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Temperate East Marine Parks Network Synthesis Report

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Executive summary

The Temperate East Marine Parks Network spans approximately 1.47 million km^2 of Commonwealth waters extending from southern Queensland and New South Wales to the offshore waters surrounding Lord Howe and Norfolk Islands. The network encompasses an exceptional diversity of marine environments, including continental shelf, slope and abyssal ecosystems, seamounts, submarine canyons, oceanic coral reefs and isolated volcanic island systems. Situated within the dynamic influence of the East Australian Current (EAC), the region forms one of Australia's most biologically diverse marine transition zones, where tropical, subtropical and temperate species coexist.

This report synthesises the current understanding of the natural values, ecosystem distribution, human uses and environmental pressures across the Temperate East Marine Parks Network. It brings together recent information from seabed mapping, ecological surveys, oceanographic studies and species observations to provide an evidence base for adaptive management of the network.

Knowledge of the physical environment has increased substantially over the past two decades through investment in multibeam bathymetry, habitat mapping and characterisation and monitoring surveys. Fine-resolution mapping has revealed complex seafloor features including shallow and mesophotic reefs, seamounts, shelf-edge reefs, submarine canyons, volcanic pinnacles and deep-ocean habitats that underpin patterns of biodiversity throughout the region. These data have greatly improved understanding of ecosystem distribution and representativeness across the network.

Twenty-two benthic and four pelagic ecosystem types are recognised within the Temperate East Network. These range from shallow coral and rocky reefs, mesophotic and rariphotic coral and rocky reefs, continental shelf sediments and shelf-incising canyons through to deep-slope, abyssal and pelagic ecosystems. While progress has been made in mapping these ecosystems, knowledge remains uneven across the network, with many deep-water environments (rariphotic and greater depths), offshore seamounts and abyssal habitats remaining poorly sampled biologically.

The network contains several areas of exceptional ecological significance. Lord Howe Island, Elizabeth Reef and Middleton Reef support some of the world's southernmost coral reef systems and provide habitat for diverse coral communities, reef fishes, seabirds and threatened species. The seamounts of the Tasmantid Chain, Norfolk Ridge and extensive submarine canyon systems create structurally complex habitats that support high biodiversity and enhance ecological connectivity across the Tasman Sea. Mesophotic and rariphotic reef systems have emerged as particularly important ecosystems supporting diverse benthic communities and functioning as potential refugia under changing ocean conditions.

The Temperate East Network provides habitat for numerous nationally and internationally significant threatened, migratory and endemic species. These include humpback whales, grey nurse sharks, white sharks, marine turtles, seabirds and the vulnerable black cod, together with recently recognised important reproductive habitat for Galapagos sharks around the Lord Howe Island group. The region represents an important intersection between tropical and temperate faunas and supports high species richness across fishes, corals, sponges, crustaceans, molluscs and echinoderms.

Recent marine imagery programs have transformed understanding of ecosystem composition across many marine parks. Integrated surveys using autonomous underwater vehicles, remotely operated vehicles, baited remote underwater video systems and high-resolution seabed mapping have documented previously undescribed habitats and species assemblages across continental shelf, slope and oceanic reef ecosystems. These case studies demonstrate the value of combining physical mapping with biological observations to characterise ecosystem condition and improve predictive habitat models.

The network also supports important economic, cultural and recreational values. Commercial fisheries, recreational fishing, tourism, maritime shipping and scientific research all occur throughout the region, although their spatial distribution and intensity vary considerably among marine parks. Many offshore areas experience relatively low direct human disturbance compared with coastal ecosystems, while some shelf environments support multiple compatible uses.

Climate change represents the most significant long-term pressure affecting the Temperate East Marine Parks Network. The change in the dynamics and southward extension of the East Australian Current, increasing marine heatwaves, ocean warming, ocean acidification and sea-level rise are already driving ecological change across the region. These changes are contributing to the tropicalisation of temperate ecosystems, shifts in species distributions and altered ecosystem functioning. Additional pressures include invasive species, land-based impacts on coastal ecosystems and the cumulative effects of multiple stressors acting across interconnected marine environments.

The synthesis highlights improvements in understanding of the Temperate East Marine Parks Network. Advances have been made in mapping physical habitats and documenting biodiversity within accessible shelf and reef systems, yet many deep-water habitats, seamounts and pelagic ecosystems remain poorly understood. Continued investment in standardised and integrated seabed mapping, long-term ecological monitoring and data synthesis will be essential to improve understanding of ecosystem condition, detect environmental change and support evidence-based management of Australia's temperate eastern marine parks.

The information presented in this report provides an updated scientific foundation for management of the Temperate East Marine Parks Network. It identifies significant natural values across the network, and documents the current state of knowledge that will strengthen conservation outcomes and improve the long-term management and resilience of these nationally significant marine ecosystems.

1. Introduction

1.1 Temperate East Marine Parks Network

The Temperate East Marine Region covers approximately 1.47 million km² of temperate and subtropical ocean adjacent to the coastlines of southern Queensland and New South Wales, and extends offshore to encompass the waters around Lord Howe and Norfolk Islands. The Temperate East Network covers 383,339 km² of waters across the broader region, and includes eight marine parks. The Temperate East Marine Parks Network Management Plan assigns an International Union for Conservation and Nature (IUCN) category to each of the eight marine parks in the network, which includes National Park Zone (II), Habitat Protection Zone (IV), Special Purpose Zone (VI), Habitat Protection Zone (Lord Howe) (IV), Recreational Use Zone (IV) and Multiple Use Zone (VI) (Figure 1).

The seascape spans continental shelf, slope and abyssal environments, with considerable variation in seafloor topography including lagoon and shelf reef systems, seamounts and submarine canyons. Ocean circulation plays a defining role in shaping the region's ecology, with the East Australian Current carrying warm Coral Sea waters southward along the outer shelf, pushing the distributional limits of tropical species well into subtropical and temperate latitudes. The result is an unusually species-rich environment, with high diversity recorded across corals, crustaceans, echinoderms, molluscs, sponges and fish.

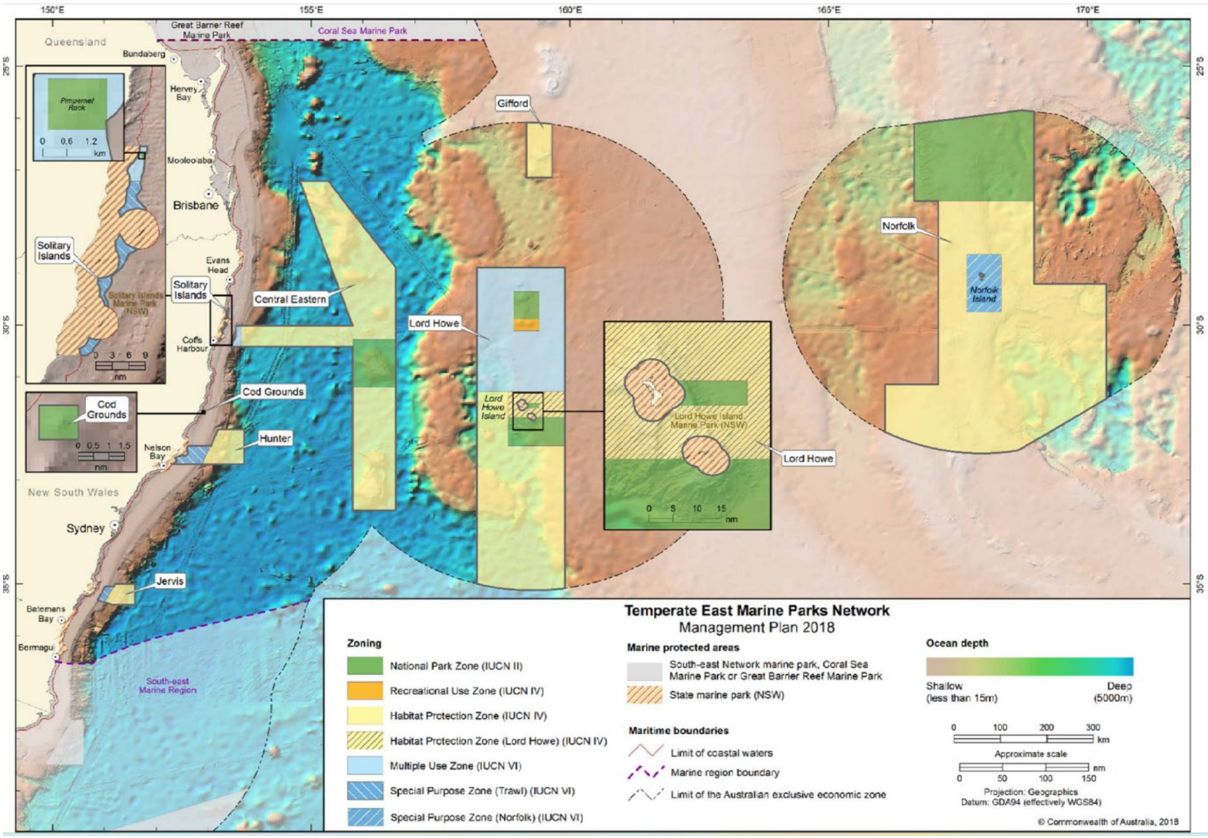


Figure 1. Temperate East Marine Parks Network with Commonwealth (Australian Marine Park) managed marine park zones. From Temperate East Marine Parks Network Management Plan 2018.

This blending of warm and cool water influences is especially striking at Lord Howe Island and Elizabeth and Middleton Reefs, where tropical and temperate species co-occur in the same reef systems. More broadly, the region supports globally significant populations of internationally threatened species, a small number of endemic taxa, and critical habitat for a range of wide-ranging species. The east coast population of grey nurse shark aggregates in New South Wales waters, migratory white sharks move through the region seasonally, and humpback whales travel through on their annual passage between southern feeding grounds and Queensland breeding areas. Offshore reef systems at Lord Howe, Norfolk, and Elizabeth and Middleton Reefs provide breeding and foraging habitat for multiple seabird species, represent the southern limit for many reef-building corals, and support the vulnerable black cod. These offshore islands and reefs were recently recognised by the IUCN Important Shark and Ray working group as important reproductive areas for Galapagos Shark (*Carcharhinus galapagensis*). Marine turtles and a diverse bony fish assemblage are also recorded throughout the region.

This report aims to synthesise the current understanding of the natural values, ecosystem distribution, human uses and environmental pressures across the Temperate East Marine Parks Network. It brings together recent information from seabed mapping, ecological surveys, oceanographic studies and species observations to provide an evidence base for adaptive management of the network. It also aims to describe the type and distribution of human uses across the network, including both recreational and commercial activities such as fishing, tourism, and boating and shipping. While many of the marine parks sit well offshore, places like Solitary Islands, Lord Howe and Norfolk marine parks offer meaningful opportunities for public engagement with these environments.

The report also aims to describe the key pressures that influence the natural values of the network, with a number of specific climate change pressures expected to result in significant long-term changes across the region. Additional pressures include invasive species, land-based impacts on coastal ecosystems and the cumulative effects of multiple stressors acting across interconnected marine environments.

Economically, the region underpins important industries including commercial fishing and maritime shipping, which support employment and community wellbeing in coastal towns. The broader supply chains and services that sustain these industries, from marine equipment suppliers to vessel repair facilities, are themselves significant contributors to local economies. While it is recognised that there are a wide range of cultural, heritage and socio-economic values associated with marine parks throughout the network, a detailed synthesis of these are outside the scope of this report.

1.1.1 Scope and literature selection

This synthesis draws on approximately 156 published papers, technical reports, government documents and monitoring reports to summarise the current understanding of the natural values, uses and pressures within the Temperate East Marine Parks Network. The emphasis was on literature directly relevant to the Australian Marine Parks or to ecological processes operating across the broader offshore region.

The review focused on studies that were undertaken within the Temperate East Australian Marine Parks, or that addressed offshore ecosystems, oceanography, threatened species, fisheries, habitat mapping and ecosystem processes directly applicable to the network. National assessments, management plans, and Parks Australia technical reports were also included where they provided authoritative information on ecosystem distribution, condition, management or conservation significance. Where a series of publications were reviewed that focused on progressing the understanding of natural values or pressures in the region, the most current publication is included as the most up-to-date source.

A large body of ecological research has been undertaken in adjacent New South Wales State marine parks and other coastal environments. While this literature provides valuable ecological context, it was generally excluded from the synthesis unless it directly informed understanding of Commonwealth marine parks, demonstrated ecological connectivity across marine park boundaries, or provided the only available information for comparable habitats. For example, studies from the Solitary Islands and Port Stephens–Great Lakes regions were incorporated where they helped interpret ecosystem structure extending into adjacent marine parks or provided temporal context unavailable from Commonwealth waters.

Similarly, the review did not attempt to comprehensively synthesise the extensive literature on coastal estuaries, nearshore reefs or species ecology where these studies had limited relevance to offshore Commonwealth waters. Instead, emphasis was placed on evidence that improved understanding of ecosystem distribution, biodiversity, ecological processes, human uses and environmental pressures within the Temperate East Marine Parks Network.

This selective approach reflects the objective of producing a management-focused synthesis rather than a comprehensive review of all marine research undertaken along Australia's east coast. Where direct evidence from Australian Marine Parks was unavailable, broader regional studies were used to provide ecological context while clearly distinguishing between observations made within Commonwealth marine parks and those derived from adjacent coastal systems.

1.2 Regional oceanography

The Temperate East Marine Region is dominated by the poleward flowing East Australian Current (EAC), a western boundary current that transports warm, saline, and generally nutrient poor tropical waters from southern Queensland along the New South Wales continental shelf before separating from the coast and turning eastward into the Tasman Sea toward Lord Howe and Norfolk islands (Figure 2) (Ridgway and Dunn 2003, Cetina-Heredia et al. 2014). The EAC exerts a primary control on regional circulation, water mass structure, and biological connectivity across shelf and oceanic environments (Roughan and Middleton 2004).

Along the continental shelf, interactions between the EAC, wind forcing, and bathymetry generate strong cross shelf gradients and high variations in temperature, nutrients, and productivity. While inshore shelf waters are intermittently influenced by upwelling, mixing, and cooler temperate water masses, offshore waters are more consistently dominated by warm EAC intrusions and mesoscale features. This variability strongly shapes ecosystem structure and biogeographic patterns across the network.

The EAC commonly separates from the continental margin and flows eastward into the Tasman Sea, shedding large warm-core eddies that pass through or near the parks. These eddies promote prolonged exposure to warm, oligotrophic conditions and episodic mixing, shaping pelagic productivity and local food-web dynamics. Cross-shelf gradients associated with EAC influence result in inshore assemblages that remain richer in temperate and endemic species, while offshore assemblages are increasingly dominated by tropical Indo-Pacific taxa. These patterns are particularly pronounced in biogeographic overlap zones such as the Solitary Islands, which experience frequent alternation between temperate and subtropical conditions (Malcolm et al. 2011, Oliver et al. 2018).

In waters at larger distances off the continental shelf many of the marine parks such as Lord Howe Marine Park, Gifford Marine Park and Central East Marine Park are located near the boundary between tropical Coral Sea and temperate Tasman Sea water masses. The marine parks are located in a region known as the Tasman Front. Circulation patterns associated with the Tasman Front are driven largely by major wind systems and result in alternating incursions of cooler temperate and warmer subtropical waters (Boland and Church 1981; Nilsson and Cresswell 1980). More recent analysis indicates that the Tasman Front is better characterised as a dynamic extension of the EAC rather than a fixed frontal system (Oke et al. 2019). It strongly influences the physical and chemical characteristics of waters surrounding seamounts, reefs, and island systems.

With a significant part of the marine parks in the Temperate East Marine Region being in depths <100 m, much of the oceanography of this region is dominated by bathypelagic water masses. The bottom water masses in the Tasman Sea region are dominated by Antarctic Bottom Water mixed with Lower Circumpolar Deep Water which enters the western Tasman Basin and circulates in a slow, clockwise (cyclonic) direction. These fills the abyssal floor of the Tasman Basin. At depths <1000 m the region is characterised Subantarctic Mode Water and Antarctic Intermediate Water. These water masses are characterised by measurable differences temperature, salinity, oxygen and nutrient levels.

In the Temperate East Region this ecosystem is especially dynamic because the warm subtropical waters, cool southern waters, eddies, seamount chains, and frontal systems all interact. These are dominated by the East Australian Current (EAC) extension, Tasman Front and seasonal mixed-layer boundaries. The Tasman Front generally sits between latitudes 31°S and 37°S, extending east across the Tasman Sea toward northern New Zealand. These frontal areas are characterised by higher productivity and mesopelagic biomass. In addition, dominant underwater features such as the Lord Howe Rise, Norfolk Ridge and Tasman Basin seamount chains currents and cause local upwelling, retention zones, prey concentration and vertical mixing.

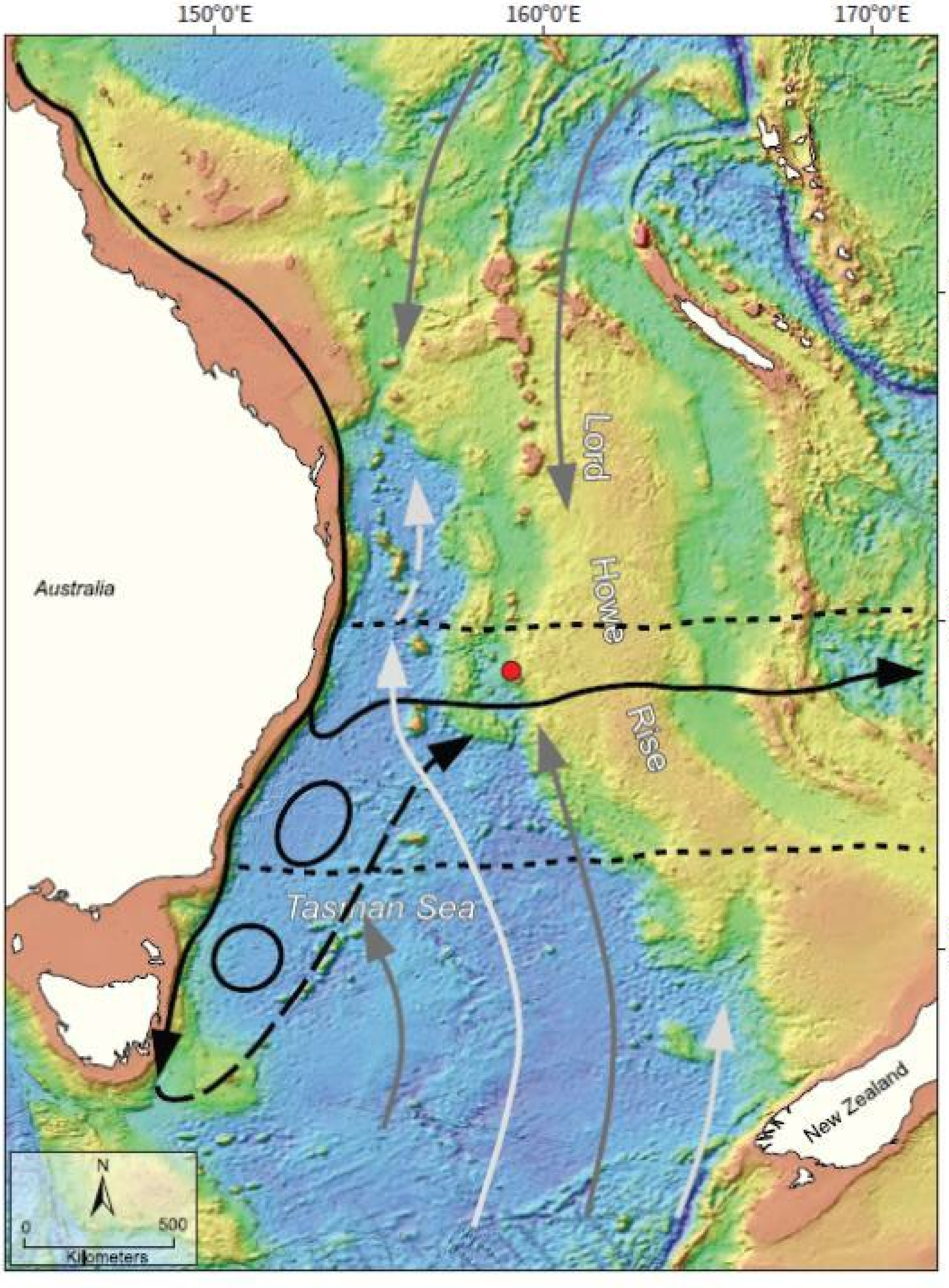


Figure 2 Schematic of the Tasman Sea regional oceanography influencing the waters in the Temperate East Marine Region. Black lines indicate surface circulation: the southward and eastward arrows represent the Eastern Australian Current; the black circles represent warm-core eddies. Dark grey lines represent circulation of intermediate waters. Light grey lines represent circulation of bottom waters. Dotted lines indicate the northern and southern limits of the seasonally migrating Tasman Front. Image modified from Przeslawski et al. (2011).

2. Understanding of natural values of the Temperate East Network

2.1 Large scale ecological features

The planning process associated with the development of the Temperate East Network identified a number of large-scale ecological features that support distinct or important ecological communities at a regional scale. These are defined as key ecological features when they are of regional importance for either a region's biodiversity or its ecosystem function and integrity (Director of National Parks 2018). The following seven key ecological features are represented in the Temperate East Network:

- Shelf rocky reefs
- Canyons on the eastern continental slope
- Tasman Front and eddy field
- Tasmantid Seamount Chain
- Lord Howe Seamount Chain
- Norfolk Ridge
- Elizabeth and Middleton Reefs

These features contributed to the broader sources of environmental information on water depth, habitats and species distributions where more detailed knowledge was known.

2.2 Broad scale bathymetry

There has been a substantial increase in the understanding of broad scale bathymetry along Australia's temperate eastern margin in the last 20 years through improvement in seafloor mapping technologies, targeted and coordinated investment in surveys and regional synthesis of bathymetric data. Much of this has focused on areas inside marine parks across the Temperate East Network also resulting in high resolution bathymetric data across several of the marine parks (Figure 3).

The region is characterised by the usual marine features of the continental shelf, slope, and abyssal plain, with significant broad-scale features including seamounts, canyons, ridges, valleys and basins, and fine-scale features include volcanic peaks, moats and scarps. These features reflect the regions geological history, tectonic processes and variations in sea level. Much of the high-resolution data is focussed on the continental shelf and slope, both adjacent to the mainland coast and surrounding offshore islands. At a broad scale the continental shelf is relatively narrow along much of the New South Wales coast, generally extending 20–50 km offshore before descending rapidly across a steep continental slope. Shelf depths are typically less than 200 m and support a mosaic of soft sediments and localised rocky outcrops associated with relict reef structures and coastal headlands.

The continental slope forms a prominent bathymetric feature throughout the network, dropping from the shelf break to depths of 2000–3000 m over relatively short horizontal distances. The slope is dissected by numerous submarine canyons, channels and gullies, particularly off central and northern New South Wales. These features provide conduits for sediment transport and oceanographic connectivity between shelf, slope and deep-sea environments, contributing to pronounced habitat heterogeneity. Beyond the slope, the seabed grades into the deep basins and plains of the Tasman Sea, where water depths exceed 4000 m. Although these abyssal environments are relatively uniform at broad spatial scales, they represent the dominant proportion of the network by area and are punctuated by isolated elevated features.

Raised bathymetric features associated with the Tasmantid Seamount Chain occur offshore of New South Wales and southern Queensland, forming a series of volcanic seamounts, guyots and ridges that rise hundreds to thousands of metres above the surrounding abyssal plains. A key feature is Lord Howe Island, Balls Pyramid and the associated offshore islands which are of volcanic origin and occur at the southern end of a chain of nine seamounts extending for 1,000 km along the Lord Howe Rise. Some seamounts rise to within approximately 150 m of the sea surface, creating discrete areas of steep relief and hard substrata. While these features occupy only a small proportion of the total network area, they are considered ecologically significant due to their structural complexity, influence on local currents, and role as biodiversity hotspots relative to adjacent soft-sediment basins.

2.3 Understanding of ecosystems and habitats

Biological diversity can be described and classified on several levels, and information about the spatial distribution of biodiversity is mostly very limited. Ocean currents, climate, bathymetry and geomorphology result in the formation of many types of marine ecosystems, which support a variety of habitats, communities and populations of animals and plants. These ecosystems are interconnected as species move between them and currents pass in and out of the marine park, transporting larvae, sediments and nutrients.

Classification of marine environments and their associated biodiversity can be applied at a number of levels, and to assist the process of categorisation to inform marine park planning and management a natural values common language has been defined at three hierarchical levels (Hayes et al. 2021) - 1) ecosystem complexes, 2) ecosystems, and 3) ecosystem components (Figure 4). The system identifies 26 different ecosystems within Australian Marine Parks, with 22 of these benthic and 4 pelagic ecosystems.

The defined ecosystems are delineated by habitat and depth, with their boundaries identifiable from the national 250 m resolution bathymetry, and additional information on seabed habitats where available (e.g. shallow rocky reefs, seagrass and coral reefs). The use of this information results in a functional, mostly geomorphic perspective to define ecosystems, which assumes a combination of physical (e.g. rocky reefs) and biological (e.g. seagrass) attributes to represent Australia's marine ecosystems. The most distinct separation of species occurs between consolidated and unconsolidated habitats. The resulting ecosystem map does not therefore, by itself, define the distribution of biodiversity in Australia's Commonwealth marine area.

The past twenty years has seen a significant increase in the collection and collation of benthic ground truthing information across the network which has led to increases in knowledge of the distribution and extent of habitats, particularly shallow rocky and mesophotic reefs across the continental shelf within the Temperate East Network. The broad distribution of these ecosystem types across the Network are summarised in the following sections, and the specific ecosystems that occur in each marine park are presented in Table 1.

2.3.1 Beaches

This habitat is characterised by a gently sloping zone of sand and/or gravel sized rock and/or biological fragments along the shore, extending from the highest high-tide point to the lowest low-tide point. Beach habitat is known to exist as small cays at Middleton and Elizabeth Reefs within the Lord Howe Marine Park, and at locations on Norfolk Marine Park.

2.3.2 Intertidal coral reefs

These are defined as coral reefs that are found in the intertidal zone. The only location where this ecosystem occurs in the Temperate East Marine Parks Network is within the lagoon and reef crest areas of Middleton and Elizabeth Reefs within the Lord Howe Marine Park. These areas are unique in that they represent the southern-most platform reefs in the world, and at low tide much of the reef flat is exposed.

2.3.3 Shallow coral reefs

These represent coral reefs occurring in continental shelf areas shallower than 30 m and are limited in extent across the Temperate East Marine Parks Network reflecting the small area of Commonwealth marine parks in continental shelf regions. They occur within the Lord Howe Marine Park at Elizabeth and Midleton Reefs, and within the shallow waters surround Norfolk Island within the Norfolk Marine Park.

2.3.4 Rocky shores

Rocky shores are intertidal areas that are composed of rock platforms, boulders or cobbles. As above, these only occur on Norfolk Island, and are the dominant intertidal ecosystem on the island, but due to the steep nature of most of the coastline and low tidal range (~1.6-1.8 m) the rocky shores are narrow in most places. Similar areas of narrow rocky shore are present on the adjacent areas of Nepean and Phillip Islands.

2.3.5 Shallow rocky reefs

These represent rocky reefs occurring in continental shelf areas shallower than 30 m. There are few areas of shallow rocky reef across the Temperate East Marine Parks Network reflecting the limited extent of Commonwealth marine parks in inner continental shelf regions. There are small areas of reef that extend into shallow depths within the Cod Grounds Marine Parks, and with the area known as Pimpernel Rock within the Solitary Islands Marine Park.

2.3.6 Oceanic shallow coral reefs

These represent coral reefs occurring seaward of the shelf break in depths shallower than 30 m in areas adjacent to offshore islands and reefs. Much of the oceanic shallow coral reef is located across the Middleton and Elizabeth Reefs within the Lord Howe Marine Park reflecting the presence of shallow depths in Commonwealth waters in this area.

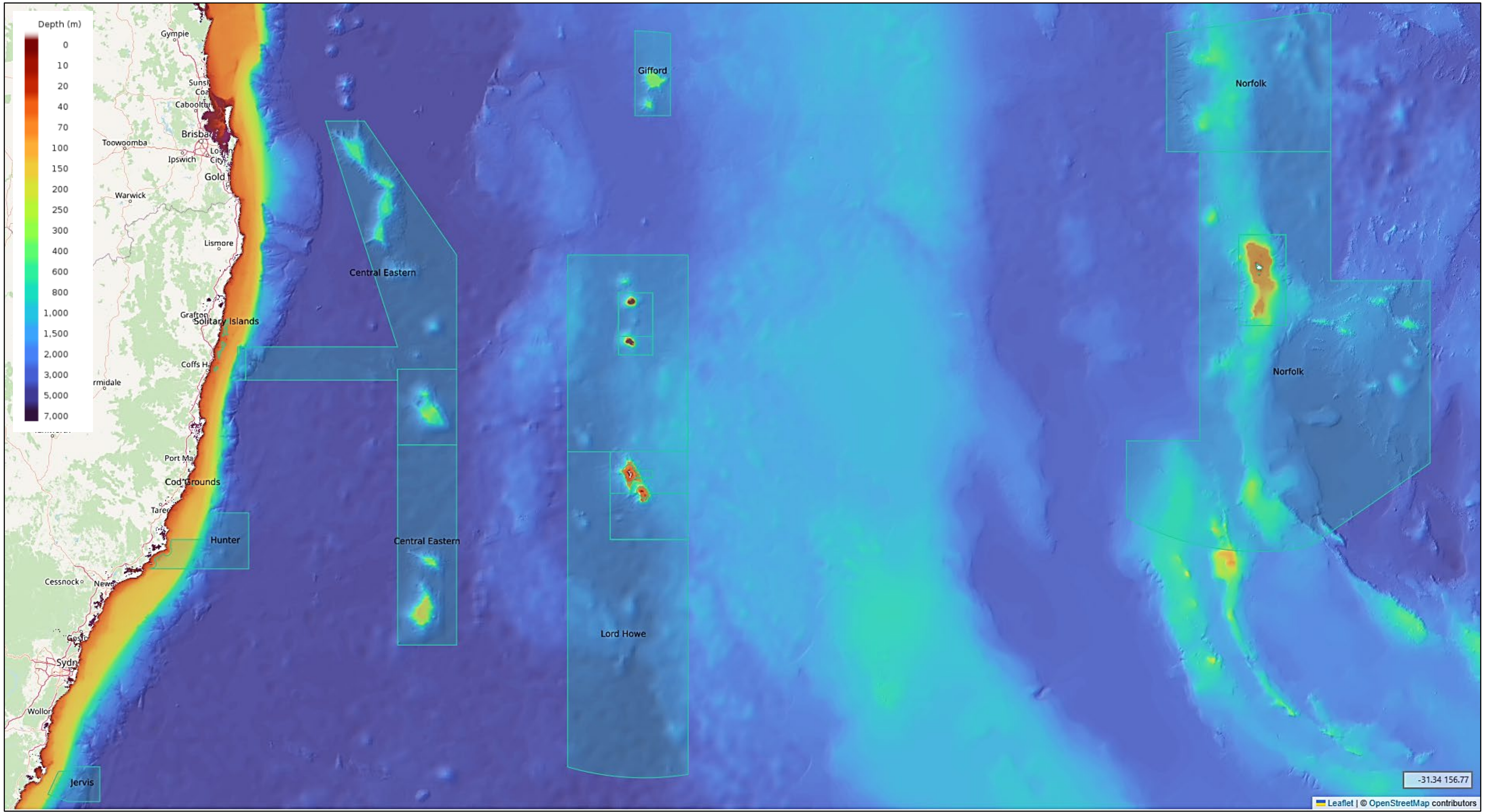


Figure 3 Broadscale bathymetry of the Temperate East Network Region. Green polygons represent marine marks across the network. Seamap Australia link: https://seamapaustralia.org/map/#b268bf1e-1049-46b9-b258-b57470c5d12e

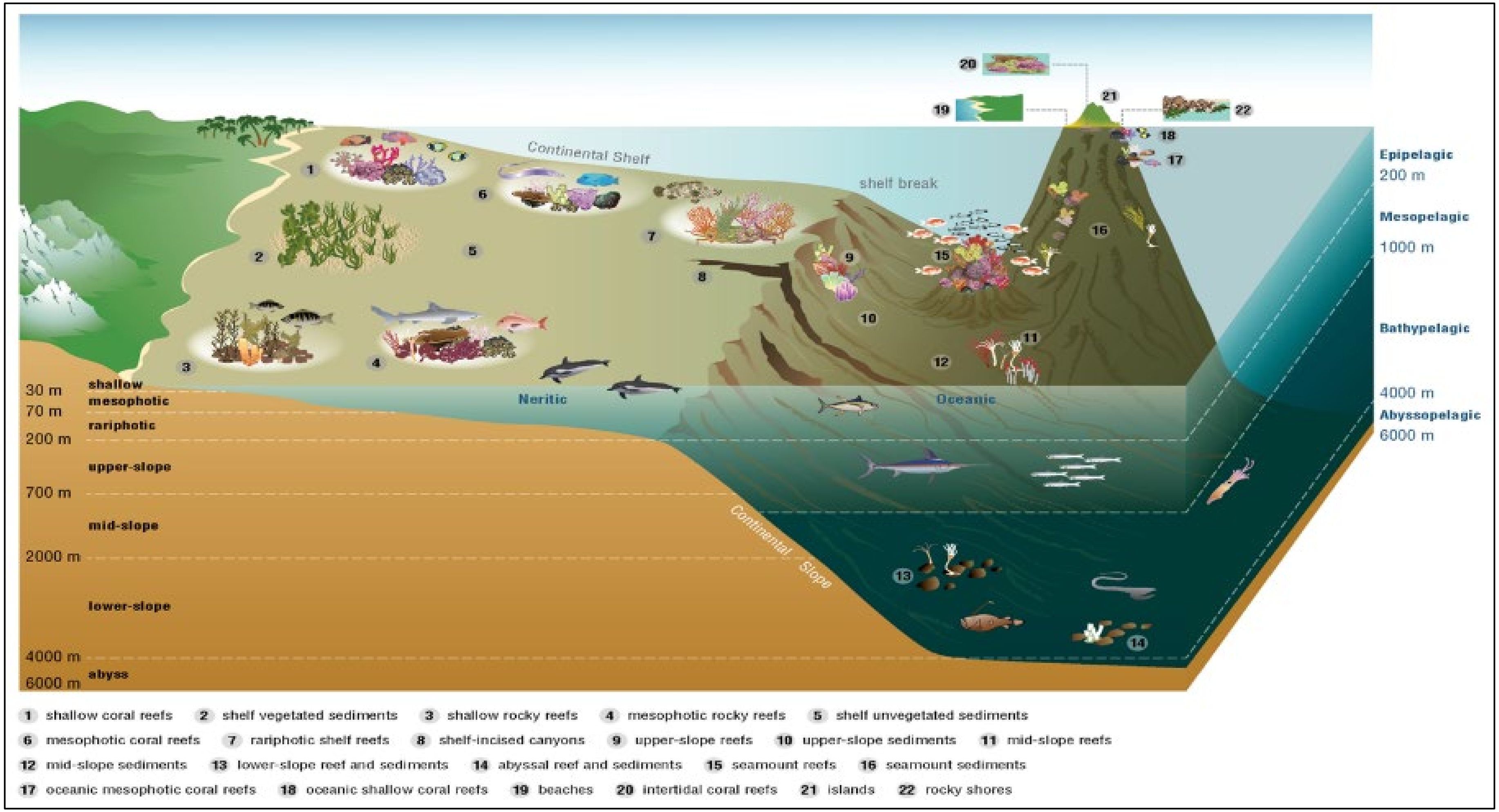


Figure 4 Conceptual representation of ecosystem types identified across the Australian Marine Park Network

Table 1. Presence of ecosystems (blue cells) within each marine park in the Temperate East Network

	Gifford Marine Park	Lord Howe Marine Park	Central East Marine Park	Norfolk Marine Park	Solitary Island Marine Park	Cod Grounds Marine Park	Hunter Marine Park	Jervis Marine Park
Beaches								
Rocky shores								
Intertidal coral reefs								
Shallow coral reefs								
Shallow rocky reefs								
Oceanic coral reefs								
Mesophotic rocky reefs								
Mesophotic coral reefs								
Oceanic mesophotic coral reefs								
Shelf vegetated sediments								
Shelf unvegetated sediments								
Rariphotic reef								
Upper and Mid slope reefs								
Upper and Mid slope sediments								
Lower slope sediments and reefs								
Shelf incising canyons								
Seamount reefs								
Seamount sediments								
Abyss reef and sediments								
Epipelagic								
Mesopelagic								
Bathypelagic								
Abyssopelagic								

2.3.7 Mesophotic rocky reefs

Many inner and mid continental shelf areas contain reef habitat in depths greater than 30 m and extend out to the maximum depth at which there is sufficient penetration of sunlight to support photosynthesis. These are defined as mesophotic reefs, and in continental shelf areas this deeper boundary is defined as 70 m, although this is variable depending on the average water clarity in the region. These reefs are often continuous with shallow reefs but can also form discontinuous areas, the distribution of which are determined by the regional geology and history, local currents and extent of sediment transport, and influences from previous sea level changes. At a local scale these influence the structure and extent of reefs that can vary significantly in profile, rugosity, patchiness and persistence.

Through the Temperate East Marine Park Network there are limited continental shelf areas within the depth range of mesophotic habitats, which in some marine parks has resulted in extensive coverage of mapping of these habitats. Mesophotic rocky reefs are known to occur on the inner continental shelf areas of Hunter Marine Park, Solitary Islands Marine Park (Commonwealth) and Cod Grounds Marine Park.

Recent mapping of mesophotic reefs in southern Australia have also identified and categorised a gradient of 'functional reef' habitats that support emergent sessile biota that provide habitat structure and resources for "reef-affiliated" species, but would not be mapped as reef based on acoustic data alone (Monk et al. 2024) (Figure 5).

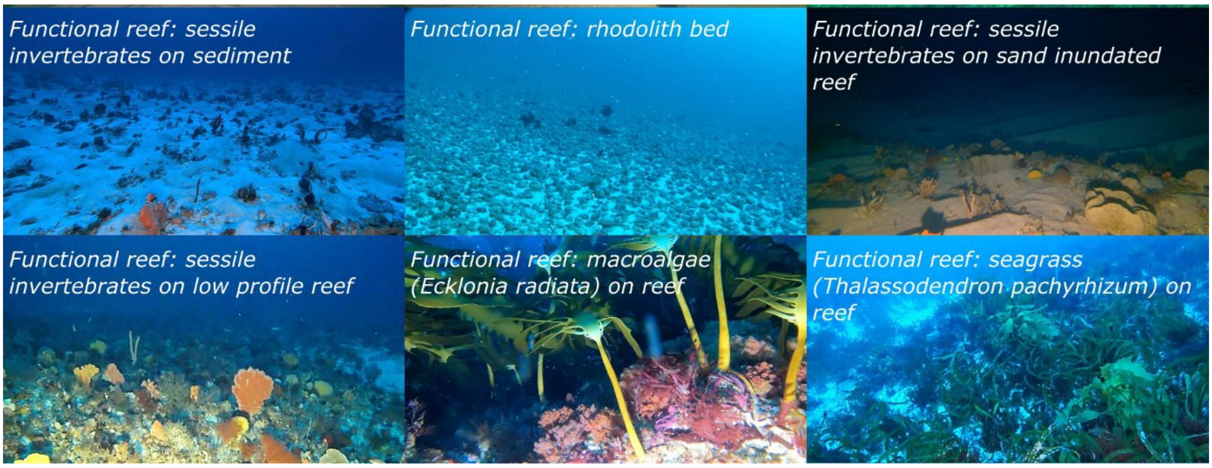


Figure 5 Example images of how various the organisms and substrata map into the 'functional reef' concept.

2.3.8 Mesophotic coral reefs

Mesophotic coral reefs can on tropical continental shelf areas in the mesophotic zone: a reduced light zone between 30 m and the maximum depth at which there is sufficient penetration of sunlight to support photosynthesis. In continental shelf areas this deeper boundary is defined as 70 m. There are no known mesophotic coral reefs within Commonwealth waters of the Temperate East Network, with those present on within Lord Howe Marine Park and Norfolk Marine Park defined as oceanic (next section).

2.3.9 Oceanic mesophotic coral reefs

Coral reefs occurring in ocean regions with shelf environments that contain depths >30 m are defined as oceanic mesophotic coral reefs. In continental shelf regions these are nominally defined to occur in depths up to 70 m depth, but oceanic regions with greater water clarity can result in these expecting into depths up to 150 m. Oceanic mesophotic coral reefs are a dominant ecosystem on the shelf areas across the Middleton and Elizabeth Reefs within the Lord Howe Marine Park (Carroll et al. 2020), on the shelf surrounding Norfolk Island Marine Park, and in limited areas surrounding Lord Howe Island and Balls Pyramid (Linklater et al. 2015, 2016). This reflects the presence of mesophotic depths in Commonwealth waters in these areas. Further details on the structure and composition of these reefs are provided in sections 3.2, 3.2 and 3.4.

2.3.10 Rariphotic shelf reefs

There is limited information on the distribution of rariphotic shelf reefs across the Temperate East Marine Park network, which are those reefs found on the continental shelf below the mesophotic zone and generally occur between 70 m and 200 m (the nominal depth of the shelf break). This reflects the limited extent of seabed mapping surveys on the mid to outer shelf.

There is evidence from high resolution surveys that reefs in shelf areas in depths >70 m are present on the shelf in the Hunter Marine Park and Elizabeth and Middleton Reefs. Limited areas of rariphotic reefs also occur in Commonwealth waters on the northern edge of the shelves surrounding Lord Howe Island and Balls Pyramid. A much larger area of seabed mapped as ‘mixed hard/soft substrate also occurs in this region (Linklater et al. 2018). Due to the water clarity in these oceanic regions, reefs in these rariphotic depths are generally characterised by similar benthic assemblages as those found on the mesophotic depths, and are almost exclusively coral dominated. Further details of the ecosystem components of these reef systems are presented in section 3

2.3.11 Shelf vegetated sediments

Sediment habitats on the continental shelf that support marine macroalgae or seagrass, and typically, these occur in depths of less than 30 m but can extend beyond this in areas with very clear waters. There are no known areas of shelf vegetated sediments in the Temperate East Marine Park network.

2.3.12 Shelf unvegetated sediments

Sediment habitats on the continental or oceanic shelves (0-200 m) that lack marine macroalgae or seagrass are defined as shelf unvegetated sediments. These are often the dominant ecosystem types present in these areas, generally determined by the regional geology, sediment input and ocean currents. These ecosystems are distributed across the continental shelf areas of Solitary Islands Marine Park (particularly in the south), Cod Grounds Marine Park, and across the large shelf area of the Hunter Marine Park. They are often located within a matrix of mesophotic or rariphotic reefs, and in continental shelf regions the sediment composition varies considerably, often influenced by location, depth and proximity to reefs (Jordan et al. 2010).

There are also known areas of this ecosystem on the shelves surrounding Elizabeth and Middleton Reefs, Lord Howe Island and Balls Pyramid, and Norfolk Island, with details of these detailed in sections 3.2, 3.3 and 3.4, respectively. These consist of coarse sediments reflecting the lack of finer terrestrial sediment inputs.

Collation of data on soft-sediment assemblages within shelf unvegetated sediments across the Temperate East Network’s continental shelf is limited and is mostly focussed on fish assemblages. Where available, details of these for individual marine parks are included in section 3.

2.3.13 Upper and Mid slope reefs

This ecosystem represents reef habitats on the upper section of the continental slope between the shelf break (nominally 200 m) and those on the mid slope (nominally 200 m to 700 m). These are known to occur across all marine parks in the region that contain areas at these depths and sit within slope-confined and shelf-incising canyons. Slope-confined canyons are defined as those that are restricted to the continental slope with heads that end below the shelf break. They are the most common form of canyons on the Australian margin, with current estimates identifying 658 slope-confined canyons (Huang et al. 2014).

The slopes on the sides of the seamounts are commonly in the range of 10 to 20 degrees but locally can be much steeper or form flat terraces cut at historical sea levels. 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. This ecosystem occurs across all Temperate East marine parks, apart from the Solitary Marine Park and Cod Grounds Marine Park.

2.3.14 Upper and Mid slope sediments

This ecosystem represents soft-sediment habitats on the upper section of the continental slope between shelf break (nominally 200 m and 700 m) and those on the mid slope (nominally 200 m to 700 m). They form an important part of slope-confined and shelf-incising canyons. The ecosystem occurs across all Temperate East marine parks, apart from the Solitary Marine Park and Cod Grounds Marine Park.

2.3.15 Lower slope sediments and reefs

This ecosystem represents rocky reef and sediment habitats on the lower continental slope and continental rise (i.e. between 2000 m and nominally 4000 m). They form an important part of slope-confined and shelf-incising canyons. The ecosystem occurs across all Temperate East Marine Parks, apart from the Solitary Marine Park and Cod Grounds Marine Park (Figure 6).

2.3.16 Shelf incising canyons

Submarine canyons are located offshore in all regions in Australia and are regarded as a specific class of seabed geomorphic feature with relatively high surrogacy potential for predicting marine biodiversity (Harris et al. 2008, Huang et al. 2018). An analysis of available 250 m resolution bathymetric data for the Australian EEZ identified 713 submarine canyons on the continental margin, with an additional 40 canyons that fringe islands within Australia's external territories (Huang et al. 2014). The present estimate of the overall number of canyons in the Temperate East Marine Region is 124 (SoE 2021).

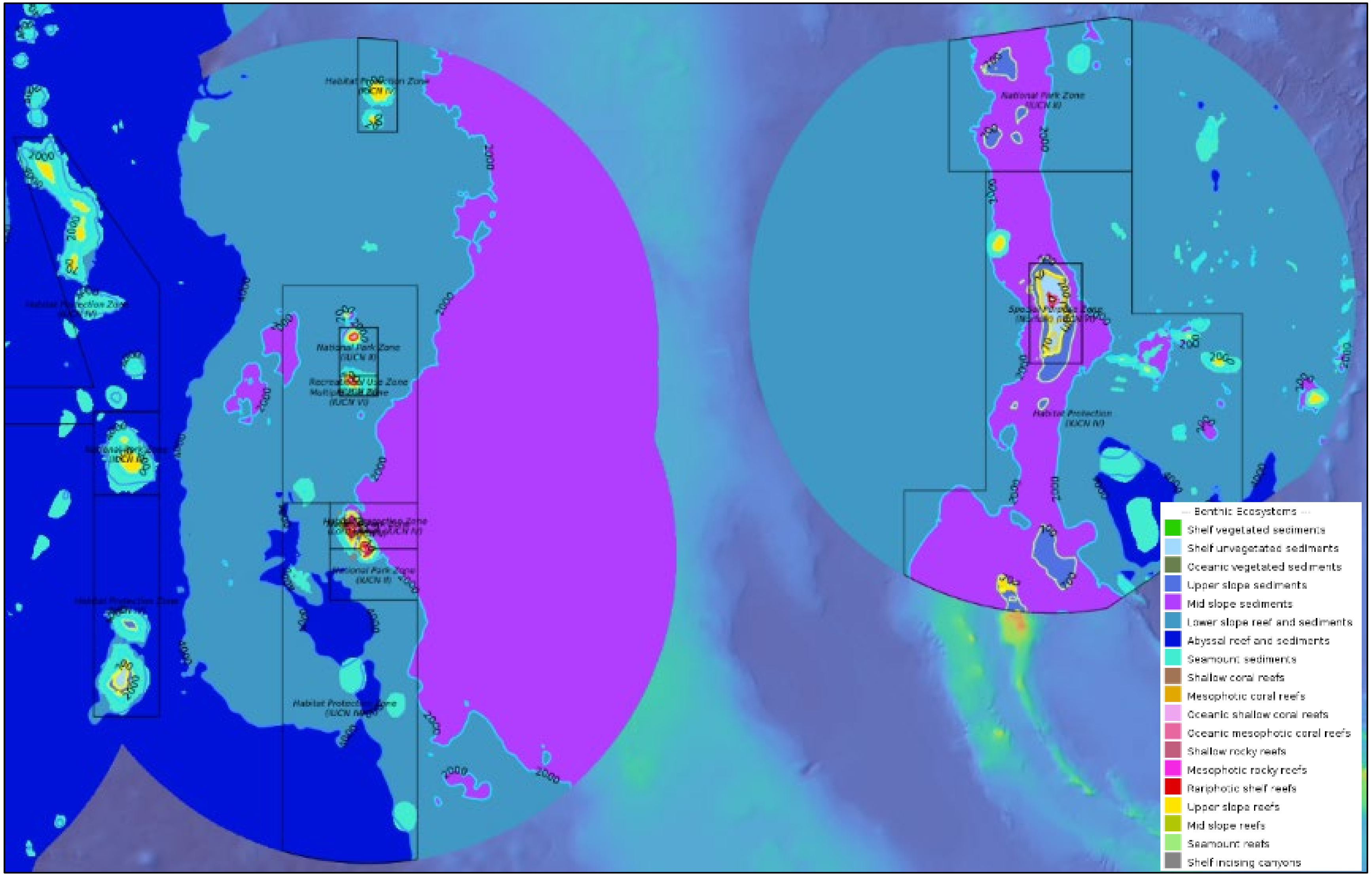


Figure 6 . Distribution of ecosystem types across Lord Howe, Central East and Norfolk Marine Parks. Seamap Australia link: https://seamapaustralia.org/map/#9057e605-5471-433f-a014-a69f6a4dbc38

Shelf-incising canyons are one of two classified types of canyons, with those in Australia extending onto the shelf but do not extend across the shelf as shelf valleys nor do they connect to river systems (Huang et al. 2014). They are characterised as steep sided submarine valleys that cut landward across the continental slope and are among the most important geomorphic and ecological features of the margin along the subtropical and temperate regions. They often contain steep V-shaped upper reaches, amphitheatre canyon heads, branching tributaries, sediment channels or fan deposits downslope. These canyons funnel sediment, organic matter, and water masses from shallow shelf seas into the deep ocean, while also creating biodiversity hotspots.

In the Temperate East Network region shelf-incising canyons have been identified in the Central East Marine Park (Figure 36), Jervis Marine Park (Figure 41) and Lord Howe Marine Park adjacent to Lord Howe Island and Balls Pyramid shelves (Figure 36).

2.3.17 Seamount reefs

This ecosystem represents rocky and deep-sea cold-water coral formations occurring on seamounts. There is limited information on their extent and distribution in the Temperate East network region, but are likely to occur on those seamounts that rise to depths suitable for coral formation.

2.3.18 Seamount sediments

This ecosystem represent soft-sediment habitats occurring on seamounts, which are expected to be present across all known seamounts in the Temperate East Region. This ecosystem is particularly dominant in the Central Eastern Marine Park associated with the numerous seamounts that occur along this section of the marine park network. There are also a number of areas of seamount sediments within the Lord Howe, Gifford and Norfolk Marine Parks (Figure 6).

2.3.19 Abyssal reef and sediments

The ecosystem represents reef and sediment habitats in the abyssal zone (4000 m and 6000 m), which is known to occur across all Temperate East Marine Parks, apart from the Solitary, Cod Grounds and Gifford Marine Parks (Figure 6). This ecosystem is particularly dominant in the Central Eastern Marine Park.

2.3.20 Epipelagic

This represents the uppermost layer of the ocean extending from the surface to 200 m that occurs across the entire Temperate East Network region in waters above the continental shelf and offshore. The ecosystem is shaped by subtropical currents, temperate waters and storms, and frequently contains vertical structuring, with the upper depths characterised by high light levels, rapidly changing temperature, oxygen-rich waters and strongest seasonal variability. Sunlight declines rapidly with depth, with temperatures also decreasing rapidly associated with the thermocline.

Distinct horizontal gradients also occur, influenced mostly by the dominant currents, frontal zones and eddy systems, with upwelling events often important. For example, warm-core and cold-core eddies spun off the East Australian Current can persist for months. Much of the epipelagic ecosystem in the Temperate East Network region is off the continental shelf. The ecosystem occurs across all Temperate East Marine Parks.

2.3.21 Mesopelagic

This represents the layer of the ocean between 200 m and 1000 m, not influenced by the seafloor and is a large “twilight layer” where low light levels at the shallowest depth is reduced to darkness and photosynthesis stops. Temperatures often ~4–12°C depending on latitude and water mass, and strong oxygen gradients exist. Most of the Temperate East Region contains mesopelagic ecosystems that are deep open water above abyssal depths of 2,000–4,000 m.

In the Temperate East Region this ecosystem is especially dynamic because warm subtropical waters, cool southern waters, eddies, seamount chains, and frontal systems all interact. These are dominated by the East Australian Current (EAC) extension, Tasman Front, Subtropical Front and seasonal mixed-layer boundaries. These frontal areas are characterised by higher productivity and mesopelagic biomass. In addition, dominant underwater features such as the Lord Howe Rise, Norfolk Ridge and Tasman Basin seamount chains currents and cause local upwelling, retention zones, prey concentration and vertical mixing.

The ecosystem occurs across all Temperate East Marine Parks, apart from the Solitary Marine Park and Cod Grounds Marine Park.

2.3.22 Bathypelagic

This region represents the layers of the ocean between 1000 m and 4000 m not influenced by the seafloor. It is an ecosystem that is in characterised by perpetual darkness, high pressure and cold temperatures (commonly 2-5^{0}C). In the Temperate East Region this zone occupies most of the basin volume above the abyssal plain and around major underwater ridges such as the Lord Howe Rise and Norfolk Ridge. Much of the water masses in these depths in the Tasman Sea are dominated by Antarctic Bottom Water (AABW) mixed with Lower Circumpolar Deep Water (LCDW), which enters the western Tasman Basin and circulates in a slow, clockwise (cyclonic) direction.

The ecosystem occurs across all Temperate East Marine Parks, apart from the Solitary Marine Park and Cod Grounds Marine Park.

2.3.23 Abyssopelagic

This region represents the layers of the ocean between 4000 m and 6000 m not influenced by the seafloor and lying above the abyssal seabed and below the bathypelagic zone. In the Temperate East Region this ecosystem occurs mainly over the deepest central basin areas where the seafloor is sufficiently deep for a true abyssal water column to exist. It is permanently dark, and has very high pressure, temperatures around 1.5–3°C, very weak seasonal variability and slow-moving deep currents.

The ecosystem occurs across all Temperate East Marine Parks, apart from the Solitary Marine Park and Cod Grounds Marine Park.

3. Ecosystem knowledge

3.1 Gifford Marine Park

Gifford Marine Park is located approximately 480 km north of Lord Howe Island and 600 km east of Brisbane. It covers 5828 km^2, and the entire park is Habitat Protection Zone. The marine park ranges in depths between approximately 220 m and 4000 m, and is dominated by the 2000 m high Gifford Tablemount (also known as a guyot). This is a flat-topped volcanic seamount which is part of the Lord Howe Seamount Chain, a series of submerged mountains running 1000 km north to south from the Coral Sea to Lord Howe Island (Figure 7). A smaller unnamed guyot is located approximately 20 km to the south. The gently sloping summits are mostly around 300 m deep and contain veneers of sediment, which in places have formed fields of bedforms. Steep cliffs, debris and large mass movement scars encircle each seamount, and contrast with the lower gradient abyssal plains from which they rise.

Limited surveys suggest that the rocky outcrops and sediment plains of Gifford Guyot support relatively sparse benthic communities compared with the dense and diverse assemblages often associated with seamounts (Table 2). Exposed rocky habitats support a diverse epibenthic fauna, including mixed cold-water coral and sponge assemblages, while ridges and the summit support typical seamount fauna such as gorgonians, sponges, crinoids, ascidians and demersal fishes (Figure 8; Anderson et al. 2010). Underwater imagery from the TAN0713 survey illustrates the range of habitats present, from low- and moderate-relief limestone ridges on the summit to sediment veneers over consolidated bedforms and calcareous-conglomerate outcrops on the upper slopes (Figure 8; Nanson et al. 2018). These habitats support a range of fauna, including small gorgonians and sponges, crinoids, ascidians, sharks and *Ateleopus* sp.

Soft sediment areas are characterised by evidence of bioturbation, including trails, burrows and mounds, with greater bioturbation at depth likely reflecting increased sediment deposition. The small size and abundance of sessile invertebrates on the upper apron may indicate frequent disturbance from sediment movement or landslides (Anderson et al. 2010).

Gifford Guyot demonstrates that seamounts do not uniformly support dense coral or high-biodiversity assemblages. Differences in biodiversity and community structure are likely driven by interacting environmental factors, including depth, temperature, oceanography, habitat structure, sediment dynamics and anthropogenic impacts (Anderson et al. 2010).

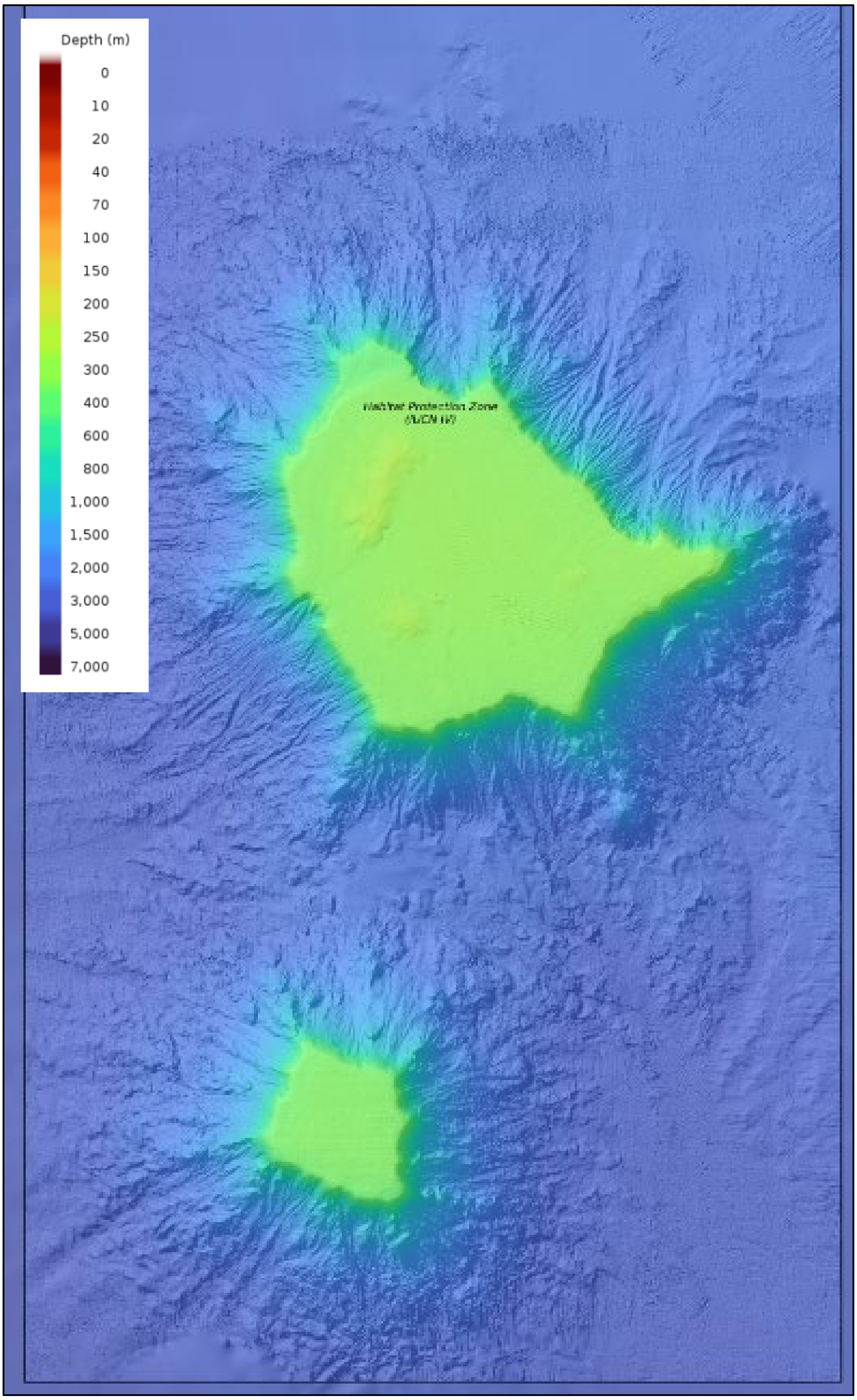


Figure 7 Broadscale bathymetry of the Gifford Marine Park region (Seamap Australia link: https://seamapaustralia.org/map/#0901a817-7c55-4acc-be69-45a9df951aab A flythrough movie highlighting the seafloor bathymetry of the Gifford Marine Park is located at https://www.youtube.com/watch?v=mSZ6H5E6nTw

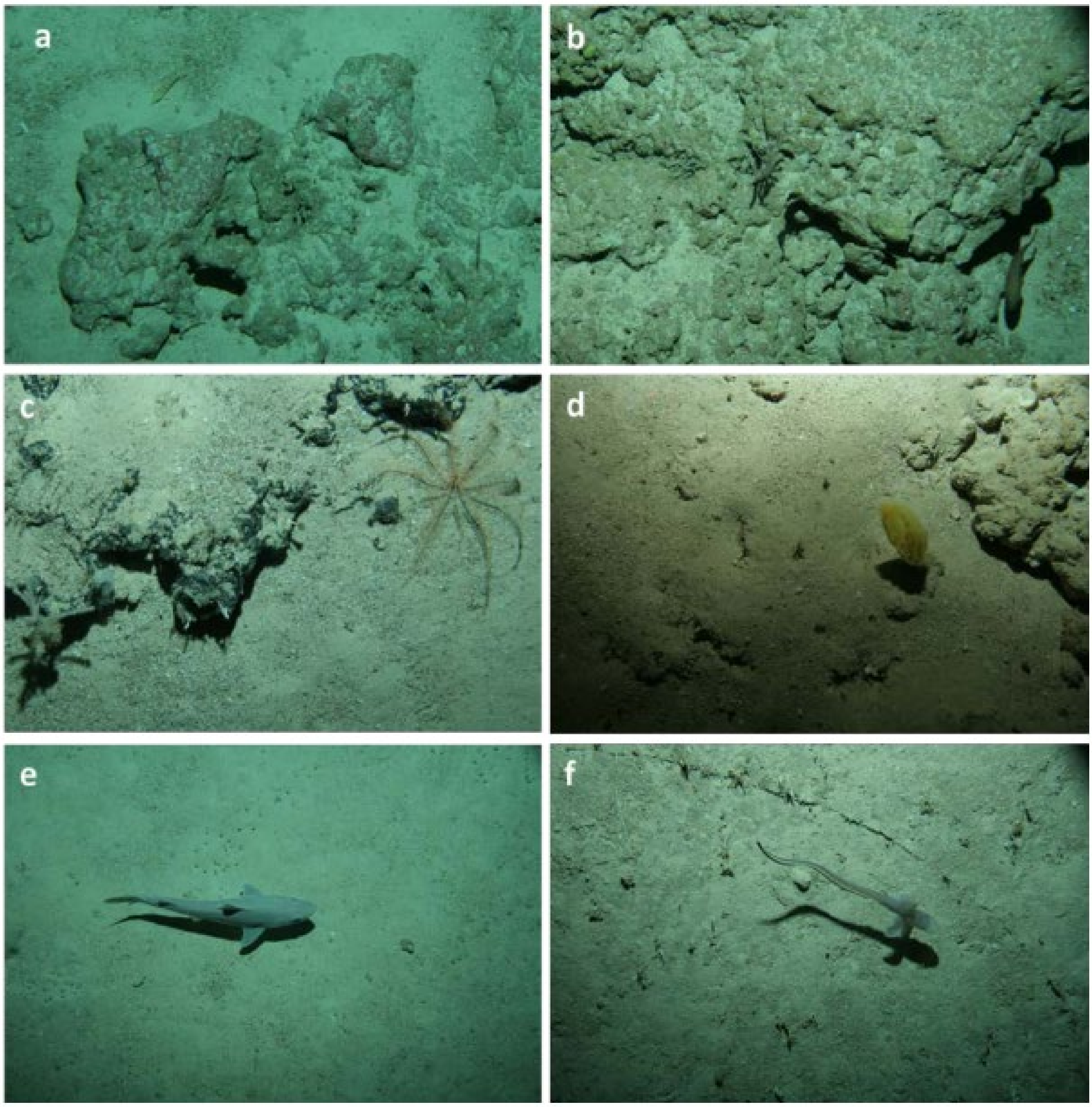


Figure 8. Still colour photographs of benthic habitats from Gifford Guyot collected during TAN0713 survey. a) Station 40 (248 m; summit): – low-relief limestone ridge with small gorgonians, sponges, and *Parapercis* fish, b) Station 40 (248 m; summit) – moderate-relief limestone ridge with sponges, gorgonian, and small fish, c) Station 37 (414 m; upper slope) – mixed sediment veneer and calcareous-conglomerate outcropping with crinoid, d) Station 34 (288 m; summit) – mixed sediment veneer and limestone outcropping with yellow ascidian (sea squirt), e) Station 34 (288 m; summit) – sediment veneer over consolidated bedform with shark (possibly *Squalus griffini*), f) Station 37 (414 m; upper slope) – sediment veneer over consolidated bedform with a *Ateleopus* sp.. Source: Nanson et al. (2018)

While the Gifford Marine Park encompassing a broad depth range from approximately 200 m to more than 4,000 m, the available survey information is limited to a single survey conducted in 2007, comprising 40 spatially discrete sites sampled using deep-tow camera imagery (Table 2). Sampling was concentrated in the 200–2000 m depth range and was classified as preferential, indicating that sites were selected to investigate particular habitats or features rather than to provide statistically representative coverage of the marine park. Consequently, substantial gaps remain in both the spatial and depth coverage of biodiversity knowledge, particularly in deeper ecosystems and areas away from the Gifford Guyot summit and upper slopes.

Table 2. Biodiversity surveys within the Gifford Marine Park by ecosystem depth range and zone type. The extent of the park by ecosystem depth range and zone type is given in the first row. Classification of survey design standards is based on Foster et al. 2024 - Statistical Considerations for Monitoring and Sampling - NESP. Sites refers to spatially discrete sampling units at least 250 m apart.

Time	Sites	Platform	Ecosystem components	Ecosystem Depth (m)	Zones	Reports	Survey design standards*
2007	40	Deep Tow Camera seabed imagery	Demersal and benthic fish, Mobile macroinverts, Sessile macroinverts, Infauna	200-700, 700-2000	hpz01	1	Preferential

1 Anderson, T.J., Nichol, S.L., Syms, C., Przeslawski, R. and Harris, P.T. 2011. Deep-sea bio-physical variables as surrogates for biological assemblages, an example from the Lord Howe Rise. *Deep Sea Research Part II*: *Topical Studies in Oceanography* 58, 7–8, 979-991.

3.2 Elizabeth and Middleton Reef Region (Lord Howe Marine Park)

3.2.1 Ecosystems and ecosystem components

Given the large area of the in the Elizabeth and Middleton Reef region within the Lord Howe Marine Park, and the main geomorphic features, the park extends from intertidal areas at Elizabeth and Middleton Reefs to depths of over 4000 m. These reefs are a pair of isolated oceanic platform reefs separated from one another by 45 km of deep oceanic waters (Figure 9). The region between the reefs is dominated by seamount sediments, and lower slope reef and sediments (Figure 6). The reefs contain two small sand cays, one located on Elizabeth Island, found on Elizabeth Reef, and the second on The Sound located on Middleton Reef, both of which barely emerge 1 m above the high-water level.

The morphology of Middleton reef shelf is characterised by a gradually steepening seabed that extends from 20 m water depth on the seaward side of the reef lagoon to ~120 m at the shelf break at ~120 m (Figure 9). There are distinct terraces and semi-continuous low-profile ridges that extend for tens of kilometres around the shelf at consistent depth intervals. The continuity of these ridges is interrupted only on the northwest sector of the shelf, where a spatially complex field of irregular ridges and mounds defines the greatest area of seabed complexity. Importantly, these raised hardground features occur in key mesophotic depth zones (30 – 50 m and 50–70 m), and collectively occupy approximately 35% of the mapped area of the shelf.

These fine-scale data reveal sharp depth transitions and structural complexity over tens to hundreds of metres, particularly on seamount flanks (Carroll et al. 2020). In contrast, deeper basin areas within the park are more sparsely mapped and exhibit broader-scale relief with limited fine resolution detail. The mapped northwest area of Elizabeth Reef shelf is characterised by a gradually steepening seabed that increases from 15 m water depth at the lagoon entrance to ~120 m at the shelf break (Figure 9). The shelf is widest in the northwest where the shelf break is 3.7 km from the lagoon, whereas to the south and east the shelf is narrower at ~800 m and 1.4 km wide, respectively. Along these sections the shelf steepens at the 60 – 70 m depth contour, beyond which the seabed has a gradient of ~30 degrees. The fine-scale morphology of the mapped area of Elizabeth shelf seabed can be categorised into three broad categories: plane, depression and ridges and mounds; the latter category representing all raised and steepened areas of seabed on Elizabeth reef shelf (Carroll et al. 2020). The ridge and mounds occupy almost 50% of the mapped area providing extensive raised hardground reef habitat across the full depth range of the shelf.

Extensive high-resolution seabed mapping of the shelf surrounding Middleton Reef identified that the morphology is characterised by a gently sloping seabed with distinct terraces and semi-continuous low-profile ridges that extend for tens of kilometres around the shelf at consistent depth intervals (Carroll et al. 2020) (Figure 10). These ridge and mound features occur in mesophotic and rariphotic depths. Seabed mapping is more limited on the shelf of Elizabeth Reef, but show similar features of that of the adjacent Middleton Reef.

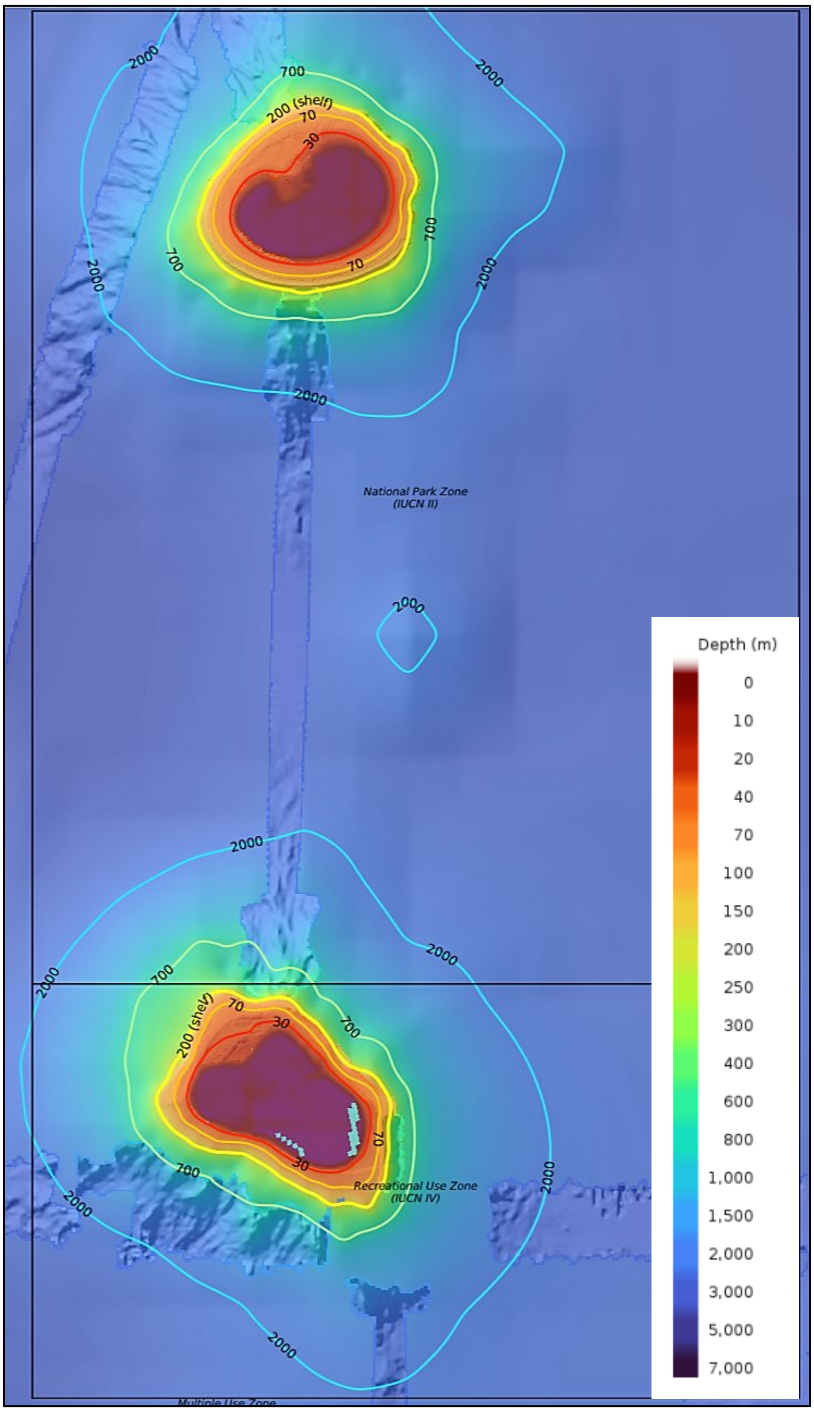


Figure 9 Broadscale bathymetry data Elizabeth and Middleton Reefs in the Lord Howe Marine Park. Seamap Australia link: https://seamapaustralia.org/map/#98ce2756-6a0b-4a44-a96e-a5caa0f9605b

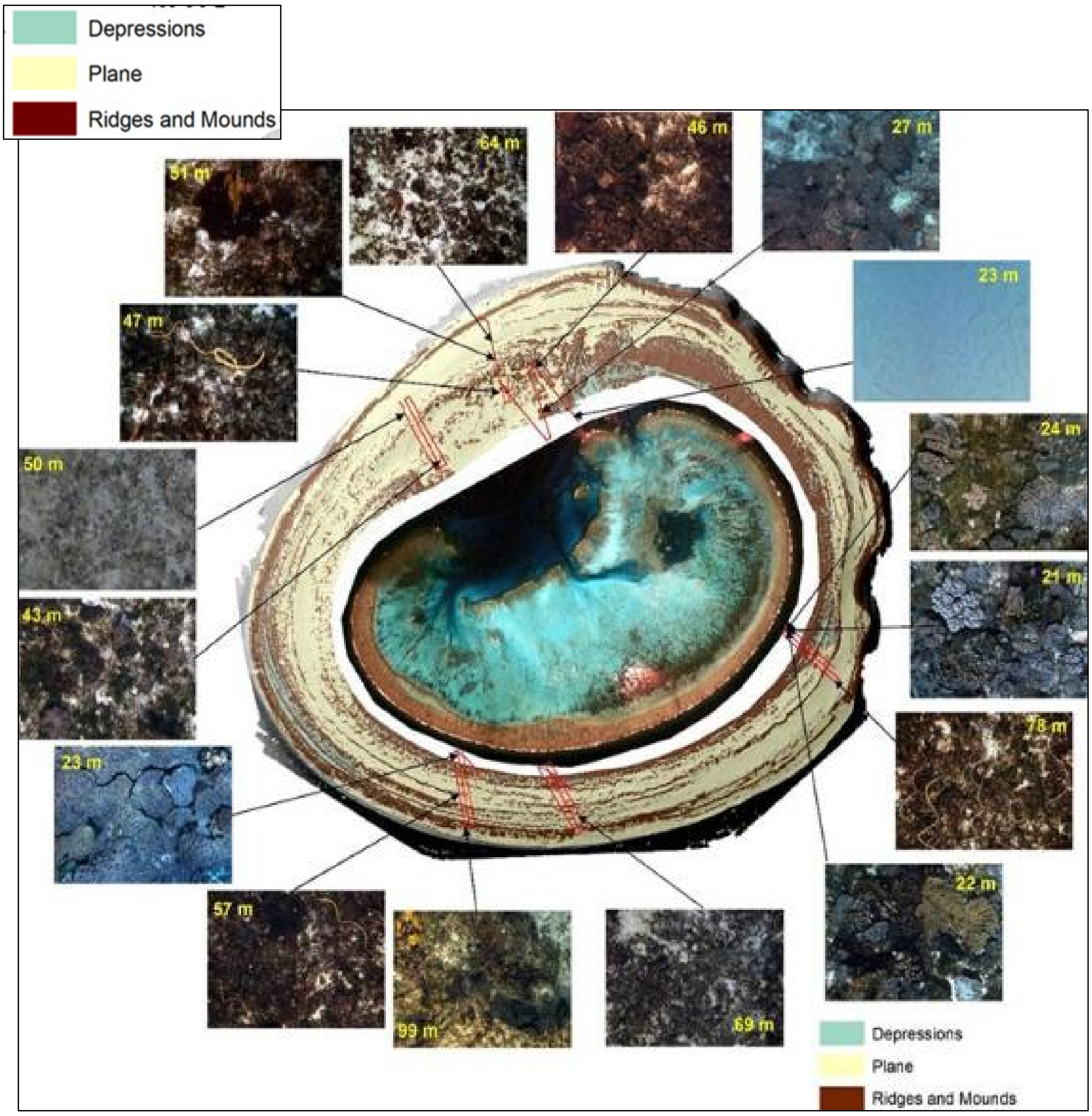


Figure 10 AUV images showing the distribution and range of benthic habitats across key geomorphological features at Middleton Reef shelf. Generally, ridges and mounds in mesophotic depths are colonised by a dense cover of hard and soft corals, with planes characterised by a mix of barren sediments and moderate cover of turfing algae, with rhodolith beds in deeper areas toward the shelf edge. AUV track lines are shown in red (From Carroll et al. 2020).

Elizabeth and Middleton Reefs reveal strong depth-related patterns in benthic habitat structure, with corresponding differences in fish assemblages and predator use. On the inner shelf (approximately 20–50 m depth), ridge and mound features were dominated by turfing macroalgae and cnidarian corals, including reef-building hard corals and soft leather corals, forming structurally complex reef habitats (Carroll et al. 2020) (Figure 11). Comparable features on the outer shelf (approximately 70–110 m depth) were characterised by extensive areas of coarse carbonate sand interspersed with turfing algae, bacterial mats, calcareous rhodoliths and black corals (branching and whip morphologies), supporting a distinct mesophotic assemblage (Carroll et al. 2020).

Across both lagoonal and mesophotic shelf habitats, demersal fishes were abundant and diverse. Quantitative surveys recorded 195 species from 36 families, encompassing a broad range of trophic groups and habitat associations (Figure 11) (Carroll et al. 2020). These findings are supported by Reef Life Survey (RLS) data, which document consistently high fish species richness, biomass and trophic complexity at Elizabeth and Middleton Reefs relative to many temperate reef systems. RLS surveys indicate a strong representation of large-bodied predators and long-lived reef species, reflecting low fishing pressure and the availability of structurally complex reef habitat.

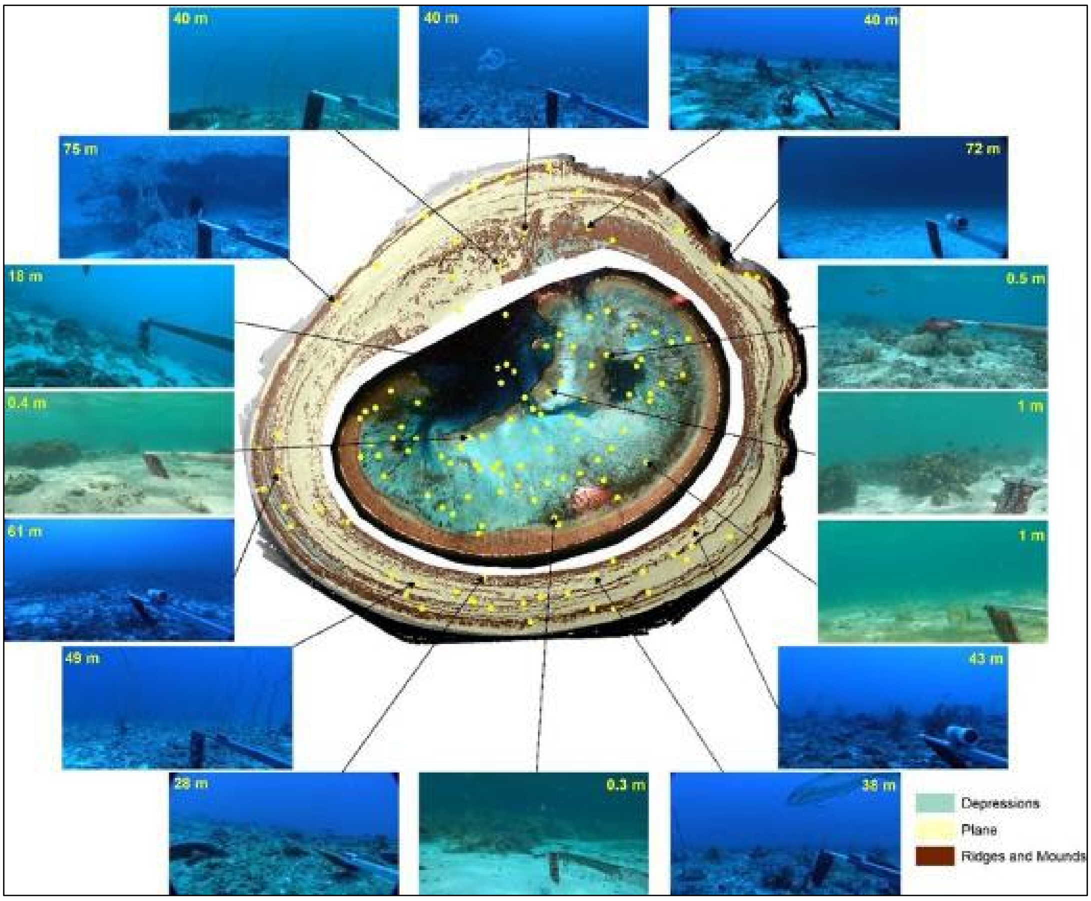


Figure 11 Stereo-BRUV images showing a range of benthic habitats across shelf and lagoon environments of Middleton Reef shelf. Yellow dots indicate Stereo-BRUV locations (From Carroll et al. 2020).

Elizabeth and Middleton Reefs are recognised as important locations for populations of predatory fishes and EPBC-listed threatened species, including mature black cod (*Epinephelus daemelii*) and tiger sharks (*Galeocerdo cuvier*), as well as immature Galapagos sharks (*Carcharhinus galapagensis*) (Figure 12) (Carroll et al. 2020). Reef Life Survey observations further highlight the persistence of intact predator assemblages, with relatively high biomass of upper-trophic-level fishes compared with more heavily fished reef systems (RLS 2026a).

Telemetry studies reinforce the ecological importance of the reef complex for large, mobile predators. Acoustic and satellite tracking demonstrate repeated visitation and extended residency of tiger sharks and Galapagos sharks at Elizabeth and Middleton Reefs, indicating that the area functions as an important aggregation and foraging habitat within a broader southwest Pacific movement network. These studies suggest that the reefs act as an offshore ecological node or stepping-stone habitat linking pelagic movement corridors along the Lord Howe Rise (Huveneers et al. 2018).

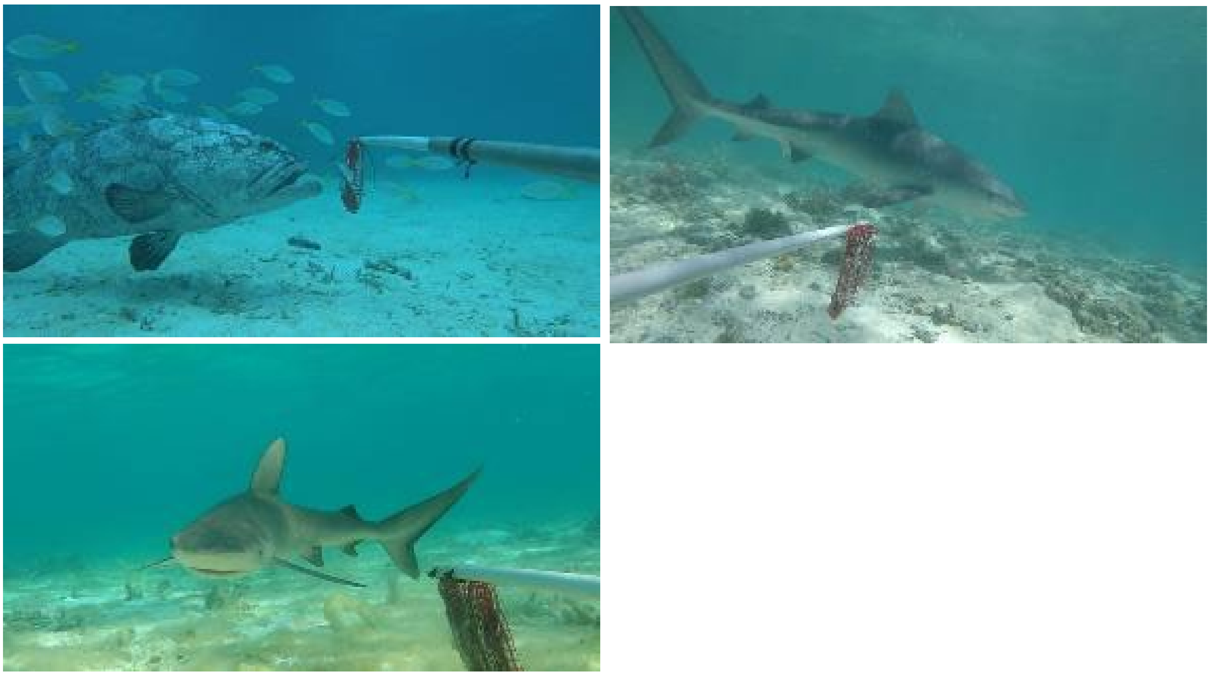


Figure 12 Black Cod, *Epinephelus daemelii,* Tiger shark, *Galeocerdo cuvieri* and Galapagos shark, *Carcharhinus galapagensis* at Middleton Reef lagoon. Link to videos: https://seamapaustralia.org/map/#18b71f0a-bed2-4fad-a9c1-ae0b433d9b82

3.2.2 Temporal surveys

Temporal surveys have been conducted on reefs at Elizabeth and Middleton Reefs, principally using diver-based underwater visual census methods (Table 3). Detailed surveys of coral, fish and macro-invertebrate communities and associated reef health at 14 sites have been conducted in 2011, 2014, 2018 and 2024 (Hoey et al. 2018, 2024).

The key findings from the 2024 surveys indicate that:

- Average coral cover across Elizabeth and Middleton Reefs (31.3%) was the highest recorded between 2011 and 2024, and represents an increase on 2018 cover (30.1%).
- Low to moderate levels of bleaching of corals were recorded during early February 2024 (13.6% of coral colonies were pale or bleached), although this was prior to the peak in bleaching condition in the region experienced between late March and June.
- The biomass of reef fish is high relative to coral reefs globally, and together with the high biomass of Galapagos sharks and large-bodied piscivores (e.g., Black cod), likely reflects the limited fishing pressure on these reefs.
- The density of endemic and vulnerable/threatened fish species was generally stable or increased from 2018 to 2024, including small increases in the populations of McCulloch's anemonefish, *Amphiprion mccullochi*, over the past 6 years.
- The density of the 'vulnerable' Black cod, *Epinephelus daemelii* was consistent between the 2018 and 2024.

Table 3. Biodiversity surveys within the Elizabeth and Middleton Reefs in the Lord Howe Marine Park by ecosystem depth range and zone type. The extent of the park by ecosystem depth range and zone type is given in the first row. Classification of survey design standards is based on Foster et al. 2024 - Statistical Considerations for Monitoring and Sampling - NESP. Sites refers to spatially discrete sampling units at least 250 m apart.

Time	Sites	Platform	Ecosystem component	Ecosystem Depth (m)	Zones	Reports	Survey design standards*
2004, 2005	45	mono-ROV, mono-Towed Video, mono-BRUV	Demersal and benthic fish, Benthic habitats	30-70, 70-200	hpz05, hpl04, npz06	1	Preferential
2013, 2018, 2023	42	RLS-UVC	Demersal and benthic fish, Benthic habitats, Mobile macroinverts, Sessile macroinverts	0-30	ruz03, npz02	2, 3, 4, 5, 6	Preferential
2011, 2014, 2018, 2024	66	JCU-UVC, mono-BRUV	Demersal and benthic fish, Benthic habitats, Mobile macroinverts, Sessile macroinverts	0-30	ruz03, npz02	7,8	Preferential
2020	11	AUV	Sessile macroinvertebrates	0-30, 30-70, 70-200	ruz03, npz02	8	Representative
2009, 2013, 2017, 2020	190	stereo-BRUV	Demersal and benthic fish, Benthic habitats	0-30, 30-70, 70-200	ruz03, npz02, hpz05, hpl04, npz06	8, 9, 10	Representative

1 Speare, P., Cappo, M., Rees, M., Brownlie, J., Oxley W. 2004. Deeper Water Fish and Benthic Surveys in the Lord Howe Island Marine Park (Commonwealth Waters). Report for Dept of the Environment and Heritage

2 Edgar, G.J., Ceccarelli, D., Stuart-Smith, R.D. and Cooper, A.T. 2017a. Biodiversity Survey of the Temperate East Coast Commonwealth Marine Reserve Network: Elizabeth & Middleton Reefs, Lord Howe Island & Norfolk Island. Reef Life Survey Foundation Incorporated.

3 Reef Life Survey 2017. Lord Howe Marine Park. Report to Parks Australia.

4 Reef Life Survey 2026a. Shallow reef biodiversity of the Lord Howe Marine Park. Report to Parks Australia.

5 Reef Life Survey 2026b. Shallow reef biodiversity of the Temperate East Marine Parks Network. Report to Parks Australia.

6 Edgar, G.J., Ceccarelli, D., Stuart-Smith, R.D. and Cooper, A.T. 2017b. Reef biodiversity surveys of Australia's Commonwealth Marine Reserve network: An overview. Report for Parks Australia, Department of the Environment. Reef Life Survey Foundation Incorporated.

8 Hoey, A.S., Pratchett, M.S., Sambrook, K., Gudge, S and Pratchett, D.J. 2018. Status and trends for shallow reef habitats and assemblages at Elizabeth and Middleton Reefs, Lord Howe Marine Park. Report prepared for Department of Environment, 65pp.

8 Hoey, A.S., Burn, D., Chandler, J.F., Huertas, V., Cresswell, B., Galbraith. G., Martin, C., McClure, E.C. 2024. Elizabeth and Middleton Reefs (Lord Howe Marine Park) Coral Reef Health Survey 2024. Report prepared for Parks Australia.

9 Carroll, A.G., Monk, J., Barrett, N., Nichol, S., Dalton, S.J., Dando, N., Siwabessy, J., Leplastrier, A., Evans, H., Huang, Z., Hulls, J., Brown, K., Swete, T., Turak, E., M., Linklater, M., Ingleton, T., Williams, J., Jordan, A., Harasti, D, Louden, B., Hammond, M. 2021. Elizabeth and Middleton Reefs, Lord Howe Marine Park, Post Survey Report. Report to the National Environmental Science Program, Marine Biodiversity Hub. Geoscience Australia.

10 Rees, M.J., Knott, N.A., Davis, T.R., Davis, A.R., Gudge, S., Neilson, J.M., Fetterplace, L.C., Jordan, A. 2021. Temporal stability in a protected and isolated fish community within marine parks surrounding Lord Howe Island. *Regional Studies in Marine Science*. 48, 102038

Shallow reef biodiversity has also been monitored through Reef Life Survey in the Lord Howe Marine Park (MP) since 2009, including sites at Middleton Reef within the National Park Zone (NPZ) and Elizabeth Reef in the Recreational Use Zone (RUZ). Temporal trends indicate that biomass of large reef fish (≥20 cm total length, excluding sharks) is significantly higher at Middleton Reef in the National Park Zone, where fishing is prohibited, compared to Elizabeth Reef in the Recreational Use Zone, where fishing is permitted. Galapagos sharks (*Carcharhinus galapagensis*) are more abundant at Middleton Reef (NPZ) than Elizabeth Reef (RUZ), and in 2023 they were recorded on 75% of transects at Middleton Reef. At Elizabeth Reef, sharks were observed at similar frequencies, but in lower numbers. Overall, populations appear stable over time.

3.3 Lord Howe Island region (Lord Howe Marine Park)

3.3.1 Ecosystems and ecosystem components

Lord Howe Marine Park begins at approximately 550 km offshore of New South Wales and extends around 600 km north to south covering 110,126 km^2. The marine park includes Elizabeth and Middleton reefs at the northern end of the park (see section 3.2) which, along with the reefs surrounding Lord Howe Island, are the southernmost coral reefs in the world. Parts of the marine park are within the Lord Howe Island Group World Heritage Area, and Elizabeth and Middleton Reefs are listed as wetlands of international significance under the Ramsar Convention. It has five zone types: National Park, Habitat Protection, Habitat Protection (Lord Howe), Recreational Use and Multiple Use.

The Lord Howe Island region is characterised by two broad rectangular shelf areas surrounding both Lord Howe Island and Balls Pyramid, both with an average depth of around 30–50 m (Figure 13). The complete shelf regions surrounding Lord Howe Island and Balls Pyramid within the Lord Howe Marine Park have been mapped at high resolution resulting in a detailed understanding of the distribution and extent of seabed habitats. Within Commonwealth waters on the shelf extensive areas of mesophotic reefs are present in the eastern areas of the Lord Howe Island shelf, with smaller areas on the north and south-west areas of the Balls Pyramid shelf (Figure 14). These fossil reefs around both shelves occur at similar depths and cover approximately one-third of the shelf area (Linklater et al. 2018a, Linklater et al. 2019). The Commonwealth waters component of this habitat extends from depth of around 50-70 m and represents the outer section of the two shelves, which are separated by a trough that averages 600 m deep.

The mesophotic reefs within the Commonwealth marine park contain scleractinian corals common, with sub-massive and foliose scleractinian corals and sponge crusts (Figure 15) (Linklater et al. 2015). Abundant scleractinian corals occur on the submerged reefs, and these have been surveyed in depths up to 94 m at Balls Pyramid. Corals are more prevalent on the south-western and eastern mid-shelf reefs around Balls Pyramid, with some locations around the LHI mid-shelf reporting similar coral cover (Linklater et al. 2018a). There are also branching octocorals, whips and urchins, with coralline and fleshy sheet-like algae. Much of the habitats on the outer shelf are continuous with those that extend into shallow depths within the Lord Howe Island Marine Park in State Coastal Waters, and further details on these habitats are presented in Harasti et al. (2022).

The mid-shelf reefs of both shelves are located adjacent to outer shelf platforms, which appear to be limestone surfaces veneered with carbonate sands. A sequence of terraces characterise the outer shelf edge in 65 to 100 m water depth, formed as erosional and depositional features during periods of lower sea level (Linklater et al. 2015, Linklater et al.

2018a). A distinct shelf break occurs at a depth of 70–100 m, while a steep drop-off falls away quickly at 200 m to depths of more than 2,000 m.

The deeper seamount habitats offshore from the shelves include highly variable slopes with a high degree of seafloor complexity, including downslope flow structures, canyons and numerous volcanic cones and pinnacles, many 150–300 m high (Figure 13) (Hill et al. 2000). The slopes consists mostly of rocky volcanic outcrops with thin patches of sediment, while the trough between the two islands contains very coarse sediment (Hill et al. 2000, Williams et al. 2006).

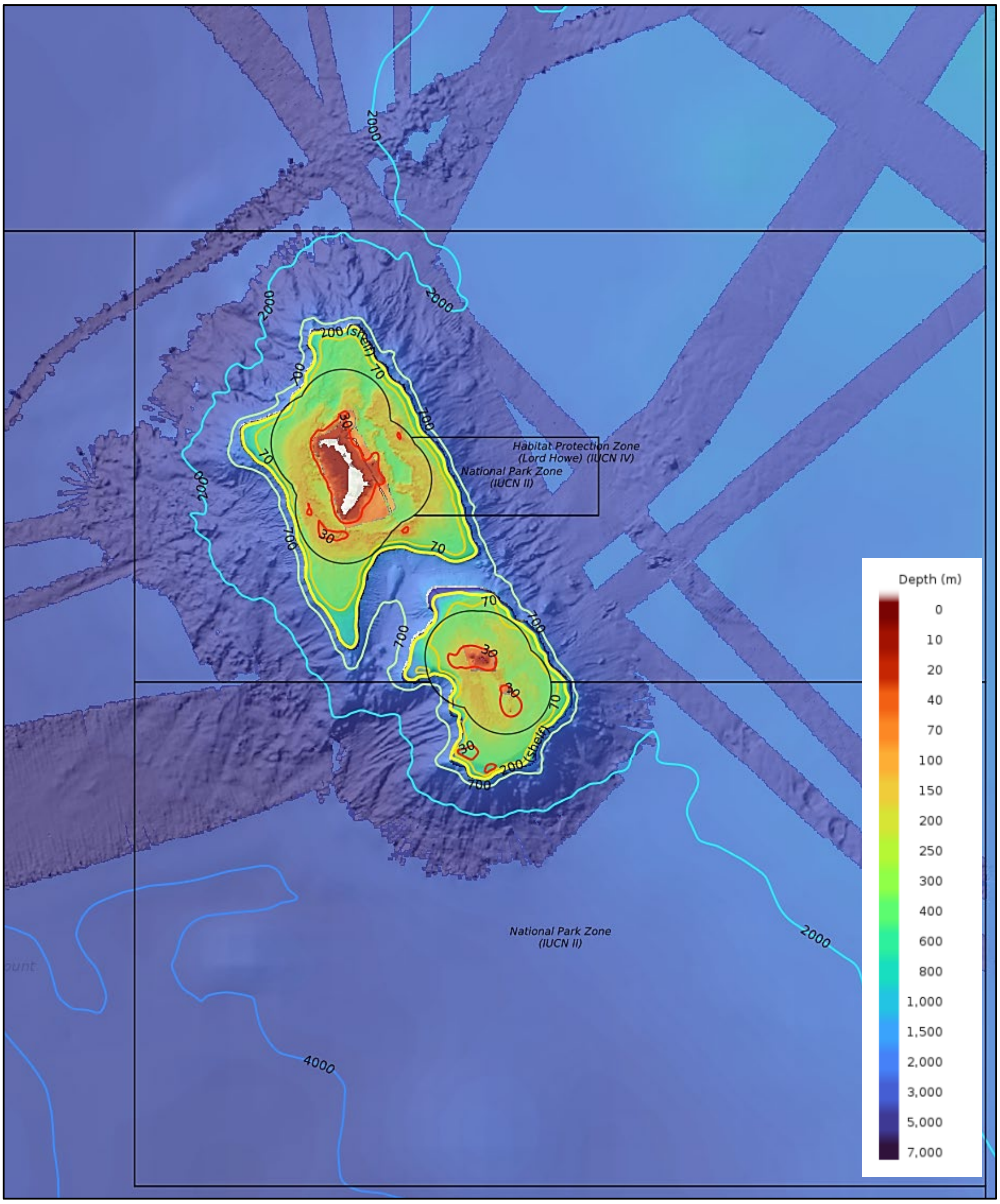


Figure 13 Bathymetry of the Lord Howe Island region representing high resolution bathymetry across the shelf areas surrounding Lord Howe Island and Ball Pyramid (From Linklater et al. 2018a, Seamap Australia link: https://seamapaustralia.org/map/#774b436a-b7f4-42b9-838b-e193a056e10b A flythrough movie highlighting the seafloor bathymetry of the Lord Howe Island shelf is located at https://www.youtube.com/watch?v=6fKCeFl4b_w&t=3s

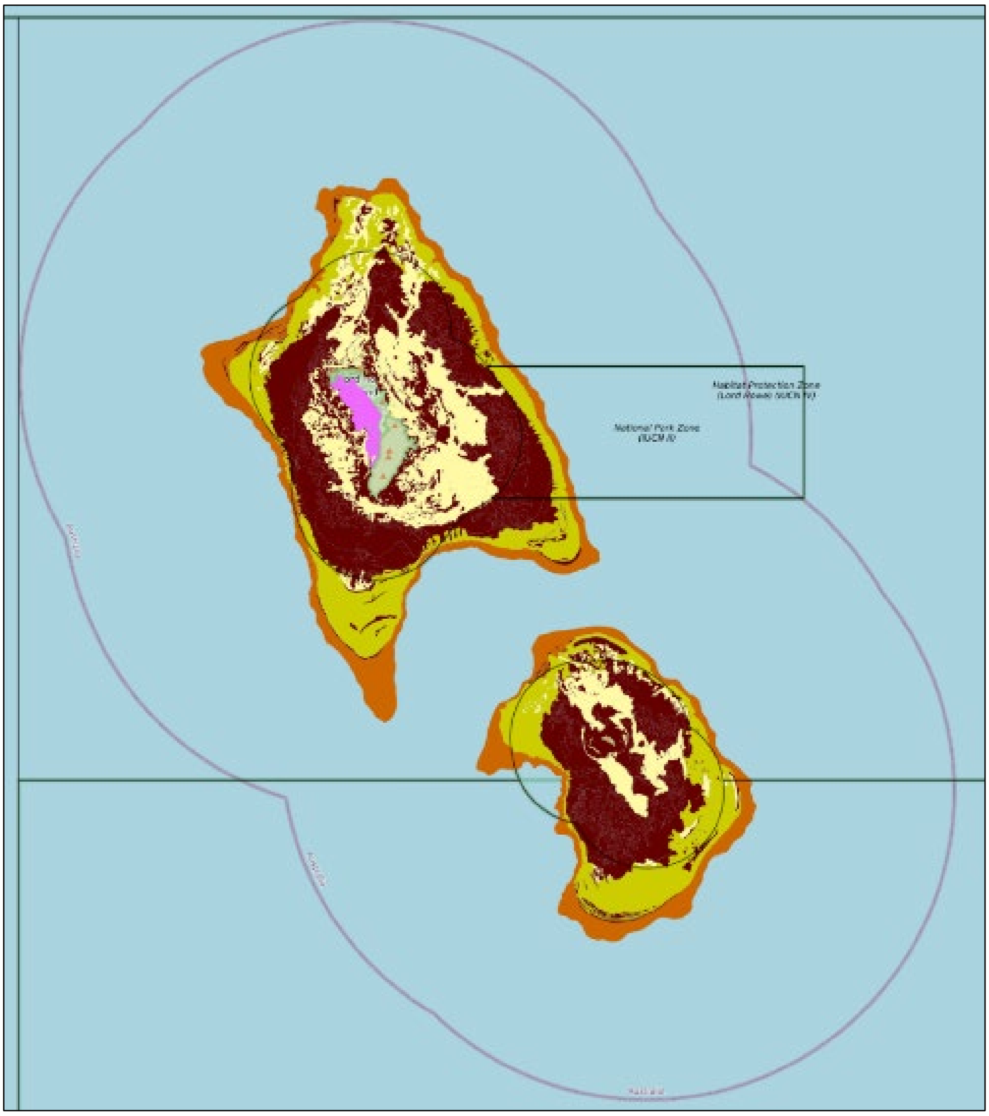


Figure 14 Distribution of seabed habitats around Lord Howe Island and Balls Pyramid shelves. Seamap Australia link and map legend at: https://seamapaustralia.org/map/#77e217d3-ad45-4778-9c06-1276c68dd3c0

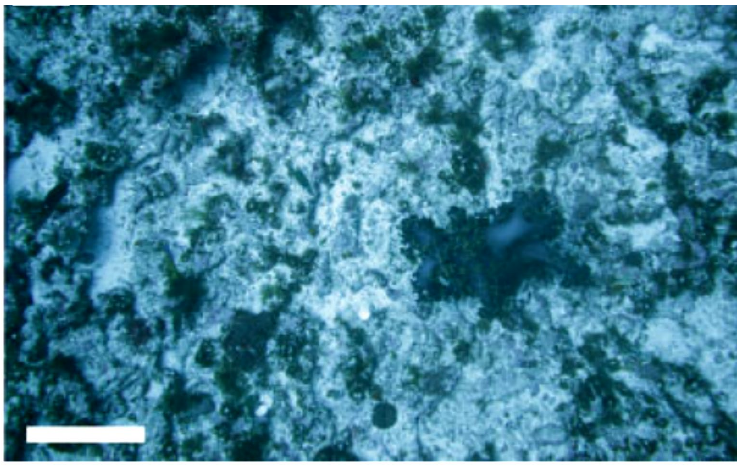


Figure 15 Southern outer-shelf reef (O3), with encrusting scleractinian corals, branching soft coral *Dendronepthya* sp., laminate *Padina* sp. and branching *Dictoyta* sp. algae. Scale bar: 30 cm (Modified from Linklater et al. 2018b) (Dynamic link to habitat videos: [https://seamapaustralia.org/map/#7b42d428-c409-48fd-83a6-e44c687ddc8b)](https://seamapaustralia.org/map/#7b42d428-c409-48fd-83a6-e44c687ddc8b)

Fish surveys of mesophotic reefs in Commonwealth waters of Lord Howe Marine Park have identified a range of species that are commonly found in the deeper waters of the shelf, including Black cod (*Epinephelus daemelii)* and bluefish *Girella cyanea* (Figure 16) (Davis et al. 2017). Key pelagic species on the shelf areas of this marine park are Galapagos shark (*Carcharhinus galapagensis*), which is an abundant predator in the region (Mitchell et al. 2021, and yellowtail kingfish (*Seriola lalandi*) which have been observed in higher abundances on shelf habitats with greater topographic complexity (Rees 2013, Rees et al. 2021).

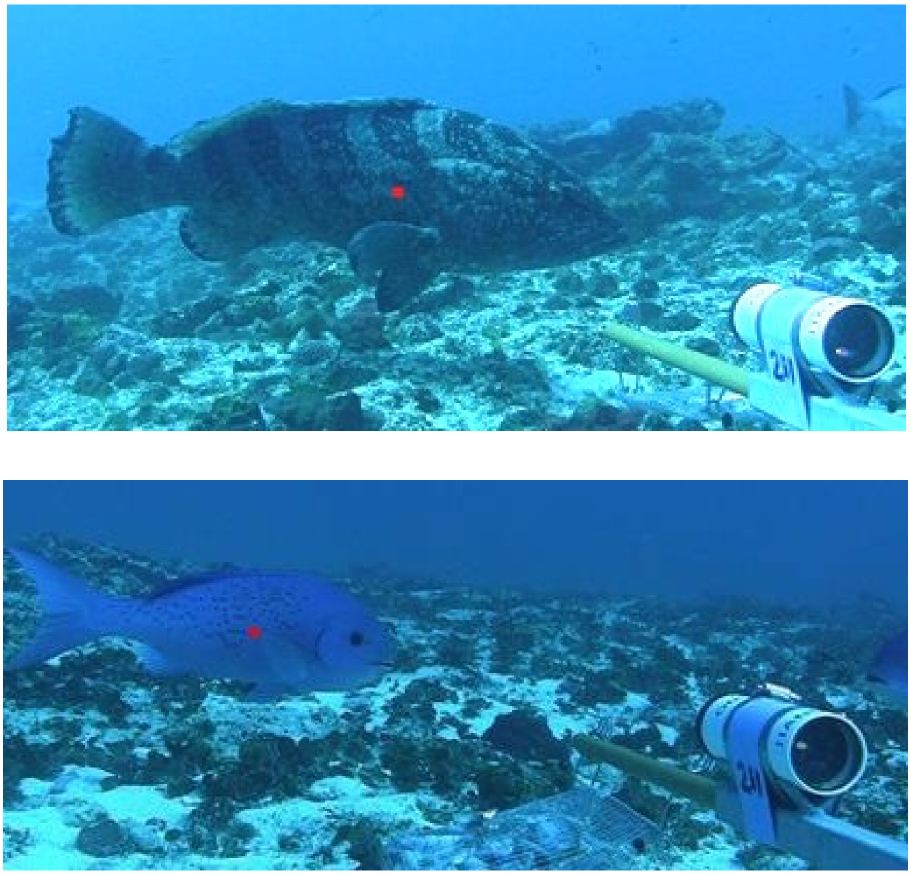


Figure 16 Examples of fish species surveyed using BRUVs on the outer shelf of Lord Howe Island; a) *Epinephelus daemelii* and b) *Girella cyanea* (Modified from Davis et al. 2017)

The Lord Howe Marine Park includes a large area of lower slope reef and sediment ecosystems (Figure 6). Surveys conducted during the NORFANZ voyage (Williams et al. 2006) found that this region supports highly distinctive benthic assemblages with strong depth structuring and high local endemism, including many rare or undescribed species confined to single sites. The seafloor comprises seamounts, escarpments and bedrock outcrops, all of which contain diverse communities of sponges, octocorals, echinoderms and deep-sea fishes. These were influenced by the regions geological age and position between subtropical and temperate waters. The distribution patterns of benthic invertebrates were strongly influenced by depth and oxygen concentration (correlated with depth), with assemblages identified from three depth-zones: 100–400m (deep continental shelf and shelf edge), 400–700m (upper continental slope) and 4700 m (mid-continental slope) (Williams et al. 2011). The NORFANZ survey of sites on Lord Howe Rise revealed a sparse but diverse demersal fish community including several skate species (Przeslawski et al. 2011; Zintzen et al. 2011), with the demersal fish assemblages thought to be highly structured by depth, with strong regional endemism.

Table 4. Biodiversity surveys within the Lord Howe Marine Park by ecosystem depth range and zone type. The extent of the park by ecosystem depth range and zone type is given in the first row. Classification of survey design standards is based on Foster et al. 2024 - Statistical Considerations for Monitoring and Sampling - NESP. Sites refers to spatially discrete sampling units at least 250 m apart.

Time	Sites	Platform	Ecosystem component	Ecosystem Depth (m)	Zones	Reports	Survey design standards*
2004, 2005	45	mono-ROV, mono-Towed Video, mono-BRUV	Demersal and benthic fish, Benthic habitats	30-70, 70-200	hpz05, hpl04, npz06	1	Preferential
2013, 2018, 2023	42	RLS-UVC	Demersal and benthic fish, Benthic habitats, Mobile macroinverts, Sessile macroinverts	0-30	ruz03, npz02	2, 3, 4, 5, 6	Preferential
2011, 2014, 2018, 2024	66	JCU-UVC, mono-BRUV	Demersal and benthic fish, Benthic habitats, Mobile macroinverts, Sessile macroinverts	0-30	ruz03, npz02	7	Preferential
2020	11	AUV	Sessile macroinvertebrates	0-30, 30-70, 70-200	ruz03, npz02	8	Representative
2009, 2013, 2017, 2020	190	stereo-BRUV	Demersal and benthic fish, Benthic habitats	0-30, 30-70, 70-200	ruz03, npz02, hpz05, hpl04, npz06	8, 9, 10, 11	Representative
2003	24	Demersal trawl, epibenthic sled, dredge, drop camera	Demersal and benthic fish, Benthic habitats, Mobile macroinverts, Sessile macroinverts	50-2000		12	Preferential

1 Speare, P., Cappo, M., Rees, M., Brownlie, J., Oxley W. 2004. Deeper Water Fish and Benthic Surveys in the Lord Howe Island Marine Park (Commonwealth Waters). Report for Dept. of the Environment and Heritage
2 Edgar, G.J., Ceccarelli, D., Stuart-Smith, R.D., Cooper, A.T. 2017a. Biodiversity Survey of the Temperate East Coast Commonwealth Marine Reserve Network: Elizabeth & Middleton Reefs, Lord Howe Island & Norfolk Island. Reef Life Survey Foundation Incorporated.
3 Reef Life Survey 2017. Lord Howe Marine Park. Report to Parks Australia.
4 Reef Life Survey 2026a. Shallow reef biodiversity of the Lord Howe Marine Park. Report to Parks Australia.
5 Reef Life Survey 2026b. Shallow reef biodiversity of the Temperate East Marine Parks Network. Report to Parks Australia.
6 Edgar, G.J., Ceccarelli, D., Stuart-Smith, R.D., Cooper, A.T. 2017b. Reef biodiversity surveys of Australia's Commonwealth Marine Reserve network: An overview. Report for Parks Australia, Department of the Environment. Reef Life Survey Foundation Incorporated.
7 Hoey, A.S., Burn, D., Chandler, J.F., Huertas, V., Cresswell, B., Galbraith. G., Martin, C., McClure, E.C. 2024. Elizabeth and Middleton Reefs (Lord Howe Marine Park) Coral Reef Health Survey 2024. Report to Parks Australia.
8 Carroll, A.G., Monk, J., Barrett, N., Nichol, S., Dalton, S.J., Dando, N., Siwabessy, J., Leplastrier, A., Evans, H., Huang, Z., Hulls, J., Brown, K., Swete, T., Turak, E., M., Linklater, M., Ingleton, T., Williams, J., Jordan, A., Harasti, D, Louden, B., Hammond, M. 2021. Elizabeth and Middleton Reefs, Lord Howe Marine Park, Post Survey Report. Report to the NESP, Marine Biodiversity Hub. Geoscience Australia.
9 Rees, M.J., Knott, N.A., Davis, T.R., Davis, A.R., Gudge, S., Neilson, J.M., Fetterplace, L.C., Jordan, A. 2021. Temporal stability in a protected and isolated fish community within marine parks surrounding Lord Howe Island. *Regional Studies in Marine Science*. 48, 102038
10 Neilson, J., Jordan, A., Gudge, S. and Kerr, I. 2010. Baited remote underwater video surveys of fish assemblages on reef shelf habitats in Lord Howe Island Marine Park. NSW Department of Environment, Climate Change and Water: Sydney
11 Davis, T., Gudge, S., Henry, E. and Woods, C. 2017. Baited Remote Underwater Video Surveys of Lord Howe Island Marine Park Fish Assemblages: 2017 Project Summary. NSW Department of Primary Industries.
12 Williams, A., Gowlett-Holmes, K. and Althaus, F. 2006. Biodiversity survey of seamounts and slopes of the Norfolk Ridge and Lord Howe Rise. Final report to the Department of the Environment and Heritage, 591 pp

3.3.2 Temporal surveys

Temporal variation in fish populations on the Lord Howe Island and Balls Pyramid shelf have been examined using Baited Remote Underwater Video surveys (BRUVs) and were completed in 2009 (Neilson et al. 2010), 2013 (Rees 2013) and 2017 (Davis et al. 2017) (Table 4). Analysis of the 2009–2017 data from this monitoring identified no clear changes in fish assemblage, diversity, total abundance and abundance of key species between SZs and HPZs within the LHIMP and Commonwealth Lord Howe Marine Park (Rees et al. 2021). This lack of change was attributed to the relatively pristine environment and minimal current human threats to fish assemblages on shelf habitats in the region (Harasti et al. 2022).

3.4 Norfolk Island (Norfolk Marine Park)

3.4.1 Ecosystems and ecosystem components

The Norfolk Marine Park begins 1400 kilometres offshore, east of Evans Head in New South Wales, and covers 188,444 km^2 over a north-south distance of around 730 km. It has National Park and Multiple Use zones, as well as a Special Purpose Zone in an area surrounding Norfolk Island. The marine park is unusual in that it extends from the high tide mark out to depths of over 4000 m as the locations is a territory of the Commonwealth (Figure 17). There is a very limited extent of shallow ecosystems in the Temperate East Marine Parks Network, with beaches present on Norfolk Island. These are located in the south and east of Norfolk Island but only represent a small fraction of the overall intertidal area of the island.

There is a shelf area surrounding Norfolk Island that is around 100 km long north to south, has an average depth of around 50 m, and which extends to depths of approximately 100 m. Extending north-south through the marine park is the Norfolk Ridge, a long, narrow, steep-sided undersea ridge with seamounts and pinnacles. This ridge is mostly around depths of 2000 m, with several areas both in the north and south that rise up to depths shallower than 700 m, and some small features up to around 450 m. There are also several basin areas to the east of Norfolk Ridge that are regions at abyssal depths of >4000 m.

The Norfolk Marine Park encompasses a remote, fully oceanic reef and island system that supports a distinct assemblage of pelagic and reef-associated species, including several large shark species of conservation significance. The park was established to protect the ecological values of the Norfolk Ridge and surrounding deep-water environments, with particular importance for apex predators and migratory species that use the region for foraging, aggregation and movement between oceanic habitats.

The seabed within the Norfolk Marine Park is characterised by steep volcanic slopes and rocky reef platforms that rise abruptly from deep oceanic waters (Figure 18). Shallow reef areas fringing Norfolk Island and adjacent pinnacles provide structurally complex hard-substrate habitat, while depths increase rapidly offshore to the surrounding abyssal plain (Figure 6). This configuration creates strong depth gradients over short spatial scales and supports a mosaic of reef, slope and pelagic habitats. Reef and upper-slope environments support diverse fish assemblages, while deeper waters are utilised by large pelagic species moving along the Norfolk Ridge.

The Norfolk Marine Park also encompasses part of the Norfolk Ridge, a major deep-sea biogeographic corridor linking Australia, New Zealand and New Caledonia. Findings from the NORFANZ survey (Williams et al. 2006) found that this ridge supports highly distinctive benthic assemblages with strong depth structuring and high local endemism, including many rare or undescribed species. Its rugged seafloor, comprising seamounts, escarpments and bedrock outcrops, hosts diverse communities of sponges, octocorals, echinoderms and deep-sea fishes, shaped by the ridge's geological age and position between subtropical and temperate waters. These characteristics highlight the need for protection across multiple depth zones and careful management of vulnerable, slow-growing ridge-associated ecosystems.

A detailed survey of Norfolk Marine Park shallow and mesophotic habitats was conducted in 2022 (Pendoley 2022). Habitat mapping was conducted around Norfolk, Phillip, and Nepean Islands using satellite imagery, community consultation with local fishers, surfers, and divers at Norfolk Island, ground-truthing using towed video surveys, followed by a review and interpretation of field data to assess classification accuracy.

The resulting habitat map indicates a complex mosaic of habitats dominated by shallow rocky reefs, shallow coral reefs and soft sediments with a range of sediment types that get finer the further offshore (Figure 18). Detailed surveys of ecosystem components and associated assemblages are focused principally on shallow rocky and coral reefs habitats surrounding Norfolk Island. The coral reefs and coral reef lagoons contain a diverse range of tropical hard corals and other reef species and are most prevalent on the southern and eastern shores of the island.

Surveys have found highly variable inshore coral reef ecosystems with substantial within-reef variability in coral cover, algal cover and coral growth form (Ainsworth et al. 2021). This study also found site variability for coral condition with substantially higher diseased, dead and algal colonised corals evident with some reef areas. A coral bleaching event was identified to occur in 2020, the first record within the Norfolk Island coral reef ecosystem, however bleaching events have also likely occurred within the bay during previous anomalously high temperature conditions (Ainsworth et al. 2021).

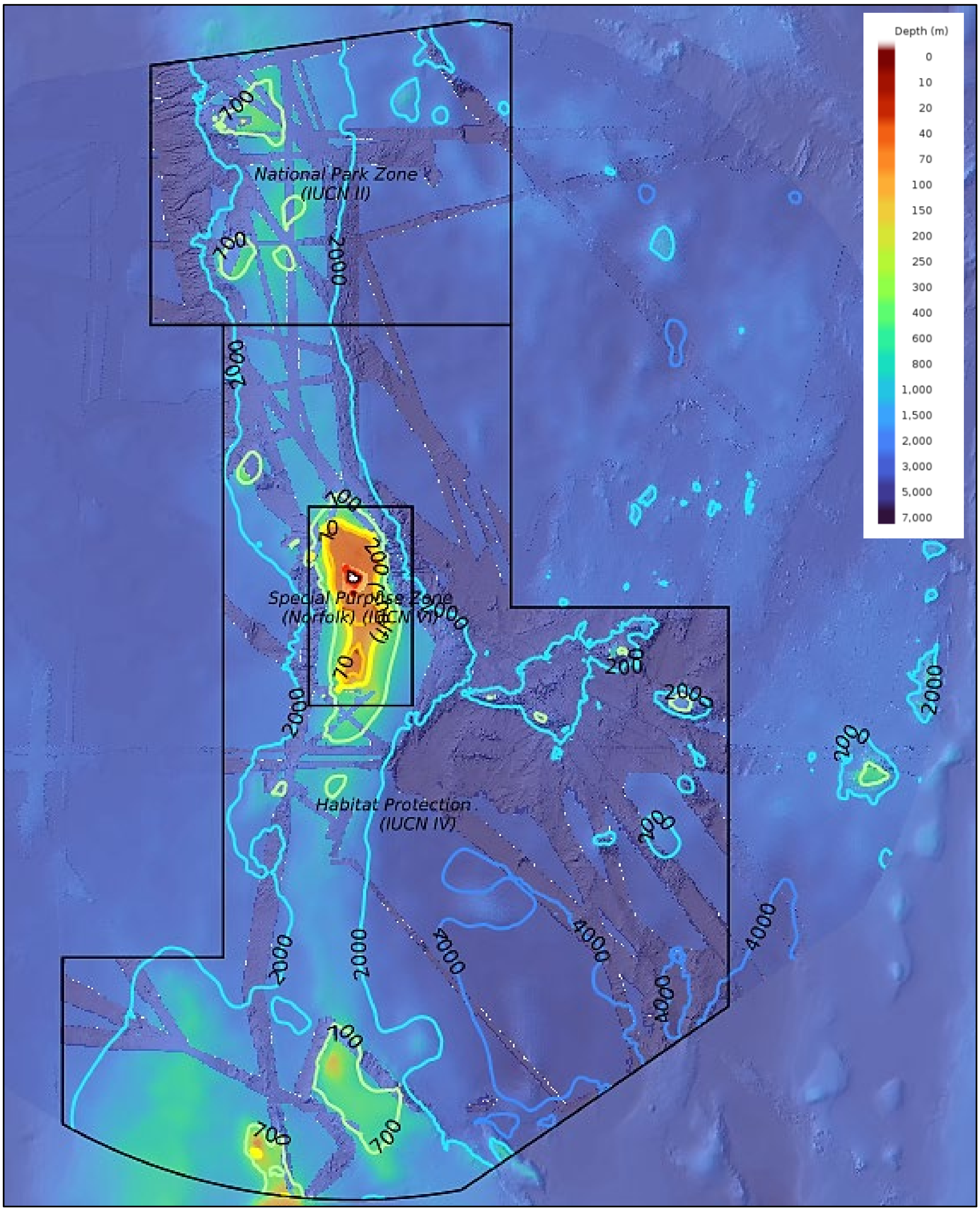


Figure 17 Broadscale bathymetry of the Norfolk Island Marine Park region (Seamap Australia link: https://seamapaustralia.org/map/#02afeee2-7e08-4670-a08e-21e3a10857dc)

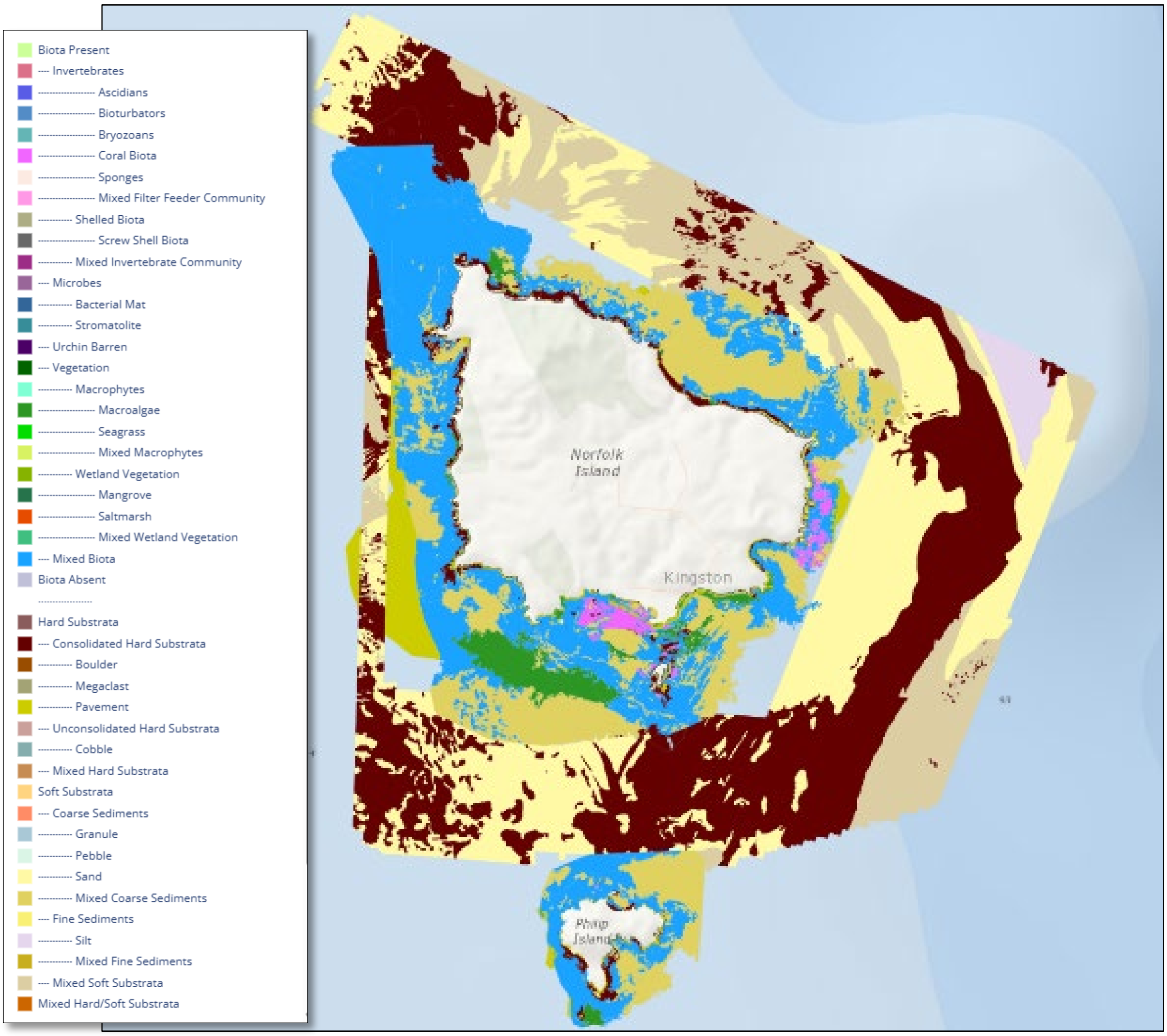


Figure 18 Distribution of seabed habitats in the shelf areas of the Norfolk Marine Park (Seamap Australia link: https://seamapaustralia.org/map/#162bd3f4-a78c-4363-8978-4b6144b1e587)

3.4.2 Temporal surveys

There are a number of survey programs that have conducted temporal surveys on ecosystem components in the Norfolk Marine Park, although they are principally restricted to shallow reefs at a limited number of locations (Table 5), particularly inshore coral reefs (Figure 19). Firstly, monitoring of coral cover and associated biota and water quality on the reefs has occurred on shallow reefs since 2020, which identified a coral bleaching event, the first record within the Norfolk Island coral reef ecosystem (Page et al. 2023a), however bleaching events have probably occurred within the bay during previous anomalously high temperature conditions (Ainsworth et al. 2021). The same period saw coral disturbance caused by Cyclone Gretel and significant winter and autumn rain events that resulted in flooding, sedimentation and nutrient input into the inshore lagoon. This resulted in extensive coral bleaching within the lagoonal reef, with corals remaining bleached through the subsequent winter, which was followed by declining water quality (Ainsworth et al. 2021).

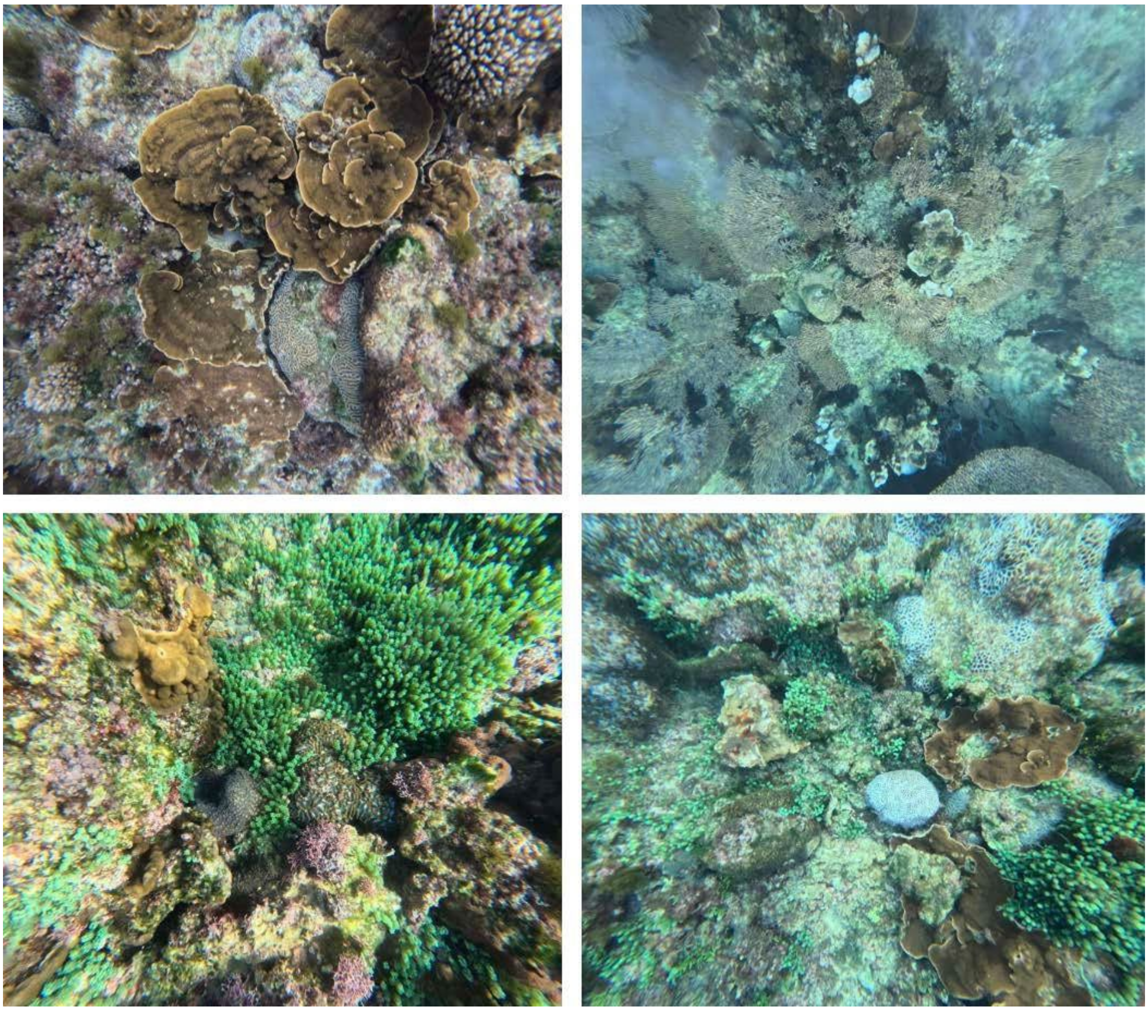


Figure 19 Norfolk Marine Park - Examples of shallow coral dominated habitat types on Norfolk Island (From Ainsworth et al. 2026).

Survey conducted again in 2024 and 2025 found little change in coral cover on inshore reefs since 2020 (~26%) whereas fringing reef coral cover in 2025 was found to be ~42% of the benthic community (Ainsworth et al. 2025). The primary habitat forming species were *Acropora* and *Montipora* at ~70% of the coral community, with risks identified to the inshore reef due to a phase shift due to losses of these primary habitat forming genera. Both species are at risk of continued disease outbreak, with coral bleaching also impacting *Montipora*. Coral disease can also occur across inshore reefs and potential for a new disease outbreak in 2025 associated with land-based run off into the inshore coral reefs. There is also potential for recruitment failure following marine heatwave and coral bleaching events (Ainsworth et al. 2025).

Reef Life Survey have conducted surveys on the reefs around Norfolk Island in 2009, 2013, 2021 and 2025 and have a significant database on mobile and cryptic fish, mobile and sessile invertebrates (RLS 2026). Biomass of large fish (≥20 cm total length, excluding sharks) is relatively low in the Norfolk Marine Park compared to reference sites in the NSW Lord Howe Island Marine Park. Very few large fish were recorded on surveys in the lagoon in 2025, despite its designation as no-take in 2023.

Table 5. Biodiversity surveys within the Norfolk Marine Park by ecosystem depth range and zone type. The extent of the park by ecosystem depth range and zone type is given in the first row. Classification of survey design standards is based on Foster et al. 2024 - Statistical Considerations for Monitoring and Sampling - NESP. Sites refers to spatially discrete sampling units at least 250 m apart.

Time	Sites	Platform	Ecosystem	Ecosystem Depth (m)	Zones	Reports	Survey design standards*
2009, 2010, 2013, 2021, 2022, 2025	16	RLS-UVC	Demersal and benthic fish, Benthic habitats, Mobile macroinverts, Sessile macroinverts	0-30	spn03	1, 2, 3, 4, 5	Preferential
2020, 2025, 2026	100	drop camera (downward facing), UVC, mono-ROV, USV	Sessile macroinvertebrates, Benthic habitats, Demersal and benthic fish	0-30	spn03	7, 8, 9	Preferential
2021	45	stereo-BRUV	Demersal and benthic fish, Benthic habitats	0-30, 30-70, 70-200	spn03		Representative
2022	150	drop camera (downward facing)	Benthic habitats	0-30	spn03	6	Representative
2003	24	Demersal trawl, epibenthic sled, dredge	Demersal and benthic fish, Benthic habitats, Mobile macroinverts, Sessile macroinverts	100-1300		10	Preferential

1 Heather, F.J., Stuart-Smith, R.D., Cooper, A.T. and Edgar, G.J. 2022. Reef Life Survey Assessment of Marine Biodiversity in Norfolk Marine Park. Reef Life Survey Foundation Incorporated.
2 Reef Life Survey 2017. Norfolk Marine Park. Report to Parks Australia.
3 Reef Life Survey 2026. Shallow reef biodiversity of the Norfolk Marine Park. Report to Parks Australia.
4 Reef Life Survey 2026. Shallow reef biodiversity of the Temperate East Marine Parks Network. Report to Parks Australia.
5 Edgar, G.J., Ceccarelli, D., Stuart-Smith, R.D. and Cooper, A.T. 2017b. Reef biodiversity surveys of Australia's Commonwealth Marine Reserve network: An overview. Report for Parks Australia, Department of the Environment. Reef Life Survey Foundation Incorporated.
6 Pendoley Environmental Pty Ltd., 2022. Nearshore marine habitat mapping of the Norfolk Marine Park. Final project report to the Director of National Parks. Grant Activity ID: 4-FIZ391E. https://doi.org/10.13140/RG.2.2.35188.94080
7 Ainsworth, T., Heron, S., Lantz, C. and Leggat, W. 2021. Norfolk Island Lagoonal Reef Ecosystem Health Assessment 2020-201. Report to Parks Australia, 136pp.
8 Ainsworth, T., Gaston, T., Leggat, W., Roughan, M. 2025. Norfolk Island Lagoonal Reef Ecosystem Health Assessment. Report to Parks Australia, 37pp.
9 Ainsworth, T., Moir, T., Gaston, T., Leggat, W., Roughan, M. 2026. Norfolk Island Lagoonal Reef Ecosystem Health Assessment. Report to Parks Australia, 31pp.
10 Williams, A., Gowlett-Holmes, K. and Althaus, F. 2006. Biodiversity survey of seamounts and slopes of the Norfolk Ridge and Lord Howe Rise. Final report to the Department of the Environment and Heritage (National Oceans Office), 591 pp

Galapagos sharks (*Carcharhinus galapagensis*) abundance is consistently low but appear stable over time. Galapagos sharks are not observed in the lagoon, where habitat is unsuitable, but occurred on 11% of surveys in the Special Purpose (Norfolk) zone conducted over the latest monitoring period. Research has demonstrated that waters surrounding Norfolk Island form part of a broader southwest Pacific shark movement network, with satellite and acoustic tagging revealing repeated use of the area by wide-ranging species such as tiger sharks (*Galeocerdo cuvier*), silky sharks (*Carcharhinus falciformis*), Galapagos sharks and great white sharks (*Carcharodon carcharias*). These studies indicate that Norfolk Island functions as an important offshore stepping-stone habitat, facilitating connectivity between Australian, New Zealand and Pacific island ecosystems, and supporting both transient and seasonally resident individuals. The presence of apex predators highlights the ecological role of the park in maintaining pelagic food-web structure at regional scales.

Telemetry research has shown that sharks using the Norfolk Island region exhibit strong vertical and horizontal movement patterns associated with these bathymetric features, with repeated use of reef edges, drop-offs and slope environments. Such areas are likely to provide foraging opportunities and navigational cues for highly mobile predators. Although the marine park boundary encompasses only part of the broader functional habitat used by these species, it protects a core area repeatedly utilised by sharks that range across multiple jurisdictions.

3.5 Solitary Islands Marine Park (Commonwealth)

3.5.1 Ecosystems and ecosystem components

The Solitary Islands Marine Park (Commonwealth) is offshore from northern New South Wales and is a narrow area around 3-4 km wide that extends from the eastern boundary of the NSW State marine park across the mid shelf to around 80 m depth offshore. It covers 152 km^2 and has National Park, Multiple Use and Special Purpose zones. It is relatively flat containing areas of low relief reef mainly in the northern section, but is also characterised by a submerged pinnacle that rises to around 12 m of the surface (Figure 20). This pinnacle is known as Pimpernel Rock, which forms a key feature of the National Park Zone within the marine park.

Mapping of seabed habitats has been significantly extended within the Solitary Islands Marine Park (State and Commonwealth) since 2016 from only discrete areas in the north, central and southern areas of the region to full coverage in the Commonwealth marine parks areas (Figure 20). This has been complemented by extensive mapping surveys in nearshore waters resulting in a detailed understanding of the distribution and extent of shelf ecosystems (Jordan et al. 2010, Ingleton et al. 2024). Extensive areas of mesophotic reefs have been mapped across the shelf, particularly within the Commonwealth marine parks zone located north of North Solitary Island. Many reefs are separated by unconsolidated sediments that results in a complex mosaic of reefs, with many being continuous to zones within the State marine park.

In contrast, the central and southern Commonwealth zones contains little mesophotic reef and are dominated by unconsolidated sediments (Figure 21). In general, the unconsolidated areas are dominated by areas of fine sands of the outer nearshore zone (depths <40 m), medium to coarse grain inner shelf sands (or gravels) (typically between 40-50 m); to the fine muddy sands of the gently sloping, low energy inner-mid shelf unit (depths >50 m) (Ingleton et al. 2024). The Commonwealth zone in the north contains the regionally significant feature, Pimpernel Rock, which is a pinnacle that rises to within ~12 m of the surface (Figure 21). Recent surveys have identified two relatively smaller rocky pinnacles lying at ~1.1 and 1.3 km north-east of Pimpernel Rock that had not been previously mapped (Ingleton et al. 2024). These features are less than 100 m across, each rising to depths of 34.4 and 30.8 m, respectively.

A range of methods including diver surveys, BRUVs and acoustic receivers have identified both a diverse array of fish and sharks species in the Pimpernel Rock National Park Zone, and a reef fish assemblage that is unique when extensively compared with other locations in the Solitary Islands region and elsewhere (Malcolm et al. 2025) (Table 6). The sites characteristics of pinnacle morphology (and associated large depth range), complex surrounding habitat, cave system and influence of the East Australian Current are key drivers of the unique assemblage composition (Malcolm and Ferrari 2019). This includes a high biomass of large schooling predators and their small abundant schooling prey species. Species that dominate the fish assemblage across the mesophotic reefs in the Commonwealth zones include labrids, serranids (rockcods) and carangids (jacks and trevallies (Malcolm et al. 2025).

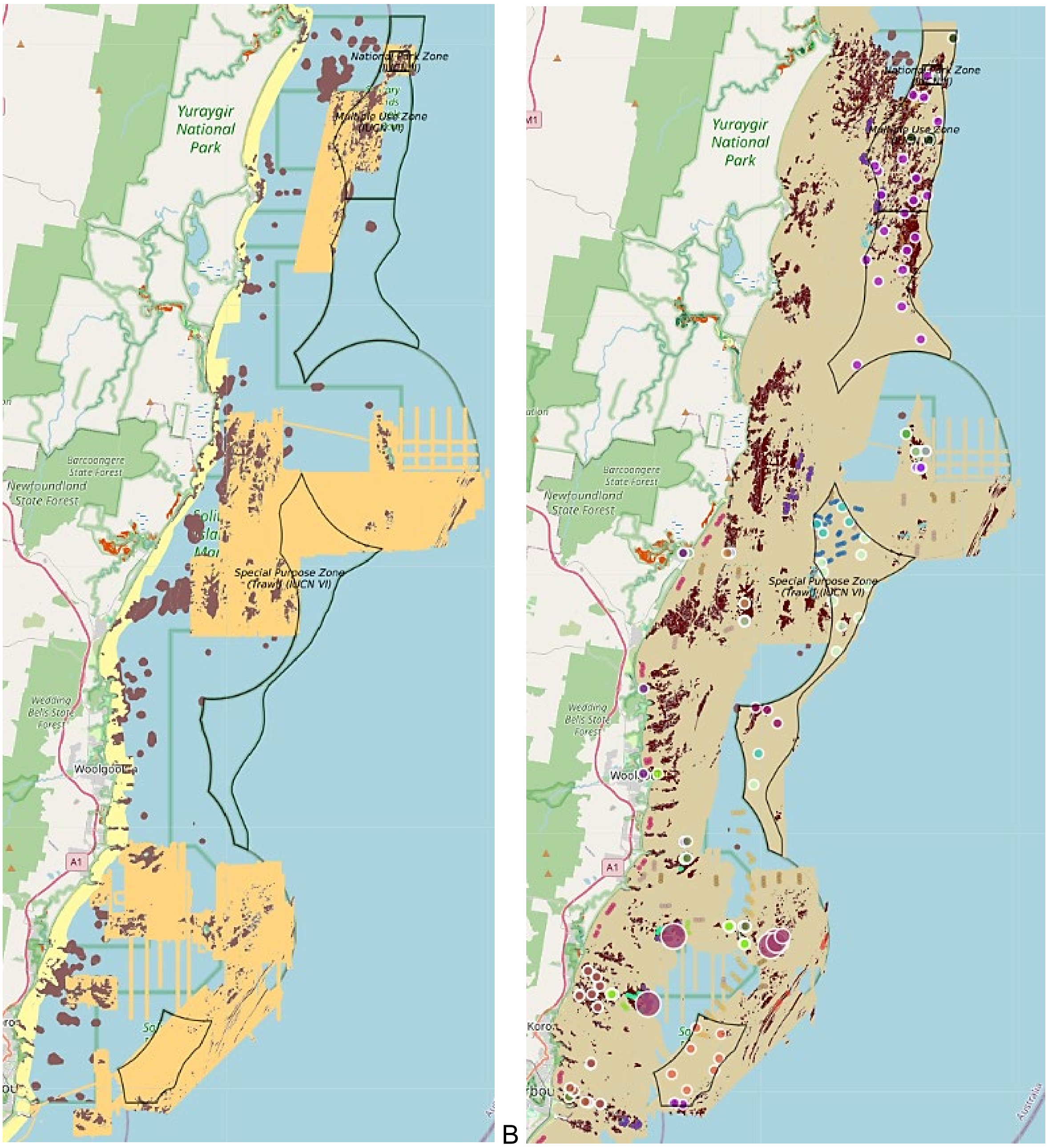


Figure 20 Distribution of seabed habitats in the northern areas of the Solitary Islands Marine Park (State and Commonwealth waters) as defined in A. 2016 and B. 2026. Rocky reef is brown and unconsolidated substrate is tan coloured. Bubble plots in B represent sampling effort using towed video, AUV or BRUVs as detailed in Table 6.

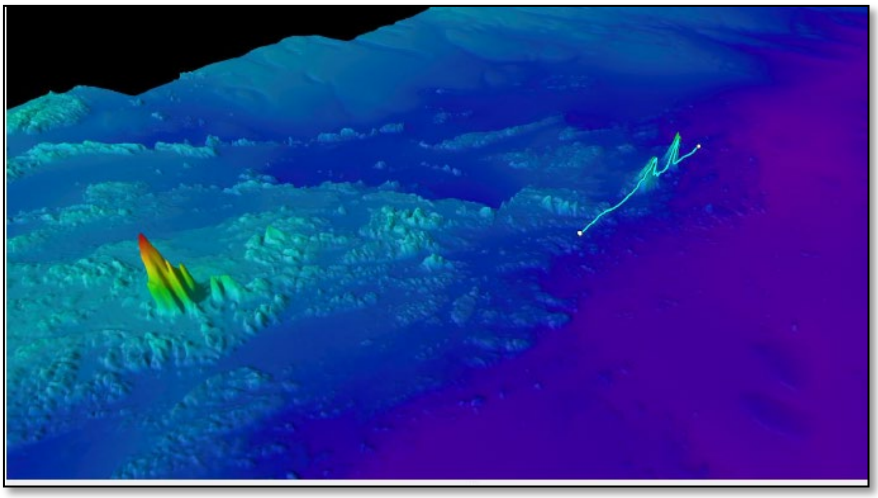


Figure 21. Bathymetry in region surrounding the Pimpernel Rock National Park Zone in the northern region of the Solitary Islands Marine Park (Commonwealth (from Ingleton et al. 2024)

Underwater video analysis of mesophotic reefs in the region indicate they are dominated by sessile epifauna, predominantly sponges (Porifera), black coral and octocorals (Cnidaria) and bryozoans (Bryozoa) (Figure 22). The diversity and densities of morphospecies are generally greater in northern and southern sites compared to the central section of the park (Ingleton et al. 2024). Sponges were dominated by massive forms, with cups more common on reefs in the north compared to central and southern sites. Branching corals dominated the relative abundances for the Cnidaria in the north, with hydroids and branching and stony corals more common in the central and south. Mobile species observed over reefs were mainly fishes, sea stars and crinoids.

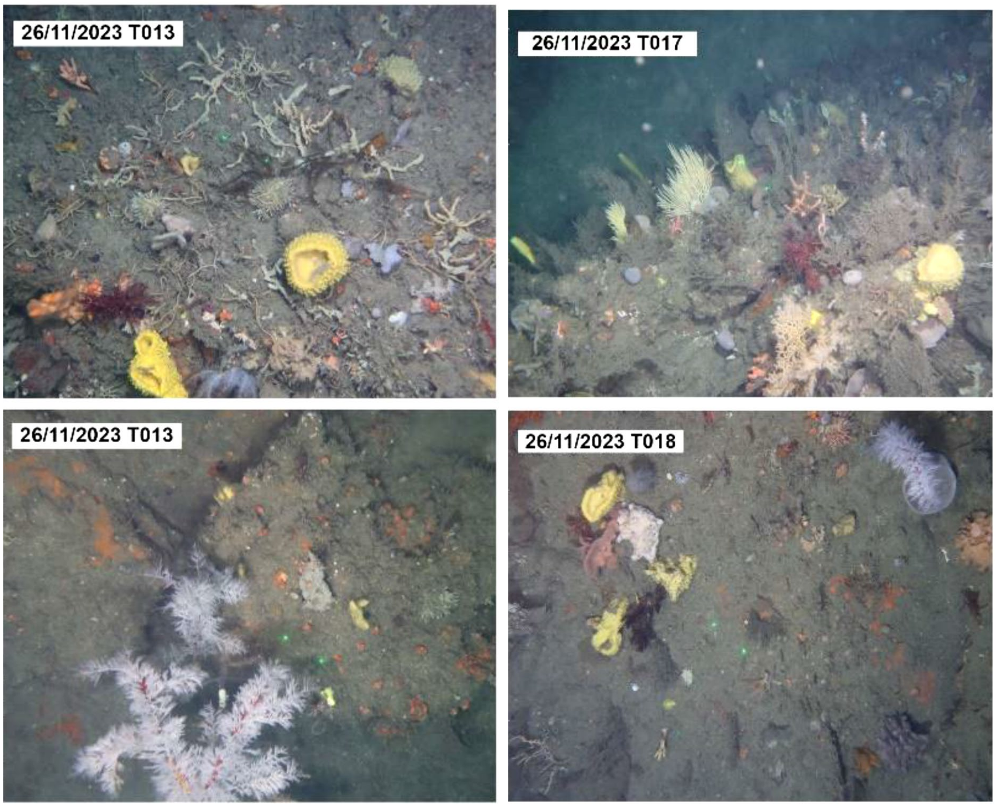


Figure 22. Examples of benthic fauna associated with mesophotic reefs within the Solitary Marine Park (Commonwealth) (modified from Ingleton et al. 2024)

The seabed in the Solitary Islands region contains a wide variety of soft-sediment types, with areas of sand, boulder, cobble and/or gravel habitats or even sand covered reefs (Jordan et al. 2010, Ingleton et al. 2024) (Figure 23). Little is known how these sediment variations influence mobile and sessile assemblages, although Schultz et al (2015) identified a strong pattern in fish assemblage structure in relation to habitat type, with distinct assemblages between 'gravel' and 'fine sand' habitats.

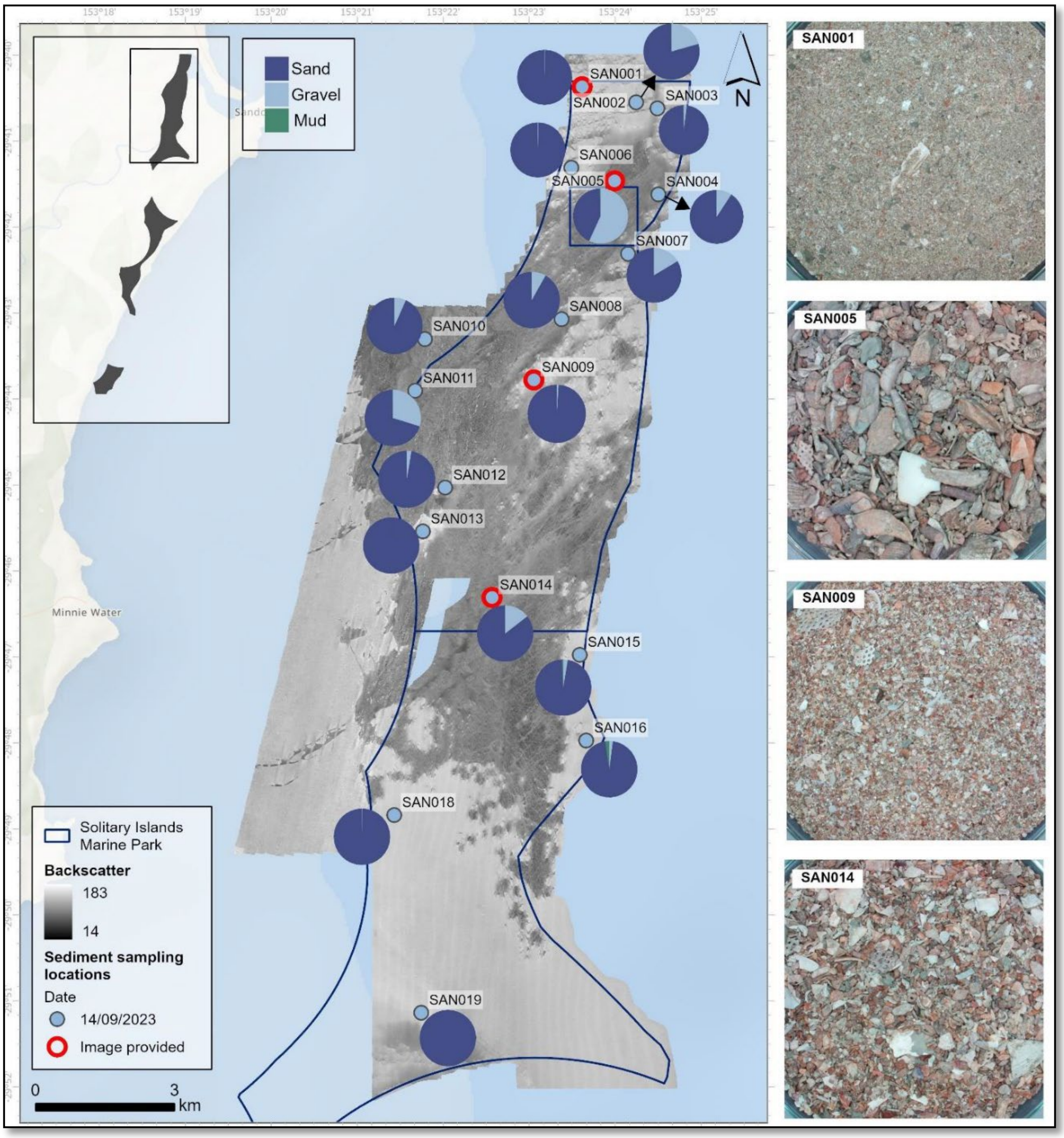


Figure 23. Backscatter mosaic, sediment sample locations and images of collected on shelf unvegetated habitat in the Solitary Islands Marine Park (Commonwealth) (From Ingleton et al. 2024).

3.5.2 Temporal surveys

There are limited temporal surveys on ecosystem components in the Solitary Islands Marine Park (Commonwealth), although these are principally restricted to mesophotic reefs at a limited number of locations (Table 6). The key exception to this is within the Pimpernel Rock National Park zone which has been the focus of regular divers surveys since 2001, fish surveys using BRUVs since 2007, and long-term acoustic listening stations (Malcolm et al.

2025, RLS 2026). These surveys have principally focused on the threatened species, grey nurse shark (*Carcharias taurus)* and black rockcod (*Epinephelus daemelii*) as Pimpernel Rock provides complex habitat for these species.

Both long-term patterns of tag detections and diver observations confirm that it is an important site for male and female adult grey nurse sharks throughout the year and among years (Otway and Louden 2025). However, no distinct apparent upward or downward trends are apparent in abundance, sex ratio, or length for grey nurse shark at Pimpernel Rock indicated from diver surveys conducted between 2015 and 2024 (Malcolm et al. 2025). Trends from Reef Life Survey monitoring at Pimpernel Rock since 2009 also indicate that the species has had stable numbers through time, with individual recorded on all transects in 2023 (RLS 2026).

Diver surveys indicate that abundance of black rockcod at Pimpernel Rock (Figure 24) show no long-term trend, with numbers fluctuating from 11 to 4 between 2010 and 2024. The overall trend from 2010 to 2024 indicates a slightly declining abundance from a peak in 2015, although the decline has flattened out since 2019 (Malcolm et al. 2025).

Figure 24. Black rockcod *E. daemelii* observed at Pimpernel Rock

Other regional long-term surveys of shallow reef fishes have focused on habitats within State waters of the Solitary Islands Marine Park using diver surveys (Malcolm et al. 2025, RLS 2026) and BRUVs (Malcolm et al. 2015, 2018, Knott et al. 2021). Most of these surveys were designed to evaluate temporal changes in fishes associated with marine park zoning by sampling no-take and partially protected zones, and areas outside of the marine park.

Surveys on shallow reefs using BRUVs between 2002 and 2014 found snapper (*Chrysophrys auratus*) were significantly more abundant in no-take zones overall and in most years compared with the other zone types, which did not significantly differ (Malcolm et al. 2015). Snapper numbers rapidly increased after 2 – 3 years protection in all management types, especially in no-take zones, although there was considerable variation in abundance between years. In addition, more larger snapper were present in no-take zones, with 58%

legal-sized (>25.7 cm FL) compared to the other zones and outside sites that were dominated by individuals below legal size. This pattern of positive effects of no-take protection on *C. auratus* abundance is consistent on shallow reefs across NSW bioregions (Knott et al. 2021).

Table 6. Biodiversity surveys within the Solitary Islands Marine Park by ecosystem depth range and zone type. The extent of the park by ecosystem depth range and zone type is given in the first row. Classification of survey design standards is based on Foster et al. 2024 - Statistical Considerations for Monitoring and Sampling - NESP. Sites refers to spatially discrete sampling units at least 250 m apart.

Time	Sites	Platform	Ecosystem	Ecosystem Depth (m)	Zones	Reports	Survey design standards*
2016, 2023	1	RLS-UVC	Demersal and benthic fish, Benthic habitats, Mobile macroinverts, Sessile macroinverts	0-30	npz02	1, 2, 3, 4, 5	Preferential
2023	57	mono-Towed Video	Benthic habitats	0-30, 30-70	npz02, muz01, spt03	6	Representative
2010, 2023	45	mono-BRUV, stereo-BRUV	Demersal and benthic fish	0-30, 30-70	npz02, muz01, spt03	7	Preferential

1 Stuart-Smith, R.D., Ceccarelli, D., Edgar, G.J. and Cooper, A.T. (2017) 2016 Biodiversity surveys of the Cod Grounds and Pimpernel Rocks Commonwealth Marine Reserves. Report for Parks Australia, Department of the Environment. Reef Life Survey Foundation Incorporated.
2 Reef Life Survey (2017) Solitary Islands Marine Park. Report to Parks Australia.
3 Reef Life Survey (2026) Shallow reef biodiversity of the Solitary Islands Marine Park (Commonwealth waters). Report to Parks Australia.
4 Reef Life Survey (2026) Shallow reef biodiversity of the Temperate East Marine Parks Network. Report to Parks Australia.
5 Edgar, G.J., Ceccarelli, D., Stuart-Smith, R.D. and Cooper, A.T. (2017) Reef biodiversity surveys of Australia's Commonwealth Marine Reserve network: An overview. Report for Parks Australia, Department of the Environment. Reef Life Survey Foundation Incorporated.
6 Ingleton, T., Sutherland, M., Doszpot, N., Linklater, M., Doyle, T., Cruz, D., Morris, B., Jones, A., Ryall, B., Magos, J., Williams, A., Hanslow, D, and Bilham, K (2024). Mapping and characterising seabed habitats of Australia's Solitary Islands Marine Park. Report to the Director of National Parks, Department of Climate Change, Energy, the Environment and Water. Australian Government.
7 Malcolm, H.A., Schultz, A.L., Louden, B. and Harasti, D. 2025. June Pimpernel Rock NPZ benefits grey nurse shark, black rockcod, and fish diversity. A summary of Diver Survey and Baited Remote Underwater (BRUV) fieldwork conducted 2001 to 2024 in Pimpernel Rock National Park Zone (NPZ), Solitary Islands Marine Park (Commonwealth waters). NSW Department of Primary Industries and Regional Development. Unpublished Report to Commonwealth Marine Parks.

3.6 Cod grounds

3.6.1 Ecosystems and ecosystem components

The Cod Grounds Marine Park is a small (approximately 4 km²) but fully protected National Park zone that is located on the mid-shelf region offshore of Camden Haven approximately 30 km south of Port Macquarie, New South Wales. The marine park was established primarily to protect critical aggregation habitat for the grey nurse shark (*Carcharias taurus*). The marine park ranges in depths from 21 m near the centre point of the parks pinnacle reef to a maximum of 46 m in the southeast of the park. The reef forms a roughly circular outcrop approximately 800 m across, with the eastern side having a relatively gentle gradient averaging 1.8 degrees (NSW DECC 2008). The Cod Grounds reef 'pinnacle' is surrounded by areas of boulders and cobbles that overlie the bedrock formations. The pinnacle of reef within the marine park forms the northernmost and shallowest of three peaks extending toward the south-west from the centre point of the reserve. The seabed within the marine park consists of a number of different substrate types occurring across a range of depths and topography, contributing to a variety of habitat types.

The reef system sits within a more extensive rocky reef system that is known to extend for up to 20 km to the south-west (Jordan et al. 2010). Neighbouring reefs, outside the boundary of the reserve are similar in size (horizontal area) and topographic form as the marine park, although they do not rise to quite as shallow depths. The shallowest rocky peaks are relatively sparsely vegetated and are characterised by extensive urchin barrens, while deeper consolidated reef areas and adjacent boulder and cobble slopes support dense brown macroalgal communities. In deeper sections of the reef complex, benthic assemblages are increasingly dominated by sponges and ascidians.

Despite its limited spatial extent, the park supports a high conservation value assemblage of species, with listed fauna including one endangered, four vulnerable and five migratory species under the EPBC Act. Other protected species regularly recorded in the park include loggerhead turtles (*Caretta caretta*), great white sharks (*Carcharodon carcharias*), as well as diverse reef fish assemblages and wobbegongs. The park is therefore an important location for protecting a key habitat for regionally significant species.

Suitable grey nurse shark habitat is primarily concentrated on the eastern side of the outcrop, where slopes are steepest and exposed bedrock forms a series of sand- and cobble-filled gutters that provide shelter and aggregation sites. The reef complex extends beyond the current boundaries of the marine park, with additional pinnacles of similar size and character occurring to the south and south-west, although these features are not as shallow. It is likely that suitable grey nurse shark habitat also occurs at these adjacent sites. Portions of the reef system also extend into state waters, highlighting the broader spatial context of the habitat beyond the boundaries of the marine park.

3.6.2 Temporal surveys

There are limited temporal surveys on ecosystem components in the Cod Grounds Marine Park and principally restricted to mesophotic reefs at a limited number of locations (Table 7). The key time series information that is available comes from detections of acoustically tagged grey nurse shark (*Carcharias taurus*) over the period 2011 to 2021 (Otway and Louden 2025). Acoustically tagged *C. taurus* occurred at the Cod Grounds throughout the year, with adult males most prevalent in Autumn to Summer, and greater numbers of female *C. taurus* present over late Autumn to early Spring. This included reproductively active females ready to migrate north and mate, pregnant females migrating south to pup, and juvenile females (Otway and Louden 2025). Continuous occupations lasted for up to 18 days, although almost 88% and 87% of all occupations were ≤ 5 days in duration for male and female *C. taurus*, respectively This is consistent with earlier acoustic tracking studies at the Cod Grounds where 95% of individuals stayed for less than 10 days, but some individuals (i.e. pregnant females) had an occupation of up to 35 days (Otway and Louden 2017, 2019).

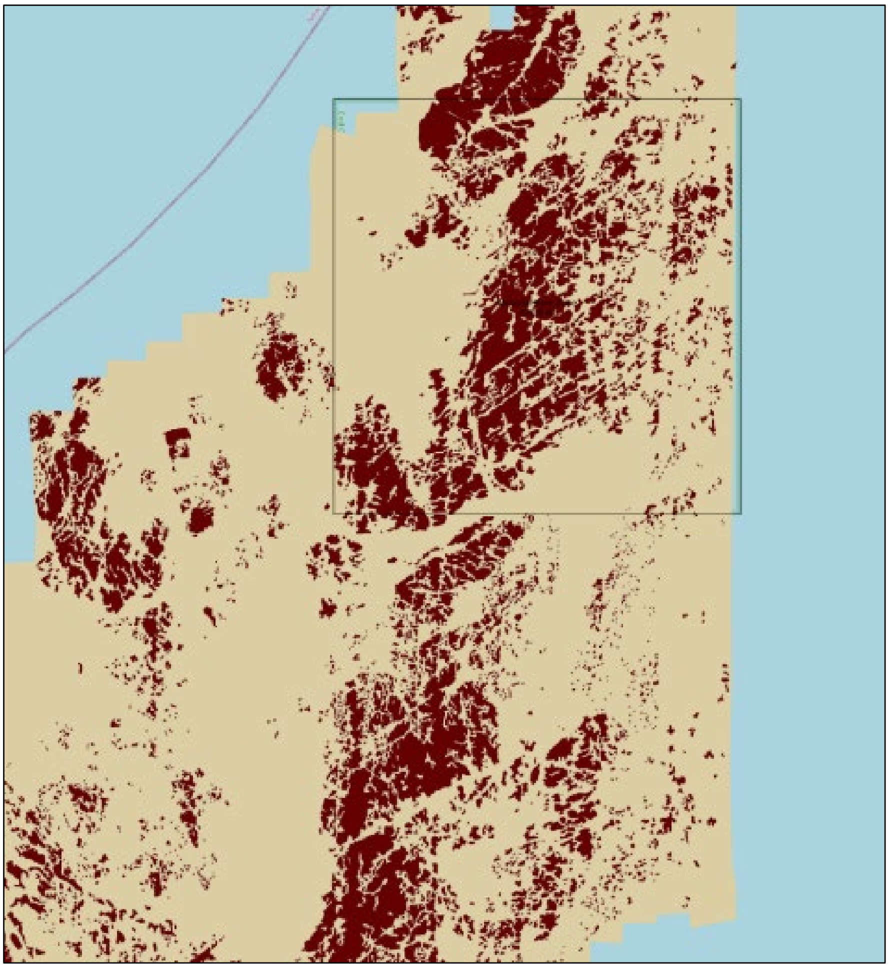


Figure 25. Distribution of seabed habitats in the Cod Grounds Marine Park (square box) and surrounding Commonwealth waters. Seamap Australia link https://seamapaustralia.org/map/#f8ad5558-5d14-4108-ae4c-d5d479523e79

The overall usage pattern of the site reflected: (1) the annual northerly migration of males to Qld waters; (2) their return (southerly) migration in Spring to mate; (3) the northerly migration (in Spring) of females for mating and thence to Qld waters for gestation; and (4) their return (southerly) migration in the following Autumn/Winter for parturition in NSW waters. This was most likely attributable to the presence of gestating females in Autumn and post-partum females in late Winter/Spring prior to mating.

More generally, the results from this study have also reinforced the previously documented patterns of relative abundance, usage, gender and size-composition of *C. taurus* at the Cod Grounds (Otway and Parker 2000, Parker and Bucher 2000, Otway et al. 2003, Otway & Burke 2004, Otway et al. 2009, Otway & Louden 2017, 2019). The continued use of this site indicates that it represents important habitat for *C. taurus* along the mid-north coast of NSW and will, most likely, be similarly occupied in the future. Importantly, the extensive use of the Cod Grounds by *C. taurus* for substantial periods of time throughout the year further supports the need to ensure that the sharks are adequately protected from potential fishing interactions that can occur at critical habitat sites (Otway and Parker 2000, Otway et al. 2003, Otway and Burke 2004, Otway et al. 2009, Robbins et al. 2013). Finally, the information obtained during this study, together with the previous studies, will form a firm basis for the future management of *C. taurus* aggregating at the Cod Grounds by the Commonwealth government.

In addition, as part of the Reef Life Survey program, quantitative underwater visual census surveys have been conducted at sites on shallow reefs in the marine park since 2009. The frequency of *C. taurus* on transects has increased since baseline surveys, with individuals recorded on 50% of surveys conducted in 2023, and the pinnacle supporting a very large aggregation of >60 individuals. The clear increase between surveys could reflect either increased usage of the MP as an aggregation site, be a chance associated with timing of surveys, or relate to an improving eastern Australian population trend. Other shark species may also be benefiting from protection. Wobbegong sharks have increased slightly in frequency within the MP but are rarely observed at sites outside. Overall, sharks were recorded on 75% of surveys conducted within the park, which is high for any temperate Australian location.

Table 7. Biodiversity surveys within the Cod Grounds Marine Park by ecosystem depth range and zone type. The extent of the park by ecosystem depth range and zone type is given in the first row. Classification of survey design standards is based on Foster et al. 2024 - Statistical Considerations for Monitoring and Sampling - NESP. Sites refers to spatially discrete sampling units at least 250 m apart.

Time	Sites	Platform	Ecosystem	Ecosystem Depth (m)	Zones	Reports	Survey design standards*
2008	2	mono-Towed Video	Demersal and benthic fish	0-30, 30-70	hpz01	1	Preferential
2009, 2016, 2023	7	RLS-UVC	Demersal and benthic fish, Benthic habitats, Mobile macroinverts, Sessile macroinverts	0-30	hpz01	2, 3, 4, 5, 6, 7	Preferential
2011-2021	NA	Passive acoustic surveys	Pelagic fish	0-30, 30-70		8	Preferential

1 Davies, P., Jordan, A., Ingleton, T., Neilson, J., Mesley, E. and Pritchard, T. 2008. Cod Grounds Commonwealth Marine Reserve: Swath survey and habitat classification. Final report to the Department of the Environment, Water, Heritage and the Arts, 37pp.
2 Stuart-Smith, R.D., Ceccarelli, D., Edgar, G.J., Cooper, A.T. 2017. 2016 Biodiversity surveys of the Cod Grounds and Pimpernel Rocks Commonwealth Marine Reserves. Report for Parks Australia, Department of the Environment. Reef Life Survey Foundation Incorporated.
3 Stuart-Smith, R.D., Stuart-Smith, J., Cooper, A. and Edgar, G. 2009. Baseline biodiversity survey of the Cod Grounds Commonwealth Marine Reserve. Report to the Dept of the Environment, Water, Heritage and the Arts.
4 Reef Life Survey 2017 Cod Grounds Marine Park. Report to Parks Australia.
5 Reef Life Survey 2026 Shallow reef biodiversity of the Cod Grounds Marine Park. Report to Parks Australia.
6 Reef Life Survey 2026. Shallow reef biodiversity of the Temperate East Marine Parks Network. Report to Parks Australia.
7 Edgar, G.J., Ceccarelli, D., Stuart-Smith, R.D. and Cooper, A.T. 2017. Reef biodiversity surveys of Australia's Commonwealth Marine Reserve network: An overview. Report for Parks Australia, Department of the Environment. Reef Life Survey Foundation Incorporated.
8 Otway, N.M. and Louden, B.M. 2025. Occupation of aggregation sites and migratory movements of the Grey Nurse Shark (*Carcharias taurus*) off eastern Australia. NSW Department of Primary Industries and Regional Development. Port Stephens Fisheries Institute. September 2025.

3.7 Hunter Marine Park

3.7.1 Ecosystems and ecosystem components

The Hunter Marine Park extends from the eastern boundary of the Port Stephens-Great Lakes Marine Park across the shelf to around 130 km offshore and covers 6,257 km^2, and includes a Habitat Protection and Special Purpose (Trawl) zone. The inner part of the marine park is on the continental shelf, with the distance from the shore to the shelf break (at ~200 m depth contours) ranging from 32 km offshore of Seals Rocks to ~52 km south of

Broughton Island (Figure 26). The eastern boundary extends across the continental slope and abyssal plain to depths >4000 m.

Offshore of the shelf break the marine park contains a mid-slope escarpment incised by numerous gullies, slide scars and small box canyons (Figure 26). A large box canyon occurs at the southern end of the park, which represents the northern section of the Hunter Canyon complex. South of the park tributary linear canyons extend up to the outer shelf. Extending along the base of the continental slope there are a series of wide terraces that step down to the abyssal plain. The Manning Canyon lies just to the north of the park. Overall, the park extends from the relatively narrow continental shelf to a steep, canyon-incised continental slope and adjacent offshore environments, creating strong physical and biological gradients over relatively short distances.

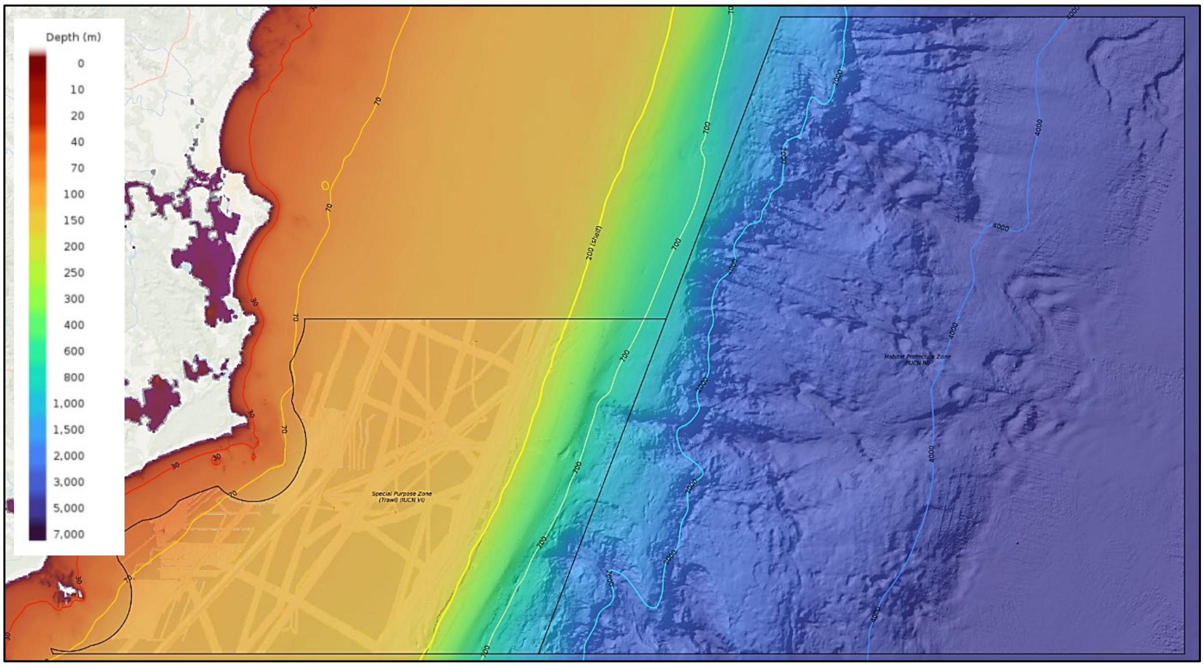
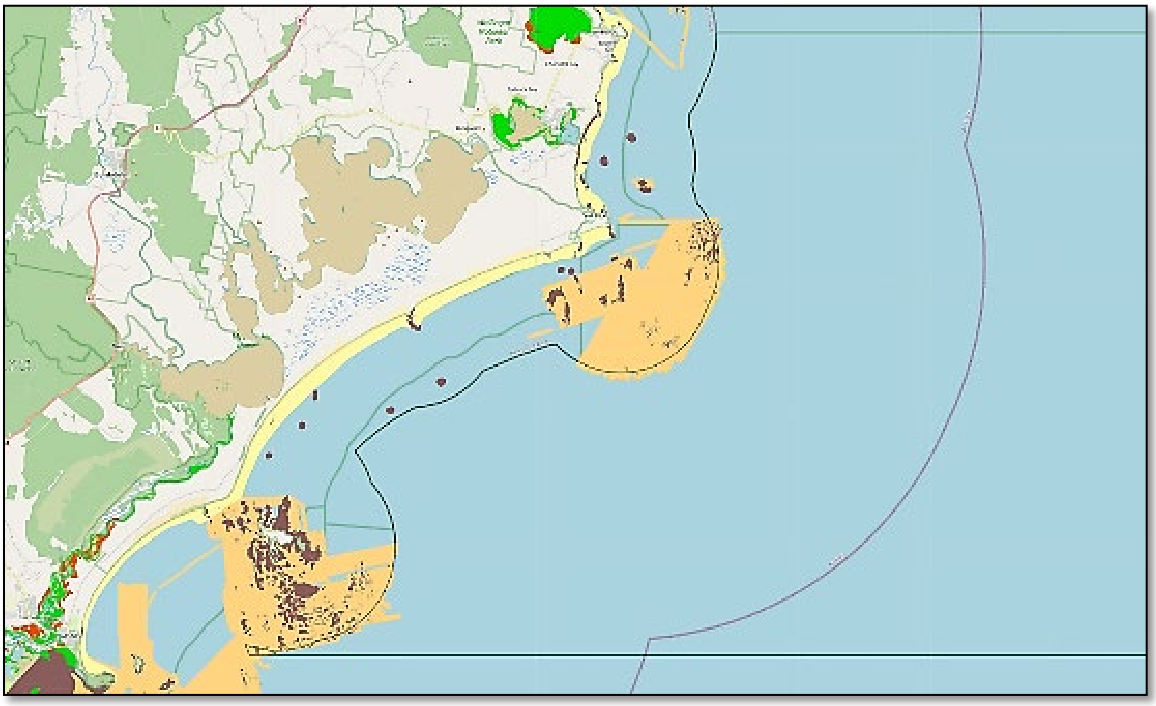


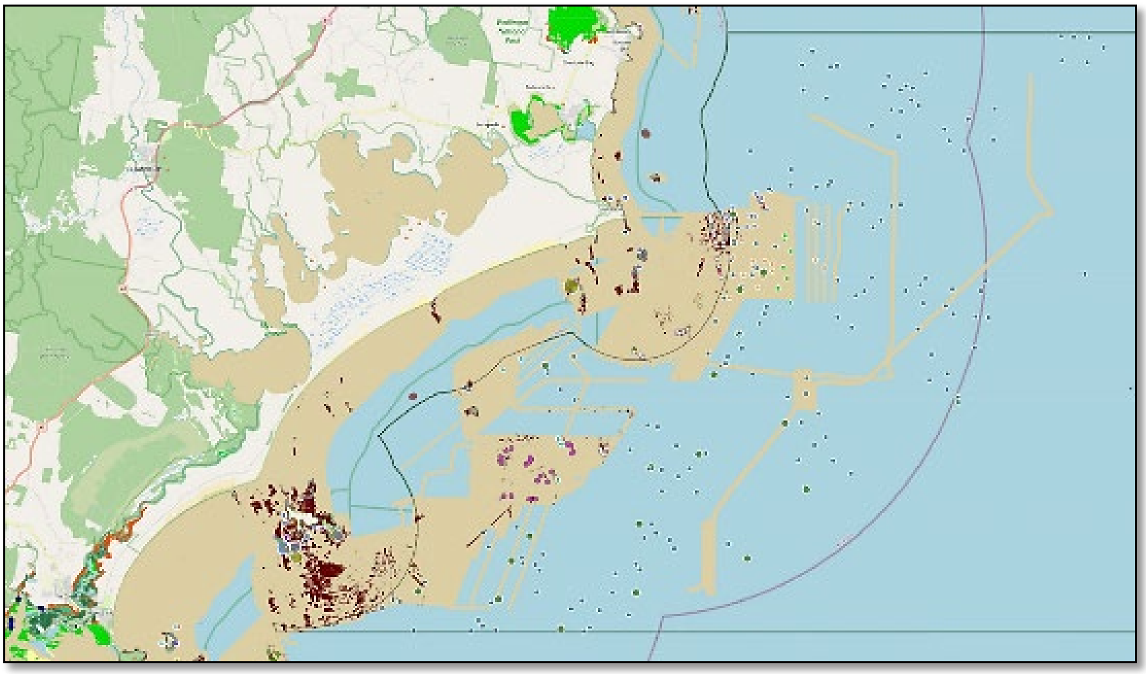
Figure 26 Broadscale bathymetry of Hunter Marine Park, including depth contours representing boundaries between ecosystem types. Seamap Australia link: https://seamapaustralia.org/map/#8dd610d8-062b-4156-b390-85d4da373f9e

High-resolution bathymetric mapping of seabed habitats has been significantly extended into the continental shelf areas of the Hunter Marine Park since 2016, which includes extensive video-based surveys of benthic habitats and fishes across the continental shelf (Figure 27). This has been complemented by extensive mapping and fish surveys in nearshore waters (Williams et al. 2020, Knott et al. 2021), resulting in a significant improvement in the understanding of the distribution and extent of shelf ecosystems.

The new mapping has identified isolated rocky reef features offshore of Seal Rocks, Outer Gibber and offshore Broughton (Williams et al. 2020). This includes both mesophotic and rariphotic reefs set within a broad area of shelf unconsolidated sediments. Many reefs are separated by unconsolidated sediments that results in a complex mosaic of reefs, with many being continuous to zones within the State marine park. In the Hunter Marine Park the 70 m contour is close to the inner boundary of the park, and there is evidence of these patchy reefs extend from the state marine park onto the midshelf region (Williams et al. 2020). These are rocky reefs contain assemblages consistent with those found more broadly at those depths along the NSW continental shelf (Jordan et al. 2010). A larger area of rariphotic reef is predicted to occur along the western edge of the shelf break (Figure 28), within limited mapping confirming its presence in the southern area of the marine park (Figure 31).



A



B

Figure 27 Distribution of seabed habitats in the continental shelf areas of the Hunter Marine Park (State and Commonwealth waters) as defined in A. 2016 and B. 2026. Dots on B represent sample sites using towed video, AUV or BRUVs as detailed in Table 8.

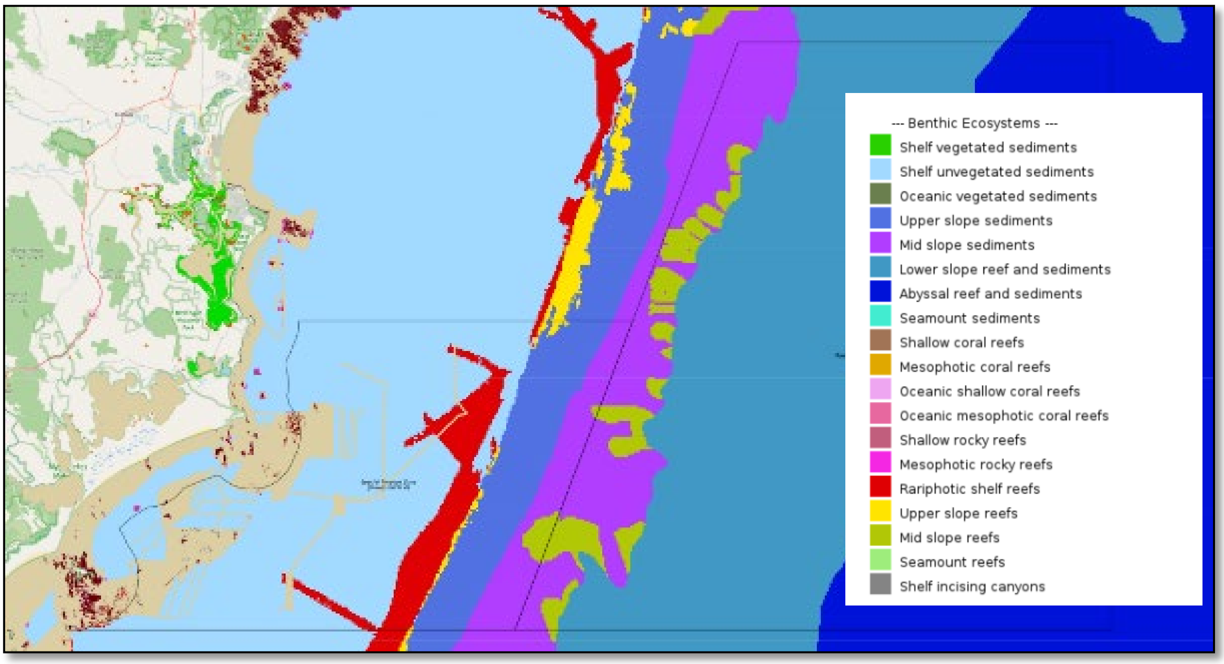


Figure 28 Distribution of benthic ecosystems across the slope region of the Hunter Marine Park. Seamap Australia link: https://seamapaustralia.org/map/#9f46b32e-48ee-4545-8ddd-80e5d81b5ce1

Unvegetated sediments dominate the shelf region of the Hunter Marine Park, although mapping is limited mostly to the inner shelf. Soft sediments features can be characterised as flat low slope plains, platform/plateau plains, bedform plains or a trough, channel-shaped seabed landform offshore of Seal Rocks/Sugarloaf Point (Williams et al. 2020). The shelf unvegetated sediments range from coarse sand in the shallower areas through to fine mud on the mid to outer shelf (Jordan et al. 2010, Williams et al. 2020) (Figure 29).

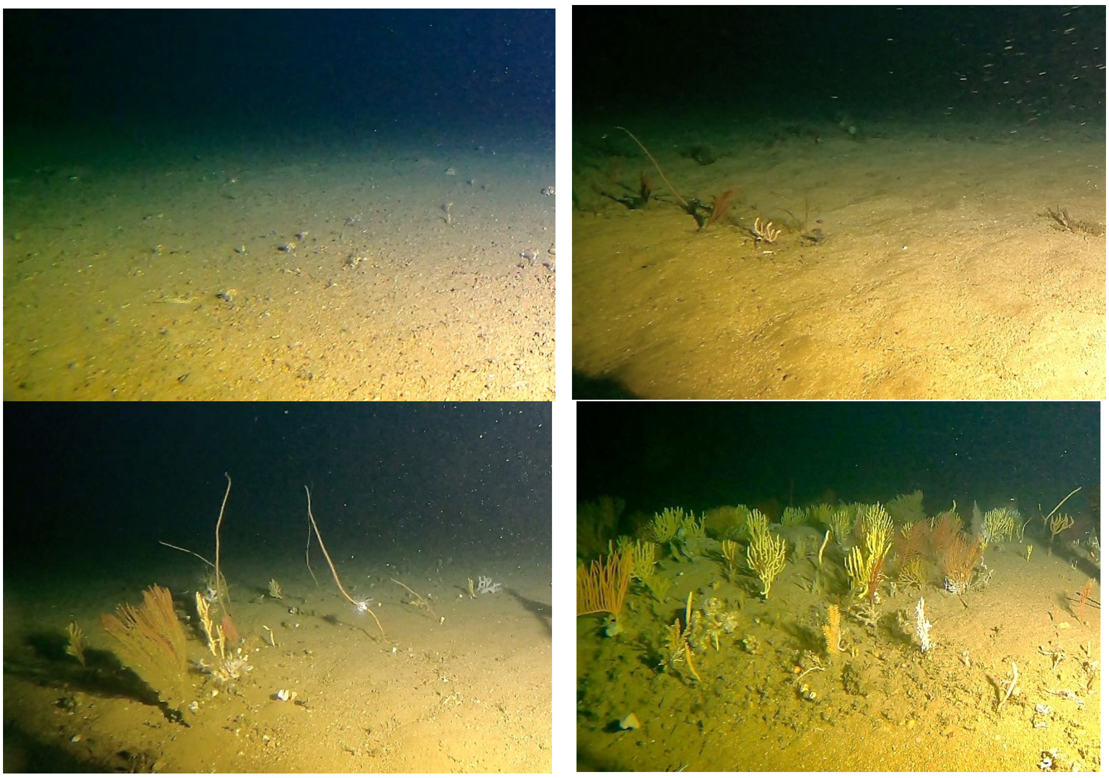


Figure 29 Example of shelf unvegetated sediments in the Hunter Marine Park (Images from Seamap Australia)

These fine sediments result from discharge of sediment laden water primarily from the Hunter River, particularly during flood events. They support a high density of infaunal burrows, likely reflecting elevated organic inputs from adjacent river systems. There are also a range of sessile invertebrates associated with the unvegetated sediments that vary in species composition and abundance (Figure 29), with this gradient resulting in some areas containing areas of 'functional reef (see Figure 5).

Towed video transects identified a range of benthic and pelagic organisms within the Hunter Marine Park across depths out to ~110 m within the Hunter Marine Park (Williams et al. 2020). Benthic communities on reefs were dominated by branching sponges, corals, sea whips with symbiotic brittle stars, sea stars and urchins (Figure 30). Towed video surveys (IN2026_T03) conducted in July 2026 confirmed the presence rariphotic reefs on the shelf break region of the Hunter Marine Park, with these habitats containing a range of sessile invertebrates (Figure 31).

Figure 30 Examples of mesophotic reefs within the inner shelf region of the Hunter Marine Park (from Williams et al. 2020).

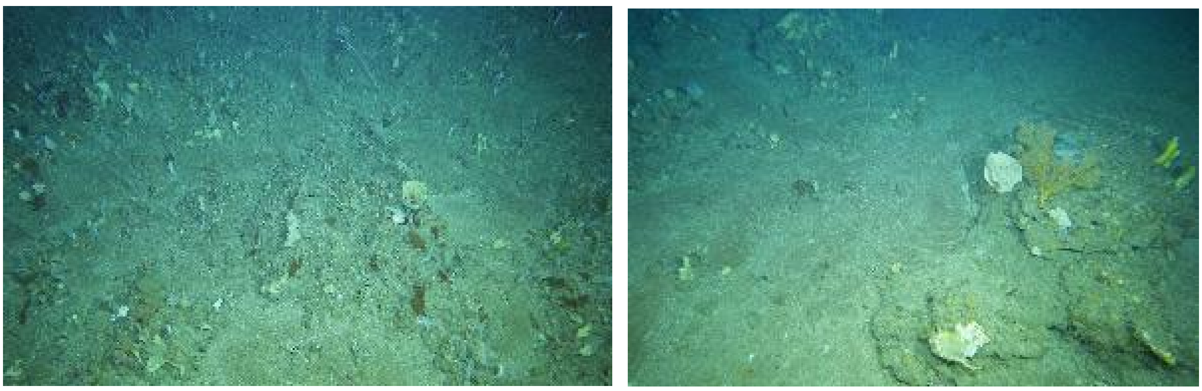


Figure 31 Examples of fauna on rariphotic reefs on the shelf break region of the Hunter Marine Park (Williams unpubl. data)

Research has demonstrated that these shelf habitats within the Hunter region support diverse and structured fish assemblages, including a mix of demersal, bentho-pelagic and pelagic species (Figure 33) (Williams et al. 2018, 2020, Monk et al. in prep). highly abundant species schooling species including the yellowtail scad (*Trachurus novaezelandiae*), Australian mado (*Atypichthys strigatus*) and redfish (*Centroberyx affinis*) and two of the most important fishery species, pink snapper (*Chrysophrys auratus*) and blue morwong (*Nemadactylus douglassi*) (Figure 32). This research has highlighted the importance of depth, substrate type and proximity to reef features in shaping fish community composition, with elevated diversity and biomass often associated with shelf-break and slope environments.

Figure 32. A selection of the fish assemblages recorded using stereo-BRUV on reef habitats in 80-100 m of water in the Hunter Marine Park. a) An example of mado (*Atypichthys strigatus*) and ocean leatherjacket (*Nelusetta ayraudi*). b) An example of Port Jackson shark (*Heterodontus portusjacksoni*) and silver sweep (*Scorpis lineolata*). c) An example of a school of nannygai (*Centroberyx affinis*) and an eastern wirrah (*Acanthistius ocellatus*). d) A conger eel (*Conger verreauxi*) and a school of nannygai (*Centroberyx affinis*). e) An example of a school of pearl perch (*Glaucosoma scapulare*), mado (*Atypichthys strigatus*), and Port Jackson shark (*Heterodontus portusjacksoni*). f) An example of a teraglin (*Atractoscion aequidens*).

Recent surveys (Monk et al. in prep; videos) spanning the continental shelf of the Hunter marine park suggest that the most abundant fish species include mackerel/scad (*Trachurus* spp.), mado (*Atypichthys strigatus*), leatherjacket (*Nelusetta ayraudi*) (Figure 32), and silver trevally (*Pseudocaranx georgianus*), each showing moderate abundance values (around 600–900) and exhibit broad distribution across the shelf. Pink snapper (*Chrysophrys auratus*) also contributed noticeably, while the eastern fiddler ray (*Trygonorhina fasciata*) and eastern shovelnose ray (*Aptychotrema rostrata*) appeared less often, consistent with their more solitary, bottom-dwelling habits. Redfish (*Centroberyx affinis*) and rough leatherjacket (*Meuschenia scaber*) were recorded only occasionally, but their presence remains ecologically relevant, particularly given redfish's association with deeper shelf habitats.

The spatial distribution of fish species across the Hunter continental shelf was heterogeneous and ecologically informative. Fish species with the widest distributions, such as ocean leatherjacket (*Nelusetta ayraudi*), eastern fiddler ray (*Trygonorhina fasciata*), and eastern shovelnose ray (*Aptychotrema rostrata*), were detected across a broad range of shelf habitats. In contrast, pelagic and demersal species including silver trevally (*Pseudocaranx georgianus*), spotted wobbegong (*Orectolobus maculatus*) and pink snapper (*Chrysophrys auratus*) showed more localised patterns, with sightings clustered primarily offshore of Seal Rocks and Outer Gibber in areas likely associated with reef and mixed-substrate environments. Elasmobranchs, including both batoids (*Trygonorhina fasciata*, *Aptychotrema rostrata*) and sharks such as gummy shark (*Mustelus antarcticus*), Port Jackson shark (*Heterodontus portusjacksoni*), and sawshark (*Pristiophorus cirratus*), were recorded across multiple sites but tended to cluster in mid-shelf habitats, consistent with their known affinities for sandy and mixed substrates at shallower shelf depths.

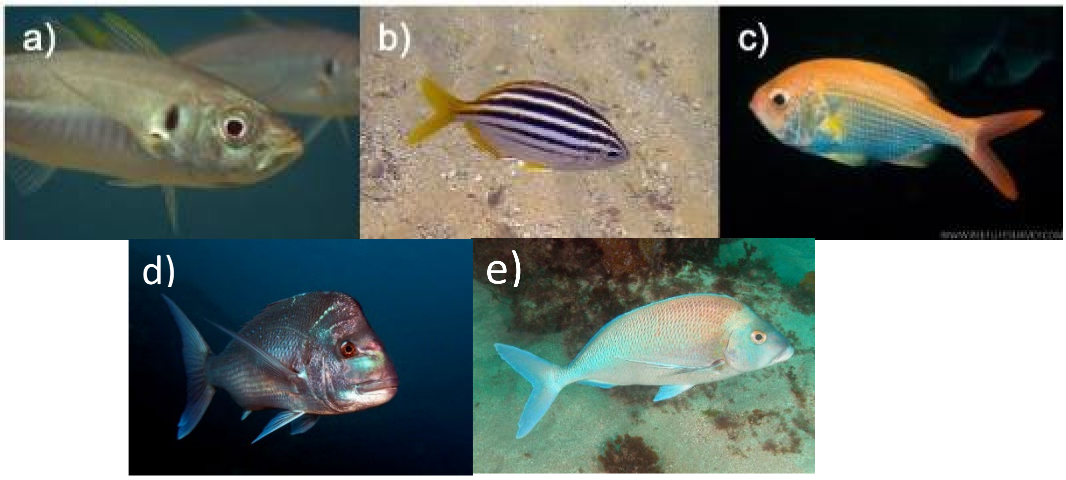


Figure 33 Examples of some of the highly abundant species schooling species a) yellowtail scad (*Trachurus novaezelandiae*), b) Australian mado (*Atypichthys strigatus*) and c) redfish (*Centroberyx affinis*) and two of the most important fishery species d) pink snapper (*Chrysophrys auratus*) and e) blue morwong (*Nemadactylus douglassi*). Photo credits: Reef Life Survey and David Harasti (From William et al. 2020).

By biomass, the assemblage was dominated by large-bodied pelagic and carcharhiniform species, with tiger shark (*Galeocerdo cuvier*) contributing the greatest cumulative mass of any recorded fishes, followed by white shark (*Carcharodon carcharias*), leatherjacket (*Nelusetta ayraudi*), pink snapper (*Chrysophrys auratus*), and silver trevally (*Pseudocaranx georgianus*). This pattern reflects the disproportionate influence of large, intermittently detected elasmobranchs on biomass estimates, a well-recognised feature of BRUV-derived assemblage data in Australian shelf systems. The presence of large carcharhinids, including tiger and white sharks, highlights the functional importance of the Hunter shelf as foraging habitat for apex predators and aligns with the broader role of continental shelf environments in supporting large, mobile species that move across multiple habitat types.

Collectively, the BRUV data reveal a fish assemblage that is diverse in taxonomic composition, heterogeneous in spatial distribution, and structured by a combination of habitat type, depth, and proximity to reef features. The co-occurrence of demersal elasmobranchs, reef-associated teleosts, and large pelagic predators within a relatively compact survey area reflects the ecological connectivity and habitat mosaic characteristic of the Hunter continental shelf. These findings build on and corroborate the patterns documented by Williams et al. (2020), reinforcing the importance of substrate heterogeneity and shelf-break proximity in driving elevated diversity and biomass, and highlighting the conservation significance of the Hunter region for both commercially targeted species and functionally important elasmobranch fauna.

Research published during this study reported that the fish assemblage of the mesophotic reefs of the Hunter Marine Park were distinct from the state managed Port Stephens – Great Lakes Marine Park that covers reef in <40 m of water (Williams et al. 2019). However, the abundance of fishery targeted species was very similar across the depth range sampled. Interestingly, key fishery species weren’t necessarily more abundant but were larger in size in the Hunter Marine Park when compared to the Port Stephens - Great Lakes Marine Park (Williams et al. 2019).

Mapping and biological surveys of the slope region of the Hunter Marine Park by O’Hara (2019) revealed that faunal assemblages are strongly structured by depth and latitude, with clear separation between temperate and tropical communities at lower bathyal and abyssal depths. Hunter Marine Park lies between these tropical and temperate regions and consistently exhibits intermediate characteristics, highlighting its function as a biogeographic transition zone.

Seabed habitats across the parks are shaped by rugged continental margin topography, including box canyons, escarpments, terraces and exposed hardgrounds. These features create strong environmental gradients over relatively short distances and support a wide range of benthic taxa, including sponges, octocorals, echinoderms, crustaceans, molluscs and deep-sea fishes (Figure 34), many of which are undescribed or represent significant range extensions Patterns of abundance and diversity are closely linked to gradients in surface productivity and the flux of organic matter to the seafloor, rather than to water mass properties alone.

The region represents one of the first areas where systematic sampling has demonstrated that strong biogeographic structuring persists to depths exceeding 4000 m, despite relatively uniform deep-water temperature and chemistry. Together, the parks that contain these slope regions protect a diverse mosaic of slope, canyon and abyssal environments that support taxonomically rich and compositionally distinct benthic assemblages.

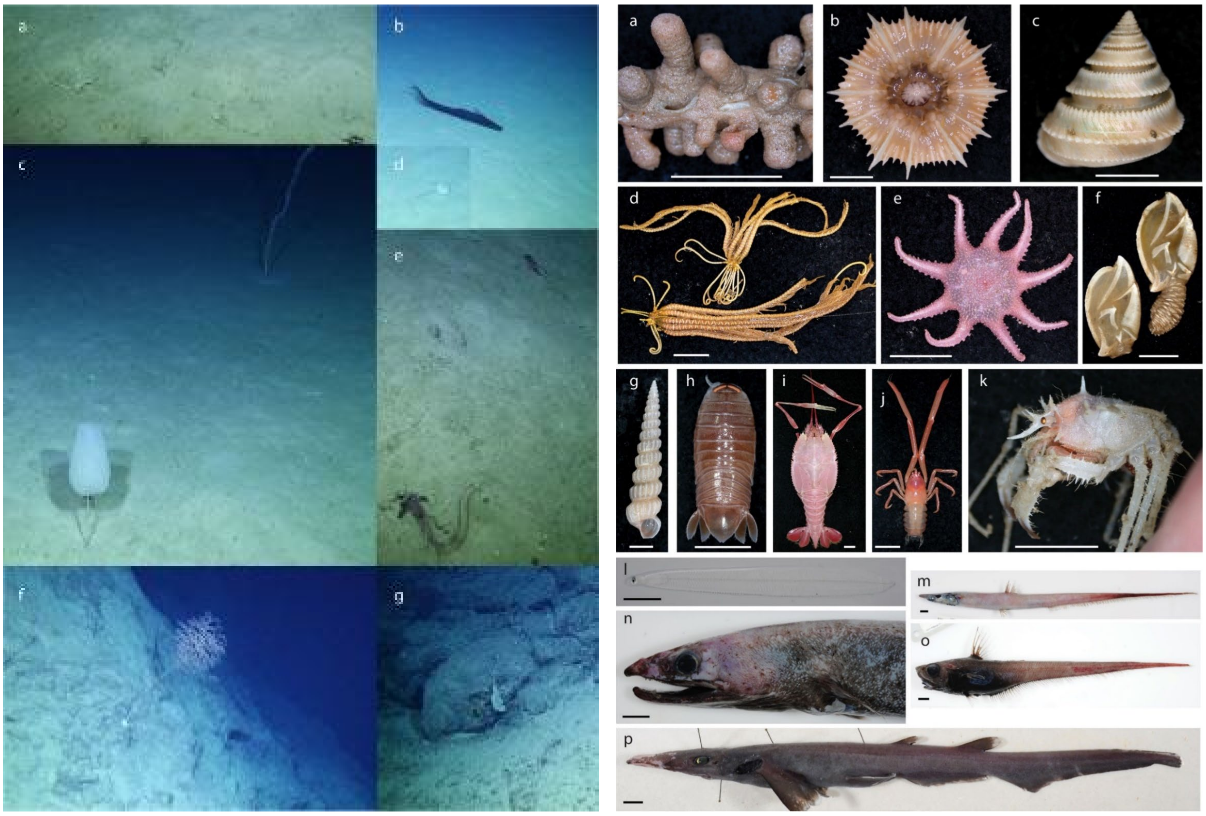


Figure 34 Examples of benthic biota within the slope ecosystems of the Hunter Marine Park. (From O'Hara 2019).

3.7.2 Temporal surveys

There are limited temporal surveys on ecosystem components in the Hunter Marine Park, and principally restricted to mesophotic and rariphotic reefs, and mainly focussed on fish assemblages (Table 8). Other regional long-term surveys of shallow reef fishes have focused on habitats within State waters of the Port Stephens-Great Lakes Marine Park using diver surveys (RLS 2026) and BRUVs (Malcolm et al. 2015, 2018, Knott et al. 2021). Most of these surveys were designed to evaluate temporal changes in fishes associated with marine park zoning by sampling no-take and partially protected zones, and areas outside of the marine park.

Surveys on shallow reefs using BRUVs between 2002 and 2014 found snapper (*Chrysophrys auratus*) were significantly more abundant in no-take zones overall and in most years compared with the other zone types, which did not significantly differ (Malcolm et al. 2015). Snapper numbers rapidly increased after 2 – 3 years protection in all management types, especially in no-take zones, although there was considerable variation in abundance between years. In addition, more larger snapper were present in no-take zones, with 58% legal-sized (>25.7 cm FL) compared to the other zones and outside sites that were dominated by individuals below legal size. This pattern of positive effects of no-take protection on *C. auratus* abundance are consistent on shallow reefs across NSW bioregions (Knott et al. 2021).

Table 8. Biodiversity surveys within the Hunter Marine Park by ecosystem depth range and zone type. The extent of the park by ecosystem depth range and zone type is given in the first row. Classification of survey design standards is based on Foster et al. 2024 - Statistical Considerations for Monitoring and Sampling - NESP. Sites refers to spatially discrete sampling units at least 250 m apart.

Time	Sites	Platform	Ecosystem	Ecosystem Depth (m)	Zones	Reports	Survey design standards*
2017, 2026	10	Deep Tow Camera seabed imagery, Beam trawl, Sled net	Benthic habitats, Demersal and benthic fish, Mobile macroinverts	200-700, 700-2000, 2000-4000	npz02, spz01	1,2	Preferential
2016, 2017, 2018	40	stereo-BRUV	Demersal and benthic fish	30-70	spt01	3	Preferential
2018	4	AUV	Benthic habitats, Sessile macroinverts	30-70	spt01		Preferential
2018	200	mono-Towed Video	Benthic habitats	30-70, 70-200	spt01	3	Representative
2025	200	stereo-BRUV	Demersal and benthic fish, Benthic habitats	30-70, 70-200	spt01	4	Representative
2025	150	stereo-ROV	Demersal and benthic fish, Benthic habitats, Sessile macroinverts	30-70, 70-200	spt01	4	Representative

1 INV2017_v03. https://www.csiro.au/en/about/facilities-collections/mnf/voyages-schedules/voyages/2017/may/in2017_v03
2 INV2026_t03. https://www.csiro.au/en/about/facilities-collections/mnf/voyages-schedules/voyages/2026/july/in2026_t03
3 Williams, J., Ingleton, T., Sutherland, M., Davies, P., Monk, J., Barrett, N. and Jordan, A. (2020). Mapping and characterising reef habitat and fish assemblages of the Hunter Marine Park. Report to the National Environmental Science Program, Marine Biodiversity Hub. NSW Government.
4 Monk, J., Bastiaansen, A. and Hulls, J. (in prep). Hunter Marine Park: synthesis of benthic ecosystem and demersal fish natural value data. Report to the National Environmental Science Program, Marine Biodiversity Hub.

3.8 Central Eastern Marine Park

3.8.1 Ecosystems and ecosystem components

The Central Eastern Marine Park extends from the upper continental slope as a narrow section ~ 45 km wide offshore of Coffs Harbour, NSW to across the abyssal plain of the Tasman Sea before widening into a T-shape at around 220 km offshore that then extends north to an area at 30.4°S (see Figure 3). The marine park in the east-west section nearest the coast is characterised by a large complex box canyon near the northern boundary and a smaller canyon complex, known as the Coffs Canyon at the southern end (Figure 35, 35) (O'Hara 2019). This northern canyon is fed by several rugose linear canyons which widen into gullies at ~1800 m before combining into the box canyon complex at 3500 m.

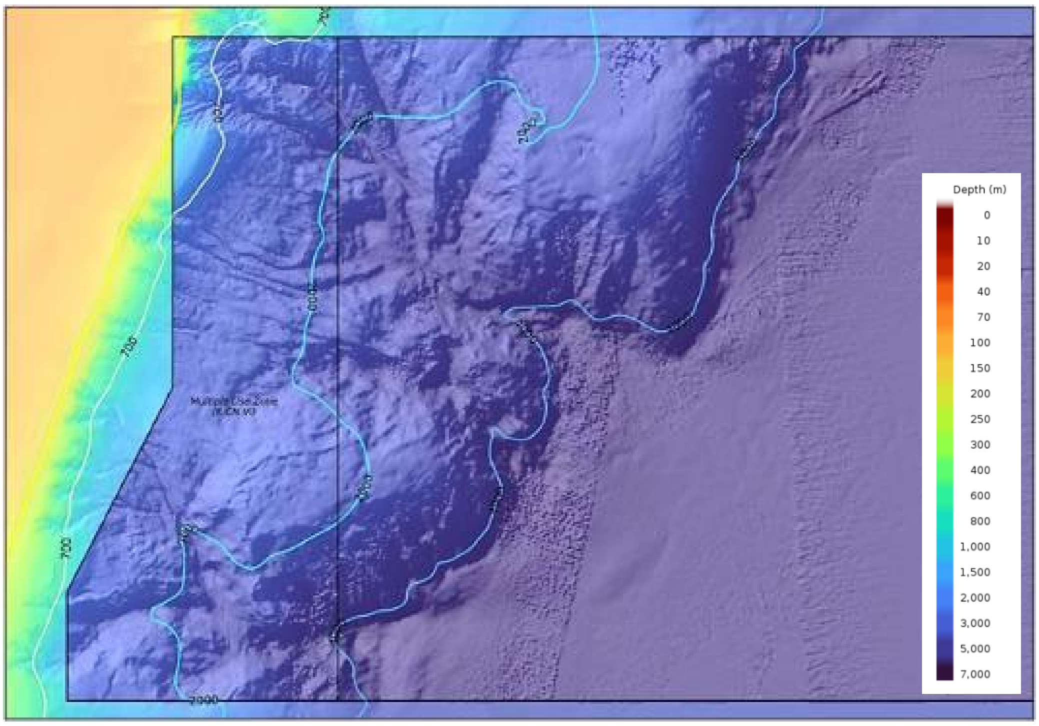


Figure 35 Broadscale bathymetry of the western section of the Central East Zone including depth contours representing boundaries between ecosystem types. Seamap Australia link: https://seamapaustralia.org/map/#36ea9cf6-9a20-434e-bff8-290bbe4511b8

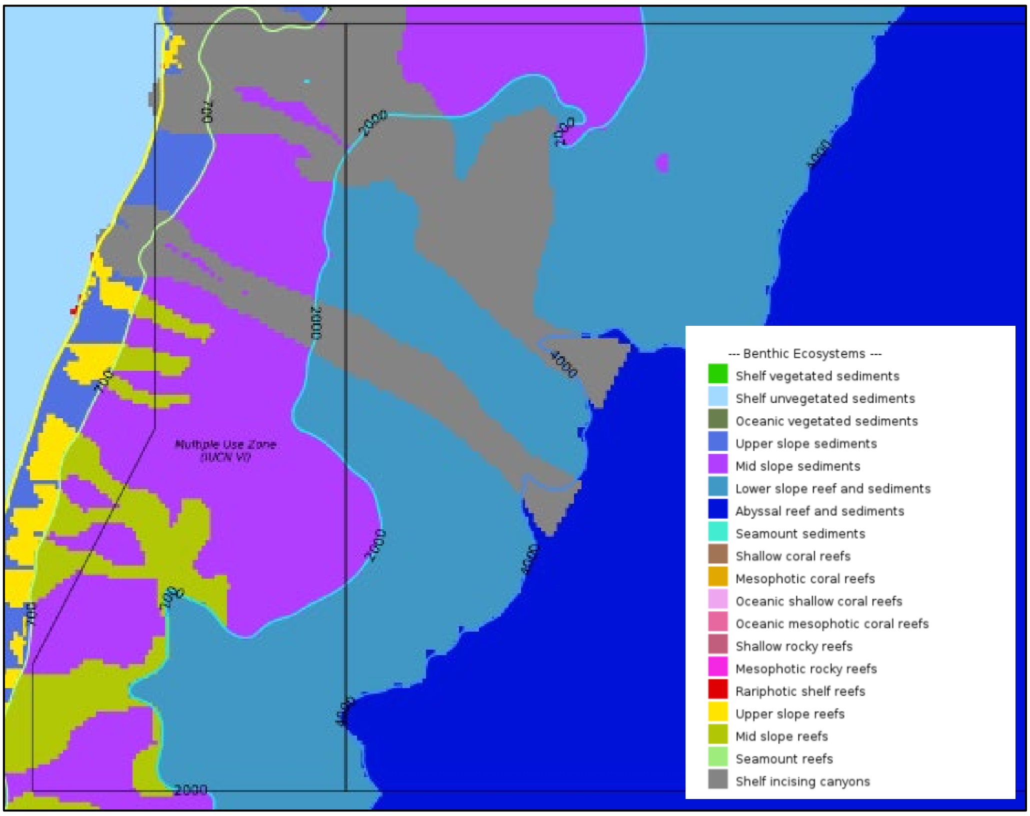


Figure 36. Distribution of ecosystem types across the continental slope region of the western section of the Central East Marine Park. Seamap Australia link: https://seamapaustralia.org/map/#be8c860a-8811-416a-a09b-e97b1adf3ad1

Solitary Canyon is characterised as a steep complex ecosystem dominated by unconsolidated sediments (~ 97.7% of the seafloor) with the remaining small areas containing hard substrates are rare (~2.3%) (Sloyan et al. 2026). These occur throughout the canyon as thinly stratified or blocky outcrops supporting reef communities. The presence of a large submarine fan at ~4300 m depth, and evidence of erosion and bioturbation indicate that the Solitary Canyon contains processes that continue to shape habitat structure and availability.

Detailed information on the oceanographic, bathymetry and benthic assemblages in depths from 85 m to 3477 m in the Solitary Canyon and its surrounding environments is detailed in Sloyan et al. (2026) based on a voyage on *RV Investigator* in 2024. There is a convex sediment-draped upper slope that extends between the two canyons, with the canyons connected by mid-slope sediments (Figure 36). The lower slope region is narrow in this section of the marine park, with an erosional moat present at the base of the scarp in the soft calcareous sediments of the inner edge of the abyssal plain.

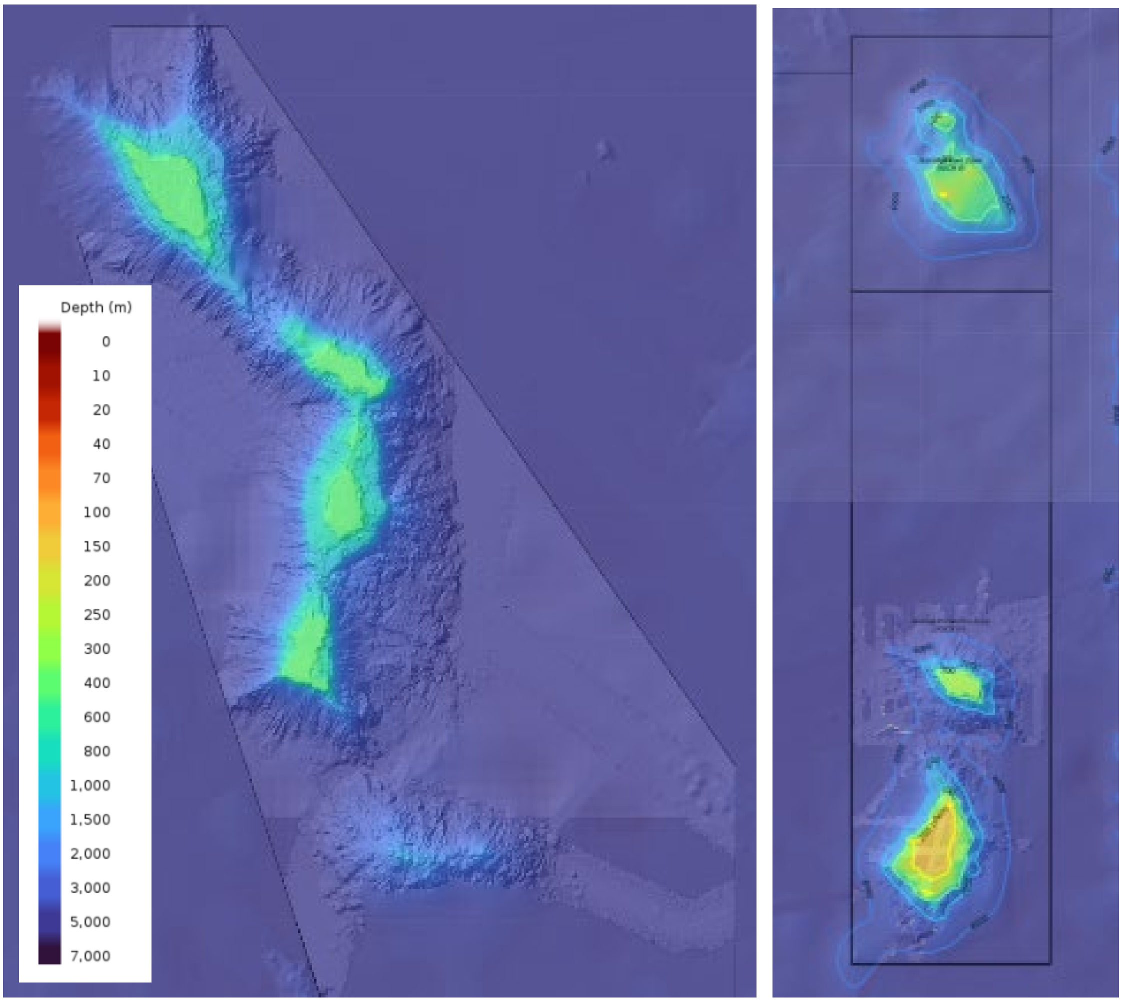


Figure 37 Broadscale bathymetry of the northern and southern sections of the Central Eastern Marine Park, (From O'Hara 2019, Seamap Australia link: https://seamapaustralia.org/map/#dd7c8bf2-fd57-4ead-bfcc-f83e88f6a12f, https://seamapaustralia.org/map/#bb3e10d8-8080-46e8-b4e6-fb4f20104f6d

The offshore section of the Central East Marine Park runs north-south from around the Queensland seamount in the north to the Taupo Seamount in the south, collectively known as the Tasmantid seamount chain. The northern area containing the Queensland Guyot and

Britannia Guoyots are particularly prominent and extend for ~160 km to close to the northern boundary (Figure 37). These seamounts extend across depths of around 400 m to over 4000 m over short distances resulting in steep slopes from the upper to lower slopes that end to abyssal depths. A large area of lower slope habitats are particularly evident in the south-eastern corner of the seamounts.

The southern area of the offshore zone is characterised by the Derwent-Hunter Seamount, Barco Seamount and Taupo Seamount. The Taupo Seamount is the largest seamount at ~60 km in diameter at its base and rises from ~4800 m up to a flat shelf that is ~130 m deep and ~40 km north to south and up to 15 km wide. There are also many smaller unsurveyed and unnamed seamounts along marine park area. The seamounts slopes are mostly around 20 degrees but are much steeper in places and also form flat terraces reflecting historical sea levels.

Central Eastern Marine Park span an important section of Australia's eastern continental margin that encompasses upper bathyal to abyssal habitats and forms part of a major temperate–tropical transition zone in the deep sea. This marine park protects a diverse mosaic of slope, canyon and abyssal environments that support taxonomically rich and compositionally distinct benthic assemblages O'Hara (2019) (Figure 38). The region represents one of the first areas where systematic sampling has demonstrated that strong biogeographic structuring persists to depths exceeding 4000 m, despite relatively uniform deep-water temperature and chemistry. Seabed habitats across the parks are shaped by rugged continental margin topography, including box canyons, escarpments, terraces and exposed hardgrounds.

Research from O'Hara (2019) revealed that faunal assemblages are strongly structured by depth and latitude, with clear separation between temperate and tropical communities at lower bathyal and abyssal depths. Central Eastern Marine Park is characterised by distinctly tropical assemblages. These features create strong environmental gradients over relatively short distances and support a wide range of benthic taxa, including sponges, octocorals, echinoderms, crustaceans, molluscs and deep-sea fishes, many of which are undescribed or represent significant range extensions (Figure 38). Patterns of abundance and diversity are closely linked to gradients in surface productivity and the flux of organic matter to the seafloor, rather than to water-mass properties alone.

Targeted deep towed camera transects in the Solitary Canyon documented in Sloyan et al. (2026) provides an assessment of seafloor habitats and benthic communities on the mid (700–2000 m) and lower slopes (2000–4000 m) (Sloyan et al. 2026). Habitats were strongly dominated by unconsolidated sediments (>84% of observations), and while reef substrates were present at all depths and formed a secondary component they were most common on the upper slope (200–700 m) (Figure 39). Adjacent non-canyon areas showed less consistent reef occurrence, largely lacking reef on the upper and mid slopes.

Coral- and sponge-dominated assemblages were patchy but occurred on sediment-dominated habitats on the mid and lower slopes supported high invertebrate diversity, with the canyon supporting higher habitat heterogeneity than surrounding slope environments (Sloyan et al. 2026).

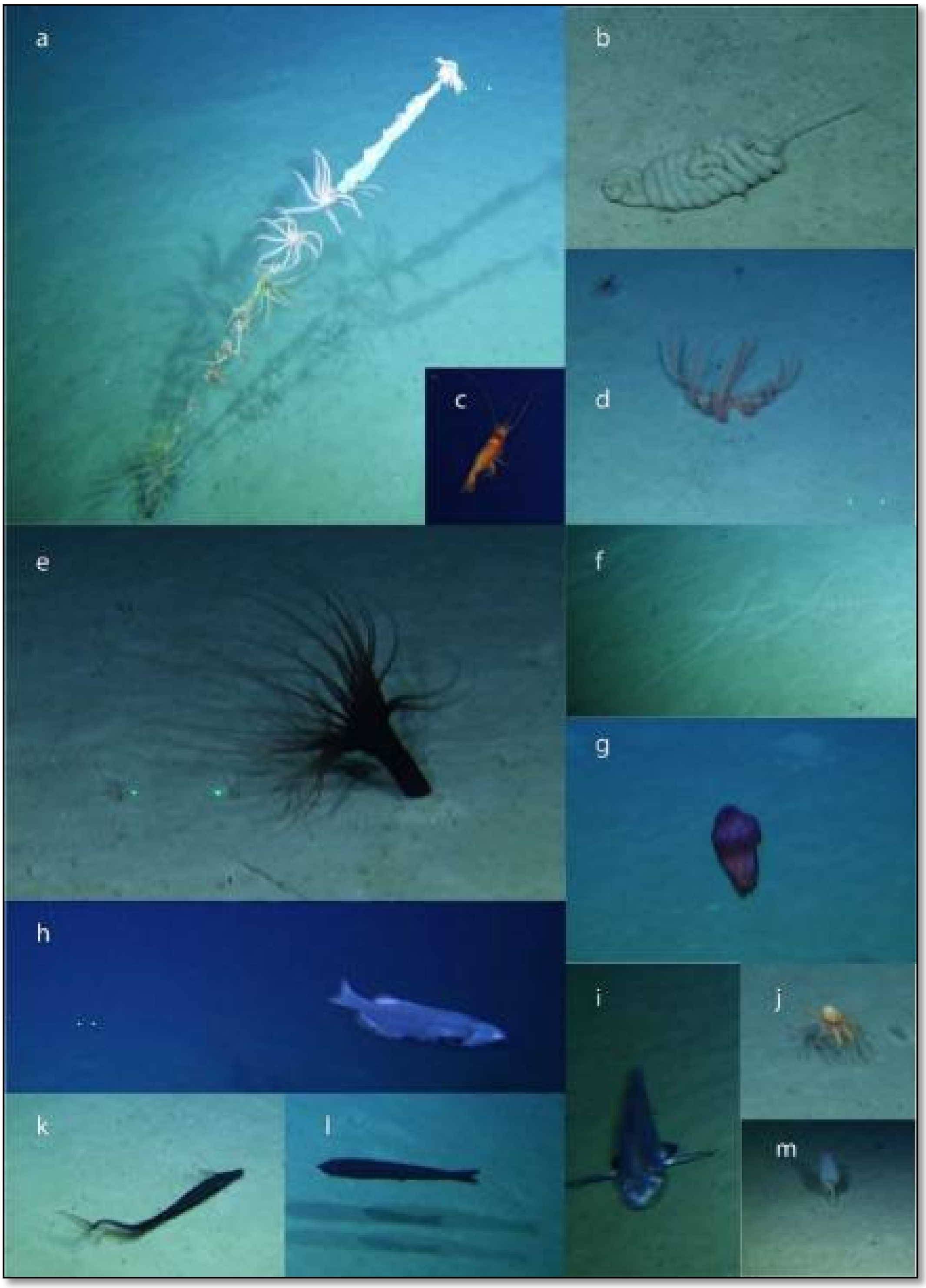


Figure 38 Examples of benthic biota within the slope ecosystems of the Central East Marine Park. (From O'Hara 2019).

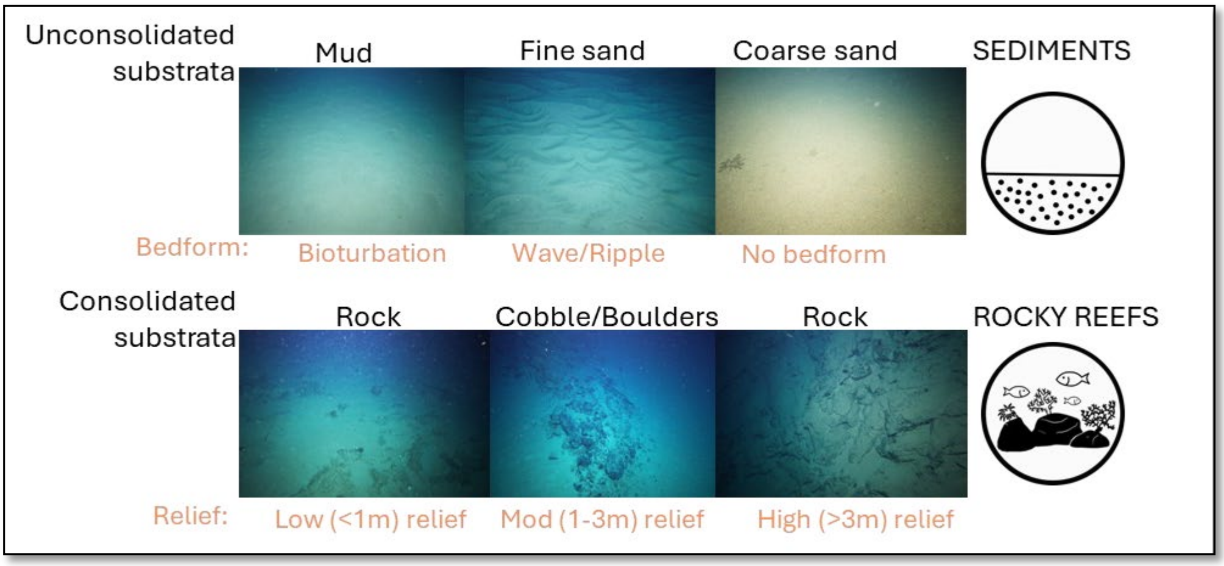


Figure 39. Examples of the physical habitats within the Solitary Canyon. The corresponding Ecosystem and its icon from Untiedt et al. (2022) are shown in the end column. (Figure from Sloyan et al. 2026).

Collectively, Hunter, Jervis and Central Eastern Marine Parks protect ecologically distinct deep-sea assemblages and an important temperate–tropical transition. The findings from deep water surveys in these parks reinforce their conservation value, particularly the Hunter Marine Park as a zone of overlap and turnover, and highlight the need to recognise biogeographic transitions, deep-sea connectivity and the evolutionary distinctiveness of fauna across the Australian eastern margin.

3.8.2 Temporal surveys

There are no temporal surveys on ecosystem components in the Central East Marine Park, reflecting the deep water habitats and related costs and logistics associated with structured surveys (Table 9).

Table 9. Biodiversity surveys within the Central Eastern Marine Park by ecosystem depth range and zone type. The extent of the park by ecosystem depth range and zone type is given in the first row. Classification of survey design standards is based on Foster et al. 2024 - Statistical Considerations for Monitoring and Sampling - NESP. Sites refers to spatially discrete sampling units at least 250 m apart.

Time	Sites	Platform	Ecosystem	Ecosystem Depth	Zones	Reports	Survey design standards*
2017, 2024	20	Deep Tow Camera seabed imagery, Sled net, Beam trawl	Demersal and benthic fish, Benthic habitats, Mobile macroinverts, Pelagic fish, Sessile macroinverts	70-200, 200-700, 700-2000, 2000-4000	hpz01, muz02	1,2	Preferential

1 IN2017_V03. https://www.csiro.au/en/about/facilities-collections/mnf/voyages-schedules/voyages/2017/may/in2017_v03
2 IN2024_V04. https://www.csiro.au/en/about/facilities-collections/mnf/voyages-schedules/voyages/2024/june/in2024_v04

3.9 Jervis Marine Park

3.9.1 Ecosystems and ecosystem components

The Jervis Marine Park is located approximately 20 km offshore of the New South Wales Jervis Bay Marine Park and Commonwealth Booderee National Park, and covers 2473 km^2. It extends seaward from approximately the 140 m depth contour, located between 2-3 km landward of the shelf break for around 62 km offshore beyond the 4000 m depth contour (Figure 40). Most of the marine park is in mid lower continental slope depths (700-2000 m) with the eastern boundary on the abyssal plain. Jervis Marine Park spans a section of Australia's eastern continental margin that encompasses upper bathyal to abyssal habitats and forms part of a major temperate–tropical transition zone in the deep sea.

The marine park is characterised by several distinct linear canyons that are collectively known as the Shoalhaven canyons (Figure 41). Three of these extend across the upper slope (Perpendicular, Beecroft and St George) and are up to 200 m deep, becoming wider (400 m) and shallower (100 m) as they extend down the slope and coalesce into box canyons as they extend through the mid-slope escarpment (2000-3500 m). The canyons have the appearance of river valleys, although they are caused by the slow de-watering and compaction of sediments over geological time frames and likely proceeds in stages through collapse of sediments and associated turbidity currents (O'Hara 2019).

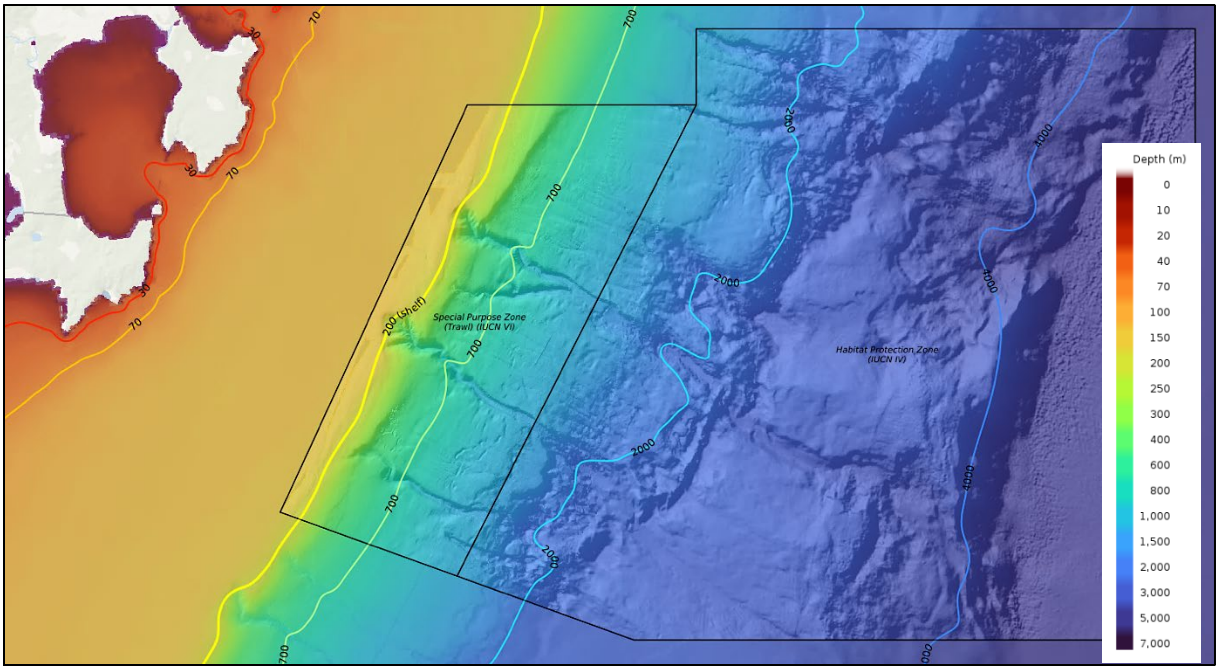


Figure 40 Broadscale bathymetry of Jervis Marine Park, including depth contours representing boundaries between ecosystem types. Seamap Australia link: https://seamapaustralia.org/map/#735a1d4f-5a32-48a5-ae00-96d3558abceb

These diverse mosaic of slope, canyon and abyssal environments support taxonomically rich and compositionally distinct benthic assemblages (O'Hara 2019). Surveys across the slope region of Jervis Marine Park revealed a diversity of benthic biota, including sea pens, brittle-stars, sea-stars, and sea spiders (Figure 42). Surveys at around 2650-2636 m included numerous polychaetes, *Parapagurus* hermit crabs, a new species of crangonid prawn, barnacles, seastars, stalked bathycinid feather stars, ophiuroids (Ophiocten, Ophiura, Ophiosphalma), glass scallops, turritellid and mangeliid gastropods, and the sponge

Chondrocladia clavata. The deeper trawl at 3952-4011 m resulted in chaetopterid and onuphid polychaetes, and two species of the holothurian *Molpadia*, amongst many others.

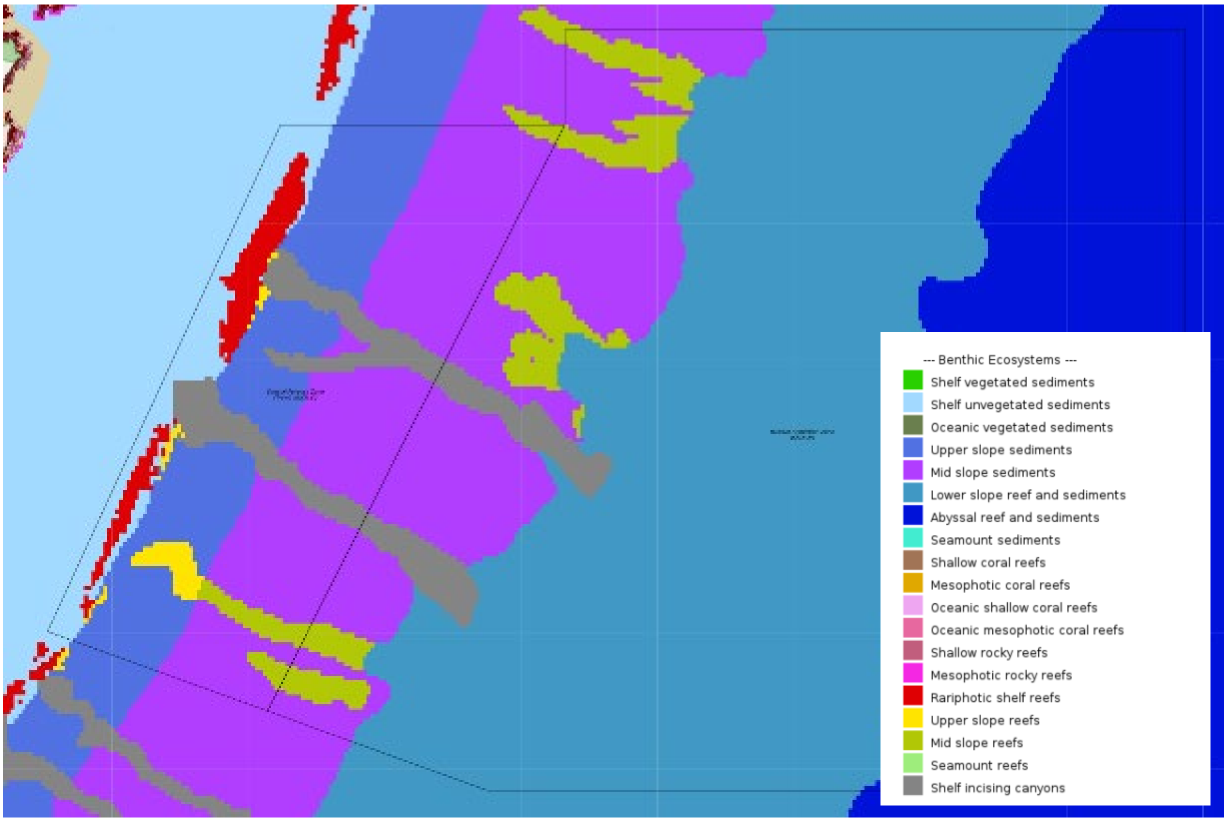


Figure 41 Distribution of ecosystem types across the slope region of the Jervis Marine Park. Seamap Australia link: https://seamapaustralia.org/map/#4f81db90-0898-45c9-bf92-8c5781d1f4f6

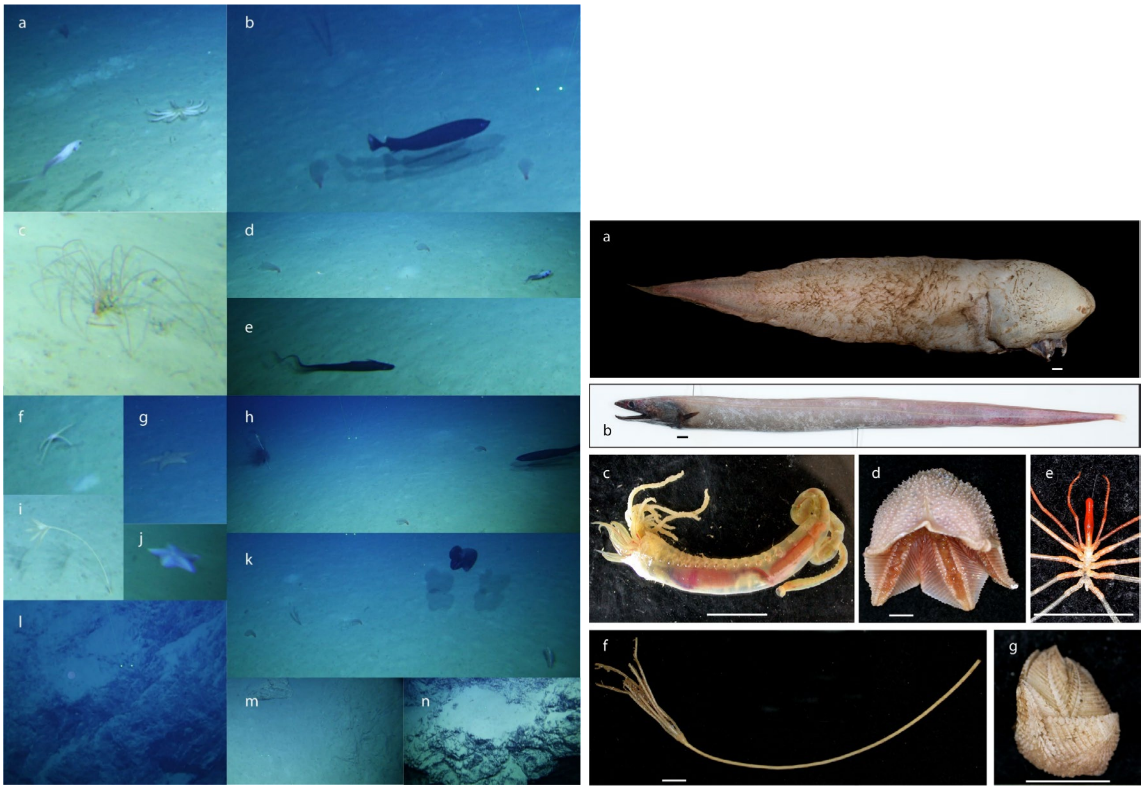


Figure 42 Examples of benthic biota within the slope ecosystems of the Jervis Marine Park (From O'Hara 2019)

3.9.2 Temporal surveys

There are no temporal surveys on ecosystem components in the Jervis Marine Park, reflecting the deep water habitats and related costs and logistics associated with structured surveys (Table 10).

Table 10. Biodiversity surveys within the Jervis Marine Park by ecosystem depth range and zone type. The extent of the park by ecosystem depth range and zone type is given in the first row. Classification of survey design standards is based on Foster et al. 2024 - Statistical Considerations for Monitoring and Sampling - NESP. Sites refers to spatially discrete sampling units at least 250 m apart.

Time	Sites	Platform	Ecosystem	Ecosystem Depth	Zones	Reports	Survey design standards*
2017	7	Deep Tow Camera seabed imagery, Beam trawl, Sled net	Demersal and benthic fish, Benthic habitats, Mobile macroinvertebrates	700-2000, 2000-4000	npz02	1	Preferential

1 INV2017_v03. https://www.csiro.au/en/about/facilities-collections/mnf/voyages-schedules/voyages/2017/may/in2017_v03

4. Threatened and migratory species

The Temperate East Marine Park Network supports a range of important habitats for protected species, including spatially defined biologically important areas (BIAs). BIAs are areas where aggregations of individuals of a regionally significant species display key life history behaviours such as breeding, foraging, resting and/or migration, and are therefore critical to the persistence of populations. For example, within Lord Howe Marine Park biologically important areas include breeding and foraging habitat for seabirds, as well as a recognised migratory pathway for humpback whales (*Megaptera novaeangliae*) moving between Antarctic feeding grounds and low latitude breeding areas (Director of National Parks 2018).

Further information on protected species distributions and BIAs within the region is provided in the Marine Bioregional Plan for the Temperate East Marine Region (Commonwealth of Australia 2012a) and the Conservation Values Atlas on the Department's website.

4.3.1 Marine mammals

The Temperate East Marine Park Network and adjacent eastern Australian waters support a diverse assemblage of cetaceans and other marine megafauna. This diversity reflects the broad latitudinal extent of the network, spanning cool temperate to subtropical waters, and the wide range of depths encompassed, from shallow continental shelf to deep offshore environments. Up to 40 EPBC listed whales and dolphins are known or likely to utilise pelagic habitats across the region, although many are vagrants or uncommon (see Table 1, Appendix B). Several studies have documented species presence and broad distribution patterns within the region, although many are restricted to coastal and shelf waters (McLean et al. 2024). Many species are also mainly restricted to deep offshore waters and have widespread distribution.

Commonly recorded marine mammals include humpback whales, listed as migratory under the EPBC Act, and southern right whales (*Eubalaena australis*), listed as endangered. Humpback whales migrate annually through the Temperate East Marine Region between Antarctic feeding grounds and low-latitude breeding areas, with most movement concentrated over the continental shelf. This migration includes waters within the Hunter and Solitary Islands marine parks. The region is recognised as a Biologically Important Area for Humpback whale migration, with distinct subpopulations known to congregate over the Lord Howe Seamount Chain when migrating between tropical breeding grounds and polar feeding grounds (Derville et al. 2020).

Southern right whales use temperate shelf and coastal zones for calving and nursery habitat in winter in other Southern Hemisphere regions, with modelling indicating a strongly seasonal distribution characterised by nearshore use in winter and more offshore distribution in summer (Purdon et al. 2020, Baines and Weir 2020). This suggests that nearshore sections of the network may function as occasional migratory or nursery habitat.

A large range of other whales and dolphins are known to occur in the region, although most information is from areas on the continental shelf or adjacent to offshore islands. Further details on the conservation status and protection, and known pressures on the species which the region is important from a conservation perspective are provided in the species group report cards (Commonwealth of Australia 2012b).

4.3.2 Fish and sharks

Several threatened fish and shark species are known to occur within the marine parks of the Temperate East Marine Region. Firstly, the eastern Australian population of the grey nurse shark *Carcharias taurus* is listed as Critically Endangered under the EPBC Act, and the population is now restricted to a small number of key aggregation sites along the New South Wales coast, with the Cod Grounds Commonwealth Marine Park and the Solitary Islands marine park complex representing two of the most important and well documented sites for the species.

Tagging studies have revealed that grey nurse sharks undertake seasonal north–south migrations along the New South Wales coast, with Cod Grounds and Solitary Islands functioning as key nodes within a broader movement network rather than isolated habitats (Otway and Louden 2019, 2025). These movements link aggregation sites, potential mating areas and pupping grounds, reinforcing the importance of connectivity between Commonwealth and state marine parks for effective conservation outcomes.

Long-term monitoring using diver surveys, photographic identification and acoustic tagging has demonstrated strong site fidelity and philopatry at both Cod Grounds and Solitary Islands, with individual sharks returning repeatedly to the same aggregation sites over multiple years (e.g. Otway et al. 2003, Bansemer and Bennett 2010). These sites are predominantly used outside the pupping season and are characterised by steep rocky reefs, overhangs and gutter systems that provide shelter and resting habitat. Cod Grounds supports predictable seasonal aggregations associated with a discrete reef outcrop, while the Solitary Islands region comprises multiple reef sites used intermittently by sharks moving along the coast. Updated estimates of population status for the eastern population are provided in Bradford et al. (2025).

A key species of conservation status in the region is the McCulloch's anemonefish, which is critically endangered, and only occurs at Elizabeth Reef, Middleton Reef and Lord Howe Island (Hobbs 2022, Hoey et al. 2024). The black rockcod is a large reef fish is endemic to the warm-temperate and subtropical southwest Pacific waters of Australia, New Zealand, and the Kermadec Islands (Choat et al. 2006, Francis et al. 2015). In Australia, the species has been recorded from southern Queensland to east Victoria and offshore islands of Lord Howe Island, Norfolk Island and Elizabeth and Middleton Reefs (Kuiter 1993, Harasti and Malcolm 2013, Hoey et al. 2024). Although the species has been protected from fishing and spearfishing for over 40 years, the relative abundance of *E. daemelii* does not appear to be increasing over the past 15 years since monitoring commenced. This indicates that there has been limited recovery, although there is evidence of an increase in the proportion of mature females in the population from 2010 to 2023 (Harasti and Malcolm 2024).

White sharks are found throughout the world in temperate and subtropical oceans, with a preference for cooler waters (NSW DPI 2005, Weng et al. 2007). Its distribution includes the coastal waters of NSW, with electronic tagging studies identifying the Port Stephens region as one of the two important nursery areas for juvenile white sharks in eastern Australia (Bruce and Bradford 2008, 2012, Bruce et al. 2013). The species is highly mobile, and can travel large distances in a relatively short time. It can also remain in the same area for weeks or even months (NSW DPI 2005, Bruce et al. 2006). White sharks inhabit a wide range of habitats, from offshore pelagic to coastal inshore waters surrounding rocky reefs and islands, often near seal colonies (NSW DPI 2005, Weng et al. 2007). It is also known to transit through the offshore waters on the region as it moves between Australia and Aotearoa/New Zealand (Duffy et al. 2012).

A large range of other fish, shark and ray species are known to occur in the region (see Table 2, Appendix B), although most information is from areas on the continental shelf or adjacent to offshore islands. Several species are restricted to deep water habitats. Further details on the conservation status and protection, and known pressures on the species which the region is important from a conservation perspective are provided in the Commonwealth of Australia (2012a).

4.3.3 Marine reptiles

The Temperate East Marine Park Network supports a relatively small assemblage of marine reptiles compared with birds and marine mammals, with distributions largely influenced by temperature and oceanographic conditions (see Table 3, Appendix B). Published studies from the region focus primarily on leatherback turtles (*Dermochelys coriacea*) and loggerhead turtles (*Caretta caretta*).

Overlay of Species of National Environmental Significance distributions indicates that the Hunter region lies within the modelled ranges of five turtle species: loggerhead, leatherback, green (*Chelonia mydas*), flatback (*Natator depressus*) and hawksbill (*Eretmochelys imbricata*) turtles. Leatherback and loggerhead turtles are listed as endangered under the EPBC Act, while green, flatback and hawksbill turtles are listed as vulnerable. These species primarily use the region as foraging habitat and migration corridors, with loggerhead turtles nesting further north along the eastern Australian coastline.

Sea snakes occur only occasionally within the region, typically as warm-water incursions, and are listed as marine species but not threatened or migratory under the EPBC Act. A total of 20 species of sea snake are thought to occur in the Temperate East Marine Region, with details of 12 of the species presented in Commonwealth of Australia (2012c). Further details on the conservation status and protection, and known pressures on the species which the region is important from a conservation perspective are provided in the Commonwealth of Australia (2012a, c).

4.3.4 Birds

The Temperate East Marine Park Network supports a diverse assemblage of marine dependent birds, including pelagic seabirds, coastal shorebirds and waders, waterfowl and raptors. These species rely on marine and estuarine habitats for foraging, roosting and migration stopovers. Offshore islands and coastal islets provide important breeding habitat for colonial seabirds, where vegetation structure, geomorphology and absence of introduced predators strongly influence nesting opportunities and colony size (Borsa and Baudat-Franceschi 2023). The region is recognised as a Biologically Important Area (BIA) for 14 seabird species during breeding and foraging phases.

A number of birds are identified as endangered and occur within the Temperate East region. The region supports multiple albatross and petrel species listed as vulnerable, particularly in offshore and southern waters of the Tasman Sea (see Table 4, Appendix B). A range of EPBC-listed migratory seabirds regularly occur within the Temperate East Marine Park Network, although not all are listed as threatened. Further details on the conservation status and protection, and known pressures on the species which the region is important from a conservation perspective are provided in the Commonwealth of Australia (2012a, d).

Species listed as migratory but not threatened include numerous shearwater species, which are particularly prominent in southern parts of the network, with short-tailed shearwaters (*Ardenna tenuirostris*) especially abundant around Tasmania and Victoria, where major breeding colonies occur. Other migratory shearwaters recorded in the region include sooty (*Ardenna grisea*), flesh-footed (*Ardenna carneipes*), wedge-tailed (*Ardenna pacifica*) and little shearwaters (*Puffinus assimilis*). The network also supports a diverse assemblage of migratory petrels and storm-petrels, such as great-winged, Providence, white-necked, Kermadec and black-winged petrels, as well as white-bellied and Wilson's storm-petrels. In addition, a range of migratory terns, noddies and tropical seabirds occur, particularly in the northern parts of the network, including sooty tern (*Onychoprion fuscata*), common and black noddies (*Anous* spp.), white tern (*Gygis alba*), grey ternlet (*Procelsterna cerulea*) and red-tailed tropicbird (*Phaethon rubricauda*). Other marine birds that occur within the network include masked boobies (*Sula dactylatra*) and little penguins (*Eudyptula minor*), the latter forming locally important breeding colonies in Tasmania.

5. Understanding uses in the Temperate East Network

5.1 Commercial fishing

A number of commercial fisheries operate across the broader eastern marine region, including within the marine parks of the Temperate East Marine Park Network. Many of these fisheries are concentrated in the coastal and continental shelf waters of New South Wales. Fishing activity within the network encompasses a wide range of methods, with demersal trawl, pelagic longline, and trap fisheries being the dominant gear types. The rules for commercial fishing activities in the Temperate East Network, including the types of fishing gear and methods allowed in different zones, and requirements for vessel monitoring systems are outlined in the Temperate East Marine Parks Network Management Plan (Director of National Parks 2018).

5.1.1 Commonwealth Eastern Tuna and Billfish Fishery

The Eastern Tuna and Billfish Fishery (ETBF) is made up of two commercial sectors, the longline sector, and the minor line sector, with the most common fishing method being pelagic longlining. This involves using baited hooks attached to long sections of line suspended in the water column, whereas minor line methods consist of pole and line, handline, trolling and rod and reel. The fishery operates throughout much of the Temperate East Marine Region, with a focus along the NSW continental shelf and into offshore waters in the northern part of the region (Figure 43). The Eastern Tuna and Billfish Fishery includes specific closures within 12 nm of Lord Howe Island and in the vicinity of Norfolk Island.

This fishery is managed under a quota system that limits the amount of fish that boats can take in the fishery, with albacore (*Thunnus alalunga)*, bigeye tuna (*T. obesus)*, yellowfin tuna (*T. albacares)*, stiped marlin (*Kajikia audax)* and swordfish (*Xiphias gladius*) all managed by quota in this fishery. Yellowfin tuna generally is the dominant species landed by the fishery. Ecological risk assessments are conducted on the fishery, and impacts on the environment are regularly monitored (Marine Stewardship Council 2026). ETBF operators also target southern bluefin tuna (*T. maccoyii*) along the New South Wales Coast during certain times of the year. This fishing activity is managed under the SBT Fishery Management Plan 1995.

The ETBF operates across offshore waters of the Temperate East Marine Park Network, targeting highly migratory pelagic species that move seasonally along the continental shelf and slope and into deeper oceanic habitats (Hartog et al. 2011). Fishing effort is highest in the areas within the Hunter, Central Eastern and Jervis Marine Parks, where longline sets frequently occur along the continental shelf break and adjacent deep-water habitats (Figure 43). Spatial catch data from the ETBF indicate that high-use pelagic fishing areas coincide with multiple IUCN-classified marine park zones, including habitat protection and multiple use zones (both IUCN IV). Specific details on the fishery, management arrangements and environmental assessment are provided in DCCEEW (2025a).

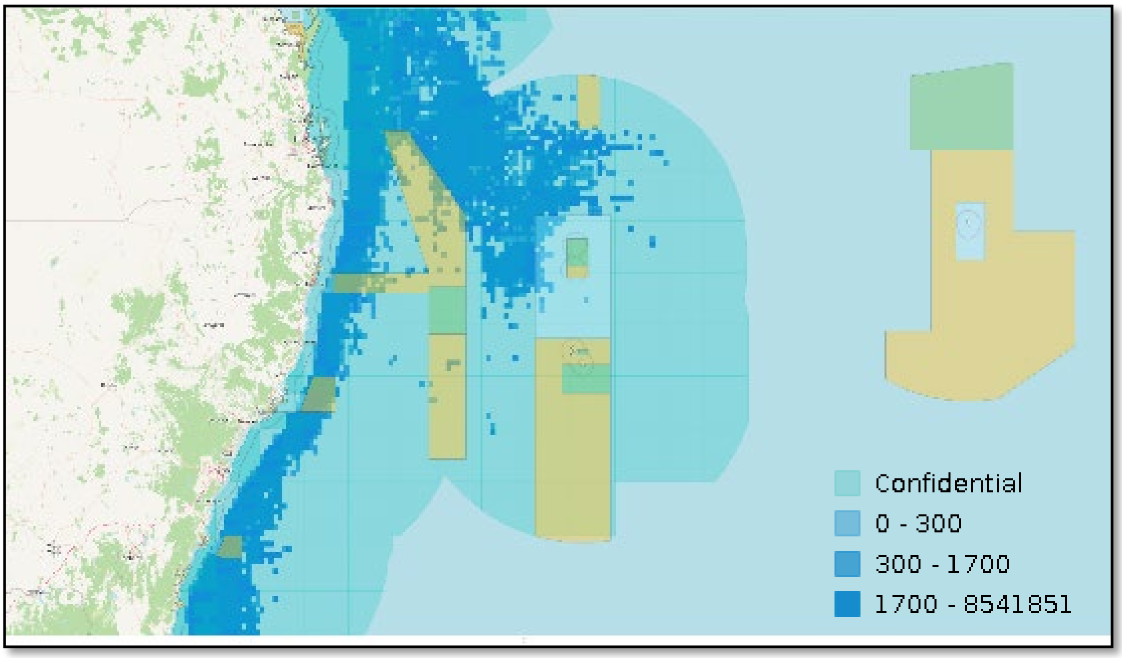
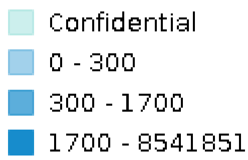


Figure 43 Distribution of catches (kgs) from the Eastern Tuna and Billfish Fishery 2018-19 to 2022-23 (Data from the Blue Economy CRC [Futures of Seafood Atlas](https://futuresofseafood.imas.utas.edu.au/map/#63e345d7-d4ac-4a10-9083-7acc6d5d642c): https://futuresofseafood.imas.utas.edu.au/map/#63e345d7-d4ac-4a10-9083-7acc6d5d642c

5.1.2 Southern and Eastern Scalefish and Shark Fishery

The Southern and Eastern Scalefish and Shark Fishery is a multi-sector, multi-species fishery that extends south from Fraser Island in southern Queensland, around Tasmania, to Cape Leeuwin in southern Western Australia. The fishery operates in both Commonwealth and state waters under different Offshore Constitutional Settlement arrangements with state governments. All fishing methods are prohibited within 25 nm of Lord Howe Island and Ball's Pyramid, and the sector is bounded to the west by a trawl exclusion zone. The main target species are blue-eye trevalla (*Hyperoglyphe antarctica*), pink ling (*Genypterus blacodes*), with ribaldo (*Mora moro*), hapuku (*Polyprion oxygeneios)* and ocean perch (*Helicolenus barathri* and *H. percoides*) being other important commercial species.

In the temperate east marine region the auto-longline fishery includes waters off southern Queensland (south of Sandy Cape) and New South Wales from approximately the 4000 m depth contour (60–80 nm from the coast) to the extent of the Australian Fishing Zone. Waters inside this line off the New South Wales and Queensland coasts are managed under the jurisdiction of the state governments. Relative to landings across the extent of the fishery, recent landings are small in the temperate east marine region, and are evenly distributed across most of the marine parks in the region (Figure 44).



Details on the fishery, management arrangements and priority issues requiring changes to manage pressures from the fishery are addressed in DCCEEW (2025b). Further related documents are also available at
https://www.dcceew.gov.au/environment/marine/fisheries/commonwealth/scalefish

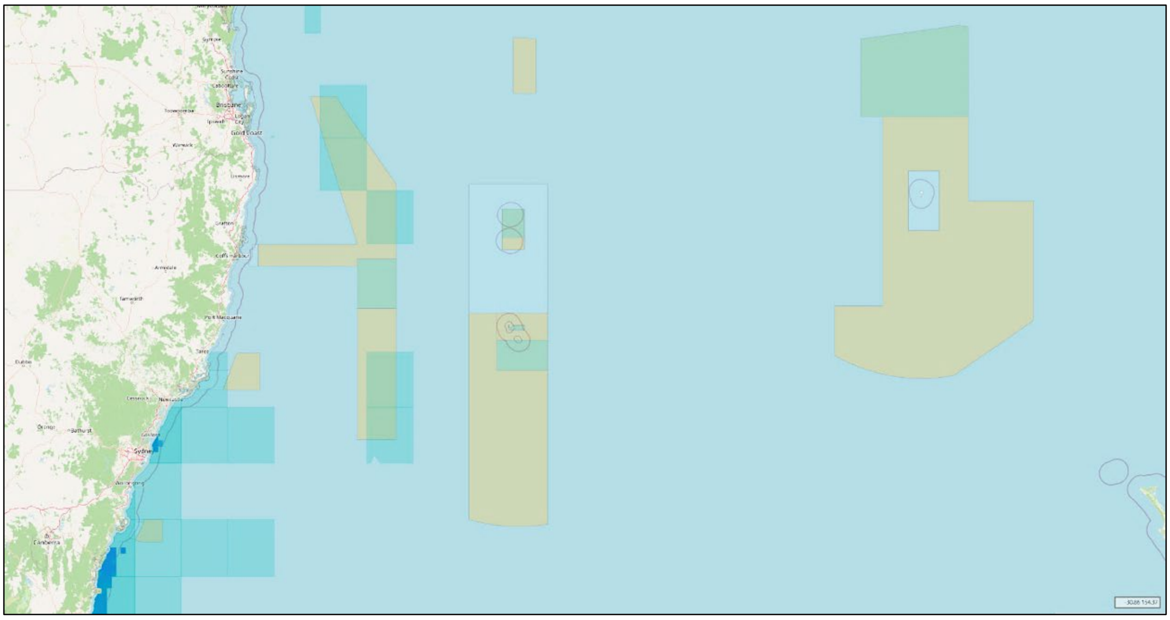


Figure 44 Distribution of catches (kgs) from the Southern and Eastern Scalefish and Shark Fishery 2018-19 to 2022-23 (Data from the Blue Economy CRC Futures of Seafood Atlas). https://futuresofseafood.imas.utas.edu.au/map/#cb3958c4-42da-45a2-9f2c-22aa26c7ac6a

5.1.3 Norfolk Island Fishery

The fishery activity in this area consists of an inshore shelf/upper slope fishery and an exploratory offshore deepwater fishery. It consists of the Norfolk Island Offshore Demersal Finfish Fishery which extends 200 nm from Norfolk Island, excluding the area of the Norfolk Island Inshore Fishery and abutting the New Caledonian EEZ in the north and New Zealand EEZ in the south. Commercial fishing in this fishery goes back to the 1970s but has been sporadic and has met with variable success. There are currently no commercial fishing concessions in this fishery. Exploration of the fishery and its resources has generated a range of information, but to date this has been insufficient to define the nature of any ongoing fishery.

It also includes the Norfolk Island Inshore Fishery which covers an area of approximately 67 x 30 nm and was designed to include all shelf waters surrounding Norfolk Island. No commercial fishing permits currently exist in the inshore waters adjacent to Norfolk Island although fishing is undertaken by residents of Norfolk Island. The principal species targeted in this fishery is redthroat emperor (*Lethrinus miniatus*).

5.1.4 NSW Ocean Trap and Line Fishery

The Ocean Trap and Line fishery that uses multiple methods targeting a range of demersal and pelagic fish in continental shelf and slope waters along the NSW coast.

The fishery most commonly uses traps or lines with hooks, with the key species taken by each method, are:

- demersal fish trap (snapper, silver trevally, rubberlip morwong, and leatherjackets)
- setlines or trotlines (snapper and sharks)
- driftlines (spotted and Spanish mackerel, yellowtail kingfish, and sharks)
- hand-held line (mulloway, yellowtail kingfish, and bonito)

- trolling or leadlining (yellowtail kingfish, mackerel, and tuna)

A wide range of finfish species are taken in the fishery, while spanner crabs are also harvested from Tweed Heads to approximately Hat Head on the mid-north coast of NSW.

There are several distinct line-fishing endorsements that are relevant to the Ocean Trap and Line fishery in the Temperate East Region (NSW DPI 2006) include:

- ‘line fishing west’ (waters west of the 183 m depth contour)
- ‘line fishing east’ (waters east of the 183 m depth contour to the 4000 m depth contour) (primarily Commonwealth waters)
- demersal fish trap: authorises the holder to take fish from ocean waters by means of a fish trap set or used on the seabed
- spanner crab southern zone: authorises the holder to use a spanner crab net to take spanner crabs from ocean waters that include waters in the region of the Solitary Marine Park.

These endorsements result in differences in the fishery methods and catch composition throughout the extent of the fishery. There is limited information on the catch and catch composition specifically within the Commonwealth marine parks in which it operates on the NSW coast, which is restricted to the Solitary Island Marine Park and Hunter Marine Park.

5.1.5 NSW Rock Lobster Fishery

The Lobster Fishery is a quota-managed fishery that extends from the Queensland border to the Victorian border and includes all waters under the jurisdiction of NSW. The fishery primarily uses traps set in continental shelf waters off the NSW coast. Gear is mainly deployed on rocky reefs, but also on soft sediment on the mid and outer continental shelf. The fishery is characterised by inshore and offshore sectors, with inshore fishers typically using small beehive or rectangular traps in waters up to 10 m deep, and larger rectangular traps in depths to about 50 m. Offshore fishers fishing the mid and outer continental shelf use large rectangular traps (up to 2 m in length).

The lobster fishery is the only Australian commercial fishery that targets the eastern rock lobster (*Sagmaraisus verreauxi*), with catches of the species representing ~99.9% (by weight) of all rock lobster species in the NSW commercial catch. Other lobster species harvested occasionally include the southern rock lobster (*Jasus edwardsii*) and tropical rock lobster (*Panulirus longipes* and *P. ornatus*). Small quantities of other byproduct species are also retained.

The lobster fishery operates within and surrounding the Jervis, Hunter and Solitary Island Marine Parks, with largest catches in the parks occurring in the Hunter region (Figure 45). There is limited information on the catch and catch composition specifically within the Commonwealth marine parks in which it operates on the NSW coast. Details on the fishery, management arrangements and priority issues requiring changes to manages pressures from the fishery are addressed in DCCEEW (2018). Further related documents are also available at https://www.dcceew.gov.au/environment/marine/fisheries/nsw/lobster

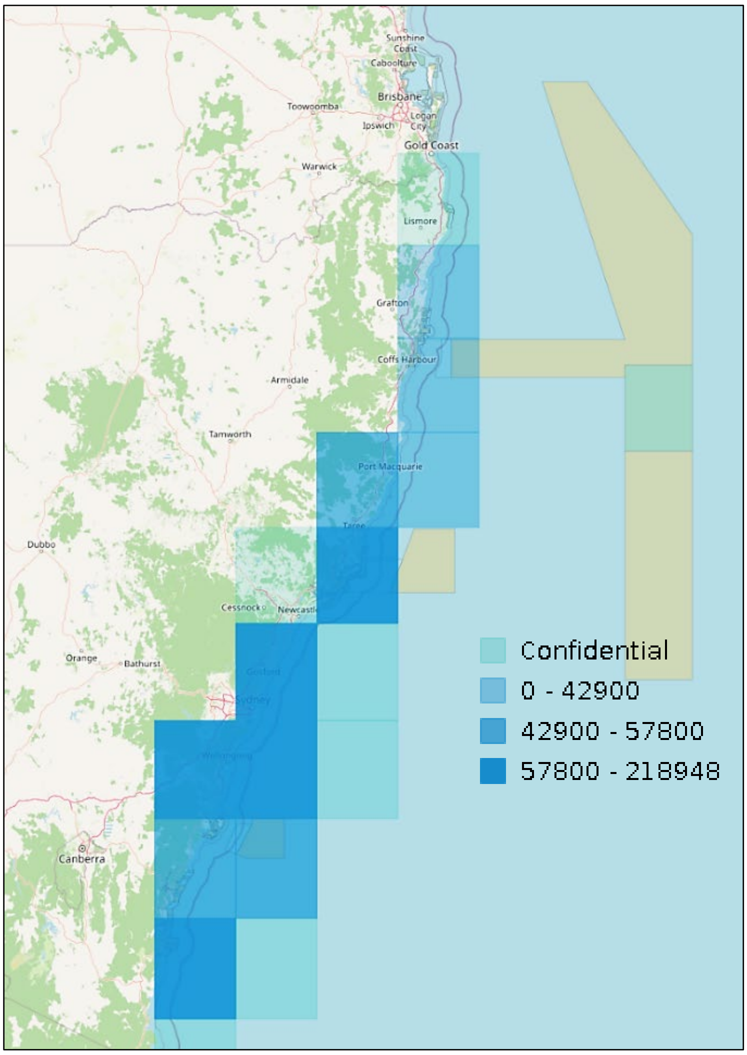


Figure 45 Distribution of catches (kgs) from the NSW Lobster Fishery 2018-19 to 2022-23 ((Data from the Blue Economy CRC Futures of Seafood Atlas). https://futuresofseafood.imas.utas.edu.au/map/#2bbf8219-b4ee-461b-963e-d003ead35b92

5.1.6 NSW Ocean Trawl Fishery

Two sectors currently operate in ocean waters under the NSW Ocean Trawl Fishery (OTF): prawn trawling and fish trawling. The major species taken in the fishery include school whiting (comprising of stout whiting and red spot whiting), eastern king, school and royal red prawns, tiger flathead, and to a lesser extent, silver trevally, various species of sharks and rays, squid, octopus and bugs.

Trawling occurs on continental shelf areas of the Hunter Marine Park and Solitary Marine Park, with the species composition of landings varying between regions, characterised by a higher proportion of prawns in the north of the state (NSW DPI, 2017). There is little information on the precise location of trawl grounds in the marine park or how frequently they are trawled. The known pressures resulting from ocean trawl include extraction of benthic mobile invertebrates, fish and free-swimming invertebrates, and habitat modification (physical disturbance and removal). Assessment of trawl fisheries in Commonwealth waters indicates that impacts on soft sediments are likely to range from minimal for most area of trawl area up to significant localised effects in areas that are trawled very frequently.

5.2 Recreational fishing

Recreational fishing is a popular activity throughout the Temperate East Marine Parks Network, and is concentrated along continental shelf waters. A range of methods are used including traditional hook-and-line angling, trapping, jigging, netting, spearfishing, and hand collecting, mostly of which can be either shore- or boat based. The diversity of fishing methods and areas fished results in a wide range of harvested species. There are also sections of the fishery that target specific species with hook and line, such as black marlin and tuna, and much of this is conducted through game fish tournaments (Ghosn et al. 2015). Overall, the recreational catch is limited by a range of bag and size limits, gear restrictions and a number of regional fishing closures.

Broad statewide surveys across NSW continental shelf waters indicate that around 7% of the total recreational harvest comes from waters defined as ‘offshore’, although this does not equate specifically to Commonwealth waters (West et al. 2015). The dominant species harvested in offshore waters were found to be yellowtail kingfish, tunas, wrasses, snapper, gropers and a range of flathead and shark and ray species.

There are limited recreational fishing surveys along the NSW coast that have sufficient resolution at the scale of marine parks to assess recreational fishing catch and effort within individual marine parks. Analysis of the NSW statewide recreational fishing survey database specifically to assess catch and effort in the Hunter Marine Park found low sample sizes at the scale of the park resulting in little quantitative data (Lynch et al. 2019). Numerous boat ramp facilities in coastal areas adjacent to Hunter and Solitary Island Marine Parks provides effective access for larger recreational boats to fishing in offshore Commonwealth waters on the continental shelf in these regions.

Recreational fishing occurs in the Commonwealth waters surrounding Lord Howe Island, with much of the fishing effort on the shelf and slope of Lord Howe Island and Balls Pyramid (Figueira and Hunt 2017, Figueria and Harianto 2022). The fishery is dominated by charter fishing, where fish are taken and sold for use on the island, with a smaller effort from privately-owned vessels that are not authorised to sell catch. The primary fishing method is line fishing, with yellowtail kingfish, silver trevally, wahoo and emperor fish the dominant target species, although around 61 species of fish, shark and squid are reported. Around 86% of the kingfish catch by numbers and weight is generally taken on the Lord Howe Island shelf and shelf edge and Balls Pyramid shelf, a considerable component of which is located in Commonwealth waters within the Lord Howe Marine Park (NSW Marine Parks Authority 2010).

Recreational fishing is a popular activity in the waters surrounding Norfolk Island, and with the Norfolk Marine Park extending to shore, this includes land-based recreational fishing.

Much of this is focussed around the two main jetties where a range of pelagic species including trevally, kingfish, bonito, and mackerel are targeted. Rock fishing also occurs in a number of locations where drummer and wrasse are often targeted. Much of the offshore fishing effort occurs through charter fishing operations, with the main species targeted including trumpeter, snapper and yellowtail kingfish.

5.3 Commercial shipping

A wide range of vessels use waters in the Temperate East Network that can be categorised as large commercial vessels that include all international and domestic vessels carrying cargo or passengers (e.g. coal ships, container ships, oil tankers, cruise ships and naval vessels), and domestic small commercial vessels such as passenger vessels (carrying more than 12 passengers), trading vessels (e.g. tugs, barges, dredgers), and fishing vessels and hire-and-drive vessels (e.g. cruisers, houseboats and powered dinghies) used for commercial, governmental or research activity.

Shipping relating to large commercial vessels occurs primarily outside state coastal waters, with the major shipping lane of the east coast of Australia being located between 10–15 nm offshore and running parallel to the coast. This shipping lane is the most active in Australia, with as many as 350 vessels in excess of 300 tonnes operating in the shipping lane at any one time. These vessels operate principally out of the ports in Newcastle, Sydney and Wollongong. Out of all the Commonwealth marine parks in the Temperate East region the highest shipping density occurs in the continental shelf regions in the Hunter Marine Park and Solitary Islands Marine Park (Figure 46).

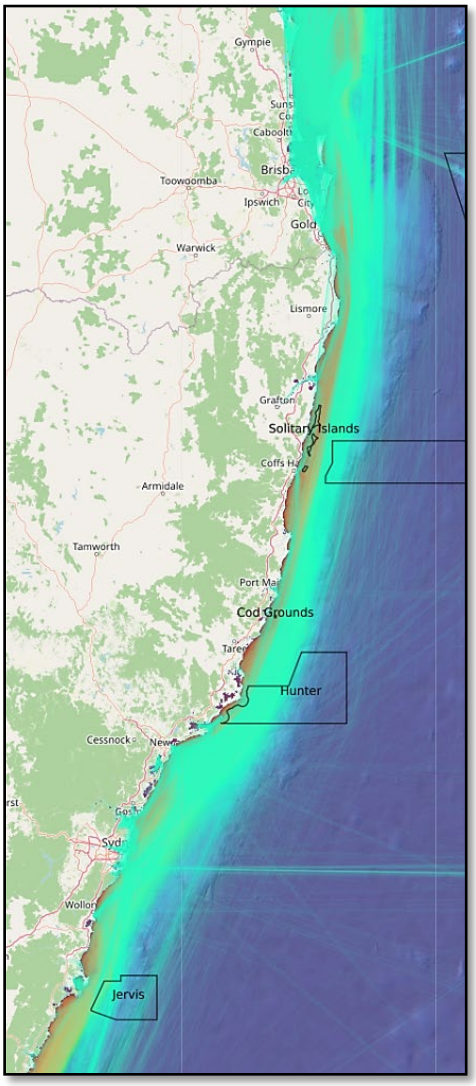


Figure 46. Aggregated vessel traffic data from a variety of source green lines), including terrestrial and satellite shipborne Automatic Identification System (AIS) data sources, for 2020. Data from Seamap Australia -

5.4 Commercial tourism

Commercial tourism in the Temperate East Network includes whale watching, coastal cruise ships and nature tours. Cetacean watching is an important commercial activity in continental shelf waters in NSW offshore of Port Stephens and Jervis Bay (O'Connor et al. 2009). Charters in NSW are primarily directed towards Indo-Pacific bottlenose dolphins, which occur year-round, and humpback whales during their annual migration. Expansion of the whale watching industry may subject migratory populations to continual rates of disturbance as they move along the east coast of Australia (Smith 2001). Cetacean-watching tours opportunistically target other wildlife and any of the 36 cetacean species present in NSW may be viewed, as well as seals, seabirds, turtles, and other marine fauna species.

Charter fishing activities provide opportunities for recreational anglers to undertake marine fishing and for adventure tourism for visitors. Licenced boats and localised fishing expertise helps recreational anglers to fish successfully across a range of fishing types and species, and to access areas not normally available to them. Operators derive a profit from the use of fishery resources by hiring out their knowledge and equipment to recreational fishers.

The NSW marine and estuarine recreational charter fishing boat fleet has many different sized vessels that target a great variety of fish species. Although they can theoretically move from port to port in response to seasonal and tourist demand, most operators are port based and do not move their operations. The ocean charter boat sector is subdivided into three subcomponents, with game fishing and deep-sea-bottom fishing activities the most common with the marine parks in the region.

5.5 Recreational use – non-extractive

Non-extractive recreation in the Temperate East Marine Parks Network includes sailing, scuba diving and wildlife watching, although the level of these activities is significantly less in offshore Commonwealth waters that within estuaries and coastal waters. Activity is expected to be concentrated on inner continental shelf waters, particularly Hunter and Solitary Islands marine parks.

5.6 Mining

Construction and operation of mining infrastructure and subsea pipelines in Australian Marine Parks have the potential to create hard substrate, altering demersal fish assemblages and sometimes enhancing fisheries value, while leaving contaminants (e.g. mercury) that complicate decommissioning decisions (McLean et al. 2018, 2021). There is currently no mining infrastructure within the Commonwealth marine parks in the Temperate East Region.

5.7 Carbon capture and storage

The Australian carbon capture and storage (CCS) roadmaps have not identified and locations in the Temperate East Marine Parks Network as an area of activity.

5.8 Commercial aquaculture

There is no established commercial aquaculture operating within the Australian Marine Park boundaries in the Temperate East Marine Region.

5.9 Renewable energy

There are no established renewable energy activities operating within the Australian Marine Park boundaries in the Temperate East Marine Region.

5.10 Research and monitoring

Research collecting and tagging are activities that are known to occur throughout the Temperate East Region. The use of passive observational techniques in marine research is increasing, reflecting recent developments in underwater video and acoustic techniques. This also reflects the increasing use of marine park for understanding changes in marine populations where extractive sampling is generally not allowed.

5.11 Structures and works

This includes a broad range of uses and activities including artificial reefs, dredging or disposal of dredged material, excavation other than dredging, erection and maintenance of structures, and works (including cables, trenching & boring), fish aggregating devices and moorings. There are no significant structure and work activities operating within the Commonwealth marine park boundaries in the Temperate East Region.

6. Understanding pressures in the Temperate East Network

6.1 Climate change

The key components of climate change that are considered in this report in the context of potential physical impacts on the natural values across the Temperate East Marine Parks Network include:

- Altered ocean currents and nutrients
- Increased sea temperature
- Increased frequency and severity of weather events (including marine heat waves)
- Sea-level rise.
- Ocean acidification

Information relating to each of these climate change components is summarised from recent analysis presented in the National Climate Risk Assessment (Bugnot et al. 2025). A detailed description of the key components of marine climate change, and an assessment of the impacts on a range of environmental assets in Australia is presented in Poloczanska et al. (2012, 2016) and references within.

In general, Australia's south-east marine region is considered a global hot spot for ocean warming, due to increased strength and southward penetration of the East Australian current (EAC) (Hobday et al. 2006, Ridgway 2007, Poloczanska et al. 2012). Significant effects have already, and are predicted to continue to occur across south-east Australia (Cetina-Heredia et al. 2015, Coleman et al. 2017, Hobday et al. 2006, Provost et al. 2017, Wernberg et al. 2011, Verges et al. 2014, Verges et al. 2016, Campbell et al. 2011, Harvell et al. 2002, Wernberg et al. 2011), including changes to:

- marine species distribution and abundance
- biological communities via species interactions
- phenology or timing of life cycle events
- physiology, morphology and behaviour (e.g. rates of metabolism, reproduction, development)
- movement of propagules/organisms and subsequent change to genetic patterns
- spread, establishment and virulence of pathogens and exotic species

Further details on the known pressures relating to climate change on threatened and migratory species which the region is important from a conservation perspective are provided in the Commonwealth of Australia (2012a, b, c, d).

6.1.1 Altered ocean currents and nutrients

As detailed in section 2.1, the Temperate East Marine Region is dominated by the poleward flowing East Australian Current (EAC) which transports warm, saline, and generally nutrient poor tropical waters from southern Queensland along the New South Wales continental shelf before separating from the coast and turning eastward into the Tasman Sea toward Lord Howe and Norfolk islands (Figure 2) (Ridgway and Dunn 2003, Cetina-Heredia et al. 2014). The Tasman Front is the main mesoscale current carrying warm subtropical water from the Australian east coast and Lord Howe Island region toward the Norfolk Island region.

The intensity of such western boundary currents is increasing on continental east coasts (Cai et al. 2005), and this is consistent in south-east Australia, with the increased strength and southward penetration of the EAC (Ridgway 2007) and an increasing latitude of the EAC separation point (Cetina-Heredia et al. 2014). An important feature of the EAC are mesoscale eddies that advect warm EAC water onto the shelf, and as the energy within these eddies continues to increase in the EAC southern extension they are expected to become more common, larger and more intense (Li et al. 2021, 2022). The movement of EAC water onto the continental shelf can also result in coastal upwellings that produce increased shelf productivity (Roughan and Middleton 2002, Roughan and Middleton 2004).

These changes, and associated increasing sea temperature, are resulting in southward range extension of many tropical and subtropical fishes, microbes, and harmful algal taxa (Figueira and Booth 2010, Suthers et al. 2011, Messer et al. 2020, Verma et al. 2020, Phillips et al. 2022), resulting in a greater diversity of subtropical and tropical species, including tropical fish and urchins (Booth et al. 2007, Ling et al. 2008). They are set to have further impacts on marine species in the future (Cetina-Heredia et al. 2015, Coleman et al. 2017). For example, increased EAC influence may result in changes in biodiversity within the Solitary Islands region by reducing representation of temperate biota, with corals and other tropical fauna likely to increase in abundance on coastal reefs (Verges et al. 2014, 2016).

Overall, the increasing dominance of the EAC along the east coast will have substantial effects on biological activity in coastal pelagic ecosystems in southeast Australia, including a potential reduction in the accessibility of prey to surface feeding predators (Phillips et al. 2024).

6.1.2 Increased sea temperature

There is evidence of long-term warming of surface marine waters surrounding Australia, with increases particularly significant along the south-east coast, including much of the Temperate East Marine Region (Richardson and Pattiaratchi 2020). This warming region is driven primarily by the climate-driven changing dynamics and poleward extension of the East Australian Current (EAC) (Li et al. 2022, Ridgway 2007), which brings warmer tropical waters further down the coast, increasing sea surface temperatures in south-eastern Australia. Sea surface temperature (SST) is projected to increase throughout Australia's EEZ, with the Temperate-East Australia showing a high degree of spatial variability in warming (Bugnot et al. 2025). This particularly evident across the Temperate East marine park network reflecting the large latitudinal and longitudinal range in which the parks extend. Recent analysis of ocean warming along the New South Wales State marine parks downscaled to coastal scales for 2024–2080 found that warming is more rapid in higher latitude (southern) NSW marine parks compared to northern parks (Champion et al. 2024). This is because the EAC's influence is strongest as it pushes warm water further south.

More specifically, Jervis Bay Marine Park (southernmost) show the highest projected annual warming rates, while the Solitary Islands Marine Park warmed more slowly, but still above the global average (Champion et al. 2024). The EAC separation point and associated eddy activity and upwelling also results in local variability in warming rates along the coast, reflected in more variability in the region of the Hunter Marine Park (Oke and Middleton 2001, Roughan et al. 2003, Cetina-Heredia et al. 2014). Lord Howe Marine Park, located ~600 km offshore of the mainland is expected to warm more slowly than marine parks on the NSW continental shelf due to the eastward-flowing Tasman Front which locates Lord Howe Island in different oceanographic conditions. These spatial and temporal patterns are mostly consistent with hindcast and forecast patterns of monthly sea surface temperature anomalies between 1995 and 2045 by marine park in waters of the Temperate East network. Monthly SST anomalies are greatest in Jervis Marine Park, followed by the other parks that are located mostly on the continental shelf. Long-term patterns in SST anomalies are consistently lower in Gifford, Central East, Norfolk and Lord Howe Marine Parks (Figure 47).

Key habitats in the Commonwealth marine parks and associated biota likely to be affected in the longer term include intertidal and shallow coral reefs, and shallow rocky reefs due to direct impacts and broader changes in several ecological functions and processes (Poloczanska et al. 2012). The ecological impacts of these spatial patterns in predicted changes in SST across the network will be strongly determined by the type and extent of specific ecosystems in each park. For example, while those marine park ecosystems on the shelf are expected to have larger increases in SST, several offshore parks including Norfolk Island and Elizabeth and Middelton Reefs contain shallow coral reefs that are susceptible to coral bleaching resulting from localised warming (Hoey et al. 2024, Ainsworth et al. 2021).

The extent of impacts will also depend on whether species are at the extremes of their distribution and temperature tolerance (Gillanders et al. 2011), and how changes in assemblages influence other species. For example, decadal declines in kelp (*E. radiata)* abundance in the Solitary Islands Marine Park (near its northern range limits) during a period in which SST warmed by 0.6°C was caused by increased grazing by herbivorous fish (Vergés et al. 2016). The expected increased in temperate and changing EAC influence in the northern NSW region, there is also potential for an increase in the prevalence of coral disease (Dalton and Smith 2006), and coral bleaching, which has been recorded in the Solitary Islands region.

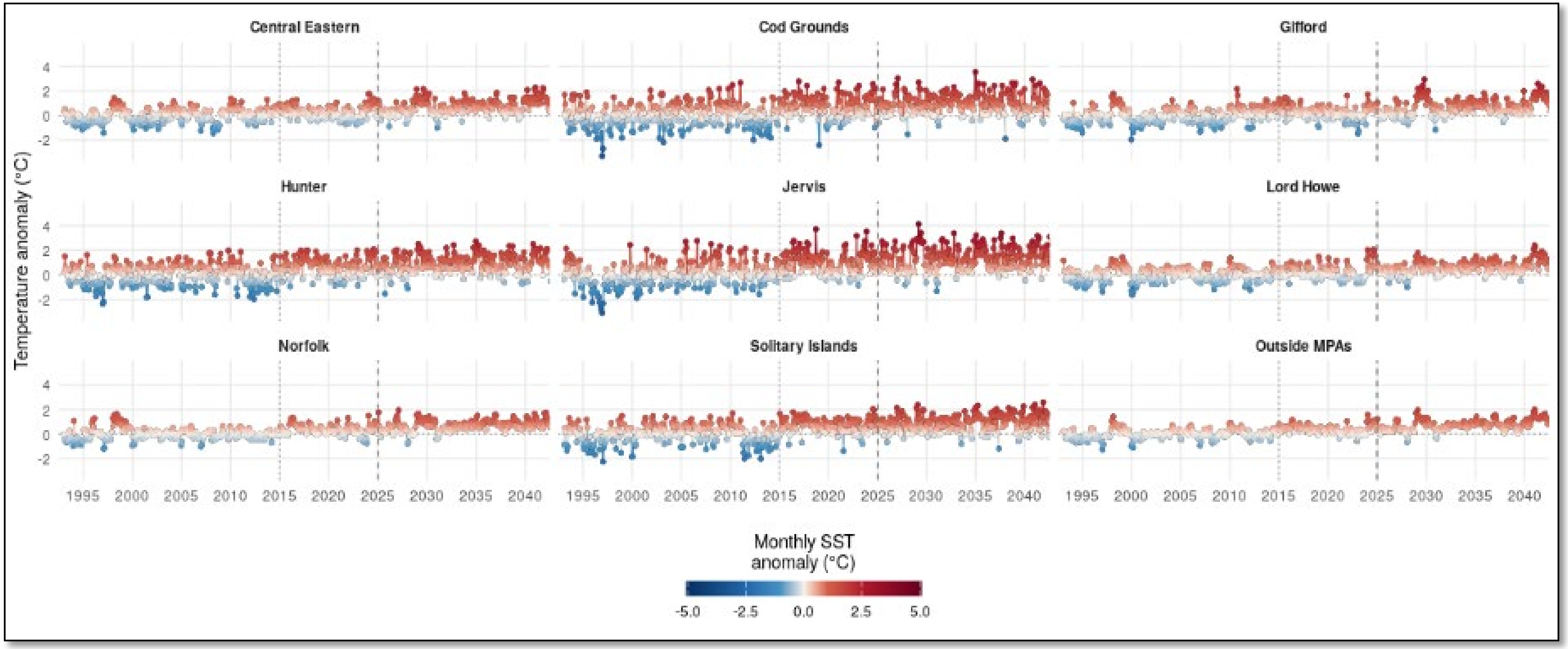


Figure 47. Hindcast and forecast patterns of monthly sea surface temperature anomalies between 1995 and 2045 (relative to 1993-2014 climatological baseline) by marine park in waters of the Temperate East network (CSIRO unpublished data).

6.1.3 Increased frequency and severity of weather events (including marine heat waves)

Climate pressures impacting marine parks in the Temperate East network include a number of physical processes associated with both atmospheric and oceanographic drivers. This included an increase in storm activity and associated changes in rainfall, storm surge and associated flooding along the east coast of Australia. This is expected to result in measurable impacts across a number of shallow water ecosystems. Many of these changes will interact, resulting in cumulative impacts on natural values in marine parks.

On the NSW continental shelf many of the impacts will result from physical disturbance associated with east coast lows (intense low pressure systems). These will lead to increased nutrient and sediment inputs to coastal waters, and a greater and more frequent physical disturbance to the seabed. Superimposed on the background oceanographic setting, extreme rainfall and severe flood events are increasing, reshaping both coastal catchments and nearshore waters (Babcock et al. 2019). Climate change is increasing the frequency and intensity of flooding events along the NSW coast. On the continental shelf this is likely to impact physical and ecological characteristics most directly in the Hunter Marine Park given the strong influence of the Hunter River system on adjacent areas of the shelf. Flooding of this river delivers massive freshwater discharge, sediment plumes, and nutrient loads that extend past Newcastle and onto the adjacent narrow continental shelf of the Tasman Sea.

Such impacts also occur on offshore islands such as Norfolk Island where a regime of disturbance since 2020 has included repeated flooding and associated sedimentation, which has degraded the lagoonal reef within Norfolk Marine Park by promoting blooms of nuisance algae (including red cyanobacteria) and intensifying coral–algal competition (Ho et al. 2025). These flood-driven inputs of sediments and nutrients, coupled with heat stress highlight how land-based runoff from severe rainfall events is emerging as a critical driver of ecosystem decline at this high-latitude reef.

A key climate driven impact on marine parks in the region is expected to result from marine heatwaves as there is increasing evidence that the waters in the temperate east region will increasingly be impacted by marine heatwaves (MHWs) based on the definitions of Hobday et al. (2016). MHWs are prolonged discrete, anomalously warm water events that exceed the long-term ocean temperature average for a specific region. MHW occurred during 2015/2016 in the Tasman Sea, and lasted over 250 days with a maximum intensity of 2.9°C above climatology (Oliver et al. 2017). The study of the Tasman Sea MHW concludes a dominant forcing of the anomalous East Australian Current (EAC) southward flow which is further influenced by anthropogenic climate change. Broad areas of the continental shelf in the region are regularly exposed to extreme temperatures more-or-less simultaneously, indicating strong along-shelf connectivity of MHW events (Chapman et al. 2025).

Episodic and persistent marine heatwaves linked to EAC variability now occur more frequently and with greater intensity, producing pronounced and sometimes rapid shifts in zooplankton communities and increasing the prevalence of warm-water taxa throughout the region (Oliver et al. 2017; Oliver et al. 2018).

Between 2002 and 2019, the influence of MHWs were detected in four summers: 2009–10, 2010–11, 2016–17 and 2017–18 in the Lord Howe Marine Park region (Carroll et al. 2020), with severe coral bleaching to selective coral species found at Elizabeth Reef compared to Middleton Reef during February 2018 surveys (Hoey et al. 2018).

These events are projected to increase in duration and magnitude throughout the Temperate East Marine Region, and on average MHW duration will continue to increase in the region (from historical baseline) under increased global warming scenarios to around 250 days per year by 20260 (Bugnot et al. 2025). While there are often short-term and less intense events (<10 days), the increasing trend of MHW areas over the entire Australian region is mainly driven by the warming of the ocean surface (Hu 2023).

Knowledge and monitoring of MHW's are continuing to improve, and regular mapping of marine heatwave categories (ranging from moderate to extreme) are provided by the Bureau of Meteorology, with the category indicates if any events are forecast and how extreme they could be. Mapping of MHW probability also indicate show how likely a marine heatwave event could be in the months ahead. Details of these are provided at:

https://www.bom.gov.au/climate/ocean/long-range-forecasts/?variable=mh_cat&region=AUS

6.1.4 Sea level rise

The rate of sea-level rise since the mid-19th century has been larger than the mean rate during the previous two thousand years. Relative sea level along the southeast coast rose at roughly 1.4 to 1.9 mm per year through much of the 20th century, but accelerated to over 3.7 mm per year in recent decades (1993–2019) (Figure 48). These changes are driven by global warming which drives thermal expansion of seawater and the melting of land ice. By 2050 projections indicate that on average sea levels will rise roughly 0.26 m above late-20th-century baselines. Regional factors like the EAC also influence local water heights by actively piling up water and driving localized acceleration faster than the national average. The south-east region of NSW is a dense hotspot of accelerated sea level rise where the rise intensifies sharply, reaching 4.5 to 5.5 cm per decade.

Due that most of the Temperate East network marine parks are in depths mostly below 50-60 m, direct impacts from sea level rise are expected to be minimal. The exception are those intertidal habitats at Elizabeth and Middleton Reefs and areas surrounding Norfolk Island that will be affected by a rising sea level. In combination with more frequent and severe storms, sea level rise is likely to result in loss of habitat and displacement of some species, particularly shorebirds. It will also impact rocky shore and coral reef biota through changes in the availability of vertical and horizontal intertidal habitat, and change in composition of assemblages (Vaselli et al. 2008).

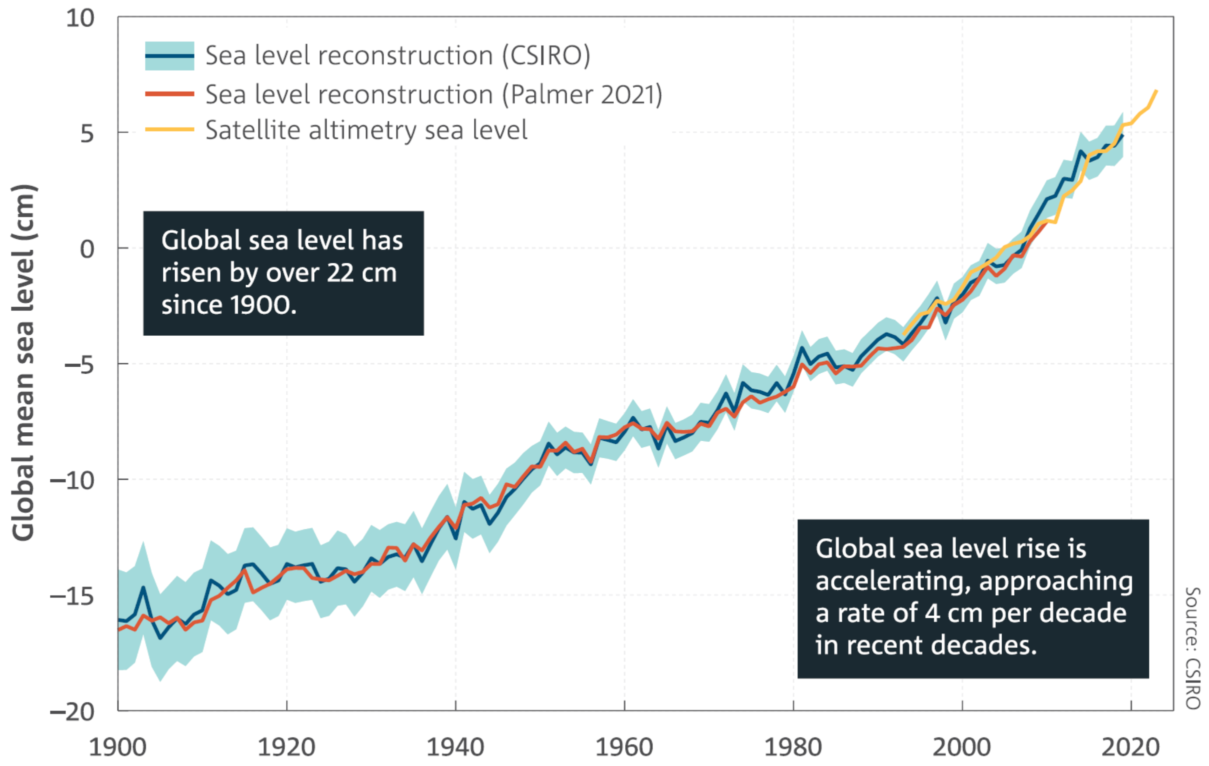


Figure 48. Annual global sea level change reconstructed from tide gauge data (1900–2019, CSIRO blue line, Palmer et al. 2021 red line;), and annual sea level change based on satellite altimetry (1993–2023, yellow line). Shading indicates confidence range. Source State of Climate 2024.

6.1.5 Ocean acidification

It is anticipated that increases in atmospheric carbon dioxide concentrations will result in acidification and key changes in ocean chemistry. Current modelling of trends in the change of pH in surface waters throughout the region indicate greatest decreases in the mid north coast region of NSW extending into offshore waters of the Solitary Marine Park (Figure 49). The area of greatest change also covers waters of most marine parks in the Temperate East network.

There is growing information on the potential level of impacts of acidification on many species, although much of this information comes from laboratory experiments. The elevated carbon dioxide is expected to affect marine organisms through changes to metabolic physiology, calcification rates of hard structures (e.g. shells, external skeletons) and secondary effects through changes to food webs (Parker et al. 2013, Ross et al. 2011). Marine molluscs (e.g. oysters, abalone, whelks) are particularly vulnerable, which would be most evident in their pelagic calcifying larval stages (Parker et al. 2010, Scanes et al. 2014). Species diversity and abundance will generally decrease, shifting to communities of non-calcifying organisms. Overall, a lower pH will likely impact on planktonic assemblages, but empirical data is rare (Poloczanska et al. 2016). These result in changes to trophic structures and an overall simplification of communities, with little evidence for adaptation to lower pH (Nagelkerken and Connell 2015).

Ocean acidification will likely impact most ecosystems throughout the temperate east region given that changes are expected occur throughout the water column, although changes to benthic biota in deeper habitats on the shelf and further offshore are not clearly understood.

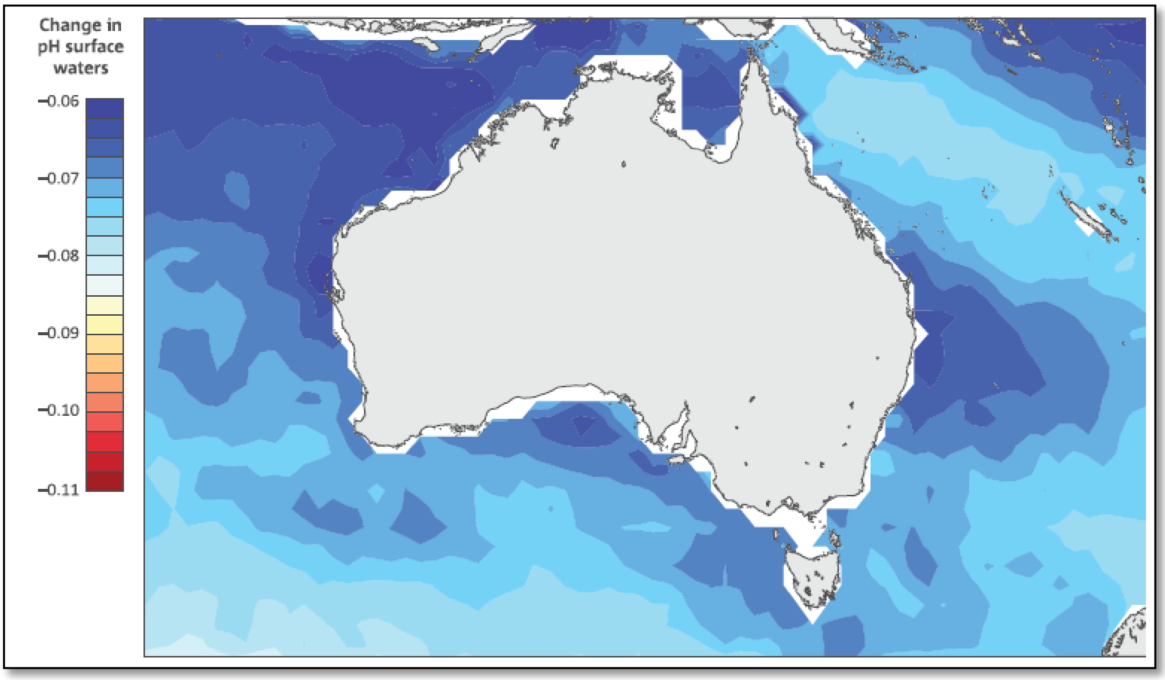


Figure 49. Change in pH of surface waters around Australia between 1982 and 2022. (Figure from State of the Climate 2024).

6.2 Extraction of living resources

Harvesting of living resources is described as a pressure of concern in the temperate east marine region. The known pressures resulting from the various fisheries detailed in section 5.1 include extraction of benthic mobile invertebrates, and fish and free-swimming invertebrates (Appendix B). Specific measures are in place in the fisheries that operate in the region that mitigate the impact of these pressures, including relevant spatial closures, the mandatory use of bycatch reduction devices, and trigger limits.

The known fishery pressures and priority issues relating to management of these pressures are detailed for the Lobster Fishery in DCCEEW (2018), Ocean Trap and Line fishery in DCCEEW (2024), Commonwealth Eastern Tuna and Billfish Fishery in DCCEEW (2025a), and Southern and Eastern Scalefish and Shark Fishery in DCCEEW (2025b).

There is limited information on the extent of pressures associated with recreational fishing within the Temperate East marine parks. Overall, the recreational catch is limited by a range of bag and size limits, gear restrictions and a number of fishing closures associated with zoning arrangements.

Further details on the known pressures relating to fishery activities on threatened and migratory species which the region is important from a conservation perspective are provided in the Commonwealth of Australia (2012a, b, c, d).

6.3 Physical disturbance

Physical disturbance to seafloor habitats is described as pressures of concern in the temperate east marine region. Assessment of trawl fisheries in Commonwealth waters indicates that impacts on soft sediments are likely to range from minimal for most of the trawl area up to significant localised effects in areas that are trawled very frequently (Pitcher et al.

2015). Most trawl effort in the Temperate East marine parks occurs on the shelf in the Hunter Marine Park, although as there is little information on the distribution and intensity of trawling in this area it is not possible to determine the potential extent of physical disturbance.

Specific measures are in place in the fishery that mitigate the impact of these pressures, including relevant spatial closures, the mandatory use of bycatch reduction devices.

The known pressure of physical disturbance to habitats and species resulting from commercial fishing, and priority issues relating to management of these pressures are detailed for the Lobster Fishery in DCCEEW (2018), Ocean Trap and Line fishery in DCCEEW (2024), Commonwealth Eastern Tuna and Billfish Fishery in DCCEEW (2025a), and Southern and Eastern Scalefish and Shark Fishery in DCCEEW (2025b).

A number of pressures are known to be related to commercial shipping, including habitat impacts associated with anchoring, wildlife disturbance, introduction of marine pests, and pollution. The risks to marine wildlife are increased in areas where the density of shipping traffic is correspondingly high. Several marine species use sound as their primary sensory input for social communication, foraging and other vital processes. Background noise may affect marine mammals and reptiles by masking normal sounds and vocalisations, or causing hearing deficit. Noise from shipping traffic is an important source of anthropogenic noise in oceans (Wright et al. 2007, Soto et al. 2006), and the intensity of noise can impede the ability of marine animals to navigate, hunt, and communicate (Southall, 2005). Under specific conditions noise disturbance from shipping activities can include hearing damage and strandings (Wright et al. 2007).

Vessel strike on large marine fauna is recognised as significant global threat to marine wildlife and Australia accounts for approximately 17% of vessel strikes with whales worldwide (Peel et al. 2016). Commercial shipping vessel activity has increased considerable in recent decades, and this increased vessel traffic is increasing the risk collisions between wildlife and vessels (Peel et al. 2016). The risk of shipping-related incidents with cetaceans along the NSW coast is seasonal, with large whales, including humpback whales and southern right whales, migrating through NSW waters between June and November each year. There is no specific data on the incidents of vessels strikes in Commonwealth Marine Parks in the Temperate East Region.

Anchoring by large vessels can heavily scour benthic habitats, defaunating rocky reefs and altering soft sediment communities (Broad et al. 2020, Davis and Watson 2025, Davis et al. 2022), although the extent of anchoring within Temperate East marine parks is likely limited.

Further details on the known pressures relating to physical disturbance on threatened and migratory species which the region is important from a conservation perspective are provided in the Commonwealth of Australia (2012a, b, c, d).

6.4 Marine pollution

Intensified land use around coastal waters adjacent to the Temperate East Marine Park Network can increase nutrient, metal and pesticide loads to adjacent marine parks via diffuse agricultural and urban runoff and point discharges, degrading water quality and benthic communities. A summary of these pressures on the NSW continental shelf is provided in NSW Marine Estate Management Authority (2017). In general, there is little information on exports from rivers to coastal waters, with negative effects likely associated with toxicants, litter and microplastics that are carried within flood plumes.

Direct measurements of nutrient export and their effect on offshore marine waters are yet to be determined in NSW. Due to the offshore location of most marine parks in the Temperate East network there is likely limited direct impact associated with the changes in land-use in adjacent coastal catchments. Impacts are most likely on the shelf waters of the Hunter Marine Park associated with sediment and nutrient discharge from the Hunter River due to its highly disturbed catchment (Roper et al. 2011). Localised pollution has been identified at Norfolk Marine Park were there was evidence for exposure of near-shore coral reef sites to terrestrially derived Dissolve inorganic nitrogen inputs at Norfolk Island (Page et al. 2023a, b).

Further details on the known pressures relating to marine pollution on threatened and migratory species which the region is important from a conservation perspective are provided in the Commonwealth of Australia (2012a, b, c, d).

6.5 Marine invasive species

The is no evidence of established populations of invasive species in the Temperate East Marine Park Network. A key potential location for invasive species reflecting the availability of suitable shallow habitats and substantial vessel traffic is in the waters surrounding Norfolk Island. Detailed surveys in this marine park in 2022 found no evidence of any established introduced marine pest, which was indicated to reflect the lack of any substantial port infrastructure prohibiting vessels from residing close and for extended periods, and limited ballast water discharge (Biofouling Solutions 2002). This limits the ability for marine pests to transfer and establish at a location.

Table 11. Known pressures that exist within individual marine parks in the Temperate East Network

		Gifford Marine Park	Lord Howe Marine Park	Central East Marine Park	Norfolk Marine Park	Solitary Island Marine Park	Cod Grounds Marine Park	Hunter Marine Park	Jervis Marine Park
Climate change	Altered ocean currents								
	Increased frequency & severity of weather events								
	Increased sea surface temperature								
	Ocean acidification								
	Sea level rise								
Extraction of living resources	Extraction of benthic mobile invertebrates								
	Extraction of fish and free-swimming invertebrates								
	Extraction of megafauna (excluding fish)								
Physical disturbance	Habitat modification (physical disturbance & removal)								
	Habitat modification (due to changes in nutrients & organic matter)								
	Habitat modification (due to suspended sediments, including smothering)								
	Human presence (disturbance of mobile fauna communities or populations)								
Marine invasive species	Marine pathogens/disease								
	Marine pests								
	Overabundant marine native species								
Island invasive sp.	Animal pests								
	Weeds and plant pests								
Marine pollution	Light pollution								
	Marine debris								
	Noise pollution								
	Noxious substances (chemicals & heavy metals)								
	Oil/fuel spill or leak								
	Sewage waste								
	Changes in nutrients and organic matter								

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Appendix A – Temperate East Marine Parks Network – Natural values defined as ecosystem complexes and ecosystems

Ecosystem complex and ecosystems
Islands (including cays and islets)
Islands (including cays and islets) - Relatively small body of land surrounded by water; Cay – a low bank or reef of coral or sand; Islet – a little island.
Intertidal areas
Beaches
Intertidal coral reefs - Coral reefs found in the intertidal zone (between the highest and lowest tides)
Rocky shores
Shelf vegetated sediments
Shelf vegetated sediments Sediment habitats on the continental shelf that support marine macroalgae or seagrass. Typically, these occur in depths of less than 30m but can extend beyond this in areas with very clear waters.
Shallow reefs
Shallow coral reefs Coral reefs occurring in continental shelf areas shallower than 30m.
Shallow rocky reefs Rocky reefs occurring in continental shelf areas shallower than 30m.
Deep shelf reefs
Mesophotic coral reefs Coral reef formations on tropical shelf areas in the mesophotic zone: a reduced light zone between 30m and the maximum depth at which there is sufficient penetration of sunlight to support photosynthesis. The maximum depth varies dependent upon water clarity and may extend to 150m, however, as a national average it is nominally defined as 70m.
Mesophotic rocky reefs Rocky reef formations on temperate continental shelf areas in the mesophotic zone: nominally defined as up to 70m depth (as above).
Rariphotic shelf reefs Rocky reef formations found on the continental shelf below the mesophotic zone where light is insufficient to support photosynthesis. Nominally rariphotic shelf reefs occur between 70m and 200m.
Upper and mid slope reefs (including canyons)
Upper-slope reefs Reef habitats on the upper section of the continental slope between shelf break (nominally 200m and 700m).
Mid-slope reefs Reef habitats on the mid-continental slope (700-2000 m).

Shelf-incised canyons Steep sided valleys in the seabed that extend onto the continental shelf at least 500m shoreward of the shelf break.
Shelf, upper and mid slope unvegetated sediments
Shelf unvegetated sediments Sediment habitats on the continental and oceanic shelves (0-200 m) that lack marine macroalgae or seagrass.
Upper-slope sediments Sediment habitats on the upper continental slope (200-700 m).
Mid-slope sediments Sediment habitats on the mid continental slope (700-2000 m).
Oceanic coral reefs
Oceanic shallow coral reefs Coral reefs occurring seaward of the shelf break in depths shallower than 30m.
Oceanic mesophotic coral reefs Coral reefs occurring seaward of the continental shelf break in in the mesophotic zone: nominally defined as up to 70m depth (as above).
Seamounts (including guyots)
Seamount reefs Rocky and deep-sea cold-water coral formations occurring on seamounts.
Seamount sediments Sediment habitats occurring on seamounts.
Lower slope and abyssal reef and sediments
Abyssal reef and sediments Reef and sediment habitats in the abyssal zone (4000 and 6000m).
Lower slope reef and sediments Sediment and reefs habitats on the lower continental slope and continental rise (i.e. between 2000m and nominally 4000m).
Water column
On-shelf (neritic) epipelagic The uppermost layer of the ocean extending from the surface to 200m, that occurs above the continental shelf.
Off-shelf (oceanic) epipelagic The uppermost layer of the ocean extending from the surface to 200m, that occurs seaward of the continental shelf break.
Mesopelagic The layer of the ocean between 200m and 1000m, not influenced by the seafloor.
Bathypelagic and Abyssopelagic The layers of the ocean between 1000m and 4000m (bathypelagic) and 4000m and 6000m (abyssopelagic), not influenced by the seafloor.

Appendix B – Threatened and migratory species

Table 1. Marine mammal species that are likely to occur throughout the Temperate East Marine Region

Endangered (Threatened and/or Migratory)
Southern right whale (*Eubalaena australis*)
Antarctic blue whale (*Balaenoptera musculus intermedia*)
Pygmy blue whale (*Balaenoptera musculus brevicauda*)
Vulnerable (Threatened)
Fin whale (*Balaenoptera physalus*)
Sei Whale (*Balaenoptera borealis*)
Marine mammals (listed migratory or cetaceans)
Humpback whale (*Megaptera novaeangliae*)
Minke whale (*Balaenoptera acutorostrata*)
Bryde's whale (*Balaenoptera edeni*)
Sperm whale (*Physeter macrocephalus*)
Killer whale, Orca (*Orcinus orca*)
Long-finned pilot whale (*Globicephala melas*)
Short-finned pilot whale (*Globicephala macrorhynchus*)
False killer whale (*Pseudorca crassidens*)
Cuvier's Beaked Whale (*Ziphius cavirostris*)
Risso's dolphin (*Grampus griseus*)
Melon-headed Whale (*Peponocephala electra*)
Hector's Beaked Whale (*Mesoplodon hectori)*
Tasman Beaked Whale (*Tasmacetus shepherdi*)
Common dolphin (*Delphinus delphis*)
Bottlenose dolphin (*Tursiops truncatus*)
Indo-Pacific bottlenose dolphin (*Tursiops aduncus*)
Striped dolphin (*Stenella coeruleoalba*)
Fraser's Dolphin (*Lagenodelphis hosei*)
Spinner dolphin (*Stenella longirostris*)
Dwarf Sperm Whale (*Kogia sima)*
Gray's Beaked Whale (*Mesoplodon grayi)*
Pygmy Sperm Whale (*Kogia breviceps)*
Strap-Toothed Beaked Whale (*Mesoplodon layardii*)
Other protected marine mammals
Australian fur seal (*Arctocephalus pusillus doriferus*)
Australian Sea Lion (*Neophoca cinerea)*
New Zealand fur seal (*Arctocephalus forsteri*)

Table 2. Marine fish and shark species that are likely to occur throughout the Temperate East Marine Region

Critically Endangered
McCulloch's anemonefish (*Amphiprion mccullochi*)
Endangered
-
Vulnerable
Black cod (*Epinephelus daemelii*)
Whale shark (*Rhincodon typus*)
White shark (*Carcharodon carcharias)*
Marine
Booth's pipefish (*Halicampus boothae*)
Duncker's pipehorse (*Solegnathus dunckeri*)
Kellogg's seahorse, Great Seahorse (*Hippocampus kelloggi*)
Lord Howe pipefish (*Cosmocampus howensis*)
Spiny pipehorse (*Solegnathus spinosissimus*)
Migratory
Giant manta ray (*Mobula birostris*)
Longfin mako (*Isurus paucus*)
Oceanic whitetip Shark (*Carcharhinus longimanus*)
Longfin mako (*Isurus paucus*)
Oceanic whitetip shark (*Carcharhinus longimanus*)
Porbeagle (*Lamna nasus*)
Reef manta ray (*Mobula alfredi*)
Shortfin mako (*Isurus oxyrinchus*)
Conservation dependent
Orange roughy (*Hoplostethus atlanticus*)
Harrisson's dogfish (*Centrophorus harrissoni*)
Scalloped hammerhead (*Sphyrna lewini*)
School shark (*Galeorhinus galeus*)

Table 3. Marine reptiles that are likely to occur throughout the Temperate East Marine Region

Endangered
Loggerhead Turtle (*Caretta caretta)*
Leatherback turtle (*Dermochelys coriacea*)
Vulnerable
Flatback Turtle (*Natator depressus)*
Green Turtle (*Chelonia mydas)*
Hawksbill Turtle (*Eretmochelys imbricata)*
Marine
Horned seasnake (*Acalyptophis peronii*)
Dubois' seasnake (*Aipysurus duboisii*)
Marbled or spine-tailed seasnake (*Aipysurus eydouxii*)
Olive seasnake (*Aipysurus laevis*)
Stokes' seasnake (*Astrotia stokesii*).
Turtle-headed seasnake (*Emydocephalus annulatus*
Beaked seasnake (*Enhydrina schistosa*)
Elegant seasnake (*Hydrophis elegans*)
Spectacled seasnake (*Hydrophis kingii*) is
Small-headed seasnake (*Hydrophis mcdowelli*)
Olive-headed seasnake (*Hydrophis major*)
Yellow-bellied seasnake (*Pelamis platurus*)

Table 4. Bird species that are likely to occur throughout the Temperate East Marine Region

Critically Endangered	Occurrence
Tristan albatross (*Diomedea dabbenena)*	Vagrant
Orange-bellied parrot (*Neophema chrysogaster)*	Rare
Swift parrot (*Lathamus discolor)*	Rare
Curlew sandpiper (*Calidris ferruginea)*	Common
Far eastern curlew (*Numenius madagascariensis)*	Common
Great knot (*Calidris tenuirostris)*	Common
Endangered	
Lesser sand plover (*Charadrius mongolus)*	Rare
Chatham albatross (*Thalassarche eremita)*	Vagrant
Northern royal albatross (*Diomedea sanfordi)*	Common
Shy albatross (*Thalassarche cauta)*	Common
Gould's petrel (*Pterodroma leucoptera leucoptera)*	Rare
Southern giant petrel (*Macronectes giganteus)*	Rare
Black-tailed godwit (*Limosa limosa)*	Rare
Red knot (*Calidris canutus)*	Common
Vulnerable	
White-throated needletail (*Hirundapus caudacutus)*	Common
Greater sand plover (*Charadrius leschenaultia)*	Rare
Antipodean wandering albatross (*Diomedea antipodensis antipodensis)*	Rare
Black-browed albatross (*Thalassarche melanophris)*	Common
Buller's albatross (*Thalassarche bulleri)*	Rare
Campbell albatross (*Thalassarche impavida)*	Vagrant
Gibson's wandering albatross (*Diomedea antipodensis gibsoni)*	Rare
Indian yellow-nosed albatross (*Thalassarche carteri)*	Common
Royal albatross (*Diomedea epomophora)*	Common
Salvin's albatross (*Thalassarche salvini)*	Vagrant
Sooty albatross (*Phoebetria fusca)*	Rare
Wandering albatross (*Diomedea exulans)*	Rare
White-capped albatross (*Thalassarche steadi)*	Rare
Northern giant petrel (*Macronectes halli)*	Vagrant
Blue-winged parrot (*Neophema chrysostoma)*	Common
Alaskan bar-tailed godwit (*Limosa lapponica)*	Common
Marine	
Little penguin (*Eudyptula minor)*	Common
Migratory	
Double-banded plover (*Charadrius bicinctus)*	Common
Little tern (*Sternula albifrons)*	Rare
Short-tailed shearwater (*Ardenna tenuirostris)*	Common
Black petrel (Procellaria parkinsoni)	Common
Wilson’s storm-petrel (*Oceanites oceanicus*)	Rare

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