A Method for Classifying and Mapping Intertidal and Subtidal Ecosystems in Central Queensland

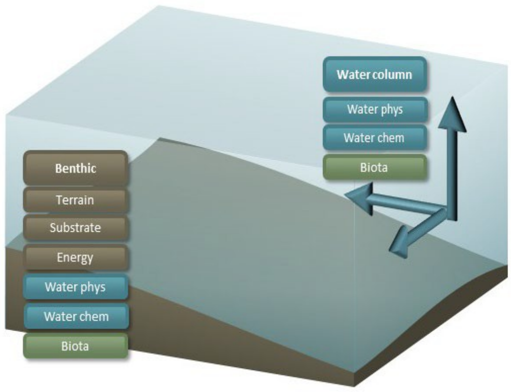
The Queensland Intertidal and Subtidal Classification Scheme (the Scheme) provides a pool of biophysical attributes or factors that determine the nature and extent of water column and sea floor (benthic) ecosystems and a framework for applying them. An **attribute-based classification** is assembled from a pool of these attributes to describe the ecosystems in a transparent, robust and repeatable manner. A **typology** is then developed to address a specified purpose at a specified scale, by compiling a hierarchy of rules to describe the nature and distribution (spatial extent) of these ecosystems based on 'types'. The scheme was applied to **describe** and **map** Central Queensland tidal ecosystems to complement existing mapping of freshwater wetlands and terrestrial Regional Ecosystems. These products provide an information-rich, non-statutory knowledge base to enable seamless land-to-sea management, planning and monitoring.

About attribute-based classification

Ecosystems can be classified using measurable characteristics, variables or factors known as 'attributes' that influence where biotic habitats (ecosystems) are found.

Key features of the scheme

- Attribute-based classification is an information enrichment process.
- Separate benthic and water column classifications account for different variability within these two interrelated systems.
- A hierarchy of (nested) levels or scales provides for the importance of different attributes at the following scales: regional, subregional, seascape, habitat and community.
- Enduring attributes that remain relatively constant in ecosystems are most applicable for mapping.
- Attribute 'qualifiers' describe change in attributes including naturalness (human use modification), trend and period.
- Components of systems can be classified (as ecosystems) but the ecosystem processes and drivers are not part of the scheme.
- Spatial attributes provide information on the relative position, size and location of features.
- Ecosystem condition is not dealt with in the scheme, but some attributes and qualifiers may be useful as an input to condition assessments.



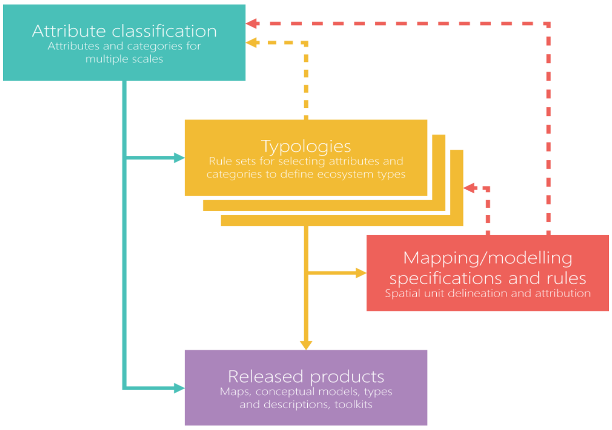
Advantages of the scheme

- Provides a common language, to assist with communication and reduce complexity about ecology, values and management for technical and non-technical audiences
- Consolidates existing data and knowledge into a consistent platform for intertidal and subtidal ecosystems
- Integrates with and complements other state and national classifications and mapping
- Provides the basis for mapping, describing ecosystems and developing conceptual models
- Provides a consistent, measurable, transparent, repeatable and flexible approach.

Classification or typology?

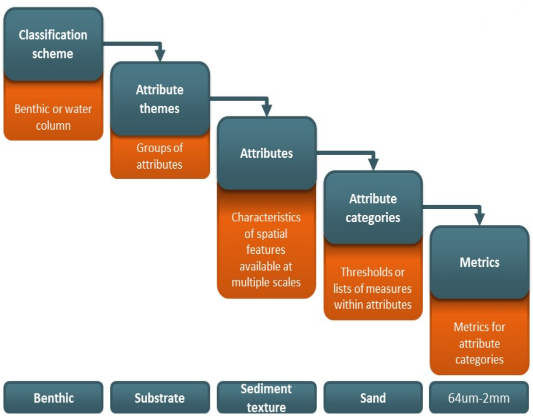
1. Attribute-based classification compiles a pool of attributes relating to an ecosystem (e.g. sediment size, structural biota, salinity etc.), independent of each other. These are further split into categories (e.g. for structural biota broken into seagrass, coral etc.). There are five spatial levels to allow ecosystems to be classified at the regional, subregional, seascape, habitat or community scale.

2. A typology is developed to address a particular purpose at a given scale. Ecosystem types are designated using combinations of selected attributes applied in a hierarchy of rule-sets. The rule-sets are used to determine, describe and delineate (map) ecosystem types.



Classification terms

- **Attribute themes** group similar attributes e.g. *terrain, substrate, biota, and hydrology*.
- **Attributes** are descriptive characteristics or features relating to biophysical ecosystems.
- **Metrics** define how the attributes are measured in the field.
- **Categories** break measurements into meaningful intervals that are relevant to ecosystem and biotic patterns.



Applying the scheme

Stage 1: Attribute classification

a. Assemble data by translating ('cross-walking') to the attributes and categories of the scheme.
b. Shortlist attributes and categories, through expert workshops, for a specific scale and purpose, including thresholds and qualifiers.

Stage 2: Typology

a. Determine the scale and purpose of the typology.
b. Identify the attributes crucial to the typology by ordering the attributes in a hierarchy.
c. 'Collapse down' the categories that are not necessary to split different types.
d. Define and run rule-sets consisting of one or more attributes and categories in combination. Each rule-set equates to an ecosystem type based on a combination of attributes and categories. Rule-sets are captured in a spreadsheet.
e. Re-examine the order of the rule sets, as these will determine the dominant type where ecosystems overlap (subdominant ecosystems are designated 'co-types').
f. Review and refine ecosystem type rule-sets (reclassification) after viewing the mapping.
g. Name the types, describing them in terms of their biophysical attributes and categories.

Mapping applications include one or more of:

- **A mapped attribute-based, classification** compiles disparate datasets into a single dataset for each attribute, with relevant categories. Mapped attributes serve many different purposes and applications.
- **A mapped typology** shows the spatial extent of ecosystem types for a specific purpose. Using the mapped attribute-based classification, types are mapped according to typology rule-sets.

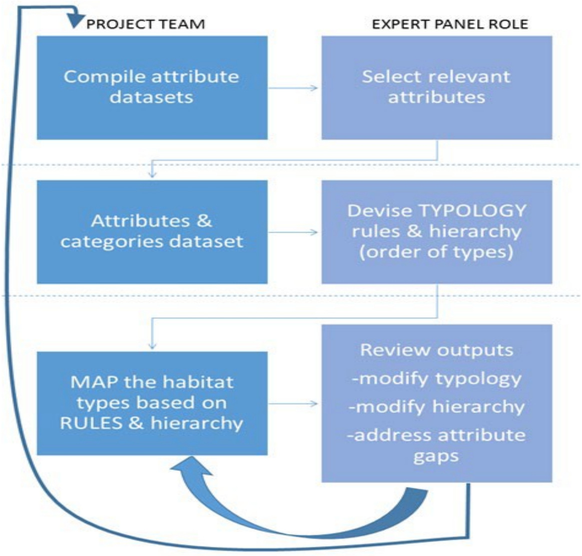
Classification and typology can also be used for non-mapping applications, such as:

- **Describing** ecosystems based on their attributes, which enables identification in the field
- **Targeting field inventory and monitoring** towards attributes that are needed to address knowledge gaps
- **Informing ecosystem process models** e.g. conceptual modelling, three-dimensional modelling of water column processes

Classification, typology and mapping of ecosystems in Central Queensland

Existing tidally-influenced ecosystems mapping available across Central Queensland (CQ) has been developed using different methods and scales. For the [CQ intertidal and subtidal ecosystem mapping project](), these datasets were compiled into a seamless layer, based on biophysical attributes, to create **the first comprehensive seascape mapping of its kind in Queensland.**

Advised by a panel of technical experts and managers, an attribute-based classification and typology was developed based on the biophysical attributes of the scheme. The typology purpose and scale was to develop a seascape-scale benthic biophysical typology of ecosystems for general management purposes, using data from 2000 – 2015.



Experts chose eight attributes to combine in a dichotomous key that 'split off' ecosystem types according to category values based on rule sets.

Eight **biophysical attributes underpin** ecosystem types:

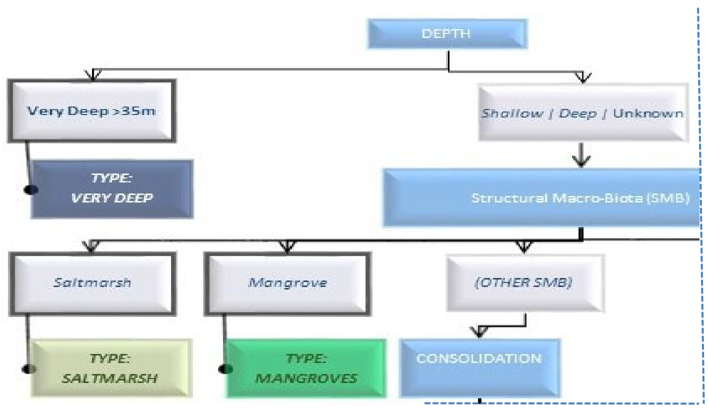
- **Benthic depth**: depth to the sea floor
- **Inundation**: areas that are tidally influenced
- **Consolidation**: for the attachment of biota
- **Sediment texture**: sandy mud, muddy sand etc.
- **Substrate composition**: the content of substrate
- **Energy magnitude**: high or low wave energy
- **Terrain morphology**: shape of the sea floor
- **Structural macrobiota composition**: animal and plant structure that is habitat-forming for biota

Rules were recorded in a spreadsheet, which then formed the basis for a key input to the geographic information system (GIS).

The example below shows in the first rule, the 'Depth' attribute was used to split the 'very deep' ecosystem type. Next, 'shallow', 'deep' or 'unknown' categories were split using the 'Structural macrobenthos' (SMB) attribute. If the SMB categories was 'Saltmarsh' or 'Mangrove' these ecosystem types were split out in the second and third rules. Remaining categories filter down to the next attribute in the decision tree (i.e. 'Consolidation' etc.).

Data sources were classified using the metrics (categories and thresholds), translating them into the common language of the scheme. This enabled their incorporation into a comprehensive and seamless intertidal and subtidal ecosystem type map.

The mapping provides comprehensive information about the distribution of intertidal and subtidal ecosystems (e.g. saltmarsh and mangroves to coral reefs, seagrass meadows, and other rocky, muddy and sandy ecosystems) at a scale that provides sufficient detail to support management actions and guide further mapping and inventory work.



Mapping steps for a typology classification

For a typology classification to be successfully mapped, mapping considerations need to be integrated into all the stages of the project.

Before the facilitated workshops

Preparation
- Map proposed project boundary
- Design the data model
- Cross-walk source data to scheme
- Compile candidate attributes

Gather
- Data and attribute contacts
- Source data/metadata
- Advice on source data interpretation
- References on datasets and attributes

During the workshop

Present the technical experts with
- Project boundaries
- Candidate attribute maps clearly showing categories available for selection
- Highlight attribute knowledge gaps

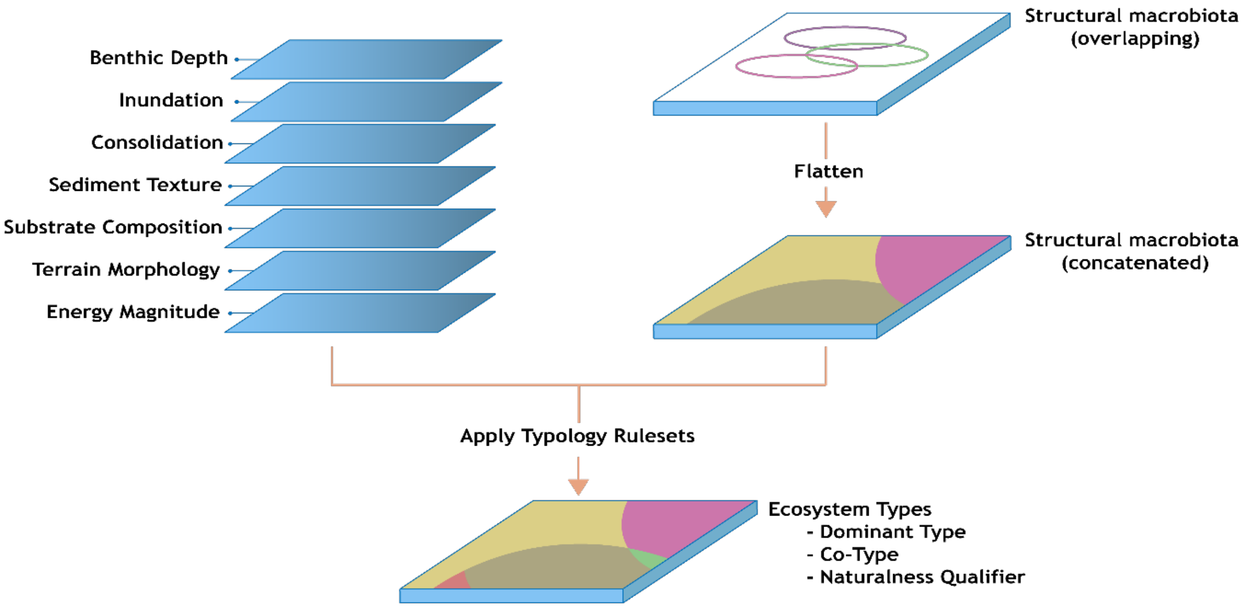
Document
- Workshop decisions
- Typology rules (in a spreadsheet)
- Biology and ecology, i.e. expert knowledge on the types and attributes
- References and data sources

Apply the scheme post-workshop

- Follow up data contacts, secure data agreements, seek expert advice on data interpretation

Map the attribute-based classification
- Cross-walk source datasets to the scheme, incorporate the data into seamless attribute datasets
- Update attribute mapping and categories, clean and conduct quality assurance (QA) on final attribute datasets

Map the typology to produce a map of ecosystem types
- **Join** all the attributes datasets into a single GIS layer, noting that some may be overlapping (see below)
- **Query** the joined attribute GIS layer, applying the typology rules in the spreadsheet
- Name the types in the GIS map with the dominant type as determined by the order of types
- Check over the draft types map with the technical working group, fine tune the rulesets and re-map

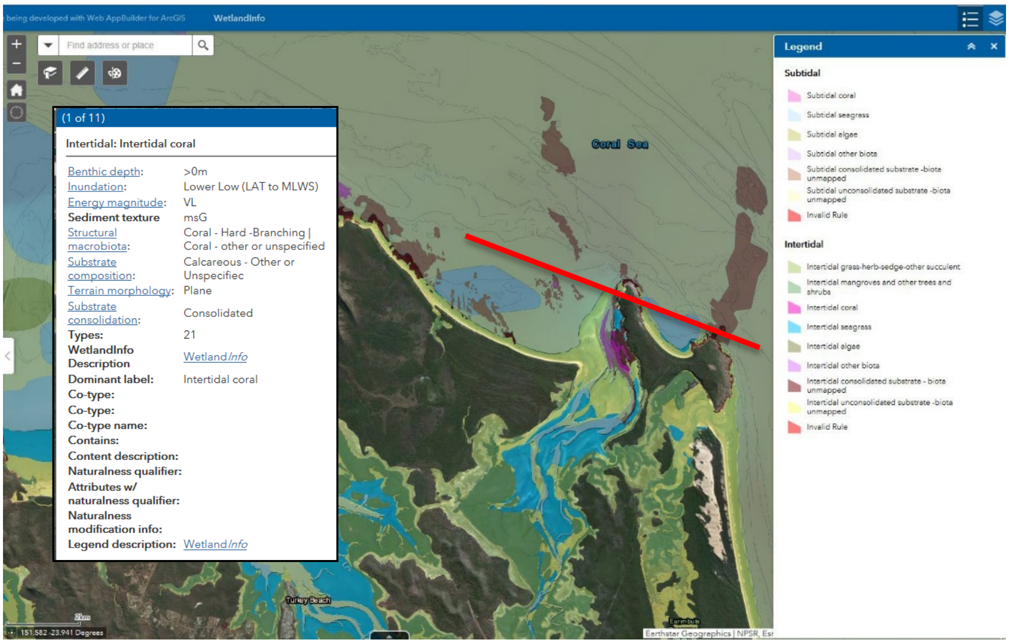


After the draft types map is produced

Release and review
- Draft outputs according to user needs including online, cartographic, managers etc.

Compiling the CQ mapping

Attribute datasets are the point of truth that link the ecosystem types to their original data sources. In GIS software, the candidate data layers were 'cross-walked' to the categories of the classification scheme. Data sources were given a unique code retained in the attribute dataset. Candidate data source layers were then arranged in order of their accuracy and scale, with small scale and highly accurate datasets used to 'cookie-cut' those of lesser accuracy and broader scale. Source datasets originating from raster (pixel) data were converted to polygons, visible as square boundaries either within an ecosystem type polygon or as part of its boundary. Datasets sourced from a variety of scales and time series (between 2000 and 2015) did not always coincide with visible boundaries on the ground. Recent inventory datasets validating the original mapping were used, where possible.



Generalised online ecosystem mapping, displaying information about an ecosystem type in a pop-up window

Elevation data is an essential base dataset. The [CEQ 30 DEM] is a bathymetric digital elevation model (DEM) compiled from existing bathymetric data to 30 metre pixels. This data was incorporated into the 'Benthic depth' attribute. The compilation highlights substantial knowledge gaps requiring future detailed sea floor inventory.

Merging attributes data sources. All source datasets were merged into composites for each attribute dataset. Disparate attribute boundaries were re-aligned and ecosystem types confirmed against a backdrop of high resolution aerial orthophotography (i.e. aerial photograph that has been geometrically corrected so that the scale corresponds to the ground) and LiDAR (Light Detection and Ranging) elevation models. Subtidal attribute layers were checked against bathymetry and contours. Attribute qualifiers (naturalness, period, trend, cover etc.) were added to each of the attributes dataset.

Ecosystem types and generalising. All attribute datasets were joined into a single seamless layer. The expert panel's typology spreadsheet was developed into a Python script in ArcMap, which allocated ecosystem types based on attribute combinations. Biotic data overlapped, thus ecosystem types include dominant types and co-types. The detailed ecosystem type mapping, which links back to the attributes, was generalised for online user acceptance testing. Feedback was incorporated into the final online version.

Mapping content and versioning. The CQ intertidal and subtidal mapping is a seascape-scale polygon dataset that is based on imagery and spatial inventory data from 2000 to 2015. It incorporates more than 220 source datasets combined into eight attributes and over 90 ecosystems. Map scales range from 1:25,000 to 1:250,000 with horizontal accuracy between 50 and 250 metres.

About CQ project products

- Module 1, describes the peer-reviewed and trialled intertidal and subtidal classification scheme with application steps.
- Module 2, provides a comprehensive review of national and international classification schemes that places the Queensland Intertidal and Subtidal Ecosystem Classification Scheme in context.

- Module 3 (online documentation), the biophysical attributes underpinning the mapping, including qualifiers to describe change.
- Module 4, a method for providing baseline mapping of intertidal and subtidal ecosystems in Queensland.
- Mapping that displays CQ's intertidal and subtidal ecosystems in a number of different formats (pdf, KML using Google maps, via online download, and Wetland*Maps*) for
    - Intertidal ecosystems
    - Subtidal ecosystems
    - Naturalness qualifiers showing where biophysical attributes are modified by anthropogenic activity
- Descriptions of intertidal and subtidal ecosystem types based on underlying biophysical attributes (including those diagnostic of the type).

Applications

The products provide a non-statutory knowledge base with many potential uses, including:

- As a primary tool and framework to support policy development,
- guiding prioritisation and on-ground works investment in natural resource management,
- tracking changes in ecosystem extent and type, and monitoring program design (e.g. report cards, habitat condition),
- prioritising knowledge gaps for inventory and data,
- assessing connectivity and determining ecosystem services,
- assisting in predicting species presence or absence based on ecosystem types,
- developing management guidelines for intertidal and subtidal ecosystems using key attributes,
- informing resource utilisation, management and offsets,
- assisting with integrated planning and policy across agencies and jurisdictions,
- informing identification of Matters of National and State Environmental Significance (MNES, MSES) (including Outstanding Universal Value of World Heritage areas and criteria under Ramsar),
- assisting with assessment of climate change impacts, and
- as a sound basis for marine park and fisheries habitat, management and review, and initiatives to protect the Great Barrier Reef.

Project participants and links

This project was led by the Department of Environment and Science in collaboration with the Department of Agriculture and Fisheries (DAF), and the Gladstone Ports Corporation (GPC) Limited. Contributions have also been provided from other Queensland universities, Geoscience Australia, Commonwealth Scientific and Industrial Research Organisation (CSIRO), the Great Barrier Reef Marine Park Authority (GBRMPA) natural resource management (NRM) bodies and consultants of the above organisations.

The DAF have provided financial assistance to this project as a fish habitat initiative (DAF 1498CQA-2), meeting approved development related fish habitat offset requirements for GPC.

This project worked with allied DAF-funded projects to value-add knowledge and enhance fish habitat outcomes.

The project was undertaken through the intergovernmental Queensland Wetlands Program (QWP). The QWP’s Governance Group provided project governance, an Advisory Group provided strategic advice, and an interdisciplinary team produced the mapping and products.

The Queensland Wetlands Program supports projects and activities that result in long-term benefits to the sustainable management, wise use and protection of wetlands in Queensland. The tools developed by the Program help wetlands landholders, managers and decision makers in government and industry. The Queensland Wetlands Program is currently funded by the Queensland Government.

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