# SEA LIONS, SEADRAGONS AND SEAWEEDS

## Environmental values of Western Australia's proposed south coast marine park

Centre for Conservation Geography
*Strategic Tools and Conservation Innovation*

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## CENTRE FOR CONSERVATION GEOGRAPHY

The Centre for Conservation Geography (conservationgeography.org) is a research group established in June 2011 to provide expert technical support and advice to government and non-government decision-makers and stakeholders. We focus on applying world's best practice in decision support to planning for biodiversity conservation. Our main areas of expertise are marine and terrestrial protected area planning, including protected area performance assessment, cost-efficient conservation priority setting and planning for multiple objectives (eg carbon sequestration and biodiversity conservation).

Based in Australia, our goal is to build a multi-disciplinary team capable of providing support for conservation decisions across the world's ecoregions. We currently have projects in Australia, Canada and the Southern Ocean.

## ABOUT THE AUTHORS

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# EXECUTIVE SUMMARY

Western Australia's south coast has had a long time to generate its biological riches – with about 80 million years of isolation from other continents and a long-equitable climate that has allowed it to avoid mass extinction events resulting from glaciation and ice sheets. Superimposed onto this long-term stability, high levels of disturbance (strong winds and waves), environmental fluctuations, and diverse habitats are likely to have fostered species diversification. The diverse habitats have been crafted by contrasting geologies (granite, gneiss and limestone), diverse landforms (including reefs, cliffs, pinnacles, islands and beaches), varying levels of exposure to wind and waves, and a great variety of habitat-forming species (seagrasses, kelps, rhodoliths).

Provided that the Traditional Owners of the south coast regard a jointly managed marine park in their sea countries as desirable, we recommend that the proposed park encompasses waters from the South Australian border to west of Bremer Bay (east of Albany). Covering about 14,000 $km^2$, it would overlap the sea country of the Wagyl Kyp and Southern Noongar, The Esperance Nyungars, Ngadju and WA Mirning People. Planned in consultation with, established with the consent of, and jointly managed with Traditional Owners, this park should be designed to protect their enduring connections to sea country and increase their capacity to meet ongoing custodial responsibilities.

In this report, we make generic recommendations about zoning – based on the conservation importance of sizeable sanctuary zones and the opportunities for complementary sanctuaries across jurisdictions – and we identify broad areas with high values that warrant consideration for sanctuary protection. But we do not make specific recommendations about where sanctuaries should be placed or how large they should be. Zoning recommendations should be based on consideration of many other factors (eg existing uses, cultural, social and recreational values, economic consequences) and require meaningful consultation with stakeholders, including recreational and commercial fishers and the tourism and dive industries.

With its outstanding conservation values and iconic tourism assets, the south coast could become one of Western Australia's premier marine parks. In combination with existing South Australian and Commonwealth sanctuaries, it would enable the creation of Australia's largest, and one of the world's top-5, coastal shelf marine sanctuaries by adjoining with existing South Australian and Commonwealth sanctuaries. The entire region warrants marine park status for the following reasons:

- to protect sites of global and national conservation significance and foster resilience to climate change
- to better enable Traditional Owners to exercise custodial responsibilities over their traditional sea country (if they regard a marine park as desirable)
- to secure long-term sustainable regional economic development and jobs
- to protect a substantial part of the Great Southern Reef, the diverse rocky reef system spanning Australia's southern coastlines
- to protect and enhance the region's recreational fishing values

- to protect and promote a region of outstanding beauty and high social, recreational and tourism values
- to advance the state's long-standing goal to achieve a comprehensive, adequate and representative marine parks network
- to facilitate complementary management with adjacent reserves on land and in Commonwealth and South Australian waters

In this report, we aim to assist decision-makers (the Western Australian Government and Traditional Owners) and stakeholders with planning and proposals for the proposed marine park by:

- describing (and mapping where data are available) some of the main features and natural values of the area and threats to those values
- identifying areas of outstanding conservation value
- making broad recommendations about how to optimise the conservation benefits of the marine park.

## SOUTH COAST BIOREGIONS

About three-quarters of the proposed marine park falls into the WA South Coast bioregion and the remainder is in the Eucla bioregion. A substantial marine park with large sanctuaries in each bioregion is essential for Western Australia to achieve a comprehensive, adequate and representative marine park network, for the WA South Coast bioregion currently has only one tiny (14 $km^2$) marine park and no sanctuaries, and the Eucla bioregion has no marine parks in Western Australian waters. The proposed park adjoins marine sanctuaries in Commonwealth and South Australian waters, and much of the coastline is encompassed within national parks and nature reserves, offering opportunities for complementary management across jurisdictions and across land and sea.

## HABITATS AND GEOMORPHOLOGICAL FEATURES

To achieve a comprehensive, adequate and representative marine park will require careful design to ensure that each of the following habitat types are adequately represented in sanctuary zones.

Seagrass meadows: The meadows along the south coast, with 17 recorded seagrass species, are among the most diverse in the world. The south-west has more co-occurring seagrass species than any other temperate region, approaching the richness of many tropical regions. The south coast seagrasses are globally unusual for the depths to which they grow (down to 52 metres) and the strong swells they consistently endure. The proposed marine park would encompass all the mapped seagrass meadows in the WA South Coast bioregion and 93% of those in the Western Australian part of the Eucla bioregion.

Seaweed-kelp beds: Australia's southern coast has the highest seaweed diversity (>1500 species) and endemicity (>60%) of any region in the world. On Western Australia's south coast, kelp forests, particularly on limestone reefs, are a major and heterogeneous habitat, varying in their structure and species composition over small and large scales due to different wave and light exposure and

canopy density. Other than in the Recherche Archipelago, spatial information about this habitat is highly deficient. This is concerning given its demonstrated vulnerability to climate warming. The future of kelp communities in Western Australia is potentially dire due to more-frequent heat waves and the intrusion of tropical species.

Wrack deposits: Rotting piles of seaweed and seagrass on beaches and in the surf-zone are another important macroalgal habitat type on the south coast, as a nursery habitat for fish and an important source of carbon and nutrients in nearshore food webs.

Rhodolith beds: This poorly known, but probably ecologically significant, habitat type consists of loose-lying, non-jointed coralline red algae, of several different species, known as rhodoliths. They can build up over millennia to create vast beds covering thousands of hectares. They are important for carbon sequestration, and in other areas are known to support an abundant and diverse suite of algae and invertebrates in otherwise sparsely populated soft substrates. Trawling is a major threat to rhodolith beds and they are probably also highly vulnerable to ocean acidification and global warming.

Estuaries: Just 14 estuaries have been mapped in the proposed marine park, all in the WA South Coast bioregion. Most open to the sea only occasionally, some only every few years, after heavy rain. Because of their extreme variability in salinity, the south coast estuaries are harsh environments, but they are also highly productive. Many fish, crab and prawn species spawn in the ocean and enter the estuaries as juveniles, coming and going in response to changing salinity levels. They are important also for waterbirds and migratory shorebirds and highly valued by people for their scenery and for recreational fishing and boating. Six estuaries in the proposed marine park contain subtropical and temperate coastal saltmarsh, listed nationally as a vulnerable ecological community, and 3 estuaries are part of wetland systems designated as nationally significant.

Geomorphic features: The WA South Coast bioregion has a fairly narrow continental shelf, mostly 25–65 km wide, with diverse geomorphic features (typically of rock), while the Eucla bioregion has a broad, rather flat shelf, exceeding 200 km at its widest, and fewer features. Much of the seafloor is covered in carbonate sediments, the remains of marine animals. Australia's southern shelf is the largest area of cool-water carbonate sedimentation in the world.

Mapping geomorphic features is critical for understanding the distribution and diversity of marine biota, particularly where biological sampling has been limited. But the available geomorphic data for the south coast is coarse, showing only large features, and important habitats such as reefs are poorly captured. Mapped features encompassed by the proposed marine park in the WA South Coast bioregion comprise pinnacles, reefs (broadscale, intertidal and shallow subtidal) and banks/shoals. Those in the Eucla bioregion comprise terraces and reefs (intertidal and shallow subtidal).

## SIGNIFICANT SPECIES

Australia's southern coast has outstanding conservation significance, particularly for a temperate region, for the uniqueness and diversity of its marine life, but it is poorly studied and much of the biodiversity has yet to be documented.

The proposed park offers great potential to arrest the decline and boost the recovery of several threatened species – particularly those threatened by particular methods of commercial fishing (mainly gillnetting). Many threatened south coast species share the characteristics of longevity, late maturity and low fecundity that make them susceptible to over-exploitation and environmental change. Many are also ecologically important – particularly the apex or high level predators such as the shark species, Australian sea lion and western blue groper. Protecting them could help boost the resilience of south coast ecosystems in the face of climate change.

Several species are also south coast icons – particularly the southern right whale, Australian sea lion, long-nosed fur seal, western blue groper, seadragons, and seabirds such as albatrosses and the little penguin. Boosting protection for them is an investment in important assets for tourism and recreation.

Following are brief profiles of some of the south coast's significant species.

Australian sea lion (IUCN/Australia endangered, WA vulnerable): Since being hunted almost to extinction by the early 1900s, Australia's only endemic pinniped has been slow to recover. A 2020 assessment found the national population had declined in recent times, dropping by more than 60% over the previous 3 generations. There were an estimated 6500 in 2015. Their greatest threat is fishing – mainly accidental capture in gillnets – and entanglement in marine debris. The south coast has about 80% of the sea lion habitat in Western Australia and has 17 known breeding sites. About 300 pups are produced per season on the south coast, 63% of the Western Australian total. The proposed marine park would encompass 14 of the 20 breeding sites in Western Australia regarded as critical habitat (producing >5 pups) and two thirds of the area mapped as biologically important for sea lion foraging in Western Australia, none of which has sanctuary protection. Less than half of this area on the south coast is protected by gillnet fishing closures.

Southern right whale (Australia endangered, WA vulnerable): The south coast is a nursery for southern right whales from May to October each year. The species was hunted almost to extinction in the 1800s, with no more than about 300 surviving in the 1920s. The Australian population makes up about a quarter of the estimated global population and southern Australia is one of 4 major calving areas. The genetically distinct western population, numbering about 3200, comprises 90% of the Australian population. The entire proposed marine park is classified as a biologically important area and encompasses 2 of Australia's 3 calving hotspots. Overall, the proposed park would encompass 57% of calving habitat in Western Australian waters, of which less than 1% has sanctuary protection. Threats in Australian waters include entanglement in commercial fishery gear and marine debris, vessel collision and behaviour disruption. Global warming could reduce the availability of their prey.

Humpback whale (Australia vulnerable, WA conservation dependent): From May to November each year, Western Australia hosts the world's largest population of humpback whales. The proposed marine park would encompass about 50% of their migration route between Esperance and Cape Leeuwin, mapped as a biologically important area. The species is listed as vulnerable by the Australian Government and conservation dependent by the state government. Humpbacks are among the most susceptible of the large whales to entanglement, often fatal, in fishing gear and debris. Climate change could lead to many impacts – ocean acidification, for example, reduces reproduction by Antarctic krill, their primary food.

Long-nosed fur seal (WA specially protected): The species was hunted to near extinction in several locations in the 1700s and 1800s, including Western Australia, but has recovered well. In 2011 the Western Australian population numbered about 17,000, making up about 14% of the Australian population. Threats include illegal shooting, entanglement in fishing gear, human disturbance during the breeding season, oil spills and disease. Of 20 breeding colonies in Western Australia recorded in 2011, 15 are encompassed by the proposed marine park.

Great white shark (IUCN/Australia/WA vulnerable): Australia's population is likely to number no more than about 3000 adults, and there is no evidence of recovery since the species was first protected in 1997. The proposed marine park is mapped as a biologically important area for white shark foraging or high use across most of its area. It encompasses 69% of the mapped foraging area in Western Australian waters and all the mapped high-use habitat. Just 0.2% of these habitats in Western Australia are protected in sanctuaries. The white shark is captured as bycatch in several fisheries, particularly in gillnet fisheries.

Grey nurse shark (IUCN/Australia/WA vulnerable): Almost nothing is known about the abundance or critical habitats of the genetically distinct west coast population of grey nurse sharks. Very few aggregation sites (used for mating and pupping) have been confirmed in Western Australia, and none are known on the south coast, but there are occasional reports from spear fishermen of large numbers off Bremer Bay and other south coast sites.

School shark (IUCN critically endangered, Australia conservation dependent): The proposed marine park would encompass most of the school shark habitat in Western Australia, but the location of biologically important areas is unknown. The major threat is commercial fishing. Australian stocks have been classified as overfished since 1992, despite a stock rebuilding strategy initiated in 2008. The initial goal is to rebuild populations to 20% of unfished biomass within 66 years (3 generations), from a level of about 10%.

Dusky shark (IUCN endangered) and sandbar shark (IUCN vulnerable): The proposed marine park would encompass an important part of the range of dusky sharks in Western Australia, potentially including nursery areas, and the eastern extent of the southern range of sandbar sharks. The location of biologically important areas on the south coast is unknown. Too little is known about their populations in Australia to assess their conservation status. The main threat globally is their capture in commercial fisheries. In Australia, most exploited dusky and sandbar sharks are taken in the west coast and south coast demersal shark fisheries. The stocks of dusky and sandbar sharks are

currently classified as 'recovering', with the targeted recovery to 40% of their unfished levels expected to take up to several decades.

Western blue groper (IUCN vulnerable): This large inquisitive hermaphroditic wrasse endemic to southern Australia is a favourite of divers and a south coast icon. The IUCN assessment in 2008 found the population had declined by at least 30% over the previous 30 years, with a severe decline of 60–90% over 20 years in at least a third of its western distribution. An updated assessment is needed to determine the current status of this species. The blue groper is fished commercially and recreationally over most of its range in Western Australia, mainly in the temperate demersal gillnet and longline fisheries. There are concerns that changes in reef habitats (such as loss of kelp forests) and competition from warmer-water fish species, combined with fishing pressure, could result in declines and local extinctions of the western blue groper. The rocky reefs of the south coast are important habitats – the nearshore reefs serve as nurseries for juveniles and the deeper reefs (down to 65 m) are occupied by sub-adults and adults. The proposed marine park would cover a substantial part of the blue groper range, including where they are thought to be most abundant.

Seadragons: With a beauty and elegance much admired by divers and snorkelers, seadragons are south coast icons. The leafy, weedy and ruby seadragons occur only in Australia's southern waters, and the south coast is the only region where all 3 species are known to still occur. The ruby seadragon was described only in 2015 and recent collections and observations (for more than 60 years) have all been on the south coast. The lack of basic information about its distribution, habitats, ecology and threats has led to its listing as data deficient by the IUCN. The western populations of leafy and weedy seadragons are genetically distinct from those in the east. Although assessed as least concern by the IUCN, their populations are thought to be declining due mainly to habitat degradation and loss near urban centres, and perhaps due to incidental capture in trawl fisheries for the leafy.

Seabirds: The proposed marine park is of regional and national significance for seabird breeding and foraging. More than 40% of Australia's seabird species occur in the south coast region and about a quarter of the species that breed in Australia do so in the Recherche Archipelago and west to Stokes Inlet, mostly on islands. The proposed marine park would encompass at least 50% of the areas mapped in Western Australia as biologically important foraging areas for the following 9 species that breed on the south coast: fairy tern (listed as vulnerable at state, national and international levels), flesh-footed shearwater (listed as vulnerable by the state), black-faced cormorant, bridled tern, Caspian tern, little penguin, little shearwater, Pacific gull, white-faced storm petrel. None of the biologically important areas have any sanctuary protection in Western Australia. Other threatened seabirds – northern giant petrel, wandering albatross, black-browed albatross, Atlantic yellow-nosed albatross and grey-headed albatross – forage on the south coast.

Shorebirds: Southern Australia is a non-breeding refuge for migratory shorebirds that breed in the northern hemisphere. Surveys on the south coast have recorded 28 species, of which 18 are migratory. Records on the south coast include the endangered or critically endangered (at state and national levels) curlew sandpiper, great knot, eastern curlew, lesser sand plover and red knot. The major threats on the south coast are human disturbance and invasive predators.

## THE GREAT SOUTHERN REEF

The proposed south coast marine park would encompass over 10% of an immense kelp-clad rocky reef system recently dubbed the Great Southern Reef, stretching from Kalbarri to Moreton Bay in the east. Uniting Australia's temperate reefs under one banner has many potential benefits – fostering greater recognition of the ecological interconnections, encouraging complementary management across state borders, and lifting the public profile of kelp forests.

The Great Southern Reef is more than a match for its tropical counterpart, the Great Barrier Reef. Both reef systems are biodiversity hotspots of global significance. Like corals, the habitat-forming macroalgae are the foundation of rich, complex ecological communities. The Great Southern Reef is particularly significant for its diversity of seaweeds, sponges, crustaceans, fishes, bryozoans, echinoderms, molluscs and other invertebrates. Although extolled for their reef habitats, each system also comprises many other habitats – seagrass meadows and sponge gardens, for example. One globally significant feature of the Great Southern Reef not shared by the Great Barrier Reef is an extremely high rate of endemism: 40–77% in seaweeds, 85% in fishes and 22–56% in invertebrates (75–95% for molluscs, 31% for echinoderms, 56% for sponges).

Currently, less than 3% of the Great Southern Reef is protected in sanctuaries – in contrast to the Great Barrier Reef, with 33% in sanctuaries. The proposed south coast marine park would be by far the largest marine park in the Great Southern Reef and could do much to raise its public profile and highlight the importance and vulnerability of kelp communities. The waters off Australia's south-east and west coasts have experienced some of the highest rates of ocean warming in the world, 2–4 times the average global rate, and have already suffered major damage to kelp forests.

## AREAS OF OUTSTANDING CONSERVATION VALUE

The entire proposed marine park area has high conservation values. The 8 areas described below (from west to east) have been selected as outstanding areas for one or more of the following characteristics:

- substantial areas of biological importance for significant species
- extensive areas or a high diversity of important habitats
- features representative of the WA South Coast or Eucla bioregions that are unique or rare elsewhere in the proposed marine park.

Due to the lack of spatial information about some important habitats and significant species, the values of each area are likely to considerably greater than indicated here. These areas are not recommended sanctuary zones. But they can be regarded as broad candidate areas for sanctuaries, the final selection and sizing of which would need to consider social, cultural and economic factors as well as conservation values and be subject to extensive analysis and consultation.

Haul Off Rock to Dillon Bay (Wagyl Kyp and Southern Noongar sea country):

- a breeding site and important foraging habitat for endangered Australian sea lions

- an important breeding site for long-nosed fur seals
- important foraging habitat for several seabird species, including threatened fairy terns and flesh-footed shearwaters
- extensive seagrass meadows
- diverse coastline habitats.

Fitzgerald River National Park coastline (Wagyl Kyp and Southern Noongar sea country):

- a calving hotspot for endangered southern right whales
- 2 breeding sites and important foraging habitat for endangered Australian sea lions
- 6 estuaries – the highest concentration in the proposed marine park and almost half the estuarine habitat – including the least modified estuary, 3 estuaries that are part of nationally important wetland systems and 2 estuaries with a threatened saltmarsh ecological community
- extensive seagrass meadows.

Mason Bay to Barker Inlet (Esperance Nyungar sea country):

- 2 breeding sites and important foraging habitat for endangered Australian sea lions
- important foraging habitat for 10 seabird species, including threatened fairy terns and flesh-footed shearwaters
- 4 coastal estuaries, with a quarter of the estuarine habitat in the proposed marine park
- the largest concentration of coastal reefs outside the Recherche Archipelago along the south coast of Western Australia
- diverse coastline habitats.

Central Recherche (Esperance Nyungar sea country):

- 2 breeding sites and important foraging habitat for endangered Australian sea lions
- one of Australia's most important seabird breeding areas
- a rich fish fauna with many endemic species
- important for threatened great white sharks and western blue gropers
- a hotspot for seadragons, with all 3 species
- the most extensive seagrass beds mapped along the south coast of Western Australia
- the most extensive kelp forests mapped along the south coast of Western Australia
- the largest rhodolith bed mapped in the Recherche Archipelago.

Eastern Recherche and Israelite Bay (Ngadju and Esperance Nyungar sea country):

- calving hotspot for endangered southern right whales
- critically important breeding and foraging area for endangered Australian sea lions
- one of Australia's most important seabird breeding areas
- important breeding sites for specially protected long-nosed fur seals
- a rich fish fauna with many endemic species
- extensive seagrass meadows and kelp forests
- transition zone between the WA South Coast and Eucla bioregions.

Bilbunya Beach and Baxter Cliffs (Ngadju sea country):

- diverse coastline habitats and 3 landscapes unique in the bioregion -- Baxter Cliffs, Bilbunya Dunes and Wylie Scarp
- extensive seagrass meadows and wrack deposits on beaches
- important foraging area for 6 seabird species and breeding sites for 2 species.

Twilight Cove and Scorpion Bight (WA Mirning sea country):

- extensive seagrass meadow (perhaps the longest stretch in the bioregion)
- diverse sandy and rocky shoreline habitats
- an important haul out site for endangered Australian sea lions

Red Rocks Point to Eucla (WA Mirning sea country):

- a wild, remote, largely unexploited area that could become part of one of the top shelf sanctuaries in the world
- longest stretch of subtidal rock platform and rocky reefs in the bioregion, with extensive kelp forests
- a centre of rarity for seaweeds
- extensive seagrass meadows
- important high-use habitat for great white sharks.

## RECOMMENDATIONS

Provided that the Traditional Owners of the south coast regard a jointly-managed marine park as desirable in their sea countries, we recommend that the government works with stakeholders and local communities to:

1. Design one large world-class marine park with a sanctuary network that achieves comprehensive, adequate and representative protection of the WA South Coast and Eucla bioregions.

2. Assess the potential to create the largest shelf sanctuary in Australia and one of the 5-largest in the world by establishing a sanctuary adjoining existing South Australian and Commonwealth sanctuaries.

3. Consistent with best-practice marine park design principles, ensure that representative areas of all habitat types are protected in sanctuaries that span natural biophysical gradients and ecological processes, with replicates spread to maximise resilience. Aim for a high (science-based) level of sanctuary protection of important habitats such as seagrass meadows, kelp forests and rhodolith beds within each bioregion.

4. In recognition of the high structural and species diversity of kelp–seaweed beds at local to regional scales, the lack of detailed knowledge of their distribution, and their vulnerability to climate warming, provide a high (science-based) level protection in sanctuaries.

5. Provide a high (science-based) level of protection for all threatened, declining and data deficient species, including the following, particularly those that have small breeding ranges in Australia (marked with an asterisk):

- Australian sea lion*
- southern right whale*
- humpback whale
- ruby seadragon*
- great white shark
- grey nurse shark
- school shark
- sandbar shark
- dusky shark
- western blue groper
- flesh-footed shearwater
- fairy tern

6. Eliminate as many threats as possible to threatened or declining species in the proposed marine park, with a high-priority focus on preventing the capture of the following species in fisheries:

- Australian sea lion
- great white shark
- school shark
- grey nurse shark
- dusky shark
- sandbar shark

7. Promote the proposed south coast marine park as part of the Great Southern Reef and as an important refuge area for Australia's temperate reef communities.

# 1 INTRODUCTION

The Western Australian Government's *Plan for Our Parks* identifies the south coast as an important area for a marine park, focused on 'the Recherche Archipelago and Stokes Inlet, and their surrounding waters'. This area was recommended as a potential marine park more than 25 years ago by the Western Australian Marine Parks and Reserves Selection Working Group [1]. The working group also recommended investigating other areas east of Albany: Twilight Cove, Fitzgerald, and Cape Vancouver to Bald Island.

Provided that the Traditional Owners of the area regard a jointly managed marine park in their sea country as desirable, we recommend that the proposed park encompasses Western Australian waters from the South Australian border to west of Bremer Bay (east of Albany) (see Figure 1). It would cover about 14,000 km$^2$ and overlap the sea country of 4 Traditional Owner groups. Except where native title rights to intertidal waters have been clarified as extinguished or non-exclusive, we assume here that the proposed marine park extends to the mean low water mark rather than the high-water mark.

There is now a deeper understanding of the values of the south coast, and the entire region warrants marine park status for the following reasons (among others):

- to protect sites of global and national conservation significance, including habitats for endangered whales and sea lions and threatened sharks and seabirds, and foster resilience to climate change
- to secure long-term sustainable regional economic development and jobs by protecting and promoting regional assets and fostering greater economic activity
- to better enable Traditional Owners to exercise custodial responsibilities over their traditional sea country (if they regard a marine park as desirable)
- to protect and promote a substantial part of the Great Southern Reef, the richly diverse rocky reef system spanning Australia's southern coastlines
- to protect and promote a region of outstanding beauty – coastal cliffs, rocky headlands, white sandy beaches, island chains, kelp forests – and high social, recreational and tourism values
- to protect and enhance the region's recreational fishing values
- to advance the state's long-standing goal to achieve a comprehensive, adequate and representative marine parks network, in bioregions with no existing sanctuary protection and just one small marine park in Western Australian waters
- to facilitate complementary management with adjacent reserves on land and in Commonwealth and South Australian waters
- to enable the creation of Australia's largest, and one of the world's top-5, coastal shelf marine sanctuaries in combination with existing South Australian and Commonwealth sanctuaries.

There are several compelling reasons to create one large marine park rather than a few smaller ones. The diverse values of the region are dispersed throughout the area, so one all-encompassing park would be far more beneficial for conservation than a series of smaller parks and enable optimal buffering for sanctuary and cultural zones. The Western Australian Government acknowledges the benefits of larger reserves for achieving an adequate reserve system, especially where there is a high level of connectivity ('a few very small reserves are not truly sustainable in the long term') [2]. One substantial marine park with minimal zoning categories would minimise boundary complexity, thus facilitating management and compliance with zoning rules. A larger park is more able to accommodate most existing uses and effective biodiversity protection through an intelligent mix of sanctuaries and other zones. One large marine park also offers far more branding potential to promote tourism.

The proposed marine park overlaps the sea country areas (from east to west) of the Wagyl Kyp and Southern Noongar, The Esperance Nyungars, Ngadju and WA Mirning People. The areas shown in Figure 1 are indicative only, based on terrestrial and intertidal native title determination areas. Along the 1500 km-long mainland intertidal area, native title (non-exclusive) has been recognised over a quarter of the area (371 km) and has been extinguished or does not exist over half the area (744 km). Native title claims have not been lodged over the remainder of the mainland intertidal area (384 km) or the islands (528 km intertidal), but a claim is being prepared for parts of the Recherche Archipelago.

A south coast marine park designed in consultation with, established with the consent of, and jointly managed with Traditional Owners would go some way to providing recognition of their enduring connections to sea country and increasing their capacity to meet ongoing custodial responsibilities. As the traditional custodians, they are far more than stakeholders in the planning process. Their relationship with their sea country brings with it [3]:

> *a complexity of cultural rights and responsibilities, including the right to access, use and distribute resources, and the responsibility to manage those resources from generation to generation. Clan members are owners of their country, they belong to their country, they identify with their country and they are stewards of their country, including their sea country.*

In this report, we aim to assist decision-makers (the Western Australian Government and Traditional Owners) and stakeholders with their planning and proposals for the proposed marine park by:

- describing (and mapping where data are available) some of the main features and natural values of the area and threats to those values
- identifying areas of outstanding conservation significance
- making broad recommendations about how to optimise the conservation benefits of the marine park.

The information available for this work is far from comprehensive, for there have been few or no biodiversity surveys in several areas.

We do not describe any cultural values, for this requires specialist knowledge and should be led by Traditional Owners for Indigenous values. We also do not document here the existing human uses of

the area – eg recreational and commercial fishing, tourism and diving – or the potential to enhance certain economic and recreational activities. This information is essential for decisions about the marine park and will be addressed separately.

We make generic recommendations about zoning – based on the conservation importance of sizeable sanctuary zones and the opportunities for complementary sanctuaries across jurisdictions – and we identify broad areas with high values that warrant consideration for sanctuary protection. But we do not make specific recommendations about where sanctuaries should be placed or how large they should be. Zoning recommendations should be based on consideration of many other factors (eg existing uses, cultural, social and recreational values, economic consequences) and require meaningful consultation with stakeholders, including recreational and commercial fishers and the tourism and dive industries.

The Centre for Conservation Geography welcomes feedback on this report and can provide further maps and analyses to help planning for the proposed park.

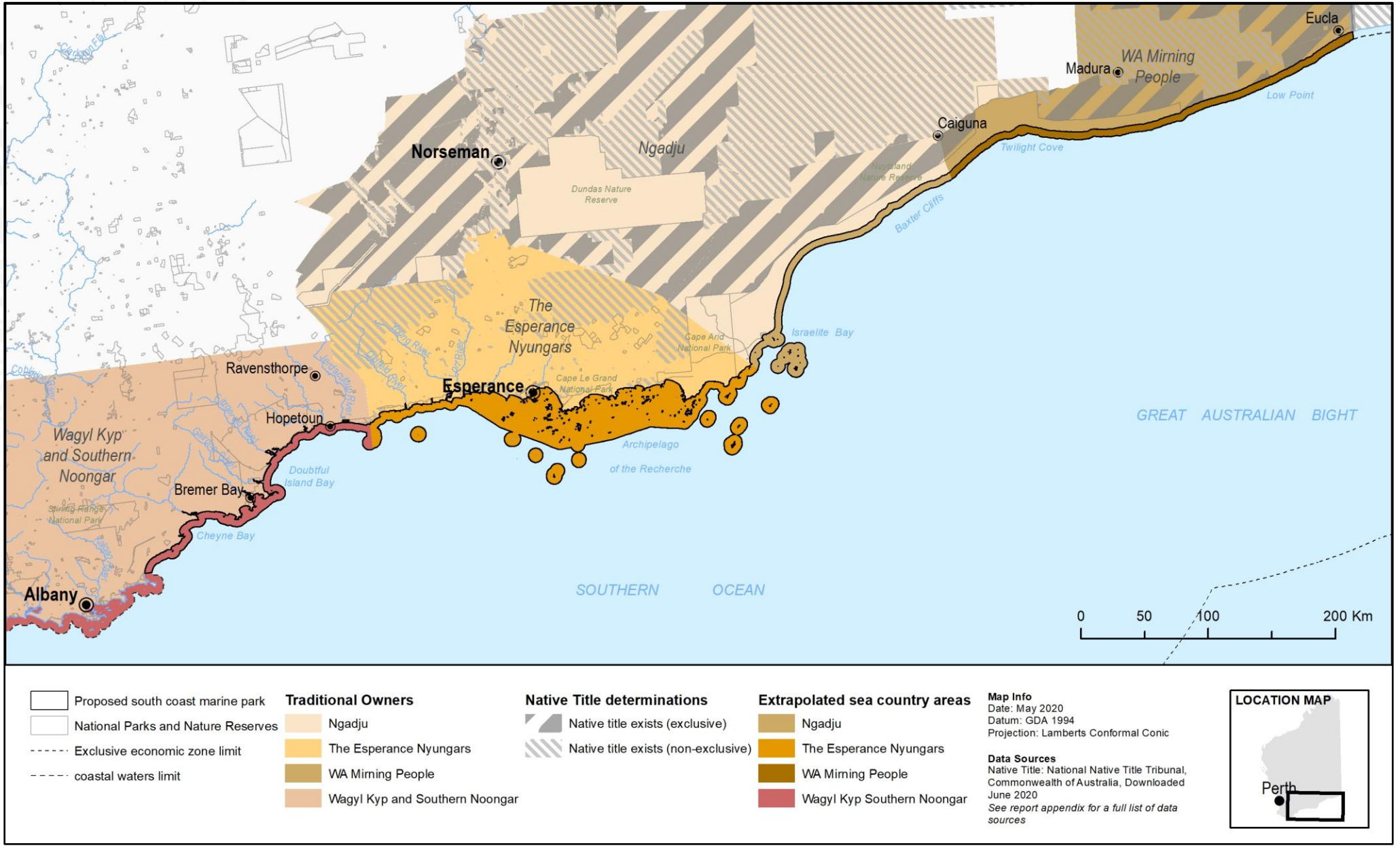


*Figure 1. Indicative sea country areas in the proposed south coast marine park*

# 2 SOUTH COAST BIOREGIONS

The proposed marine park overlaps 2 provincial bioregions and 2 meso-scale bioregions, all intersecting at Israelite Bay (in the Integrated Marine and Coastal Regionalisation of Australia [IMCRA]). Bioregions are areas that 'make sense ecologically', sharing biological and physical attributes such as geomorphology, oceanography and species distributions [4].

About three-quarters (74%) of the proposed marine park falls into the WA South Coast bioregion (part of the Southwest Shelf Province) and the remainder (26%) into the Eucla bioregion (part of the Great Australian Bight Shelf Transition) (see Figure 2).

These 2 bioregions have different geological histories and features. Sections 3.1 and 3.2 provide a brief overview of their physical features – based mainly on descriptions by the IMCRA Technical Group and the Marine Parks and Reserves Selection Working Group [1,5] – and section 3.3 describes some of the major ecological influences on the south coast.

A substantial marine park with large sanctuaries in both bioregions is essential for Western Australia to achieve a comprehensive, adequate and representative marine park network and offers opportunities for complementary conservation management across land and sea (section 3.4).

## 2.1 WA South Coast bioregion

This bioregion has a long complex geological history featuring major tectonic activity during the Proterozoic period (2.5 billion to 540 million years ago) as continental plates parted and collided [1]. It lies on the southern margin of the ancient Yilgarn Craton. The geology of the bioregion is dominated by granites (volcanic) and gneisses (metamorphic), with some dolerite (volcanic) intrusions and limestone features.

The coastline is ruggedly scenic, with long curved sandy beaches backed by dunes and bordered by rocky headlands (many over 300 metres high), points, rocks and reefs. In the east, particularly in the Recherche Archipelago, there are hundreds of granite islands [6].

This is the most-exposed and the highest-energy coastline in Australia but the tidal range – not much more than a metre – is the lowest in Australia [6]. This range is extended by almost a metre at times by weather-induced sea-level fluctuations and annual variations in sea level [7]. The coast is subject to a persistent moderate-to-high southerly swell and periodic strong southerly-to-westerly winds. The most exposed parts of the headlands (facing south and south-west) are steep and swept by swell surge. The less-exposed parts (facing south-east) often have boulder fields along the shore. The headlands often drop off steeply into the water, meeting the sandy seafloor at depths of 20–30 metres.

Offshore rocky reefs of granites or gneisses are common, often with steep walls and underwater canyons. There are also narrow limestone reefs lying parallel to the shore (between Hopetoun and

Esperance), thought to represent different positions of the shore during Pleistocene and Holocene times. The offshore sediments are mainly bioclastic carbonates (consisting of fragments and shells of dead animals) and the water is very clear.

## 2.2 Eucla bioregion

This bioregion is part of the Eucla Basin, a large sedimentary basin extending inland and seaward by several hundred kilometres. The geology is dominated by limestone. This bioregion did not undergo the tectonic upheavals of the WA South Coast bioregion.

Most of the shoreline on the Western Australian side of the Eucla bioregion consists of long sandy beaches backed by high dunes, but there are steep 100–120 metre-high limestone cliffs (the Baxter Cliffs) from Twilight Cove to west of Dover Point, with a narrow rock platform or boulder field at sea level. Due to low rainfall and a lack of rivers, there are no estuaries, and very little sediment flows from the land.

This is mostly a moderate-to-high energy coastline with a heavy swell, while the tidal range is very small (about 1 metre). The swell has helped build the numerous beaches and, in combination with strong onshore winds, has stripped the shelf of sediments, which now make up large barrier systems that include some of the world's largest deposits of marine sand [6]. The energy is attenuated in some areas (eg on the Roe Plain) by shallow limestone reefs that greatly reduce the swell. Breaker waves vary from an average 2 metres (eg along the Baxter Cliffs) to a few centimetres in sheltered areas [6].

The offshore sediments are dominated by bioclastic carbonates (animal remains) and the waters are clear. With its wide continental shelf, the Great Australian Bight is the largest carbonate cold-water environment in the world [8].

## 2.3 Major ecological influences

The southern Australian coast is renowned for its highly distinctive and diverse biota. Its seaweeds, for example, are more diverse and endemic than those in any other region [9]. This has been enabled in part by its long isolation, over about 80 million years, from other continents and the long-equitable climate that has allowed it to avoid mass extinction events resulting from glaciation and ice sheets [9,10]. Superimposed onto this long-term stability, high levels of disturbance (strong winds and waves), environmental fluctuations (such as climate change and intensification of currents) and abundant and diverse habitats are likely to have fostered species diversification [9,10].

South coast species have mixed origins – some groups are mainly temperate, while others are tropical, subtropical or polar (as exemplified by seaweeds [9]). As the south coast was being created – by continental drift and seafloor spreading from about 96 million years ago as Australia separated from Antarctica – it was colonised from the west by species whose ancestors came from the tropical Tethys Ocean, which once bathed the shores of north-west Australia [9]. These original colonisers are likely to have been then largely replaced by species that evolved on the south coast as the

waters cooled from about 55 million years ago. After the last land link with Antarctica was severed about 30 million years ago, species could also migrate from the east coast. But far more have come from the west, and this remains the case today, due to the east-flowing Leeuwin Current.

The Leeuwin, which has been flowing for more than 40 million years, transports warm, low-salinity waters from north-western Australia down the west coast and then east along the south coast [10,11]. It first rounds Cape Leeuwin and flows onto the southern shelf about May each year and remains flowing for about 6 months, pushed along by the winter westerlies [11]. These warm waters raise inshore temperatures during winter and facilitate the migration and mixing of species, including the introduction of subtropical and tropical species.

The Leeuwin appears to extend all the way to the southern tip of Tasmania (supplemented by another major water mass from the eastern Great Australian Bight), making it probably the longest continuous coastal current system in the world [11]. In the Recherche Archipelago, it moves offshore, and another inshore current, the Cresswell Current, moves in the opposite direction, taking cooler waters westward during much of the year [12].

As well as being comparatively warm, the waters of the south coast are very low in nutrients (by global standards) and have an unusually deep 'photic zone' (the depth to which light can penetrate), due largely to a lack of suspended materials and scarce nutrients [8,12]. Because of the clear waters, photosynthesising organisms are able to live, in some places, down to 70 metres and seagrasses grow down to more than 50 metres [13,14]. Another distinctive, highly influential feature of the south coast is the regular battering it receives from fierce winds and big swells, as the highest energy section of the Australian coast [6]. This limits where plants and algae can grow and requires special adaptations in seagrasses such as thick leaves and deep burial of rhizomes [14].

## 2.4 Implications of the proposed marine park

A substantial marine park with large sanctuaries in both bioregions is essential for Western Australia to achieve a comprehensive, adequate and representative marine park network. A global review of 144 studies in 2016 found that, on average, 37% high-level marine protection is needed to achieve marine park goals such as protecting biodiversity, providing connectivity, avoiding species collapse and ensuring sustainable fisheries [15]. The IUCN World Conservation Congress recently passed a resolution calling on nations to fully protect (in sanctuaries) at least 30% of the ocean 'to reverse existing adverse impacts, increase resilience to climate change, and sustain long-term ocean health' [16].

Currently, the WA South Coast bioregion has only one tiny (14 $km^2$) marine park and no sanctuaries (Table 1). The proposed marine park would encompass 80% of the Western Australian portion of this bioregion. The Eucla bioregion has no marine parks in Western Australian waters. The proposed marine park would encompass 100% of the Western Australian portion of this bioregion.

The proposed park adjoins marine sanctuaries in Commonwealth and South Australian waters, offering the potential for complementary management. Creating a large sanctuary in the Eucla bioregion could lead, in collaboration with the South Australian and Australian governments, to the

creation of the largest coastal shelf marine sanctuary in Australian waters and one of the 5 largest in the world. In addition, much of the coastline is encompassed within national parks and nature reserves, offering opportunities for complementary conservation management across land and sea.

*Table 1. Existing and proposed marine parks of the south coast bioregions*

| Bioregion | Existing WA reserves | | | | | Proposed marine park (% WA waters) |
|---|---|---|---|---|---|---|
| | Marine parks | WA waters (%) | | All waters (%) | | |
| | | Marine parks | Sanctuaries | Marine parks | Sanctuaries | |
| WA South Coast | Walpole-Nornalup Inlets MP | <0.1 | 0 | 26 | 5 | 80 |
| Eucla | None | 0 | 0 | 27 | 12 | 100 |

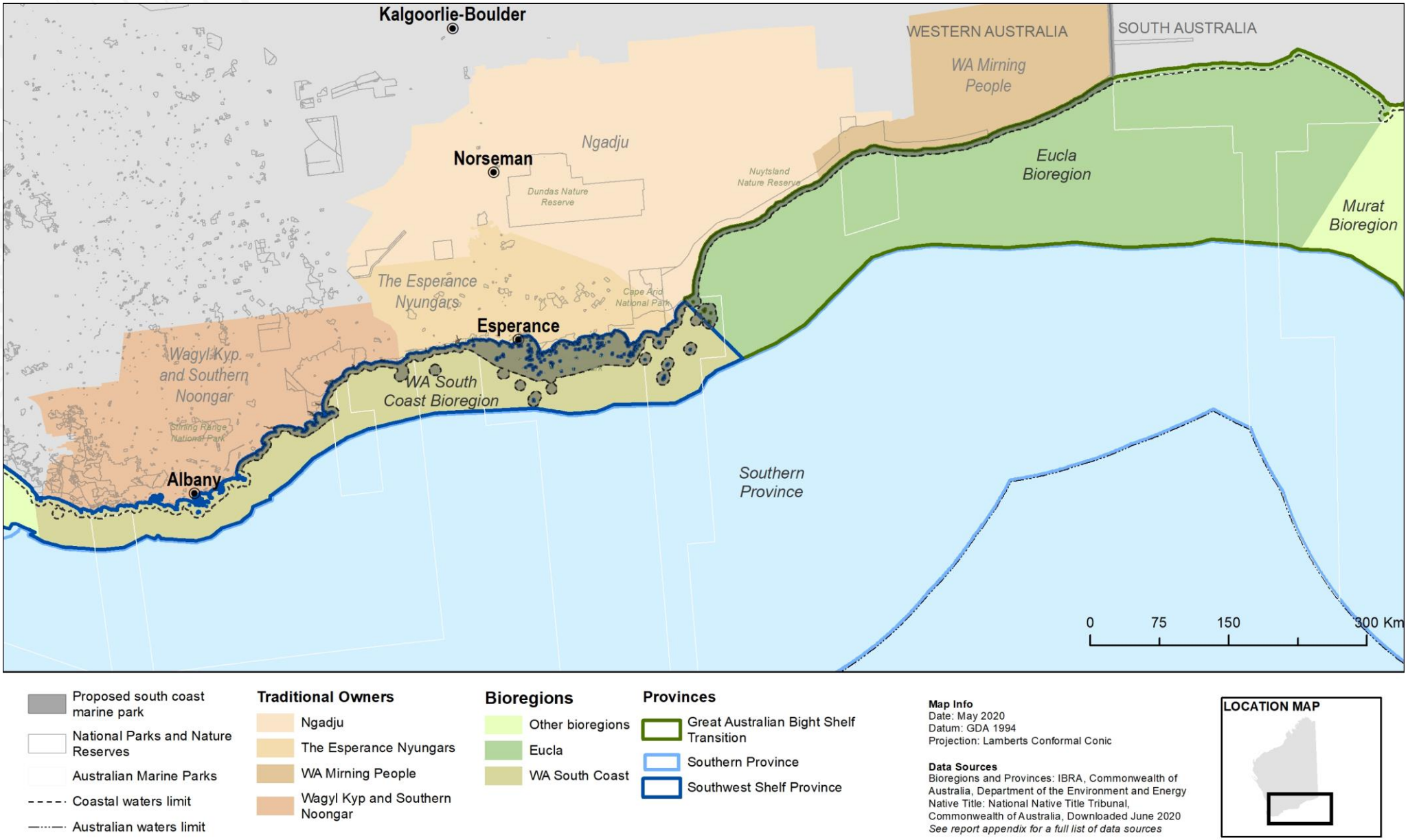


*Figure 2. Bioregions (meso-scale and provincial) overlapping the proposed south coast marine park*

## RECOMMENDATIONS

Provided that the Traditional Owners of the south coast regard a jointly-managed marine park as desirable in their sea countries, we recommend that the government works with stakeholders and local communities to:

- Design one large world-class marine park with a sanctuary network that achieves comprehensive, adequate and representative protection of the WA South Coast and Eucla bioregions.

- Assess the potential to create the largest shelf sanctuary in Australia and one of the 5-largest in the world by establishing a sanctuary adjoining existing South Australian and Commonwealth sanctuaries.

# 3 IMPORTANT HABITATS AND FEATURES OF THE SOUTH COAST

The diversity of habitats on the south coast – seagrass meadows, kelp and seaweed forests, rhodolith beds, estuaries, rocky reefs and islands, sandy plains, beaches and cliffs – is a major reason for its rich diversity of marine life. Here we describe and map a few of the most important habitats and features for which data are available.

## 3.1 Seagrass meadows

Seagrass meadows along the south coast are among the most diverse in the world. In fact, the south-west has more co-occurring seagrass species than any other temperate region, approaching the richness of many tropical regions [14]. The seagrass diversity has been bolstered by the Leeuwin Current, which has been carrying warm water and seagrass propagules from the tropics and subtropics for 40 million years [14,17]. Seventeen seagrass species, including 3 that occur only in estuaries, have been recorded on the south coast. Ten are endemic to Australia's southern or south-western coastlines [14].

The south coast seagrasses are also unusual for the depths to which they grow and the swells they consistently endure. The clear waters allow seagrasses to grow down to 52 metres – among the deepest globally – and they withstand swells up to 7–10 m, much greater than those in other major seagrass regions [14]. The coastal and estuarine waters of the south-west are also, by global standards, low in nutrients (eg with nitrate concentrations in the water column of 0.1–0.7 µM compared to a global mean of 2.7 µM for seagrass meadows) [14].

The densest meadows on the south coast grow in sheltered bays protected by granite headlands (eg Esperance Bay) [18]. They range from meadows dominated by a single species to mosaics of up to 8 species [14]. These sheltered meadows are rich in suspension feeders (animals that feed on particles suspended in the water) such as bryozoans, amphipods, ascidians and sponges, which can filter an enormous volume of water each day, equivalent to that of the entire water column above the meadow [14,19].

Another unusual aspect of south-western seagrass habitats is a lack of grazers. The only animals known to eat their leaves are isopod borers (small crustaceans that burrow into seagrass tissues) [14]. Instead, the algae attached to seagrasses (epiphytes) are an important source of food for invertebrates and fish, and fish in seagrass meadows also eat a lot of drifting algae detached from nearby reefs, 'showing the importance of trophic linkages between macro-algal reef communities and seagrass meadows' [14,20].

Seagrasses also grow in dynamic and challenging environments on the south coast. Meadows along the open coast often have to withstand strong swells and massive sand movements – requiring heavy-fibre reinforcement of stems and leaves and deep burial of rhizomes – while those in estuaries

have to cope with highly variable salinity and nutrient levels [14]. Although estuarine meadows are not extensive, they are important habitats for small fish species and nursery areas for the juveniles of larger fish, including species important for commercial and recreational fishing [1].

As with seagrass habitats elsewhere, their ecological functions and services make them a high priority for conservation. They recycle nutrients, stabilise sediments, trap particles, protect beaches from erosion, capture and store carbon, and provide food and shelter for many species [1,18].

The proposed south coast marine park would encompass all the mapped seagrass meadows in the WA South Coast bioregion and 93% of those in the Western Australian part of the Eucla bioregion (Table 2). The existing sanctuary protection for seagrass meadows in these bioregions (all waters) is paltry (<0.1% of those in the Eucla bioregion) or non-existent.

Extensive seagrass meadows in the WA South Coast bioregion occur in the following areas (see Figure 3):

- all bays and coves within the Recherche Archipelago, including between Alexander Bay and Wharton, west group islands, Esperance Bay, bays along Cape Le Grand National Park, islands west of Cape Le Grand (Sandy Hook, Woody, Thomas, Frederick), Wharton to Alexander Bay, Arid Bay and Middle Island
- along most of the coastline between Esperance and Bremer Bay, including on the western side of Stokes inlet and along Fitzgerald River National Park (Doubtful Islands Bay)
- Wray Bay and Cheyne Bay (west of Bremer Bay).

Extensive seagrass meadows in the Eucla bioregion occur in the following areas (Figure 3):

- Eucla
- Scorpion Bight to Kanidal Beach
- Bilbunya beach (between Wattle Creek and Bilbunya Dunes)
- Israelite Bay
- Recherche Archipelago (around the eastern group islands).

*Table 2. Seagrass meadows in the proposed south coast marine park (% bioregional extent in Western Australian waters)*

| Bioregion | Extent in the proposed marine park (%) | | | | | Existing sanctuary protection (WA waters) |
|---|---|---|---|---|---|---|
| | Sea country areas | | | | South coast marine park | |
| | Esperance Nyungars | Ngadju | Wagyl Kyp & Southern Noongar | WA Mirning | | |
| Eucla | – | 67 | – | 33 | 100 | 0 |
| WA South Coast | 77 | 6 | 10 | – | 93 | 0 |

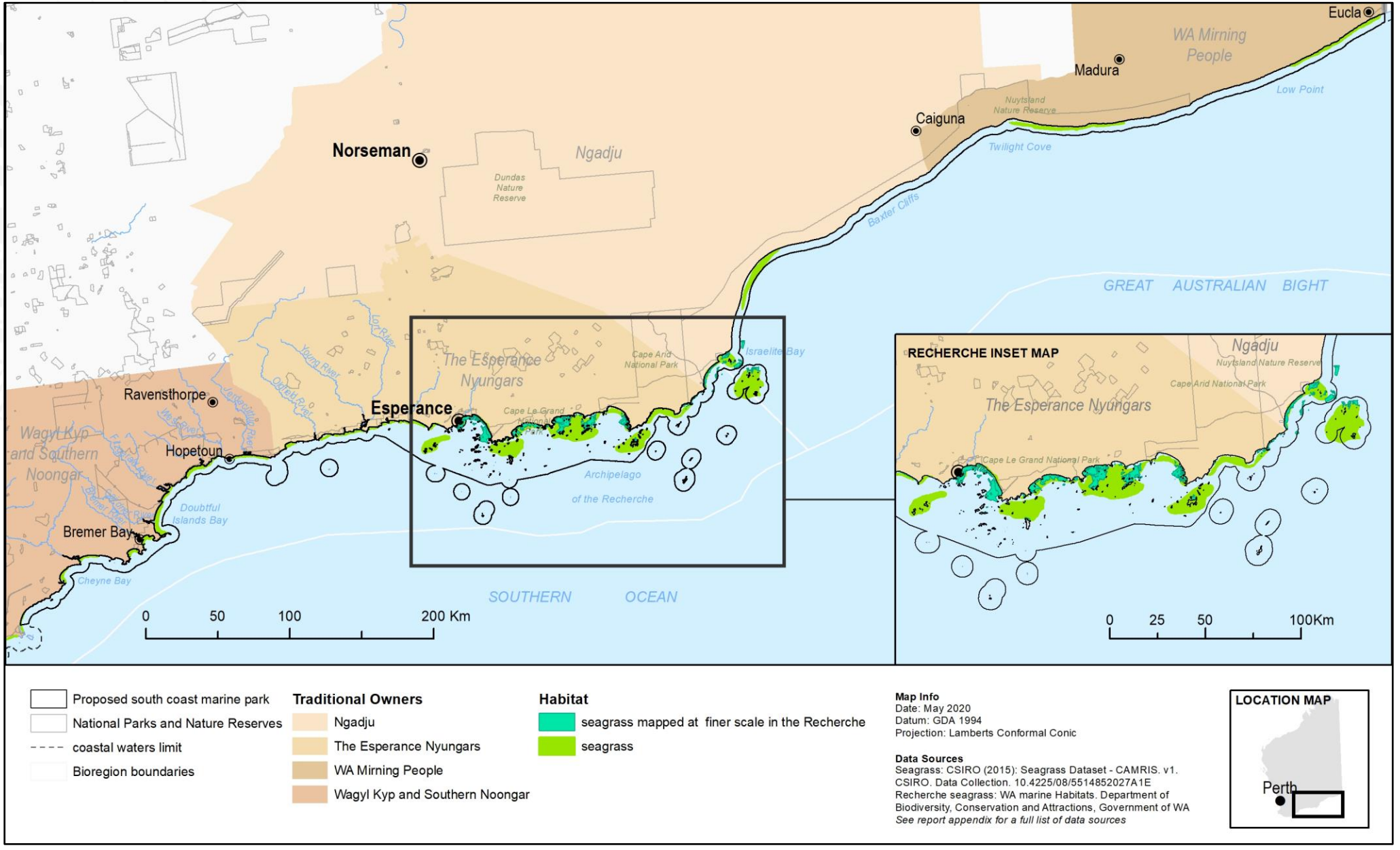


*Figure 3. Seagrass meadows in the proposed south coast marine park*

## 3.2 Seaweed–kelp beds

Seaweeds (macroalgae) are extremely important in south coast waters – for their species diversity and habitat values. Australia's southern coast has the highest seaweed diversity (>1500 species) and endemicity (62%) of any region in the world – due in part to the variety and extent of rocky habitats, the isolation of the south coast over the past 80 million years, and the lack of mass extinction events (caused elsewhere by glaciation and ice sheets) [9,21].

Many seaweeds have only small ranges and are rare. Eucla has been identified as one of 6 'centres of rarity' for seaweeds – areas with a high proportion of rare species (the other centres in Western Australia are King George Sound and Rottnest Island) [22]. Rare seaweeds are associated with low nutrients and sandy habitats and possibly also habitat complexity and escape routes along glacial drainage pathways during sea-level change.

The south coast is part of what has been dubbed the Great Southern Reef – 'an entity made up of thousands of kilometres of rocky temperate reefs, dominated by kelp forests and interconnected through oceanographic, ecological and evolutionary processes' [23] (see section 5). These shallow rocky reefs, stretching from southern Queensland to Kalbarri, are defined largely by the distribution of kelp forests. They are among the most productive ecosystems on the planet – a 'biological engine room' [23].

Kelp forests, particularly on limestone reefs, are a major habitat on Western Australia's south coast [24]. The canopy-forming golden kelp (*Ecklonia radiata*) typically grows to 1–2 metres and often forms dense beds, providing habitat for many understorey seaweeds and animals. In contrast to the west coast, where golden kelp dominates the canopy, on the south coast other brown algae also contribute substantially to the canopy [25].

Kelp forest communities vary greatly in their structure and species composition over small and large scales – they are 'heterogeneous to the extreme' – due to great habitat variability, arising from differences such as wave and light exposure and canopy density [13,24]. In contrast to eastern Australia, grazing on the south coast does not appear to be a major influence on seaweeds, due to lower populations of urchins and gastropods, the main grazers.

Researchers have warned that the future of kelp communities in Western Australia is 'grim', due to global warming, more-frequent heat waves and the intrusion of tropical species [26].

Other than in the Recherche Archipelago, spatial information about the south coast reefs and kelp–seaweed beds is highly deficient. The extent of reefs is greater than indicated here (see Figure 4), and the following location information applies only to the largest reefs. There is also no distinction in the mapping between limestone and granite reefs, and only in the Recherche Archipelago have reefs with macroalgal beds (mainly limestone reefs) been distinguished from bare reefs. Limestone reefs generally provide better protection and are an easier surface for seaweeds to attach to than granite or gneiss. The following information has been compiled from 3 different data sources – marine hazard mapping, detailed habitat surveys of the Recherche Archipelago and broadscale geomorphological data.

In the WA South Coast bioregion, reefs and other rocky features likely to support kelp–seaweed habitats and important locations include the following:

*Shallow reefs*: 43 reefs (mapped because they are visually prominent or a potential shipping hazard) are scattered throughout the Recherche Archipelago, with concentrations around Twin Peak Islands, and along the coast west of Esperance, between Stokes Inlet and Hopetoun, mainly around the rocky headlands.

*Broadscale reefs*: 1 in the proposed marine park (4 within the bioregion) fringing Termination and Little islands and extending to Brown Reef.

*Macroalgal reefs in the Recherche Archipelago*: Most Recherche reefs are high relief (>1 m high). Important areas are from Alexander Bay to Taylor Island (the largest mapped patch, 25 $km^2$, 14% of the total, all high-relief reefs), around Middle Island (low relief), central and western Esperance Bay (high relief) and Sandy Bight (high relief).

*Other rocky features likely to support macroalgal beds*: Subtidal rocky reefs or patchy rocky reefs and subtidal rocky platforms or rocky bottoms occur along the coast from Hopetoun to Esperance. Subtidal sloping rocky bottoms (326 km mapped) are common along the coast around headlands.

In the Eucla bioregion, reefs and other rocky features likely to support kelp–seaweed habitats and important locations include the following:

*Shallow reefs*: 11 reefs (mapped because they are visually prominent or a potential shipping hazard) occur in a small area west of Eucla adjacent to the Roe Plain (east of Low Point).

*Macroalgal reefs in the Recherche Archipelago*: Important areas in the eastern group of islands, including around Daw Island and the northern islands (all high-relief reefs).

*Other rocky features likely to support macroalgal beds:* Subtidal rocky reefs or patchy rocky reefs and subtidal rocky platforms or rocky bottoms occur along the coast from Twilight Cove to the border.

Wrack deposits are another important macroalgal habitat type. These rotting piles of seaweed and seagrass on beaches and in the surf-zone are a 'vital link in a complex food chain' [27]. The amphipod *Allorchestes compressa* lives in wrack along the south coast and is then eaten by fish such as mullet, herring and school whiting when swept off the beach during rough weather. As wrack breaks down, it becomes an important source of carbon and nutrients in nearshore food webs, feeding suspension feeders, fishes, seabirds and shorebirds. Roes abalone feeds almost exclusively on drifting seaweed fragments. Wrack in the surf-zone also serves as a nursery habitat for fish [27]. Wrack deposits are extensive and persistent in the Eucla bioregion between Israelite Bay and Point Culver, and between Twilight Cove and the border (see Figure 4).

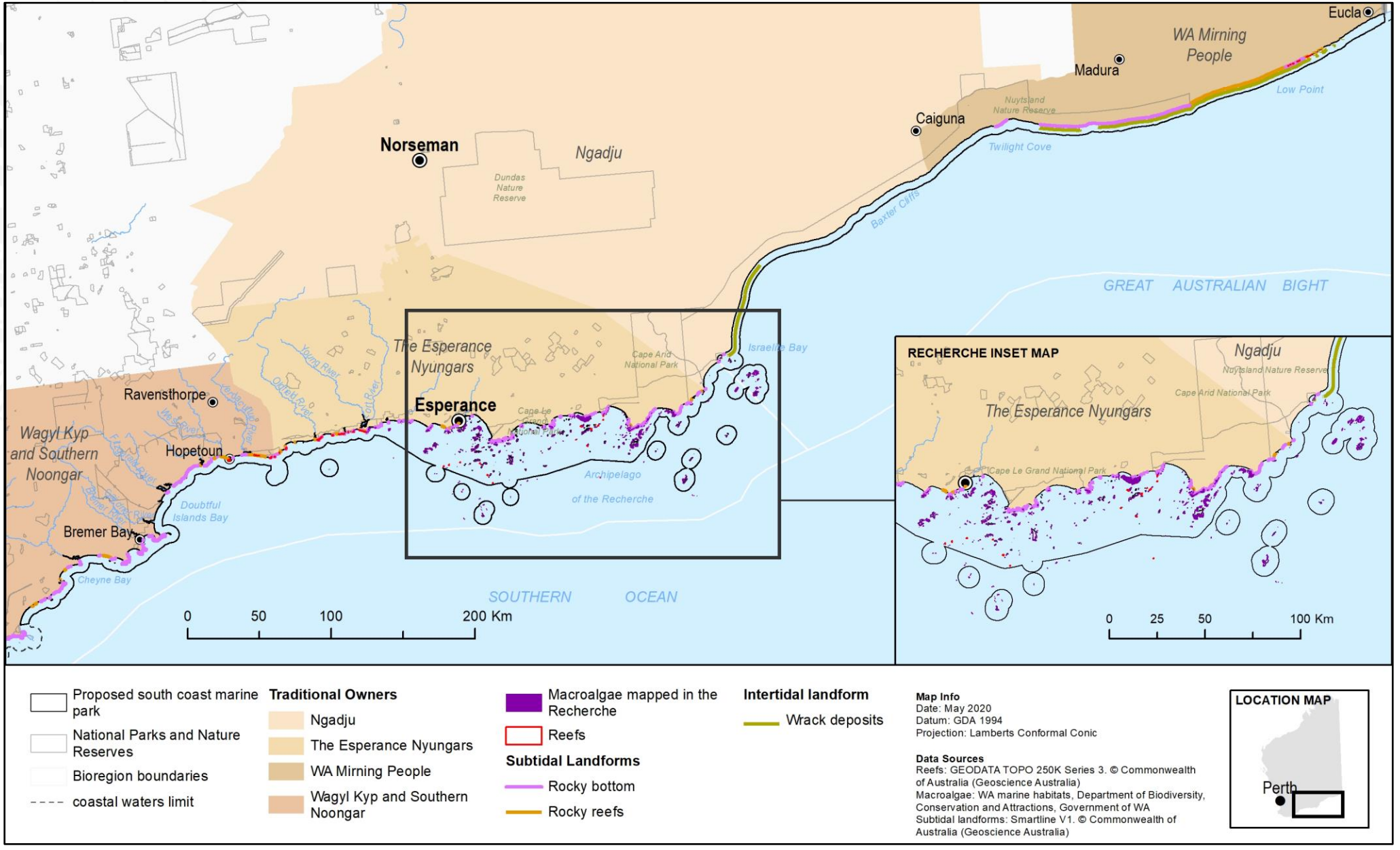


*Figure 4. Rocky habitats in the proposed south coast marine park likely to support kelp–seaweed beds (including surveyed macroalgal beds in the Recherche Archipelago) and wrack deposits on beaches*

## 3.3 Rhodolith beds

One poorly known habitat type on the south coast – but potentially as ecologically significant as seagrass meadows and kelp forests – are communities of loose-lying, non-jointed coralline red algae (of several different species) known as rhodoliths [28,29]. They can build up over millennia to create vast beds covering thousands of hectares and undergo a continuous cycle of building, erosion, burial and recolonisation [29]. Radiocarbon dating of a rhodolith bed in Esperance Bay returned dates ranging back to 1050, suggesting that fossil rhodoliths had been recolonised after periods of burial or erosion [28].

Worldwide, rhodolith beds occur in tropical to temperate waters from the intertidal zone to over 100 metres depth. In Australia, rhodolith beds have largely been overlooked in biodiversity surveys because they are not a major fish habitat, but the abundance and diversity of algae and invertebrates they support, in otherwise sparsely populated soft substrates, are very high, often exceeding that of other local habitats [29]. Overseas, rhodolith beds are known to be nursery grounds for important commercial species, but whether they play this role in Australia is uncertain. They are also very important for carbon sequestration, with carbonate production comparable to that by coral reefs [29].

Rhodolith beds are likely to be extensive in the proposed marine park in at least 2 areas – in the Recherche Archipelago and on the western Roe Terrace in the Great Australian Bight (see Figure 5). Their apparent absence in other areas could be due to a lack of surveys.

The western Roe Terrace may contain Australia's most extensive high-density rhodolith bed [8,29]. The rhodoliths make up 70% to 100% of the sediment and are of various sizes (granule to cobble size) and shapes (compact, round and branching forms). They support a 'luxuriant growth' of red, green, and brown macroalgae as well as numerous large living and dead scallops, other bivalves, snails, oysters and bryozoans [8]. This bed may cover up to 20,000 $km^2$, in which case it would rival a bed in the South West Atlantic as 'the largest rhodolith bed on earth' and the Great Barrier Reef as 'Australia's largest calcium-carbonate biofactory' [29]. This habitat has not been mapped in the Eucla bioregion and the extent of its occurrence in coastal waters is unknown.

Rhodolith beds are widely distributed in the Recherche Archipelago, particularly in the west between the islands and open offshore waters, in waters 27–65 metres deep (see Figure 5) [28,30]. Surveys of the Esperance region in 2001 found rhodolith beds covering 17% of the mapped benthos, mostly in waters less than 45 metres deep, in large beds up to 9000 hectares in area [30]. The rhodolith habitats support greater diversity and species richness of macrofauna than any other benthic habitat in the surveyed area. The beds in Esperance Bay are in areas of moderate wave energy – they are likely to be buried in low-energy conditions and removed in high-energy conditions – and associated with calcium carbonate gravels, consisting of broken rhodolith thalli [31]. The beds have a high mud content, due to the tendency of rhodoliths to trap fine sediments, which provides 3-dimensional microhabitats for numerous other organisms [31].

Trawling is a major threat to rhodolith beds [29]. Surveys in the Spencer Gulf found lower than expected biodiversity on rhodolith beds in areas subject to prawn trawling, and the more they had been trawled the lower were their biomass, abundance and cover [32]. With their magnesium-calcite skeletons, rhodoliths are also thought to be highly vulnerable to ocean acidification and global warming [29]. Dissolution rates are expected to exceed net calcification rates by the end of the century.

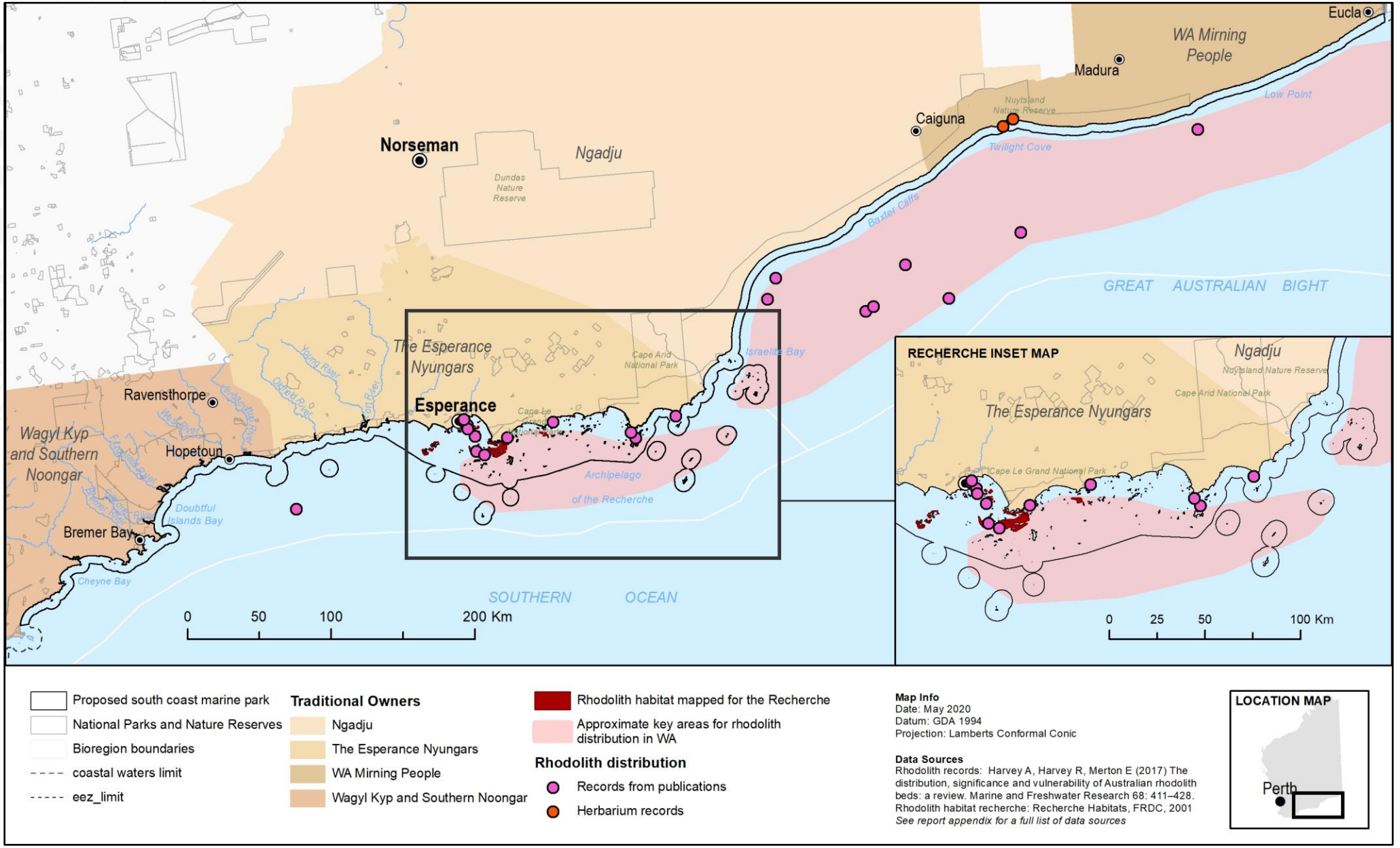


*Figure 5. Recorded locations for rhodoliths and likely locations of rhodolith beds in the proposed south coast marine park*

## 3.4 Estuaries

Many of the south coast estuaries 'are dying and some are already dead' – not biologically but as estuaries [7]. In the recent past, when sea levels were higher by a metre or so, they were classic estuaries – open to the sea and tidal for some distance inland, as shown by extensive fossil shell beds (4000 to 8000 years old) [7]. But now most of the south coast estuaries open only seasonally or occasionally, and most in the proposed marine park are normally closed (see Table 3). This is due to the small tidal range, the extreme seasonality of river flows, the enclosure of the estuary entrances by limestone barrier dunes, entrance bars created by the longshore drift of coastal sand and flood-tide deltas that restrict tidal exchange and infilling with catchment sediment [7].

Despite the length of the coastline, there are few estuaries along the south coast – just 14 have been mapped in the proposed marine park, all in the WA South Coast bioregion (see Figure 6, Table 3). East of Cape Arid there is no surface runoff into coastal waters.

Most estuaries in the proposed marine park open to the sea only after heavy rainfall and are classified as 'normally closed' (Table 3) [1]. Cheyne Inlet is the only seasonally open estuary. Torradup Inlet (the most easterly riverine estuary) opens for about a week each year [1]. Others open only every few or several years: in the 45 years from 1972 to 2016, Culham Inlet opened only 3 times, Hamersley Inlet at least 8 times, and Stokes Inlet 12 times (it has become more frequent in recent times due to clearing in the catchment) [1,33]. Culham and Jerdacuttup Lakes (2 lagoons) are classified as permanently closed estuaries (Table 3). Separated from the sea by a 10-metre-high dune, Jerdacuttup is a 'fossil estuary' that has been closed for probably some 6000 years [34].

When the entrance bar to an estuary is closed, the water level and salinity can fluctuate widely depending on river flow and evaporation [7]. The salinity recorded at a site in Culham Inlet, which has a very high rate of evaporation, was apparently the highest recorded for any estuary globally [33]. Because of their extreme variability in salinity, the south coast estuaries are harsh environments. But they are also highly productive feeding grounds and nursery areas. Only a few fish species breed in the estuaries, including black bream and the cobbler (of commercial and recreational importance), but many fish, crab and prawn species spawn in the ocean and then enter the estuaries as juveniles, coming and going in response to changing salinity levels [1]. For example, in Stokes Inlet – the largest estuary in the proposed marine park (1300 ha) and an important fish habitat – the number of fish species present ranges from 12 to 22 depending on the salinity and time since the bar last opened to the sea [35]. The estuaries are important also as feeding grounds for waterbirds, including threatened migratory shorebirds. And they are highly valued by people for their scenic qualities and for recreational fishing and boating.

All except one estuary in the proposed marine park are classified as wave dominated (Table 3), which means the estuarine processes are mainly driven by wave action. The exception is the permanently closed Jerdacuttup Lakes [6]. There are also tide-dominated and river-dominated estuaries in the WA South Coast bioregion, but all are west of the proposed marine park.

Estuarine habitats have been mapped for 25 estuaries in the WA South Coast bioregion. The 14 estuaries in the proposed marine park account for more than a quarter of the extent of all estuarine habitats in the bioregion except for rocky reefs (13%). The following estuaries are important for particular habitats (the proportion of habitat in the proposed marine park is indicated):

- rocky reefs: Cheyne Inlet (25%), Hamersley Inlet (25%), Oldfield Estuary (25%), Stokes Inlet (25%)
- intertidal flats: Stokes Inlet (21%), Beaufort Inlet (20%)
- saltmarshes: Wellstead Estuary (26%), Gordon Inlet (24%)
- channels: Stokes Inlet (20%).

Subtropical and temperate coastal saltmarsh is listed nationally as a vulnerable ecological community and by Western Australia as a priority 3 ecological community [36]. Almost half (48%) the estuarine saltmarsh mapped in the WA South Coast bioregion occurs in the proposed marine park – in the Wellstead, Gordon, Fitzgerald, Beaufort, St Marys River and Cheyne estuaries. Saltmarshes are inhabited by a wide range of invertebrates such as bivalves, slugs and snails, crabs and insects (terrestrial and aquatic), and low-tide and high-tide visitors such as prawns, fish and birds [36]. They are often important nursery habitats for fish and prawn species, and among the most efficient ecosystems for sequestering carbon. Saltmarshes on the south coast are thought to have suffered a 10–20% decline while the state as a whole has probably lost more than half [36].

Most estuaries in the proposed marine park are classed as modified or extensively modified (Table 3) because of nutrient enrichment, sedimentation and increased flooding frequency due to extensive clearing in their catchments [1]. The exceptions are 2 estuaries with their catchments in Fitzgerald River National Park – Fitzgerald Inlet, classed as largely unmodified, and Saint Marys River, which has not been assessed.

The area adjoining Fitzgerald River National Park has 6 estuaries, the highest concentration of estuaries in the proposed marine park. Three of these – Fitzgerald, Dempster and Culham inlets – are part of wetland systems listed as nationally significant [37]. They are also part of the Fitzgerald River Important Bird and Biodiversity Area (listed by Birdlife International) [38].

Fitzgerald and Dempster inlets are part of the Fitzgerald Inlet System, which is regarded as a 'good example of naturally saline rivers and undisturbed coastal lagoons ... that exhibit cycles of flooding and drying of variable length'. The system provides habitat for thousands of waterbirds. At least 29 bird species have been recorded on the inlets, including darters, cormorants, ducks and shorebirds. They are also a migratory stopover for at least 3 migratory shorebird species, including the red-necked stint. The inlets are part of a major drought refuge for chestnut teal.

Culham Inlet on the eastern edge of Fitzgerald River National Park is part of the Culham Inlet System, which is regarded as a 'good example of a closed estuary and inflowing saline rivers'. This system also meets 2 criteria for international significance. It provides habitat for at least 31 bird species, mostly ducks and shorebirds. When listed in 1992, it had recorded the third-highest number of waterbirds for a site in western Australia (>10,000 in 1991). It is a major dry season refuge for the banded stilt (an estimated 44,000 in 1986) and a migratory stopover for at least 6 shorebird species.

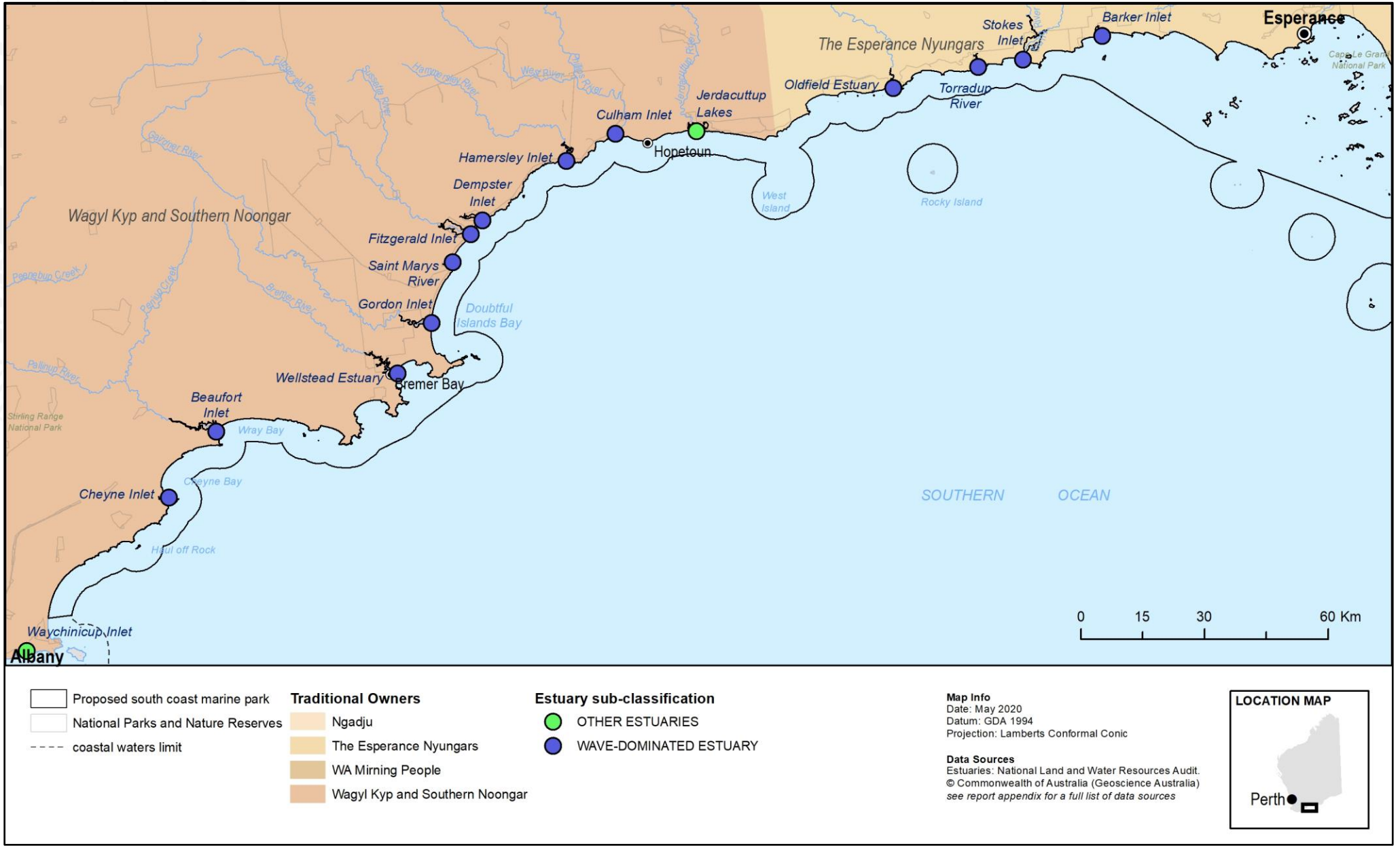


*Figure 6. Mapped estuaries in the proposed south coast marine park*

*Table 3. Estuaries in the proposed south coast marine park (type, condition and catchment size)*

| Classification | Subclass | Condition | Estuary | Sea country | Entrance condition | Catchment size |
|---|---|---|---|---|---|---|
| Other | Other | Modified | Jerdacuttup Lakes | Wagyl Kyp Southern Noongar | Permanently closed | NA |
| Wave dominated | Wave dominated | Extensively modified | Culham Inlet[A] | Wagyl Kyp Southern Noongar | Permanently closed | 2500 |
| Wave dominated | Wave dominated | Largely unmodified | Fitzgerald Inlet[A] | Wagyl Kyp Southern Noongar | Normally closed | NA |
| Wave dominated | Wave dominated | Modified | Barker Inlet | Esperance Nyungars | Normally closed | NA |
| Wave dominated | Wave dominated | Modified | Beaufort Inlet | Wagyl Kyp Southern Noongar | Normally closed | 4775 |
| Wave dominated | Wave dominated | Modified | Cheyne Inlet | Wagyl Kyp Southern Noongar | Seasonally open | NA |
| Wave dominated | Wave dominated | Modified | Dempster Inlet[A] | Wagyl Kyp Southern Noongar | Normally closed | 300 |
| Wave dominated | Wave dominated | Modified | Gordon Inlet | Wagyl Kyp Southern Noongar | Normally closed | 3050 |
| Wave dominated | Wave dominated | Modified | Hamersley Inlet | Wagyl Kyp Southern Noongar | Normally closed | 800 |
| Wave dominated | Wave dominated | Modified | Oldfield Estuary | Esperance Nyungars | Normally closed | NA |
| Wave dominated | Wave dominated | Modified | Stokes Inlet | Esperance Nyungars | Normally closed | 5325 |
| Wave dominated | Wave dominated | Modified | Torradup Inlet | Esperance Nyungars | Normally closed | 105 |
| Wave dominated | Wave dominated | Modified | Wellstead Estuary | Wagyl Kyp Southern Noongar | Normally closed | 695 |
| Wave dominated | Wave dominated | Not assessed | Saint Marys River | Wagyl Kyp & Southern Noongar | Normally closed | 115 |

*Notes: A. These inlets are part of wetland systems recognised as nationally important [37].*

*Additional sources: [6,7]*

*Table 4. Estuarine habitat types in the WA South Coast bioregion in the proposed south coast marine park*

| Estuarine habitat | Sea country | | Proposed marine park |
|---|---|---|---|
| | Esperance Nyungars | Wagyl Kyp & Southern Noongar | |
| Barrier/ back-barrier | 20% | 40% | 60% |
| Central basin | 21% | 29% | 50% |
| Channel | 15% | 22% | 36% |
| Flood- & ebb-tide delta | 7% | 18% | 25% |
| Fluvial (bay-head) delta | 6% | 21% | 27% |
| Intertidal flats | 10% | 31% | 41% |
| Rocky reef | 6% | 6% | 13% |
| Saltmarsh/saltflat | 0% | 48% | 48% |
| Unassigned | 19% | 11% | 30% |
| Total | 9% | 28% | 37% |

## 3.5 Coastline habitats and features

The coastline of the proposed south coast marine park stretches over more than 2000 kilometres, roughly a fifth of the state's coastline. Coastal features vary markedly between the 2 bioregions in the proposed park. The WA South Coast bioregion features sequences of 3 main coastal types [1]:

- long, wide beaches and bays with a shallow shelving shore, often backed by perched dunes or limestone cliffs, and with exposed limestone rock platforms at sea level (usually at the eastern end)
- high granite or gneiss headlands exposed to ocean swells, with wave-swept slopes, precipitous shores, cliffs, and sometimes small lunate bays between the headlands
- east-facing, semi-exposed shores with granite or gneiss boulders and tide pools.

The Eucla bioregion is typical of the Great Australian Bight with 2 main coastal types:

- steep limestone cliffs
- long exposed beaches backed by dunes or bedrock systems.

In the following sections we analyse data (Smartline v1) on the variety of rocky and sandy coastal landforms in and adjoining the proposed south coast marine park, how they vary between the shoreline, intertidal and subtidal zones, and the variation in exposure of the coastline to wind and waves. The backshore and offshore islands have not been included in this analysis (data on the shoreline characteristics of offshore Islands is limited).

## ROCKY SHORES

Many coastal habitats in the proposed marine park are rocky. They include headlands of large, sloping granite or gneiss outcrops, limestone cliffs, sheltered intertidal boulders with rock pools, intertidal rock platforms and subtidal reefs. Rocky shorelines often drop off suddenly to deep sandy floors (up to 40 metres deep) creating underwater rock walls and canyons. Intertidal rock provides habitat for limpets, abalones, chitons, and barnacles, which usually separate into zones depending on tidal exposure and depth. But zonation along the south coast is less obvious than elsewhere due to the low tidal range and the influence of barometric pressure on sea levels [1]. Rocky habitats down to 20 metres are usually dominated by kelp forests and seagrass, and in deeper waters are inhabited by sponges, ascidians and coelenterates [1].

### *Soft rock shorelines*

Soft rock (sedimentary) landforms dominate the backshore zone along just 2% (20 km) of the coastline in the WA South Coast bioregion within the proposed marine park (see Figure 7). Soft rock shoreline types in this bioregion, the bioregional proportion in the proposed park (%) and key locations include:

*Low-profile soft rock shore* (1%): Long Beach (Cheyne Bay) (26%, 3 km) and Dunn Rocks to Victoria Harbour (Cape Le Grand National Park) (65%, 7.3 km)

*Moderately to steeply sloping soft rock shore* (1%): Talgon Bay and western Yokinup Bay (Cape Arid National Park) (56%, 5 km)

*Very steep to cliffed soft rock shore* (0.1%): eastern end of Hassell Beach (100%, <1 km).

No soft rock shorelines have been mapped in the Eucla bioregion.

### *Hard rock shorelines*

Hard rock landforms – including gently to steeply sloping hard rocky intertidal and proximal backshore landforms – cover 29% (370 km) of coastline in the WA South Coast bioregion within the proposed marine park (see Figure 8). Hard rock shoreline types in this bioregion, the bioregional proportion in the proposed park (%) and key locations include:

*Gently to moderately sloping hard rock shore* (18%): Cape Knob to Point Swamp (headlands around Bremer Bay) (21%, 71 km), Dempster Inlet to Culham Inlet (Fitzgerald River National Park) (14%, 50 km), Cape le Grand to Rossiter Bay (Cape Le Grand National Park) (10%, 36 km)

*Hard rock coastal cliffs >5 m high* (<1%): Point Gordon (65%, 7.2km), Western Dillon Beach, Groper Bluff and inland of Red Island.

In the Eucla bioregion, hard rock shorelines cover less than 1% (3 km) of coastline in the proposed marine park. Hard rock shoreline types, the bioregional proportion in the proposed park (%) and key locations include:

*Gently to moderately sloping hard rock shore* (1%): Southern headland of Israelite Bay and east of Point Lorenzen (next to Israelite Bay) (100%).

### *Undifferentiated rock shorelines*

Intertidal or proximal backshore areas dominated by bedrock of unknown hardness cover less than 1% (10 km) of coastline in WA South Coast bioregion within the proposed marine park (see Figure 9). Undifferentiated rocky shoreline types in this bioregion, the bioregional proportion in the proposed park (%) and key locations include:

*Low-profile undifferentiated rock shore* (<1%): Point Malcolm to Point Dempster

*Moderately to steeply sloping undifferentiated rock shore* (<0.1%): Point Malcolm to Point Dempster

*Undifferentiated-profile undifferentiated rock shore* (<0.1%): Point Malcolm to Point Dempster

In the Eucla bioregion undifferentiated rock shorelines cover 28% (168 km) of coastline within the proposed marine park. Undifferentiated rock shoreline types, the bioregional proportion in the proposed park (%) and key locations include:

*Low-profile undifferentiated rock shore* (<1%): Scorpion Bight (100%, 1.2 km)

*Moderately to steeply sloping undifferentiated rock shore* (4%): Wylie Scarf at the western end of the Baxter Cliffs (100%)

*Undifferentiated rock coastal cliffs >5 m high* (27%): the Baxter Cliffs (100%, 162 km).

The Baxter Cliffs are a 100–120-metre-high line of limestone cliffs extending from Twilight Cove to Point Culver. South of Point Culver they continue inland as the Wylie Escarpment. Dunes on the cliffs contain ‘a massive amount of sand’ and extend up to 50 km inland [6].

### *Subtidal rocky shores (primary features)*

Rocky bottoms are the primary subtidal feature up to 500 m from shore across 26% of the coastline in the WA South Coast bioregion within the proposed marine park (see Figure 10). Subtidal rocky seafloor types in this bioregion, the bioregional proportion in the proposed park (%) and key locations include:

*Rocky platform undifferentiated* (<1%): Between Short Beach and Fishery Beach (Bremer Bay) (100%)

*Flat rocky bottom undifferentiated* (1%): small patches between Esperance and Hopetoun with the largest at the entrance to Jerdacuttup Lakes (27%, 3.4 km) and east of Barker Inlet (34%, 4.2 km)

*Sloping rocky bottom undifferentiated* (25%) – corresponds to hard rocky shorelines (above): Cape Knob to Point Swamp (headlands around Bremer Bay) (22%, 71 km), Dempster Inlet to Culham Inlet (Fitzgerald River National Park) (15%, 49 km), Cape Arid to Sandy Bight (Cape Arid National Park) (10%, 34km).

In the Eucla bioregion, subtidal rocky bottoms have been mapped as the primary feature along 22% of the coastline in the proposed marine park. Subtidal rocky seafloor types, the bioregional proportion in the proposed park (%) and key locations include:

*Rocky bottom undifferentiated* (12%): between Twilight Cove and Kanidal Beach (13%, 10 km), east of Scorpion Bight to Red Rocks Point (68%, 51 km), east of Low Point (19%, 14 km)

*Rocky platform undifferentiated* (10%): east of Kanidal Beach (99%, 57 km), east of Point Lorenzen (1%, <1 km)

*Sloping rocky bottom undifferentiated* (<1%): Point Dempster (the only occurrence).

#### *Subtidal rocky reefs*

Rocky reefs occur along 7% of the coastline in the WA South Coast bioregion within the proposed marine park (see Figure 10). Subtidal rocky reefs types, the bioregional proportion in the proposed park (%) and key locations include:

*Patchy rocky reefs and exposed rocks* (<1%): between Short Beach and Fishery Beach (Bremer Bay) (the only occurrence)

*Rocky reefs undifferentiated* (6%): adjacent to Jerdacuttup Lakes Nature Reserve (24%, 20 km), west of Hopetoun to Cave Point (13%, 11 km), Oldfield Estuary of Stokes Estuary (20%, 17 km)

In the Eucla bioregion, subtidal rocky reefs occur along 13% of the coastline in the proposed marine park. Subtidal rocky reefs types and key locations include:

*Rocky reefs undifferentiated* (13%): Red Rocks Point to Low Point (84%, 74 km), West Kanidal Beach (7%, 6 km).

### SANDY SHORES

The south coast is famous for its squeaky white beaches. Some 60–80% of the mainland shoreline is sandy, with beach sand in the east rich in carbonates (animal detritus) and that in the west rich in quartz (probably derived from granites in the western hinterland and offshore islands west of Point Lorensen) [6].

#### *Intertidal sandy shores*

Intertidal areas dominated by sand and soft sediments, including sandy beaches and tidal flats, cover 33% (428 km) of the coastline in the WA South Coast bioregion in the proposed marine park (see Figure 11). Sandy shoreline types in this bioregion, the bioregional proportion in the proposed park (%) and key locations include:

*Open coast sandy shore backed by bedrock rising above sea level* (5%): Hopetown to Starvation Boat Harbour (>50%)

*Open coast sandy shore backed by soft sediment deposits to below sea level* (5%): Esperance Bay south, Rossier Bay to Victor Harbour and Alexander Bay (73%)

*Open coast sandy shore undifferentiated* (23%): scattered along the coastline, no key areas.

In the Eucla bioregion, sandy shorelines cover 68% (413 km) of coastline in the proposed marine park. Sandy shoreline types, the bioregional proportion in the proposed park (%) and key locations include:

*Open coast sandy shore backed by bedrock rising above sea level* (41%): from Twilight Cove to the border (94%)

*Sandy shore backed by bedrock rising above sea level* (10%): between Low point and Eucla (100%)

*Open coast sandy shore backed by soft sediment deposits to below sea-level* (4%): adjacent to the Bilbunya Dunes (100%)

*Open coast sandy shore undifferentiated* (13%): Israelite Bay to Point Culver (100%).

Over the 46 years from 1972 to 2018, the shoreline at Twilight Cove expanded 600 metres seawards from the western cliff base [6]. A 19$^{th}$ century shipwreck was reportedly found 200 metres inland of Twilight Cove in the 1960s. The cove is clearly a major sink for quartz-rich sand, with about 100,000 m$^3$ deposited each year, coming from an unknown source much further west [6].

### *Subtidal sandy shores*

Sandy subtidal landforms are common across both bioregions. They occur along 35% of the coastline in the WA South Coast bioregion within the proposed marine park (see Figure 11). Subtidal sandy habitat types in this bioregion, the bioregional proportion in the proposed park (%) and key locations include:

*Sandy lagoons (generally protected by reefs)* (5%): west of Esperance at Reef Beach (Wray Bay) (36%, 8 km), Jerdacuttup Lakes Inlet (24%, 5 km), Stokes Inlet (24%, 5 km)

*Sandy bottom undifferentiated* (30%): widespread.

In the Eucla bioregion, sandy subtidal landforms cover 63% of the coastline in the proposed marine park. The only habitat type and key locations are:

*Sandy bottom undifferentiated* (63%): most of the bioregion, including off the Baxter Cliffs, which plunge into the ocean until they meet the sandy seafloor.

## COASTLINE EXPOSURE

The south coast is a high-energy environment, with heavy swells generated by the Roaring Forties wind belt in the Southern Ocean [6]. South-facing beaches and headlands are exposed to strong waves most of the time. East-facing headlands are more protected from waves and from the prevailing south-easterly winds in summer and westerlies in winter. Islands and rocky reefs also provide protection, particularly for the mainland shore in the Recherche Archipelago.

Coastline exposure in the proposed marine park varies from low to high, with most areas classified as moderately exposed or unclassified (Figure 12). Low-exposure areas face away from (by >135°), or are well sheltered from, the dominant oceanic storm and swell wave directions. High-exposure

areas face towards (by <45°) the dominant oceanic storm and swell wave directions. Exposure types in the WA south coast bioregion, the bioregional proportion in the proposed park (%) and key locations include:

*Low exposure* (4%, 46 km): generally east-facing beaches protected by pronounced headlands, such as Stream Beach, Fishery Beach and John Cove (all in Bremer Bay), with the largest section from Point Hood to the southern end of Tooregullup Beach (30%, 16 km).

*High exposure* (11%, 137 km): generally south-facing shorelines outside the Recherche Archipelago with stretches west of Esperance, around Bremer Bay; in the Recherche, only Sandy Bight and Yokingup Bay.

*Moderate exposure* (47%): widespread.

*Unclassified* (39%): Recherche Archipelago.

In the Eucla bioregion, there are a persistent moderate-to-high south-west swell and onshore winds, but the size of breaker waves varies considerably along the coast. The Baxter Cliffs receive the full force of the deep-water waves, while the low-gradient shelf and shallow seagrass-covered limestone reefs of the Roe Plain greatly reduce shoreline exposure to waves and winds [6]. Most of the coastline in the Eucla bioregion is classified as moderately exposed. Exposure types, the bioregional proportion in the proposed park (%) and key locations include:

*Low exposure* (15%, 6 km): the southern end of Israelite Bay and east of Point Lorenzen (100%)

*High exposure* (1%): east of Israelite Bay to Wylie Scarp (the western end of Baxter Cliffs) (100%)

*Moderate exposure* (70%): widespread.

*Unclassified* (15%): Recherche Archipelago

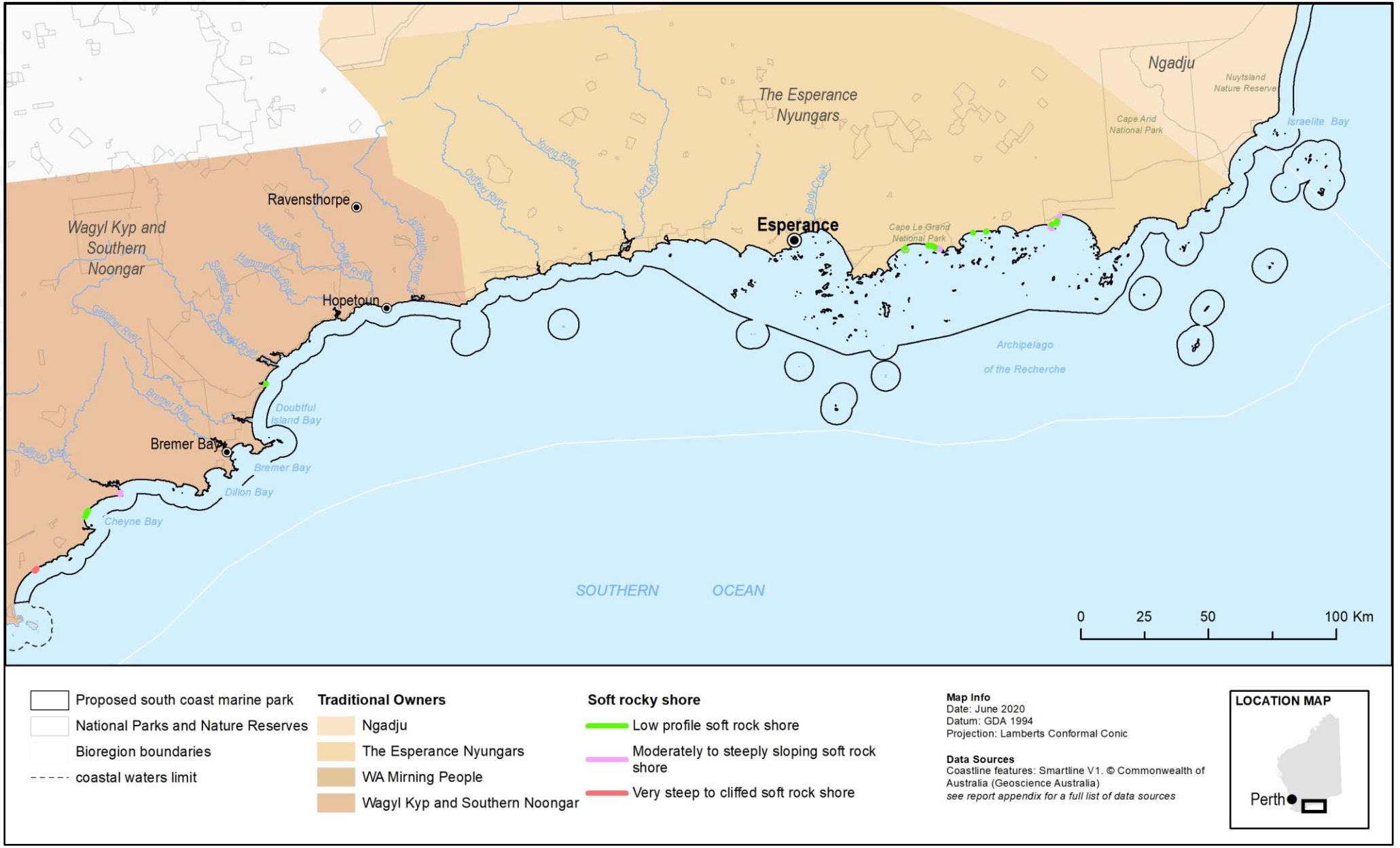


*Figure 7. Soft rock shorelines in the proposed south coast marine park (WA South Coast Bioregion)*

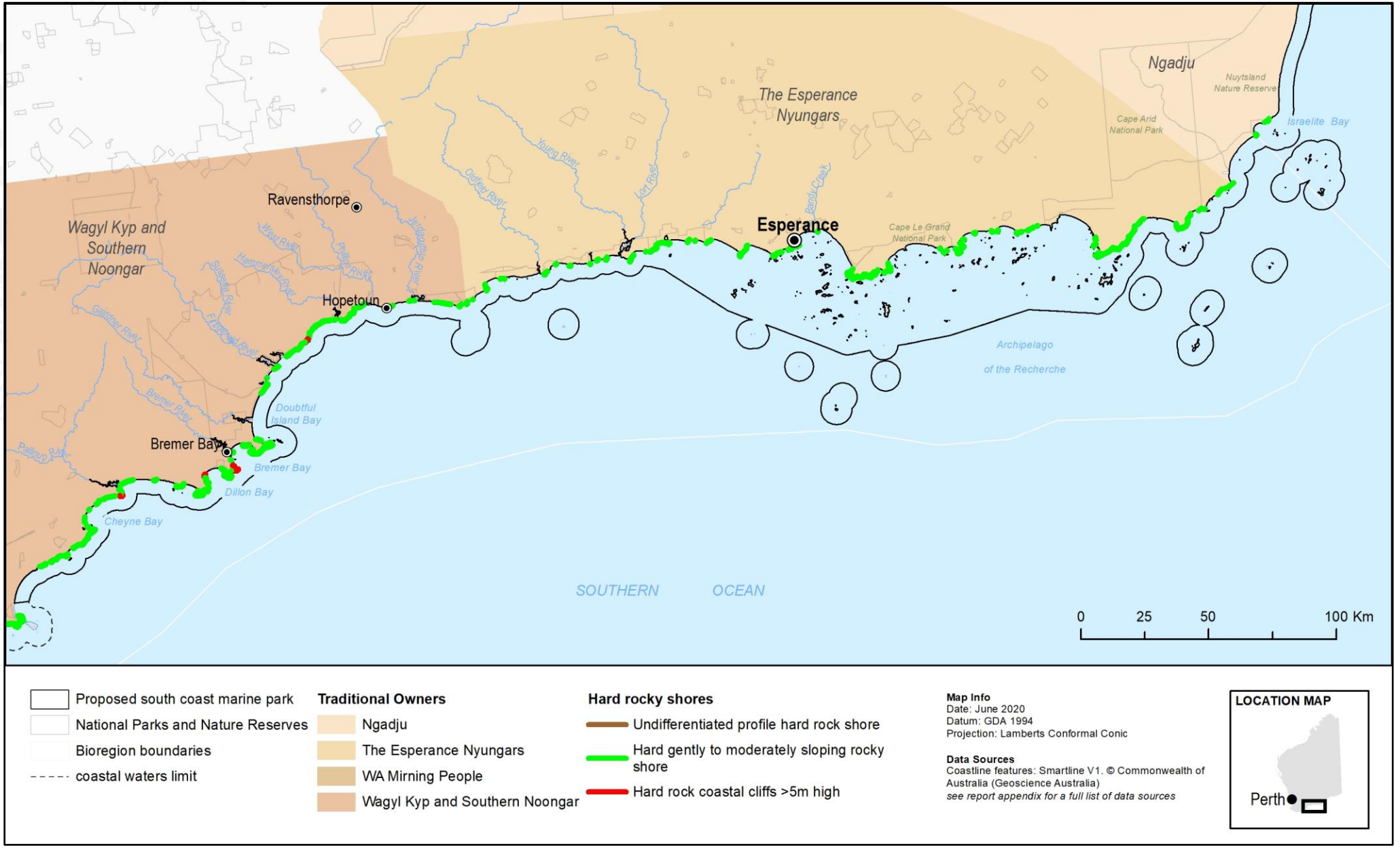


*Figure 8. Hard rock shorelines in the proposed south coast marine park (Eucla bioregion)*

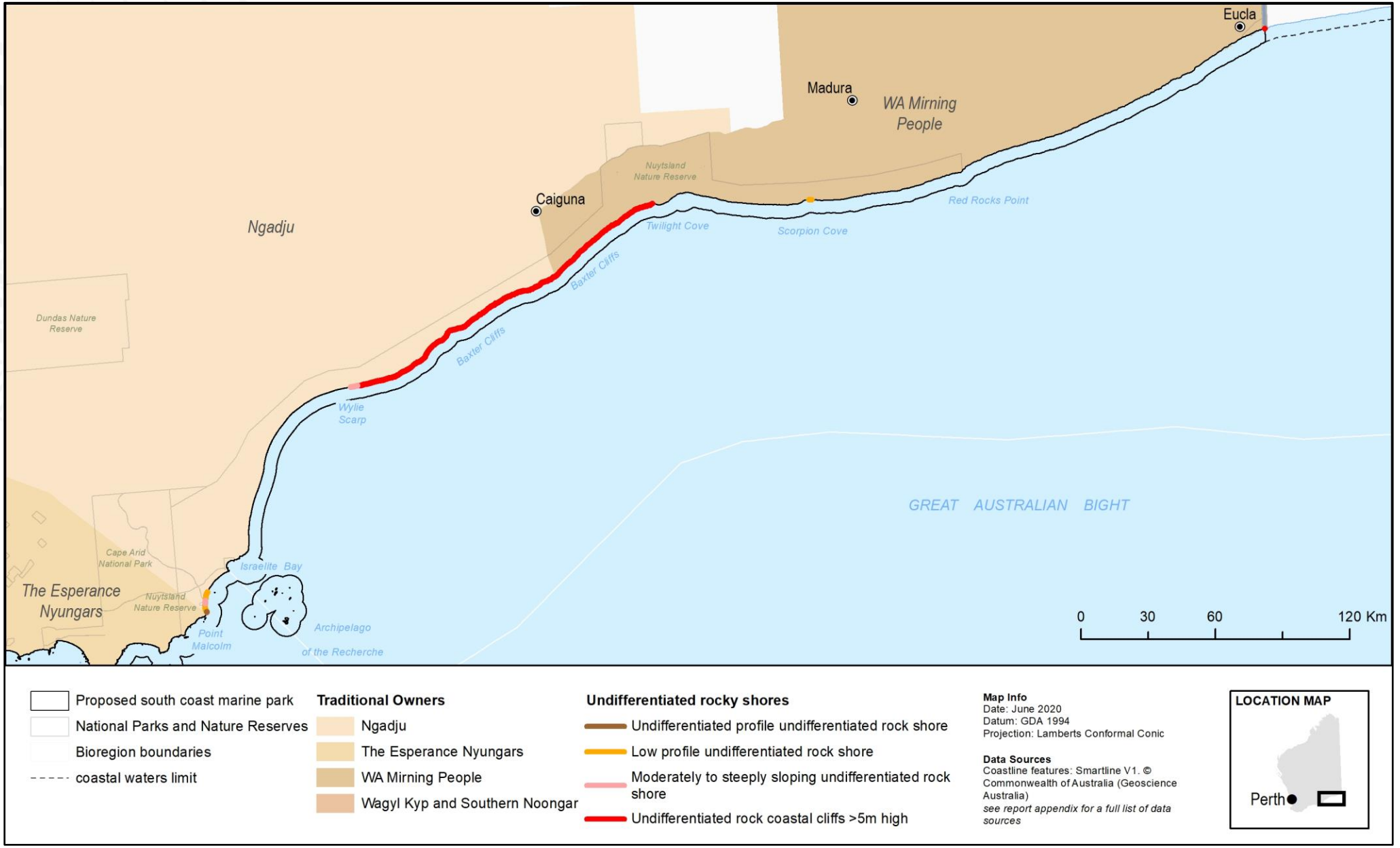


*Figure 9. Undifferentiated rock shorelines in the proposed south coast marine park*

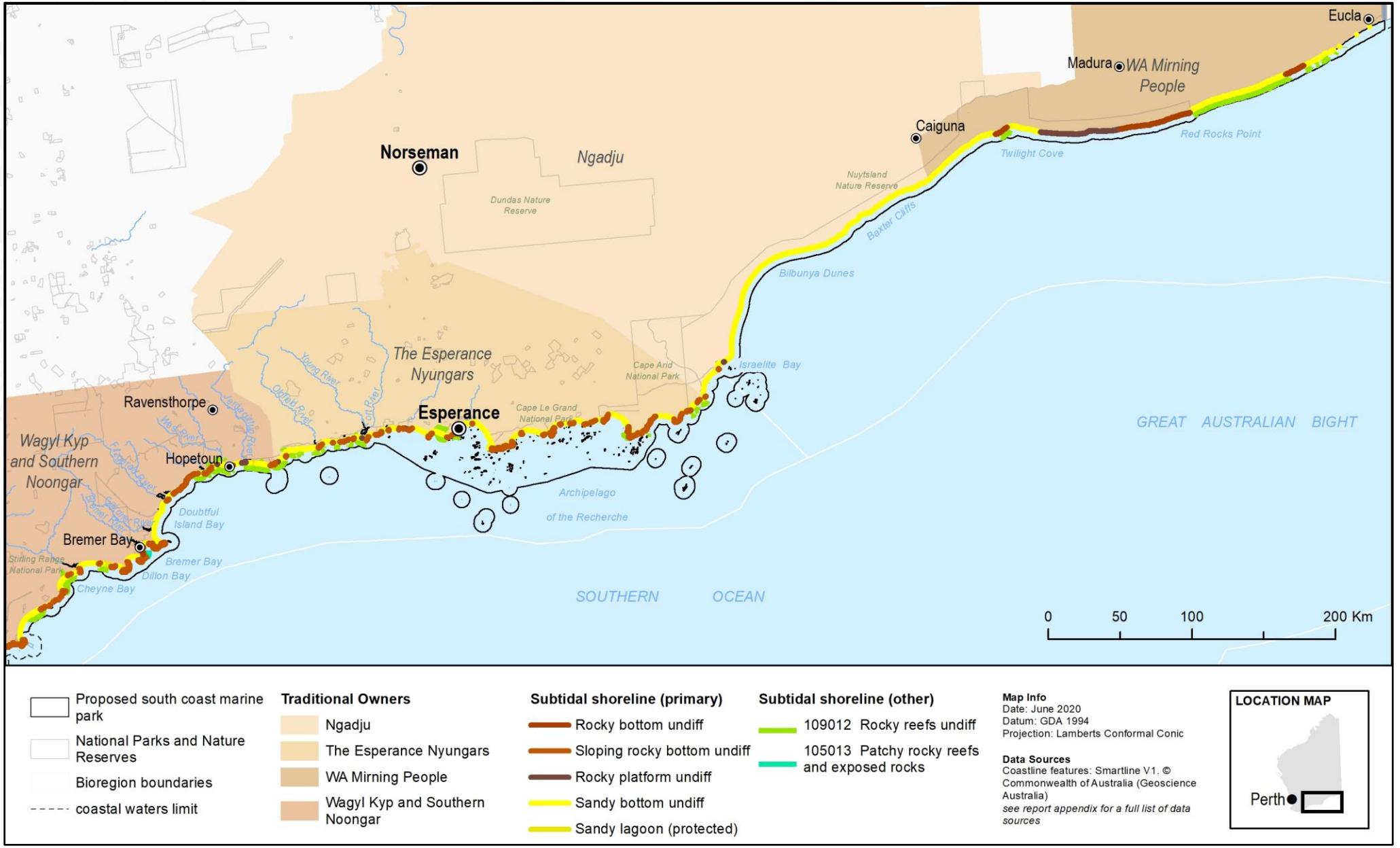


*Figure 10. Subtidal landforms in the proposed south coast marine park*

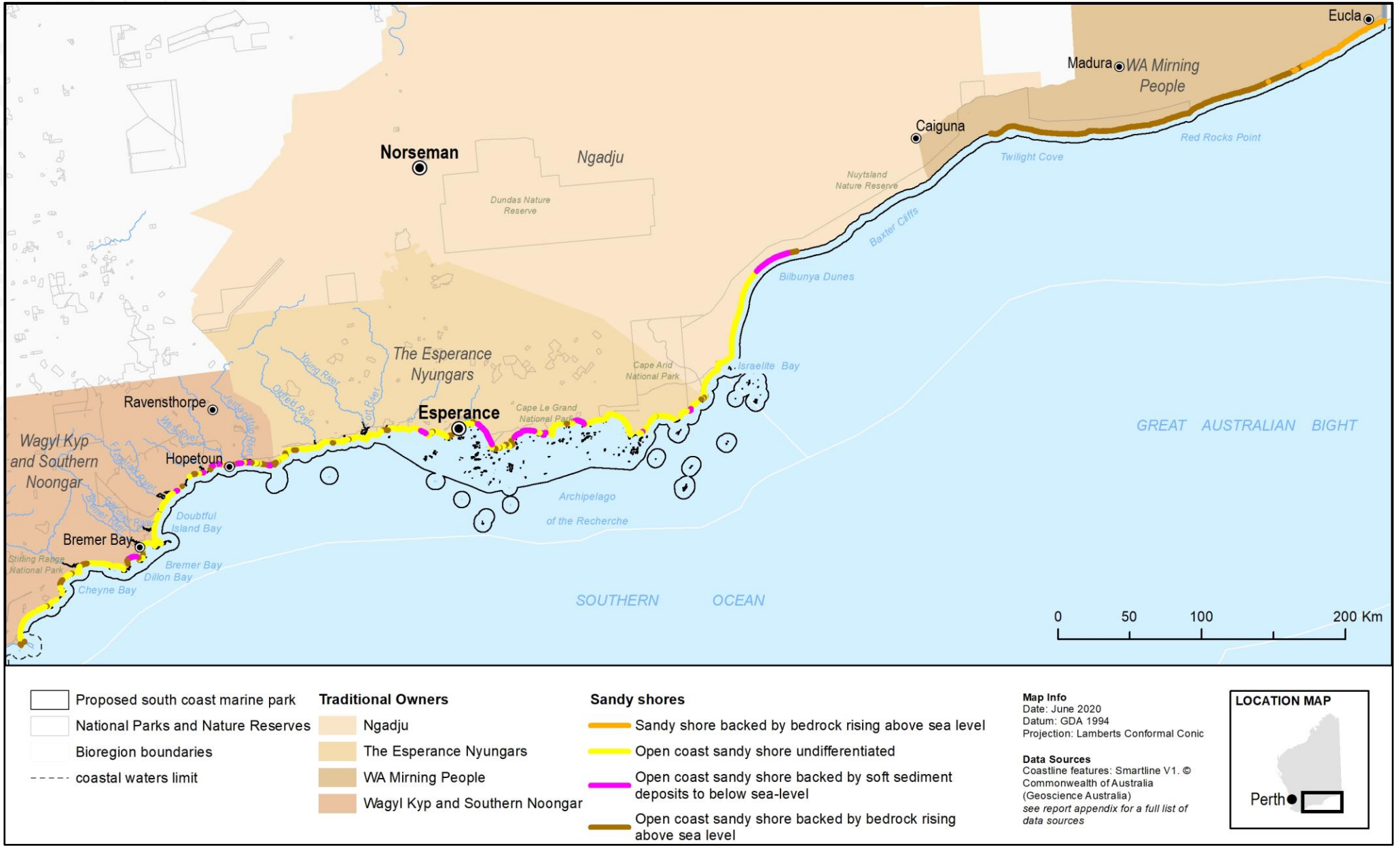


*Figure 11. Sandy shorelines in the proposed south coast marine park*

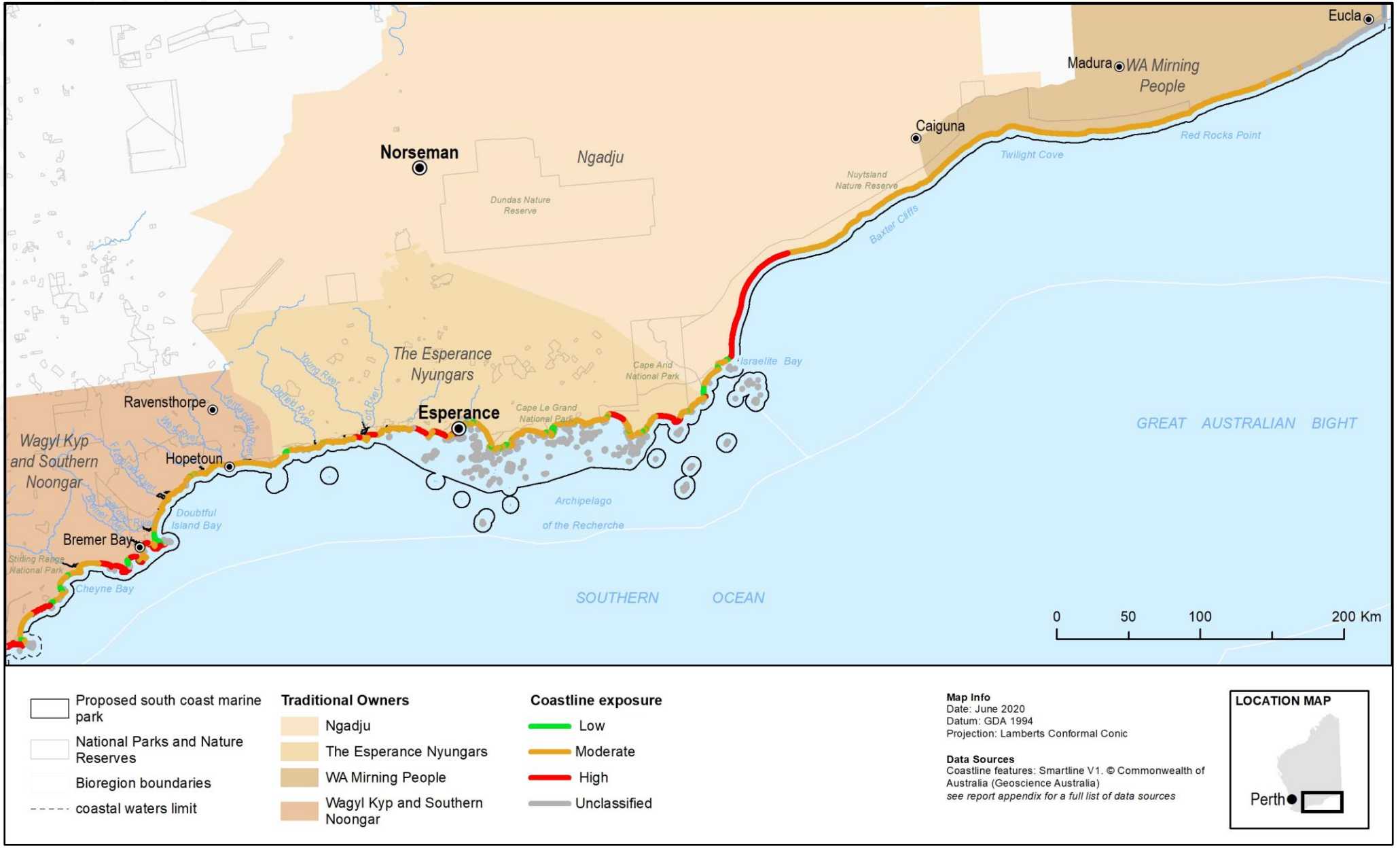


*Figure 12. Coastline exposures (low, medium, high) in the proposed south coast marine park*

## 3.6 Geomorphic features

As on land, geomorphic features (the seabed forms) are critical for understanding the distribution and diversity of marine biota, particularly where biological sampling has been limited, as is the case for the south coast [39]. The available geomorphic data for the south coast is coarse (with a 250 metre spatial resolution) so it only shows large features. Important habitats such as reefs are poorly captured in this data.

The WA South Coast bioregion has a fairly narrow continental shelf, mostly 25–65 km wide, with diverse geomorphic features (typically of rock), while the Eucla bioregion has a broad, rather flat shelf, exceeding 200 km at its widest, and fewer features [39]. The waters in the proposed marine park are mostly shallow (see Figure 13). They average 40 metres depth in the Recherche Archipelago [40]. Much of the seafloor is covered in carbonate sediments, which are the remains of marine animals – mainly bryozoans, molluscs, sponges, coralline algae, and benthic foraminifers. Australia's southern shelf is the largest area of cool-water carbonate sedimentation in the world [8].

Across the entire WA South Coast bioregion, only 6% of shelf habitat occurs within a marine park. The proposed park would encompass 79% of the shelf habitat of this bioregion in Western Australian waters. Across the Eucla bioregion, 14% of the shelf occurs within marine parks, and the proposed park would encompass an additional 2% (see Table 5).

Mapped features in the WA South Coast bioregion encompassed by the proposed marine park include the following:

*Pinnacles*: 7 (of 8 in Western Australian waters and 21 in the bioregion) clustered in the south-western Recherche Archipelago (Giant Rocks, 2 at Moby Dick, Middle Rock, Termination Island, Brown Reef and just north of Brown Reef).

*Reefs (broadscale)*: 1 (of 4 in Western Australian waters and 5 in the bioregion) surrounding Termination and Little islands and extending north to encompass Brown Reef. This is the largest boardscale reef mapped in the bioregion (71 $km^2$).

*Reefs (intertidal or shallow subtidal)*: 43 (of 48 in Western Australian waters and 52 in the bioregion) scattered throughout the Recherche with concentrations around Twin Peak Islands, and along the coastline west of Esperance between Stokes Inlet and Hopetoun, mainly around the rocky headlands. These reefs have been mapped because they are visually prominent or a hazard to shipping.

*Banks or shoals*: 4 (of 4 in the entire bioregion) in the western Recherche, inshore of Twin Rocks (the largest), and around the west group Islands and Investigator Island.

Mapped features in the Eucla bioregion encompassed by the proposed marine park include the following:

*Terraces*: 8% of Roe Terrace, a large feature extending from west of Twilight Cove almost to the Head of Bight in South Australia. Terraces in the Great Australian Bight are thought to

correspond to a former shelf formed from sediments eroded from the eastern Australian highlands [39]. Roe Terrace supports important rhodolith habitats.

*Reefs (intertidal or shallow subtidal)*:11 (of 13 in the entire bioregion), in a small area west of Eucla adjacent to the Roe Plain (just east of Low Point). These reefs have been mapped because they are visually prominent or a hazard to shipping.

*Table 5. Geomorphic features in the proposed south coast marine park (type, number, percentage area and existing protection)*

| Bioregion | Geomorphic feature | Number (WA waters) | Proposed marine park (%) | | | | | Existing sanctuary protection (%) | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Sea country area | | | | Total | WA waters | Australian waters |
| | | | Esperance Nyungars | Ngadju | Wagyl Kyp & Southern Noongar | WA Mirning | | | |
| Eucla | Shelf | 1 | – | 86 | – | 14 | 100 | 0 | 14 |
| Eucla | Terrace | 1 | – | 0 | – | 100 | 100 | 0 | 5 |
| WA South Coast | Bank/shoal | 4 | 100 | 0 | 0 | – | 100 | 0 | 0 |
| WA South Coast | Pinnacle | 8 | 59 | 0 | 0 | – | 59 | 0 | 0 |
| WA South Coast | Reef | 4 | 52 | 0 | 0 | – | 52 | 0 | 22 |
| WA South Coast | Shelf | 1 | 61 | 3 | 15 | – | 79 | 0 | 6 |

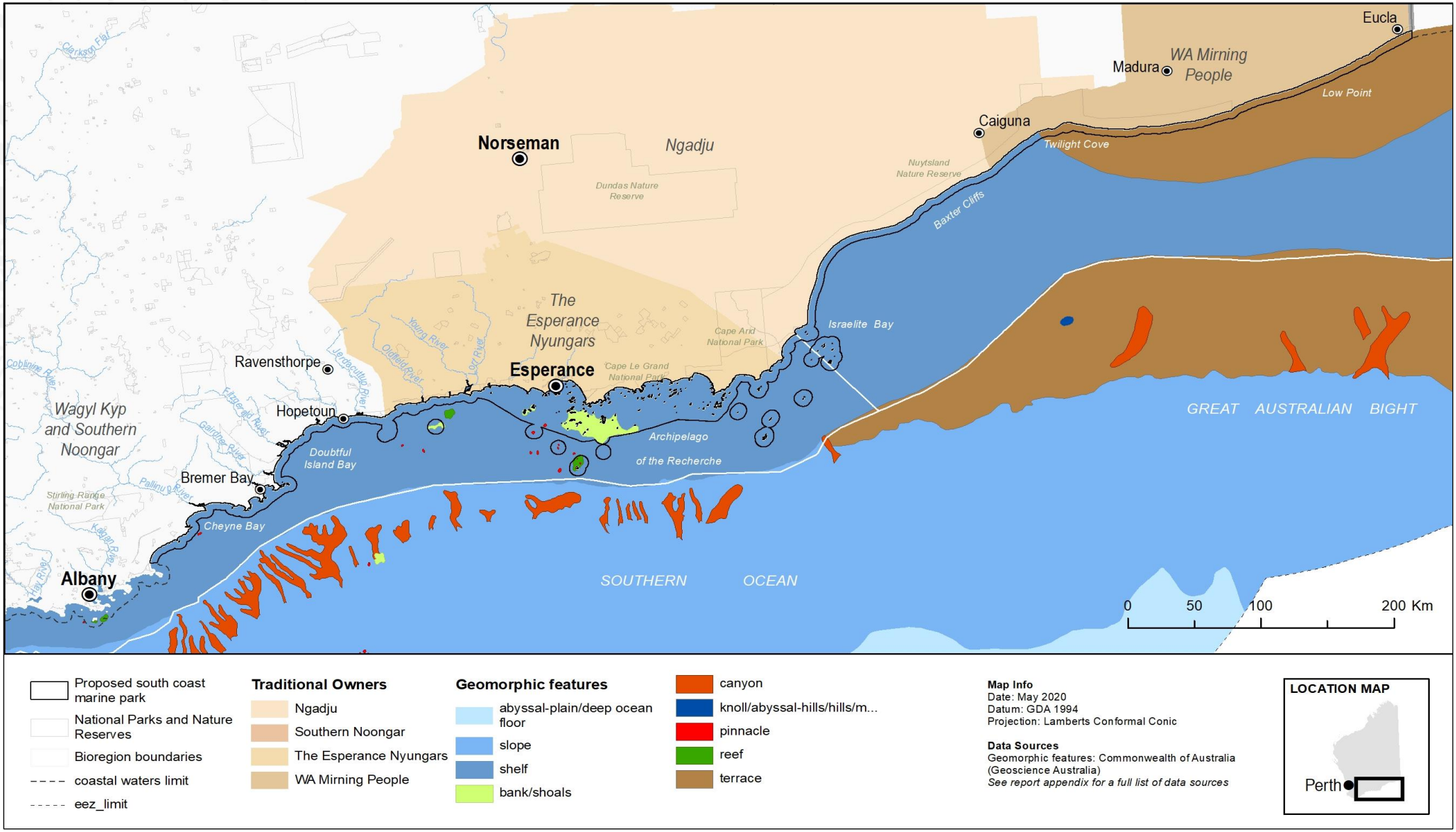


*Figure 13. Geomorphic features in the proposed south coast marine park*

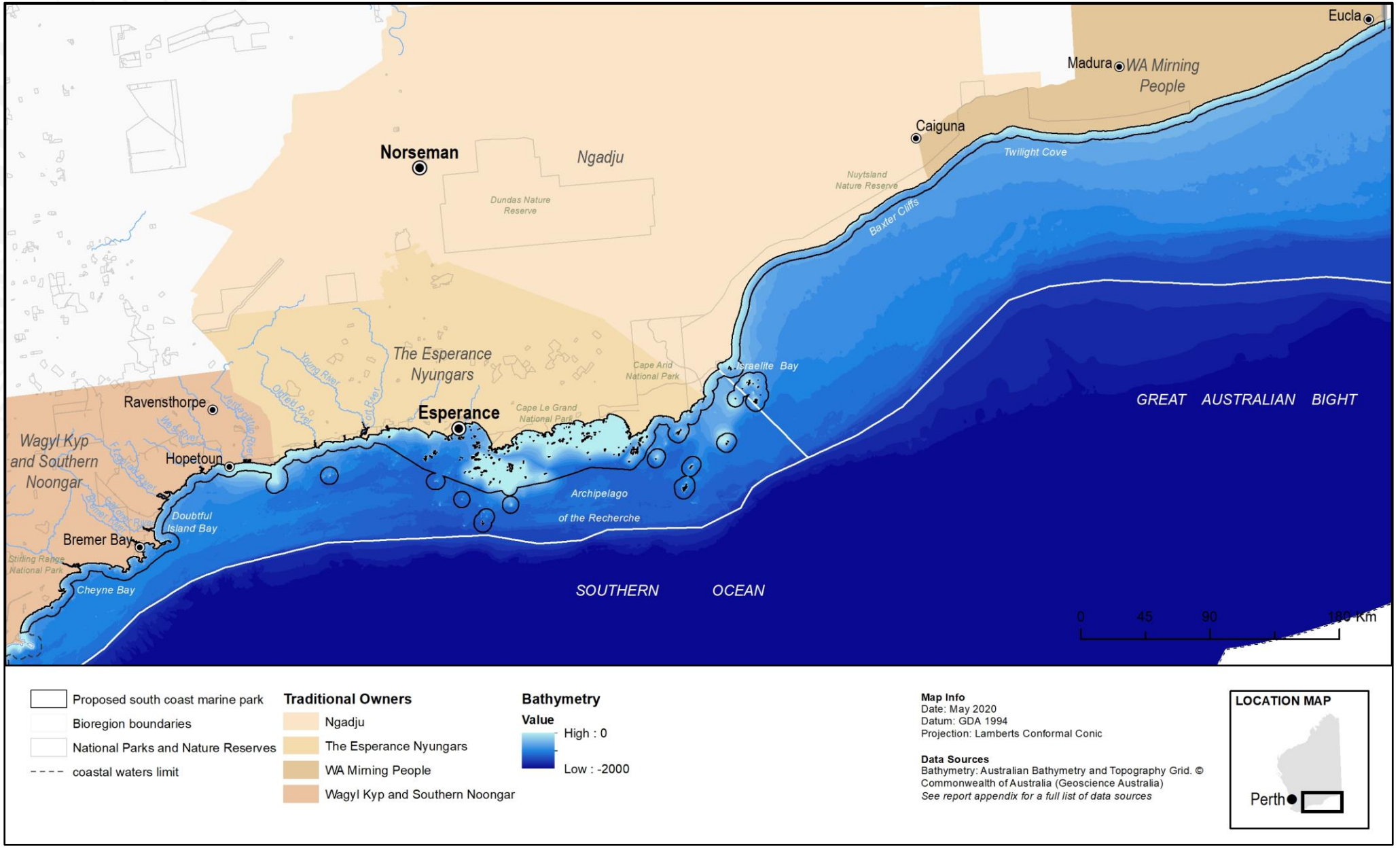


*Figure 14. The bathymetry of the proposed south coast marine park*

## 3.7 Recherche Archipelago habitats

The Recherche Archipelago – encompassing 105 islands and more than 1500 islets – is known to have outstanding conservation values. A major reason for this is the diversity of habitats it offers, including seagrass meadows, kelp-seaweed beds, rhodolith beds, bare reefs, gravel/rubble, mobile sand and pelagic habitats (see Figure 15).

Even with the islands and headlands offering some protection, this is a highly exposed and high-energy coast [6]. The width of the continental shelf ranges from 50 to 300 kilometres and the seafloor depth averages 40 metres. Some of the outer islands rise from depths of 80 metres or more.

Commonwealth marine parks encompass parts of the Recherche, but generally only deeper waters, with most habitats having little or no protection. In the eastern part, in the Eucla bioregion, 57% of pelagic habitat but only 3% of mobile sand (subtidal) and seagrass habitats are protected in sanctuaries. The proposed marine park encompasses all remaining habitats. In the Eucla bioregion habitat types and key locations include the following:

*Macroalgal beds (subtidal)*: Islands of the Eastern Group, particularly large areas around Daw island and the northern islands.

*Bare reefs (subtidal)*: Israelite Bay and directly offshore.

*Seagrass meadows*: 13 km south-east of Israelite Bay and offshore from Point Lorenzen (eastern Israelite Bay).

In the western Recherche encompassed by the WA South Coast bioregion, only 5% of pelagic and 1% of mobile sand (subtidal) habitats are protected in sanctuaries. The proposed marine park encompasses all remaining habitats. Habitat types and key locations in the WA South Coast bioregion include the following:

*Silt habitats*: Stokes Inlet (98%)

*Macroalgal beds (subtidal)*: Alexander Bay to Taylor Island (high relief, the largest mapped patch, 25 $km^2$, 14% of the total), around Middle Island (low relief), central and western Esperance Bay (high relief), Sandy Bight.

*Seagrass meadows*: Duke of Orleans Bay to Alexander Bay and south to Mart Islands (the largest continuous patch, >20% total seagrass area), between Twin Peak Island and Taylor Island, surrounding the Barrier Islands, south-east and northern Esperance Bay (88$km^2$, 25% of total mapped seagrass area).

*Gravel/rubble habitats*: below Cape Le Grand National Park, between Hastings and Mondrain islands (88% of the total mapped habitat area).

*Bare reefs (subtidal)*: Cape Arid to Israelite Bay

*Bare reefs (intertidal)*: east of Station Island (24% of total mapped habitat area), rocks south of the Mart Islands.

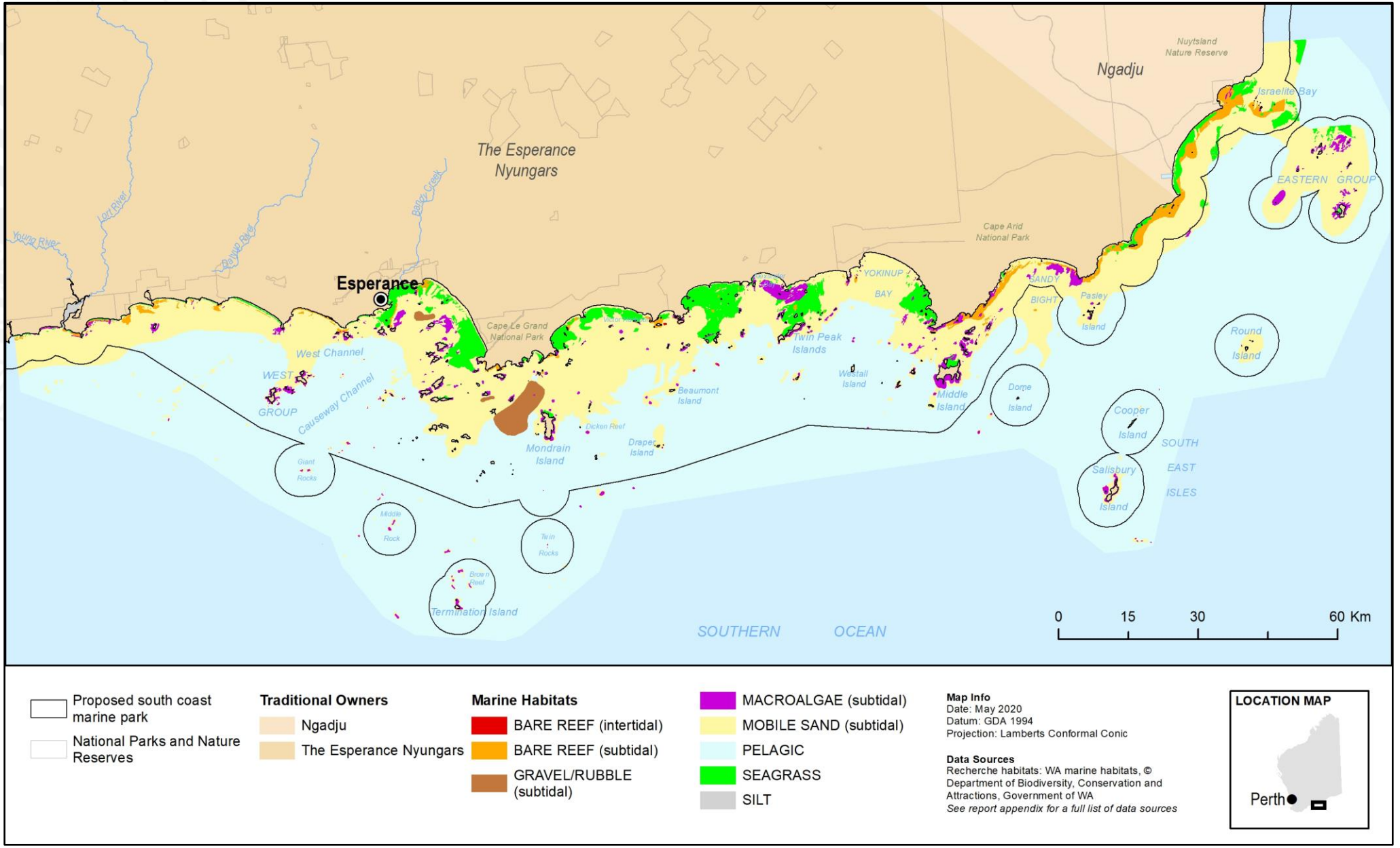


*Figure 15. Major marine habitats of the Recherche Archipelago*

## 3.8 Implications of the proposed marine park

Crafted by contrasting geologies (granite, gneiss and limestone), diverse landforms (including cliffs, islands and reefs), varying levels of exposure to wind and waves, and a great variety of habitat-forming species (seagrasses, kelps and rhodoliths), the habitats of the south coast are outstandingly diverse – one of the major reasons for the richness and uniqueness of its species.

This habitat diversity is evident at all scales. For example, the structure and composition of seaweed communities – 'heterogeneous to the extreme' – vary greatly even at a local level due to the variety of reef formations at different depths and kelp canopies ranging from sparse or patchy to dense (depending on wave intensity) [13,24].

To achieve a comprehensive, adequate and representative marine park therefore requires careful design to ensure that all habitat types are adequately represented in sanctuary zones. This is particularly important for fostering resilience to climate change in sensitive habitats. Recommendations for designing resilient marine parks include protecting areas that span natural biophysical gradients and ecological processes, and habitats sensitive to climate-driven changes [41]. It requires risk-spreading measures such as protecting at least 3 examples of each habitat type and spreading replicates to limit their risk of being affected by the same disturbance event [42].

Table 6 is a compilation of some high-priority areas for important habitat types or features in the proposed marine park based on the preceding analysis. Because of inadequate surveys for some habitats, particularly outside the Recherche Archipelago and particularly for macroalgae (kelp–seaweed beds and rhodolith beds), there are undoubtedly additional important habitat areas. Although there is a strong bias in the availability of data towards the Recherche Archipelago, this area is clearly outstanding for its diversity of habitats and the extent of vegetated habitats. The lack of detailed knowledge of the distribution of kelp–seaweed beds is a particular concern given their demonstrated vulnerability to climate warming.

*Table 6. Important locations for habitat types or features in the proposed south coast marine park*

| Habitat type | WA South Coast bioregion | Eucla bioregion |
|---|---|---|
| Seagrass meadows | Recherche Archipelago – Duke of Orleans Bay to Alexander Bay and south to Mart Islands | Eucla area |
| | Recherche Archipelago– between Twin Peak Island and Taylor Island, around the Barrier Islands | Scorpion Bight to Kanidal Beach |
| | Esperance Bay and Esperance to Bremer Bay coastline | Bilbunya beach (between Wattle Creek and the Bilbunya dunes) |
| | Doubtful Islands Bay | Israelite Bay |
| | Wray Bay and Cheyne Bay (west of Bremer Bay) | Recherche Archipelago, around the eastern group islands |

| Habitat type | WA South Coast bioregion | Eucla bioregion |
|---|---|---|
| Seaweed–kelp beds (Recherche only) | Alexander Bay to Taylor Island | Eastern group of islands – Daw Island, northern islands |
| | Around Middle Island | |
| | Sandy Bight | |
| | Central and western Esperance Bay | |
| Other rocky reefs (potential macroalgae habitats) | Esperance to Hopetoun (mainly around rocky headlands) | Adjacent to the Roe Plain |
| | | Twilight Cove to the border |
| Rhodolith beds | Esperance Bay | Potentially extensive on the Roe Terrace, but locations not mapped |
| | Western Recherche Archipelago between the islands and open waters | |
| Estuaries | Jerdacuttup Lakes – the only barrier estuary in the proposed park | No estuaries |
| | Fitzgerald Inlet – the only 'largely unmodified' estuary in the proposed park and with extensive areas of saltmarsh (a threatened ecological community). Inlets adjoining Fitzgerald River National Park account for 43% of estuaries in the proposed park | |
| | Stokes Inlet – contains at least 20% of 3 estuarine habitats in the proposed park: rocky reefs, intertidal flats, channels | |
| | Wellstead Estuary and Gordon Inlet – the largest areas of saltmarsh habitat (a threatened ecological community) in the proposed park | |
| Pinnacles | South-western Recherche Archipelago (7 pinnacles) | No pinnacles |
| Large reefs | Recherche Archipelago – Twin Peaks | Adjacent to the Roe Plain (11 reefs) |
| | Stokes Inlet to Hopetoun | |
| Banks / shoals | Western Recherche Archipelago (4) | No banks or shoals |
| Terraces | No terraces | Roe Terrace |

## RECOMMENDATIONS

Provided that the Traditional Owners of the south coast regard a jointly-managed marine park as desirable in their sea countries, we recommend that the government works with stakeholders and local communities to:

- Consistent with best-practice marine park design principles, ensure that representative areas of all habitat types are protected in sanctuaries that span natural biophysical gradients and ecological processes, with replicates spread to maximise resilience. Aim for a high (science-based) level of sanctuary protection of important habitats such as seagrass meadows, kelp forests and rhodolith beds within each bioregion.

- In recognition of the high structural and species diversity of kelp–seaweed beds at local to regional scales, the lack of detailed knowledge of their distribution, and their vulnerability to climate warming, provide a high (science-based) level of protection in sanctuaries.

# 4 SIGNIFICANT SPECIES OF THE SOUTH COAST

Australia's southern coast has outstanding conservation significance for the uniqueness and diversity (particularly for a temperate region) of its marine life [43]. But it is poorly studied and much of the biodiversity has yet to be documented [44,45].

The majority of south coast species are thought to be unique to the region and many are local endemics [1]. Groups rich in endemic species include seaweeds, seagrasses, fishes, sponges, molluscs, crustaceans, echinoderms and ascidians [43]. Some are relicts of ancient lineages. For example, the snail *Diastoma melanioides*, which carries a turreted shell of convex whorls and lives in seagrass beds from east of Albany to Streaky Bay, is the sole survivor of a family (Diastomatidae) that was common in the Tethys Sea during the Eocene (34–56 million years ago) [46]. Another lone survivor is the giant creeper (*Campanile symbolicum*), which lives on algal reefs along the south-west coast, and is also from a family of snails that thrived in the Tethys Sea during the Eocene [47]. Some snails in that lineage were more than a metre long. Many endemic south coast species have their origins in the Tethys Sea.

Following are brief profiles of a few south coast species of high conservation significance, mostly because they are threatened, at state, national or international levels. Several are also regarded as south coast icons and are important for cultural, recreational or economic reasons. Where data are available, breeding sites and 'biologically important areas' (BIAs) have been mapped. A BIA is an area particularly important for the conservation of a species and where aggregations engage in biologically important behaviour such as breeding, foraging, resting or migration [48].

## 4.1 Mammals

### AUSTRALIAN SEA LION

#### *Conservation status*

| Species | WA status | National status | International status |
|---|---|---|---|
| *Neophoca cinerea* | Vulnerable | Endangered[A] | Endangered[B] |

*Notes: A. Listed in late 2020. B. Assessed by the IUCN in 2015.*

The Australian sea lion is Australia's only endemic pinniped (seals and close relatives) and the only species in its genus. It lives only off the southern coasts of Western Australia and South Australia, with breeding colonies from the Houtman Abrolhos Islands in the west to Kangaroo Island in the east. It is likely to have once also bred in Bass Strait [49].

This sea lion was hunted almost to extinction from the late 1700s to early 1900s. Its population has been slow to recover, with an estimated 6500 mature animals in 2015 [50]. A 2020 assessment found the national population has declined in recent times, dropping by more than 60% over the previous 3 generations (42 years). This was based on pup production in monitored colonies (accounting for more than three quarters of the population), which has dropped from about 6700 pups in 1977 to 2600 in 2019 [51].

### *Vulnerabilities and pressures*

With slow maturation, long breeding cycles (about 18 months), small colonies and natal philopatry (female loyalty to their birth colonies), Australian sea lions are highly vulnerable to decline from low levels of imposed mortality and slow to recover from decline [50]. Because of the loyalty of females to their birth colony and limited dispersal of males between breeding colonies (up to 200 km), the loss of only a few sea lions each year could lead to the extinction of small colonies, reducing genetic diversity and genetic flow between colonies [49]. Of 80 sites where breeding has been recorded (32 in Western Australia and 48 in South Australia), only 28 (and only 6 in Western Australia) produce more than 30 pups a breeding season [51]. The extreme philopatry of females means that most breeding sites are 'effectively closed subpopulations' [51] and that the species is unlikely to recolonise former habitats or expand its range in the near future.

The greatest threat to sea lions is fishing – mainly accidental capture in gillnets – and entanglement in marine debris [49,50]. Other likely or potential threats include interactions with rock lobster traps (largely mitigated now by sea lion excluder devices), habitat degradation, interactions with aquaculture operations, human disturbance to colonies, deliberate killings, disease, pollution and oil spills, prey depletion and climate change (eg by submersion of low-lying breeding sites or if seagrass meadows are affected) [49].

Sea lions forage over a large proportion of southern shelf waters, overlapping extensively with gillnet shark fisheries. They target prey at or near the seafloor and may also be drawn to feed on fish and small sharks in gillnets, so it is not surprising that they regularly become entangled and drown in these nets [52]. The numbers reported or observed captured are probably only a fraction of those killed, for many drop out of the nets as they are hauled onto the boat and some escape only to die later of injuries [52]. Modelling of population trajectories in Western Australia showed that in nearly all scenarios 'the addition of any ongoing incidental mortality resulted in population decline and increased the risk of extinction' [53].

### *Significance of south coast waters*

The south coast makes up about 80% of the 'known to occur' sea lion habitat in Western Australia and has 17 known breeding sites (21% of the national total, 53% of Western Australian sites) [51]. However, only 20 sites in Western Australia produce more than 5 pups and are thus classified as 'breeding colonies' and considered as 'habitat critical to the survival of the species' [49]. Fourteen of these occur on the south coast – in the Recherche Archipelago and Bremer Bay regions – all encompassed by the proposed marine park (see Figure 16). About 300 pups are produced per season on the south coast, 12% of the Australian total, 63% of the Western Australian total [51]. The

largest colonies on the south coast are on Spindle, Six Mile and Kimberley islands in the Recherche Archipelago. There are also 6 known haul-out sites in the proposed park (Figure 16).

Two-thirds (67%) of the area mapped as biologically important for sea lion foraging in Western Australia would be encompassed by the proposed marine park – from the eastern Recherche Archipelago to the western boundary of the proposed park and in the Great Australian Bight region (Figure 16). The existing protection for this foraging habitat is fragmentary: 17% is in a marine park, but none has sanctuary protection (Table 7). Less than half of this area on the south coast is protected by gillnet fishing closures – they apply to 48% of the mapped male and female foraging areas and 33% of the male-only foraging areas.

The main threat to sea lions in the proposed marine park area is gillnet fishing in the Joint Authority Southern Demersal Gillnet and Demersal Longline Managed Fishery (targeting mainly gummy and dusky sharks) [50]. In 2018 the Western Australian Government created 33 gillnet exclusion zones around pupping colonies, with a radius of 6–33 km [54]. It is too early to tell how effective they are. However, the closures cover less than half the area mapped as biologically important for sea lion foraging on the south coast – 48% of mapped male and female foraging areas and 33% of foraging areas used only by males – so continuing deaths in gillnets are likely. Sea lions typically travel up to about 60 km from their colony on a foraging trip, and males travel considerably further [49]. Closures and other protection measures in South Australian waters, first applied in 2010, do not appear to have been effective in arresting the decline in pup production in monitored colonies [51]. Given the risks posed by gillnetting and the vulnerability of sea lions to very low levels of imposed mortality, protection should be considered for their entire foraging range in the proposed marine park.

*Table 7. The proportion of sea lion foraging grounds in the proposed south coast marine park (% Western Australian waters)*

| Important sea lion habitat | Proposed marine park (%) | | | | | Existing reserves (%) | |
|---|---|---|---|---|---|---|---|
| | Sea country areas | | | | South coast marine park | Marine parks | Sanctuaries |
| | Esperance Nyungars | Ngadju | Wagyl Kyp & Southern Noongar | WA Mirning | | | |
| Foraging (male & female) | 58 | 8 | 11 | 3 | 79 | 12 | 0 |
| Foraging (male) | 16 | 7 | 8 | 13 | 44 | 29 | 0 |
| Total | 43 | 8 | 10 | 6 | 67 | 17 | 0 |

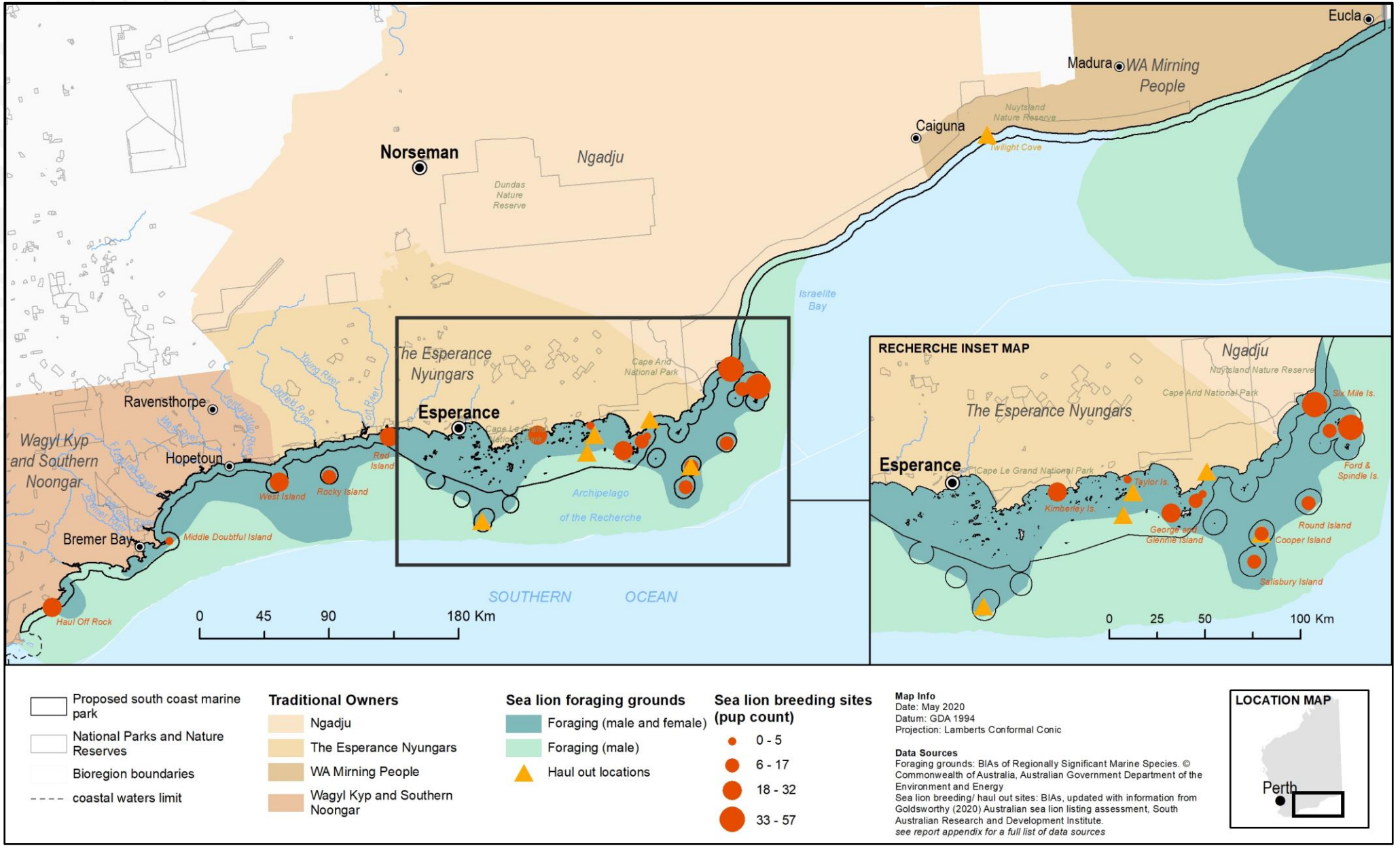


*Figure 16. Important habitat for Australian sea lions (breeding and haul-out sites and biologically important foraging areas) in the proposed south coast marine park*

## SOUTHERN RIGHT WHALE

### *Conservation status*

| Species | WA status | National status | International status |
|---|---|---|---|
| *Eubalaena australis* | Vulnerable | Endangered[A] | Least concern[B] |

*Notes: A. Assessed nationally prior to 1999. B. Assessed by the IUCN in 2018.*

Southern right whales were hunted almost to extinction in the 1800s, from an estimated 70,000 in the late 1700s to no more than about 300 in the 1920s [55]. Commercial hunting of the species was banned in the 1930s but illegal hunting continued until the early 1970s [55]. Southern Australia is one of 4 major calving areas for the species. The Australian population of about 3500 is a quarter of the estimated global population of 13,600 (in 2009) [55,56]. The genetically distinct western population (from Ceduna to Cape Leeuwin), numbering about 3200, comprises 90% of the Australian population [57]. It has been increasing at an annual rate of about 5.5% (close to the maximum possible). The eastern population has been recovering more slowly and numbers fewer than 300 [58].

### *Vulnerabilities and pressures*

The life history of southern right whales is poorly known. With a long life expectancy – thought to be more than 50 years and perhaps more than 100 – and giving birth to a single calf only every 3 years, they are likely to be susceptible to population decline from low levels of imposed mortality [59].

Southern right whales make long annual migrations between their coastal winter nursery grounds and offshore high-latitude summer feeding grounds. Calves appear to learn these sites and routes from their mother. If followed faithfully for life, it would explain why southern right whales have not returned to many parts of their historic range. If this site fidelity is strongly maintained over many generations, it could limit their potential to shift to new summer feeding areas if krill availability is reduced under climate change [60]. Reproductive failures in Argentina have been correlated with periods of low krill abundance and sea surface temperature anomalies at South Georgia [61]. It appears that 'even quite small changes in oceanographic conditions in the Southern Ocean could affect southern right whale population dynamics' [61]. Thus, climate variability and change is potentially a very high risk due to reduced ocean productivity and altered prey availability [56].

Other threats in Australian waters are entanglement in commercial fishery gear and marine debris, and vessel collision and behaviour disruption [56]. Southern right whales appear to be the main whale species hit by vessels in the southern hemisphere.

### *Significance of south coast waters*

The south coast is a nursery area for southern right whales from May to October each year, with calving usually occurring in waters less than 10 metres deep. Warm water from the Leeuwin Current may be important, since the young are born with little insulation [62]. The entire area of the proposed

marine park is classified as a biologically important area for the species (Figure 17, Table 8). It encompasses 2 of Australia's 3 calving hotspots and 89% of their area – in and around Doubtful Island Bay and Israelite Bay. It also includes several smaller aggregation and calving areas, which are important as potential areas for expansion of habitat occupancy and for maintaining genetic diversity. Overall, the proposed park would encompass 57% of calving habitat in Western Australian waters. Currently, just 7% of this habitat in Australia is protected in sanctuaries, and less than 1% in Western Australia. Protection of connecting habitat along the coast is also important, for its use on migration and as future calving habitats.

*Table 8. The proportion of biologically important calving areas for southern right whales in the proposed south coast marine park (% Western Australian waters)*

| Important habitat | Proposed marine park (%) | | | | | Existing reserves (%) | |
|---|---|---|---|---|---|---|---|
| | Sea country areas | | | | South coast marine park | Marine parks | Sanctuaries |
| | Esperance Nyungars | Ngadju | Wagyl Kyp & Southern Noongar | WA Mirning | | | |
| Calving (high numbers) | 0 | 67 | 33 | 0 | 100 | 0 | 0 |
| Seasonal calving habitat | 21 | 7 | 13 | 16 | 57 | 10 | <0.1 |
| Calving buffer | 37 | 9 | 9 | 10 | 65 | 7 | <0.1 |
| Total | 34 | 9 | 10 | 11 | 64 | 36 | <0.1 |

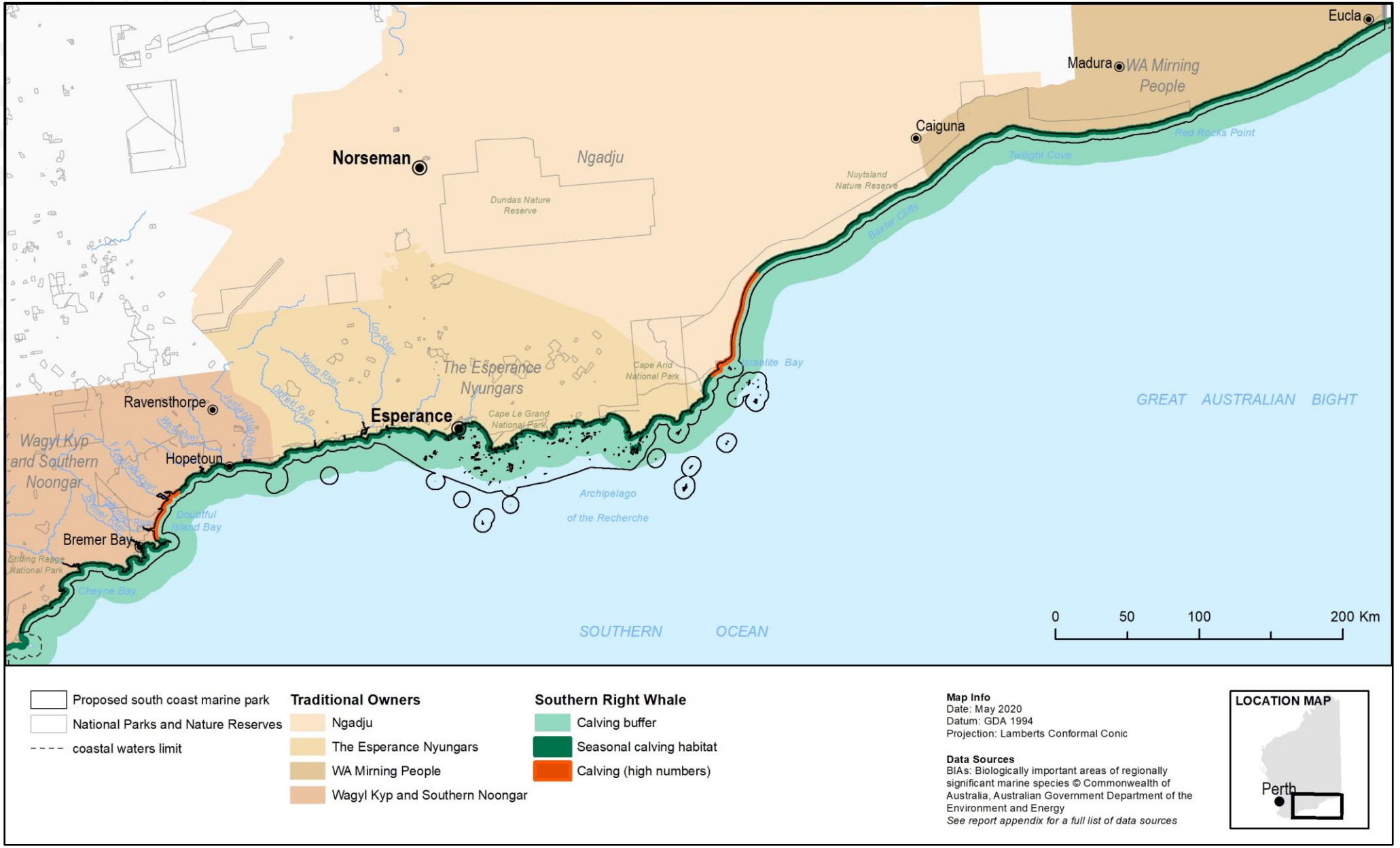


*Figure 17. Important calving areas for southern right whales in the proposed south coast marine park*

## HUMPBACK WHALE

### *Conservation status*

| Species | WA status | National status | International status |
|---|---|---|---|
| *Megaptera novaeangliae* | Conservation dependent | Vulnerable[A] | Least concern[B] |

*Notes: A. Assessed nationally prior to 1999 and currently being considered for reassessment [63]; B. assessed by the IUCN in 2018.*

Humpback whales are found in all the major ocean basins. Most migrate between mating and calving grounds in tropical coastal waters and high latitude feeding areas [64]. The estimated global population is 135,000 [64]. Many populations are now recovering well from intensive hunting during the 20th century. More than 220,000 were killed in the southern hemisphere and the Australian population was reduced to a few hundred animals [63,64].

Humpback whales migrate along Australia's east and west coast from May to November each year for calving on the north-west and north-east coasts [63]. These populations have been increasing at a rate of 10%–13% each year (at or close to the maximum possible) and now number well over half of their pre-whaling abundance, with a western population of more than 20,000 and an eastern population of more than 15,000 [63,65]. This recovery is a major conservation success.

### *Vulnerabilities and pressures*

Threats or potential threats include entanglement in fishing gear and marine debris, vessel strike, anthropogenic noise (eg seismic exploration, industrial noise, shipping and sonar systems), and climate change [63,64]. Humpback whales are among the most vulnerable of the large whales to becoming entangled, often fatally, in fishing gear and debris [64]. Increased reports of entanglements in Australian waters have coincided with an increase in humpback whale populations. Climate change could lead to many impacts. For example, ocean acidification compromises reproduction by Antarctic krill, which are the primary food of humpback whales.

### *Significance of south coast waters*

From May to November each year, Western Australia hosts the world's largest population of humpback whales [66]. Travelling from feeding grounds in Antarctic waters, they first reach the Australian coastline at around Esperance, where they turn west. The proposed marine park would encompass about 50% of the migration route between Esperance and Cape Leeuwin, mapped as a biologically important area, none of which is in a marine park (Figure 18). It's important to protect migrating whales from disturbances. Whether they can adapt their migratory routes to avoid such disturbances is unknown [63].

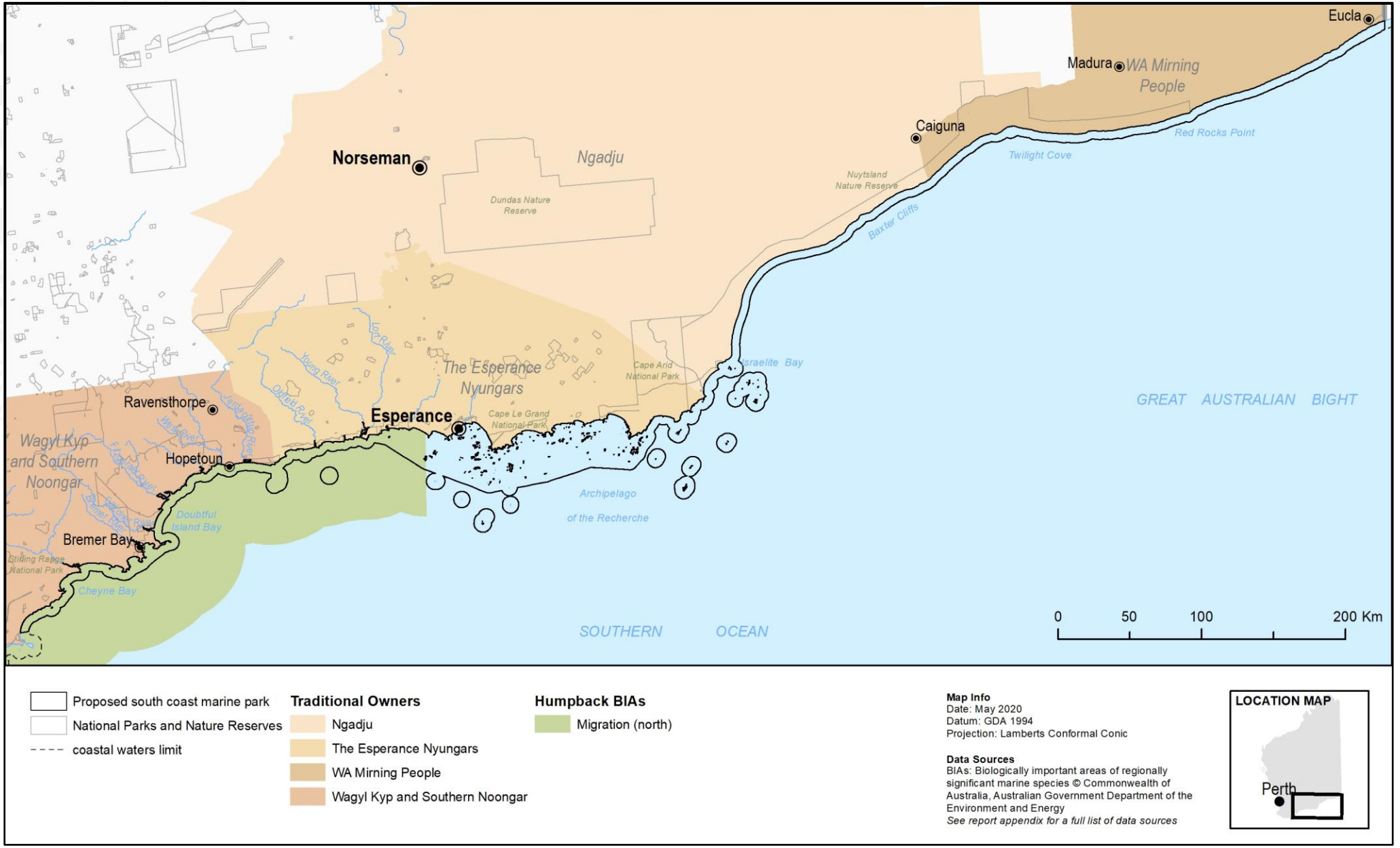


*Figure 18. Biologically important (northern migration) area for humpback whales in the proposed south coast marine park*

## LONG-NOSED FUR SEAL

### *Conservation status*

| Species | WA status | National status | International status |
|---|---|---|---|
| *Arctocephalus forsteri* | Specially protected | Not listed | Least concern[A] |

*Note: A. Assessed by the IUCN in 2015*

Long-nosed fur seals (also known as New Zealand fur seals) inhabit the waters of New Zealand, Australia and subantarctic islands [67]. In Australia, they occur in coastal waters and on offshore islands from the southwest corner to east of Kangaroo Island, and in southern Tasmania, Bass Strait, and Victorian and southern New South Wales. The species was hunted to near extinction in several locations in the 1700s and 1800s, including Western Australia [67,68]. There has been a strong recovery in numbers, and the global population is now an estimated 200,000, with about 120,000 in Australia [67]. The species is still considered threatened in NSW and Victoria, where colonies have only recently re-established, and rare in Tasmania.

### *Vulnerabilities and pressures*

Threats include illegal shooting, entanglement in fishing gear, human disturbance during the breeding season, oil spills and disease [50]. Fur seals are reported as occasional bycatch in the demersal gillnet fishery [68].

### *Significance of the south coast*

In 2011 the Western Australian population of long-nosed fur seals numbered about 17,000 (with 3500 pups), making up about 14% of the Australian population [67,68]. The abundance and density in Western Australia are mostly lower than in other parts of their range, probably reflecting a lower carrying capacity on the south coast due to lower prey densities in the low-nutrient waters [68].

Of 19 breeding colonies in Western Australia (those known in 2020), 14 are encompassed by the proposed marine park. Most (10) are in the Recherche Archipelago, where an additional 20 islands are used as haul-out sites (see Figure 19). The largest breeding sites in 2011 (with >200 pups) were Salisbury Island (1251 pups), Libke Island (340 pups), Cooper Island (306 pups), Haul Off Rock (285 pups) and Seal Rock (276 pups). Data for pup numbers are in Table 12 in Appendix A.

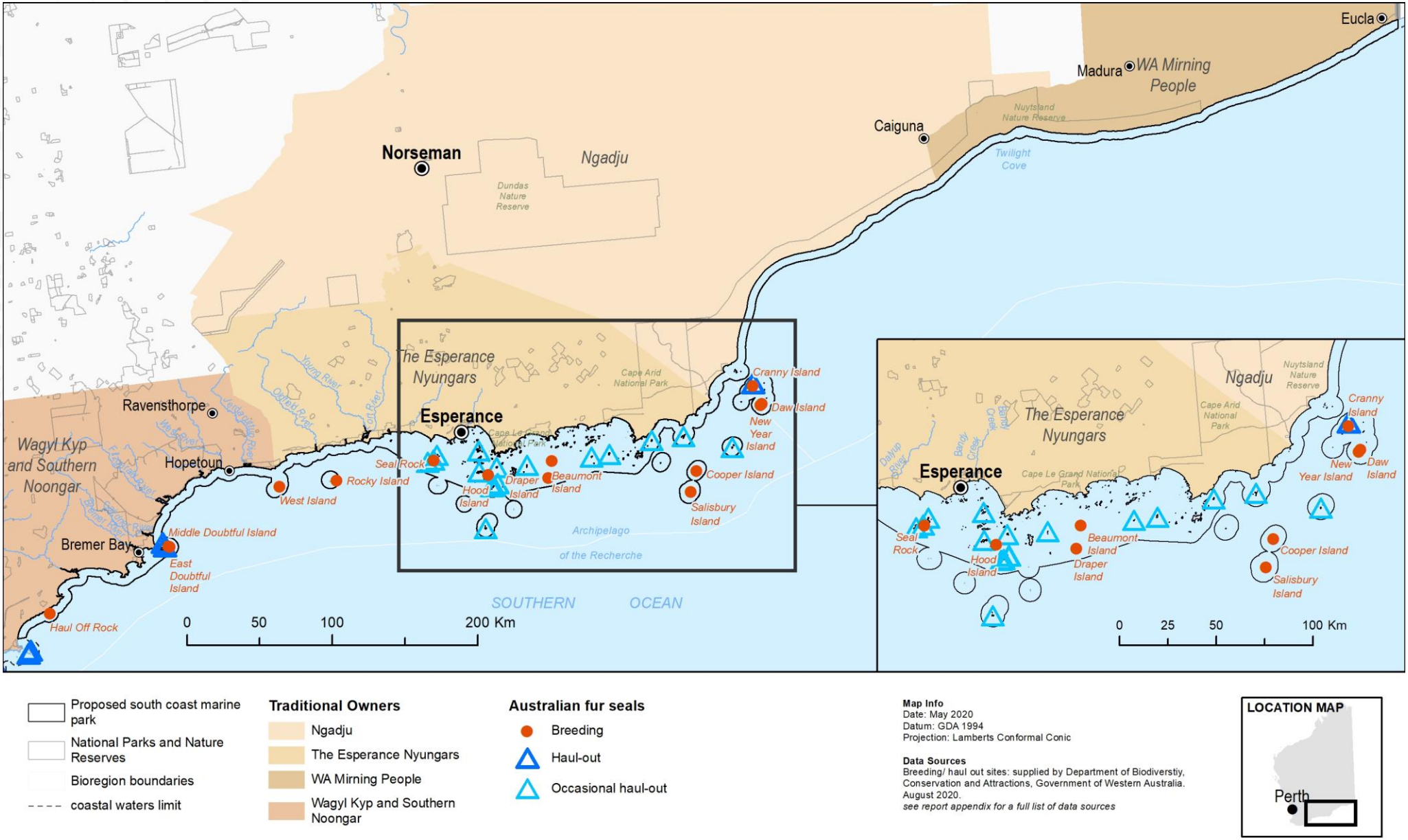


*Figure 19. Long-nosed fur seal breeding and haul-out sites in the proposed south coast marine park*

## 4.2 Fishes

The fish species in the proposed marine park are highly diverse, and many are unique to southern waters. In the Recherche Archipelago, for example, more than 170 species have been recorded on nearshore reefs, of which more than a quarter (28%) are endemic to the Recherche [30]. They are dominated by predators of molluscs, crustaceans and cephalopods inhabiting the seagrass and seaweed beds of the Recherche (in contrast to the prevalence of fish- and plankton-eaters in northern Australian coastal waters) [12]. Another common feature of south coast fish is that they are slow-growing and long-lived with low reproductive potential, and therefore inherently vulnerable to decline as targets or bycatch in fisheries [12]. This is the major threat to most species profiled here. There are no data available on their biologically important areas, except for the great white shark.

### GREAT WHITE SHARK

#### *Conservation status*

| Species | WA status | National status | International status |
|---|---|---|---|
| *Carcharodon carcharias* | Vulnerable | Vulnerable[A] | Vulnerable[B] |

*Notes: A. Assessed under the Commonwealth Endangered Species Protection Act in 1997. B. Assessed by the IUCN in 2019.*

The great white shark is found throughout most temperate and tropical oceans but most frequently in temperate waters. Populations globally are in decline [69]. Australia's population is likely to number between 1200 and 3300 adults [70]. A 2018 genetic analysis returned an estimate of 1460 (760–2250) adults in the genetically distinct south-western population (west of Bass Strait) and 750 (470–1030) in the eastern population (east coast, New Zealand and south-west Pacific Ocean) [70]. There is no evidence of population recovery since the species was first protected in Australia in 1997 [71]. Claims that the south-western population has grown is not borne out by modelling of likely population trajectories, with most scenarios predicting decline or an increase no greater than 10% since 1997 [72]. This is consistent with the 2018 genetic study, which indicated a stable or declining abundance in both populations [70]. Declines seem evident in the eastern population, with catch per unit effort in the Queensland beach program dropping by 92% over 5 decades (from 1962) [73].

#### *Vulnerabilities and pressures*

Being long-lived (probably 70 years or more, reaching maturity at >30 years) with a low reproductive potential (litter sizes of 2–17 and a suspected 2–3 year reproductive cycle), white sharks are vulnerable to decline from low imposed levels of mortality [69,72]. The south-western population is captured as bycatch in several fisheries, particularly in gillnet fisheries targeting sharks and scalefish [71,74]. The numbers captured are unknown (fisher reporting is unreliable), but have been estimated to range from 45–56 to 61–79 a year (under the lowest and highest catch scenarios), including 35 a year in Western Australia [74]. It is mandatory to release white sharks, but their

survivorship after release is uncertain [75]. Threats to the eastern population include shark control programs (mesh nets and baited drumlines along beaches) as well as incidental capture in commercial fisheries [71].

***Significance of south coast waters***

The proposed marine park is highly significant for great white sharks, mapped as a biologically important area for foraging or high use across most of its area (Table 9, Figure 18). This may be due in part to the presence of fur seals and sea lions, on which white sharks prey [76]. The proposed park encompasses 69% of the mapped foraging area in Western Australian waters (about 9% of Australia's total) and all of the mapped high-use habitat. The waters of the Great Australian Bight are the only mapped high-use area for great whites in Australia. There is very little sanctuary protection for important white shark habitats – just 7% across Australia and 0.2% in Western Australia.

No nursery areas have yet been identified for the south-western population [70]. Neonates have been captured as fisheries bycatch in the western Great Australian Bight, and pregnant females have been caught off the west coast of South Australia, suggesting that pupping may occur in or near the proposed park area [71]. Protecting pupping sites is important because white sharks return to their birth sites for breeding.

The main pressure on white sharks on the south coast is incidental capture in gillnets. Based on interviews of fishers, it has been estimated that 17–40 a year were captured from 2005 to 2012 in zone 2 of the fishery, which overlaps with the proposed marine park [75]. The number reported by the fishery in 2016–17 were 2 dead and 9 live white sharks. However, in interviews in 2013 of commercial shark fishers on the west and south coasts, 40% said that reported numbers were unreliable 'due to industry-wide concerns that reporting leads to future fishing restrictions or closures' [75].

*Table 9. The proportion of biologically important areas for great white sharks in the proposed south coast marine park (% Western Australian waters)*

| Biologically important area | Proposed marine park (%) | | | | | Existing reserves (%) | |
|---|---|---|---|---|---|---|---|
| | Sea country areas | | | | South coast marine park | Marine parks | Sanctuaries |
| | Esperance Nyungars | Ngadju | Wagyl Kyp & Southern Noongar | WA Mirning | | | |
| Foraging | 51 | 6 | 10 | 2 | 69 | 20 | <1 |
| Distribution (high use) | 0 | 37 | 0 | 63 | 100 | 0 | 0 |
| Total | 50.8 | 6.3 | 9.6 | 2.4 | 69 | 20 | 0.2 |

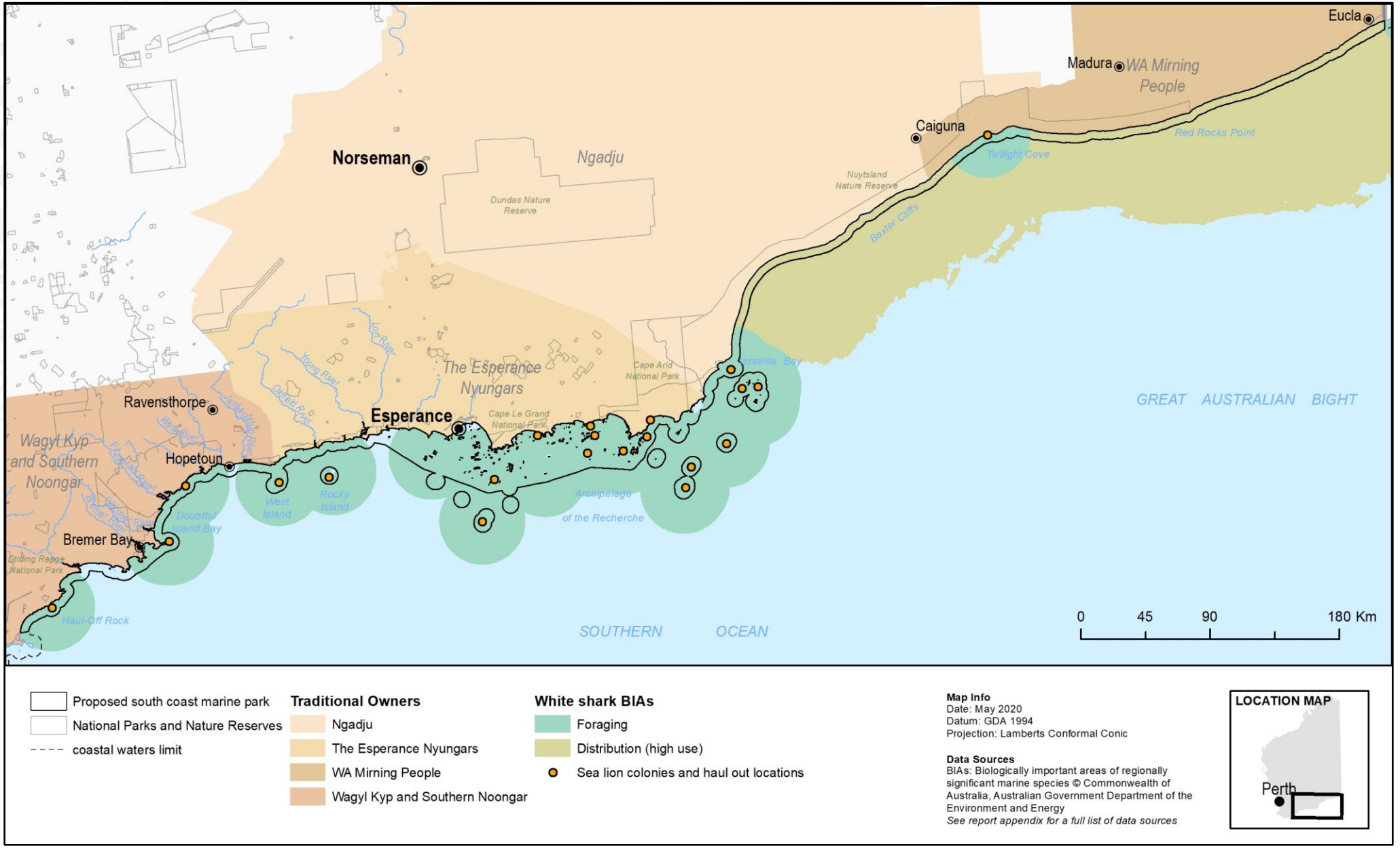


*Figure 20. Biologically important (foraging and high use) areas for great white sharks in the proposed south coast marine park*

## GREY NURSE SHARK

### *Conservation status*

| Species | WA status | National status | International status |
|---|---|---|---|
| *Carcharias taurus* | Vulnerable[A] | Vulnerable (west coast population)[B] | Near threatened (WA population) [C]<br>Vulnerable (species)[D] |

*Notes: Assessed by the WA Government in 2018. B. Assessed nationally in 2001. C. Assessed by the IUCN in 2003. D. Assessed by the IUCN in 2005.*

This species is found in cool temperate to subtropical waters from the surf zone to the outer continental shelf to a depth of 230 metres [77,78]. It has suffered major declines throughout its range, and is now restricted to the east coasts of North and South America, South Africa, and the east and west coasts of Australia [79].

The eastern Australian population, with probably fewer than 1500 individuals, is listed nationally as critically endangered [77]. Numbers in the genetically distinct western population are unknown but, unlike the eastern population, they have not been subjected to targeted fishing. Annual catches from 1989 to 1997 in western shark fisheries of 70–105 grey nurse sharks, and a stable trend in those catch rates, suggest that the west coast population was larger than the east coast population at the time, and shark fishing effort has decreased since then [77].

### *Vulnerabilities and pressures*

The life history characteristics of grey nurse sharks – long-lived ( up to 40 years for females), late onset of sexual maturity (9–10 years for females) and low fecundity (only 2 pups every second year) – combined with a limited inshore distribution and low genetic variability make them highly susceptible to decline from over-exploitation and rapid environmental change [77,80]. They are limited to 2 pups by in-utero cannibalism, with embryos hunting and eating each other until just one remains in each uterus.

The main threat in Western Australia is the incidental capture (accidental or illegal) by commercial and recreational fishers [77]. Commercial fishers reported releasing 28 alive in 2017–18 and 18 deaths [81] and recreational fishers reported releasing 70 [82]. A study on the east coast found that up to 52% of males and 29% of females showed signs of incidental hooking and that more were likely to have ingested hooks [83]. This was after protection of aggregation sites was already in place. Even though short-term survival after escape or release from fishing gear is high, there is a risk of longer-term mortality from ingested hooks and associated diseases such as peritonitis.

### *Significance of south coast waters*

The western population is known to range from Cocklebiddy in the Great Australian Bight to Exmouth on the west coast [78,84]. Almost nothing is known about their abundance or critical

habitats. Very few aggregation sites (used for mating and pupping) have been confirmed for the grey nurse shark in Western Australia, and none are known on the south coast. However, there are occasional (unconfirmed) reports from spear fishermen of large numbers off Bremer Bay and other south coast sites, indicating potential aggregation sites (Alexandra Hoschke personal communication, June 2020).

## SCHOOL SHARK

### *Conservation status*

| Species | WA status | National status | International status |
|---|---|---|---|
| *Galeorhinus galeus* | Not listed | Conservation dependent[A] | Critically endangered[B] |

*Notes: A. Assessed nationally in 2009. Eligible for a status as endangered. B. Assessed by the IUCN in 2020*

School sharks are widespread in temperate seas around the world, mainly occupying coastal and bottom habitats [85]. In Australia they occur from southern Queensland to Perth, from shallow inshore bays to about 800 metres depth on the continental slope. Pup production levels were assessed in 2007 as 9–14% of unfished levels, indicating a species decline of at least 86% between 1927 and 1999 [86].This qualified the species as endangered but it was listed as conservation dependent to enable continued fishing. The adult population was recently estimated to number about 80,000 [87].

### *Vulnerabilities and pressures*

School sharks are long-lived (>50 years), late maturing (16 years) and low in fecundity compared to most fish species (15–43 pups every 2–3 years), making them vulnerable to overfishing [88].

The major threat to school sharks is commercial fishing. Stocks have been classified as overfished since 1992, despite a stock rebuilding strategy initiated in 2008 [87,88]. The initial goal is to rebuild populations to 20% of unfished biomass within 66 years (3 generations), from a level of about 10% [88]. School sharks are mainly caught in the Commonwealth Southern and Eastern Scalefish Shark Fishery, extending from the western border of South Australia to the northern border of Victoria [89]. School sharks used to be the primary target species but are now classified as bycatch. Even so, they are the second most economically valuable species in the fishery, with about 200 tonnes retained each year since 2000 [87]. An additional unknown quantity is released, of which more than 40% from gillnets and 100% from trawl nets probably die. School sharks are also caught in state commercial and recreational fisheries (from Western Australia to New South Wales) [89]. Recent (2017–18, 2018–19) commonwealth stock assessments estimated total fisheries mortalities ranging from about 230–250 tonnes, exceeding the 225 tonne maximum that would reportedly allow recovery to 20% unfished biomass within 66 years [87,89].

Other potential threats to the school shark such as climate change are not considered in stock assessments. There is evidence already of a 'major shift (downward) in productivity and potential maximum stock size' [90].

### *Significance of south coast waters*

The proposed marine park would encompass most of the school shark population in Western Australia. The location of biologically important areas in south coast waters is unknown [48]. Nursery areas are known only for south-eastern Australia. Although the presence of neonates in the Great Australian Bight region indicate there could be pupping sites further west, small juveniles have not been reported in Western Australia [91]. Numbers on the south coast are unknown, but it is the fourth or fifth most commonly caught shark in the demersal fishery on the south coast (all in zone 2), with 27 tonnes captured in 2017–18, which is more than 10% of the nationally reported total [87,92].

## WHALER SHARKS (DUSKY AND SANDBAR)

### *Conservation status*

| Species | WA status | National status | International status |
|---|---|---|---|
| Dusky shark (*Carcharhinus obscurus*) | Not listed | Not listed[A] | Endangered[B] |
| Sandbar shark (*C. plumbeus*) | Not listed | Not listed[C] | Vulnerable[D] |

*Notes. A. Assessed and rejected for listing under the EPBC Act in 2014 due to data deficiency. B. Assessed by the IUCN in 2018. C. Nominated under the EPBC Act in 2010 but not assessed due to data deficiency. D. Assessed by the IUCN in 2014.*

Both species are widespread in tropical and temperate seas [93,94]. In Australia, the dusky shark is found around the continent and the sandbar shark occurs along most of the Western Australian coastline and along part of the east coast.

Both species were nominated for listing as nationally threatened, but there was insufficient information for an assessment. Another whale shark species on the south coast, the bronze whaler, is listed by the IUCN as near threatened. Like the dusky and sandbar sharks, it is taken by the demersal gillnet shark fishery on the south coast, but in smaller numbers [95].

### *Vulnerability and pressures*

Both species are highly susceptible to overfishing being long-lived and late maturing and having low fecundity [92]. The dusky shark is thought to live for up to 55 years, with females maturing at 26–35 years and reproducing only every 3 years [92,96]. The sandbar shark is thought to live for up to 40 years, with females maturing at 13–19 years of age and reproducing every second year [92].

The main threat to dusky and sandbar sharks globally is their capture in commercial fisheries. In Australia, the majority of exploited dusky and sandbar sharks are taken in the west coast and south coast demersal shark fisheries, currently the only fisheries permitted to land sharks in Western Australia [92]. They target juveniles: dusky sharks up to about 3 years of age and sandbar sharks up to about 6 years. Since 1995, the management objective of the shark fisheries has been to maintain biomass of each species at or above 40% of their unfished levels. For dusky sharks the goal is to reach 40% by 2040 [92]. The stocks of dusky and sandbar sharks are currently classified as 'recovering', with recovery expected to take up to several decades [92]. In 2017–18 the commercial catches were 204 tonnes (dusky) and 17 tonnes (sandbar) [97]. These catches are considerably lower than those in the early 2000s – about 30% of the peak catches of dusky sharks and less than 10% for sandbar sharks (commercial and recreational catches for sandbar sharks peaked between 2001 and 2004 at more than 900 tonnes) [92,98].

These sharks are also captured by recreational fishers. In 2017–18, 1852 dusky sharks were reported captured, 96% of which were released, and 41 sandbar sharks were reported captured, 34% of which were released [82].

### *Significance of south coast waters*

The location of biologically important areas on the south coast for dusky and sandbar sharks is unknown. The proposed park would encompass an important part of the range of dusky sharks in Western Australia, potentially including nursery areas. They give birth in the southern part of the state between February and June [99]. The proposed marine park would encompass the eastern extent of the southern range of sandbar sharks.

## WESTERN BLUE GROPER

### *Conservation status*

| Species | WA status | National status | International status |
|---|---|---|---|
| *Achoerodus gouldii* | Not listed | Not listed | Vulnerable[A] |

*Notes: A. Assessed by the IUCN in 2008.*

This large inquisitive wrasse is a favourite of divers and a south coast icon. It is endemic to southern Australia (from the Houtman Abrolhos to west of Melbourne) and the south coast's largest bony fish, growing to 1.7 metres. As a protogynous hermaphrodite, it changes sex from female (usually green) to male (usually blue), typically between 35 and 39 years of age [100].

The 2008 IUCN assessment found the population had declined by at least 30% over the previous 30 years, with a severe decline of 60–90% over 20 years in at least a third of its western distribution. Its abundance was 'very low' and declining across most of its range [101]. An updated assessment is needed to determine the current status of this species.

### *Vulnerabilities and pressures*

The longevity (up to 70 years), slow growth and late maturity (about 17 years) of the western blue groper make it highly vulnerable to overfishing and environmental change [100–102]. Fishing and climate change are the main threats.

The blue groper is fished commercially and recreationally over most of its range in Western Australia, mainly in the temperate demersal gillnet and longline fisheries in the WA South Coast bioregion [103]. The catch has ranged between 20 and 50 tonnes annually since 1990 [104]. In 2017–18 the commercial catch was 41 tonnes, and recreational fishers on the south coast reported catching just over 200 blue gropers, of which 11% were released [94,95]. Charter catches are not reported.

The 2008 IUCN assessors concluded that the blue groper was overfished in Western Australian waters, based on catch data, estimates of yield per recruit and fishing mortality [101]. A 2009 study found that fishing mortality in the south-west was equivalent to 74% of natural mortality, indicating that the species was close to or at full exploitation [100]. However, in 2016 the Western Australian Government assessed the risk to the blue groper stock as low [104]. This assessment was based on data from 2013–2014, so is now out of date (the commonwealth policy is that stock assessments start losing their value, and require lower catch limits in their system, after 5 years) and it applied assumptions that may not be appropriate for a long-lived hermaphroditic wrasse (Adrian Meder personal communication July 2020). There does not appear to have been any assessment of the stock structure to determine whether populations are genetically connected across their range. Too little is known to be confident about the current conservation status of the western blue groper.

Wrasse assemblages on shallow coastal reefs in the south-west have been changing rapidly [102]. In a decade of severe heat waves as well as gradual warming from 2006 to 2015, tropical and subtropical wrasses previously rarely observed in the temperate waters on the west coast became much more common and 3 large, slow-growing temperate species became less common. There were also changes in the cool temperate waters of the south coast – in the composition of wrasse assemblages. There are concerns that changes in reef habitats (such as loss of kelp forests) and competition from warmer-water fish species, combined with fishing pressure, could result in declines and local extinctions of the western blue groper [102].

### *Significance of south coast waters*

The rocky reefs of the south coast are important habitats for the blue groper. The nearshore reefs serve as nurseries for juveniles and the deeper reefs (down to 65 m) are occupied by sub-adults and adults [100,105]. The proposed marine park would cover a substantial part of the blue groper range, including where they are thought to be most abundant. The 2008 IUCN assessment noted that abundance was highest around Esperance, and lower further west, from Albany to the Capes, as reflected in lower landings in gillnet fisheries.

Strategically located sanctuary zones are important for blue gropers and could benefit the diving industry, for which they are a prized species. Blue gropers occupy quite small home ranges (2.5–6.4 hectares in a South Australian study), making them ‘particularly amenable to protection from fishing and other localised impacts’ within relatively small sanctuaries [105].

## SEADRAGONS

| Species | WA status | National status | International status |
|---|---|---|---|
| Ruby seadragon (*Phyllopteryx dewysea*) | Not listed | Not listed | Data deficient[A] |
| Weedy seadragon (*Phyllopteryx taeniolatus*) | Not listed | Not listed | Least concern[B] |
| Leafy seadragon (*Pycodurus eques*) | Priority 2 (poorly known) | Not listed | Least concern[B] |

*Notes: A. Assessed by the IUCN in 2015. B. Assessed by the IUCN in 2016; both species are reported to be declining.*

With a beauty and elegance much admired by divers and snorkelers, seadragons are south coast icons. That males brood the young adds to their appeal. They occur only in Australia's southern waters, and the south coast is the only region where all 3 species are known to still occur.

The ruby seadragon was described only in 2015, based on 4 museum specimens collected from near Perth in 1919 and 1956, and from the Recherche Archipelago in 2007 [106]. It has since been observed live (via a remotely operated vehicle) in the Recherche (off Esperance) in sponge habitat at more than 50 metres depth, and 2 bodies have washed ashore – at Esperance and Point Culver (east of Recherche) [107]. Whether the species still occurs on the west coast, 60 years after 2 individuals were captured in trawl nets, is unknown. The lack of basic information about its distribution, habitats, ecology and threats has led to its listing as data deficient by the IUCN.

Leafy and weedy seadragons occur in shallower habitats – mainly in kelp and seagrass beds – across the southern coastline, from south of Perth to east of Adelaide (leafies) and to the central New South Wales coast (weedies). Their western populations are genetically distinct from those in the east [108,109]. Most sightings in Western Australia come from the bays, sounds and headlands in the Recherche Archipelago [30]. Although assessed as least concern by the IUCN, their populations are thought to be declining due mainly to habitat degradation and loss near urban centres, and perhaps due to incidental capture in trawl fisheries for the leafy [110,111].

## 4.3 Birds

### SEABIRDS

#### *Conservation status*

At least 11 seabird species breed on the south coast, including 2 threatened species.

| Species | WA status | National status | International status |
|---|---|---|---|
| Fairy tern (*Sternula nereis*) | Vulnerable | Vulnerable[A] | Vulnerable[B] |
| Flesh-footed shearwater (*Ardenna carneipes*) | Vulnerable[C] | Not listed | Near threatened[C] |

*Notes: A. Assessed by the Australian Government in 2011. B. Assessed by the IUCN in 2018. C. Assessed by the Western Australian Government in 2015. D. Assessed by the IUCN in 2019.*

Threatened seabird species that forage but don't breed on the south coast include the following (their state/national threat status is indicated in brackets) [35].:

- northern giant petrel (not listed/vulnerable)
- wandering albatross (vulnerable/vulnerable)
- black-browed albatross (endangered/vulnerable)
- Atlantic yellow-nosed albatross (vulnerable/not listed)
- grey-headed albatross (vulnerable/endangered)

The global population of fairy terns numbers an estimated 5000–10,000 birds [112]. Western Australia hosts the largest breeding population, with at least 1600 pairs. The species was listed nationally after an estimated population decline of 24% over 3 generations, mainly in the south-east, with an expectation that declines would be ongoing [113].

Western Australia hosts about 35% of the world's breeding flesh-footed shearwaters, a population assessed as vulnerable in 2015 [114]. The species was listed as globally near-threatened after a suspected population decline of at least 20–29% over 3 generations [115].

#### *Vulnerabilities and pressures*

The life history of many seabird species, including long lifespans, late reproduction, small numbers of young and philopatry (return to their birth colony for breeding) make them vulnerable to a range of pressures [116]. The main pressures or potential threats include the consequences of climate change such as sea level rises and acidification, marine debris, capture as bycatch, depletion of prey, oil pollution, disturbance of breeding colonies, and nest predation (eg by cats and foxes).

The main threats to fairy terns are thought to be introduced predators (red foxes, cats, black rats), increased populations of native predators (silver gulls, Pacific gulls) and nest disturbance [113]. Colonies have been abandoned along the west coast due to increased human access [112].

More than 500 flesh-footed shearwaters (mostly breeding adults) die each year as bycatch in Western Australia [114]. Their main prey is pilchards, which brings them into regular contact with purse seine nets. They may also be caught in fisheries while overwintering in the northern Indian Ocean. The ingestion of plastic and associated chemicals may be an emerging threat [117].

### *Significance of south coast waters*

The proposed marine park is of regional and national significance for seabird breeding and foraging. More than 40% of Australia's seabird species occur in the south coast region and about a quarter of the species that breed in Australia do so in the Recherche Archipelago and west to Stokes Inlet, mostly on islands (Figure 21) [40,118]. The archipelago has been identified by Birdlife International as an 'important biodiversity area' for breeding seabirds [119].

The proposed marine park would encompass at least half the area mapped in Western Australia as biologically important foraging areas (BIAs) by the following species that breed there, including the 2 threatened species (see Table 13 in Appendix A):

*Fairy tern*: 78% of the high-use foraging BIA; 3 breeding sites – Glasse Island, Six Mile Island and Stokes Inlet.

*Flesh-footed shearwater:* 100% of the foraging BIA and 78% of the high-use foraging BIA; 14 breeding sites (50% of sites in Western Australia), mainly in the Recherche Archipelago.

*Black-faced cormorant:* 100% of the foraging BIA; 5 breeding sites (100% of those in Western Australia) on islands in the Recherche Archipelago west of Esperance.

*Bridled tern*: 58% of the high-use foraging BIA; 1 breeding site on Termination Island in the Recherche Archipelago.

*Caspian tern*: 52% of the foraging BIA for provisioning young; 14 breeding sites (29% of sites in Western Australia) at Israelite Bay and on islands.

*Little penguin*: 70% of the foraging BIA for provisioning young; 18 breeding sites (36% of sites in Western Australia), mainly on islands in the Recherche Archipelago, also at Twilight and Toolinna coves.

*Little shearwater* (*Puffinus assimilis tunneyi*, a subspecies endemic to the south-west coast): 50% of the high-use foraging BIA; 15 breeding sites (31% of sites in Western Australia), mainly on islands in the Recherche Archipelago.

*Pacific gull*: 100% of the foraging BIA and 51% of the high-use foraging BIA; 19 breeding sites (42% of sites in Western Australia), mainly on islands in the Recherche Archipelago.

*White-faced storm petrel*: 48% of the high-use foraging BIA; 12 breeding sites (41% of sites in Western Australia) on offshore islands in the Recherche Archipelago.

None of these biologically important areas have any sanctuary protection in Western Australia and only the foraging areas for the little shearwater and Pacific gull have more than 5% sanctuary protection in Australian waters.

In addition, the following species breed in the proposed marine park but don't have any biologically important areas mapped in the area:

*Great-winged petrel*: 9 breeding sites in the Recherche Archipelago. These islands host the only breeding population in Australia, estimated to exceed 30,000 breeding pairs [116].

*Short-tailed shearwater*: 5 breeding sites in the Recherche Archipelago. This species is the most abundant seabird that breeds in Australia (making up about 80% of the total) [120]

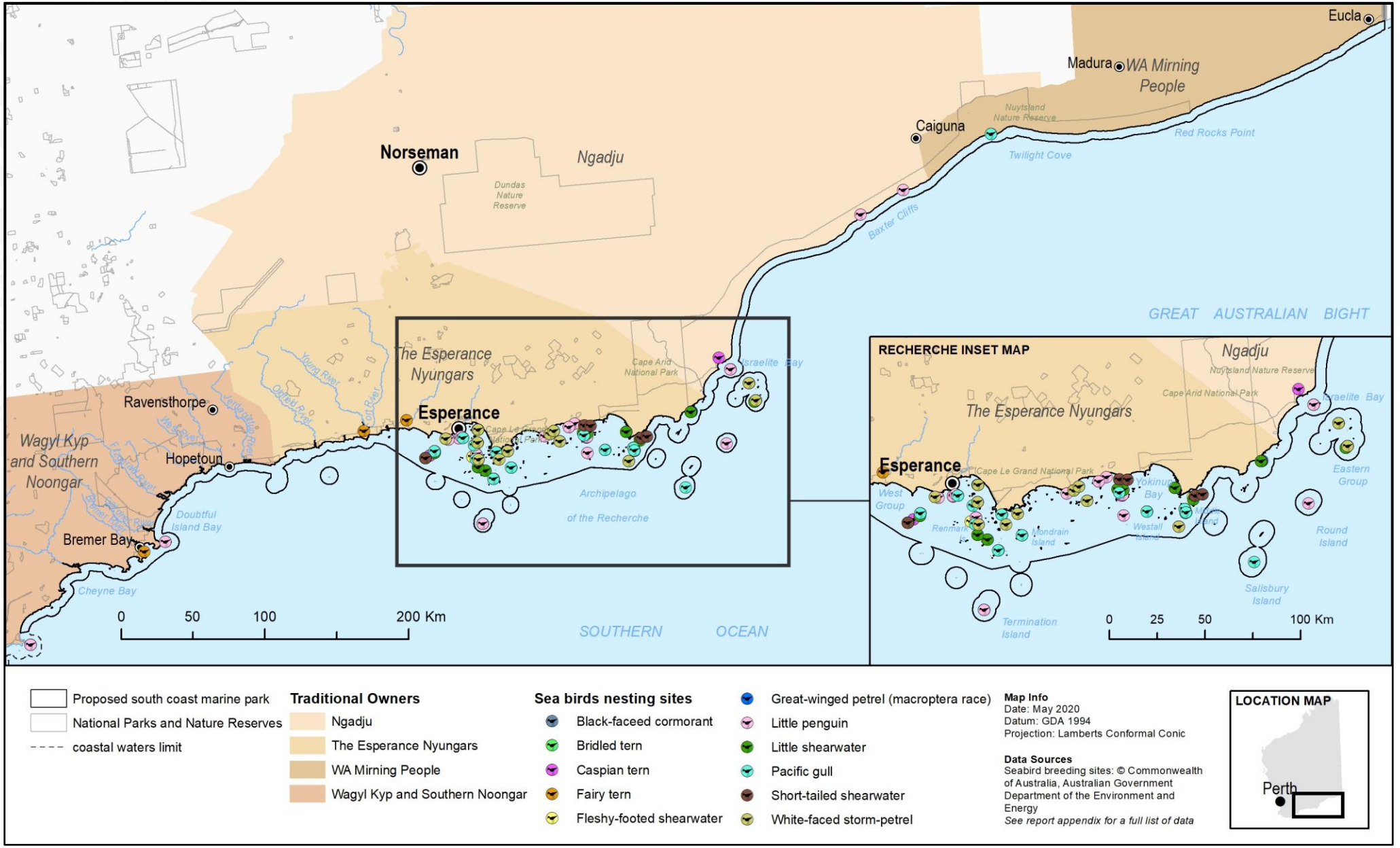


*Figure 21. Biologically important (nesting) areas for seabirds in the proposed south coast marine park*

## SHOREBIRDS

### *Conservation status*

Southern Australia, including the south coast of Western Australia, has long been known as a refuge where migratory shorebirds that breed in the northern hemisphere spend their non-breeding months [121]. Those recorded on the south coast include the following highly threatened species.

| Species | WA status | National status | International status |
|---|---|---|---|
| Curlew sandpiper (*Calidris ferruginea*) | Critically endangered[A] | Critically endangered[B] | Near threatened[C] |
| Great knot (*Calidris tenuirostris*) | Critically endangered[A] | Critically endangered[B] | Endangered[C] |
| Eastern curlew (*Numenius madagascariensis*) | Critically endangered[A] | Critically endangered[B] | Endangered[C] |
| Lesser sand plover (*Charadrius mongolus*) | Endangered[A] | Endangered[B] | Least concern[C] |
| Red knot (*Calidris canutus*) | Endangered[A] | Endangered[B] | Near threatened[C] |

*Notes: A. Assessed by the Western Australian Government in 2018. B. Assessed by the Australian Government in 2015 or 2016. C. Assessed by the IUCN in 2019.*

### *Vulnerabilities and pressures*

Migratory shorebirds are threatened mainly by the destruction of staging areas in eastern Asia on their annual migration route [122]. The major threats on the south coast are human disturbance (mostly 4WDs and dogs) and invasive predators [121].

### *Significance of the south coast*

Surveys on the south coast from Augusta to near the Eyre observatory have recorded 28 shorebird species, of which 18 are migratory. In 2013, the most recent survey, about 14,000 shorebirds were recorded, about two-thirds of which were in the Esperance region in coastal or near-coastal habitats [121]. Counts of the hooded plover (a non-migratory species listed by the Western Australian Government as priority 4) in the Esperance region exceeded the 1% population threshold required for potential international significance [121]. Numbers of the sooty oystercatcher counted on islands of the Recherche Archipelago (359 birds in 1993) were of national significance [123].

## 4.4 Implications of the proposed marine park

The proposed south coast marine park is of international or national conservation significance for several species of threatened marine mammals, fishes and birds. It offers great potential to arrest their decline and boost recovery – particularly those species for which particular methods of commercial fishing (mainly gillnetting) are the main threat. Many threatened species of the south coast share the characteristics of longevity, late maturity and low fecundity that make them susceptible to over-exploitation and environmental change. Many are also ecologically important – particularly the apex or high-level predators such as the shark species, Australian sea lion and western blue groper. Protecting them is likely to help boost the resilience of south coast ecosystems in the face of climate change.

Several threatened species are also south coast icons – particularly the southern right whale, Australian sea lion, western blue groper. Other icons are seadragons, the long-nosed fur seal, and seabirds such as albatrosses and the little penguin. Boosting protection for these species is an investment in important assets for tourism and recreation.

Table 10 summarises high-priority locations for those species for which there is information about biologically important areas. For species whose biologically important areas have not been mapped – including dusky, sandbar and grey nurse sharks and western blue groper – a substantial network of sanctuaries is needed to maximise their chances of recovery.

One relevant best-practice design principle for marine parks is to target the habitats of threatened and highly range-restricted species for full protection, provided reserves are 'considered an effective management tool for those species' [41]. This would apply, for example, to the Australian sea lion and southern right whale, which give birth in only in a few areas in southern coastal waters. Another best-practice design principle is to capture 'areas of high biodiversity value (exceptionally limited human influence, of global significance, high levels of endemism)' [41]. This would apply, for example, to the Recherche Archipelago, known to have high levels of fish endemism.

*Table 10. Important locations for significant species in the proposed south coast marine park*

| Significant species | WA South Coast bioregion | Eucla bioregion |
|---|---|---|
| Australian sea lion – breeding (>10 pups per season) | Recherche Archipelago – Ford, Round, Salisbury, George, Glennie, Kimberley islands | Eastern Recherche Archipelago – Spindle, Six Mile islands |
| | Bremer Bay – Investigator, West, Middle Doubtful islands, Red Islet, Haul Off Rock | |
| Australian sea lion – foraging | The entire proposed park area | Recherche Archipelago |
| | | Great Australian Bight area |
| Southern right whale – calving hotspot | Doubtful Island Bay area | Israelite Bay area |

| | | |
|---|---|---|
| Southern right whale – seasonal calving | Entire mainland coastline | Entire mainland coastline |
| Humpback whale – migration route | Esperance to western boundary | |
| Long-nosed fur seal – breeding (>100 pups recorded) | Recherche Archipelago – Cooper, Salisbury, Libke, Hood islands | Recherche Archipelago – Cranny, Daw islands |
| | Bremer Bay – Haul Off Rock | |
| Great white shark – high use | | Israelite Bay to the South Australian border |
| Great white shark – foraging | Almost the entire area | Recherche Archipelago |
| Western blue groper – highest abundance | Esperance area | |
| Seadragons – all 3 species occur | Recherche Archipelago | |
| Flesh-footed shearwater – breeding | Recherche Archipelago | Recherche Archipelago |
| Flesh-footed shearwater – foraging in high numbers | Almost the entire area | Eastern Recherche to Israelite Bay |
| Fairy tern – breeding | Glasse Island, Stokes Inlet | Recherche Archipelago – Six Mile |
| Other seabirds – breeding | Mainly Recherche Archipelago | Recherche Archipelago |
| Seabird foraging | Mainly Recherche Archipelago | Recherche Archipelago |
| Shorebirds – highest abundance | Esperance region | |

## RECOMMENDATIONS

Provided that the Traditional Owners of the south coast regard a jointly-managed marine park as desirable in their sea countries, we recommend that the government works with stakeholders and local communities to:

- Provide high (science-based) levels of protection for all threatened, declining and data deficient species, including the following, particularly those that have small breeding ranges in Australia (marked with an asterisk):
    - Australian sea lion*
    - southern right whale*
    - humpback whale
    - ruby seadragon*

    - great white shark
    - grey nurse shark
    - school shark
    - sandbar shark
    - dusky shark
    - western blue groper
    - flesh-footed shearwater
    - fairy tern
- Eliminate as many threats as possible to threatened or declining species in the proposed marine park, with a high-priority focus on preventing the capture of the following species in fisheries:
    - Australian sea lion
    - great white shark
    - school shark
    - grey nurse shark
    - dusky shark
    - sandbar shark

# 5 THE GREAT SOUTHERN REEF

In 2016 several marine scientists proposed that the kelp-clad rocky reefs fringing Australia's southern coasts, from Moreton Bay in the east to Kalbarri in the west, be regarded as one vast system – interconnected by currents and ecological and evolutionary processes [23]. They called it the Great Southern Reef.

The proposed south coast marine park would encompass almost a fifth of the 8100-km length and over 10% of the 70,000-km$^2$ area of this immense reef system (see Figure 22), which is distinguished simply by depths up to 30 metres. Here, we outline the Great Southern Reef concept, its benefits and the potential contribution of the proposed marine park to its future.

## 5.1 The importance of an identity

Uniting Australia's temperate reefs under one banner has many potential benefits – fostering greater recognition of the ecological interconnections, encouraging complementary management across state borders, and lifting the public profile of kelp forests.

The name of course invites comparisons with the much more renowned Great Barrier Reef. Just as the GBR 'is recognised as an entity made up of more than 2900 individual reefs dominated by corals', so the promoters of the GSR argue that the southern reefs should be considered 'as an entity made up of thousands of kilometres of rocky temperate reefs dominated by kelp forests' [23]. This temperate reef system – of 'profound ecological, social and economic' importance – is more than a match for its tropical counterpart.

Both reef systems are biodiversity hotspots of global significance. Like corals, the habitat-forming macroalgae (kelps and other seaweeds) are the foundation of rich, complex ecological communities. The Great Southern Reef is particularly significant for its diversity of seaweeds, sponges, crustaceans, fishes, bryozoans, echinoderms, molluscs and other invertebrates. Although extolled for their reef habitats, each system also comprises many other habitats – seagrass meadows, sponge gardens and sand, for example – that are important in their own right and facilitate connectivity between reefs [23].

One globally significant feature of the Great Southern Reef not shared by the Great Barrier Reef is an extremely high rate of endemism: 40–77% in seaweeds, 85% in fishes and 22–56% in invertebrates (75–95% for molluscs, 31% for echinoderms, 56% for sponges) [23,124]. The isolation, antiquity and stability enabling this high level of endemism (see section 3.3) contrast with the more-recent origins of the Great Barrier Reef and its connectedness to other tropical systems [23]. 'One of the reasons we coined the term Great Southern Reef [is] to get people to focus on the fact we have a truly unique ecosystem here,' says marine scientist Thomas Wernberg [125].

Despite their high values, Australia's temperate reefs are far less known and studied than the tropical reefs. Although tens of thousands of species are yet to be scientifically discovered and described

there is very little investment in research: in the 5 years from 2010 to 2014, the Australian Research Council provided just $4 million for temperate reef research compared to $55 million for coral reef research [23].

Work is now underway to lift the public profile of the Great Southern Reef. A website and educational materials have been developed, a feature film is in production, and an 'impact campaign' is planned (greatsouthernreef.com). A new marine park in the Great Southern Reef could also do much to raise public awareness.

## 5.2 Ecosystem services and blue carbon

Kelp forests are among the most productive ecosystems on Earth and provide ecosystem services worth billions of dollars annually [126]. They create habitats with a multitude of niches, including for many species of commercial and recreational importance [23,126]. The dominant kelp species in southern waters, golden kelp, provides habitat for more than 350 species in its holdfast structure alone (the part that attaches to rock), including copepods, polychaetes, gastropods, amphipods, bryozoans, bivalves and sponges [126].

As food and detritus, kelps drive nutrient and energy cycles that sustain marine life in coastal waters and beyond [23,126]. On shallow reefs (<30 metres depth) dominated by seaweed canopies, the nutrient cycling services may be worth as much as $187 billion a year in Australia [23].

Kelps are capable of rapid growth and produce up to 65 tonnes of biomass per hectare per year, 16 times more than Australia's most fertile wheat fields [23]. Although the amount of carbon sequestered into long-term carbon sinks (marine sediments and the deep ocean) is unknown, kelp forests are thought to capture a substantial proportion of the planet's blue carbon [23]. Greater protection of the Great Southern Reef therefore is likely to contribute to limiting climate change.

## 5.3 Implications of the proposed south coast marine park

Currently, less than 25% of the Great Southern Reef occurs in marine parks and less than 3% is protected in sanctuaries – in contrast to the Great Barrier Reef, with 100% in the marine park and 33% in sanctuaries. The proposed south coast marine park would be by far the largest marine park in the Great Southern Reef. Bordering the largest existing state marine park in the region – South Australia's Far West Coast Marine Park – it would facilitate complementary management across jurisdictions, one of the major challenges for protecting the Great Southern Reef.

In addition to the outstanding biodiversity values of the south coast (as documented in this report), the proposed marine park represents one of the least impacted parts of the Great Southern Reef due to the relatively low level of human activity on this coast. It is also likely to be an important climate refuge. The waters off Australia's south-east and west coasts have experienced some of the highest rates of ocean warming in the world, 2–4 times the average global rate, and have already suffered major damage to kelp forests [23,127,128]. The dominant canopy species, golden kelp, is projected to become restricted to Australia's south coast by 2100 [128]. The proposed marine park

is thus likely to play an important role harbouring species forced out of waters elsewhere by warming or competition with more tropical species.

## RECOMMENDATION

Promote the proposed south coast marine park as part of the Great Southern Reef and as an important refuge area for Australia's temperate reef communities.

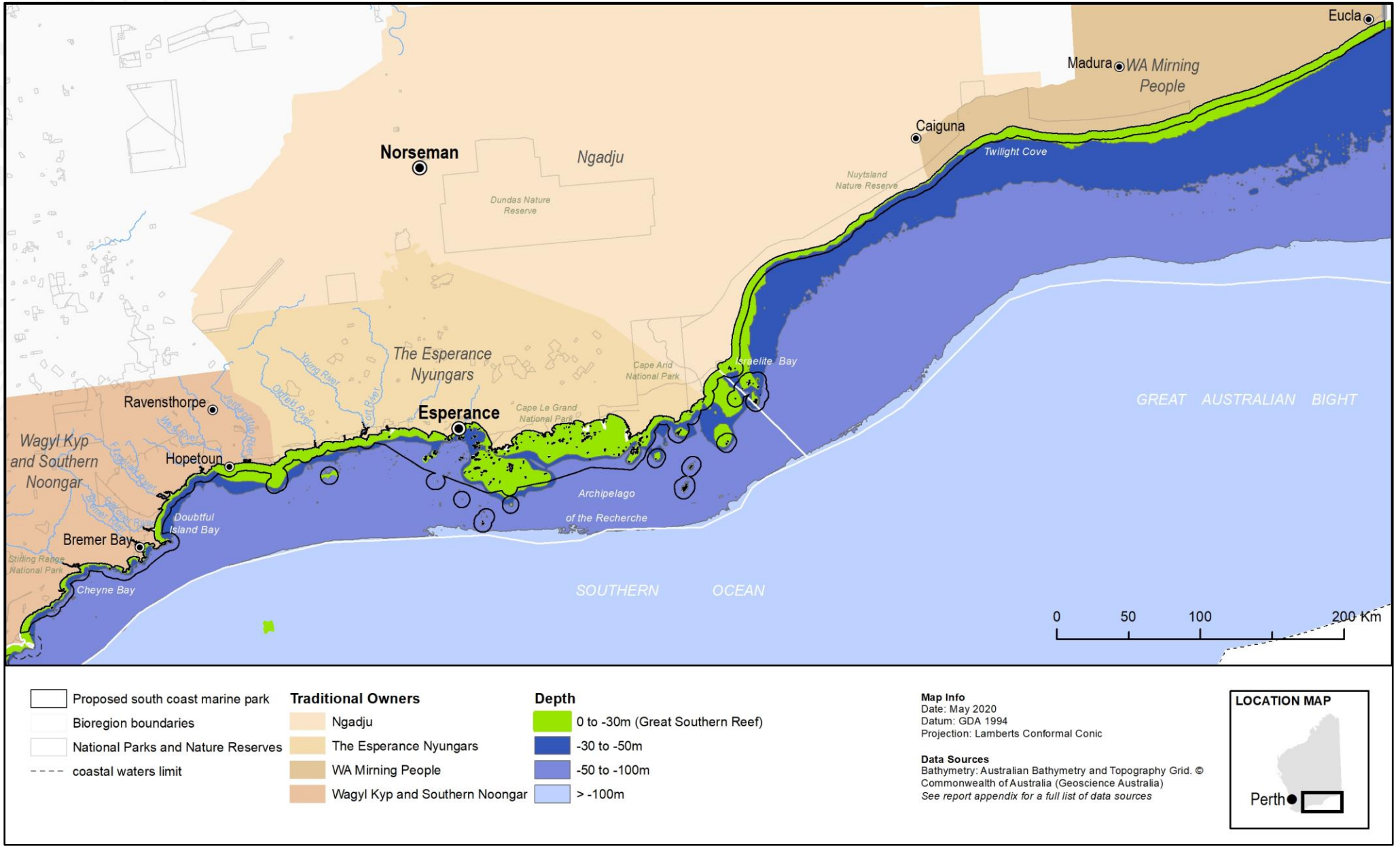


*Figure 22. The Great Southern Reef and its overlap with the proposed south coast marine park (based on water depth to 30 metres)*

# 6 AREAS OF OUTSTANDING CONSERVATION VALUE

The entire proposed marine park area has high conservation values. The 8 areas described below (from west to east) (see Figure 23) have been selected as outstanding areas for one or more of the following characteristics:

- substantial areas of biological importance for significant species
- extensive areas or a high diversity of important habitats
- features representative of the WA South Coast or Eucla bioregions that are unique or rare elsewhere in the proposed marine park.

The values of each area are considerably greater than indicated here. For example, the south coast is highly significant for threatened shark species, but 4 species are not included in this analysis because there is no information about their biologically important areas.

These areas are not recommended sanctuary zones. But they can be regarded as broad candidate areas for sanctuaries, the final selection and sizing of which would need to take into account social, cultural and economic factors as well as conservation values and be subject to extensive analysis and consultation.


*Figure 23. Areas of outstanding conservation value in the proposed south coast marine park*

## 6.1 Haul Off Rock to Dillon Bay (Wagyl Kyp and Southern Noongar sea country)

- A breeding site and important foraging habitat for endangered Australian sea lions
- An important breeding site for long-nosed fur seals
- Important foraging habitat for several seabird species, including threatened fairy terns and flesh-footed shearwaters
- Extensive seagrass meadows
- Diverse coastline habitats

### AREA DESCRIPTION

This area extends from Willyun Beach to Dillon Bay to the boundary of state waters. Coastal sites include Ledge point, Cape Riche, Schooner beach, Cheyne Bay, Groper Bluff, Wray Bay, Reef beach, Foster Beach, Cape Knob, and Stream Beach. Islands include Haul Off Rock, Cheyne Island, Smooth Rocks and Roe Rocks.

### IMPORTANT HABITATS

Estuaries: This area has 2 estuaries – Cheyne Inlet and Beaufort Inlet. Cheyne is the only seasonally open estuary in the proposed marine park. These estuaries account for 17% of the mapped estuarine habitat in the proposed park, including a quarter of the rocky reef.

Seagrass meadows: This area has large seagrass beds at Cheyne, Wray and Dillon bays.

Coastline habitats: This area features diverse coastline habitats, including a substantial proportion of the following types in the proposed marine park:

- a fifth of the hard rocky shore, including intertidal rock platforms, moderately sloping rocky shore and cliffs >5 metres
- over three-quarters of the intertidal soft bedrock shore platforms
- a third of the subtidal protected sandy lagoons.

### SIGNIFICANT SPECIES

Australian sea lion:

- endemic to southern Australia, listed as internationally endangered and nationally vulnerable (under assessment as endangered), in decline, under threat from gillnet fishing

- 1 breeding site – Haul Out Rock (>20 pups/season), and the surrounding area is biologically important for foraging.

Long nosed fur seal:

- listed by the state as specially protected
- Haul Out Rock has one of the 5 largest breeding colonies in Western Australia.

Great white shark:

- listed at the state, national and international levels as vulnerable
- area around Haul Out Rock and Dillion Bay eastwards is biologically important for foraging.

Seabirds:

- foraging grounds (provisioning of young) for Caspian tern, little penguin
- foraging grounds (high numbers) for fairy tern, flesh-footed shearwater, bridled tern, little shearwater, Pacific gull
- fairy tern is listed as vulnerable at international, national and state levels; flesh-footed shearwater is listed as vulnerable at the state level.

Humpback whale:

- entire area is part of its northern migration route.

## 6.2 Fitzgerald River National Park coastline (Wagyl Kyp and Southern Noongar sea country)

- A calving hotspot for endangered southern right whales
- 2 breeding sites and important foraging habitat for endangered Australian sea lions
- 6 estuaries – the highest concentration in the proposed marine park and almost half the estuarine habitat – including the least modified estuary, 3 estuaries that are part of nationally important wetland systems and 2 estuaries with a threatened saltmarsh ecological community
- Extensive seagrass meadows

### AREA DESCRIPTION

This area extends from Point Hood to Culham Inlet to the boundary of state waters. Coastal sites include Whale Bone Point, Tooregullup and Trigelow beaches, Cheadanup Cliffs, Point Charles Bay, Twin Bays, Marshes Beach, Quoin Head, Whale Bone beach, Edwards Point, and Cave Point. Islands include Doubtful and Red. Reefs include French, Walker and Stewart.

### IMPORTANT HABITATS

Estuaries: This area has 6 estuaries, all wave dominated. Three are part of nationally important wetlands – Fitzgerald, Dempster and Culham – the Fitzgerald River Important Bird Area noted in part for significant waterbird populations. Gordon and Fitzgerald inlets feature extensive areas of a nationally threatened saltmarsh ecological community. The 6 estuaries account for nearly half the mapped estuarine habitat in the proposed marine park, including:

- over half of the flood- and ebb-tide delta, fluvial (bay-head) delta and saltmarsh
- over a third of the barrier/back barrier, central basin, channel and intertidal flats
- over a quarter of the rocky reef.

Seagrass meadows: Seagrass beds span most of the coastline in this area, and are particularly extensive off Tooregullup, Marshes and Whale Bone beaches.

### SIGNIFICANT SPECIES

Southern right whale:

- listed as nationally endangered
- Doubtful Bay is 1 of 3 calving hotspots in Australia, 1 of 2 in Western Australia
- other biologically important areas include other calving sites and calving buffer areas.

Australian sea lion:

- endemic to southern Australia, listed as internationally endangered and nationally vulnerable (under assessment as endangered), in decline, under threat from gillnet fishing
- 2 breeding sites – Red Islet (>20 pups/season) and Doubtful Island
- entire area is biologically important for foraging.

Great white shark:

- listed at the state, national and international levels as vulnerable
- entire area is biologically important foraging habitat.

Humpback whale:

- entire area is part of its northern migration route.

Seabirds:

- breeding sites for flesh-footed shearwater and little penguin on Doubtful Islands
- foraging grounds (provisioning of young) for Caspian tern, lttle penguin
- foraging grounds (high numbers) for fairy tern, flesh-footed shearwater, bridled tern, little shearwater, Pacific gull
- fairy tern is listed as vulnerable at international, national and state levels; flesh-footed shearwater is listed as vulnerable by the state.

## POTENTIAL FOR COMPLEMENTARY MANAGEMENT

This area adjoins the Commonwealth Bremer Marine Park and the entire length of Fitzgerald River National Park.

## 6.3 Mason Bay to Barker Inlet (Esperance Nyungar sea country)

- 2 breeding sites and important foraging habitat for endangered Australian sea lions
- Important foraging habitat for 10 seabird species, including threatened fairy terns and flesh-footed shearwaters
- 4 coastal estuaries, with a quarter of the estuarine habitat in the proposed marine park
- The largest concentration of coastal reefs outside the Recherche Archipelago along the south coast of Western Australia
- Diverse coastline habitats

### AREA DESCRIPTION

This area extends from Mason Bay to Barker inlet to the boundary of state waters. Coastal sites include Powell Point, Starvation Boat Harbour, Munglinup Beach, Margaret Cove, Skippy Rock, Dunster Castle Bay, Shoal Cap, Fanny Cove and Quagi Beach. Offshore islands include West, Rocky and Red Islands.

### IMPORTANT HABITATS

Estuaries: This area has 4 estuaries (Oldfield, Torradup, Stokes, Barker), all wave dominated. They account for a quarter of the mapped estuarine habitat in the proposed marine park, including:

- over half the rocky reef
- over a third of central basin, channel habitats and barrier/back barrier habitats
- over a quarter of the intertidal flats and flood- and ebb-tide delta habitats.

Reefs: This area has 20 mapped reefs, the highest concentration of mapped shallow reefs along the south coast and the highest concentration of any reefs outside the Recherche Archipelago along the south coast of Western Australia.

Coastline habitats: This area features diverse coastline habitats, including a substantial proportion of the following types in the proposed marine park:

- exposed sandy shores – a third of the perched sandy beaches, a quarter of the dune fields exploited to wave attack, and a quarter of the dunes, dune-field or putative beach ridges disconnected from wave attack.
- subtidal rocky areas – a quarter of the rocky bottom (undifferentiated), a quarter of the rocky reefs (undifferentiated) and a quarter of protected sandy lagoons.

## SIGNIFICANT SPECIES

Australian sea lion:

- endemic to southern Australia, listed as internationally endangered and nationally vulnerable (under assessment as endangered), in decline, under threat from gillnet fishing
- 2 breeding sites (West and Rocky islands)
- entire area is biologically important for foraging.

Great white shark:

- listed at the state, national and international levels as vulnerable
- entire area is biologically important foraging habitat.

Humpback whale:

- entire area is part of the northern migration route for the humpback whale.

Seabirds:

- breeding site for fairy tern at Stokes Inlet
- foraging grounds (provisioning of young) for Caspian tern, little penguin
- foraging grounds (high numbers) for bridled tern, black-faced cormorant, fairy tern, flesh-footed shearwater, bridled tern, little shearwater, Pacific gull and short-tailed shearwater
- fairy tern is listed as vulnerable at international, national and state levels; flesh-footed shearwater is listed as vulnerable by the state.

## POTENTIAL FOR COMPLEMENTARY MANAGEMENT

This area adjoins the Commonwealth South-west Corner Marine Park, Stokes National park and Jerdacuttup Lakes, Lake Shaster, and Springdale nature reserves.

## 6.4 Central Recherche (Esperance Nyungar sea country)

- 2 breeding sites and important foraging habitat for endangered Australian sea lions
- One of Australia's most important seabird breeding areas
- A rich fish fauna with many endemic species; important for threatened great white sharks and western blue gropers; a hotspot for seadragons, with all 3 species
- The most extensive seagrass beds mapped along the south coast of Western Australia
- The most extensive kelp forests mapped along the south coast of Western Australia
- The largest rhodolith bed mapped in the Recherche Archipelago

### AREA DESCRIPTION

This area extends from southern Esperance Bay to West Rock in the east and Termination Island in the south. Coastal sites include Cape Le Grand, Hellfire Bay, Thistle bay, Rossiter Bay, Victoria Harbour, Hammer Head and Alexander Bay. There are more than 140 islands. Nearshore islands (in decreasing size) include Twin Peak Islands, Sandy Hook, Remark, Frederick, Mart, Tory, Pasco, York, Hastings, Station, Ben, Hull, Inshore, Taylor, Cloud, Hope and New. Offshore islands (in decreasing size) include Mondrain, Hood, Wilson, Corbett, Termination, Howe, Mackenzie, Beaumont, Pearson and Kermadec. Mapped reefs include Brown, French, Walker, Stewart reef, Ferguson, Scatterbreak, Pratt Barlow, Sulfur, Rawson and Belches.

### IMPORTANT HABITATS

Seagrass meadows: This area contains over half the mapped seagrass in the Recherche, the most extensive meadows along the south coast of Western Australia. They are particularly extensive in southern Esperance Bay*, Rossiter Bay, inshore from Mart Islands*, and offshore from Alexander Point to Twin Peaks Islands, and include the 2 largest seagrass expanses in the Recherche Archipelago (*).

Kelp forests: This area contains a third a third of the mapped kelp forest in the Recherche, the most extensive along the south coast of Western Australia. This includes the largest single area (2500 ha) in the Recherche, at Alexander Bay. Kelp forests are also extensive around Mondrain and Twin Peaks islands.

Rhodolith beds: This area contains the largest rhodolith bed mapped in the Recherche – between Sand Hook and Mondrain islands.

Gravel/rubble habitat: This area has over 90% of the mapped gravel/rubble in the Recherche – to the west of Mondrain Island, overlapping the gravel-rich rhodolith beds.

Banks/shoals: This area has the largest bank/shoal mapped in the WA South Coast bioregion (around Mondrain, Long, Remark, Hood, Wilson, Frederick and Corbett islands).

Reefs: This area has extensive reef habitat, including the largest broadscale reef mapped in the bioregion (surrounding Termination and Little islands and north to Brown Reef); 7 shallow reefs (mapped as marine hazards); 11 offshore intertidal bare reefs (half of this habitat mapped in the Recherche) and 43 subtidal bare reefs (fringing the Cape Le Grand National Park, over a third of this habitat mapped in the Recherche).

Coastline habitats: This area features a substantial proportion of the following habitat types in the proposed marine park:

- over half the sandy shore backed by soft sediment, including aeolian sand-sheets both exposed to and disconnected from wave attack
- over a quarter of the soft rocky shore, including over half the low-profile soft rock shore and a fifth of the sloping soft rock shore.

## SIGNIFICANT SPECIES

Australian sea lion:

- endemic to southern Australia, listed as internationally endangered and nationally vulnerable (under assessment as endangered), in decline, under threat from gillnet fishing
- 2 breeding sites – on Kimberley and Taylor islands
- 1 haul out site – at Little Island (of 9 mapped in Western Australia)
- entire area is biologically important for foraging (>15% of sea lion foraging grounds in state waters).

Long nosed fur seal:

- listed by the state as specially protected
- Libke Island is one of the 5 largest breeding colonies in Western Australia.

Seabirds:

- breeding sites for 10 species (black-faced cormorant, Caspian tern, fleshy-footed shearwater, great-winged petrel, little penguin, little shearwater, Pacific gull, short-tailed shearwater, white-face storm petrel, wedge-tailed shearwater)
- breeding sites on 25 islands, with key breeding locations (3 or more species) on Lorraine, Mackenzie, Ram and Renmark islands
- biologically important foraging areas for fairy tern and flesh-footed shearwater around breeding sites
- fairy tern is listed as vulnerable at state, national and international levels; flesh-footed shearwater is listed as vulnerable by the state and internationally as near threatened.

Shorebirds:

- highest number of shorebirds recorded along the south coast (about two-thirds of the total in 2013 were recorded in coastal and near-coastal habitats in the Esperance region)
- internationally significant numbers recorded of hooded plover (listed by the state as priority 4) in the Esperance region.

Seadragons:

- likely location for the newly discovered ruby seadragon (listed internationally as data deficient)
- likely to have all 3 species of seadragon – ruby, weedy and leafy (a priority 2 species in Western Australia).

Great white shark:

- listed at the state, national and international levels as vulnerable
- entire area is biologically important foraging habitat.

Fishes:

- high fish diversity and endemicity
- potentially the highest abundance of western blue gropers (listed as internationally vulnerable).

## POTENTIAL FOR COMPLEMENTARY MANAGEMENT

This area adjoins the Cape Le Grand National Park and parts of the Recherche Archipelago Nature Reserve.

## 6.5 Eastern Recherche and Israelite Bay (Ngadju and Esperance Nyungar sea country)

- Calving hotspot for endangered southern right whales
- Critically important breeding and foraging area for endangered Australian sea lions
- One of Australia's most important seabird breeding areas
- Important breeding sites for specially protected long nosed fur seals
- A rich fish fauna with many endemic species
- Extensive seagrass meadows and kelp forests
- Transition zone between the WA South Coast and Eucla bioregions

### AREA DESCRIPTION

This area extends from just east of Cape Arid to east of Point Lorenzen to the boundary of state waters. Coastal sites Sandy Bight, Cape Pasley, Marlbemup Beach, Point Malcom, Point Dempster, Israelite Bay. There are about 50 islands. Inshore islands include Pasley, Bellinger, Stanley, George and Six Mile. Offshore islands include Salisbury, Round, Dome, Cooper and the eastern group (Rodona, Daw, New Year, Anvil, Halfway/Ford, Nook, Spindle, Cranny, High North and Tadpole).

### IMPORTANT HABITATS

Seagrass meadows: This area contains almost a third of the seagrass mapped in the Recherche Archipelago, including all of that in the Eucla bioregion part of the Recherche. Seagrass is particularly extensive between Point Malcolm and Point Dempster, east of Six Mile Island, east of Point Lorenzen and around the northern Islands in the eastern group.

Kelp and seaweed forests: This area contains over a third of the kelp forest mapped in the Recherche Archipelago (about 80 $km^2$). It is particularly extensive around Sandy Bight, Middle Island, Salisbury Island and the eastern group of islands. There are extensive wrack deposits along Israelite Bay and the beaches north-east of Point Lorenzen.

Bare reef: This area contains three-quarters of the subtidal bare reef mapped in the Recherche, and nearly half of the offshore intertidal bare reef (a rare habitat type with just 1.7 $km^2$ mapped). It is particularly extensive along the coastline between Cape Arid and Israelite Bay.

Coastline habitats: This area features habitat types unique in the Eucla bioregion part of the proposed marine park, including all the low exposure coastline (6 km) and all the hard rocky shores (including hard rocky shore platforms and sloping hard rock shore).

## SIGNIFICANT SPECIES

Southern right whale:

- listed as nationally endangered
- Israelite Bay and adjacent coastline is 1 of 3 calving hotspots in Australia, 1 of 2 in Western Australia
- other biologically important areas including calving sites and calving buffer areas.

Australian sea lion:

- endemic to southern Australia, listed as internationally endangered and nationally vulnerable, in decline, under threat from gillnet fishing
- 6 breeding sites (on Salisbury, Round, Six Mile*, Stanley, Spindle* and Halfway [aka Ford] islands in the Eastern group), accounting for more than a quarter of breeding sites in Western Australia, including 2 of the state's top pupping locations (*)
- 2 haul out sites – at Cooper Island and Western Sandy Bight (of just 9 mapped in Western Australia)
- almost the entire area is biologically important for foraging.

Long nosed fur seal:

- listed at the state level as specially protected.
- Cooper and Salisbury Islands are 2 of the 5 largest breeding colonies in Western Australia.

Seabirds:

- breeding sites for 9 species: fairy tern, flesh-footed shearwater, little penguin, little shearwater, white-faced storm petrel, black faced cormorant, Caspian tern, great-winged petrel, Pacific gull
- breeding sites on 7 islands (Anvil, Bellinger, Daw, New Year, Round, Salisbury and Six Mile ) and at Israelite Bay
- biologically important foraging areas for fairy tern and flesh-footed shearwater around breeding sites.
- fairy tern is listed as vulnerable at state, national and international levels; flesh-footed shearwater is listed as vulnerable by the state and internationally as near threatened.

Great white shark:

- listed at the state, national and international levels as vulnerable
- entire area is biologically important foraging habitat.

Fishes:

- high fish diversity and endemicity.

## POTENTIAL FOR COMPLEMENTARY MANAGEMENT

This area adjoins the Commonwealth Eastern Recherche Marine Park, Cape Arid National Park and parts of the Recherche Archipelago and Nuytsland nature reserves.

## 6.6 Bilbunya Beach and Baxter Cliffs (Ngadju sea country)

- Diverse coastline habitats and 3 landscapes unique in the bioregion -- Baxter Cliffs, Bilbunya Dunes and Wylie Scarp
- Extensive seagrass meadows and wrack deposits on beaches
- Important foraging area for 6 seabird species and breeding sites for 2 species

### AREA DESCRIPTION

This area extends from Bilbunya Beach (Wattle Camp) to Toolina Cove to the boundary of state waters. Coastal sites include the Bilbunya Dunes, Wylie Scarp, Point Culver and Toolina Cove.

### IMPORTANT HABITATS

Coastline habitats: This area features diverse coastline habitats, including a substantial proportion of the following types in the Eucla bioregion part of the proposed marine park:

- a third of the intertidal cliffs >5 m (Baxter Cliffs)
- a third of the subtidal sandy seafloor habitat (Baxter cliffs)
- all of the moderately to steeply sloping undifferentiated rock shore (Wylie Scarp)
- three-quarters of the intertidal rocky shore platform (Wylie Scarp)
- all of the open coast sandy shore backed by soft sediment deposits to below sea-level (Bilbunya Dunes)

Seagrass meadows: Seagrass occurs off Bilbunya Beach from Wattle Camp to Bilbunya Dunes, extending out as far as 5 km in parts.

### SIGNIFICANT SPECIES

Seabirds:

- a high-use breeding sites for little penguin (Toolina Cove)
- foraging grounds (provisioning of young) for Caspian tern and little penguin
- foraging grounds for flesh-footed shearwater, little shearwater, Pacific gull and short-tailed shearwater.
- flesh-footed shearwater is listed as vulnerable by the state.

### POTENTIAL FOR COMPLEMENTARY MANAGEMENT

This area adjoins part of the Nuytsland Nature Reserve.

## 6.7 Twilight Cove and Scorpion Bight (WA Mirning sea country)

- Extensive seagrass meadow (perhaps the longest stretch in the bioregion)
- Diverse sandy and rocky shoreline habitats
- An important haul out site for endangered Australian sea lions

### AREA DESCRIPTION

This area extends from halfway between Point Dover and Twilight Cove to Scorpion Bight to the edge of state waters. Coastal sites include Twilight Cove, Kanidal beach, and the Burramull sand patch.

### IMPORTANT HABITATS

Seagrass meadows: The area from Kanidal Beach to past Scorpion Bight contains the longest (80 km) stretch of seagrass in the Eucla bioregion (whether it is continuous is uncertain).

Rhodolith beds: This area may have extensive rhodolith habitat. It has not been mapped but the western Roe Terrace features what may be Australia's, and possibly the world's, most extensive high-density rhodolith bed.

Coastline habitats: This area features diverse coastline habitats, including substantial proportions of the following types in the Eucla bioregion part of the proposed marine park:

- sandy shorelines – the only instance of perched sandy beach (Scorpion Bight) and a third of the open coastline backed by bedrock rising above sea level, three quarters of the dunes, undifferentiated dune-field or putative beach-ridges disconnected from wave attack at seawards side (Twilight Cove)
- rocky shorelines – 1 of 2 locations where intertidal rocky shore platforms exist (Scorpion Bight) and over half of the subtidal rocky platform (coastline surrounding Scorpion Bight)

Geomorphic features: This area overlaps the Roe Terrace, known to support extensive rhodolith beds.

### SIGNIFICANT SPECIES

Australian sea lion:

- endemic to southern Australia, listed as internationally endangered and nationally vulnerable, in decline, under threat from gillnet fishing
- the only mapped haul out site between Six Mile Island (offshore from Israelite Bay) and the South Australian border.

Seabirds:

- high-use breeding site and foraging area for Pacific gull and little penguin
- foraging area for flesh-footed shearwater (listed as vulnerable by the state).

Great white shark:

- listed at the state, national and international levels as vulnerable
- most of the area is biologically important foraging habitat.

## POTENTIAL FOR COMPLEMENTARY MANAGEMENT

This area adjoins the Commonwealth Twilight Marine Park and part of the Nuytsland Nature Reserve.

## 6.8 Red Rocks Point to Eucla (WA Mirning sea country)

- A wild, remote, largely unexploited area that could become part of one of the top shelf sanctuaries in the world
- Longest stretch of subtidal rock platform and rocky reefs in the bioregion, with extensive kelp forests
- Extensive seagrass meadows
- A centre of rarity for seaweeds
- Important high-use habitat for great white sharks

### AREA DESCRIPTION

This area extends from Red Rocks Point to Eucla (South Australian border) to the edge of state waters. Coastal sites include Low Point, the Roe Plains, and the Delisser Sand Hills.

### IMPORTANT HABITATS

Seagrass meadows: The area from Low Point to Eucla has the second-longest (70 km) stretch of seagrass mapped in the Eucla bioregion (whether it is continuous is uncertain).

Kelp and seaweed forests: This area is likely to have extensive kelp forests (based on the presence of rocky reefs and wrack deposits on beaches). Eucla is a centre of rarity for seaweed species (1 of 6 across southern Australia).

Rhodolith beds: This area may have extensive rhodolith habitat. It has not been mapped but the western Roe Terrace features what may be Australia's, and possibly the world's, most extensive high-density rhodolith bed.

Coastline habitats: This area features substantial proportions of the following habitat types in the Eucla part of the proposed marine park:

- sandy shores – the only instance of sandy shore backed by bedrock rising above sea level
- rocky shores – a quarter of the subtidal rocky reefs (occurring offshore from beaches with extensive wrack deposits).

Geomorphic features: This area overlaps the Roe Terrace, which is known to support extensive rhodolith beds.

## SIGNIFICANT SPECIES

This coastline is among the most remote in Western Australia, with no substantial population centre for over 500 km. This remoteness means that few marine species have been studied or surveyed.

Great white shark:

- listed as vulnerable at international, national and state levels
- entire area is part of the only mapped high-used area in Australia.

## POTENTIAL FOR COMPLEMENTARY MANAGEMENT

This area adjoins the South Australian Far West Coast Marine Park, a sanctuary zone, which adjoins the Commonwealth Great Australian Bight Marine Park, which includes a sanctuary zone. This offers the potential to create Australia's largest shelf sanctuary and 1 of the 5 largest in the world.

# 7 REFERENCES


1. Marine Parks and Reserves Selection Working Group (1994) A representative marine reserve system for Western Australia, Western Australian Government Department of Conservation and Land Management.
2. Parks and Wildlife Service Western Australian Government, CAR marine reserve system. Available from: https://www.dpaw.wa.gov.au/management/marine/marine-parks-and-reserves/270-car-marine-reserve-system.
3. Smyth D, Isherwood M (2016) Protecting sea country: Indigenous people and marine protected areas in Australia. *Big, Bold and Blue: Lessons from Australia's marine protected areas* 307–325.
4. Department of the Environment Australian Government, Integrated Marine and Coastal Regionalisation of Australia. Available from: http://www.environment.gov.au/node/18075.
5. Commonwealth of Australia (2006) A guide to the Integrated Marine and Coastal Regionalisation of Australia: IMCRA version 4.0, Canberra, Australia.
6. Short AD (2019) Australian Coastal Systems: Beaches, Barriers and Sediment Compartments, Springer Nature.
7. Hodgkin EP, Hesp P (1998) Estuaries to salt lakes: Holocene transformation of the estuarine ecosystems of south-western Australia. *Marine and freshwater research* 49: 183–201.
8. James NP, Bone Y, Collins LB, et al. (2001) Surficial sediments of the Great Australian Bight: facies dynamics and oceanography on a vast cool-water carbonate shelf. *Journal of Sedimentary Research* 71: 549–567.
9. Phillips JA (2001) Marine macroalgal biodiversity hotspots: why is there high species richness and endemism in southern Australian marine benthic flora? *Biodiversity & Conservation* 10: 1555–1577.
10. Smale DA, Kendrick GA, Wernberg T (2011) Subtidal macroalgal richness, diversity and turnover, at multiple spatial scales, along the southwestern Australian coastline. *Estuarine, Coastal and Shelf Science* 91: 224–231.
11. Ridgway K, Condie S (2004) The 5500-km-long boundary flow off western and southern Australia. *Journal of Geophysical Research: Oceans* 109.
12. Harvey ES, Cappo M, Kendrick GA, et al. (2013) Coastal fish assemblages reflect geological and oceanographic gradients within an Australian zootone. *PloS one* 8.
13. Scientific Working Group (2011) The vulnerability of coastal and marine habitats in South Australia, South Australian Government Department of Environment, Water and Natural Resources.
14. Carruthers T, Dennison W, Kendrick G, et al. (2007) Seagrasses of south–west Australia: A conceptual synthesis of the world's most diverse and extensive seagrass meadows. *Journal of Experimental Marine Biology and Ecology* 350: 21–45.
15. O'Leary BC, Winther-Janson M, Bainbridge JM, et al. (2016) Effective coverage targets for ocean protection. *Conservation Letters* 9: 398–404.
16. IUCN (2016) IUCN resolutions, recommendations and other decisions., International Union for Conservation of Nature.

17. Kendrick G, Goldberg N, Harvey E, et al. (2009) Historical and contemporary influence of the Leeuwin Current on the marine biota of the southwestern Australian Continental Shelf and the Recherche Archipelago. *Journal of the Royal Society of Western Australia* 92: 211–219.
18. Tecchiato S, Buosi C, Ibba A, et al. (2019) Geomorphological and sedimentological surrogates for the understanding of seagrass distribution within a temperate nearshore setting (Esperance Western Australia). *Geo-Marine Letters* 39: 249–264.
19. Lemmens J, Clapin G, Lavery P, et al. (1996) Filtering capacity of seagrass meadows and other habitats of Cockburn Sound, Western Australia. *Marine Ecology Progress Series* 143: 187–200.
20. Smit A, Brearley A, Hyndes G, et al. (2005) Carbon and nitrogen stable isotope analysis of an Amphibolis griffithii seagrass bed. *Estuarine, Coastal and Shelf Science* 65: 545–556.
21. Waters JM, Wernberg T, Connell SD, et al. (2010) Australia's marine biogeography revisited: Back to the future? *Austral ecology* 35: 988–992.
22. Scott F (2013) Rare marine macroalgae of southern Australia.
23. Bennett S, Wernberg T, Connell SD, et al. (2016) The 'Great Southern Reef': social, ecological and economic value of Australia's neglected kelp forests. *Marine and Freshwater Research* 67: 47–56.
24. Wernberg T, Kendrick GA, Phillips JC (2003) Regional differences in kelp-associated algal assemblages on temperate limestone reefs in south-western Australia. *Diversity and Distributions* 9: 427–441.
25. Smale DA, Kendrick GA, Wernberg T (2010) Assemblage turnover and taxonomic sufficiency of subtidal macroalgae at multiple spatial scales. *Journal of Experimental Marine Biology and Ecology* 384: 76–86.
26. Wernberg T, Bennett S, Babcock RC, et al. (2016) Climate-driven regime shift of a temperate marine ecosystem. *Science* 353: 169–172.
27. Kirkman H, Kendrick GA (1997) Ecological significance and commercial harvesting of drifting and beach-cast macro-algae and seagrasses in Australia: a review. *Journal of Applied Phycology* 9: 311–326.
28. Goldberg N (2006) Age estimates and description of rhodoliths from Esperance Bay, Western Australia. *Journal of the Marine Biological Association of the United Kingdom* 86: 1291–1296.
29. Harvey A, Harvey R, Merton E (2017) The distribution, significance and vulnerability of Australian rhodolith beds: a review. *Marine and Freshwater Research* 68: 411–428.
30. Kendrick G, Harvey E, McDonald J, et al. (2005) Characterising the fish habitats of the Recherche Archipelago. *Fisheries Research and Development Corporation report project*.
31. Ryan DA, Brooke BP, Collins LB, et al. (2007) The influence of geomorphology and sedimentary processes on shallow-water benthic habitat distribution: Esperance Bay, Western Australia. *Estuarine, Coastal and Shelf Science* 72: 379–386.
32. Svane I, Hammett Z, Lauer P (2009) Impacts of trawling on benthic macro-fauna and-flora of the Spencer Gulf prawn fishing grounds. *Estuarine, Coastal and Shelf Science* 82: 621–631.
33. Hoeksema SD, Chuwen BM, Tweedley JR, et al. (2018) Factors influencing marked variations in the frequency and timing of bar breaching and salinity and oxygen regimes among normally-closed estuaries. *Estuarine, Coastal and Shelf Science* 208: 205–218.
34. Department of Environment (2004) Jerdacuttup River Action Plan, Western Australian Government.

35. Department of Parks and Wildlife (2016) Esperance and Recherche parks and reserves management plan 84, Western Australian Government.
36. Threatened Species Scientific Committee (2013) Conservation advice for subtropical and temperate coastal saltmarsh, Australian Government Department of Environment.
37. Directory of Important Wetlands in Australia Department of Agriculture, Water and the Environment. Available from: http://www.environment.gov.au/.
38. Birdlife International BirdLife Data Zone, Fitzgerald River. Available from: http://datazone.birdlife.org/site/factsheet/fitzgerald-river-iba-australia.
39. Harris P, Heap A, Passlow V, et al. (2005) Geomorphic Features of the Continental Margin of Australia, Geoscience Australia, Record 2003/30.
40. Lee S, Bancroft K (2001) Review of the existing ecological information for the proposed Recherché Archipelago marine conservation reserve, Western Australian Government Department of Conservation and Land Management.
41. The Ecology Centre (2009) Scientific Principles for Design of Marine Protected Areas in Australia: A Guidance Statement, University of Queensland.
42. McLeod E, Salm R, Green A, et al. (2009) Designing marine protected area networks to address the impacts of climate change. *Frontiers in Ecology and the Environment* 7: 362–370.
43. South Coast Regional Marine Planning Working Group (2010) Oceans of Opportunity: A proposed strategic framework for marine waters of Western Australia's south coast, Western Australian Government.
44. Department of Environment and Conservation (2009) Walpole and Nornalup Inlets Marine Park management plan 2009–2019, Western Australian Government.
45. South Coast Regional Marine Planning Advisory Group (2010) South Coast Draft Regional Marine Strategic Plan 2010, Western Australian Government.
46. Houbrick RS (1984) Diastoma melanioides (Reeve), a relict snail from South Australia, *Living fossils*, Springer, 236–239.
47. Houbrick RS (1984) The giant creeper, Campanile symbolicum Iredale, an Australian relict marine snail, *Living fossils*, Springer, 232–235.
48. Department of the Environment (2012) Marine bioregional plan for the South-west Marine Region, Australian Government.
49. Department of Environment (2013) Recovery plan for the Australian sea lion (Neophoca cinerea), Australian Government.
50. Goldsworthy SD (2015) Neophoca cinerea. The IUCN Red List of Threatened Species 2015: e.T14549A45228341, International Union for the Conservation of Nature.
51. Goldsworthy S (2020) Australian sea lion listing assessment, South Australian Research and Development Institute.
52. Hamer DJ, Goldsworthy SD, Costa DP, et al. (2013) The endangered Australian sea lion extensively overlaps with and regularly becomes by-catch in demersal shark gill-nets in South Australian shelf waters. *Biological Conservation* 157: 386–400.
53. Campbell R (2011) Assessing and managing interactions of protected and listed marine species with commercial fisheries in Western Australia. Report to the Fisheries Research and Development Corporation, Department of Fisheries.
54. Kelly D (2018) Greater sea lion protection builds social licence for WA fishers, Western Australian Government.

55. Cooke J, Zerbini A (2018) Eubalaena australis. The IUCN Red List of Threatened Species: e.T8153A50354147, International Union for the Conservation of Nature.
56. Department of Environment (2012) Conservation Management Plan for the Southern Right Whale: A Recovery Plan under the Environment Protection and Biodiversity Conservation Act 1999, 2011–2021, Australian Government.
57. Smith J, Jones D, Travouillon K, et al. (2019) Monitoring population dynamics of 'western' right whales off southern Australia 2018-2021 - final report on activities for 2018, National Environmental Science Programme Marine Biodiversity Hub.
58. Stamation K, Watson M, Moloney P, et al. (2020) Population estimate and rate of increase of southern right whales Eubalaena australis in southeastern Australia. *Endangered Species Research* 41: 373–383.
59. Australian Government Department of the Environment (2016) Species Profile and Threats Database, Eubalaena australis — southern right whale, 2016. Available from: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=40.
60. Valenzuela LO, Sironi M, Rowntree VJ, et al. (2009) Isotopic and genetic evidence for culturally inherited site fidelity to feeding grounds in southern right whales (Eubalaena australis). *Molecular Ecology* 18: 782–791.
61. Leaper R, Cooke J, Trathan P, et al. (2006) Global climate drives southern right whale (Eubalaena australis) population dynamics. *Biology Letters* 2: 289–292.
62. Director of National Parks (2015) Great Australian Bight Marine Park (Commonwealth & state waters) – a description of values and uses, Australian Government Department of the Environment & Heritage.
63. Threatened Species Scientific Committee (2015) Conservation advice: Megaptera novaeangliae, humpback whale, Australian Government.
64. Cooke J (2018) Megaptera novaeangliae. The IUCN Red List of Threatened Species 2018: e.T13006A50362794, International Union for the Conservation of Nature.
65. Bejder M, Johnston DW, Smith J, et al. (2016) Embracing conservation success of recovering humpback whale populations: Evaluating the case for downlisting their conservation status in Australia. *Marine Policy* 66: 137–141.
66. International Whaling Commission (2011) Report of the Workshop on the Comprehensive Assessment of Southern Hemisphere humpback whales, 4–7 April 2006, Hobart, Tasmania. *Journal of Cetacean Research and Management* Special Issue 3: 1–50.
67. Chilvers B, Goldsworthy S (2015) Arctocephalus forsteri. The IUCN Red List of Threatened Species 2015: e.T41664A45230026., International Union for the Conservation of Nature.
68. Campbell R, Holley D, Collins P, et al. (2014) Changes in the abundance and distribution of the new zealand fur seal (arctocephalus forsteri) in western australia: are they approaching carrying capacity? *Australian Journal of Zoology* 62: 261–267.
69. Rigby C, Barreto R, Carlson J, et al. (2019) Carcharodon carcharias. The IUCN Red List of Threatened Species: e.T3855A2878674, International Union for the Conservation of Nature.
70. Bruce B, Bradford R, Bravington M, et al. (2018) A national assessment of the status of white sharks, National Environmental Science Programme Marine Biodiversity Hub.
71. Department of Environment (2013) Issues paper for the white shark (Carcharodon carcharias), Australian Government.

72. Braccini M, Taylor S, Bruce B, et al. (2017) Modelling the population trajectory of West Australian white sharks. *Ecological modelling* 360: 363–377.
73. Roff G, Brown CJ, Priest MA, et al. (2018) Decline of coastal apex shark populations over the past half century. *Communications biology* 1: 1–11.
74. Taylor S, Braccini JM, McAuley R, et al. (2016) Review of potential fisheries and marine management impacts on the south-western Australian white shark population, Department of Fisheries, Government of Western Australia.
75. Taylor S, Braccini J, Bruce B, et al. (2018) Reconstructing Western Australian white shark (Carcharodon carcharias) catches based on interviews with fishers. *Marine and Freshwater Research* 69: 366–375.
76. Malcolm H, Bruce BD, Stevens JD (2001) A review of the biology and status of white sharks in Australian waters, CSIRO Marine Research.
77. Department of the Environment (2014) Issues paper for the grey nurse shark (Carcharias taurus), Australian Government.
78. Hoschke AM, Whisson GJ (2016) First aggregation of grey nurse sharks (Carcharias taurus) confirmed in Western Australia. *Marine Biodiversity Records* 9: 17.
79. Department of the Environment (2014) Recovery plan for the grey nurse shark (Carcharias taurus), Australian Government.
80. Ahonen H, Harcourt R, Stow A (2009) Nuclear and mitochondrial DNA reveals isolation of imperilled grey nurse shark populations (Carcharias taurus). *Molecular Ecology* 18: 4409–4421.
81. Gaughan DJ, Molony B, Santoro K (2019) Status reports of the fisheries and aquatic resources of Western Australia 2017/18: The state of the fisheries, Western Australian Government Department of Primary Industries.
82. Ryan KL, Hall NG, Lai EK, et al. (2019) Statewide survey of boat-based recreational fishing in Western Australia 2017/18, Western Australian Government Department of Primary Industries.
83. Bansemer C, Bennett M (2010) Retained fishing gear and associated injuries in the east Australian grey nurse sharks (Carcharias taurus): implications for population recovery. *Marine and Freshwater Research* 61: 97–103.
84. Chidlow J, Gaughan D, McAuley R (2005) Identification of Western Australian Grey Nurse Shark aggregation sites. *Final Report to the Australian Government, Department of the Environment and Heritage, Canberra, ACT Australia*.
85. Walker T, Cavanagh R, Stevens J, et al. (2006) Galeorhinus galeus. The IUCN Red List of Threatened Species 2006: e.T39352A10212764, International Union for the Conservation of Nature.
86. Threatened Species Scientific Committee (2009) Galeorhinus galeus (school shark). Advice to the Minister for the Environment, Heritage and the Arts on Amendments to the list of Threatened Species under the Environment Protection and Biodiversity Conservation Act 1999, Australian Government Department of the Environment.
87. Emery T, Woodhams J, Curtotti R (2019) Shark gillnet and shark hook sectors, *Fisheries Status Reports 2019*, ABARES.
88. Australian Fisheries Management Authority (2015) School shark Galeorhinus galeus stock rebuilding strategy: revised 2015, Australian Government.

89. Woodhams J, Stobutzki I, Vieira S (2018) Shark gillnet and shark hook sectors, *Fisheries Status Reports 2018*, ABARES.
90. Rayns N (2019) Review of recovery planning for threatened sharks; status, analysis & future directions. A report prepared for Australian Marine Conservation Society and Humane Society International, Future Catch Consulting.
91. Rogers P, Knuckey I, Hudson R, et al. (2017) Post-release survival, movement, and habitat use of school shark Galeorhinus galeus in the Great Australian Bight, southern Australia. *Fisheries research* 187: 188–198.
92. Braccini M, Blay N, Hesp A, et al. (2018) Resource assessment report: Temperate demersal elasmobranch resource of Western Australia Matias Braccini, Nick Blay, Alex Hesp & Brett Molony, Western Australian Government Department of Primary Industries.
93. Ferretti F, Walls R, Musick J, et al. (2015) Carcharhinus plumbeus. The IUCN Red List of Threatened Species 2015: e.T3853A48946805., International Union for the Conservation of Nature.
94. Rigby C, Barreto R, Carlson J, et al. (2019) Carcharhinus obscurus. The IUCN Red List of Threatened Species 2019: e.T3852A2872747, International Union for the Conservation of Nature.
95. Duffy C, Gordon I (2003) Carcharhinus brachyurus. The IUCN Red List of Threatened Species 2003: e.T41741A10551730., International Union for the Conservation of Nature.
96. Threatened Species Scientific Committee (2014) Listing advice: Carcharhinus obscurus, dusky shark, Australian Government Department of the Environment.
97. Braccini M, Blay N (2019) Temperate demersal gillnet and demersal longline fisheries resource status report 2018, *Status reports of the fisheries and aquatic resources of Western Australia 2017/18*, Western Australian Government Department of Primary Industries and Regional Development.
98. Braccini M, Johnson G, Walton L, et al. Fisheries Research & Development Corporation, Sandbar shark 2018. Available from: http://www.fish.gov.au/report/184-Sandbar-Shark-2018.
99. Simpfendorfer CA, McAuley R, Chidlow J, et al. (1999) Biology and stock assessment of western Australia's commercially important shark species, Fisheries Research & Development Corporation.
100. Coulson PG, Hesp SA, Hall NG, et al. (2009) The western blue groper (Achoerodus gouldii), a protogynous hermaphroditic labrid with exceptional longevity, late maturity, slow growth, and both late maturation and sex change. *Fishery Bulletin* 107: 57–75.
101. Choat J, Gillanders B, Pollard D (2010) Achoerodus gouldii. The IUCN Red List of Threatened Species 2010: e.T187520A8556943, International Union for the Conservation of Nature.
102. Parker JR, Saunders BJ, Bennett S, et al. (2019) Shifts in Labridae geographical distribution along a unique and dynamic coastline. *Diversity and Distributions* 25: 1787–1799.
103. Caputi N, Feng M, Pearce A, et al. (2014) Management implications of climate change effect on fisheries in Western Australia. Part 2. Case studies. *Fisheries research report*.
104. Norriss J, Fisher E, Hesp S, et al. (2016) Status of inshore demersal scalefish stocks on the South Coast of Western Australia, Western Australian Government Department of Fisheries.
105. Bryars S, Rogers P, Huveneers C, et al. (2012) Small home range in southern Australia's largest resident reef fish, the western blue groper (Achoerodus gouldii): implications for adequacy of no-take marine protected areas. *Marine and Freshwater Research* 63: 552–563.

106. Stiller J, Wilson NG, Rouse GW (2015) A spectacular new species of seadragon (Syngnathidae). *Royal Society open science* 2: 140458.
107. Rouse GW, Stiller J, Wilson NG (2017) First live records of the ruby seadragon (Phyllopteryx dewysea, Syngnathidae). *Marine Biodiversity Records* 10: 2.
108. Wilson NG, Stiller J, Rouse GW (2017) Barriers to gene flow in common seadragons (Syngnathidae: Phyllopteryx taeniolatus). *Conservation Genetics* 18: 53–66.
109. Stiller J, Wilson NG, Donnellan S, et al. (2017) The leafy seadragon, Phycodurus eques, a flagship species with low but structured genetic variability. *Journal of Heredity* 108: 152–162.
110. Pollom R (2017) Phyllopteryx taeniolatus. The IUCN Red List of Threatened Species 2017: e.T17177A67624517, International Union for the Conservation of Nature.
111. Pollom R (2017) Phycodurus eques. The IUCN Red List of Threatened Species 2017: e.T17096A67622420., International Union for the Conservation of Nature.
112. Birdlife International (2018) Sternula nereis. The IUCN Red List of Threatened Species 2018: e.T22694691A132568135., International Union for the Conservation of Nature.
113. Threatened Species Scientific Committee (2011) Approved conservation advice for Sternula nereis nereis (fairy tern), Australian Government.
114. Lavers JL, Lisovski S, Bond AL (2019) Preliminary survival and movement data for a declining population of Flesh-footed Shearwater Ardenna carneipes in Western Australia provides insights into marine threats. *Bird Conservation International* 29: 327–337.
115. Birdlife International (2019) Ardenna carneipes. The IUCN Red List of Threatened Species 2019: e.T22698188A155469189., International Union for the Conservation of Nature.
116. Department of Environment (2012) Species group report card—seabirds. Supporting the marine bioregional plan for the South-west Marine Region, Australian Government.
117. Lavers JL, Hutton I, Bond AL (2019) Changes in technology and imperfect detection of nest contents impedes reliable estimates of population trends in burrowing seabirds. *Global ecology and conservation* 17: e00579.
118. Surman C, Nicholson L (2006) Seabirds, *The South-west Marine Region: ecosystems and key species groups*.
119. Birdlife International (2020) Important Bird Areas factsheet: Recherche Archipelago, 2020. Available from: http://datazone.birdlife.org/site/factsheet/recherche-archipelago-iba-australia.
120. Department of the Environment and Water Resources (2007) The South-west Marine Region: Ecosystems and key species groups. Part 2 -- key species groups, Australian Government.
121. Taylor P (2013) Shorebirds on WA's South Coast, Green Skills and South Coast NRM.
122. Clemens R, Rogers DI, Hansen BD, et al. (2016) Continental-scale decreases in shorebird populations in Australia. *Emu-Austral Ornithology* 116: 119–135.
123. Singor M (2006) Sooty oystercatcher sites in south western Australia. *Western Australian Bird Notes*.
124. Richards Z, Kirkendale L, Moore G, et al. (2016) Marine biodiversity in temperate Western Australia: multi-taxon surveys of Minden and Roe Reefs. *Diversity* 8: 7.
125. Bradley P (2017) The Monthly, The Great Southern Reef, 2017. Available from: https://www.themonthly.com.au/issue/2017/november/1509454800/james-bradley/great-southern-reef.

126. Teagle H, Hawkins SJ, Moore PJ, et al. (2017) The role of kelp species as biogenic habitat formers in coastal marine ecosystems. *Journal of Experimental Marine Biology and Ecology* 492: 81–98.
127. Hobday AJ, Pecl GT (2014) Identification of global marine hotspots: sentinels for change and vanguards for adaptation action. *Reviews in Fish Biology and Fisheries* 24: 415–425.
128. Martínez B, Radford B, Thomsen MS, et al. (2018) Distribution models predict large contractions of habitat-forming seaweeds in response to ocean warming. *Diversity and Distributions* 24: 1350–1366.

# APPENDIX A

*Table 11. Known Australian sea lion breeding sites and pup counts in the proposed south coast marine park.*

| Region | Breeding site | Survey year | Pup count |
|---|---|---|---|
| Twilight Cove | Twilight Cove | 1996 | 4 |
| Recherche Archipelago | Spindle Island | 1990 | 53 |
| | Ford (Halfway) Island | 1990 | 17 |
| | Six Mile Island | 2017 | 45 |
| | Round Island | 2013 | 13 |
| | Salisbury Island | 2014 | 10 |
| | Wickham (Stanley) Island | 2014 | 5 |
| | George Island | 2011 | 13 |
| | Glennie Island | 1999 | 21 |
| | Taylor Island | 2013 | 4 |
| | Kimberley Island | 2014 | 32 |
| | Cooper Island | 2014 | 8 |
| Bremer Bay | Investigator Island | 1989 | 17 |
| | West Island | 1992 | 20 |
| | Red Islet | 2017 | 25 |
| | Middle Doubtful Island | 2012 | 1 |
| | Haul Off Rock | 2016 | 24 |
| Total | | | 312 |

*Source: [51]*

*Table 12. Known long-nosed seal sites and pup counts in Western Australia*

| Colony | P | | |
|---|---|---|---|
| | 1989[A] | 1999[A] | 2011 |
| Cranny Island | 60 | 140 | 120 |
| Daw Island | 73 | 88 | 125 |
| New Year Island | 32 | 29 | 45 |
| Cooper Island | 123 | 287 | 306 |
| Salisbury Island | 451 | 963 | 1251 |
| Beaumont Island | 75 | 88 | 39 |
| Draper Island | 22 | 52 | 39 |
| Finger Island | 4 | 17 | 37 |
| Libke Island | 166 | 333 | 340 |
| Hood Island | 33 | 90 | 175 |
| Seal Rock | 187 | 296 | 276 |
| Investigator Island | 27 | 83 | 47 |
| West Island | 43 | 104[B] | 57[B] |
| Middle Doubtful Island | 56 | 135 | 71 |
| Haul Off Rock | 59 | 249 | 285 |
| Eclipse Island | 38 | 132 | 136 |
| **Stanley Island** | – | – | 5 |
| **Chatham Island** | – | – | 154 |
| Flinders Islet | 0 | 4 | 12 |
| **Bunker Bay** | – | – | 2 |

*Source: [68]*

*Table 13. Breeding sites and the proportion of biologically important foraging areas for seabirds in the proposed south coast marine park (% Western Australian waters)*

| Common name | Notes | BIA | Reserves | | | | Breeding sites in proposed marine park |
|---|---|---|---|---|---|---|---|
| | | | Sanctuaries (Australia) | Sanctuaries (WA) | Proposed marine park (Australia) | Proposed marine park (WA) | |
| Black-faced Cormorant | Forage in sheltered, shallow inshore waters in bays, gulfs, inlets and around reefs. The Recherche Archipelago are a key foraging grounds for this species (species report card- seabirds) | Foraging grounds | 2 | 0 | 11 | 100 | Recherche Archipelago, west of Esperance to Hopetoun (Bellinger Island, Islet off Remark Island, Lion Island [2], Middle Island) 5 of 5 in WA |
| Bridled Tern | In WA breeding (total population tens of thousands) in loose colonies on Ashmore Reef (12º15'S) and on west coast from Lesueur I. (13º50'S) to Seal I. (34º23'S) and east to Termination I. (off Esperance) and wintering north of the Equator | Foraging (high use) | 3 | 0 | 8 | 58 | Recherche Archipelago (Termination Island) 1 of 114 in WA |
| Caspian Tern | Found in much of world, but not America south of Mexico. In Western Australia, total population thousands. | Foraging (provisioning young) | 5 | 0 | 12 | 52 | East of Israelite Bay to Albany (Bellinger Island, Canning Island, Capps Island, Charley Island, Douglas Island, Fur Rock, Goose Island, Fur Rock, Israelite Bay, Lorranise Island, Mackenzie Island, Middle Island, Ram Island, Rock off Twin Peaks, Six Mile Island) 14 of 49 in WA |

| Common name | Notes | BIA | Reserves | | | | Breeding sites in proposed marine park |
|---|---|---|---|---|---|---|---|
| | | | Sanctuaries (Australia) | Sanctuaries (WA) | Proposed marine park (Australia) | Proposed marine park (WA) | |
| Fairy Tern | Breeding (total population thousands) colonially (6 to several hundred pairs), mainly on islands; off north-west coast, in Shark Bay; in Houtman Abrolhos; off lower west coast; off south coast; also on mainland from Cape Preston to Lake Kubitch. | Foraging (in high numbers) | 4 | 0 | 15 | 78 | from Flinders Bay east to Israelite Bay (Glasse Island, Lake Kubitch, Six Mile Island, Stokes Inlet) 4 of 40 in WA |
| Flesh-footed Shearwater | Pelagic and offshore. Foraging from Cape Naturaliste to Eyre, 1-150km offshore. Pre departure zone in some years from Rottnest Island to Bunbury. | Foraging | <1 | 0 | <1 | 100 | Eyre to Israelite Bay (see below for breeding) |
| | | Foraging (in high numbers) | 5 | 0 | 17 | 78 | Israelite Bay to Albany (Barrier Island, Charley Island, daw Island, Doubtful Islands, Forrest ISland, Harlequin Island, Hull Island, Long Island, Mondrian Island, Rabbit Island, Ram Island, Remark Island, Sandy Hook Island, Woody Island) 14 of 28 |

| Common name | Notes | BIA | Reserves | | | | Breeding sites in proposed marine park |
|---|---|---|---|---|---|---|---|
| | | | Sanctuaries (Australia) | Sanctuaries (WA) | Proposed marine park (Australia) | Proposed marine park (WA) | |
| Little Penguin | Aust supports 90% of global population. Adults mainly sedentary and spending whole year near breeding grounds. Forage btw 20 - 40 km for inshore colonies. Perth to Bunbury and South-west WA from Augusta to Twilight Cove | Foraging (provisioning young) | 5 | 0 | 18 | 70 | Albany to Twilight Cove (Anvil Island, Barrier Island, Baxter Cliffs, Bellinger Island, Ben Island, Boxer Island, Capps Island, Charley Island, Combe Island, Cull Island, Daw Island, Doubtful Islands, Figure of Eight Island, Forrest Island, Goose Island, Inshore Island, Kermadec Island, Mart Islands, New Year Island, North Twin Peak Island, Observatory Island, Rabbit Island, Rob Island, Round Island, Sandy Hook Island, Six Mile Island, Station Island, Taylor Island, Termination Island, Toolinna Cove, Twilight Cove, Wickham Island ) 18 o 50 |
| LIttle Shearwater | Puffinus assimilis tunneyi is endemic subspecies. Pelagic and offshore, foraging 4-200 km off coast. From Kalbarri to Eucla including offshore waters | Foraging (in high numbers) | 11 | 0 | 3 | 50 | Albany to Eyre (Anvil Island, Barrier Island, Bellinger Island, Boxer Island, Combe Island, Figure of Eight Island, Gulch Island, Hood Island, Hull Island, Lion Island, Mackenzie Island, New Year Island, Owen Island, Tunney Island, Wilson Island) 15 of 48 |

| Common name | Notes | BIA | Reserves | | | | Breeding sites in proposed marine park |
|---|---|---|---|---|---|---|---|
| | | | Sanctuaries (Australia) | Sanctuaries (WA) | Proposed marine park (Australia) | Proposed marine park (WA) | |
| Pacific Gull | GAB and Port Lincoln | Foraging | 11 | 0 | 3 | 100 | GAB coastline (see below) |
| | South coast and islands, west to Cape Leeuwin. Common around Albany and Esperance and in the Archipelago of the Recherche. | Foraging (in high numbers) | 2 | 0 | 22 | 51 | around Albany and Esperance and in the Archipelago of the Recherche (Capps Island, Cave Island, Combe Island, Cull Island, Daw Island, Figure of Eight Island, Frederick Island, Goose Island, Lorraine Island, Mackenzie Island, Middle Island, Mondrain Island, Nares Island, Ram Island, Remark Island, Salisbury Island, Thomas Island, Twilight Cove, Woody Island) 19 of 45 in WA |
| White-faced Storm petrel | Breeding on subtropical and temperate islands of southern Australia, and dispersing northwards. Other subspecies including O. m. marinus, in north and south Atlantic and south-west Pacific. | Foraging (in high numbers) | 9 | 0 | 1 | 48 | Offshore islands of the Recherche (Anvil Island, Canning Island, Daw Island, Douglas Island, Frederick Island, Hope Island, Lion Island, Lorraine Island, Mart Islands, Nares Island, Rob Island, Woody Island) 12 of 29 in WA |

# APPENDIX B

*Table 14. Data sources for report figures*

| Map Number | Description | Data source |
|---|---|---|
| All | Localities | GEODATA TOPO 250K Series 3. © Commonwealth of Australia (Geoscience Australia). Downloaded from: http://www.ga.gov.au |
| All | Coastline | GEODATA COAST 100K 2004. © Commonwealth of Australia (Geoscience Australia). Downloaded from: http://www.ga.gov.au/metadata-gateway/metadata/record/61395/ |
| All | State border | GEODATA TOPO 250K Series 3. © Commonwealth of Australia (Geoscience Australia). Downloaded from: http://www.ga.gov.au |
| All | State waters | Alcock, M.B., McGregor, M.J., Hatfield, A & Taffs, N.J., 2014. Coastal Waters (State/Territory Powers) Act 1980 - Australian Maritime Boundaries 2014a - Geodatabase. Geoscience Australia, Canberra. http://dx.doi.org/10.4225/25/5539DF797A8BA |
| All | EEZ limit | Alcock, M.B., McGregor, M.J., Hatfield, A & Taffs, N.J., 2014. Seas and Submerged Lands Act 1973 - Australian Maritime Boundaries 2014a - Geodatabase. Geoscience Australia, Canberra. http://dx.doi.org/10.4225/25/5539DFE87D895 |
| All | Reserves | Collaborative Australian Protected Areas Database (CAPAD) 2018, © Commonwealth of Australia 2019 |
| 1 | Native title areas | Native Title Determination Applications, Register of Native Title. © Commonwealth of Australia, National Native Title Tribunal. Downloaded from: http://www.ntv.nntt.gov.au |
| 2 | Bioregions | Integrated Marine and Coastal Regionalisation of Australia (IMCRA) v4.0 - Provincial Bioregions. © Commonwealth of Australia, Australian Government Department of Agriculture, Water and the Environment. (2006). |
| 3 | Seagrass | CSIRO (2015): Seagrass Dataset - CAMRIS. v1. CSIRO. Data Collection. 10.4225/08/5514852027A1E |

| Map Number | Description | Data source |
|---|---|---|
| 3 | Seagrass (Recherche) | Recherche Habitats, FRDC, 2001 downloaded from https://data.pawsey.org.au/public/?path=/WA%20Node%20Ocean%20Data%20Network/ |
| 4 | Macroalgae (Recherche) | WA marine habitats 2004- supplied by Department of Biodiversity, Conservation and Attractions, Government of WA |
| 4 | Reefs (marine hazards) | GEODATA TOPO 250K Series 3. © Commonwealth of Australia (Geoscience Australia). Downloaded from: http://www.ga.gov.au |
| 4 | Subtidal/intertidal landforms | Sharples, C., Mount, R.E., Pedersen, T.K., Lacey, M.J., Newton, J.B., Jaskierniak, D. and Wallace, L.O. (2009) Australian Coastal Smartline Geomorphic and Stability Map, version 1. Canberra: Australian Government, Geoscience Australia. http://www.ozestuaries.org/ |
| 5 | Rhodoliths | Harvey, As & Harvey, R. & Merton, E. (2016). The distribution, significance and vulnerability of Australian rhodolith beds: A review. Marine and Freshwater Research. 68. 10.1071/MF15434. |
| 6 | Estuaries | National Land and Water Resources Audit. © Commonwealth of Australia (Geoscience Australia) 1998. Downloaded from: http://www.ozcoasts.gov.au/search_data/estuary_data.jsp |
| 7-12 | Shorelines | Sharples, C., Mount, R.E., Pedersen, T.K., Lacey, M.J., Newton, J.B., Jaskierniak, D. and Wallace, L.O. (2009) Australian Coastal Smartline Geomorphic and Stability Map, version 1. Canberra: Australian Government, Geoscience Australia. http://www.ozestuaries.org/ |
| 13 | Geomorphic features | Geomorphic Features of the Continental Margin of Australia. © Commonwealth of Australia (Geoscience Australia) 2003. Downloaded from: https://www.environment.gov.au |
| 14 | Bathymetry | Australian Bathymetry and Topography Grid. © Commonwealth of Australia (Geoscience Australia). 2009 |

| Map Number | Description | Data source |
|---|---|---|
| 15 | Recherche habitats | WA marine habitats 2004- supplied by Department of Biodiversity, Conservation and Attractions, Government of WA |
| 16 | Australian sea lions haul-out rocks and colonies | Digistsed from Goldsworthy, S.D. (2020). Australian sea lion listing assessment. Report to the Department for Environment and Water, Department of Agriculture, Water and the Environment. South Australian Research and Development Institute (Aquatic Sciences), Adelaide. SARDI Publication No. F2020/000131-1. SARDI Research Report Series No. 1056. 26pp. |
| 16 | Australian sea lion feeding grounds | Biologically Important Areas of Regionally Significant Marine Species. © Commonwealth of Australia, Australian Government Department of the Environment and Energy. 2015. Downloaded from: https://data.gov.au/ |
| 17 | Southern right whale habitat | Biologically Important Areas of Regionally Significant Marine Species. © Commonwealth of Australia, Australian Government Department of the Environment and Energy. 2015. Downloaded from: https://data.gov.au/ |
| 18 | Humpback whale habitat | Biologically Important Areas of Regionally Significant Marine Species. © Commonwealth of Australia, Australian Government Department of the Environment and Energy. 2015. Downloaded from: https://data.gov.au/ |
| 19 | White shark habitat | Biologically Important Areas of Regionally Significant Marine Species. © Commonwealth of Australia, Australian Government Department of the Environment and Energy. 2015. Downloaded from: https://data.gov.au/ |
| 20 | Seabird biologically important areas | Biologically Important Areas of Regionally Significant Marine Species. © Commonwealth of Australia, Australian Government Department of the Environment and Energy. 2015. Downloaded from: https://data.gov.au/ |
| 21 | Great Southern Reef | Based on bathomes from Australian Bathymetry and Topography Grid. © Commonwealth of Australia (Geoscience Australia). 2009 |