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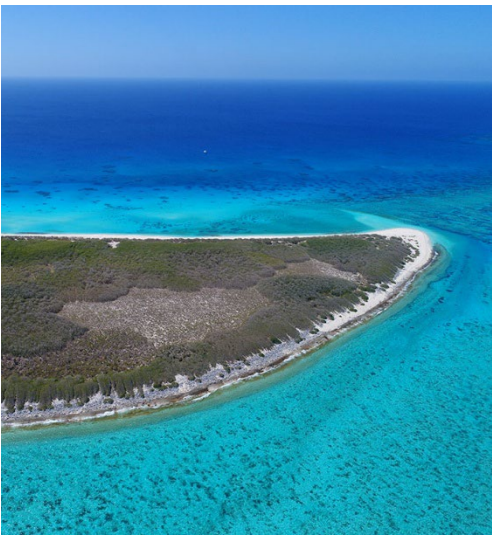
RESEARCH REPORT

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Coral Sea Marine Park Synthesis Report

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Executive summary

The Coral Sea Marine Park (CSMP) spans approximately 989,836 km² of Commonwealth waters and represents Australia's largest marine park. Extending from the outer edge of the Great Barrier Reef to more than 1,200 km offshore, the park encompasses a vast and geomorphically complex seascape that includes continental shelf and slope systems, abyssal basins, extensive plateau structures, seamount chains, submarine canyons, oceanic reefs and isolated coral cays. Situated within the dynamic influence of the South Equatorial Current (SEC) and the East Australian Current (EAC), the Coral Sea forms a major oceanic transition zone that connects tropical Pacific waters with temperate Australian systems and supports high levels of ecological connectivity across the southwest Pacific.

This report brings together current knowledge of the CSMP's natural values, ecosystems, oceanography, uses and pressures. It provides a synthesis rather than a comprehensive review. It integrates evidence from seabed mapping programs, ecological surveys, long-term monitoring datasets, oceanographic studies and species observations to provide a consolidated scientific basis to support management of the CSMP and identify key knowledge gaps that constrain understanding of ecosystem condition and change. The review does not attempt to comprehensively synthesise species ecology literature of limited relevance to the Coral Sea; emphasis is instead placed on evidence that improves understanding of ecosystem distribution, biodiversity, ecological processes, human uses and pressures within the CSMP itself.

Understanding of the physical environment has advanced significantly over the past two decades through multibeam bathymetry, targeted research voyages and remote sensing. These efforts have revealed a highly heterogeneous seabed comprising reef complexes, submerged plateaux, steep escarpments, volcanic seamount chains and deep abyssal basins exceeding 5,000 m in depth. Although these features occupy a small proportion of the park's total area, they underpin much of its ecological diversity by structuring habitat availability, influencing circulation and enhancing local productivity through topographic interaction with major ocean currents.

The CSMP is characterised by strong oceanographic forcing driven primarily by the westward-flowing South Equatorial Current, which bifurcates and contributes to the formation of the East Australian Current along the continental margin. Interactions between these currents, regional wind systems and complex bathymetry generate mesoscale eddies, internal waves and episodic upwelling that regulate nutrient availability, productivity and biological connectivity. Seasonal and interannual variability, including ENSO-driven changes, further modulates these processes and influences ecosystem dynamics across reef, pelagic and deep-sea environments. The region is also experiencing increasing impacts from ocean warming and marine heatwaves, which are contributing to coral heat stress and ecosystem stress.

A hierarchical ecosystem framework identifies a diverse suite of ecosystems across the CSMP, ranging from shallow coral reefs and cay systems through mesophotic and deep reef environments to abyssal plains and pelagic waters. However, ecological knowledge remains

highly uneven. While shallow reef systems and selected seamounts have been relatively well surveyed, most deep-sea habitats remain relatively low surveyed, with gaps in understanding of benthic community composition, ecosystem structure and functional processes below 1,000 m depth.

The park contains several areas of high ecological significance, including the Ashmore, Boot, Bougainville, Mellish, Moore, and Cato Reef systems, as well as the Tasmantid and associated seamount chains. These habitats support structurally complex benthic communities and act as important stepping-stone environments for species dispersal across the Pacific. Offshore cays and islets provide critical breeding habitat for seabirds and marine turtles, while deep-sea environments support diverse but still poorly known assemblages of sponges, corals and other invertebrates. Together, these systems contribute to the Coral Sea's role as a globally significant reservoir of marine biodiversity and connectivity.

The CSMP supports a wide range of threatened, migratory and ecologically important species, including reef-associated fishes, sharks, cetaceans, seabirds and marine turtles. Offshore cays, particularly within the Coringa–Herald and Lihou Reefs, are nationally significant breeding sites for multiple seabird species. Pelagic predators and migratory species utilise the region as part of broader movement pathways across the southwest Pacific, highlighting the importance of large-scale connectivity processes driven by ocean currents.

Recent marine research and monitoring programs, including *RV Investigator* voyages, have substantially improved baseline ecological understanding of selected deep-sea habitats. Several initiatives have provided standardised biodiversity data, expanded species inventories and revealed previously undocumented deep-sea assemblages. However, spatial and temporal coverage remains limited relative to the scale of the park, and deep-water environments remain among the least understood marine ecosystems in Australian waters.

The CSMP is managed through zoning aligned with IUCN protected area categories, including National Park Zones, Habitat Protection Zones, Multiple Use Zones and Special Purpose Zones. This zoning aims to balance conservation of representative ecosystems and ecological processes with sustainable use and access. Earlier protected areas, including the Coringa–Herald and Lihou Reef Reefs, remain key reference sites due to their long-term protection status and relatively undisturbed ecological condition.

Given the offshore remote location of the CSMP, there are fewer uses and associated pressures evident in other Australian Marine Parks. Climate change represents the most significant long-term pressure affecting the CSMP. Increasing ocean temperatures, marine heatwaves, changes in current strength and structure, and associated shifts in nutrient dynamics are already driving observable ecological change across the region. These pressures are compounded by episodic disturbances such as cyclones and coral heat stress events, which have resulted in measurable declines in coral cover on several reefs in recent years. The cumulative effects of these stressors are expected to influence ecosystem resilience, species distributions and food-web structure across the entire marine park.

This synthesis highlights both the substantial progress made in understanding the CSMP and the persistent gaps that remain, particularly in deep-sea ecosystems and large-scale ecological processes. Continued investment in integrated seabed mapping, long-term monitoring, oceanographic modelling and targeted biological surveys will be essential to improve understanding of ecosystem condition, detect change and support adaptive, evidence-based management of this globally significant marine park.

1. Introduction

1.1 Coral Sea Marine Park

The Coral Sea Marine Park (CSMP) covers approximately 989,836 km² of tropical and subtropical Commonwealth waters immediately east of the Great Barrier Reef Marine Park, extending from Cape York Peninsula to around 40 km north of Bundaberg, Queensland, and out to the limit of Australia's exclusive economic zone (O'Hara et al. 2019; Smith et al. 2024). It is the largest marine park in Australia's national network, covering approximately 1.3 million km² when combined with the adjacent Great Barrier Reef Marine Park (Hunt 2013). It also shares a long boundary with New Caledonia's Parc naturel de la mer de Corail. Although the latter is not managed by Australia, the two parks form part of a much larger contiguous protected area across the Coral Sea. The CSMP Management Plan 2018 assigns an International Union for Conservation of Nature (IUCN) category to each of the four zones within the park: National Park Zone (II), Habitat Protection Zone (IV), Habitat Protection Zone (Reefs) (IV), and Special Purpose Zone (Trawl) (VI) (Figure 1).

The seascape spans intertidal reef flats, islands, continental shelf, slope and abyssal environments to depths exceeding 5,000–6,000 m, with considerable variation in seafloor topography including coral reef and cay systems, seamounts, submarine canyons and plains. Ocean circulation plays a defining role in shaping the region's ecology, with the South Equatorial Current bifurcating near the Queensland Plateau into the north-flowing Hiri Current and the south-flowing East Australian Current, creating a barrier that reduces species mixing between the north and south of the park and forming distinct ecological communities (Ganachaud et al. 2014; Ridgway & Dunn 2003). The result is an unusually species-rich environment, with high diversity recorded across corals, crustaceans, echinoderms, molluscs, sponges and fish, including at least 390 species of coral reef fish, 140 hard coral species, and 745 marine mollusc species at the Coringa-Herald Cay (Parks Australia 2026).

This blending of tropical influences with deep, remote oceanic conditions supports diverse reef communities and important habitat for sharks and other wide-ranging marine species across isolated reefs and seamounts far from continental influence (Hoey et al. 2026). More broadly, the park supports globally significant populations of internationally threatened species, a small number of endemic taxa, and critical habitat for a range of wide-ranging species. Six of the world's seven marine turtle species occur in the Coral Sea, tiger sharks use the reefs as mating and feeding grounds, and humpback whales migrate through the park each year on their passage from Antarctic feeding grounds to Queensland breeding areas. Offshore reef and cay systems at Coringa-Herald, Lihou Reef and the Diamond Islets provide breeding and foraging habitat for multiple seabird species, including regionally important populations of red-footed booby, lesser frigatebird and greater frigatebird, and waters adjacent to Osprey, Bougainville, Shark and Vema Reefs hosts the world's only confirmed spawning aggregation of black marlin (Domeier & Speare 2012). The park also supports 52 species of deepwater sharks, rays and chimaera, 18 of which are known only from the Coral Sea (Ceccarelli 2011; Last & Stevens 2009).

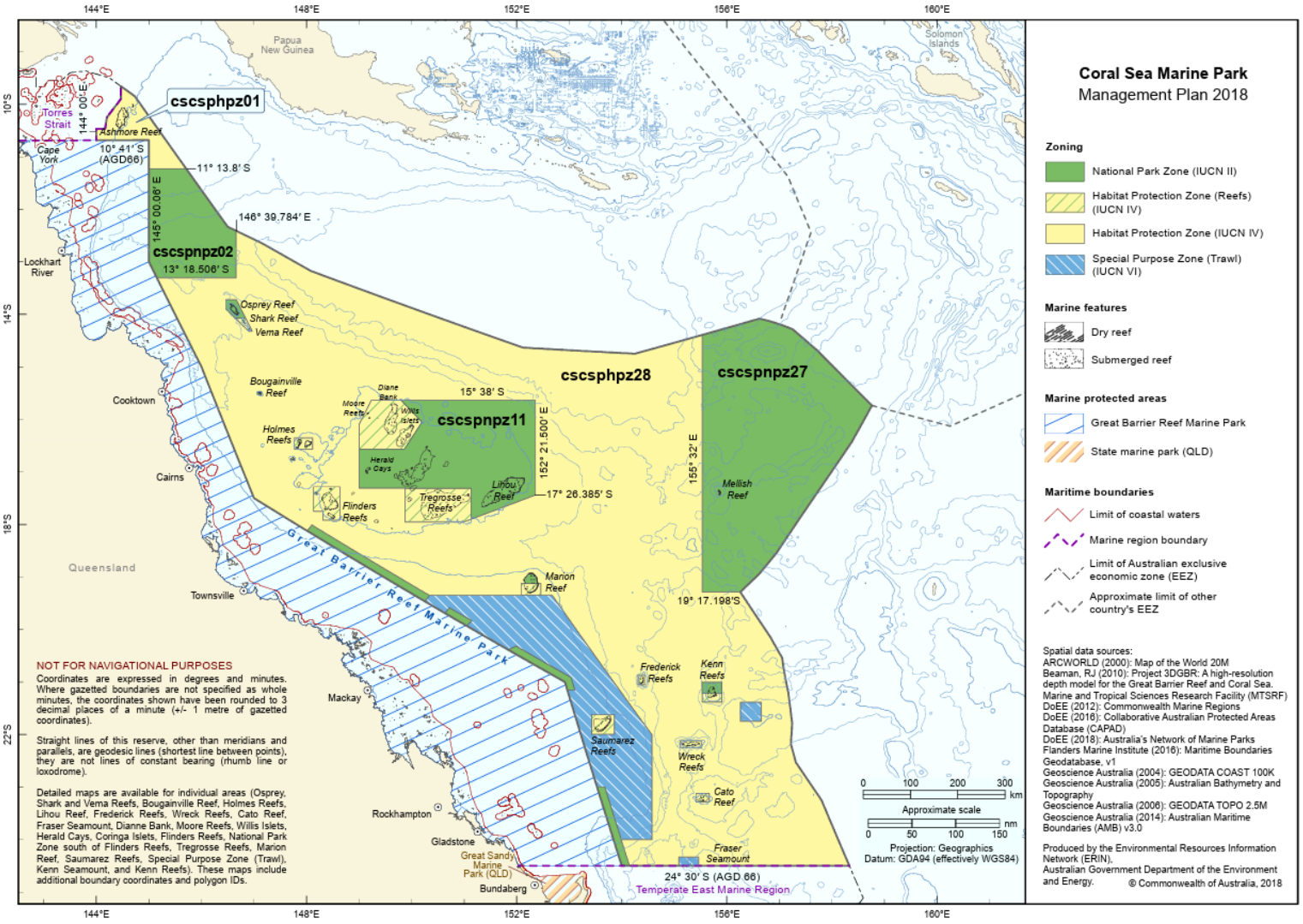


Figure 1. Coral Sea Marine Park with Commonwealth (Australian Marine Park) managed marine park zones. (https://seamapaustralia.org/map/#9de83908-a39f-4896-9aa4-8310505508b3)

This report aims to bring together the current knowledge of the CSMP's natural values, ecosystems, oceanography, uses and pressures. It provides a synthesis rather than a comprehensive review. It does not assess the Biologically Important Areas (BIAs), Key Natural Values (KNVs) or Key Ecological Features (KEFs) of the park, which are addressed separately in other park management and assessment documents. It also aims to describe the type and distribution of human uses across the park, including both recreational and commercial activities such as fishing, tourism, and boating and shipping. While much of the park sits far offshore, live-aboard dive expeditions to reefs such as Osprey Reef 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 park, with several specific climate change pressures expected to result in significant long-term changes across the region. Reef systems have already experienced repeated severe tropical cyclones and coral heat stress disturbances, with coral cover declines of 26% and 28% recorded in the central and northern CSMP respectively following the 2020 and 2021 heat stress events (Hoey et al. 2023). Additional pressures include marine debris, invasive species, 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 such as Cairns, Townsville, Gladstone and Mooloolaba. 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 the CSMP, a detailed synthesis of these are outside the scope of this report.

1.1.1 Scope and literature selection

This synthesis includes 127 published papers, technical reports, government documents and monitoring reports to summarise the current understanding of the natural values, uses and pressures within the CSMP. The emphasis was on literature directly relevant to the Commonwealth Australian Marine Parks or to ecological processes operating across the broader offshore region.

The review focused on studies that were undertaken within the CSMP, or that addressed offshore ecosystems, oceanography, threatened species, fisheries, habitat mapping and ecosystem processes directly applicable to the park. National assessments, management plans, State of the Environment reporting, 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 Great Barrier Reef and Coral Sea Natural Park New Caledonia. While literature these two regions provides valuable ecological context, it was generally excluded from the synthesis unless it directly informed understanding of Commonwealth marine parks, demonstrated ecological connectivity across

state and Commonwealth boundaries, or provided the only available information for comparable habitats.

Similarly, the review did not attempt to comprehensively synthesise the extensive literature on species ecology where these studies had limited relevance to the Coral Sea. Instead, emphasis was placed on evidence that improved understanding of ecosystem distribution, biodiversity, ecological processes, human uses and environmental pressures within the CSMP itself.

This selective approach reflects the objective of producing a management-focused synthesis rather than a comprehensive review of all marine research undertaken across the CSMP and adjacent regions. 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

Circulation within the CSMP is dominated by the westward-flowing South Equatorial Current (SEC), which originates in the central Pacific and enters the Coral Sea through a series of zonal jets deflected by the island chains of Vanuatu and New Caledonia (Figure 2; Welch et al. 2016). The SEC delivers approximately 24 Sv of inflow to the Coral Sea (1 Sv = 10^6 m^3 s^{-1}), splitting into three primary branches around these island chains (Kessler and Cravatte 2013, Welch et al. 2016). Two of these are most relevant to the Marine Park. The North Vanuatu Jet is a broad westward jet between approximately 10°S and 15°S, transporting around 16 Sv mostly above the thermocline, and carries water across the northern Coral Sea toward the Queensland Plateau (Kessler and Cravatte 2013). The North Caledonian Jet crosses the central Coral Sea and contributes approximately 11 Sv of inflow (Kessler and Cravatte 2013, Welch et al. 2016).

Inflow via the North Caledonian Jet feeds the western boundary current system on the Queensland Plateau, where the southward-flowing East Australian Current (EAC) originates from the SEC at approximately 15°S (Andutta et al. 2011, Keene et al. 2008). The EAC then flows south over the Queensland Trough and Marion Plateau, forming the western boundary of the South Pacific anti-cyclonic gyre along the southwestern margin of the Park (Hamilton 1992, Keene et al. 2008, Zann 2000).

Surface circulation in the western Coral Sea shows a clear seasonal signal driven by wind. Moderate to strong southeast trade winds prevail from April to November, and weaker northwest monsoon winds from December to March. During the trade wind season the persistent northwest-directed wind boosts northward-flowing currents and slows southward-flowing currents such as the EAC, whereas during the monsoon the winds ease and the currents behave almost as if there were no surface wind forcing (Steinberg and Lawrey 2018).

The latitude at which the SEC bifurcates into northward and southward arms also shifts seasonally between about 14°S and 20°S, sitting at the southern end of that range during the trade wind season (GBRMPA, 2024). Wind also shapes vertical exchange. Southeast trades

push surface waters onshore and suppress upwelling along the coast and shelf edge, while the weaker and less consistent monsoon winds allow episodic upwelling (Steinberg and Lawrey 2018). The monsoon period is also when winds drop and mixing and cooling are reduced, which allows surface temperatures to rise significantly and can trigger coral heat stress (AIMS eReefs), linking directly to the heat stress results from Spillman and Smith (2021).

Mesoscale variability in the southern and western Park is strongly influenced by the EAC eddy field. Meanders in the current can form loops that detach as large warm-core eddies, sometimes reaching 300 km in diameter (Zann 2000). Interannual variability in SEC transport is highly correlated with the Southern Oscillation Index, with lags of approximately two to five months between El Niño Southern Oscillation phases and SEC transport anomalies (Kessler and Cravatte 2013). Argo float observations consistently show east-to-west drift trajectories, confirming the dominant westward surface circulation associated with the SEC (Oke et al. 2019).

At intermediate and abyssal depths, the water-mass structure reflects southern-sourced inflow. Antarctic Intermediate Water flows northward at depths of approximately 700 to 1,000 m, and Antarctic Bottom Water moves northward through the Coral Sea basins, with salinities of approximately 34.47 to 34.72 psu and oxygen concentrations of 4.06 to 4.49 mL L^{-1} (Keene et al. 2008, O'Hara et al. 2019). These water masses bathe the Park's deep slope and abyssal habitats.

Phytoplankton communities in the CSMP are characteristic of oligotrophic tropical oceanic waters, with low biomass and assemblages dominated by small picophytoplankton, including Prochlorococcus, alongside dinoflagellates and other small eukaryotic phytoplankton (Young et al. 2012; Moore et al. 2019). Community composition and productivity are influenced by the southward transport of warm Coral Sea waters in the EAC, together with frontal dynamics and mesoscale eddies (Lynch et al. 2015, Hassler et al. 2010, Baird et al. 2011, Firme et al. 2023).

Ocean warming and circulation change have direct ecological consequences for the CSMP. During heat stress years, the proportion of Coral Sea grid cells where Degree-Heating Months exceeded one (DHM > 1) closely matched observed conditions, with predicted heat stress extents of 85% in 2002 and 95% in 2006 (Spillman and Smith 2021). The westward-flowing SEC also acts as a major corridor for larval connectivity, with population genetic studies showing connectivity between New Caledonian reef fish populations and those of the Great Barrier Reef (Herwerden et al. 2009). Coral Sea reefs may therefore act as dispersal stepping-stones between the western Pacific and the Great Barrier Reef, a process that depends on the persistence and direction of regional currents (Ceccarelli 2012).

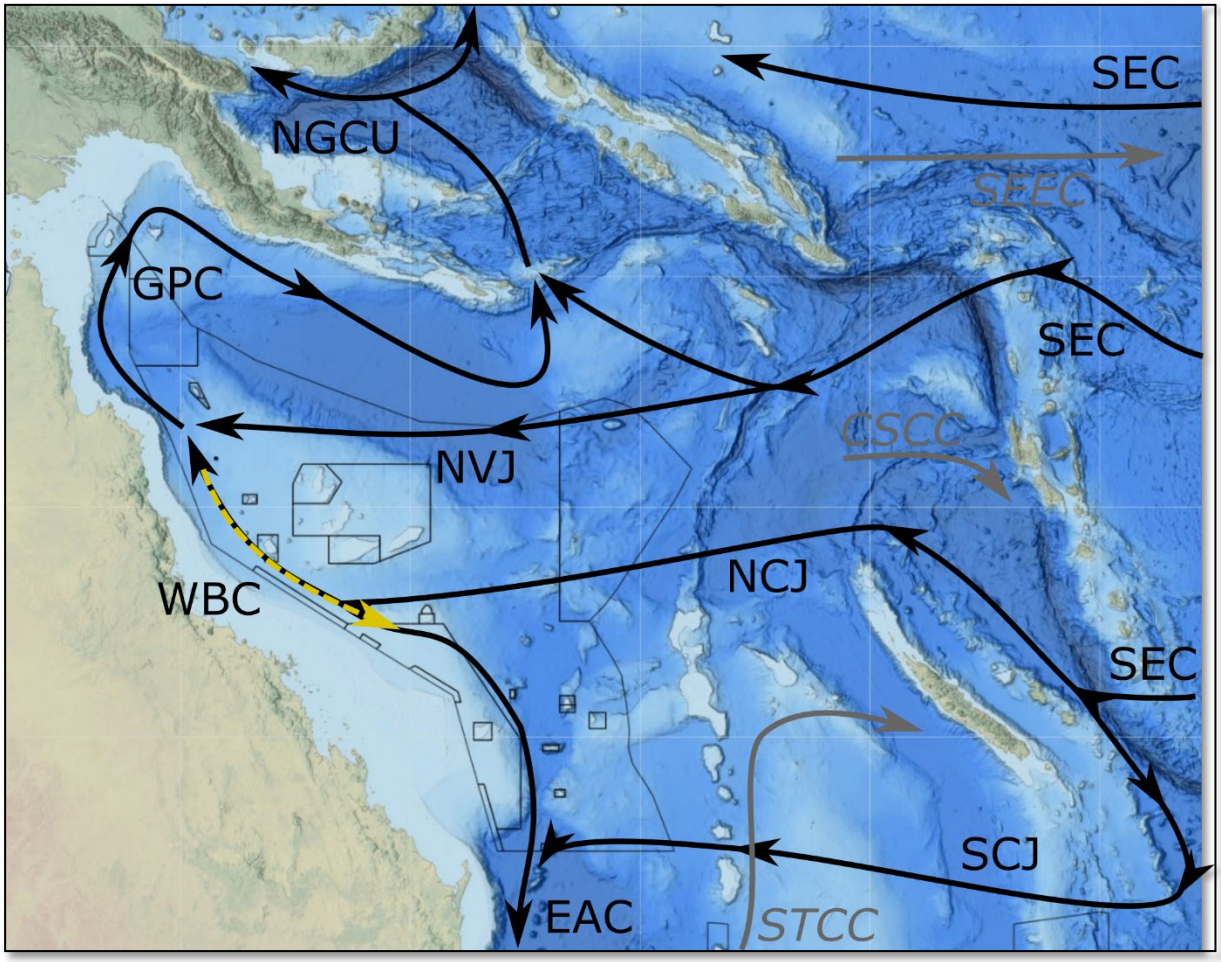


Figure 2. Schematic of the Coral Sea showing the currents in the region (top 1000 m) derived from Ganachaud et al. (2014) including the SEC and its jets, the North Vanuatu Jet (NVJ), North Caledonian Jet (NCJ) and South Caledonian Jet (SCJ) (black arrows). Western boundary currents (WBC) (black and dashed yellow arrows): New Guinea Coastal Undercurrent (NGCU), Gulf of Papua Current (GPC) and East Australian Current (EAC). Counter-currents (grey arrows): South Equatorial Counter Current (SECC), Coral Sea Counter Current (CSCC) and South Pacific Subtropical Counter Current (STCC).

2. Understanding of natural values of the Coral Sea Marine Park

The natural values of the CSMP can be grouped into three broad settings: islands and cays, coral reefs, and the deep-sea and open-ocean environments that make up most of the park. The emergent habitats are low-lying carbonate cays and islets, of which there are about 56 across the park, with 44 known to support nesting seabirds or turtles (Hamann et al. 2025; Parks Australia 2025). Their vegetation ranges from bare sand and rubble to woody communities that include around 15% of Australia's *Pisonia grandis* forest (Batianoff et al. 2009). Because all emergent landforms are carbonate, rocky shores and shallow rocky reefs are absent. The cays sit on or beside about 3100 reefs and shoals built on the high points of plateaux and seamount summits, isolated from one another by open ocean (Ceccarelli 2012). Reefs make up only about 1% of the park's area, yet oceanic shallow coral reefs are its defining ecosystem. Their animal communities are more similar to those of the oceanic islands and atolls of Tonga and Samoa than to the nearby Great Barrier Reef (Parks Australia 2026). These reefs continue through mesophotic and rariphotic depths, where the deepest living hard corals in Australian waters occur (Hoey et al. 2023), and enclose lagoons with seagrass and algal beds (Tol et al. 2025; Hayes et al. 2024). Most of the park is deep. It includes slope reefs and sediments, canyons, seamounts including the northern end of the Tasmantid chain, and abyssal plains reaching 5,000 to 6,000 m, all overlain by a pelagic water column that extends from warm surface waters to abyssopelagic depths.

Knowledge of these settings is uneven, and it declines with depth and distance from accessible reefs. Most available data derive from dedicated survey programs and research voyages, supplemented by long-term monitoring at accessible reef sites and remote sensing programs. The first park-wide assessments of shallow reef biodiversity were conducted by Reef Life Survey (RLS) teams between 2012 and 2015. Subsequent yearly reef surveys in 2018 to 2025 (Hoey et al. 2026) have continued to build a more comprehensive ecological time series used to inform management. Surveys were undertaken at eleven reefs using diver-based methods along three replicate transects within reef crest habitats (1 to 3 m depth) and deeper reef environments, providing standardised counts of fishes, invertebrates and benthic cover (Hoey et al. 2023).

Beyond shallow reef environments, targeted research voyages have progressively expanded understanding of the CSMP's deeper and less accessible habitats. Voyage IN2019_V04 of the RV *Investigator* collected approximately 30 rock dredges across the central CSMP, yielding 94 specimens and several important biogeographic and depth-range extensions for benthic invertebrate taxa (Lucieer et al. 2020). These collections included scleractinians, octocorals and sponges from depths exceeding 1,000 m, where available records remain extremely sparse (Lucieer et al. 2020). Across the broader Coral Sea region, the order Scleractinia has more than 500,000 records globally, yet fewer than 700 records originate from depths greater than 1,000 m within the Coral Sea, highlighting substantial knowledge gaps in deep-sea biodiversity and habitat distribution (Lucieer et al. 2020). Seabird and cetacean transects conducted during voyages of the RV *Investigator* and RV *Falkor* have also contributed systematic observations of pelagic biodiversity, complementing long-running seabird monitoring programs undertaken on the Coringa-Herald cays since 1992 (Heather et al. 2022a).

Subsequent expeditions have continued to reveal the exceptional but poorly characterised biodiversity of the CSMP's deeper environments. The 2025 RV *Investigator* voyage IN2025_V06 enabled taxonomists from CSIRO and the Nippon Foundation–Nekton Ocean Census to identify more than 110 fish and invertebrate species considered new to science (CSIRO 2026). These discoveries included deep-water sharks, rays, chimaeras, crustaceans, echinoderms, anemones and sponges, demonstrating that substantial unknown biodiversity persists even within a large and long-established marine protected area.

Complementing specimen-based surveys, Schmidt Ocean Institute expeditions aboard the R/V *Falkor* have provided some of the first high-resolution visual assessments of deep-water habitats within the CSMP. The 2020 CSMP expedition used the remotely operated vehicle (ROV) *SuBastian* to conduct 14 deep-sea dives and collect more than 74 hours of high-resolution imagery across depths to 1,600 m. These surveys revealed previously undocumented habitats including deep reefs, coral atolls, submarine canyons and seamount environments, and recorded the deepest living hard corals known from eastern Australian waters. Observations included extensive deep-water coral fields dominated by *Leptoseris*, numerous range extensions for fishes and invertebrates, and several potentially undescribed species of fish, snails and sponges. Importantly, these observations demonstrated the ecological significance of deep mesophotic habitats, where coral communities occur beyond the depths typically associated with shallow-water disturbance and may provide important refuge habitats that remain poorly understood across the Coral Sea.

Together, these surveys demonstrate that understanding of the CSMP's natural values remains strongly constrained by the limited spatial and depth coverage of biological observations. The combination of targeted sampling, remotely operated vehicle surveys and emerging image-based approaches is progressively revealing new species, habitats and ecological relationships, while highlighting substantial remaining uncertainty in the distribution, composition and environmental drivers of deep-water ecosystems. These knowledge gaps are particularly important for informing conservation planning, monitoring design and adaptive management within Australia's largest marine protected area.

2.1 Broad scale bathymetry

The CSMP spans a broad bathymetric range from intertidal reef flats and shallow lagoons less than 1 m deep to abyssal basins exceeding 5,000 m, encompassing the full continuum of shelf, slope and deep-sea geomorphologies represented within the East Marine Region (Figure 3; Keene et al. 2008). The CSMP contains a complex assemblage of major bathymetric and geomorphic features including the Coral Sea Basin, the Louisiade Plateau, the New Hebrides Trench, the Queensland Plateau, the Townsville Trough, the Marion Plateau, the Kenn Plateau, the Chesterfield Plateau and the Tasmantid Seamount Chain (Welch et al. 2016). These features reflect the region's complex geological history, including hotspot volcanism, tectonic rifting associated with the opening of the Tasman and Coral Seas, and long-term sea-level fluctuations. Broad-scale geomorphic structures include extensive atoll and platform reef systems, volcanic seamount chains, submarine ridges, deep troughs and sediment-filled basins, while finer-scale features include pinnacles, scarps, moats and reef-rim escarpments.

Reefs and shoals within the CSMP are formed on the structural high points of major plateaux and the summits of seamounts. The park contains approximately 3,100 individual reefs and shoals, as well as 14 prominent seamounts distributed throughout the park (Ceccarelli 2012; Lawrey & Bycroft 2025). High-resolution bathymetric mapping has been concentrated around major oceanic reef complexes including Osprey (Figure 4), Holmes (Figure 5), Herald (Figure 6) and Flinders (Figure 7) as well as Marion, Saumarez, Kenn, Wreck and Lihou reefs, together with the Queensland Plateau and Marion Plateau (Lindhorst et al. 2026). These structures rise abruptly from depths of 1,000 to 2,000 m to form shallow reef crests, lagoonal systems and steep outer reef walls. Many atolls display characteristic annular geomorphology with deep central lagoons, encircling reef rims and sharply incised passages that facilitate tidal exchange and influence local hydrodynamics. Although elevated geomorphic features occupy only a small proportion of the total area of the CSMP, they are ecologically significant because of their structural complexity, influence on local and mesoscale circulation, and role as stepping-stone habitats facilitating connectivity across the southwest Pacific (Welch et al. 2016). In otherwise oligotrophic tropical waters, reefs and seamounts also function as localised centres of enhanced productivity through benthic production, entrainment of particles within eddies and localised upwelling of nutrient-rich waters (Welch et al. 2016).

The continental shelf along eastern Queensland forms the western boundary of the CSMP and is comparatively broad relative to southeastern Australia, extending between approximately 60 and 250 km offshore before descending across a moderately steep continental slope. Shelf depths are generally less than 200 m before transitioning into the deep-water environments of the Coral Sea Basin and adjacent plateaux. Although the continental slope is less extensively dissected by submarine canyons than in temperate southeastern Australia, major geomorphic features including the Townsville Trough, Queensland Trough and Marion Plateau escarpments strongly influence sediment transport and regional circulation patterns. Beyond the slope, the seabed transitions into extensive deep basins and abyssal plains where depths commonly exceed 4,000 to 5,000 m. While these deep-sea environments appear relatively uniform at broad spatial scales, they dominate the area of the marine park and are punctuated by isolated volcanic seamounts, guyots and drowned reef platforms that support distinct hard-substrate habitats and biological assemblages.

A defining bathymetric characteristic of the CSMP is the presence of extensive volcanic seamount chains, including the Tasmantid, Nova-Canton and Louisiade chains. These features rise hundreds to thousands of metres above the surrounding abyssal plains and frequently support enhanced local productivity and distinct benthic communities. Some seamounts rise to within 50 to 200 m of the sea surface, creating steep-relief habitats that function as regional biodiversity hotspots relative to surrounding soft-sediment basins. These elevated structures also influence regional oceanography by modifying currents, generating turbulence and enhancing vertical mixing processes that contribute to local productivity and biological aggregation.

Historical bathymetric coverage across the Australian Exclusive Economic Zone has been uneven, with continental shelf waters accounting for more than 1.9 million km², the continental slope approximately 4.1 million km², the continental rise around 97,000 km² and abyssal plains approximately 2.9 million km² (Heap and Harris 2008). Despite the ecological

significance of these environments, less than 10% of the seafloor within Commonwealth Marine Parks has been mapped at high spatial resolution. Over the past two decades, understanding of Coral Sea bathymetry has improved substantially through advances in multibeam sonar technology, coordinated seabed-mapping programs and the integration of historical survey datasets into regional bathymetric compilations. Major contributions were provided by the SOI's *RV Falkor* and *RV Investigator* (IN2019_V04) voyages, which combined mapped approximately 181,000 km² of seafloor within the CSMP at 5-100 m grid resolutions, equivalent to around 18 % of the park and representing the most spatially extensive high-resolution dataset currently available for the region (Beaman 2020; Lucieer et al. 2020). Bathymetric data for the broader East Marine Region are primarily derived from the Australian Bathymetry and Topography Grid at 250 m resolution, with geomorphic provinces delineated through integration of regional bathymetry and local seabed studies (Keene et al. 2008).

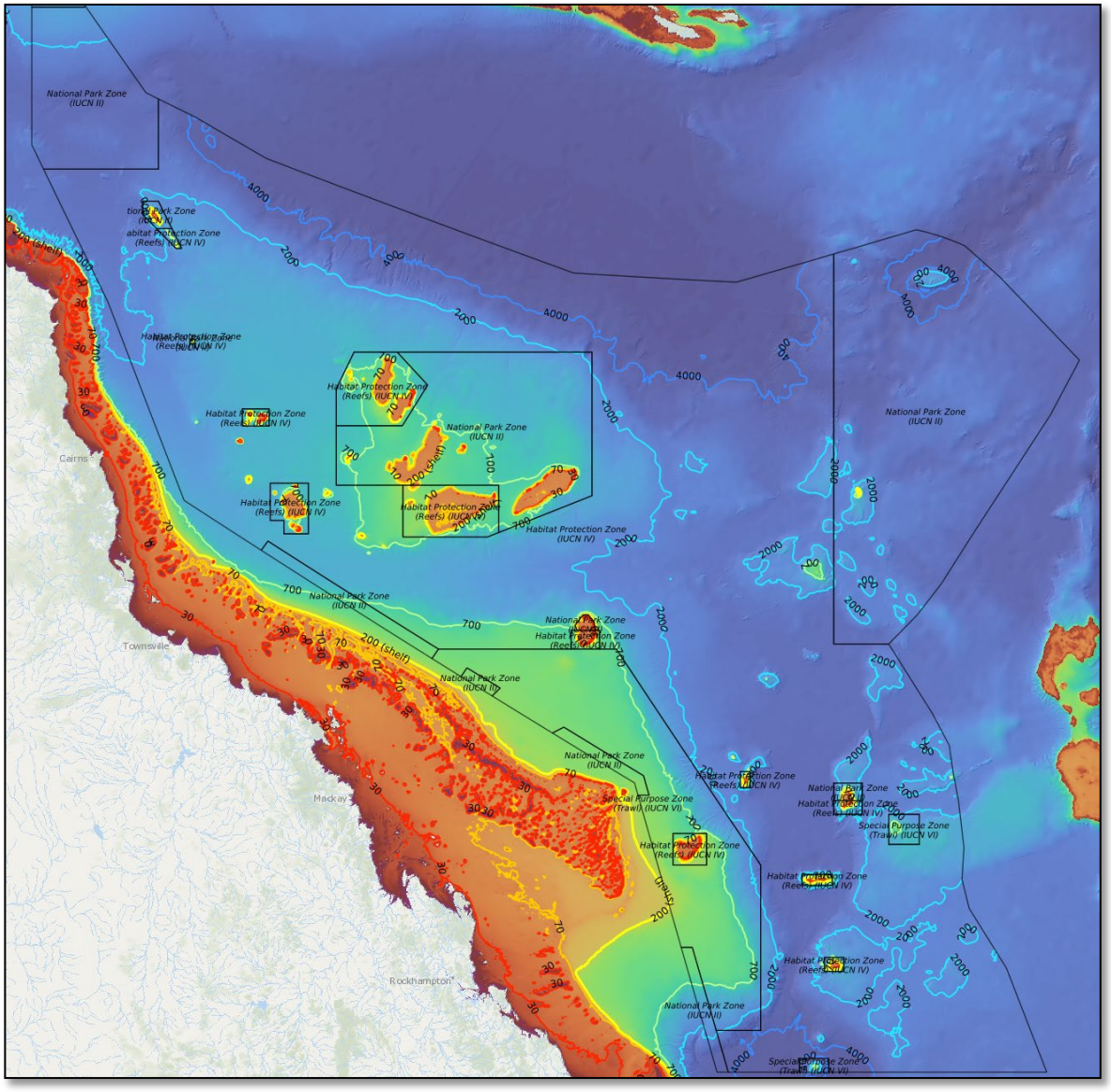


Figure 3. Broadscale bathymetry of the Coral Sea Marine Park, including depth contours representing boundaries between ecosystem types (From Seamap Australia https://seamapaustralia.org/map/#df6bc087-da22-4ea8-96ce-50de9ef93de1).

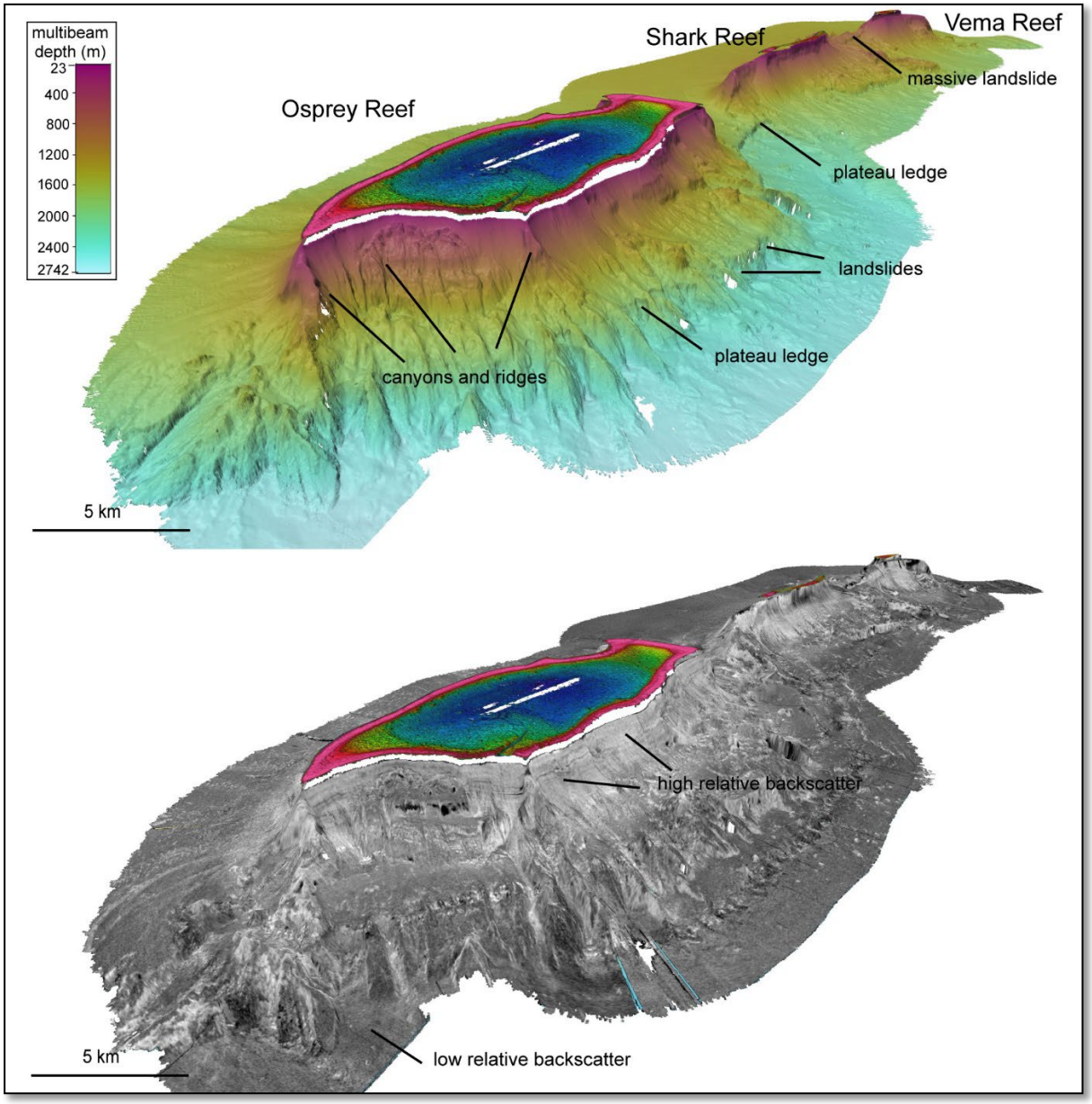


Figure 4. 3D view of Osprey Reef area: (top) multibeam bathymetry (bottom) multibeam backscatter. Shallow reef lidar bathymetry courtesy of the Australian Hydrographic Office. Vertical exaggeration x2. (Source: Beaman and Bostock 2022)

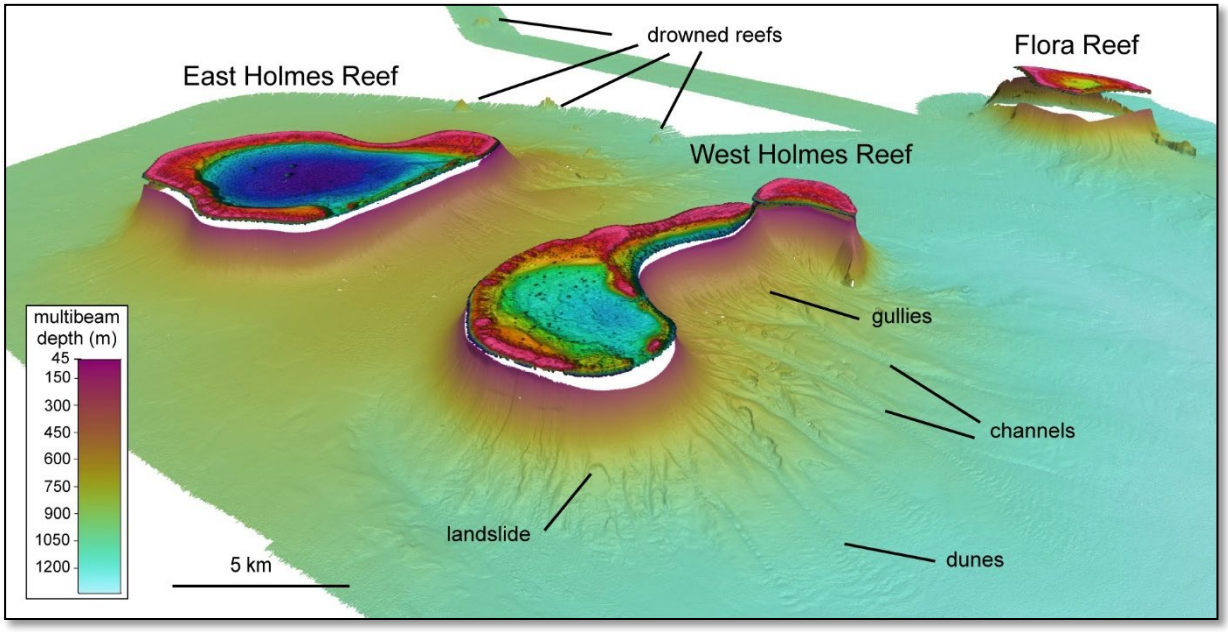


Figure 5. 3D view of West and East Holmes Reefs and Flora Reef. Shallow reef lidar bathymetry courtesy of the Australian Hydrographic Office. Vertical exaggeration x3. (Source: Beaman and Bostock 2022)

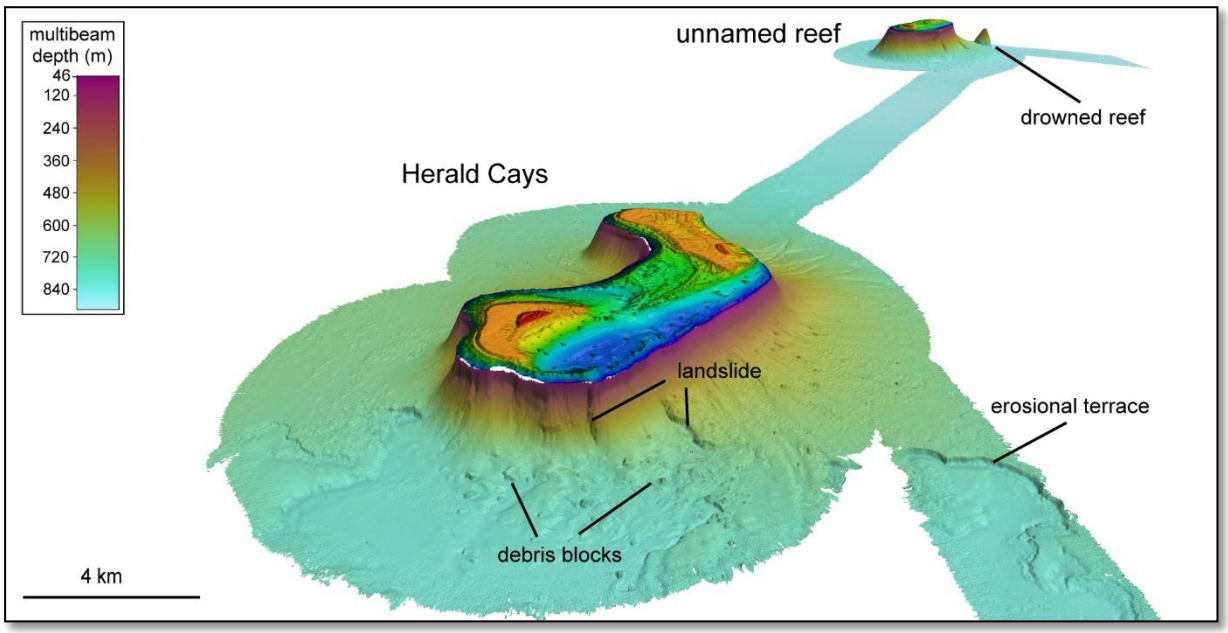


Figure 6. 3D view of Herald Cays and unnamed reef. Shallow reef lidar bathymetry courtesy of the Australian Hydrographic Office. Vertical exaggeration x3. (Source: Beaman and Bostock 2022)

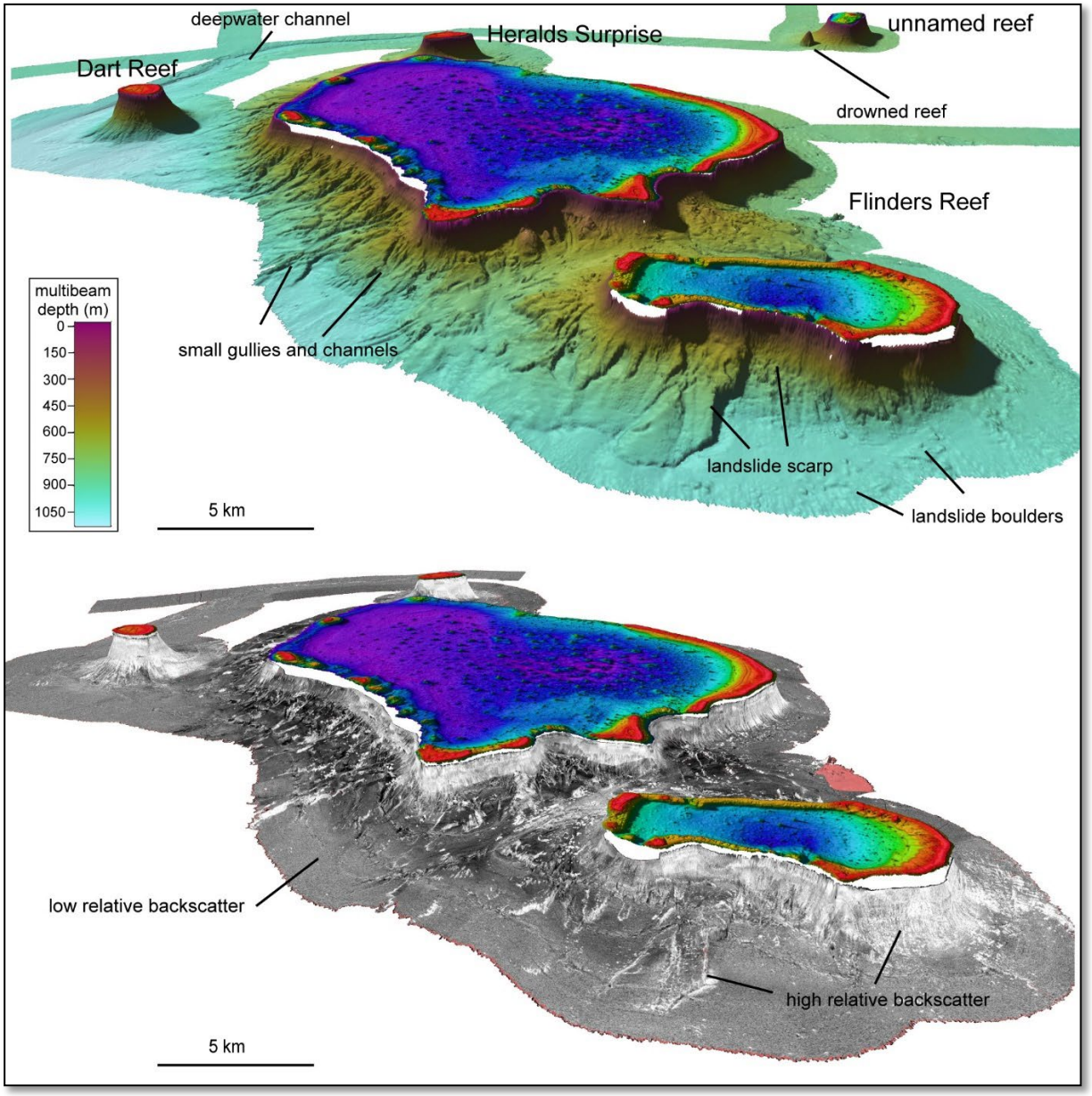


Figure 7. 3D view of Flinders Reefs area: (top) multibeam bathymetry; (bottom) multibeam backscatter. Shallow reef lidar bathymetry courtesy of the Australian Hydrographic Office. Vertical exaggeration X3. (Source: Beaman and Bostock 2022)

2.2 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 8). 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. 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. coral 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 (Figure 9).

The past twenty years has seen a significant increase in the collection and collation of benthic ground truthing information across the which has led to large increases in awareness of the occurrence and extent of reefs and cays within the CSMP (Lawrey and Bycroft 2025).

The broad distribution of these ecosystem types across the CSMP are summarised in the following sections, and the specific ecosystems that are present in the CSMP is summarised in Table 1.

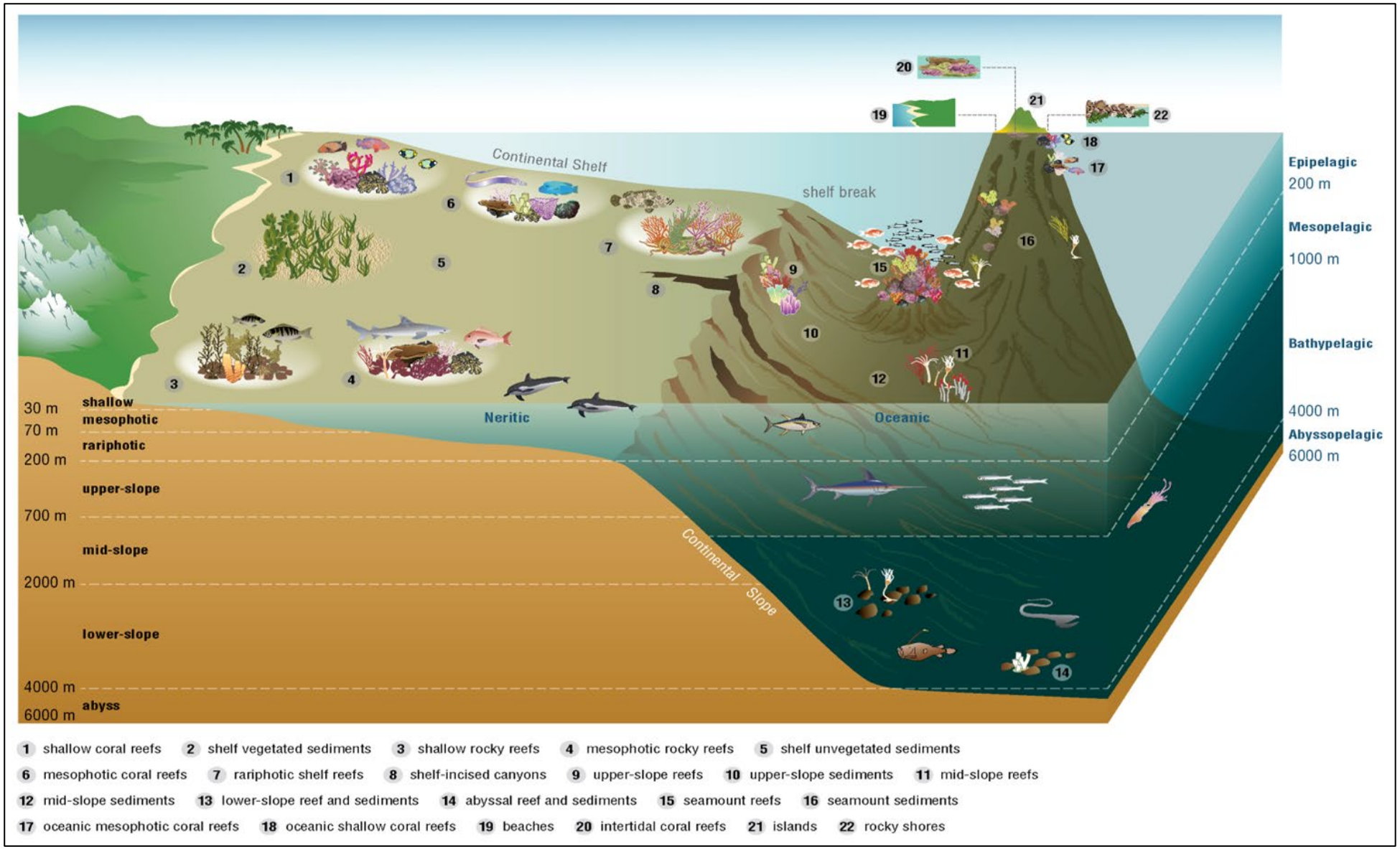


Figure 8. Conceptual representation of ecosystem types identified across the Australian Marine Parks (Source: Parks Australia)

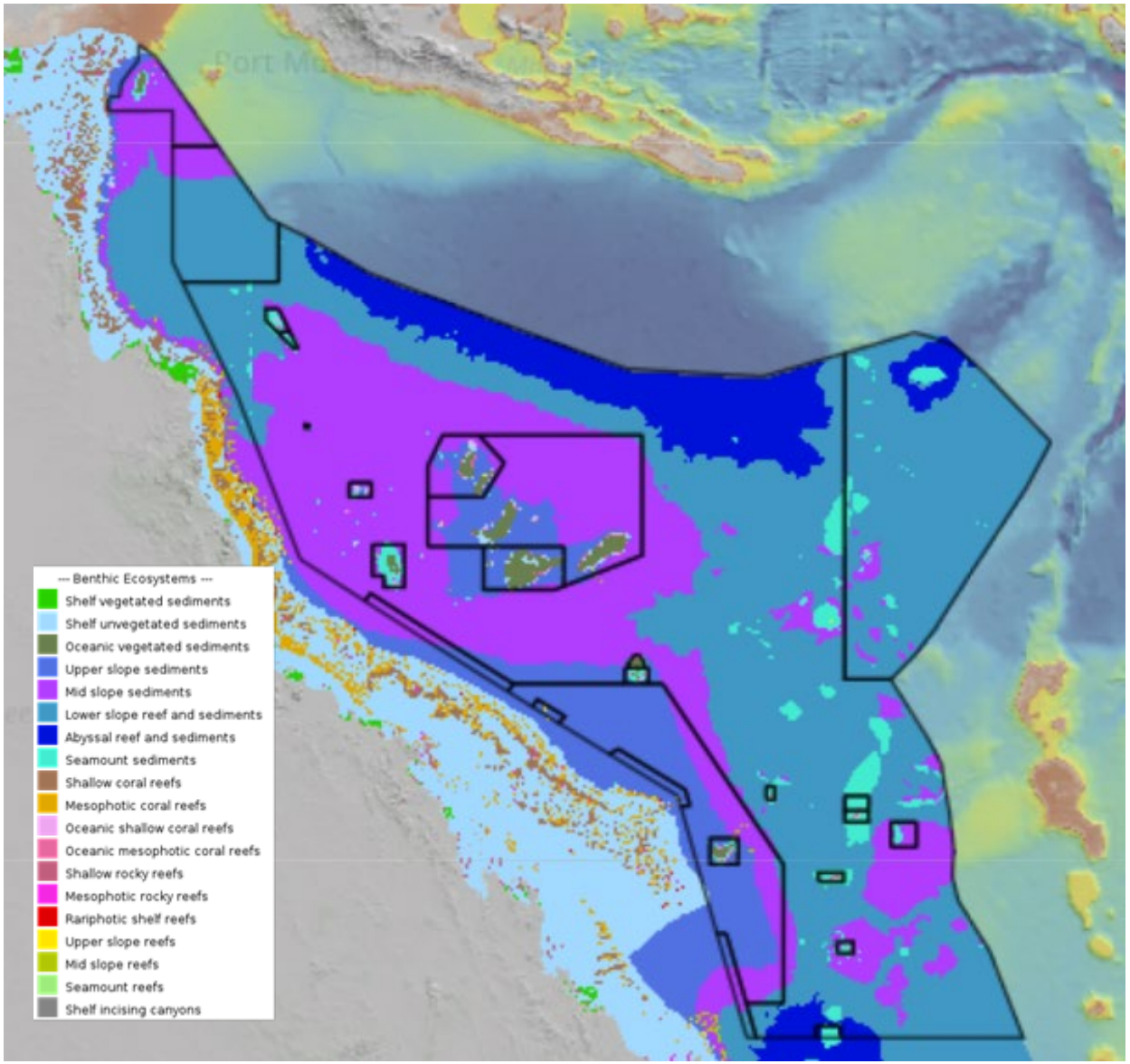


Figure 9. Distribution of ecosystem types across the Coral Sea Marine Park (https://seamapaustralia.org/map/#2513bcf5-af35-4c53-b96e-8badc93b8143)

Table 1. Presence of ecosystems within each zone in the Coral Sea Marine Park

	sphpr04	sphpr06	sphpr07	sphpr08	sphpr09	sphpr10	sphpr15	sphpr17	sphpr18	sphpr20	sphpr21	sphpr22	sphpz01	sphpz28	spnpz02	spnpz03	spnpz05	spnpz11	spnpz12	spnpz13	spnpz14	spnpz16	spnpz19	spnpz25	spnpz27	spspt23	spspt24	spspt26
Islands (inc. cays, islets) and beaches		■	■	■	■	■	■	■	■	■	■	■				■	■					■	■					
Rocky shores																												
Intertidal coral reefs		■	■	■	■	■	■	■	■	■	■	■				■	■					■	■					
Oceanic shallow coral reefs		■	■	■	■	■	■	■	■	■	■	■				■	■					■	■					
Shallow rocky reefs																												
Mesophotic rocky reefs																												
Mesophotic coral reefs																												
Oceanic mesophotic coral reefs		■	■	■	■	■	■	■	■	■	■	■				■	■					■	■					
Oceanic vegetated sediment			■	■	■	■	■		■	■			■					■				■	■					
Shelf unvegetated sediments			■	■		■			■				■					■										
Rariphotic reef																												
Upper and Mid slope reefs	■	■														■	■			■	■							
Upper/Mid slope sediments	■		■	■	■	■						■	■	■	■	■		■	■					■	■	■		■
Lower slope sediments/reef	■							■						■	■								■	■	■		■	■
Shelf incising canyons						■							■	■	■			■										■
Seamount reefs	■	■	■	■	■		■	■	■	■	■	■	■	■		■	■					■	■		■	■	■	
Seamount sediments	■	■	■	■	■		■	■	■	■	■	■	■	■		■	■					■	■		■	■	■	
Abyss reef and sediments																									■		■	
Epipelagic	■	■	■	■	■	■	■	■	■	■	■	■	■	■		■	■	■			■	■	■		■			■
Mesopelagic	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Bathypelagic	■	■	■	■	■	■		■		■	■	■	■	■	■	■	■	■	■				■	■	■	■	■	■
Abyssopelagic														■											■		■	■

2.2.1 Islands and beaches

The CSMP contains approximately 3100 reefs and 65 islands, islets and cays, 21 of which are vegetated, with a further 24 ephemeral sand cays that are present less than 50% of the time (Lawrey and Bycroft 2025). Because ephemeral cays come and go, the number of cays recorded at any one time depends on when they are observed. Of the cays and islets, 44 are known to support nesting populations of seabirds and turtles (Hamann et al. 2025; Parks Australia 2025). They range from vegetated cays with dune and pioneer plant communities to bare sand and coral rubble cays with little or no vegetation, such as Brodie Cay (Parks Australia 2023) and Holmes Reef Cay (Parks Australia 2025). Some, like Turtle Island on Lihou Reef, are low, oval-shaped sand cays sitting only a few metres above sea level (Parks Australia 2025).

Sandy beaches are found widely across the cays and islets, including Willis Island (Brushe 2021), North East Cay (Batianoff 1999), North East Cay (Herald Cays) (Figure 10) and Diamond Islets (Hicks 1984), each with its own beach or terrace along the shoreline. On North East Cay, the beach sediments are highly alkaline and made up mostly of calcareous sand and broken-down reef material, including skeletal fragments and coralline algae (Batianoff 1999). These beach and dune areas are regularly hit by storm surges and king tides, which keeps the vegetation in a constant state of disturbance and regrowth, dominated by hardy pioneer plant species that resettle after each event (Brushe 2021).

Vegetation across the Coral Sea cays ranges from bare sand and rubble through to well-developed woody communities, including around 15% of Australia's *Pisonia grandis* forest, most notably at the Coringa-Herald cays (Batianoff et al. 2009). Littoral herbland and low shrubland dominated by *Argusia argentea* typically occupy the seaward margins of cays such as North East Cay and North East Herald Cay, grading into taller *Pisonia grandis* forest, *Casuarina equisetifolia* stands and *Cordia subcordata* in more stable interior areas at sites like South West Coringa Islet, with grasses such as *Lepturus* repens also present (Batianoff et al. 2009). These woody communities are ecologically important, providing the primary nesting and roosting habitat for many of the region's breeding seabirds, including frigatebirds, noddies, boobies and the wedge-tailed shearwater (Batianoff et al. 2009).



Figure 10. North East Herald Cay (Credit: Graham Hemson, Parks Australia, 2019)

2.2.2 Intertidal coral reefs

Intertidal coral reefs are found in the intertidal zone. Intertidal habitats within the CSMP are primarily expressed as beach-rock platforms and reef-flat exposures surrounding the numerous coral cays, rather than as extensive continuous intertidal reef ecosystems. Examples are found along the exposed eastern and southern shorelines of North East Herald Cay, beach rock forms steep slopes extending from the low-water mark to the vegetation boundary, providing stable hard substrate for intertidal biota (Hemson et al. 2020). Beach-rock slabs also occur along the southern shoreline of Chilcott Islet (Hemson et al. 2020), while intertidal beach rock surrounds much of Diamond Islet (Hicks 1984). Where intertidal coral reef habitat occurs, it commonly consists of spur-and-groove barrier reef formations that emerge during low tide and support intertidal coral and algal assemblages along exposed margins (Bush Blitz 2016). Sandstone pavements extending seaward from beaches are also present around many CSMP cays and in several locations extend above the high-tide mark (Bush Blitz 2016).

2.2.3 Oceanic shallow coral reefs

Oceanic shallow coral reefs are the defining ecosystem of the CSMP and occur across the elevated platforms of the Queensland, Marion, Kenn and Chesterfield plateaux, together with seamount summits and submerged ridges (Hoey et al. 2020). Spatial mapping indicates that shallow reef habitat extends across approximately 15,287 km² of the park, including reef areas to depths of approximately 25 m (Lawry & Bycroft 2005). Central CSMP atolls supporting mean coral cover of approximately 10% and individual reef-scale coral cover ranging from 6.8 to 56.6% (Skewes and Persson 2017; Hoey et al. 2020). Coral reef communities within the CSMP are distinct from those of the adjacent Great Barrier Reef Marine Park and support approximately 600 recorded fish species (Hoey et al. 2023).

Oceanic shallow reefs have been surveyed at depths ranging from 0.8 to 30 m, with earlier surveys recording an overall mean coral cover of 18.65% and maximum values reaching 35.19% (Stuart-Smith et al. 2018). Boot Reef and Ashmore Reef exhibit characteristics transitional between the continental shelf reefs of the Great Barrier Reef and those of Torres Strait, reflecting their intermediate biogeographic position (Hosty et al. 2018). Coral cover has since declined substantially following the heat stress events of 2020, 2021, 2022 and 2024. Across matched sites on eleven central and southern reefs, mean coral cover fell by 50.7%, from 30.7% in 2020 to 15.1% in 2025, with a greater relative decline in the central CSMP (30.6% to 13.0%) than in the southern CSMP (30.9% to 17.6%) (Hoey et al. 2026). In 2025, coral cover across all surveyed sites averaged 14.3%, ranging from 7.6% at Frederick Reef in the southern CSMP to 27.0% at Holmes Reef in the central CSMP, and three reefs (Frederick Reef, Lihou Reef and Diamond Islet) had very low cover of less than 10% (Hoey et al. 2026). Cato Reef (20.3%) had the highest cover in the southern CSMP, but this was down from 33.7% in 2024, most likely because heat stress sensitive branching and tabular *Acropora*, which had largely escaped earlier heat stress events at this reef, were killed by heat stress in March 2024 (Hoey et al. 2026).

Before these events, the CSMP ranked among the highest tropical marine protected areas globally for total coral cover, comparable to protected areas in the western Indian Ocean and southeast Pacific (Strain et al. 2019). Recruitment also appears limited on these isolated oceanic reefs, with earlier surveys recording juvenile coral densities of 13.99 ± 0.72 per 10 m², approximately 42% lower than in the Great Barrier Reef Marine Park (Burn et al. 2024),

and juvenile density falling a further 66.8% between 2023/24 and 2025 (from 28.5 to 9.5 per 10 m²), with a larger decline in the central CSMP (82.2%) than the southern CSMP (36.6%) (Hoey et al. 2026). Substantial submerged aquatic vegetation has also been identified within lagoonal floors at depths of 30 to 60 m through satellite reef mapping (Hayes et al. 2024).

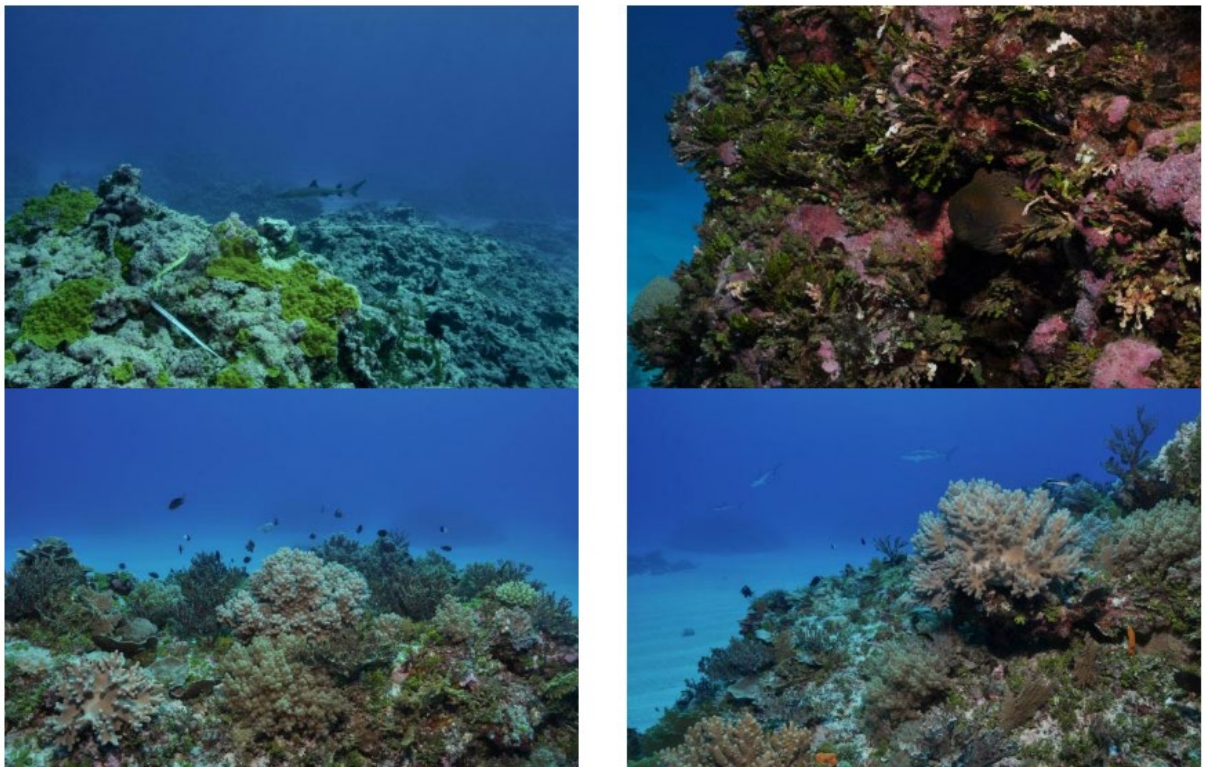


Figure 11. Examples of benthic communities associated with shallow oceanic reefs in the CSMPR showing extensive areas of coral rubble, with only encrusting and calcified algal cover (top row), to densely covered in soft and hard corals, sessile invertebrates and fleshy macroalgae (bottom row). (Source Stuart-Smith et al 2013)

2.2.4 Oceanic mesophotic coral reefs

Oceanic mesophotic coral reefs occupy the deeper extensions of coral reef habitat within the CSMP, present at depths from approximately 30 m, past the nominal 70 m threshold, down to 150 m, on the flanks of atolls and seamounts and within deeper lagoonal floors (Beaman et al. 2016; Galbraith et al. 2025). The CSMP contains several large coral atolls, including Lihou Reef, Coringa-Herald and the Flinders and Tregrosse Reefs, most with gently sloping, bowl-shaped lagoons filled with soft sediment and occasional patch reefs, providing extensive habitat for oceanic mesophotic communities (Hayes et al. 2024). Recent satellite-based mapping has revealed that a significant portion of these deeper lagoonal floors is covered by diverse submerged aquatic vegetation, primarily erect macroalgae and calcified algae such as Halimeda, extending across substantial areas at depths of 30 to 90 m that were previously unmapped due to a lack of surveys (Hayes et al. 2024). This is regionally significant because the earlier national ecosystem map did not show this vegetation, so these lagoons would have been classed as unvegetated sediment, and the new mapping has now been completed across the whole Australian Coral Sea (Lawrey & Bycroft 2025). Field surveys in Lihou Reef lagoon support the satellite results, with algae recorded at 56% of sites, complex macroalgal beds mostly in the deeper water, and seven genera including *Halimeda, Udotea* and *Caulerpa* (Tol et al. 2025). Dense *Halimeda* meadows can trap fine sediments and alter sediment biogeochemistry, so these beds probably also influence

sediment dynamics and carbonate production within the atoll lagoons, although this has not been quantified in the CSMP.

The CSMP is characterised by exceptionally high-water clarity, which is optimal for light penetration at depth and supports photosynthetic communities well below the mesophotic, including highly diverse coral communities comprising both deep-water specialists and shallow-water species extending into deeper habitats (Muir et al. 2015, Ceccarelli 2012). Areas adjacent to Edna Cay at Lihou Reef support particularly high coral cover, between 70 and 80%, at depths of 70 to 80 m, and the deepest living hard corals known from eastern Australian waters occur within the CSMP mesophotic zone, at depths reaching 149 m (Hoey et al. 2023; Schmidt Ocean Institute 2020). This is notable regionally and globally. The previous deepest zooxanthellate coral records for the Coral Sea were *Leptoseris* colonies at about 115 to 125 m at Bougainville Reef (Englebert et al. 2015), and maximum depths reported elsewhere include 119 m in the Bahamas and 153 m in Hawaii. The 2020 ROV surveys (Figure 12) also found gently sloping habitats with high hard coral cover dominated by *Leptoseris* at depths over 100 m, which had not previously been observed in the Coral Sea. These corals are specialised to deep habitats and are not found in the shallows, so they should not be assumed to offer a refuge for shallow-water species affected by heat stress, although they do show how deep light-dependent coral communities extend.

Upper mesophotic reefs between 30 and 60 m depth are commonly taxonomically and functionally similar to adjacent shallow reefs, whereas benthic assemblages become progressively distinct toward deeper mesophotic zones, with a marked community shift towards depth-specialist species that do not occur on shallow reefs (Galbraith et al. 2025). Staghorn corals of the genera *Acropora* and *Isopora* form important components of these deeper communities. A regional assessment covering the Great Barrier Reef and western Coral Sea found 38 staghorn species below 30 m, including three species newly recorded for Australia and five that occurred only below 30 m, with staghorn corals becoming scarce below 50 m but growing in situ to 73 m (Muir et al. 2015). Colonies below 40 m showed laterally flattened branches and a light, fragile skeleton (Muir et al. 2015). These findings are regionally significant for three reasons. First, staghorn corals dominate many shallow reefs and are highly sensitive to heat stress.

At Cato Reef, high cover of branching and tabular Acropora was lost following heat stress in March 2024 (Hoey et al. 2026). Second, about one fifth (21%) of the 76 staghorn species recorded in shallow waters of north-east Australia extend to mesophotic depths, with a further 22% recorded rarely to 40 m (Muir et al. 2015), so mesophotic populations hold a meaningful share of regional staghorn diversity and could potentially supply larvae to depleted shallow reefs, although the extent of this vertical connectivity has not been tested in the CSMP. Third, current reef monitoring in the park is restricted to the reef crest (1 to 3 m) and slope (7 to 10 m) (Hoey et al. 2026), so the condition of these deeper populations, including their exposure to marine heatwaves, is largely unknown. The rarity of staghorn corals below 50 m also indicates that mesophotic depths should not be assumed to provide a refuge.

Oceanic mesophotic coral reefs in the CSMP can occur at depths of 20-100 m and are characterised by declining coral cover with depth and increasing dominance of *Halimeda*, with *Halimeda* cover peaking at 47.7 per cent; most studies have found these systems dominated by crustose coralline algae, *Halimeda*, hard corals (Scleractinia), soft corals and gorgonians (Octocorallia) (Hoey et al. 2024; Galbraith et al. 2025). Mesophotic assemblages

at Osprey Reef are further characterised by abundant gorgonian fans (*Heliania* spp., *Annella* spp.) and sea whips (*Junceella* spp.), and the reef also hosts Denise's pygmy seahorse (*Hippocampus denise*), recorded at 102 m on the gorgonian *Annella reticulata* in ROV footage (Nishikawa et al. 2011; Beaman et al. 2016). The species is usually reported from about 13 to 100 m, where it lives on gorgonian fans (Lourie & Randall 2003), so this could be the deepest known observation. Its range extends from Indonesia to Vanuatu, reaching south to north-east Australia, which places Osprey Reef at the southern margin of its range. Because the species lives on gorgonian hosts, the record highlights the value of mesophotic gorgonian fans at Osprey Reef as habitat for host-specific fauna.

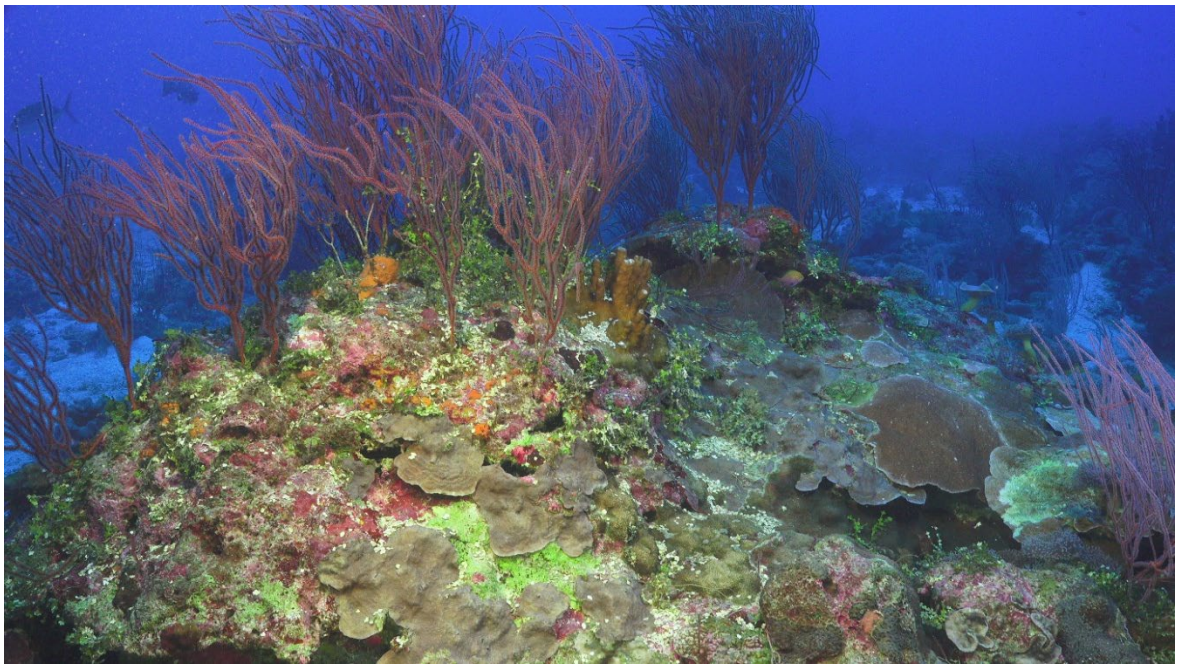


Figure 12. Mesophotic reef with a tall stand of gorgonian octocorals captured using SOI ROV Subastian during FK200802 at 60m depth (Source: Squidle+)

2.2.5 Rariphotic shelf reefs

Rariphotic shelf reefs, hard-substrate communities receiving only very low ambient light, typically at depths of 70-200 m, are present within the CSMP on the flanks of seamounts, atoll slopes and deeper bank tops (Tea et al. 2025). These rariphotic reefs are characterised by abundant soft corals and large sea fans (Maxwell 2012). Rariphotic ecosystems in the Coral Sea occur between approximately 130 and 309 m depth and represent faunistically unique realms with high habitat complexity, endemism and undescribed taxa (Tea et al. 2025). The CSMP rariphotic zone supports distinct assemblages of antipatharian (black) corals, octocorals and sponges, with limited overlap in species composition with adjacent upper-mesophotic and deeper-sea assemblages (Figure 13; Horowitz et al. 2022; Beaman and Bostock 2022). These communities are regionally significant because the Coral Sea continues to yield previously undocumented and undescribed deep-water taxa, highlighting the contribution of rariphotic and deeper habitats to regional biodiversity and the importance of the CSMP for conserving poorly known deep-reef communities. For example, Horowitz et al. (2022) described five black coral species new to science from the Great Barrier Reef and Coral Sea, while earlier sampling of deeper Coral Sea habitats identified multiple new regional records and demonstrated that black-coral diversity was substantially under-recognised.



Figure 13. Rariphotic reef showing large black and gorgonian corals captured using SOI ROV Subastian during FK200802 at 118m depth (Source: Squidle+)

2.2.6 Shelf vegetated sediments

Shelf vegetated sediments are present within the CSMP in the form of seagrass meadows and macroalgal beds on the inter-reefal and lagoonal sediments of the central CSMP atolls (Tol et al. 2025). Seagrass (*Halophila* species) have been recorded in the CSMP, with seagrass present at Tregrosse Reef, South West Cay (Herald Cays), and East and West Holmes Reef across 16 surveyed sites including 4 deep-water and 1 shallow meadow (Tol et al. 2025). Two seagrass species have been confirmed in the CSMP - *Halophila ovalis* and *Halophila decipiens* - with the first herbarium specimens for the park recently collected (Tol et al. 2025). The only known seagrass meadow in the CSMP is a deep-water meadow at Saumarez Reef, dominated by *Thalassodendron ciliatum*. It has 100 per cent seagrass cover with dense rhizomes and leaves, and forms discrete patches approximately 8 m wide (Figure 14; Galbraith et al. 2025).

Marine algal communities are a significant ecological feature of the Coral Sea reserves, often covering a larger area than corals, with *Halimeda spp*. - a calcified alga of warm seas - being a prominent feature of the benthic habitat (Phillips et al. 2006, Reolid et al. 2024). Sixty-six species of marine benthic algae were recorded in 1997 surveys of North East Cays (Herald Cay), comprising 41 red algae, 23 green algae and 2 brown algae (Phillips et al. 2006). The near-absence of brown algae is unusual for what appears to be a typical reef environment and likely reflects the oligotrophic oceanic setting (Phillips et al. 2006). Ocean currents likely transport algal propagules to these reserves, with tropical species arriving from the north via the South Equatorial Current (Phillips et al. 2006).

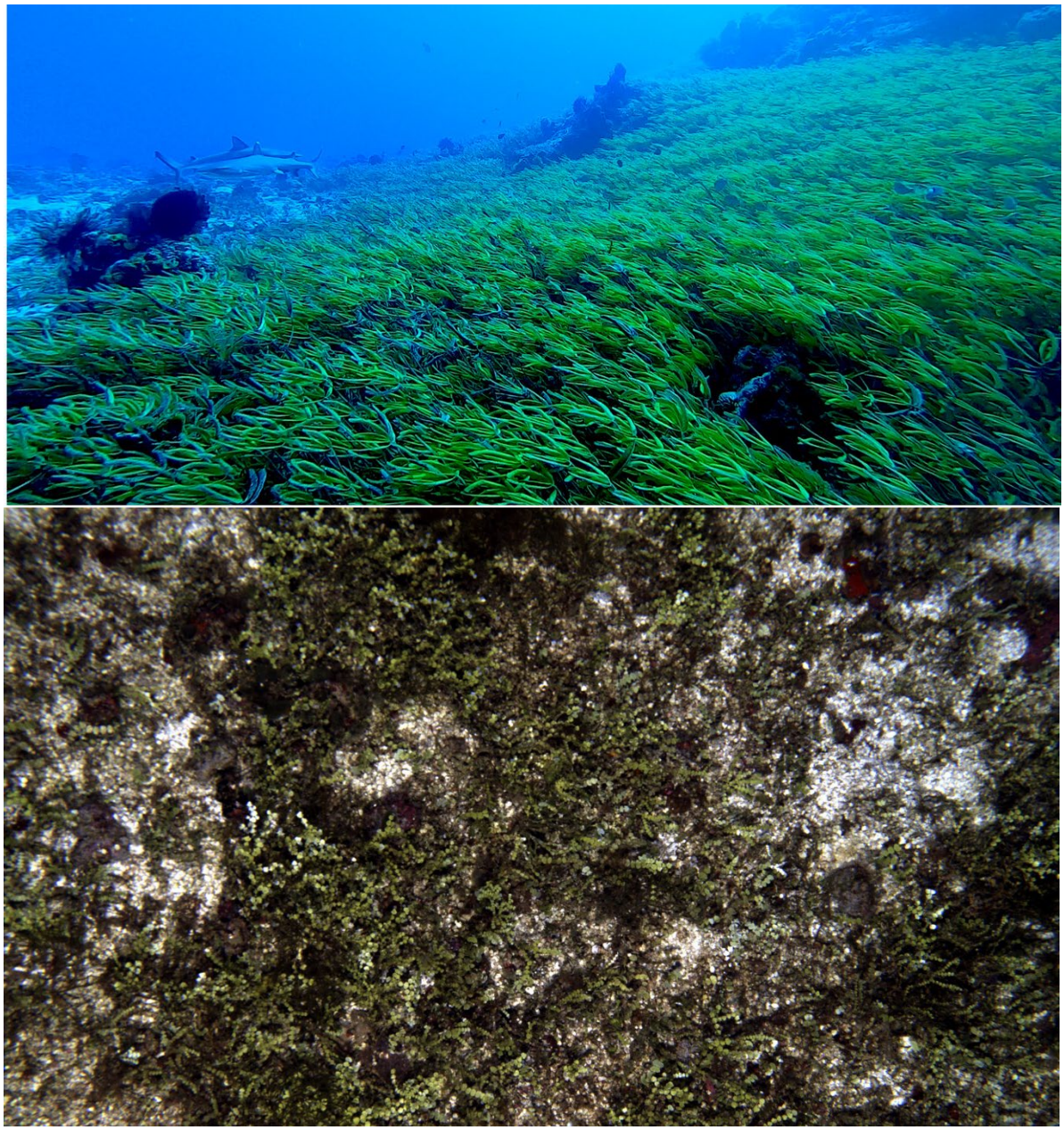


Figure 14. Examples of shelf vegetated sediments in the CSMP. Top) Seagrass meadow of *Thalassodendron ciliatum* found at Saumarez Reef (Source: Galbraith et al. 2025). Bottom) *Halimeda* bed captured using AUV Sirius at Flinders Reefs at 78 m depth (Source: Squidle+)

2.2.7 Shelf unvegetated sediments

Shelf unvegetated sediments occur extensively within the CSMP, defined as soft sediment habitats on the continental and oceanic shelves at depths shallower than 200 m (Figure 15; Dunstan et al. 2023). Shelf unvegetated sediments in the CSMP shallow reef systems include sand, coral rubble and coral rock substrates that form reef flats, back-reef areas and inter-reefal basins between coral structures (Botha et al. 2010). Bare sediments can have a thin layer of microphytobenthos and exposed sediment with ripples have been recorded as frequent benthic habitats during park-wide surveys (Tol et al. 2025).

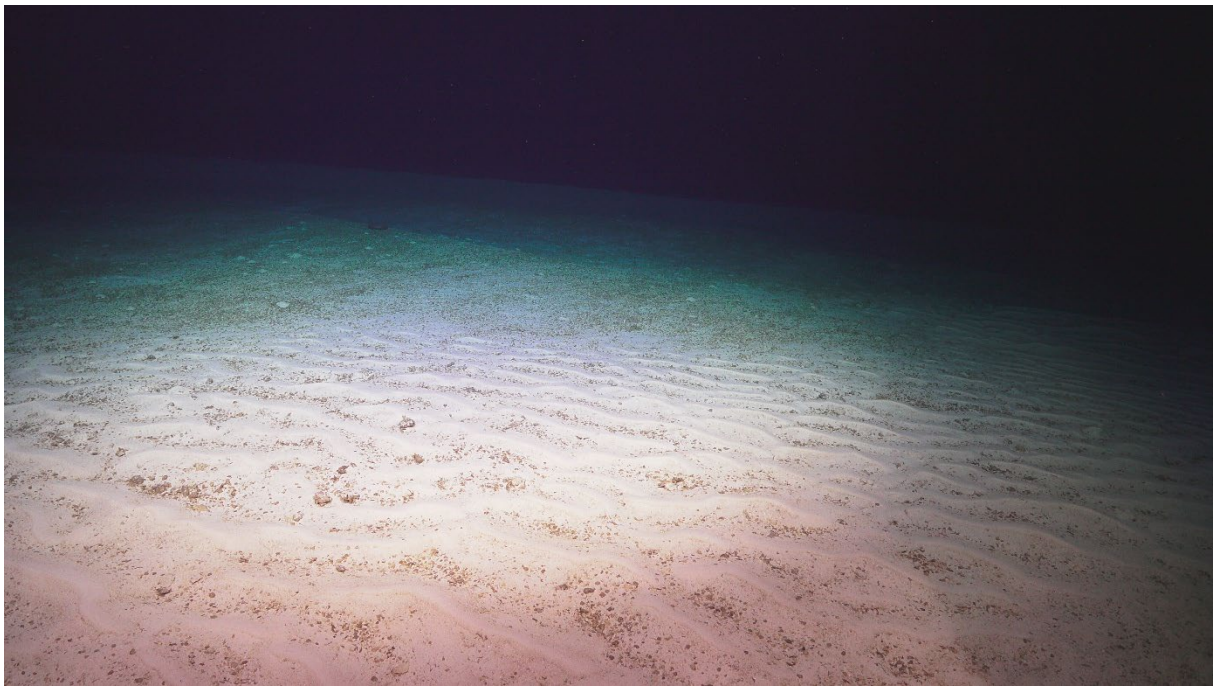


Figure 15. Shelf unvegetated sediments captured using SOI ROV Subastian during FK200802 at 200m depth (Source: Squidle+)

2.2.8 Upper and mid slope reefs

Upper and mid-slope reefs are present in the CSMP on the flanks of emergent atolls and seamounts, with diverse benthic communities documented on steep flanks of central reefs (Beaman et al. 2016) (Figure 17) The upper slope class extends across approximate depths of 200-700 m, with mid-slope habitats reaching to 2,000 m. The shelf break and upper slope are dominated by carbonate rubble, hardgrounds and biogenic reef substrates that support diverse hydroid and antipatharian communities, with 55 hydroid species recorded from the Coringa-Herald Reefs (nine new to Australian waters) including specimens collected from beach rock, shallow reef flat, the lagoon and shallow, medium and deep parts of the slope (Phillips et al. 2006). The regional significance of deeper reef habitats is further illustrated by the discovery of the black coral *Aphanipathes flailum*, which was described as a new species from the Coral Sea at 210 m depth and is currently known only from the Coral Sea (Horowitz et al. 2022). This record demonstrates that deeper reef and upper-slope habitats support previously undocumented antipatharian diversity and highlights the contribution of these habitats to the region's distinctive deep-water biodiversity.

Ocean currents likely transport hydroid larvae to these reserves, with tropical species arriving from the north via the South Equatorial Current (Phillips et al. 2006). The combination of exposed and protected reefs at this site provides varied habitats for different hydroid species (Phillips et al. 2006). ROV and towed video-based surveys conducted during recent *RV Falkor* and *RV Investigator* voyages have produced the first systematic descriptions of upper- and mid-slope reef communities in the CSMP, recording deep-water gorgonians, antipatharians and lithistid sponges associated with hard substrates between 200 and 2,000 m (Figure 16; Beaman et al. 2016).



Figure 16. Upper and mid-slope reefs showing low profile reef hosting a black coral (middle) and anemone (bottom right) captured using SOI ROV Subastian during FK200802 at 501m depth (Source: Squidle+)

2.2.9 Upper and mid slope sediments

Upper and mid-slope sediments are present in the CSMP, with fine sediments covering non-vertical surfaces below 200 m depth and mid-slope sediments documented at depths of 910-1,080 m (Beaman et al. 2016). The continental slope along eastern Australia is broadly convex from the shelf break down to 1,500 m, then concave to about 2,000 m (Lower slope), before forming a steep rocky scarp. Sediment composition is depth-dependent: mixed terrestrial siliceous and biogenic carbonate sediments dominate the shelf and upper slope, grading to predominantly biogenic carbonate ooze at intermediate depths (Yamano et al. 2015).

2.2.10 Lower slope sediments and reefs

The lower continental slope and continental rise of the CSMP, extending broadly from 2,000 m to approximately 4,000 m depth, comprise extensive rocky and sedimentary habitats that remain among the least biologically sampled environments in the region. These deep-water habitats support azooxanthellate corals, sponge gardens and other benthic communities, including documented coral and sponge assemblages below 2,000 m (Beaman et al. 2016). Their ecological significance is amplified by the limited biological sampling of the lower slope and rise, which has constrained understanding of species distributions, community composition and biogeographic connections across the Coral Sea (O'Hara 2008; O'Hara et al. 2016).

Deep-water sampling nevertheless demonstrates that these habitats contain distinctive and poorly documented biodiversity. Horowitz et al. (2018) recorded 21 black coral specimens representing five nominal species, five genera and two families from the deep Coral Sea, with specimens collected between approximately 916 and 2,542 m. *Abyssopathes lyriformis* was recorded at 2,542 m, representing a geographic range extension of more than 4,000 km

and a depth extension of more than 1,000 m (Horowitz et al. 2018). Other species, including *Bathypathes patula*, *Schizopathes affinis*, *Parantipathes cf. hirondelle* and *Heteropathes cf. americana*, also represented substantial extensions of previously known geographic distributions (Horowitz et al. 2018). Subsequent sampling during the 2019 RV *Investigator* voyage IN2019_V04 further demonstrated the taxonomic novelty of deep Coral Sea habitats, contributing material from deep-water benthic communities and supporting subsequent descriptions of new sponge taxa, including *Lycopodina coralseaensis*, recorded from approximately 2,000 m depth on the Louisiade Plateau (Ekins et al. 2021).

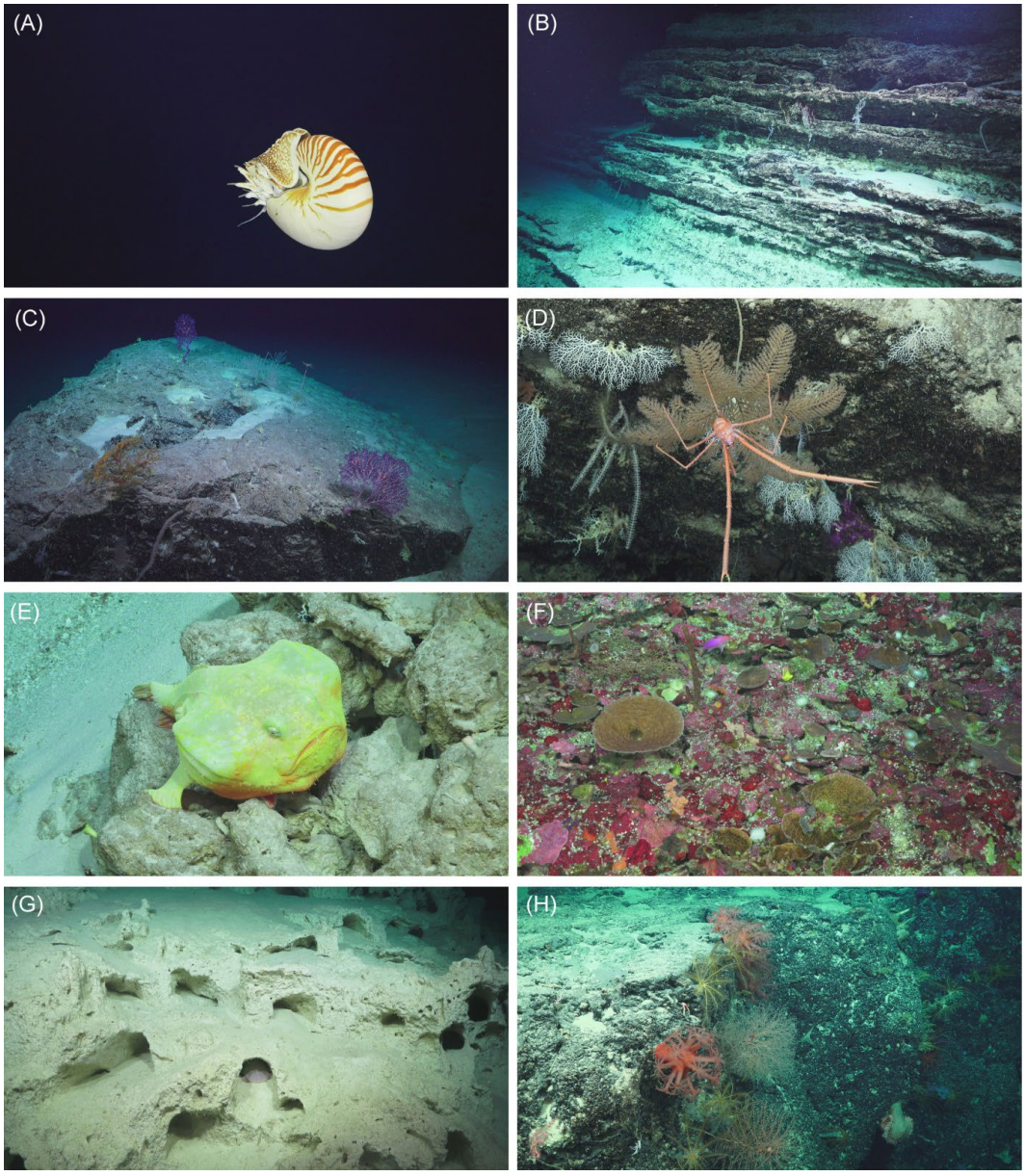


Figure 17. Selection of Subastian ROV images. (A) Nautilus cephalopod, dive 362, Magdelaine Cays, 600 m. (B) Exposed coral strata, dive 357, West Holmes Reef, 696 m. (C) Landslide boulder, dive 357, West Holmes Reef, 835 m. (D) Squat lobster on stalked crinoid, dive 360, Moore Reefs, 873 m. (E) Coffin fish, dive 360, Moore Reefs, 340 m. (F) Mesophotic corals, dive 365, Diamond Islets, 86 m. (G) Giant isopod burrows in chalk, dive 364, 816 m. (H) Coldwater corals and stalked crinoids, dive 369, Cairns Seamount, 1456 m. (Source: Beaman and Bostock 2022)

Together, these records indicate that the lower slope and continental-rise habitats of the CSMP are regionally significant reservoirs of poorly known deep-water biodiversity. The combination of extensive unsampled habitat, substantial range extensions and newly described taxa highlights both their contribution to Coral Sea biodiversity and the importance of further deep-water exploration for establishing an adequate ecological baseline for the park.

2.2.11 Shelf incising canyons

Shelf-incising canyons are not a dominant geomorphic feature of the CSMP in the same way that they are along continental shelf margins elsewhere in Australia. This reflects the offshore position of the Park, which lies beyond the Great Barrier Reef and protects a deep, open-ocean seascape rather than a broad Commonwealth-managed continental shelf. Nevertheless, canyons are a recognised and widespread feature of the CSMP, incising the continental slope wherever its gradient exceeds around 1°, and are considered to be significantly under-mapped across the region given the resolution of currently available bathymetry data (Beaman 2012).

Several canyons incise into and extend downward through the sandy apron around Osprey Reef, starting at approximately 450 m depth (Beaman et al. 2016), consistent with the broader pattern of extensive canyon incision recorded on the continental slope feeding into the Queensland and Townsville Troughs and the Bligh Trough further north, both of which in turn feed into the Osprey Embayment and the large Bligh Canyon (Beaman 2012). They are also documented in the Cape Province Sub-region of the Coral Sea, where they appear as sparse and widely spaced features (Brewer et al. 2007).

2.2.12 Seamount reefs

Seamounts are prominent biodiversity features within the CSMP, providing isolated reef and rocky habitats that support fish assemblages extending from shallow reefs into mesophotic and rariphotic environments (Figure 18). Recent ROV surveys have demonstrated that these deeper habitats contain fish assemblages and species records not captured by conventional shallow-reef surveys, including 62 new records for the CSMP, 45 new records for Australia and 21 species considered potentially new to science (Tea et al. 2025). These findings highlight the importance of seamounts as repositories of poorly documented biodiversity and as potential stepping stones for connectivity among otherwise isolated reef systems (Galbraith et al. 2024).

The broader regional significance of Coral Sea seamounts is supported by extensive sampling in the Tasman Sea and southeast Coral Sea, where more than 850 macro- and megafaunal species were recorded, with 29–34% considered new to science and potentially endemic to seamounts (Richer de Forges et al. 2000). Species overlap was low among seamounts in different ridge systems, indicating substantial faunal turnover and highly localised distributions. Such patterns suggest that individual seamounts and seamount chains can function as biogeographically distinct habitat units, with limited interchange among populations and communities (Richer de Forges et al. 2000). This spatial structuring increases the conservation significance of seamount habitats because disturbance to individual features may affect species or assemblages with relatively restricted distributions.

Seamounts also support distinctive deep-water invertebrate communities. Carnivorous sponges are an important component of bathyal and abyssal fauna, with *Lycopodina*

coralseaensis described as a new species from approximately 2,000 m on the Louisiade Plateau following sampling during the 2019 *RV Investigator* voyage (Ekins et al. 2021). The discovery of this species, together with the continued description of new deep-water taxa from Coral Sea seamount and plateau habitats, demonstrates that these environments remain incompletely characterised and contribute to the region's taxonomic and biogeographic significance.

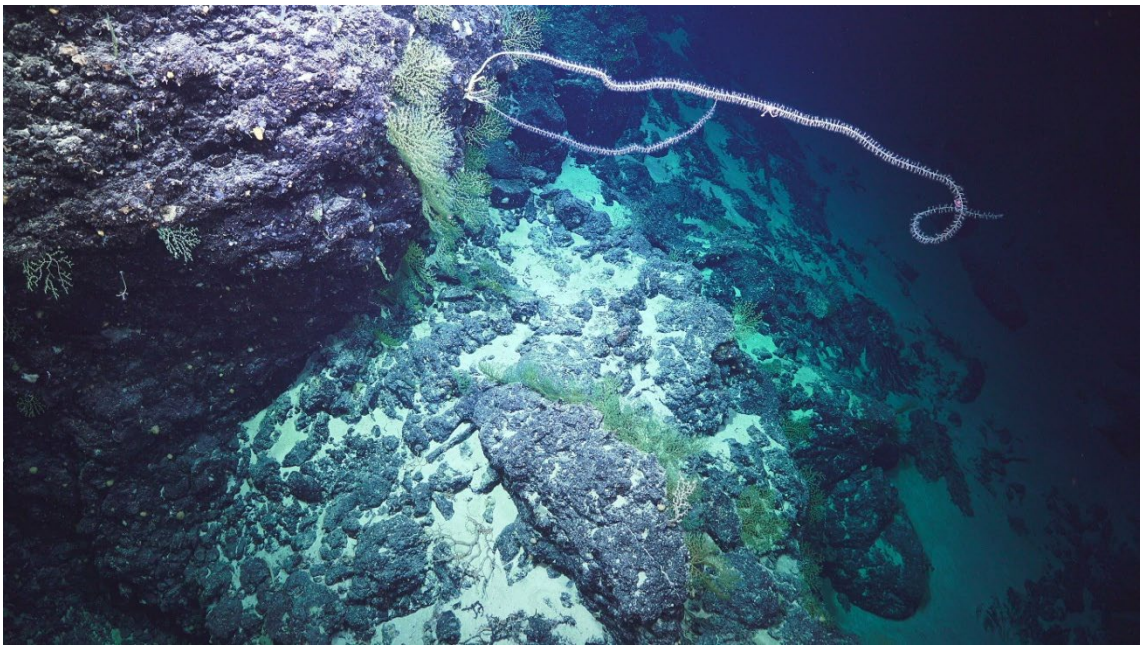


Figure 18. Seamount reefs showing vertical rocky substrate and gorgonian fans and black whip corals captured using SOI ROV Subastian during FK200802 at 1192m depth (Source: Squidle+)

2.2.13 Seamount sediments

Sediment habitats on seamounts consist of carbonate sands, volcanic gravels, and biogenic debris that accumulate on terraces, saddles, and moats (Figure 19). These sediments are thought to support invertebrate communities and provide foraging habitat for benthic fishes.

Seamount-associated sediments are a major but comparatively under-studied component of the CSMP. Although coral reefs and reef walls are the most visible and charismatic habitats, much of the seafloor surrounding and between seamounts is composed of soft sediment, carbonate sand, mud, ooze, rubble, sediment veneers, aprons, lagoonal deposits and sediment banks. Geoscience Australia's seafloor flythrough for the CSMP notes that deep and mesophotic seabed environments vary strongly with depth and substrate type, and that soft sediments, including sands, muds and oozes, dominate much of the deep seafloor. It also highlights current-generated bedforms, indicating active sediment transport at depth. These sedimentary habitats are therefore not passive or featureless; they are dynamic environments shaped by geomorphology, carbonate production, hydrodynamics, biological activity and episodic disturbance.

The origins and distribution of seamount-associated sediments are closely linked to the geological history of the Coral Sea. The Park's seafloor includes deep basins, plateaux, extinct volcanic features, drowned reefs, seamount chains, terraces and canyon systems, all of which influence sediment source, accumulation and redistribution. On plateaux and reef-capped seamounts, ancient carbonate platforms and living reefs produce biogenic sediments

from coral, coralline algae, *Halimeda*, molluscs, foraminifera and other calcifying organisms. These materials accumulate in lagoons, on reef slopes, along sediment banks and across deeper aprons, where they may be reworked by waves, internal tides, currents and storm events. On deeper seamount flanks and adjacent plains, sediment habitats may include fine-grained carbonate muds, pelagic oozes and mixed biogenic–terrigenous deposits, depending on depth, exposure and proximity to reef production zones.

Recent Coral Sea surveys have substantially improved the baseline understanding of these habitats. The IN2019_V04 voyage collected approximately 29,000 km² of new seafloor data within the Coral Sea Australian Marine Park and integrated this into a 100 m bathymetric grid to improve understanding of geomorphic shape and seabed relationships. The same project collected 94 biological specimens from 30 rock dredges, including material retained in sediment bins, and deposited specimens with the Queensland Museum for taxonomic assessment. Dredging occurred across multiple seamount and spur features, including Frederick-Calder, Kenn, Sula, Cassowary, Mellish, Fregetta, Lexington and the Louisiade Spur, providing one of the few biological datasets directly linked to deep seafloor geomorphology in this region.

Seamount-associated sediments also support a range of invertebrate communities that remain poorly resolved taxonomically. Dredge and deep-sea sampling from the wider Coral Sea has historically yielded many new records and undescribed species, and earlier deep-sea programs such as MUSORSTOM and CIDARIS contributed substantially to knowledge of bathyal fauna. Deep-sea benthic communities in the region are structured by depth and geomorphology, with slopes, summits, terraces, knolls and sedimented basins supporting different assemblages. This means that sediment habitats should not be treated as a single class. A carbonate sand bank in a mesophotic lagoon, a current-swept sediment veneer on a seamount flank, and a fine-grained basin plain at bathyal depth are likely to differ markedly in oxygenation, organic matter supply, mobility, biological assemblages and vulnerability.

Hydrodynamics are central to the ecological function of seamount-associated sediments. The interaction between seamount topography and currents can generate localised upwelling, turbulence, wakes and retention zones, enhancing productivity and concentrating organic material. These processes influence both reef and sediment habitats by affecting food supply to suspension feeders, larval retention, sediment grain size, carbonate accumulation and the distribution of demersal fishes and invertebrates. Bedforms observed in deep soft sediments provide physical evidence of active sediment transport, suggesting that some habitats are regularly reworked while others may be depositional and comparatively stable. Understanding this distinction is important because stable sediment veneers may support long-lived sessile fauna, while mobile sand sheets may favour burrowing organisms, microbial communities, mobile invertebrates and demersal fishes adapted to disturbance.

Seamount sediments are present in the CSMP, particularly in the broad sandy aprons that extend around the bases of seamounts such as Osprey Reef below approximately 450 m depth (Beaman et al. 2016). Samples from 49 seamounts and 3 oceanic islands have been collected at depths between 100 and 1,500 m in regional studies of seamount sediments, providing the basis for biogeographic comparisons (O'Hara 2008). A low-to-medium cover coldwater assemblage characterises the apron of Osprey Reef within the aphotic zone below about 450 m, contrasting markedly with the shallower mesophotic communities on the seamount flank (Beaman et al. 2016).

The Kenn Plateau, part of the Northern Seamounts Field, has seabed facies influenced by both biogenic carbonate production on the seamount summits and downslope sediment transport from the seamount flanks (Brewer et al. 2007). The northern reefs of the Coral Sea formed on high points of major carbonate plateaux during periods of lower sea levels and have kept pace with sea-level rise, leaving thick accumulations of biogenic sediment around their bases (Beaman et al. 2016).

Deepwater elasmobranchs, including squaloid sharks, as well as chimaeras, are documented across the deeper habitats of the Coral Sea, including the Queensland continental slope, Queensland Plateau and slopes associated with Marion and Saumarez reefs, with records extending across the CSMP (Ceccarelli 2011; Last and Stevens 2009). Recent sampling within the CSMP has also recorded deepwater catsharks, rays and chimaeras from depths of approximately 200–3,000 m, highlighting the importance of the Park's extensive deepwater habitats for poorly known chondrichthyan diversity (CSIRO 2026).

These species generally have slow growth, late maturity, long lifespans and low reproductive output, resulting in low population productivity and limited capacity to recover from disturbance or mortality (García et al. 2008; Rigby and Simpfendorfer 2015). Many deepwater chondrichthyans also show spatial aggregation associated with depth, benthic habitat and other seafloor features, potentially increasing their vulnerability to localised disturbance of important habitats (Bell et al. 2018). This is particularly relevant to CSMP management because the Park spans almost 1 million km² and includes extensive deepwater slopes, plateaus, seamounts, reefs and plains from shallow waters to approximately 6,000 m depth. Protecting representative areas of these deeper habitats through spatial management therefore has the potential to protect both the species themselves and the seafloor features on which their distributions may depend.



Figure 19. Seamount sediments captured using SOI ROV Subastian during FK200802 at 1219m depth (Source: Squidle+)

2.2.14 Abyss reef and sediments

The abyssal zone (4,000–6,000 m) is represented by extensive sedimentary habitats across the north-eastern and southern boundaries of the CSMP (Figure 9). These areas form part of a much larger abyssal environment extending across the Coral Sea and eastern Australian margin, but remain very poorly sampled within the Park.

Abyssal sediments in the CSMP are likely to comprise a mixture of fine pelagic ooze, carbonate-derived sediment, terrigenous material and reef-derived detritus transported from adjacent plateaux, reefs and basin margins. Below the lysocline, at approximately 3,600 m in this region, carbonate dissolution is expected to result in increasingly fine, low-carbonate sediments. Organic material reaching the seafloor nevertheless provides an important source of energy for microbial and benthic communities and contributes to deep-sea carbon cycling (Alongi 1990).

Although direct biological sampling of the CSMP abyssal zone is limited, sampling of adjacent eastern Australian abyssal habitats provides an indication of the communities likely to occur in these sediments. The RV *Investigator* IN2017_V03 expedition sampled soft sediments at approximately 4,000 m along the eastern Australian margin, including the Coral Sea region, and recorded 25,710 specimens representing 1,084 taxonomic entities.

The collection included a diverse assemblage of polychaete worms, crustaceans, molluscs, echinoderms and other benthic invertebrates, with up to 58% of species-level taxa remaining without formal species names, demonstrating the high level of unresolved biodiversity in these habitats (O'Hara et al. 2020). The same sampling program also collected and photographed fauna ranging from microbes and invertebrates to demersal fishes, providing evidence that abyssal sediments support both benthic communities and associated demersal fauna (O'Hara et al. 2020).

The broader Coral Sea biophysical assessment similarly identifies abyssal plains as low-density, patchy environments in which benthic communities are strongly influenced by sediment characteristics and the availability of organic material delivered as marine snow and animal carcasses. Expected communities include abundant meiofauna such as foraminiferans and nematodes, together with larger scavenging and deposit-feeding invertebrates and low-density demersal fishes, including lanternfishes and other deepwater taxa (Ceccarelli 2011). These communities are likely to vary spatially with sediment properties, food supply and hydrographic conditions.

The abyssal habitats of the CSMP therefore represent more than extensive areas of relatively uniform sediment. They support poorly characterised benthic and demersal communities and provide important habitat for deep-sea carbon cycling and detrital food webs. Their large spatial extent, limited sampling and high proportion of unresolved biodiversity make the abyssal zone an important component of the Park's broader representation of deep-sea ecosystems.

2.2.15 Epipelagic

Epipelagic waters (0-200 m) are present throughout all the CSMP and are characterised by tropical surface waters with mean temperatures of approximately 25-27 °C (Beaman et al. 2016, Brewer et al. 2007). Five distinct regimes of chlorophyll-a variability have been identified across the CSMP, numbered from north (Regime 1) to south (Regime 5), reflecting

strong latitudinal gradients in primary productivity and upwelling (Welch et al. 2016). Regime 1, between Cape York and the Solomon Islands, exhibits a peak mean chlorophyll-a concentration of 0.17 mg m^{-3} in July, with high temporal predictability and the highest year-round chlorophyll-a concentrations of all regimes (Welch et al. 2016). Chlorophyll-a concentrations in the Coral Sea generally show gradients from high values (maximum 0.62 mg m^{-3}) near the shelf margin to low values (minimum 0.06 mg m^{-3}) in the oligotrophic central park (Welch et al. 2016).

Epipelagic ecosystems in the Cape Province Sub-region are characterised by generally low productivity, oligotrophic conditions, and warm surface temperatures averaging 27 °C (Brewer et al. 2007).

2.2.16 Mesopelagic

This represents the ocean layer between approximately 200 and 1,000 m depth, corresponding to the disphotic and mesopelagic "twilight zone", where light levels are too low to support photosynthesis but some illumination still penetrates. Temperatures in this zone typically range from around 4 to 12°C depending on latitude and water mass, with strong oxygen gradients present. This ecosystem occurs across virtually all zones of the CSMP, reflecting its status as a deep, open-water layer above the seafloor rather than a feature confined to particular reef or slope habitats (Figure 9).

Within the CSMP, this zone is shaped by a deep chlorophyll-maximum layer at the nutricline, occurring at about 60-140 m depth, where chlorophyll concentrations peak within the photic zone (Brewer et al. 2007). Antarctic Intermediate Water is present around 1,000 m, formed at subantarctic latitudes in the Southern Ocean and entering the Tasman Sea from the south-west, north and east (O'Hara et al. 2020). The Tasman Front, separating warmer Coral Sea waters from cooler Tasman Sea waters, shifts seasonally, moving to around 30 °S in winter and south of Lord Howe Island in summer (Keene et al. 2008). These frontal systems and current interactions create areas of elevated productivity and mesopelagic biomass within the CSMP, similar to dynamics seen elsewhere along the East Australian Current system.

Coral Sea myctophids (lanternfish) show a composition similar to those in the East Australian Current but differ significantly from those in the Tasman Sea, suggesting biogeographic structuring within the Coral Sea mesopelagic (Young et al. 2012).

The mesopelagic lanternfish *Diaphus danae* forms spawning aggregations in the north-western Coral Sea, the only confirmed lanternfish spawning aggregations known in Australian waters, identifiable as a dense scattering layer on echosounders with an upper margin at 200 m extending to 350 m; the highest female gonadosomatic index recorded there was 34, exceeding previously recorded values for other lanternfish (Flynn and Paxton 2012). These aggregations, along with others in the Queensland Trough and near Cairns Seamount, are preyed upon by spawning aggregations of yellowfin and bigeye tuna (Young et al. 2012).

The upper mesopelagic layer, defined as the depth range from approximately 150 to 450 m, is inhabited during the day by resident and migrant upper mesopelagic micronekton (Receveur et al. 2021). Gelatinous zooplankton in the mesopelagic zone may be key trophic links to large deep-water planktivores such as eteline snappers, while tiger sharks use the mesopelagic (Young et al. 2012; Werry et al. 2014).

2.2.17 Bathypelagic

Bathypelagic waters (1,000-4,000 m) are present throughout the CSMP within the deep basins of the central and southern park, extending across the abyssal plain and the deeper waters above the Cato Trough and Coral Sea Basin (Beaman et al. 2016; Dunstan et al. 2023). Mesopelagic and bathypelagic waters of the Coral Sea at depths around 1,500 m support deep-sea fish fauna including ceratioid anglerfishes, with new records including *Thaumatichthys sp.* observed from ROV deployments at Cairns Seamount in the Coral Sea (Tea et al. 2025). Bathypelagic ecosystems are characterised by extreme cold, near-absent light and elevated pressures, with biota dominated by gelatinous zooplankton, mesopelagic and bathypelagic fishes, deep-sea cephalopods and rarely sampled vertebrate fauna (Brewer et al. 2007).

Bentho-pelagic coupling between the water column and seamount communities represents an important trophic pathway in the Coral Sea, with pelagic planktivores and vertically migrating zooplankton providing potential energetic links between surface production and deep-sea consumers (Young et al. 2012; Bulman and Fulton 2015). More broadly, deep-pelagic fishes and invertebrates play an important role in transferring energy between oceanic layers through vertical migration, predation and organic-matter transport (Nolé Eduardo et al. 2024; Haddock and Choy 2024). Climate-driven changes in ocean temperature, productivity, circulation and zooplankton communities are expected to alter the distribution and abundance of these organisms and consequently the transfer of energy through deep-pelagic food webs (IPCC 2019, Kaur et al. 2023).

2.2.18 Abyssopelagic

Abyssopelagic waters (depths greater than 4,000 m) occur within the CSMP in the deepest portions of the Coral Sea Basin and abyssal plain extensions of the Tasman Basin, where the seafloor reaches 4,500-5,000 m (Keene et al. 2008; Brewer et al. 2007). The abyssopelagic zone is characterised by uniformly cold temperatures, near-zero light, low organic matter flux, and biota dominated by midwater gelatinous fauna, abyssal fishes and microzooplankton (O'Hara et al. 2020). Sampling of abyssopelagic biota in the Coral Sea region remains very limited, with most knowledge derived from regional generalisations and a small number of pelagic trawl deployments at depths over 3,500 m (O'Hara et al. 2020).

Deepwater elasmobranchs that occupy abyssopelagic and lower mesopelagic settings are characterised by slow growth, long lifespans and low fecundity, and are largely insulated from coastal pressures but vulnerable to any future bathyal fisheries Rigby and Simpfendorfer 2015; Georgeson et al. 2020). The abyssopelagic environment of the Coral Sea is connected to the broader Tasman Basin abyssopelagic system via northward inflow of Antarctic Bottom Water, providing the underlying physico-chemical setting for this ecosystem (Sokolov and Rintoul 2000, Bostock et al. 2004).

3. Ecosystem knowledge

3.1 Deepening knowledge of reef condition and diversity

The CSMP's reefs are surveyed through a combination of diver-based and deep- video methods such as BRUVs, AUVs, ROVs and deep towed video, and together these paint a picture of a region that is exceptionally rich, changing over time, and still only partly understood below the shallows (Table 2).

In shallow oceanic coral reefs, park-wide surveys spanning 314 sites and over 1,000 belt transects since 2012 have shown reefs that remain among the least disturbed in the world, with relatively intact predator populations, high shark densities and distinctive Indo-Pacific fish and coral communities rarely seen at this scale elsewhere (Hoey et al. 2023; Edgar et al. 2018). The 2023 time series drew on 11 reefs across the park, including Flinders (north and south), Holmes (east and west), Lihou, Moore Reefs, Herald Cays, and Willis and Magdelaine Cays, and recorded average crustose coralline algae cover of 28%, ranging from 14% at Boot Reef to over 50% at some central CSMP sites, reflecting the ongoing benthic reorganisation seen across the park (Hoey et al. 2023).

Species of conservation concern are regularly recorded, including humphead wrasse, zebra sharks, bumphead parrotfish, paddle tail snapper (Figure 20), and grey reef, silvertip and whitetip reef sharks, alongside protected species like the Queensland groper. This condition reflects the CSMP's remoteness and low fishing pressure, and reef fish communities here align more closely with oceanic Pacific systems than with the neighbouring Great Barrier Reef, underlining the Park's distinct biogeography.

This condition is not static, however. Long-term monitoring since 2012 shows real variability, most starkly in the severe and widespread mass heat stress event recorded across the CSMP in February–March 2020 (Figure 21), when 63% of all corals surveyed across 16 reefs showed signs of heat stress, ranging from 40% of colonies affected in the southern park to 70–72% in the central and northern Park, and from 23% at Cato Reef to 89% at Willis Islets (Hoey et al. 2021). This was the third major heat stress event to affect the CSMP within six years, following events in 2016 and 2017, and twelve-year mean maximum Degree Heating Weeks more than doubled across all three CSMP regions between 1985 and 2020 (Hoey et al. 2021).

A dedicated resurvey of 43 sites across 13 reefs undertaken in February 2021 found that mean shallow-water coral cover had declined from 28.0% in 2020 to 17.2% a year later, a fall of 39.5%, with regional declines ranging from 17.1% in the northern CSMP to 43.1% in the central CSMP, and reef-level declines ranging from 12.7% at Chilcott Islet to 73.5% at Frederick Reef (Hoey et al. 2021). Losses were greatest among heat stress-sensitive branching taxa such as *Seriatopora*, *Stylophora* and tabular *Acropora*, though even comparatively heat-tolerant genera including massive *Porites* and *Favites* suffered substantial heat stress-related mortality. Bougainville Reef, previously identified as a regional "bright spot," again stood out: despite 65% of its colonies heat stress in 2020, coral cover there declined by only 13% and remained high at 35% (Hoey et al. 2021).



Figure 20. High abundances and biomasses of fish communities on the exposed aspect of Boot Reef in the north of the CSMP. Top: Large school of bumphead parrotfish (*Bolbometopon muricatum*) on the shallow reef crest. Each individual is 80-100cm long. Bottom: School of paddletail snapper (*Lutjanus gibbus*) closely associated with the benthos at 12m on the reef slope. Note the difference in the benthic communities between habitats. (Source: Hoey et al. 2023)

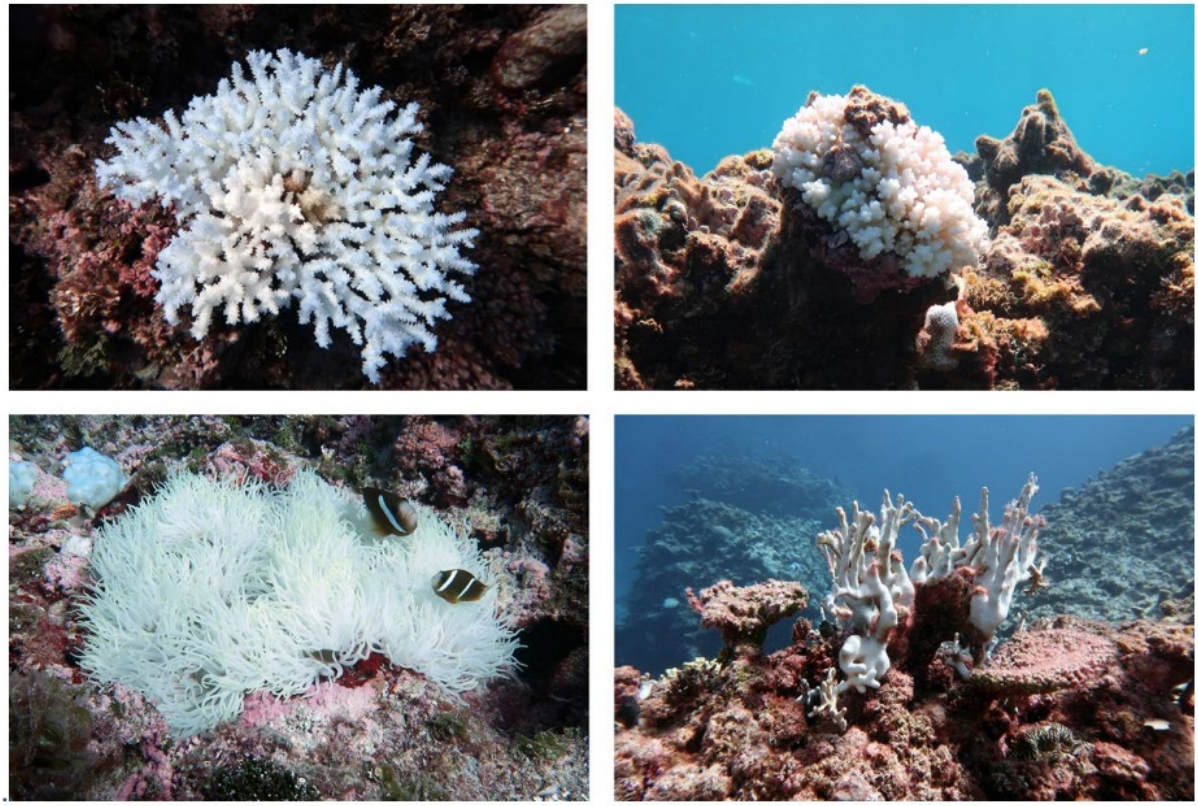


Figure 21. Examples of bleached corals and anemone observed during a UVC survey of Coral Sea Marine Park in 2020. Clockwise from top left: *Acropora* at Lihou Reef; *Pocillopora* at Lihou Reef; *Millepora* at Lihou Reef- the algae growing on the branch tips indicate these areas of the colony have already died; anemone at Herald Cays. Source: Hoey et al. (2021)

There was no corresponding regional increase in macroalgal cover, and reef fish biomass in the central and northern CSMP fell noticeably between 2020 and 2021, driven largely by declines in corallivorous, planktivorous and, more unexpectedly, grazing herbivorous fishes such as *Acanthurus lineatus* and *A. nigrofuscus* amid the heat stress; southern and northern reefs, by contrast, remained comparatively stable (Hoey et al. 2021). Despite these losses, total reef fish biomass recorded across the CSMP (500–3,000 kg per hectare) remained exceptionally high relative to coral reef systems globally, a reflection of the Park's isolation and minimal fishing pressure, and coral cover in the CSMP (17%) remained broadly comparable to contemporaneous Great Barrier Reef estimates and above the roughly 10% threshold considered critical to avoiding ecosystem collapse.

A related assessment of coral injury, as distinct from whole-colony mortality, across 16 CSMP reefs found that the background incidence of recent partial-mortality injury remained consistently low, under 5%, in both the pre-heat stress and heat stress survey years, suggesting that routine injury and acute heat stress-driven mortality operate as largely separable processes on these reefs (Burn et al. 2024).

Table 2. Biodiversity surveys within the Coral Sea 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 approximate spatially discrete sampling units at least 250 m apart for each year of sampling.

Time	Sites	Platform	Ecosystem	Ecosystem Depth	Zones	Key Reports	Survey design standards*
Ecosystem and zone present				0-30, 30-70, 70-200, 200-700, 700-2000, 2000-4000, 4000+	hpr04, hpr06, hpr07, hpr08, hpr09, hpr10, hpr15, hpr17, hpr18, hpr20, hpr21, hpr22, hpz01, hpz28, npz02, npz03, npz05, npz11, npz12, npz13, npz14, npz16, npz19, npz25, npz27, spt23, spt24, spt26		
2012, 2013, 2015, 2016, 2017, 2018, 2019, 2020, 2021, 2022, 2023, 2024, 2025	245	RLS-UVC	Demersal and benthic fish, Benthic habitats, Mobile macroinvertebrates, Sessile macroinvertebrates	0-30	hpz01, hpz28, npz27, hpr06, hpz22, hpr07, npz11, hpr10, hpr09, hpr17, hpr08, npz19, hpr20, npz16, hpr15, hpz03, hpr18, hpr21	1, 2, 3, 4, 5, 6, 7, 8, 9	Preferential
2022	705	JCU-UVC, drop camera (downward facing), RUV	Demersal and benthic fish, Benthic habitats	0-30, 30-70	npz11, hpr10, hpr09, hpz28	10, 11	Representative/ Preferential
2024	90	stereo-BRUV	Demersal and benthic fish	0-30, 30-70	hpr15, npz16, hpz28, npz11	12	Representative
2019, 2025	100	Smith-McIntyre grab, Deep Tow Camera seabed imagery, Beam trawl, Dropline	Sessile macroinvertebrates, Benthic habitats, Mobile macroinvertebrates, Infauna, Demersal and benthic fish	700-2000, 2000-4000	spt24, hpz28, spt26, spt23, npz27, hpr18, hpr20, npz19, hpr17	12, 13, 14	Preferential
2018, 2019, 2020, 2021, 2022, 2023, 2024, 2025	43	JCU-UVC	Demersal and benthic fish, Mobile macroinvertebrates, Sessile macroinvertebrates	0-30	hpr06, hpr08, hpr07, npz11, hpr09, npz16, hpr15, hpr18, hpr17, hpr21, npz19, hpz28, hpr20, npz03, hpr10	15, 16, 17, 18, 19, 20, 21	Preferential

Time	Sites	Platform	Ecosystem	Ecosystem Depth	Zones	Key Reports	Survey design standards*
2021, 2022, 2023, 2024	150	stereo-ROV	Demersal and benthic fish, Benthic habitats	0-30, 30-70, 70-200	hpr06, hpr08, hpr07, npz11, hpr09, npz16, hpr15, hpr18, hpr17, hpr21, npz19, hpz28, hpr20, npz03, hpz01	21	Preferential
2021, 2022, 2023, 2024	108	mono-BRUV	Demersal and benthic fish	0-30, 30-70	hpr06, hpr08, hpr07, npz11, hpr09, npz16, hpr15, hpr18, hpr17, hpr21, npz19, hpz28, hpr20, npz03, hpz01	17, 18	Preferential
2020, 2021	14	mono-ROV	Demersal and benthic fish, Sessile macroinvertebrates, Mobile macroinvertebrates, Pelagic fish	70-200, 200-700, 700-2000	hpz28, hpr09, npz11, hpr10, hpr08, npz03	22, 23, 24, 25	Preferential
2020	5	AUV	Benthic habitats, Sessile macroinvertebrates	0-30, 30-70, 70-200	hpr09, npz11, hpz28	21	Representative

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14 https://www.csiro.au/en/about/facilities-collections/MNF/Voyages-schedules/Voyages/2025/October/IN2025_V06

15 Hoey, A.S., Harrison, H.B. & Pratchett, M.S. (2020). Coral reef health in the Coral Sea Marine Park: Report on reef surveys, April 2018 to March 2020. Report prepared for Parks Australia, ARC Centre of Excellence for Coral Reef Studies, James Cook University, Townsville.

16 Hoey AS, Harrison HB, McClure EC, Burn D, Barnett A, Cresswell B, Doll PC, Galbraith G, Pratchett MS (2021) Coral Sea Marine Park Coral Reef Health Survey 2021. Report prepared for Parks Australia.

17 Hoey, A.S., McClure, E.C., Burn, D., Chandler, J.F., Huertas Martin, V., Cresswell, B., Galbraith, G. & Pratchett, M.S. (2022). Coral Sea Marine Park Coral Reef Health Survey 2022. Report prepared for Parks Australia, James Cook University, Townsville, Queensland.

18 Hoey, A.S., Burn, D., Chandler, J.F., Huertas Martin, V., Cresswell, B.J., Galbraith, G.F., Martin, C., Barnett, A., Faul, S., Marzonie, M. & McClure, E. (2024). Coral Sea Marine Park Coral Reef Health Survey 2023–24. External commissioned report, James Cook University, Townsville, Queensland.

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Yet the same long-term records also show signs of resilience: juvenile coral density nearly doubled between 2022 and 2023 following a subsequent heat stress event, and coral cover in 2024 reached its highest level in the monitoring record, illustrating the reef's capacity to recover when given time between disturbances (Hoey et al. 2023). Longer-term Reef Life Survey data reinforce this picture of a dynamic but functioning system: between 2013 and 2018, cryptic fish richness and abundance increased and turf algal cover declined alongside rising herbivorous fish biomass (Edgar et al. 2018).

Beyond the shallow oceanic coral reefs, ROV, BRUV, AUV and deep towed video surveys are steadily filling in what was, until recently, a very limited knowledge base. Since 2021, ROV and BRUV/RUV surveys as part of the CSMP's annual Coral Reef Health Monitoring programme and the Our Marine Parks Grants Program, sampling 140 locations across 18 reefs over five voyages between 2021 and 2024 (Hoey et al. 2022, 2024, Tea et al. 2025, Tol et al. 2025). This combined effort has been central to documenting new fish records for the park, including species new to science, from depths as great as 1,200 m, while surveys at North Horn on Osprey Reef reveal clear zonation of mesophotic and rariphotic communities down to nearly 800 m (Tea et al. 2025; Beaman et al. 2016).

An earlier output of this same survey effort, drawing on four voyages between 2021 and 2023 across 17 reefs spanning the full latitudinal extent of the park, recorded 361 fish species between 1 and 100 m depth from 274 ROV transects and 108 BRUV drops, more than a third of them (128 species, 36%) observed deeper than their previously documented maximum depth (Galbraith et al. 2024). This work yielded 16 new quantitative occurrence records for coral reef fishes in the Coral Sea, several representing substantial range extensions from adjacent biogeographic regions, including the tilefish *Hoplolatilus randalli* (extending known Indo-Pacific range roughly 10° of latitude south) and the wrasse *Bodianus paraleucosticticus* (extending west from New Caledonia), with 13 of the 16 species notably absent from the neighbouring Great Barrier Reef, consistent with the CSMP's seamount chain functioning as a distinct connectivity corridor rather than a simple southern extension of GBR fauna. Mesophotic coral ecosystems were confirmed at every reef surveyed, with hard coral cover reaching 70–85% at some sites between 50 and 100 m alongside extensive *Cycloclypeus foraminiferal* fields, octocoral walls, seagrass and *Halimeda* meadows (Galbraith et al. 2024).

A related synthesis of the CSMP's deep, demersal ichthyofauna, combining ROV imagery from Schmidt Ocean Institute expeditions with voucher specimen collection, documented a further 62 new fish records spanning 26 families, of which 45 were new Australian records (including one new family record for Australia), four were new for the Southern Hemisphere, and 21 were assessed as potentially new to science (Tea et al. 2025).

A 2025 study of herbivorous reef fish assemblages across a 2–98 m depth gradient at 17 CSMP reefs, based on 385 ROV transects, found that while richness, abundance and biomass of herbivorous fishes generally declined with depth, the rate of decline varied substantially among functional groups (Quimpo et al. 2025). Excavating and detritivorous fishes declined in abundance at rates nearly double those of cropping and scraping fishes, while detritivore biomass declined at a rate roughly 50% higher than that of croppers; herbivore richness, abundance and biomass were each greatest on gentle-to-moderate reef slopes and at intermediate levels of benthic structural complexity, patterns the authors relate to likely variation in dietary resource availability and predation risk with depth.

A complementary study of predatory fish assemblages on three Coral Sea seamounts, Osprey, Bougainville and Lihou, surveyed by ROV across a 100 m depth gradient, found comparatively limited evidence of depth specialism among predators, in contrast to the pronounced depth-structuring documented for herbivores (Cresswell et al. 2025). Also in 2025, researchers reported the first documented occurrence of a substantial deep-water seagrass meadow, *Thalassodendron ciliatum*, on Saumarez Reef, an oceanic reef in the southern CSMP, together with observations of associated reef fish assemblages, extending the known depth range of significant seagrass habitat well beyond the shallow coastal settings in which such meadows are typically mapped (Galbraith et al. 2025).

Osprey Reef in particular has emerged as a hotspot for deep discovery: its mesophotic assemblages are characterised by abundant gorgonian fans and sea whips, canyons incise the surrounding slope from around 450 m depth, and the reef has yielded the deepest confirmed observation of Denise's pygmy seahorse anywhere, at 102 m (Nishikawa et al. 2011). Elsewhere in the Park, staghorn corals of the genera *Acropora* and *Isopora* have proven far more resilient to depth than expected, with 22 mesophotic-specialist species documented, five of them deep-water specialists restricted to below 40 m (including three new to science), and individual colonies observed growing in situ to 73 m with flattened, fragile skeletons adapted to low light (Muir et al. 205). At Lihou Reef, areas near Edna Cay support coral cover of 70-80% at depths of 70-80 m, a striking exception to the general pattern of declining cover with depth (Galbraith et al. 2022).

This deeper picture has also been built substantially through Schmidt Ocean Institute expeditions on the RV Falkor. A 2020 voyage mapped the seafloor of 30 large coral atolls and banks across the park and revealing previously unknown submarine canyons, dune fields, submerged reefs and landslides. As part of this voyage, AUV *Sirius* across four mesophotic reef systems, Cairns Seamount, North Flinders Reef, Herald Cays and Malay Reef, collecting over 45,000 high-resolution, geo-referenced seafloor images alongside CTD casts, revealing extensive healthy coral communities at mesophotic depths and providing a foundation for subsequent seabed morphology and geomorphology mapping of the park (Brooke and Schmidt Ocean Institute 2022). Over 91 hours of complementary ROV video was collected down to 1,600 m, including footage at Osprey Reef showing no evidence of heat stress impacts in corals below 80 m.

At Cairns Seamount, an underwater mountain rising 1,200 m from the seafloor to a flat summit just 60 m below the surface, ROV dives imaged the site for the first time (Figure 22), while further dives at Herald Cays and Malay Reef documented previously unseen seamount and reef margins down to 700 m. Across these and subsequent expeditions, Schmidt Ocean Institute voyages have recorded some of the deepest living hard corals known in Australian waters, at approximately 149 m, and have contributed to the description of new species, including black corals and carnivorous sponges collected during these surveys.

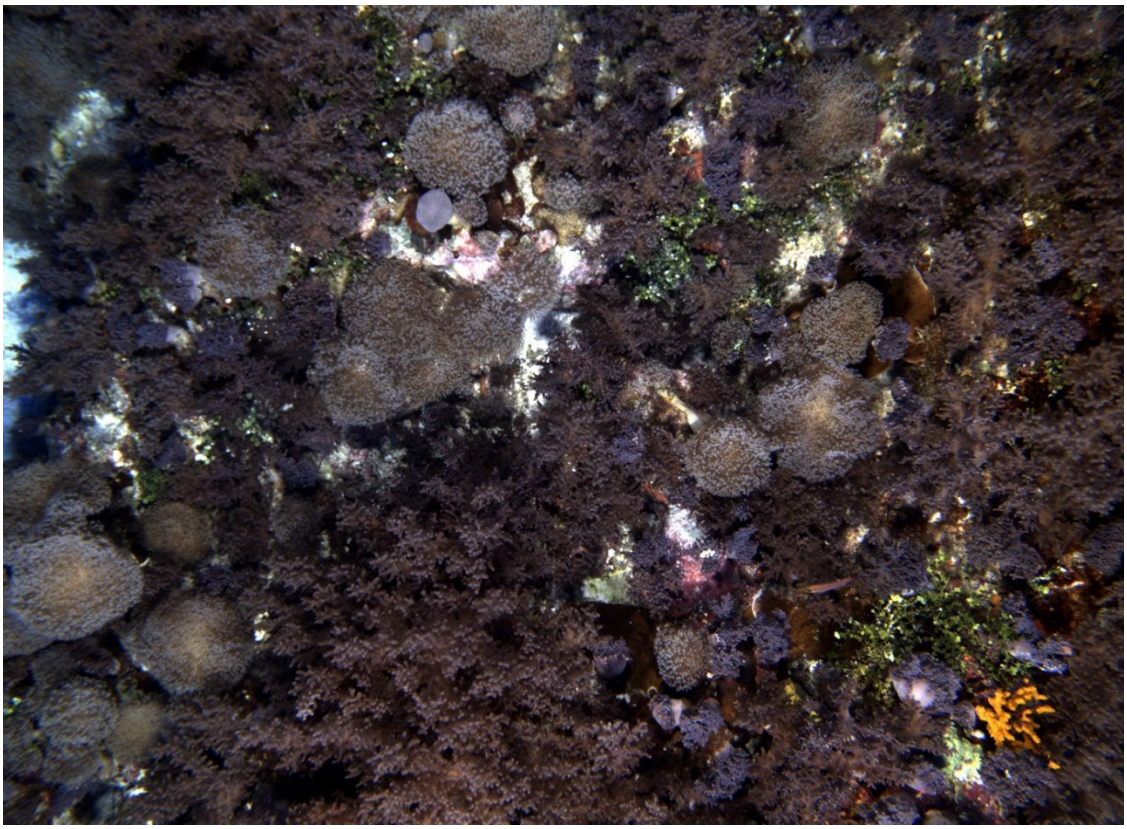


Figure 22. Extensive soft coral beds on the top of Carins seamount captured using AUV Sirius at 46m depth (Source: Squidle+)

3.2 Cays and islands

There cays and islands of the CSMP constitute discrete and highly distinctive ecosystem components that support terrestrial vegetation, invertebrate communities, seabirds and marine megafauna, particularly nesting sea turtles. Although relatively small and generally low lying, these islands have ecological importance disproportionate to their terrestrial extent because they provide isolated breeding and nesting habitat and form an important interface between terrestrial and surrounding marine ecosystems. The cays are predominantly composed of sand and coral rubble, with maximum elevations of approximately 5 m above sea level, making them particularly vulnerable to sea-level rise, erosion, storm disturbance and other climate-related pressures (Baker et al. 2008). Their geographic isolation has nevertheless limited direct human disturbance on many islands and contributed to the persistence of relatively intact vegetation and breeding communities.

Vegetation varies among cays according to substrate, elevation, exposure and freshwater availability. North East Cay (Herald Cays), a semi-circular sand cay approximately 1,200 m long and 500 m wide and located approximately 400 km east of Cairns, supports four principal habitat classes: *1. Pisonia grandis communities 2. Argusia argentea communities, 3. Cordia subcordata/Ximenia americana shrublands, and 4. Herb/Grassland/Abutilon albescens* (Baker et al. 2008, Brushe & Brushe 2025). North East Cay (Herald Cays) and Magdelaine Cay South are the only *Pisonia grandis* forested cays within the CSMP (Baker et al. 2008; Hemson et al. 2020, Parks Australia 2023,2024,2025). *Pisonia grandis* communities also existed on South West Islet (Coringa Islets) but a scale insect outbreak in the late 1990s resulted in substantial declines, with viable stands on North East Cay (Herald Cays) and

Magdelaine Cay South (Smith & Papacek 2001, Smith & Papacek 2002, Gleenslade & Farrow 2008, Hemson et al. 2020). The remaining *Pisonia* forests are important not only as vegetation communities but also as the basis of terrestrial food webs. Invertebrate trapping identified *Pisonia* leaf litter at North East Cay (Herald Cays) as one of the richest terrestrial habitats sampled, with communities dominated by Collembola, ants and beetles. North East Cay (Herald Cays) supported more than twice as many trapped individual invertebrates as South West Cay (Herald Cays), largely because of higher numbers of Formicidae (Greenslade and Farrow 2008). Larger and more elevated islands in the northern CSMP (Coringa Herald/Chilcott Magdelaine groups and the Diamond Islets) have the highest vegetation diversity. South Magdelaine has the highest species count, at 17ssp. Islands situated further away from the coastline (Herald Beacon Island and Lihou Reef islands) and the southern islands (Wreck and Cato Reefs) have lower species richness and diversity, with a complete absence of woody vegetation on some of these islands.

The vegetation and relatively undisturbed nature of the cays provide important habitat for seabirds. Isolated islands offer secure breeding sites, while surrounding reef and oceanic environments provide foraging habitat, creating a strong terrestrial–marine linkage. Historical surveys at South West Islet (Coringa Islets) illustrate the longstanding importance of these habitats, with 11 bird species recorded in 1987 and an estimated 762 red-footed boobies (*Sula sula*) present, including eggs and downy chicks confirming active breeding (Hinchey and Stokes 1987). Three crested terns (*Thalasseus bergii*) were also recorded flying over the south-west beach, representing a new record for the reserve at the time (Hinchey and Stokes 1987).

Contemporary surveys demonstrate that the CSMP cays continue to support diverse and substantial seabird breeding populations. The 2023 Coral Sea Health voyage recorded 33 bird species across surveyed cays, including 18 seabird species, of which 10 were breeding, together with three migratory shorebird species and 12 land and wetland species (Parks Australia 2023). Notable observations included approximately 39,000 breeding pairs of sooty terns (*Onychoprion fuscatus*) at Herald Beacon Islet and a record breeding aggregation of red-tailed tropicbirds (*Phaethon rubricauda*) at North East Cay (Herald Cays), where 860 breeding pairs were observed and the population was estimated to potentially reach 946 pairs after accounting for likely undercounting (Parks Australia 2023). Pelagic observations also recorded providence petrels, white-tailed tropicbirds and two species of storm-petrels, demonstrating that the ecological significance of these cays extends into the surrounding oceanic environment.

More recent surveys in 2025 further documented seabird use of the CSMP cays and provided contemporary observations from rarely visited sections of the Park (Parks Australia 2025). The 2025 surveys recorded breeding activity across multiple seabird species and continued to document large breeding aggregations on the central reef cays. The surveys also highlighted limitations in quantifying breeding effort for species such as brown noddies (*Anous stolidus*), which frequently nest within dense vegetation and therefore cannot always be counted reliably. Pelagic observations provided additional records from less frequently surveyed areas of the CSMP, extending the assessment of seabird use beyond the cays themselves (Parks Australia 2025).

The contemporary surveys demonstrate the continuing importance of the CSMP cays as breeding, roosting and foraging habitat for seabirds, while also highlighting the spatial and methodological challenges associated with monitoring these populations. The absence of

breeding New Caledonian fairy terns (*Sternula nereis exsul*) and Herald petrels (*Pterodroma heraldica*) during the 2023 survey illustrates the value of repeated monitoring for species with restricted distributions or conservation significance (Parks Australia 2023). Changes in vegetation, for example a decline or mortality of *Pisonia grandis* forest, may alter nesting habitat and terrestrial food resources available to island-associated fauna. Monitoring vegetation condition alongside seabird abundance, breeding activity and species composition is therefore critically important to continue for detecting changes in the ecological function of these island–reef systems.

The sandy beaches of the cays are also critical nesting habitat for marine turtles. The Coringa-Herald and Lihou Reefs and Cays Ramsar site supports nationally threatened green turtles (*Chelonia mydas*) and hawksbill turtles (*Eretmochelys imbricata*) (DCCEEW 2026). Green turtles nest on sandy islets throughout the CSMP, while hawksbill turtles use the surrounding reef habitats for foraging. The cays consequently form an interconnected component of marine turtle habitat, linking offshore feeding grounds with nesting beaches. Their isolation and limited human access provide relatively undisturbed breeding habitat, with nesting beaches largely free from direct human and feral animal disturbance.

Targeted turtle surveys have increasingly demonstrated the importance and extent of this function. The 2019 assessment of the Coringa Islets and Herald Cays included monitoring of turtle nesting, nesting beach characteristics and sand temperatures relevant to hatchling sex ratios, together with satellite tagging of eight turtles (Hemson et al. 2020). In February 2022, Parks Australia conducted the first aerial survey of turtle nesting activity across the CSMP, covering 39 cays and islets. More than 2,200 turtle tracks and nesting activities were recorded, despite the survey being undertaken towards the end of the principal nesting period, identified as late December to early January. The 2021 assessment of the Diamond Islets and Lihou Reef cays also recorded extensive evidence of turtle nesting, including hundreds of nests from the preceding breeding season visible on individual cays and islets (Chapman et al. 2022). These surveys demonstrate that turtle nesting is widespread across the CSMP islands and provide an important baseline for assessing the spatial distribution and intensity of nesting activity.

Repeated surveys over more than four decades provide an increasingly comprehensive picture of the condition and trajectory of these ecosystems. Early seabird surveys at Coringa Islet in 1987 established an important historical baseline for breeding populations (Hinchey and Stokes 1987), while vegetation and invertebrate surveys undertaken during the 1990s and 2000s documented both the extent of *Pisonia* forest and the ecological importance of associated leaf-litter communities (Greenslade and Farrow 2008, Hemson et al. 2020). More recent surveys have increasingly adopted an integrated approach encompassing vegetation, geomorphology, seabirds and marine turtles. The 2019 Coringa Islets and Herald Cays assessment incorporated turtle nesting, beach characteristics, sand temperature and satellite tracking alongside broader assessments of cay condition (Hemson et al. 2020). Vegetation and island condition assessments in 2021 documented plant diversity and extensive turtle nesting across the Diamond Islets and Lihou Reef (Chapman et al. 2022), while aerial turtle monitoring in 2022 substantially expanded the spatial understanding of nesting activity across the Marine Park.

Island Health assessments undertaken since 2019 have allowed repeated monitoring of the cays and islets of the Coral Sea. The program began with a voyage to more than 60 islands in November and December 2019 (Hemson et al. 2020) and has continued with further

voyages in July 2021 (Chapman et al. 2022), May and June 2022 (McDougall and Brushe 2023), July 2023 (Parks Australia 2024), July 2024 and June 2025. Delivered through a collaboration of agencies and subject-matter experts, the assessments cover vegetation communities, seabird breeding and diversity, introduced and invasive species, island geomorphology, marine debris and emerging pressures, including human activity and avian influenza.

The 2024 and 2025 assessments are the latest and most comprehensive surveys of CSMP islands to date. The 2024 voyage assessed 12 islands and cays across the Willis Islets, Magdelaine Cays, Lihou Reef, Diamond Islets, Coringa Islets and Herald Cays. It added high-resolution drone imagery and two new permanent BioCondition vegetation monitoring sites, bringing the total to 29 sites on 15 islands. It recorded 26 bird species, including a new breeding site for New Caledonian fairy terns at North West Islet and more than 600 breeding pairs of red-tailed tropicbirds on the Herald Cays. It also removed 3,130 marine debris items (almost 1.3 tonnes) from 11 islands and carried out the first avian influenza surveillance on these voyages. Vegetation findings were mixed: *Pisonia grandis* communities on North East Cay (Herald Cays) were in good condition with no evidence of scale insect outbreaks, while *Cordia subcordata* communities showed varying dieback and recovery. All nine weed species recorded on South Islet in 2023 were still present, and three had spread beyond the operational area.

The 2025 voyage extended coverage to 14 islands and cays across the Herald Cays, Coringa Islets, Willis Islets, Lihou Reef and Tregrosse Reef (Diamond Islets). It added testing and monitoring for highly pathogenic avian influenza, surveys for introduced ants and other invertebrates, and assessment of the condition of reef benthic, fish and invertebrate communities alongside the island surveys. Together, these surveys provide an increasingly integrated understanding of the condition of the cays and of the seabird populations that depend on them.

The Island Health voyage, undertaken in July 2024, illustrates the scale and detail of this ongoing monitoring effort. Two additional permanent BioCondition monitoring sites were established during the voyage, bringing the total network to 29 permanently marked sites across 15 CSMP islands and providing benchmark data against which future vegetation condition can be assessed (Brushe and Brushe 2025). The 2024 survey also recorded several new or long-absent floristic records, including *Boerhavia mutabilis* on South Islet and *Plumbago zeylanica* on Mid Islet, both previously unrecorded on those islands, and *Lepturus repens* on Georgina Cay, which had not been documented there since 1984 (Brushe and Brushe 2025).

Vegetation condition during the 2024 voyage was generally good, though drier than average conditions in the preceding months produced some canopy dieback in *Argusia argentea*, *Pisonia grandis* and *Cordia subcordata* at exposed coastal sites. No scale insect outbreaks were detected on *Pisonia grandis* communities, although some leaf damage from insect attack was recorded at Magdelaine Cay South. *Cordia subcordata*, by contrast, is now markedly less abundant across CSMP islands than in 2006–2007 surveys, and the stand at West Diamond Islet, heavily infested with scale insects when last observed in 2021, was found dead in 2024 (Brushe and Brushe 2025).

Weed incursions remain a persistent and closely managed pressure on South Islet and Bird Islet, where all nine previously recorded weed species, dominated by *Cenchrus echinatus*

(Mossman river grass) and *Euphorbia cyathophora* (dwarf poinsettia), were still present in July 2024, and three species previously confined to the island's operational area had spread into natural areas. These findings informed a South Islet Weed Management Project Plan, endorsed jointly by Parks Australia and the Bureau of Meteorology, under which weeds are hand removed or spot sprayed and monitored monthly by on-island Bureau staff (Brushe and Brushe 2025).

The 2024 voyage also recorded several notable seabird breeding events. A new breeding site for the New Caledonian fairy tern (*Sternula nereis exsul*) was discovered at Magdelaine Cay North (Magdelaine Cays), together with a second nesting record at Georgina Cay (Lihou Reef), while two Herald petrels (*Pterodroma heraldica*) were observed prospecting for nest sites at Central Diamond Islet, the only CSMP island where this species has been recorded nesting. More than 600 breeding pairs of red-tailed tropicbirds were counted across the Herald Cays (Parks Australia 2025). No introduced rodent species were detected on any island surveyed, consistent with all previous CSMP island surveys (Hagger 2025).

Marine debris removal during the 2024 voyage recovered 3,130 items, amounting to approximately 5.5 cubic metres and almost 1.3 tonnes, from 11 islands, 97% of which was plastic, rubber or PVC, including ten fish aggregating devices that are prohibited in Australian waters. Magdelaine Cay North was the largest single accumulator, contributing more than a quarter of the total debris load (Prichard 2025). Turtle nesting pits were recorded on all islands visited, alongside several deceased green turtles found trapped among rocks on the windward shore of Magdelaine Cay North, while a shallow tidal channel observed separating the south-western tail of Georgina Cay from the remainder of the island may reflect tidal fluctuation rather than a permanent geomorphological change (Hagger 2025).

The cays and islands of the CSMP are therefore small but disproportionately important components of the Coral Sea ecosystem. Their vegetation provides structural habitat and supports terrestrial food webs, while their isolation creates important breeding refuges for seabirds and relatively undisturbed nesting beaches for marine turtles. These functions are closely connected to surrounding marine ecosystems, with seabirds relying on adjacent oceanic and reef habitats for food and turtles moving between nesting beaches and offshore foraging areas. At the same time, the low elevation and dynamic nature of the islands make them particularly sensitive to sea-level rise, erosion, extreme weather and climate-driven changes in vegetation and nesting habitat. Continued integrated monitoring of vegetation, seabirds, turtles, geomorphology and invasive species will therefore be important for detecting ecological change, understanding the resilience of these isolated ecosystems and maintaining their role as critical breeding and nesting habitats within the CSMP (Baker et al. 2008).

3.3 Bright spot reefs (Ashmore, Boot, Bougainville, Mellish, Moore, and Cato Reefs)

A defining feature of the CSMP is the presence of a small number of reefs that consistently exhibit exceptionally high ecological condition, biodiversity, structural complexity and relatively intact trophic structure compared with surrounding oceanic systems. These “bright spot” reefs, including Ashmore, Boot, Bougainville, Mellish and Moore Reefs, and more recently Cato Reef, are characterised by comparatively high coral cover, fish biomass and diversity, abundant predators and evidence of resilience to repeated heat stress and cyclone disturbance. Their persistence provides an important contrast to reefs that have experienced

greater declines in coral cover and ecosystem condition and makes them valuable natural benchmarks for understanding resilience in the CSMP.

Ashmore and Boot Reefs provide some of the strongest evidence of the exceptional biodiversity associated with these bright spots. Their position in the northern CSMP, between the northern Great Barrier Reef and Papua New Guinea in the east Torres Strait, appears to contribute to their distinctive biogeographic character. Monitoring by Hoey et al. (2024), Reef Life Survey (Edgar et al. 2017) and other discovery surveys (e.g. Galbraith et al., 2024) have documented exceptionally diverse fish assemblages, with combined species lists comprising 547 species, 334 at Ashmore Reef and 273 at Boot Reef.

Ashmore Reef is particularly notable for its high abundance and richness of invertebrates, with assemblages comparable with those observed on continental-shelf reefs and substantially richer than those typically recorded from isolated oceanic reefs. This distinctive biodiversity is consistent with the reefs' location within a region of strong biogeographic connectivity, where oceanographic processes can facilitate the transport of larvae and other biological material between adjacent reef systems. The northern CSMP is also characterised by complex oceanographic conditions associated with the interaction of regional currents, shelf and basin topography and vertical water-column structure. Recent assessments of Ashmore and Boot Reefs suggest that localised upwelling of cooler deeper water may contribute to their resilience to thermal stress, providing a plausible oceanographic mechanism contributing to their status as ‘bright spot’ reefs (Galbraith et al. 2024). The same research notes that the relative contribution of cooler-water upwelling, local coral thermal tolerance and connectivity with neighbouring reef systems remains unresolved.

Boot Reef, in contrast, is particularly distinguished by its fish assemblages and trophic structure. It has supported some of the highest fish densities and diversity recorded within the region, together with elevated biomass of large predators. Approximately 29 sharks per hectare were recorded at Boot Reef, providing an indication of a relatively intact predator community and trophic structure in a system subject to comparatively little anthropogenic pressure (Edgar et al. 2017; Hoey et al. 2020). The remote offshore location of these reefs, their isolation from land-based sources of disturbance and historically low levels of fishing pressure are likely important factors contributing to their persistence. Together, these characteristics have led to their recognition as ecological “bright spots”, places where biodiversity, ecosystem structure and function remain comparatively well maintained despite the broader pressures affecting coral reef ecosystems (Heather et al. 2022a; Galbraith et al. 2025). Broader surveys, including assessments of sea cucumbers at 109 sites across the CSMP, further demonstrate the importance of these reefs within a wider offshore biodiversity hotspot and provide important baselines for commercially and ecologically significant macroinvertebrates (Skewes and Persson 2017).

Other reefs have subsequently emerged as important bright spots based on their response to major disturbances. Bougainville Reef, for example, experienced substantial exposure to the 2020 mass heat stress event, with bleaching recorded in approximately 65% of colonies. Nevertheless, coral cover declined by only 13% and remained comparatively high at 35%, well above the CSMP-wide average following the disturbance (Hoey et al. 2021). This combination of high initial coral cover, substantial heat stress exposure and relatively limited subsequent loss provides evidence of resistance at the reef scale and highlights why Bougainville has been repeatedly identified as a regional bright spot.

The identification of bright spots has also been strengthened through repeated temporal monitoring. Large-scale baseline surveys undertaken between 2018 and 2020 across the CSMP's 20 reefs established a pre-disturbance benchmark for coral cover, fish assemblages and reef structure and identified reefs with consistently elevated ecological condition (Hoey et al. 2020; Coral Sea Marine Park Coral Reef Health Survey 2020). Subsequent surveys during 2020–2021 captured the effects of widespread heat stress, with substantial declines in coral cover across the Park. Despite these impacts, the reefs identified as bright spots generally retained disproportionately high coral cover and fish biomass relative to the regional average, suggesting that their ecological condition was not simply a consequence of lower exposure to disturbance but also reflected some degree of resistance or resilience (Hoey et al. 2021; CSMP Coral Reef Health Survey 2021).

This pattern has become increasingly apparent through subsequent monitoring. Mellish Reef, at the eastern extent of the CSMP, and Ashmore Reef in the north have continued to exhibit sufficiently robust condition that they have been incorporated into a longer-term monitoring cycle rather than being surveyed annually alongside more disturbance-prone reefs (Hoey et al. 2022). Moore Reef, together with Boot Reef, has likewise been retained as an important benchmark within the CSMP monitoring program, although logistical constraints have limited the frequency with which some of these remote reefs can be revisited (Hoey et al. 2022). These repeated observations indicate that bright spot status is not based on a single survey or isolated observation, but reflects persistent spatial differences in reef condition through time.

The 2023–2024 surveys provided further evidence of these spatially persistent patterns following successive heat stress events between 2020 and 2022. Although coral cover declined across many CSMP reefs, Ashmore, Boot, Bougainville and Moore continued to support coral cover substantially above the regional mean, in some cases more than twice that of surrounding reefs (Hoey et al. 2023, Hoey et al. 2024, CSMP Coral Reef Health Survey 2023–2024). These reefs also retained comparatively high structural complexity and fish biomass, characteristics that are important because complex reef structures provide habitat for diverse fish and invertebrate assemblages and can facilitate the persistence and recovery of reef communities following disturbance. Collectively, the temporal data from 2018–2024 therefore suggest that the ecological distinction of several bright spot reefs has persisted despite repeated exposure to major disturbance events (Hoey et al. 2020–2024).

Importantly, the distribution of bright spots is not necessarily static. Cato Reef in the southern CSMP has more recently emerged as an additional example of a high-condition and potentially resilient reef. During the 2020 heat stress event, only approximately 23% of colonies at Cato Reef were recorded as affected, compared with 89% at Willis Islets (Hoey et al. 2021). By 2023–2024, Cato Reef supported approximately 34% shallow-water coral cover, the second-highest value recorded among the reefs assessed during that survey period (Hoey et al. 2024). The emergence of Cato as a southern bright spot is important because it demonstrates that areas of comparatively high resilience can occur across different regions of the Park and that the identity of bright spots may change as reefs experience different combinations of disturbance, resistance and recovery.

Taken together, the bright spot reefs represent more than isolated examples of reefs in good condition. They constitute a network of persistent ecological reference sites distributed across the CSMP, encompassing northern, eastern, central and southern parts of the Park. Their characteristics, high coral cover, diverse and abundant fish assemblages, elevated

predator biomass, complex reef structure and comparatively strong responses to disturbance, provide an opportunity to investigate the ecological processes that allow some reefs to maintain function under conditions that cause substantial degradation elsewhere. Their remote locations and relatively limited exposure to local anthropogenic pressures also make them particularly valuable as natural benchmarks against which the effects of disturbance and management can be assessed.

For Parks Australia and the CSMP monitoring program, these reefs consequently provide important long-term indicators of ecosystem condition and resilience. Continued monitoring of Ashmore, Boot, Bougainville, Mellish, Moore and Cato Reefs can help distinguish persistent ecological characteristics from short-term responses to individual disturbance events and identify the biological and environmental factors associated with resilience. Understanding why these reefs retain high coral cover, fish biomass and structural complexity may reveal the mechanisms underpinning resistance and recovery and help identify potential refugia and sources of recolonisation for more degraded reefs. In this sense, the bright spots of the Coral Sea are not only conservation assets in their own right, but also natural laboratories for understanding how coral reef ecosystems can persist and recover in an increasingly disturbance-prone ocean (Hoey et al. 2021, Hoey et al. 2022, Hoey et al. 2023, Hoey et al. 2024).

4. Threatened and migratory species

The CSMP supports a diverse range of protected, threatened and migratory marine species, including species listed under the Environment Protection and Biodiversity Conservation Act 1999 (Cwlth) (EPBC Act) and international conservation instruments such as the Convention on Migratory Species and the Convention on Biological Diversity (Cleguer et al. 2024). Biologically Important Areas (BIAs) provide a spatial representation of areas that are important for biologically critical activities of protected marine species, including breeding, foraging, resting and migration. Within the CSMP, BIAs have been identified for humpback whales (*Megaptera novaeangliae*), pygmy blue whales and migratory seabirds and marine turtles (Welch et al. 2016).

The CSMP supports important habitat and movement pathways for migratory species, with the park's extensive seamount chains and oceanographic productivity contributing to spatially variable pelagic species assemblages. In particular, the Coral Sea contains distinct chlorophyll-a regimes that reflect differences in the productivity, seasonality and predictability of pelagic environments. Welch et al. (2016) identified five spatially distinct regimes of chlorophyll-a variability, which were used as surrogates for different assemblages of pelagic species of conservation interest. These regimes capture both spatial differences in average productivity and temporal variation in chlorophyll-a, providing an oceanographic basis for distinguishing areas likely to support different pelagic food webs and mobile predators (Welch et al. 2016). In the generally oligotrophic central Coral Sea, for example, low phytoplankton biomass supports food webs dominated by small picophytoplankton and their zooplankton consumers, whereas elevated productivity occurs locally around reef margins and areas influenced by episodic nutrient enrichment and upwelling (Young et al. 2012). Consequently, the distribution of chlorophyll-a regimes provides an important ecological context for interpreting the distribution of pelagic species, BIAs and other areas of biological significance, and for assessing whether spatial management adequately represents the dynamic pelagic environments of the CSMP.

The CSMP also provides habitat for species of conservation concern under both national and international assessment frameworks. Four species listed as threatened under the EPBC Act have been recorded within the park, all of which are marine turtles, whereas 61 species recorded from the park are listed as threatened under IUCN criteria (Heather et al. 2022a). This difference reflects the distinct assessment frameworks and criteria used by the two systems, as well as differences in the geographic and ecological scope of the assessments. The apparent absence of some threatened species from the CSMP is also likely to reflect the limited overlap between the habitats occurring within the park and the breeding, foraging or other critical habitat requirements of individual species (Young et al. 2012).

Further information on protected species distributions and BIAs within the CSMP is provided in the Marine Bioregional Plan for the North Marine Region and the Conservation Values Atlas maintained by the Australian Government. These resources provide the broader regional context for understanding the distribution of protected species and the areas of the Coral Sea that are important for their life-history processes.

4.1 Marine mammals

The CSMP supports a diverse cetacean fauna, with approximately 27 cetacean species inhabiting the Coral Sea region, including humpback whales, dwarf minke whales, sperm whales and a range of dolphin species (Anon 2001). The CSMP is home to common bottlenose, Fraser's, pantropical spotted, Risso's and rough-toothed dolphins (Alpine 2014). Three marine mammal taxa were identified to species during RV Investigator voyage IN2019_V04 in the Coral Sea, with 128 marine mammals recorded including 58 dolphins and 3 humpback whales (Whittaker 2019). Short-finned pilot whales (*Globicephala macrorhynchus*) were observed four times during the voyage with 64 individuals recorded, predominantly in the southern survey area at Calder and Frederick Seamounts where they were associated with bottlenose dolphins (Lucieer et al. 2020; Whittaker 2019).

A pilot whale (*Globicephala macrorhynchus*) was found stranded on North East Cay (Herald Cays) in 1989 (Anon 2001). Pygmy blue whales (*Balaenoptera musculus brevicauda*) are listed as Endangered under the EPBC Act and their BIAs overlap parts of the southern Coral Sea. The dugong (Dugong dugon) is listed as a migratory species under the EPBC Act and is a Matter of National Environmental Significance, although in the CSMP dugong occurrence is limited because seagrass extent across the park is small compared with the adjacent Great Barrier Reef Marine Park (Cleguer et al. 2024). The dugong is the sole surviving member of the family Dugongidae and the dugong population in the northern Great Barrier Reef has shown approximately 2 per cent annual growth over 17 years, indicating good health in the adjacent waters (Cleguer et al. 2024). Humpback whale breeding grounds are located within chlorophyll-a Regimes 2 and 5 in the Coral Sea, indicating that the more productive northern and southern parts of the park are important seasonal calving habitats (Welch et al. 2016).

4.2 Fish and sharks

The fish fauna of the CSMP is dominated by reef-associated species, with more than 600 reef fish species recorded across the park and a total of 676 bony fish species documented across all habitats (Hoey et al. 2020, Hoey et al. 2021). RLS and JCU reef-health surveys have generated standardised estimates of abundance and biomass for site-attached reef fishes, while pelagic and deep-water taxa have been documented through ROV and acoustic surveys (Heather et al. 2022a). Coral reef fish diversity within the park was further quantified by Hoey et al. (2022), who recorded 640 species from five years of monitoring, including 12 species representing new records for the CSMP.

Targeted sampling of small cryptobenthic fishes using enclosed clove oil has substantially added to the park's recorded fish diversity, because these species are largely missed by visual surveys. In the southern CSMP this sampling yielded 213 cryptobenthic species, 160 of which were not detected through visual surveys. Preliminary analyses suggested that six species may be new to science (five *Eviota* dwarfgobies and one *Doryrhamphus* pipefish), seven (all *Eviota*) are likely new records for Australia, and more than 30 are likely range extensions (Hoey et al. 2020). The collections have already led to formal descriptions, including *Tempestichthys bettyae*, a new genus and species of ocean sleeper (Thalasseleotrididae) collected south-west of Marion Reef. It is the first tropical member of its family and is known only from its type locality (Goatley and Tornabene 2022).

More recently, Tea et al. (2025) substantially expanded knowledge of the park's deep demersal fish assemblage through ROV surveys undertaken during Schmidt Ocean Institute *RV Falkor* expeditions at depths of 260–1,564 m, James Cook University micro-ROV and BRUV surveys spanning 140 locations across 18 reefs, closed-circuit rebreather diving, and examination of vouchered aquarium-trade specimens. These surveys identified 62 new fish records from 26 families, including 45 new records for Australia, four new Southern Hemisphere records and 21 species considered potentially new to science.

New voucher material was documented for 29 species, while several records substantially extended known depth ranges, including *Cirrhilabrus* wrasses recorded to 145 m at Holmes and Flinders Reefs, the deepest records currently documented for the genus. Collectively, these findings demonstrate that the CSMP's mesophotic (30–150 m) and rariphotic (approximately 130–309 m) habitats, which are largely inaccessible to conventional SCUBA surveys, remain important reservoirs of undocumented fish biodiversity.

The importance of the CSMP extends beyond its exceptionally diverse reef and deep-water fish assemblages to include internationally significant habitat for highly migratory pelagic predators. The park supports tuna, billfishes, sharks and other large pelagic fishes that move between reefs, continental margins and the wider Pacific Ocean. Tagging studies have demonstrated substantial movements through the region: yellowfin tuna (*Thunnus albacares*) recaptured between 2006 and 2008 had travelled an average of 247 nautical miles, while five tagged marlin were recaptured elsewhere in the broader Coral Sea during the same period (Ceccarelli 2011).

The CSMP is also associated with the regionally and globally important black marlin (*Istiompax indica*) spawning aggregation. Black marlin aggregate seasonally in the north-western Coral Sea from approximately September to November, with spawning thought to occur near the outer Great Barrier Reef between Cairns and Lizard Island, and around Opsprey and Bougainville Reefs. Evidence from larval collections and the reproductive condition of mature females supports this being a spawning aggregation rather than simply a seasonal feeding concentration (Leis et al. 1987; Domeier and Speare 2012). Most mature females caught near the Ribbon Reefs drop-off showed histological evidence of being ripe or of having recently spawned, and larvae were collected on the outer edge of No. 10 Ribbon Reef, although only three were confirmed as black marlin by DNA analysis. The exact spawning location therefore remains uncertain. Ageing of juvenile black marlin from between Cairns and Hervey Bay also suggests that a significant proportion hatched between February and May, outside the main aggregation period (Hammond, unpublished data), indicating that spawning may extend beyond the September to November window. Satellite tagging has further demonstrated that adult black marlin disperse thousands of kilometres from the spawning area after spawning, identifying the wider Coral Sea and south-western Pacific as the catchment for this spawning stock (Domeier and Speare 2012). The aggregation is therefore important not only as reproductive habitat but also as a node linking the CSMP and adjacent Great Barrier Reef waters with extensive pelagic habitats throughout the Pacific. It has also been suggested (Flynn and Paxton 2012) that black marlin spawn in synchrony with blue marlin, bigeye tuna and yellowfin tuna around lanternfish spawning aggregations over the Queensland Trough in October and November, which would make the region important for several large pelagic predators.

Large pelagic sharks and rays similarly use the CSMP as part of extensive movement networks. Tiger sharks (*Galeocerdo cuvier*) have been documented moving between the

Great Barrier Reef Marine Park and the CSMP, with 25 of 88 satellite-tagged individuals entering the CSMP and movements of up to 1,600 km recorded (Galbraith et al. 2025). Reef manta rays (*Mobula alfredi*) satellite-tagged on the northern Great Barrier Reef also entered the CSMP and descended to depths of up to 350 m, demonstrating that deep mesophotic and pelagic habitats form part of their broader foraging environment (Galbraith et al. 2025). Six whale sharks (*Rhincodon typus*) tagged on the outer Great Barrier Reef spent one to two months in the Wreck Bay region before moving into the CSMP, highlighting connectivity between the northern Great Barrier Reef, Wreck Bay and the wider Coral Sea (Galbraith et al. 2025).

Recent satellite telemetry has further demonstrated that whale shark use of the Coral Sea extends well beyond the epipelagic zone. Miller et al. (2026) reported an extreme dive by a 7 m juvenile male whale shark tagged in the Wreck Bay region, with the satellite tag recording a depth range of 1,978–2,527 m. This represents an extension of the previously accepted maximum recorded depth for whale sharks of 1,928 m and provides the deepest recorded dive for an epipelagic fish species. The shark undertook frequent dives between 10 and 500 m, but also made repeated excursions beyond 1,000 m, with the deepest dive occurring over a deep submarine channel connecting the Coral Sea basin with the continental shelf. These observations indicate that whale sharks can exploit a much larger three-dimensional habitat than previously recognised, potentially using deep pelagic waters for foraging, navigation or other behavioural functions (Miller et al. 2026). The findings are particularly relevant to the CSMP because they demonstrate that pelagic megafauna can connect shallow reef and shelf environments with mesopelagic and bathypelagic habitats extending to several kilometres' depth.

The grey reef shark (*Carcharhinus amblyrhynchos*) and other reef-associated elasmobranchs are strongly dependent on coral reef habitats within the park, whereas tiger sharks and other large pelagic sharks move extensively between reefs and open-ocean environments (Heupel et al. 2018). Many CSMP reefs support resident shark populations and have been identified as Important Shark and Ray Areas (ISRAs). Together, the distribution, residency and long-distance movements of reef fishes, sharks, rays, tunas, billfishes and whale sharks demonstrate that the ecological importance of the CSMP is not confined to its individual reefs. Rather, the park encompasses interconnected habitats spanning shallow coral reefs, mesophotic and rariphotic environments, deep demersal habitats and open-ocean waters, supporting both resident communities and highly migratory species throughout their life cycles. The combination of exceptionally high fish diversity, poorly sampled deep-water assemblages, important shark and ray habitats, and the regionally significant black marlin spawning aggregation highlights the CSMP as a critical component of the broader Coral Sea ecosystem and south-western Pacific pelagic connectivity.

4.3 Marine reptiles

The CSMP supports six of the world's seven marine turtle species: green turtle (*Chelonia mydas*), hawksbill turtle (*Eretmochelys imbricata*), leatherback turtle (*Dermochelys coriacea*), loggerhead turtle (*Caretta caretta*), olive ridley turtle (*Lepidochelys olivacea*) and flatback turtle (*Natator depressus*), all of which are listed as Vulnerable, Endangered or Critically Endangered under Australian environmental legislation (Alpine 2014). Green turtles are the principal nesting species recorded in the CSMP, with nesting documented across multiple

sandy cays rather than being restricted to the Coringa-Herald and Lihou Reefs and Cays. Parks Australia identifies the sandy cays throughout the Marine Park as important green turtle nesting habitat, while the broader park also provides foraging, migratory and inter-nesting habitat for marine turtles (Parks Australia 2025).

The spatial extent of turtle nesting across the CSMP is demonstrated by aerial monitoring. The 2022–2023 Coral Sea Turtle Survey used aerial imagery to assess nesting activity across 44 islands within the Marine Park and recorded 849 unique turtle tracks, representing 388 adjusted complete tracks after correcting for false crawls, previous-day tracks and other sources of double counting (Swaine et al. 2023). This followed the 2021–2022 survey, which recorded 1,684 tracks and 685 adjusted complete tracks across the surveyed islands (Swaine et al. 2023). The apparent decline between seasons should be interpreted cautiously because the 2022–2023 survey was affected by poor weather and heavy cloud during the aerial capture window, which increased the proportion of faded or poorly illuminated tracks and may have reduced detectability. The surveys nevertheless demonstrate that turtle nesting activity is distributed across a substantial proportion of the CSMP's island network.

The aerial surveys also provide evidence of mortality across the wider island network. Forty-seven deceased turtles were recorded in 2022–2023, compared with 36 in the previous season, although much of this difference was attributable to the inclusion of Magdelaine Cays North, where 15 deaths were recorded (Swaine et al. 2023). More recent island assessments continue to document turtle nesting activity outside the Coringa-Herald and Lihou system, including evidence of recent nesting at North East Cay (Herald Cays) and Magdelaine Cay North (Parks Australia 2024).

The CSMP supports a genetically distinct green turtle (*Chelonia mydas*) stock. The Coral Sea stock is one of nine genetically distinct green turtle breeding stocks recognised in Australia, separate from the northern and southern Great Barrier Reef stocks (Dethmers et al. 2006; Jensen et al. 2016; Hemson et al. 2020). Although genetically distinct, the Coral Sea stock is connected to neighbouring regions through the movement of turtles. Coral Sea turtles contribute to foraging populations along the Great Barrier Reef, where they mix with turtles from the northern and southern GBR stocks (Jones et al. 2018), and rookeries in the Chesterfield Islands, New Caledonia, are genetically linked to the Coral Sea stock (Read 2015). This highlights the importance of the CSMP as the nesting habitat of a distinct stock that is part of a broader regional network, rather than an isolated nesting system. The Coral Sea green turtle stock has also been assessed as having Very High sensitivity to climate-change-related impacts (Lettrich et al. 2025). Given the long generation time and delayed demographic response of marine turtles, long-term monitoring is required to distinguish short-term variation in nesting activity from persistent changes in population size and reproductive performance (Parks Australia 2025).

Four species of sea snakes are commonly observed in the CSMP: the olive sea snake (*Aipysurus laevis*), Dubois' sea snake (*Aipysurus duboisii*), the turtle-headed sea snake (*Emydocephalus annulatus*) and the elegant sea snake (Hydrophis elegans), with the olive sea snake dominating (90 per cent of observations) and showing a marked latitudinal distribution favouring southern reefs (Hoey et al. 2022, Hoey et al. 2020). A total of 50 sea snakes were recorded across 15 CSMP reefs in 2022, an increase from 28 individuals in

2021 and 20 in 2020 (Hoey et al. 2022). The 2016 heatwave significantly impacted sea snake densities in the southern Coral Sea and at Marion Reef (Heather et al. 2022a), but longer term data is required to determine recovery.

4.4 Birds

The CSMP supports significant seabird breeding colonies across its network of isolated cays and islets. Historical surveys established the importance of the Coringa-Herald and Lihou Reefs and Cays, where at least 14 seabird species have been recorded breeding, including red-footed booby (*Sula sula*), lesser frigatebird (*Fregata ariel*), great frigatebird (*F. minor*) and red-tailed tropicbird (*Phaethon rubricauda*) (Anon 2001; Baker et al. 2008). Long-term monitoring at the Coringa-Herald Reefs has provided a multi-decadal record of breeding populations, including an estimated 1,794 frigatebird pairs on North East Cay (Herald Cays) in 2007 and 367 active red-tailed tropicbird nests on North East Cay in 1997 (Baker et al. 2008; Anon 2001). These historical records provide an important baseline against which contemporary changes in seabird abundance and breeding activity can be assessed.

Contemporary Coral Sea Health surveys demonstrate that the CSMP continues to support diverse and very large seabird breeding aggregations across multiple cays. The 2023 survey recorded 33 bird species across the surveyed cays, including 18 seabird species, of which 10 were breeding, together with three migratory shorebird species and 12 land and wetland species (Parks Australia 2023). Particularly notable were the approximately 39,000 breeding pairs of sooty terns (*Onychoprion fuscatus*) recorded at Herald Beacon Islet and 860 observed breeding pairs of red-tailed tropicbirds at North East Cay (Herald Cays), with the latter estimated to potentially reach 946 pairs after accounting for likely undercounting (Parks Australia 2023). The 2023 voyage also recorded pelagic species including providence petrel, white-tailed tropicbirds and two species of storm-petrels, demonstrating that seabird use extends beyond the breeding cays into the surrounding oceanic environment.

The 2025 Coral Sea Health survey continued monitoring seabird breeding activity across the Park and highlighted both the persistence of breeding colonies and the challenges of quantifying breeding effort. In particular, brown noddies (*Anous stolidus*) frequently nest within dense vegetation, making complete counts difficult, while species abundance and the availability of survey time can also influence count completeness (Parks Australia 2025). Photography and drone imagery were used to supplement ground observations and assess breeding activity in areas that were difficult to access directly. Pelagic observations also provided information from rarely visited sections of the CSMP (Parks Australia 2025). Together, the island health surveys demonstrate that the ecological significance of the CSMP's island network extends across multiple breeding sites and into the surrounding pelagic environment.

The distribution of suitable pelagic foraging habitat provides an important ecological context for these seabird populations. Spatial and temporal patterns in chlorophyll-a can be used as indicators of variation in pelagic productivity and as surrogates for areas where species of conservation interest, including seabirds, turtles, cetaceans and large pelagic fishes, are more likely to aggregate (Welch et al. 2016).

4.5 Migratory (not all threatened)

Seventeen of the 28 bird species recorded from the Coringa-Herald reefs are listed in the Japan-Australia (JAMBA) and China-Australia (CAMBA) Migratory Birds Agreements, with 18 species recorded from the Coral Sea Islands and Cays listed in these and related international agreements (Anon 2001, Stokes and McNamara 1979). Nineteen species of migratory and other seabirds have been recorded in the CSMP, with EPBC-listed migratory species including the flesh-footed shearwater (*Ardenna carneipes*), wandering tattler (*Tringa incana*), lesser golden plover (*Pluvialis fulva*) and turnstone (*Arenaria interpres*) (Phillips et al. 2006). Some invertebrates, such as corals and some molluscs, are also protected under Commonwealth and state legislation through the broader EPBC framework rather than as threatened species *per se*.

Green turtles are highly migratory marine species with a complex life cycle involving multiple phases in neritic and pelagic habitats: post-hatchling green turtles undergo an epipelagic phase lasting 5 to 10 years before recruiting to coastal waters as juveniles (Read et al. 2015). Male green sea turtles (*Chelonia mydas*) also migrate to their natal areas for reproduction, with a breeding periodicity 2.6 times more frequent than females, and the natal-homing hypothesis has been confirmed by genetic studies for both female and male turtles (Read et al. 2014; Read et al. 2015). Green sea turtles foraging in New Caledonian waters originate from at least four independent genetic stocks breeding in New Caledonia, Australia, Vanuatu and elsewhere in the western Pacific, illustrating the Coral Sea's role as an inter-jurisdictional migratory corridor (Read et al. 2014). The survey data from voyage IN2019_V04 provides novel, spatially explicit quantitative data on resident and migratory species, many of which are listed under the EPBC Act or international migratory species agreements (Whittaker 2019).

5. Understanding uses in the Coral Sea Marine Park

5.1 Commercial fishing

Commercial fishing is an established use of the Coral Sea, including within parts of the CSMP. Fisheries management is shared between the Australian Fisheries Management Authority (AFMA) and the Queensland Government, with jurisdiction determined by the boundary shown in Figure 23. AFMA manages Commonwealth fisheries, including the Coral Sea Fishery (CSF) and Eastern Tuna and Billfish Fishery (ETBF), while Fisheries Queensland manages relevant Queensland fisheries on the western side of the jurisdictional boundary. The extent to which fishing can occur within the CSMP depends on the interaction between fishery-specific management arrangements, fishing gear and the zoning provisions of the Marine Park. Consequently, the presence of a fishery within the broader Coral Sea does not mean that all fishing methods or sectors are permitted throughout the CSMP.

Young et al. (2012) identified five Commonwealth and 15 Queensland-managed fisheries operating across the broader Coral Sea region. This provides important historical context for the range of fishing activities associated with the region, but contemporary fishery-specific spatial data provide a more appropriate basis for assessing current fishing activity within the CSMP.

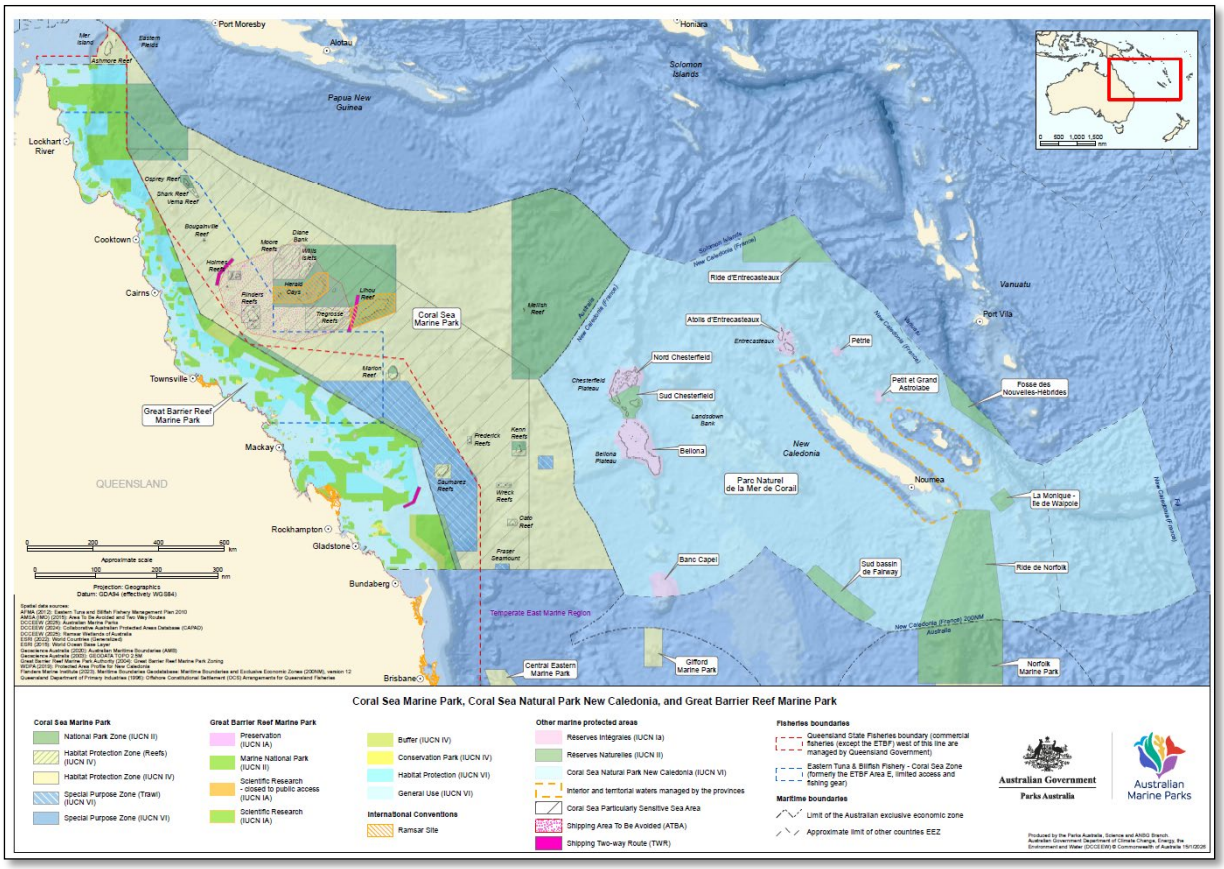


Figure 23. Fisheries jurisdiction boundaries in the CSMP are shown on the above map by a red-dashed line: west of the line managed by Fisheries Queensland; east of the line managed by AFMA (Source: Parks Australia)

5.1.1 Coral Sea Fishery (Commonwealth)

The Coral Sea Fishery (CSF) is a Commonwealth-managed fishery that AFMA administers across four sectors: Line and Trap, Aquarium, Sea Cucumber, and Lobster and Trochus. Entry is limited to 12 fishing permits split across the four sectors, with six in the Line and Trap Sector, two in the Aquarium Sector, two in the Sea Cucumber Sector, and two in the Lobster and Trochus Sector. The fishery extends from Cape York to Sandy Cape, Queensland, and includes the CSMP (Figure 24).

The different CSF sectors therefore interact with the CSMP in distinct ways. Lobster, trochus, aquarium and sea cucumber fisheries are primarily associated with reef and shallow benthic habitats, whereas the Line and Trap Sector can extend into deeper reef and demersal environments.

Details on the fishery, management arrangements and priority issues requiring changes to manages 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 and https://www.afma.gov.au/fisheries/coral-sea-fishery

5.1.2 Lobster and trochus

The Lobster and Trochus Sector targets tropical rock lobster (*Panulirus ornatus*) and trochus (*Trochus niloticus*) using predominantly diving and hand-collection methods. Activity is concentrated around suitable reef habitats and therefore has the potential to overlap directly with shallow coral reef communities and associated biodiversity. The relatively selective nature of these methods results in a different ecological footprint from line fishing or demersal trawling, although localised removal of target species remains a management consideration.

5.1.3 Line and Trap

The Line and Trap Sector targets a range of reef-associated and demersal fishes and sharks using line and trap-based methods. Fishing can occur across reef and deeper benthic habitats where permitted by CSMP zoning. The sector therefore has potential interactions with reef-associated fish assemblages and larger predatory species, with the ecological effects dependent on fishing intensity, gear type and the spatial overlap between fishing effort and sensitive habitats.

5.1.4 Aquarium

The Aquarium Sector collects live reef-associated fishes and invertebrates for the marine aquarium trade. More than 500 fish species occur within the broader Coral Sea fish fauna, although only a subset is targeted by the fishery. Collection is generally selective and undertaken by divers using hand nets and other low-impact methods. Nevertheless, the sector operates directly within shallow reef environments, making the spatial distribution of collection activity relevant to management of sites supporting high levels of reef biodiversity, endemic species or particularly vulnerable taxa.

5.1.5 Sea Cucumber

The Sea Cucumber Sector targets a range of holothurian species, including black teatfish (*Holothuria whitmaei*), prickly redfish (*Thelenota ananas*), surf redfish (*Actinopyga mauritiana*) and white teatfish (*Holothuria fuscogilva*), as well as other commercially harvested sea cucumbers. Fishing is generally undertaken by divers and is subject to species-specific size and catch limits and spatial controls.

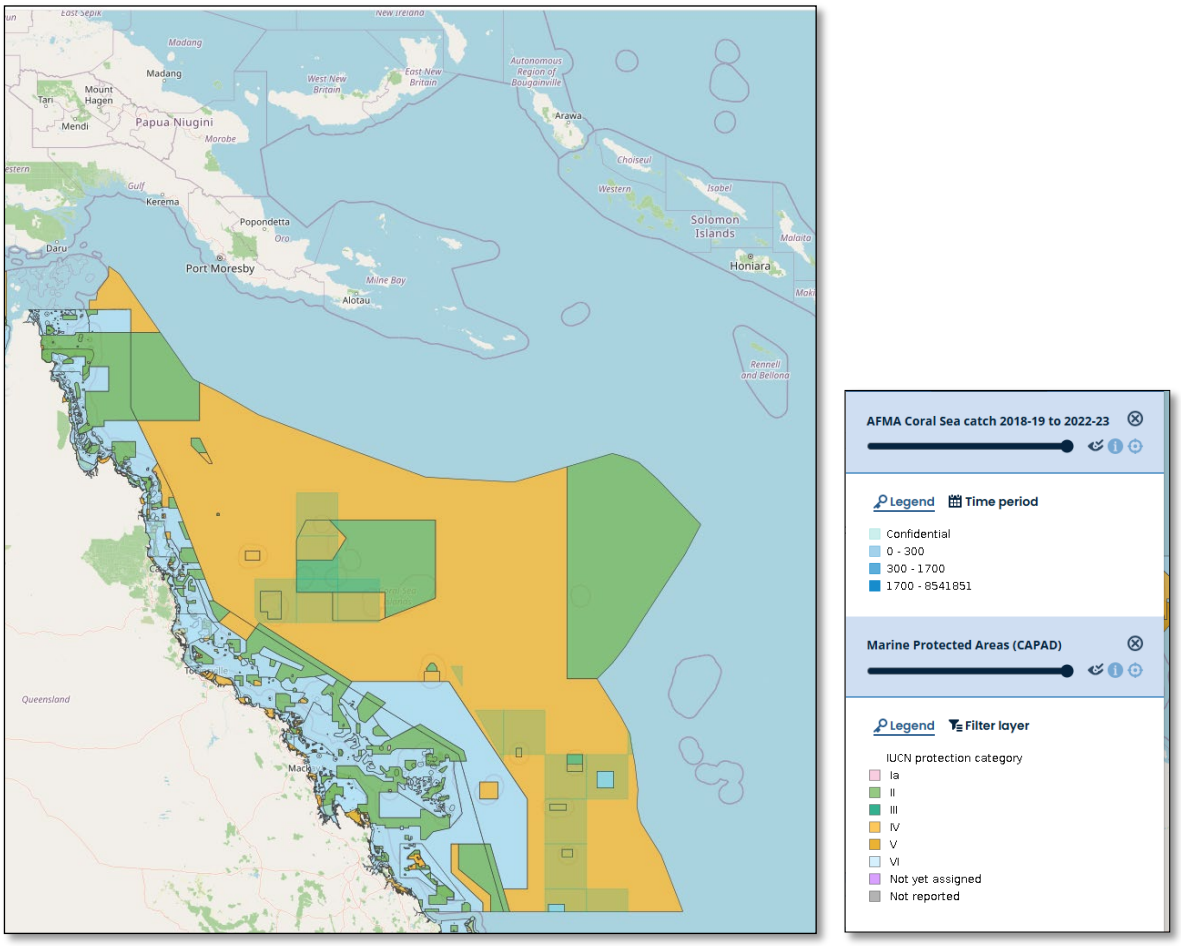


Figure 24. Distribution of catches (kgs) from the Coral Sea Fishery 2018-19 to 2022-23 (Data from the Blue Economy CRC https://futuresofseafood.imas.utas.edu.au/map/#4e196407-291b-4cc5-affd-53c71535462d

5.1.6 Eastern Tuna and Billfish Fishery (Commonwealth)

The Eastern Tuna and Billfish Fishery (ETBF) is the principal commercial fishery operating within the CSMP and targets highly migratory pelagic species across the offshore waters of the Coral Sea. The fishery comprises longline and minor line sectors, with pelagic longlining the predominant fishing method. Longline fishing involves the deployment of baited hooks along extensive mainlines suspended in the water column, while minor line methods include pole-and-line, handline, trolling and rod-and-reel fishing. Within the CSMP, fishing occurs primarily in offshore pelagic habitats and across the continental slope and deeper oceanic waters, reflecting the distribution and seasonal movements of target tuna and billfish species.

The ETBF targets a range of highly migratory species, including albacore tuna (*Thunnus alalunga*), bigeye tuna (*T. obesus*), yellowfin tuna (*T. albacares*), swordfish (*Xiphias gladius*)

and striped marlin (*Kajikia audax*), with catches managed through Commonwealth fisheries management arrangements. The fishery also interacts with other pelagic species, including southern bluefin tuna (*Thunnus maccoyii*), which is managed separately under the Southern Bluefin Tuna Fishery Management Plan 1995. The distribution of fishing effort within the CSMP is influenced by the seasonal availability and movement of pelagic species, with fishing activity extending across the park's extensive oceanic environment.

Contemporary spatial data provide a more appropriate basis for assessing the current distribution and intensity of ETBF activity within the CSMP. AFMA logbook-derived spatial datasets presented through the ABARES Fishery Status Report provide information on the distribution of fishing effort, including the number of hooks deployed and the maximum area fished, with data available through 2024. These datasets demonstrate that ETBF fishing continues to occur extensively across the Coral Sea and represents an important commercial use of the marine park (Figure 25).

The ETBF is managed under Commonwealth fisheries legislation and quota arrangements, with ecological risks assessed through established fisheries management and environmental assessment processes. The fishery is also subject to assessment under the Environment Protection and Biodiversity Conservation Act 1999 (Cwlth).

Details of the fishery, its management arrangements and priority issues associated with managing fishery-related pressures are provided in DCCEEW (2025b). Further information on Commonwealth fisheries management and environmental assessment is available from: https://www.dcceew.gov.au/environment/marine/fisheries/commonwealth and https://www.afma.gov.au/fisheries/coral-sea-fishery

5.1.7 Queensland-managed fisheries

Several Queensland-managed fisheries are permitted in parts of the CSMP under the relevant Queensland fisheries legislation and marine park zoning arrangements. These include crab, harvest, line and trawl fisheries, as well as charter (see section 5.4) and recreational fishing (see section 5.2). The spatial extent and intensity of these activities vary substantially among fisheries; however, the relatively small number of fishers and limited availability of public information make it difficult to quantify their spatial footprint.

Crab fisheries

Queensland's commercial crab fisheries include blue swimmer crab (*Portunus armatus*) and spanner crab (*Ranina ranina*), with the fisheries managed through licensing, quota, harvest strategies and gear restrictions. Blue swimmer crab is managed across Queensland under the C1 fishery symbol and is primarily taken using pots, collapsible traps or dillies. Spanner crab is managed under separate C2 and C3 management areas and is taken using dillies, with total allowable commercial catch or basket limits applying to the respective management areas. Commercial crab fishers are required to use vessel tracking, maintain logbooks and comply with marine park zoning requirements.

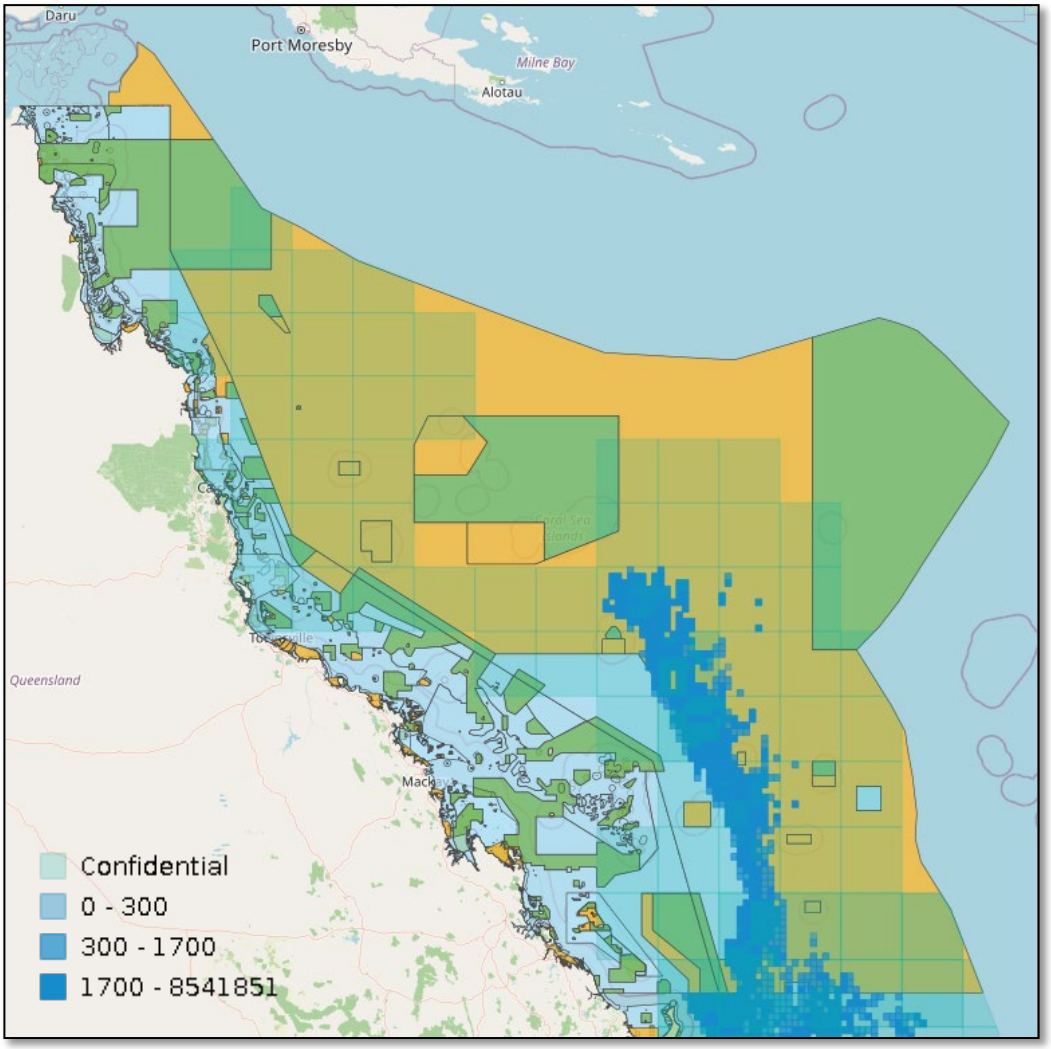


Figure 25 Distribution of catches (kgs) from the Eastern Tuna and Billfish Fishery 2018-19 to 2022-23 (Data from the Blue Economy CRC 2018-19 to 2022-23 (Data from the Blue Economy CRC https://futuresofseafood.imas.utas.edu.au/map/#4e196407-291b-4cc5-affd-53c71535462d

Harvest fisheries

Queensland's harvest fisheries comprise a diverse group of individually managed fisheries, including trochus, marine aquarium fish, sea cucumber and coral fisheries. The trochus fishery targets *Trochus niloticus* and is managed through a total allowable commercial catch and individual transferable quotas, with fishing undertaken by divers. The marine aquarium fishery targets live reef-associated fishes and is also undertaken by divers, with limited entry and spatial management intended to reduce the risk of localised depletion. The Queensland sea cucumber fishery targets species including black teatfish (*Holothuria whitmaei*), white teatfish (*Holothuria fuscogilva*) and burrowing blackfish (*Actinopyga spinea*) and is managed through limited entry, quota, species-specific catch limits and rotational harvesting.

Line fisheries

Queensland manages several line fisheries, including reef line, rocky reef, Spanish mackerel and the east coast multiple-hook fishery. Of particular relevance to the deeper waters of the CSMP is the L8 east coast multiple-hook fishery. L8 fishers may use drop lines or bottom-set lines and are required to operate in waters deeper than 200 m east of the specified longitude and the 200 m bathymetric contour. The fishery allows up to six drop lines with up to 50 hooks per line, or up to three bottom-set lines with a maximum combined total of 300 hooks.

Trawl fisheries

Queensland's trawl fisheries comprise the east coast otter trawl fishery, finfish trawl fishery and river and inshore beam trawl fishery. The east coast otter trawl fishery accounts for approximately 95% of the harvest from Queensland's trawl fisheries and operates across defined northern, central and southern management regions. T1 and other trawl fishery symbols define the areas in which particular vessels can operate, with management based primarily on effort quotas, catch limits and regional harvest strategies.

5.2 Recreational fishing

Recreational fishing in the CSMP is limited due to the park's remoteness from the Australian mainland and is primarily conducted by charter vessel companies offering rod-and-line fishing and spearfishing from live-aboard vessels (Barnett et al. 2012). Very few recreational boat-based line fishing trips are predicted to occur within the CSMP, with the national modelling estimating zero recorded trips in the most recent boat-ramp survey, compared with 360 trips estimated for the broader North Network (Navarro et al. 2021).

5.3 Commercial shipping

A wide range of vessels use waters within the CSMP, including large commercial vessels such as bulk carriers, container ships, oil tankers and cruise ships, as well as smaller domestic commercial vessels. The spatial extent and intensity of commercial vessel activity vary among vessel types and locations.

Commercial shipping is a significant use of the CSMP (Figure 26), with established shipping routes connecting Australian ports with international destinations. The Outer Route passes through the CSMP and is used by vessels transiting between ports along the eastern Australian coast and international destinations. The broader Coral Sea is also traversed by vessels operating between major Australian ports, including Brisbane, Newcastle, Sydney, Botany Bay and Port Kembla. National shipping data, including shipping routes and vessel activity derived from the Automatic Identification System (AIS), are maintained by the Australian Maritime Safety Authority (Jarvis et al. 2022).

Commercial shipping in the south-western Coral Sea is also managed through IMO ship-routing measures associated with the Great Barrier Reef and Torres Strait Particularly Sensitive Sea Area (PSSA). These measures include an Area to be Avoided (ATBA) and two two-way routes, one through Diamond Passage and the other west of Holmes Reef. These routes direct vessel traffic through defined corridors around sensitive reef and shoal areas, while the ATBA identifies areas that vessels are advised to avoid. The measures apply within

parts of the CSMP and provide additional protection for sensitive marine habitats from the risks associated with commercial shipping.

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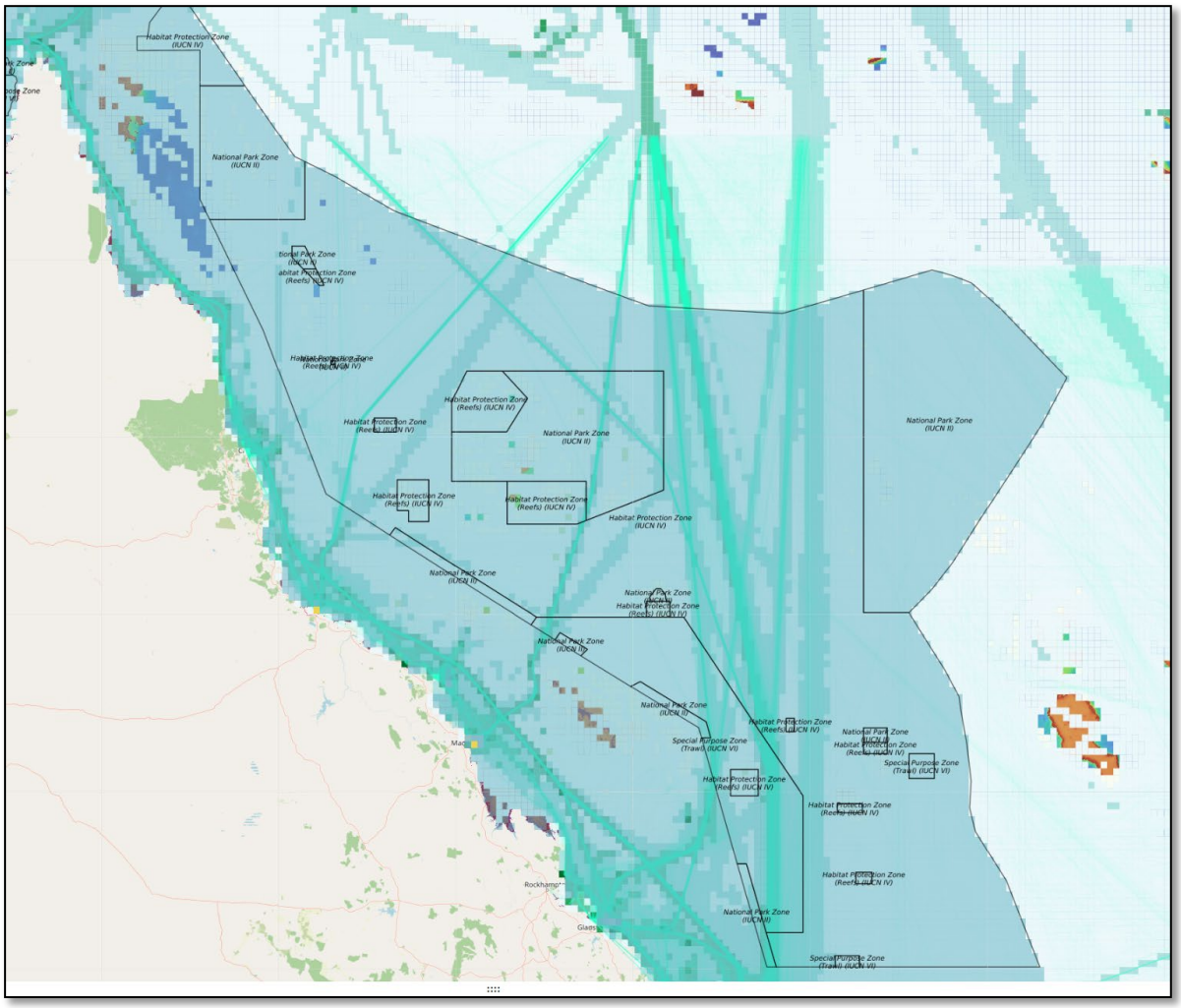


Figure 26. Commercial vessel tracks in the coral sea in 2020. More years are available: https://seamapaustralia.org/map/#a6ddda1f-9689-4bbd-a95e-a63cea0dd27e

5.4 Commercial tourism

Commercial tourism in the CSMP includes live-aboard diving, charter fishing, cruise and yacht visitation, and science and citizen-science expeditions. Most tourism activity is concentrated around accessible reef systems, particularly Osprey, Holmes and Flinders reefs, with Bougainville Reef also an established live-aboard destination. Most visitors travel on multi-day live-aboard vessels departing from Queensland ports, particularly Cairns, Port Douglas and other coastal centres.

Live-aboard diving is a major tourism use of the CSMP. Osprey Reef is a key destination, particularly for its clear water, steep reef walls and shark encounters at sites such as North Horn. Parks Australia identifies grey reef and whitetip reef sharks as abundant at Osprey Reef, with silvertip sharks and seasonal aggregations of scalloped hammerhead sharks also

encountered by divers. Other established live-aboard destinations include Holmes and Bougainville reefs, with Flinders Reef also supporting commercial diving and snorkelling.

Tourism activity is supported by permitted moorings at key reef sites, which provide secure vessel access while reducing the need for anchoring on sensitive reef habitat. The CSMP has 13 current official tourism moorings, supplemented by several historic moorings associated with long-established tourism use. Moorings occur at several of the principal tourism locations, including Osprey, Holmes, Bougainville and Flinders reefs. Tourism operators have also been involved in maintaining and upgrading mooring infrastructure, recognising its importance for both safe access and protection of reef habitats.

Charter fishing is another established tourism use, with multi-day fishing vessels accessing reef systems where permitted under the park's zoning arrangements. Cruise ships and cruising yachts also visit the CSMP, but rapid increases in tourist numbers are not anticipated because of the park's remoteness and limited shore-based infrastructure (Alpine 2014). A citizen science expedition conducted by Coral Expeditions and Australian Geographic, in partnership with Reef Ecologic, engaged 40 guests and 6 scientists across 14 days and collected 10,421 data points (5,390 records uploaded to iNaturalist), with public awareness reaching an estimated 701,000 people through advertising and media (Smith et al. 2024).

5.5 Recreational use – non-extractive

Non-extractive recreation in the CSMP includes sailing, scuba diving, snorkelling and wildlife watching, although activity levels are substantially lower in offshore Commonwealth waters than in adjacent coastal waters. Recreational diving is concentrated at established tourism destinations, particularly Osprey, Holmes and Bougainville Reefs, which are recognised as key CSMP diving destinations. Osprey Reef is particularly prominent for its steep walls, exceptional visibility and shark encounters, while Holmes and Bougainville reefs are valued for their distinctive coral habitats and reef fauna.

5.6 Mining

Mining is not identified as an activity occurring within the CSMP under the current management plan.

5.7 Carbon capture and storage

Carbon capture and storage is not identified as an activity occurring within the CSMP under the current management plan.

5.8 Commercial aquaculture

Commercial aquaculture is not identified as an activity occurring within the CSMP under the current management plan.

5.9 Renewable energy

Renewable energy is not identified as an activity occurring within the CSMP under the current management plan.

5.10 Research and monitoring

Research and monitoring are a major and continuing use of the CSMP, supported through Parks Australia permits and funding from Parks Australia and Commonwealth research programs, including the Marine National Facility, Our Community Marine Parks Grants, the National Environmental Science Program (NESP) Marine and Coastal Hub and its predecessor, the Marine Biodiversity Hub. Research and monitoring are also supported through philanthropic initiatives, including the Schmidt Ocean Institute. 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

Structures and works within the CSMP are limited to several navigational, scientific installations, weather stations, moorings and the historical remains of vessels and aircraft lost in the Battle of the Coral Sea.

Permanent structures include the Bureau of Meteorology Willis Island weather station, automatic weather stations, navigational beacons operated by AMSA and emergency markers on remote cays, with associated infrastructure (Brushe 2021).

A multibeam survey targeting the reported sinking positions of the USS Neosho and USS Lexington in the CSMP located wreck-associated features at depths of 2,952-2,997 m, documenting the only confirmed wartime wreck sites in the park (Whittaker 2019).

6. Understanding pressures in the Coral Sea Marine Park

The broad distribution of these pressures across the Coral Sea Marine Park are summarised in the following sections, and the specific pressures that are present in each zone is summarised in Table 3.

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 CSMP include:

- Altered ocean currents and nutrient transport
- Increased sea surface temperature
- Increased frequency and severity of weather events (including marine heatwaves)
- Sea-level rise
- Ocean acidification

Increasing sea surface temperature is the predominant climate-driven pressure on reef biodiversity in the park, arising from both gradual ocean warming and acute marine heatwaves. This pressure is implicated in repeated mass coral bleaching events documented within the park since the late 1990s (Mellin et al. 2021a). Five major coral heat stress events have been recorded in the CSMP over the past two decades (2002, 2004, 2016, 2017 and 2020), with four of these occurring in the past seven years alone (Hoey et al. 2021; Hoey et al. 2023b). The 2020 event was the most severe and widespread on record, affecting 63 per cent of surveyed corals across the park and up to 89 per cent of individuals at the worst-affected reefs (Hoey et al. 2021). During 2022, the central and eastern Queensland Plateau experienced seawater temperatures exceeding heat stress-induced mortality thresholds (Degree Heating Weeks greater than 6), with peak values of 8 to 11°C DHW (Hoey et al. 2023). Reef communities across the park responded differently to the 2016 and 2020 heatwaves, varying in the spatial extent of thermal stress, the magnitude of coral mortality and post-heat stress recovery trajectories (Heather et al. 2022b).

Climate change also affects the park's mobile and pelagic fauna. Elasmobranch populations are directly influenced by changes in water temperature, freshwater input and ocean acidification, and indirectly affected by altered ocean circulation, sea-level rise, severe weather events and changing light regimes (Heupel et al. 2018). Pelagic species are similarly sensitive to climate change, as they track shifts in temperature, productivity and currents (Welch et al. 2016).

The taxa and habitats considered most vulnerable to climate change in the CSMP are:

- shallow scleractinian corals
- reef-associated fishes
- ground-nesting seabirds and turtles on cays subject to inundation and elevated temperatures
- species with restricted ranges confined to individual seamounts or atolls.

6.1.1 Altered ocean currents and nutrients

Ocean circulation in the Coral Sea is poorly understood relative to the size of the region, but the Coral Sea serves as a major ocean pathway carrying water from the equator to the subtropics, with the South Equatorial Current (SEC) and its associated jets exerting primary control on inflow (Alpine 2014). The North Caledonian Jet and South Caledonian Jet flow westward through the park and potentially influence the drift of green sea turtle (Chelonia mydas) hatchlings and other larval propagules (Read et al. 2014). In the southern Coral Sea, circulation is likely influenced by the East Australian Current (EAC) and its associated eddies, along with cooler waters intruding from the Tasman Sea, producing more pronounced seasonality in primary productivity than elsewhere in the park (Welch et al. 2016).

The strength of the SEC jets varies seasonally and inter-annually, with documented links to the Southern Oscillation Index, carrying implications for productivity, larval connectivity and the heat budget of the Coral Sea (Welch et al. 2016). Uncertainty remains around the oceanographic drivers affecting the strength of the EAC, upwelling along the Great Barrier Reef margin, and larval connectivity between the Coral Sea and adjacent reef systems (Young et al. 2012).

These circulation patterns, and their sensitivity to future change, have direct consequences for species and ecosystems across the park. Strong genetic structure observed across the Indo-Pacific Barrier (FST = 0.397) indicates that current-mediated connectivity has been a long-term driver of biogeographic patterns in the region and may itself be sensitive to future circulation changes (Whitney et al. 2012).

Reef fish communities have shown divergent responses to these changes across the park, with abundance and biomass declining on southern and central CSMP reefs but increasing on northern reefs, patterns that coincide with coral cover trajectories themselves driven by climate-related variability in heat stress and nutrient supply (Hoey et al. 2022). Deep-sea demersal communities in the Coral Sea Abyssal Basin sub-region may also be vulnerable to projected changes in the delivery of detrital matter and near-bottom currents associated with continued warming (Brewer et al. 2007).

6.1.2 Increased sea temperature

There is clear evidence of an underlying warming trend in sea surface temperature across the Coral Sea region (Figure 27), with the increasing frequency, intensity and spatial extent of marine heatwaves (MHWs) over the past three decades identified as the predominant driver of coral bleaching within the CSMP (Huang et al. 2023). This warming is not simply a background trend but manifests as an underlying ocean warming rate of approximately 0.03°C per year across the Coral Sea region between 1992 and 2022, with warming more pronounced in the northern part of the region than the south (Huang et al. 2023).

Monthly SST anomalies for the CSMP show this trend clearly (Figure 27), with anomalies through the 1990s and 2000s mostly ranging between −1°C and +1°C relative to the 1993–2014 baseline, but a marked shift toward consistently positive and larger anomalies from the mid-2010s onward, with peaks increasingly exceeding +1.5°C and approaching +2°C in the most recent and projected years. This pattern is consistent with the finding that, between 2015 and 2022, the Coral Sea region experienced significant annual MHWs in all but two

years (2018 and 2019), a striking departure from the more episodic MHW activity of the preceding two decades (Huang et al. 2023).

The timing and drivers of these events vary considerably. At the interannual scale, strong and very strong El Niño events, particularly when in phase with a positive Indian Ocean Dipole, have consistently preceded the most severe MHWs and associated coral bleaching, including the 1998, 2016, 2017 and 2020 events (Huang et al. 2023; Hoey et al 2021; Figure 28). However, several of the more recent major MHWs, including those in 2017 and 2022, occurred under neutral or even La Niña conditions, pointing to the growing influence of local atmospheric and oceanic drivers such as reduced wind speed, shoaling of the mixed layer and reduced cloudiness, which precondition MHW development independently of remote climate drivers (Huang et al. 2023). At the heat-budget level, anomalous air-sea heat flux, driven mainly by shortwave solar radiation and latent heat flux, was found to be the broadest and most constant contributor to MHW intensity, with the 2015–16 MHW most likely driven by anomalously strong shortwave radiation and the 2019–20 MHW by anomalously weak latent heat flux (Huang et al. 2023).

Key habitats within the CSMP likely to be affected in the longer term include shallow scleractinian coral reefs, which are most prone to heat stress during the extended austral summer (December to March) when MHW intensity and duration peak, and mesophotic coral ecosystems at depths of approximately 30–150 m, which provide important but still poorly understood ecosystem services and potential thermal refuge from surface warming (Huang et al. 2023).

The extent of impacts on individual reefs depends strongly on local oceanographic and bathymetric context. Shallow reefs in the northern GBR lying along the path of the northward-flowing North Queensland Current (NQC) have been shown to experience up to 2°C of consistent thermal relief during the austral summer, with a substantial number of reefs along this current's path escaping bleaching altogether during both the 2016 and 2020 mass heat stress events despite MHW intensities well above the regional average (Huang et al. 2023). Within the CSMP itself, mesophotic reefs at Cairns Seamount, North Flinders Reef, Herald Cays and Malay Reef were generally found to be dampened from surface MHW signatures by a shallow mixed layer depth (typically less than 20 m in summer), resulting in markedly lower bleaching impact than on adjacent shallow reef crests; total bleaching at these four reefs in 2020 ranged from 3.4 per cent of images assessed at Cairns Seamount up to 27.4 per cent at North Flinders Reef, which also recorded the highest cumulative MHW intensity of the four reefs (33°C days) (Huang et al. 2023). This mesophotic refuge effect is not absolute, however: during the 2022 MHWs, strong winds associated with Tropical Cyclones Seth and Tiffany drove deep vertical mixing that allowed warm water to penetrate beyond 80 m at Cairns Seamount and North Flinders Reef, with MHW signatures at these mesophotic depths in December 2021 and January 2022 exceeding those at the surface and daily MHW intensity reaching up to 2°C for a sustained period, illustrating that abnormal weather events can override the thermal protection water depth otherwise provides (Huang et al. 2023).

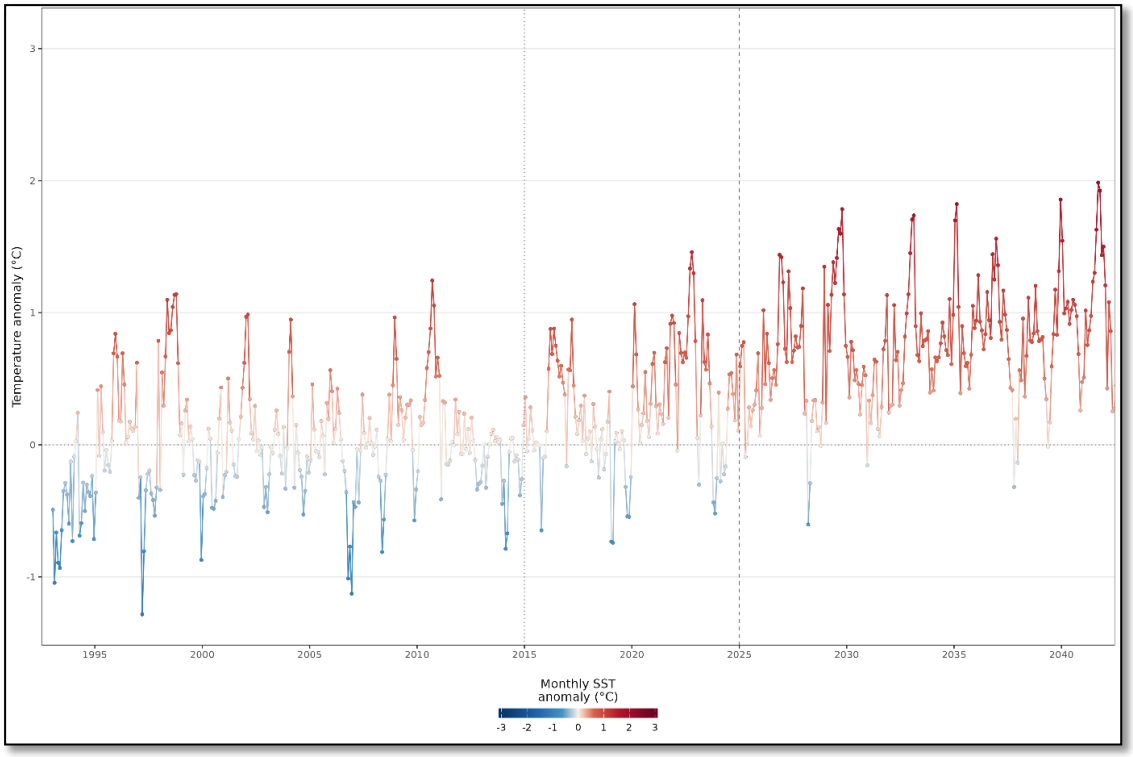


Figure 27. Hindcast and forecast patterns of monthly sea surface temperature anomalies between 1995 and 2045 (relative to 1993-2014 climatological baseline) in the Coral Sea Marine Park (CSIRO unpublished data).

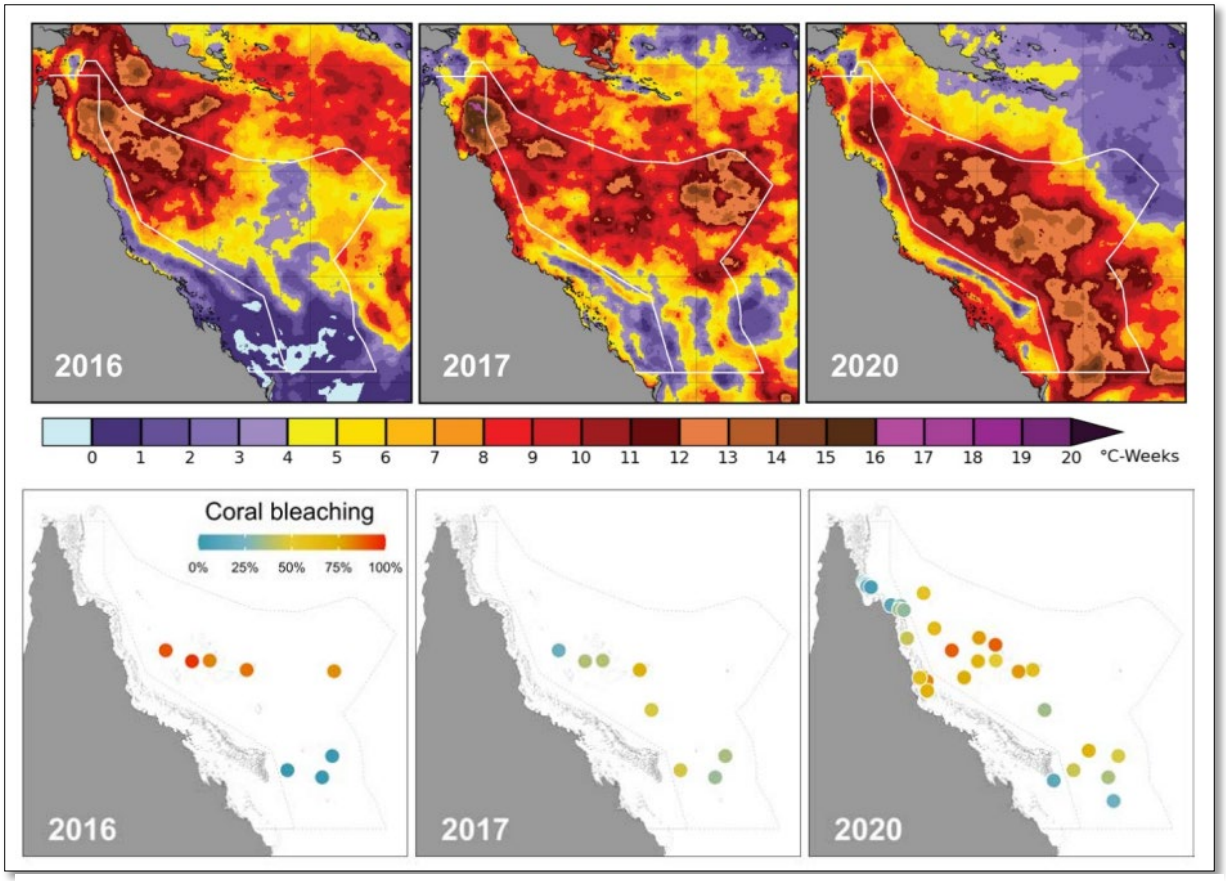


Figure 28. Maximum Degree Heating Weeks (top row), and incidence of coral bleaching (bottom row) experienced throughout the Coral Sea Marine Park during 2016, 2017 and 2020. Source: Hoey et al. (2021)

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

Climate change is increasing the frequency and severity of extreme weather events affecting the CSMP, principally through tropical cyclones and marine heatwaves (MHWs), which together represent one of the most significant physical pressures on the park's shallow and mesophotic reef systems.

Tropical cyclone activity is a persistent physical disturbance across the park, with average annual cyclone frequency over the period 1985–2015 concentrated over the central Coral Sea and the outer National Park Zone, reaching up to 5 days per year in the most exposed areas (Figure 29). Reefs and cays within these higher-frequency zones are subject to direct physical disturbance from wave energy and storm surge, and cyclones also drive strong vertical mixing of the water column that can interact with heat stress in complex ways, either dissipating surface heat and providing short-term thermal relief, or, where mixing is sufficiently deep, transporting warm surface water down to mesophotic depths and eroding the thermal refuge these deeper reefs would otherwise provide.

MHWs are prolonged, discrete, anomalously warm water events that exceed the long-term ocean temperature average for a specific region (Hobday et al. 2016). Across the Coral Sea and adjacent Great Barrier Reef, MHWs have increased in frequency, intensity and spatial extent over the past three decades (1992–2022), consistent with an underlying ocean

warming trend of approximately 0.03°C per year that is more pronounced in the northern part of the region than the south (Huang et al. 2023). Between 2015 and 2022 the region experienced significant annual MHWs in all but two years (2018 and 2019), a marked departure from the more episodic MHW activity of the preceding two decades (Huang et al. 2023). El Niño events, particularly when in phase with a positive Indian Ocean Dipole, have historically been the key remote driver of the most severe MHWs, though several recent major events, including those in 2017 and 2022, occurred under neutral or La Niña conditions, reflecting the growing influence of local atmospheric and oceanic preconditioning such as reduced wind speed, shoaling of the mixed layer and reduced cloudiness (Huang et al. 2023).

The interaction between these two pressures, physical disturbance from cyclones and thermal stress from MHWs, is particularly consequential for the CSMP. This was directly demonstrated during the 2022 event, when strong winds associated with Tropical Cyclones Seth and Tiffany drove deep vertical mixing across the central and northern Coral Sea, allowing warm water to penetrate beyond 80 m at Cairns Seamount and North Flinders Reef. MHW signatures at these mesophotic depths in December 2021 and January 2022 exceeded those recorded at the surface, with daily MHW intensity reaching up to 2°C for a sustained period, effectively overriding the thermal protection that water depth otherwise provides to the park's mesophotic reef communities (Huang et al. 2023). Given the park's dependence on remote, isolated reef systems with limited capacity for rapid recovery, where cyclone disturbance and MHW-driven bleaching coincide or occur in close succession, cumulative impacts on coral cover and reef structure are likely to exceed those from either pressure alone, with implications for the longer-term recovery trajectories of the park's shallow reef and cay habitats.

6.1.4 Sea level rise

Sea-level rise is a significant climate-driven pressure on the CSMP because the park's emergent cays and islets stand at maximum elevations of only about 5 m above sea level, leaving them highly vulnerable to inundation and erosion (Baker et al. 2008). Global sea levels rose by 20 cm between 1870 and 2004, with climate models predicting future rises of 5-15 cm by 2030 and 18-82 cm by 2100 under a range of emissions scenarios (Figure 30).

The 2025 vulnerability assessment of marine turtle nesting habitat in the CSMP combined exposure, sensitivity and adaptive capacity to rank the most vulnerable cays, with sea-level rise of 0.25 m by 2050 and 0.75 m by 2090 used as bracketing scenarios (Hamann et al. 2025). The Coral Sea green turtle stock was scored as Very High in sensitivity to climate-change related impacts, with sea-level rise compounding heat-driven shifts in incubation temperatures recorded at Willis Island since 1986 (Hamann et al. 2025). During the interglacial periods of the past 500,000 years, sea levels varied between extreme lows of approximately -80 m and highs near present-day levels, and the present Great Barrier Reef shelf edge has been the location of the GBR for 85 per cent of the last 500,000 years (Herwerden et al. 2009). These long-term sea-level variations underpin the contemporary distribution of reefs in the CSMP and provide context for the geological resilience of carbonate atoll systems to slow sea-level change, but recent rates of change are projected to outpace the accretion capacity of CSMP cays. Sea-level rise is the most frequently considered climate stressor in coastal and marine restoration projects, reflecting widespread recognition of its significance for management planning (Saunders et al. 2022).

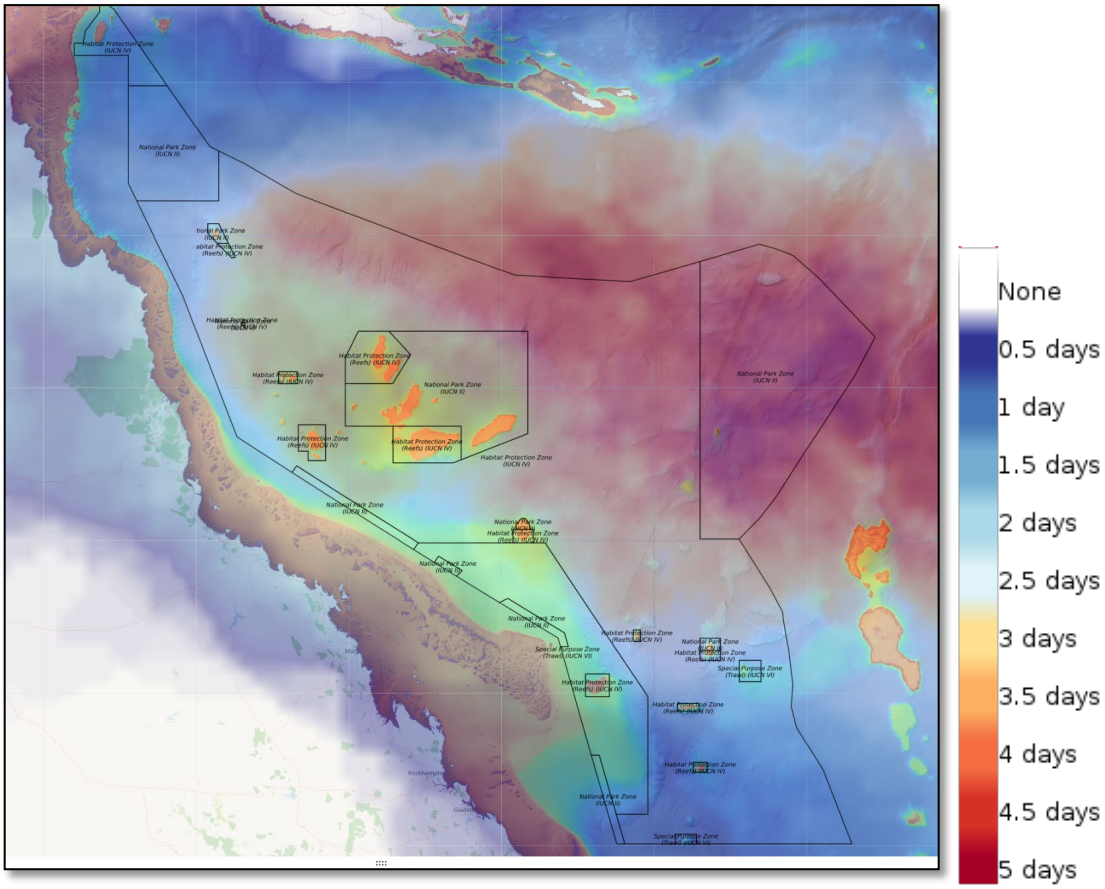


Figure 29. Average annual cyclone activity from 1985-2015 highlighting frequency over central Coral sea and outer National Park Zone (https://seamapaustralia.org/map/#db16fd00-7e10-4bec-ac68-e431c5803b41

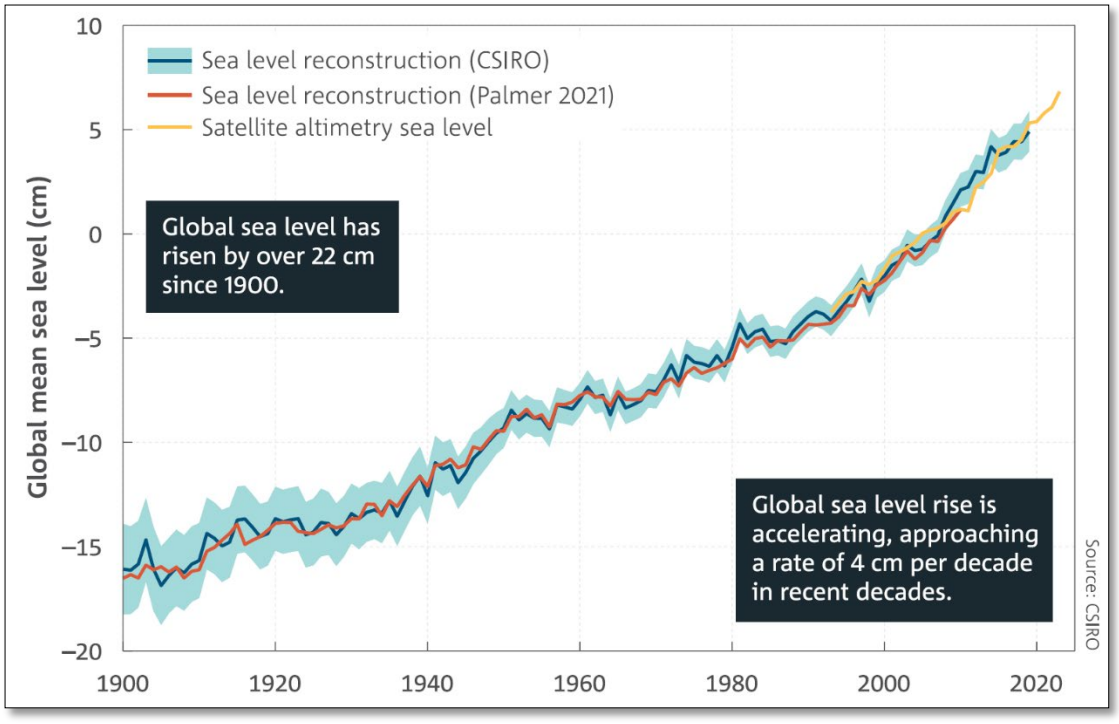


Figure 30. Annual global sea level change from 1880 in tide gauge data (1880–2019, blue line, shading indicates confidence range), and annual sea level change in satellite altimetry (1993–2019, orange line). Source: Australia State of Climate 2020.

6.1.5 Ocean acidification

It is anticipated that continued increases in atmospheric carbon dioxide (CO_2) concentrations will drive further ocean acidification and associated changes in seawater chemistry throughout the CSMP. Current modelling of trends in surface-water pH indicates that the greatest decreases are likely to occur in the mid- to north-eastern regions of the CSMP (Figure 31). Declining pH is accompanied by reductions in the availability of carbonate ions and the saturation state of aragonite, with potentially important consequences for organisms and ecosystems that rely on calcium carbonate structures.

There is growing evidence that ocean acidification can affect marine organisms through direct effects on metabolic physiology and calcification, as well as indirect effects mediated through species interactions and food webs. Early evidence was dominated by laboratory and mesocosm experiments, which demonstrated particular vulnerability among calcifying organisms and their early life stages. Marine molluscs, for example, can be especially sensitive during pelagic larval stages, when the formation of calcium carbonate shells is critical (Parker et al. 2010, 2013; Ross et al. 2011; Scanes et al. 2014). However, more recent field-based evidence provides a clearer indication of how these individual responses may translate into changes in whole ecosystems.

A recent study of tropical coral reef communities across a natural gradient in ocean acidification in Papua New Guinea found progressive changes in benthic community composition as aragonite saturation declined, rather than a single abrupt ecological tipping point (Noonan et al. 2025). Complex habitat-forming corals, crustose coralline algae and other calcifying algae declined substantially, while non-calcareous brown and red algae and, in some circumstances, sponges increased. Importantly, significant changes in coral diversity and structurally complex coral cover were detected following relatively small declines from contemporary aragonite saturation states, indicating that ecological responses may begin before extreme acidification conditions are reached. These changes were also associated with declining structural complexity and reduced diversity of both adult and juvenile corals (Noonan et al. 2025).

These findings strengthen earlier predictions that ocean acidification could simplify reef communities and alter trophic and habitat structure. Rather than uniformly reducing all species, acidification is likely to favour some taxa over others, potentially shifting communities from calcifier-dominated assemblages towards communities with greater representation of non-calcifying organisms. Such changes may have broader ecological consequences because losses of structurally complex corals and calcifying algae can reduce habitat availability, alter recruitment processes and affect associated fish and invertebrate communities.

Ocean acidification is therefore likely to affect multiple ecosystems within the CSMP, although the nature and magnitude of responses will vary among habitats, taxa and environmental settings. The strongest evidence currently concerns shallow tropical coral reefs, while the responses of deeper benthic communities, mesophotic reefs and offshore ecosystems remain comparatively poorly understood. As acidification progresses throughout the water column, improving understanding of these ecosystem-specific responses, particularly in combination with marine heatwaves, warming and other climate-related stressors, will be important for assessing the future condition and resilience of CSMP ecosystems.

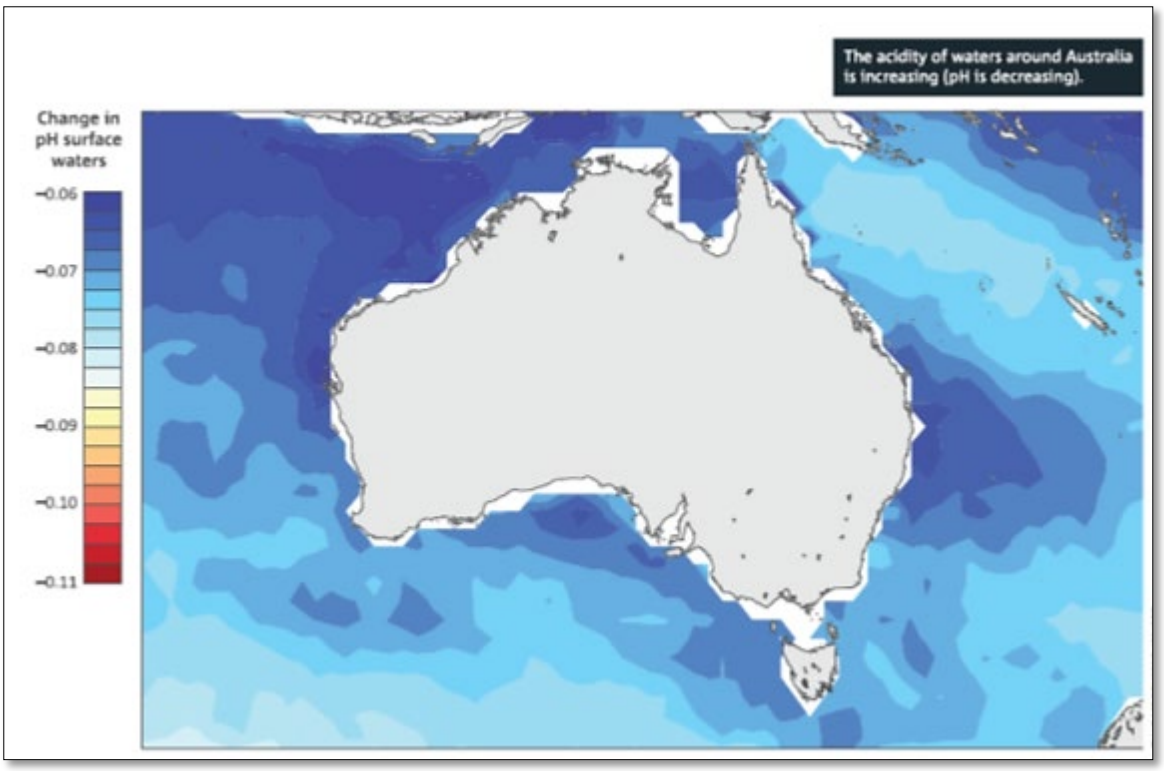


Figure 31. Trends in acidity in marine waters of Australia. Source: Source: Australia State of Climate 2020.

6.2 Extraction of living resources

Harvesting of living resources is an important pressure and commercial use within the CSMP. Fisheries operating within or adjacent to the park include Commonwealth pelagic fisheries, as well as Queensland-managed fisheries in the Queensland portion of the park. The pressures associated with these fisheries include the removal of target species, interactions with non-target and protected species, and, for some fisheries, physical disturbance of benthic habitats. The extent and intensity of these pressures vary substantially among fisheries and locations.

Harvesting of living resources is described as a pressure of concern in the CSMP. 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 in the following:

- https://www.afma.gov.au/fisheries/coral-sea-fishery
- https://www.business.qld.gov.au/industries/farms-fishing-forestry/fisheries/commercial/profile/crab,
- https://www.business.qld.gov.au/industries/farms-fishing-forestry/fisheries/commercial/profile/harvest

- https://www.business.qld.gov.au/industries/farms-fishing-forestry/fisheries/commercial/profile/line

6.2.1 Commonwealth fisheries

The Commonwealth Eastern Tuna and Billfish Fishery (ETBF) is the principal commercial fishery operating across the offshore waters of the CSMP. Pelagic longline fishing targets highly migratory species, including tunas, billfish and broadbill swordfish. Fishing activity can therefore overlap large areas of the park's oceanic habitats and may result in interactions with non-target species, including sharks, seabirds, marine turtles and marine mammals. The spatial distribution and intensity of fishing effort, together with the highly mobile nature of the target species, make the ETBF an important consideration for management of the CSMP.

6.2.2 Crab fisheries

Queensland-managed crab fisheries, including the blue swimmer crab and spanner crab fisheries, are relevant primarily to shallower shelf and sedimentary habitats in the Queensland portion of the CSMP. Pots, traps and dillies have less direct seabed disturbance than trawling, although the removal of target species and localised interactions with benthic habitats remain relevant where fishing overlaps areas of ecological significance.

6.2.3 Harvest fisheries

Queensland-managed harvest fisheries, including trochus, aquarium fish and sea cucumber fisheries, operate in shallow reef and benthic environments where suitable habitat occurs. These fisheries are particularly relevant to the CSMP because target species are closely associated with reef ecosystems. Their spatial footprint is generally more localised than that of mobile fishing methods, but repeated extraction can be relevant to the management of reefs supporting high biodiversity, vulnerable species or locally important populations. Fishing activity is subject to Queensland fisheries regulations and marine park zoning requirements.

Sea cucumber harvesting has also been subject to illegal fishing pressure in the broader Coral Sea. Historical assessments documented apprehensions associated with illegal sea cucumber harvesting, while monitoring within the CSMP has provided evidence of relatively stable sea cucumber densities at surveyed locations (Skewes and Persson 2017; Heather et al. 2022b). Illegal harvesting therefore remains a potential pressure, although the available monitoring does not indicate widespread declines in the surveyed populations.

6.2.4 Line fisheries

The Queensland L8 deepwater line fishery has the potential to overlap deeper shelf and slope habitats within the Queensland-managed portion of the CSMP. Unlike trawling, line fishing does not involve continuous contact between fishing gear and the seabed, but it results in the removal of demersal fish and can involve interactions with non-target species. The spatial overlap of fishing effort with deeper reefs, seamounts, slopes and other benthic habitats is therefore relevant when considering the management of these areas.

6.2.5 Trawl fisheries

Queensland-managed trawl fisheries, including the T1 east coast otter trawl fishery, have the potential to interact directly with the seabed and associated benthic communities. The extent of this pressure within the CSMP is constrained by fisheries closures and marine park zoning; however, where trawling is permitted, seabed disturbance and the removal of target and non-target species remain relevant management considerations.

6.2.6 Recreational and charter fishing

Recreational and charter fishing also occurs within the CSMP, although information on the spatial extent and intensity of this activity is limited. Catch and effort are managed through a combination of bag and size limits, gear restrictions, seasonal or spatial closures and marine park zoning arrangements. The relatively small number of vessels operating in the remote offshore CSMP means that the overall footprint is likely to be spatially concentrated around accessible reefs and other fishing grounds, but public information on this footprint is limited.

6.3 Physical disturbance

Physical disturbance of seafloor habitats within the CSMP can result from fishing activities, vessel anchoring and other vessel interactions. The extent of this pressure is likely to be spatially limited, reflecting the remoteness of the park and restrictions on activities in many areas.

Trawling has the greatest potential for direct physical interaction with seabed habitats among the Queensland-managed fisheries that can operate within the CSMP. Otter trawls can disturb soft sediments and benthic communities through repeated contact with the seabed. However, trawling is a relatively limited activity within the CSMP, with extensive areas closed through fisheries and marine park management arrangements. Queensland also applies gear restrictions and bycatch reduction measures, including turtle excluder devices, and prohibits trawling in waters deeper than 300 m. Consequently, widespread physical disturbance from trawling within the CSMP is likely to be limited, although localised impacts may occur where trawling is permitted.

Vessel collisions are also a recognised source of mortality for whales and other large marine fauna. The 2010 International Whaling Commission ship-strike database contained 35 records of vessel strikes in Australian waters (Peel et al. 2016), although there are limited data on the frequency of vessel strikes specifically within the CSMP. The risk is likely to vary spatially and seasonally with vessel traffic and the distribution and movements of marine fauna.

6.4 Vessel noise

Commercial shipping is a significant use of the CSMP and is associated with several pressures on marine values, including underwater noise, wildlife disturbance and vessel strike. Passive Acoustic Monitoring has identified the Coral Sea among marine park networks with relatively high exposure to shipping noise, associated with the Outer Route and other commercial vessel traffic (Peel et al. 2021). Vessel noise has the potential to affect marine fauna that rely on sound for communication, navigation and foraging.

6.5 Commercial tourism

Access to the CSMP's more than 60 islands is tightly managed because of their value as seabird rookeries and green turtle nesting habitat. Island access for commercial tourism and commercial media may be authorised following assessment, under conditions set out in the Australian Marine Parks Access Guideline for the Coral Sea Marine Park. Commercial tourism groups must not exceed 15 people on an island at any one time, up to a maximum of 30 people per day, and clients must be supervised by authorisation holder personnel at all times. Access is not permitted between sunset and sunrise, in areas of vegetation or above the high-water mark, and camping, vehicles, fires, structures, loud equipment and the disturbance of wildlife are not allowed. Water sports and commercial aviation tours are not permitted within 500 m of an island, and drones can only be operated under authorisation, with a wildlife observer present and not within 100 m of the shore of, or over, an island. South Islet (Willis Islets) is the only occupied island, because of the Bureau of Meteorology weather station, and is not open to public access.

These conditions respond to three main pressures: human presence disturbing habitats and the breeding success of seabirds and turtles, light pollution from vessels, and biosecurity risks from introduced pests and disease. Parks Australia's health voyages have noted that the islands are not big enough to accommodate high tourism loads, and that impacts on island ecosystems from heavy visitation are likely to be negative and significant. Vessel lighting is a particular concern for larger vessels such as cruise ships that stop, anchor or use dynamic positioning next to islands overnight. Light can affect seabird fledglings up to 15 km away and turtle behaviour up to 18 km away (Anon, 2019), so non-essential deck lighting should be extinguished and block-out blinds used on portholes and windows. The guideline also advises that vessels be antifouled, manage ballast water and be treated for pests by a licensed controller before island access and annually thereafter, and that fouling not be cleaned off vessels inside the park. People going ashore are advised to wear freshly washed clothing, check gear for seeds and soil, bring only pre-packaged food, take all waste back to the vessel and not take animals onto islands. The guideline is reviewed annually, and management options may include limits on the number and timing of visitors and park or area closures.

6.6 Marine debris

Beaches on remote, uninhabited offshore islands within the CSMP accumulate anthropogenic marine debris, including hard and soft plastics, fishing-related debris, plastic straps, cloth, glass, metal, rubber, foam, timber and paper (Roman et al. 2021; Tangaroa Blue 2022; Swaine et al. 2023). Reef Health Reports (Parks Australia 2025) continue to identify marine debris as a pressure on Coral Sea reefs and cays, with debris recorded at multiple reef and island sites and plastics comprising a substantial component of the material observed. Surveys at Diamond Islets and Lihou Reef have documented persistent debris accumulation, including plastic items associated with both domestic and international sources, highlighting the role of ocean currents and regional and global transport pathways in delivering marine debris to the park.

Marine debris is not confined to shorelines. Debris has also been documented on deeper reef habitats within the CSMP, including fishing line recorded by remotely operated vehicle surveys at depths of up to 94 m (Galbraith et al. 2025). Together, these observations indicate

that marine debris is distributed across both shallow coastal and deeper offshore habitats within the CSMP and represents an ongoing pressure on marine park values.

6.7 Invasive species

Invasive species remain a significant and ongoing pressure on the terrestrial and intertidal ecosystems of the CSMP, particularly on the marine park's remaining forested cays. In March 2026, Parks Australia announced increased protections, including public closures, for four remote islands, South Islet (Willis Islets), Bird Islet (Wreck Reef), North East Cay (Herald Cays) and Magdelaine Cay South, in direct response to invasive species and weed pressure (Parks Australia 2026). South and Bird Islets are currently affected by invasive weeds such as couch grass, which outcompete native vegetation and threaten nesting habitat for seabirds including sooty terns, brown noddies and shearwaters; a major remediation project is now underway on both islets to restore native vegetation and prevent further spread to neighbouring islands (Parks Australia 2026).

North East Cay (Herald Cays) and Magdelaine Cay South, part of the Coringa-Herald and Lihou Reefs and Cays Ramsar Site, hold the marine park's last remaining stands of *Pisonia grandis*, a tree of high conservation value across the Indian and Pacific Oceans. These fragile forests remain particularly vulnerable to introduced pests, including scale insects, ants and moths, that can be transported unintentionally by visitors. According to Parks Australia, several introduced ant species have been detected on these islands. Because the islands are tiny, isolated and unstaffed (aside from a small weather station on South Islet), pest species can become established well before detection (Parks Australia 2026).

Human visitation continues to carry a risk of accidental introduction of pests via seeds, insects or other organisms hitchhiking on clothing, footwear, towels, bags and equipment. In response, Parks Australia is directing visitors to other Coral Sea islands to follow the Island Access Guideline before going ashore, which includes undertaking vessel pest control, cleaning gear and footwear, avoiding taking animals, plants or soil ashore, and following rules for fishing, anchoring, watercraft and drones (Parks Australia 2026).

6.8 Disease and avian influenza

6.8.1 Avian influenza (H5N1)

High pathogenicity avian influenza (HPAI) H5N1 clade 2.3.4.4b has caused a global panzootic since 2021 in wild birds, poultry and many mammal species (WOAH 2026). It was first detected on the Australian mainland in Western Australia in June 2026.

H5N1 now circulates in Australia, and the CSMP’s seabird colonies are highly exposed. Globally, the most severe mortality has occurred in colonial surface-nesting seabirds, with losses of up to 40% in some German tern colonies and at least 56% of breeding adults in a Washington Caspian tern colony (Haman et al. 2024). The CSMP supports large breeding colonies of terns, noddies, shearwaters, boobies and frigatebirds, although how these tropical species respond to H5N1 is poorly known.

Table 3. Known pressures that exist within individual marine parks in the CSMP

		sphpr04	sphpr06	sphpr07	sphpr08	sphpr09	sphpr10	sphpr15	sphpr17	sphpr18	sphpr20	sphpr21	sphpr22	sphpz01	sphpz28	spnpz02	spnpz03	spnpz05	spnpz11	spnpz12	spnpz13	spnpz14	spnpz16	spnpz19	spnpz25	spnpz27	spspt23	spspt24	spspt26
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 (changes in nutrients & organic matter)																												
	Habitat modification (suspended sediments)																												
	Human presence (disturbance of mobile fauna)	■	■	■	■	■	■	■	■	■	■	■	■																
Marine invasive species	Marine pathogens/disease	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	Marine pests																												
	Overabundant marine native species																												

		sphpr04	sphpr06	sphpr07	sphpr08	sphpr09	sphpr10	sphpr15	sphpr17	sphpr18	sphpr20	sphpr21	sphpr22	sphpz01	sphpz28	spnpz02	spnpz03	spnpz05	spnpz11	spnpz12	spnpz13	spnpz14	spnpz16	spnpz19	spnpz25	spnpz27	spspt23	spspt24	spspt26
Island invasive sp.	Animal pests			■															■										
	Weeds and plant pests			■			■												■										
Marine pollution	Light pollution																												
	Marine debris	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	Noise pollution						■								■				■										■
	Noxious substances																												
	Oil/fuel spill or leak																												
	Sewage waste																												
	Changes in nutrients and organic matter																												

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Appendix A – Coral Sea Marine Park – Natural value 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 between 700m and 2000m.
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 shelf (0-200 m) that lack marine macroalgae or seagrass.
Upper-slope sediments Sediment habitats on the upper continental slope (200m-700m).
Mid-slope sediments Sediment habitats on the mid continental slope (700-2000m).
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 – Coral Sea Marine Park – Use and related pressures

Activity	Sub-activity	Management plan pressure	Specific pressure
Climate change [1]	Altered ocean currents	Climate change	Altered ocean currents
	Increased frequency and intensity of severe weather events		Increased frequency and intensity of severe weather events
	Increased SST		Increased sea surface temperature
	Ocean acidification		Ocean acidification
	Sea level rise		Sea level rise
Climate change adaptation	Carbon storage and sequestration	Habitat modification	Habitat modification (physical disturbance and removal)
Commercial aquaculture	Aquaculture (including commercial pearling)	Habitat modification	Habitat modification (due to changes in nutrients and organic matter), physical disturbance and removal
		Invasive species	Introduced pathogens/disease, marine pests
		Marine pollution	Marine debris (incl. microplastics and litter on islands), noise pollution
Commercial fishing	Demersal trawl	Extraction of living resources	Extraction of benthic mobile invertebrates, extraction of fish and free-swimming invertebrates, extraction of megafauna (excluding fish)
		Habitat modification	Habitat modification (physical disturbance and removal)
	Dropline	Extraction of living resources	Extraction of benthic mobile invertebrates, extraction of fish and free-swimming invertebrates, extraction of megafauna (excluding fish)
Commercial fishing	Hand collection	Extraction of living resources	Extraction of benthic mobile invertebrates, extraction of fish and free-swimming invertebrates
		Human presence	Human presence (disturbance of mobile fauna communities or populations)
	Hand net	Extraction of living resources	Extraction of benthic mobile invertebrates, extraction of fish and free-swimming invertebrates
		Human presence	Human presence (disturbance of mobile fauna communities or populations)

Activity	Sub-activity	Management plan pressure	Specific pressure
	Longline (demersal, auto-longline)	Extraction of living resources	Extraction of benthic mobile invertebrates, extraction of fish and free-swimming invertebrates, extraction of megafauna (excluding fish)
		Habitat modification	Habitat modification (physical disturbance and removal)
	Longline (pelagic)	Extraction of living resources	Extraction of benthic mobile invertebrates, extraction of fish and free-swimming invertebrates, extraction of megafauna (excluding fish)
		Habitat modification	Habitat modification (physical disturbance and removal)
	Net - demersal	Extraction of living resources	Extraction of benthic mobile invertebrates, extraction of fish and free-swimming invertebrates, extraction of megafauna (excluding fish)
		Habitat modification	Habitat modification (physical disturbance and removal)
	Net - pelagic	Extraction of living resources	Extraction of benthic mobile invertebrates, extraction of fish and free-swimming invertebrates, extraction of megafauna (excluding fish)
		Habitat modification	Habitat modification (physical disturbance and removal)
	Pot and Trap	Extraction of living resources	Extraction of benthic mobile invertebrates, extraction of fish and free-swimming invertebrates
	Trotline	Extraction of living resources	Extraction of benthic mobile invertebrates, fish and free-swimming invertebrates, and megafauna (excluding fish)
		Habitat modification	Habitat modification (physical disturbance and removal)
Commercial shipping	Anchoring	Habitat modification	Habitat modification (physical disturbance and removal)
		Invasive species	Marine pests
		Marine pollution	Light pollution
	Vessel transiting	Habitat modification	Habitat modification (due to suspended sediments - including smothering)
		Human presence	Human presence (disturbance of mobile fauna communities or populations)
		Invasive species	Introduced pathogens/disease, marine pests, overabundant native species
		Marine pollution	Marine debris (including microplastics and litter on islands), noise pollution, oil/fuel spill or leak

Activity	Sub-activity	Management plan pressure	Specific pressure
Commercial tourism	Charter fishing tours	Extraction of living resources	Extraction of fish and free-swimming invertebrates
		Habitat modification	Habitat modification (physical disturbance and removal)
		Human presence	Human presence (disturbance of mobile fauna communities or populations)
		Invasive species	Introduced pathogens/disease, marine pests
		Marine pollution	Marine debris (incl. microplastics and litter on islands), noise pollution
	Commercial aviation tours (up to 3000 m above sea level)	Human presence	Human presence (disturbance of mobile fauna communities or populations)
		Marine pollution	Noise pollution
	Non-fishing related tourism - nature watching	Habitat modification	Habitat modification (physical disturbance and removal)
		Human presence	Human presence (disturbance of mobile fauna communities or populations)
		Invasive species	Marine pests
		Marine pollution	Marine debris (including microplastics and litter on islands), noise pollution
	Non-fishing related tourism - scuba/snorkel tour	Habitat modification	Habitat modification (physical disturbance and removal)
		Human presence	Human presence (disturbance of mobile fauna communities or populations)
		Invasive species	Introduced pathogens/disease, marine pests
	Non-fishing related tourism - vessel transiting	Human presence	Human presence (disturbance of mobile fauna communities or populations)
		Invasive species	Marine pests
Commercial media	Commercial media	Human presence	Human presence (disturbance of mobile fauna communities or populations)
General use, access & waste management	Ballast water discharge and exchange	Invasive species	Introduced pathogens/disease, marine pests
	Camping	Human presence	Human presence (disturbance of mobile fauna communities or populations)

Activity	Sub-activity	Management plan pressure	Specific pressure
		Invasive species	Terrestrial pest plants and animals
		Marine pollution	Marine debris (including microplastics and litter on islands)
General use, access & waste management	Disposal of waste from normal operations of vessels	Marine pollution	Sewage waste
	Non-commercial remote piloted aircraft	Marine pollution	Noise pollution
	Recreational use – boating (including vessel transiting)	Habitat modification	Habitat modification (physical disturbance and removal)
		Human presence	Human presence (disturbance of mobile fauna communities or populations)
		Invasive species	Introduced pathogens/disease, marine pests
		Marine pollution	Marine debris (incl. microplastics and litter on islands)
	Recreational use - nature watching (above and below water)	Human presence	Human presence (disturbance of mobile fauna communities or populations)
		Marine pollution	Marine debris (including microplastics and litter on islands)
Hunting and fishing	Cultural fishing	Extraction of living resources	Extraction of benthic mobile invertebrates, extraction of fish and free-swimming invertebrates
		Habitat modification	Habitat modification (physical disturbance and removal)
	Traditional hunting	Extraction of living resources	Extraction of megafauna (excluding fish)
Land-use intensification	Agricultural diffuse source runoff	Changes in hydrology	Changes in nutrients and organic matter, suspended sediments (including smothering)
		Habitat modification	Habitat modification (due to suspended sediments - including smothering)
		Invasive species	Introduced pathogens/disease
		Marine pollution	Marine debris (including microplastics and litter on islands), noxious substances (including chemicals & heavy metals)
	Point discharges	Marine pollution	Marine debris (including microplastics and litter on islands), noxious substances (including chemicals & heavy metals), sewage waste
National security and	Actions by or under direction of the Commonwealth and	N/A	#N/A

Activity	Sub-activity	Management plan pressure	Specific pressure
emergency response	Commonwealth agencies - defence, border protection, law enforcement and emergency response		
Recreational fishing	Anchoring	Habitat modification	Habitat modification (physical disturbance and removal)
	Recreational fishing (including spearfishing)	Extraction of living resources	Extraction of benthic mobile invertebrates, extraction of fish and free-swimming invertebrates
		Habitat modification	Habitat modification (physical disturbance and removal)
		Human presence	Human presence (disturbance of mobile fauna communities or populations)
		Invasive species	Introduced pathogens/disease, marine pests, overabundant native species
		Marine pollution	Marine debris (incl. microplastics and litter on islands)
Renewable energy	Wave, tidal and wind	Extraction of living resources	Extraction of fish and free-swimming invertebrates, extraction of megafauna (excluding fish)
		Habitat modification	Habitat modification (physical disturbance and removal)
		Human presence	Human presence (disturbance of mobile fauna communities or populations)
		Invasive species	Marine pests
Research and monitoring	Research, collecting, tagging	Extraction of living resources	Extraction of benthic mobile invertebrates, extraction of fish and free-swimming invertebrates, extraction of megafauna (excluding fish)
		Habitat modification	Habitat modification (physical disturbance and removal)
		Human presence	Human presence (disturbance of mobile fauna communities or populations)
		Invasive species	Introduced pathogens/disease, marine pests
		Marine pollution	Marine debris (incl. microplastics and litter on islands)
Structures and works	Artificial reefs	Extraction of living resources	Extraction of fish and free-swimming invertebrates
		Habitat modification	Habitat modification (physical disturbance and removal)

Activity	Sub-activity	Management plan pressure	Specific pressure
	Dredging or disposal of dredged material	Habitat modification	Habitat modification (due to suspended sediments - including smothering), physical disturbance and removal
		Human presence	Human presence (disturbance of mobile fauna communities or populations)
		Marine pollution	Noise pollution, noxious substances (incl. chemicals & heavy metals)
	Excavation other than dredging, erection and maintenance of structures, and works (including cables, trenching & boring)	Habitat modification	Habitat modification (due to suspended sediments - including smothering), physical disturbance and removal
		Human presence	Human presence (disturbance of mobile fauna communities or populations)
		Invasive species	Introduced pathogens/disease, marine pests
		Marine pollution	Noise pollution, noxious substances (incl. chemicals & heavy metals), oil/fuel spill or leak
	Fish aggregating devices	Extraction of living resources	Extraction of fish and free-swimming invertebrates, extraction of megafauna (excluding fish)
		Human presence	Human presence (disturbance of mobile fauna communities or populations)
	Moorings	Extraction of living resources	Extraction of megafauna (excluding fish)
		Habitat modification	Habitat modification (physical disturbance and removal)
		Invasive species	Introduced pathogens/disease, marine pests
		Marine pollution	Light pollution

[1] Climate change is defined as a pressure in the Australian Marine Park management plans, with specific pressures or stressors that sit below this (e.g. altered ocean currents, sea level rise etc.). For the purposes of the NESP project (i.e. cumulative impact assessment), climate change and associated specific pressures were also treated as ‘activities’ and ‘sub-activities’ respectively.



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