Chapter 2 The Marine Environment of the East Marine Region

The East Marine Region includes all Commonwealth waters from the eastern side of Cape York to just north of the New South Wales–Victoria border, as well as the waters around Norfolk and Lord Howe islands, and covers an area of some 2 400 000 km² of the Coral and Tasman seas. The Region is bounded inshore by the outer limit of State waters (generally around three nautical miles from the territorial sea baseline[1]) and the boundary of the Great Barrier Reef Marine Park, and offshore by the outer limit of the Australian Exclusive Economic Zone (see figure 2.1 for a description of maritime zones). The Region also includes the air space above its waters.

The Region is adjacent to, but does not cover, the State waters of Queensland and New South Wales, the Great Barrier Reef Marine Park, and Torres Strait. This chapter is focused primarily on describing features and ecological processes in Commonwealth waters. However, in some instances, features and ecological processes occurring in adjacent waters are identified, because:

- they are important to species listed as threatened or migratory under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Such species are protected as they are matters of national environmental significance (see chapter 3 and appendix B); or
- there is connectivity between features and ecological processes across marine jurisdictions.

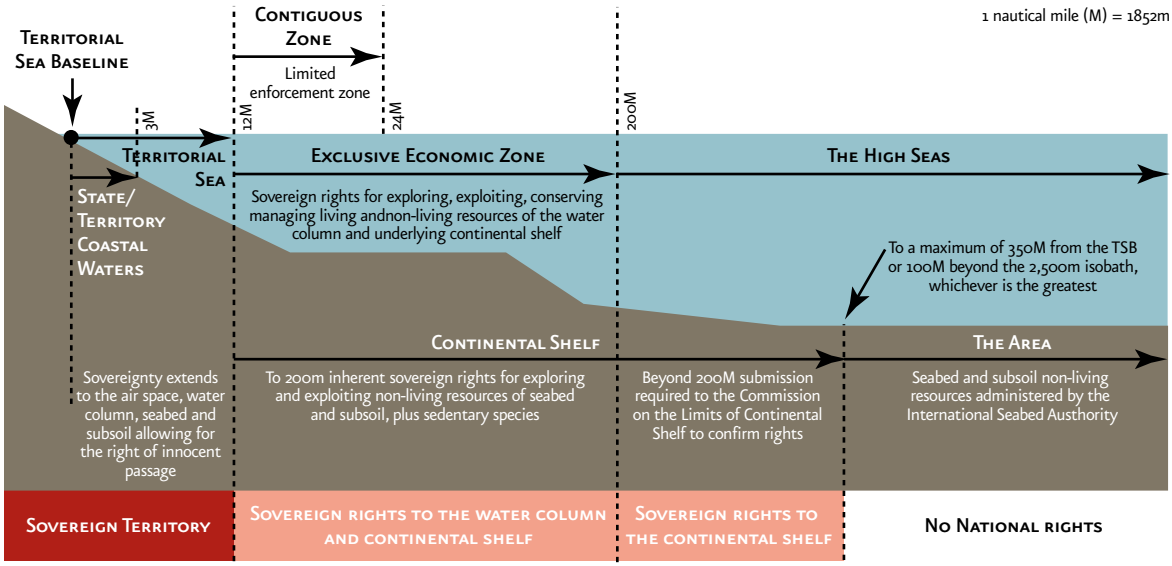
The majority of the Region encompasses waters over the continental slope having depths generally greater than 1000 m, although water depths do range from zero to over 5000 m.

From a global perspective, the Region is part of vast species-rich biogeographic zones stretching from the western Pacific to the east coast of Africa and to the Southern Ocean. The Southern Tropical Convergence and the Tasman Front at approximately 20 and 30 degrees South are water mass boundaries that mark the meeting of subtropical and temperate water masses, and on the continental shelf there is a tropical–temperate boundary between the northern tip of Fraser Island and Coffs Harbour. These physical barriers represent transition zones for the dispersal of tropical and temperate species.

Sea levels across the Region have periodically oscillated during recent geological times. Around 100 000 years ago much of the continental shelf was exposed. The periodic exposure and flooding of the continental shelf and offshore marginal plateaus is evident from the presence of large carbonate platforms formed by exposure of ancient reefs. Present-day reefs have formed on top of these carbonate platforms when they were again submerged. The East Australian Current (EAC) is the dominant oceanographic influence on ecosystems in the Region. Another factor is the different geomorphology resulting in a large range of depths across the Region as described in some detail in the following subsections.

2 While the territorial sea baseline is usually at the low water mark, the baseline extends across the openings of bays (e.g. Moreton Bay) and rivers, and extends around some coastal and offshore islands.

Figure 2.1 Australia's maritime zones



Geomorphology of the Region

The Region includes geomorphic features such as reefs, seamounts, offshore marginal plateaus and canyons, and covers extensive areas of shelf, slope and abyssal plain/deep ocean floor. These features formed during rifting and thinning of the continental crust of eastern Australia in the late Cretaceous between 110 and 80 million years ago, followed by a period of seafloor spreading up until the early Eocene (52 million years ago) with the formation of new basaltic ocean crust. The seafloor spreading and subsequent periodic volcanism and subsidence created the ocean basins, failed-rift troughs, ridges, plateaus and seamounts of the present day.

The Region went through significant fluctuations in climate, oceanography and sea level during the Quaternary (last 2 million years). Sea level was 70 to 120 metres below the present level for half of the past 300 000 years, and 40 to 80 metres below the present level for half of the last 100 000 years. Most of the present continental shelf was exposed during this time and there would have been a narrow shelf in the present Wollongong-Sydney-Newcastle area, with very little shelf anywhere else along the Queensland and New South Wales coast. The East Australian Current is likely to have been strong during the last glacial period and trade winds more intense.

The carbonate platforms, atolls and banks of the Queensland Plateau and Coral Sea would have been islands for more than half of the last 300 000 years and would have formed karst along with the Great Barrier Reef. The connection between the Coral Sea and Tasman Sea through the Cato Trough would have been reduced and Marion Plateau would have been a major promontory along the coastline. The reefs of Mellish, Frederick, Kenn, Wreck and Cato would have been slightly enlarged and exposed as islands. Norfolk and Phillip Islands would have been one larger island. The exposure of present living reefs during the last glacial period meant much lower productivity of the shallow water benthic community. Low carbonate and terrigenous mud were found for this period in cores taken from the Queensland Trough.

The Region is considered to have been tectonically stable during the Quaternary with no significant uplift, subsistence or faulting. Seamounts continue to subside, with younger seamounts in the southern end of the chains, including Lord Howe Island, subsiding faster but only at a rate of centimetres per thousand years.

Four geomorphic provinces occur in the Region. Slope makes up the largest area (77 per cent), abyssal plain/deep ocean floor (20 per cent), shelf (2 per cent), and rise (1 per cent). The region contains approximately 31 per cent of the area of slope in the entire Australian Exclusive Economic Zone. The Region has 18 of the 21 geomorphic features that have been identified on the Australian margin. Tidal sand wave/sand banks, sills and escarpments are not represented in the Region. Twenty six percent of the area of the Region–primarily abyssal plain and slope areas–have no geomorphic features identified with them. Sixty two percent of the Region is covered by basins, deepwater trenches/troughs, shallow and deep water terraces and plateaus. The Region has 69 per cent of the total area of plateaus, seamounts/guyots (42 per cent), saddles (65 per cent), basins (51 per cent), trenches/troughs (47 per cent) in the entire Australian Exclusive Economic Zone.

The sea in the Region is relatively deep with more than 80 per cent of the total area having water depths between 1000 and 5000 metres. Carbonate is dominant in 66 per cent of the sediment samples taken from the Region with carbonate content decreasing with increasing water depth and distance from the coast in the north.

Oceanography and other ecological drivers

The East Australian Current, which dominates the surface waters of the Region, is formed in the Coral Sea from the South Equatorial Current (SEC) (figure 2.2). Part of the SEC forms a clockwise circulation called the Hiri Current which flows northwards into the Gulf of Papua. The EAC flows south and is strongest between 25 and 30 degrees south. The flow of the EAC is directed off shelf at major headlands such as Fraser Island, Smoky Cape and Sugarloaf Point and is a significant process in sweeping sediments off the shelf edge.

The East Australia Current is the largest ocean current close to the coast of Australia and moves up to 30 million cubic metres per second of low-nutrient tropical water southwards down the Australian coastline towards the temperate regions, with a strong influence to 500 m depth and 100 km width. The current is strongest in summer, peaking in February at up to five knots, and weakest in winter, dropping to half its summer flow, its energy dissipating east of Tasmania. The low density, warm Coral Sea is almost one metre higher than the colder, denser Tasman Sea. The resulting slope between these two water masses gives strength to the EAC and determines the direction of flow.

The EAC frequently crosses the continental shelf in its southward run and moves close inshore, sometimes setting up northward-flowing currents on the shelf as a result of clockwise rotating 'cold core' eddies. As the

Tropical cyclone Ingrid approaching Cape York Peninsula. Image courtesy of MODIS Rapid Response Project at NASA/GSFC.

boundaries of the current fluctuate, advancing and retreating, large anti-clockwise 'warm-core' eddies with currents up to four knots at the edge are left behind. These eddies can be 200 km across and more than 1 km deep with a life of up to a year. The EAC causes upwelling of nutrient rich waters where it moves away from the coast at places like Cape Byron, Smoky Cape, and Sugarloaf Point. The current can be slowed or reversed by southerly winds within 10 nautical miles of the shore.

The differences between 'cold-core' and 'warm-core' gyres and eddies relates to the position of the nutricline (area of transition between nutrient-poor surface waters and nutrient-rich deep waters). Anti-clockwise 'warm-core' eddies position the nutricline below the euphotic zone (area where there is enough light to support photosynthesis), and therefore result in nutrient-poor conditions in surface waters. Clockwise 'cold core' gyres and eddies raise the nutricline within the euphotic zone resulting in nutrient-rich conditions in surface waters.

The strength of the East Australian Current decreases rapidly below 32° S and breaks up into 'warm-core' gyres or eddies. A 'warm-core' gyre forms along the Tasman Front at around 30° S. The Tasman Front is the interface between the warm waters of the Coral Sea and the cooler waters of the Tasman Sea and moves north-south seasonally between 30° S in winter and 34° S in summer. A 'cold-core' gyre originates in the southern part of the west Tasman Sea and meets subantarctic waters along the subtropical convergence (45° S). Surface waters of the EAC move south while deeper layers of waters, including the Antarctic Intermediate Water at 1000 metres depth and the Antarctic Bottom Water beneath it, move from south to north in the Region.

Figure 2.2 Major ocean currents in eastern Australian waters
Image courtesy of CSIRO Marine Research.

Grey reef shark. Photo: Photolibrary.

Biodiversity in the East Marine Region

Biological communities found in the provincial bioregions of the Region are closely associated with geomorphic and oceanographic features and can be grouped into six categories:

- Coral Sea cays/atolls/islets
- Coral and Tasman Seas seamounts/guyots/islands
- continental shelf
- abyssal plains and troughs
- cold-core and warm-core gyres and eddies
- continental plateaus.

Few sites within the Region have been intensively sampled and there follow detailed descriptions of only Coral Sea cays/atolls/islets, Coral and Tasman Seas seamounts/guyots/islands, and continental shelf biological communities. It is not possible to apply generalised descriptions to biological communities found in all provincial bioregions as they are based on only a few sites in the Region that have been the subject of detailed study and data gathering. The six categories of biological communities listed above are included in the provincial bioregion descriptions together with geomorphic and oceanographic features. No details are provided on the biological communities found in most provincial bioregions as they have not been the subject of detailed study and data gathering. The biological communities described below are referred to in the descriptions of provincial bioregions where they occur, with additional information on biological communities also provided for some provincial bioregions.

Coral Sea cays/atolls/islets

Coral Sea reefs, lagoons, sandy coral cays and islets support marine benthic flora and fauna that are distinct from those of the Great Barrier Reef. Algae are an important component, often covering a greater area than corals. Sixty-six species of algae have been recorded on North East Herald Cay, which is thought to be a fraction of the total present. This included 41 species of red algae, 23 species of green algae and two of brown algae. Halimeda, a calcified algae of warm seas, was a prominent feature on this cay. The near absence of brown algae was considered unusual.

In comparison to shallow reef areas of the Great Barrier Reef, a high abundance of sponges were recorded at Chilcott Islet and East Diamond Islets. Sponges have been recorded as being more abundant than corals, in places forming large and spectacular sponge gardens. Common sponge species include *Polyfibrospongia flabellifera*, *Carteriospongia lamellose*, *C. pennatula*, *and Phyllospongia pennatula*.

Hard corals are not especially abundant or diverse and cover a relatively small proportion of reef area compared to hard corals of the Great Barrier Reef. Average maximum coverage range from 19 per cent to 26 per cent. One hundred and forty species of coral have been found at the Coringa–Herald Reserve. Dominant hard coral species include *Acropora palifera*, *A. humilis* and *Pocillopora* species. Soft corals tend to be more important in sheltered areas such as the deeper reef slope areas and deep reef flats. Soft coral cover of 3.5 per cent has been recorded at North East Herald Cay, dominated by *Sarcophyton* species.

Marine molluscan fauna is moderately rich and is a subset of a more widely distributed tropical molluscan fauna. Seven hundred and forty-five species of marine molluscs have been recorded at North East Herald Cay, representing 118 families. Eighty-seven families of gastropod mollusc, 21 of bivalve mollusc, four of cephalopod mollusc, three of scaphopod mollusc, and one of amphineurid mollusc were represented. No endemic species have been recorded. *Rissopsis typica* and *Cypraea childreni* have been recorded as common in the Coral Sea while being rare over much of the rest of their range. Sponge-feeding molluscs such as Triphoridae and Cerithiopsidae were not abundant despite the presence of extensive sponge gardens.

One hundred and twenty-eight species of marine, semi-terrestrial and terrestrial decapod crustaceans were found at North East Herald Cay. Seventeen of these were new records for Australian waters. The marine crustaceans tended to be inconspicuous and not abundant, while the semi-terrestrial and terrestrial species were both conspicuous and abundant. Most species recorded had wide Indo–Pacific distribution, while many species that are common and widely distributed on the Great Barrier Reef were absent.

The hydroid fauna is considered remarkably rich compared with other reef areas. Fifty-five species have been found at North East Herald Cay, representing 14 families, with more species likely to be present. Eleven species were new records for Queensland reef waters and nine were new records for Australian waters. Starfish, brittle stars, feather stars, sea urchins, sea cucumbers and other invertebrate groups have been observed but no systematic surveys of their diversity and abundance have been undertaken. Crown-of-thorns starfish have been found in some of these communities but not in sufficient numbers to cause disturbance to indigenous reef fauna.

Fewer species of reef fish were found on some Coral Sea cays than in the Great Barrier Reef and not many endemics. The fish assemblages were distinct from those of the Great Barrier Reef. Three hundred and seventy-two species of fish have been found at the Coringa–Herald Reserve from 54 families. Six families: Labridae (wrasse), Pomacentridae (damselfish), Acanthuridae (surgeonfish), Chaetodontidae (butterfly fish), Serranidae (cod and coral trout), and Scaridae (parrotfish) comprised the most number of species.

The green turtle (*Chelonia mydas*) was found mating and nesting on cays and islets within the Coringa–Herald Nature Reserve and Lihou Reef Nature Reserve, and genetic studies have shown that they are of the same genetic stock as green turtles in the Great Barrier Reef and Torres Strait. Hawksbill turtles have been sighted but have not been observed nesting. The Coral Sea cays are included within the range of 12 cetacean species. A full list of cetacean species found in the Region is included in appendix D.

Most of the islets and cays are composed of sand, rocks and coral rubble that rise no higher than five metres above mean sea level. Some have grassland, herbfield, shrubland and forest habitats. Flowering terrestrial plants recorded are primarily widespread tropical shoreline species of the Indo–Pacific Region. The exception is *Digitaria ctenantha*, a grass native to northern Australia. Thirty terrestrial plant species have been found. Island isolation, weather patterns, island size, availability of freshwater lenses beneath cays, and frequency of 'washover' events, depositing seeds high enough on the islands for them to germinate influence the occurrence and abundance of plant species. Vegetated islets are fringed with the shrub *Argusia argentea* and have a grassy understorey dominated by *Lepturus repens*, *Stenotaphrum micranthum*, and *Sporobolus virginicus*.

Pisonia grandis shrub forest that occurs on some cays is relatively uncommon in Australia and globally despite its extensive Indo–Pacific distribution, since throughout much of its range, these forests have been cleared for subsistence agriculture and guano mining. Only 44 of the 950 islands within the Great Barrier Reef region have this forest left, it being most rare in the north of this region where it does not generally form monospecific stands. These forests provides significant habitat for nesting seabirds. Cyclones and outbreaks of scale insect (*Pulvinaria urbicola*) have damaged some forest areas.

Cave formation, Great Barrier Reef. Photo: Photolibrary.

The composition of terrestrial invertebrate fauna is not well known. Mites, spiders, spring tails, ants, flies and beetles were the most commonly recorded groups at North East Herald Cay. Of scientific interest is a species of pseudoscorpion belonging to the genus *Nannochelifer*, which was previously known from a single species in Kenya. A related species, *N. paralius*, was also found.

There are extensive seabird colonies of great significance to the Region. Fourteen seabird species breed on Coral Sea cays. The red-footed booby (*Sula sula*), least frigatebird (*Fregata ariel*), great frigatebird (*Fregata minor*), and red-tailed tropicbird (*Phaethon rubricauda*) that have an extensive distribution outside Australian waters but are uncommon within Australia, breed on these cays. Since 1992 a monitoring program focusing on these birds and the brown booby (*Sula leucogaster*), masked booby (*Sula dactylatra*), and black noddy (*Anous minutus*) has been conducted in Coringa–Herald and Lihou Reef National Nature Reserves.

Breeding of red-footed boobies, red-tailed tropicbirds and frigatebirds is largely seasonal, although eggs and chicks can be found at any time. Most breeding commences at the end of the cyclone season in March-April and continues during the cooler months. The red-footed booby population in the Coringa–Herald and Lihou Reef National Nature Reserves has remained stable at about 150 pairs in *Argusia* shrubland and 1000 pairs in the mixed *Pisonia-Cordia* forest. Three hundred and sixty-seven active nests of red-tailed tropicbird have been recorded at North East Herald Cay, making it the largest known population of this species in the Region and the second largest in Australia (after Christmas Island in the Indian Ocean). The buff-banded rail (*Gallirallus philippensis subsp.*) and the purple swamphen (*Porphyrio porphyrio*) are the only known land birds that breed on these cays. An additional 22 sea and land bird species have been found as regular or vagrant non-breeding visitors.

There are no known native terrestrial mammals recorded. The black rat (*Rattus rattus*), which is believed to have been introduced by mariners in the mid-20th century, persisted on some islets for many years. These were eradicated in 1991 and have not been recorded since. Geckos (*Gehyra mutilata*) are common on some islets.

Coral and Tasman Seas seamounts/ guyots/islands

Chains of volcanic seamounts in the Coral and Tasman Seas include the southernmost open ocean platform reefs in the world. A combination of isolation, exposure to convergent tropical and temperate ocean currents and climates has given rise to distinct and diverse assemblages of marine species, including endemics, on these seamounts. The isolation of the reefs on some seamounts has made them refuges for species such as the black cod (*Epinephelus daemelii*), once common along the New South Wales coast, but now rare. Some species found on Lord Howe Ridge and Norfolk Ridge appear to be relicts of groups believed to have disappeared in the Mesozoic. There seems to be low species overlap on different seamounts in the Region: they tend to be isolated marine systems with highly localised species distributions. Seamounts may be important sites of evolution and speciation in the otherwise deep sea.

Seamount-associated species of fish are typically slow-growing species which have exceptionally long life histories. They can be broadly categorised into those associated with the deepwater coral gardens (e.g. rockfish) that they use for refuge, and those associated with the seamount itself (e.g. orange roughy) that feed on other fish, squid and crustaceans brought in by the currents. Vertically-migrating plankton such as krill also becomes prey when they are trapped above the seamounts.

Islands cap some seamounts while other seamounts remain underwater as volcanic peaks or flat-topped guyots. Some of the islands and their surrounding waters are used as

Shy albatross. Photo: Dr Michael Double.

feeding grounds for a number of species of migratory seabirds and by green turtles (*Chelonia mydas*). The leatherback turtle (*Dermochelys coriacea*) may also be found foraging on seamounts. The common noddy (*Anous stolidus*) breeds on some islands. Other seabirds likely to forage around seamounts include the wandering albatross (*Diomedea exulans*), Antipodean albatross (*Diomedea antipodensis*), Campbell albatross (*Thalassarche impavida*), Gibson's albatross (*Diomedea gibsoni*), shy albatross (*Thalassarche cauta*), white-bellied storm-petrel (*Fregetta grallaria*), Kermadec petrel (*Pterodroma neglecta*), great-winged petrel (*Pterodroma macroptera*), white-necked petrel (*Pterodroma externa*), fleshy-footed shearwater (*Puffinus carneipes*), wedge-tailed shearwater (*Puffinus pacificus*), sooty shearwater (*Puffinus griseus*), masked booby (*Sula dactylatra*), sooty tern (*Sterna bergii*), and ruddy turnstone (*Arenaria interpres*).

Few of the seamounts in the Region have been intensively sampled. One hundred and twenty-two species of coral were recorded at Elizabeth and Middleton Reefs and the structure of these seamounts was found to consist of moderate hard coral cover with a low abundance of *Acropora* coral species, sandy lagoons, algal meadows (encrusting or turf algae) and small patches of seagrass (*Halophila ovalis*) in sheltered sandy lagoons.

There are thought to be more than 200 species of deep water ahermatypic corals found in the Region and where they occur they can be very abundant, reaching densities of up to 50 per square metre. Some reefs have been found to support an extremely rich and diverse algal flora, 18 taxa have been identified with a high potential for genetic uniqueness. Some of the sandy cays are vegetated with grass. Three hundred and twenty-four fish species have been found at Elizabeth and Middleton reefs.

Deep sea coral and sponge communities–sometimes highly diverse–have been found on seamounts, mid-ocean ridges, continental plateaus and slopes. Over 850 species of macro and megafauna have been found on seamounts in the Tasman and Coral Seas. Growth and reproduction in these deep sea communities is often very slow: some corals and sponges may live for centuries. Orange roughy (*Hoplostethus atlanticus*) has been found on some seamounts, and yellowfin tuna (*Neothunnus macropterus*) and swordfish (*Xiphias gladius*) aggregate around seamounts.

Fifteen per cent of Australian shark species such as mackerel sharks (Lamnidae), including great white sharks (*Carcharadon carcharias*), whaler sharks (Carcharhinidae), hammerheads (Sphyrnidae), and the Galapagos shark (*Carcharhinus*

galapagensis) are typically pelagic and may be found around seamounts. Holothurians (sea cucumbers) have been found at high densities on some reefs with *Holothuria whitmaei (nobilis)* (black teatfish) and *Holothuria atra* (lollyfish or black sea cucumber) the most common species found.

Sea-snakes of the Hydrophiidae and Laticaudidae families and seahorses, seadragons and pipefish of the Sygnathidae family may be found on seamounts. Three mollusc species have been found to be endemic to Elizabeth and Middleton Reefs, *Turbo cepoides*, *Astralium wallisi*, *Amphithalamus* species, and seven mollusc species have been found to be endemic to seamounts in the Tasman Sea. The Region's seamounts are included within the distribution range of thirty species of cetaceans (full list is included in appendix D).

Continental shelf

The continental shelf is generally at less than 200 m water depth and includes littoral/intertidal ecosystems, coral-fringed islands and rocky outcrops, subtidal reefs, pinnacles, and open ocean ecosystems. There is a tropical/temperate transition in the marine invertebrates found in the Region that is most evident on the continental shelf and becomes less distinct in deeper waters off the shelf (figure 2.3).

Tropical coral larvae are transported by the East Australian Current from the Great Barrier Reef and Coral Sea reefs to subtropical reefs in southeast Queensland and northern New South Wales as far south as the Solitary Islands near Coffs Harbour. The species composition of coral communities follows the tropical/temperate divide for benthic communities. Near Coffs Harbour, 77 species, or 85 per cent of coral species, are near the southern extent of their range, and 11 species, or 12 per cent of coral species, are subtropical species that are absent or rare in the Great Barrier Reef. Subtropical and temperate coral species are dominant in terms of percentage cover towards the southern limits of coral reefs on the continental shelf, and soft corals are less abundant, possibly due to higher wave action. Ninety species of hard coral, mostly from the genus *Acropora*, have been recorded at the southern limits of coral reefs, which is less than a quarter of the approximately 400 species recorded on the Great Barrier Reef.

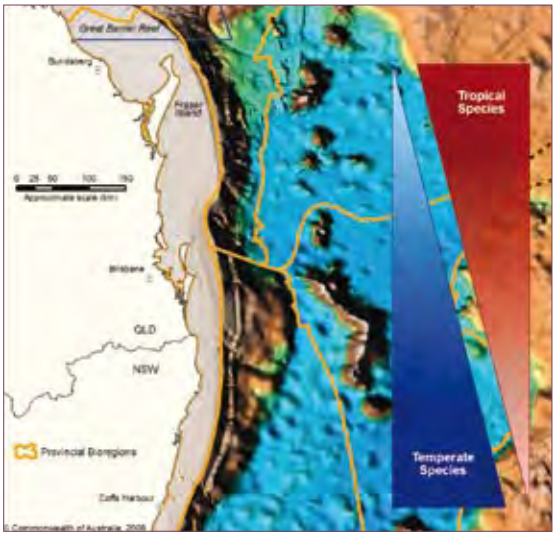
Decapod crustacean species, including shrimps, prawns, lobsters, bugs and crabs are particularly diverse, with 50 per cent of Australia's 2250 species found on the Queensland continental shelf. One hundred species of syngnathids, which includes seahorses, pipefish, pipehorses, and sea dragons, have been found in the Region. Most of the 1500 sponge species in the Region are found on the continental shelf. The distribution of decapod crustaceans, echinoderms, syngnathids, and sponges follows the tropical/temperate transition between tropical and temperate species off Tweed Heads.

Five hundred and fifty species of mollusc (octopus, squid, cuttlefish, scallop, and nautilus) have been recorded for the Region. Twenty-five species of sea snake are found in the Region, mostly confined to tropical areas. Temperate neritic (coastal) species assemblages of marine phytoplankton are found in coastal waters off New South Wales. There is natural enrichment of oceanic waters within the Region resulting from upwelling along the outer margin of the Great Barrier Reef, the New South Wales coast between the Queensland border and Port Stephens, and northern

Figure 2.3 Transition of tropical/temperate benthic species on Australia's eastern continental shelf

The continental shelf off Tweed Heads, New South Wales is a major tropical/temperate transition zone for benthic communities in the Region:

- the occurrence of **tropical benthic species** ranges from approaching 100 per cent at the northern tip of Fraser Island, to almost zero at Coffs Harbour.
- the occurrence of **temperate benthic species** ranges from approaching 100 per cent at Coffs Harbour, to almost zero at the northern tip of Fraser Island.



Lord Howe Island Group. Photo: Ian Hutton and the Department of the Environment, Water, Heritage and the Arts.

New South Wales continental shelf off Smoky Cape near Diamond Head, Forster and Seal Rocks. These areas support rich phytoplankton assemblages.

The fairy penguin (*Eudyptula minor*) nests on islands along the coast of New South Wales and Victoria and ranges northwards to subtropical coastal waters. Thirty species of petrel, shearwater, prion and diving-petrel are found in the Region, with several of these species breeding on islands along the coast. No albatross breed in the Region, but they are found in temperate waters along eastern Australia. Five species of storm-petrel occur in the Region, mainly in temperate and subtropical areas. The white-faced storm-petrel (*Pelagodroma marina*) breeds on islands along the south- east coast.

Two species of frigatebird nest on islands in the Great Barrier Reef and Coral Sea and move into subtropical areas to forage. The osprey (*Pandion haliaetus*) occurs along almost the entire mainland coast of the Region down to Coffs Harbour. There are three breeding species of gull, and 15 species of tern, nine of which breed within the Region. Four species of skua and jaeger are found in the region but do not breed near the Australian mainland. Fourteen sandpiper and three plover species are found in the Region. The white-faced heron (*Egretta novaehollandiae*) breeds in small numbers in the Region, and the cattle egret (*Ardea ibis*) and two species of oystercatcher occur in the Region.

Six species of marine turtle are found in the Region, including the loggerhead turtle (*Caretta caretta*), green turtle (*Chelonia mydas*), hawksbill turtle (*Eretmochelys imbricata*), olive ridley turtle (*Lepidochelys olivacea*), flatback turtle (*Natator depressus*), and leatherback turtle (*Dermochelys coriacea*). All marine turtle species forage on the continental shelf. Large concentrations of foraging loggerhead turtles have been found in the Hervey Bay/Moreton Bay area and they migrate to nesting beaches in the southern Great Barrier Reef and mainland beaches near Bundaberg. Small numbers breed in northern New South Wales and New Caledonia.

Green turtles are most abundant on the Queensland continental shelf but are found as far south as the Victoria/ New South Wales border. Most migrate to nesting beaches in the southern Great Barrier Reef, with small numbers migrating to breed in the northern Great Barrier Reef, New Caledonia and Vanuatu. Most hawksbill turtles are found within continental shelf waters of Torres Strait and the Great Barrier Reef but are found as far south as northern New South Wales. Breeding sites for hawksbill turtles found in southern Queensland and northern New South Wales have not been determined but there are known breeding

Loggerhead turtle laying eggs. Photo: Lochman Transparencies.

sites in the northern Great Barrier Reef, Solomon Islands and Vanuatu. Flatback turtles are found on the continental shelf as far south as Hervey Bay and migrate to breed on beaches between Townsville and Bundaberg. Olive Ridley turtles found as far south as Hervey Bay do not breed in the Region. Leatherback turtles are mainly an oceanic species, but will forage on the continental shelf from near the Sunshine Coast in south Queensland to Bass Strait. Nesting sites for these turtles have not been determined for the Region although there are known nesting sites for leatherback turtles in northern Papua New Guinea and the Solomon Islands.

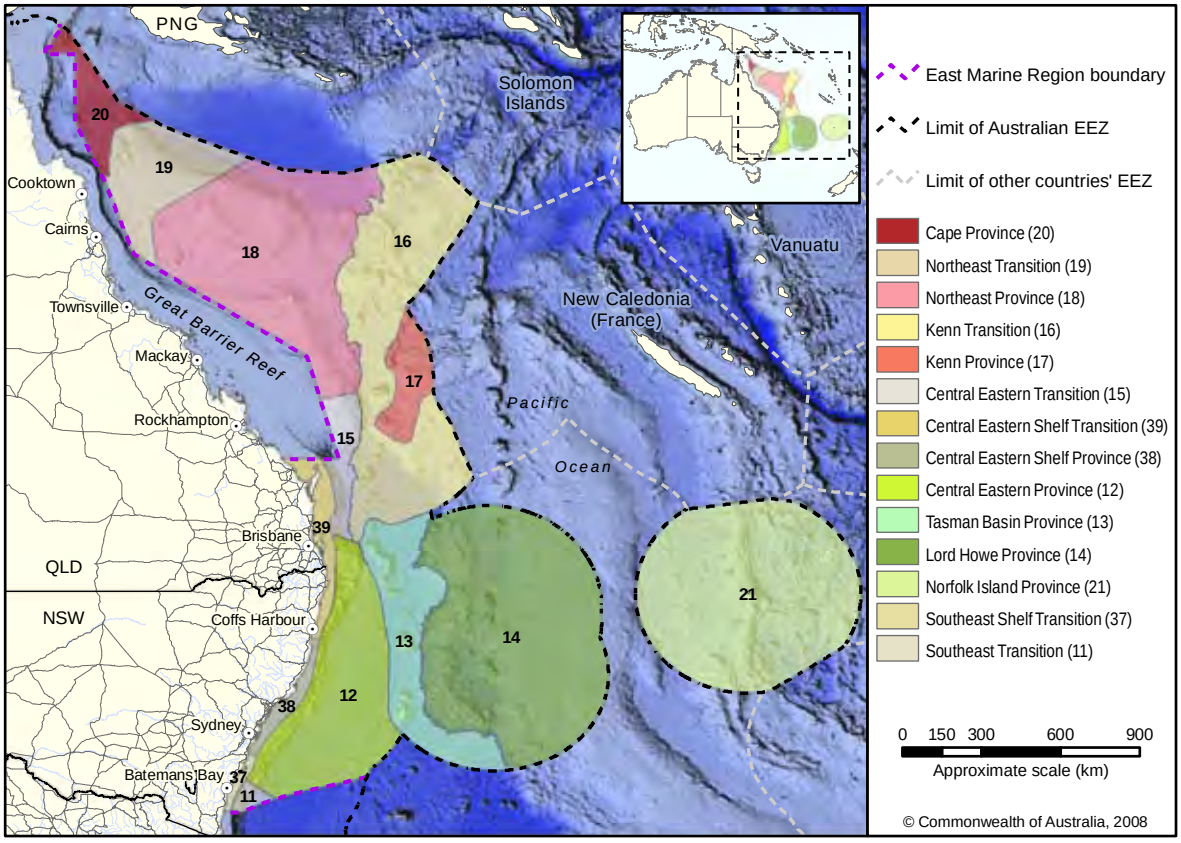
Around 200 species of shark, ray and chimaerid (ghost shark and elephant fish) have been found in waters off New South Wales and eastern Queensland. Eighty per cent of Australia's sharks and rays are demersal species. Harrison's dogfish (*Centrophorus harrissoni*) and the purple eagle ray (*Myliobatis hamlyni*) are endemic to the region. The grey nurse shark (*Carcharias taurus*), listed as critically endangered in the Region, is found in the vicinity of inshore rocky reefs and islands where there are gutters in reefs and submarine caves. The great white shark (*Carcharodon carcharias*), also found on the continental shelf, is listed as vulnerable.

Common seafloor fish species include the blue-spot flathead (*Platycephalus speculator*) and red-spot whiting (*Sillago flindersi*). Common pelagic fish species include slimy mackerel (*Scomber australisicus*), kingfish (*Seriola lalandi*), Spanish mackerel (*Scomberomorus commersoni*), and tuna species. Rare fish species include the giant Queensland groper (*Epinephilus lanceolatus*), Bleekers devil fish (or blue devil fish) (*Paraplesiops bleekeri*), and the black cod (*Epinephilus damelii*). High densities of anemone fish have been recorded in some sites, including the black anemone fish (*Amphiprion melanopus*), Barrier Reef anemone fish (*Amphiprion akindynos*), and the subtropical anemone fish (*Amphiprion latezonatus*). These species are associated with sea anemones, coral and sponges of subtidal reef habitats.

The continental shelf in the Region is included within the range of 25 cetacean species. A full list of cetacean species found in the Region is included at appendix D. Seals likely to occur include the Australian fur seal (*Artocephalus pusillis*), New Zealand fur seal (*Artocephalus forsteri*), leopard seal (*Hydrurga leptonyx*), and southern elephant seal (*Mirounga leonia*). There are no known breeding colonies of seals in the Region. Montague Island and Steamers Head, Jervis Bay are major haul-out sites for Australian and New Zealand fur seals. Australian fur seals are the most abundant seal species in the Region. Dugongs (*Dugong dugon*) have been recorded on the continental shelf, mainly in coastal waters.

2.1 The provincial bioregions of the East Marine Region

Figure 2.4 Provincial bioregions of the East Marine Region (IMCRA v.4.0)



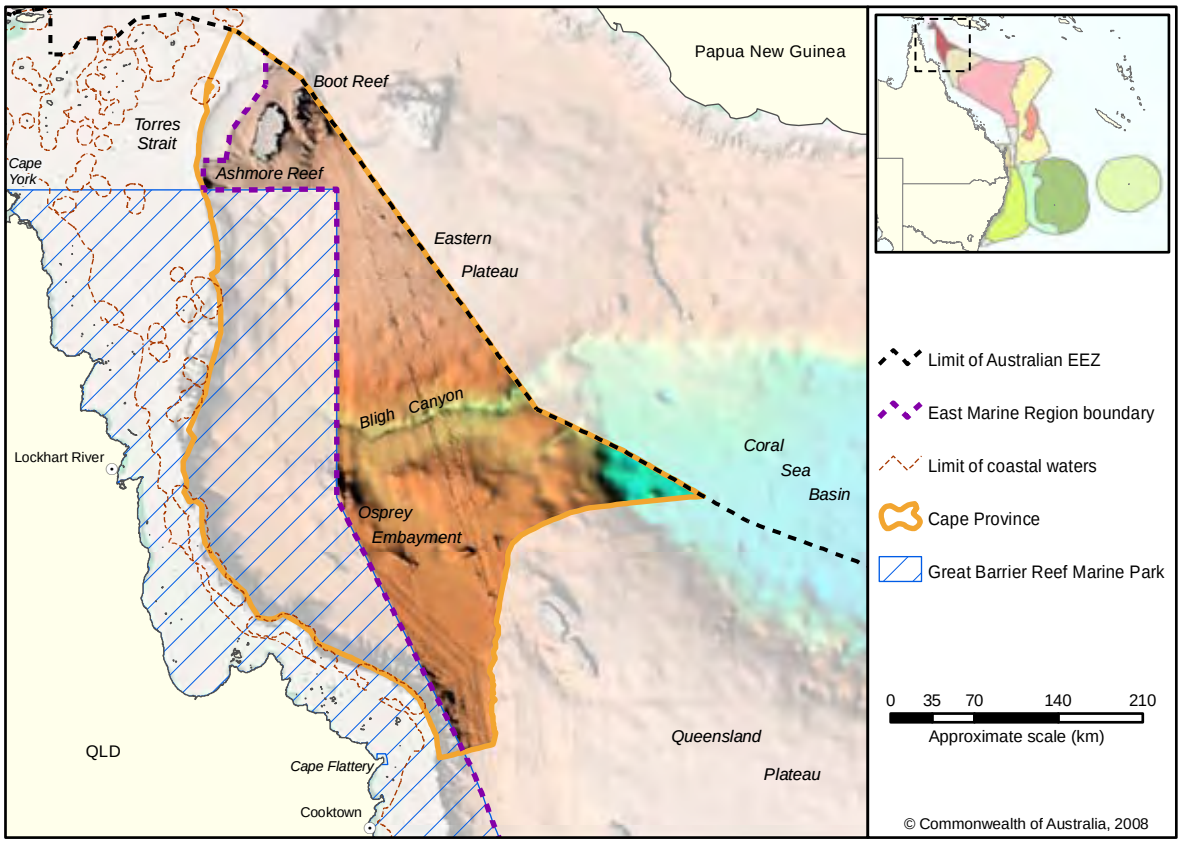
The Integrated Marine and Coastal Regionalisation of Australia Version 4.0 (IMCRA v.4.0) identifies fourteen provincial bioregions in the Region (see figure 2.4). This regionalisation represents the distribution patterns of marine life in the Region at a broad scale. The provincial bioregions described in this Bioregional Profile, beginning with the northernmost, are:

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

Each provincial bioregion is described below in terms of the characteristics of its marine environment, including its physical environments, biological communities and ecological processes.

2.1.1 Cape Province

Figure 2.5 The Cape Province



The Cape Province is located on the continental shelf between Cape York and Cape Flattery. It covers a total area of 109 340 km². Fifty-seven per cent (62 520 km²) of the provincial bioregion is within the East Marine Region, with the remainder in the Great Barrier Reef Marine Park, Torres Strait, and Queensland State waters.

Geomorphology

The Cape Province has a high proportion of the deep/hole/valley and ridge features found within the East Marine Region with the majority of the provincial bioregion deep water between 1000 and 4000 m. The main features include the Osprey Embayment, Eastern Plateau, and Ashmore and Boot Reefs. The provincial bioregion receives significant sediment flows from Papua New Guinea river systems. Carbonate mud is the dominant sediment type in the Cape Province though carbonate content of sediments is low in comparison to other offshore provincial bioregions in the Region.

The portion of the Osprey Embayment within this provincial bioregion is an area of deep water valleys and troughs that extends 300 km from the Great Barrier Reef east to the abyssal plain of the Coral Sea Basin. It is 200 km from north to south and includes Bligh Canyon which is 3600 m at its deepest point and runs east-west along the northern margin of the Osprey Embayment for 160 km. The Queensland Trough that runs adjacent to the Great Barrier Reef boundary from the south drains into Bligh Canyon as does Bligh Trough adjacent to the Great Barrier Reef to the north. Sediments entering the Cape Province from the Great Barrier Reef and offshore plateaus move through the system of deep water valleys and troughs in the Osprey Embayment to drain into the Coral Sea Basin.

The south-west corner of the Eastern Plateau–one of the three large marginal plateaus offshore of the Great Barrier Reef that formed during the break-up of the continental crust and subsequent seafloor spreading–falls within this provincial bioregion. These plateaus have been impacted by tectonic subsistence in the early Miocene and ancient reefs have formed broad limestone platforms on large areas of the drowned plateaus.

The atoll reefs of Ashmore and Boot Reefs are examples of reefs formed on limestone platforms of the Eastern Plateau. These reefs rise from depths of 1000 to 1500 m on their eastern side to form carbonate platforms less than 100 m underwater. The platforms are north-south elongate 45 by 20 km (Ashmore) and 20 by 10 km (Boot). Both platforms

are surrounded by deep water valleys and troughs between 500 and 700 m deep. The platforms are 10 km apart separated by a narrow 700 m deep channel.

Up to 50 per cent of sediments on the Eastern Plateau may be organic-rich, causing the carbonate content of sediments in Cape Province to be diluted.

Oceanography

This provincial bioregion is situated in tropical waters. The westerly flow of the South Equatorial Current through the Coral Sea, and the variation in this current caused by north-west monsoonal winds from November to May and south-east trade winds from June to October, influence the tropical provincial bioregions in the Region. The southerly direction of the north-west monsoonal winds can be maintained over a number of months from its onset, while there may be periods of relative calm–often referred to as 'doldrums'–from December to April. The South Equatorial Current bifurcates between 13° S and 22° S, creating the north-trending Hiri Current and the south-trending East Australian Current.

The Cape Province falls within the range of the bifurcation of the South Equatorial Current and is part of a 'formation phase' region for both the East Australian Current and the Hiri Current. The Hiri Current influences this provincial bioregion more than any other provincial bioregion in the Region and creates the east-trending Gulf of Papua Gyre.

Biological Communities

The Cape Province has Coral Sea cays/atolls/islets biological communities associated with Ashmore and Boot reefs. There are abyssal plain and trough biological communities

Bigeye trevally. Photo: Photolibrary.

Dwarf minke whale–The dwarf minke whale (*Balaenoptera acutorostrata* unnamed *subsp.*) is not listed under the EPBC Act. However, at the species level, the minke whale (*B. acutorostrata*) is listed as both cetacean and migratory under the Act.

Dwarf minke whale, Great Barrier Reef. Photo: Matt Curnock.

Between March and October, dwarf minke whales are seen in Cape Province and the northern Great Barrier Reef, with about 80% of sightings in June and July. Scattered sightings and strandings from southern Queensland and northern New South Wales early in the season (May-June) and late in the season (September) give hints of a migration along the east Australian coast but records are incomplete to document movements of the whales.

Dwarf minke whales are known for their curiosity. A swim-with-whales industry has recently developed in waters of the northern Great Barrier Reef based on the voluntary approaches of dwarf minke whales. Here people may swim with whales only if the whales initiate the encounter. A range of management measures govern people's behaviour during an encounter. Research is focussed on learning more about the dwarf minke whales, their interactions with swimmers and on monitoring any potential impacts of this activity on the whales.

Red-tailed tropicbird. Photo: Mark Holdsworth.

associated with the Osprey Embayment, and cold-core and warm-core gyre and eddy biological communities associated with the Gulf of Papua Gyre and Hiri Current eddies. The biological communities in this provincial bioregion have not been the subject of detailed study or data gathering. Approximately 300 species of demersal fish are found in the Cape Province, and 24 endemic species.

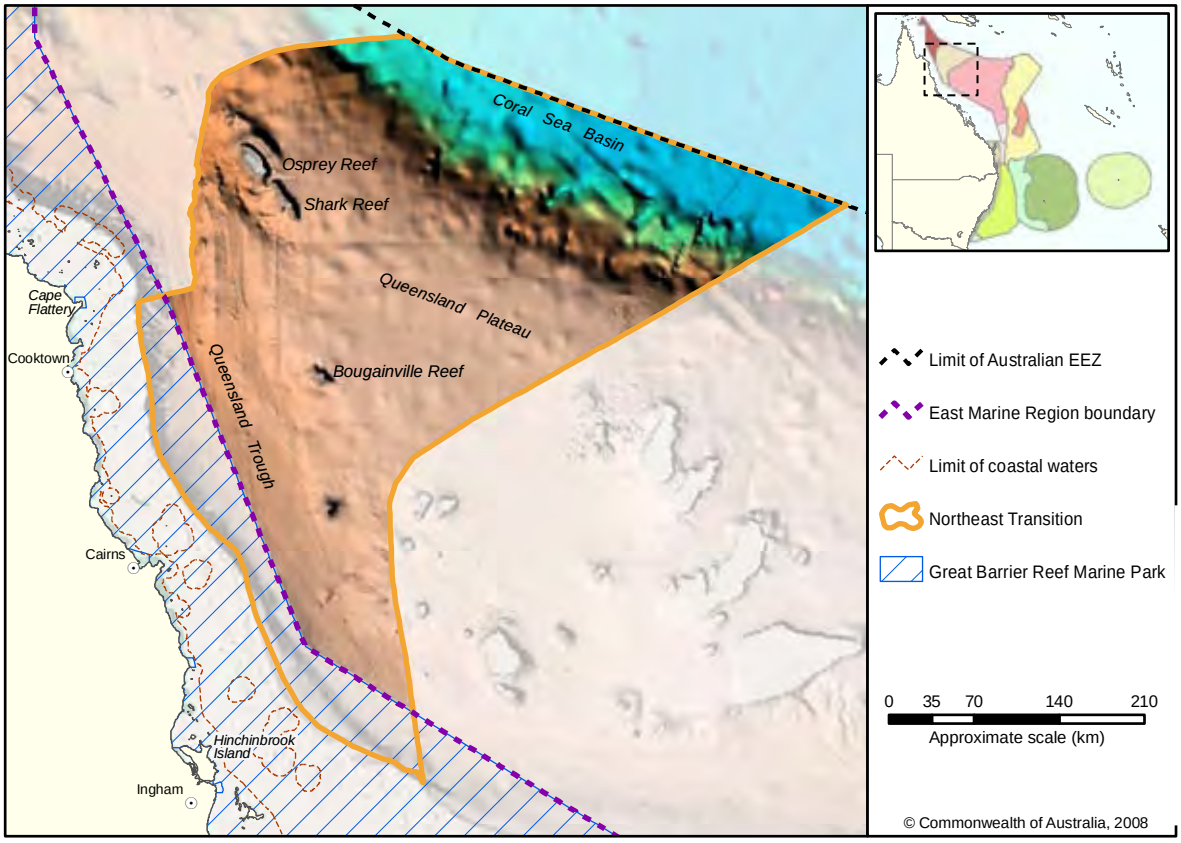
Ecosystem Processes

The Cape 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 Cape Province. The ecological significance of this gyre and the flow of the Hiri Current is not clear but the biological communities on the northern reefs may be distinct from reefs in southern provincial bioregions that are more heavily influenced by the southern divergence of the South Equatorial Current as it becomes the East Australian Current. The Cape Province biological communities may be distinct from those of the Torres Strait and Papua New Guinea region since the Hiri Current moves in a clockwise direction so is not likely to encourage recruitment from this region, though there may be some connectivity between billfish populations.

This is the most geologically active provincial bioregion in the East Marine Region. The continental crust underlying this provincial bioregion is subsiding and a significant supply of sediment from Papua New Guinea's river systems enters the Cape 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 Cape Province. However, the influence of sediments is probably restricted to the northern part of Cape Province where it has buried reefs, its inflence declining towards the southern parts. The Ashmore and Boot reefs are similar to atolls, growing in elevation at the same rate as the underlying continental crust is subsiding. Some deep valleys in the southern part of the Cape Province channel sediments flowing off the northern Great Barrier Reef into the Coral Sea Basin. Sediments moving down these valleys contribute nutrients to the Cape Province and may be significant in supporting benthic communities.

2.1.2 Northeast Transition

Figure 2.6 The Northeast Transition



The Northeast Transition is located off the shelf between Lockhart River and Hinchinbrook Island. The provincial bioregion covers a total area of 148 700 km², 89 per cent (132 490 km²) of it within the East Marine Region, with the remainder in the Great Barrier Reef Marine Park.

Geomorphology

This provincial bioregion has the largest area of rise of any provincial bioregion in the Region yet the majority of it is deep water, greater than 1000 m. The main features of the Northeast Transition include the Queensland Trough, Queensland Plateau, Shark, Osprey and Bougainville Reefs. Carbonate mud is the dominant sediment type.

The Queensland Trough is a rift basin that extends 550 km in a north-south direction between the Great Barrier Reef and the Queensland Plateau to a depth of 2900 m. The trough is broader in the south and narrows north of Bougainville Reef before widening again as it drains into the Osprey Embayment. Organic-rich sediments flushed through the Great Barrier Reef from the continental shelf are found in the Queensland Trough.

The Queensland Plateau is one of the three large marginal plateaus offshore of the Great Barrier Reef that formed during the break-up of the continental crust and subsequent seafloor spreading. On the basis of water depth, the Queensland Plateau can be divided into a north-west half that falls in this provincial bioregion and a south-east half that falls in the Northeast Province. The north-west half of the plateau is 1000 to 2000 m deep and the south-east half is less than 1000 m deep. The northern edge of the plateau falls steeply to the abyssal plain of the Coral Sea Basin at around 4000 m deep. The western side of the plateau drops down to the Queensland Trough at around 2900 m deep. Prominent terraces occur at 450 to 500 m depth, and carbonate platforms that provide foundations for present reefs are at 50 m depth. There are numerous drowned reefs on the platform, and some large isolated pinnacles on the western edge of the plateau. Osprey Reef rises steeply from over 2000 m on its western side to reach sea level.

Oceanography

The Northeast Transition has a transitional water mass ranging from tropical to warm temperate.

Nautilus–Two species of nautilus, *Nautilus pompilius* and *N. stenomphalus* (taxonomy being revised—now proposed as morphs of the same species, *N. pompilius*) occur in the waters of the East Marine Region (Tzioumis and Keable 2007).

Having survived relatively unchanged for millions of years, nautilus represent the only living members of the subclass Nautiloidea, and are often considered to be "living fossils". Today the nautilus only occurs in areas where shallow coral reefs are close to deeper water. They are mobile benthic animals that live at depths of 300 to 500 m during the day and rise to shallower waters (about 200 m) at night to feed (Norman 2000, Norman and Reid 2000, Jered and Roper 2005). They are generally scavengers feeding on animal remains as well as smaller live prey such as hermit crabs.

Their strong complex shell is used as both protection and as a tool for buoyancy control. They have the ability to hang midwater without having to constantly swim.

The population of nautilus at Osprey Reef is approximately 7500 animals (Undersea_Explorer 2008). Since Osprey is so remote and surrounded by such deep waters, it is very unlikely that the animals would migrate on or off the reef.

Nautilus. Photo: Gavin Leese, QLD Department of Primary Industries and Fisheries Fishery Observer Program.

In essence, they are "imprisoned' by the 1500 m deep surrounding waters and their lack of a larval dispersal phase, which means that it is particularly important to ensure the conservation of this small, long-lived, and slow-growing population (Undersea_Explorer 2007).

Nautilus are not of commercial interest in Australia but are intensively harvested for the ornamental shell trade elsewhere in the Indo–Pacific (e.g. Indonesia, Fiji, New Caledonia and the Philippines) (Jered and Roper 2005).

Studies currently underway of the Coral Sea populations of nautilus (at Osprey Reef and other locations) are providing information on life history, movement patterns and population structure that will aid the management of Nautilus fisheries in the Indo–Pacific region (Andy Dunstan, *pers comm*).

This provincial bioregion falls within the range of the bifurcation of the South Equatorial Current and is part of a 'formation phase' region for the East Australian Current and the Hiri Current. Surface currents are known to form ocean gyres in the Queensland plateau region. High frequency and high intensity cyclones occur in this provincial bioregion, sometimes generating wind-driven north-directed current flows in excess of 2.5 knots that erode the seabed and influences sediment deposition.

Biological Communities

The Northeast Transition has Coral Sea cays/atolls/islets biological communities associated with Osprey, Shark and Bougainville reefs. There are abyssal plain and trough biological communities associated with the Queensland Trough, continental plateau biological communities associated with the Queensland Plateau, and cold-core and warm-core gyre and eddy biological communities associated with Hiri Current and East Australian Current eddies. Biological communities in this provincial bioregion have not been the subject of detailed study but approximately 400 species of demersal fish have been found.

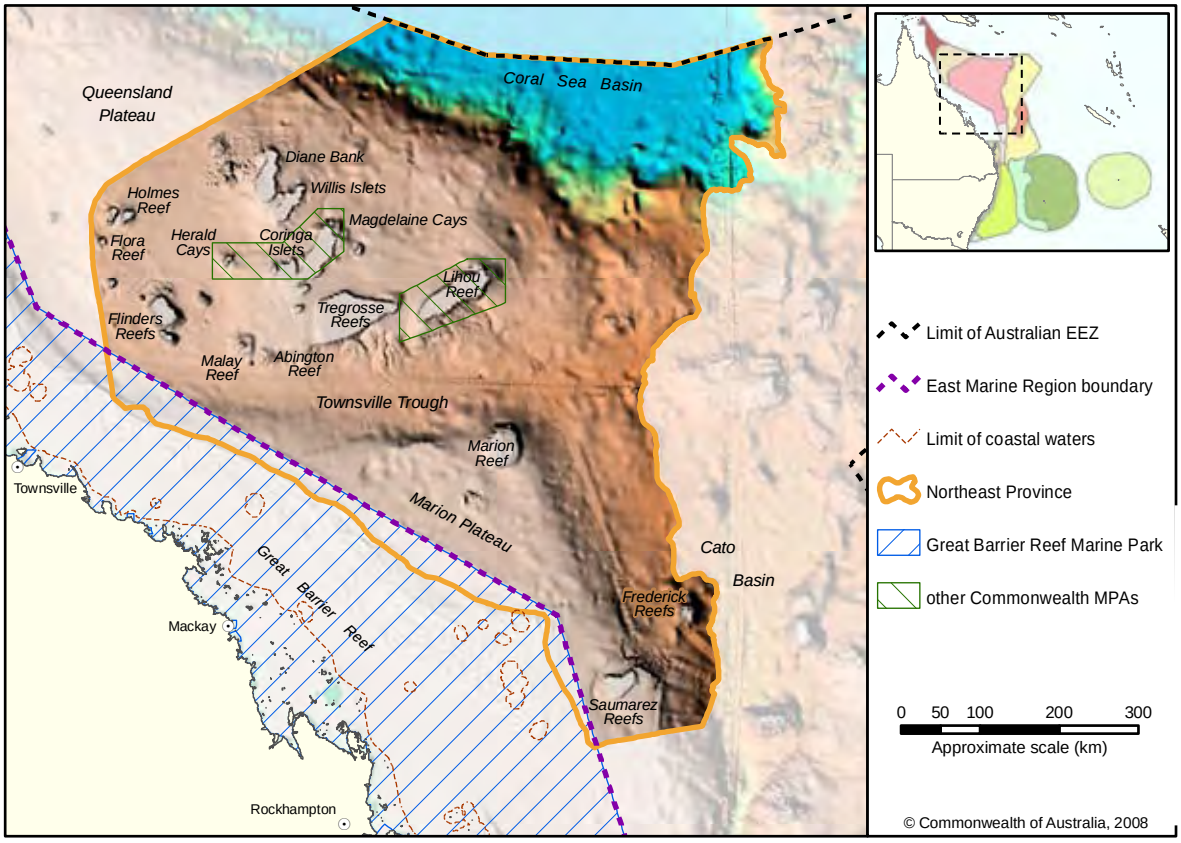
Ecosystem Processes

The bifurcation point of the Southern Equatorial Current moves into and out of the Northeast Transition, 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 provincial bioregion depending on where the bifurcation point of the Southern Equatorial Current is. The variability in the currents in the provincial bioregion may have a significant influence on the biological communities of Osprey and Shark reefs.

The northern part of the Queensland Plateau lies in this provincial bioregion and is one of the most important submerged ecological features of all the tropical provincial bioregions in the East Marine Region. The Queensland Plateau is like a 'biogeographic island' at about 1000 m depth surrounded on all sides by deeper waters. The reefs built on top of the Queensland Plateau are emergent reefs and may have relict fauna dating back to the Pleistocene era. Recruitment into these biological communities is from the Southern Equatorial Current, and, in their turn, the Queensland Plateau communities are important sources of recruitment for the Great Barrier Reef as the Hiri and East Australian Currents move across the Plateau. Nutrients on the Queensland Plateau are primarily derived from the water column. The Plateau is generally nutrient-poor except where upwelling of deeper nutrient-rich waters occurs where deep water currents interact with reef structures. The Queensland Trough running along the western side of the Queensland Plateau may be found to support some significant deep water coral communities.

2.1.3 Northeast Province

Figure 2.7 The Northeast Province



The Northeast Province is located on the slope and abyssal plain/deep ocean floor to the east of the Great Barrier Reef. It covers a total area of 442 870 km², 95 per cent (422 460 km²) of which lies within the East Marine Region, with the remainder in the Great Barrier Reef Marine Park and Queensland State waters.

Geomorphology

The Northeast Province contains the largest area of reefs in the Region and a high proportion of the trench/trough, terrace, and apron/fan features found in the Region. The majority of the Northeast Province ranges from 10 to 2000 m deep. Key features include the Coral Sea Basin, Queensland Plateau, Townsville Trough, Marion Plateau, Marion and Saumarez Reefs, Frederick Seamount, Tregrosse and Lihou complex of reefs, and Coringa Bank and Diane–Willis complex of reefs. Carbonate mud is the dominant sediment type, with carbonate content highest near the Great Barrier Reef.

The Coral Sea Basin makes up 13 per cent of the area of the Northeast Province and lies in 4000 to 5000 m deep water. The basin is the only area of the Region that has evidence of diatoms in significant quantities within its sediments. Most sediment is derived from the deltas along the Papua New Guinea coast which mix with sediments coming off the Queensland Plateau and Great Barrier Reef.

The Queensland Plateau is one of the three large marginal plateaus offshore of the Great Barrier Reef that formed during the break-up of the continental crust and subsequent seafloor spreading. The shallower south-east half falling within the Northeast Province is mostly less than 1000 m deep. The north side of the plateau drops steeply to the abyssal plain of the Coral Sea Basin at 4000 m deep. The plateau drops less steeply on its south east side, where there is a rise extending out from the base of the slope and two terraces form at depths of 1400 to 1600 m and 2200 m east of Lihou Reefs. The south side of the plateau drops steeply down to the Townsville Trough at 2000 m deep and is cut by many canyons. Ancient reefs have formed broad limestone platforms that extend over approximately half of the Queensland Plateau. Present day reefs have developed on these platforms to cover 10 to 15 per cent of the area of the plateau. The Tregrosse and Lihou complex of reefs form the largest platforms on the Queensland Plateau. They are each nearly 100 km long from east to west, and are 50 and 25 km wide, respectively. They rise steeply from greater than 1000 m deep near the edge of the plateau. The smaller Coringa Bank and Diane–Willis complex of reefs further north rise up from 500 m deep.

South West Herald Cay, Coringa-Herald National Nature Reserve. Image courtesy of Australian Customs.

Green Turtle–The green turtle (*Chelonia mydas*) is listed as a marine species, a threatened species, and a migratory species under the EPBC Act.

As iconic marine megafauna, marine turtles are an attraction to the broader community wherever they are encountered. All marine turtles are slow growing with delayed maturity (Chaloupka 1998, Chaloupka and Musick 1997, Chaloupka and Limpus 1997, Limpus and Chaloupka 1997): they can take about 35 years from hatchling to first breeding.

Green turtles nest, forage and migrate across tropical northern Australia, usually preferring to stay between the 20°C isotherms although individuals sometimes stray into temperate waters.

The green turtle is a widespread and common breeding species within north-eastern Australia and the Western Pacific Ocean. There are currently eight recognised genetic stocks of green turtle identified as breeding in north-eastern Australia and the adjacent western Pacific Ocean (Dethmers et al. 2006, FitzSimmons et al. 1997). One of these, the Coral Sea stock (many hundreds to thousands of females are estimated to breed annually) is restricted to breeding on the Coral Sea National Nature Reserves within the Northeast Province.

Green turtle hatchling. Photo: Robert Thorne.

Breeding adults migrate to their traditional nesting beaches in eastern Australian from dispersed foraging areas scattered within a 3000 km radius of these beaches (as far as Eastern Indonesia, Papua New Guinea, Vanuatu, New Caledonia, Fiji, Northern Territory, Queensland and New South Wales) (Limpus et al. 1992).

Green turtles spend their first five to ten years drifting on ocean currents. During this pelagic (ocean-going) phase, they are often found in association with rafts of Sargassum (a floating marine plant) (Carr and Meylan 1980).

Adult green turtles eat mainly seagrass and algae, although they will occasionally eat other items including mangroves (Forbes 1994, Limpus and Limpus 2000, Pendoley and Fitzpatrick 1999), fish egg cases (Forbes 1994), jellyfish (Limpus et al. 1994) and sponges (Whiting et al. 2000).

Marine turtles have varying significance within aboriginal communities. For some they are totemic while for others they play a significant part of the cultural practices such as use in initiation ceremonies or for traditional food.

The Townsville Trough separates the Queensland Plateau from the Marion Plateau to the south and extends eastward from the Great Barrier Reef to the Cato Basin and on into the Mellish Plateau. The trough is wide and deep (2000 m) in the east and narrows near the Great Barrier Reef where it is shallower at 900 m deep.

The Marion Plateau is one of the three large marginal plateaus offshore of the Great Barrier Reef that formed during the break-up of the continental crust and subsequent seafloor spreading. Most of the plateau is 300–400 m deep. The north-east corner of the Marion Plateau falls within this provincial bioregion and slopes gently north-east from 300 m deep to 600 m deep down to the Cato Basin at 3000–3500 m deep. It gradually drops down in the north to the Townsville Trough at 900–2000 m deep. Half the surface area of the plateau is covered by two major and two minor carbonate platforms formed by ancient reefs that were drowned in the Pliocene. Marion Reef is built on the northern minor carbonate platform and Saumarez Reef is on the seaward margin of the southern platform. Both reefs are ancient, dating back to the Pliocene drowning of the platforms. Off the eastern edge of the plateau, Frederick seamount rises up from the Cato Basin at a depth of 3000 m. Frederick seamount is capped by a living reef that reaches present sea level.

Oceanography

The Northeast Province is situated in tropical waters.

This provincial bioregion is within the 'formation phase' region where the South Equatorial Current bifurcates to form the East Australian Current and the Hiri Current. Surface currents are known to form ocean gyres in the Queensland Plateau region, while the Marion Plateau is strongly influenced by tidal processes and the East Australian Current as it is directed around the plateau forming a slow-flowing clockwise eddy. Tidal flooding drives upwelling of deeper nutrient-rich waters onto the inner plateau. High intensity cyclones occur with a relatively high frequency in this provincial bioregion. The northward movement of a deep sub-Antarctic water mass from the Tasman Sea Basin may influence the east side of the Marion plateau and the Cato Basin.

Biological Communities

The Northeast Province has Coral Sea cays/atolls/islets biological communities associated with the Tregrosse–Lihou, Coringa–Herald, Diane–Willis reef complexes; the Marion and Saumarez reefs; and Coral and Tasman Seas seamounts/guyots/islands biological communities associated with Frederick Seamount. There are abyssal plain and trough biological communities associated with the Townsville Trough and Coral Sea Basin; continental plateau biological communities associated with the Queensland and Marion Plateaus; and cold-core and warm-core gyre and eddy biological communities associated with the Hiri and East Australian Current. The Tregrosse–Lihou and Coringa–Herald reef complexes have been the subject of detailed study and data gathering, and descriptions of these biological communities are found at the beginning of this chapter in the Coral Sea cays/atolls/islets section. Approximately 440 species of demersal fish are found in the Northeast Province, including 70 endemic species.

Ecosystem Processes

The northern part of this provincial bioregion 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 Northeast Province break the surface as islands and cays and are important breeding areas for sea birds and marine turtles.

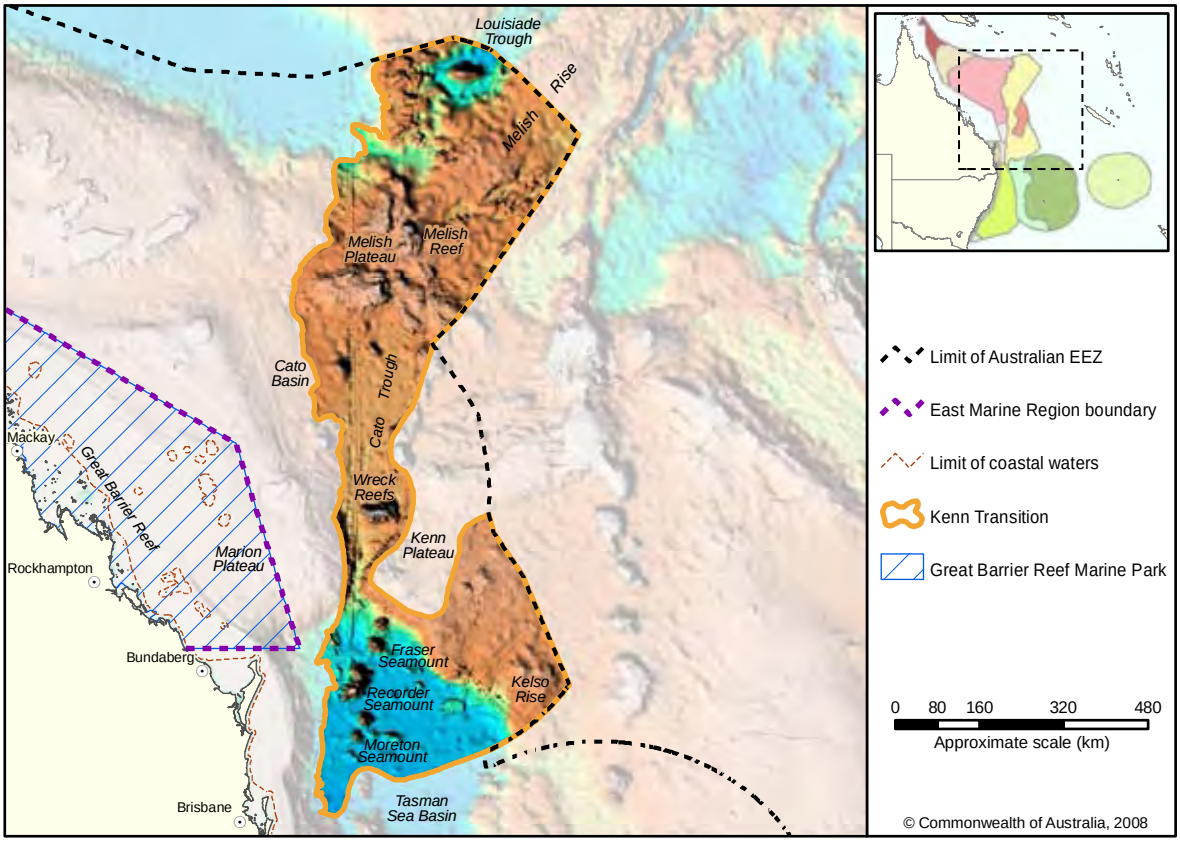
The southern part of the Northeast Province includes the north-east section of the Marion Plateau with some significant reefs on its outer edge. At depths of between 100 and 600 m, the Marion Plateau is much shallower than the Queensland Plateau. There is likely to be some connection between demersal fauna on Marion Plateau and the Great Barrier Reef.

A semi-permanent gyre forms towards the south-east corner of the Northeast Province. This gyre may have a significant impact on productivity of the biological communities of the outer reefs on the Marion Plateau by encouraging upwelling of deeper nutrient-rich waters around the outer reefs.

Severe storm events in this provincial bioregion are likely to be important for the dispersal of demersal fauna between the islands and reefs of the provincial bioregion and the Great Barrier Reef for those species that do not have a pelagic larva stage. 'Cyclone alley'–an area of the Coral Sea where many cyclones form and approach the coast–lies across this provincial bioregion and the Northeast Transition Province.

2.1.4 Kenn Transition

Figure 2.8 The Kenn Transition



Masked Booby - The masked booby (*Sula dactylatra*) is listed as a marine and migratory species under the EPBC Act. It is widespread in tropical waters between 30° N and 30° S in the Pacific, Indian and Atlantic Oceans (Marchant and Higgins 1990).

The masked booby is often observed far from land over deep tropical and subtropical waters.

Breeding colonies are usually situated on tropical oceanic islands, atolls and cays, far from the mainland. They can use very small low-lying cays and reefs, such as Mellish Reef* and Wreck Reefs in Kenn Transition Province, washed over by highest tides and storm waves. These cays and reefs are sometimes physically unstable, changing size and shape under the action of winds, currents, waves and tides. Preferred nesting areas are located on exposed, open, level ground so that they can take off directly into the wind (Hutton 1991). The proximity of deep water tends to be an important determinant in the selection of breeding grounds (Marchant and Higgins 1990).

Masked booby. Photo: Ian Hutton and the Department of the Environment, Water, Heritage and the Arts.

Masked boobies may range widely from their breeding islands in search of food (Hutton 1991), and individuals have been sighted foraging at upwellings of cool nutrient-rich waters (Marchant and Higgins 1990).

The diet of the masked booby is primarily comprised of fish with some squid (Marchant and Higgins 1990). Food is obtained by deep plunging in the ocean from a height of 10 m or more (Hutton 1991).

* Mellish Reef is approximately 10 km long by 3 km wide but it is totally submerged when the sea is above half tide. The only land mass is Herald Beacon Islet, a 600 m long by 120 m wide sand cay which stands two metres above the high water line.

The Kenn Transition is located on the lower slope and abyssal plain/deep ocean floor offshore between Cooktown and North Stradbroke Island. It covers a total area of 377 130 km^2, all of which lies within the East Marine Region.

Geomorphology

This provincial bioregion has a high proportion of the seamount/guyot and saddle features found in the Region. The majority of the provincial bioregion is deep water, between 2000 and 5000 m deep. The main features include the Kenn Plateau, the Cato Trough, Cato Basin, the Tasman Sea Basin, and seamounts/guyots of the Tasmantid Seamount Chain. The Mellish Rise, Louisiade Trough, and Mellish Plateau are significant features. Carbonate mud is the dominant sediment type, with a higher carbonate content found in sediments in the north of the provincial bioregion.

The Kenn Plateau is one of three tectonic blocks of continental crust that form the eastern margin of the Tasman Sea Basin. Part of the south-west of the Kenn Plateau falls within the Kenn Transition. The plateau consists of a series of ridges that are shallower than 2000 m deep, and basins with depths between 1800 and 3000 m. The plateau drops steeply down to the Cato Trough at 3000 m deep on its west side, and down to the Tasman Sea Basin at 3750 m deep on its south side.

The Cato Trough extends 550 km from the Tasman Sea Basin in the south to the Mellish Plateau in the north and separates Kenn Plateau from Marion Plateau. The trough is narrowest in the south where, for 50 km of its length, it is only 10 km wide and 3400 to 3500 m deep. The trough opens up to the Cato Basin in the north. The Kenn Plateau rises steeply from the 3000 m deep Cato Basin and on its east side has many small and large canyons flowing into the basin off the Kenn Plateau. The basin is around 3000 m deep and has Wreck seamount rising up out of it. Wreck seamount is capped by limestone reefs and forms Bird Island, part of the Tasmantid Seamount Chain.

Three southern seamounts, Fraser, Recorder, and Moreton are included in this provincial bioregion and rise up out of the Tasman Sea Basin abyssal plains from depths between 4000 and 4600 m but do not reach sea level. Fraser's summit is 360 m below sea level; Recorder has two platforms at its summit which are 400 and 1170 m below sea level; and Moreton's summit is 753 m below sea level and is another volcanic peak. The seamounts are progressively younger southwards along the chain.

Oceanography

The Kenn Transition has a transitional water mass (tropical–warm temperate).

This provincial bioregion falls within the range of the bifurcation of the South Equatorial Current, part of a 'formation phase' region for the East Australian Current and the Hiri Current. Surface currents are known to form ocean gyres in the Queensland Plateau region. The northward movement of a deep sub-Antarctic water mass from the Tasman Sea Basin may influence this provincial bioregion as it moves through the Cato Basin to the Mellish Plateau. A semi-permanent ocean gyre forms near the Cato Trough at the south-east edge of the Marion Plateau coinciding with Cato Island and Kenn Reef, and creating an area of high biological productivity off Fraser Island.

Biological Communities

The Kenn Transition has Coral and Tasman Seas seamounts/guyots/islands biological communities associated with Mellish, Wreck, Fraser, Recorder, and Moreton reefs and seamounts. There are abyssal plain and trough biological communities associated with the Cato and Louisiade Troughs and Cato and Tasman Sea Basins, continental plateau biological communities associated with the Mellish Rise and Mellish and Kenn Plateaus, and cold-core and warm-core gyre and eddy biological communities associated with the East Australian Current. The biological communities in this provincial bioregion have not been the subject of detailed study.

Ecosystem Processes

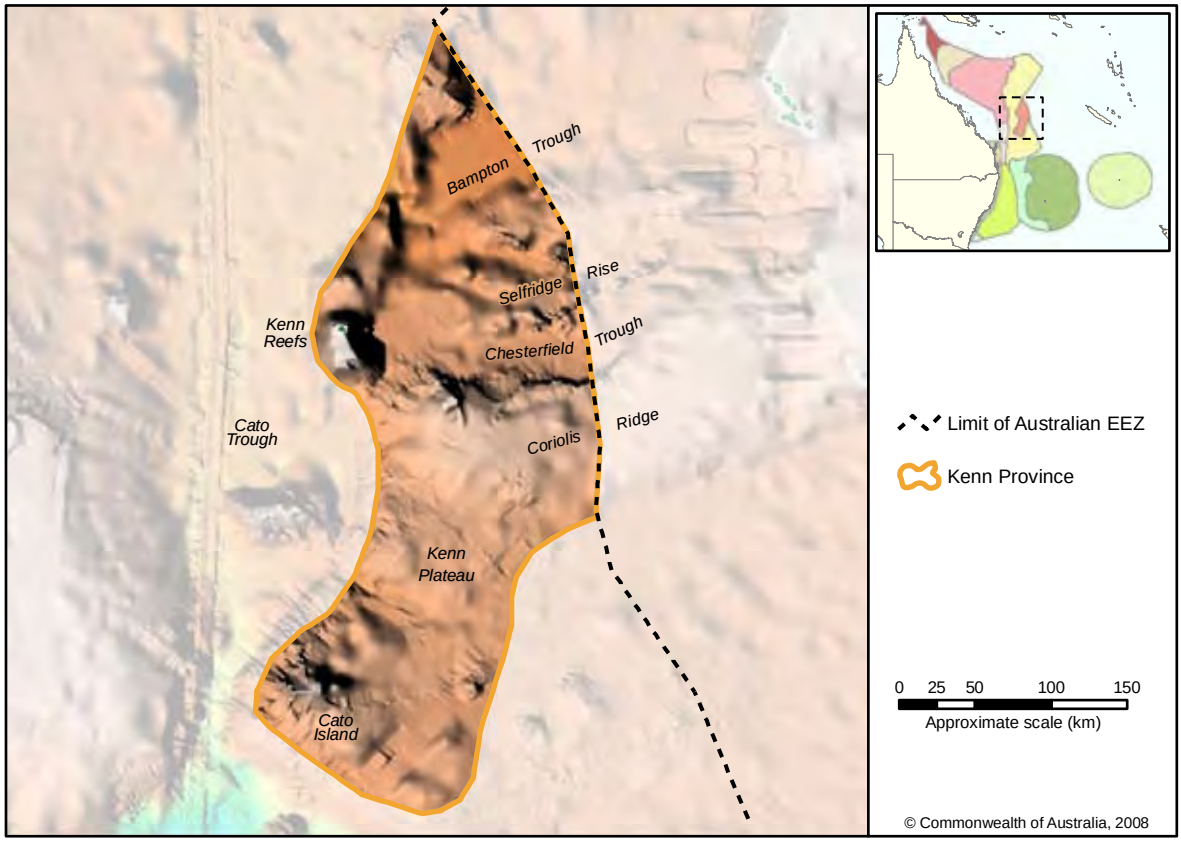
The Cato Basin and the northern Tasman Basin form the deep water western margin of this provincial bioregion. They are linked by the narrow Cato Trough. East of the Cato Trough is the Kenn Plateau. North-flowing sub-Antarctic waters move through the Cato Trough and interact with the south-flowing East Australian Current to create areas of high productivity around structures such as Wreck Reef, and other seamounts and islands.

The seamounts rising up from the Kenn Plateau differ from the more southerly seamounts of the Region in that they break the sea surface as islands and are older. Recruitment between seamounts in this chain is likely to occur over long (geological) 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.

2.1.5 Kenn Province

Figure 2.9 The Kenn Province



The Kenn Province is located on the Kenn Plateau at the junction of the Coral and Tasman Seas. It covers a total area of 57 420 km² and is all within the East Marine Region.

Geomorphology

Important geomorphologic features of the Kenn Province are seamounts/guyots and plateaus. The majority of the Kenn Province occurs in water depths between 1000 and 3000 m. Carbonate mud is the dominant sediment type. The main features include Kenn Plateau, Cato Island and Kenn Reef.

Dolphin. Image courtesy of CSIRO.

Kenn Plateau is one of three tectonic blocks of continental crust that form the eastern margin of the Tasman Sea Basin. The central western section of the plateau is included in this provincial bioregion. The plateau consists of a series of ridges at less than 2000 m deep and basins with depths between 1800 and 3000 m. Coriolis Ridge at around 1000 m deep has fields of sand dunes which are four to five metres high. Three seamounts rise up from the plateau, namely Kenn, Chesterfield, and Cato. Kenn and Cato rise above present sea level from depths of 3000 and 1500 m, respectively, and have living reefs on limestone caps.

Oceanography

The Kenn Province is situated in tropical waters.

This provincial bioregion falls within the range of the bifurcation of the South Equatorial Current and is part of a 'formation phase' region for the East Australian Current and the Hiri Current. Surface currents are known to form ocean gyres in the Queensland plateau region. A deep sub-Antarctic water mass moves northward from the Tasman Sea Basin through the Cato Basin to the Mellish Plateau. A semi-permanent ocean gyre forms near the Cato Trough at the south-east edge of the Marion Plateau coinciding with Cato Island and Kenn Reef, creating an area of high biological productivity off Fraser Island.

Frigate bird. Photo: A. Dunn

Giant Trevally–The giant trevally (*Caranx ignobilis*) is the largest species of trevally frequenting the warm tropical waters of Australia. It can grow up to 1.7 m (60 kg), but is generally caught at much smaller sizes.

Giant trevally. Photo: Dr. Dwayne Meadows, NOAA/NMFS/OPR.

The giant trevally, or GT as it is often known, is usually seen cruising along reef drop-offs in tropical marine waters. It is a pelagic fish, occurring over the tropical continental shelf and offshore reefs, and sometimes venturing further offshore into southern waters. Most individuals of this species aggregate in large schools. Larger individuals tend to be solitary, and prefer to feed at night.

The giant trevally is a highly-prized game fish. International visitors in particular, undertake specialised charters to the Coral Sea, to areas like Kenn Reef and Cato Island, to fish for this species.

Biological Communities

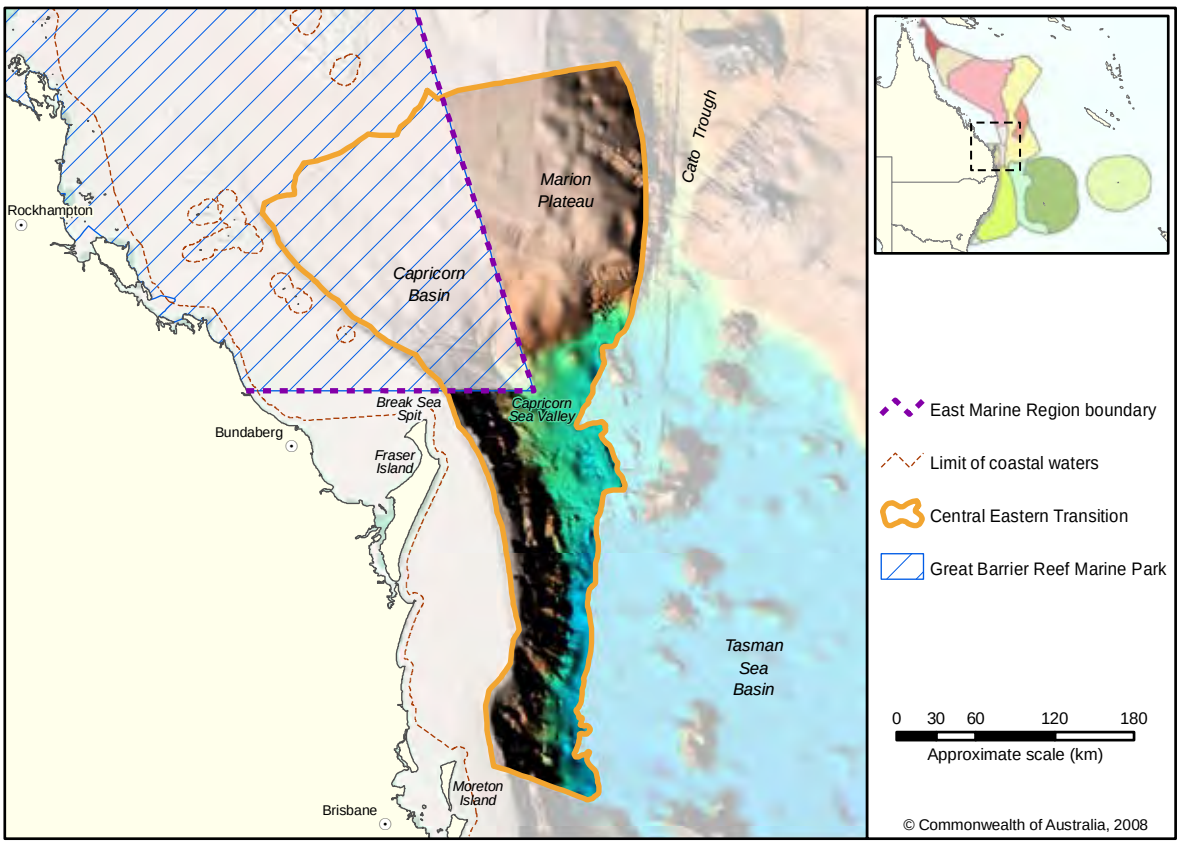
The Kenn Province has Coral and Tasman Sea seamounts/guyots/islands biological communities associated with Kenn Reefs and Cato Island. There are continental plateau biological communities associated with Kenn Plateau, and cold-core and warm-core gyre and eddy biological communities associated with the East Australian Current. The biological communities in this provincial bioregion have not been the subject of detailed study.

Ecosystem Processes

Part of the Kenn Plateau lies within this provincial bioregion 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 biological communities. Plankton communities around Cato Island may also be distinctive.

2.1.6 Central Eastern Transition

Figure 2.10 The Central Eastern Transition



The Central Eastern Transition is located on the slope and rise to the east of Fraser Island, and to the south-east of the Great Barrier Reef Marine Park. It covers a total area of 67 150 km². Sixty-seven per cent (44 840 km²) of the provincial bioregion is within the East Marine Region, with the remainder in the Great Barrier Reef Marine Park.

Geomorphology

Important geomorphic features of the Central Eastern Transition are slope, rise, submarine canyons, and terraces. This provincial bioregion has the second largest area of rise in the Region. Water depth over the provincial bioregion ranges from around 2000 m deep on slope, around 4000 m deep on the rise, and around 420 m deep on terraces. Carbonate sand is the dominant sediment type. Main features include Marion Plateau, Tasman Sea Basin, and active submarine canyons along the slope.

Marion Plateau is one of the three large marginal plateaus offshore of the Great Barrier Reef that formed during the break-up of the continental crust and subsequent seafloor spreading. Most of the plateau is 300 to 400 m deep. The south-eastern corner of the plateau falls within this provincial bioregion. The south margin of the plateau runs east-west for 100 km and is steep and rough, descending from 800 m to 3600 m deep. One large submarine canyon forms the Capricorn Sea Valley that cuts the margin to a depth of 4700 m and runs for over 120 km. The east side of the Marion Plateau drops steeply to the Cato Trough at 3500 m depth. The northwest section of the Tasman Sea Basin in this provincial bioregion is shallower than in the south due to the accumulation of a thick sequence of pelagic sediments. The continental shelf along the western edge of the provincial bioregion is one of only two areas along the Australian coast where significant amounts of sediment are moving across the continental shelf and reaching the heads of the submarine canyons.

Oceanography

The Central Eastern Transition has a transitional water mass (tropical–warm temperate).

The northward movement of a deep sub-Antarctic water mass from the Tasman Sea Basin may influence this provincial bioregion as it moves along the steep continental shelf and around the south east margins of the Marion Plateau through the Cato Trough. A semi-permanent ocean gyre forms near the Cato Trough at the south-east edge of the Marion Plateau coinciding with Cato Island and Kenn Reef, and creating an area of high biological productivity off Fraser Island.

Yellow-bellied Sea Snake–The yellow-bellied sea snake (*Pelamis platurus*) is listed as a marine species under the EPBC Act. It possesses a colour pattern that is unique amongst the sea snakes–the dorsal surface of the body is black or brown which contrasts with the cream, yellow or pale brown of the ventral surface.

This is the most widely distributed sea snake in the world (Cogger 1996), found in both the Pacific and Indian Oceans. It ranges from the East coast of Africa through the Indian and Pacific Oceans to the West coast of the Americas (Kropach 1975, Cogger 1996). It is found in most Australian waters with the exception of the colder southern coastline (Cogger 1996). Biggest populations exist south of the tropics (Cogger 1975, Cogger 1996) where the yellow-bellied sea snake is commonly found on beaches after storms (Storr 1986).

Yellow bellied sea snake. Image courtesy of the Australian Institute of Marine Science.

The yellow-bellied sea snake is the only true pelagic sea snake. It inhabits the slicks and drift lines of ocean currents where it feeds on fish attracted to the body of the snake resting motionless on the surface (Kropach 1975).

The yellow-bellied sea snake is often washed ashore by a combination of ebbing tides and onshore winds (Guinea 1992). It is quite helpless on land and sea snakes washed onto beaches during storms seldom manage to return to the sea.

The species is caught incidentally in commercial and research trawling operations in Australia. Sea snake species may have a low capacity to recover from fishing and are potentially threatened by the impacts of trawling (Marsh et al. 1993), due mainly to their low fecundity and longevity.

Biological Communities

The provincial bioregion has continental shelf biological communities associated with active and non-active canyons. There are abyssal plain and trough biological communities associated with the Tasman Sea Basin, continental plateau biological communities associated with the Marion Plateau, and cold-core and warm-core gyre and eddy biological communities associated with the East Australian Current. The biological communities in this provincial bioregion have not been the subject of detailed study or data gathering. Approximately 500 demersal fish species are found in this provincial bioregion.

Ecosystem Processes

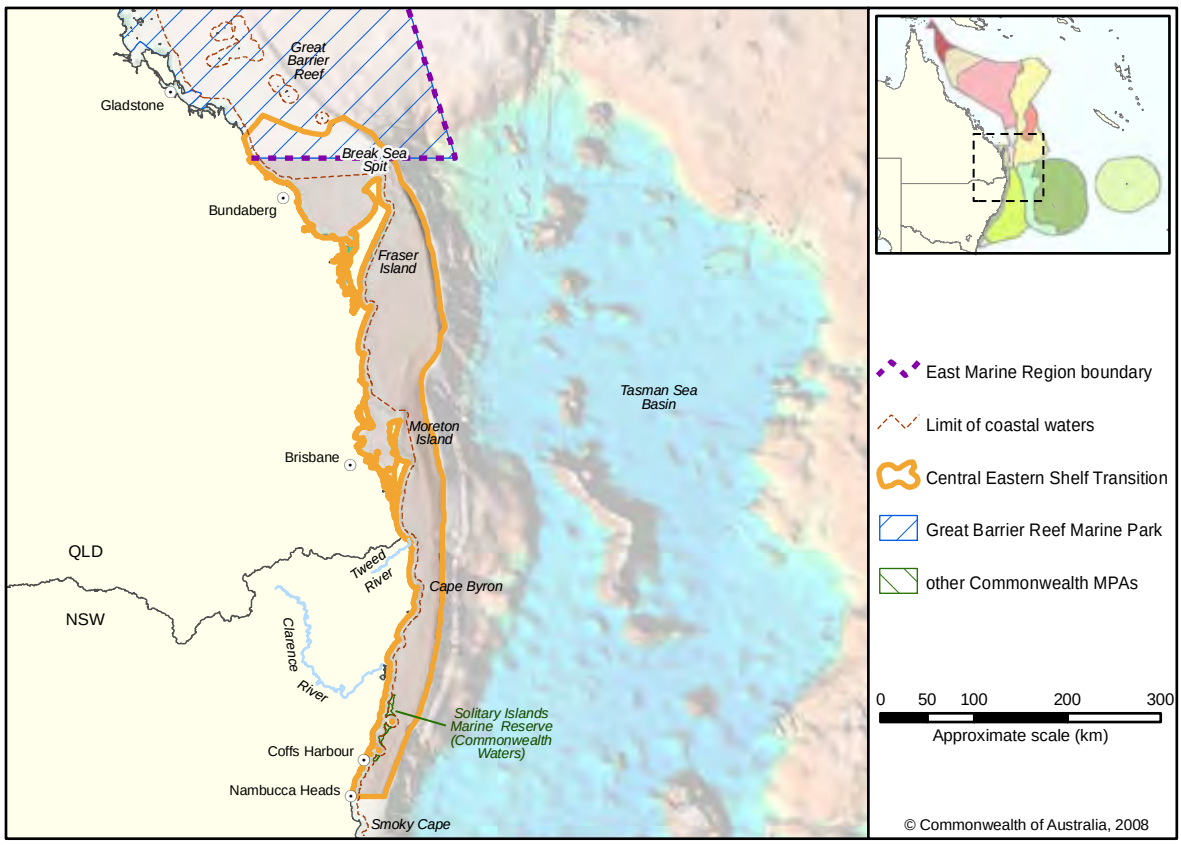
The slope and canyons off southern Queensland are geologically younger than areas further south. The slope is incised with small canyons (less than 500 m deep). The different characteristics of these canyons compared to those found further south result in different biological communities being associated with them. Limestone ridges (old reefs) form exposed scarps on the upper slope.

Quartz sand originating from Fraser Island is being fed down the slope into the provincial bioregion, 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 examples of modern active canyons; the only other example of an active canyon in Australia is in Bass Strait. The northerly extent of the larger inactive canyons is to the north of Moreton Island.

Humpback whale. Photo: Dave Paton.

2.1.7 Central Eastern Shelf Transition

Figure 2.11 The Central Eastern Shelf Transition



The Central Eastern Shelf Transition is located on the continental shelf between Fraser Island and Nambucca Heads. It covers a total area of 43 030 km². Sixty-one percent (26 340 km²) of the provincial bioregion is within the East Marine Region, with the remaining percentage in the Great Barrier Reef Marine Park, and in New South Wales and Queensland State waters.

Geomorphology

The Central Eastern Shelf Transition is located predominantly on the continental shelf (78 per cent) and includes a small section of upper slope. The shelf varies in width from 130 km to the north of Fraser Island to less than 25 km adjacent to Macksville (near Nambucca Heads). Significant features include: three shallow water terraces that run parallel to the coast, separating the shelf from the upper slope; a small area of reef to the north of Fraser Island; and two submarine canyons that occur on the slope offshore of Coolangatta and extend offshore of the provincial bioregion boundary into the Central Eastern Province.

Break Sea Spit, north of Fraser Island, is the shallowest point, with a depth of one metre. The deepest point in the provincial bioregion is 240 metres. This provincial bioregion is the shallowest on average of all the shelf provincial bioregions in Australian Commonwealth waters.

Sediment texture is relatively homogenous, dominated by sand with localised gravel deposits and negligible mud. Sand is the dominant sediment type associated with the geomorphic features found in this provincial bioregion including shelf, slope and shallow water terraces. Shallow water terraces in this provincial bioregion also contain a significant proportion of gravel. The carbonate content of seabed sediments is moderate (approximately 40 to 60 per cent) and increases towards the outer shelf and upper slope.

Most of the shelf in the Region can be divided on the basis of water depth into an inner shelf (less than 60 m water depth), middle shelf (60 to 120 m) and an outer shelf (120 m to shelf break). In general, the inner shelf is relatively steep down to 60 m water depth, the middle shelf has a more gentle slope seaward and the outer shelf is a flat, near-horizontal plain.

Oceanography

This provincial bioregion has a transitional water mass (tropical–warm temperate).

Although generally moving in a southerly direction, the path of the East Australian 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.

Biological Communities

The Central Eastern Shelf Transition has continental shelf biological communities associated with it, and gyre and eddy biological communities associated with the East Australian Current eddies that pass through the provincial bioregion.

The provincial bioregion includes the continental shelf off Tweed Heads, New South Wales. This area is a transition zone for benthic communities and represents a major tropical/temperate divide for the Region. The Central Eastern Shelf Transition has been the subject of detailed study, and descriptions of the biological communities are found at the beginning of this chapter under the continental shelf section.

The reef building capability of corals reduces toward the south of this provincial bioregion, 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.

Ecosystem Processes

The major ecosystem processes are similar across the three shelf provincial bioregions of the Region: the Central Eastern Shelf Transition; the Central Eastern Shelf Province; and the Southeast Shelf Transition.

The East Australian Current's movement along and away from the shelf causes upwelling of nutrient-rich, cool water onto the shelf, resulting in phytoplankton growth and increased primary production. A region of relatively predictable upwelling is known to occur in the region between Cape Byron and Smokey Cape in New South Wales, which has resulted in a large seasonal variation in the surface temperature across the area and a number of submarine canyons being created along the shelf edge.

Riverine sediments occurring along the length of the coast, for example from the Shoalhaven, Hawkesbury, Hunter, Clarence and Tweed rivers are deposited as mud on the continental shelf off the mouths of these rivers. Longshore drift and wave action move sand north along the inner shelf, forming the Moreton and Fraser sand islands. Further offshore, sediment on the shelf is carried southwards by the East Australian Current.

Geomorphology and sediment types are the primary determinates of the distribution of benthic organisms. Pelagic species distribution is more closely linked with variations in water masses.

Ecological connections across the shelf provincial bioregions in the Region are driven by the southward-moving East Australian Current and the northward-moving longshore drift in the inshore area. These shelf provincial bioregions also have connections to the slope provincial bioregions of the Region by the movement of the Tasman Front and the associated eddy fields extending out into the Tasman Sea.

Humpback Whale–The humpback whale (*Megaptera novaeangliae*) is listed as a cetacean, and as a threatened and migratory species under the EPBC Act.

Each year between April and November, humpback whales migrate along Australia's eastern coastline. After a summer of feeding on krill in Antarctic waters, the whales migrate north to sub-tropical waters where they mate and give birth. During their annual migration of up to 10 000 km, humpbacks attract thousands of visitors to coastal towns such as Eden, Sydney and Byron Bay in New South Wales, and the Gold Coast and Hervey Bay in Queensland.

Humpback whale, Hervey Bay. Photo: Mark Farrell.

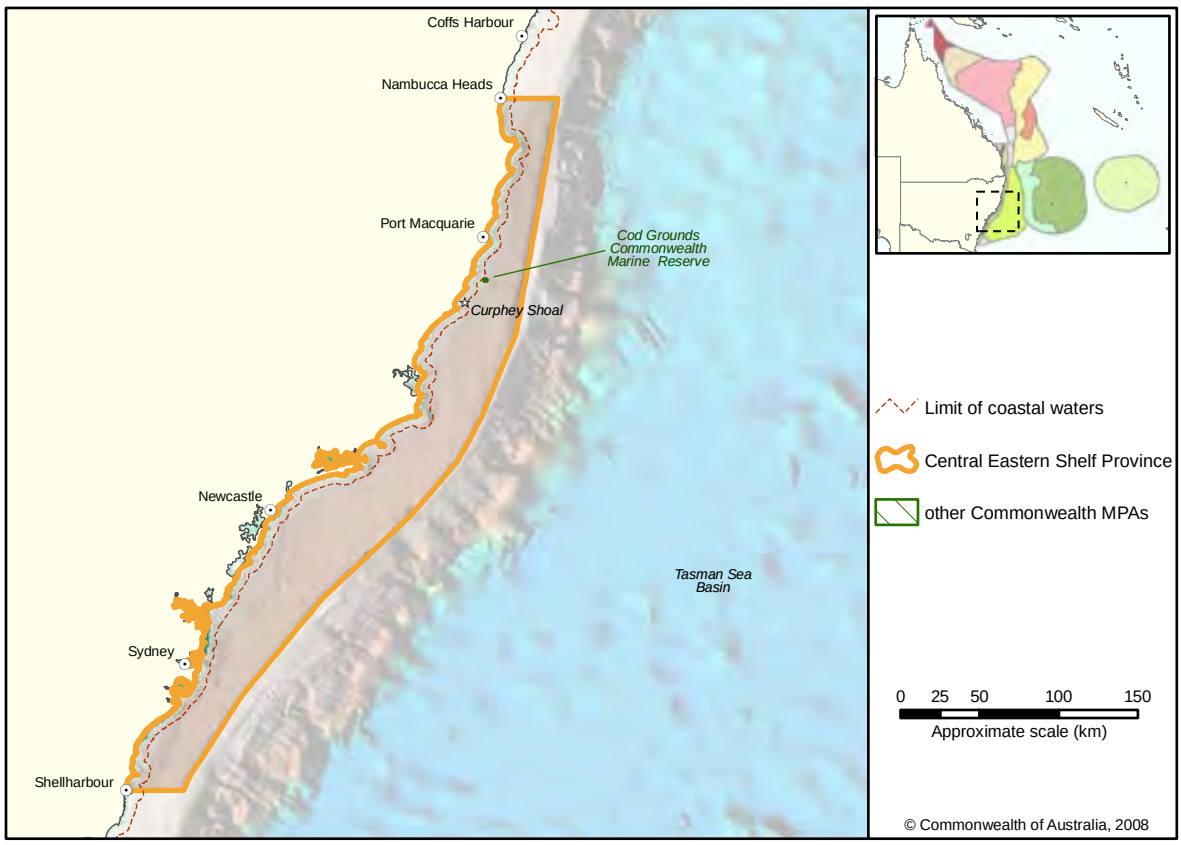
The exact timing of the migration period can vary from year to year depending on water temperature, sea ice, predation risk, prey abundance and the location of their feeding ground. The majority of humpbacks in Australian waters migrate north from June to August, and back towards the Southern Ocean from September to November.

It is estimated that when the Australian east coast whaling industry ended in 1963, the east coast population of humpbacks had been reduced to a little over 100 individuals. This population has shown steady recovery of around 10 to 11 per cent a year, and in 2006 was estimated at around 8000.

The recovery of the humpback population has contributed significantly to the rapid growth of Australia's whale-watching industry. The Australian National Guidelines for Whale and Dolphin Watching 2005 have been developed to minimise impacts on whales, dolphins and porpoises and to give people the best opportunity to enjoy and learn about them.

2.1.8 Central Eastern Shelf Province

Figure 2.12 The Central Eastern Shelf Province



The Central Eastern Shelf Province is located on the eastern Australian shelf between the towns of Nambucca Heads and Shellharbour. It covers an area of 13 310 km² or one per cent of the East Marine Region. Seventy-nine per cent of the provincial bioregion is in the Region, with the remaining area in New South Wales state waters.

Geomorphology

The Central Eastern Shelf Province runs parallel to the coast and includes an elongate area of continental shelf ranging in width from 10 to 60 km. A series of small terraces run parallel to the shoreline at the shelf edge covering over 15 per cent of the Central Eastern Shelf Province area.

The deepest point in the provincial bioregion is 240 metres. Curphey Shoal is the shallowest point at 19 metres. Sediment texture of the Central Eastern Shelf Province is dominated by sand with localised deposits of gravel in the north of the provincial bioregion. Sand is the dominant sediment type associated with the geomorphic features found in this provincial bioregion including shelf, slope and shallow water terraces. High mud contents are located offshore of Sydney and Newcastle. The carbonate content of seabed sediments is high and increases towards the outer shelf and upper slope.

Oceanography

The Central Eastern Shelf Province is situated in warm temperate waters.

The oceanography is very similar along the shelf provincial bioregions, and is driven by the southerly movement of the East Australian Current that meanders across the shelf depending on its strength and other seasonal conditions.

Biological Communities

The Central Eastern Shelf Province has continental shelf biological communities associated with it, as well as some gyre and eddy biological communities associated with the East Australian Current eddies that pass through the bioregional province. The Central Eastern Shelf Province has been the subject of detailed study and data gathering, and descriptions of its biological communities are found at the beginning of this chapter under the continental shelf section.

Ecosystem Processes

The major ecosystem processes described for the Central Eastern Shelf Transition also apply to this provincial bioregion. The upwelling described in the Central Eastern Shelf Transition between Byron Bay and Coffs Harbour can also occur in the northern portion of the Central Eastern Shelf Province.

Grey Nurse Shark (East Coast population)–the grey nurse shark (east coast population) (*Carcharias tauras*) is listed as a threatened species (Critically Endangered) under the EPBC Act.

In Australia, the grey nurse shark is now restricted to two populations, one on the east coast from southern Queensland to southern New South Wales and the other around the south-west coast of Western Australia. It is believed that the east and west coast populations do not interact and ongoing research will probably confirm that the populations are genetically different.

Grey nurse sharks gather at a number of key sites along the coast of New South Wales and southern Queensland, including – from north to south – Wolf Rock, Moreton Island, Stradbroke Island, Byron Bay, Solitary Islands, South West Rocks, Laurieton (Cod Grounds), Forster, Seal Rocks, Port Stephens, Sydney, Bateman's Bay and Narooma. These sites have gravel or sand filled gutters, or rocky caves, and are close to inshore rocky reefs or islands. The sharks have been recorded at various depths, but are mainly found in waters between 15 and 40 m deep, with the majority of time spent in waters less than 30 m deep.

Grey nurse sharks in the Looking Glass at Broughton Island. Photo: David Harasti.

Despite their fierce appearance, grey nurse sharks are not a threat to divers or swimmers unless provoked. They are a passive species, mainly active at night, with teeth designed for capturing prey such as fish, squid and crustaceans. Their placid nature, combined with their occupation of shallow inshore reef areas, has allowed diving with grey nurse sharks to become the focus of an ecotourism industry.

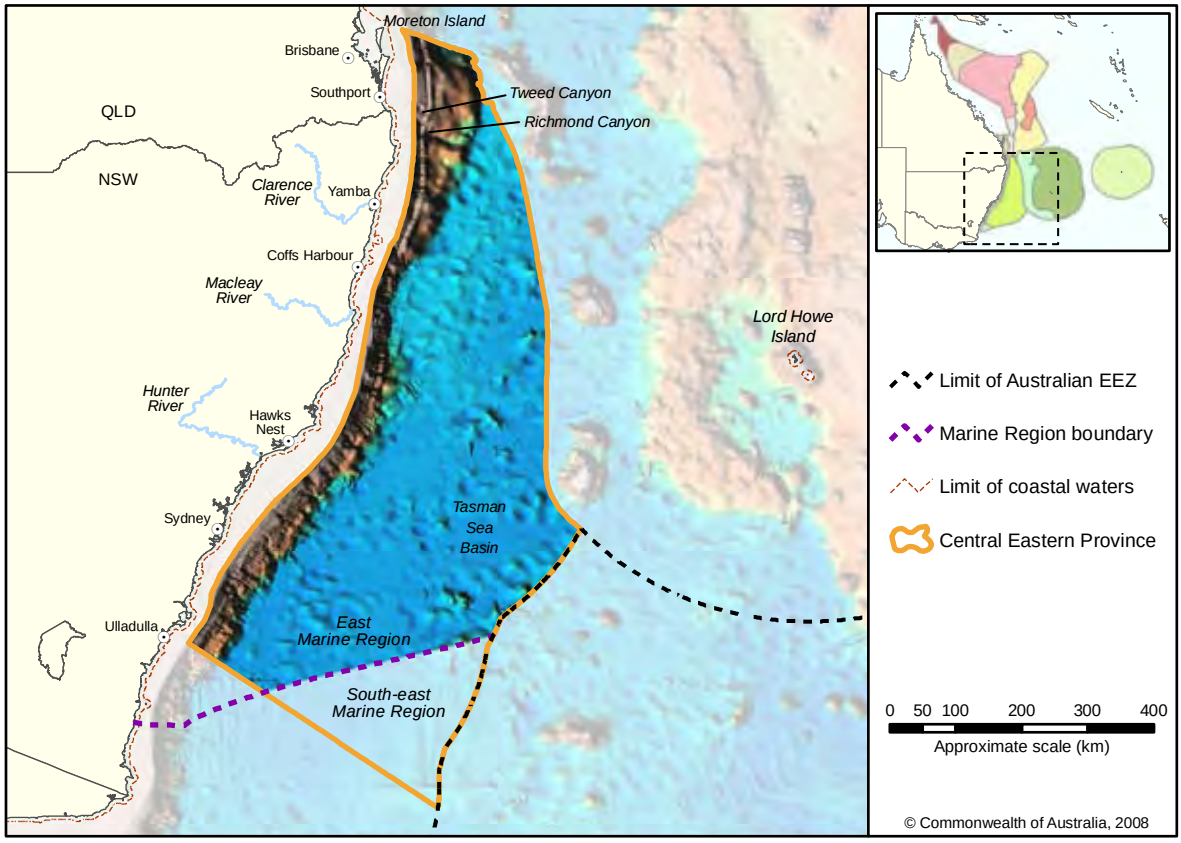
Although the sharks are protected today, they were commercially fished quite extensively in the past. Current threats to the species are believed to be incidental catch in other shark fisheries, recreational fishing and to a much lesser extent, beach meshing.

The Cod Grounds Commonwealth Marine Reserve was declared on 10 May 2007 to protect important habitat of the critically endangered grey nurse shark. This Marine Protected Area covering an area of about 300 ha is managed as an IUCN Category 1a (no take) Sanctuary Zone.

Floating anemone. Photo: Matt Carr.

2.1.9 Central Eastern Province

Figure 2.13 The Central Eastern Province



The Central Eastern Province is located offshore between North Stradbroke Island and Ulladulla. It covers a total area of 266 590 km². Eighty-eight percent (233 820 km²) of the provincial bioregion lies within the East Marine Region. The remaining 12 per cent lies within the South-East Marine Region.

Geomorphology

The Central Eastern Province is located predominantly on the abyssal plain/deep ocean floor, and to a lesser extent the eastern continental slope. Geomorphic features in this area include submarine canyons, terraces, pinnacles, knolls/abyssal hill/hill/mountain/peaks, and bank/shoals. Although pinnacles and submarine canyons comprise less than one per cent and less than two per cent of the total area of the provincial bioregion respectively, they represent 17 per cent and four per cent of the total area of these features in the Region.

Pinnacles cluster on the upper slope adjacent to Yamba and are also scattered across the abyssal plain/deep ocean floor. A series of canyons extend from the upper slope to the abyssal plain/deep ocean floor and are oriented broadly orthogonally to the coast. They include the Tweed and Richmond Canyons on the slope in northern New South Wales. Elongate shallow water terraces run parallel to the coast on the upper slope. These are similar to terraces in the Central Eastern Shelf Transition and Central Eastern Shelf Province.

The abyssal plain of the Central Eastern Province occupies the western part of the Tasman Sea Basin where it extends from the base of the slope to a sharp boundary with abyssal hills on the deep ocean floor. The floor of the basin is unusual in that the greatest depths are adjacent to the slope off New South Wales where the seabed is around 4900 to 5000 m below sea level.

A characteristic of the Australian continental shelf is the lack of depositional fans at the base of the slope. The only submarine fans identified along the western margin of the basin are very small, less than 30 km wide, and located off the Hunter River at Newcastle, Macleay River at Smoky Cape and the Clarence River at Yamba in this provincial bioregion, and off Breaksea Spit at Sandy Cape, Fraser Island to the north. Other features on the abyssal plain are isolated basement outcrops forming seamounts and ridges, debris deposits/channels at the base of the slope on the western margin of the continental shelf, and elongate drift mounds on the plain itself.

Along its south-eastern margin the abyssal plain is up to 50 m lower than the sediment draped abyssal hill region. In the south the plain extends more than halfway across the basin and the surface of the plain rises gradually to the north. It is 200 to 250 km wide in the southern part of the Region where it extends eastward to Taupo, Barcoo, and Derwent Hunter Seamounts, located in the Tasman Sea Province.

Water depths in the Central Eastern Province range from 170 to 5100 m. Water depths are between 4000 and 5000 m over approximately 80 per cent of the area of the provincial bioregion. Terraces are located in water depths of 165 to 780 m and banks/shoals in depths of 200 to 290 m. Pinnacles on the upper slope occur in water depths of 200 to 400 m, and pinnacles on the abyssal plain/deep ocean floor in water deeper than 4000 m.

Sediment texture of the Central Eastern Province is variable and grades from sand on the upper slope to mud on the abyssal plain/deep ocean floor. The gravel content of sediments in this provincial bioregion is generally less than five per cent, being highest to the north of Hawks Nest.

At a depth of 200 to 1500 m, the sediment found on the slope is formed of foraminiferal/calcareous ooze. Sediment wedges and a few submarine canyons exist at the top of the slope where there is evidence of echinoderm and sponge communities. On the mid-slope at depths of 1500 to 3500 m 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 3500 m, the submarine canyons amalgamate into larger canyon complexes that extend down to the abyssal plain at 5000 m. The sediment in these areas is primarily made up of coccolith ooze and there is evidence of siliceous sponge communities.

Oceanography

The Central Eastern Province is situated in warm temperate waters.

The main component of the East Australian Current leaves the Australian coast at about 34° S to flow around the north of New Zealand and then down the east coast of that country when it becomes the East Auckland Current. Southward of the separation point, a portion of the current remains connected to the coast and continues south past the east coast of Tasmania.

The Tasman Front, the path of the East Australian Current between Australia and New Zealand, separates the cooler waters of the Tasman Sea and the warmer, more saline

Great-winged petrel. Photo: Dr Peter Milburn.

waters of the Coral Sea. Along the southern edge of the Tasman Front, west-bound Rossby speed eddies are shed that move southward with the smaller component of the East Australian Current as they travel over the continental slope and reach the Australian coast. As these eddies travel southward they may be consumed and integrated within the East Australian Current or remain as separate entities.

Biological Communities

There is strong distinctiveness in the structure of demersal outer shelf and slope fish assemblages (40–2000 m) in this provincial bioregion, distinctiveness implying evolutionary relatedness and some likelihood of endemism among the fish fauna. Typically narrow-ranging, endemic species identified within this provincial bioregion, from Southport in Queensland to Ulladulla in New South Wales, include flathead (*Bembrops morelandi*), sea toad (*Chaunax* species), batfish (*Halieutopsis* species, *Solocisquama* species and *Malthopsis* species), sharp head perch (*Lepidoperca magna*), snailfish (*Paraliparis eastami*), piedtip cucumberfish (*Paraulopus okamurai*) and skate (*Dipturus* species). Of the more than 630 demersal species found in this provincial bioregion, approximately 56 have been identified as endemic.

Indicator species have been used to vertically separate the continental slope into Upper Slope, Mid-upper Slope and Mid Slope. For the Central Eastern Province, this categorisation resulted in the following biomes:

- The Upper Slope biome (280–490 m): a biome characterised by the distribution of the longnose houndshark, *Iago garricki*);
- The Mid-upper Slope biome (610–830 m): a biome characterised by the distribution of the lined lanternshark, *Etmopterus dislineatus*; and
- The Mid Slope biome (910–1080 m): a biome characterised by the distribution of the deep-sea lizardfish, *Bathysaurus ferox*).

Given the predominance of abyssal plain in this provincial bioregion and the path of the East Australian Current, abyssal plain and trough biological communities and gyre and eddy biological communities associated with the Current are significant in the provincial bioregion. Myctophid, crustacean and squid communities characteristic of the northern provincial bioregions in the Coral Sea, are found in this provincial bioregion.

Ecosystem Processes

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 provincial bioregion.

Canyons within the slope are important for the ecology of this provincial bioregion as they have important influences on the faunal abundance and composition. These canyons channel upwelling water over the slope and shelf, while downwelling flows may also seasonally reverse the flow through these structures. Canyons provide key habitat for a range of species, including whales, and comprise a range of biomes differentiated by depth.

Warm-core eddies resulting from the pinching off of the East Australian Current tend to form over the slope and are a highly variable, annual event that influences the ecology of the Central Eastern Province. Eddy features have been identified as having an influence on biological distribution patterns due to the relative distributions of trapped nutrients, notably upwelling or downwelling at the eddy core leads to nitrate enrichment and high phytoplankton concentrations. Various fauna are dependent on seasonal mixing and the interaction of the eddy with the slope and shelf. Pelagic tunicates and coelenterates are drawn to these blooms and are themselves prey for a wide array of species including albatross and crustacean, as well as fish such as the blue grenadier, blue warehou and banded whiptail. Without the presence of these eddies it would be unlikely that yellowfin tuna would be found in the southern Tasman Sea as it is well below the usual thermal range of this species.

Connections between communities in an east-west direction is related to the seasonal variation in water temperatures caused by north-south variations in the location of the Tasman Front and eddies spawned at the junction of the East Australian Current and the Tasman Front.

Sunfish – the ocean sunfish (*Mola mola)* belongs to the family Molidae and is one of three species of sunfish known to occur within the East Marine Region. The other two species are the southern ocean sunfish (*Mola ramsayi*) and the slender sunfish (*Ranzania laevis*). The fourth Australian species, the sharptail sunfish (*Masturus lanceolatus*) occurs in southern waters of South Australia and Western Australia.

The common name, sunfish, refers to the animal's habit of "sunbathing" at the surface of the water. The ocean sunfish resembles a fish head without a tail, and the species presently holds the record for the world's heaviest bony fish–a 3.1 m long specimen weighing 2235 kg–was struck by a boat off Sydney in September 1908 (Carwardine 1995). Typically, a mature ocean sunfish has a length around 1.8 m and weighs around 1000 kg.

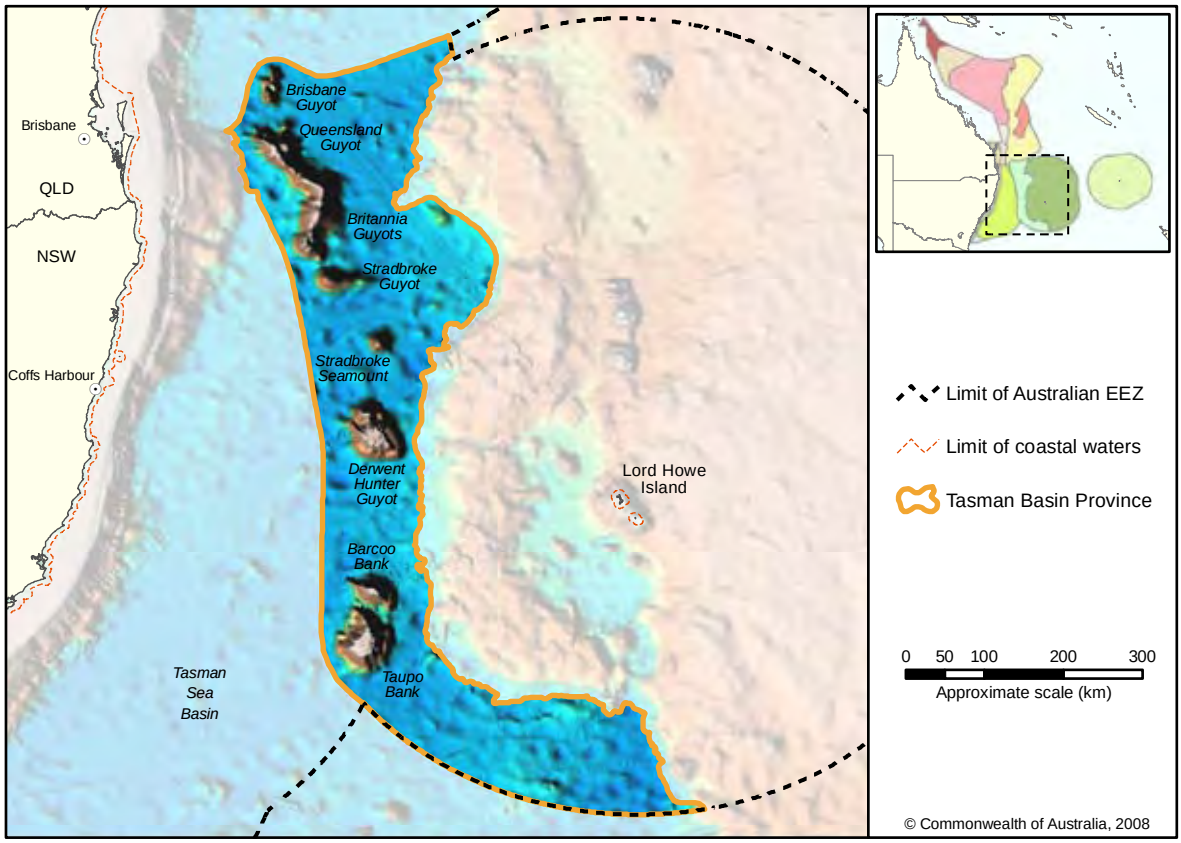
Sunfish. Photo: U.S. National Oceanic and Atmospheric Administration.

The ocean sunfish occurs in temperate marine waters worldwide. In Australia, it has been recorded from the central coast of New South Wales to Tasmania and west to Mandurah, Western Australia. Ocean sunfish are usually found in oceanic waters, but occasionally come inshore. Sunfish are often seen at the surface where they may be mistaken for sharks because of the large dorsal fin.

Adult sunfish are vulnerable to few natural predators, but sea lions, orcas and sharks will consume them. Sunfish are considered a delicacy in some parts of the world, including Japan and Taiwan. Sunfish are frequently, accidentally caught in gillnets, and are also vulnerable to harm or death from ingesting floating marine debris.

2.1.10 Tasman Basin Province

Figure 2.14 The Tasman Basin Province



Snakestar on coral. Photo: NORFANZ, Department of the Environment, Water, Heritage and the Arts, CSIRO, New Zealand's Ministry of Fisheries and NIWA.

The Tasman Basin Province of 156 420 km² is located offshore between North Stradbroke Island and Sussex Inlet (south of Jervis Bay). It lies wholly within the Region, representing six per cent of the Region's total area. It includes part of the Tasmantid Seamount chain, which runs from the south of this provincial bioregion into the Kenn Transition in the north.

Geomorphology

The Tasman Basin Province is the only provincial bioregion in Australian Commonwealth waters to occur entirely on abyssal plain/deep ocean floor. Within this area, three geomorphic features are identified: seamounts/guyots (18 480 km²); knolls/abyssal hills/hills/mountains/peaks (1120 km²); and pinnacles (210 km²). Water depth ranges between 120 m and 5100 m in this provincial bioregion. The deepest point occurs in eroded channels along the eastern margin of the basin and in depressions south of Taupo Seamount.

The upper surface of the abyssal plain is generally smooth, with patches of sediment that appear to form ribbons of silt separated out by abyssal currents. Sediments on the abyssal plain/deep ocean floor are composed almost entirely of mud. Carbonate content of the mud is around

50 per cent–similar to sediments found at greater than 4000 m depths in the adjacent Lord Howe Province.

The Tasmantid Seamount chain runs north-south at approximately 155° E longitude beginning with Fraser Seamount in the Kenn Transition. Included in the Tasman Basin Province, moving southward, are the Brisbane Guyot and Brittania Guyots constituting the Queensland Guyot, Stradbroke Guyot, Stradbroke Seamount, Derwent–Hunter Guyot, Barcoo Bank and Taupo Bank. All these features are flat-topped, with the seamounts to the south having limestone caps formed by ancient drowned reefs over volcanic basalt bases.

The seamounts rise from depths of 4800 m to 5000 m, which is deeper than the northern Tasmantid seamounts located to the north of this provincial bioregion. Taupo Seamount is the largest in the Region at 60 km in diameter at its base. It rises from 4800 m to a flat top only 120 m below sea level. This shallow platform with relief of less than 10 m is approximately 40 km north to south and up to 15 km wide. The seamounts tend to be a complex of several volcanoes forming a volcanic chain. There are many smaller unnamed and unsurveyed seamounts along this chain as well as subsidiary cones on the flanks of larger edifices.

The slopes on the side of the seamounts are commonly in the range of 10 to 20 degrees but locally can be much steeper or form a flat terrace cut at sea level. These slopes consist of rugged rock outcrops with boulders and blocks covered by a relatively thin layer of sediment. The seamounts shed sediment to the adjacent seabed to form an apron at their base. In some cases this apron is removed by bottom currents to form a moat.

Basalt samples from Taupo Bank to Queensland Guyot reveal ages of 6.4 to 24 million years, i.e. early to late Miocene. Samples are progressively older to the north confirming they were formed as the crust moved over a hot-spot in the mantle.

Oceanography

The Tasman Basin Province lies in warm temperate waters.

As with the other temperate provincial bioregions of the East Marine Region, the main physical drivers are the Eastern Australian Current eddy field and the Tasman Front.

Biological Communities

The Tasman Basin Province has Coral Sea and Tasman Sea biological communities associated with the Tasmantid seamount chain. There are also abyssal plain and trough biological communities associated with the Tasman Basin, and gyre and eddy biological communities associated with the East Australian Current. These biological communities have not been extensively studied.

Scalloped Hammerhead Shark - the scalloped hammerhead shark (*Sphyrna lewini*) is one of four hammerhead sharks found in Australian waters, and is one of the most visible pelagic sharks in the East Marine Region. The scalloped hammerhead is found in tropical and warm temperate waters from Geographe Bay in Western Australia, around the tropical north, and south to Sydney in New South Wales.

As a coastal pelagic and semi-oceanic species, this shark occurs over continental and insular shelves as well as adjacent deep water. It has been observed close inshore as well as offshore to depths of at least 275 m.

The seamounts of the Tasman Basin Province provide refugia for prey species, and consequently feeding locations for associated predator species, including hammerhead sharks (Hixon and Beets 1993, Norse and Crowder 2005, Richer de Forges 2000). Seamounts also serve as rendezvous points where scalloped hammerhead sharks can converge to mate and spawn (Klimley 1995).

Scalloped hammerhead shark. Photo: Graham Edgar, University of Tasmania.

Scalloped hammerheads feed primarily on teleost fish and a variety of invertebrates as well as other sharks and rays. Adults occur singly, in pairs, and in small schools while young scalloped hammerhead sharks live in large schools.

The scalloped hammerhead is distinguished from other hammerheads by an indentation located centrally on the front margin of the broadly arched head. Two more indentations flank the main central indentation, giving this hammerhead a "scalloped" appearance.

The status of scalloped hammerhead shark on the IUCN Red List of threatened species was heightened from Near Threatened to Endangered in February 2008, noting their susceptibility to overfishing.

Wandering albatross. Photo: Dr Michael Double.

The northern seamounts in the Tasman Basin Province are more similar, ecologically speaking, to the southernmost seamounts in the Kenn Transition than to the southern seamounts of this provincial bioregion. For the southern seamounts, there is limited information available on their biota, although what is known suggests that the biota here is different to that found in the nearby Elizabeth-Middleton Reefs area to the east.

Ecosystem Processes

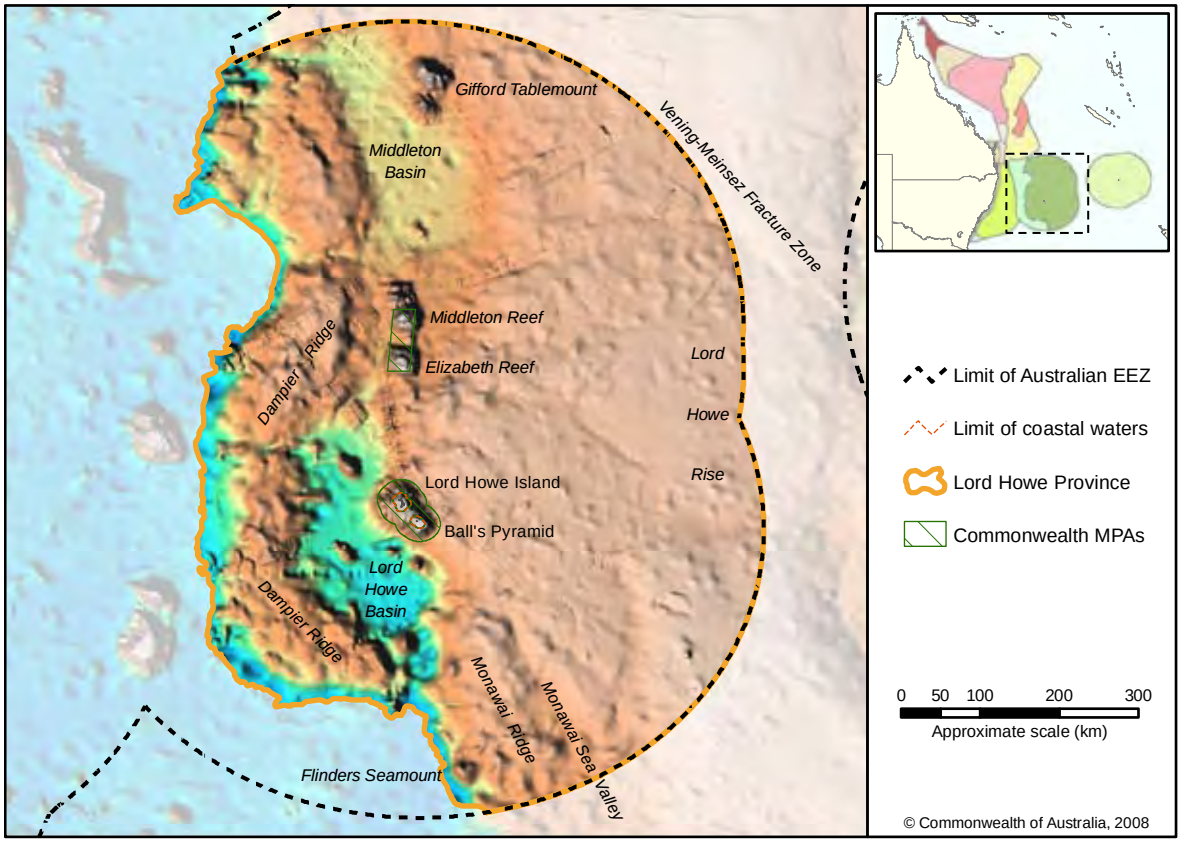
The Tasmantid Seamounts comprise a unique deep-sea environment characterised by substantially enhanced currents and a fauna that is dominated by suspension feeders such as corals. Seamounts are an iconographic marine habitat which provides topographical structure across the continental slopes and abyssal plains of the deep sea, altering oceanic circulation patterns with local upwellings, turbulent mixing and closed circulation cells. 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 deep-reef communities dominated by filter-feeders. Flow acceleration is favourable for recruitment and growth of passive suspension feeders, as shown by the relatively high abundance of corals on seamount peak edges where periods of flow acceleration have been observed.

Many large oceanic species spawn, nest, or calve only in places where they can optimise the balance between food availability and predation risk for their young. To reach breeding areas they journey hundreds or even thousands of kilometres; seamounts are therefore ideal 'stepping stones' within the open ocean.

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 fields.

2.1.11 Lord Howe Province

Figure 2.15 The Lord Howe Province



The Lord Howe Province is located in the Tasman Sea, on the slope surrounding Lord Howe Island. Covering an area of 484 880 km², it is the largest provincial bioregion in the East Marine Region, representing 20 per cent of its total area. Adjacent to the western border of Lord Howe Province are the southern seamounts of the Tasman Basin Province and to the east is the New Caledonia Basin, which is part of the Norfolk Island Province.

Geomorphology

The entire Lord Howe Province occurs on the slope and contains several geomorphic feature types. Significant features identified for the Lord Howe Province include basins, ridges, seamount/guyots, plateaus and saddles. Plateaus are the most dominant feature covering 80 per cent of the provincial bioregion. Basins cover greater than 13 per cent of the Lord Howe Province, representing 18 per cent of the total area of basins in the Region. While ridge, seamount/guyot and saddle features cover relatively small proportions of this large provincial bioregion (less than 5 per cent), the areas of these features represents significant proportions of the total areas of each feature in the Region as a whole. For example, ridges in the Lord Howe Province represent 20 per cent of the total area of ridges, and saddles represent 25 per cent of the area of saddles in the Region. Water depths in Lord Howe Province range from zero to 4100 m. Over 90 per cent of the total area occurs in water deeper than 1000 m.

The approximately 80 km wide Dampier Ridge extends south from the southern Kenn Plateau for 900 km. It can be divided into four plateaus at 2000 to 3400 m water depth representing four continental fragments joined by narrow saddles 20 to 40 km wide at 3500 to 3600 m water depth. The western margin of the Dampier Ridge is generally steep, with scarps of 1000 to 1500 m common, reflecting its plate tectonic origin. Along the margin there are small canyons eroding the slope and scarps caused by slumping or faulting. The southern Dampier Ridge is continental crust but there is evidence that the more rugged northern part is volcanic, perhaps of the same age or even younger than the Tasmantid Seamounts.

Between the Dampier Ridge and the Lord Howe Rise lies a depression that is divided into two basins, the Lord Howe Basin in the south and the Middleton Basin in the north. Both basins have a relatively flat seabed and small canyons occur on the slopes around the margins of the basins.

The Lord Howe Province extends approximately two-thirds (400 km) of the way across the Lord Howe Rise and

extends north-south for over 800 km. In the southern part of the plateau water depth is less than 1000 m, while to the north it is mostly 1200 to 1500 m. In general the seabed on the plateau is draped by thick sediment gradually sloping to the west into the basins, although in the south the margin with Lord Howe Basin can be steep and rugged. Along this slope are small seamounts protruding through the sediment cover, and small scale roughness on the seabed indicating erosion and mass movement of sediment. In the north-east of the provincial bioregion the Lord Howe Rise is cut by the north-west trending Vening-Meinsez Fracture Zone resulting in linear scarps, rough topography and seamounts. Erosion by bottom currents has created moats in the sediments at the base of these ridges. The Rise is draped with pelagic calcareous sediments known as oozes.

In the south the Monawai Ridge is a linear north-west trending feature 100 km wide on the south-western flank of the Lord Howe Rise extending into the Lord Howe Province for 160 km. On its western side it rises from the abyssal floor depths of the Tasman Basin from about 5000 m to 2000–3000 m with steep scarps up to 1500 m high. Flinders Seamount is a volcanic intrusion along this scarp and rises from water depths of approximately 5000 m in the Tasman Basin to a depth of 1740 m at its summit giving a relief of over 3000 m. The seabed on its eastern side is at a depth of 2300 m. Between the Monawai Ridge and the Lord Howe Rise proper is the broad 100 km wide Monawai Sea Valley.

The Lord Howe seamounts form a north-south chain along the western flank of the Lord Howe Rise from Balls Pyramid and Lord Howe Island in the south to Elizabeth Reef, Middleton Reef and Gifford Guyot in the north. This chain is parallel to the Tasmantid Chain some 300 km to the west. It is believed that this chain is also formed by the northward movement of the Australian Plate over a 'hot spot' in the mantle. The older seamounts to the north have subsided below sea level allowing reefs to develop limestone platforms on their summits. Gifford Guyot near the northern boundary of the Lord Howe Province is a 2000 m high guyot that comes to within approximately 300 m of the surface and is capped by a drowned limestone platform. Other smaller and unnamed seamounts occur both along this chain and adjacent to it in the Lord Howe Basin.

Within the Lord Howe Province, the largest of the seamounts in this chain is the Lord Howe Island/Balls Pyramid volcanic edifice. It is a basaltic volcano built between 6.9 and 6.4 million years ago with a base about 40 km wide by 80 km long. It rises steeply from water depths of over 3000 m on its western and southern sides; on its eastern side it merges with the Lord Howe Rise at water depths of less than 2000 m. There is a broad shelf around both Lord Howe Island and Balls Pyramid due to marine planation. The shelf around Lord Howe Island has a well-established coral reef–the southernmost occurrence of coral reefs in the world. Coralline algae are the dominant sediment component with coral and algal rhodoliths common, and gravelly muds occuring within the lagoon. Balls Pyramid shelf has no reef. It is 4 km south-east of the Lord Howe shelf, and is linked to it by a 500 m deep sill.

The Commonwealth Marine Protected Areas of Middleton Reef and Elizabeth Reef are located on the saddle that joins the Dampier Ridge with the Lord Howe Rise and separates the Middleton Basin from the Lord Howe Basin. The two reefs have roughly circular bases with diameters approximately 40 km and they rise steeply from 2500 m water depth. Both reefs have undergone wave erosion as they subsided below sea level resulting in a planated surface for coral growth to form oval shaped rim reefs

Black Cod–the black cod (*Epinephelus daemelii)* is found in warm temperate and subtropical waters of the south-western Pacific. In Australia, its distribution ranges from southern Queensland to northern Victoria, including offshore of Lord Howe Island. Isolated populations of black cod are also found in waters offshore of Elizabeth and Middleton Reefs, and Norfolk Island.

Black Cod, Middleton Reef. Photo: Ian Kerr and the Department of the Environment, Water, Heritage and the Arts.

The black cod is a large reef-dwelling groper that can grow up to two metres in length and more than 80 kg in weight, although it is more common to see smaller individuals 40–80 cm in length. Small black cod are females and change sex at 100 –110 cm to become males. Black cod are slow-moving, opportunistic carnivores that prey on fish and crustaceans, and can change colour from light to dark within seconds according to mood and background.

The black cod is most commonly found in caves, gutters and on rocky reefs in coastal waters at least 50 m deep. It is a curious, highly territorial species and individuals may occupy one particular cave for most of their adult lives, which makes them susceptible to line and spear fishing. Their populations have been greatly reduced over the last 100 years.

Sooty terns at North Bay, Lord Howe Island. Photo: Ian Hutton and the Department of the Environment, Water, Heritage and the Arts.

enclosing lagoons. Elizabeth Reef is an oval atoll oriented NW-SE 10.7 km long by 6.2 km wide. It is slightly larger than Middleton Reef which is 9.3 by 5.7 km and oriented NE-SW. The lagoons have a maximum depth of 30 m, but are mostly in-filled with sediment and on average are less than five metres deep. Sediments from the seabed and within the lagoons of Middleton and Elizabeth Reefs are characterised by gravelly sands with some mud in the deepest parts. Local sediment is composed of coral and coralline algae with lesser amounts of Halimeda, molluscs and foraminifers.

Oceanography

The Lord Howe Province is situated in warm temperate waters.

The Lord Howe Province is impacted upon by the southerly flow of the East Australian Current and the anti-clockwise warm core eddies (the Tasman Front) it forms at its point of divergence. The Tasman Front can be followed eastwards across the Lord Howe Rise. Upon initial contact with the Lord Howe Rise that lies on the western side of the plateau, the current flow has been observed to dissipate and part of the flow is deflected northward. As the main flow continues over the platform towards the west coast of New Zealand however, it regains its energy.

The surface currents of the East Australian Current bring warm tropical surface water into the provincial bioregion. This inflow of low density tropical water causes water temperature to fluctuate between 18 and 23 degrees Celsius and salinity to change on a seasonal basis.

Biological Communities

This provincial bioregion supports a unique mix of tropical, sub-tropical and temperate species and includes the southernmost coral reefs in the world. The presence of tropical species suggests linkages to northern waters along the Chesterfield range of seamounts or inflow of tropical or sub-tropical water and larvae through eddies of the East Australian Current. Gyre and eddy biological communities may be expected to occur in the Lord Howe Province.

The Lord Howe Province has seamounts and reef systems with associated biological communities (see description of Coral and Tasman Seas seamounts/guyots/islands biological communities, p 16). High numbers of Galapagos sharks (*Carcharhinus galapagensis*) are present at Elizabeth and Middleton Reefs and around Lord Howe Island. The presence of the sharks is significant as this species is unlikely to be present at other Australian reef systems. Size data suggest that Elizabeth and Middleton reefs are

important nursery areas for Galapagos sharks. Both these reefs have been intensively sampled: detailed descriptions of their biological communities are found at the beginning of this chapter under the Coral and Tasman Seas seamounts/guyots/islands sub-heading.

There are continental plateau biological communities associated with the Lord Howe Plateau but data on their composition are limited, particularly for the demersal environment. The platform is expected to be dominated by its relatively featureless seabed and sparse population. It is probably dominated by epi-benthic detritivores and filter-feeders. Where the appropriate conditions are met, including availability of hard sediment and suitable delivery of organic matter via bottom currents, the platform is likely to support deep water reef communities. These deep reefs would be expected to be dominated by filter-feeding epifauna (i.e. sponges, bryozoans, azooxanthellate corals), which may in turn support demersal consumers such as crustaceans, echinoderms, bivalves, cephalopods and fish.

The pelagic environment of the Lord Howe Plateau includes transient populations of highly migratory, secondary and tertiary pelagic consumers, notably small fish schools and pelagic predators such as yellow-fin tuna (*Thunnus albacares*), blue marlin (*Makaira nigricans*) and striped marlin (*Tetrapturus audax*).

Ecosystem Processes

Lord Howe Island together with Norfolk Island and the Kermadec Islands are the only three subtropical island groups in the south-west Pacific Ocean, with species diversity of tropical and temperate fish, corals and other marine organisms declining across these island groups from west to east.

The incoming stream of warm tropical surface water carried by the East Australian Current allows the Lord Howe Province to support the southernmost coral reefs in the world. Transportation of planktonic larvae and larger vagrant and migratory species across the provincial bioregion, including many tropical species from the north, is facilitated by this current.

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 Lord Howe 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.

The area to the northeast of the Lord Howe Rise has a stable water mass with a uniform thermocline that may be the result of the Lord Howe Rise sheltering the area from the effects of the eddy fields to the west. This enables the area to support a relatively stable and homogenous pelagic and benthic environment–a large desert-like plain covered in calcareous pelagic ooze, with small seamounts poking through the sediments. The seamounts–some as young as two million years old–are biological hotspots in the area; however, extensive bioturbation has occurred on the plain itself. There is evidence of localised scouring around the seamounts, while on the plain soft sediment deformation has occurred due to dewatering. It is likely that this environment extends south along the length of the eastern side of the Lord Howe Rise.

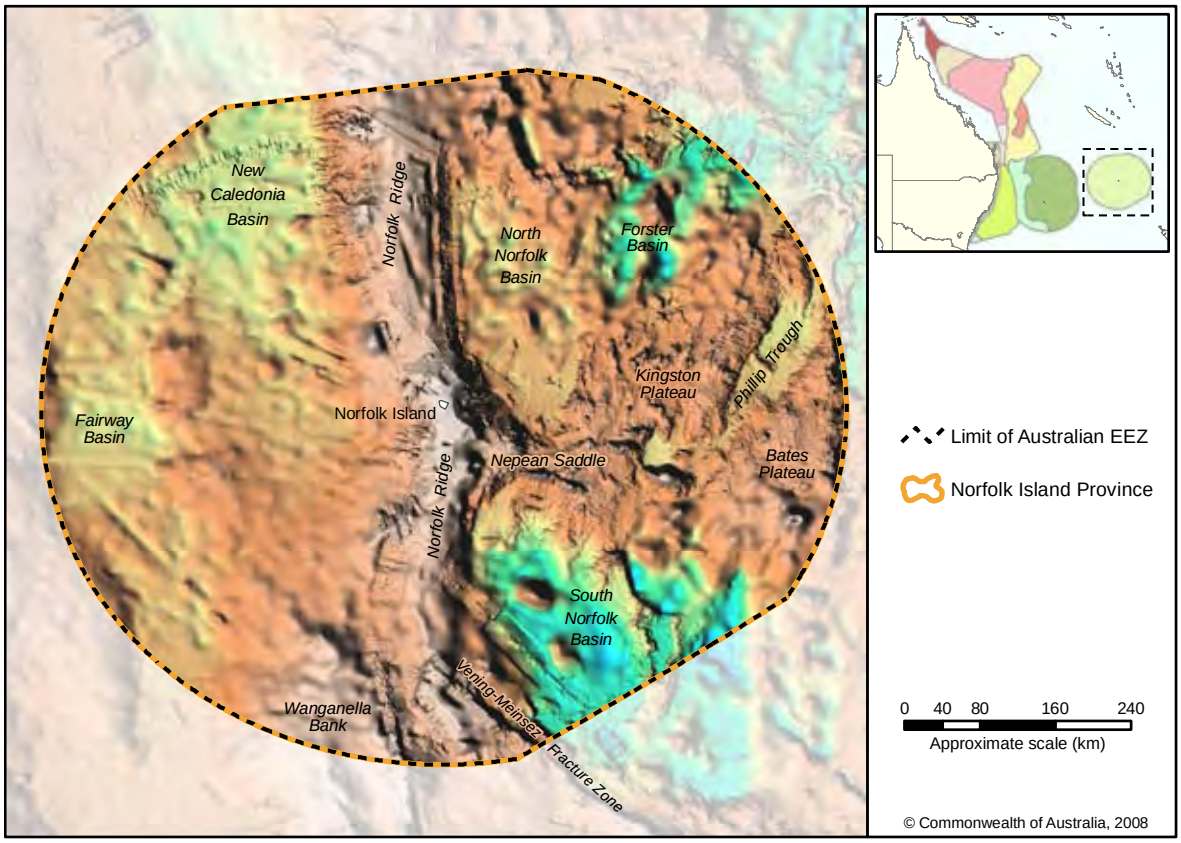
Ecological connections are in a north-south direction and are influenced by southward moving surface currents passing along the Chesterfield chain of seamounts in the Coral Sea (outside the Exclusive Economic Zone) and by north-moving sub-Antarctic currents along the sea floor beside the Lord Howe Ridge.

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

Connectivity in the demersal environment across the Lord Howe Province and into neighbouring provincial bioregions is relatively low. The steep rise of the Dampier Ridge and the Lord Howe Plateau can act as a physical barrier to most demersal species inhabiting adjacent basins and the western border of the Norfolk Island Province.

2.1.12 Norfolk Island Province

Figure 2.16 The Norfolk Island Province



The Norfolk Island Province is situated in the central Tasman Sea, approximately midway between New Caledonia and New Zealand. It surrounds Norfolk Island but is separated from the rest of Australia's Exclusive Economic Zone by a strip of seabed approximately 100 km wide that is not within Australian waters. Norfolk Island Province covers an area of 430 790 km², which represents 18 per cent of the East Marine Region.

Geomorphology

The Norfolk Island Province is located predominantly on slope, with a very small area of shelf that surrounds Norfolk Island. The Norfolk Island Province contains a complex geomorphology with thirteen geomorphic features identified on the slope. Fourteen per cent of slope, 99 per cent of banks/shoals, 12 per cent of trenches/troughs, 45 per cent of basins, 40 per cent of knoll/abyssal hills/hills/mountains/peaks, 11 per cent of seamount/guyots, 32 per cent of pinnacles, 17 per cent of plateaus, and 31 per cent of saddles within the Region are located within the Norfolk Island Province. Together basins and plateaus cover 345 470 km², or 80 per cent of the Norfolk Island Province. This area includes the Kingston Plateau, New Caledonia Basin, North Norfolk Basin, and South Norfolk Basin.

Water depths in the Norfolk Island Province range from zero to 4300 m with approximately 80 per cent of the Province having water depths greater than 2000 m. Bank/shoals generally occur in relatively shallow areas of the slope at depths less than 1000 m, while other features – plateaus, seamount/guyots, pinnacles, saddles, knoll/abyssal hills/hills/mountains/peaks, trench/troughs, and basins – all occur at significantly greater depths (over 2000 m).

The geomorphology in the Norfolk Island Province is dominated by north-south trending rugged volcanic ridges separated by basins partly filled by sediments. The major feature is the Norfolk Ridge which bisects the region and is comprised of a complex system of ridges and basins, extending from New Caledonia in the north to New Zealand in the south. The volcanically formed Norfolk Island is situated on the central section. The Ridge is approximately 70 km wide and at depths shallower than 1500 m. It is mostly flat-topped with steep sides sloping into the New Caledonia Basin on the west and Norfolk Basin on the east. Numerous small canyons cut these slopes. There are three shallower plateaus along its length. The most southern of these is called the Regina Ridge and its north-east margin is part of the Vening-Meinsez Fracture

Green turtle. Photo: Robert Thorne and the Department of the Environment, Water, Heritage and the Arts.

Zone. A 2000 m deep narrow (20 km) gap separates this ridge from the Wanganella Bank (water depth 100 to 1000 m) on West Norfolk Ridge at the southern margin of the Province. Wanganella Bank comprises a significant area of pinnacles shallower than 500 m.

The north-south trending New Caledonia Basin is an area of very flat seabed 3500 m deep at the northern margin where it is 150 km wide and narrowing to the south where it is 2500 m deep. The West Norfolk Ridge forms the basin's southern margin. This ridge continues NNW across the Region as a discontinuous bathymetric feature known as the Northern West Norfolk Ridge and separates the New Caledonia Basin on its east from the 100 km wide, 3000 m deep Fairway Basin on its west. This ridge is probably volcanic and consists of steep-sided ridges and seamounts with steep relief of 1000 m where it rises from the 3200 m abyssal floor of the New Caledonia Basin.

East of the Norfolk Ridge is a zone of complex topography on the seafloor known generally as the Norfolk Basin but composed of plateaus, seamounts, basins, depressions and fault-bounded troughs.

Along the northern boundary of the Norfolk Island Province is the North Norfolk Plateau 2000 to 3000 m deep. South of this plateau is the North Norfolk Basin (3000 to 3500 m deep) separated from the deeper South Norfolk Basin (4000 to 4250 m) by the 50 km wide Nepean Saddle that is 900 to 1400 m deep. Numerous small seamounts on the Nepean Saddle have a linear east-west trend that may correspond to a fault at this location. The basin floors are flat due to sediment fill of several hundreds of metres that is thickest at the margins and at the base of ridges. Numerous volcanic ridges protrude from the basin floor with varying relief.

East of the North Norfolk Basin and separated from it by a ridge is the deeper Forster Basin (water depth greater than 4000 m) that continues its north-east trend outside the Province to the Cook Fracture Zone. A large seamount in the Foster Basin has a summit only 800 m below the sea surface. South of the Forster Basin is the Kingston Plateau, a large, irregular shaped area approximately 200 by 150 km between 2000 and 3000 m below the sea surface. This plateau has many seamounts, some rising to within 1000 m of the sea surface. South-east of the

Red-tailed Tropicbird (or Bosun Bird)–The red-tailed tropicbird (*Phaethon rubricauda)* is an oceanic seabird widely distributed through the tropical Pacific and Indian Oceans.

The red-tailed tropicbird is a pelagic or ocean-going species that inhabits tropical, marine waters. This species prefers waters of between 24° and 30°C, but is recorded occasionally in cooler waters, following warm currents (Marchant and Higgins 1990). Nests are located on isolated islands in inaccessible places such as cliffs. The species is present on Norfolk Island all year, where breeding takes place in the summer on Norfolk, Phillip and Nepean Islands).

Red-tailed tropicbird. Photo: Mark Holdsworth.

The red-tailed tropic bird nests individually or in small breeding colonies and is territorial (Marchant and Higgins 1990). Nests are simple scrapes that may be surrounded by plant material and stones (Hutton 1991).

The birds forage on fish and squid (Barker and Vestjens 1989) by diving deeply into the water. The adult red-tailed tropicbird is predominantly white with a pink sheen of varying intensity. Central tail feathers are characteristically bright red and elongated, into streamers.

Kingston Plateau is the Bates Plateau separated by the Philip Trough, 3000–3500 m deep and 20 –50 km wide with an irregular boundary. Bates Plateau is similar to the Kingston Plateau having a relatively smooth surface at water depths of 2100 to 2600 m with low relief crenulations and the general absence of abyssal hills or ridges. However, they do have many seamounts, some part of linear volcanic ridges along the margins of the plateaus where slopes are up to 30 degrees. The eastern margin of the Bates Plateau has a chain of seamounts in the Norfolk Island Province with three of them rising to depths of 800, 840 and 570 m respectively. South of Bates Plateau and separated from the South Norfolk Basin by a ridge is an unnamed group of small basins deeper than 4000 m and separated by ridges.

Sediments in this provincial bioregion are dominated by pelagic carbonates consisting mostly of the remains of foraminifers and coccoliths. There is also a small contribution from the siliceous plankton (radiolarians and diatoms). Volcanic ash and pumice make a minor contribution forming non-biogenic particles. Boulders, blocks, and rock fragments are common near rock outcrops.

Oceanography

The Norfolk Island Province is situated in warm temperate waters.

The Norfolk Island Province is situated within the Tasman Front. The Tasman Front, which splits off from the East Australian Current at approximately 34° S to flow in an easterly direction, passes through the south of the Norfolk Island Province. The North Tasman flow, a current filament which detaches from the East Australian Current at approximately 31° S, loops northward over the Lord Howe Rise before entering the deep waters of the Norfolk Basin, then veers diagonally north-westward between 165° E and 170° E. This diversion is caused when the North Tasman flow encounters the subsurface westward flow on the northern edge of the Norfolk Eddy. This quasi-permanent eddy is a stationary feature in the Norfolk Island Province. Within the thermocline, the Norfolk Eddy has a temperature and salinity signature of more than one degree Celsius and 0.05 practical salinity units, and is still evident as a distinct feature at 1500 m.

The Norfolk Island Province is also affected by the warm currents from New Caledonia which flow from October through to May each year.

Biological Communities

The Norfolk Island Province has seamounts and reef systems with associated biological communities (see description of Coral and Tasman Seas seamounts/guyots/islands biological communities ,p 16).

Species diversity of tropical and temperate species of fish, corals and other marine organisms around Norfolk Island is very similar to those found in the reefs surrounding Lord Howe Island, but with lower diversity. Two very common fish species are endemic to Norfolk Island – a bigeye cardinalfish (*Archamia leai*) and a blenny (*Parablennius serratolineatus*). Both species are found in large numbers around coral bommies and vertical reef faces.

At these latitudes there is significant competition for space between corals and seaweeds (marine algae). The balance appears to be maintained by algal grazers, the most significant of which are sea-urchins, and some fish species of the families Scaridae, Acanthuridae and Siganidae. Coral cover and diversity increase dramatically within 50 m of the stream outflow at Kingston on Norfolk Island. Kingston lagoon contains a unique and diverse sub-

tropical coral fauna that includes at least 32 species of reef-building corals from 11 of the 16 coral families.

In 2003 a joint Australian–New Zealand survey, termed NORFANZ, attempted to identify the biodiversity and endemicity of the benthic seamount fauna at six locations on the Norfolk Ridge. From this survey, 516 species of fish and macro-invertebrates were collected, 36 per cent of which were new to science and potentially endemic to the Norfolk Ridge. The survey also found that there were few similarities between biological communities sharing the same type of habitat on different seamounts in the area. It may be that these species have adapted to the small size and the isolation of the seamount, which restricts species dispersal and concentrates site-specific populations.

There are also abyssal plain and trough biological communities and continental plateau biological communities associated with the geomorphology of this provincial bioregion, and gyre and eddy biological communities associated with the East Australian Current eddies and the Norfolk Eddy. What little is known about demersal communities at sub-tropical and temperate latitudes throughout the Pacific Ocean, is evident in this provincial bioregion.

Migratory species which have been seen in the Norfolk Island Province include humpback, killer and right whales. Large sharks, including white pointers, have been seen and caught in Norfolk Island waters. Other sightings in the area include sei, fin, pilot and sperm whales. The most interesting marine mammal sightings are of what might be Longman's beaked whale, *Mesoplodon pacificus*, in the waters east of Norfolk Island.

Ecosystem Processes

World-wide there are few isolated oceanic islands at similar latitudes to Norfolk Island and there are few coral reefs further than this from the equator.

The Norfolk Island 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 Norfolk Ridge to its flanks where canyons have formed.

The area is influenced by the east-moving eddies associated with the Tasman Front that transport Coral Sea biota including corals, crustaceans and molluscs, to this provincial bioregion.

The south-east area of the Norfolk Island Province has relatively high productivity and biodiversity. The seamounts and pinnacles in this area are distinct from the rest of the

Goblin shrimp. Photo: NORFANZ, Department of the Environment, Water, Heritage and the Arts, CSIRO, New Zealand's Ministry of Fisheries and NIWA.

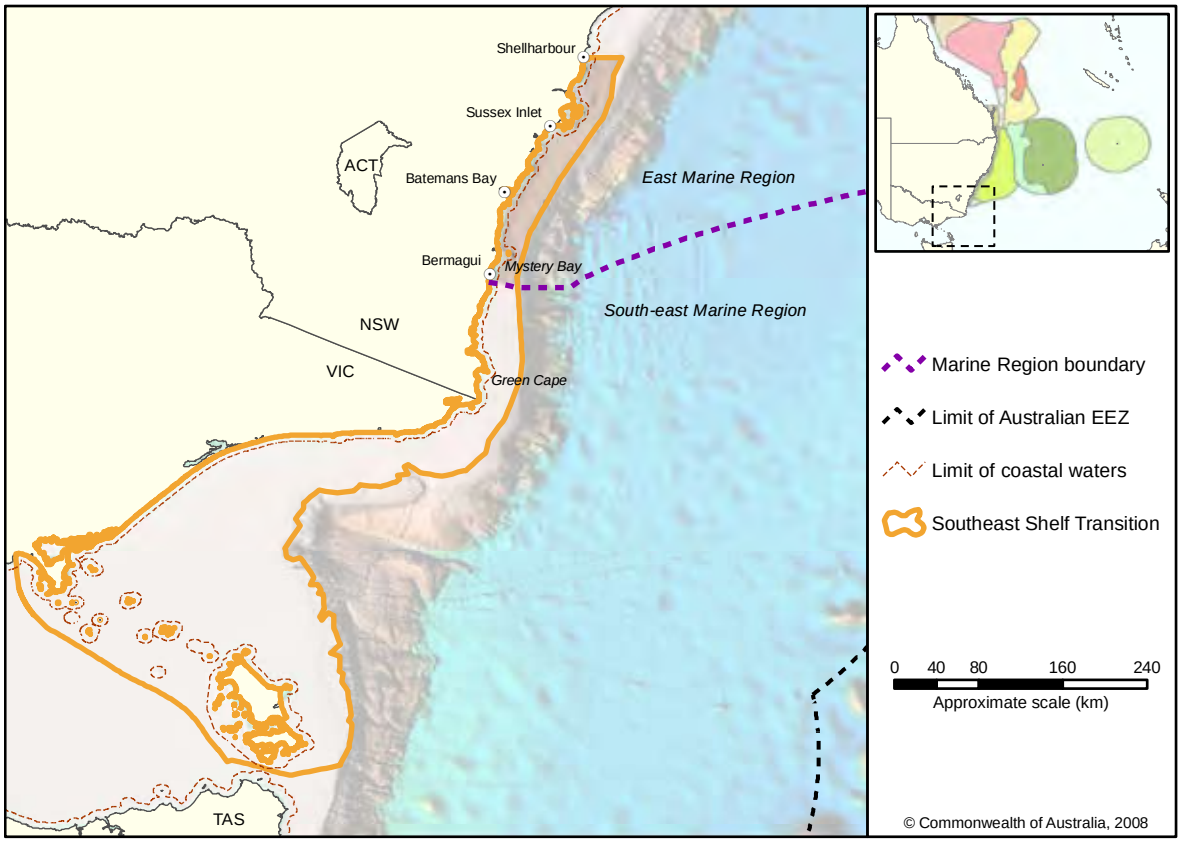
Norfolk Island Province due to the influence of the quasi-permanent Norfolk Eddy. The Eddy breaks down over time but is seasonally replaced. This creates a set of stable conditions different to those found in other areas of the Norfolk Island Province. The seamounts and pinnacles in the north-east of the Norfolk Island Province are deeper and are influenced by lower steric heights.

Increased larval residence time in waters overlying seamount and pinnacle structures has been attributed to the Norfolk Eddy, allowing eggs and larvae to successfully establish on suitable hard substrate. Geographic isolation may eventually modify the life-histories of resident fauna towards reproductively-isolated endemics. Given that the Norfolk Eddy's physical conditions exist down to 1500 m, the potential for larval retention from the seamounts of the Nepean Saddle, Bates Plateau and South Norfolk Basin region is high and is therefore likely to contribute to high levels of endemism in the area immediately under the eddy.

Due to it's isolation from the other provincial bioregions of the Region, connectivity between the Norfolk Island Province and these provincial bioregions is not clear, but there is possibly a connection with the Lord Howe Island Province.

2.1.13 Southeast Shelf Transition

Figure 2.17 The Southeast Shelf Transition



The Southeast Shelf Transition is located predominantly on the continental shelf with a small section on the upper slope between Kiama and Bermagui. It is the most southerly shelf provincial bioregion in the East Marine Region with an area of 59 620 km² of which 4270 km² (seven per cent) lies within the Region. This provincial bioregion contributes less than one per cent to the total area of the Region, falling mainly within the South-East Marine Region and the state waters of New South Wales and Victoria.

Geomorphology

The Southeast Shelf Transition is physically homogeneous relative to other provincial bioregions, with only two geomorphic features identified. Shelf covers 3931 km² or 92 per cent of the provincial bioregion and slope covers 342 km² or eight per cent. The provincial bioregion is relatively narrow, 5 to 30 km wide, and runs parallel to the coast. The narrowest sections occur adjacent to Sussex Inlet and Mystery Bay. The maximum water depth in the Southeast Shelf Transition is 240 m and the shallowest point is Sir John Young Banks at 16 m.

Seabed sediments of the provincial bioregion are dominated by sand, with mud and gravel forming less than 20 per cent. Carbonate content is high and increases towards the outer shelf and upper slope.

Oceanography

This provincial bioregion has a transitional water mass (warm temperate–cold temperate).

As with the other shelf provincial bioregions in the Region, the main oceanographic driver is the southerly movement of the East Australian Current as it meanders along the coastline. There is a predictable eddy field in this area which is associated with mixing cold and warm temperate water masses.

Biological Communities

The Southeast Shelf Transition has continental shelf biological communities associated with it, as well as some gyre and eddy biological communities. The Southeast Shelf Transition has been the subject of detailed study and data gathering,

Black-browed Albatross – the black-browed albatross (*Thalassarche melanophris*) is listed as a marine species, a threatened species, and a migratory species under the EPBC Act.

The black-browed albatross is a medium-sized albatross, characterised (in adults) by comparatively long wings, short tail, a white head and short neck, a bright yellow-orange bill and neat black eyebrows that give it a frowning look. The black-browed albatross has a circumpolar distribution and is found over Antarctic, sub-Antarctic and sub-tropical waters. It is a common vagrant in the northern hemisphere. The birds are most abundant in south-eastern Australian and Tasmanian waters (Marchant and Higgins 1990).

Within the Australian jurisdiction, black-browed albatrosses breed in colonies at a number of sub-Antarctic locations, namely Heard Island, McDonald Island (historically so, but there is now some doubt as recent extensive volcanic activity has reshaped the island), Macquarie Island, and the nearby Bishop and Clark Islands. During the summer breeding season, black-browed albatrosses forage in sub-Antarctic waters around the breeding colonies. Over winter, adults from the Australian breeding colonies, and from breeding colonies in other jurisdictions, generally disperse northwards and forage in coastal waters off southern Australia from Perth on the west coast, to north of Brisbane on the east coast, as well as off New Zealand, South Africa and South America.

Black-browed albatross. Photo: Dr Michael Double.

Black-browed albatrosses forage in the coastal waters of continents, over upwellings or boundaries of currents and are often found sheltering in harbours, bays or channels. The species is usually associated with mixed flocks of other seabirds, including other albatrosses and giant petrels (Marchant and Higgins 1990).

Black-browed albatrosses fly fairly low and take food from the sea surface or just below. They eat mostly krill and fish, with some salps, jellyfish and cephalopods. They are also enthusiastic scavengers (Marchant and Higgins 1990). The species is gregarious at sea and will accompany fishing boats to scavenge offal, waste and bait (Robertson and Gales 1998). They are highly vulnerable to longline fishing without seabird bycatch mitigation measures.

and descriptions of these biological communities are found at the beginning of this chapter under the continental shelf section.

As a transition zone, this provincial bioregion shares many species with its neighbouring provincial bioregions, although the portion of the Southeast Shelf Transition within the East Marine Region is more likely to have species in common with its neighbouring provincial bioregions to the north and east than to the south. In the area of Green Cape, to the immediate south of the Region, there is a change in the inshore species composition of some groups of organisms. Eastern warm temperate species are replaced by species with distributions primarily in southern and western warm temperate, and southern cool temperate areas.

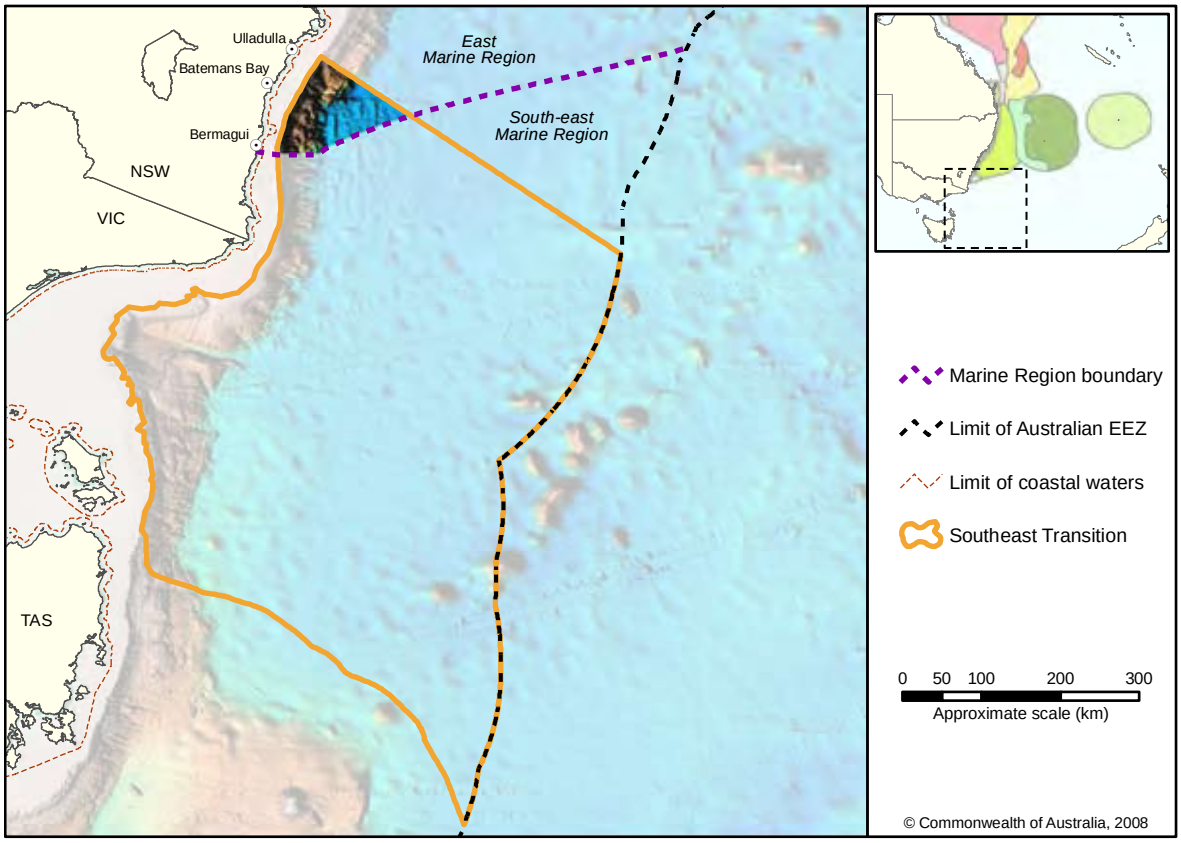
Ecosystem Processes

The major ecosystem processes described under the Central Eastern Shelf Transition also apply to this provincial bioregion.

White's seahorse. Photo: Photolibrary.

2.1.14 Southeast Transition

Figure 2.18 The Southeast Transition



Striped marlin – the striped marlin (*Tetrapturus audax)* is a migratory pelagic billfish that is distributed throughout the Pacific Ocean (40° S to 40° N) and Indian Ocean (north of 40° S). Satellite and archival tagging studies have demonstrated that this species spends the majority of its time inhabiting the surface layer to depths of around 150 m (Holts and Bedford 1989, Domeier and Dewar 2003).

The striped marlin is a large species that can grow to over 200 kg weight and over 3 m in length. Off the east coast of Australia, striped marlin is present from the Coral Sea to Tasmania depending on currents and seasons.

The fish are opportunistic predators. They have a very varied diet consisting mostly of species that inhabit the surface layers of the pelagic ecosystem. Generally the diet consists of a mix of fish and squid, with relative proportions of these changing with season and region (Ueyanagi and Wares 1975).

Striped marlin. Photo: www.boyceimage.com.

The striped marlin is generally perceived as an "enigmatic" billfish species by both recreational and commercial fishers.

A recreational fishery for striped marlin has existed off the east coast of Australia since the 1930s, and has become a very important species in tournament fishing, charter fisheries, and for gamefishers in general.

Japanese longliners took substantial catches of striped marlin from waters of the East Marine Region prior to their withdrawal from the area in November 1997. Catches of striped marlin by the domestic longline fleet off the east coast of Australia tripled between 1996 and 2000, making it one of the top five species taken annually in the Eastern Tuna and Billfish Fishery.

Striped marlin is rarely discarded in the eastern fisheries and there is evidence of opportunistic targeting, probably due to the presence of strong domestic and foreign (sashimi) markets for this species (Bromhead et al. 2004).

Australian fur seal. Image courtesy of CSIRO.

The Southeast Transition is located offshore between Ulladulla and Bermagui. It covers a total area of 241 910 km² of which 8800 km² (four per cent) is located within the East Marine Region, contributing to less than one per cent of the total area of the Region. Ninety six per cent of the provincial bioregion falls within the Southeast Marine Region

Geomorphology

The area of the Southeast Transition in the Region occurs on the slope and abyssal plain/deep ocean floor. Two geomorphic features are identified within the area of the slope: canyons (14 per cent of the provincial bioregion); and knoll/abyssal hills/hills/mountains/peak in the south of the region (greater than one per cent). No features occur on the abyssal plain/deep ocean floor.

The deepest point in the Region at 5200 m is found in the Southeast Transition. More than 80 per cent of the provincial bioregion lies in water depths greater than 2000 m.

Oceanography

The Southeast Transition has a transitional water mass (warm temperate–cold temperate).

Biological Communities and Ecosystem Processes

As the majority of this provincial bioregion is in the neighbouring South-East Marine Region, the fragment of this provincial bioregion that does occur in the Region is essentially the same as the bordering provincial bioregion, the Central Eastern Province, described in Section 2.1.8.

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