Characterisation of the marine environment of the East Marine Region

A summary of an expert workshop convened in Brisbane, Queensland, 28-29 November 2007.

Prepared by the Department of the Environment, Water, Heritage and the Arts

1. Preface

This paper is a report summarising the outcomes and discussions of an expert workshop convened in Brisbane, Queensland on 28-29 November 2007 by the Department of the Environment, Water, Heritage and the Arts. The objective of this workshop was to characterise the marine environment of the East Marine Region in a way that would improve the Department's understanding of how the Region's natural systems work. More specifically, the workshop aimed to:

- characterise ecological systems within the Region on the basis of their location, their biological and physical components and how these interact;
- understand links across functional systems and the broad scale drivers of ecosystem functioning across the Region, including the importance of the interface between functional systems and the key processes that link neighbouring systems;
- understand the key areas of uncertainty surrounding the Region's ecological systems; and
- determine which aspects of the Region's ecological systems have good empirical evidence available to support our understanding of them.

2. Attendance at workshop

A broad range of marine and environmental scientists with expertise in oceanography, and the nearshore and offshore ecosystems of eastern Australia attended the workshop.

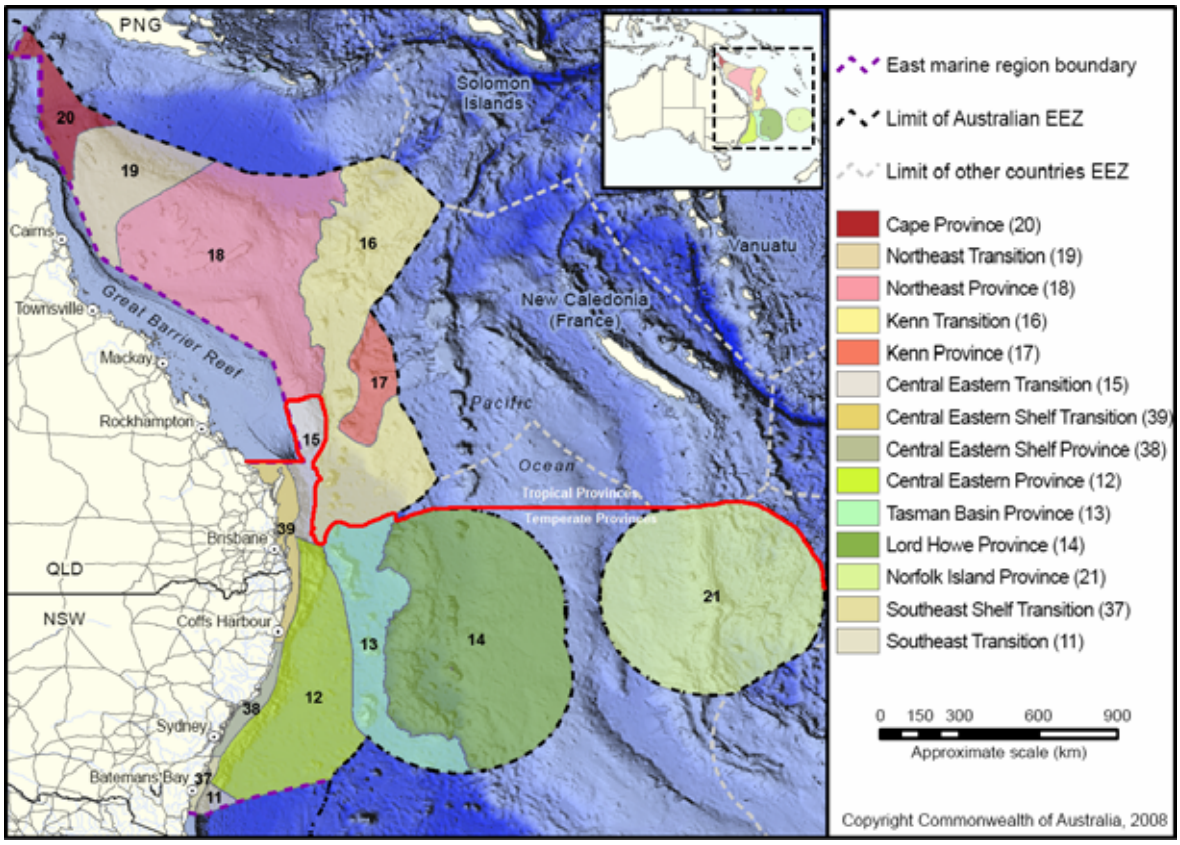
Attendees included:

Professor Bruce Mapstone (Chair) - CRC for Antarctic Climate and Ecosystems
Dave Brewer – CSIRO
Tim Skewes – CSIRO
Adrian Flynn – Hydrobiology Pty Ltd
Dr Stephen Keable – Australian Museum
Dr Pat Hutchings – Australian Museum
Dr John Hooper – Queensland Museum
Professor Peter Harrison – Southern Cross University
Professor Jock Keene – Geoscience Australia
Dr Peter Harris – Geoscience Australia
Dr Scott Nichol – Geoscience Australia
Paul Garrett – Department of the Environment, Water, Heritage and the Arts
Rob McKelleher - Department of the Environment, Water, Heritage and the Arts
Ben Addison - Department of the Environment, Water, Heritage and the Arts
Mark Deters - Department of the Environment, Water, Heritage and the Arts
Wendy Quinn - Department of the Environment, Water, Heritage and the Arts
Dr Ilse Kiessling - Department of the Environment, Water, Heritage and the Arts
Dr Nancy Dahl-Tacconi - Department of the Environment, Water, Heritage and the Arts

3. The East Marine Region

The East Marine Region includes more than 2.4 million square kilometres of ocean and seafloor from the northern reaches of the Coral Sea, south into the Tasman Sea. The Region also includes waters around Norfolk Island and Lord Howe Island. The Great Barrier Reef Marine Park is not considered a part of the East Marine Region as it is already closely managed under its own specific legislation.

Figure 1: Map of the East Marine Region depicting Provincial Bioregions (IMCRA v4.0)

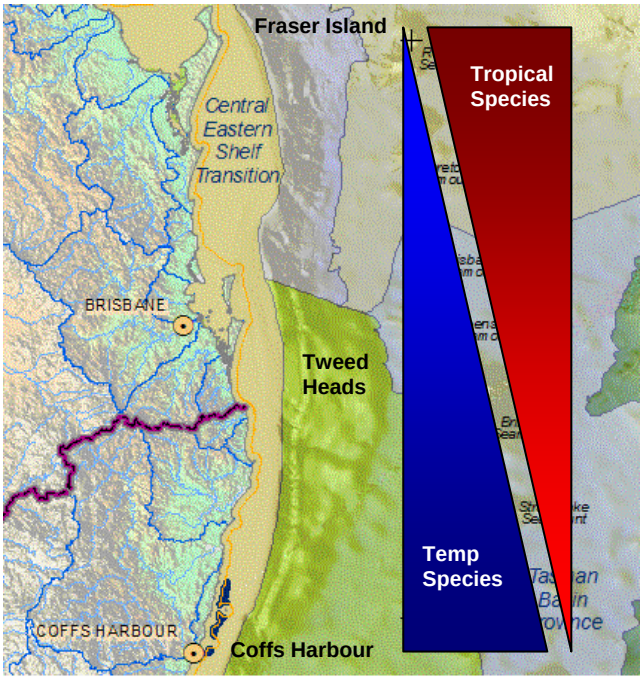


4. Breaking down the Region

There is a tropical/temperate distinction or divide in the East Marine Region – this is most evident on the continental shelf and becomes less distinct in deeper waters off the shelf.

The continental shelf off Tweed Heads, NSW is a major tropical/temperate divide for the East Marine Region. The area is a transition zone for benthic communities:

- the occurrence of tropical benthic species ranges from approaching 100% at the northern tip of Fraser Island, to almost 0% at Coffs Harbour.
- the occurrence of temperate benthic species ranges from approaching 100% at Coffs Harbour, to almost 0% at the northern tip of Fraser Island.



There are also differences between tropical and temperate pelagic fauna, but in general there is more connectivity, and therefore similarities, in the pelagic environment in a horizontal direction throughout the Region. The physical environment of the water column is heavily differentiated by depth (e.g. thermoclines, photic zone, pressure gradients).

The following provincial bioregions are considered tropical bioregions:

- Cape Province
- Northeast Transition
- Northeast Province
- Kenn Transition
- Kenn Province

The following provincial bioregions are considered temperate bioregions:

- Central Eastern Transition
- Central Eastern Shelf Transition
- Central Eastern Shelf Province
- Central Eastern Province
- Tasman Basin Province
- Lord Howe Province
- Norfolk Island Province
- Southeast Shelf Transition
- Southeast Transition

The tropical and temperate provincial bioregions are linked by the complex oceanography of the Region. The westerly flowing Southern Equatorial Current moves into the Region from the Pacific Ocean through the Coral Sea. It hits the continental shelf between 13^{o}S and 22^{o}S latitude at which point it divides (or bifurcates) into the northward flowing Hiri current and the much larger southward flowing East Australian Current. The East Australian Current is a major and oceanographic feature that flows southwards along the

outer continental shelf and upper slope. This current system is characterised by meandering, southerly-migrating currents, gyres at various locations and a characteristic eddy field known as the Tasman Front in the zone where the warm East Australian Current meets the cool Tasman Sea at approximately 33^{o}S latitude or roughly even with Sydney. These eddies are temporary (eddies appear for a limited time) or quasi-permanent (as each eddy collapses, a new eddy immediately forms in the same location) and migrate in a meandering easterly direction. The East Australian Current and its eddies create the primary process whereby warm low-nutrient waters are delivered to cool southern coastal waters (and to the outlying Lord Howe and Norfolk islands) as well as being the primary driver of abundance, distribution and dispersal of pelagic and shelf-slope demersal organisms.

Underlying the East Australian Current, beyond a depth of approximately 500 m, is a cool and generally northwards-moving sub-Antarctic water mass. The exact path of this current is not known, although there is evidence of scouring along the base of the continental slope, the Tasmantid Seamounts and the Lord Howe Rise .This suggests that there is a northward flow of water across the floor of the western Tasman Basin and a southerly flow along the eastern margin.

5. Important Characteristics, Features, Ecological Drivers and Processes of Provincial Bioregions

5.1 TROPICAL PROVINCIAL BIOREGIONS

The tropical provinces are characterised by surface waters with low primary productivity (dominated by oligotrophic waters). The shallow waters in these provinces are dominated by corals and other shallow water autotrophic species. Suitable shallow water substrate for these species is confined to the Great Barrier Reef coastal shelf, the Queensland Plateau and a number of islands, atolls, cays, seamounts and guyots which are mostly geographically isolated from each other. The coral reef communities that form on these shallow water substrates support heterotrophic communities to top predators such as sharks, tuna, billfish, cetaceans and seabirds.

The interaction of currents with geomorphic features such as reefs, atolls, seamounts and canyon heads creates areas of enhanced productivity. The vertical mixing of waters as currents move around prominent geomorphic structures brings nutrient rich deeper waters into the photic zone. Typically, sharks, tuna and billfish are resident top predators in some of these consistent areas of enhanced productivity.

Oceanographic features in these Provinces, such as gyres, eddies, thermal fronts, island wakes and debris fields also form transient areas of enhanced productivity. Some of these oceanographic features can cause vertical mixing of waters, bringing deep, cool, nutrient-rich waters into the photic zone leading to enhanced local primary productivity and attracting consumers. Many tertiary consumers such as tuna and billfish are transient predators that move large distances searching out such features. Some of these oceanographic features can be semi-permanent, such as the gyre that forms over the southeast corner of the Marion Plateau in the Kenn Transition Province.

Sediment inputs only play a significant role in nutrient transport in the northern part of the Cape Province and in some of the troughs adjoining the Great Barrier Reef coastal shelf. Nutrients are likely to enter the Province through seafloor sediments flowing off the Great

Barrier Reef coastal shelf and from riverine sediments flowing in from Papua New Guinea. Most of the area has very low sedimentation rates of organic carbon, with most organic matter being consumed in the photic zone before it can form sediments on the ocean floor. The sediments are composed dominantly of inorganic carbon in the form of calcium carbonate remains of plankton and minor benthos.

The variable nature of the strength and distribution of currents over these provinces has a significant influence on the oceanography of the entire Region. The point at which the Southern Equatorial Current bifurcates varies from season to season between latitudes 13°S and 22°S. The location of this bifurcation point determines where the Hiri and East Australia Currents form and influences the northerly and southerly flow of waters through different areas of the Region.

The frequency and intensity of tropical storms, including cyclones, has a significant impact on shallow water corals, particularly in the southern tropical provinces where they are most frequent. The high diversity of these communities may be due to frequent regeneration of reefs following storm events. Storm events within and outside the Region can rapidly transport normally sessile benthic species long distances either in the water column or on floating debris.

Some species are known to migrate between the inshore and offshore and north-south through the topical provinces of the Region. For example, freshwater eels, mudcrabs, prawns, and turtles are known to migrate inshore-offshore seasonally. Billfish (marlin and sailfish), tuna and some cetaceans, including humpback whales, seasonally migrate north-south through the entire East Marine Region.

5.1.1 Cape Province

- The Province is influenced by the bifurcation of the Southern Equatorial Current that at its northern divergence becomes the Hiri Current. The Torres Strait Islands and Papua New Guinea form a barrier to the northern movement of the Hiri Current. The flow of the Hiri Current as it hits these barriers is diverted in a north easterly direction and forms a gyre over the Province. The ecological significance of this gyre and the flow of the Hiri Current is not clear but the ecological communities on the northern reefs may be distinct from reefs in southern provinces that are more heavily influenced by the southern divergence of the South Equatorial Current as it becomes the East Australian Current. The ecological communities of the Cape Province are also likely to be distinct from the Torres Strait and Papua New Guinea region as the Hiri Current moves in a clockwise direction and therefore is not likely to encourage recruitment from outside the Province. There may be some connectivity between billfish populations in the Province and with populations to the north around Papua New Guinea.
- This is the most geologically active Province in the East Marine Region. The continental crust underlying this Province is subsiding and a significant supply of sediment from Papua New Guinea's river systems enters the Province from the north. This flow of sediments contributes significant levels of nutrients and in combination with the gyre formed by the Hiri Current is likely to increase the productivity of the Province. However, the influence of sediments is probably restricted to the northern part of the Province around the northern reefs where it has buried reefs and thins out towards the southern parts of the Province. The Ashmore and Boot reefs are similar to

atolls and are growing in elevation at the same rate as the underlying continental crust is subsiding.
- Some deep valleys in the southern part of the Province channel sediments flowing off the northern Great Barrier Reef into the Coral Sea Basin. The sediments moving down these valleys contribute nutrients to the Province and may be significant in supporting benthic communities.

5.1.2 Northeast Transition Province

- The bifurcation point of the Southern Equatorial Current moves into and out of this Province with the northern divergence becoming the Hiri Current and the southern divergence becoming the East Australian Current. Both currents can have an impact on the Province depending on where the bifurcation point of the Southern Equatorial Current is. The variability of currents in the Province may have a significant influence on the ecological communities such as those found on Osprey and Shark reefs.
- The northern part of the Queensland Plateau lies in this Province and is one of the most important submerged ecological features of all the tropical provinces in the East Marine Region. The Queensland Plateau is like an underwater "island" at about 1000m depth and is surrounded on all sides by deeper waters. The reefs lying on top of the Queensland Plateau are emergent reefs and have relict fauna dating back to the Pleistocene era. Recruitment into these ecological communities is from the Southern Equatorial Current, though the Queensland Plateau communities themselves are important sources of recruitment to the Great Barrier Reef. Nutrients on the Queensland Plateau are primarily derived from the water column and the Plateau is generally nutrient poor apart from where upwelling of deeper nutrient rich waters occurs in areas where deep water currents interact with reef structures.
- The Queensland Trough runs along the western side of the Queensland Plateau. It is possible that the Trough may support some significant deep water coral communities.

5.1.3 Northeast Province

- The northern part of this Province is dominated by the Queensland Plateau and has the same characteristics as described for the Queensland Plateau in the Northeast Transition Province. A number of the emergent reefs on the Queensland Plateau within the Province break the surface as islands and cays and are important breeding areas for sea birds and marine turtles.
- The southern part of the Province includes the northeast section of the Marion Plateau that has some significant reefs on its outer edge. At a depth of between 100-600 m, the Marion Plateau is much shallower than the Queensland Plateau.
- A semi-permanent gyre forms towards the southeast corner of the Province. This gyre may have a significant impact on the ecological communities of the outer reefs on the Marion Plateau by encouraging upwelling of deeper nutrient rich waters around the outer reefs thereby increasing productivity in the area.
- Severe storm events in this Province may assist the recruitment of demersal fauna between the islands and reefs within this Province and the Great Barrier Reef, for those species that do not have a pelagic larva stage. 'Cyclone alley', an area of the Coral Sea in which many cyclones form and approach the coast, lies across this Province and the Northeast Transition Province.
- Along the northern boundary of this province is an area of abyssal plain which is likely to be very different to the rest of the province which is part of the Queensland Plateau.

5.1.4 Kenn Transition Province

- The Cato Basin and the northern Tasman Basin form the deep water western margin of this Province. They are linked by the narrow Cato Trough. East of the Cato Trough is the Kenn Plateau. North flowing sub-Antarctic waters move through the Cato Trough and interact with the south flowing East Australian Current to create areas of high productivity around structures such as Wreck Reef, seamounts and islands.
- The seamounts rising up from the Kenn Plateau differ from the more southerly seamounts of the East Marine Region in that they break the sea surface as islands and they are older. Recruitment between seamounts in this chain is likely to occur over large time scales giving rise to distinctive ecological communities on different seamounts.
- The narrow Cato Trough is an area of highly dynamic interactions between a semi-permanent gyre, the south flowing East Australian Current, and north flowing sub-Antarctic waters. These interactions create upwelling of nutrient rich waters that support high productivity including regionally significant billfish populations.
- The northern section of this Province is very poorly known but appears to be an area of geomorphologic heterogeneity that may be ecologically significant. Part of the Kenn Plateau is within the southeast section of the Province, though the ecological significance of the Kenn Plateau is not known.

5.1.5 Kenn Province

- Part of the Kenn Plateau lies within this Province and includes Kenn Reefs and Cato Island. The ecological significance of Kenn Plateau is not known but the reefs and islands on the western edge of the Plateau are likely to support significant and distinctive ecological communities.

5.2 TEMPERATE PROVINCIAL BIOREGIONS

Temperate Shelf Provinces

The temperate coastline of the East Marine Region is adjacent to three bioregional provinces: the Central Eastern Shelf Transition; the Central Eastern Shelf Province; and the South-east Shelf Transition.

All three provinces are subjected to similar ecosystem processes. The input of riverine sediments occur along the length of the coast (e.g. Shoalhaven, Hawkesbury, Hunter, Clarence and Tweed rivers) and deposits of mud are found on the continental shelf off the mouths of these rivers. Long shore drift and wave action move sand north along the inner shelf, forming the Moreton and Fraser sand islands that have built across the shelf. Further offshore, sediment on the shelf is carried southwards by the East Australian Current. Although always generally moving in a southerly direction, the path of the Current meanders across different areas of the shelf depending on a number of seasonal conditions such as the strength of the East Australian Current and the seasonal location of the South Equatorial Current bifurcation point in the Coral Sea.

The three temperate shelf provinces of the East Marine Region are connected in a north-south direction by the southward moving East Australian Current and the northward moving longshore drift in the inshore area. The three provinces are also connected to the slope provinces of the East Marine Region by the movement of the Tasman Front and the associated eddy fields extending out into the Tasman Sea.

5.2.1 Central Eastern Shelf Transition

- There is a large seasonal variation in the sea surface temperature in the areas between Byron Bay and Coffs Harbour. Upwellings of cold, nutrient-rich water occur in these areas off headlands and also where canyons have incised the shelf edge. Increases of plankton occur, on the NSW coast between the Queensland border and Port Stephens, associated with the upwelling.
- Sediments in this Province consist of mud, sands and gravels along with rock outcrop.
- Geomorphology and sediment types are the primary determinants of the distribution of benthic organisms in the Province. Pelagic species distribution is more closely linked with variations in water masses.
- The reef building capability of corals reduces toward the south of the Province, with the southern limit of coral reef growth being the Solitary Islands. While some coral species that are found associated with reefs further north are also found south of the Solitary Islands, these species do not build reefs south of this point due to limiting temperatures, reduced winter day length and available calcium carbonate for skeleton formation.

5.2.2 Central Eastern Shelf Province

- The upwelling that is described in the Central Eastern Shelf Transition section above also occurs in the northern half of the Central Eastern Shelf Province.

5.2.3 South-east Shelf Transition

- The majority of this Province falls within the neighbouring South-east Marine Region.
- As a transition zone, this Province shares many species with neighbouring Provinces.
- To the immediate south of the East Marine Region in the vicinity of Green Cape, there is a change in the inshore species composition of some groups of organisms. The eastern warm temperate species are replaced by those with distributions primarily in southern and western warm temperate, and southern cool temperate areas.

Temperate Slope Provinces

Temperate waters over the continental slope of the East Marine Region cover three provinces: the Central Eastern Transition; Central Eastern Province; and the South-east Transition.

A significant characteristic of the temperate slope provinces is that most eddies spawned by the East Australian Current form here before moving eastwards. These eddies can be as broad as 200 kilometres across, rotating mainly anti-clockwise at up to four knots at the edge. They can be more than one kilometre deep and have a life of up to a year. They play a significant role in mixing ocean waters and the transport of larvae offshore, and they are a major ecological driver of the offshore ecological communities around Norfolk and Lord Howe Islands.

The slope running through these provinces is incised with canyons. These canyons formed through erosion by slumping, the action of turbidity currents, upwellings, the southerly movement of the East Australian Current, and the northerly movement of a sub-Antarctic return current that follows the base of the slope.

Connections between ecological communities in an east-west direction is related to the seasonal variation in the north-south location of the Tasman Front (cold water occurs

further north in winter and further south in summer) and the eddies spawned at the junction of the East Australian Current and the Tasman Front.

5.2.4 Central Eastern Transition

- The slope and canyons off southern Queensland are geologically younger and generally smaller than areas further south in the Region. Limestone ridges (old reefs) form exposed scarps on the upper slope. The slope is incised with small canyons (i.e. <500m deep) which are likely to support distinctive ecological communities due to the different characteristics of these canyons compared to those found further south, although there is currently no analyses to confirm this.
- Quartz sand originating from Fraser Island is being fed down the slope into the Province, and into a deep sea valley on the abyssal plain. The movement of this sediment is an important ecological driver in that associated species have adapted to this unstable environment. The canyons off Break Sea Spit that are feeding into the deep sea valley are one of the few canyons known to be active in Australia (the other known active canyon system is in Bass Strait).
- The northerly extent of the larger inactive canyons lies to the north of Moreton Island.

5.2.5 Central Eastern Province

- Although the majority of this Province consists of abyssal plain, the characteristics of the Province are derived mainly from knowledge of the continental slope on the western limits of the Province. The abyssal plain is likely to support distinct communities more in common with the neighbouring Tasman Basin Province than the slope areas of the East Marine Region.
- At a depth of 200-1500 m, the sediment found on the continental slope is formed of foraminiferal/calcareous oozes and mud. Sediment wedges and a few canyons exist at the top of the slope where there is evidence of echinoderm and sponge communities.
- On the mid-slope at a depth of 1500-3500m there are terraces and exposed bedrock. Canyon heads incise these terraces and the sediments are the remains of foraminifera and coccolith plankton.
- On the lower slope at depths in excess of 3500m, canyons amalgamate into larger canyon complexes that extend down to the abyssal plain at 5000m. The sediment in these areas is primarily made up of coccolith ooze and there is evidence of siliceous sponge communities.
- Depth, and related parameters such as light availability, temperature and pressure, as well as substrate and deep water currents are fundamental factors that influence the biological communities in this Province.
- Eddies resulting from the East Australian Current tend to form over the slope and are a highly variable, annual event that influence the ecology of this Province.

5.2.6 South-east Transition

- The majority of this Province is in the neighbouring South-east Marine Region. The fragment of this Province that does occur in the East Marine Region is essentially the same as described in the Central Eastern Province section above.

Tasman Basin
The Tasman Basin is characterised by a deep abyssal plain with the Tasmantid chain of seamounts aligned in a north/south direction through the centre of the Province. There is some evidence to suggest that the southernmost limits of the adjacent Kenn Transition Province could be included in this Province as the southern seamounts in the Kenn Transition are very similar to those found in the Tasman Basin Province.

Ecological connections in a north - south direction are influenced by the southerly flowing East Australian Current and associated eddies that move waters across the Tasmantid seamounts. Ecological connections in an east-west direction are influenced by the Tasman Front and associated eddy field.

5.2.7 Tasman Basin Province

- The northern cluster of seamounts in this Province and the southernmost cluster from the Kenn Transition may be grouped together. These seamounts differ (ecologically speaking) from those in the south.
- The gyre system that is situated over this northern cluster of seamounts creates conditions that are suitable for a number of species of cephalopod and mid-sized fish. Predators of those species, such as billfish, tuna and broadbill swordfish, appear to aggregate here and are found between Stradbroke Island and Fraser Islands (within the Kenn Transition).
- The southern cluster of seamounts have limestone caps (formed by ancient drowned reefs) over volcanic basalt bases. There is limited information available on the biota of these seamounts, although what is known suggests that the biota here is different to that found in the nearby Elizabeth-Middleton Reefs area to the east.
- Topographically-induced upwelling at seamounts and the interaction between eddies and seamounts can create conditions that lead to concentration of pelagic productivity around seamounts and conditions conducive to the establishment of filter-feeder dominated deep-reef communities.

Lord Howe Rise
The Lord Howe area is characterised by a large ridge and plateau complex extending in a north-south direction through the Province.

Ecological connections in a north-south direction are influenced by southward moving surface currents passing along the Chesterfield chain of seamounts in the Coral Sea (outside the EEZ) and by northward moving sub-Antarctic currents moving along the sea floor along the Lord Howe ridge.

Ecological connections in an east-west direction are associated with the Tasman Front and associated eddies, which generally migrate across the northern portion of the Lord Howe Province.

5.2.8 Lord Howe Province

- The western edge of the Lord Howe Rise is bordered by a series of discontinuous escarpments. The scarps have a shallower gradient in the north, becoming steeper in the south in the vicinity of Flinders seamount. The western side of the ridge is a more energetic environment than in the east, however, most of this energy is at the top of the water column. A slow moving sub-Antarctic water mass moves north along the western edge of the ridge and is known to cause upwellings of cold nutrient-rich water on the

Dampier Ridge. This is also likely to occur in other locations along the western escarpments.

- Recent studies in the area to the northeast of the Lord Howe Rise have found that the area has a relatively stable and homogenous pelagic and benthic environment. The area has a stable water mass with a uniform thermocline that may be the result of the Rise sheltering the area from the effects of the eddy fields to the west. The area is a large desert-like plain covered in calcareous pelagic ooze. Small seamounts poke through the sediments, some as young as 2 million years old. There is evidence for localised scouring around seamounts and on the plain soft sediment deformation has occurred due to dewatering. The seamounts are biological hotspots in the area, however, there is evidence of extensive bioturbation on the plain itself. It is likely that this environment extends south along the length of the eastern side of the Rise.
- This Province supports a unique mix of tropical, sub-tropical and temperate species and includes the southernmost known coral reef at Lord Howe Island. The presence of tropical species suggests linkages to northern waters along the Chesterfield range of seamounts or an avenue of connectivity for tropical or sub-tropical water and larvae through eddies of the East Australian Current.
- The Elizabeth and Middleton Reefs, and Lord Howe Island Reef systems are the highest latitude coral reefs in the world. These coral reef systems have affinities with the reefs of the Coral Sea, and are reliant on the southerly flow of the East Australian Current (which brings warm tropical surface water) to Lord Howe Island via Tasman Front eddies.

Norfolk Island

The Norfolk Island area is characterised by the Norfolk Island Ridge extending in a north-south line through the centre of the Province. The western flank of the Province is an abyssal plain while the eastern flank is characterised by seamounts and ridges.

The area is strongly influenced by New Caledonia to the north (making this bioregion unique in the East Marine Region), and by the easterly moving eddies associated with the Tasman Front which transport Coral Sea biota including corals, crustaceans and molluscs.

5.2.9 Norfolk Island Province

- The Province is geologically active and much younger than Lord Howe Island. The Norfolk Ridge includes many scarps and has been heavily eroded. There is evidence that currents move sediments from the crest of the to its flanks where canyons have formed by the slumping of sediments down the slope.
- The south-east seamounts off Norfolk Island are distinct from the rest of the Province. Several rise to within 1000 m of the sea surface. The quasi-permanent Norfolk Eddy creates a set of stable conditions different to those found in other areas of the Province. This area has a relatively high productivity and high biodiversity.
- Wanganella Bank at the southern margin of the Province forms a significant area of pinnacles shallower than 500 m. (Supports a game fishing industry)

6. Uncertainties and Gaps in Knowledge

Connectivity

- Although it is clear that in general there is an ecological connection between the different provinces of the East Marine Region, the specific nature of that connection is not always known.
- Where one species of animal is found in two different locations, it is often unclear whether this is a case of a single population of the species travelling between the two locations, or whether it is two distinct populations that do not interact with one another. The only way to be certain of the relationship between populations is to conduct comprehensive genetic testing, which is cost and labour prohibitive. An example is the black cod populations of Elizabeth-Middleton Reefs (north of Lord Howe Island) and south coast NSW. These animals were thought to be one population, but recent genetic work has shown them to be two distinct populations.
- Some aspects of the oceanographic connectivity of the East Marine Region are not well understood. Evidence such as scouring at the base of the continental slope and around seamounts suggests the presence of bottom currents moving through the East Marine Region. However, the exact path and nature of these water masses is not known.
- While knowledge of oceanographic and biological connectivity is important, it is not possible to gain comprehensive knowledge of these within short time frames as they require extensive and time consuming research.
- Data obtained from sampling undertaken during the NORFANZ voyage will be very valuable in increasing our understanding of oceanographic and biological connectivity. However samples have not yet been fully analysed, though considerable analysis would be possible within the timeframe of the East Marine Bioregional Planning process.

Biodiversity Knowledge and Ecological Community Mapping

- Existing bioregionalisation analyses such as IMCRA have relied on a limited knowledge of the distribution of certain species groups (such as commercial fish stocks) or on the use of geomorphic surrogates to determine ecosystem boundaries. Other species group distributions do not necessarily match those of the surrogate species or geomorphic features used in these bioregionalisations. To improve our understanding of the nature of ecological communities in the East Marine Region, improvements in our knowledge of the distribution of species groups is necessary.
- There is considerable information stored within museum collections that is not widely available. Although individual museums and universities may have large and comprehensive collections, they are not collated into a single searchable database. Collating this stored information data would be valuable, however different data standards/databases used by different institutions limits easy collation of this information.
- For planning purposes, improved fine-scale information on inshore communities is more important than improvements in our knowledge of offshore communities.

Variability of Currents

- The major currents in the East Marine Region are highly variable. For example the Southern Equatorial Current strikes the Queensland coast anywhere between 13^{o} and 22^{o} south. In turn, this significantly influences the location of the East Australian Current and the Hiri Current. A better understanding of why and how these currents vary in location and over time would be useful.

- Deep water currents in the East Marine Region are poorly understood, although it is known that they play a major role in transporting nutrients and may also have a role in shaping the topography of the Region. In addition, the influence of topographically-induced currents at seamounts and canyon heads, while hypothesised to be important from other examples, is not well understood for the Region. Further understanding of the influence of these deep water currents would be useful.

Patchy Data Coverage

- There is generally better information available in the Region for areas close to shore – along the coast of the mainland and around Lord Howe and Norfolk Island – than deep and isolated areas such as the abyssal plain and the north-eastern reaches of the Coral Sea. Both key species and sediments are fields of study where there is significantly more data available in shallow waters than in deep or remote locations.

7. Implications and Issues for the Management and Conservation of Biodiversity in the East Marine Region

Since European settlement human activity and use has significantly influenced the East Marine Region. The following question was considered by the group of experts, at the workshop: 'is human activity an important driver of ecosystem health?'.

It was generally agreed that human activity is an important driver of ecosystem health – particularly in the East Marine Region where the adjacent human population is so heavily concentrated in coastal environments. A number of activities were identified as adversely affecting the environments and species of the East Marine Region, including:

- whaling and sealing – includes the impacts of historical hunting on modern distributions and populations of key species groups that are still recovering;
- dam building – impacts on freshwater flows, sediments and nutrients (particularly south of the Great Barrier Reef);
- introduction of pest species into fragile habitats through hull fouling and ballast water exchange;
- marine debris – some impacts on key species groups through ingestion, entanglement and ghost fishing;
- fishing – impacts on habitat and the distribution and abundance of key species groups, particularly at seamounts, through bottom trawling;
- coastal development (eg. sewage outfalls) – impacts on the diversity and abundance of key species groups and on ecosystem health; and
- climate change – causing higher water temperatures, changes to seawater acidity, coral bleaching, increased cyclone intensity, etc.
- Land use practises – increasing turbidity and sedimentation from river outflows

ATTACHMENT A: Sedimentology Overview of the East Marine Region

Sedimentology:
The seabed of the East Marine is characterised by a range of sediment types. Mud is the dominant size fraction on the slope and abyssal plain/deep ocean floor, whilst sand dominates the upper slope and shelf. Localised gravel deposits occur most frequently on the slope and are generally absent from deep water areas. The carbonate content of sediment is highest in the tropical bioregions and at the shelf edge of the temperate bioregions. Sample coverage of the EMR is highest within the shelf bioregions and there is a lack of data that represents the sedimentary environment of the abyssal plain/deep ocean floor.

5.1.1 Cape Province
Sediment texture of the CP is fine and dominated by carbonate mud. Gravel forms less than 1% of the sediment volume and sand dominates sediment closest to the Great Barrier Reef. Slope is the dominant geomorphic feature of this bioregion and this is characterised by carbonate mud.

5.1.2 Northeast Transition
Sediment texture of the NET is variable with mud dominating trenches/troughs and sand dominating plateaus. Bulk carbonate content of the sediment is high and decreases with increasing water depth and distance from the Great Barrier Reef.

5.1.3 Northeast Province
Sediment texture of the NEP is variable and grades from sand dominated on the upper slope to mud dominated on the abyssal plain/deep ocean floor. Gravel content is low in this bioregion and bulk carbonate content is high, generally exceeding 90% $CaCO_3$. Carbonate content of sediments reduces with distance from the Great Barrier Reef. Mud is the dominant sediment type of the slope, trench/troughs and basins. Plateaus within the NEP are sand dominated.

5.1.4 Kenn Transition Province
Sediment texture of the KP is relatively homogenous and dominated by mud. Sand constitutes the dominant sediment type of seabed offshore Townsville. Gravel content is generally low (<1%) with a localised deposit offshore of Cairns. Carbonate mud is the dominant sediment type on the Kenn Plateau.

5.1.5 Kenn Province
Mud is the dominant size fraction in this bioregion followed by sand. A localised accumulation of gravel is present on the plateau. The bulk carbonate content of the sediments is high (~75-90% $CaCO_3$).

5.2.1 Central Eastern Shelf Transition
Sediment texture of the CEST is relatively homogenous, dominated by sand with localised gravel deposits and minimal mud content. Sand dominates the geomorphic features found in this bioregion including shelf, slope and shallow water terraces. Shallow water terraces in the CEST also contain a significant accumulation of gravel. The carbonate content of seabed sediments is moderate (~40-60% $CaCO_3$) and increases towards the outer shelf and upper slope.

5.2.2 Central Eastern Shelf Province

Sediment texture of the CESP is sand dominated with localised deposits of gravel situated in the north of the bioregion. Sand dominates the geomorphic features found in this bioregion including shelf, slope and shallow water terraces. Sediments with high mud content are located offshore Sydney and Newcastle. The carbonate content of seabed sediments is high and increases towards the outer shelf and upper slope.

5.2.3 South-east Shelf Transition

Seabed sediments of the SEST are sand dominated with mud and gravel consistently forming less than 20% of the sediment volume. Carbonate content of sediments is high and increases towards the outer shelf and upper slope.

5.2.4 Central Eastern Transition

The seabed of the CET is homogenous and dominated by sand size sediments. Sand is the dominant fraction of slope and terrace sediments with gravel present on terraces. The bulk carbonate content is highest in slope sediments.

5.2.5 Central Eastern Province

Sediment texture of the CEP is variable and grades from sand dominated on the upper slope to mud dominated on the abyssal plain/deep ocean floor. The bulk carbonate content of sediments decreases with increasing water depth and is lower in areas dominated by mud. The gravel content of sediments in this bioregion is generally less than 5%.

5.2.6 South-east Transition

At present there is insufficient sample coverage of the area of this bioregion within the EMR to confidently assess its sedimentology.

5.2.7 Tasman Basin Province

At present there is insufficient sample coverage of this bioregion to confidently assess its sedimentology.

5.2.8 Lord Howe Province

At present there is insufficient sample coverage of this bioregion to confidently assess its sedimentology.

5.2.9 Norfolk Island Province

At present there is insufficient sample coverage of this bioregion to confidently assess its sedimentology.