RESOURCE ASSESSMENT FOR THE PROPOSED REVIEW AND EXTENSION OF MARMION MARINE PARK

Prepared by
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Noongar language

Within Noongar country, there are many dialects and ways to speak Noongar language. As the Noongar language is traditionally a non-written language, words have been spelt differently throughout European history. In this document, the Marribank orthography is used to maintain consistency. This orthography is based on historical records and a series of Noongar language and culture meetings that took place in the southwest from the 1980's to the 1990's:

- 1985 Marribank;
- 1990 Wellington Mills;
- 1991 Narrogin;
- 1992 Dryandra Noongar Language Festival; and
- 1997 Marribank.

Hundreds of Noongar Elders and their families attended these meetings. This orthography was finally agreed upon in 1997 and it is taught in Western Australian Primary Schools.
(Noongar Boodjar Language Cultural Aboriginal Corporation 2020)

The Department of Biodiversity, Conservation and Attractions *kaadatj moort moolyak Marawar boodja-k nyin. Bandang moort kalyakoorl Marawar boodja-k nyininy. Nidja boodja-k wer wardan-ak baalap yeyi, kalka nyininy. Ngalak kaadatj Marawar boodja moort baalap warda-kadak. Ngalak warda baalabang mayayin, nakolak wer baalabang dema koomber wer bridiya, koor koora wer yeyi*.

The Department of Biodiversity, Conservation and Attractions acknowledges the traditional owners of country throughout Western Australia and their continuing connection to land, sea and community. We pay our respect to them, their culture and to their Elders past and present.

About this resource assessment

- This document is an important first step in the marine park planning process.
- This document is a summary of resource related information to inform the marine park planning and engagement process.
- This document has been prepared based on information for Marmion Marine Park and the identified expansion area.
- The Department of Biodiversity, Conservation and Attractions welcomes information from the community that expands on, clarifies or amends the information provided in this document.

What this resource assessment document **does**:

- This document is a desktop study compiling a variety of information from a variety of sources.
- It is a broad background document and a first step in the planning process.
- It assists the planning team and community to begin to understand the context of the planning area in preparation for the marine park planning process
- It is a fluid document, that can be added to throughout the marine planning process with additional information relevant to the study area.

What this resources assessment document **does not do**:

- This document does not include detailed spatial information on human use. This will be gathered early in the planning process.
- This document does not provide an economic assessment of any activities. This will be considered when there is clarity regarding the marine park zoning scheme.

- This document does not make any recommendations, inferences or provide any options for the management of the marine park, including the zoning scheme.
- This document does not include all information about every ecological, cultural and socio-economic value of the study area. Further information, amendment or clarification from the community on any information in this document is welcomed.

This report may be cited as:
Department of Biodiversity, Conservation and Attractions (2021). Resource Assessment for the Proposed Review and Extension of Marmion Marine Park. Department of Biodiversity, Conservation and Attractions, Kensington, Western Australia. (Unpublished report). **For internal use only.**

CONTENTS

INTRODUCTION

As a signatory to the international Convention on Biological Diversity 1992, Australia (Commonwealth, State and Territory governments) has committed to establishing a National Representative System of Marine Protected Areas (NRSMPAs). To conserve the diverse and valuable natural and cultural heritage values of our nearshore marine environment the Western Australian (WA) Government is committed to establishing a state-wide representative system of marine parks and reserves under the *Conservation and Land Management Act 1984* (CALM Act). The CALM Act provides the framework for sustainable commercial and recreational use of these areas.

In 1972, the Environmental Protection Authority (EPA) of Western Australia established a Conservation Through Reserves Committee (CTRC) to review and update national parks and nature reserves in Western Australia. Compared to the eastern states, Western Australian was underdeveloped, and much of the land was not surveyed; hence, Western Australia had the opportunity to establish a comprehensive, adequate, representative system of nature reserves denied to more populous countries.

CTRC divided Western Australia into 12 systems, with System 6 covering an area about 430km north to south and 100 kms east to west including the Darling Range and Perth metropolitan area. In March 1984, State Cabinet accepted the System 6 report and approved implementation of its recommendations. This included recommendation M10, for a proposed marine reserve adjacent to the northern Perth metropolitan area.

Marmion Marine Park was gazetted in March 1987 as the State's first marine park, with management guided by the *Marmion Marine Park Management Plan 1992-2002*. It is situated between Trigg Island and Burns rocks, encompassing 9500 hectares.

A review of the management plan was recommended by the then Marine Parks and Reserves Authority in 2012, and the Office of the Auditor General in its 2016 report *Management of Marine Parks and Reserves*. The management plan is outdated and was not underpinned by an outcome based-adaptive management framework. The recommended review would allow for consideration of the changing pressures and uses, increased visitation to the area, and management priorities.

In 2019, the State Government announced the Plan for Our Parks initiative. An extension to Marmion Marine Park was identified as a key part of the initiative to contribute to the comprehensiveness, adequacy and representativeness of WA's networks of marine parks and reserves. That same year, development approval for the Ocean Reef Marina required the excision of 143 hectares from Marmion Marine Park enacted through the *Reserves (Marmion Marine Park) Act 2019.* This provided an opportunity for review of the management plan to include the proposed extension, with Development WA contributing funding to DBCA to resource the planning process.

The State Government's 1998 marine conservation policy, *New Horizons - The way ahead in marine conservation and management,* recommended that part of the process to be followed in establishing a marine park or reserve include:

"A comprehensive assessment of the areas biological and economic resources, and social values is carried out".

This document provides a summary of the ecological and socio-economic information that is available and relevant to the proposed review and extension of Marmion Marine Park. This information will provide the necessary background to support the community consultation and planning process by DBCA to facilitate the development of an indicative management plan, and ultimately the establishment of the extended marine park. This document is prepared in accordance with the Department's generic Resource Assessment Framework (Hill & Ryan 2002) which provides guidance on the information required for marine park planning, including the degree of detail, scale and relative importance.

The Resource Assessment is based on information (written and spatial) from both the Department and external sources including other Government agencies, non-Government agencies, literature reviews, personal communications and community sources amongst others.

This report is intended for internal use by DBCA in the planning process and is not structured with the intent of being published. The report is intended to provide an overview of the information available on each value/area with appropriate referencing and links to enable further and more detailed information to be sought during the planning process.

The report should be considered a first step in obtaining the required information to develop an indicative management plan. It is a working document with the potential for amendment where relevant information becomes available during the planning process.

1 Scope

Marmion Marine Park is approximately 9,500 hectares, extending from Trigg Point in the south to Burns Beach in the north, from high water mark to approximately 5km offshore. The proposed expansion seeks to shift the marine park boundary north to Two Rocks and west to the limit of State waters, increasing the size of Marmion Marine Park to approx. 34,500 hectares (Figure 1). The planning process will also include existing zoning arrangements (Figure 2). The scope of this document considers the proposed expansion boundary, referred to hereafter as the 'study area'.

The marine environment of the West Coast Bioregion between Kalbarri and Augusta is predominantly a temperate oceanic zone, but it is heavily influenced by the Leeuwin Current, which transports warm tropical water southward along the edge of the continental shelf. The Integrated Marine and Coastal Regionalisation for Australia (IMCRA 2006) scheme divides this Bioregion into three meso-scale regions: Abrolhos Islands, Central West Coast and Leeuwin (Figure 3). The study area is located within the Central West Coast meso-scale bioregion.

This meso-scale bioregion is home to one of Australia's largest temperate limestone reefs. The limestone reefs and island complexes are key characteristics of the marine area (Gaughan & Santoro 2021). The coast along the bioregion is composed of sandy beaches with occasional rocky cliffs (Interim Marine and Coastal Regionalisation for Australia Technical Group 1998). Additionally, the study area comprises several rocky islets, lagoons and seagrass meadows bordered by limestone reefs, that contribute to its quality and diverse ecosystems.

Due to its accessibility and proximity to the metropolitan area, the Central West Coast marine bioregion is utilised for a number of recreational activities, including recreational fishing (Smallwood et al. 2011).

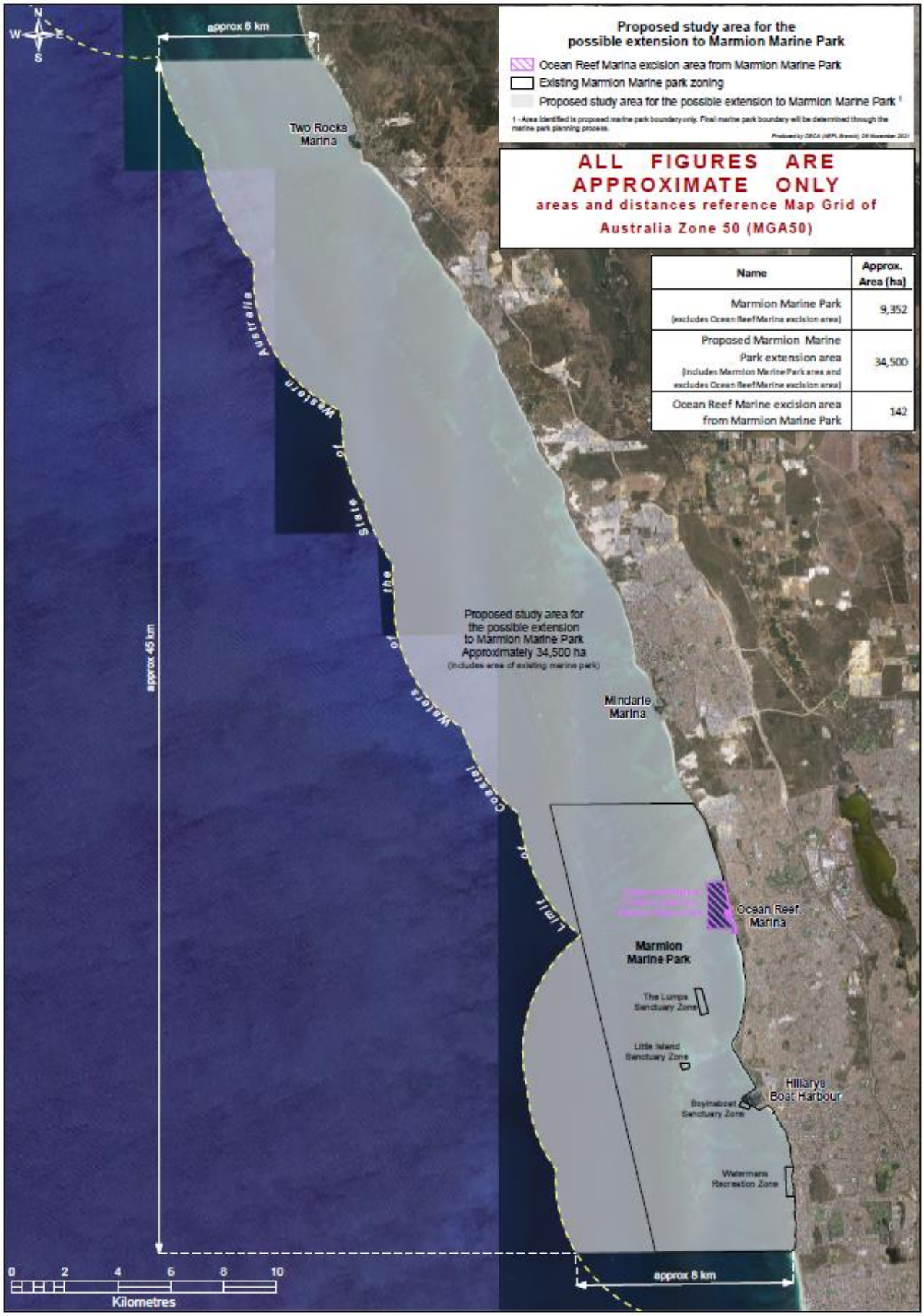

Figure 1. Locality of the proposed Marmion Marine Park expansion study area.

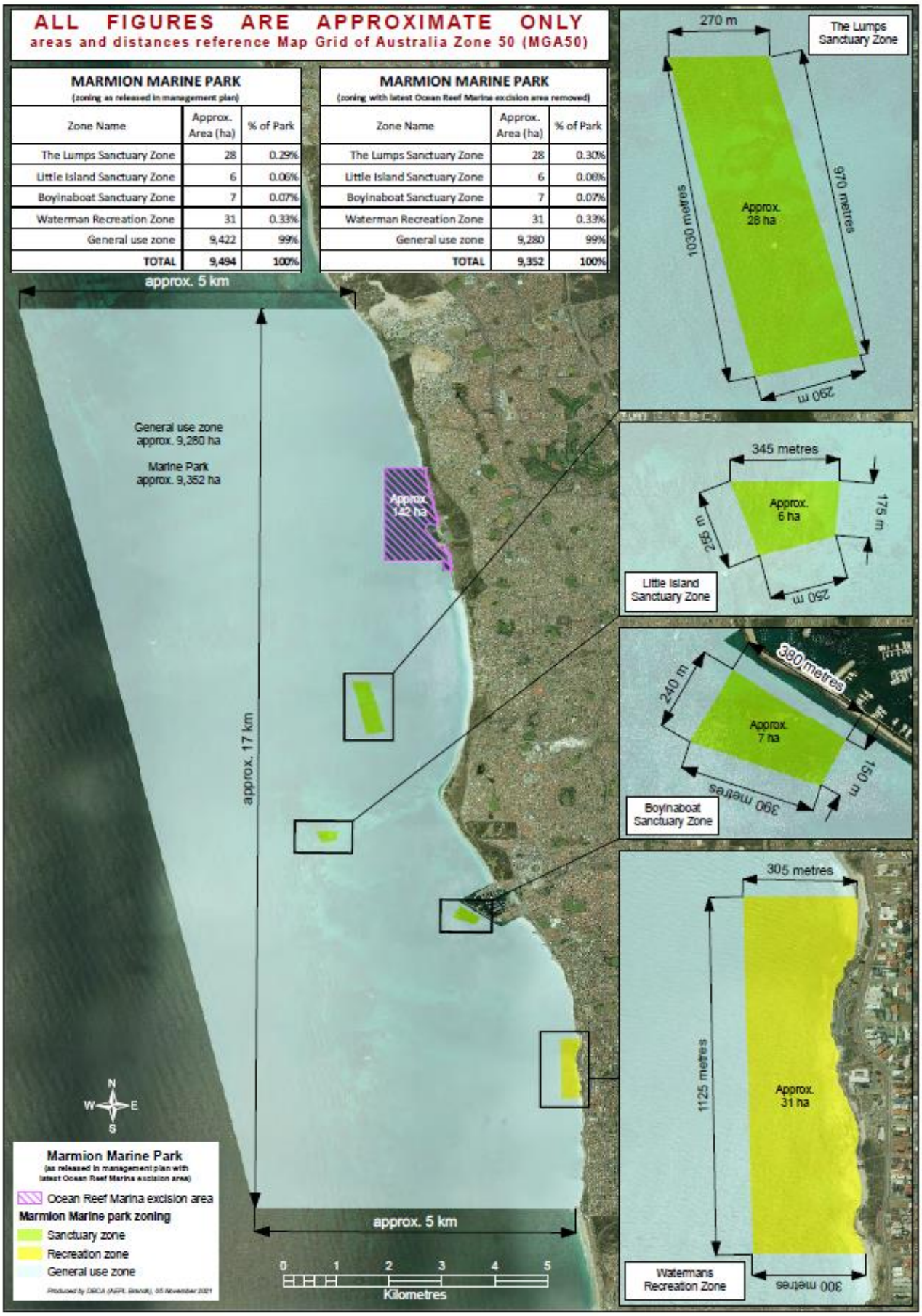

Figure 2. Existing Marmion Marine Park zoning arrangements**.**

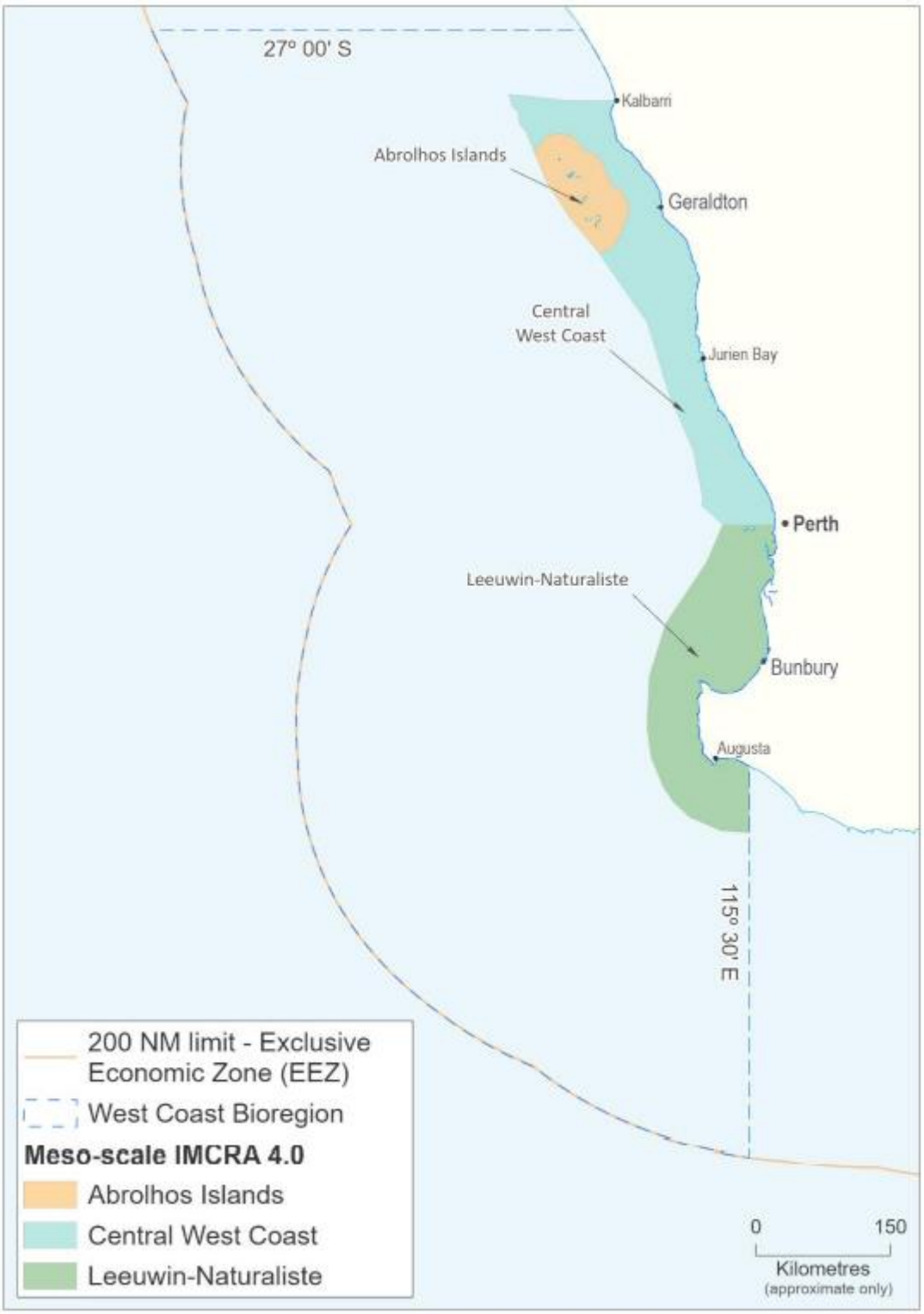

Figure 3. Map of IMCRA (V4.0) ecosystems in the West Coast Bioregion: Abrolhos Is, Central West Coast and the Leeuwin-Naturaliste.

2 Geology and geomorphology

This coast is formed over the Perth Sedimentary Basin. Through the Pleistocene there has been a succession of transgressions and regressions of the sea over the Swan Coastal Plain. Each regression has

left a coastal dune field and the oldest of these have consolidated to form N–S aligned ridges of aeolianite limestones. Ridges above present day sea level usually bear a mantle of Holocene dunes. Those below it form sublittoral reefs, often undercut and cavernous. The shore is comprised of long sandy beaches with occasional rocky cliffs and headlands where the aeolianites outcrop. Small islands representing high points of flooded ridges can be seen nearshore, including Burns Rocks and Little Island. Notched intertidal rock platforms are a feature of this coast, with semi-sheltered lagoonal habitat located behind limestone reefs. The geomorphology of the study area comprises a combination of nearshore sandy seafloor, intertidal and supratidal rock platforms and submerged limestone reefs (Moore 1987).

The limestone in the study area is known as Tamala limestone, was deposited around 1.5-1.8 million years ago during the Pleistocene period. This limestone forms the substrate of the parallel dune sand ridges that can be seen running along the study areas coastline.

The coastline of the study area is characterised by a large seasonal variation in wave height and beaches exhibit a marked seasonal change in morphology. However, these morphological adjustments are better explained by a seasonal reversal in the nearshore drift direction than by changes in wave energy conditions.

In summer, when northward sediment transport prevails due to sea breeze activity, beaches located south of coastal structures, groynes, headlands or rocky outcrops become wider due to the accumulation of sand against the obstacle. These beaches will subsequently erode in winter during storms when the longshore sediment transport is southward. In contrast, beaches located north of coastal obstacles will become narrower during summer and wider during winter (Masselink & Pattiaratchi 2001). The geomorphology and geology of the study area is also influenced by the dominant prevailing winds. These winds generate waves and transport sand inland exposing the deposited limestone formations to weathering. Though only lasting for short time periods, winds created from tropical cyclones further north have been highlighted to have significant impacts on sand deposits within the area (Masselink & Pattiaratchi 2001).

Movement of sediment within the study area occurs within primary, secondary and tertiary sediment cells (Figures Figure 4,Figure 5Figure 6), with little or no sediment movement occurring across cell boundaries, noting that:

- Primary cells are related to large landforms, and are most relevant to potential change in large landform assemblages or land systems over longer coastal management timescales of more than 50 years.
- Secondary cells incorporate contemporary sediment movement on the shoreface and potential landform responses to inter-decadal changes in coastal processes.
- Tertiary cells are defined by the reworking and movement of sediment in the nearshore and are most relevant for seasonal to inter-annual changes to the beachface (Stul et al. 2015).

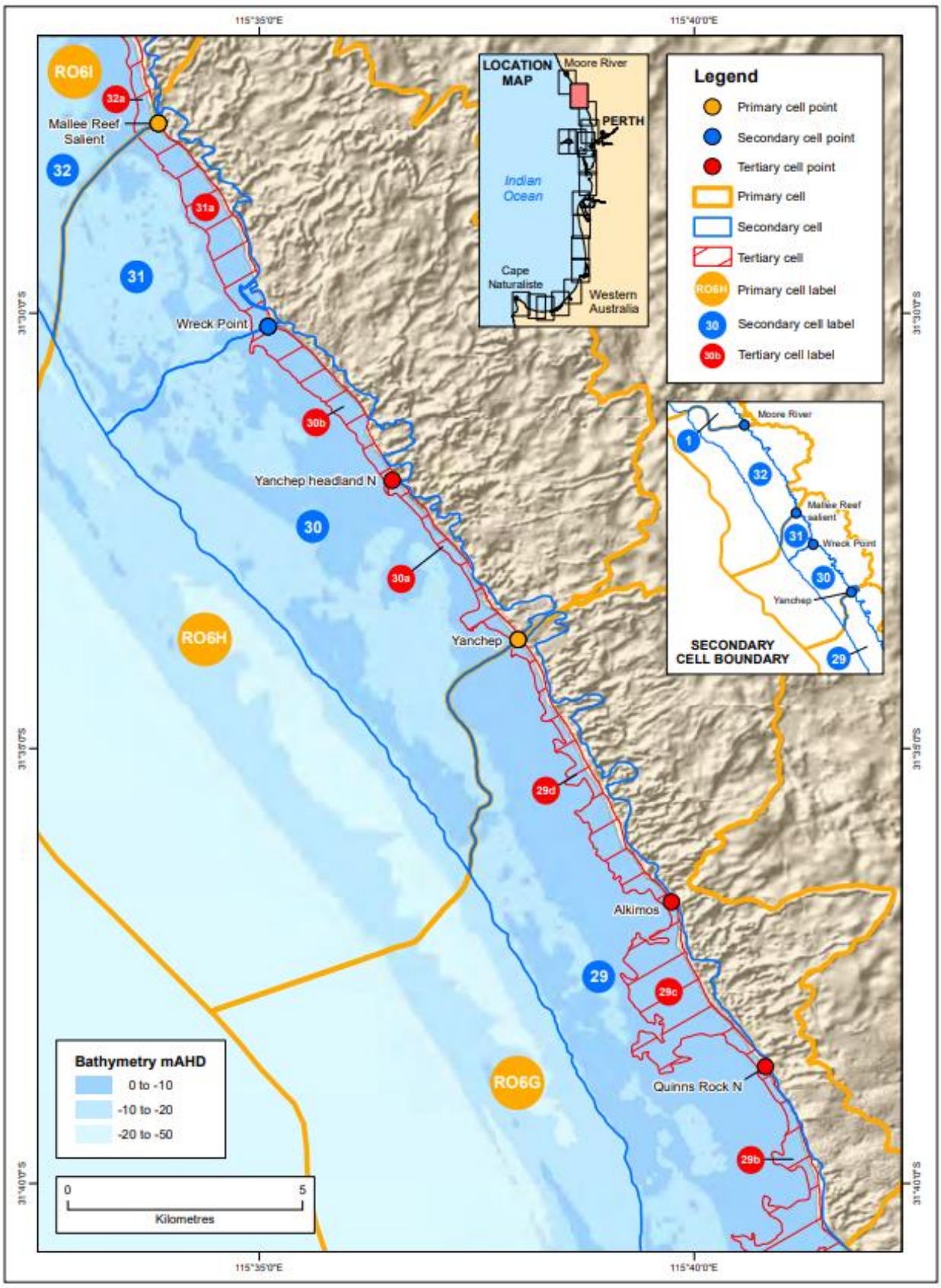

Figure 4. Sediment cells of the Vlamingh Region relevant to the study area (Stul et al. 2015).

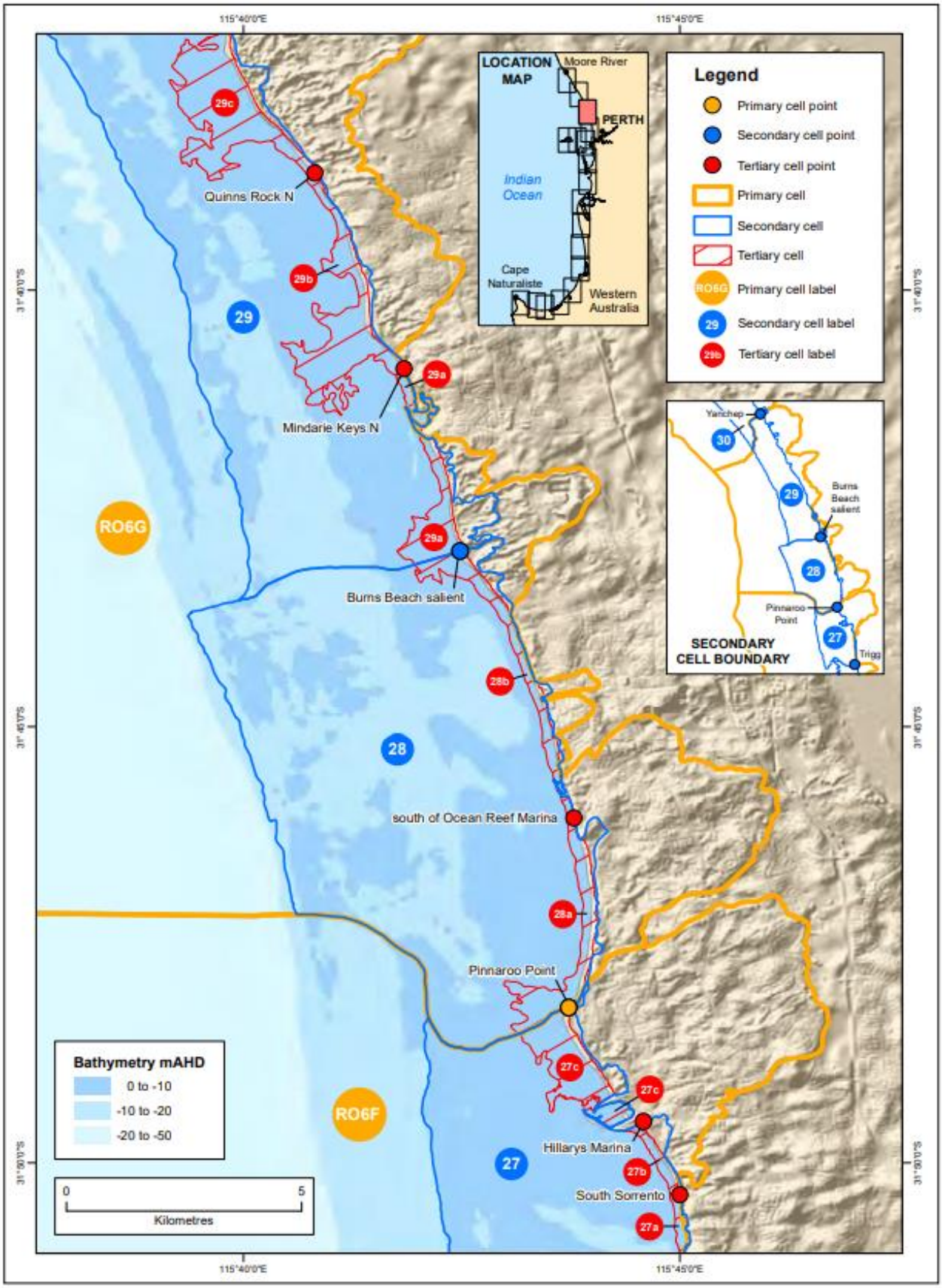

Figure 5. Sediment cells of the Vlamingh Region relevant to the study area (Stul et al. 2015).

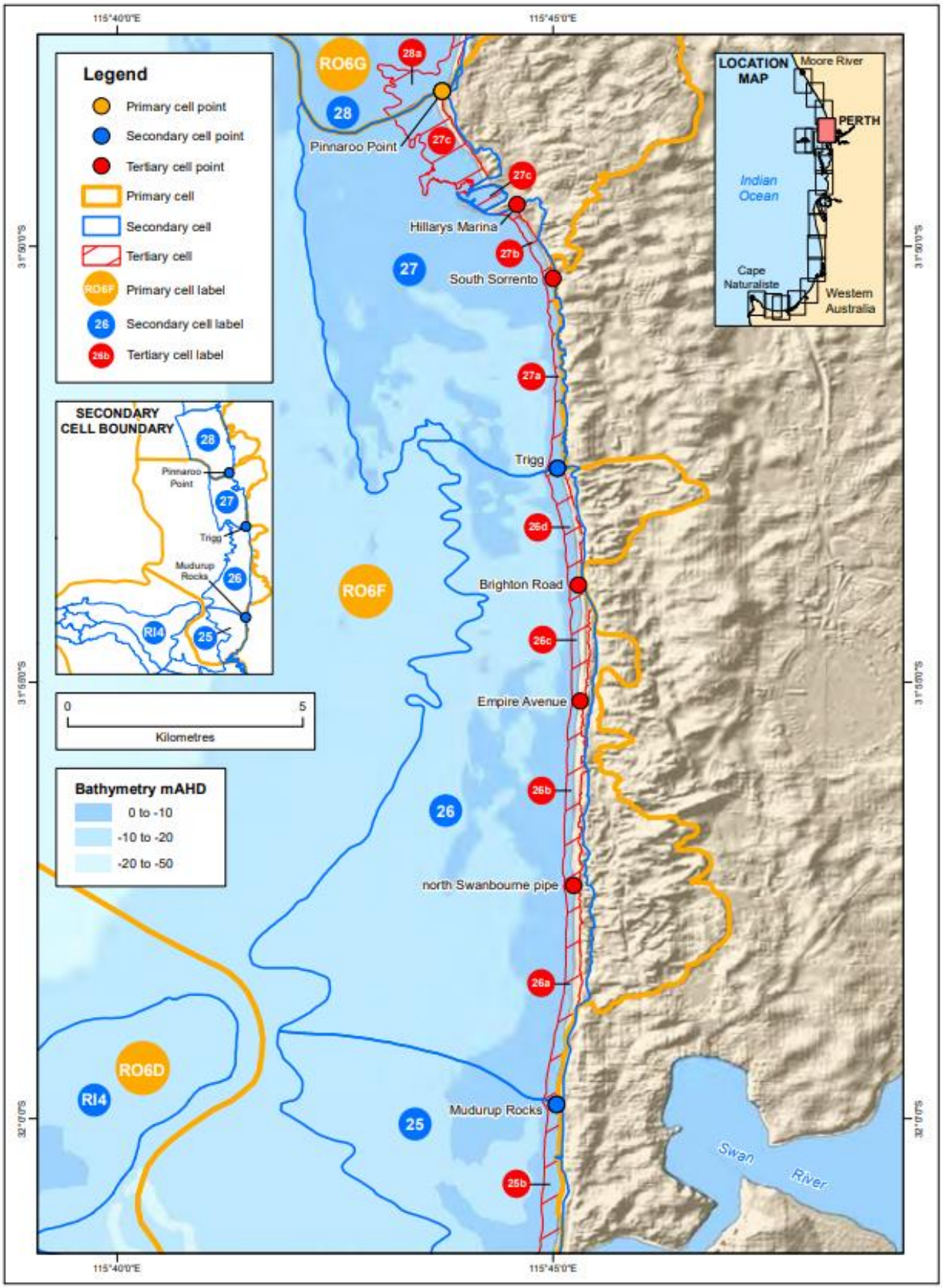

Figure 6. Sediment cells of the Vlamingh Region relevant to the study area (Stul et al. 2015).

The seafloor along the study area coast is characterised by a series of broken limestone reef structures in the nearshore environment to approximately 5km offshore. The complex reef structures are typically irregular in shape and depth, some reefs only exposed at low tides. A moderately sloping inner continental shelf can be found running along the coastline. A complex carbonate ridge and depressed topography can be seen where the shelf and mainland shore are separated forming a lagoon area. This lagoon area is predominantly covered with sand and some low relief reef structures (Moore 1987).

Environmental impacts on the geologic/geomorphic values of the study area include disturbance from coastal infrastructure development (i.e. Ocean Reef Marina development) and the effects of climate change (i.e. increased storm frequency and intensity, sea level rise).

The Cities of Stirling, Joondalup and Wanneroo are all currently engaged in various stages of planning and management for coastal hazards in accordance with State Planning Policy 2.6. Adaptation to coastal erosion and inundation under projected sea level rise scenarios is a priority for these Local Government Areas (LGAs), with a both soft and hard protection measures likely to be implemented at several vulnerable locations within the study area before 2040. Construction of coastal revetment, seawalls and artificial sand renourishment is expected to place pressure on coastal geomorphology. Existing coastal structures are listed inTable 1. Existing coastal protection structures in the study area Table 1.

Table 1. Existing coastal protection structures in the study area.

LGA	Existing coastal protection structures
City of Stirling	Geotextile Sea Container (GS) revetment at Waterman's Bay between Mary St and Beach Rd GSC revetment at Mettam's Pool Rock revetment between Lynn St and Bailey St Rock revetment at Waterman's Indian Ocean Marine Research Centre GSC revetment between Hamersley St and Beachton St
City of Joondalup	3 groynes at Sorrento Seawall in front of Marmion Angling and Aquatic Club (MAAC) and carpark Seawall at Sorrento SLSC and Mullaloo SLSC
City of Wanneroo	4 groynes at Quinns beach Buried seawall Quinns beach Groyne at Capricorn Beach, Yanchep *Note: additional rock seawalls and sand renourishment proposed for further investigation at Yanchep lagoon, Mindarie and Two Rocks*

Proposed developments likely to have a significant impact on the environment are referred to the Environmental Protection Authority and may be subject to the EIA requirements of the *Environmental Protection Act 1986.*

3 Drainage and groundwater

Stormwater

The Carine Main Drain discharges stormwater into the study area at Hamersley Street in North Beach (Figure 7). (Water Corporation 2021a). This Water Corporation drain has been in place since the 1970s, however, the volume of urban stormwater runoff is likely to have increased since then as a result of impervious infill development and less infiltration at source (DWER, 2021).

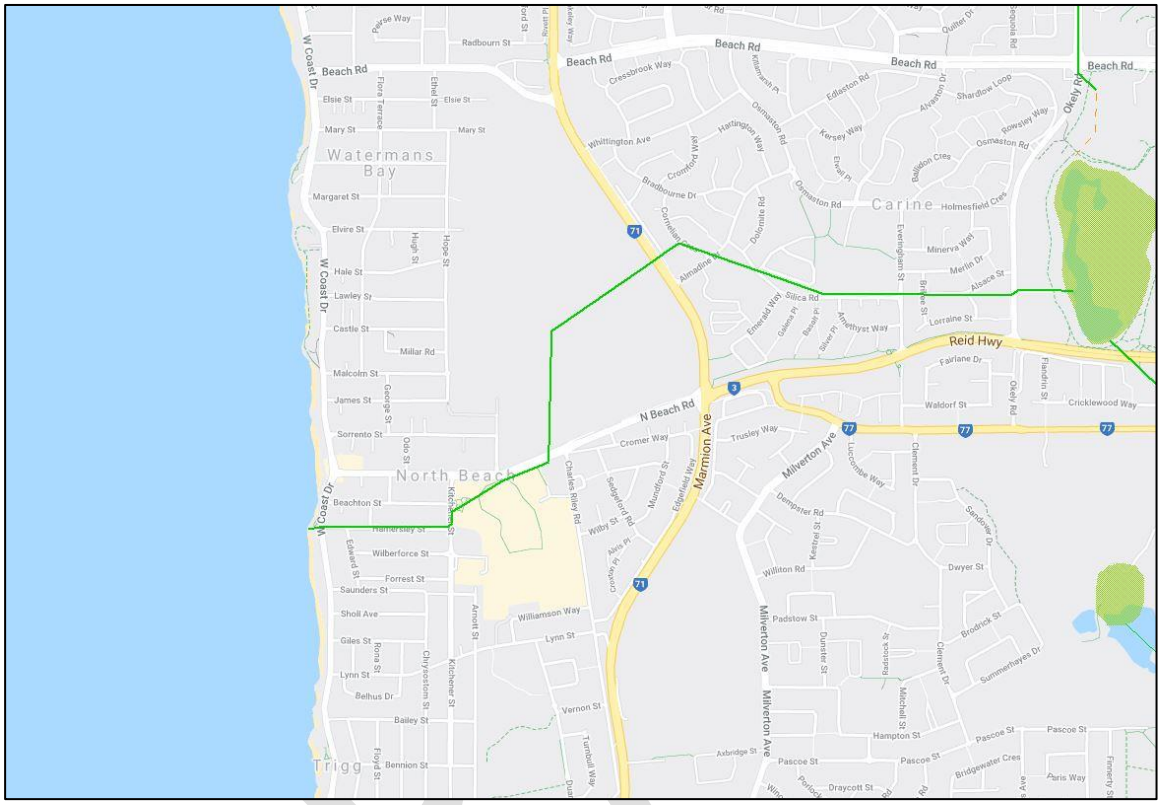

Figure 7. Location of stormwater discharge via the Carine Main Drain (green) (Water Corporation 2021a)

There are no other stormwater outfalls from Water Corporation managed drainage systems north of this outfall. Stormwater from new urban developments adjacent to the study area is typically treated in purpose built drainage basins prior to infiltration to groundwater, rather than direct ocean discharge.

Alkimos Wastewater Treatment Plant

The Alkimos wastewater treatment plant is located approximately 1km east of the study area. The plant has an advanced secondary treatment level capability and has a current treatment capacity of 20 megalitres per day ($ML.d^{-1}$) with a goal of 160 $ML.d^{-1}$ by 2050. The Alkimos wastewater treatment plant discharges approximately 2.5 billion litres of treated wastewater annually. The Alkimos wastewater treatment plant discharges effluent into the study area via a 300m long diffuser approximately 3.7 km west from the shoreline (Figure 8) and discharges approximately 7300 ML annually. The Alkimos wastewater treatment plant currently services approximately 80,000 people (Water Corporation 2018).

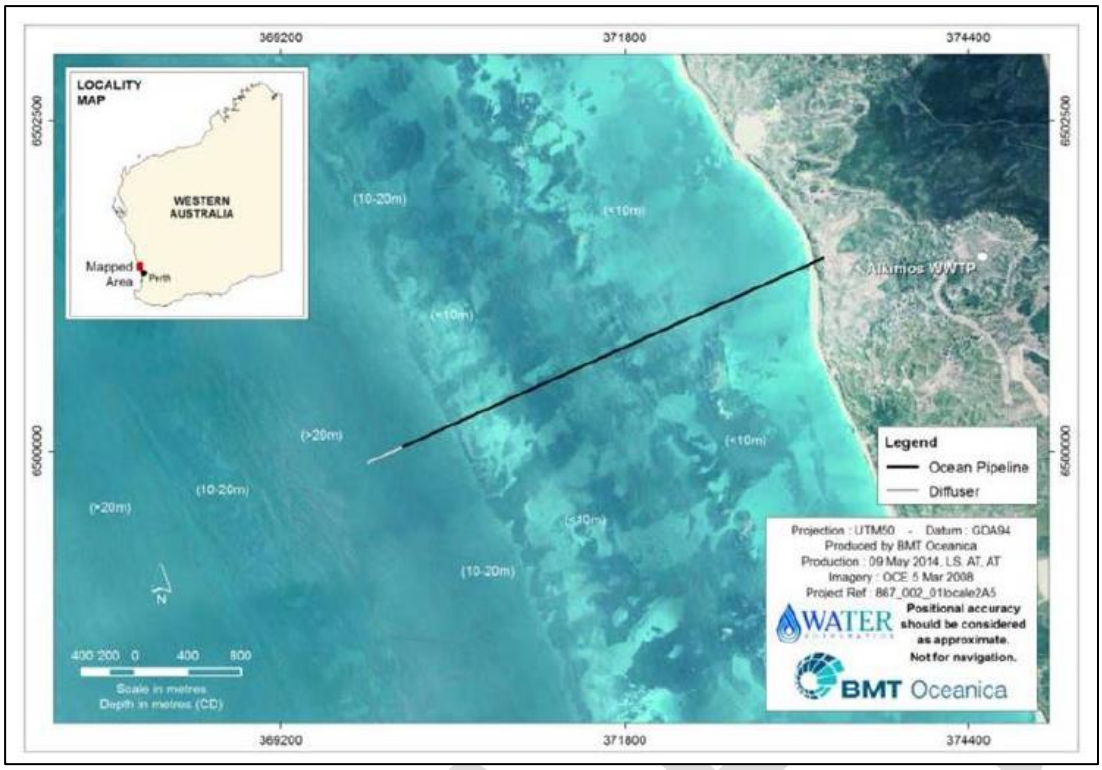

Figure 8. Location of the Alkimos wastewater treatment plant and ocean outlet (Water Corporation 2018).

Beenyup Wastewater Treatment Plant

The Beenyup wastewater treatment plant is located within the suburb of Craigie, approximately 3.8km away from the study area (Figure 9). The plant's current daily treatment capacity is 135 $ML.d^{-1}$, a number expected to grow to 180 $ML.d^{-1}$ by 2050. The Beenyup plant has an advanced secondary treatment level capability and two ocean outlets located at Ocean Reef within the study area. These ocean outlets are located 1.65km and 1.85km offshore from the Ocean Reef boat ramp and discharges approximately 4900ML annually. The wastewater treatment plant services about 660,000 people (Water Corporation 2018).

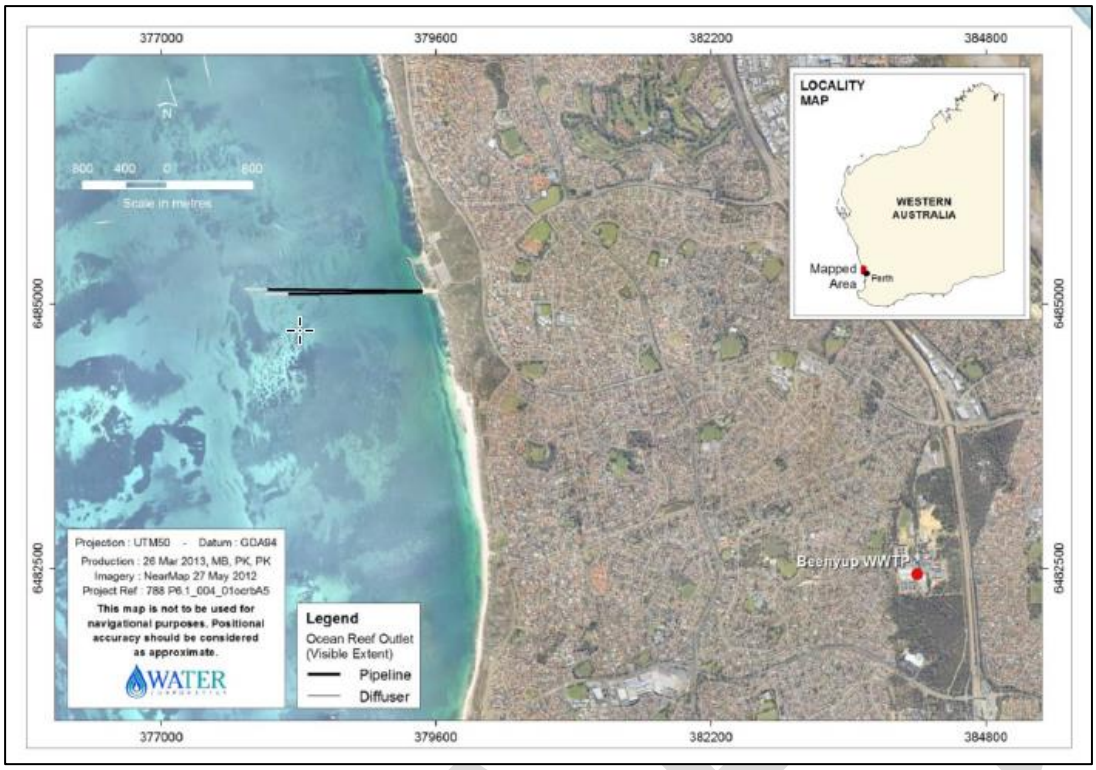

Figure 9. Location of the Beenyup wastewater treatment plant and Ocean Reef ocean outlets (Water Corporation 2018).

4 Climate

Perth metropolitan overview

Winds

The wind regime in the study area is largely driven by the seasonal migration of the anti-cyclonic belt (pressure systems) to the north in winter and south in summer. The study area has a diurnal wind variation that continues throughout the year. Winds are seasonally stronger during summer which has both a sea breeze and land breeze. Southeast winds occur during morning and night, which are broken by a prevailing sea breeze created by south westerly winds in the afternoon.

Summer has a mean afternoon wind speed of 18.8km/h and a mean morning wind speed of 13.9km/h. Offshore winds at night and in the morning, and onshore winds in the afternoon are most characteristic of winter. Winter has a mean morning wind speed of 9.9km/h and a mean afternoon wind speed of 13.5km/h. Overall, the study area has a mean wind speed of 16.1km/h of which is predominantly from the southwest (Bureau of Meteorology 2021).

The natural occurrences of tropical northern cyclones and passing low pressure systems can impact wind patterns within the study area. Passing low pressure systems in winter bring northwest gales that back to the west and southwest, whilst tropical cyclones during summer bring wind gusts up to 129km/h (Bureau of Meteorology 2021).

Atmospheric Temperature

The study area experiences an annual mean maximum temperature of 24.8°C and has a minimum mean temperature of 12.9°C. During summer, the mean max temperature reaches 30.6°C and has a mean minimum temperature of 17.6°C. The hottest month of the year is February which has a mean maximum temperature of 31.6°C and a mean minimum temperature of 18.4°C. During winter, the study area has a mean maximum temperature of 19°C with an associated minimum mean temperature of 8.3°C. The

coldest month of the year is July which has a mean maximum temperature of 18.4°C and a mean minimum temperature of 7.9°C (Figure 10). Long term data implies that in general terms, atmospheric temperature has been increasing by approximately >0.2°C per decade (Figure 11) (Bureau of Meteorology 2021).

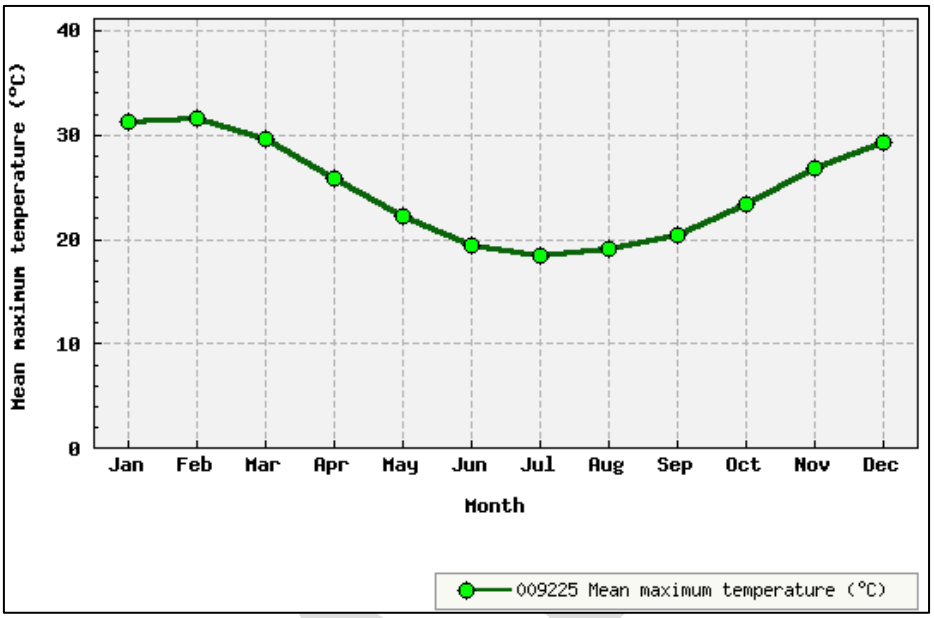

Figure 10. Perth average monthly maximum atmospheric temperature (1994-2020) recorded at the Perth Airport (Bureau of Meteorology 2021).

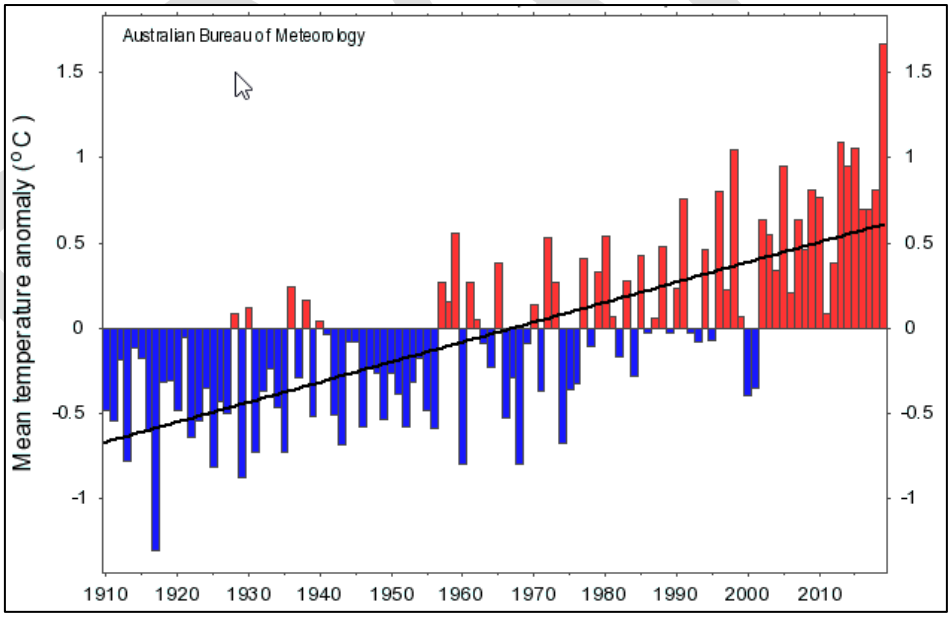

Figure 11. Trend in mean atmospheric temperature anomaly in Western Australia (1910-2019). Scale represents loss (blue bars) or gain (red bars) in degrees Celcius (°C) per decade with a linear trend (black line) of 0.12°C.decade^{-1} based on 30-year climatology (1961-1990) (Bureau of Meteorology 2021).

Rainfall

The study area receives an average annual rainfall of 733.2mm, with approximately 55% (397.8mm) of this falling in winter months. July is the wettest month with 144.5mm mean monthly rainfall and December has the lowest mean monthly rainfall of 10.6mm. During summer, rainfall is minimal with only 6% of the annual rainfall occurring from December through to February (approximately 43.1mm)

(Figure 12). Long term data for Western Australia implies that in general terms, rainfall has been decreasing by approximately 10mm.decade^{-1}. Within this trend, summer rains are increasing by 6.41mm.decade^{-1} and winter rains are decreasing by 1.08mm.decade^{-1} (Bureau of Meteorology 2021).

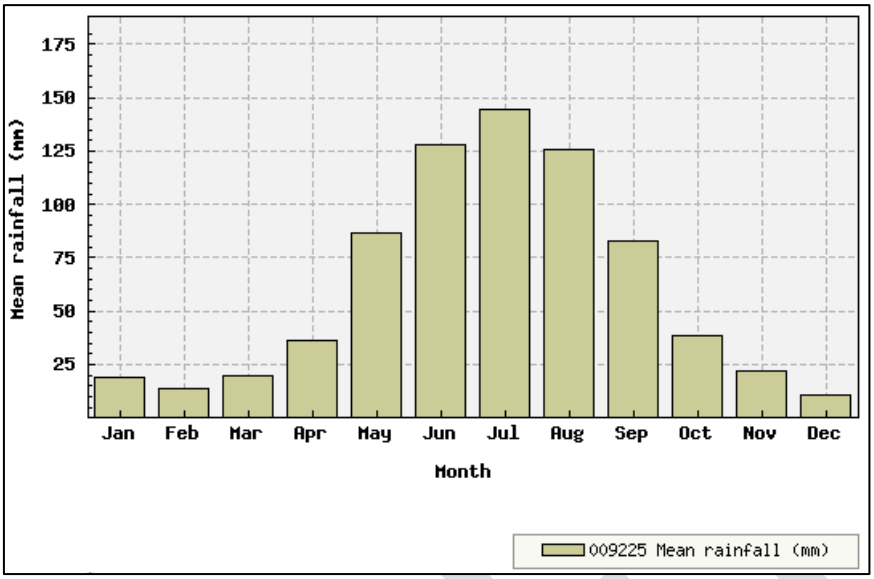

Figure 12. Perth average monthly mean rainfall (1993-2020) recorded at the Perth Airport (Bureau of Meteorology 2021).

Humidity

Mean annual relative humidity for Perth metropolitan area (1994-2010) is 63% at 0900 and 47% at 1500. July has the highest monthly mean relative humidity for both 0900 (Figure 13) and 1500 (Figure 14) with 80% and 57% relatively. However, the lowest mean monthly relative humidity recorded at 0900 was in December with 50% and at 1500 was in February with 30% (Bureau of Meteorology 2021).

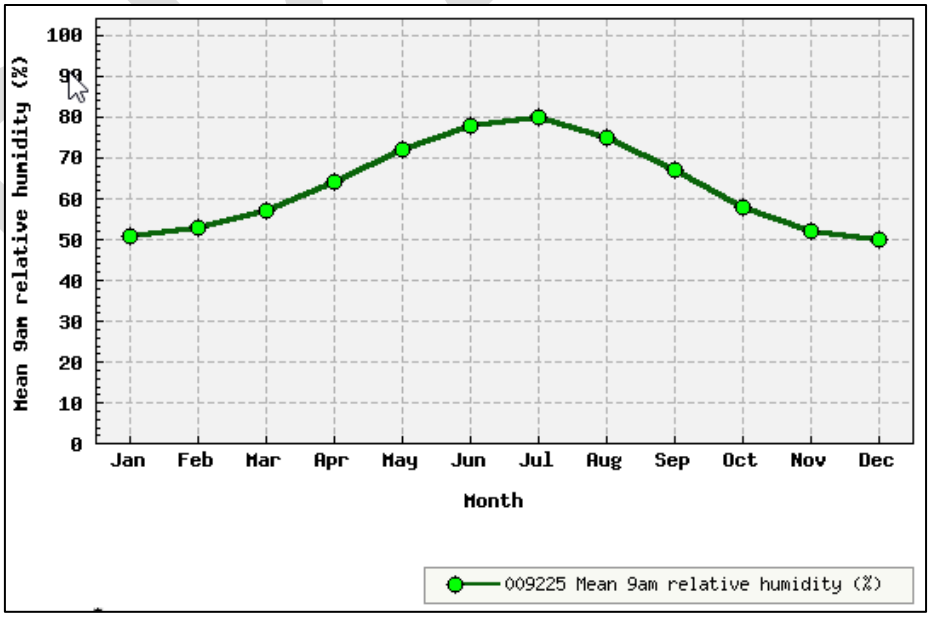

Figure 13. Mean monthly relative humidity at 0900 for the Perth Metropolitan region (1994-2010) (Bureau of Meteorology 2021).

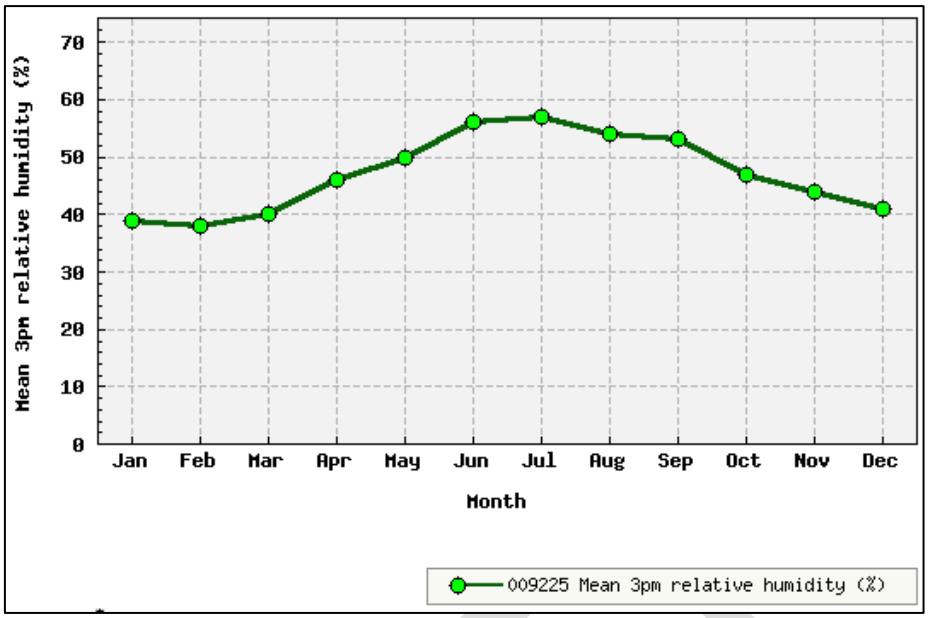

Figure 14. Mean monthly relative humidity at 1500 for the Perth Metropolitan region (1994-2010) (Bureau of Meteorology 2021).

Global Solar Exposure

The daily global solar exposure is the total solar energy for a day falling on a horizontal surface. It is measured from midnight to midnight. The values are usually highest in clear sun conditions during the summer and lowest during winter or very cloudy days. The mean daily global exposure recorded at Perth Airport (1990-2020) ranges from 9.4MJ.m^{-2} in June to 29.9MJ.m^{-2} in December (Figure 15) (Bureau of Meteorology 2021).

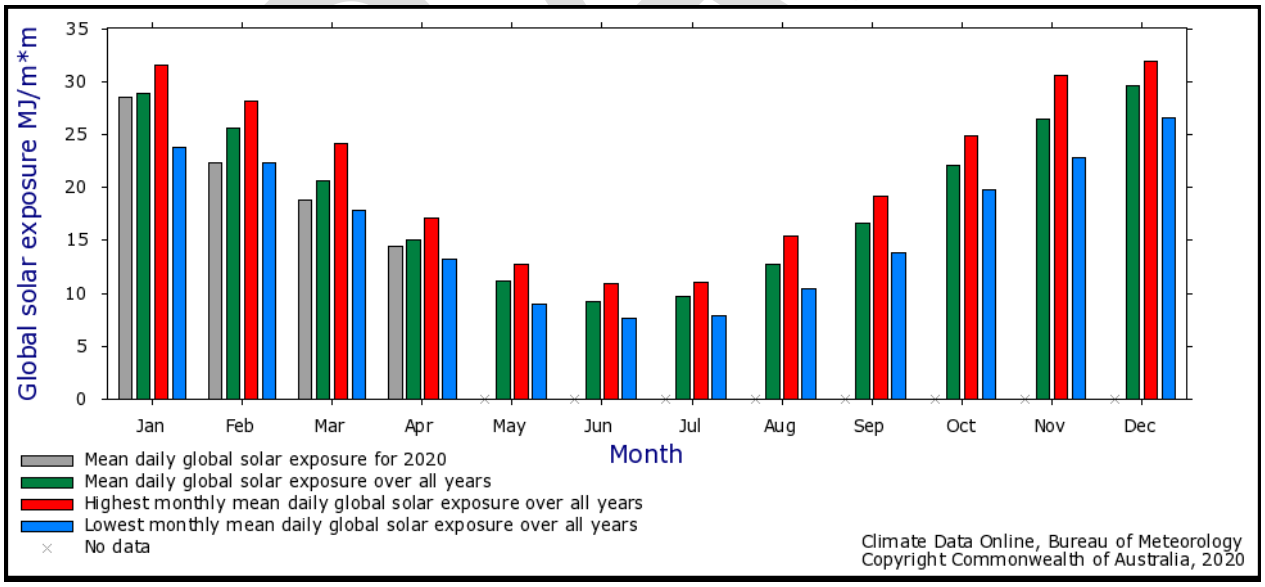

Figure 15. Monthly statistics for mean daily global exposure recorded at Perth Airport between 1990 to 2020 (Bureau of Meteorology 2021).

Climate Change

The West Coast Bioregion is predicted to be at enhanced risk from the effects of climate given that it spans a transitional zone between tropical and temperate regions. The variables expected to drive climate change impacts include changes in water temperature, ocean currents, winds, rainfall, sea level, ocean chemistry and extreme weather conditions (Gaughan & Santoro 2021).

Whadjuk Noongar seasons

The Whadjuk Noongar people, whose country includes the study area, identify six seasons (Figure 16). Each of the six seasons has its own diet and colour. The six seasons are not subject to dates but determined by the state of the environment and climatic conditions and patterns. Therefore, they vary with the complexities of the natural environment. There were major campsites all along song lines that were travelled during the six seasons. People were born, lived, died and buried on song lines. Noongars say every part of that environment contains the DNA/molecules of Noongar people. They are related to it by DNA/molecules through the Totemic system, in caring for everything. For tens of thousands and many more thousands of years, the soil, the biota, insects, animals and the elements have contained their DNA/molecules (Robertson 2016).

Each of the six seasons lasts approximately eight weeks so that is forty-eight weeks of a calendar year. The elements control the length of each season so that the remaining four weeks of the year act as a buffer to allow some seasons to be longer or shorter. Each person knew their role within the complexities associated with the six seasons that are closely connected to "everything" (Robertson 2016).

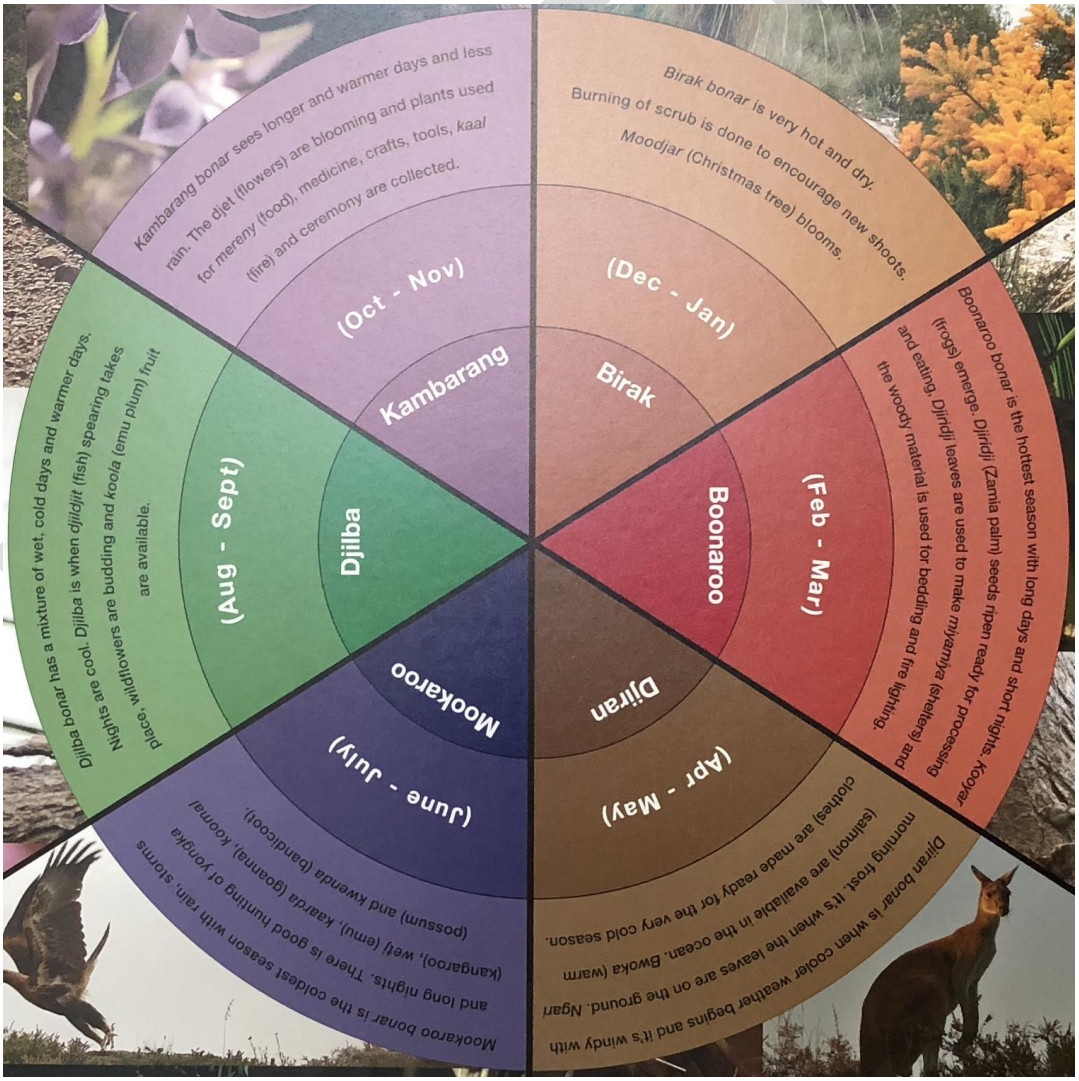

Figure 16. The six seasons recognised by the Noongar Whadjuk people (Image courtesy of Noongar Boodjar Language Cultural Aboriginal Corporation).

5 Oceanography

Tides

The study area has a generally diurnal tidal pattern with a relatively small tidal amplitude of 1.2m (Highest Astronomical Tide to Lowest Astronomical Tide range) and a spring tide range (mean lower low water to mean higher high water) of 0.46m. This small tidal range contributes to waters which are moderately clear, noting that river discharge has a minor effect on coastal waters in the area.

Water levels are influenced by a range of meteorological factors including barometric pressure and storm surge. The average tidal range within the area has been identified as 0.5m throughout the day and tidal currents for the Perth shelf are typically less than about $0.02 m.s^{-1}$ (Masselink & Pattiaratchi 2001). However, tide affecting factors such as winds, wave pumping, gravitational currents, and seasonal changes results in tidal variations throughout the year. These factors have been recorded to impact the tide by up to 1m.

The lagoonal system of the study area experiences highly transient circulation patterns. The low tidal range plays a part in the hydrodynamics of the study area, however other environmental factors have synergistic effects. These factors include atmospheric pressures (e.g. along shore water levels), local wind forcings (longshore current variability), tropical low pressure systems (southward coastally trapped waves) and persistent northwards wind stress (waves and currents) (Masselink & Pattiaratchi 2001).

Swell

Wave energy in the study area is moderate to high. Northwest and westerly gales create high energy waves in winter. During summer, a strong sea breeze creates moderate southwest waves. Limestone reef influences swell and waves, creating sheltered areas popular with beach goers. The prevailing swell comes from the south west as its origins are from the 'Roaring Forties' of the Indian and Southern Oceans. Cyclones which occur further north of the State during the summer season also heavily influence swell and wind patterns (Masselink & Pattiaratchi 2001).

The coastline of Perth is characterised by a large seasonal difference in the incident wave height and as such, local beaches display a distinctive seasonal change in their morphology (Masselink & Pattiaratchi 2001).

Currents

The coastal waters in the study area are characterised by seasonal interactions between the Leeuwin Current and other predominantly wind driven local currents. Different to other Southern Hemisphere continental west coasts, Western Australia is unique that the normal nutrient rich up welling is inhibited by the presence of the southern poleward flowing Leeuwin Current.

<u>The Leeuwin Current</u>

The Leeuwin Current is a regional poleward flowing buoyant warm current driven by the Indonesian Throughflow (Cresswell & Domingues 2009). Due to climatic factors, the Leeuwin Current strength varies seasonally. It is most predominant when southerly winds weaken and pressure gradients along the shore strengthen between May through until August and is weakest during summer when opposing winds are strong. Stronger flows can also occur during *La Niña* years and weaken during *El Niño* years. The Leeuwin Current brings warm low salinity and nutrient poor waters southwards which releases hot air during air-sea interaction. Strong westerly winds and eddies are also associated with the Leeuwin current. The current can reach maximum velocities of approximately $1.8 ms^{-1}$. The Leeuwin Current has been decreasing in annual strength due to climate change and a naturally changing climate system (Cresswell & Domingues 2009).

Capes Current

Driven by predominate southerly summer winds, the Capes current is a northward bound seasonal, cool inner shelf current that flows from the coast of Cape Leeuwin past Perth in summer months (Pearce & Pattiaratchi 1999). It is considered as being narrow (i.e. <20km wide) and high in chlorophyll-a (due to localised upwelling). Whilst the flow is relatively unknown, the Capes Current may be linked to the 20-40 cm/s northward current that can be recorded in December which is driven by the prevailing south westerly winds. In early May or early April, the Capes current is replaced by the stronger Leeuwin Current (Pearce & Pattiaratchi 1999).

Seawater Temperature

The study area has water temperatures that range seasonally from 17°C to 22°C with relatively low salinity (Bellchambers et al. 2009). Low salinity waters flow through the study area driven by the Leeuwin Current in winter and Capes current in the summer (Pearce & Pattiaratchi 1999). The changing waters from the Leeuwin Current and Capes Current are the reason for the diversity of tropical, subtropical and temperate distributions of fish, invertebrate, algae and seagrass species within the study area (Westera et al. 2009).

In 2011, an unusual heat event with record high ocean temperatures was experienced along temperate Western Australia associated with a record strength Leeuwin Current, a strong *La Niña* event (Figure 17F) and anomalously high air-sea heat exchange into the ocean (Pearce et al. 2011).

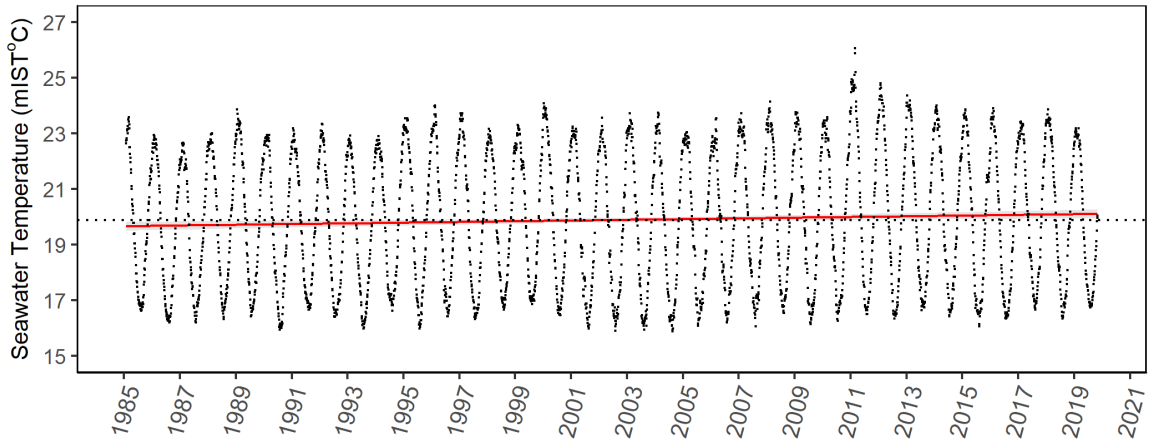

Figure 17. Mean seawater temperature representative of the Marmion Marine Park expansion study area 1985 - 2019. Mean seawater temperature is calculated using modelled *in situ* seawater temperature (*m*IST) averaged twice weekly across nocturnal periods (n=104 per year). The black dotted line represents the overall mean. The fitted red line indicates a significant trend based on seasonally adjusted Mann-Kendall trend analysis (tau = 0.0459; p <0.001). Source: National Oceanic and Atmospheric Administration (2019).

Intra-Seasonal Variability and Severe Weather

During the February/March 2011 marine heat wave event, nearshore water temperatures along the Gascoyne and mid-west coast were 5°C above the long-term average for that time of year. The waters of the study area were less affected, with average seawater temperatures exceeding the long-term average by ~1.5°C (Figure 18).

These anomalously high seawater temperatures have been attributed to both a very strong Leeuwin Current (unusually high coastal sea levels) during an intense *La Niña* period and anomalously high air-sea heat flux entering the ocean (Pearce & Feng 2013). Unusually strong easterly winds in the low latitudinal western Pacific and very low sea level pressure off the coast of Western Australia have been identified to be environmental drivers causing the local wind and Leeuwin Current anomalies in early

2011. This resulted in the peak of the *Ningaloo Niño* events (Pearce & Feng 2013). Effects of the marine heat wave on the marine biota were devastating, with massive mortality in some areas (Wernberg et al. 2012). There were also sightings of tropical species (including some iconic megafauna) well south of their normal ranges (Pearce et al. 2011).

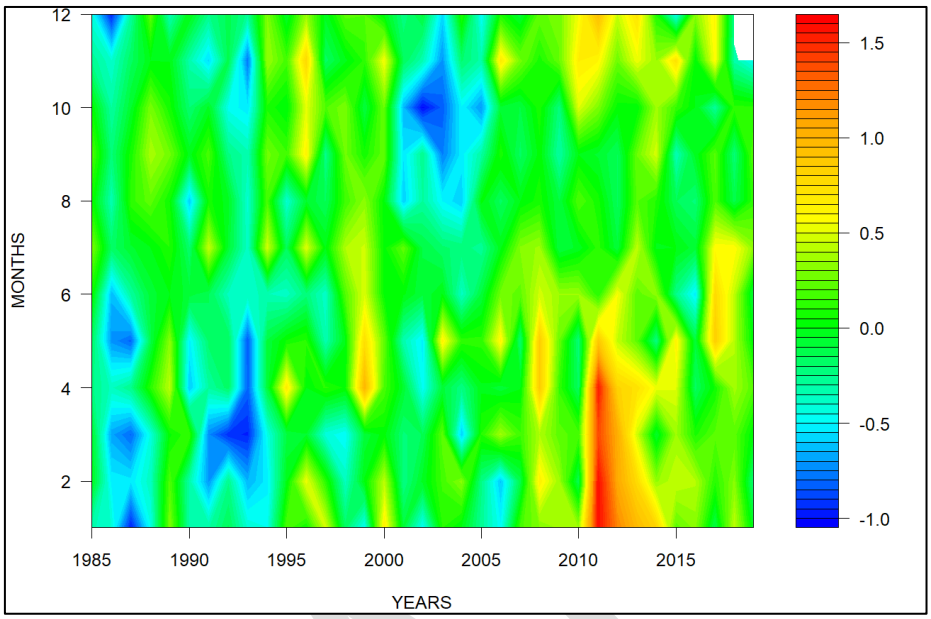

Figure 18. Colour plot of the fluctuations in mean monthly seawater temperature (°C) from the long-term monthly mean for Marmion Marine Park expansion study area, 1985 - 2019. Areas that are in shades of green and light blue (< +/-0.5°C) are considered as being in the normal range of mean monthly seawater temperatures. Areas that are dark blue (cooler than -0.5°C) are considered as anomalously low mean monthly seawater temperatures, and areas in yellow to red (> 0.5°C) are considered as anomalously high mean monthly seawater temperatures. Values are calculated using modelled *in situ* seawater temperature (*m*IST) determined from remotely sensed National Oceanic and Atmospheric Agency (NOAA) surface seawater temperature (SST), averaged twice weekly across nocturnal periods. Monthly means are based on twice weekly temperature measurements (n=8 per month). Source: National Oceanic and Atmospheric Agency (2019).

The NOAA Coral Reef Watch developed a set of Heat Stress Gauges to reflect the observed and forecast bleaching alert level surrounding select islands or reefs. With a La Nina event continuing through 2020 and 2021, Alert Level 1 (Bleaching Likely) and Level 2 (Mortality Likely) were recorded for the reefs at Marmion and Rottnest Island (NOAA, 2021). Rising SST may also place pressure on the study area through climate change induced species tropicalisation (Cheung et al. 2012).

Bathymetry

The bathymetry within the study area varies from 0-20m with deeper waters around 20-50m occurring further out to the western boundary Figure 19. It has been recognised that the tidal currents within the study area are associated with the creation of dunes and reefs over time. The varying bathymetry has allowed for the establishment of diverse ecosystems that range from subtidal and intertidal reef systems which are surrounded by seagrass and sand habitats (Moore 1987).

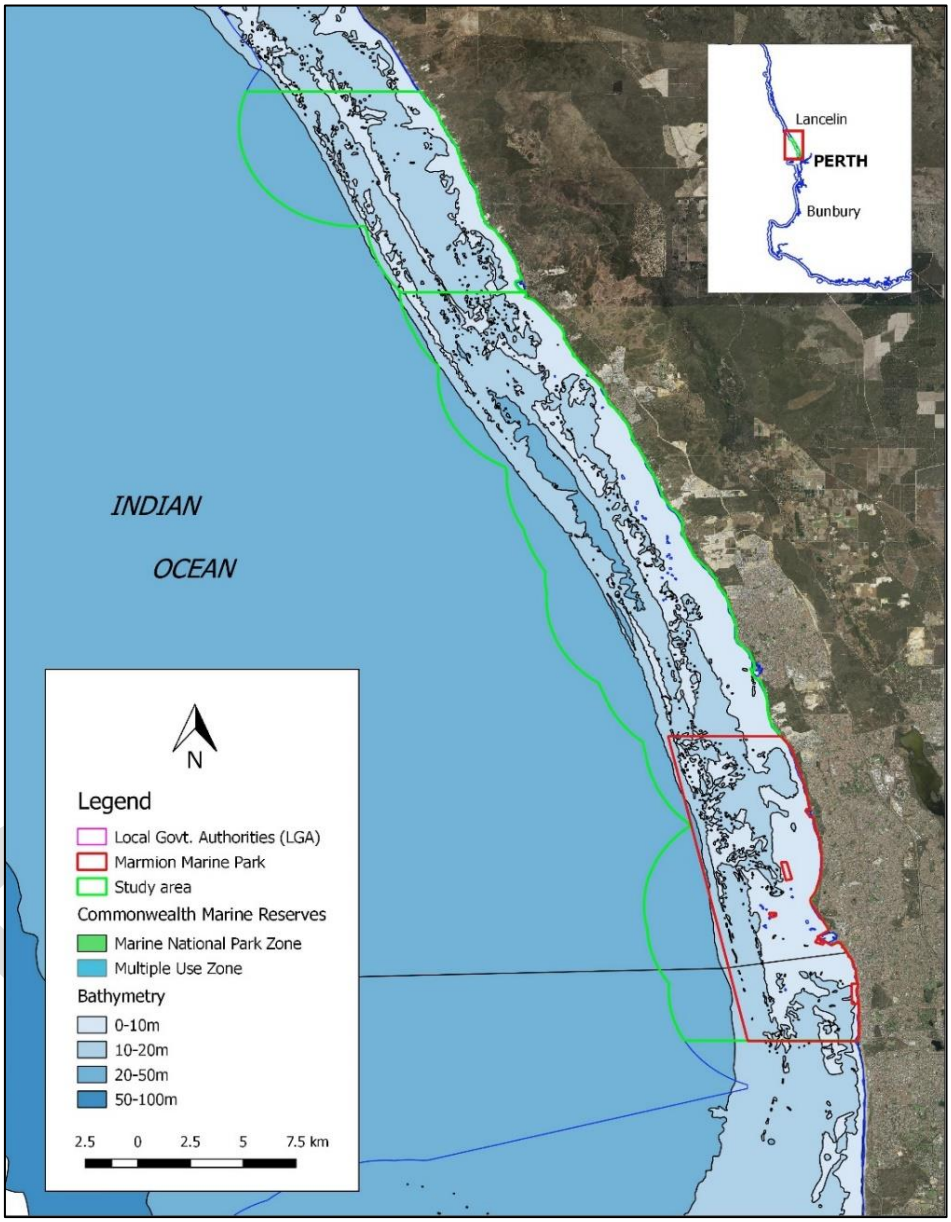

Figure 19. Bathymetry within the Marmion Marine Park expansion study area. The majority of the bathymetry is less than 20m, with offshore from the fringing reef is 20-50m.

6 Marine fauna

Australian sea lion

The Australian sea lion (*Neophoca cinerea*) is endemic to Australia, with restricted breeding grounds that range from the Houtman Abrolhos Islands in Western Australia to The Pages Islands in South Australia (Shaughnessy *et al*. 2013). There are no breeding grounds within the study area, however, Australia sea lion haul-out sites include Burns Rocks and Little Island which are frequented by adult and sub-adult male sea lions. The Australian sea lion is listed as endangered under the EPBC Act and Vulnerable under the BC Act. Surveys of known breeding sites estimate an overall population of <10000 mature individuals/adults. About 20% of the population occurs at sites in WA and 80% in SA. The Australian sea lion is considered to be declining (Goldsworthy *et al* 2021), and is in the process of being listed as Critically Endangered by the IUCN.

The Australian sea lion has a non-seasonal and asynchronous breeding cycle varying amongst colonies, that ranges between 17-18 months (Campbell, 2003; Shaughnessy *et al*. 2011). Pups will remain in the vicinity of their birth site for 4-5 months, often returning in the future (Shaughnessy *et al*. 2013).

It has been recognised that tourism, such as interactions with wildlife, can negatively impact haul-out cycles, influencing the survival rate of pups (Osterrieder *et al*., 2017). Observations of MMP have revealed important sea lion habitat, such as Little Island, Burns Rock and Burns Beach are being impacted by human activities (Osterrieder *et al*. 2017). Further, to address commercial fishing impacts, the area from 33 deg S to 31 deg S out to the 250m isobath has been closed to commercial line fishing and commercial demersal gillnet and longline fishing since 15 November 2007. This covers all of the existing MMP and study area. In addition, Sea Lion Exclusion Devices (SLEDs) are required to be used in commercial rock lobster fisheries.

Current threats to the species include prey availability, fisheries bycatch, entanglement in demersal gillnets and marine debris, displaced or disturbed habitats and introduced diseases (Shaughnessy et al. 2013). The adequacy of current management measures requires review in the context of increased visitation levels. Recently prescribed separation distances under the *Biodiversity Conservation Regulations 2018* should also be considered.

Cetaceans

A variety of whale and dolphin species are known to occur in coastal waters of Perth, some as seasonal visitors on their annual migration such as the humpback (*Megaptera novaeangliae*), and Southern right whales (*Eubalaena australis)*, and some as resident populations such as the Indo-pacific bottlenose dolphin (*Tursiops aduncus).* Others such as the blue whale (*Balaenoptera musculus*), striped dolphins (*Stenella coeruleoalba*), common dolphins (*Delphinus delphis*), spotted dolphins (*Stenella attenuata*), and bottlenose dolphins (*Tursiops truncatus*), are typically found in more pelagic waters but are also occasionally sighted inside the study area.

Humpback whales

The humpback whale population seen in WA state waters is one of three breeding populations in the Australasian region. The WA coastline, including the Perth region, is part of the migratory pathway for Group IV population of humpback whales, which migrates between their summer feeding grounds located in the krill-rich waters of Antarctica from December-January to their winter breeding grounds in the Kimberley where they stay from June-August.

Humpback populations have increased from their once perilously low numbers at a rate of 10% per annum since the end of commercial whaling in WA waters in 1963. It is widely reported that the Group IV population of humpback whales is the largest population in the world with population estimates from 2008 of more than 33,850 (Salgado-Kent *et al*. 2012). The humpback whale has recently been delisted from its status as vulnerable under the EPBC Act and is now considered to be protected under the EPBC Act and conservation dependant under the BC Act (WA). The humpback whale is subject to International Whaling Commission regulations and protected within the Australian Whale Sanctuary established under the EPBC Act, which includes the entire Commonwealth marine area. Within this area it is an offence to kill, capture, injure, harass, chase or herd any species of whales, dolphins and porpoises. Both Commonwealth and State legislation also include minimum separation distances for vessels and people to provide additional protection from human activities. Several commercial tours anoffer whale-watching within the study area and a number of recreational vessels interact with migrating whales each year.

Current threats to humpback whales include entanglement in fishing gear, vessel disturbance (including boat srtike), underwater noise from seismic surveys, shipping and industrial noise, habitat modification and climate change.

The Western Rock Lobster Council, in association with the Western Australian Government and non-government agencies, developed a *Whale Entanglement Code of Practice* in 2007 to reduce interactions between commercial fishing activities and whales and other marine wildlife. Specifically, the Code of Practice aimed to minimise entanglement of migrating humpback and southern right whales in rock lobster pot lines. Whale entanglements are recognised as a management issue for the West Coast Rock Lobster Managed Fishery by both the WA and Commonwealth Governments, however, the extent of rock lobster fishing inside the study area is minimal.

Southern right whales

Southern right whales (*Eubalaena australis*) visit the warmer waters of WA's south and southwest coast between June and October each year. They feed in the cold waters of the southern ocean outside these months, although their movements are not as extensive or as well-known as humpback whales. The females use sheltered areas of the southwest coast as birthing and nursery areas and cows with calves are often seen close to the shore for extended periods from August to October. While several southern right whales are seen in Perth waters each year, they are not present in the same numbers as humpback whales.

They are susceptible to similar pressures as the humpback whale. This species is listed as Vulnerable under both Commonwealth and State legislation and while there is some evidence of recovery since whaling, this has occurred at a slower rate than that for humpback whales.

Indo-pacific bottlenose dolphin

The Indo-pacific bottlenose dolphin is the most common cetacean species within the study area. These dolphins have a broad distribution in coastal waters of the Indian and Pacific Oceans. They are often present as resident populations in coastal areas, though range size may vary with some animals ranging more broadly and with seasonal patterns. W (Smith et al. 2013). The Indo-Pacific bottlenose dolphin is listed as Near Threatened under the IUCN Red list of threatened species and are listed as protected under Commonwealth and State legislation.

Birds (seabirds and shorebirds)

Scattered small islands and coastal habitat all play a critical role in hosting bird populations in the area. Sea and shorebirds rely heavily on such islands and coastlines to provide foraging and breeding habitat.

Migratory birds utilise the study area and are protected under several international agreements, including the Convention on International Trade in Endangered Species (CITES); Japan-Australia Migratory Birds Agreement (JAMBA); and China-Australia Migratory Birds Agreement (CAMBA) (Department of Agriculture, Water and Environment 2021).

There are many species that are regular visitors to the study area including: terns (*Sterna* spp.; *Sternula* spp.), albatross *(Diomedea spp)*, skuas (*Stercorarius* spp.), gannets (*Morus* spp.), shearwaters (*Puffinus* spp.), petrels (*Procellariiformes* spp.), ospreys (*Pandion haliaetus*), darters (*Anhingidae* spp.), oystercatchers (*Haematopodidae* spp.) and little pied cormorants (*Microcarbo melanoleucos*) (Birdlife 2021). There are 31 conservation significant bird species with potential to occur in the study area (Birdlife 2021).

Reptiles

Loggerhead, leatherback and green turtles can sometimes be found in the study area. Loggerhead and green turtles are residents in the park and are reliant on invertebrates and and seagrass/algae respectively for food. In December 2018 an adult loggerhead turtle was satellite tagged while laying eggs on south Muiron Islands and was tracked, post nesting, to Mindarie, a distance of over 1100 km (Figure 20).

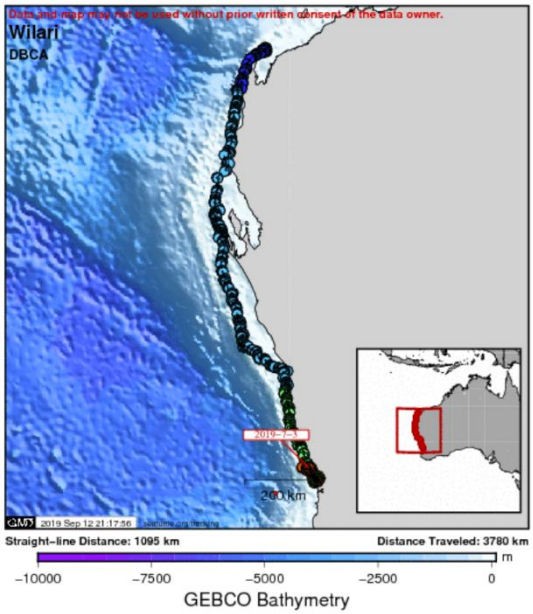

Figure 20. Adult Loggerhead (Wilari) satellite tracked from South Muiron Island rookery to Mindarie.

Leatherback turtles are usually open ocean foragers and travel the oceans chasing jellyfish as prey. Leatherback are common, but unpredictable fauna in these waters. Other non- resident turtles pass through these waters. Most commonly are neonate loggerhead turtles, originating as hatchlings from Shark Bay or Ningaloo Coast beaches and are seeking open ocean habitat to spend the next 5 to 10 years. However, currents push them south and they can often be pushed ashore along the south-west coast. Rehabilitated turtles are re-released at Ningaloo and tracks individuals appear to be successful. Transient green and hawksbill turtles sometimes strand along this coast indicating usage of these water.

Sea snakes are transported by the strong south-flowing Leeuwin Current and are carried hundreds of miles from their home territory. Generally, these species are found in warmer waters in the north of Western Australia. DBCA plays a major part in the conservation of these species by rehabilitating and relocating individuals back to northern areas of the state.

For all marine reptiles that are highly influenced by water temperature, locations such as the Marmion Marine Park will become increasingly more important as temperatures increase beyond optimal limits in current core ranges of these species.

Fish

Reef, macroalgae and seagrass habitats found within the study area support a relatively diverse fish assemblage. Over 500 fish species are known to occur along the Perth coast between Mandurah and Two Rocks (Whisson and Hoschke 2021), and surveys within Marmion Marine Park conducted by DBCAs marine science program using diver operated and baited remote underwater video surveys found 112 species of fish over a 10-year period.

There are a number of fish, shark and ray species of high conservation value present within the study area. The common seadragon (*Phyllopteryx taeniolatus*) and leafy seadragon *(Phycodurus equesis)* are both protected under the *Fish Resources Management Act 1994* (FRMA) (DPIRD 2021). The common seadragon is distributed throughout the entire southern coast of Australia from Western Australia to New South Wales and Tasmania. The leafy seadragon is distributed along the southern coastline of Australia from Jurien Bay to Victoria, but is much rarer than the common seadragon. The white shark (*Carcharodon carcharias*) and grey nurse shark (*Carcharias taurus*) also occur in the study area and are listed under both the *Environment Protection and Biodiversity Conservation Act (1999)* (EPBC Act) and the *Biodiversity Conservation Act 2016* (BC Act). Other shark species known to occur in the study area include the Port Jackson shark (*Heterodontus portusjacksoni*), blackspot catshark (*Aulohalaelurus labiosus*) and the western wobbegong (*Orectolobus hutchinsi)*. Ray species that are known to inhabit the study area include the smooth stingray (*Dasyatis brevicaudata*), eagle ray (*Myliobatis tenuicaudatu*), western stingaree (*Trygonoptera mucosa*) and striped stingaree (*Trygonoptera ovalis*).

There are numerous studies to suggest that climate change induced ocean warming is influencing the distribution and affecting the growth of temperate marine fishes (Booth *et al*., 2009, Cheung *et al*. 2012). For example, Shalders *et al*. (2018) and Parker *et al*. (2019) demonstrated potential climate mediated changes to the distribution and abundance of reef fishes in south-western Australia. Ocean temperature increases will change the preferred habitats for a range of species, including fish and sharks, with some experts suggesting that habitat ranges could shift southwards by an average of 3.5 degrees (i.e. ~390 km) along the west coast of Australia (Booth *et al*. 2009). The effect of the warm Leeuwin Current extends the range of many subtropical fish species into temperate areas of the south west coast (Cheung *et al*. 2012). The Leeuwin Current provides a means of dispersal of eggs and larvae of subtropical biota, creating a mix of temperate endemic fishes and subtropical fishes in the southwest region known as the 'western overlap zone' (ranging from Albany to Shark Bay) and provides a distinctive western character to the fish fauna (Hutchins 2001).

Over recent timeframes (2010 to present), the condition of fish in the park is considered to be stable. The marine heatwave that influenced the region in 2010/11 resulted in a large recruitment event into the area. Most notably, the western king wrasse (*Coris auricularis*) increased in abundance over medium timeframes, while the sub-tropical herbivore *Signaus fuscenscens* (dusky rabbitfish) increased and has remained in higher abundance since. Monitoring indicates that the abundance of some highly targeted species (i.e. Western Australian dhufish, G*laucosoma herbraicum;* baldchin grouper, *Choerodon rubescens;* pink snapper, *Pagrus auratus*) within the current park boundaries are extremely low (unpublished DBCA/Curtin University data). While suboptimal depth is likely in part responsible for this, oral histories suggest that both species were present in far higher abundance in the 1950's and 1960's (Ottaway et al. 1987), indicating that historical depletion likely occurred prior to monitoring commencing. Targeted whiting (*Sillago* spp.) and Australian herring (*Arripis georgianus*) are not sampled well using the current survey design and are hence not currently evaluated within the park.

Sharks are also not well sampled using current techniques. Effort is currently being placed into modifying survey design and methodologies to address these issues.

The distribution and abundance of fishes can change over small spatial scales, which has important implications for management. A study within Marmion Marine Park found that even over small depth gradients (3-23 m), there were distinct changes in fish assemblages, highlighting the need to ensure zoning strategies take into account representative depths to maximise efficacy (Bach et al. 2019).

Invertebrates

DBCA's Marine Science Program has identified over 85 intertidal invertebrate species within MMP. Common species include the red waratah anemone (*Actinia tenebrosa*), the turban shell (*Turbo torquatus*), the western six-armed star (*Meridiastra occidens*) and Roe's abalone (*Haliotis roei*). Densities can exceed 500 organisms per m^2 (from different taxa) in certain areas.

Recreational and commercial fishing in the study area is a known pressure on Roe's abalone metropolitan population, however, the Department of Primary Industry and Regional Development (DPIRD) monitor the species and implement measures to ensure this fishery is sustainably managed (noting the fishery is Marine Stewardship Council certified). Yet, data on the ecological impacts of recreational abalone fishing at present on the broader invertebrate community is currently insufficient. Although the physical damage caused by an individual fisher reef walking may be minor, cumulative effects may cause localised mortality of sensitive sessile organisms and lead to biodiversity loss. This should be further tested, especially in metropolitan areas where many pressures act cumulatively to impact these communities.

The western rock lobster (*Panulirus cygnus*) can also be found throughout the study area. While western rock lobster may use a range of habitats throughout their life-cycle, including shallow water reefs and adjacent seagrass beds as juveniles, or un-vegetated areas during their migratory phase, the algal covered limestone reefs form the habitat for the majority of the population.

While macroalgae are dominant on most of the temperate reefs, corals can often be found among the algae in low density. A recent study found the most prominent genera of hard corals within MMP were *Paragoniastraea, Dipsastraea,* and *Favites* (Ross *et al*. 2021). Numerous other species of corals have been recorded within the study area, such as *Montipora mollis, Plesiastrea versipora, Turbinarea reniformis, Coelastrea aspera* and *Pocillopora damicornis* (Tuckett and Wernberg 2018). Coral reefs in Western Australia are regularly affected by seasonal storms and cyclones, and increasingly by heat stress and subsequent coral bleaching. Since 2010, there has been a noticeable increase in heat stress and coral bleaching across Western Australia (Gilmour *et al*. 2019, Moore *et al*., 2012). Many temperate reefs are experiencing a shift towards a greater abundance of tropical species in response to marine heatwaves and long-term ocean warming worldwide (Cheung *et al*. 2012).

In addition to climate change impacts, the construction of the Ocean Reef Marina will inflict direct pressure upon the intertidal reef communities through permanent removal of this habitat within the development envelope as well as ongoing impacts to water quality and temperature (City of Joondalup 2016, EPA 2019, Gaughan & Santoro 2021). Further, the Public Environmental Review for Ocean Reef Marina indicates that there are very few locations of comparable intertidal habitat elsewhere in the area and that indirect impacts from the development are likely to extend 0-500m from the development envelope (City of Joondalup 2016, EPA 2019). Ongoing monitoring and management of actual and potential impacts will be undertaken in accordance with several plans prepared on behalf of Development WA to satisfy EPA approval conditions of Ministerial Statement 1107, including an Abalone Habitat and Biomass Baseline Survey and Abalone Habitat and Biomass Monitoring Plan. These documents are publicly available on the Development WA website.

7 Marine flora and benthic habitats

Benthic habitats

Remote sensing monitoring within the park conducted by CSIRO in collaboration with DBCA Remote Sensing have created broadscale habitat maps (Figure 21). This remote sensing showed sand was the most dominate habitat type, followed by macroalgae, then seagrass (Table 2 &Table 3).

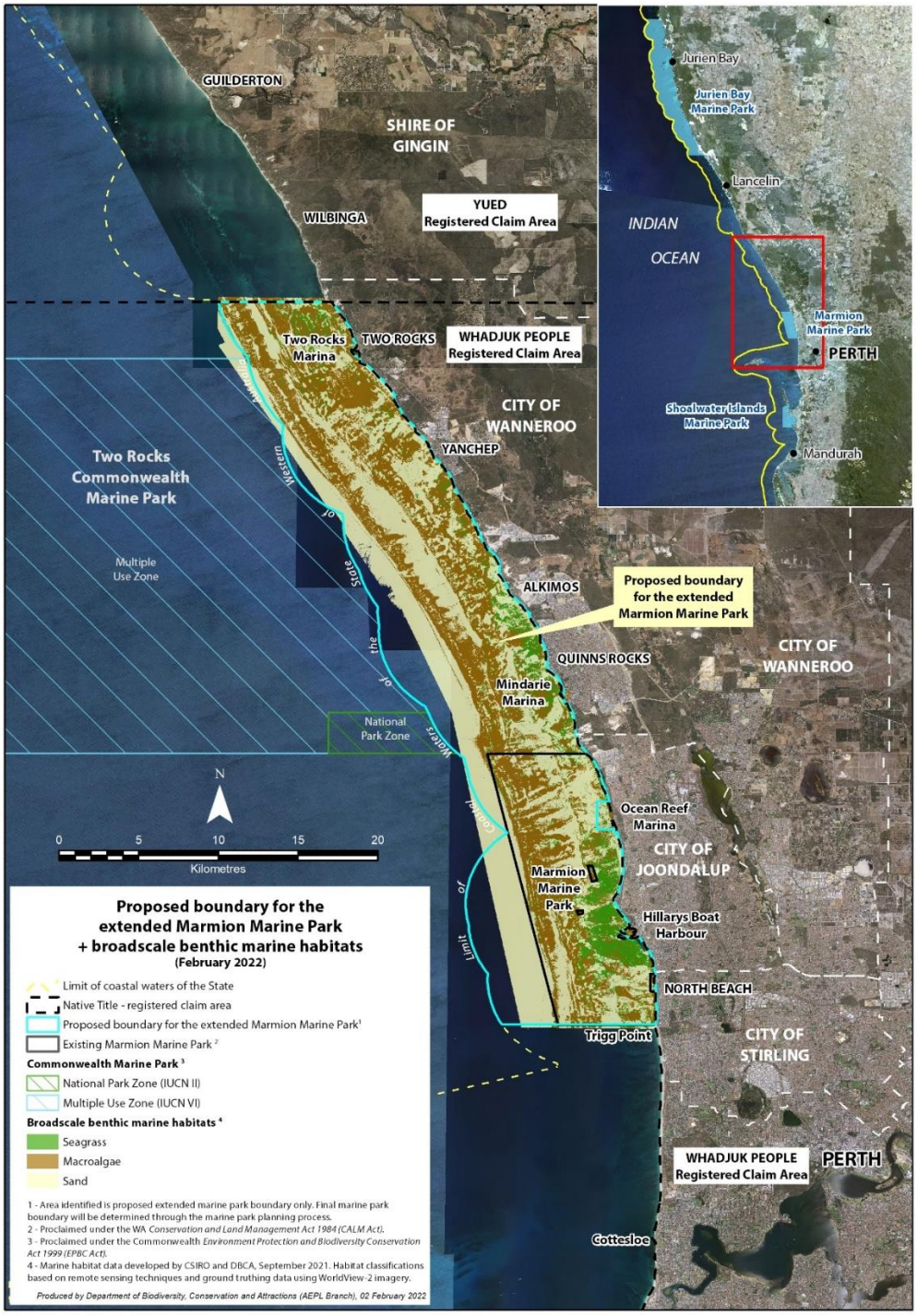

Figure 21. Broadscale benthic habitats in the proposed expansion of Marmion Marine Park.

Table 2. Benthic habitats of Marmion Marine Park.

Habitat Type	Area (hectares)	% area
Macroalgae	12114	34.95%
Seagrass	2493	7.19%
Sand	16643	48.01%
Bare intertidal reef	42	0.12%
Wrack	2	0.01%
No data	3370	9.72%
TOTAL	**34664**	**100%**

Table 3. Benthic habitats of Marmion Marine Park according to zone type,

Habitat Type - broadscale	ZONE TYPE									TOTAL	
	General Use		% area of marine park	Recreation Area		% area of marine park	Sanctuary Area		% area of marine park		
	Area (hectares)	% area		Area (hectares)	% area		Area (hectares)	% area of zone		Area (hectares)	% area
Macroalgae	3816	40.5%	40.2%	13.6	44%	0.1%	20.861	50.32%	0.2%	3851	40.6%
Seagrass	1384	14.7%	14.6%	2.1	7%	0.02%	12.558	30.29%	0.13%	1399	14.7%
Sand	4158	44.1%	43.8%	12.5	40%	0.13%	7.239	17.46%	0.08%	4178	44.0%
Bare intertidal reef	18	0.2%	0.2%	1.9	6%	0.02%	0.794	1.91%	0.01%	21	0.2%
No data	46	0.5%	0.5%	0.8	3%	0.01%	0.002	0.01%	0.00%	47	0.5%
TOTAL	**9422**	**100%**	**99.2%**	**31**	**100%**	**0.33%**	**41**	**100%**	**0.44%**	**9495**	**100%**

Macroalgae

The Leeuwin and Capes current strongly influence the distribution of macroalgae along the southwestern and southern coasts of Australia (McClatchie *et al*., 2006). Within the study area, subtidal reefs support an extensive macroalgae community that have a high floral diversity. The macroalgae communities are important primary producers, which in turn provide habitat and are important refuge areas for a diverse range of finfish and invertebrates (Government of Western Australia Conservation and Parks Commission 2012). Up to 46 macroalgae species have been recorded within the current MMP, some common species include *Ecklonia radiata, Rhodymenia sonderi, Sargassum* spp, *Pterocladia lucida, Kallymenia cribrosa* and *Amphiroa anceps* (Ryan 2008).

Over recent timeframes (2012 to present), the condition of macroalgal communities within the park is considered stable (Figure 22). This assessment is based on the density of the primary canopy forming species, *Ecklonia radiata*. The condition of understory communities is less known. However, it is worth noting that monitoring of macroalgal communities commenced after the 2010/2011 heatwave event that influenced the area. Given the documented effects of this event on macroalgae communities just to the north in Jurien Bay (Wernberg et al. 2016), it is possible that there were negative effects on those in the MMP prior to the commencement of monitoring. Certainly, there is evidence to indicate that the density of another canopy forming species, *Scytothalia dorycarpa*, declined in the Perth metrpolitan region following the 2010/2011 event (Smale and Wernberg 2013).

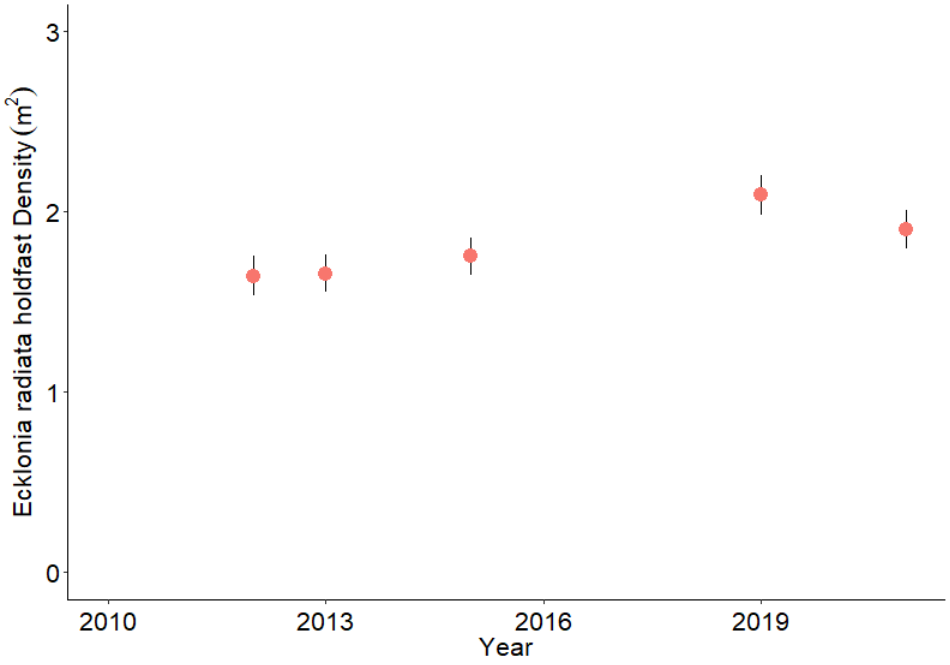

Figure 22. *Ecklonia radiata* density per m^2 over time within Marmion Marine Park.

Some of the impacts and threats to macroalgal communities include:

- climate change, causing a reduction to the diversity and abundance of habitat forming seaweeds following marine heatwave events along the coast of Western Australia (Wernberg et al., 2012; 2016);
- population growth which has the potential to contribute to large-scale degradation of macroalgal habitats and altering of species composition and relative abundance (McClatchie et al., 2006);
- decrease in water quality that can reduce the depth of the photic zone, therefore restricting macroalgal depth distribution (McClatchie et al., 2006);
- pollution from sewage or urban run-off (McClatchie et al., 2006);
- sedimentation from coastal developments i.e. marinas, groynes, housing developments, and dredging activity (McClatchie et al., 2006);
- dredging and sediment infill that can impact macroalgal recruitment due to smothering of algal propagules and recruits (McClatchie et al., 2006);
- anchoring damage from the use of rock lobster pots and other fishing apparatus (McClatchie et al., 2006);
- altered local hydrodynamics from coastal developments can also alter local hydrodynamics resulting in fragmented algal distributions (McClatchie et al., 2006).

Seagrass

The study area is located within a region that hosts the world's largest number of temperate seagrass species (Carruthers et al. 2007). The extensive and diverse presence of seagrass within the area has been directly linked to the Leeuwin Current that brings seasonal warmer waters.

Seagrass within the study area occur at depths up to 20m and provides critical nursery habitat for a range of fish species and the western rock lobster (Gaughan & Santoro 2021). Furthermore, echinoderms, molluscs and crustaceans all rely on the seagrass as a source of food. The seagrass beds also play an important role in stabilizing the sandbanks within the study area.

Changes in seagrass species within the study area are results of "blowouts" from catastrophic storms and wave movement. These "blowouts" leave open sandy banks within the *Posidonia* meadows,

allowing other seagrass species to establish themselves (Kirkman & Kirkman 2000). Seagrasses within the study area comprise *Posidonia* spp. (*P. sinuosa*, *P. australis*, *P. augustifolia*), *Amphibolis spp. (A. antarctica*, *A. griffithii)*, *Halophila ovalis*, *Heterozostera tasmanica* and *Thalassodendron pachyrhizum*; with *Posidonia* spp. most predominant (Department of Conservation and Land Management 1992)

As the incidence of Marine Heat Waves (MHW) increase with climate change, heat stress is a potential pressure for seagrass communities globally (Strydom, 2020). The Marine Parks and Reserves Authority (2012) identified two minor pressures on seagrass in the area; local water degradation and local vessel anchors. However, with increasing urban population and boat ownership in Perth, these two minor pressures may present significant issues for the future. The scouring of seagrass by vessel moorings has been found to negatively impact seagrass ecosystem integrity (Walker & Kendrick 1998), Besides navigation and marine park moorings, there are no public or private moorings present in the study area. Due to the increasing indirect pressure from fishing and anchoring, continuous monitoring has been highlighted as crucial

Over recent timeframes (2014 to present), the condition of seagrass communities within the park is considered stable. This is based on density surveys of the dominant seagrass species, *Posidonia australis* (Figure 23). The condition of other seagrass species present in the park is less known. As monitoring commenced after the 2010/2011 heatwave event, the effects of the high water temperature on seagrasses in the park is unknown. However, given that longer term studies in nearby Cockburn Sound indicate negligible impacts, it is likely to be minimal.

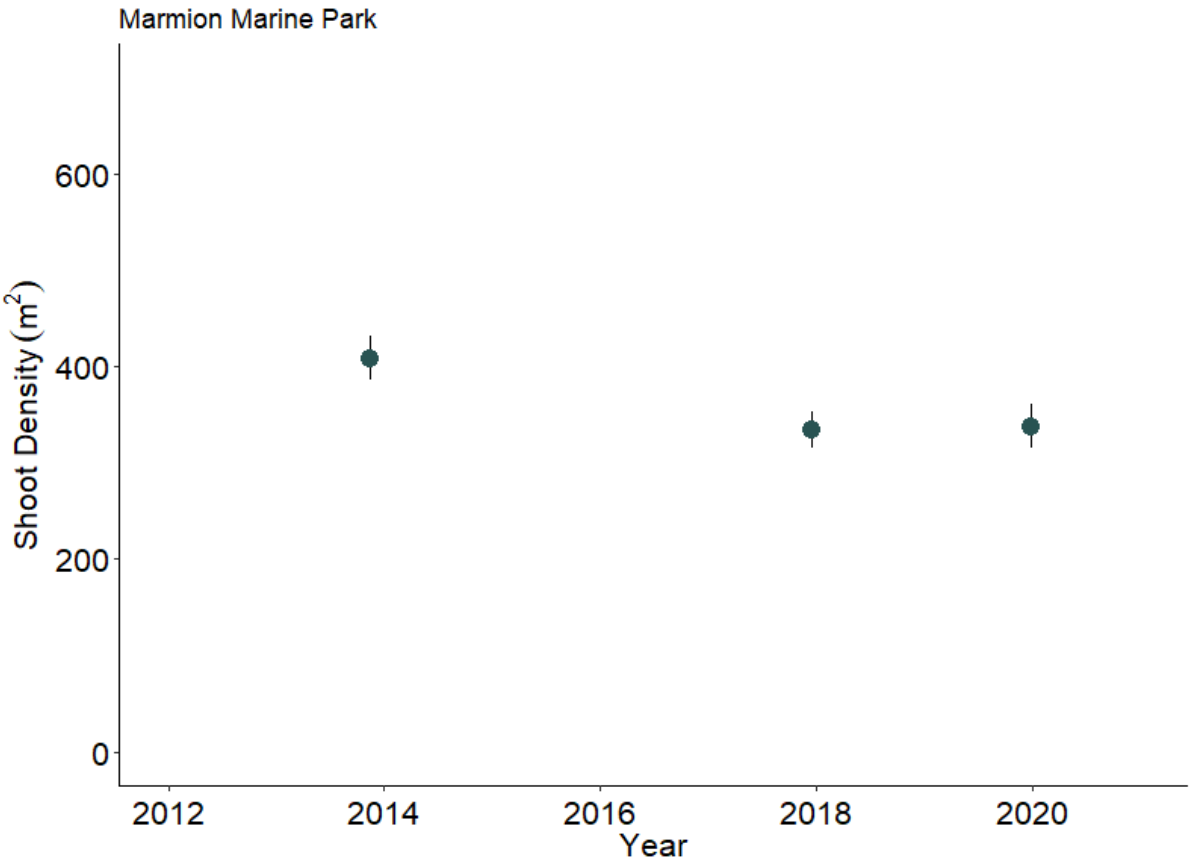

Figure 23. *Posidonia australis* shoot density per m^2 over time.

Intertidal reef platforms

The varying bathymetry of the study area has allowed for the establishment of intertidal reef systems which are surrounded by macroalgae, seagrass, and sand habitats (Moore 1987). These reefs contribute significantly to the biological diversity of the area. Intertidal reef communities are affected by wave action and support diverse assemblages of organisms that are resistant to desiccation, including bivalve shells, snails, crabs, worms, and small fish seeking refuge in shallow rock pools at low tide. Larger fish and other marine animals come in to feed on these organisms when the tide is high. The abundance of invertebrate life on these intertidal reefs also provides a valuable food source for shorebirds.

The intrinsic biological attributes and accessibility of intertidal reefs often attracts a variety of recreational uses (e.g. collecting, fishing, reef-walking) as well as providing a range of educational and scientific opportunities. This accessibility and relatively high use also make these reefs among the most vulnerable habitats to human degradation, such as that caused by reef-walking and recreational fishing.

Significant areas of intertidal reef platforms are located between Trigg and Watermans, and between Hillarys and Iluka. Offshore reefs, biodiversity hotspots amidst deeper waters, include Burns Rocks, Whitfords, Wanneroo Reef, and Wreck Rock.

Monitoring

The DBCA Marine Science Program monitor key ecological values (communities and species) to assess on-going condition of values and the anthropogenic pressures acting on them. Data from this program has been used to provide information on recent condition trends of ecological values in the relevant sections above. This quantitative information is used to inform annual marine park performance reporting to the Conservation and Parks Commission (CPC), coordinated through the Regional and Fire Management Services Division.

SOCIAL VALUES

8 Cultural history

Aboriginal cultural heritage values

Traditional owners for the study area are the Whadjuk Noongar people. Whadjuk Boodja; Noongar lands as they existed at the time of colonisation can be seen in Figure 24. Noongars have a cultural memory and history that have been passed to each generation in an oral tradition, through memory coding via the great library that is contained in song lines. Some creation stories closely resemble the current scientific accounts of history. Nyidiny, yarns or Dreaming stories/history account for significant events lying within and beyond living memories of the Noongar. These stories are much more than simple stories designed for small children, they are kadadjiny (knowledge), they are imbedded physically and spiritually in the landscape. Like any library, there is layer upon layer upon layer of connected information, intellectual levels and intellectual property that are taught and learnt at different stages of life. Within song lines lay Noongar history, present and past. Noongars are invested in caring for country in a way that is as ancient as the beginning of time and in ways that are deep, and little understood by non-indigenous people (Robertson et al. 2016).

Reconstructing the history of nonliterate or preliterate societies makes necessary the study and interpretation of oral traditions. Noongars have gone to great lengths to preserve and transmit the knowledge of their past in oral forms of knowledge. Noongars developed complex exchanges of encyclopaedic knowledge through methods of memory and repetition, perfected over centuries of practice and adaptation. The place-associative memorization systems, whether patterned through songs, dance, mythological stories, stars, landscape, or handheld totems, were instrumental in generating and maintaining kaadatj (learn/think/teach/listen) and kadadjiny (Robertson et al. 2016).

Noongar people believe that the Waakarl (the Rainbow Serpent; spirit water snake) dominates the earth and the sky and makes the malka (thunder), bindari (lightning) and boorong (rain). During the Nyitting (ancient, cold, dark time), Waakarl created the fresh waterways such as the bilya/beelier (rivers), binjar (swamp), moolar (lakes) and ngaama (waterholes). The Darling Scarp represents the body of the Waakarl, that created the curves and contours of the hills and gullies. As the Waakarl slithered over the land, its track shaped the sand dunes, its body scoured out the course of the rivers, and where it occasionally stopped for a rest, bays and lakes were created (Robertson et al. 2016).

Other Nyitting (ancient, cold, dark time) stories and oral histories demonstrate the importance of the coast, the sea and the islands to the local Whadjuk (Noongar) people. Following the last glacial minimum around 18,000 years ago, sea levels had begun to rise. The sea flooded and drowned the Rottnest Shelf and the coastal plain situated between Perth and Rottnest. The story "When the sea level rose" as told by Dr Noel Nannup, a Whadjuk Noongar Elder, demonstrates the Noongar people's long-standing relationship with their changing coastline (Nannup 2020).

"When the sea level rose" is the story of Nyingarn, the echidna and Kaarda, the goanna, who were given the special role of representing the spirit of those who passed on, and the story of Maamoong, the whale and Kwila, the dolphin and the special role they were given in country. When the sea level rose, it trapped the spirits of children underneath the sea, and Maamoong and Kwila were instrumental in assisting to bring the spirits back to the land. When the sea levels rose approximately 10,000 years ago, many spirits were trapped under the sea. The only way these spirits can return to the land is through the assistance of the whales. Whenever a whale calf is born, one of these spirits attaches itself to it. After 80-90 years swimming around the ocean, Maamoong returns to this coast. Maamoong the whale beaches itself to return the spirit being carried by the whale back into the land where it belongs. The Noongar men intuitively knew when the whales were coming. They would prepare a daap, a ceremonial knife that was used to cut open the whale while its body was beached. When the blood from the whale ran into the land, the people would be satisfied that the spirit had returned (Nannup 2020).

The inundation of coastal lands by the sea, as described above, made it impossible for Noongars to access important traditional sites such as Wadjemup (Rottnest). Wadjemup was a high point in the terrain which was used for ceremonial and spiritual purposes. Of great concern to the Noongar was that the spirits of the buried dead at these now submerged locations were trapped beneath the sea. Nannup (2020) describes the inundation of Noongar country and the spirits being trapped as the sea rose rapidly (Stocker & Shaw 2016). The story of 'When the Sea Levels Rose' (Nannup 2020) demonstrates the synergy between Noongar history and western scientific knowledge. It is important to protect all known or currently unresearched sacred places and areas of significance that were once above sea level and now submerged due to sea level rise in the study area.

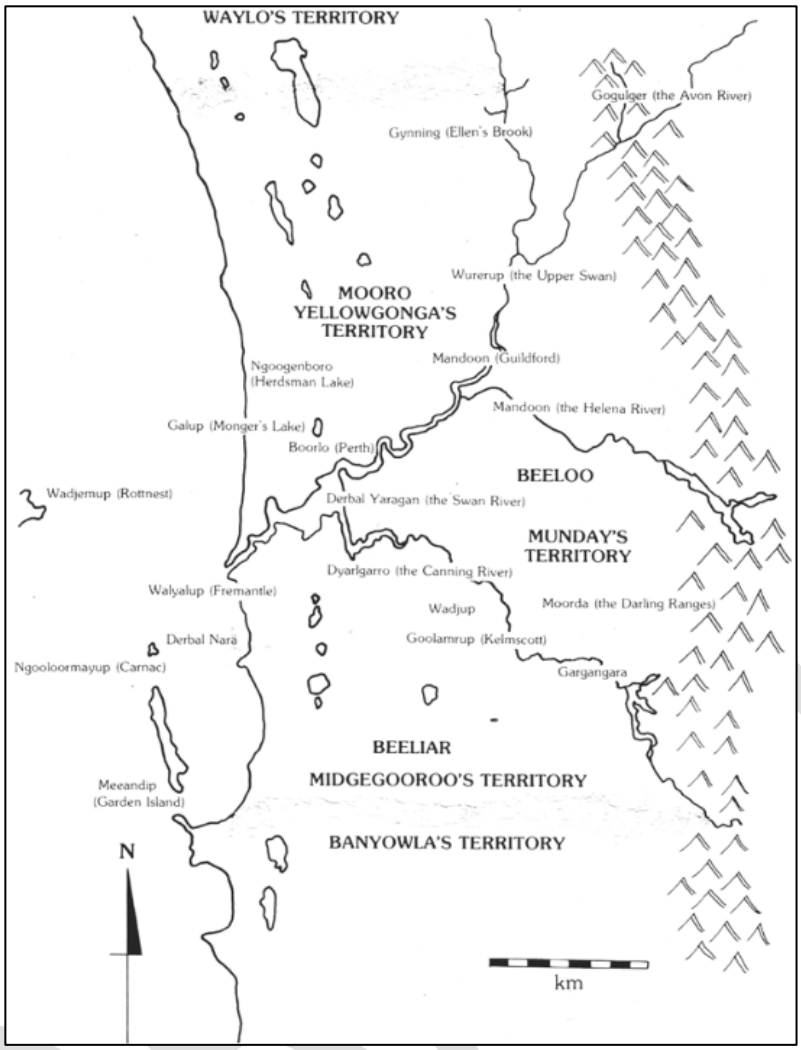

Figure 24. Whadjuk Boodja – Noongar lands at the time of colonisation. Place names and territories recorded by Robert Lyon in 1832 (map drawn by Neville Green, 1979).

Aboriginal heritage sites

The *Aboriginal Heritage Act 1972* establishes a provision which allows for the preservation of places and objects customarily used by the traditional inhabitants of Australia or their descendant. Aboriginal sites contain footprints which are crucial for ensuring a link between past and current Aboriginal people and culture continues to exist. Whilst not all Indigenous cultural heritage sites have been recorded, sites include, but are not limited to; rock shelters, burial sites, quarries, camps, artefacts, shelters, mythological, gathering and hunting grounds, and language. The region around the study area was historically non-submerged land used by the Noongar people prior to sea level rising during the last inundation 7000-10000 years ago.

There are a range of Aboriginal sites throughout the Perth metropolitan environs, of which some are in close proximity to the study area (Figure 25**Error! Reference source not found.**). Four of those registered sites occur within the study area (Table 4).

Table 4. Registered Aboriginal Sites within the study area.

ID	Name	Type	Gender restrictions	Reliable boundary

17599	Yanchep Beach	Mythological	No	Yes
17596	Limestone Reef	Mythological	No	Yes
3509	Karli Spring	Mythological, Water Source	No	Yes
20772	Jindalee	Mythological, Water Source, Natural Feature	No	Yes

Aboriginal sites have been related to the following categories: mythological, skeleton material, camp, rock shelter, natural feature, water course, meeting place, massacre, artefacts, modified tree, manmade structure, historical, arch deposit, and/or hunting place.

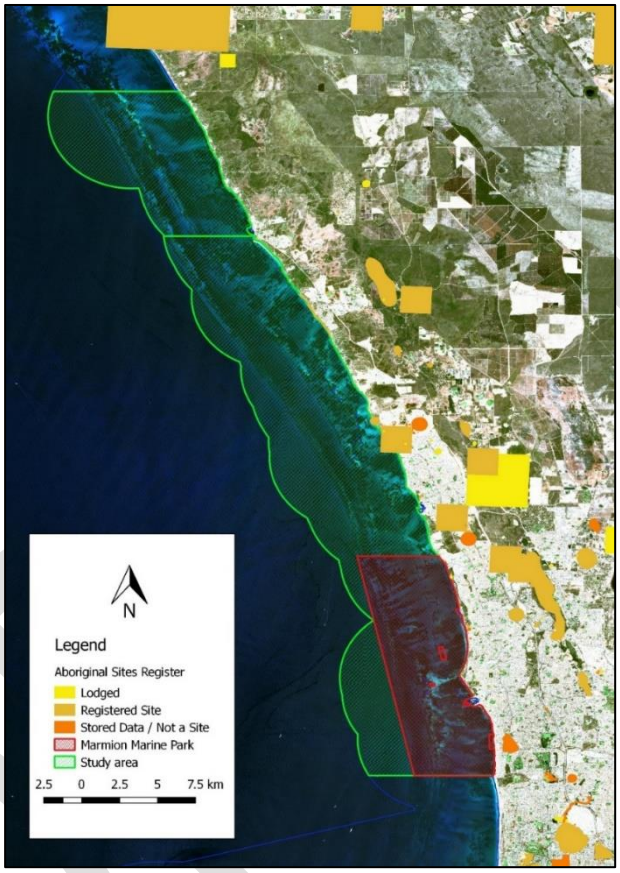

Figure 25. Aboriginal heritage sites located within and nearby the study area for the proposed expansion of Marmion Marine Park area.

European heritage

Pre-colonisation
The first record of Europeans being close to the study area was in 1656 with the vessel the *Vergulde Draeck (Gilt Dragon)* skippered by Captain Pieter Albertsz. Unfortunately, the *Vergulde Draeck* encountered a reef five kilometres off the coast, south of Ledge Point on 28 April 1656, about 75km north of Perth. The vessels *Waeckende Boei* (Samuel Volkersen) and *Emeloort* (Aucke Pieters Jonck) sailed in search of the lost *Vergulde Draeck* heading north from Rottnest Island in 1658 (Kenderdine 1995). Most likely these were the first Europeans to investigate the waters and coast of the proposed Marmion Marine Park expansion area. Later European vessels encountered the waters of the area included:

- *1697* - Willem de Vlamingh (*Geelvinck, Nijptangh & Weseltje);*
- *1772* - Louis de Saint Alöuarn (*Gros Ventre*);
- *1790's*-1800's - French, British and American sealers and whalers frequent the west and south coasts;
- *1801*-1803 - Nicolas Baudin and Jacques Felix Emmanuel Hamelin (*Géographe and Naturaliste*);
- *1822* – Phillip Parker King (*Bathhurst*), Louis Duperrey (*Coquille*); and
- *1827 Captain James Stirling (HMS Success).*

There are five shipwrecks in the study area that have been listed with the Western Australian Museum and are described in Section 0.

Colonisation
In 1827 Captain James Stirling arrived in Western Australia in the HMS *Success*. He surveyed the Swan Estuary and he recommended that it would be suitable for settlement, particularly as the French were also looking at colonising Western Australia. Two years later in 1929, Captain Charles Fremantle arrived at Swan River onboard the HMS *Challenger*, to take formal possession on behalf of Britain, all of Australia not included in the colony of New South Wales. In June 1929, HMS *Sulphur* and HMS *Parmelia* brought the newly appointed Lieutenant-Governor James Stirling with settlers, who proceeded to dispossess the local Whadjuk Noongar Aboriginals of their fertile Swan River flood plains in establishing the Swan River colony (WA Museum 2021)

Between 1934 and 1841, surveyors and explorers traversed the coastal plain inland of the northern beaches. In 1834, John Butler explored and surveyed the Wanneroo/Joondalup area for first time. Lieutenant George Grey, two other British men and two Noongar men investigated the country in an area called Doondalup (Joondalup) during 1838. Other adventurers included John Septimus Roe (the first surveyor General of Western Australia), John Butler (who was searching for lost cattle) and Thomas Watson (Surveyor). John Smithies a Methodist Missionary was one of the founders of farming in the Lake Goollelal area around 1840. It was an experimental farm established by the Wesleyan Missionary Society. In 1844, George Shenton leases most of the northern beaches to use as a stock route and by 1849, more settlers take land around Lake Joondalup to establish farming properties, with consultation with the Noongar people. Patrick Marmion, a 26-year-old clerk from Downpatrick, Ireland, opens a whaling station in 1949. The whaling station operated for three years. In 1852 it was permanently abandoned - possibly as a result of reduced whale numbers combined with skilled crew shortages that were mainly due to men leaving the whaling industry to pursue the lure of gold during the Victorian Gold Rushes (City of Joondalup 2013).

By the 1850's, Trigg was established as a timber-cutting and grazing region. Sorrento and Mullaloo were an integral part of the Wanneroo Stock Route linking Perth to the North West of Western Australia during the early 1970s. By 1872, there was a blossoming pastoral and farming community of around 60 families living around the string of lakes and swamps along the vital north/south route.

By the early 1900s, shacks were erected at Trigg Point. During World War 1 (1908), Burns Beach was a small community of fishing and camping shacks. In the 1920s, holiday houses were being erected at Burns Beach. By the 1930s when better road access was established, holiday and fishing shacks sprang up from Trigg to Burns Beach: 1930 saw the first shacks erected at Hillarys; there were 42 shacks amongst the dunes at Marmion by 1944; and by the early 1950s, shack were appearing at Sorrento (Figure 26) (City of Joondalup 2013).

Figure 26. By the 1950s, there were many fishing shacks located at the most popular beaches from Trigg to Burns Beach Rushes (City of Joondalup 2013)

Localities

Trigg

Trigg was named after Henry Trigg, Superintendent of Public Works for the Swan River Colony in 1842. Three shacks were built in the early 1900 in the vicinity of Trigg Island and after 1920, fishing and holiday shacks began to appear.

Mettams Pool

Frank Mettam with the assistance of his family, painstakingly removed the limestone reef that divided the then named Lennards Pool. They removed the reef piece by piece only using pickaxes and a large crowbar (Figure 27) however, it is thought anecdotally that he also used explosives sourced from nearby roadworkers for a carton of beer. The pool was renamed in the 1940's to Mettams Pool.

Figure 27. Frank Mettam at Mettams Pool in the mid-1960s with his famous giant crowbar removing the never-ending 'just one more rock'

North Beach
North Beach was named in 1888 when surveyor Charles Crossland referred to the pastoral leases of Samuel Richard Hamersley as his "north beach coastal run". A quarantine station for camels entering the country for service in the Goldfields was established during the gold rush era at North Beach. The area became a holiday destination in the 1940s and 1950s for the people of Perth and as a result many coastal shacks and holiday houses were built in North Beach (City of Stirling 2019a).

Hamersley Pool
Hamersley Pool is a small reef-enclosed tidal pool which has attracted swimmers and bathers since the early 20th Century. In the 1880's, Edward Hamersley and family built the first house in the North Beach area. By 1920, Hamersley Pool was a popular swimming location and dressing sheds were erected.

Watermans Bay
The suburb of Watermans Bay was originally known as Waterman Bay and named after Alfred Waterman who was a fisherman who built the first house (called 'Zephyr') in the area in 1908. The Bay was a well-known and popular fishing spot. In 1962, the name Watermans Bay was shortened to Waterman and was changed back to Watermans Bay in 2003.

Marmion
Marmion was named after the master whaler, Patrick Marmion, who built and operated a whaling station in the area in 1849. There are still some remains of the old whaling station in the adjacent suburb of Sorrento.

Sorrento
In 1929, subdivision of freehold land known as 'Sorrento' was surveyed here. Sorrento Beach was a very popular fishing and holidaying location and subsequently many shacks were established along the shoreline. The first beach shacks in the Sorrento Beach areas were constructed around 1925.

Hillarys
Just to the north of Hillarys Boat Harbour, a fishing shack was erected around 1930 by Bertram John Hillarys; a Gallipoli war veteran from World War One (Department of Transport 2013). In circa 1950, there were many beach shacks lining Marmion Beach (~45 in the surrounding dunes) and Whitfords Beach north of Pinnaroo Point (Figure 28). Bertram's shack and the 14 or so others surrounding it, were destroyed during a storm in 1964.

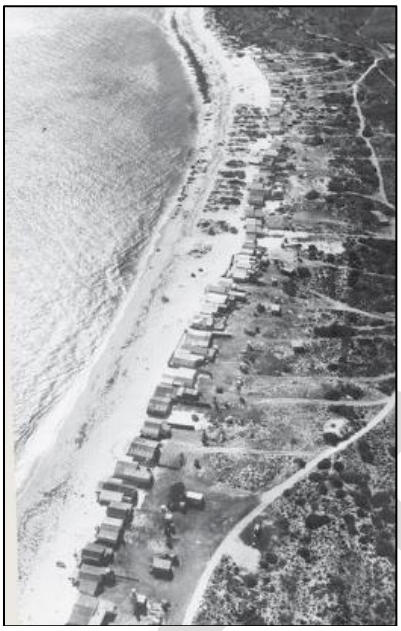

Figure 28. Aerial view of the Whitford Nodes beach shacks circa 1950 (City of Joondalup 2013).

Kallaroo
Kallaroo was named in 1970 and is an Aboriginal word meaning 'road to the water' (Landgate 2019).

Mullaloo
Mullaloo is named from an Aboriginal word meaning "place of the rat kangaroo". The name was first recorded for a point on the coast near here in 1919. It was first shown as Moolalloo Point, but the spelling was later changed to Mullaloo, and the feature is now known as Pinnaroo Point. The beach here was locally known as Mullaloo Beach around the turn of the century (Landgate 2019).

Ocean Reef
Ocean Reef is a descriptive name used by developers. It is derived from a line of reefs offshore from Mullaloo and was approved in 1974 (Landgate 2019).

Iluka
Iluka is an Aboriginal word from an eastern states dialect and is said to mean 'near the sea' (Landgate 2019).

Burns Beach
By the late 1920s the area was well-used by locals as a camping and health resort. It was referred to by them as 'Burns Beach' after a farmer who ran sheep in the area (Landgate 2019).

Mindarie
This area is named after Mindarie Lake. Mindarie is an Aboriginal name first recorded by Alexander Forrest in 1874. The meaning for the name is possibly "the place near which is held a ceremony" or "green water" (Landgate 2019).

Quinns Rock
Quinns Rocks takes its name from the offshore reef first noted during a coastline survey by Surveyor James Cowle in 1867. It is thought that the rocks were named after Robert Quinn who emigrated to Western Australia in 1863 and he was appointed as an Assistant Surveyor (Landgate 2019).

Jindalee
This is an Aboriginal word meaning "a bare hill" which probably refers to Eglinton Hill located within the locality (Landgate 2019).

Alkimos
The area is named after the Greek freighter *Alkimos* which ran aground on the coast adjacent to the suburb (Landgate 2019).

Eglinton
Eglinton is named after the Barque 'Eglinton' which was wrecked on rocks, which now also bear its name in 1852. Eglinton Rocks are located off the coast adjacent to the area (Landgate 2019).

Yanchep
The name Yanchep is of Aboriginal origin, and is derived from "yanget", a native flax or bullrush. The name was first recorded for Lake Yanchep by surveyor Robert Quinn in September 1866 (Landgate 2019). Yanchep Lagoon has been frequented by holiday makers and fishermen since the early 1900s.

Two Rocks
This area is named after two prominent rocks offshore from Wreck point. Two Rocks achieved prominence when a yachting marina was constructed here in 1973/74 (Landgate 2019).

Whaling
European settlement within Western Australia saw the state's coast used extensively for its food and economic resources. Such uses of the coast were also seen within the study area during and after European settlement. Patrick Marmion, whom Marmion Marine Park was named after, ran a shore whaling station built on ten acres of leased crown land in 1849. Shore whaling involved rowing small shore-based chaser boats to intercept migrating whales. If the whaling crew was successful, they towed the dead whales back to shore for processing. The whaling station operated for three years. In 1852, it was permanently abandoned when the whalers relocated to the Goldfields to make their fortunes (City of Joondalup 2013). A monument to Marmion can be found in Geneff Park in Padbury Circle, Sorrento.

Maritime History
There are five shipwrecks of important heritage value and listed by the Western Australian Museum (Kenderine 1995) in the study area (Figure 29):

- Centaur 1874;
- Conference 1904;
- Eglinton 1852;
- Alkimos 1963; and

- Alex T. Brown 1917.

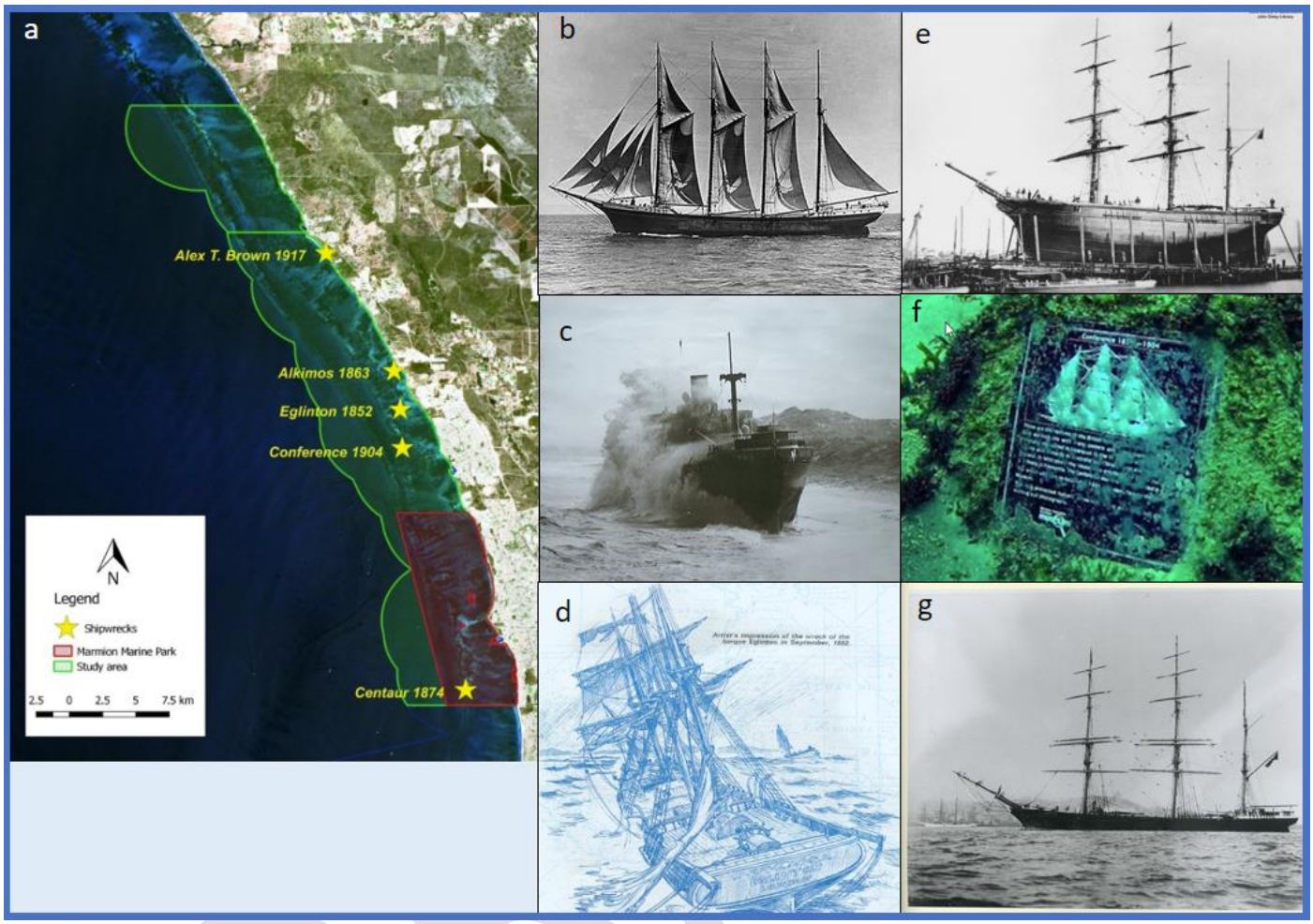

Figure 29. a) Location of shipwrecks of historical significance in the study area, b) The 210-foot, 4-masted wooden schooner, the *Alex T Brown*, c) The *Alkimos* stranded on the beach in 1963, d) An artist's impression of the wreck of the barque *Eglinton* in 1852, e) The three-masted iron barque *Conference* 1855-1904, f) Western Australian Museum Interpretive plaque at the *Conference* dive site, g) The iron brig *Centaur* 1849-1874 in an unidentified port.

Centaur 1874

The *Centaur* was a 98-foot iron three-masted brig with one deck that was built in 1849 in order to transport machinery to Mauritius. However, in 1874, when being used as a cargo ship for the mining sector, the *Centaur* whilst loaded with 200 tonnes of lead ore (galena) struck a reef (31°51.8238' S; 115°42.6671' E) and sank (Kenderine 1995). The wreck of the *Centaur*, which now sits within Marmion Marine Park on the south-eastern side of Centaur Reef, supports a range of diverse flora and fauna.

The shipwreck provides an opportunity for visitors and divers to explore the footprint that was a part of Western Australia's early mining industry (Kenderine 1995). There is a memorial on the foreshore of North Beach and an interpretive plaque located at the dive site

Conference 1904

The *Conference* was a 165 foot three-masted iron barque which was registered between various owners in New Zealand and around Australia. The ship was used in the mining industry to transport coal for

Albany and Fremantle. However, 32 kilometres north of Fremantle in 1904, the *Conference* was wrecked on a reef. The wrecked vessel was towed, scuttled and left to sink in the Quinns Rocks area (31˚40.2850' S; 115˚39.6400' E) (Kenderine 1995).

The wreck of the *Conference* sits at 17m on a reef two miles north west of Mindarie Marina and is a popular dive site. There is a Western Australian Museum interpretive sign located at the dive site.

Eglinton 1852
The *Eglinton* was a 119-foot three-masted carvel-built barque, built in 1848 in Quebec, Canada. It was used for its speed and cargo capacity in the trade sector. In 1852, the *Eglinton* was used to transport passengers between Gravesend (Kent, England) and the Swan River. On the 03/09/1852, the vessel struck a reef and sank 2.4 kilometres from Eglinton Rocks (31˚38.4500' S; 115˚39.5400' E). The site holds significant historical and archaeological value due to its accompanying sunken material (Kenderine 1995). The *Eglington* was carrying 65,000 gold sovereigns at the time of its sinking. Apparently accounts of the time, suggested that the survivors walked to Perth and that the *Eglinton's* chronometer had been found to be faulty earlier on the journey and was considered the main cause for the shipwreck (Kenderine 1995).

Alkimos 1963
The *Alkimos*, was a 440-foot Liberty ship built in the United States in 1943 and renamed when purchased by a Greek shipping company (Kenderine 1995). After being damaged near the Beagle Islands on March 1963 and some repairs in Fremantle, it was being towed to Hong Kong in May 1963 when the tow line snapped and the *Alkimos* was pushed inshore where it came to rest on the beach. It was re-floated in February 1964 but was left anchored offshore in February 1964. The *Alkimos* broke its anchor (02/05/1964) and came to rest on reef (31˚36.6134' S; 115˚39.2413' E) where it remained stranded (Kenderine 1995).

Alex T. Brown 1917
The *Alex T. Brown* was a 210-foot, 4-masted wooden schooner built in Washington, USA (**Error! R eference source not found.**42). The schooner was travelling from Fremantle to Manila however, it was blown ashore north of Two Rocks (31˚31.0000' S; 115˚36.0000' E) during a storm around midnight on 29th May 1917.The wreck has been a landmark in the area since 1917 and is the only example of a USA-built 4-masted wooden schooner in Australia. Up to 12m of the keel becomes visible above the high-water mark following winter storms.

9 Tenure

CALM Act Estate
Marmion Marine Park which lies in State waters from Trigg Island in the south to Burns Rocks in the North and extends to high water mark approximately 5.5km offshore. The ~9500ha park was declared in 1987 as an A Class reserve under the Conservation and Land Management Act (1984) and vested to the National Parks and Nature Conservation Authority (now the Conservation and Parks Commission - CPC) (Department of Conservation and Land Management 1992). There are various coastal areas tenured under the CALM Act, however they are above high water.

Local governments
The local government authorities responsible for the administration of the areas adjacent to the study area are:

City of Wanneroo

The City of Wanneroo is the most northern metropolitan local government authority along the study area, and covers an area of 685.8 km^2. The City of Wanneroo has a rapidly growing population as a result of Perth's northern sprawling developments. Butler is the local government's largest fastest growing suburb. The population of Butler has increased by 8,222 people since 2006 and has a current residency of 13,278 (Australian Bureau of Statistics 2019). The City of Wanneroo administers around 35km of coastline between Two Rocks and Tamala Park, which represents ~55% of the study area's coastline.

City of Joondalup

Marmion Marine Park is located along the entire City of Joondalup coast and is bordered by eight of its suburbs. The City of Joondalup covers and area of 98.9 km^2. The City of Joondalup's rapidly growing population will continue to increase the usage of the study area. The most populated City of Joondalup suburb bordering the study area is Hillarys which has a total population of 10,808. However, the fastest growing suburb along the municipalities coast is Burns Beach which has increased by 3152 residents since 2006 (Australian Bureau of Statistics 2019). The major town centre located within the City of Joondalup is the suburb of Joondalup. The City of Joondalup has 18km of coastline from Tamala Park to Marmion in the south.

City of Stirling

The City of Stirling is located alongside a small section of Marmion Marine Park's southern boundary and covers and area of 105.2 km^2 . The three adjacent suburbs of this area are Watermans Bay, North Beach and Trigg, which accounts for approximately four kilometres of coastline. North Beach is the most populated neighbouring suburb in the City of Stirling with 2949 residents; an increase of 461 residents since 2006 (Australian Bureau of Statistics 2019). The major town site within the City of Stirling is the suburb of Stirling.

Suburbs

The immediate surrounding population of the study area's eastern boundary is hosted by 19 suburbs (Figure 30), which contain a total population of 94,145 people (Australian Bureau of Statistics 2019).

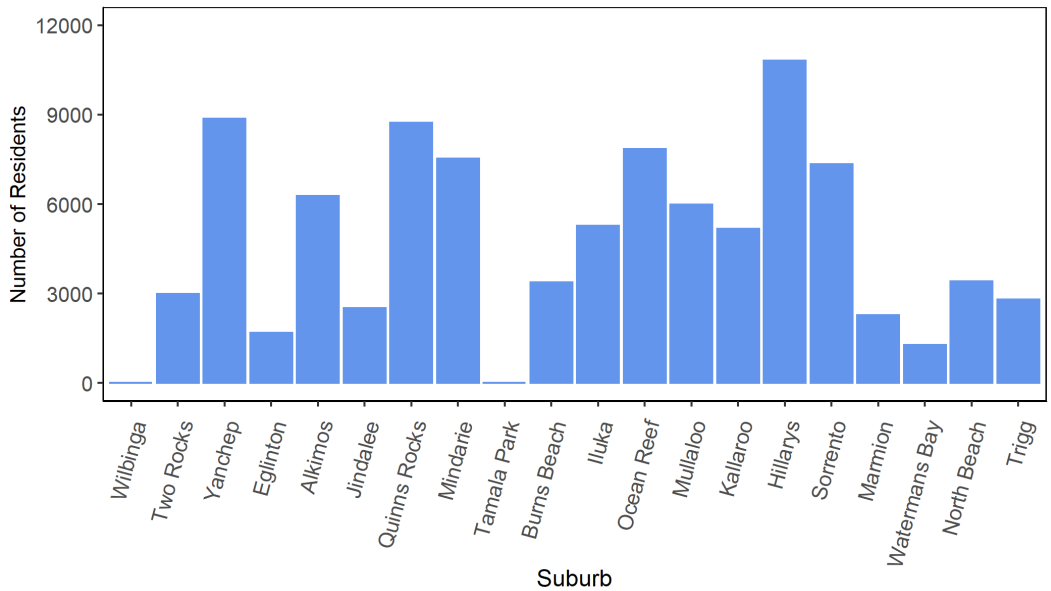

Figure 30. Population in northern Perth metropolitan suburbs that are contiguous with the proposed Marmion Marine Park expansion study area.

Existing Leases
There currently are two seabed easements allowing the installation of swimming enclosures within the study area at Sorrento Beach and Quinns Beach, respectively with the City of Joondalup and City of Wanneroo. The shark barriers at both locations extend 85m offshore and 300m along the beach.

10 Infrastructure and facilities

As a result of growing infrastructure and population along Perth's northern coast, the study area is highly accessible. Perth's vast road infrastructure provides residents with easy access to the northern beaches that are located along the study area

Marinas
There are four marinas; Hillarys, Ocean Reef, Mindarie and Two Rocks, that are the gateway to the marine waters of the study area and consequently experience substantial vessel traffic. These marinas are a potential source of hydrocarbons, toxicants, and wastewater pollution.

Hillarys Boat Harbour:
Hillarys Boat Harbour was opened in 1988 and has 475 boating pens which are always full (Figure 31). Hillarys Yacht Club manages another 260 berths. The Harbour is popular due to its six public boat ramps, one universal jetty, and the service/lift and fuelling facilities. Hillarys Boat Harbour is a focal point for visiting Rottnest Island, coastal helicopter tours and adventure fishing, diving and whale-watching charters. Hillarys Boat Harbour is managed by the Department of Transport (Department of Transport 2013).

Figure 31. Aerial view of Hillarys Boat Harbour showing berths, pens, stacking facility, shopping precincts, associated apartments and parking.

Ocean Reef Boat Harbour
Currently Ocean Reef Marina has no mooring capacity or boat pens. Its existing infrastructure and land uses include car and boat trailer parking, boat ramps, finger jetties, coastal recreation and amenities and sea sports club facilities (Figure 32).

Figure 32. Aerial view of Ocean Reef Boat Harbour showing boat ramps, finger jetties, recreational areas and carparks.

In 2017, the State Government of Western Australia allocated $120 million for the development of a large-scale marina that would replace the current Ocean Reef Boat Harbour. Construction commenced in August 2020 and the first stage is expected to be complete by the end of 2023.

The proposed development includes associated boating clubs, commercial and marine industrial uses in the northern precinct, a central retail, tourist and residential precinct; and a southern boating precinct inclusive of public boat ramps (Figure 33).

Figure 33. The footprint of the proposed development of Ocean Reef Marina.

In 2019, development approval for the Ocean Reef Marina required the excision of 143ha from Marmion Marine Park, enacted through the *Reserves (Marmion Marine Park) Act 2019.* Approval for the development was subject to Environmental Protection Authority assessment through a Public Environmental Review.

The EPA determined that the nearshore macroalgal reefs would be significantly impacted by the proposed development which will result in a loss of 12.5ha of habitat. Nearshore macroalgal habitat types are considered significant as they support a high diversity of primary producers and refuges for fish and a range of marine invertebrates.

To satisfy development approval conditions (Ministerial Statement 1107), the proponent developed a suite of documents including the Marine Offset Strategy (MOS), which included the provision of funding to DBCA to support a review and extension of Marmion Marine Park. The review and extension of Marmion Marine Park was triggered the excision and removal of habitat for the Ocean Reef Marina development.

The MOS aims to provide long term improvement to the ecological integrity of remaining nearshore reef habitats through on ground management, research, monitoring and education. The MOS commits to delivering these improvements within 5 to 7 years following completion of the development (DevelopmentWA, 2021). Key commitments by the proponent include:

- Provision of artificial habitat
- Visitor management
- Stormwater monitoring
- Human usage monitoring program
- Interpretive signage
- Provision of funding to DBCA for planning and management
- Habitat monitoring

MS 1107 also required several plans to provide for the collection of monitoring data and information to demonstrate whether impacts from the proposal are as predicted, including:

- Condition 6-3 - Marine Construction Monitoring and Management Plan;
- Condition 6-4 - Marine Operations Management Plan;
- Condition 7-2 – Coastal Processes and Wrack Management Plan;
- Condition 8-1 - Abalone Habitat and Biomass Baseline Survey Plan; and
- Condition 9 - Abalone Habitat and Biomass Monitoring Plan (DevelopmentWA, 2021)

Mindarie Keys

Mindarie Keys is a privately-owned marina (Figure 34) that can dock 248 boats at the lengths between 10m and 20m in length. There are associated commercial premises such as the Marina Hotel, food outlets, the Indian Ocean Brewing Co, and residential development (canal estate).

Figure 34. Aerial view of Mindarie Keys Marina

Two Rocks Marina

Two Rocks Marina is approximately 60km north of Perth and has a variety of pens that hold approximately 121 boats between the lengths of 8m and 20m (Figure 35). The marina is used extensively by the Western Rock Lobster fishing vessels and by recreational boat owners. Beside the boat pens, there are also other facilities which includes a boat ramp, service wharf, a boat lifter, hardstand and a fuel facility.

Figure 35. Aerial view of Two Rocks Marina

The Two Rocks Marina is currently undergoing redevelopment in order to improve current facilities and infrastructure. The Department of Transport has also committed to revamp the facility over a period of two years in order to replace and improve current infrastructure (Department of Transport 2017b). A $14 million budget has been committed to the project currently under construction, with completion expected in late 2021. It is recognised that the turbidity from the marina development may have indirect impacts on the benthic habitats within the area (Department of Transport 2017).

Trigg Island boat launching

There is a boat launching area at Trigg Island on the southern edge of the study area (Figure 36). This facility is suitable for small, shallow draft vessels to be launched on days will swells less than 1m.

Figure 36. Trigg Island boat ramp at the southern boundary of the study area is suitable for small vessels with a shallow draft

North Beach Jetty

There are no wharfs in the Marmion Marine Park expansion study area, however there is a small jetty at North Beach (Figure 37). The North Beach Jetty is 22m in length was built in 1922 by the Perth Road Board and is now maintained by the City of Stirling.

Figure 37. North Beach Jetty (City of Stirling 2019b)

Residential Development

Over the last decade, the suburban areas adjacent to the study area have been developing at a fast rate, particularly between Two Rocks and Mindarie. The City of Wanneroo (2018) reports that between 2001 and 2017, the population grew from around 80,400 to 199,882 residents. It is estimated this population may grow to approximately 413,000 residents by 2041. The City of Joondalup reports that its current population is around 160,500 and estimates that it will rise to 182,000 by 2041 (City of Joondalup 2018b). The City of Stirling has a population of 221,000, WA's largest local government area by population (ABS 2019).

Shipping and Boating

There are no significant shipping/boating channels associated with the study area. In contrast to Fremantle, the study area has a low presence of commercial shipping with most of the commercial boat movement being that from Hillarys Boat Harbour to and from Rottnest Island and commercial fishers working out of Two Rocks Marina.

11 Water quality

Water quality is essential to maintain healthy ecosystems. Oceanographic processes, including water temperature, currents, winds, wave action and tidal flow, influence the water quality by impacting on transport, dispersal and mixing of sediments, biota and pollutants. Like marine waters off much of the south-west coast of Western Australia, the waters of the marine park are nutrient-poor, primarily as a result of both no riverine inputs and the absence of significant upwellings of nutrient-rich waters from the deeper ocean. Low nutrient concentrations limit biological productivity in the water column. These low rates of pelagic productivity result in high water clarity and penetration of light to benthic primary producers such as seagrass and macroalgae, which contribute significantly to the primary productivity of the marine park and other similar marine systems in south-west Western Australia.

The water quality of the coastal waters off Perth is managed in accordance with an environmental management framework developed by the Environmental Protection Authority (EPA). There are two ocean outfalls within the study area, located at Alkimos and Ocean Reef, that return treated wastewater to the marine environment. These outfall systems are routinely monitored by the Water Corporation, and the water quality surrounding these outlet systems has been noted to be compliant with ecosystem protection guidelines and public health criteria (BMT 2021a, Water Corporation 2021b).

There has been a slow increase in seawater temperature in the marine park across the last 33 years. It is highly likely that this trend is associated with climate change. Confidence in this assessment is high due to the extended time over which continuous data is available. While not as high as historical highs in 2010/2011 and 2011/2012, recent monitoring by DBCA showed summer water temperature was again warm across the 2020/2021 and 2021/2022 summer/autumn periods.

Sediment Quality

Sediments have an important role in marine environments as both substrate for biota and an environment where a multitude of ecologically significant chemical processes occur. Sediments can act as a sink for organic particulates from the overlying water column, providing resources for benthic organisms, predominantly through re-mineralising nutrients bound to organic material. In addition to organic particulates including bound nutrients, sediments can act as a sink for other materials entering the local marine environment including toxicants such as heavy metals, pesticides, antifouling and hydrocarbons (Li *et al.* 2000, Zoumis *et al.* 2001).

New Sewage Facilities and/or Expand Existing Facilities
There are no plans to develop additional sewage facilities and/or expand existing facilities, however predictions for wastewater discharges are estimated to increase from 20 $ML.d^{-1}$ to 220 $ML.d^{-1}$ for Alkimos by 2030 and 135 $ML.d^{-1}$ to 180$ML.d^{-1}$ for Ocean Reef for 2050 (Water Corporation 2018).

Vessel Sullage
Marmion Marine Park is regulated by the International Convention for the Prevention of Pollution from Ships (MARPOL), of which, ensures that pollution from recreational and commercial vessels, including fishing vessels, have minimum impact on the subjected marine area. Annex IV of MARPOL prohibits "the discharge of sewage into the sea, except when the ship has in operation an approved sewage treatment plant; is discharging comminuted (or macerated) and disinfected sewage at a distance of more than three nautical miles from the nearest land; or is discharging untreated sewage from a holding tank at a prescribed rate and at a distance of more than 12 nautical miles from the nearest land".

Vessel Incident Pollution

Over a 4 year period from 2017 – 2021, 42 vessel related incidents were recorded by the Department of Transport's Maritime Environmental Emergency Response unit within the study area (Table 5)

Table 5 Vessel related incident data (Department of Transport, 2021).

	Oil related	**Other pollutant**	**Non pollution related**
Two Rocks	5	1	2
Yanchep	0	0	1
Mindarie	5	3	1
Ocean Reef	0	0	2
Hillary's	12	6	5
Total	22	10	11

Marine debris/litter

Marine debris is a pressure on ecological values of the study area. This debris may come from a variety of sources both within and outside the study area; such as commercial and recreational vessels, marinas, fishers and the many coastal users.

Only limited marine debris surveys have been completed in Western Australia and there is a general lack of quantitative data. The Western Australian Fishing Industry Council (WAFIC) has developed a Code of Practice for rubbish disposal at sea by commercial fishers operating in Western Australian waters.

Ocean acidification

The increasing levels of atmospheric carbon dioxide and the subsequent absorption of CO_2 by the world's oceans is changing the water chemistry of the ocean and in turn causing ocean acidification. Since pre-industrial times, acidification has reduced ocean pH by 0.1 units (Howard et al. 2012). Research is underway to improve the methods and equipment used for high-precision carbonate chemistry measurements. Monitoring of carbon chemistry in the open ocean and some shallow coastal systems, has already commenced (Howard et al. 2012).

12 Tourism

Marmion Marine Park is estimated to attract more than 1.75 million visitors per year. With sandy beaches and diverse ecosystems, the broader study area's accessible location provides opportunities for West Australian's as well as interstate and international tourists. This has been recognised by the tourism industry which provides visitors exposure to the spectacular marine systems within the area. Marine nature-based tourism within the area provides a range of economic, social and environmental benefits. The accessibility to such diverse marine life has created a large charter boat industry that offers visitors opportunities to dive, fish or observe wildlife.

The major tourist industry within the study area is whale-watching. During the months of winter and spring the Western Australian coast is home to one of the largest humpback whale migrations within the southern hemisphere (Salgado-Kent et al. 2012). The consistent presence of whales provides ample opportunity for whale watching charters. As a result, numerous whale-watching charters operate out of the Hillarys Boat Harbour; located on the southern end of the study area.

The tourism industry along the coast is a major economic contributor creating a range of local jobs. A key element within the City of Wanneroo's planning strategy is to enhance tourist activities along the coast with a focus on the Mindarie Marina and Quinns Beach. The Ocean Reef Marina is currently the largest tourism related development within the study area.

Overall, the study area is highly valued by the relevant local government authorities as a result of the economic benefits created by the attraction of local and international visitors.

Attractions

Hillarys Boat Harbour
Hillarys Boat Harbour is a retail and restaurant precinct that attracts a range of local, interstate, and international tourists. The Harbour's proximity and accessibility to Perth's marine life has resulted in the area being a critical location for boat diving, whale watching and fishing charters. Hillarys Boat Harbour receives over 4.5 million visitors annually making it one of the most popular boating and recreational destinations in Perth (Department of Transport 2013).

Islands
Little Island and Burns Rocks are located within Marmion Marine Park. Little Island has sandy shores that host a range of sea birds and adult and sub-adult male sea lions. Due to its amenity and location, the Island is becoming an increasingly popular surfing location, and attracts a range of jet skis and watercraft. Little Island is in a sanctuary zone. Susceptibility of Little Island to sea level rise should be considered in future management. Burns Rocks is more rugged but is also an important haul out for adult and sub-adult male Australian sea lions and roosting area for seabirds. The marine life around these islands also attracts sightseers.

Sandy Beaches
The study area borders a range of popular sandy beaches used by local, interstate and international tourists. Such beaches include Trigg, Sorrento, Mullaloo and Burns Beach.

Mettams Pool
Mettams Pool's protective limestone reef and sandy beach attracts many locals and tourists throughout the year. Mettams Pool is a prime swimming area and hosts a range of activities throughout the year such as snorkelling, swimming, wind surfing and paddle boarding, The City of Stirling is planning to undertake coastal protection works at Mettam's Pool in 2021 to manage erosion issues, including sand renourishment and placement of geotextile sand containers (GSC) (City of Stirling, 2021). The City

notes that future sand renourishment and protection works will be necessary to maintain a sandy beach at Mettam's Pool, subject to further investigation of all adaptation options.

Yanchep Lagoon
Yanchep Lagoon is a popular snorkelling and fishing location that has a protective reef that often provides calm waters. The lagoon is patrolled by Yanchep Surf Life Saving Club between October and March, making it a prime location for families looking to make use of this ideal location. Yanchep Lagoon beach is vulnerable to coastal erosion and the City of Wanneroo have identified construction of a 750m length of seawall as a possible management option to protect landward assets in the short to medium term, before 2050 (Cardno, 2018).

Snorkel/Dive Trails
There are two snorkel/dive trails in the study area located at:

- Boyinaboat reef; and
- Marmion Angling and Aquatic Club beach.

Boyinaboat Reef is a popular, easily accessible open water snorkel/dive location. Boyinaboat Reef is about 75m off the southern rock groyne of Hillarys Boat Harbour and is in a sanctuary zone of Marmion Marine Park. There are interpretive plaques to explore clockwise around the reef at depths of 4-7m, with a series of caves, swim throughs and ledges (Figure 38).

Figure 38. A swim through at Boyinaboat Reef, Marmion Marine Park.

The Marmion Angling and Aquatic Club (MAAC) dive and snorkel trail is suitable for both snorkelers and divers. The trail starts only 20m off the beach in Marmion and consists of 20 interpretive plinths (Figure 39) that run for approximately 400m in depths of 2-6m. Marmion Marine Park's lagoons and reefs are filled with the most spectacular macroalgae reefs supporting an array of fish species such as western blue devils, banded sweep and crested morwong.

Figure 39. There are twenty interpretive plinths located along 400 metres of MAAC dive trail.

Commercial Tour Operators

There are many commercial tour operations that occur in the study area, providing sight-seeing, wildlife interaction, diving and fishing experiences:

- Rottnest Fast Ferries provide travel to Rottnest Island daily as well as specific whale-watching tours on the humpback whale northward migration (between March and May) and the peak southern right whale season September to December (webpage: https://www.rottnestfastferries.com.au/). Rottnest Fast Ferries (MV Voyager, MV Starflyte Express) work out of Hillarys Boat Harbour.

- Mills Charters provide whale watching during the humpback whale southern migration September to November (webpage: https://www.whalewatchingperth.com/). Mills Charters also provide, private charters and inshore and offshore fishing charters (webpage: https://www.millscharters.com.au/). Mills Charters mainly works out of Hillarys Boat Harbour.

- Blue Juice Charters provide fishing tours typically on the outer reefs offshore from Hillarys Boat Harbour (webpage: https://www.bluejuicecharters.com.au/). Their vessel is the MV Blue Water is also available for personalised charters.

- Image Dive and Charters provide dive tours within the study area as well as to Rottnest and the Key Biscayne, departing from Hillarys Boat Harbour and Two Rocks Marina, respectively (webpage: http://www.imagedive.com.au/).

- Western Blue Dive Charters works out of Mindarie Keys Marina (webpage: https://www.westernbluedive.com.au/). They offer dive charters for seven days a week. Their vessel "Seaquest" also offers private charters as well.

- Perth Diving Academy (PDA) offers diving with the study area, all year round using. PDA utilises their vessel MV Wildcat (webpage: https://www.perthdiving.com.au/). The Perth Diving Academy mainly operates from Hillarys Boat Harbour.

- Perth Fishing Safaris provide land based fishing and beach fishing lessons at some of the beaches in the study area (webpage: https://www.perthfishingsafaris.com.au/).

- Mindarie Charters departs from both Hillarys Boat Harbor and Mindarie Keys Marina (webpage: https://www.mindariecharters.com.au/). They typically fish outside the fringing reef line into Commonwealth Territorial Waters.

- Best of Boat Worlds, Performance Fishing Adventures runs fishing charters from both Hillarys Boat Harbour and Mindarie Keys Marina (webpage: https://www.bestofboatworlds.com.au/). They typically fish offshore waters from 25m depth to 110m, in both State and Commonwealth waters. Their other activities include diving, wildlife watching and snorkelling. Their vessel is Lady Flo II, a custom-built 31ft Preston Craft**.**

- Rotovation Helicopters provide scenic flights from the helipad on the south groyne of Hillarys Boat Harbour (webpage: https://www.rotorvation.com.au/hillarys-helicopter-perth/). They offer tours featuring the boat harbours and natural attractions of the marine waters and the coastline of the study area.

- Nautical Adventures provide extreme jet ski experience out of Hillarys Boat Harbour (webpage: https://www.nauticaladventures.com.au/).

- Shore Water Shore and Bits provides stand-up paddle boards and kayaks for hire from their shop in Mindarie Keys Marine (webpage: https://www.shorewaterboatsandbits.com.au/).

Marine Tourism Management Frameworks

Department of Primary Industries and Regional Development (DPIRD)
DPIRD regulates commercial and recreational fishing licences throughout Western Australia, including charter fishing operations. Charter vessel fishing tours operate within the study area and provide Western Australians and interstate and overseas visitors an enjoyable fishing experience. Commercial tour operators are required to be licenced and adhere to the rules, provisions and regulations outlined by DPIRD and *Fisheries Resource Management Act* (1994). For more information on recreational and commercial fishing see sections 14 and 15.

Department of Biodiversity, Conservation and Attractions
As established under part 7 of the *Conservation and Land Management Regulations 2002*, DBCA is responsible for the distribution and management of commercial operations licensing. Commercial operations licensing ensures that DBCA can monitor commercial access, use and environmental impact of commercial businesses on the natural and cultural values of Department managed lands. Payments made to acquire a commercial operations licence contribute to funding the management and protection of Department managed lands. Conditions placed upon commercial operations licence ensure sustainable activities are conducted.

DBCA have published commercial operator handbook which is a legal and informative document for all licenced commercial tour operators. The Handbook serves several purposes:

- to educate and inform operators as to how they can help maintain and protect Western Australia's natural environment for the long-term benefit of the state's tourism industry;
- to minimise risks to park visitors;
- to outline opportunities that are available to operators who are already conducting, or wish to conduct, operations on land managed by the department; and
- to clearly identify the licence conditions which apply to specific operations and areas by which operators must abide.

Rules apply to whale interactions in Western Australia. Only commercial tour operators with vessels licensed by DBCA are to run commercial vessel tours involving whale watching in WA's marine parks. Private vessels including surfboards, kayaks, dinghies, yachts and motor launches, do not require whale

watching licences, however they must comply with separation distances prescribed under the *Biodiversity Conservation Act 2016.*

13 Mining and petroleum

There are no mining or petroleum interests in the study area.

14 Commercial fishing

The study area is located within the Central West Coast ecosystem within the West Coast Bioregion (Figure 40). A summary of fisheries resources in the West Coast Bioregion that are active or have access to the Marmion Marine Park and extended study is provided in Table 6.

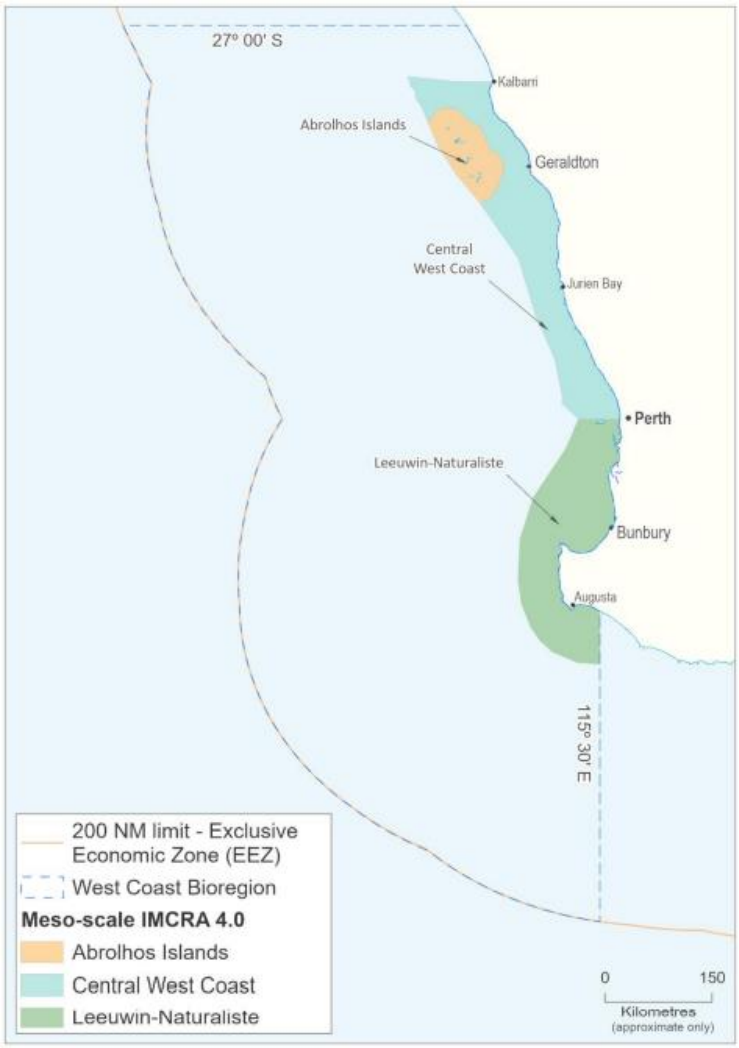

Figure 40. Map showing the three main IMCRA (V4.0) ecosystems in the West Coast Bioregion: Abrolhos Is.; Central West Coast and the Leeuwin-Naturaliste.

Table 6. Summary of fisheries resources in the West Coast Bioregion that are active or have access to the Marmion Marine Park and extended study area (Newman *et al.* 2021)

West Coast Fishery Resource	Method/target species/location	No. of licences	Total catch (most recent 2020/21 aggregated)		Total $ value 2018-19	Current fishery status
			Commercial	Recreational		
West Coast Rock Lobster Managed Fishery (WCRLMF)	Western Rock Lobsters are taken throughout their range by both the commercial and recreational sector and each sector operates to formal resource allocations. The WCRLF is a pot based fishery, for western rock lobster (*Panulirus cygnus)* in the area Cape Leeuwin to NW Cape. A Harvest Strategy and Control Rules are used to manage this resource via quota and input controls (maximum pot numbers, size limits, escape gaps and protection of breeding females). Licenced recreational fishers are allowed to take lobsters using a maximum of two baited pots or by hand collection when diving to collect legal sized lobsters up to legislated bag and/or boat limits	Commercial - MFL = 710 Vessels = 235 Recreational - over 55,000 Charter - a three-year trial commenced 2019 to provide increased tourism opportunities for pot-based rock lobster fishing tours.	9,132 t (18-month season)	Recreational 526 t Charter 16 t (12-month season)	Commercial $225M (2020/21 Financial year). Recreational Very high social value	Sustainable - adequate
West Coast Roe's Abalone Resource	Roe's Abalone (*Haliotis roei)* resource is a dive and wade based fishery.	Commercial – 30 state-wide Commercial – 16 Perth metro	18.2 t (state-wide) 12.7 t (Perth metro)	45.2 t (state-wide) 31.2 t (Perth metro)	Commercial $0.5M (2020) Recreational High social value	Sustainable - adequate

	Commercial - operates in 6 management areas from the WA/NT border to WA/SA border. A harvest strategy is used to manage each area under Annual Total Allowable Commercial Catches (TACCs), size limits and spatial closures Recreational - operates in 3 management areas from the WA/NT border to WA/SA border. A Total Allowable Recreational Catch (TARC) is used to manage catch in the Western Zone (including Perth metropolitan area) by size limits, daily bag and possession limits, temporal and spatial closures.	Recreational – 18,328 state-wide				
Marine Aquarium Fish Managed Fishery	The Marine Aquarium Fish Managed Fishery operates in all WA State waters. While the fishery potentially includes 1,500 species of marine aquarium fishes including coral, live rock, algae, seagrass and invertebrates, a relatively low number per species are caught. Fish are caught by hand using scuba or surface supplied air (hookah). harvest strategy manages the catch	13	Small numbers of individual species taken annually.	N/A	Est. $1-5M	Sustainable - adequate

Octopus Interim Managed Fishery (OIMF)	The OIMF targets Octopus (*Octopus djinda*), managed in three zones between 26°30'S and the WA/SA border by three different fisheries. The majority coming from the Octopus Interim Managed Fishery (OIMF) using 'trigger traps' managed under a harvest strategy. The Cockburn Sound Line and Pot Managed Fishery (CSLPMF) also targets octopus using unbaited or passive (shelter) pots. Octopus are also caught as by-product in the WCRLMF.	25 vessels (OIMF) 4 vessels (CSLPMF) >20 vessels (WCRLMF)	254 t	1 t	Commercial $2.8 M	Sustainable - adequate
South West Trawl Managed Fishery	The South West Trawl Managed Fishery (SWTMF) is a multi-species trawl fishery that primarily targets Saucer scallops, (*Ylistrum balloti*). Managed by quota, limited entry, gear controls and seasonal closures.	4 vessels (only one boat fished in the SWTMF in 2020)	Negligible, reported as part of the total value for the entire Saucer Scallop Resource	N/A	The estimated annual economic value of this fishery is currently not assessed	Sustainable - adequate
Specimen Shell Managed Fishery	Specimen Shell Managed Fishery (SSMF) collects approximately 200 species of shell each year. Collection is mainly by hand, but also uses remotely operated underwater vehicles in some instances. The fishery covers the entire WA coastline, although some	30 (15 fished in 2020)	4,258 distributed over 206 species	N/A	The estimated annual economic value of this fishery is currently not assessed.	Sustainable - adequate

	concentration of effort occurs in areas adjacent to population centres such as Broome, Exmouth, Shark Bay, Geraldton, Perth, Mandurah, the Capes area and Albany.					
West Coast Deep Sea Crustacean Managed Fishery (WCDSCMF)	The WCDSCMF targets crystal crabs (snow) (*Chaceon albus*), Champagne crabs (spiny) (*Hypothalassia acerba*) and Giant crabs (king) (*Pseudocarcinus gigas*). The WCDSCMF uses baited pots in shelf edge waters (>150 m) of the West Coast and Gascoyne Bioregions. Managed by harvest strategy using total allowable catch	five vessels operated in 2020	156.1 t	N/A	$6.8 M	Sustainable - adequate
West Coast Purse Seine Managed Fishery (WCPSMF)	The WCPSMF targets scaly mackerel (*Sardinella lemuru*) and Australian sardine (pilchard, *Sardinops sagax*) using purse seine gear in waters between Geraldton and Cape Leeuwin with fishing in the Perth Metropolitan area occurring predominantly Cockburn Sound. Managed by harvest strategy with catches limited to a Total Allowable Commercial Catch	five active vessels	493 t	N/A	<$1 M	Sustainable - adequate

The West Coast Demersal Scalefish Resource (WCDSR)	The WCDSR comprises over 100 species in inshore (20-250 m deep) and offshore (>250 m) demersal habitats of the West Coast Bioregion (WCB) between Kalbarri (26º 30'S) and Augusta (115º 30E). The indicator species include West Australian dhufish, Snapper and Baldchin groper. The WCDSR is exploited by both commercial -West Coast Demersal Scalefish Interim Managed Fishery (WCDSIMF) and recreational (including charter) boat-based line fishers. The WCDSR is managed using a constant catch strategy and a formal allocation of 64% of the catch to the commercial sector and 36% to the recreational sector.	Commercial 33 vessels (LFBs) operated in 2020 Recreational 135,561 Recreational Fishing from Boat Licences state-wide (Sept 2017 to August 2018)	213 t	Recreational 231 t (2017/18) Charter 61 t (2017/18) Charter 36 t (2019/20) decreased to 36 t from 51 t fr charter in 2018/19, due in part by the effects of COVID-19 restrictions	Commercial GVP $1-5 M. Recreational High social amenity The value of recreational fishing in the Mid-West, Wheatbelt, Metro, Peel and South West regions estimated to be worth over $1.7 billion per year	Commercial Sustainable - acceptable Recreational no acceptable
West Coast Demersal Gillnet and Demersal Longline (Interim) Managed Fishery (WCDGDLF)	WCDGDLF target mainly sharks Gummy (*Mustelus antarcticus*), dusky (*Carcharhinus obscurus*), whiskery (*Furgaleus macki*), and sandbar (*C. plumbeus*) with demersal scalefish being a by-product. The WCDGDLF operates between Shark Bay (26º 00'S) and north of Bunbury (33o 00'S) the Perth Metropolitan coastal	17 licences	Reported as part of the total catch for the Temperate Demersal Gillnet and Demersal Longline Fisheries Resource. Which includes the	N/A	$0.11 M	Sustainable - adequate

	area is a closed area for the fishery. The WCDGDLF uses demersal gillnets (demersal longline is also permitted but is not widely used). Managed under a constant catch harvest strategy via input controls including transferable time/gear effort units and restrictions on mesh and hook sizes, net height ('drop') and maximum net length.		Southern Demersal Gillnet and Demersal Longline Managed Fishery (SDGDLF) and the WCDGDLF			
The South West Coast Beach Net Fishery (Prohibition Order 43)	The South West Coast Beach Net Fishery (Prohibition Order 43), permits Open Access fishing in the West Coast Bioregion using nets. The resource is harvested using a constant exploitation approach. All indicator species are assessed annually based on catch and/or catch rate trends, where data is available	3 FBL condition exemptions	Reported as part of the total catch for West Coast Nearshore And Estuarine Finfish Resource	N/A	Reported as part of the total value for West Coast Nearshore And Estuarine Finfish Resource	Sustainable - adequate
State-wide large pelagic finfish resource	The statewide large pelagic finfish resource includes three indicator species; Spanish mackerel (*Scomberomorus commerson*) and grey mackerel (*S. semifasciatus*) representing the tropical suite in the North Coast and Gascoyne Bioregions targeted by the Mackerel	N/A in Perth Metro area	>10 t Samson fish (West Coast and South Coast Bioregions combined)	87-121 t for top 10 pelagic species state-wide in 2017/18	Commercial Samson fish and other large pelagic species is estimated at less than $500,000	Sustainable - adequate

	Managed Fishery. In the West Coast Bioregion, the major retained temperate species is Samson fish mostly as bycatch in a number of line and net fisheries. The Perth coastal metropolitan area is closed to the fisheries that have historically taken large pelagic species.				Recreational High social value	

Of the 12 fisheries resources with access to the area, there are only 7 that currently operate within the existing and proposed extension area of the MMP.

1. West Coast Rock Lobster Managed Fishery
2. Abalone Managed Fishery
3. Marine Aquarium Managed Fishery
4. Octopus Interim Managed Fishery
5. South West Trawl Managed Fishery
6. Specimen Shell Managed Fishery
7. West Coast Purse Seine Managed Fishery

Further information about each of these fisheries in the West Coast Bioregion (unless otherwise stated) is provided below. All information is taken from DPIRD's *Status Reports of the Fisheries and Aquatic Resources of Western Australia 2019/20: The State of the Fisheries* (Gaughan & Santoro 2021).

West Coast Rock Lobster Managed Fishery
The WCRLMF has historically been Australia's most valuable single species wild capture fishery and, in 2000, became the first fishery in the world to achieve Marine Stewardship Council (MSC) Certification. In 2017 it was the first fishery globally to be certified by MSC for the fourth time.

Bycatch and protected species interactions
The main bycatch species landed in the WCRLMF are octopus, champagne crabs and baldchin grouper. Octopus contributed most to the total bycatch landings with 15.0 t in 2019 and only incidental landings of the other species being recorded (2.9 t and 2.1 t for CC and BG, respectively).

To mitigate the risk to juvenile Australian sea lions (ASL) all pots fished within designated sea lion areas are now fitted with devices to stop the accidental drowning of ASL. Since their implementation there have been no records of drowned ASL.

During the whale migration season (May – October inclusive) all pots must comply with mitigation measures aimed at reducing the entanglement of migrating whales. This has resulted in a significant (~60%) reduction in reported whale entanglements. There were seven entanglements in lobster gear reported in 2019.

Turtles can also get caught in the float rigs of lobster pots. In 2019 no turtles were reported to have been entangled in lobster fishing gear.

Habitat and ecosystem interactions
WRL are an omnivorous generalist feeder, with a diet that consists of a variety of invertebrate, algae, carrion and bait. Results from monitoring in areas closed and open to WRL fishing, established to examine the potential ecosystem effects of WRL removal, suggest that lobsters do not play a keystone role in ecosystem functioning.

Social and economic value
Social
The WCRLMF is important for regional employment with 235 commercial vessels operating in 2019 with most of the catch handled by four main processing establishments. The rock lobster fishery is also a major recreational activity and provides a significant social benefit to the Western Australian community with over 60,000 recreational fishers holding rock lobster licences in 2019. At current high stock levels there is a moderate risk to this valuable social amenity.

Economic
The estimated average price across all processors and all zones of the WCRLMF received by commercial fishers for the western rock lobster in 2019 was $65.23/kg. This was down slightly from

that paid in 2018 ($66.31/kg). The slightly lower beach price with the same TACC resulted in the overall value of the WCRLMF dropping slightly to $417 million. As the majority of landed lobsters are exported to a single market (China) this represents a moderate risk.

External drivers
The variations in WRL recruitment to the fishery are largely a result of variable levels of puerulus settlement 3-4 year previously. Catches are also dependent upon the environmental conditions at the time of fishing. Investigation into the puerulus downturn in 2007-2009 have identified that when the spawning started early (water temperature driven) and was coupled with low numbers of winter storms during the larval phase, the puerulus settlement was significantly lower.

In 2011 and to some extent 2012 and 2013, abnormally warm water temperatures were recorded throughout the northern half of the western rock lobster fishery. Preliminary analysis indicates that this event negatively impacted the puerulus to juvenile relationship in the northern region of the fishery (e.g. Kalbarri). As of mid 2020 there are strong signs that this area may be recovering towards it historical pattern.

At a longer time scale, WRL have been rated a high risk to the effects of climate change as many aspects of its life history are highly sensitive to environmental conditions (Caputi et al., 2010).

Abalone Managed Fishery
The commercial Roe's abalone fishery has undergone full MSC assessment and achieved certification in 2017.

Bycatch and protected species interactions
Divers have the ability to target abalone of choice (species, sizes and quality of abalone) and do not inadvertently harvest bycatch in their normal fishing activities. The only potential listed species interaction is with the white shark (*Carcharodon carcharias*), with some divers adopting the 'shark shield' technology. Negligible risk.

Habitat and ecosystem interactions
The fishing activity makes minimal contact with the habitat, which typically consists of hard rock surfaces in a high wave energy environment. As abalone feed on drift algae, their removal is unlikely to result in any changes to the algal growth cover in fished areas, and hence it is considered unlikely that the fishery has any significant effect on the food chain in the region. Negligible risk.

Social and economic value
Social
There are 21 vessels commercially fishing for Roe's abalone, employing approximately 40 people across WA. The dispersed nature of the Roe's abalone fishery means that small coastal towns from Perth to Eucla receive income from the activity of divers. The recreational fishery provides a major social benefit to those members of the community that appreciate the abalone as a delicacy, and 16,385 licences were issued that would have allowed fishers to participate in the recreational abalone fishery. High risk.

Economic
Estimated annual value (to commercial fishers) for 2019 was $1.32 million, based on the estimated average price for Roe's abalone of $27.86/kg whole weight. The price of Roe's abalone has dropped by 50% since 2000, when it was $55/kg whole weight. This is due to the value of the Australian dollar and wild caught Roe's abalone being in direct market competition with aquaculture produced abalone. High risk.

External drivers
During the summer of 2010/11, the West Coast experienced a marine heatwave such that in the area north of Kalbarri mortalities on Roe's abalone were estimated at 99.9% (Strain et al. 2019). A complete

closure of the commercial and recreational fisheries was then implemented. The heatwave also affected the Perth metropolitan stock but to a lesser extent. The recovery of the stock has been assisted by a marine cold spell during 2016-2019. Roe's abalone has been assessed as a significant risk to climate change effects. Weather conditions during the time of fishing have a significant effect on catch rates and total catch of recreational fishers. The small size of Roe's abalone results in its direct competition with aquaculture-produced abalone and therefore, there has been a decline in beach price and overall economic value during the last decade. The Ocean Reef Marina development to be located within the Perth Metropolitan Fishery poses significant risk to the Roe's abalone stock and subsequently the commercial and recreational fishery's. Significant risk.

Marine Aquarium Managed Fishery (state wide)

Bycatch and protected species interactions

There is no bycatch in either fishery as both fisheries target specific taxon by hand (with the MAFMF also targeting specific taxon by fishing line), therefore chances of retaining non-targeted species are negligible. This results in a negligible risk for bycatch interactions.

The potential for listed species interactions is limited due to low fishing effort and small areas accessed on each trip. The MAFMF has a small take of syngnathids under a WTO from the Commonwealth. However, there is a prohibition on the take of leafy sea dragons (*Phycodurus eques*). This results in a low risk for protected species interactions.

Habitat and ecosystem interactions

Habitat and ecosystem impacts are considered negligible. This is due to the small scale of the fisheries and the hand collection methods.

Social and economic value

Social

Eleven licences were active in 2019 across the MAFMF and the HCF. Collections by the MAFMF are usually undertaken on SCUBA or surface supplied air (hookah) from small vessels, typically in small teams of 2 – 3 people. There is currently a low level of risk to these values.

Economic

The value per individual aquarium fish and hermit crab licence is relatively high but difficult to estimate directly as operators can sell direct to the public, to wholesalers or they have vertically integrated businesses including export. It is likely the combined value of both fisheries exceeds several million dollars (value is estimated to be $1-5 million). There is currently a low level of economic risk to these values.

External drivers

Fishers are typically limited by sea and weather conditions, and access to beaches. Consumer demand and unit prices also influence the target species and numbers landed. The external drivers pose a negligible risk to these fisheries.

Octopus Interim Managed Fishery

Bycatch and protected species interactions

The selective method of fishing used results in a minimal level of bycatch of other species. In 2019 there was two reported entanglements with a whale in octopus fishing gear. Fishers have adopted gear changes to mitigate entanglements, which includes setting pots on longlines, and using weighted ropes that hang vertically in the water column. Low risk.

Habitat and ecosystem interactions

In the CSLPMF and OIMF, octopus-specific pots are set in similar habitats to those fished in the WCRLMF, as well as sandy and seagrass areas, particularly in Cockburn Sound. These are not expected to impact on benthic habitats. This fishery harvests only a small amount of octopus available in the ecosystems per annum. The effect from this harvesting on the rest of the ecosystem, given that the catch is spread over a wide region, is likely to incur a Negligible risk to the ecosystem.

Social and economic value

Social

Each dedicated octopus fishing vessel employs between 2 and 4 people, with 25 vessels in the OIMF. More than 20 vessels landed octopus as a by-product in the WCRLMF. There is also a substantial processing and value added component to the octopus catch with factories in Fremantle and Geraldton. Low Risk.

Economic

The estimated annual value for 2019 was $5.9 million based on the total catch of 453 t and an average product price of $13.11 /kg live weight. Low Risk.

External drivers

Cephalopods in general, including octopus, are known to be subject to large environmentally driven fluctuations in abundance. Octopus was rated as a low risk to climate change.

The move of the rock lobster fishery from an effort-controlled fishery to a catch quota fishery, coupled with significant effort reductions, will ensure the octopus catch in the WCRLMF remains a low proportion of the overall catch.

South West Trawl Managed Fishery

Bycatch and protected species interactions

Owing to the legislated 100 mm mesh size of the nets, the relatively short duration of the fishing season and the reduced number of boats operating since quota was implemented, the total bycatch landed is minimal. Protected species that are susceptible to capture by trawling do not occur regularly in the fishing areas of the SWTMF. Interactions with turtles are minimal, and with the compulsory use of grids in the fishery their capture has been minimised. No protected species were reported in the SWTMF in 2019. Low risk.

Habitat and ecosystem interactions

Habitat effects are considered low risk, with trawl boats generally sweeping a small proportion of the designated trawl area. Less than 1% of the allowable area was trawled in the SWTMF. The ecosystem impacts of scallop fisheries are considered to be low risk, due to the relatively low total biomass taken by these operations. The high natural recruitment variability, and therefore scallop stock abundance, and short life span (up to 3 years) also means that few predators will have become highly dependent on the species.

Social and economic value

Approximately 30-40 skippers and other crew were employed in scallop fishing in WA in 2019 with support staff in Geraldton and Fremantle. The overall GVP for the fisheries that operated through WA (not only the West Coast Bioregion) in 2019 was $9.0 million.

External drivers

Strong La Niña events that typically result in strong Leeuwin Currents and warm sea-surface temperature result in below-average scallop recruitment.

Specimen Shell Managed Fishery (state wide)

Bycatch and protected species interactions
There is no bycatch in this fishery owing to the highly selective fishing methods. This results in a negligible risk for bycatch interactions. The fishery reported no interactions with listed protected species during 2019.

Habitat and ecosystem interactions
Habitat and ecosystem impacts are considered negligible. This is due to the small scale of the fishery and the hand collection methods.

Social and economic value
Social
In 2019, around 9 licences recorded consistent activity, with around 15 people operating occasionally in the fishery statewide. It is expected that approximately 22 people are employed regularly in this fishery. There is currently a low level of risk to these values.

Economic
The value per individual specimen shell can be relatively high but difficult to estimate as operators can sell direct to the public, to wholesalers or through vertically integrated businesses including export. Estimated annual economic value of this fishery is currently not assessed. There is currently a low level of economic risk to these values

External drivers
Fishers are typically limited by sea and weather conditions and access to beaches. Consumer demand and unit prices also influence the target species and numbers landed.

West Coast Purse Seine Managed Fishery

Bycatch and protected species interactions
Small quantities of finfish species are sometimes taken as bycatch, but this occurs infrequently and the majority are released from the net unharmed. Negligible risk. WCPSF interactions are rare and usually result in the animal released unharmed, indicating the fishery poses a negligible risk.

Habitat and ecosystem interactions
Purse seine nets are pelagic in nature, with little impact on benthic habitats during normal operations. On rare occasions nets may be deployed in shallow waters and come into contact with habitats such as seagrass beds. The light structure of the net is expected to cause minimal damage to benthic habitats when this occurs, and would be kept to a small, localised area. The WCPSF is therefore considered to be a negligible risk to these habitats.

Social and economic value
Social
Small pelagic fish are not a major target for recreational fishers and catches are low: the only species detected in the catch of boat-based recreational fishers during 2017/18 was <1 t of yellowtail scad. Negligible risk.

Economic
Local employment was provided by five active vessels as well as local processing factories. A small proportion of the catch is sold for human consumption while most is sold for bait or feed for aquaculture or pets. The estimated gross value of production (GVP) for the WCPSF in 2019 was <$1 million.

External drivers

Climate change is likely to be causing a southward contraction in the natural distribution of pilchards (moderate risk) and facilitating a southward extension for tropical sardine (negligible risk).

Requirements of commercial fishing in the West Coast Bioregion

Climate change is the main external drivers identified with potential to affect commercial fisheries in the West Coast Bioregion. The West Coast Bioregion is predicted to be at enhanced risk from the effects of climate given that it spans a transitional zone between tropical and temperate regions. The variables expected to drive climate change impacts include changes in water temperature, ocean currents, winds, rainfall, sea level, ocean chemistry and extreme weather conditions (Gaughan & Santoro 2021).

Management of commercial fishing in the West Coast Bioregion

DPIRD place several input (i.e. limits on number of licences issued, gear restrictions, seasonal closures) and output controls (i.e. Total Allowable Catches) on commercial fishers to minimise environmental impacts.

Marine benthic habitats and their associated biodiversity along most of the West Coast are largely protected from any physical impact of commercial fishing due to the extensive closures to trawling. These closures inside 200 m depth were introduced in the 1970s and 1980s, in recognition of the significance of extensive areas of seagrass and reef as fish habitat. Demersal gillnet and longline fishing was also prohibited from waters inside the 250 m isobath between 31º and 33º South from November 2007 (Gaughan & Santoro 2021).

15 Recreational fishing

Western Australia's magnificent coastline and diverse marine environment makes it an extremely popular destination for ocean based activities, including recreational fishing. During 2018/19, over a quarter of WA's population participated in recreational fishing (Tate *et al*. 2019). During aerial surveys in 2010 and 2011, shore-based recreational fishing was observed to be widespread along the coastline of MMP, with the main focal points along the rock walls at Ocean Reef Marina and Hillarys Boat Harbour (Smallwood *et al*., 2012). This activity also occurred to the north of the existing MMP, with the main focal points along the rock walls at Mindarie Marina and Two Rocks Marina. Beaches and natural rock platforms were also widely used by shore-based recreational fishers, with the greatest number of observations at Quinns Rocks and Yanchep (Smallwood *et al*, 2012; Smallwood *et al*, 2011).

Recreational fishing is a popular activity in Western Australia, providing an important source of recreation, relaxation and food to many WA families and delivering significant social and economic benefits to the State's population. This contribution of recreational fishing to the WA economy, estimated at $2.4 billion annually, is provided in a variety of ways, including through supporting tackle shops (estimated annual turnover of $159 million), purchasing bait and ice (approximately $244 million per year) and purchasing food and drink (over $600 million annually) (Macleod, 2018).

The close proximity of the study area to boat ramps and accessible beach and groyne locations, makes this part of the metropolitan area popular for shore and boat based fishing. Popular species targeted by recreational fishers include demersal species such as West Australian dhufish, pink snapper, baldchin groper, invertebrates such as Roe's abalone, western rock lobster, octopus, squid, and nearshore fish species such as herring, skippy, whiting, tailor and West Australian salmon.

Recreational fishing is managed by DPIRD under the FRMA, using a variety of management tools including bag and size limits, boat and possession limits, gear restrictions, seasonal restrictions, closures, and licensing.

Summary of popular recreational fishing activities

Abalone

Marmion Marine Park and the proposed expansion area falls within the Perth Metropolitan Zone for Roe's abalone, with over 18,000 licences issued in 2020/21. The reef platforms are exposed during low tide, making the fishery very accessible for large numbers of people wading out to collect abalone recreationally. The recreational fishery for abalone in Western Australia is strictly managed across three zones through seasons, licences, minimum size limits, catch restrictions, and possession limits.

During the short recreational abalone fishing season along Perth reefs, a field survey is conducted involving departmental research staff and Fisheries Volunteers to count the numbers of fishers on reefs and count and weigh their catches. Less frequently, a telephone survey is used to estimate the state-wide recreational abalone catch.

Octopus and squid

Octopus (*Octopus djinda*) (djinda meaning 'star' in Noongar) is recreationally caught in the area. While the species is caught in pots, it is commonly targeted by spearfishers, meaning it cannot be caught within 1.8km of the shoreline within the current Marmon marine Park boundary.

Squid (*Sepioteuthis australis*) and cuttlefish (*Sepia apama*) are also a popular species and can be caught with a jig and line, either from a boat or one of the many jetties, platforms or groynes throughout the area.

Western rock lobster

Western rock lobster or crayfish (*Panulirus cygnus)* is the target of WA's largest and most valuable fishery. A recreational rock lobster fishing licence is required to catch the species, with two individually identifiable pots permitted per licence holder. There are particular float, rope and pot speciation's for fishers to comply with. Divers may only catch rock lobster by hand, a hand-held loop or a blunt crook. Spears, nets and other similar items that can damage rock lobster are illegal.

Western rock lobster can be caught in daylight hours, year-round, although are particularly popular for recreational fishers in early summer, when the lead up to Christmas holidays coincides with the 'whites running' (particular stage in the rock lobster lifecycle).

The species can be caught throughout the Marmion Marine Park expansion area, with areas of the 3-mile reef out from the various boat launching facilities (i.e. Mindarie, Ocean Reef, Hillarys, Two Rocks) being particularly popular due to ease of access.

Nearshore finfish

Popular nearshore finish targeted in the area include herring, skippy, whiting and tailor. Tailor and herring are particularly popular for shore-based fishing in the area.

Demersal finfish

Popular target species for recreational fishing include baldchin groper (*Choerodon rubescens*), dhufish (*Glaucosoma hebraicum*) and pink snapper (*Chrysophrys auratus),* primarily caught by boat-based rod and line fishing, but also spearfishing. A 20-year recovery plan for the West Coast Demersal Scalefish Resource from Kalbarri to Augusta has been in place since 2010, after a period of overfishing in the early 2000s, to ensure there are stocks of these iconic fish for the future.

While current management arrangements have protected demersal stocks from declining any further, new measures are needed to boost the recovery effort and safeguard the sustainability of these important fish. The recreational and commercial fishing sectors are working with the Department of Primary Industries and Regional Development to develop new management options to get the recovery back on track. Commercial fishing of this resource has not been permitted in the metropolitan area since 2007.

Despite the vast majority of individual anglers following the rules and fishing for the future, the combined recreational sector's retained catches of demersal scalefish are either at or above benchmark levels and, in the case of some species, have been for some time. This may be due to a number of following factors:

- there is no limit on effort in the recreational sector apart from a two-month closure;
- recreational catches of pink snapper in metropolitan and south-west waters are dominated by a large recruitment pulse;
- improvements in fishing technologies means recreational fishers are becoming more efficient at targeting and catching demersal scalefish;
- fishing behaviour has responded to existing rules in recent years, making them less effective at maintaining the overall recreational catch below recovery benchmarks; and
- recreational catches are likely to increase as stocks start to rebuild.

The State Government has accepted a recommendation from a fishing sector Harvest Strategy Reference Group to reduce the total allowable catch for demersal species by 50 per cent in order to meet the 2030

recovery targets. DPIRD will work closely with stakeholders to develop management options to meet the new catch limits. Management changes will need to be introduced by the end of 2022 to allow recovery of the resource by 2030 (Fairclough et al. 2021)

Fishing effort

Participation in recreational fishing in Western Australia has averaged 30% of the State's population (aged five years or above) for over a decade, with most occurring in inshore waters (up to 250 m) (Department of Fisheries, 2017). The Perth metropolitan (Metro) area of Western Australia has approximately 73% of the statewide population and the majority of RBFL holders reside there. Most boat-based recreational fishing in Western Australia occurs in the coastal waters off the Metro area (Lai et al., 2019). Estimated fishing effort in the Metro area was lowest in 1996/97 and highest in 2005/06 (Figure 41. Estimated effort (boat hours) from ocean line-fishing for each zone and the West Coast Bioregion (WCB) from access-point surveys conducted in 1996/97 (9697), 2005/06 (0506), 2008/09 (0809) and 2009/10 (0910)(Figure 63) (Lai et al., 2019).

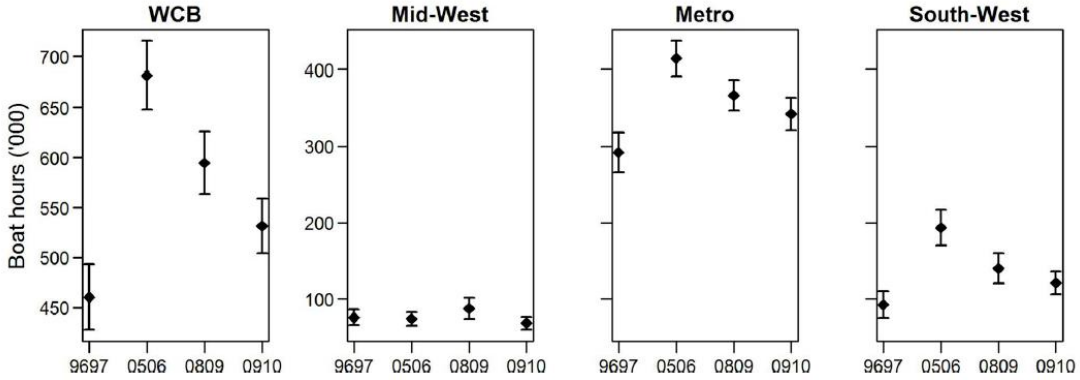

Figure 41. Estimated effort (boat hours) from ocean line-fishing for each zone and the West Coast Bioregion (WCB) from access-point surveys conducted in 1996/97 (9697), 2005/06 (0506), 2008/09 (0809) and 2009/10 (0910)

The substantial increase (˜50%) in the estimated effort from ocean-line fishing between 1996/97 and 2005/06 in the WCB, particularly in the Metro and South-West zones, was most likely related to human population growth, improved access to boating facilities and increased boat ownership. For example, in the Metro zone, the annual number of recreational boat registrations across all vessel sizes from 1996 to 2006 steadily increased by about 3.6% each year, relative to population growth, which increased approximately 1.6% per annum (Department for Planning and Infrastructure, 2009). The decreases in fishing effort following 2005/06 are therefore likely to reflect decreases in the annual number of recreational boat registrations (Department of Transport, 2010) and management changes including temporal or spatial closures that were implemented in late 2005 and 2009 (Table 7).

Management changes

The private boat-based (non-charter) recreational fishery in the WCB is managed using output controls to restrain catch (e.g., minimum size limits for retention and daily bag limits) and input controls to restrain effort (e.g., seasonal closures) (Lai et al. 2019).

Table 7. Key management changes in the West Coast Bioregion (WCB) boat-based recreational finfish fishery between 1996/97 and 2009/10 (Lai et al. 2019).

Year	Major recreational fishing rules changes
2000	1 1/2 months closure to snapper fishing in Cockburn and Warnbro Sounds.
2003	Reductions in minimum size limits and daily bag limits for individual and mixed-species finfish, including halved daily bag limits for baldchin groper, snapper and WA dhufish. Daily bag limits reduced from 20 to 8 for King George whiting and silver trevally. Three months closure within the Abrolhos Islands Fish Habitat Protection Area.
Late 2005	Four months closure to snapper fishing in Cockburn and Warnbro Sounds.
Early 2009	Halved daily bag limits for snapper, WA dhufish and mixed demersal species. Increased minimum size limit for snapper from 41 to 45 cm. Four months closure to snapper fishing in Cockburn and Warnbro Sounds.
Late 2009	Halved the daily bag limit for WA dhufish. Increased minimum size limit for snapper from 45 to 50 cm. 25% reduction in daily bag limits for mixed nearshore species. Two months closure of the WCB to fishing for demersal species.

16 Non-extractive recreational activities

Due to its proximity to Perth, the study area is arguably one of the most recreationally used in Western Australia, with an estimated 1.75 million visitors to Marmion Marine Park in 2019/20. The Perth population is expected to grow to 3.5 million by 2056 which will likely result in future intensification of non-extractive recreational activities in the study area.

Non-extractive recreational activities occurring within the Marmion Marine Park expansion study area include boating, swimming, surfing, diving, kayaking, wind surfing, walking and dog exercising. There are multiple points of access to the beaches for vehicles, watercraft and in particular, for people via existing formalised infrastructure (paths, roads, marinas and boat ramps) or informal coastal tracks.

Beaches

Mettams Pool

Mettams Pool, located between North Beach and Trigg, is an enclosed beach area with a limestone reef that hosts a range of fish, invertebrates and macroalgae. Being an easily accessible marine experience, the area attracts a range of recreational beach users such as paddlers, swimmers, surfers and wind surfers. However, snorkelling is the primary use of the area with families often seen utilising its calm waters (King 2018).

Trigg Beach

Trigg Beach is located upon the southern boundary of the study area. The beach is one of Western Australia's most popular beaches due to its often perfect surfing conditions (City of Stirling 2019b).

Hammersley Pool

Like Mettams Pool, Hammersley Pool is enclosed by a limestone reef which makes it a prime location for snorkelling. Families are also attracted to Hammersley Pool due to its public facilities and picnic area (City of Stirling 2019b).

Waterman's Bay

Watermans Bay and associated beaches are popular for beach goers, attracted to its secluded sandy coves, nearby lawned picnic areas with BBQ facilities, playground and café/restaurant. Recreational activities consist of swimming, snorkelling, fishing, surfing, kayaking, kite surfing, windsurfing and stand-up paddle boarding (City of Stirling 2019b).

Sorrento Beach

Sorrento Beach, located just south of Hillarys Boat Harbour, is a popular relaxing beach scene for residents of Perth. With its sandy beach, large grass area, shark barrier and picnic facilities, Sorrento Beach is an ideal family location (City of Joondalup 2019c).

Whitfords Beach

Whitfords Beach is a sandy beach that stretches from the north groyne of Hillarys Boat Harbour, past Pinnaroo Point up to Mullaloo Beach. It features nearby Whitfords Nodes (large persistent sand dunes), undercover picnic settings, benches and barbecues. Recreational activities include boating, swimming, stand-up paddle-boarding, kite surfing, dog beach, horse exercising and beach walking (City of Joondalup 2020a).

Mullaloo Beach
Mullaloo Beach hosts a range of activities such as: walking, dog exercise, photography, nature watching, and picnics. The beach also has well established infrastructure, such as bike paths, that are used by joggers and cyclists (City of Joondalup 2018c).

Burns Beach
Burns Beach is a family favourite, with a sheltered swimming spot that sits at the northern perimeter of Marmion Marine Park. Activities that occur on Burns Beach are walking of coastal paths, relaxing on the white-sand beach, barbecues in the grassed parks, or relaxing at the top the limestone cliffs and appreciating a spectacular Indian Ocean sunset (City of Joondalup 2019a).

Yanchep Lagoon and Beach
The main Yanchep Lagoon and beach extends north from the northern bluff with the beach curving to the east forming a wide opening to the north. Waves are usually low in the lagoon, water rushing over the reef flows northward along the lagoon and out of the deep 50 m wide channel as a permanent rip. Besides swimming, sunbaking and beach walking, it is a popular snorkelling, diving and fishing location (some spatial exclusions). Yanchep lagoon also is a popular for abalone fishing as is Fisherman's Hollow to the south (Beachsafe.org.au 2020).

Two Rocks
Two Rocks beach starts at the northern side of the north breakwater follows in a NNW direction for 3.6km to a low reef tied sandy foreland. The southern corner of the beach has eroded making it necessary to be partly backed by a makeshift seawall to protect the foreshore dunes. In the middle of Two Rocks Beach is a popular surfing spot locally known as Dewars (Derrs, Durrs). This section and the northern part of the beach is only accessible by ways of a 4WD track . The beach receives waves averaging just over 1m. The beach is interrupted by small patches of beach rock, with a continuous 500m long section towards the northern end, where there is a shallow lagoon (Beachsafe.org.au 2020).

Board riding and kite/wind surfing
Board riding and kite/windsurfing activities have been observed at Trigg Point, Mettam, North Beach, Watermans Bay, Pinnaroo Point, Little Island, Mullaloo Beach, the Alkimos Reef, "the Spot" and "Derrs" just north of Two Rocks. Several offshore reefs are also popular for surfing.

Dog and horse exercising
Bennion St, North Beach, Hillarys, Quinns, Yanchep and Two Rocks dog beaches. Pinnaroo Point has the only horse exercising area in the study area (City of Joondalup 2020a).

Recreational boating and yachting
The marinas and harbours located at Two Rocks, Mindarie, Ocean Reef and Hillarys facilitate a variety of recreational boating activities such as motor boating, jet skiing and yachting. Hillarys Yacht, Sun City Yacht and Ocean Reef Sea Sports Clubs are major sailing organisations which are highly active in the study area. Boat ramps located in the study area are at Hillarys, Ocean Reef, Mindarie and Two Rocks, as well as a beach launch for very small boats at Trigg Point. Within the study area there are two designated water-skiing areas: between Pinnaroo Point and Ocean Reef Harbour, and; between Quinns Rock and Jindalee Beach.

Swimming and water sports
The study area also hosts a variety of open sandy beaches that attract local, national and international visitors. There Surf Lifesaving clubs supervising water-based activities at Trigg, Sorrento and Mullaloo beaches, North Mindarie, Alkimos Beach and Yanchep. There are enclosed (shark proof) swim areas at Sorrento and North Mindarie Beach.

Recreational events
Hillarys Yacht, Sun City Yacht and Ocean Reef Sea Sports Clubs regularly have racing events, either weekly or fortnightly all year round. The Surf Life Saving Clubs at Sorrento, Mullaloo, Quinns Mindarie, Alkimos and Yanchep have regular intra-club and inter-club competitions. Board riding clubs including Mullaloo Boardriders, Metro Boardriders, Trigg Junior Boardriders and Surfing Mums Western Australia are active within the study area. There are various intra-club competitions held in the study area.

17 Education and community groups

The study area plays an important role in providing a link between individuals and the marine environment.

Active conservation focused community groups in the area include:

- Reef Life Survey - a non-profit citizen science program which trains and use trained SCUBA divers to undertake underwater visual surveys of reef biodiversity on rocky and coral reefs around the world utilising a standardised methodology (Reef Life Surveys 2020). Within the study area, Reef Life Surveys have sampled 15 sites between Trigg Point and Mindarie.

- Quinns Rocks Environmental Group - a community organisation supporting conservation of natural assets and transition toward sustainable living in and around Quinns Rocks in Perth's northern coastal suburbs. They promote community environmental awareness, advocate to protect the local environment, educate on sustainable living and undertaken conservation work in local bushland.

- Joondalup Community Coastcare Forum - monitor and comment on coastal development issues, campaign for environmentally responsible management of beaches and coastal bushland, weed and replant degraded coastal reserves and seek to preserve and enhance the biodiversity of the bushland along the coastline.

- Friends of North Ocean Reef - Iluka Foreshore – work to restore the foreshore vegetation by removing weeds and planting local native species, to preserve the foreshore environment, including the beach dunes and rock formations, by minimizing degradation by human activities like tramping of vegetation, and to educate the public on the environmental and biodiversity values of the reserve.

- Mullaloo Beach Community Group - are aligned with the Joondalup Community Coastcare Forum and focus efforts on community education and engagement through hands on conservation activities such as weed management, dune restoration, erosion and litter reduction.

- Friends of Marmion Marine Park - works to further the conservation interests of Marmion Marine Park by educating the users of the park. This includes organising beach walks, touch pools, displays, educational speakers, social gatherings and snorkelling and diving excursions.

- Friends of Sorrento Beach and Marmion Foreshore - working to restore 2.5km of coastal foreshore reserve through revegetation.

- Friends of Trigg Bushland – includes monthly bush restoration mornings, quarterly guided walks and two general meetings per year.

- Stirling Natural Environment Coastcare - working to rehabilitate the coastline of Hamersley Beach, North Beach, Trigg and Watermans in the Perth metropolitan area.

There are also several fishing clubs and non-for- profit groups who operate in the area:

- Fishability – supporting disabled participants to use specially designed rods and reels to enjoy the pleasure of fishing.
- Bluewater Freedivers of WA
- Coastal Angling Club of WA
- Hillarys Yacht Club (Angling)
- Marmion Angling and Aquatic Club
- Ocean Reef Sea Sports Club
- Offshore Angling Beach Club
- Perth Game Fishing Club
- Perth Offshore Boat Angling Club of WA
- Quinns Rock Fishing Club
- Surf Casting and Angling Club
- Two Rocks Tightliners Fishing Club
- West Coast Angling Club

18 References

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