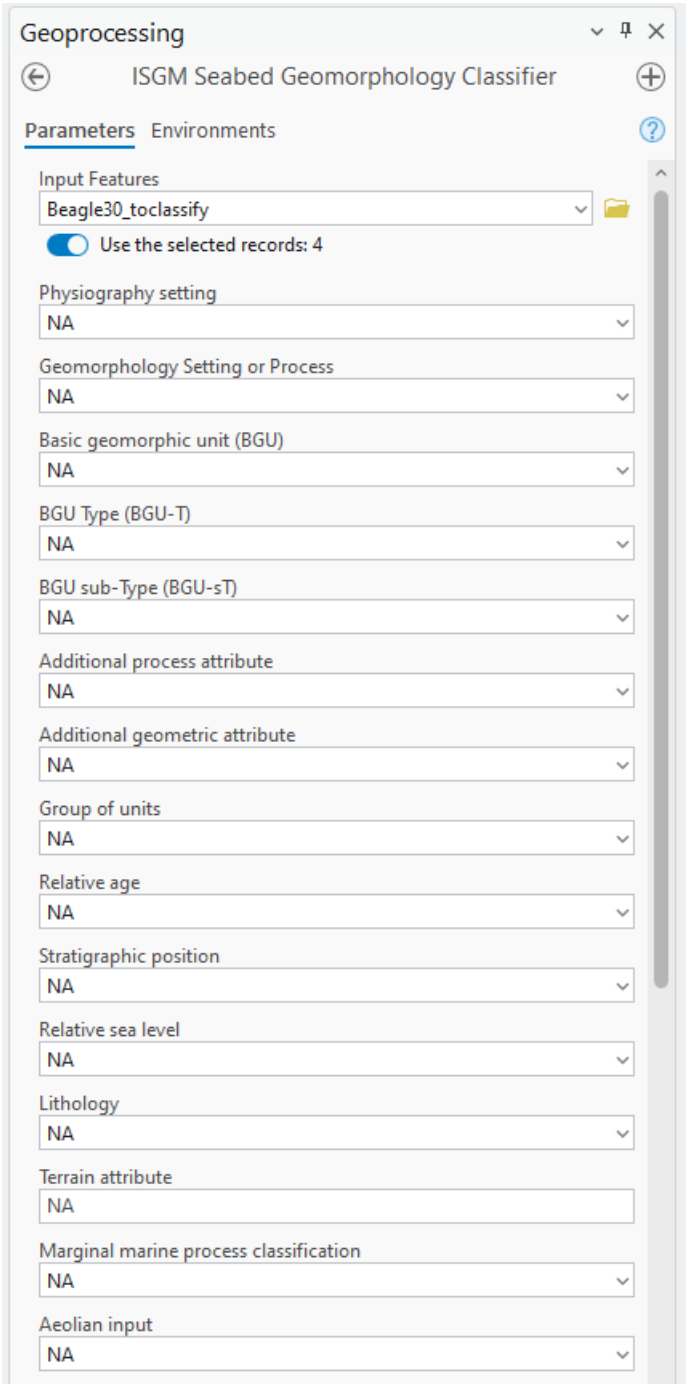


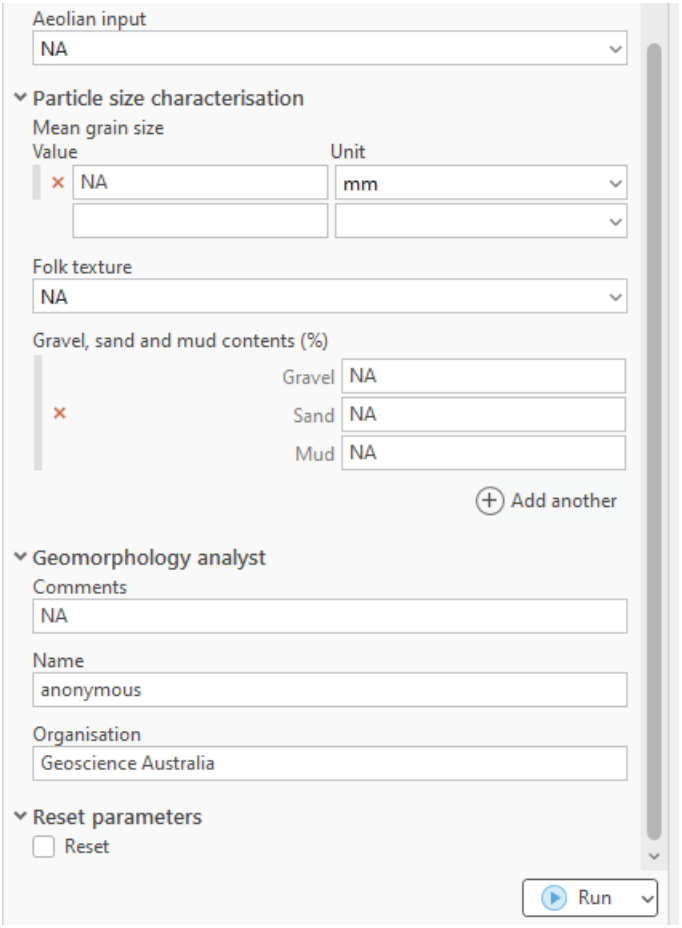


16. Now, you want to select the Mound features and use the below table to add geomorphology attributes.

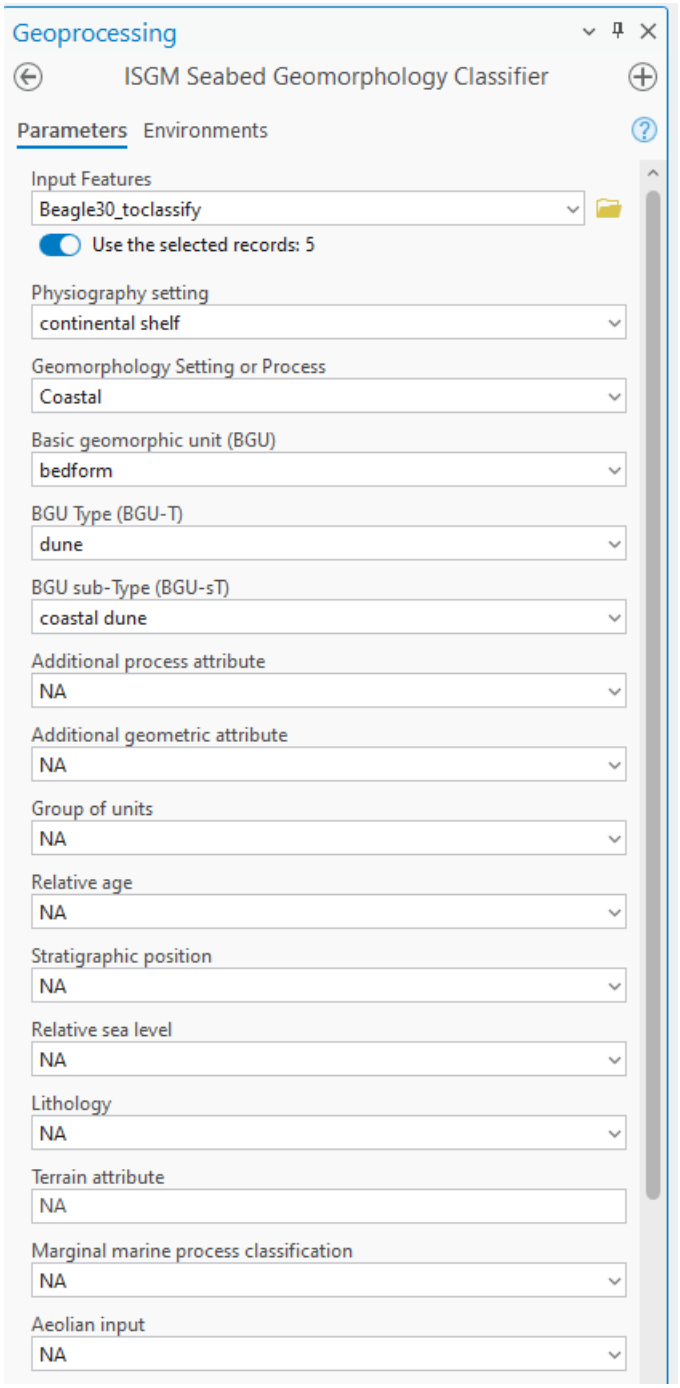
Tool Parameter	**Drop-down selection**
Input Features	Beagle30_toclassify
Physiography Setting	continental shelf
Geomorphology Setting or Process	Coastal
Basic Geomorphic Unit (BGU)	bedform
BGU Type (BGU-T)	dune
BGU Sub-Type (BGU_sT)	coastal dune
Geomorphology analyst name	Your name
Geomorphology analyst organisation	Your organisation name

17. First, open the Reset parameters group; then tick the Reset parameter box. This will reset all tool parameters to their default values (except the Geomorphology analyst name and the Geomorphology analyst organisation parameters).


Geoprocessing
ISGM Seabed Geomorphology Classifier
Parameters
Environments
Input Features
Beagle30_toclassify
Use the selected records: 4
Physiography setting
NA
Geomorphology Setting or Process
NA
Basic geomorphic unit (BGU)
NA
BGU Type (BGU-T)
NA
BGU sub-Type (BGU-sT)
NA
Additional process attribute
NA
Additional geometric attribute
NA
Group of units
NA
Relative age
NA
Stratigraphic position
NA
Relative sea level
NA
Lithology
NA
Terrain attribute
NA
Marginal marine process classification
NA
Aeolian input
NA



18. Select the Mound features, and use the table above to assign the geomorphology attributes.

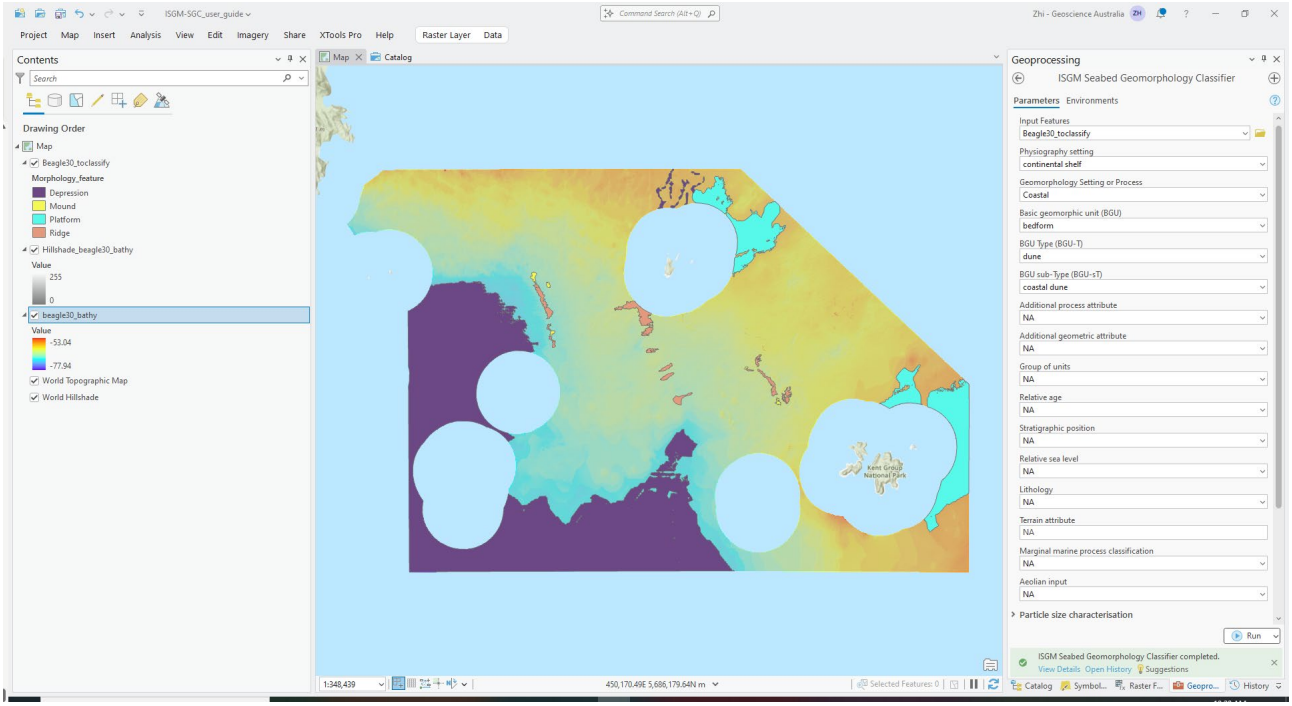


19. Congratulations! You have successfully completed this main tutorial.

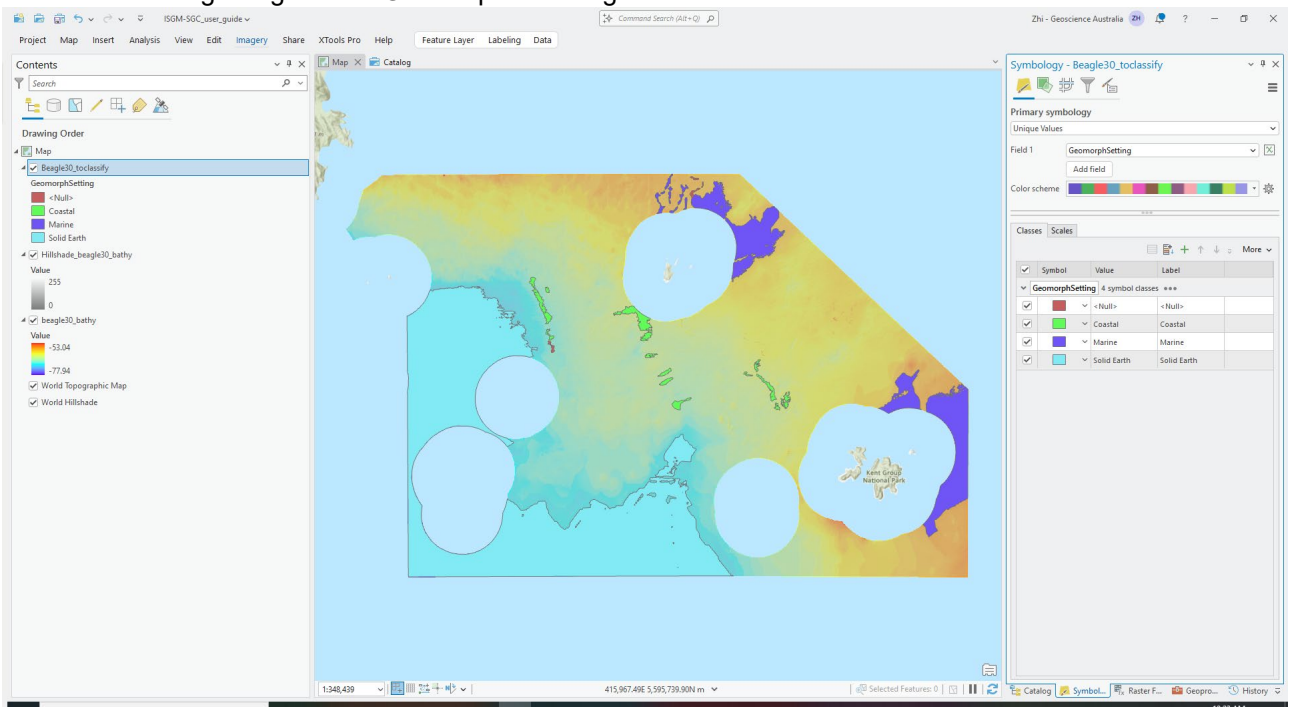
5 Display the seabed features using the geomorphology attributes

Now that you have added geomorphology attributes to all or selected Morphology Features, we will visualise them on maps.

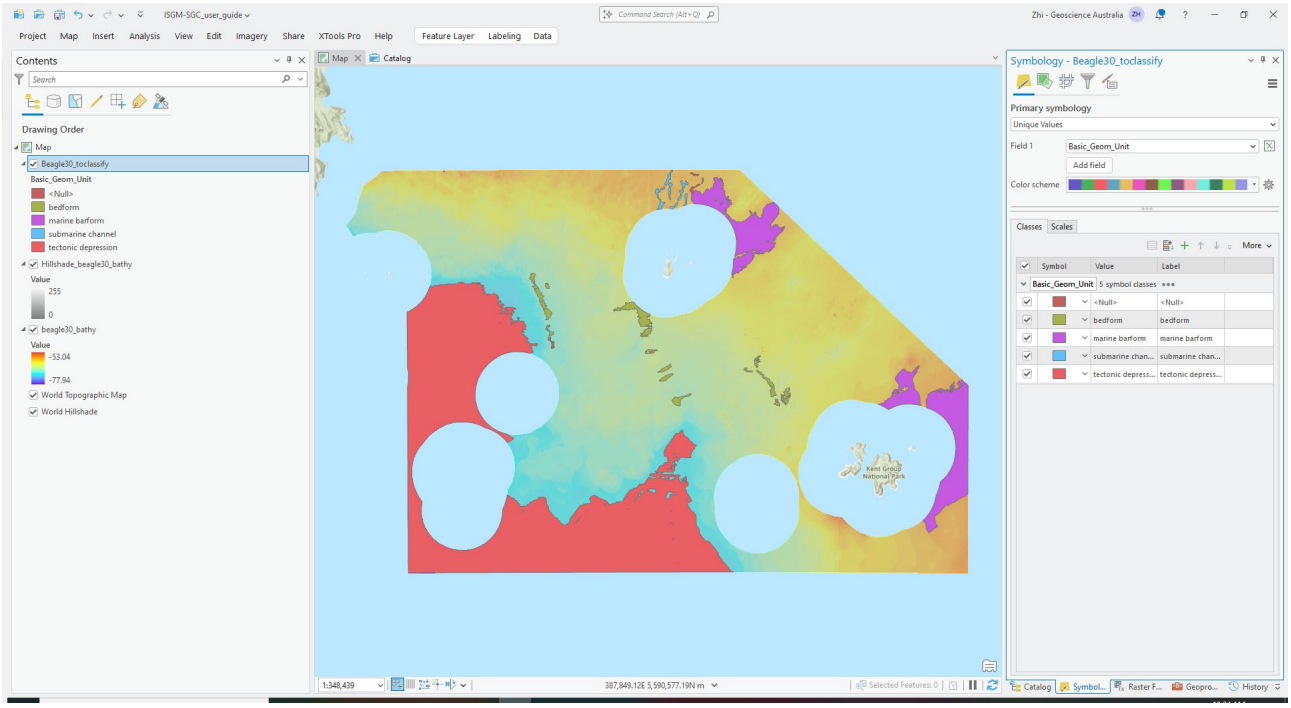
1. On the top menu bar, Activate the Map menu bar, and on the Selection part select the Clear button to clear all selection. Close the attribute table. Zoom to the full extent of the bathymetry data.



2. Select the Beagle30_toclassify dataset on the Contents pane; Activate the Symbology pane for this dataset. Select the Unique Values option for the Primary symbology, Select the “GeomorphSetting” under Field 1, Select a suitable colour scheme from the list, and Add all Geomorphic Setting types by using the Add all values button. If you have a Null category, this is because there are some features not being assigned the Geomorphic Setting or Process values.



3. Follow the same procedure to display the Basic Geomorphic Unit (“Basic_Geom_Unit” field) types.



4. Congratulations! You have successfully completed all tutorials.

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