Marine Biodiversity Hub

National Environmental Science Programme

An eco-narrative of South-west Corner Marine Park - Capes region

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Project D3: Implementing monitoring of Australian Marine Parks and the status of marine biodiversity assets on the continental shelf

December 2021

For Parks Australia



1 University of Western Australia
2 University of Tasmania
3 Geoscience Australia
4 CSIRO

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Important Disclaimer

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EXECUTIVE SUMMARY

This report is part of a series of eco-narrative documents that synthesize our existing knowledge of individual Australian Marine Parks. This series is a product of the National Environmental Science Program Marine Biodiversity Hub Project D3, which seeks to determine the status of marine biodiversity assets on the continental shelf to inform monitoring of Australian Marine Parks. These documents aim to enable managers and practitioners to rapidly ascertain the ecological characteristics of each park, and to highlight the knowledge gaps for future research projects.

The South-west Corner Marine Park contains large areas of high biodiversity and benthic productivity, although most of the marine park still remains to be surveyed. The park is defined by extensive plains across the continental shelf covered by mixed communities of macroalgae, seagrasses and sponges. Since these plains cover ~95% of the surveyed area, such communities account for a large proportion of benthic productivity and biodiversity in the region. Black and octocorals, hydroids and bryozoans are present in deeper areas of the continental shelf, while areas deeper than 120 m are mostly formed by soft sediments. A total of 140 fish species across 61 families were identified in the area surveyed within the Capes region of the South-west Corner Marine Park, including several shark species and other commercially targeted species. The Park is also habitat for numerous seabirds and migratory passage for several cetacean species.

Climate change and changes to the patterns of the Leeuwin and Capes currents are potential impacts on the region, however existing knowledge of these threats is not sufficient to report on their potential current and future impacts. This eco-narrative collates the existing information for an initial characterisation of the habitats and benthic marine communities in the South-west Corner Marine Park.

1. INTRODUCTION

South-west Corner Marine Park is located within the South-west Network of Australian Marine Parks and this eco-narrative focuses on the Capes region of this marine park. The park extends across the continental shelf and upper continental slope to the limit of Australia's exclusive economic zone, covering an area of 271,833 km^2 (Figure 1). Conservation values within the park include reefs and banks on the continental shelf, submarine canyons that locally connect the shelf to the deeper waters of the continental slope, the extensive Naturaliste Plateau located beyond the slope, and the Diamantina Fracture Zone that reaches to depths of 6,500 m (Director of National Parks, 2018). Benthic biological communities within the continental shelf areas of the marine park include sponges, hard and soft corals associated with reefs and hard substrates but information on these communities is limited.

South-west Corner Marine Park comprises five different management zones that break the park into sixteen areas including National Park Zones (seven areas), Habitat Protection Zone (one area), Multiple Use Zones (four areas), Special Purpose Zone (two areas) and Special Purpose Zone (Mining Exclusion; two areas).

This eco-narrative presents an overview of the physical and oceanographic setting for the continental shelf area offshore from the Cape Naturaliste to Cape Leeuwin coastline of the South-west Corner Marine Park (the Capes region hereafter) adjacent to the Ngari Capes Marine Park in State waters, then focuses on the results from a recent marine biodiversity survey within the National Park Zone and adjacent Special Purpose Zone (Mining Exclusion) that characterised a variety of habitats from the boundary with State waters in ~35m depth out to the shelf break in 250m depth.

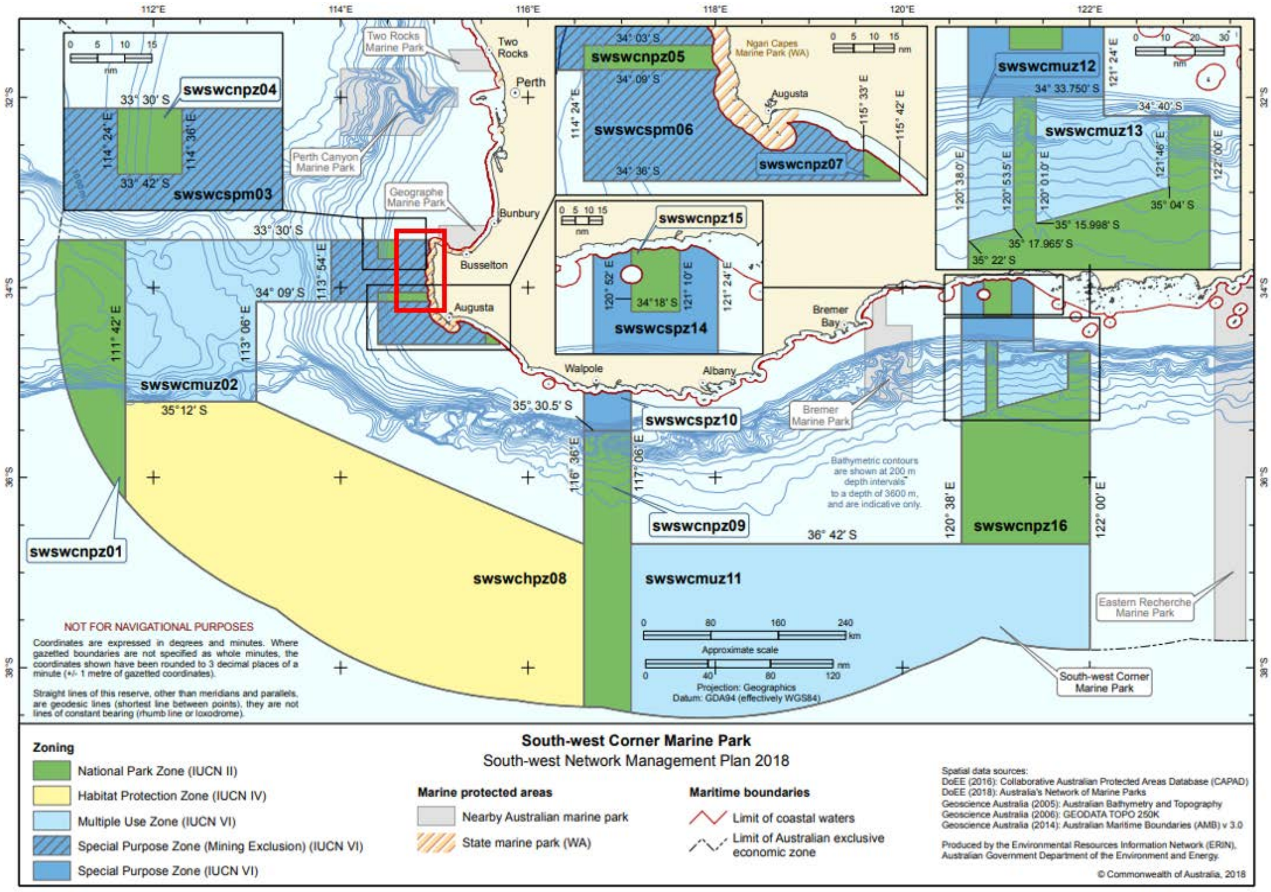

Figure 1. a) South-west Corner Marine Park and western Capes region (indicated by red box). Management zones of the South-west Corner Marine Park are shown. Comparable management zones within State waters are not shown due to scale.

2. TRADITIONAL KNOWLEDGE INFORMING MARINE PARK BIODIVERSITY SURVEYS

Traditional Ecological and Scientific Knowledge has informed the recent marine biodiversity benchmark surveys of the South-west Corner Marine Park through a cultural mapping project documented in a separate report "The Cultural Seascape of Wadandi Boodja: The Cultural Values of Australia's South West Marine Parks". Traditional Ecological and Scientific Knowledge informed the planning, activity and interpretation of marine biodiversity data revealed in that survey. This included an appreciation of how rapid sea-level rise after the last glacial maxima would have resulted in the inundation of coastal landscapes (Figure 2) that now lie within the Ngari Capes (State waters) and South-west Corner Marine Parks. These coastal landforms would have included ancient river channels, dunes and beaches that formed during the period from 21,000 to 11,000 years ago and were subsequently drowned (Brooke et al., 2017).

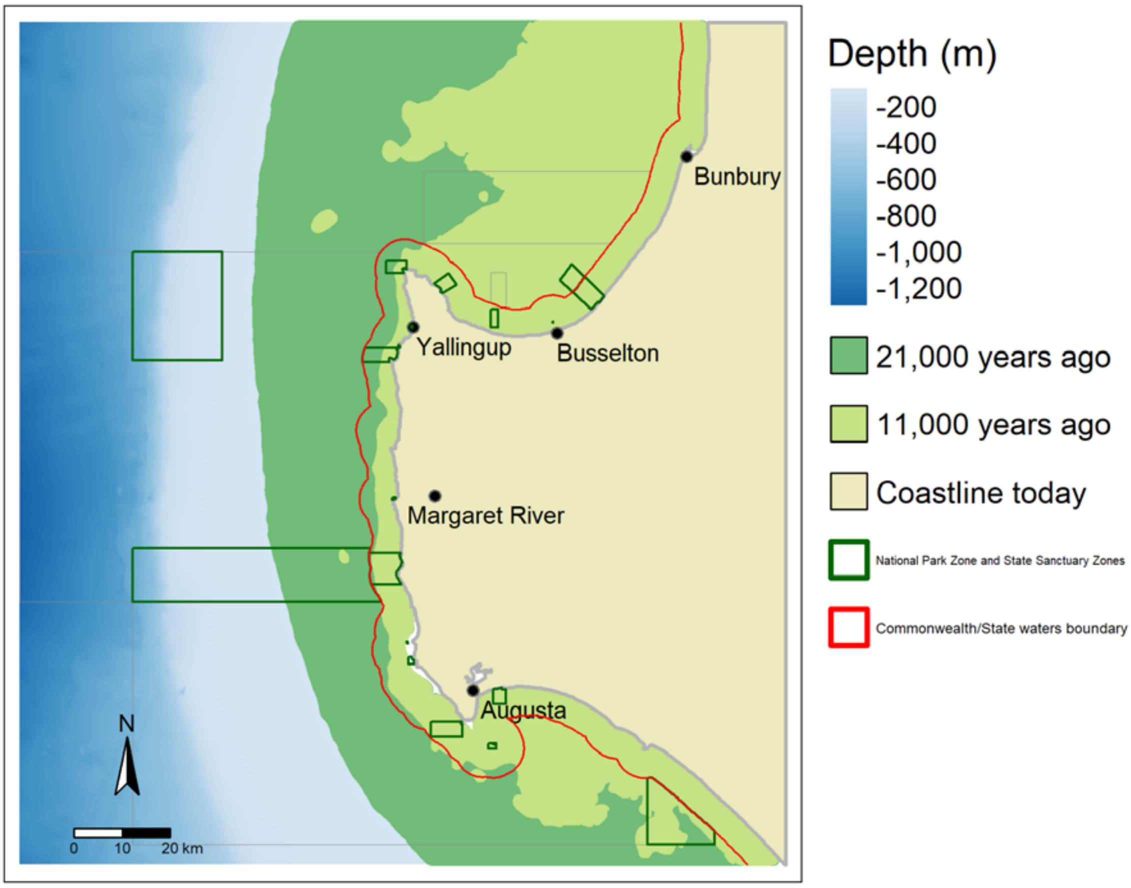

Figure 2. Submerged and modern coastal zones within the western Capes region of the Ngari Capes (State waters) and South-west Corner Marine Parks. The position of the 21,000 year old coastline is based on the -120 m depth contour and the 11,000 year coast is based on the -40 m contour.

2.1 Physical setting

The area of South-west Corner Marine Park located offshore from the Cape Naturaliste to Cape Leeuwin region of the southwest incorporates the 45 – 50 km wide continental shelf to the upper continental slope of the southwest margin of Australia. Water depths range from ~40 m on the inner shelf to over 800 m on the lower slope. Large scale seabed geomorphic features include extensive plains across the shelf, isolated shelf reefs and a broad terrace that extends the length (100 km) of the southwest region and defines a break in slope on the continental slope.

The recent geological history of the southwest continental shelf is closely linked to the onshore geology, with development of coastal landforms occurring during the late Quaternary Period (i.e. last 250,000 years). This period of time was characterised by multiple sea-level cycles (linked to worldwide glacial and interglacial stages), with periods of low sea level leading to exposure of the continental shelf and development of coastal dune fields (Kendrick et al. 1991). These dunes comprised locally generated carbonate sands and extended across the shelf and onto the present day coast, and are now preserved as aeolianite that forms coastal cliffs along the coast of southwest Western Australia (Playford 1997). With multiple episodes of dune activity during the Late Quaternary Period, the accumulation of carbonate sediment on the shelf has formed a limestone, named the Tamala Limestone (Playford et al., 1975). The Tamala Limestone is a regionally extensive formation, extending north to the Shark Bay region and its occurrence in the southwest represents its southern limit (Hearty and O'Leary, 2008; Lipar and Webb, 2014). On the modern continental shelf, the Tamala Limestone is exposed at the seabed as a hard pavement; with thin to no sediment cover. This is indicative of a shelf with a low sediment supply (also termed sediment-starved), with the only source of sediment being biogenic production by calcifying organisms on the seabed (e.g. bryozoans, encrusting algae, corals, gastropods and bivalves).

The geology of the southwest region is also characterised by an assemblage of metamorphic rocks (granitic gneiss) that are of much greater age than the Tamala Limestone. These metamorphic rocks are part of the Leeuwin Complex that formed when the Australian continent was joined with the Antarctic and Greater Indian continents as part of the ancient supercontinent of Gondwanaland. The rocks of the Leeuwin Complex are estimated to be approximately 600 million years in age, with the rifting of Gondwana in the vicinity of the Leeuwin Complex commencing about 132 million years ago leading to the exposure of these rocks (Wilde and Nelson, 2001). Today, the metamorphic rocks of the Leeuwin Complex form erosion-resistant granite outcrops along the headlands of the southwest coast at localities such as Cape Mentelle, Cape Freycinet and Cowaramup Point. In places, these rocks also form reefs on the inner shelf to nearshore zones.

3. OCEANOGRAPHY

The poleward-flowing Leeuwin Current is the dominant ocean current affecting the Capes region of the South-west Corner Marine Park. The area is entirely flooded by the Leeuwin Current during winter when the current is strong (Pearce and Pattiaratchi, 1999). In summer, when the southerly wind dominates, the Leeuwin Current becomes weaker and moves offshore to the outer-shelf and upper-slope (Pearce and Pattiaratchi, 1999; Huang and Feng, 2015); while the equatorward-flowing Capes Current develops in the inner- and mid-shelf (Gersbach et al., 1999; Pearce and Pattiaratchi, 1999) (Figure 3a).

Although it is generally nutrient-depleted, the Leeuwin Current and its eddy field have significant ecological impact on the marine ecosystem (Feng et al., 2009; Pearce et al., 2011; Waite et al., 2007; Huang and Feng, 2015 and references therein). As summarised in Huang and Feng (2015), such ecological impact includes: phytoplankton primary production; the abundance, biomass and community composition of zooplankton; recruitment of invertebrates, fish and fisheries, most notably western rock lobster (*Panulirus cygnus*), and the distribution of marine flora such as algae and seagrass.

In contrast to the warm Leeuwin Current, the Capes Current delivers cooler waters that are upwelled from the base of the Leeuwin Current, Leeuwin Undercurrent via the Cape Mentelle upwelling, and driven by persistent and strong southerly winds during summer (Gersbach et al., 1999). The upwelling raises primary production, leading to localised productivity hotspots, particularly in near coastal waters (<20 m depth) of the Capes region, as evidenced by elevated chlorophyll-a concentrations (Figure 3b; Hanson et al., 2005). The ecological influence of the Capes Current on the pelagic communities is to facilitate the recruitment, movement, and feeding of some of the iconic commercial and non-commercial species of Western Australia, including the West Australia salmon (*Arripis truttaceus*), western rock lobster (*Panulirus cygnus*), pilchard (*Sardinops sagax*), Australian herring (*Arripis georgianus*) and tailor (*Pomatomus saltatrix*) (Gersbach et al., 1999; Pearce & Pattiaratchi, 1999; Hanson et al., 2005) and likely explains the aggregation of deep water Hapuku *(Polyprion oxygeneios)* groper on the shelf break at the transition depth between the Leeuwin Current and Leeuwin Undercurrent (e.g. the Cape Mentelle upwelling).

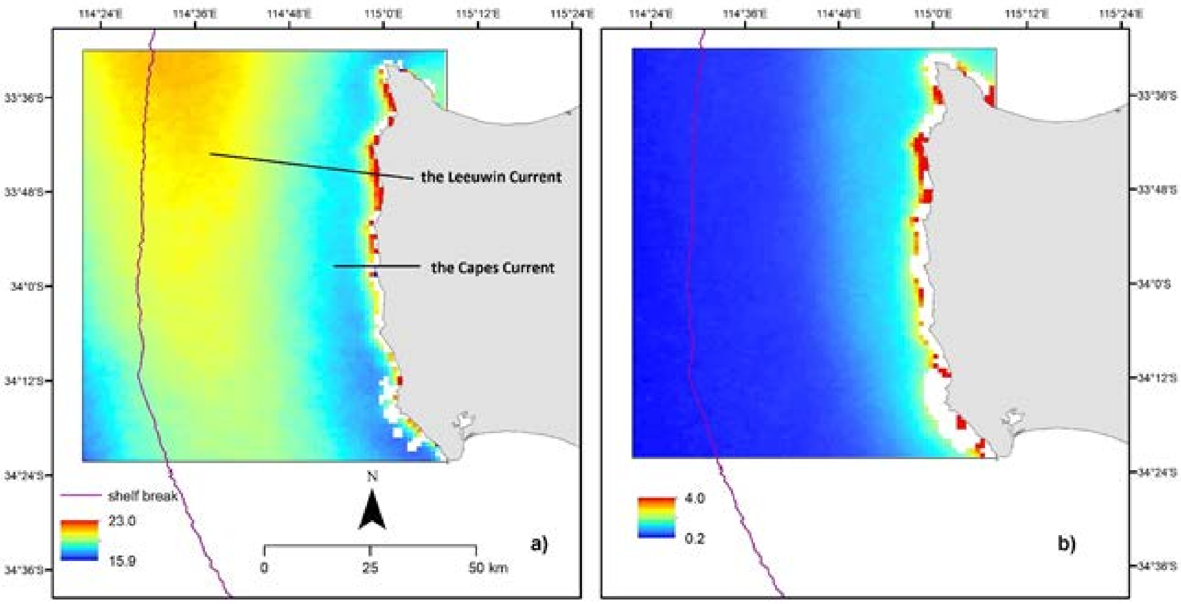

Figure 3. Long-term mean a) SST (°C) and b) Chlorophyll-a (mg/m3) for the Capes region of Southwest Corner Marine Park.. Data derived from daily MODIS satellite imagery for the period 2003 to 2018 inclusive at 1km2 resolution.

Tides in the Capes region are micro-tidal with mixed diurnal and semi-diurnal types and a tidal range generally less than 1.0 m. Based on long-term averages (+40 years), southerly winds dominate in summer, with wind speeds of 10-13 knots; while westerly winds dominate in winter, with similar wind speeds. Consequently, the mean significant wave height is 2.75-3.0 m in the area.(http://www.bom.gov.au/jsp/ncc/climate_averages/wind-velocity/index.jsp?period=sep#maps).

Satellite-derived (MODIS) Sea Surface Temperature (SST) and Chlorophyll-a data were obtained from the Integrated Marine Observing System (IMOS; http://imos.org.au/) to analyse the SST and surface Chlorophyll-a characteristics of surface waters of the Capes region (Figure 4). Sea surface temperatures show a clear seasonal pattern, with warmest conditions in March (monthly mean of 21.9°C) and coolest waters in September (monthly mean of 17.9°C). There is also notable inter-annual variation in SST, but with no significant ($p>0.1$) warming trend (Figure 4b). Over the last 16 years (2003 to 2018 inclusive), the highest annual mean SST (~ 21.2 °C) occurred in 2011; while the lowest annual mean SST (~ 19.1 °C) occurred in 2005. The long-term average SST varies substantially in spatial distribution within the marine park (20.4 ± 0.31 °C). The warm waters extending from mid-shelf to the shelf break are associated with the warm Leeuwin Current; while, the cool waters in inner-shelf are associated with the Capes Current.

Analysis of surface Chlorophyll-a concentrations shows a clear seasonal pattern (Figure 4). The highest surface Chlorophyll-a concentrations occur in late austral autumn and early austral winter (May and June), with monthly means of 0.41-0.42 mg/m^3; while the lowest surface concentrations occur in late austral spring and early summer (November and December), with values of ~0.16 mg/m^3. The inter-annual variation of the surface Chlorophyll-a concentrations over the period 2003 to 2018 is substantial, indicating a slight upward trend (Figure 4d) approaching statistical significance ($p>0.1$). There is a clear spatial pattern across the area of the Capes region of the South-west Corner Marine Park in the long-term mean Chlorophyll-a concentrations (Figure 3). Relatively high surface Chlorophyll-a concentrations occur at the shallow part of the area, with concentrations between 0.3-0.4 mg/m^3. This is most likely due to the upwelling associated with the Capes Current (Gersbach et al., 1999; Hanson et al., 2005). The deeper part of the area is associated with the nutrient-depleted Leeuwin Current which is characterised by relatively uniform Chlorophyll-a concentrations of ~0.2 mg/m^3.

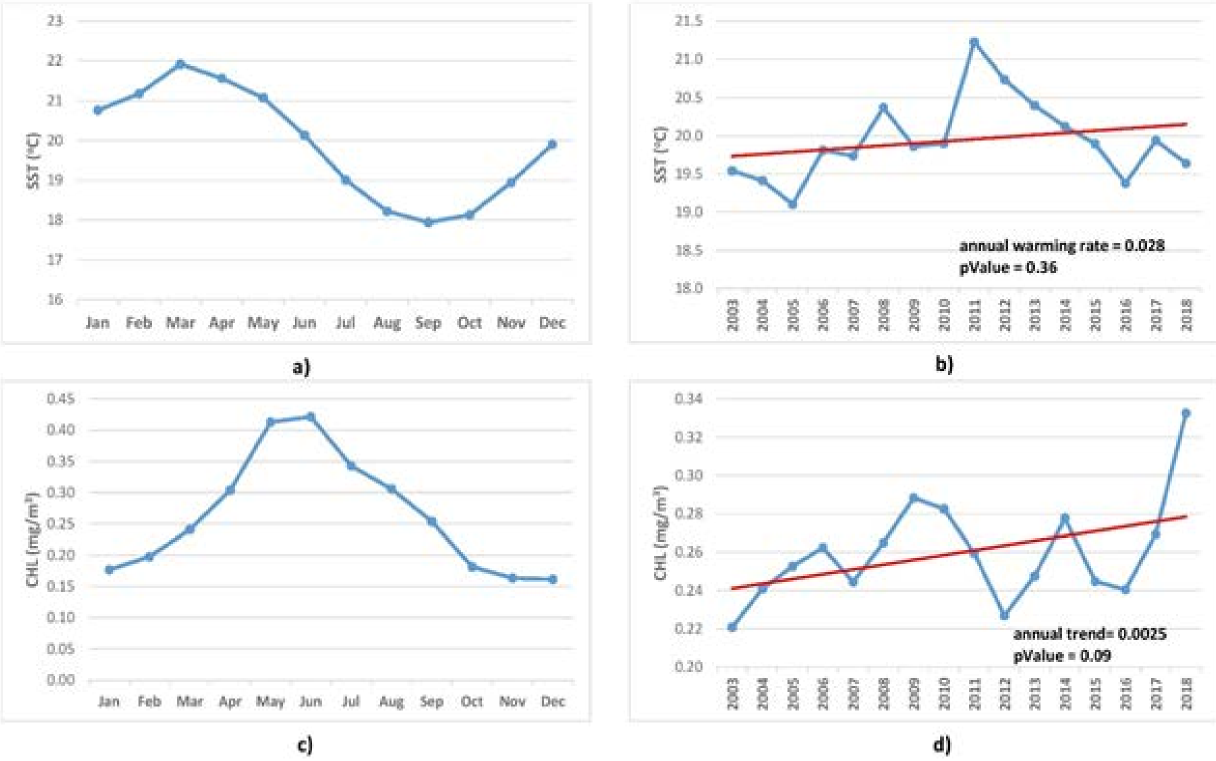

Figure 4. Sea Surface Temperature and surface Chlorophyll-a properties for the Capes region of South-west Corner Marine Park. Data derived from daily MODIS satellite imagery (July 2002- July 2019), showing; a) SST seasonal variation; b) SST inter-annual trend; c) Chlorophyll-a seasonal variation; d) Chlorophyll-a inter-annual trend.

Despite the lack of a clear warming trend for the period of MODIS satellite data (Figure 4b), the waters of the Capes region have been impacted by multiple marine heatwaves (MHWs) during the past decade (following the definition of Hobday et al. (2016) for such events). In particular, during the two consecutive seasons of 2010-11 summer and 2011 autumn, and again in the following 2011-12 summer, MHWs were most intensive and long-lasting (Table 1). The unprecedented event in 2011 started in January and lasted for around five months, and was caused by an unseasonal surge of the Leeuwin Current forced by the extraordinary La Nina conditions along the equator in the western Pacific (Feng et al., 2013; Pearce & Feng, 2013).

The spatial patterns of MHWs indicate that in the 2010-11 summer, warming mostly affected the off-shore locations over 50% of the observed time (Figure 5a). In the following autumn of 2011, MHWs intensified and expanded to affect the majority of the area, with elevated temperatures for over 70% of the observed time (Figure 5b). In the following summer (2011-12), the MHW condition re-appeared for over 50% of the observed time (Figure 5c). This event occurred along the southwest coast of Western Australia, with significant ecological impact observed, such as fish kills and changes of biodiversity patterns of temperate seaweeds, sessile invertebrates and demersal fish (Pearce & Feng, 2013; Smale & Wernberg, 2013; Wernberg et al., 2013). The impact to the Capes region of South-west Corner Marine Park was likely limited because the increased water temperature was still below the physiological threshold of many temperate species (Smale & Wernberg, 2013; Wernberg et al., 2013).

Table 1. Seasonal MHWs statistics derived from daily MODIS SST data between July 2002 and June 2019 Red text indicates the marine heat wave (MHW).

Season	Duration [1]	Mean Intensity[2]	Cumulative Intensity[3]	Season	Duration	Mean Intensity	Cumulative Intensity
2008 autumn	9	0.38	3.39	**2011 winter**	2	0.50	1.01
2008 winter	6	0.42	2.50	**2011 spring**	6	0.27	1.61
2009 autumn	3	0.15	0.46	**2011-12 summer**	38	0.67	25.49
2009 winter	2	0.22	0.43	**2012 autumn**	23	0.32	7.37
2010 spring	11	0.37	4.05	**2012-13 summer**	17	1.23	20.94
2010-11 summer	32	0.91	29.25	**2014 spring**	14	0.83	11.59
2011 autumn	82	0.92	75.77	**2018 winter**	5	0.45	2.26

Note: 1. The duration indicates the total number of MHW days; 2. The mean intensity (ºC day^{-1}) indicates the averaged MHW intensity over all of the MHW days; 3. The cumulative intensity (ºC days) indicates the accumulated MHW intensity over all of the MHW days.

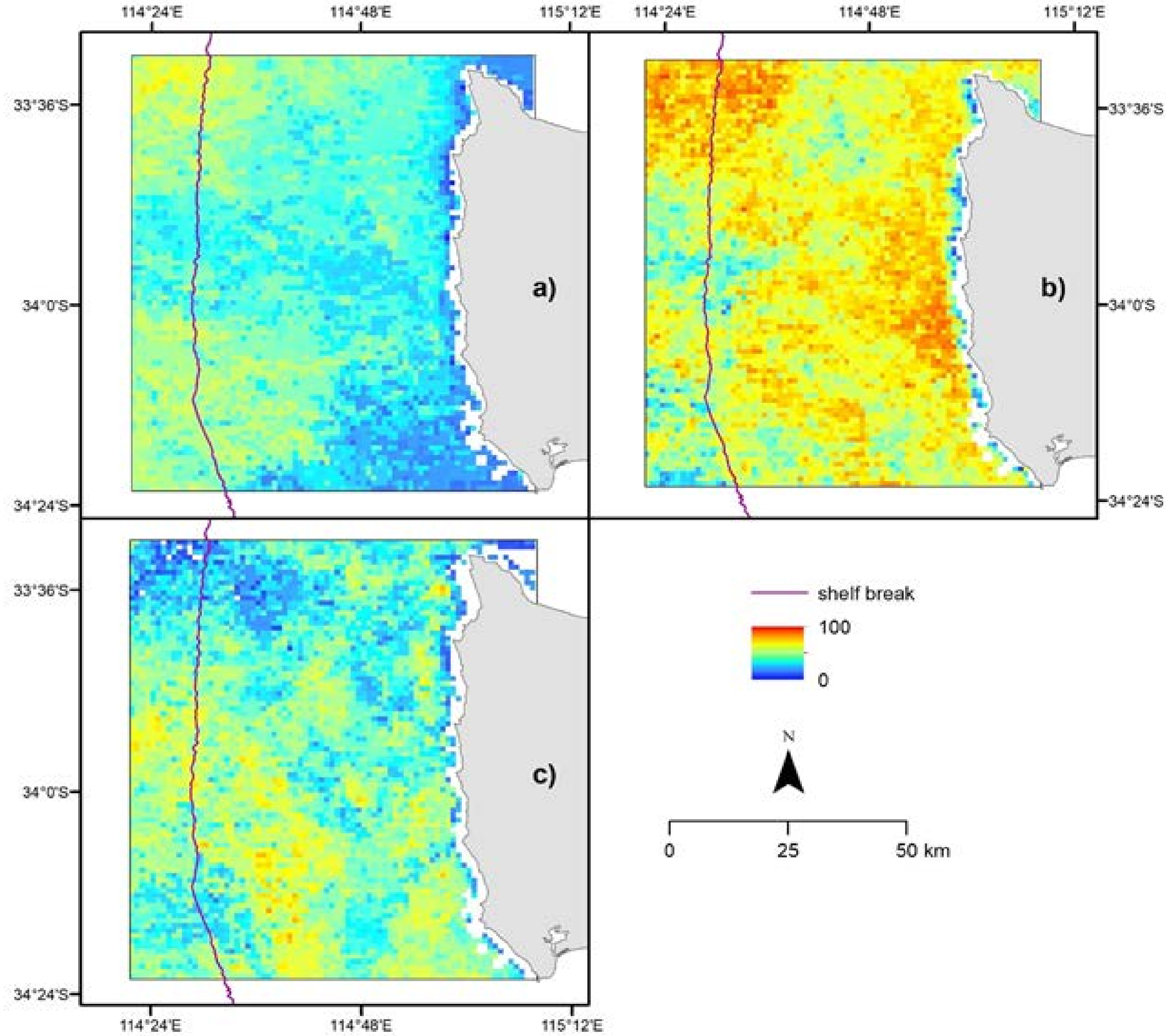

Figure 5. The percentage of MHW days. The percentage of MHW days out of the total observed days from MODIS daily imagery for events in; a) 2010-11 summer; b) 2011 autumn; c) 2011-12 summer. Data derived from daily MODIS satellite imagery at 1km² resolution.

4. GEOMORPHOLOGY AND POTENTIAL HABITATS

Seabed geomorphic features within the Capes region of South-west Corner Marine Park have been previously mapped at a coarse scale by Heap and Harris (2008) using the 250 m resolution bathymetry model for the Australian region (Whiteway, 2009). These features include low gradient plains and reefs on the continental shelf, and terraces and slopes on the continental slope (Figure 6). Of these, the shelf (plain) covers 38% of the Capes region offshore area, with terrace and slopes covering 35% and 27%, respectively. At this scale of mapping, reef occupies less than 0.1% of the region and is clearly under-represented, particularly for the continental shelf. This gap was addressed by a Marine Biodiversity Hub survey of the Capes region within the South-west Corner Marine Park undertaken in 2020 and 2021 that targeted the shelf and reef seabed habitats within the National Park Zone and Special Purpose Zone in the marine park. Details of that survey are reported in Langlois et al. (2021) and are summarised below.

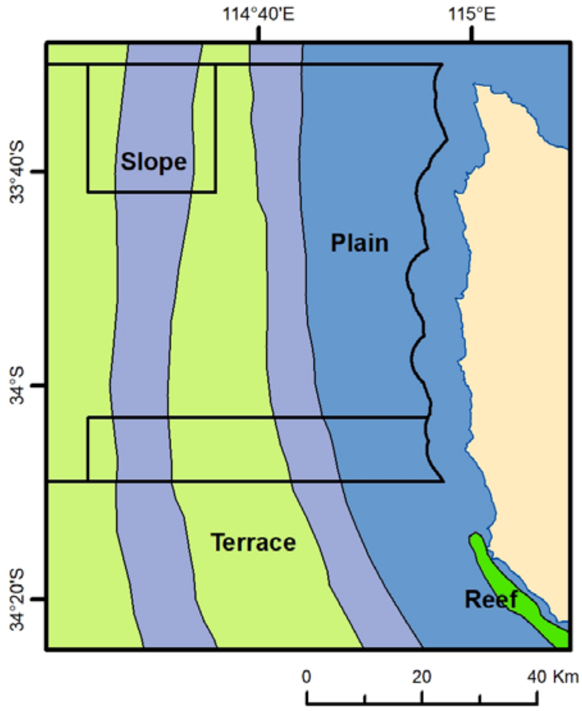

Figure 6. Seabed geomorphic features offshore from the Capes region (from Heap and Harris, 2008), with South-west Corner Marine Park indicated.

4.1 Seabed features on the shelf

An assessment of the physical character of seabed features within the Capes survey area is revealed by the seabed gradient across the mapped area (Figure 7). This analysis classifies the seabed into three categories: (1) Planes, defined as seabed with less than 2° gradient; (2) Slopes, defined as areas with gradients of 2-10°, and; (3) Escarpments, areas steeper than 10°. This classification shows that across the 274 km^2 mapped area of the shelf, low gradient plain covers 94.4% (259 km^2) and slopes that occur on reefs and ledges cover ~5.5% (15 km^2). Escarpments form the steepest substrate for sessile biota cover <0.1% (0.2 km^2) and are restricted to the narrow perimeter of the larger reefs on the inner shelf.

Examples of these inner shelf raised seabed features occur in the southeast of the mapped area where outcrops of granite form reefs in water depths of 35 - 45 m (Figure 8). These rocky reefs form discrete areas of hard substrate with gradients that range from ~5 to 10° with locally steeper escarpments that form near vertical rock faces, typically on the outer parts of the reef.

Overall, however, the extent of these rocky reef features on the inner shelf is limited, covering a combined area of approximately 3 km^2. Limited seabed observations suggest that these reefs are surrounded by a pavement surface of limestone with only a thin to patchy sediment cover of sand and gravel.

In contrast to the very localised rock outcrops on the inner shelf, the outer shelf contains a more spatially extensive low profile reef structure (Figure 9). These reefs rise less than 2 m above the surrounding seabed, extend the full 10 km north-south extent of the mapped area and form a zone that is up to 2 km wide. As such, it forms the most complex seabed habitat structure in the mapped area and most likely continues the length of the Capes region outer shelf. Similar low profile ridges also occur on the mid-shelf and inner shelf, but these are mostly isolated features less than 1 km in length and narrow (<100 m). The remainder of the shelf is characterised by a flat pavement surface with thin to negligible sediment cover.

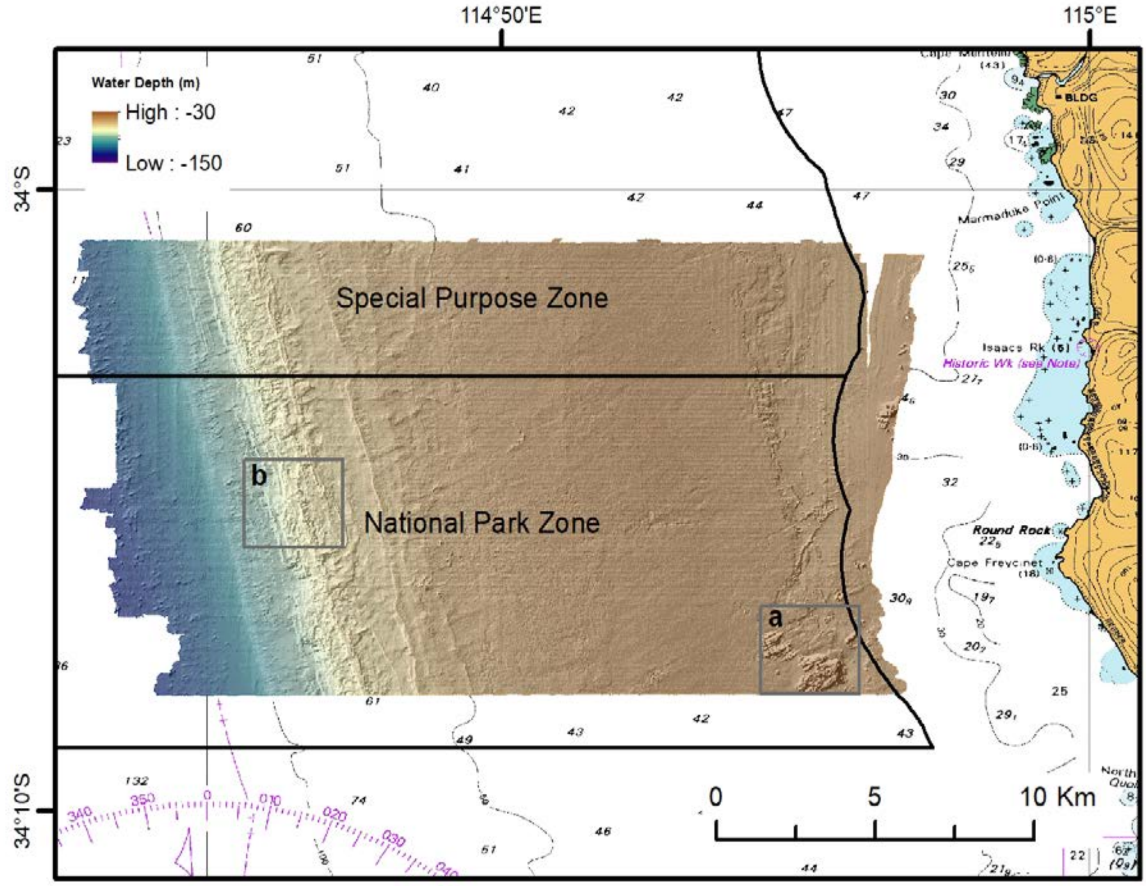

Figure 7. Seabed features for the Capes region shelf. South-west Corner Marine Park, showing: High-resolution multibeam bathymetry data gridded at 4 m. Inset boxes show locations of Fig. 8 (inset a) and Fig. 9 (inset b).

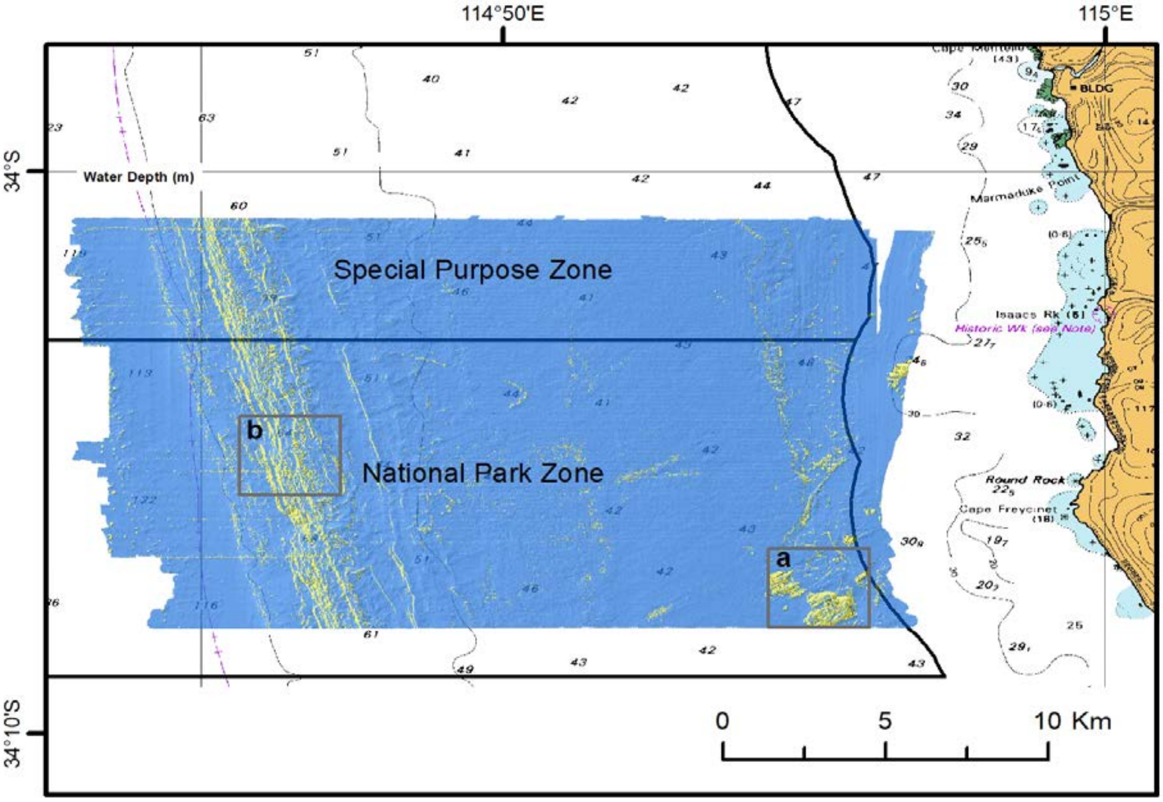

Figure 8. Seabed features for the Capes region shelf. South-west Corner Marine Park, showing: Surface features, highlighting inner shelf reefs and continuous low profile reef on the outer shelf. Inset boxes show locations of Fig. 8 (inset a) and Fig. 9 (inset b).

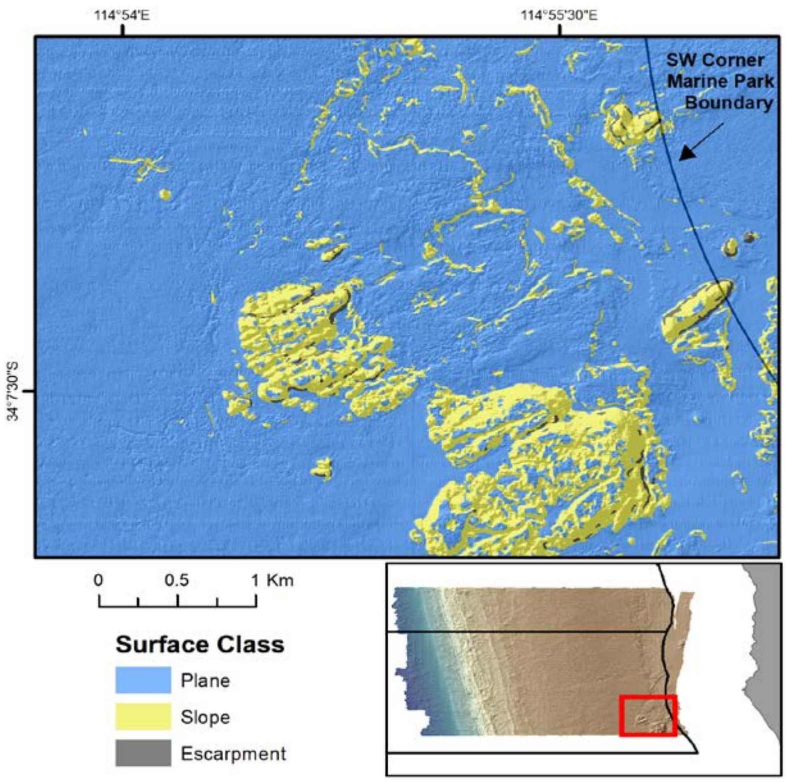

Figure 9. Reef features and surface classes on the inner shelf and surrounding seabed. Reef features within the National Park Zone, Capes region, South-west Corner Marine Park. These reefs are interpreted as outcrops of granite that are part of the Leeuwin Complex that forms the underlying geology of the Capes region.

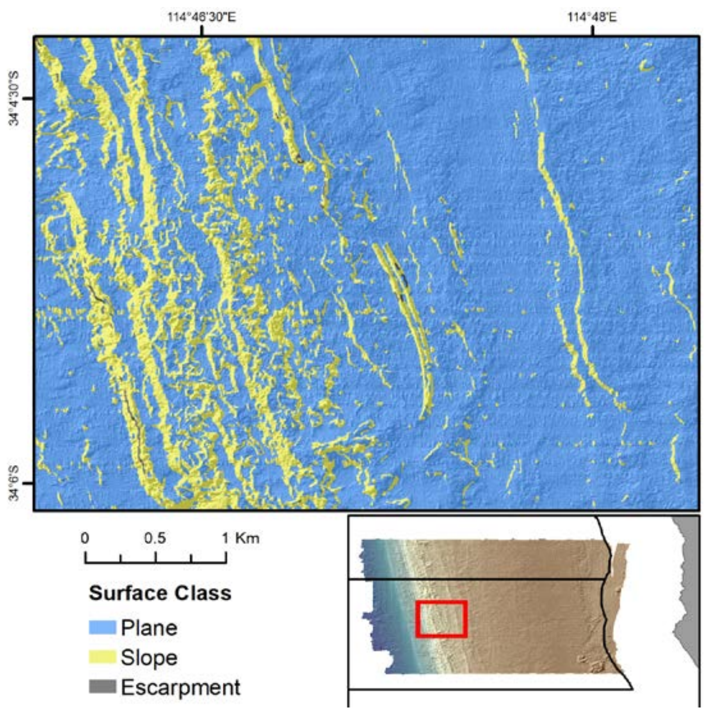

Figure 10. Extensive low profile reef features and surface classes on the outer shelf. Extensive low profile reef features within the National Park Zone, Capes region, South-west Corner Marine Park.

5. THE ECOLOGICAL SIGNIFICANCE OF THE CAPES REGION OF THE SOUTH-WEST CORNER MARINE PARK

5.1 Pelagic fauna

5.1.1 Cetaceans

The Capes region of the South-west corner of Western Australia is an important seasonal migratory habitat for a variety of cetaceans including the Antarctic Blue Whale (*Balaenoptera musculus intermedia*) (Gavrilov, McCauley and Gedamke 2012), the protected Humpback (*Megaptera novaeangliae*) (Jenner, Jenner, and McCabe 2001) and Pygmy Blue Whales (*Balaenoptera musculus brevicauda*) (Double et al., 2014). Flinders Bay is also recognised as an emerging area of importance for Southern Right Whale calving (DSEWPaC 2012). There are also records of several species of beaked whales including Gray's Beaked Whale (*Mesoplodon grayi*) and Andrew's Beaked Whale (*Mesoplodon bowdoini*) (Groom, Coughran and Smith, 2014), and historical records of sperm whales inhabiting offshore the south-west corner (Johnson et al., 2016).

5.1.2 Seabirds

The continental shelf and offshore waters of the South-west corner are habitat for several species of seagulls, shearwaters, terns, petrels and storm-petrels (Surman and Wooler, 2000). The continental islands of the south-west coast also provide important nesting sites for seabirds (Dunlop and Wooler, 1990). The prevalent conditions of the Leeuwin Current strongly influence the reproductive periodicity of the seabirds in the region (Dunlop and Wooler, 1990).

5.2 Benthic Assemblages

The shallow regions (30-70 m) of the park support a typical seagrass (dominated by seasonally variable, perennial *Thalassodendron pachyrhizum*) and macroalgae (dominated by *Ecklonia radiata* and fleshy reds) community with moderate cover (~20-50%; Figure 11). Importantly, there appears to be a difference in seagrass cover (mean ~10%) between the National Park Zone and the Special Purpose Zone to the north (Figure 11). To a lesser extent, hard corals and massive sponges are also present around the shallows of the National Park and Special Purpose Zones of the South-west Corner Marine Park until the consolidated reefal pavement becomes more patchy in ~70-90 m. Here the reef outcrops become interspersed with areas of coarse sandy sediment supporting a variety of communities dominated by a diverse assemblage of black and octocorals, hydroids and bryozoans, which peak in mean cover across depths of 70-120 m (Figures 11 and 12). Some patches of Rhodoliths were also observed in the 40-100 m depths although they appear to be not extensive. In the deeper areas >120 m the substrate was almost exclusively soft sediments dominated by silty mud. The drop camera imagery of these areas indicate sessile benthic organisms are sparse (<0.1% cover) or entirely absent, although the prevalence of some bioturbation suggests the biota here is mainly infaunal (Figures 12 and 13).

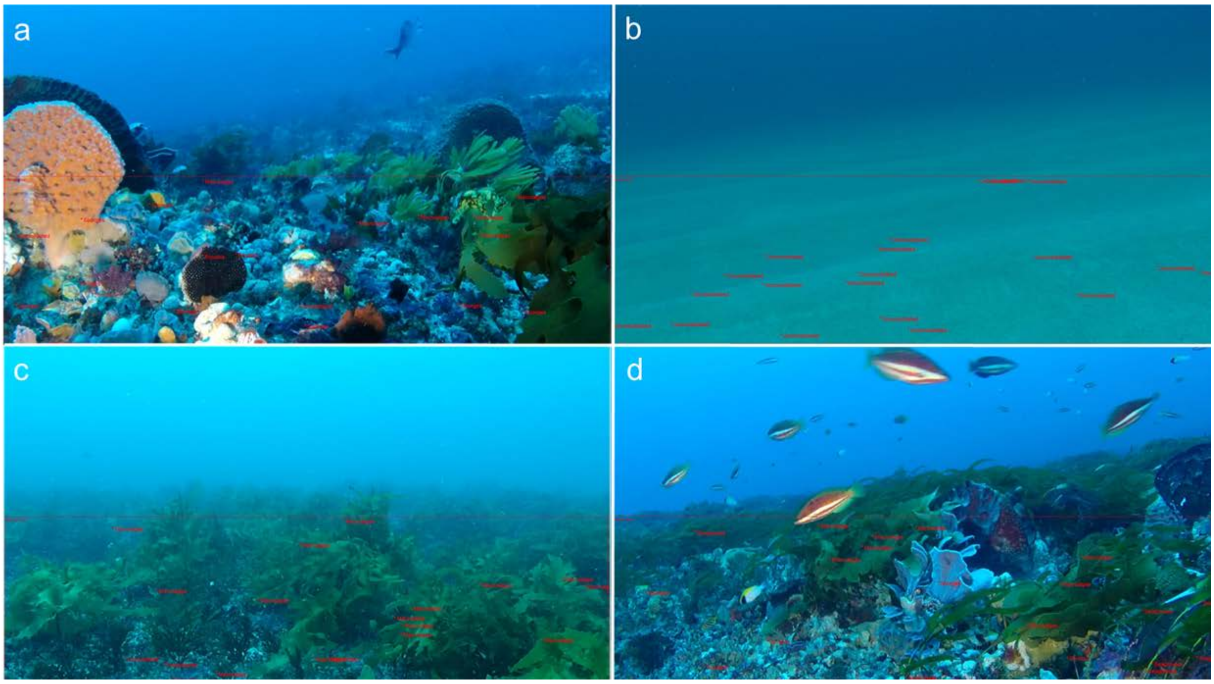

Figure 11. Example of benthic assemblages in the survey area. Mixed communities of sponges, a) macroalgae and bryozoans (b) unconsolidated sediments (c) macroalgae and (d) macroalgae, sponges and seagrasses.

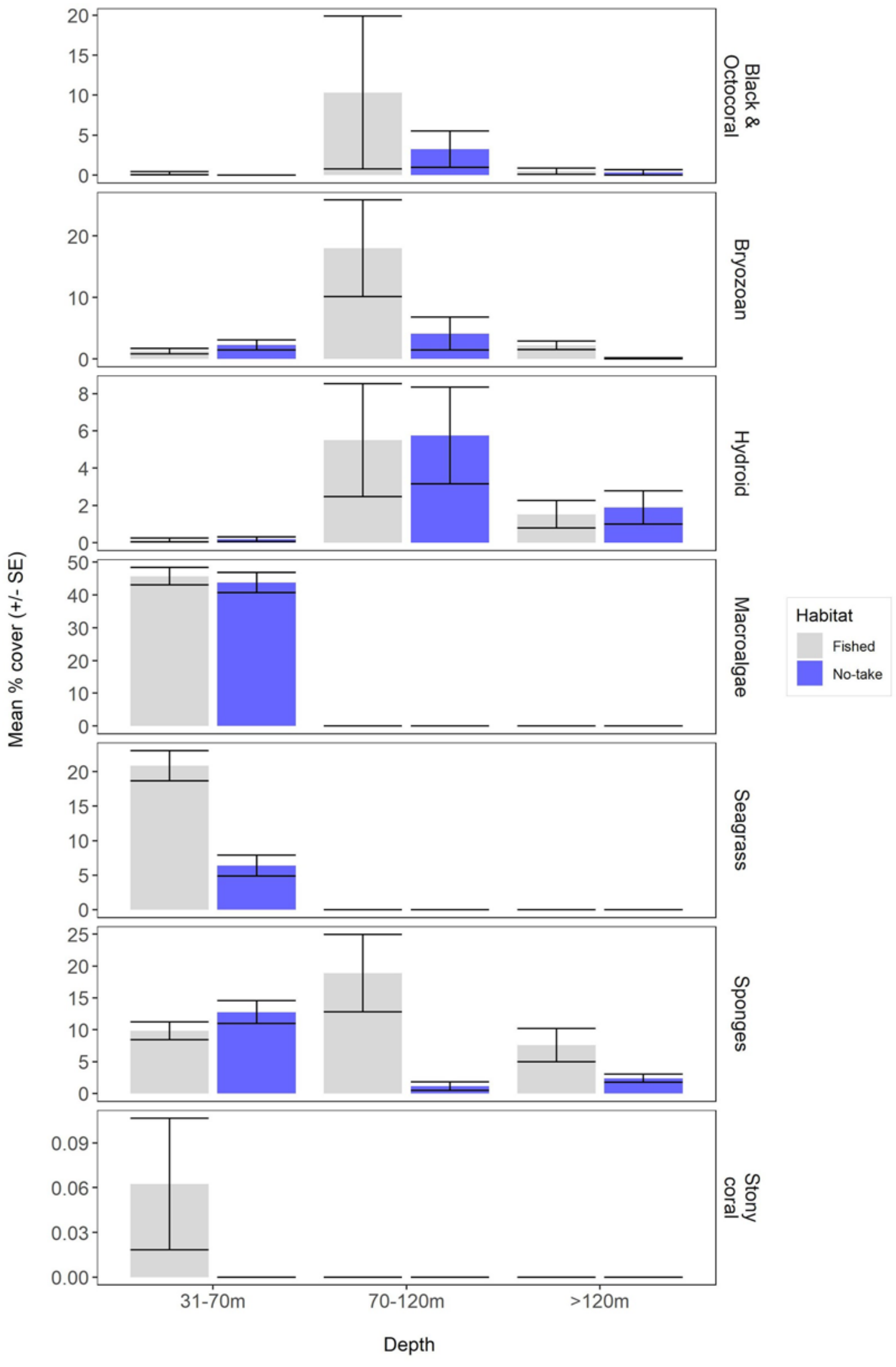

Figure 12. Mean cover of key epibiota groups recorded in stereo-BRUV-dataset. This highlights depth related turnover of benthic assemblages and differences between Special Purpose (fished) and National Park (no-take) Zones.

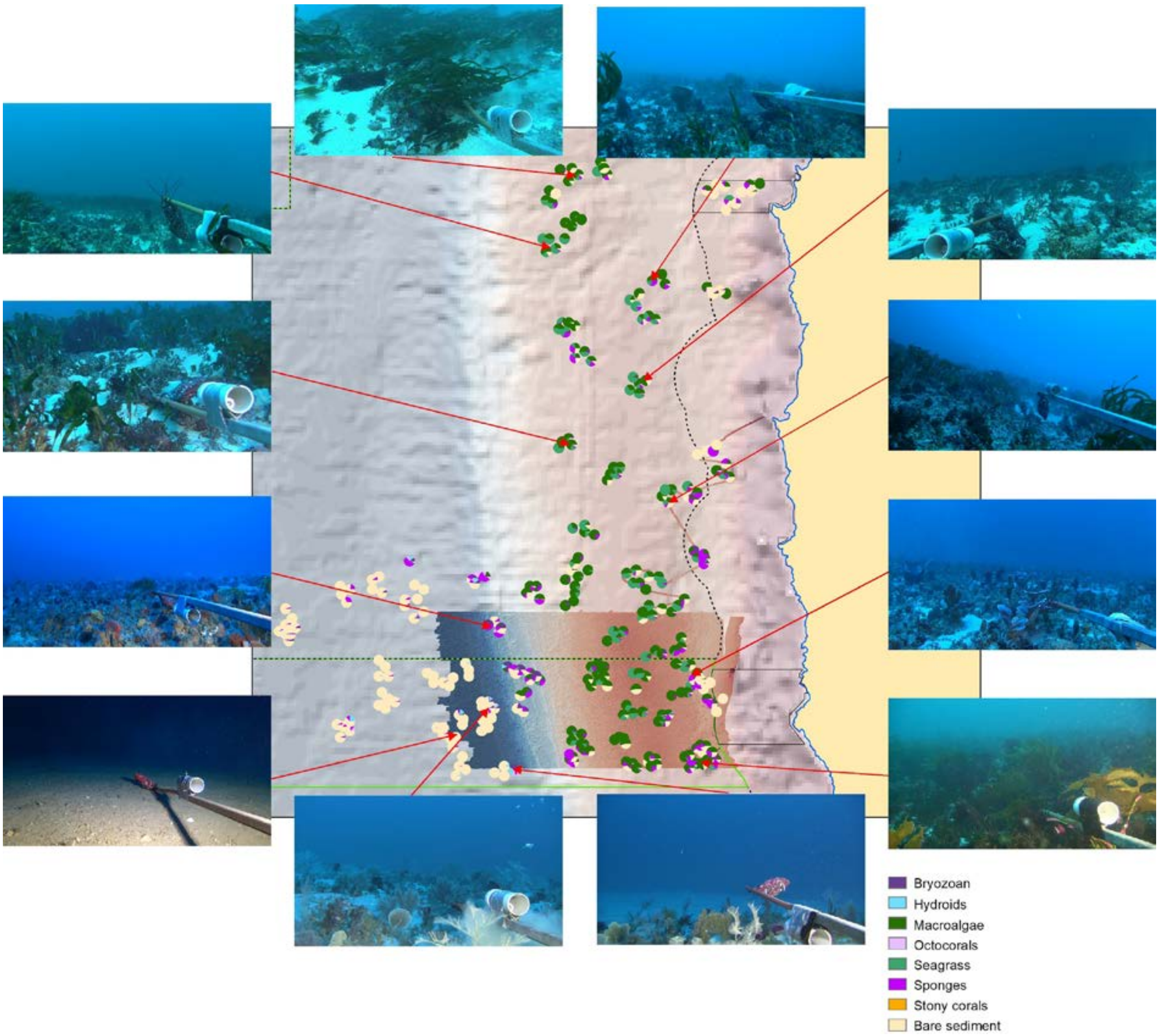

Figure 13. Habitat distribution from stereo-BRUV imagery. Images highlight the Ecklonia radiata dominated isolated reef to the south-east and flat pavement reef interspersed with sand characteristic of the mid-shelf habitat. Deeper ledge habitat supports a diverse filter feeding assemblage dominated by hard bryozoans, hydroids and sponges. Beyond 140 m substates dominated by mud/silt sediment with very sparse epibiota.

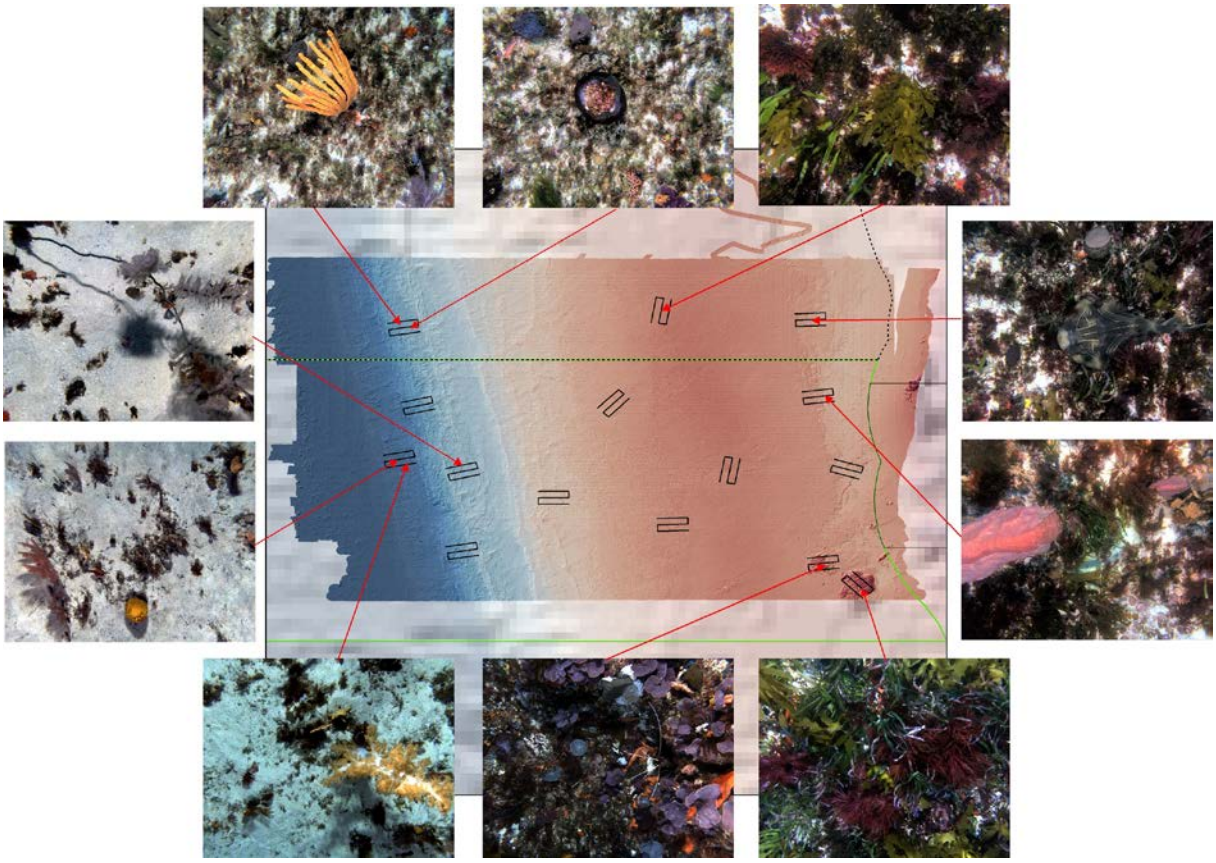

Figure 14. Habitat distribution from AUV imagery. Images highlight similar patterns in epibiota as the drop and stereo-BRUV datasets with macroalgae, stony coral and seagrass dominating shallows to the sparse sessile filter feeding epibiota beds at depth.

5.3 Demersal fish and shark assemblage

The South-west Corner Marine Park provides a variety of important habitats for fish, supporting great abundance and biodiversity. According to Langlois et al., (2021), stereo-BRUV deployments recorded 140 species from 61 families, for a total abundance of 13,901 fish across the stereo-BRUV sampling sites (Figure 12). For these samples, similar fish mean abundance and species richness is reported between Zones (Figure 16), with clear declines at depths >120 m (Langlois et al., 2021) which is likely reflective of a lack of reefal habitat. The three most abundant species in the National Park Zone differed slightly from the Special Purpose Zone (Mining exclusion) (Figure 16). In the National Park Zone Western King wrasse (*Coris auricularis*), slender bullseye (*Parapriacanthus elongatus*) and footballer sweep (*Neatypus obliquus*) were most abundant (Figure 16). Whereas in the Special Purpose Zone (Mining exclusion) Western King wrasse (*Coris auricularis*), footballer sweep (*Neatypus obliquus*) and the maori wrasse (*Ophthalmolepis lineolatus*) were the most abundant species (Figure 16). The three most ubiquitous species were the Western King wrasse (*C. auricularis*), Southern Maori wrasse (*Ophthalmolepis lineolatus*) and the redband wrasse (*Pseudolabrus biserialis*) (Langlois et al., 2021). The Park is also habitat for a number of commercially and economically valuable species, including the West Australian Dhufish, *Glaucosoma hebraicum* (Figure 14a), the Pink snapper, *Chrysophrys auratus* (Figure 14b), the yelloweye nannygai, *Centroberyx australis* (Figure 14c), and Hapuku, *Polyprion oxygeneios* (Figure 14d). Several species of sharks, rays and cuttlefish have been observed inside the South-west Corner Marine Park (Figure 15). Five species observed are ranked as vulnerable by the IUCN, and are the sandbar shark, *Carcharhinus plumbeus*, the Western blue groper, *Achoerodus gouldii*, the bigeye tuna, *Thunnus obesus*, the smooth hammerhead, *Sphyrna zygaena*, and the school shark, *Galeorhinus galeus*.

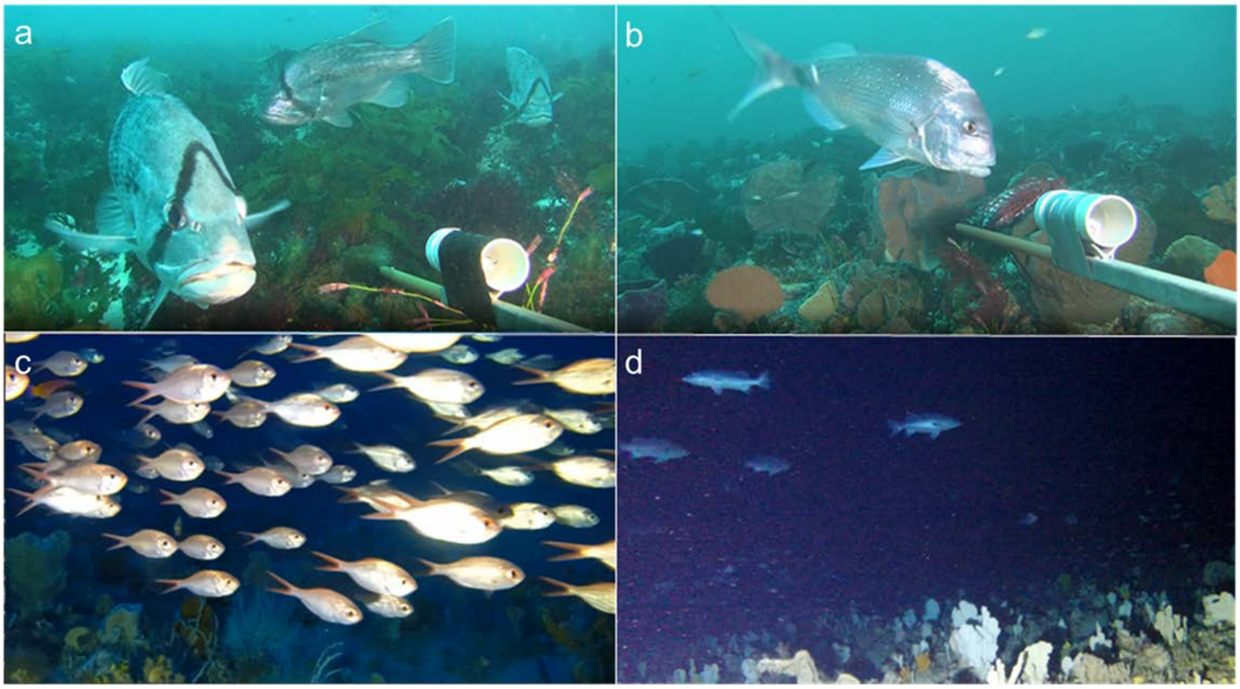

Figure 15. Examples of highly targeted species observe on stereo-BRUV and drop camera deployments. (a) West Australian dhufish (Glaucosoma hebraicum) in 39 m of depth; (b) Pink snapper (Chrysophrys auratus) in 46 m of depth; (c) Swallowtail (Centroberyx lineatus) and yelloweye redfish (Centroberyx australis) in 129m of depth; (d) Hapuku (Polyprion oxygeneios) in 201m of depth on the shelf break at the suspected location of the Mentelle upwelling.

Figure 16. Examples of fish, sharks, rays and other mobile fauna that have been observed within the South-west Corner Marine Park.

Examples of fish, sharks, rays and other mobile fauna that have been observed within the South-west Corner Marine Park. (a) an endemic Horseshoe leatherjacket (Meuschenia hippocrepis, left) and bight redfish (Centroberyx gerrardi). (b) Port Jackson shark (Heterodontus portusjacksoni, front) and pink snapper (Chrysophrys auratus, back). (c) Smooth stingray (Bathytoshia brevicaudata). (d) Curious cuttlefish (Sepia spp.). (e) Harlequin fish (Othos dentex, front) and whiskery shark (Furgaleus macki, back). (f) Smooth hammerhead (Sphyrna zygaena), listed as vulnerable by the IUCN. (g) Woodward's Moray (Gymnothorax woodwardi) attacking the bait bag. (h) a latchet (Pterygotrigla polyommata, right). (i) an endemic common sawshark (Pristiophorus cirratus, right)

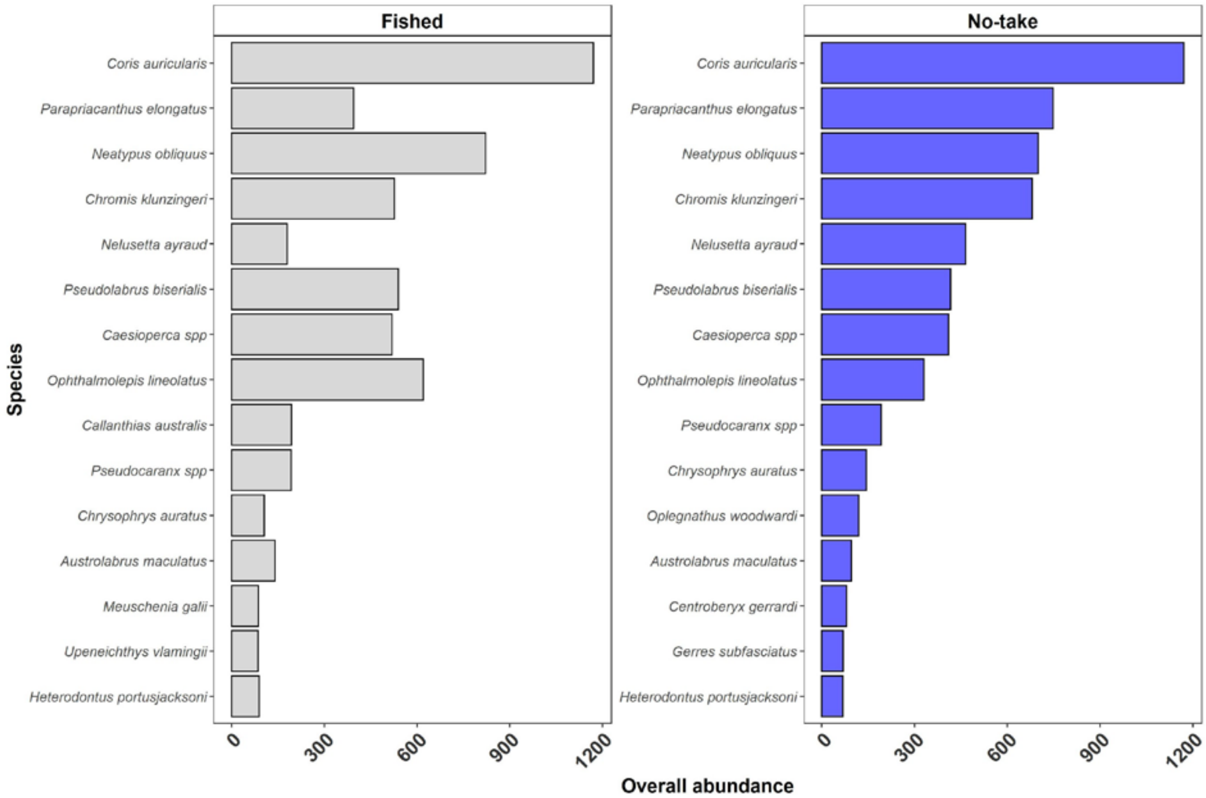

Figure 17. The 15 most abundant fish species observed on the stereo-BRUV deployments. Located in the Special Purpose (fished - grey) and National Park Zones (no-take - blue).

5.3.1 FishNClips

FishNClips, developed by the NESP Marine Biodiversity Hub's Project 'D2: Standard Operating Procedures (SOP) for survey design, condition assessment and trend detection' is a web-service hosted on the NECTAR cloud designed to showcase marine imagery collected to benchmark Australia's marine biodiversity. FishNClips currently displays imagery collected within Geographe Marine Park, the Capes region of the South-west Corner Marine Park and Ningaloo Marine Park (Commonwealth) from existing baited remote underwater stereo-video (stereo-BRUV), Autonomous Underwater Vehicle (AUV) and towed-video surveys, that were conducted according to Hub best practice field manuals.

Landing page

The FishNClips landing page provides an easily navigable spatial interface, where the user can select the marine park to be viewed, and a check-box to select the types of imagery to be displayed (fish highlight clips, habitat imagery or towed video 3-D models, Fig. 17). Clips are indicated by coloured markers on the map and nearby clips are clustered together as indicated by the numerals on the markers.

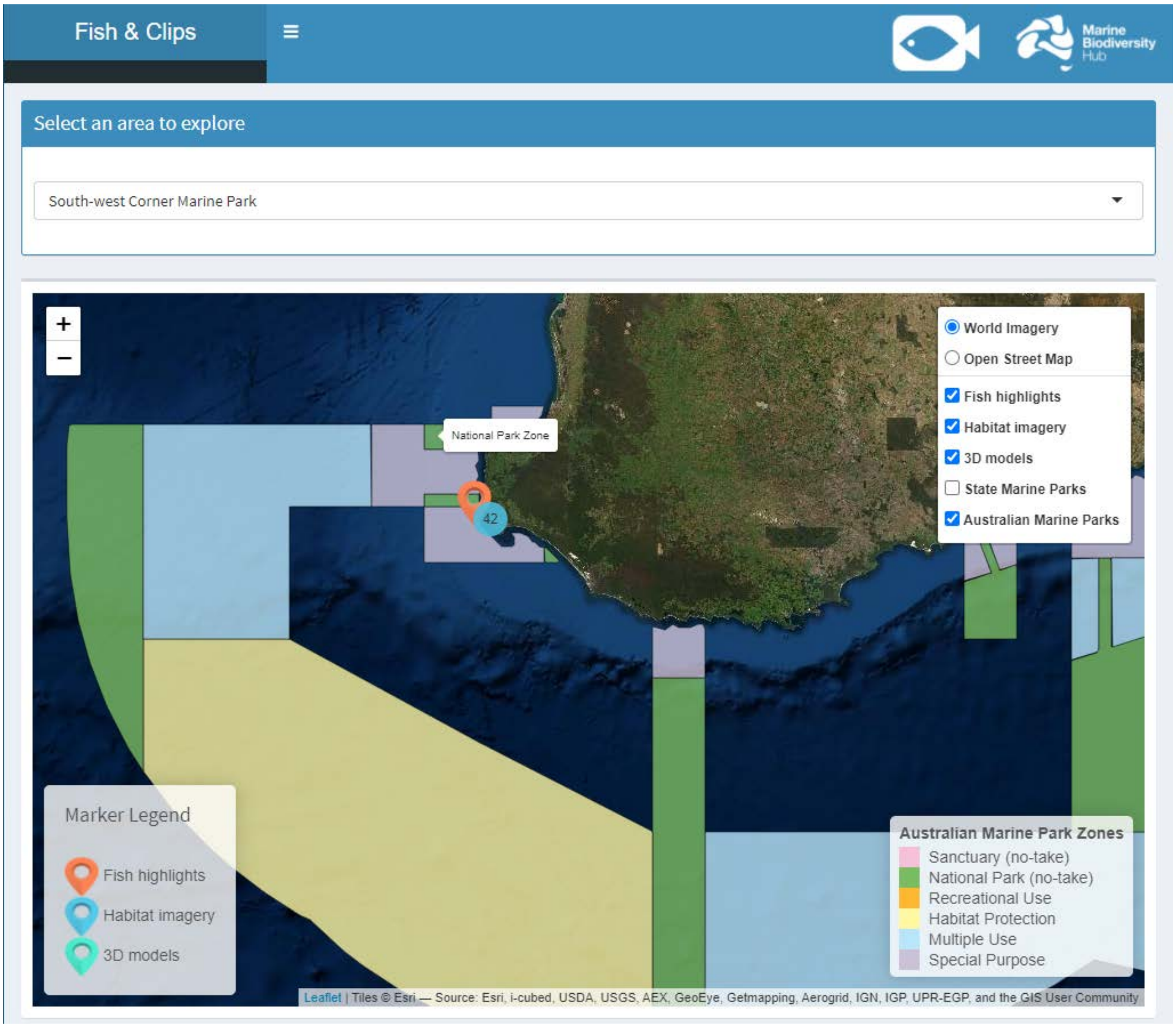

Figure 18. South-west Corner Marine Park viewed in FishnClips
The landing page of the FishNClips platform showing the map South-west Corner Marine Park (top) with its zones (bottom left corner), and the checkbox with the types of imagery available to be displayed (top right corner).

Using FishNClips to view imagery from the South-west Corner Marine Park

Marine park zoning maps for both Australian Marine Park and adjacent State networks can be displayed by selecting the checkbox (Figure 17), to discern which zone the imagery occurs in.

Fish highlight clips are located in the centre of each Australian Marine Park zone (Figure 18). These curated video clips are created using the '*MBH Guide for Producing Science Communication Videos of Video Surveys of Fish and Benthic Assemblages*'. The position of these clips is purposefully not spatially accurate to avoid FishNClips becoming a tool for locating fishing spots. These clips are played by clicking on the orange markers on the map (Figure 18).

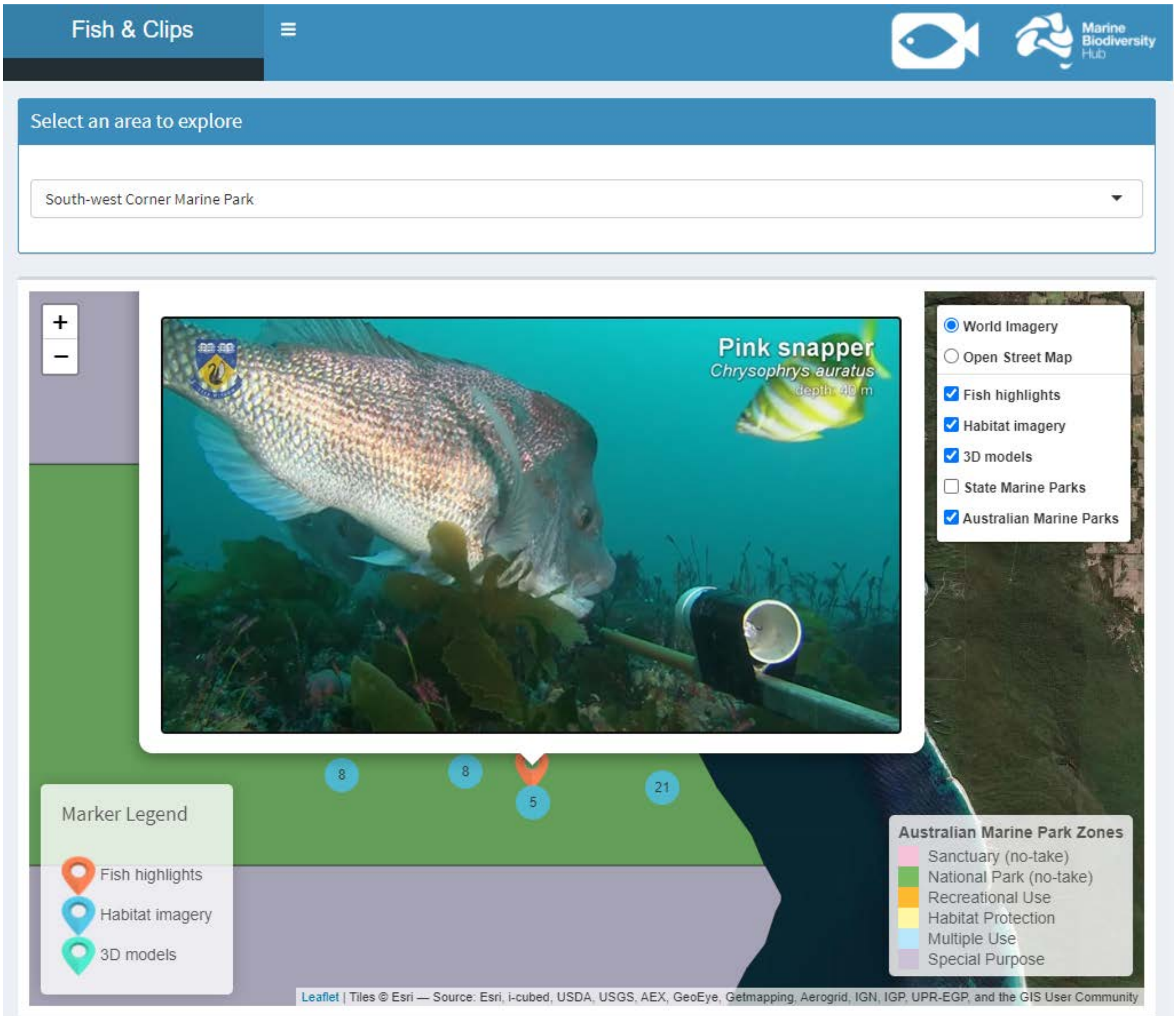

Figure 19. An example of fish highlights (orange markers) from FishNClips
Clips of fish are played by clicking on the orange markers on the map. Habitat clips, from stereo-BRUVs, are displayed spatially providing an immersive science discovery resource (Figure 19). A new habitat clip plays when a blue marker on the map is clicked.

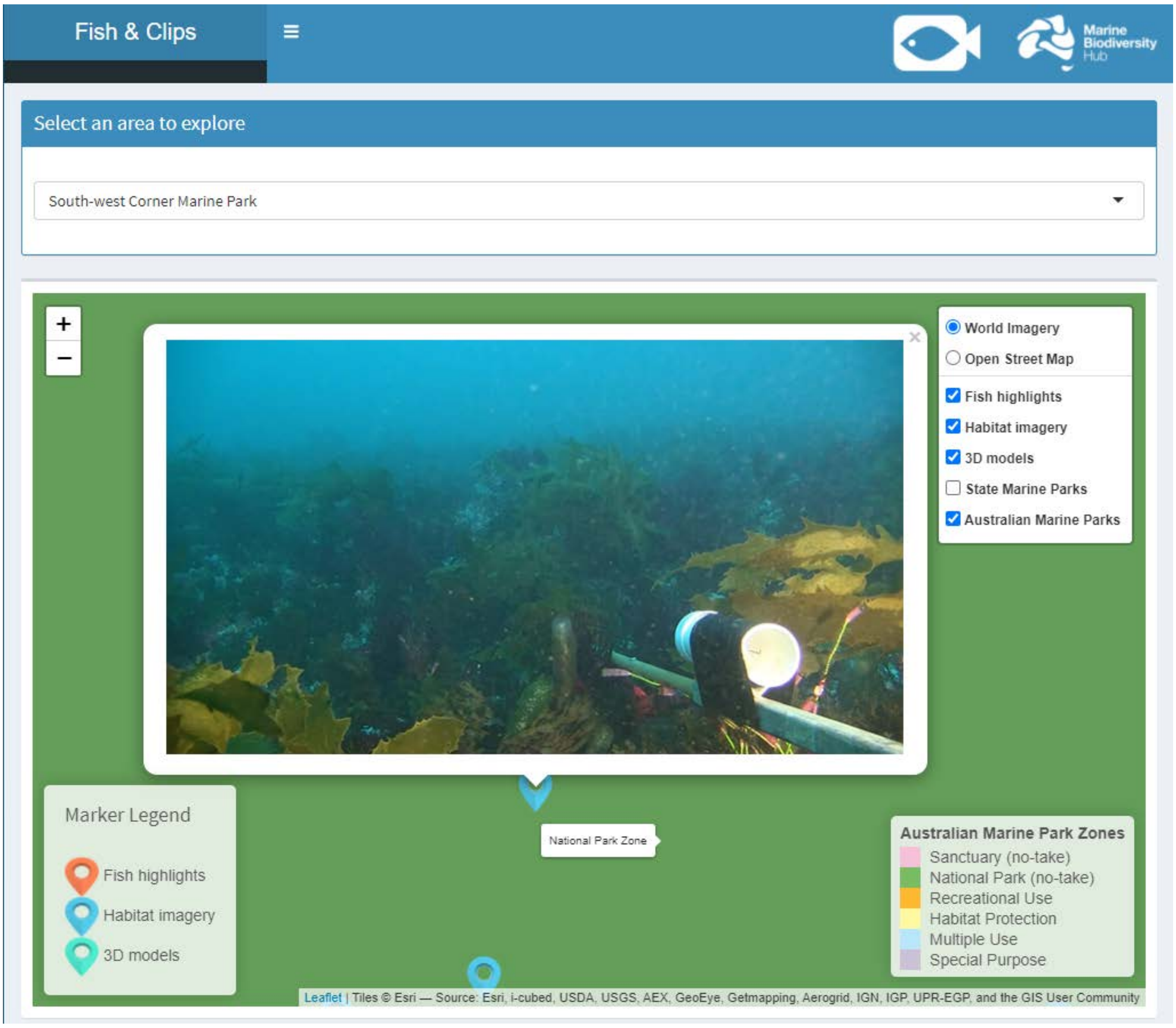

Figure 20. An example of habitat imagery (blue markers) from FishNClips Habitat imagery is seen by clicking the blue markers on the map.

5.3.2 Threatened species

Within the National Park Zone we observed smooth hammerhead (*Sphyrna zygaena*: Figure 15f) listed as vulnerable by the IUCN and currently under assessment through the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act), and found evidence of a potential aggregation site for grey nurse sharks (*Carcharias taurus*). Identification and protection of grey nurse shark aggregation sites is important for conserving this species (Lynch et al., 2013). Although the west coast population of *C. taurus* is listed as Vulnerable under the EPBC Act, the eastern Australian populations of this species are listed as Critically Endangered. Their biennial reproductive cycle and slow population growth make *C. taurus* populations vulnerable to decline (Hoschke & Whisson, 2016). We observed five individuals at one site at a depth of 137 m (Figure 20). To our knowledge this would represent the deepest aggregation site for C. taurus and would represent the second aggregation site identified in the west coast population, with the other site located at the Navy Pier in Exmouth (Hoschke & Whisson, 2016). Although population estimates have been made for the eastern Australian population, there is no such information for the western population reflecting the lack of knowledge and high degree of uncertainty on the status of this subpopulation (Bradford et al. 2018). Repeat surveys of this aggregation are needed to confirm site use on a recurrent basis, and to determine whether this site is used seasonally, or year-round.

Figure 21. A Grey nurse shark (Carcahrias taurus) in the National Park Zone. Imagery taken from a drop camera deployment in 141m.

Figure 22 Aggregation of Hapuka (Polyprion oxygeneios) over sponge gardens on the continental shelf break in the National Park Zone. Imagery taken from a drop camera deployment in 250m.

6. FUTURE WORK AND RECOMMENDATIONS

Due to the interruptions and delays caused by COVID not all data sets were able to be annotated and only exploratory analysis of the processed data was undertaken in the current Eco-narrative

Despite these issues an initial picture of patterns in seabed habitats and demersal fish assemblages within National Park and adjacent Special Purpose Zones is possible. Several small isolated high-profile reefs exist in ~30-50 m depth in the south-east of the National Park Zone, with the majority of mid-shelf habitat consisting of flat pavement reefs interspersed with sand sediments, with both reef types supporting diverse assemblages of macroalgae, seagrass, hard corals and sponges. Further offshore, deeper ledge features, orientated in a north-south direction at ~100m depth, supports a diverse filter feeding assemblage dominated by hard bryozoans, hydroids, black and octocorals, and sponges. From 120-180m substrates are dominated by silty mud sediment with very sparse epibiota, whereas deep sponge gardens are again present on the high relief continental shelf break in 250m within the National Park Zone.

Total abundance and species richness in demersal fish assemblages showed no marked difference between Zones, but clear declines at depths >120m, which is likely reflective of a lack of reefal habitat between 120 and 180m. Some differences in individual species abundance and biomass may be evident between National Park and Special Purpose (Mining exclusion) Zones. A more thorough analysis is required to explore these initiation observations further.

This survey provides an excellent example of multiple extensive data sets collected by Standard Operating Procedures and will provide an excellent case to explore how these data can be used to identify key natural values and potential reporting indicators and metrics to inform Parks Australia's Monitoring Evaluation and Reporting Framework.

We recommend that follow up research should be undertaken to finish the annotation and processing of the data collected in this survey and that the data should then be interrogated and compared with other comparable national datasets, to identify key natural values and develop potential reporting indicators and metrics.

REFERENCES

Benthuysen, J., Oliver, E.C.J., Feng, M., & Marshall, A.G. (2018). Extreme marine warming across tropical Australia during Austral Summer 2015–2016. *Journal of Geophysical Research: Oceans*, 123, 1301-1326.

Brooke, B.P., Nichol, S.L., Huang, Z., Beaman, R. (2017). Palaeoshorelines on the Australian continental shelf: Morphology, sea-level relationship and applications to environmental management and archaeology. *Continental Shelf Research,* 134, 26-38.

Director of National Parks. (2018). South-west Marine Parks Network Management Plan 2018, Director of National Parks, Canberra.

Double, Michael C., Virginia Andrews-Goff, K. Curt S. Jenner, Micheline-Nicole Jenner, Sarah M. Laverick, Trevor A. Branch, and Nicholas J. Gales. (2014). Migratory Movements of Pygmy Blue Whales (Balaenoptera Musculus Brevicauda) between Australia and Indonesia as Revealed by Satellite Telemetry. *PloS One* 9:4, e93578.

Dunlop, J. N., and R. D. Wooler. (1990). The breeding seabirds of southwestern Australia: Trends in Species, Populations and Colonies. *Australasian Bird Reviews* 14, 107–12.

Feng, M., McPhaden, M.J., Xie, S., & Hafner, J. (2013). La Niña forces unprecedented Leeuwin Current warming in 2011. *Scientific Reports*, 3, 01277.

Feng, M., Waite, A., & Thompson, P. (2009). Climate variability and ocean production in the Leeuwin Current system off the west coast of Western Australia. *Journal of the Royal Society of Western Australia*, 92, 67-81.

Gavrilov, Alexander N., Robert D. McCauley, and Jason Gedamke. (2012). Steady Inter and Intra-Annual Decrease in the Vocalization Frequency of Antarctic Blue Whales. *The Journal of the Acoustical Society of America,* 131, 4476–80.

Gersbach, G.H., Pattiaratchi, C., Ivey, G.N., & Cresswell, G.R. (1999). Upwelling on the south-west coast of Australia—source of the Capes Current? *Continental Shelf Research*, 19, 363-400.

Groom, Christine j., Douglas k. Coughran, and Holly c. Smith. (2014). Records of Beaked Whales (family Ziphiidae) in Western Australian Waters. *Marine Biodiversity Records*, 7, 1-13.

Hanson, C.E., Pattiaratchi, C., & Waite, A. (2005). Seasonal production regimes off south-western Australia: influence of the Capes and Leeuwin Currents on phytoplankton dynamics. *Marine and Freshwater Research*, 56, 1011-1026.

Heap, A.D., Harris, P.T. (2008). Geomorphology of the Australian margin and adjacent seafloor. *Australian Journal of Earth Sciences,* 55:4, 555 – 585.

Hearty, P.J., O'Leary, M.J. (2008). Carbonate eolianites, quartz sands and Quaternary sea-level cycles, Western Australia: A chronostratigraphic approach. *Quaternary Geochronology,* 3, 26-55.

Hobday, A.J., Alexander, L.V., Perkins, S.E., Smale, D.A., Straub, S.C., Oliver, E.C.J., Benthuysen, J., Burrows, M.T., Donat, M.G., Feng, M., Holbrook, N.J., Moore, P.J., Scannell, H.A., Gupta, A.S., & Wernberg, T. (2016). A hierarchical approach to defining marine heatwaves. *Progress In Oceanography*, 141, 227-238

Hobday, A.J., Alexander, L.V., Perkins, S.E., Smale, D.A., Straub, S.C., Oliver, E.C.J., Benthuysen, J., Burrows, M.T., Donat, M.G., Feng, M., Holbrook, N.J., Moore, P.J., Scannell, H.A., Gupta, A.S., & Wernberg, T. (2016). A hierarchical approach to defining marine heatwaves. *Progress In Oceanography, 141*, 227-238.

Hobday, A.J., Oliver, E.C.J., Sen Gupta, A., Benthuysen, J., Burrows, M.T., Donat, M.G., Holbrook, N.J., Moore, P.J., Thomsen, M.S., Wernberg, T., & Smale, D.A. (2018). Categorizing and naming marine heatwaves. *Oceanography, 31*, 162-173.

Hoschke, Alexandra M., and Glen J. Whisson. 2016. First Aggregation of Grey Nurse Sharks (Carcharias Taurus) Confirmed in Western Australia. *Marine Biodiversity Records* 9:1, 1–10.

Huang, Z., & Feng, M. (2015). Remotely sensed spatial and temporal variability of the Leeuwin Current using MODIS data. *Remote Sensing of Environment*, 166, 214-232.

Jenner, K. C. S., M. N. M. Jenner, and K. A. McCabe. (2001). Geographical and Temporal Movements of Humpback Whales in Western Australia Waters. *Journal of Australian Petroleum Production & Exploration Association (APPEA),* 41, 749–465.

Johnson, Christopher M., Lynnath E. Beckley, Halina Kobryn, Genevieve E. Johnson, Iain Kerr, and Roger Payne. (2016). Crowdsourcing Modern and Historical Data Identifies Sperm Whale (Physeter Macrocephalus) Habitat Offshore of South-Western Australia. *Frontiers in Marine Science,* 3: 167.

Kendrick, G.W., Wyrwoll, K. H. & Szabo, B.J. (1991). Pliocene-Pleistocene coastal events and history along the western margin of Australia. *Quaternary Science Reviews*, 10, 419-439.

Langlois T., Monk J., Giraldo A., Gibbons B., Adams K., Barrett N., Sims H., Leplastrier H., Boyd, M., Siwabessy J., Nichol S. (2021). South-West Corner Marine Park Post Survey Report. Report to the National Environmental Science Program, Marine Biodiversity Hub. The University of Western Australia. 61pp.

Lipar, M., Webb, J.A. (2014). Middle–late Pleistocene and Holocene chronostratigraphy and climate history of the Tamala Limestone, Cooloongup and Safety Bay Sands, Nambung National Park, southwestern Western Australia. *Australian Journal of Earth Sciences*, 61:8, 1023-1039.

Lynch, Tim P., Robert Harcourt, Graham Edgar, and Neville Barrett. (2013). Conservation of the Critically Endangered Eastern Australian Population of the Grey Nurse Shark (Carcharias Taurus) through Cross-Jurisdictional Management of a Network of Marine-Protected Areas. *Environmental Management,* 52:6, 1341–54.

Pearce, A., & Pattiaratchi, C. (1999). The Capes Current: a summer countercurrent flowing past Cape Leeuwin and Cape Naturaliste, Western Australia. *Continental Shelf Research*, 19, 401-420.

Pearce, A., Slawinski, D., Feng, M., Hutchins, B., & Fearns, P. (2011). Modelling the potential transport of tropical fish larvae in the Leeuwin Current. *Continental Shelf Research*, 31, 2018-2040.

Playford, P.E., 1997. Geology and hydrology of Rottnest Island, Western Australia. In: Vacher, H.L., Quinn, T. (Eds.), Geology and Hydrology of Carbonate Islands, pp. 783–810.

Playford, P.E., Cope, R.N., Cockbain, A.E., Low, G.H., Lowry, D.C. (1975). Phanerozoic, in geology of Western Australia. Western Australia Geological Survey Memoire, 2, 223–433.

Smale, D.A., & Wernberg, T. (2013). Extreme climatic event drives range contraction of a habitat-forming species. *Proceedings of the Royal Society B*, 280: 20122829.

Surman, C. A., and R. D. Wooler. (2000). Seabirds off the South-Western Coast of Australia. *The Emu* 100, 312–17.

Waite, A.M., Pesant, S., Griffin, D.A., Thompson, P.A., & Holl, C.M. (2007). Oceanography, primary production and dissolved inorganic nitrogen uptake in two Leeuwin Current eddies. *Deep Sea Research Part II: Topical Studies in Oceanography*, 54, 981-1002.

Wernberg, T., Smale, D.A., Tuya, F., Thomsen, M.S., Langlois, T.J., de Bettignies, T., Bennett, S., & Rousseaux, C.S. (2013). An extreme climatic event alters marine ecosystem structure in a global biodiversity hotspot. *Nature Climate Change*, 3, 78-82.

Wijffels, S.E., Beggs, H., Griffin, C., Middleton, J.F., Cahill, M., King, E., Jones, E., Feng, M., Benthuysen, J.A., Steinberg, C.R., & Sutton, P. (2018). A fine spatial-scale sea surface temperature atlas of the Australian regional seas (SSTAARS): Seasonal variability and trends around Australasia and New Zealand revisited. Journal of Marine Systems, 187, 156-196.

Wilde, S.A., Nelson, D.R. (2001). Geology of the Western Yilgarn Craton and Leeuwin Complex, Western Australia – A Field Guide. Geological Survey of Western Australia Record 2001/15, 47 pp.

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