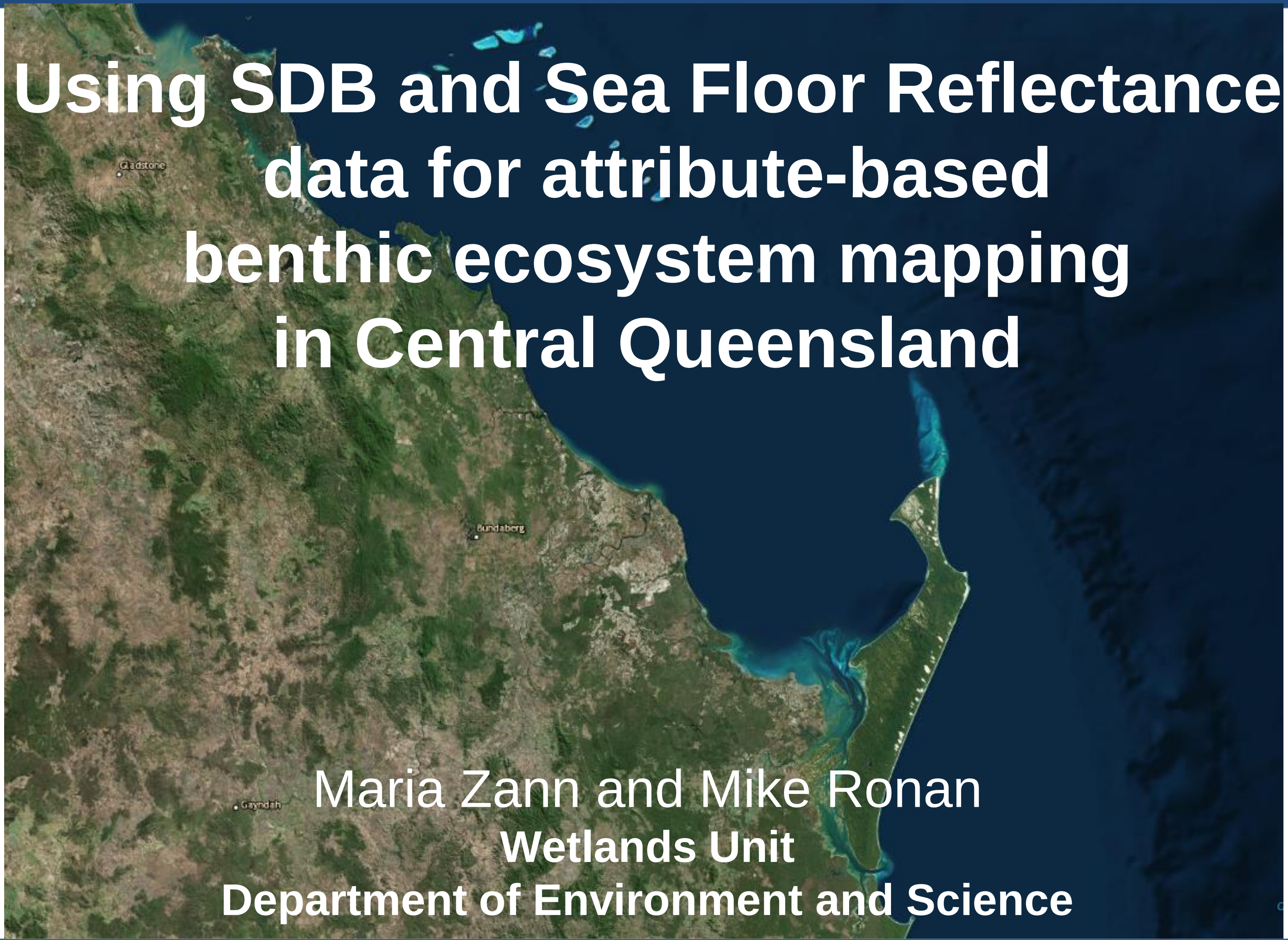
Using SDB and Sea Floor Reflectance data for attribute-based benthic ecosystem mapping in Central Queensland



Maria Zann and Mike Ronan
Wetlands Unit
Department of Environment and Science

Queensland Wetlands Program

Queensland Government

About this talk

- Classification - difference between classification and typology
- Principles and application of the attribute-based classification scheme
- Devising the attribute datasets
- SDB incorporation into CEQ 30 bathymetry DEM – Beaman 2017
- Attribute contributions from SDB
- Attribute contributions from SFR
- Demonstration – online ecosystem type mapping linked to attributes
- Advantages / limitations of using SDB in nearshore ecosystems
- Conclusion & effectiveness of attribute classification source datasets

Why classify – to understand the nature of things

Classification vs. Typology

Classification

Defining individuals according to different attributes

- E.g. height, body mass, body fat %, gender, hair colour etc.
- All attributes are equal, no order implied

Typology

Assigning individuals to "types" – named combinations of homogenous classes

- E.g. "athletic", "fit", "slim", according to height, body mass AND body fat %
- Typology uses a subset of all available attributes for a specific purpose
- For the above typology, attributes such as hair colour or gender were not needed.
- Types are created in a hierarchy

An attribute-based classification scheme

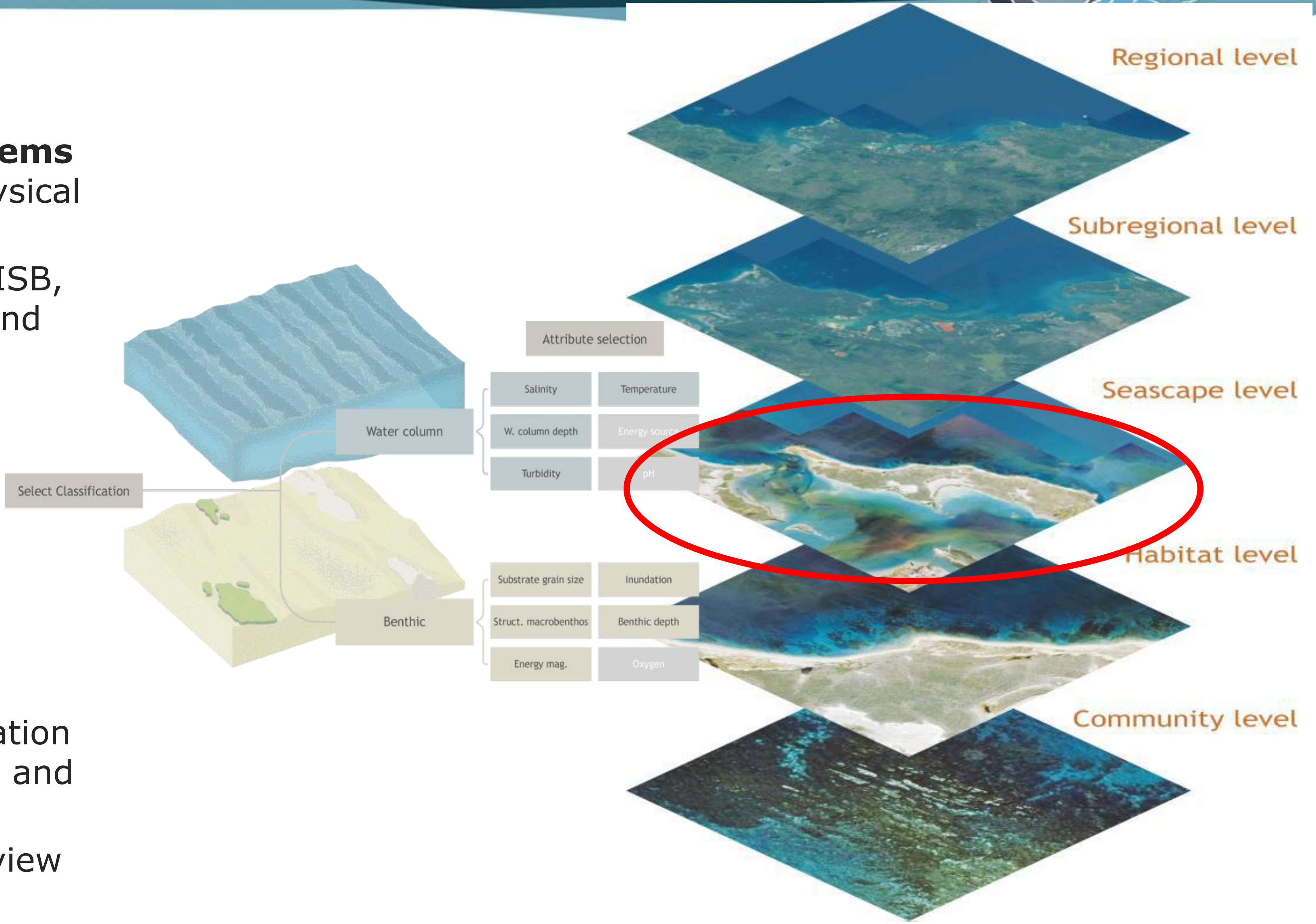
*'The Qld Intertidal & Subtidal Ecosystem Classification Scheme' (QISC) **

Principles

- the **nature and extent of ecosystems** is underpinned by biological and physical attributes
- Nationally compatible with ANAE /NISB, and with Qld Regional Ecosystems and Wetlands
- Levels – a spatial hierarchy
- Benthic & water column treated separately

Informed by

- QISC Module 1 –devised in collaboration and consultation with >70 scientists and managers 2014 - 2017
- QISC Module 2 - Comprehensive review



*https://wetlandinfo.des.qld.gov.au/wetlands/what-are-wetlands/definitions-classification/classification-systems-background/intertidal-subtidal/

Applied in separate Attribute Classification and Typology stages

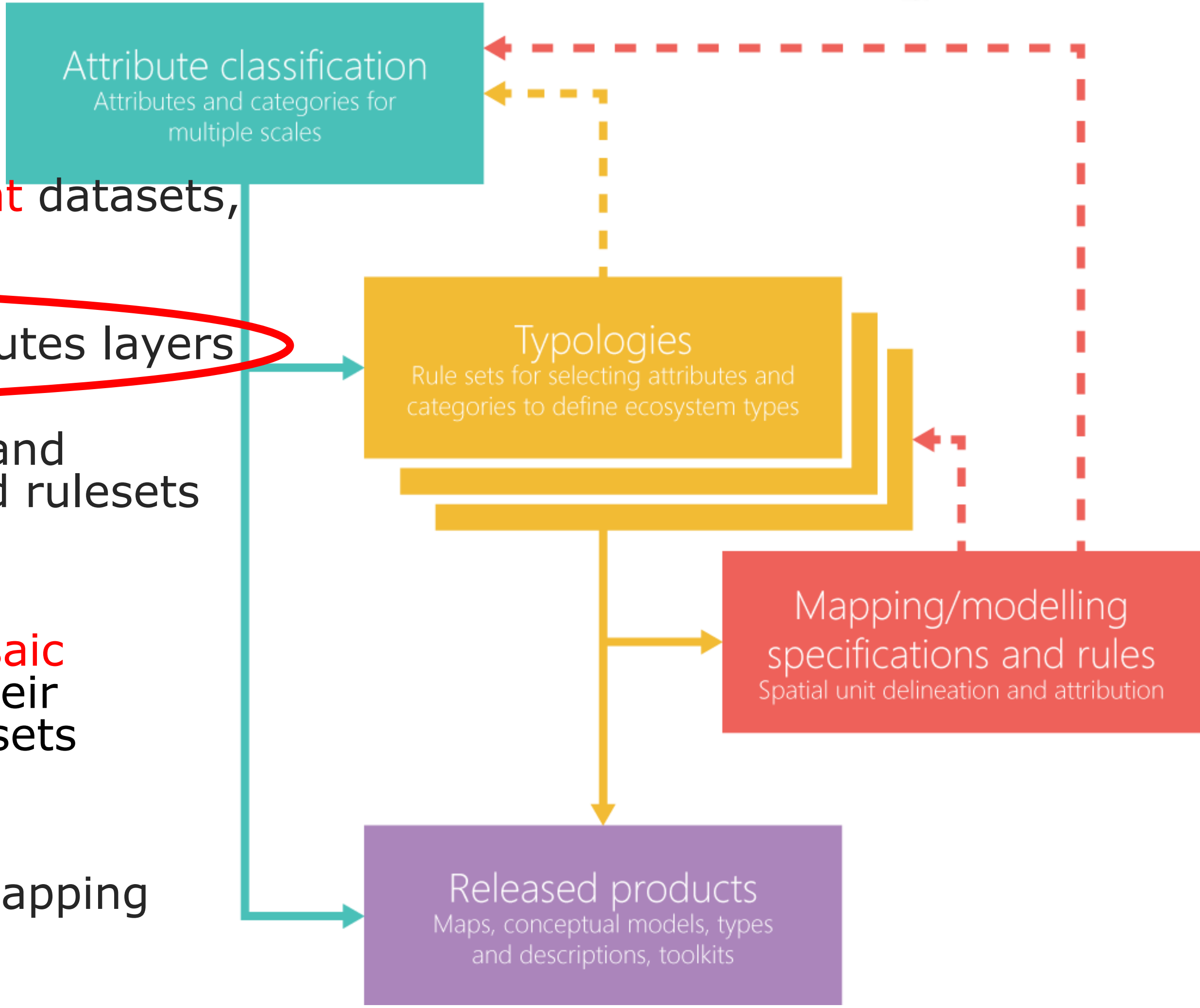
- **Attribute classification stage** precedes devising **Typology** rules based on a subset of attributes – to address a specific
  - Purpose, and
  - Level.

- **Mapping inputs** include inventory from multiple extent datasets, "cross-walked" to the attributes of the classification

  - **Mapped attribute classification**: compiled attributes layers

  - **Mapped typology**: attribute combinations define and delineate ecosystem types based on expert-devised rulesets

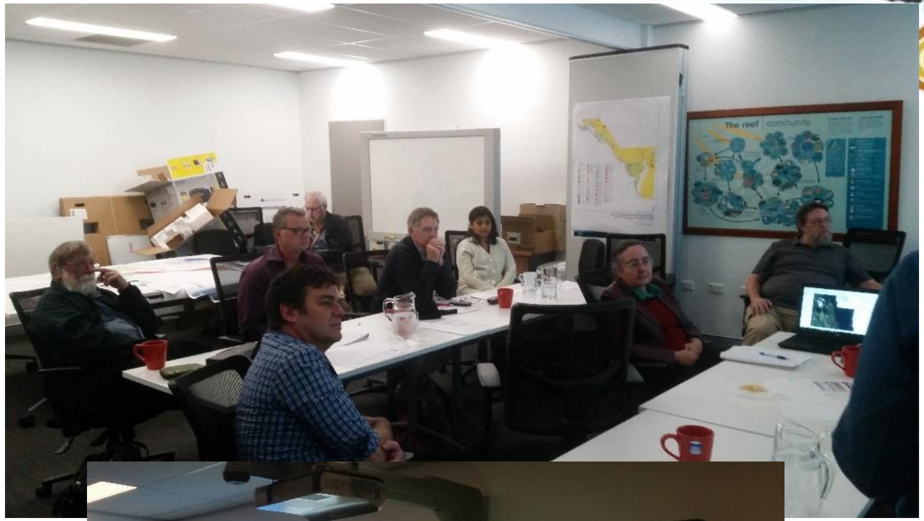
- **Products** (e.g. CQ project)
  - **Ecosystem components** –i.e. a seamless mosaic composite map of ecosystem types based on their biophysical attributes, compiled attributes datasets
  - **Descriptions** of each ecosystem type
  - Conceptual models
  - Spatial attributes can be applied to the types mapping
  - Toolkits etc.

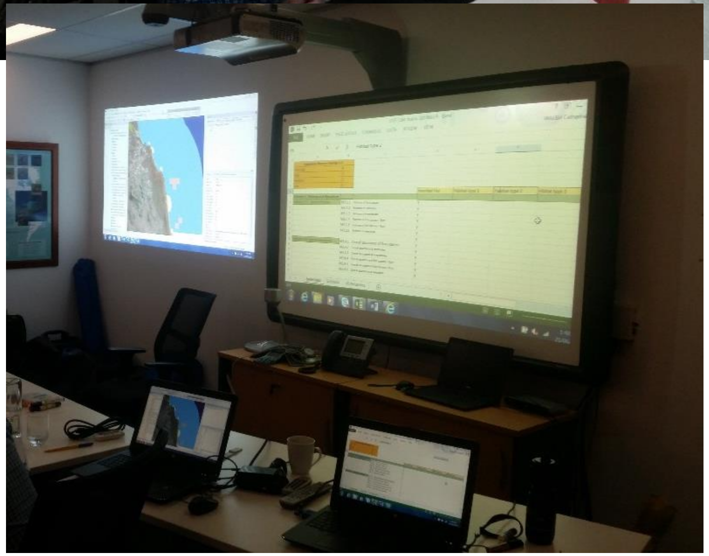


Central Queensland Project Activities & Outputs

- Extent: Fitzroy to Double Island Point state waters
- Module 1: QISC Introduction and Guide 2017 *
- CQ Technical panel workshops 2017, 2018
- **Attribute & type mapping**

- **Conservation Assessment** panels 2018
- Wetland*Info* online releases mid 2019:
    - ***Seascape scale ecosystem types***
    - ***Ecosystem type descriptions***
    - ***Mapping method fact sheet***
    - ***Module 2 Review***
    - ***Module 3 Attribute pages***
- Wetland*Info* online release scheduled mid 2019
    - Conservation assessment Baffle Fitzroy
    - Mapped attribute datasets
    - Mapping Module 4





* https://wetlandinfo.des.qld.gov.au/resources/static/pdf/resources/reports/intertidal-subtidal/module-1-int-sub.pdf

Bathymetry – Fundamental dataset underpins many biophysical attributes of ecosystems

Six of the eight biophysical attributes are informed by the **bathymetry** dataset

- Improved bathymetry a high priority

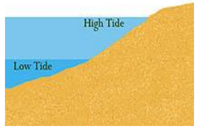
shallow, deep very deep <-

BDEPTH benthic depth

'Consolidated' (rocky ridges and peaks) <-

CONSOL consolidation (rockiness)

subtidal (below LAT) <-



INUNDTN inundation (tidal)

energy model inputs <-

NRG_MAG energy magnitude (wave) [also current]

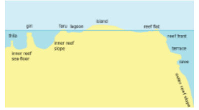
Boulder, etc. <-

SED_TEX sediment texture

SMB_CMP structural macrobenthos composition

SUB_CMP substrate composition

ridges, peaks, holes, channels <-



T_MORPH terrain morphology

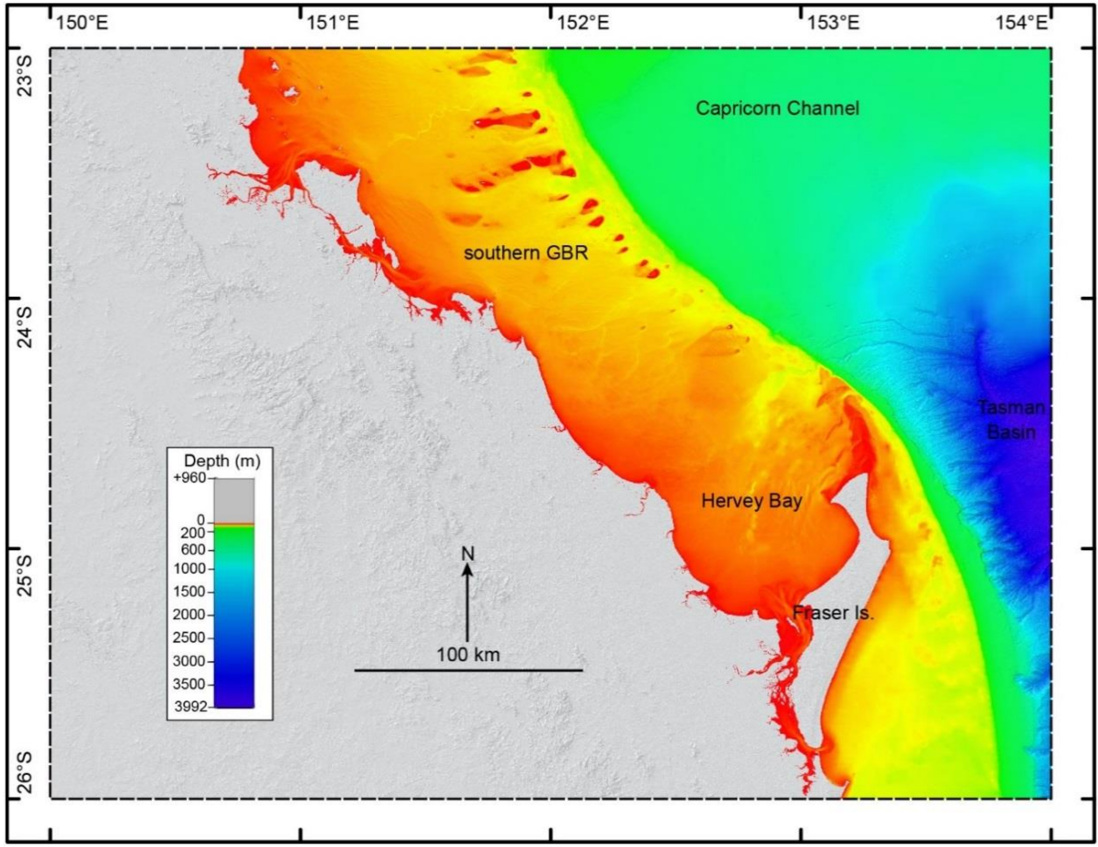
CEQ 30 DEM – Beaman 2017 (DES 2019)

Purpose – to update the GBR100 DEM with existing source data within the Central Queensland project area

Extent - Fitzroy estuary to Double Island Point

Compilation of new & existing source bathymetry data:

- Multibeam and singlebeam echosounder data, incorporating estuaries soundings (USC)
- Electronic Navigational Chart (ENC) spot depths
- Airborne lidar bathymetry (ALB) data
- Intertidal Extents Model (ITEM v1.0) Digital Elevation Model (DEM)
- Satellite derived bathymetry (SDB)
- Coastline data.



Source data are current to 22 June 2017

Citation:
Department of Environment and Science 2019, Development of the ceq30 bathymetry grid for the Intertidal and Subtidal Habitat Mapping and Conservation Values Assessment for Central Queensland State Waters Project, Queensland Government, Brisbane.

Incorporated into
[High-resolution depth model for the Great Barrier Reef - 30 m]

Total Vertical Uncertainty (TVU) of SDB in CEQ30

Based upon International Hydrographic Organization Standards for Hydrographic Surveys Special Publication 44.

- "TVU = Maximum allowable vertical uncertainty at the 95% confidence level (i.e. worst-case uncertainty) for bathymetry surveys."
- *"Satellite derived bathymetry (SDB) data -relatively new - uncertainty values calculated do not conform to established IHO S44 categories.*
- *Work is occurring worldwide validating SDB data against observed lidar and sonar bathymetry data.*
- *The EOMAP-supplied SDB data using Landsat8 imagery quotes the vertical uncertainty of pixels as within an absolute error of 0.5 m, plus a relative (i.e. depth dependent) error of 15%.*
- *These uncertainty results are considered typical for SDB data using similar satellite imagery over tropical waters.*
- *For this Project, the TVU calculations were applied to every depth point prior to interpolation of the TVU grid."*

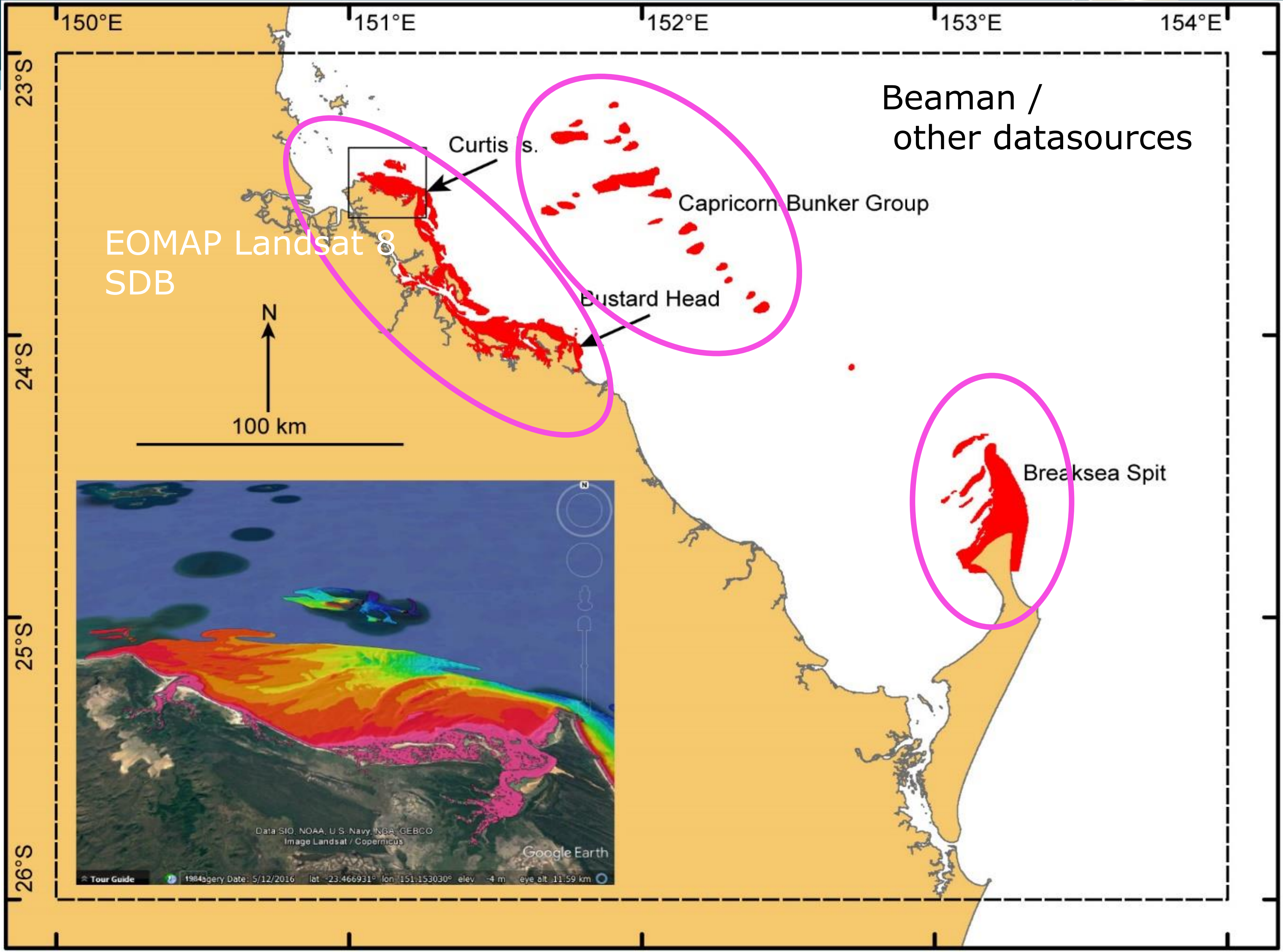
Depth	TVU
0	0.5
5	1.25
10	2.00
15	2.75
20	3.50
25	4.25
30	5.00

Table 4 TVU calculations for SDB data against true depths 0-30 m

SDB data sources

Nearshore coastal bathymetry was very poorly known, very few soundings outside the Port of Gladstone

- EOMAP SDB data based on Landsat 8 imagery 2014 filled a critical gap
- Extent limited by water clarity



SDB data

- EOMAP SDB data
- Merged into CEQ30 DEM

Incorporates USC estuaries datasets

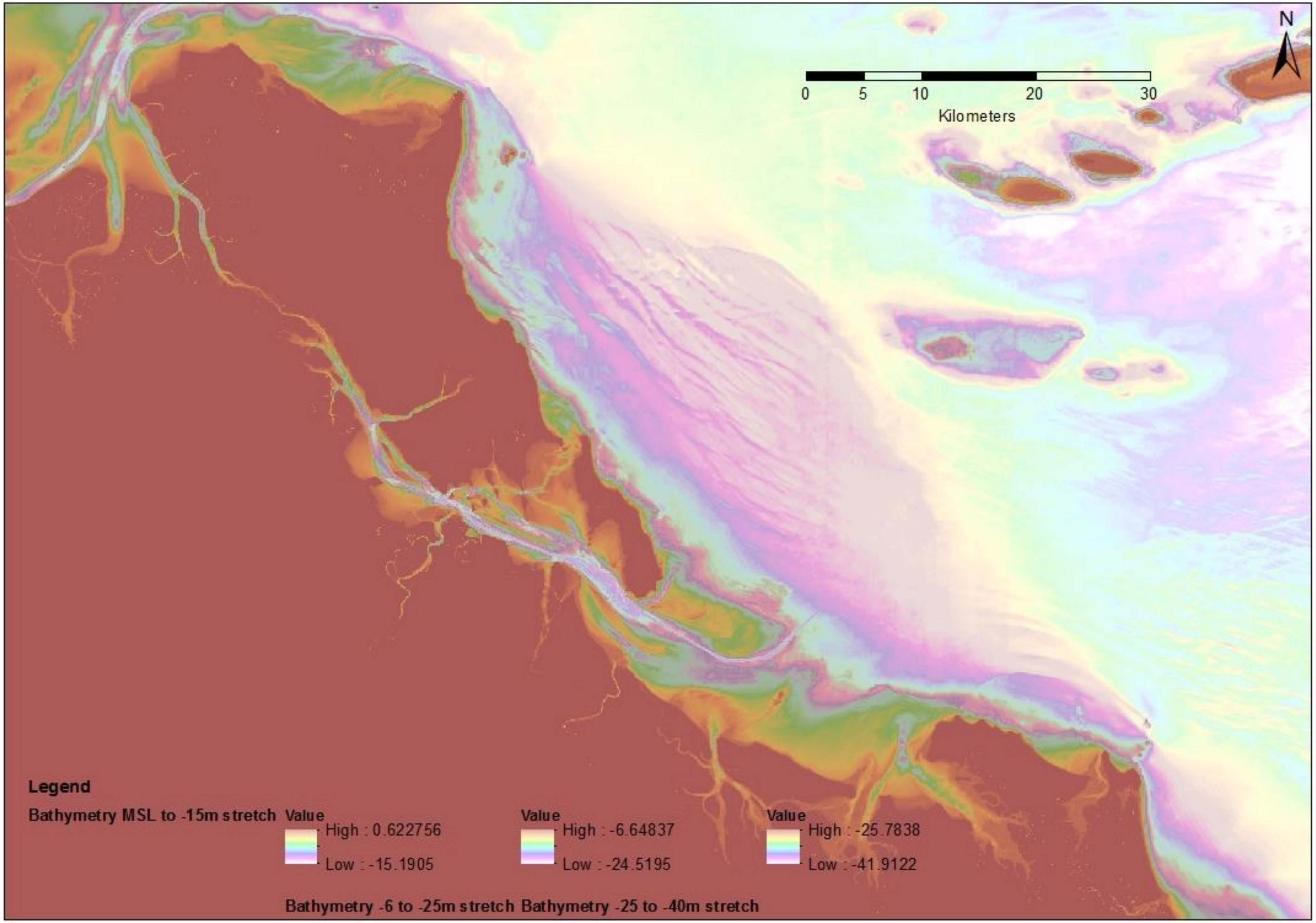
ITEM GA dataset

Point soundings

MBES offshore

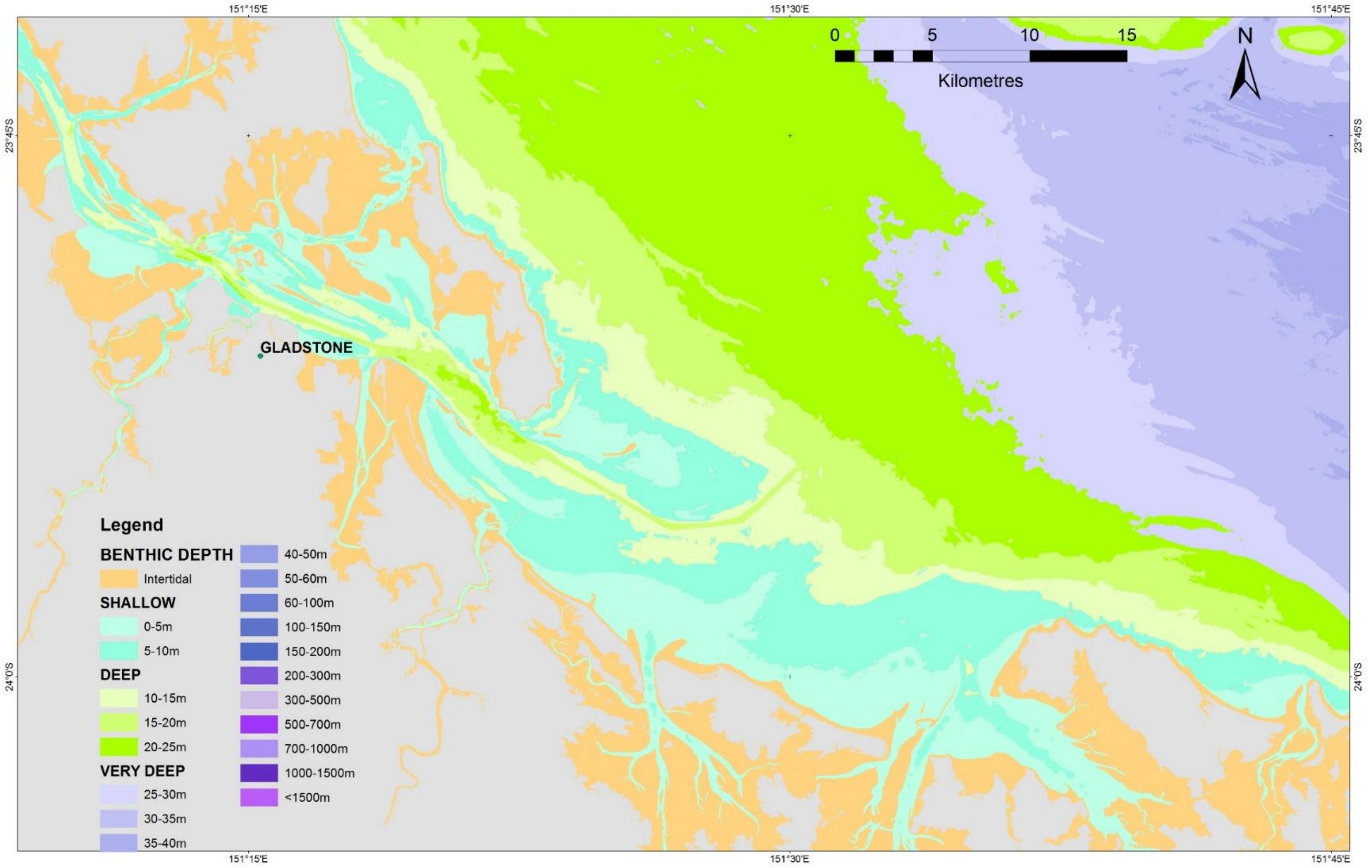
- Close to shore use Terrestrial LiDAR

-> replace intertidal shuttle values with LiDAR



Attribute dataset - Benthic depth

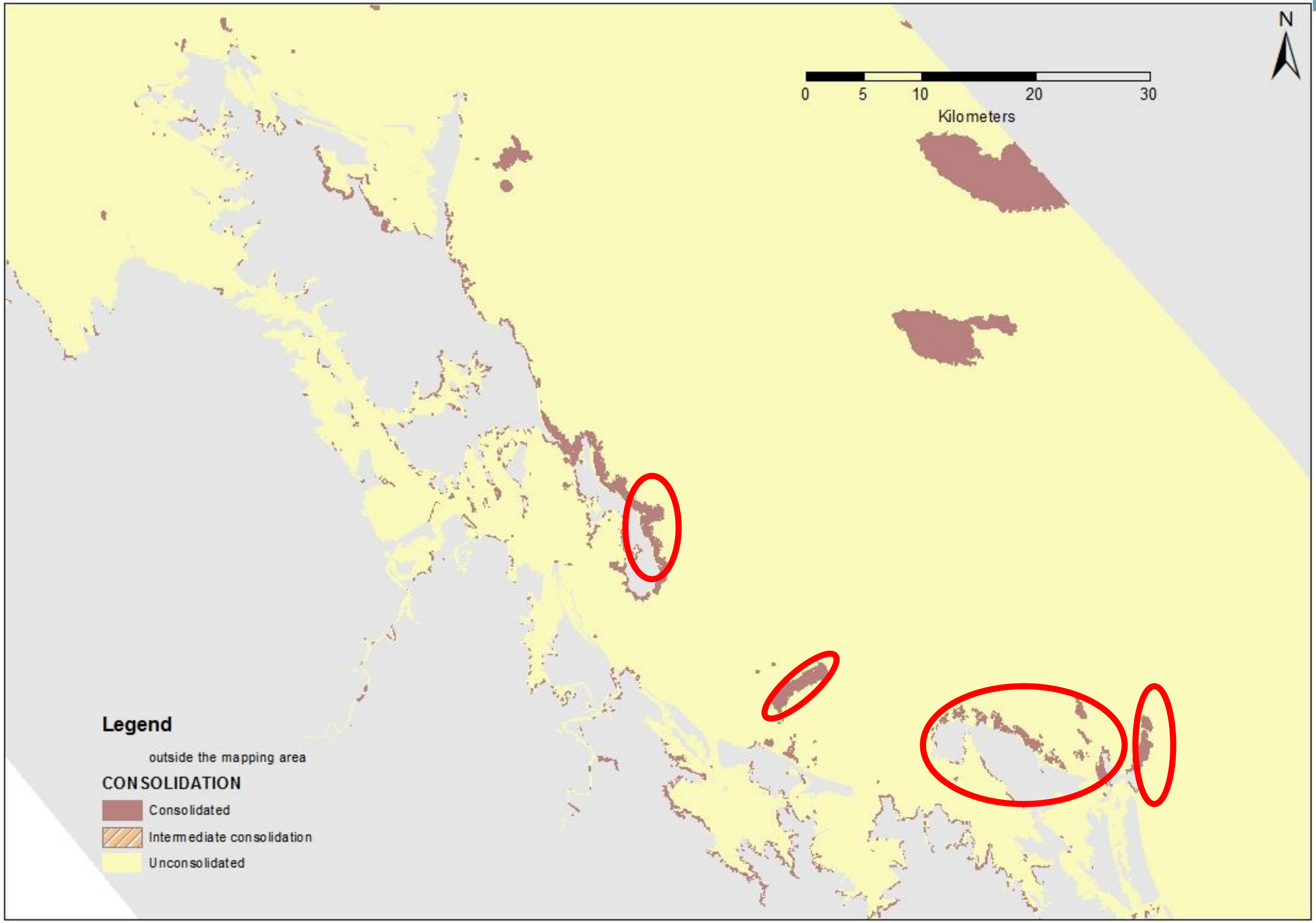
Bathymetry is classified into seascape scale depth intervals
'shallow'
'deep'
'very deep'



Consolidation – for the attachment of biota

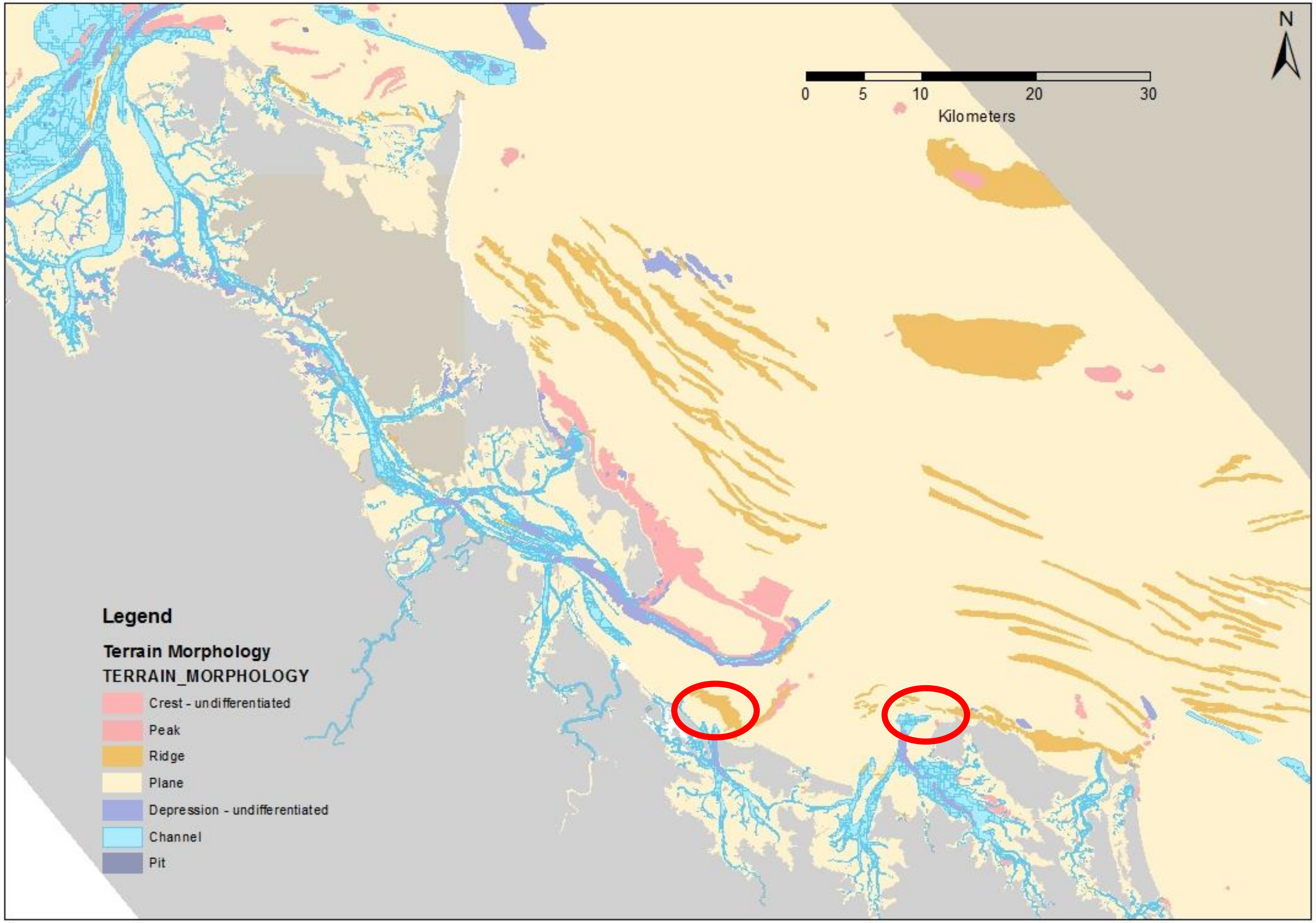
- SDB and Sea Floor Reflectance data sources revealed hitherto invisible subtidal features close to the coast including:
  - Additional reef extent surrounding Facing Island
  - Seal Rocks is a continuous subtidal feature
  - Rodd's Peninsula a complex of reefs
  - Bustard Head's Inner, Middle and Outer rocks are revealed as a continuous subtidal ridge of reefs

➢ A useful base to plan further inventory or review current point or transect SMB data (e.g. coral)



Terrain Morphology

- Nearshore ridges, peaks and channels
- Possibly channel tidal discharge contributing to poor water clarity (potentially affecting depth physics algorithms, SFR)

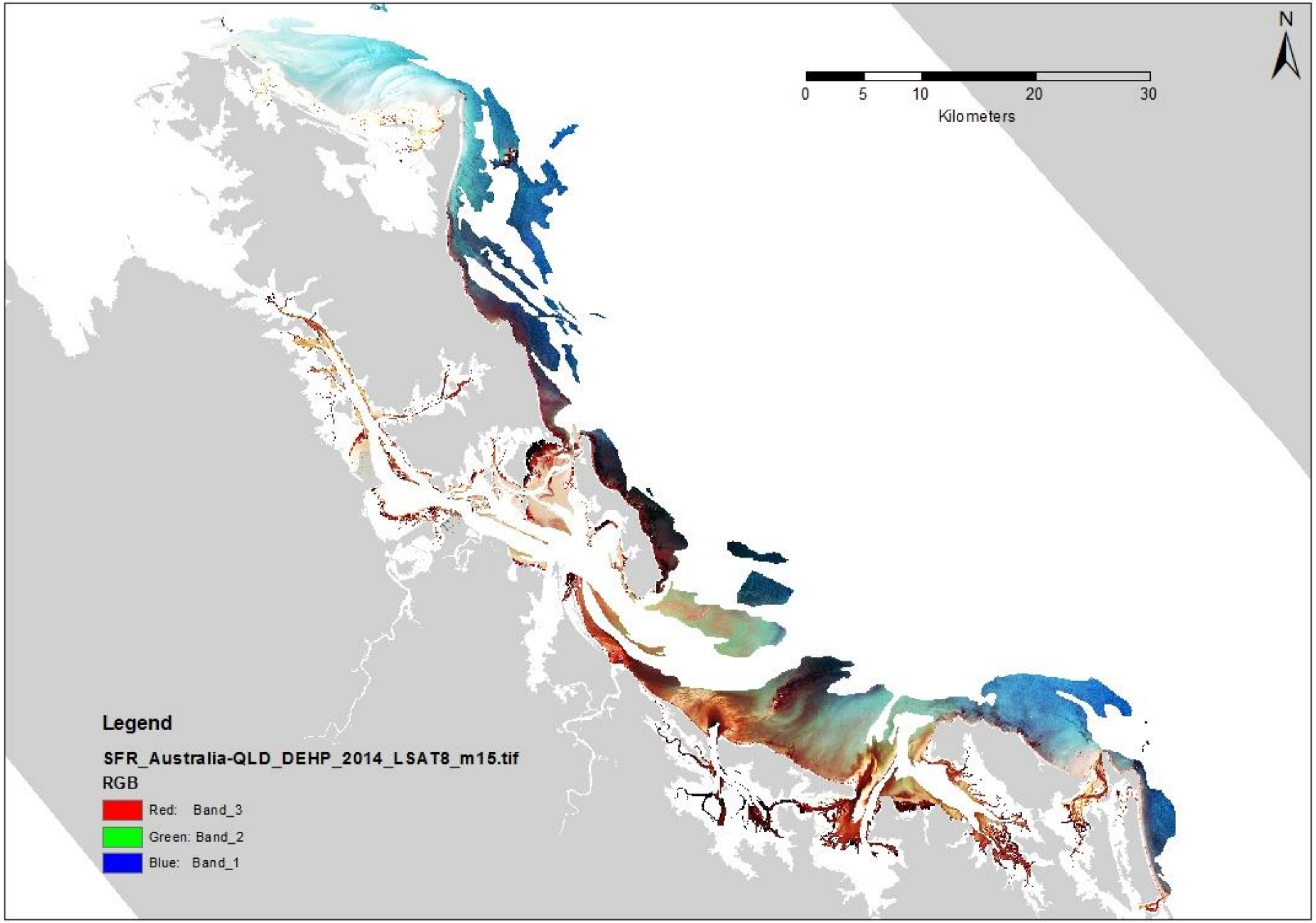


Sea Floor Reflectance data

Depth invariant

Informed:

- Sediment texture
- Consolidation
- (structural macrobiota)



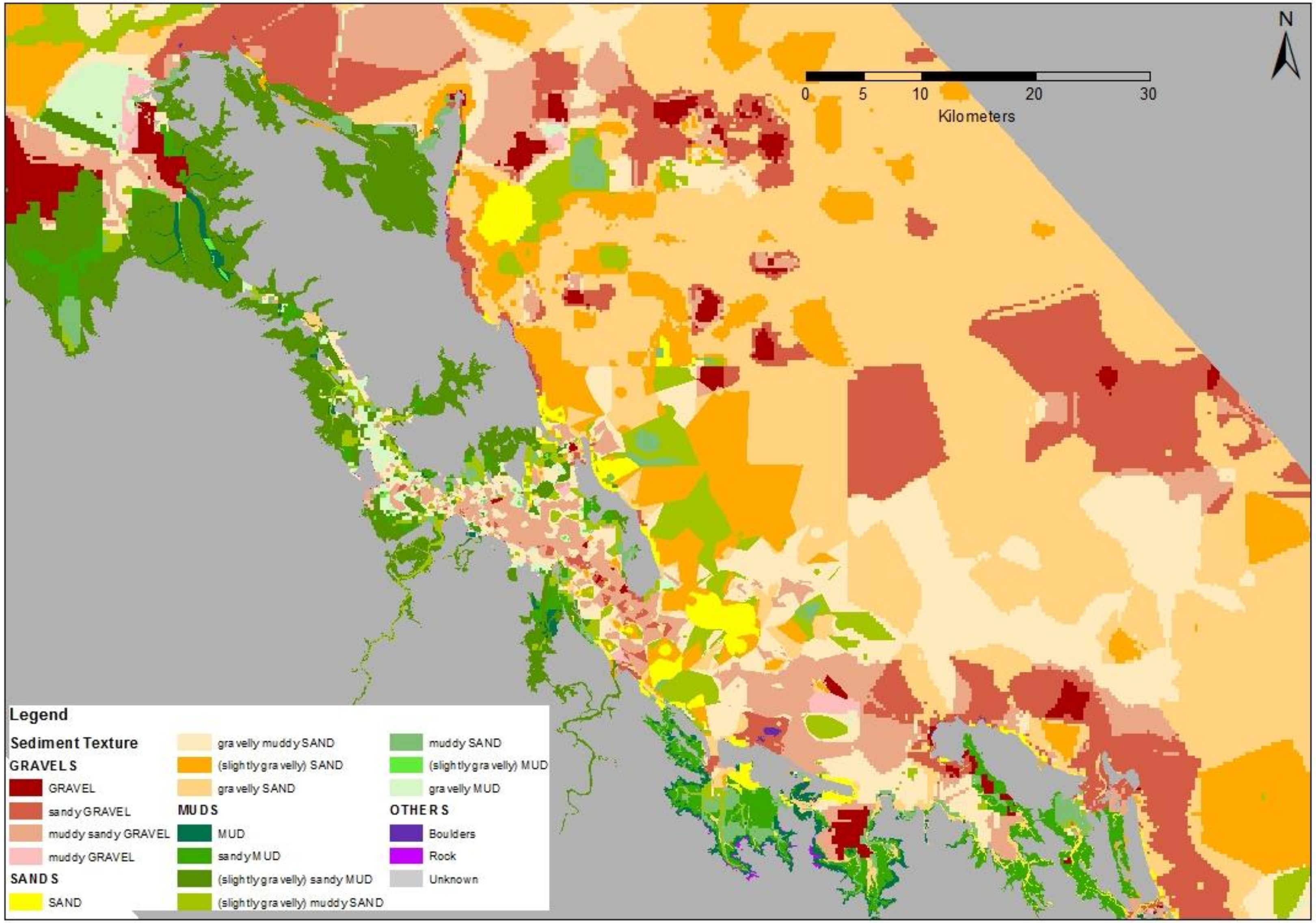
Sediment Texture

Issues

- dbSEABED extracted & interpolated output
- Resolution doesn’t justify smoothing of pixel to 100m

➢ Dearth of sediment info in the intertidal & shallow subtidal

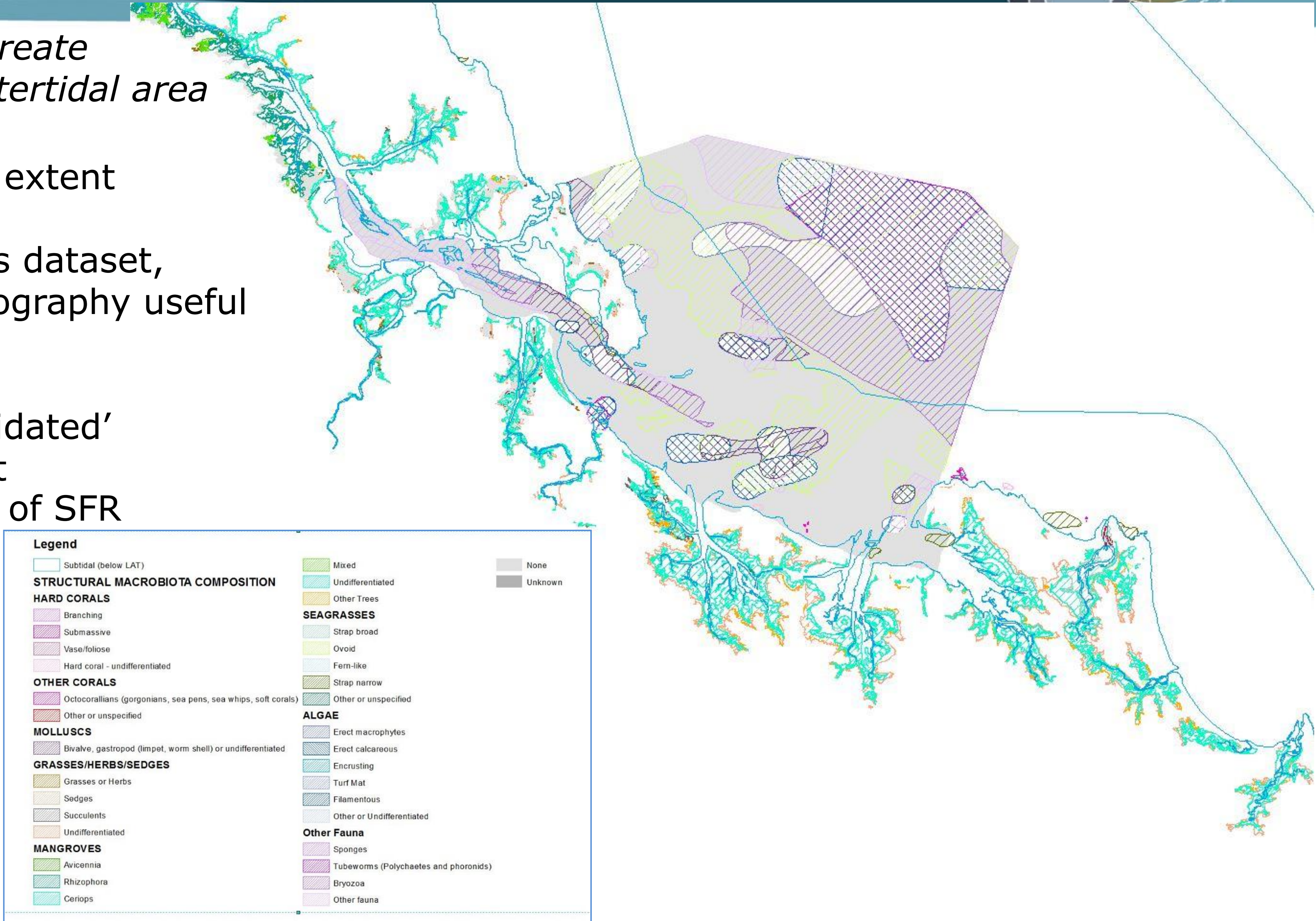
➢ Gap filling exercise, classified SFR data informed manual interpretation of sediment texture



Attribute dataset: Structural macrobiota

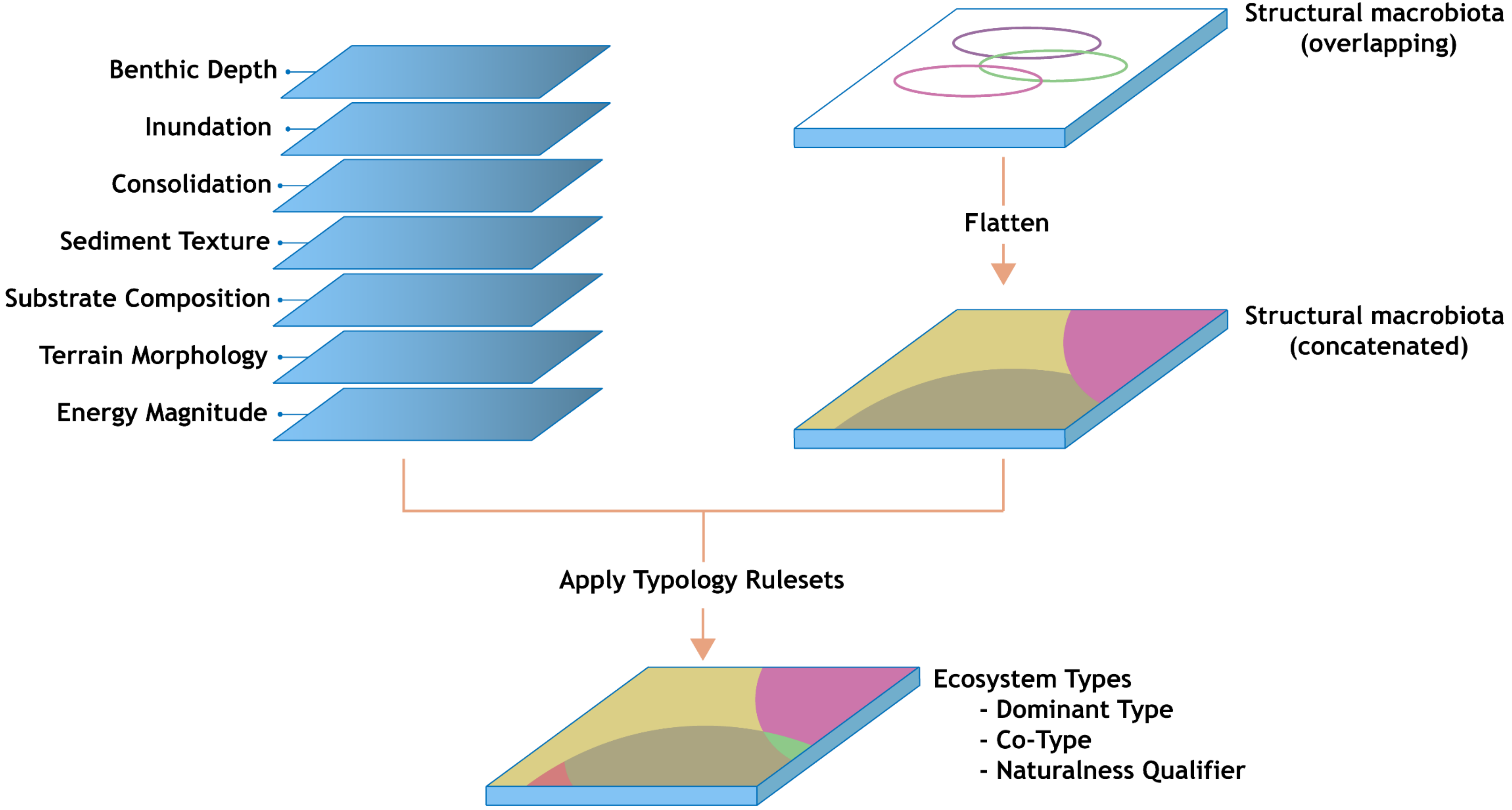
Animals and plants that create structure on the sea floor / intertidal area

- Based on existing mapped extent
- SFR not used to inform this dataset, high resolution aerial photography useful for close inshore
- Potential to review ‘Consolidated’ polygons with coral against unsupervised classification of SFR



From Attribute layers to Ecosystem Types

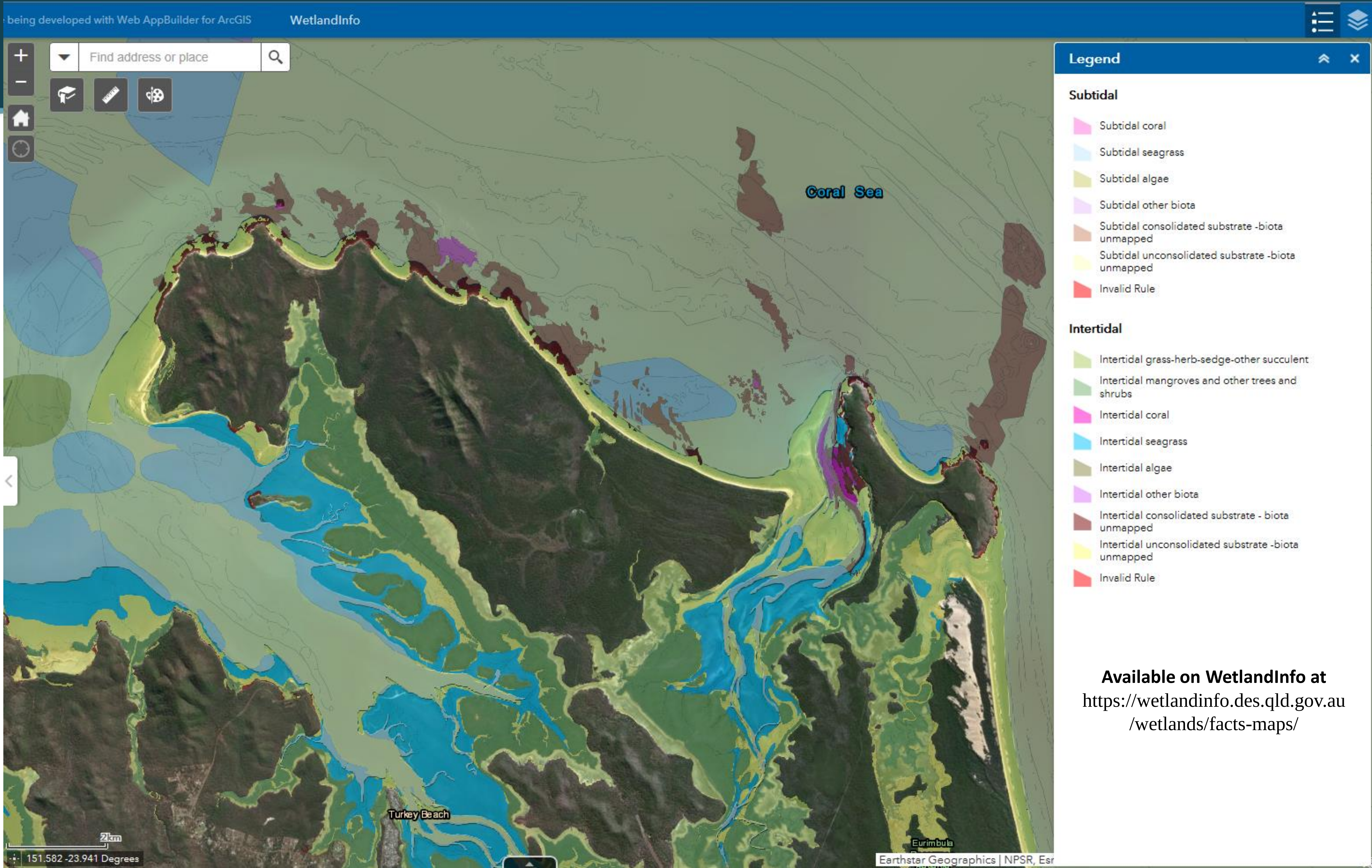
Applying expert panel decision rules



WEB MAPPING

MOSAIC and Types

Descriptions Demo



Available on WetlandInfo at
https://wetlandinfo.des.qld.gov.au/wetlands/facts-maps/

Effectiveness of SDB / SFR and use in ecosystem mapping

SDB limitations and advantages

- Inshore turbid discharge likely to skew the usually exponential relationship between light and depth
- Insufficient point bathymetry to validate SDB, thus use TVU
- ✓ A low-cost option to fill inshore data, provided water is clear as possible at time of image capture
- ✓ Useful base data to populate many different biophysical attribute datasets

Ecosystem mapping and type descriptions - current and future use

- Non-statutory seamless land to sea dataset for a range of management purposes
- Representation: e.g. Marine Parks re-zoning (Great Sandy Marine Park)
- Explore spatial ecosystem mosaic patterns, field connectivity projects e.g. tropicalisation
- Design monitoring projects, future field inventory to address knowledge gaps
- Use the QISC as a field inventory tool, ‘Rosetta stone’ to map to a common language

Suggestions for the future:

- Project areas are stratified by bathymetry inventory method to estimating survey costings
- Queensland governments and universities could combine for priority bathymetry capture efficiency
- Address the gap between nearshore ecosystems and UQ offshore coral mapping?

Acknowledgements

- EOMAP for supply of SDB and SFR data
- Bathymetry data CEQ30 DEM and method report by Robin Beaman JCU for DES
- DES Wetlands team: Remy Usher, Natasha Jones, Cathy Ellis for WetlandInfo content and mapping tools. Mapping support: Andrew Irwin and Troy Honeman.
- DES Qld Herbarium: Evanthia Karpouzli for sediment analysis, Jack Kelley for typology tool
- CSIRO: Erin Kenna for typology training
- Coral expert panel: Chris Roelfsema, Jenn Loder, Ian Butler, Angus Thompson, Danni Ceccarelli
- Technical expert panels: Andrew Olds, Jan Arens, Cheryl Watson, QPWS: Dave Orgill, Felicity Chapman, John Schwarzrock, James Murphy, Scott McKinnon. GPC: Gordon Dwane, Megan Ellis. CQU: Emma Jackson, Owen Nevin. JCU Tropwater: Marcus Sheaves, Mike Rasheed, Len McKenzie, Alex Carter, Norm Duke, Jock McKenzie. Catchment Solutions: Trent Power, GU: Tim Stevens. DAF: Bart Mackenzie.
- Mesophotic corals types descriptions, literature and photos: Paul Muir, MTQ
- Sediment and carbonate data modelling by dbSEABED (Chris Jenkins)
- Wave energy model for Gladstone by Emma Jackson CQU
- Consolidation and Structural Macrobiota datasets by Andrew Olds USC, Zann, Ian Butler UQ, Burnett-Mary Regional NRM Group, Alquezar, Bunce CQU.
- Numerous helpful people provided feedback, tracked down data, validated fishing spots etc.