discover.
collaborate.
innovate.

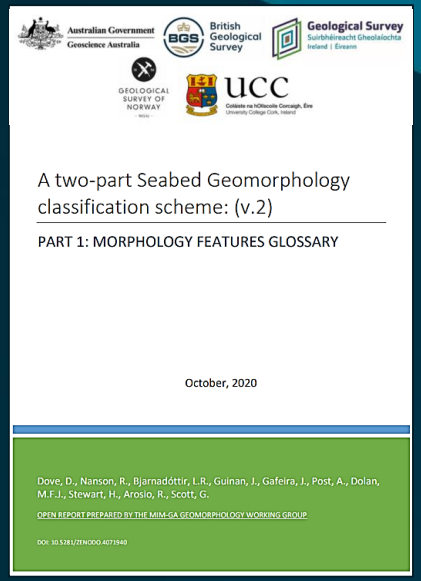
A two-part seabed geomorphology mapping scheme for multidisciplinary applications

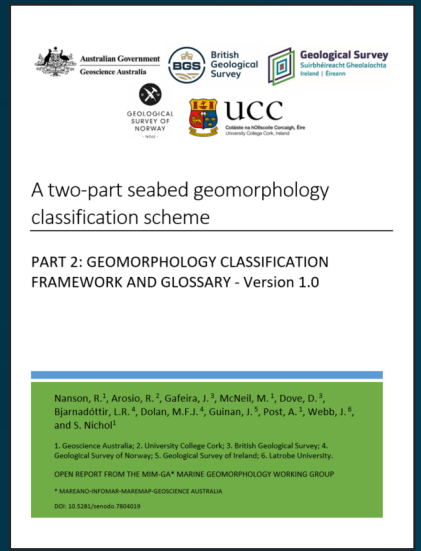
An Ocean Best Practice approach

Rachel Nanson[1] and Joana Gafeira J. [3]

McNeil M. [1], Huang Z., [1] Wenderlich M., Orr M. [1], Arosio R. [2], , Dove D. [3], Bjarnadóttir L.R. [4], Dolan M.F.J. [4], Guinan J. [5], Post A. [1], Webb J. [6], Nichol S.[1] and Carroll A. [1]

1. Geoscience Australia;
2. University College Cork;
3. British Geological Survey;
4. Geological Survey of Norway;
5. Geological Survey of Ireland;
6. Latrobe University.





Geoscience Australia Strategy 2028

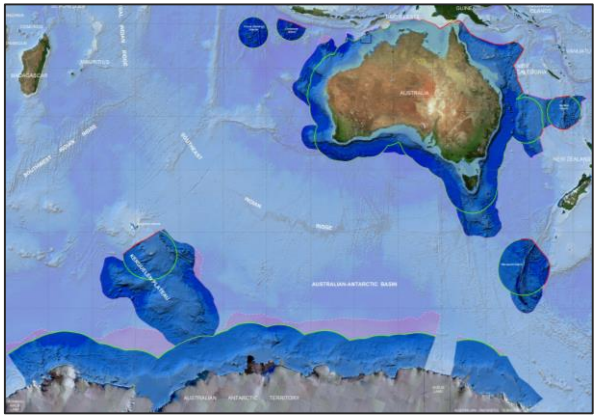
VISION

Geoscience Australia's science activities support the agency's role as the trusted source of information on Australia's geology and geography for government, industry and community decision-making

- Relevant Science
- Collaborative Science
- Quality Science
- Transparent Science
- Communicated Science
- Sustained Science

1. **Building Australia's resources wealth**
2. **Supporting Australia's community safety**
3. Securing Australia's water resources
4. **Managing Australia's marine jurisdictions**
5. Creating a location enabled Australia
6. Enabling an informed Australia

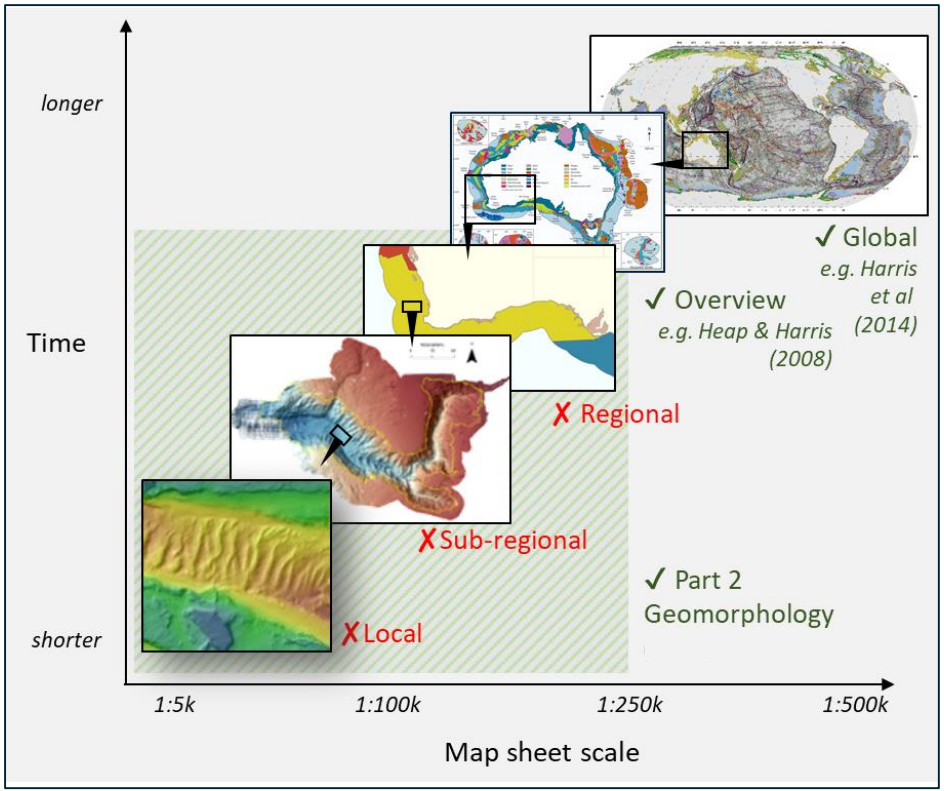
- Pursuing Science Excellence
- Making the most of our Data
- Ensuring Supportive Stakeholders
- Enhancing Positive Organisational Culture



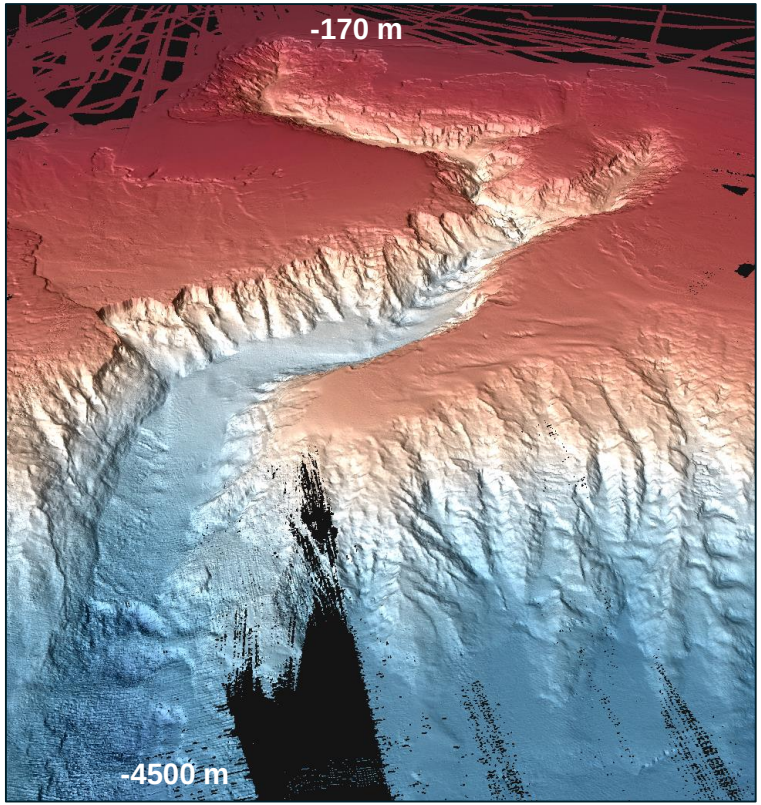
Geoscience Australia Marine Strategy

1. Map and **understand** our seabed, to support growth of the Blue Economy to $100b per year.
2. Coastal landform monitoring
3. Support legal and regulatory certainty for marine jurisdiction

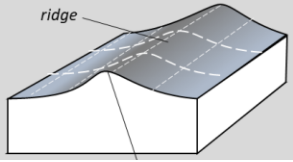
Marine geomorphology maps - diverse users, diverse scales



Marine geomorphology mapping: a two-part approach



Part 1. Morphology



Steps to developing an ocean best practice

Download via:
https://www.oceanbestpractices.org/repository/

SCOPE AND RECRUIT

1 Confirm the need
- Consider best practices training
- Review similar methods
- Survey the community
- Develop scoping report

2 Form a working group
- Identify leaders
- Invite contributors and institutions
- Be inclusive
- Set scope of method

DEVELOP AND RELEASE

3 Develop content
- Assess/integrate related methods
- Consult in working group
- Create strawman
- Complete final draft

4 Review final draft
- Invite full community review
- Respond and revise
- Maintain adjudication record

5 Release
- Publish at repository
- Notify stakeholders
- Promote to target audiences

REVISE AND RATIFY

6 Invite feedback
- Survey users
- Publish in journal
- Assess uptake via repository
- Consider new version

7 Obtain community endorsement for an accepted best practice!
- Obtain GOOS endorsement
- Obtain institutional endorsement
- Include in permitting recommendations
- Maintain and update

Benefits of using a best practice

- Collaborative opportunities
- Efficient use of time
- Improved systems interoperability
- Data comparability and collatability
- Greater trust in data
- Streamlined regulatory approval
- Higher funding success

Przeslawski et al (2023)

Workshop participants (16 countries)

1	Australia
2	Croatia
3	Denmark
4	Germany
5	Greece
6	Ireland
7	Israel
8	Italy
9	Malta
10	Norway
11	New Zealand
12	Romania
13	Slovenia
14	Spain
15	United Kingdom
16	United States

Part 1

A two-part Seabed Geomorphology classification scheme: (v.2)

PART 1: MORPHOLOGY FEATURES GLOSSARY

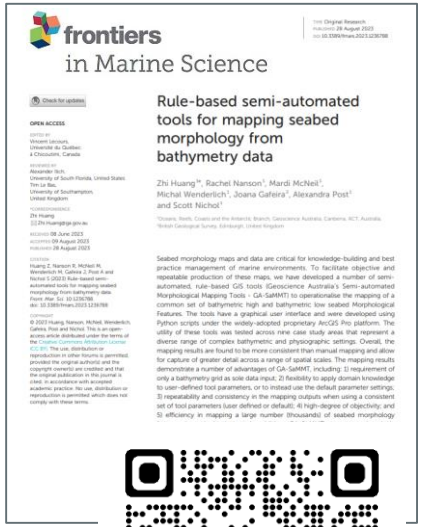
October 2020

Dove, D., Nanson, R., Bjarnadóttir, L.R., Guinan, J., Gafeira, J., Post, A., Dolan, M.F.J., Stewart, H., Arc

OPEN REPORT PREPARED BY T

DOI: 10.5281/ZENODO.4071940

Part 1 GIS paper and Tools



Part 2

Australian Government Geoscience Australia | BGS British Geological Survey | Geological Survey Ireland | Geological Survey of Norway | UCC

A two-part seabed geomorphology classification scheme

PART 2: GEOMORPHOLOGY CLASSIFICATION FRAMEWORK AND GLOSSARY - Version 1.0

April 2023

Nanson, R.[1], Arosio, R.[2], Gafeira, J.[3], McNeil, M.[1], Dove, D.[3], Bjarnadóttir, L.R.[4], Dolan, M.F.J.[4], Guinan, J.[5], Post, A.[1], Webb, J.[6], and S. Nichol[1]

1. Geoscience Australia; 2. University College Cork; 3. British Geological Survey; 4. Geological Survey of Norway; 5. Geological Survey of Ireland; 6. Latrobe University.

OPEN REPORT FROM THE M

* MAREANO-INFOMAR-MAREMA

DOI: 10.5281/zenodo.7804019

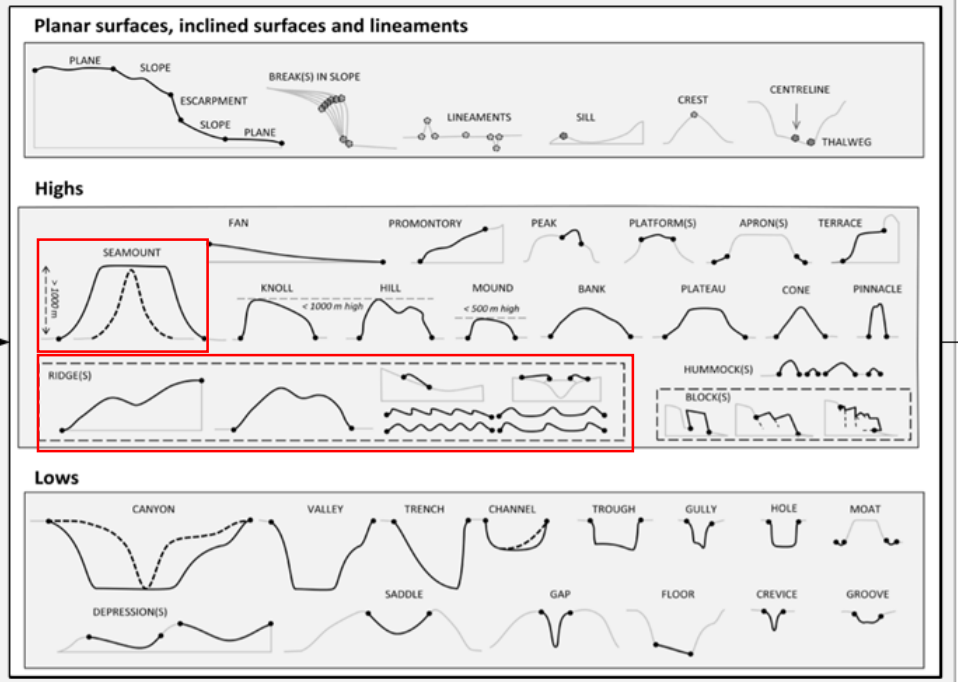
Part 2 paper and GIS Tools

Submit 2024

Tools coming soon…

Part 1: Morphology

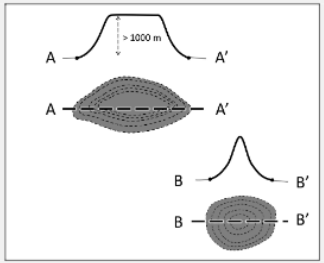
Step 1: map shapes & define Morphology



SEAMOUNT

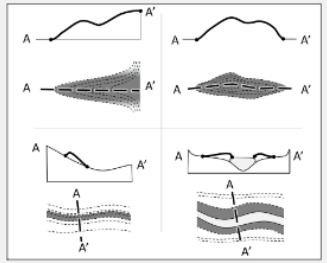
A prominent feature rising more than 1000 m above the surrounding relief (modified from IHO, 2019).

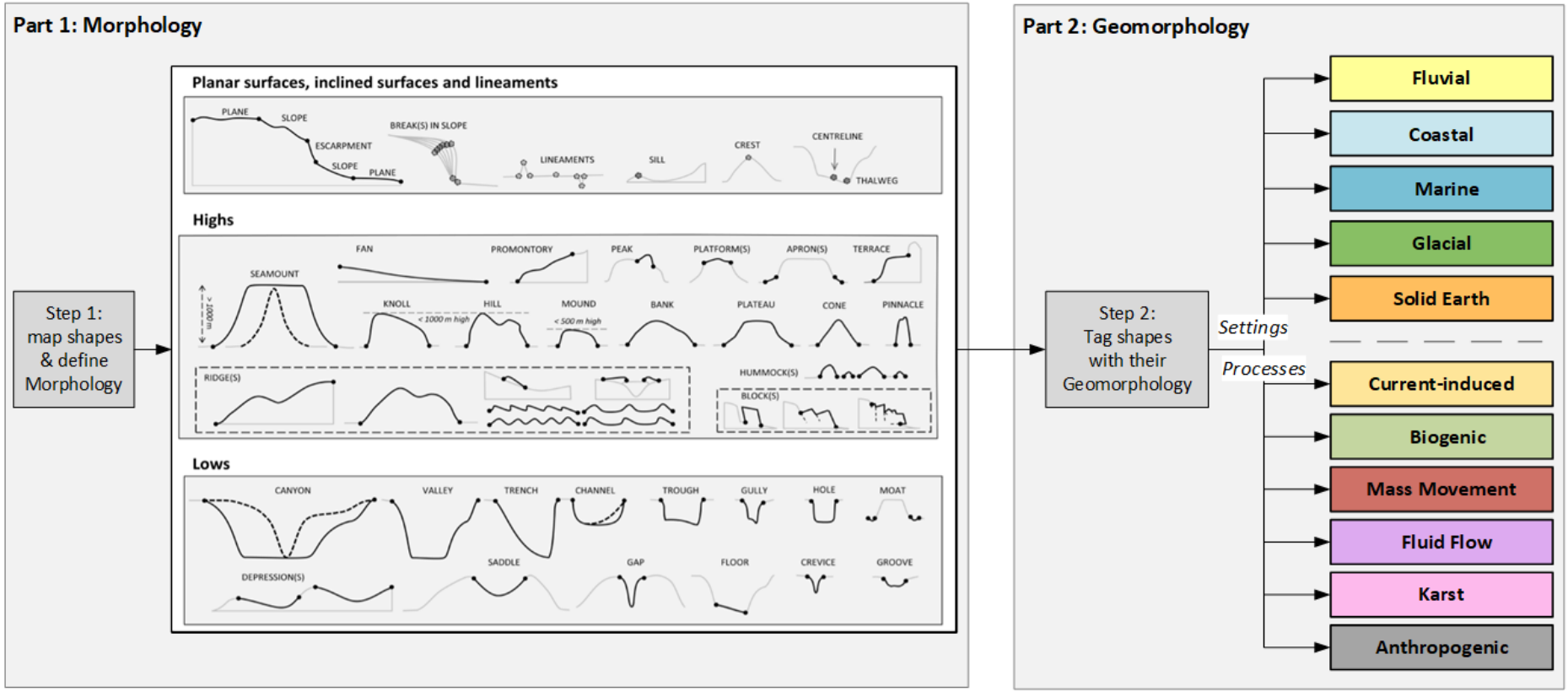
SEAMOUNTS are larger than KNOLLS and HILLS (<1000 m) and may incorporate PEAKS (and other features).

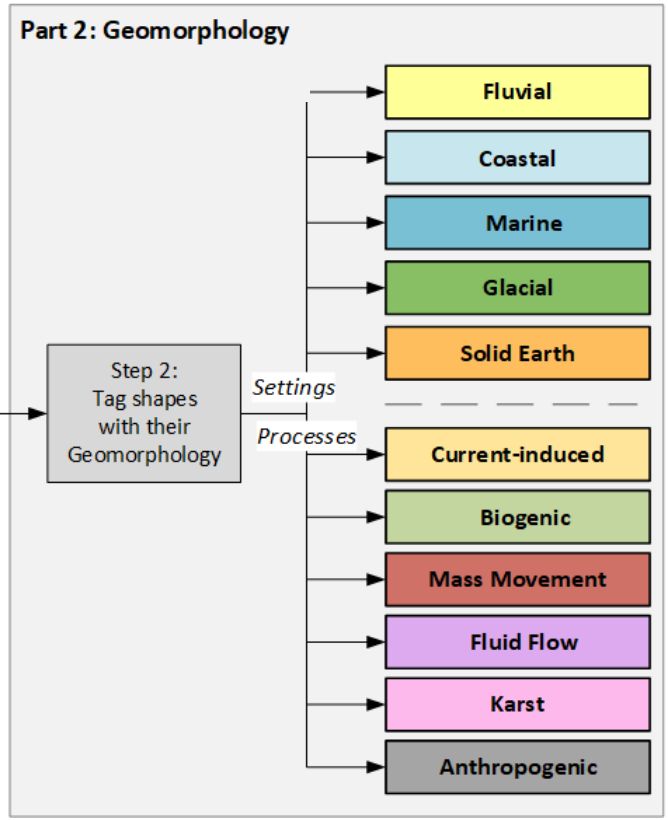


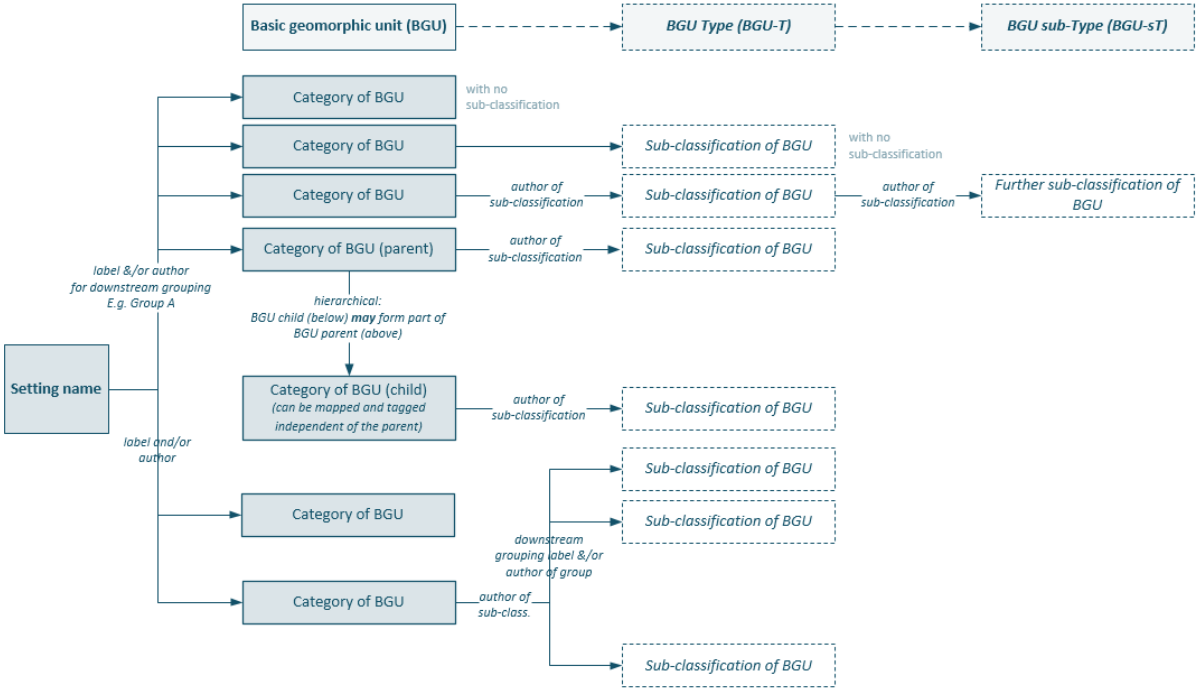
RIDGE

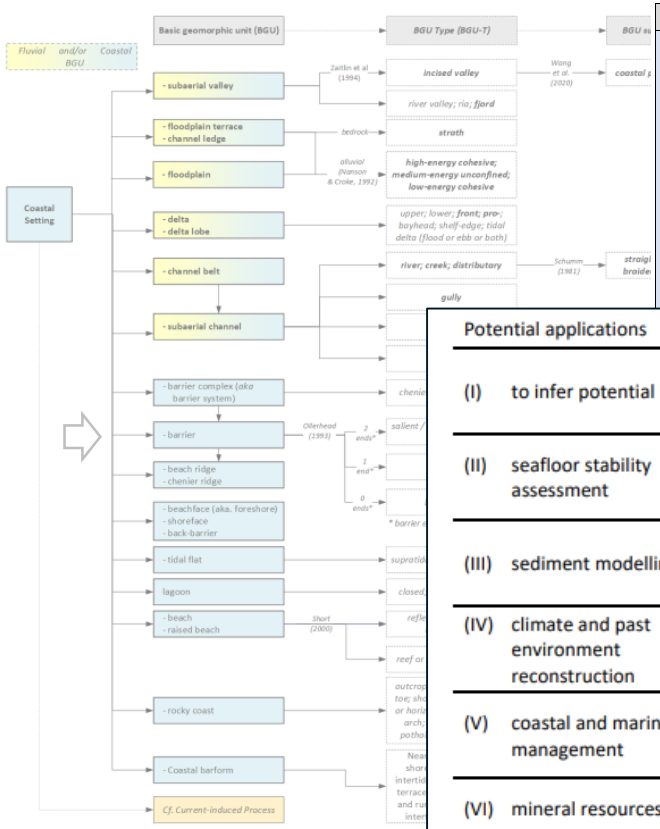
An elongated elevation of varying complexity, size and gradient (length > width) (modified from IHO, 2019).











Classification tree

Setting / Process	BGU *	BGU-T *	Part 2 Geomorphology definition **	Apps *** I – VI
		ridge and runnel	A low gradient sand bar and trough that forms alongshore in the intertidal zone of a BEACH. On macrotidal beaches, multiple ridges (Cf. INTERTIDAL BARS) and runnels may form across the intertidal zone spanning tens to hundreds of metres (Masselink and Hughes, 2014).	V
		washover bar	A low gradient sandy to gravelly deposit located on the landward side of a BARRIER deposited over a BACK-BARRIER FLAT or LAGOON facies, formed by storm surge or tsunami run-up. Typically fan shaped in plan view (Reineck and Singh, 2012).	III, IV, V
		intertidal bar (*aka. ridgebar*)	A low gradient sand bar that forms in the intertidal zone of BEACHES. On macrotidal coasts, multiple bars typically form into a RIDGE AND RUNNEL system (Masselink and Hughes, 2014).	II, III, IV
		tidal bar	Discontinuous COASTAL BARS that typically form in tide-dominated SUBAERIAL CHANNELS, which are aligned to the dominant flow direction (Dalrymple et al., 1992).	II, III, IV
	barrier complex		Amalgamated, shore-parallel sand bodies incorporating BEACH, coastal	

Potential applications		Examples
(I)	to infer potential habitat	Ocean management, seafood industry, biodiversity, conservation (e.g. Harris and Baker, 2011).
(II)	seafloor stability assessment	To assess landslide and tsunami risk (e.g. Bardet et al., 2003); develop GIS ground models for offshore renewables (e.g. Barwise et al., 2014); for safe navigation, infrastructure for hydrocarbons.
(III)	sediment modelling	To infer near seafloor energy, sediment transport pathways, volumes / budgets (e.g. Stow et al., 2009).
(IV)	climate and past environment reconstruction	For studies of modern climate change, palaeoenvironmental reconstruction, archaeology (e.g. Brooke et al., 2017; O'Leary et al., 2020).
(V)	coastal and marine management	To investigate environmental, erosion, seafood industry, recreational fishing, administrative borders.
(VI)	mineral resources assessment	To locate fluvial and coastal placer deposits (Kudrass, 2017) and aggregates.

18 Index of terms

The following list of terms is provided to assist the user in finding which Setting / Process chapter each term is classified. BGU-T marked with an asterix are not defined in the glossary.

A

Abyssal hill	*Solid Earth*	BGU
Accumulation zone	*see "-Deposition zone"*	
Agglutinating	*Biogenic*	BGU-T
Alluvial fan	*Fluvial*	BGU
Alluvial fan lobe	*Fluvial*	BGU
Anchor drag	*Anthropogenic*	BGU-T
Angular drainage network*	*Fluvial*	BGU-T
Annulate/annular	*Biogenic*	BGU-T
		BGU-T
		BGU
		BGU-T
		BGU-T
		BGU
		BGU-T
		BGU-T
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		BGU-T
		BGU
		BGU-T

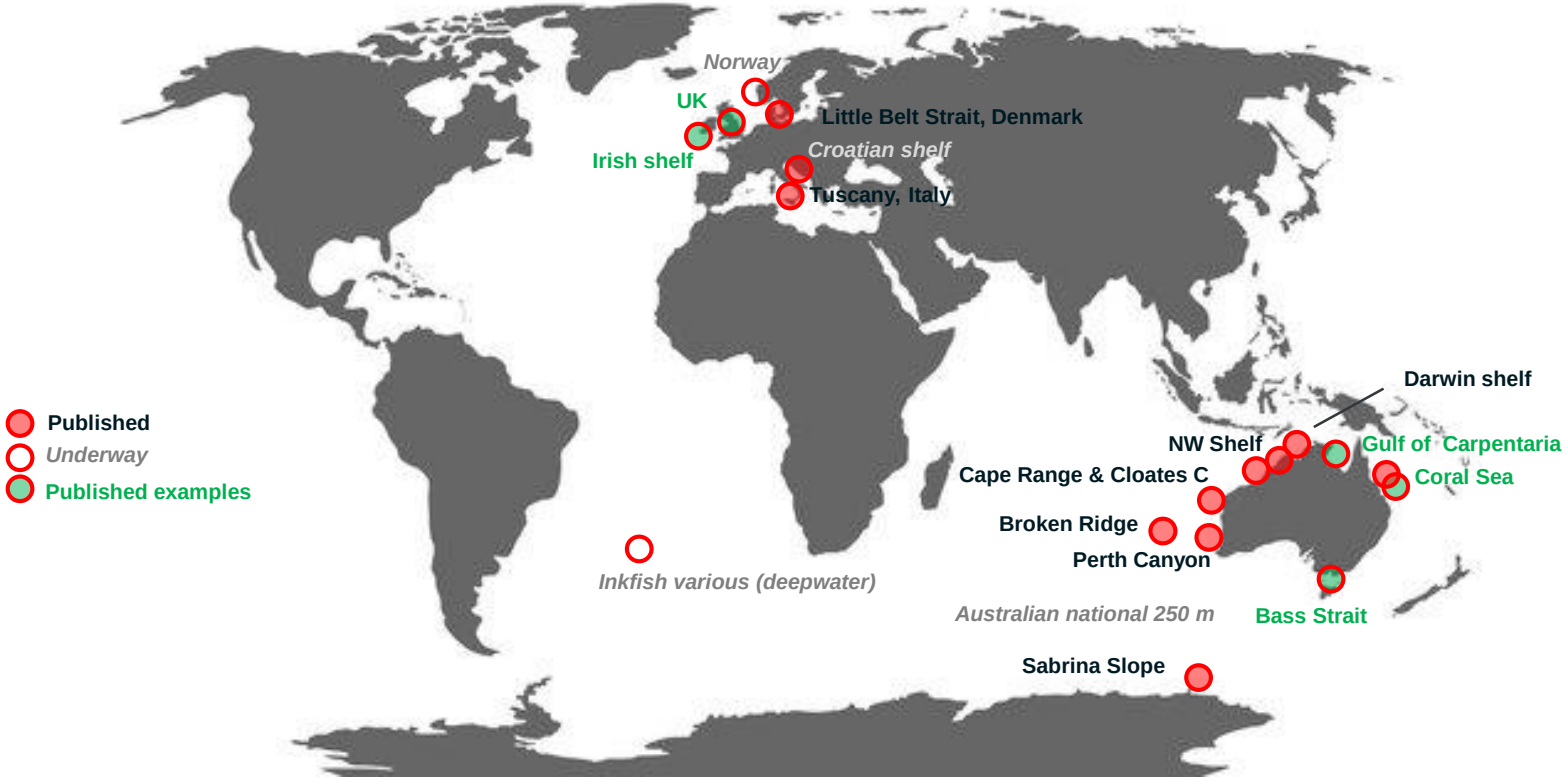
Beach ridge	*Coastal*	BGU
Bed (biogenic)	*see "Biostrome" or "Mat"*	
Bedded bedrock outcrop	*Solid Earth*	BGU-T
Bedding ridge	*Solid Earth*	BGU
Bedform	*Current-induced*	BGU
Bedrock outcrop	*Solid Earth*	BGU
Bench	*Current-induced*	BGU-T
Bench	*see "Dip slope"*	
Berm	*Coastal*	BGU-T
Bioherm	*Biogenic*	BGU
Biostrome	*Biogenic*	BGU
Black smokers	*Fluid Flow*	BGU-T
Blind canyon	*see "Slope-confined canyon"*	
Blind valley	*Karst*	BGU-T
Blowout crater	*Fluid Flow*	BGU
Boring*	*Biogenic*	BGU-T
Bottom trawl	*Anthropogenic*	BGU-T
Bundle structure	*Glacial*	BGU-T
Burrow*	*Biogenic*	BGU-T

C

Cable	*Anthropogenic*	BGU-T
Caldera (mud volcano)	*Fluid Flow*	BGU
Canyon head	*Marine*	BGU
Canyon mouth	*Marine*	BGU
Carbonate doline	*Karst*	BGU-T
Carbonate karst	*Karst*	BGU
Catchment	*see "Drainage basin"*	
Cave	*Coastal*	BGU-T
Centrifugal drainage network*	*Fluvial*	BGU-T
Centripetal drainage network*	*Fluvial*	BGU-T
Channel belt	*Coastal*	BGU
Channel ledge	*Coastal or Fluvial*	BGU
Chenier plain	*Coastal*	BGU-T
Chenier ridge	*Coastal*	BGU
Chute channel	*Current-induced*	BGU
Circular volcanic depression	*Solid Earth*	BGU-T
Cliff	*Coastal*	BGU-T
Cliff	*see "Scarp slope"*	

Index of terms

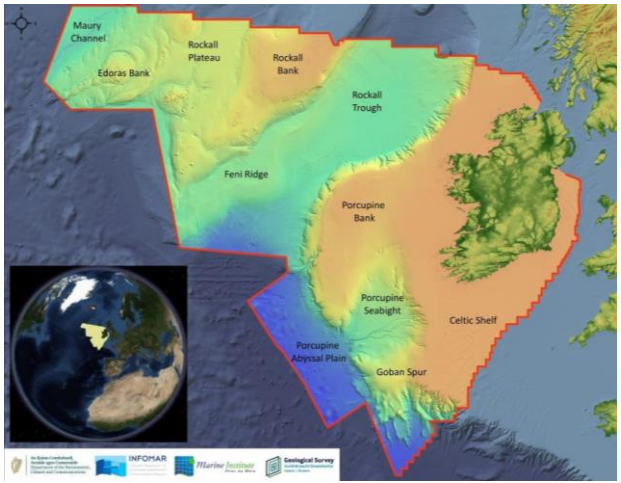
Products based on the scheme (to October 2023)

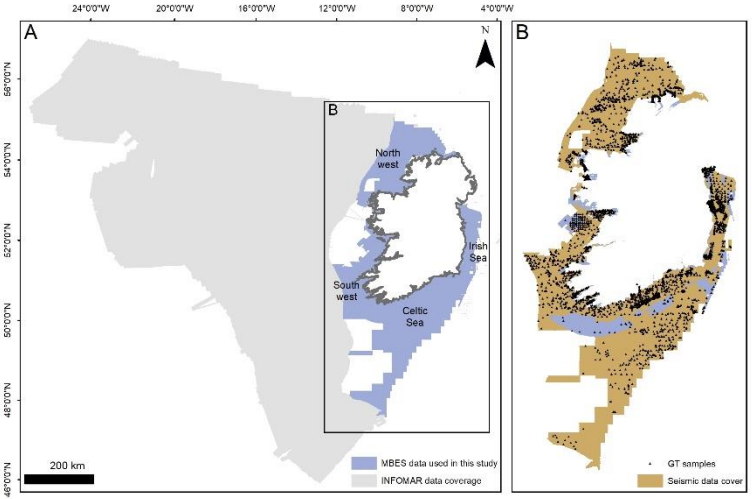


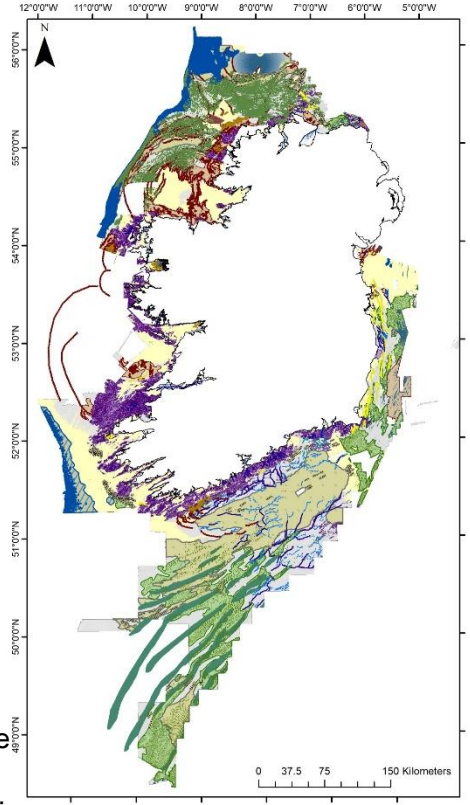
Foras na Mara
Marine Institute

INFOMAR Programme: more than 85% seabed mapped at high resolution.

UCC University College Cork, Ireland
Marine Geosciences Research Group University College Cork





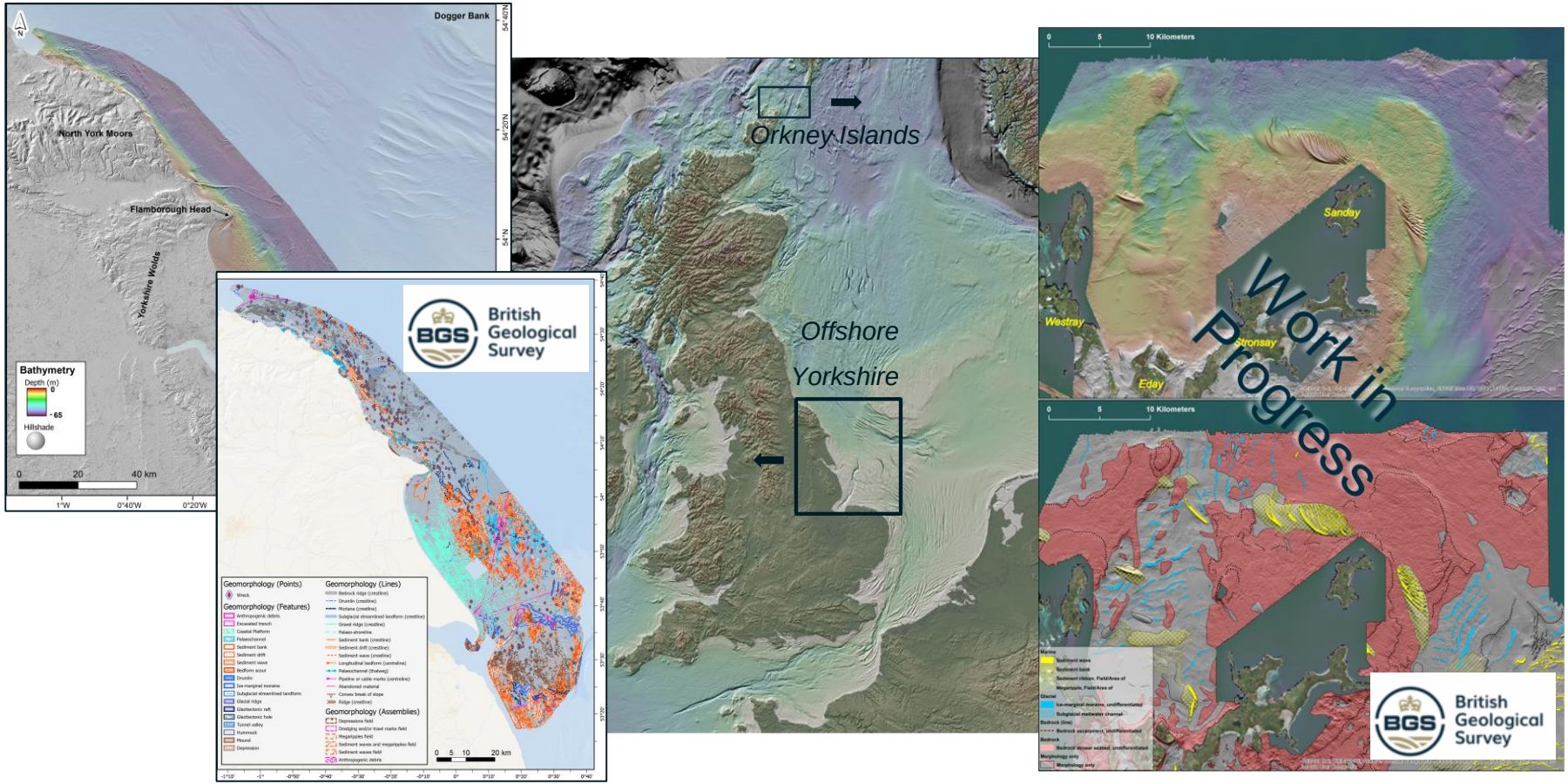


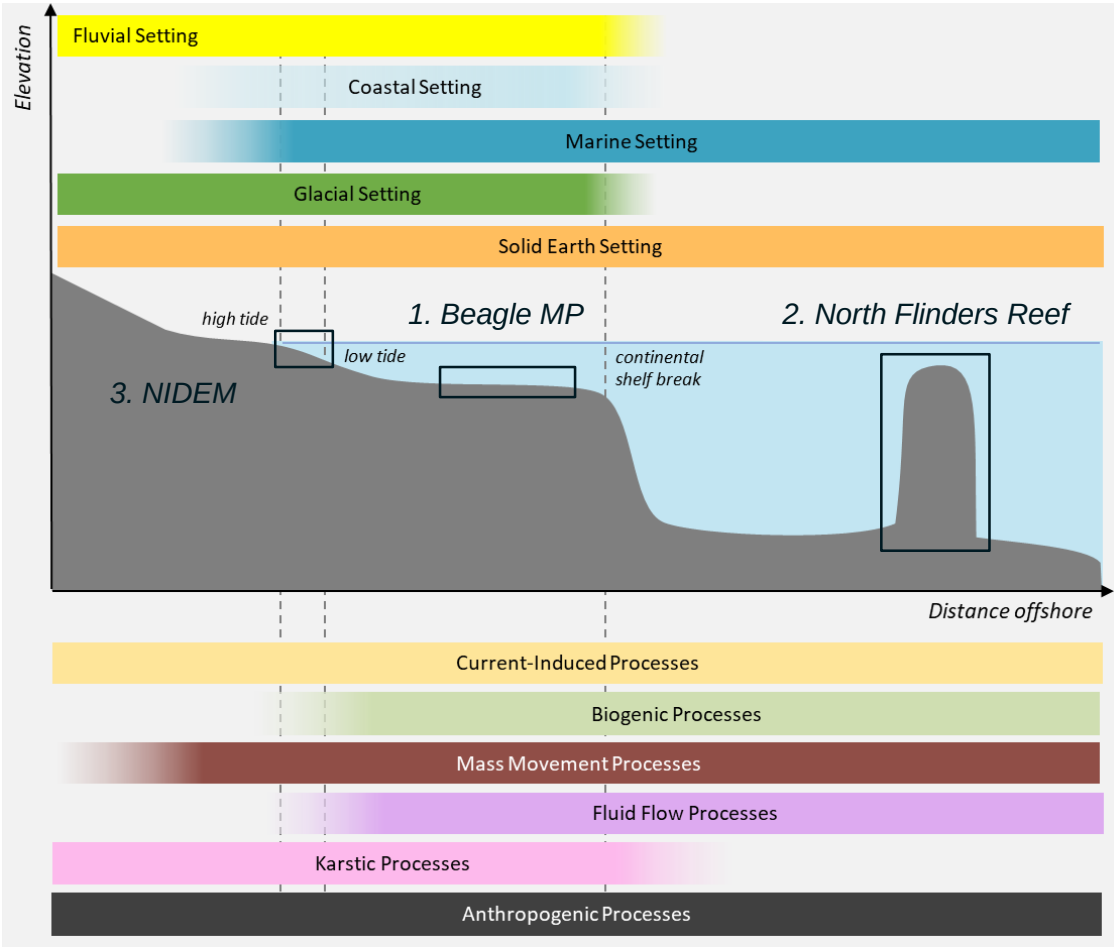
Ireland's Marine Atlas
Access to Ireland's marine data and related information

- includes 33 different geomorphic units and 3 substrate types;
- adopted the **MIM-GA (two-part) classification scheme**;

https://atlas.marine.ie

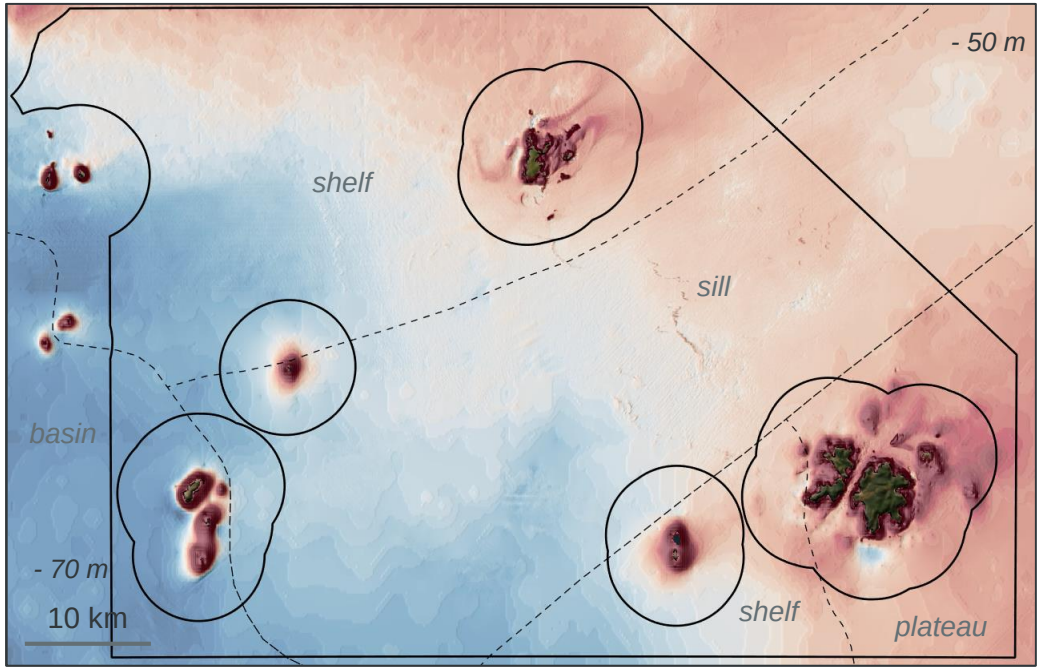
BGS Seabed Geology – map series



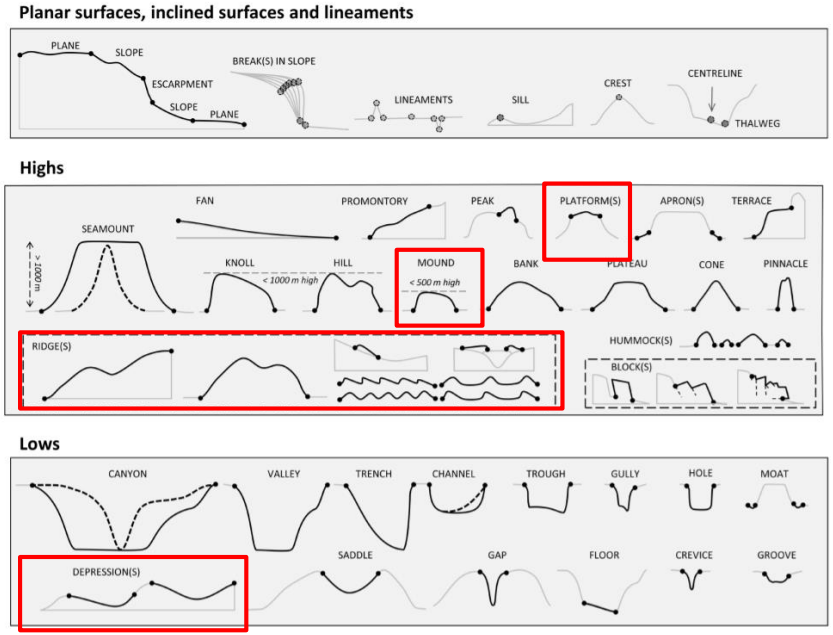


1. Beagle Marine Park

Part 1: Morphology (bathymetry)

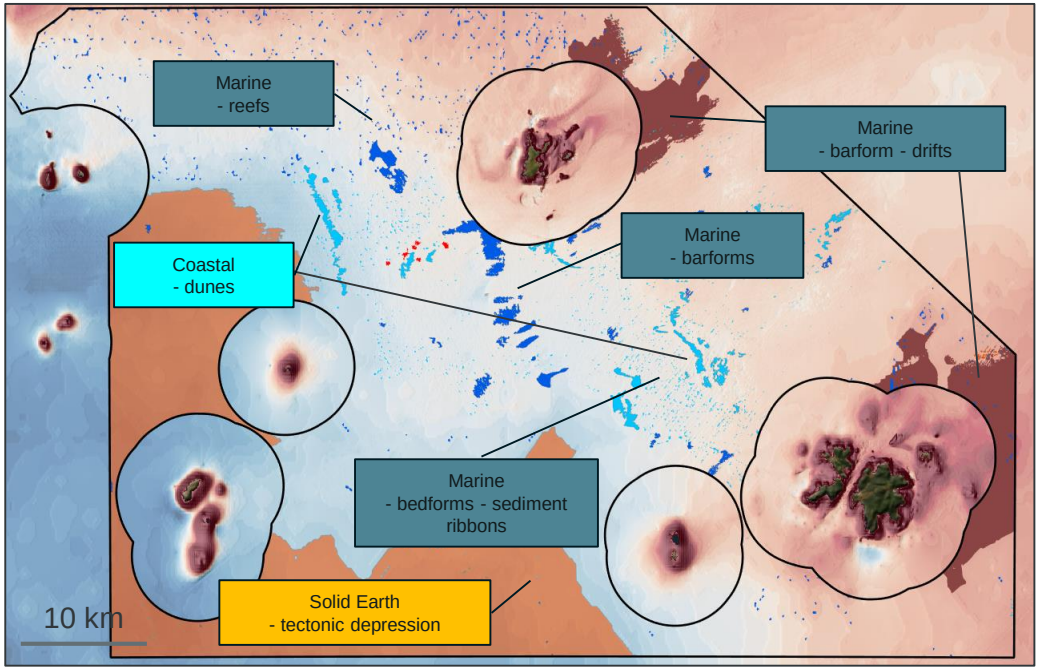


Heap and Harris (2008)

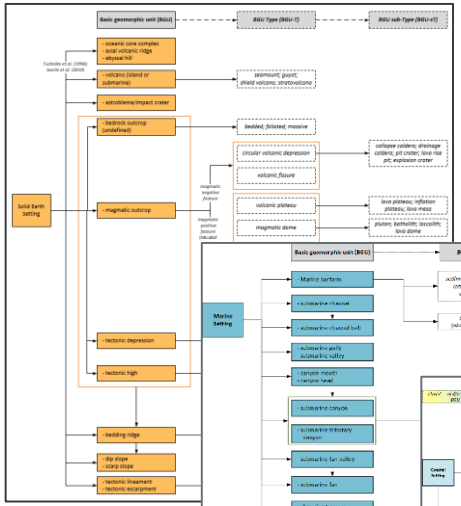


1. Beagle Marine Park

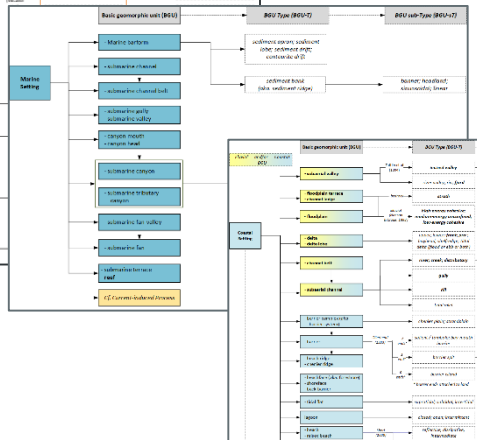
Part 2: Geomorphology



Solid Earth Setting



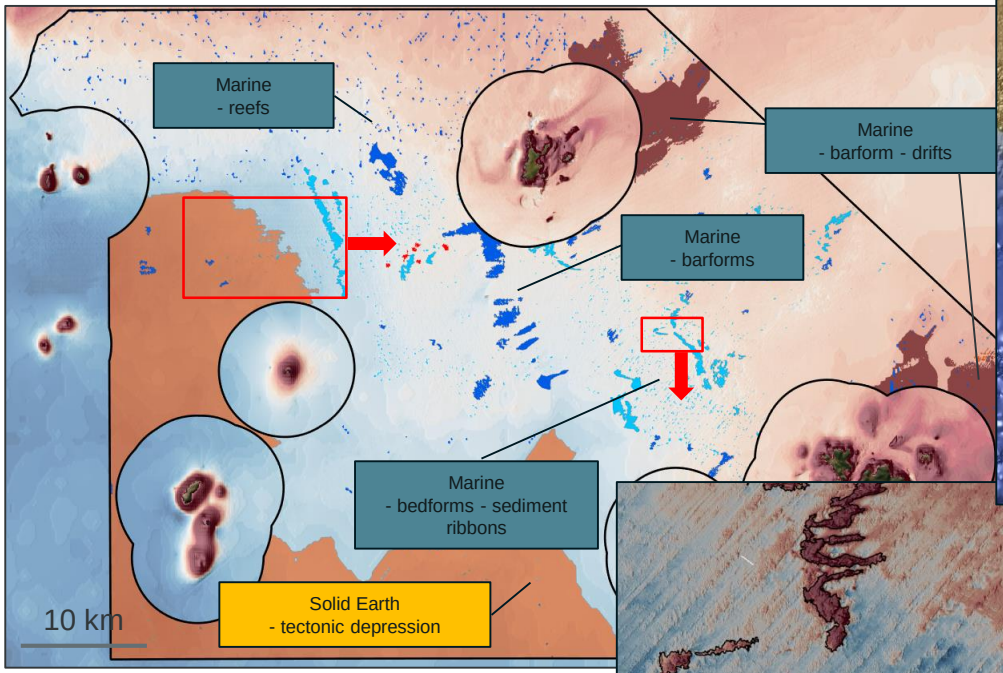
Marine Setting

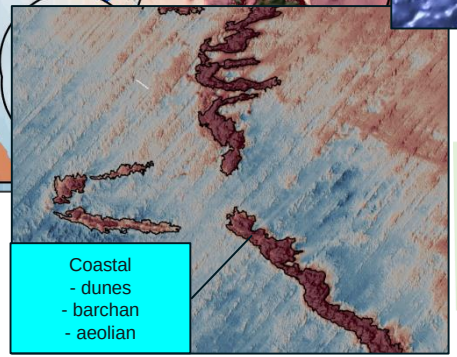


Coastal Setting

1. Beagle Marine Park

Part 2: Geomorphology





Potential applications

(I) to infer potential habitat

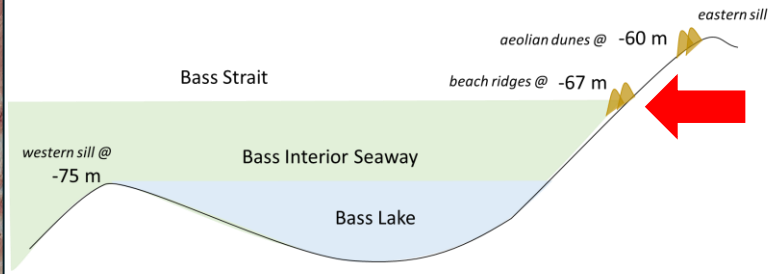
(II) seafloor stability assessment

(III) sediment modelling

(IV) climate and past environment reconstruction

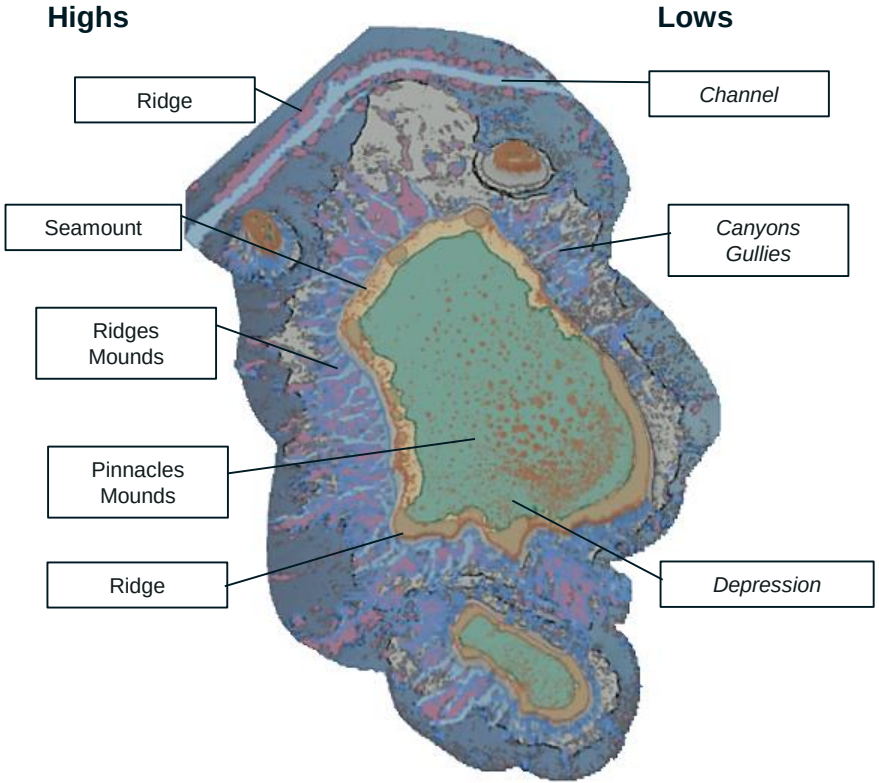
(V) coastal and marine management

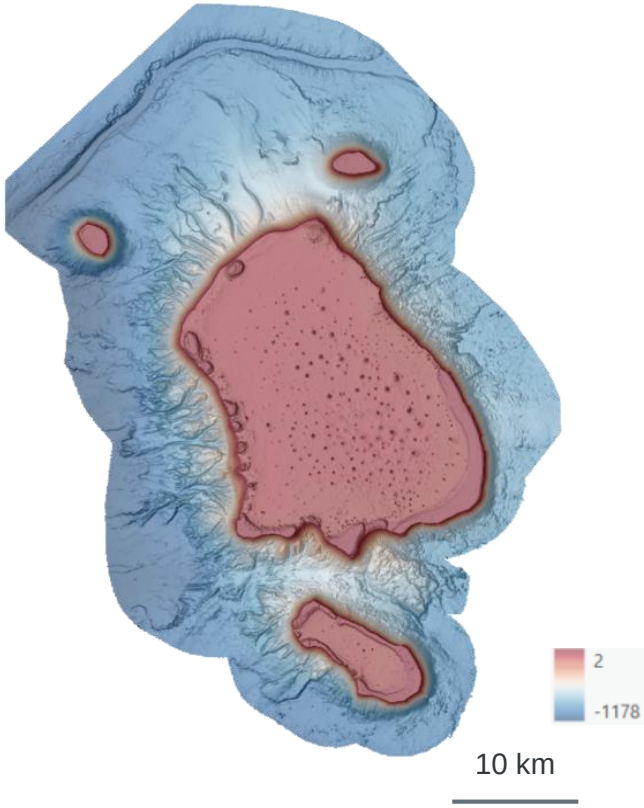
(VI) mineral resources assessment



1. North Flinders, Coral Sea Marine Park

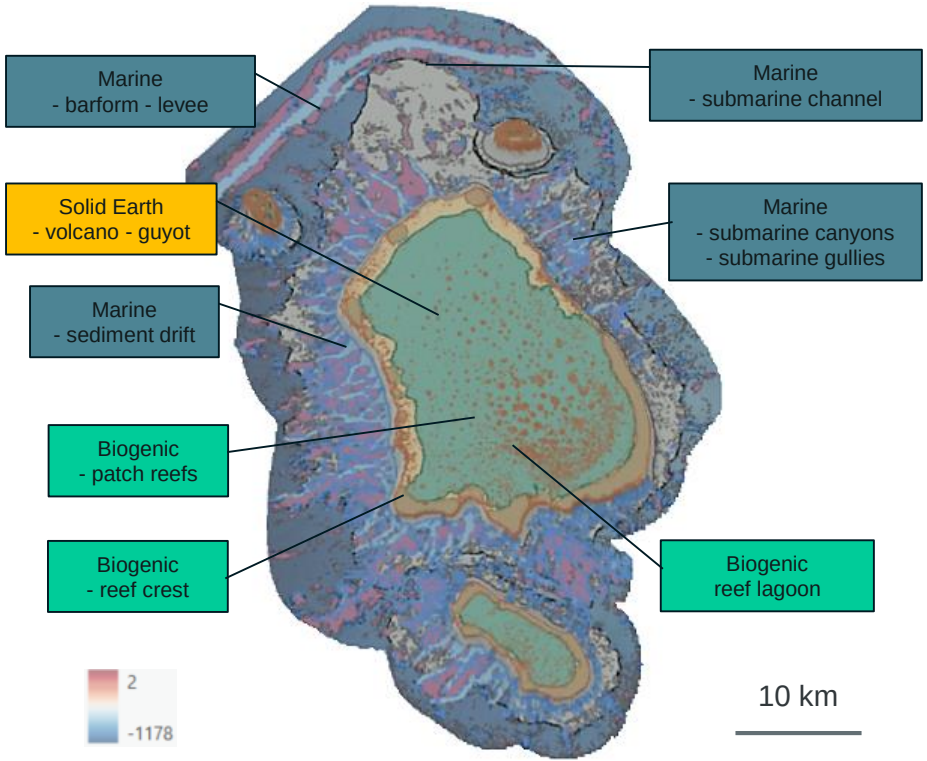
Part 1: Morphology



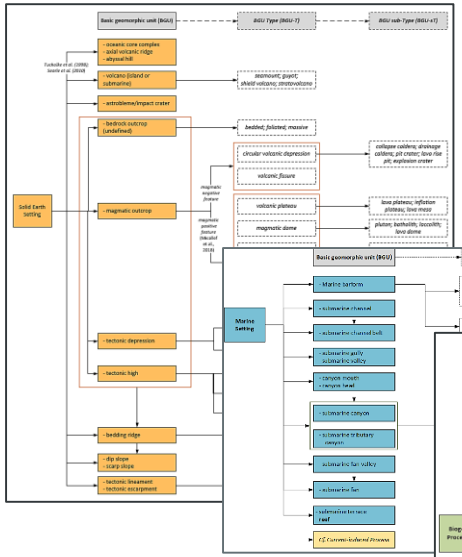


1. North Flinders, Coral Sea Marine Park

Part 2: Geomorphology

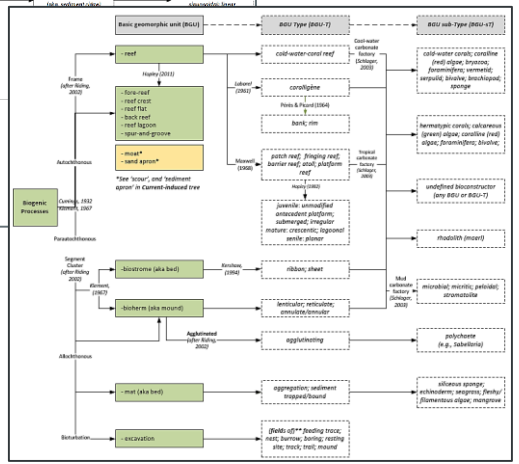


Solid Earth Setting



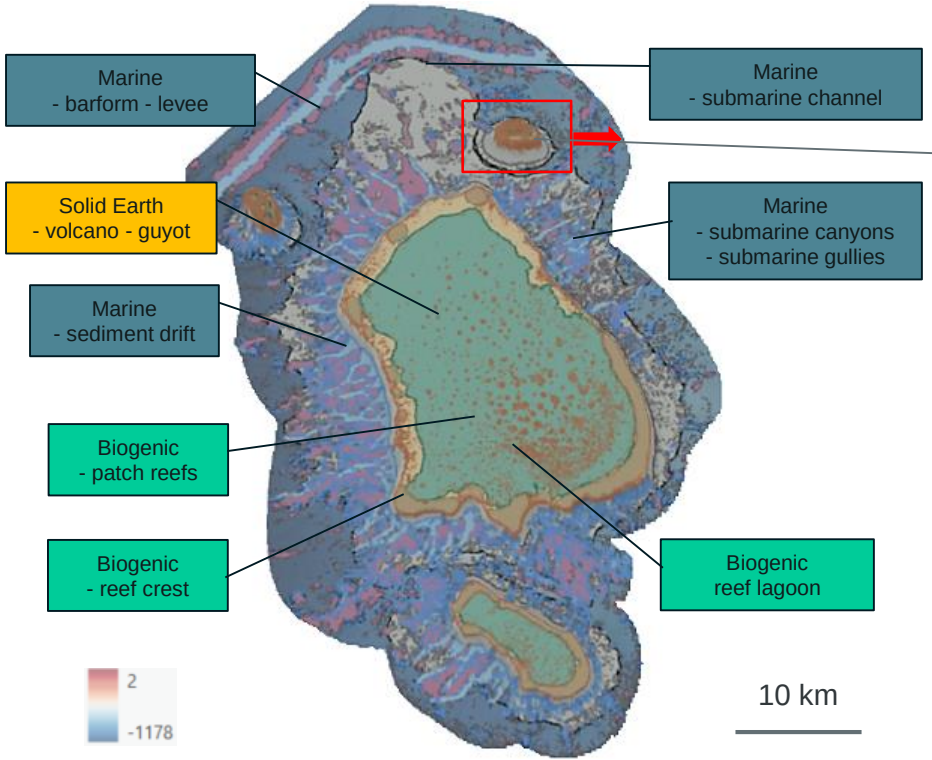
Marine Setting

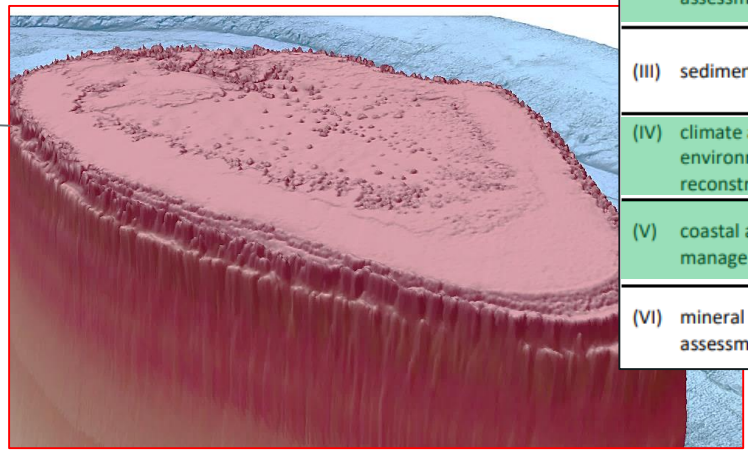
Biogenic Processes



1. North Flinders, Coral Sea Marine Park

Part 2: Geomorphology





Potential applications	
(I)	to infer potential habitat
(II)	seafloor stability assessment
(III)	sediment modelling
(IV)	climate and past environment reconstruction
(V)	coastal and marine management
(VI)	mineral resources assessment

Multiple palaeo-*reef crests (BGU)*

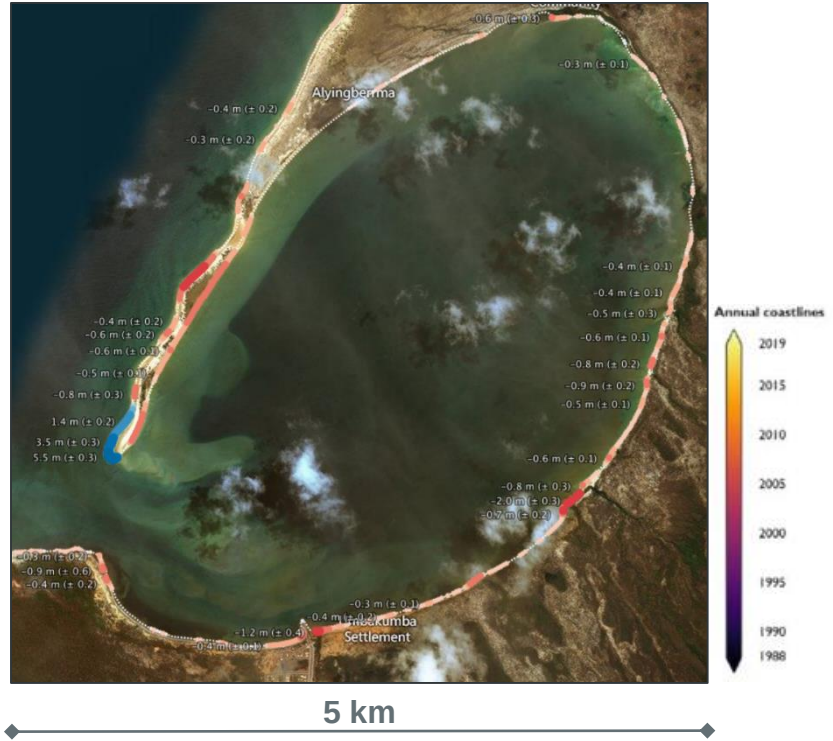
- indicate former sea levels
- now comprise the *fore-reef* (BGU)

3. Groote Eylandt (NT)

DEA Intertidal DEM pilot project – the new NIDEM

Groote Eylandt Archipelago

Dynamic (DEA) Coastlines

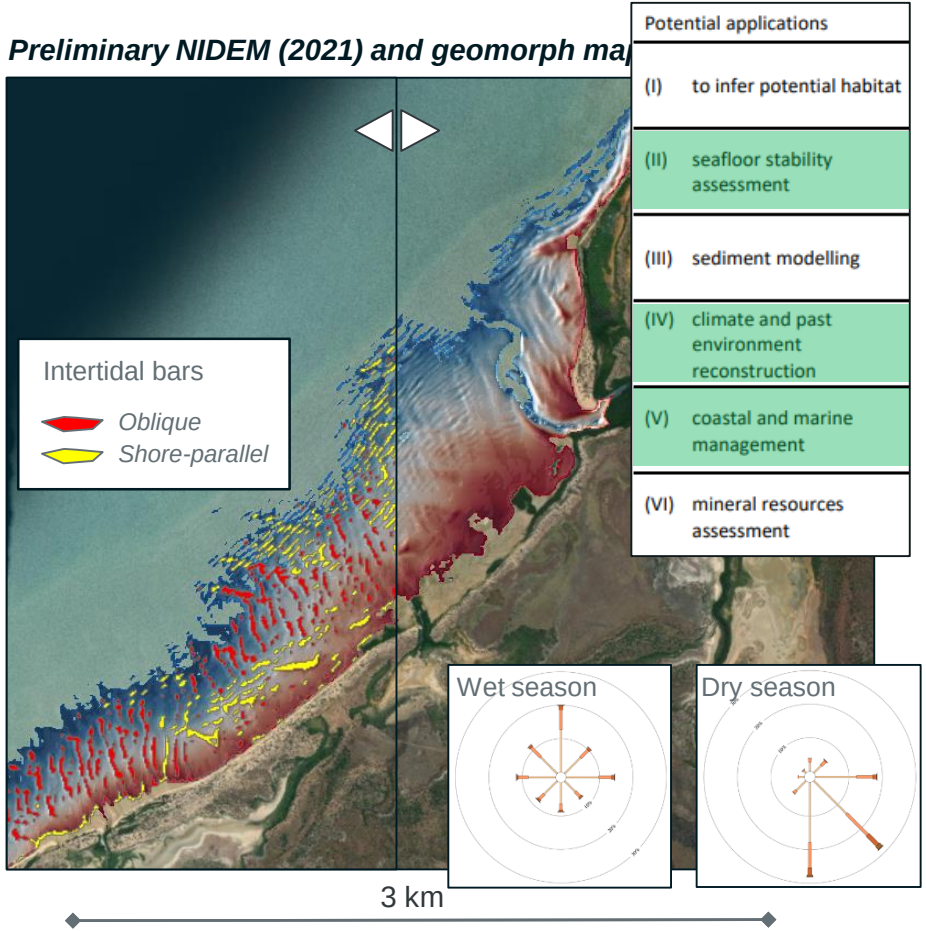


3. Groote Eylandt (NT)

DEA Intertidal DEM pilot project – the new NIDEM

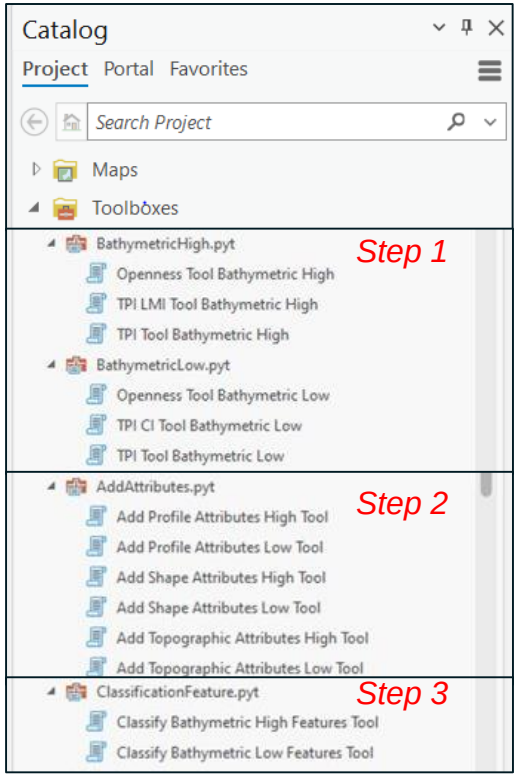
Groote Eylandt Archipelago

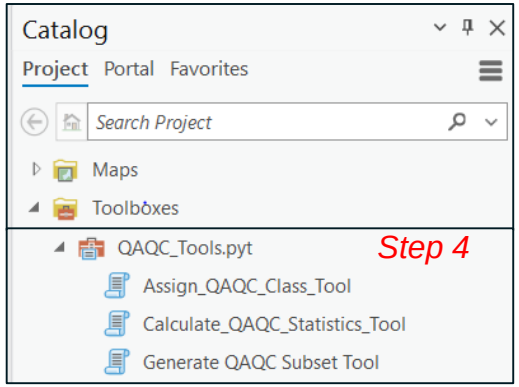
Preliminary NIDEM (2021) and geomorph ma



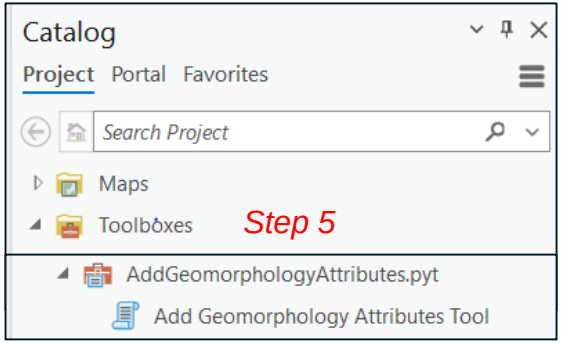
Operationalising the two-part scheme – ESRI

Part 1 Morphology mapping tools - published





Part 2 Geomorphology tool (DRAFT)



Cartographic style (DRAFT)

Step 6:

Future work

1. Application:
   - To the new (2023) national 250 m grid >>
   - To regional grids (e.g. Bass Strait 30 m 2023)
   - Advice to IHO/SCUFFN on how to translate B6

2. Tools
   - Finalise Part 2 tools
   - Migrate all tools to Github to support their refinement

3. Products:
   - SOP, ESRI cartographic style, web services, Part 2 manuscript, Story Map, tutorial module

https://www.ausseabed.gov.au/resources/news

Please direct feedback to: Rachel.Nanson@ga.gov.au

IHO-based classifications

IHO B-6 (2019)

I. GENERIC TERMS

NOTE: Only the generic terms in this section should be used in any new undersea feature name proposal that is intended for submission to SCUFN.

ABYSSAL PLAIN

An extensive, flat or gently sloping region, usually found at depths greater than 4000 m.

APRON

A gently dipping SLOPE, with a smooth surface, commonly found around groups of islands and SEAMOUNTS.

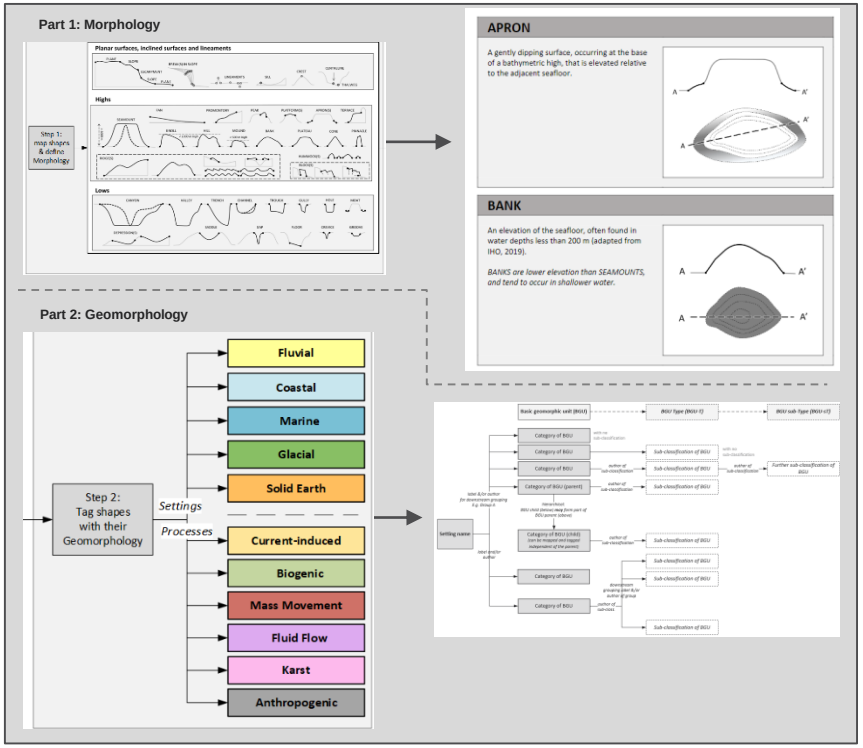
BANK

An elevation of the seafloor, at depths generally less than 200 m, but sufficient for safe surface navigation, commonly found on the continental shelf or near an island.

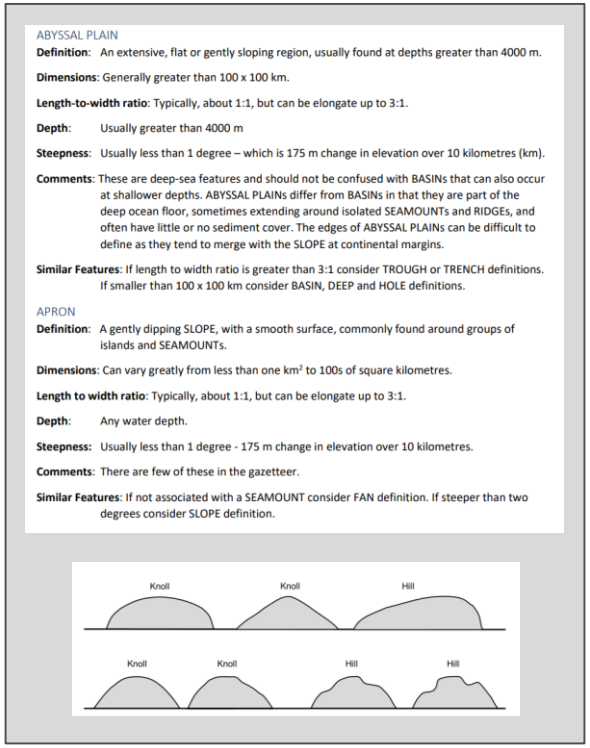
BASIN

A depression more or less equidimensional in plan and of variable extent.

Two-part scheme (2020, 2022)



Cookbook (2022)



IHO-based classifications

Term	B6	Two-part scheme def	Morph (Part 1) or Geomorphology (Part 2)?	Cookbook
APRON	A gently dipping SLOPE, with a smooth surface, commonly found around groups of islands and SEAMOUNTS.	A gently dipping ~~SLOPE~~ surface, occuring at the base of a bathymetric high, that is elevated relative to the adjacent seafloor.	Morphology	Definition: A gently dipping SLOPE, with a smooth surface, commonly found around groups of islands and SEAMOUNTs Dimensions: Can vary greatly from less than one km2 to 100s of square kilometres. Length to width ratio: Typically, about 1:1, but can be elongate up to 3:1. Depth: Any water depth. Steepness: Usually less than 1 degree - 175 m change in elevation over 10 kilometres.
BANK	An elevation of the seafloor, at depths generally less than 200 m, but sufficient for safe surface navigation, commonly found on the continental shelf or near an island.	An elevation of the s found in depths less ~~but sufficient for safe navigation, common continental shelf or r~~		

Term	B6	Two-part scheme def	Morph (Part 1) or Geomorphology (Part 2)?	Cookbook
ABYSSAL HILL	An isolated small elevation on the deep seafloor.	An isolated (or tract of) small elevation(s) on the deep seafloor parallel to a mid ocean ridge and formed by volcanism and block faulting.	Geomorphology Solid Earth – abyssal hill;	Definition: An isolated small elevation on the deep seafloor Comments: Alternative Term: HILL
ABYSSAL PLAIN	An extensive, flat or gently sloping region, usually found at depths greater than 4000 m	An extensive, flat or gently sloping region, usually found at depths greater than ~~4000 m~~ 4 km, covered by up to 1 km sediment thicknesses consisting of fine-grained erosional detritus and biogenic particles	Geomorphology Physiographic – abyssal plain	Definition: An extensive, flat or gently sloping region, usually found at depths greater than 4000 m. Dimensions: Generally greater than 100 x 100 km. Length-to-width ratio: Typically, about 1:1, but can be elongate up to 3:1.

Term	B6	Two-part scheme def	Morph (Part 1) or Geomorphology (Part 2)?	Cookbook
MEDIAN VALLEY	The axial depression of the MID-OCEANIC RIDGE.	N/A	N/A	Definition: The axial depression of the MID-OCEANIC RIDGE. Comments: Alternative Term: TROUGH.