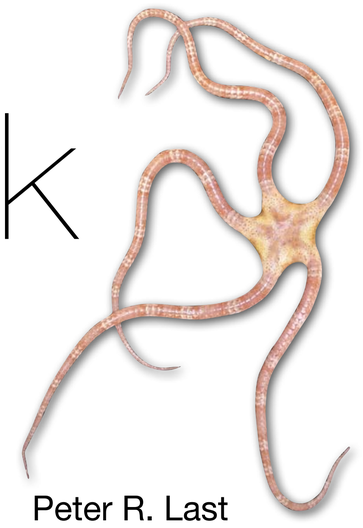
CERF a hierarchical framework

for classifying seabed biodiversity with application to planning and managing Australia's marine biological resources



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Classifying biodiversity

Biodiversity can be interpreted in many ways. Classifications can include biotic and/or abiotic components, depend on scale and context, and often reflect the disciplinary bias of the authors.

Marine biodiversity has almost exclusively been examined at the scale of local or modern processes, which are often less informative than biogeographic or ancient processes for understanding species richness patterns. However, modern and ancient processes are the endpoints of a natural hierarchy where different processes influence distribution at each level. Patterns and processes of biodiversity are scale dependent, with lower levels fully or partially nested in those above. Comparisons that omit this scale dependency will be compromised.

Hierarchical framework

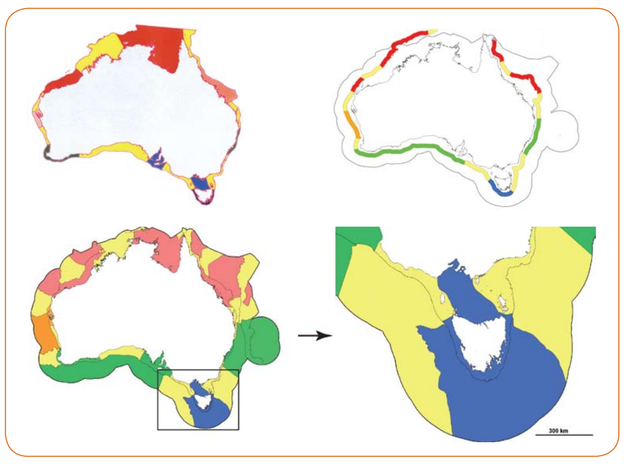
We present here a hierarchical framework for describing the structure of marine demersal biodiversity across all spatial scales. This system explicitly recognizes the overarching influence of large-scale biodiversity patterns at realm (ocean basin and tectonic), provincial (palaeohistorical) and bathomic (depth-related) levels. The functional roles and spatial scales are captured within ten nested levels within realms, where the first seven are primarily spatially nested and ecosystem based, and the lowest levels represent units of taxonomic inheritance. The framework is conceptual and each level needs to be validated for its general applicability.

Marine resource management

Our hierarchical framework was developed to guide marine resource planning and management in Australia. The system has been used successfully for continental-scale bioregionalisation, including identification of Australia's National Representative Systems of Marine Protected Areas, and has wider application at a global scale.

Level 1. Biogeographic Provinces:

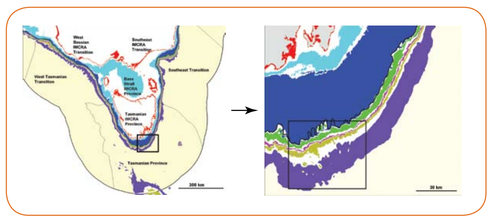
Large-scale biogeographic units derived from evolutionary processes and characterised by broad centres of endemism.
Typical units: *province-level biogeographic assemblages.*



LEVEL 1
Provinces

Level 2. Bathomes:

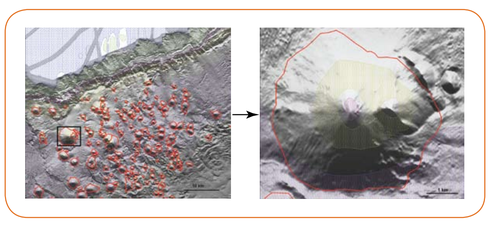
We propose a new term, bathome, to describe the finer-scale subdivisions of provinces that are characterised primarily by the bathymetric distribution of the biota. Bathomes have also been variably referred to as environmental regions or zones, and in an Australian context as 'marine biomes'. Like provinces, the spatial scales of bathomes are large (usually exceeding 1000 km^2 and much larger at abyssal depths). Provinces, bathomes, and their associated transitions are continuous throughout a region, unlike lower level units which are spatially disjunct and patchy.
Typical units include: *coastal, continental shelf, continental slope and abyssal bathomes.*



LEVEL 2
Bathomes

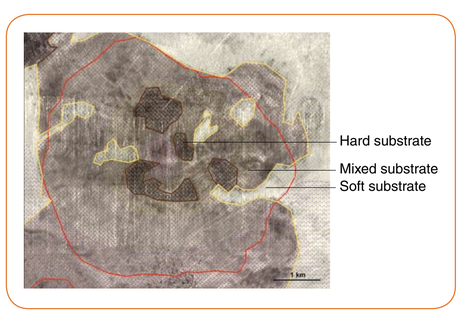
Level 3. Geomorphological units:

Bathomes can be further partitioned into Level 3 mesoscale units, these units are typically smaller in size and are based primarily on geomorphology, and defined by their abiotic characteristics. These units are often used as surrogates for suites of biological assemblages at intermediate spatial scales.
Typical units include: *fringing reefs, beaches, estuaries, coral cays, glaciation structures, sand banks, rocky banks, submarine canyons, seamounts and valleys.*



LEVEL 3
Geomorphological

Level 4. Primary biotopes:



Mappable biodiversity surrogates that are coarsely divided according to the key units of substrate hardness.
Typical units include: *soft, hard and mixed substrates.*

LEVEL 4
Primary Biotopes

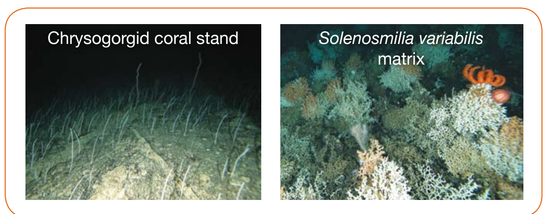
Level 5. Secondary biotopes:

Nested within primary biotopes and consisting of smaller-scale, abiotic and/or biotic substructural units of the seafloor. Secondary biotopes are characterised by 'specific types' of physical substrate, for example soft substrate being subdivided into, for example, different types of sediments – calcareous ooze, silt or mud.
Typical units include: *igneous, calcareous and sedimentary bedrock, silts, mud, sands, gravels, seagrass mangrove stands, canyons, seamounts and valleys.*

LEVEL 5
Secondary Biotopes

Level 6. Biological facies:

The fundamental units for the management of biodiversity. Biological facies are firmly nested within all levels above and act as surrogates for all levels below. They are characterised by recognisable groups or particular species of seagrasses, corals, sponges, or other macro-biotic groups; hence, mobile taxa such as fish are likely to be less informative discriminators of facies than sessile animals and plants.
They typically occur at the scale of a km or smaller, and are represented by one or more indicator species acting as surrogates for the broader biological assemblage to which they belong.
Typical units include:
Macrocystis *(kelp) and* Zostera *(seagrass) stands, and coral.*



LEVEL 6
Biological Facies

Micro-communities and the nested components below are generally well known and well defined.

Level 7. Micro-communities: small-scale assemblages, dependent on other member species, or groups of species, within a 'host' facies.

Typical units include: *endofaunal associations of kelp holdfasts and sponges, and the infauna of muddy sediments.*

Level 8. Species: The species-based units of our hierarchy (Levels 8, 9 and 10) are the levels of genetic relatedness of biological diversity in the strict sense.

Typical units include: *species-level taxa, operational taxonomic units (OTUs) and evolutionary significant units (ESUs).*

Level 9. Populations: Populations (and metapopulations) are attributes of species and the way they function, and two disjunct populations of the same species usually differ genetically.

Typical units include: *subspecies, phenotypes, and monospecific assemblages of geographic and extralimital isolates.*

Level 10. Genes: Genetic diversity, itself a hierarchical concept, given differing rates of evolution in different parts of the genome, is an important base-line level in our hierarchy.

Typical units include: *alleles and DNA sequences.*

LEVEL 7
Micro-communities
and the nested components below (Levels 8–10)

Delineation and management of lower level units (7–10):

For Bioregional Marine Planning conservation of elements at these levels will often be achieved through the management of higher level units above. Understanding micro-scale levels of biodiversity can be critical for biodiversity management, as habitat protection alone cannot be used to protect some threatened and endangered species. These levels can therefore be crucial for understanding and managing MPAs and threatened species, and for measuring temporal change and variability.

MARINE BIODIVERSITY RESEARCH
Prediction and Management of Australia's Marine Biodiversity

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