Marine Biodiversity Hub

National Environmental Science Programme

Biological and habitat feature descriptions for the continental shelves of Australia's temperate-water marine parks - including collation of existing mapping in all AMPs

Jacquomo Monk, Joel Williams, Neville Barrett, Alan Jordan, Vanessa Lucieer, Franzis Althaus, Scott Nichol

Project D3 - Evaluating and monitoring the status of marine biodiversity assets on the continental shelf

December 2017

Milestone 4 – Research Plan v2 (2016)

UNIVERSITY of TASMANIA

CSIRO

NSW GOVERNMENT Department of Primary Industries

Australian Government Geoscience Australia

ISBN: 978-1-925646-14-6

Enquiries should be addressed to:
Dr Jacquomo Monk
jacquomo.monk@utas.edu.au

Dr Neville Barrett
neville.barrett@utas.edu.au

Distribution list

DoEE- Parks Australia (CMRs)	Amanda Parr Jason Mundy Cath Sampson
DoEE- Parks Australia-SE CMR management	Hilary Schofield John Lloyd
DoEE- Regional Marine Planning	Jillian Grayson /Amelia Tandy
DoEE SoE reporting.	Boon Lim
Department of Environment and Energy – Biodiversity Conservation Division – Biodiversity Policy Section	Tia Stevens Gavin Hinten
Department of Environment and Energy – Biodiversity Conservation Division – Reef Trust	Kevin Gale Ingrid Cripps
AFMA	Yvonne Zunic/Beth Gibson
NOPSEMA	Christine Lamont/Cameron Sim

Preferred Citation

Monk J, Williams J, Barrett N, Jordan A, Lucieer V, Althaus F, Nichol S (2017). *Biological and habitat feature descriptions for the continental shelves of Australia's temperate-water marine parks- including collation of existing mapping in all AMPs.* Report to the National Environmental Science Programme, Marine Biodiversity Hub. *Institute of Marine and Antarctic Studies, University of Tasmania.*

Copyright

Acknowledgement

This work was undertaken for the Marine Biodiversity Hub, a collaborative partnership supported through funding from the Australian Government's National Environmental Science Programme (NESP). NESP Marine Biodiversity Hub partners include the University of Tasmania, CSIRO, Geoscience Australia, Australian Institute of Marine Science, Museum Victoria, Charles Darwin University, the University of Western Australia, Integrated Marine Observing System, NSW Office of Environment and Heritage, NSW Department of Primary Industries.

Important Disclaimer

Contents

List of Figures

List of Tables

EXECUTIVE SUMMARY

Understanding the distribution of reef habitats and associated biota on the continental shelf is important for managing Australia's Marine Park (AMP) network. This is because reef habitats on the continental shelf are highly productive when compared abysal habitats, and are often subjected to disproportionate pressures from fishing, oil and gas and shipping sectors. This report documents the collation, synthesis and location of publically available datasets describing the distribution of reef habitats and associated sessile and mobile biota on the continental shelf regions of AMPs in the Temperate east, South-east, and South-west marine planning regions. Additionaly, this project has also been the identification of key gaps in our understanding of the physical mapping and sampling of reef-affiliated biota to assist in the prioritisation of future research programmes.

The collation of fine-scale reef mapping data (i.e. multibeam sonar) was restricted to the continental shelf regions of both temperate and tropical water AMPs. We found that, with the exception of Lord Howe (100 %), Cod Grounds (98 %), Perth Canyon (65 %) and Tasman Fracture (48 %) AMPs, most continental shelf regions of the remaining 54 AMPs assessed in this report had < 25 % mapping coverage. Importantly, Boags, Cartier Island and Central Eastern AMPs had no fine-scale mapping.

The report provides an updated description of reef-affiliated seabed biota in many of the AMPs within the Temperate east, South-east and South-west marine planning regions. We focused on temperate water AMPs as the tropical AMPs have been fairly were covered by the North-west Atlas (http://northwestatlas.org/nwa), Great Barrier Reef Marine Park Authority (http://www.gbrmpa.gov.au/) and Ceccarelli (2011; Coral Sea). In undertaking this process we found that 12 of the 36 temperate water AMPs assessd had no scientific sampling of seabed reef-affiliated biota, including: Boags, Bremer, Central Eastern, Eastern Recherche, Hunter, Jervis, Jurien, Murray, Southern Kangaroo Island, Twilight and Western Kangaroo Island AMPs. Interestingly, most of our understanding of reef-affiliated sessile seabed biota comes from, often limited, towed video transects undertaken by CSIRO and others, which were done for purposes often related to defining fisheries habitat prior to the the establishment of the AMP boundaries.

While the Autonomous Underwater Vehicle (AUV) has been adopted as a standard tool for quantifying sessile seabed biota, only Beagle, Geographe, Huon, Flinders, Freycinet and Tasman Fracture AMPs have existing AUV transects. In the context of informing national State of Environment Reporting, the lack of AUV transects in the AMPs along most of the southern and western coastline of mainland Australia was identified as a significant gap in the national AUV monitoring programme.

We identified datasets for reef-affiliated demersal fishes (and in some instances mobile invertebrate fauna such as southern rock lobster). A revised description of reef-affiliated demersal fishes for all except two (i.e. Central Eastern and Jervis AMPs) of the continental shelf regions within the Temperate east marine planning region was completed. In the South-

east marine planning region, we were able to identify datasets on reef-affiliated demersal fish for just over half of the AMPs, with AMPs in Bass Strait generally being the least sampled. Similarly, in the South-west marine planning region, we have identified a number of baited remote underwater video datasets collected by Department of Primary Industries and Regional Development (formally Department of Fisheries), consultants and university researchers describing the reef-affiliated fish assemblages for more than half of the AMPs. Unfortunately, we have been unable to access some of these data in the timeframe of this project, but is likely to be available in Global Archive (http://globalarchive.org/) towards the end of 2017. As a result, detailed descriptions of the reef-fish biota in the South-west AMPs has yet to be as comprehensively undertaken as their South-east and Temperate east counterparts. Importantly, we have identified a number of AMPs with no sampling for reef-affiliated fishes, these include; Apollo, Boags, Central Eastern, Great Australian Bight, Huon, Jervis, Jurien, Murat, Murray, Southern Kangaroo Island, Two Rocks, Western Kangaroo Island and Zeehan AMPs. It should also be noted that very little fish data is available for the Beagle AMP. Our current understanding comes from four exploratory BRUV deployments and animal-borne cameras deployed from 2008-2012 by Prof. John Arnould (Deakin University), with the latter representing a non-standardised means of fish data collection.

In addition to the updated descriptions and identified sampling gaps, we have been able to evaluate and improve the comprehensiveness of online data portals such as CSIROs Australian Region MArine Data Aggregation (ARMADA). For example, the ARMADA platform now contains the ability to summarise physical and biological datasets from geoservers around Australia by AMPs and proposed zones. Further, the data collected is assisting in the development of new interactive data portals such SeaMap Australia, GlobalArchive and Squidle + that are currently in beta testing phase, with the latter two providing a mechanism to lodge, explore and download unprocessed and processed baited remote underwater stereo video cameras (stereo BRUVs) and AUV imagery. These online data portals will improve the discovery of these datasets via links to the AODN, and set the stage for automated image processing that is being developed internationally. Ultimately, this project has improved access to mapping and biological datasets that will better inform the fishing, research and management communities.

1. INTRODUCTION

The Australian Government manages an estate of marine protected areas known as Australian Marine Parks (AMPs) that were expanded or added to in 2012 under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act).

Within the network, 60 AMPs have been established covering representative areas in each of the seven marine planning regions, including North-west, North, Coral Sea, Temperate east, South-east, South-west and Heard Island and McDonald Islands (Figure 1). These AMPs cover ~ 2.8 million km^2, and extend from the outer limits of the state and territories coastal waters (3 nm) to the outer limit of Australia's Exclusive Economic Zone (200 nm).

While these AMPs cover only a small proportion of continental shelf habitats, it is important to understand the distribution of reef habitats and associated biota for the management of AMP network. This is because reef habitats on the continental shelf harbour a wealth of biodiversity (Gray 1997), provide valuable ecosystem services to humans (Barbier et al. 2011), and, accordingly, subjected to disproportionate pressures from fishing, oil and gas and shipping sectors (Halpern et al. 2008).

Over the past decade, researchers within the Marine Biodiversity Hub funded through the Australian Government's CERF, NERP and now NESP initiatives have undertaken a number of mapping and biodiversity sampling exercises targeted at reef-habitats within the AMPs. Additional research has been undertaken by organisations such as universities, oil and gas industry, consultants, Museums and CSIRO outside the Marine Biodiversity Hub within some of these AMPs, often before 2012.

To date, the synthesis of much of AMP-related research has mainly focused on the tropical marine planning regions via the North-west Atlas (http://northwestatlas.org/nwa), the Great Barrier Reef Marine Park Authority (http://www.gbrmpa.gov.au/), and the Coral Sea (Ceccarelli, 2011). Accordingly, this report specifically focuses on the reef-habitats and associated biota in the three temperate-water marine planning regions of Temperate east, South-east and South-west where such a synthesis is yet to be undertaken.

This report identifies and synthesises the mapping and biological sampling data available for reef habitats on the continental shelf regions within the temperate-water AMPs. For the purpose of this report, we define continental shelf as any regions in < 200 m water depth, which includes shelf regions around Lord Howe Island and Norfolk Island. Where sufficient coverage in multibeam echosounder (MBES) data was identified, the geoform classification scheme developed by Nichol et al. (2016) was used to annotate reef features.

While the focus of this report was on AMPs covering the temperate marine planning regions of Australia, it also presents the existing fine-scale reef mapping data collated as a part of the *Project D3 - evaluating and monitoring the status of marine biodiversity assets on the continental shelf* (Lucieer et al. 2017). This collation of mapping covers both temperate- (Appendix A) and tropical water AMPs (Appendix B).

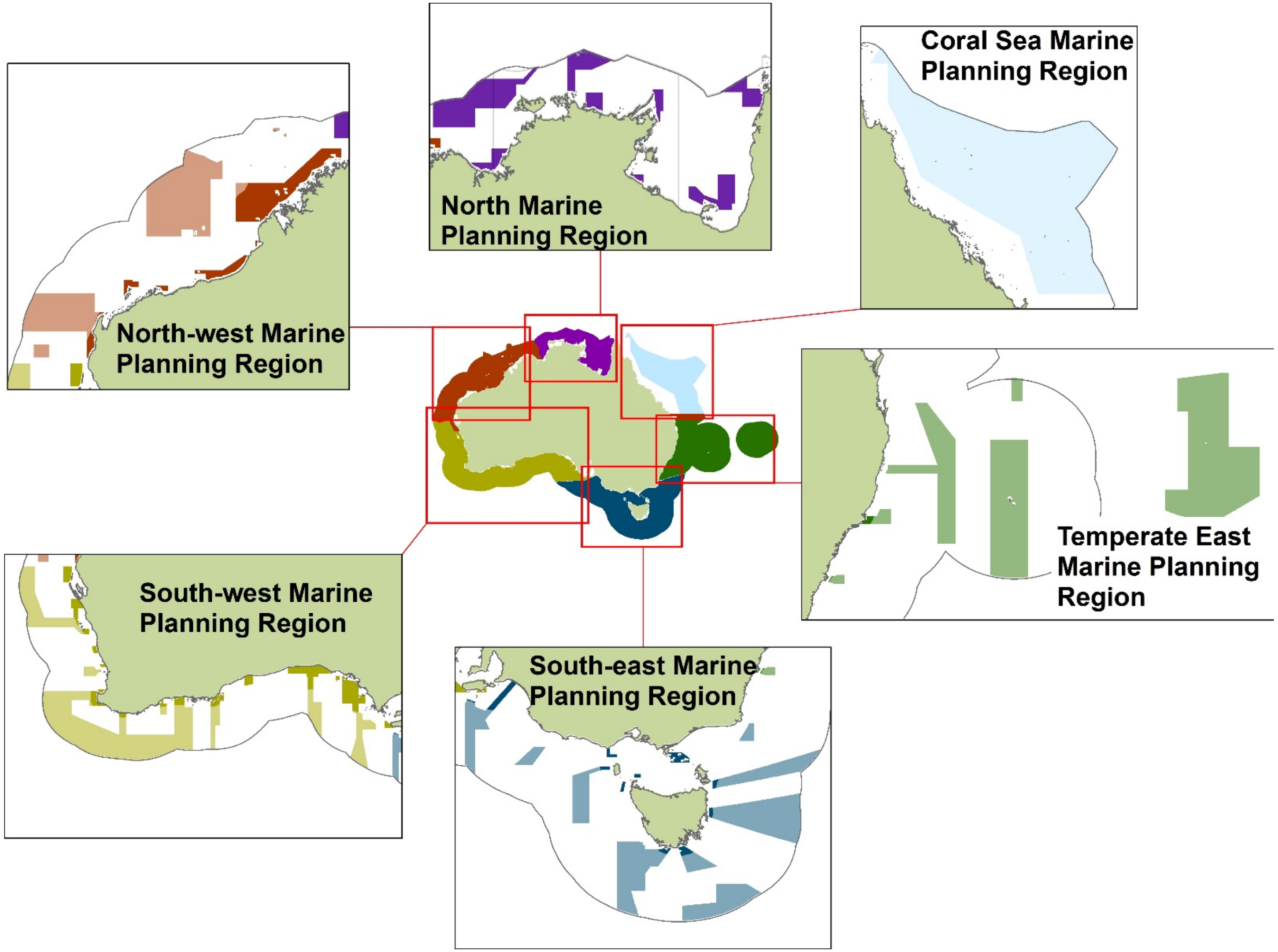


Figure 1. Overview of the Australian Marine Parks in the six of the seven commonwealth marine planning regions (MPR). Insert boxes show AMPs with shelf regions shown in darker colours. Note also Macquarie Island (in the South-east marine planning region) and Heard and MacDonald Islands AMPs are not shown on map.

2. TEMPERATE EAST MARINE PLANNING REGION

2.1 Overview

The Temperate east marine planning region includes eight reserves and covers 383,352 km^2 of marine waters from the southern most extent of the Great Barrier Reef Marine Park (GBRMP), approximately 40 km north of Bundaberg in Queensland, to offshore Jervis Bay in southern New South Wales (NSW) as well as the waters surrounding Lord Howe Island and Norfolk Island (Figure 2).

Of the eight AMPs within the Temperate east marine planning region, seven contain continental shelf waters. These include the Central Eastern, Cod Grounds, Hunter, Jervis, Lord Howe, Norfolk Island and Solitary Islands AMPs (Table 1).

While there are six proposed zones within the Temperate east marine planning region, only four of these: Habitat Protection, Marine National Park, Multiple Use and Special Purpose Zones, pertain to the continental shelf regions of the AMPs (Table 2). The proposed Multiple Use and Special Purpose Zones are the largest zoning on the continental shelf regions within the network, covering 1,680 km^2 and 1,474 km^2, respectively (Table 2). The remaing two zones cover a combined 321 km^2 (Table 2). The AMP management plans are yet to be finalised for these AMPs, and thus the zoning currently proposed may be subject to change.

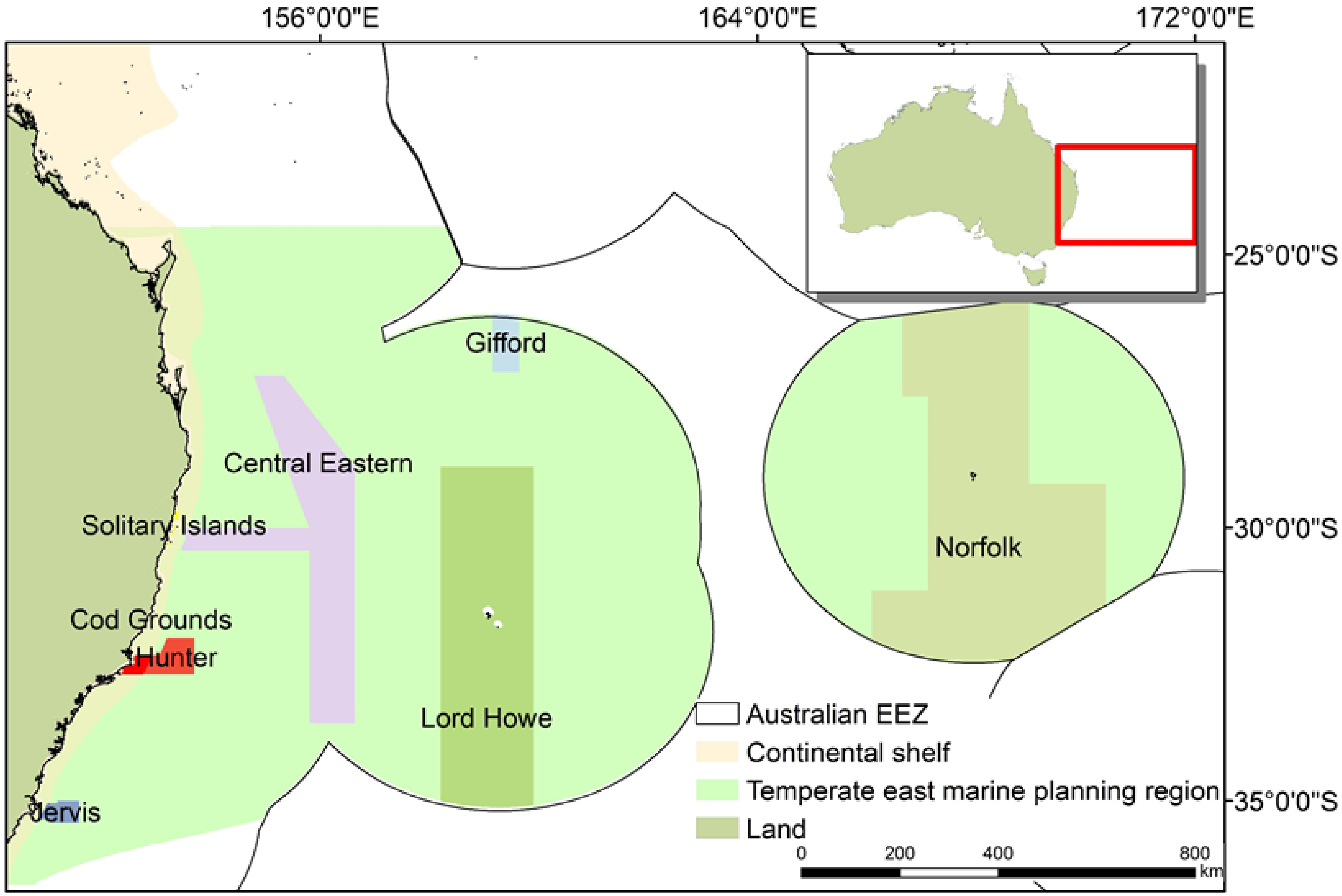


Figure 2. Location of the AMPs within the Temperate east marine planning region.

Table 1. Total coverage (km^2) for each AMP and area represented on the continental shelf in the Temperate east marine planning region.

AMP	Total area (km^2)	Area on shelf (km^2)	Percentage (%)
Central Eastern	70,054	346	0.5
Cod Grounds	4	4	100
Gifford	5,829	0	0
Hunter	6,857	1307	19
Jervis	2,473	103	4
Lord Howe	110,139	447	0.4
Norfolk	188,144	161	0.1
Solitary Islands	152	152	100
Total	*383,352*	*3215*	*0.8*

Table 2: A summary of the area (km^2) of each proposed protection zone within continental shelf region of each AMP in the Temperate east marine planning region.

AMP	Habitat Protection Zone	Marine National Park Zone	Multiple Use Zone	Special Purpose Zone
Central Eastern	0	0	2	0
Cod Grounds	0	4	0	0
Hunter	0	0	0	1,269
Jervis	0	0	0	93
Lord Howe	257	58	0	0
Norfolk	0	0	1,641	0
Solitary Islands	1	1	36	112
Total	*258*	63	*1,680*	*1,474*

2.2 List of publications for AMPs in the Temperate east marine planning region

A total of 37 publications was identified that pertain to the AMPs in the Temperate east marine planning region. Lord Howe AMP had the most information available with 20 publictions, with Solitary Islands, Norfolk and Cod Grounds having eight, four and three publications, respectively. Bibliographic details and web links are provided in Table 3.

Table 3: List of publications containing biological sampling of continental shelf reef-habitats in AMPs for Temperate east marine planning region.

AMP	Date	Authors	Title	URL
Cod Grounds	2011	Jordan A, Davies P, Ingleton T, Foulsham E, Neilson J, Pritchard T.	Seabed habitat mapping of the continental shelf of NSW	http://www.environment.nsw.gov.au/research/SeabedHabMap.htm
	2008	Davies P, Ingleton T, Neilson J, Mesley E, Jordan A, Gardiner R, Pritchard T	HABMAP Cod Grounds Commonwealth Marine Reserve swath survey and habitat classification	https://www.environment.gov.au/system/files/resources/4a9cdf71-6e22-4878-a70f-0136daef21ad/files/cod-grounds-swath-survey.pdf
	2003	Otway NM, Burke AL, Morrison NS., Parker PC	Monitoring and identification of NSW critical habitat sites for conservation of grey nurse sharks.	http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0006/545631/FFRS-47_Otway-et-al-2003.pdf
Hunter	2016	Davies P, Ingleton T, Jordan A, Barrett N	Mapping Shelf Rocky Reef Habitats in the Hunter Commonwealth Marine Reserve	https://www.nespmarine.edu.au/document/mapping-shelf-rocky-reef-habitats-hunter-commonwealth-marine-reserve
Lord Howe	2016	Linklater M	Past and present coral distribution at the latitudinal limit of reef development, southwest Pacific Ocean	http://ro.uow.edu.au/theses/4684
	2016	Linklater M, Carroll AG, Hamylton SM, Jordan AR, Brooke BP, Nichol SL, Woodroffe C D	High coral cover on a mesophotic, subtropical island platform at the limits of coral reef growth	http://www.sciencedirect.com/science/article/pii/S0278434316304277
	2015	Linklater M, Brooke BP, Hamylton SM, Nichol SL, Woodroffe CD	Submerged fossil reefs discovered beyond the limit of modern reef growth in the Pacific Ocean	http://ro.uow.edu.au/cgi/viewcontent.cgi?article=3985&context=smhpapers

AMP	Date	Authors	Title	URL
	2014	Hoey AS, Pratchett MS, Johansen J, Hoey J	2014 Marine ecological survey of Elizabeth and Middleton reefs, Lord Howe Commonwealth Marine Reserve	https://www.environment.gov.au/system/files/pages/c88b8428-662f-4d9e-bbd2-165493df813c/files/2014-marine-ecological-survey-elizabeth-and-middleton-reefs.pdf
	2011	Pratchett MS, Hobbs JA, Hoey AS, Baird AH, Ayling AM, Gudge S, Choat HJ	Elizabeth and Middleton Reefs Marine National Nature Reserve, Marine Survey 2011	http://www.environment.gov.au/system/files/pages/c88b8428-662f-4d9e-bbd2-165493df813c/files/2011-marine-survey-elizabeth-and-middleton-reefs.pdf
	2008	Hobbs JPA, Choat JH, Robbins WD, van Herwerden L, Feary DA	Unique fish assemblages at world's southernmost oceanic coral reefs, Elizabeth and Middleton Reefs, Tasman Sea, Australia	http://researchonline.jcu.edu.au/24906/
	2008	van Herwerden L, Almojil D, Choat H	Population genetic structure of Australian Galapagos reef sharks *Carcharhinus galapagensis* at Elizabeth and Middleton Reefs Marine National Reserve and Lord Howe Island Marine Park	https://www.environment.gov.au/system/files/resources/4eb48ca1-e394-4032-a4a8-bca31ea1ed20/files/elizabeth-galapagos-shark.pdf
	2007	Heagney EC, Lynch T P, Babcock RC, Suthers IM	Pelagic fish assemblages assessed using mid-water baited video: standardising fish counts using bait plume size	http://www.jstor.org/stable/24872095?seq=1#page_scan_tab_contents
	2006	Choat JH, Herwerden L, Robbins WD, Hobbs JP	A report on the ecological surveys undertaken at Middleton and Elizabeth Reefs, February 2006	
	2005	Woodroffe CD, Dickson ME, Brooke BP, Kennedy DM	Episodes of reef growth at Lord Howe Island, the southernmost reef in the south-west Pacific	http://www.sciencedirect.com/science/article/pii/S0921818105001700
	2004	Oxley WG, Ayling AM, Cheal AJ, Osborne K	Marine surveys undertaken in the Elizabeth and Middleton Marine National Nature Reserve, December 2003	

AMP	Date	Authors	Title	URL
	2004	Speare P, Cappo M, Rees M, Brownlie J, Oxley W	Deeper water fishes and benthic surveys in the Lord Howe Island Marine Park (Commonwealth Waters): February 2005	Australian Institute of Marine Science
	1998	Harriott VJ	Preliminary report on the status of corals and crown-of-thorns starfish at Middleton Reef	Report to Environment Australia
	1992	Australian Museum	Reef Biology- A survey of Elizabeth and Middleton Reefs, South Pacific	Australian National Parks and Wildlife Service Publication
	1993	Francis MP	Checklist of the coastal fishes of Lord Howe, Norfolk, and Kermadec islands, south-west Pacific Ocean	https://scholarspace.manoa.hawaii.edu/handle/10125/1755
	1993	Francis MP, Randell JE	Further additions to the fish faunas of Lord Howe and Norfolk islands, south-west Pacific Ocean	https://scholarspace.manoa.hawaii.edu/handle/10125/1754
	1991	Francis MP	Additions to the fish faunas of Lord Howe, Norfolk, and Kermadec islands, south-west Pacific Ocean	https://scholarspace.manoa.hawaii.edu/handle/10125/520
	1981	Ponder WF	'Marine mollusca', in HF Recher and WF Ponder (eds) Lord Howe Island: a summary of current and projected scientific and environmental activities	
	1976	Allen GR, Hoese DF, Paxton JR, Randall JE, Russell BC, Starck WA, Talbot FH, Whitley GP	Annotated checklist of the fishes of Lord Howe Island	https://australianmuseum.net.au/uploads/journals/17505/287_complete.pdf
	1974	Allen GR, Paxton JR	A tropical outpost in the Pacific	https://australianmuseum.net.au/uploads/documents/36295/ams370_vxviii_02_lowres.pdf
Norfolk	2016	Francis MP, Harasti D, Malcolm HA	Surviving under pressure and protection: a review of the biology, ecology and population status of the highly vulnerable grouper *Epinephelus daemelii*	http://www.publish.csiro.au/mf/mf15099

AMP	Date	Authors	Title	URL
	2010	Australian Fisheries Management Authority	2006-2009 Data Summary Norfolk Island Inshore Fishery	http://www.afma.gov.au/wp-content/uploads/2014/02/2006-2009-Data-Summary-Norfolk-Island-Inshore-Fishery.pdf
	2006	Williams A, Althaus F, Furlani D	Assessment of the conservation values of the Norfolk Seamounts area: A component of the Commonwealth marine conservation assessment program 2002-2004	https://www.environment.gov.au/system/files/resources/c446eb8c-67a9-45e9-a6c3-9e7f8a8a2b33/files/norfolk-seamounts.pdf
	2006	Williams A, Althaus F, Gowlett-Holmes K	Biodiversity survey of seamounts and slopes of the Norfolk Ridge and Lowe Howe Rise	http://www.environment.gov.au/apps/coasts/discovery/publications/norfanz-voyage-report.html
	1993	Francis MP	Checklist of the coastal fishes of Lord Howe, Norfolk, and Kermadec Islands, Southwest Pacific Ocean	https://scholarspace.manoa.hawaii.edu/handle/10125/1755
Solitary Islands	2016	Althaus F, Barrett N, Dambacher JM, Davies P, Ferrari R, Ford J, Hayes KR, Hill N, Hosack G, Hovey R, Huang Z, Hulls J, Ingleton T, Jordan A, Kendrick G, Kool J, Lawrence E, Leeming R, Lucieer V, Malcolm H, Meyer L, Monk J Nichol S, Peel D, Perkins N, Siwabessy J Sherlock M, Martin T, Tran SM, Walsh A, Williams A	Analysis of Approaches for Monitoring Biodiversity in Commonwealth Waters – Fieldwork Report	https://www.nespmarine.edu.au/document/analysis-approaches-monitoring-biodiversity-commonwealth-waters-field-work-report
	2015	Shultz AL, Malcolm HA, Linklater M, Jordan AR, Ingleton T, Smith SDA	Sediment variability affects fish community structure in unconsolidated habitats of a subtropical marine park	http://www.int-res.com/abstracts/meps/v532/p213-226/
	2012	Malcolm HA, Foulsham E, Pressey RL, Jordan A, Davies PL, Ingleton T, Johnstone N, Hessey S, Smith SDA	Selecting zones in a marine park: Early systematic planning improves cost-efficiency; combing habitat and biotic data improves effectiveness	http://www.sciencedirect.com/science/article/pii/S0964569111001918

AMP	Date	Authors	Title	URL
	2011	Jordan A, Davies P, Ingleton T, Foulsham E, Neilson J, Pritchard T	Seabed habitat mapping of the continental shelf of NSW	http://www.environment.nsw.gov.au/research/SeabedHabMap.htm
	2011	Malcolm, HA, Jordan A, Smith DA	Testing a depth-based habitat classification system against reef fish assemblage patterns in a subtropical marine park	http://onlinelibrary.wiley.com/doi/10.1002/aqc.1165/abstract
	2007	Ingleton T, Davies P	Solitary Islands Marine Reserve commonwealth waters, underwater data capture and habitat classification	
	2003	Otway NM, Burke AL, Morrison NS, Parker PC	Monitoring and identification of NSW critical habitat sites for conservation of grey nurse sharks.	http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0006/545631/FFRS-47_Otway-et-al-2003.pdf
	1971	Leitch EC, Neilson MJ, Hobson E	Dorrigo - Coffs Harbour 1:250 000 Geological Sheet SH/56-10 & part SH/56-11, 2nd edition, Geological Survey of New South Wales	

2.3 List of biological datasets for continental shelf depths of AMPs in the Temperate east marine planning region

Five sampling platforms, along with a synthesis from the publications, provide the basis of the biological descriptions provided in the subsequent sections relating to the AMPs within the Temperate east marine planning region. A summary of the associated datasets in relation to each AMP in the Temperate east marine planning region is provided in Table 4.

Table 4: Available biological data records within the continental shelf regions of the AMPs in Temperate east marine planning region.

AMP	Survey Method	Biological resolution	Number of Samples/ Transects/ Images	Proportion of data records scored	Number of time series	Contact for data
Cod Grounds	Towed video	full taxonomy (Fish) Biotope (Sessile benthos)		100 %	1	Alan Jordan, NSW DPI
	BRUV	Species		100 %		Brendan Kelaher, SCU
	Reef Life Survey	Species (Fish, invertebrates, algae)		100 %	1	Graham Edgar, UTas
Hunter	BRUV	Species (fish and lobster)	85	33 %	2	Alan Jordan, NSW DPI
	BRUV	Species (Fish)	28	100 %	4	David Harasti, NSW DPI
Lord Howe Island	Towed video	Species and other CATAMI classes			1	Michelle Linklater, NSW OEH
	BRUV	Species				

AMP	Survey Method	Biological resolution	Number of Samples/ Transects/ Images	Proportion of data records scored	Number of time series	Contact for data
	Reef Life Survey	Species (Fish, invertebrates, algae)		100 %	1	Graham Edgar, UTas
	Coral Diver Survey	Species		100 %	3	Australian Museum
	Coral and Fish Diver Survey	Species		100 %	5	Department of Environment
	Reef Life Survey	Species (Fish, invertebrates, algae)		100 %	1	Graham Edgar, UTas
Norfolk	Reef Life Survey	Species (Fish, invertebrates, algae)		100 %	2	Graham Edgar, UTas
	Diver Survey	Species (Fish)		100 %	>5	Malcolm Francis, NIWA
Solitary Islands	BRUV (Commonwealth monitoring)	Species	8	100 %	2	Alan Jordan, NSW DPI
	BRUV (Malcolm et al. 2011)	Species	9	100 %	2	Alan Jordan, NSW DPI
	Diver timed swims	Species		100 %	1	Alan Jordan, NSW DPI
	Diver incidental observations	Species		100 %	Ongoing	Alan Jordan, NSW DPI
	Acoustic tags	Species (Grey nurse Shark)	31	100 %	1	Alan Jordan, NSW DPI

2.1 Central Eastern AMP

2.1.1 Description of physical habitat

Mapping data in the continental shelf region of the Central Eastern AMP is of limited resolution and is represented by the very coarse (250 m cell resolution) Australian Bathymetry and Topography Grid (Figure 3). Further, the continental shelf region of the Central Eastern AMP only covers 346 km^2 (or 0.5 %) (Table 1) and ranges in depth from ~ 130 – 200 m (top insert in Figure 3). No fine-scale MBES mapping was identified for the continental shelf area of this AMP.

2.1.2 Description of biological assemblages

There has not been any documented targeted sampling of reef-habitat within the continental shelf region of the Central Eastern AMP.

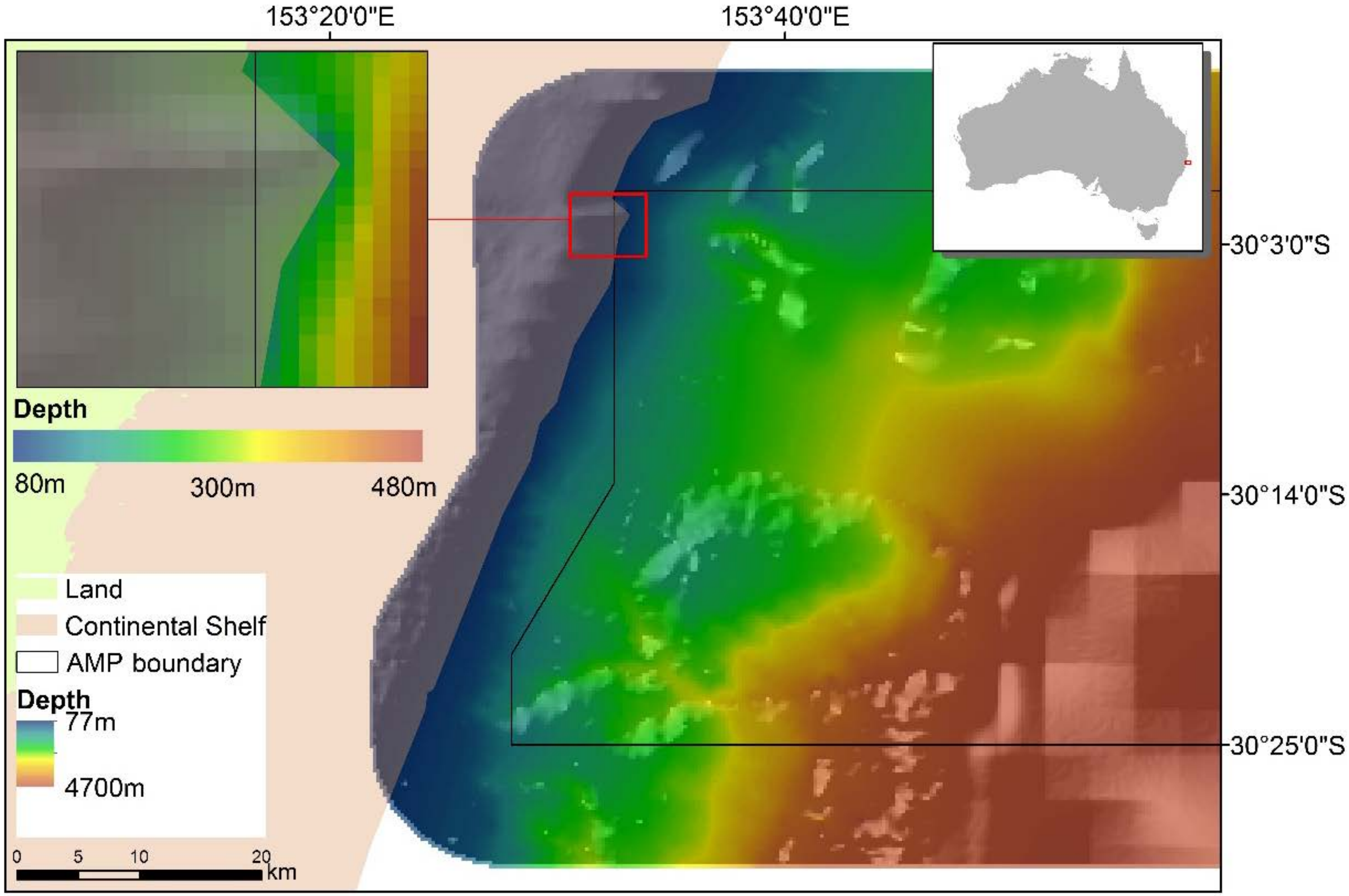


Figure 3. Mapping coverage of the Central Eastern AMP based on the Australian Bathymetry and Topography Grid, produced by Geoscience Australia in June 2009. Top insert shows the 346 km^2 region of the AMP in continental shelf waters.

2.2 Cod Grounds AMP

2.2.1 Description of physical habitat

The Cod Grounds AMP is the smallest reserve (areal coverage), covering ~4 km^2. Broad-scale mapping of the Cod Grounds AMP based on the Australian Bathymetry and Topography Grid, produced by Geoscience Australia, shows the general bathymetry of the AMP in context with the surrounding area (Figure 4). The continental shelf region of the Cod Grounds AMP represents 100 % of its total area

Fine-scale mapping collected by the Department of Primary Industries NSW and as reported in Jordan et al. (2011), reveals that the inner to mid shelf area offshore of the Camden Head is characterised by extensive rocky reef habitat of varying complexity (Figure 4). The mapped reefs in this area extend from directly offshore of Perpendicular point north as a semi-continuous feature into Commonwealth waters to include the pinnacle within the Cod Grounds AMP (Figure 4 and Figure 121 in Appendix A). The broad-scale bathymetry shows a moderately rough seafloor in the northern part of this area, suggesting that the reef complex extends further to the north beyond the entrance to Camden River towards Tacking Point (Figure 4).

The seabed in the area of Commonwealth waters consists of a series of irregular platform and ridge reefs that rise up to 10 m above the surrounding seabed and appear to be made up of a different lithology than the surrounding cobble fields. The area predominantly consists of a main ridge (Pinnacle reef) in the northeast of the mapped area where depths range from 21 m to 46 m in the southeast (inserts in Figure 4). The reef forms a roughly circular outcrop approximately 800 m across. The eastern side has a slope of up to 10 degrees while on the western side the slopes are steeper, with the terrain falling away to 50 m over a horizontal distance of 300 m resulting in a moderate slope of around 25 degrees. This reef is surrounded by areas of distinct reef ridges that are oriented north-east/south-west creating a series of gutters 1-2 m deep and 10-20 m across, and boulders and cobbles that overlie the bedrock formations. The gutters are typically filled with cobbles and sand.

The backscatter data indicates that reef interlaces with the surrounding sand areas (top insert in Figure 4). These sand fields are covered in ripples that are approximately 10 to 20 cm between crests. The troughs of the sand ripples are filled with relatively small amounts of coarser fragmented shell material. The crests of the ripples are oriented east-west indicating sediment is moving in a southerly direction possibly in response to the south flowing East Australia Current. The sands are fine-grained, but give a stronger backscatter signal because of the coarser shell grit contained within the troughs. Areas of weaker backscatter response are likely to indicate areas of relatively fine sand devoid of or with minor coarser shell grit component.

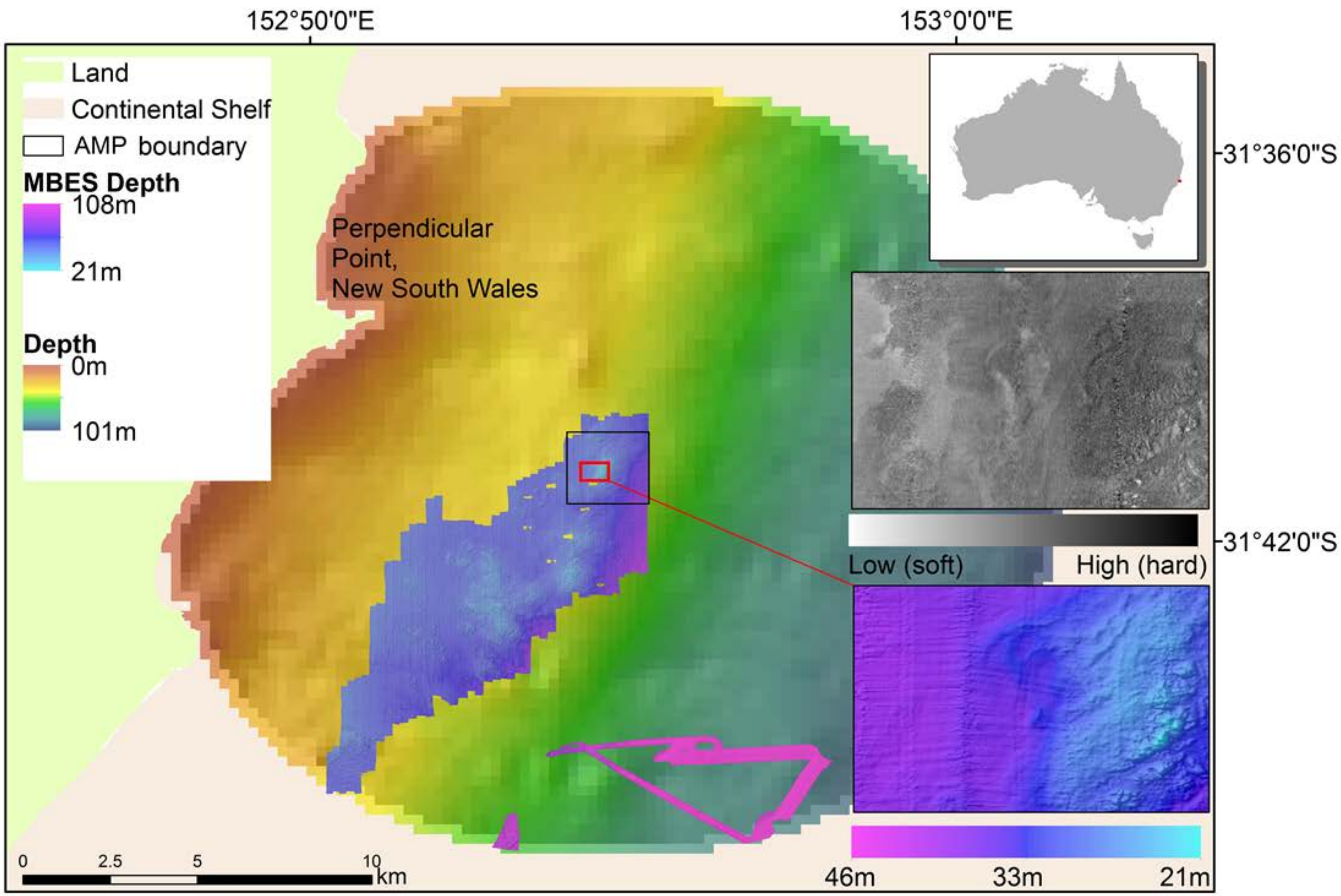


Figure 4. Mapping of the Cod Grounds AMP based on the Australian Bathymetry and Topography Grid, produced by Geoscience Australia in June 2009 and fine-scale 5-m resolution multibeam sonar (MBES depth) collected by the CSIRO Southern Surveyor/Investigator transits and NSW Office of Environment and Heritage (Jordan et al. 2011). Top insert shows backscatter returns showing soft (light grey) and hard substrata (black). Bottom insert showing the reef pinnacle.

2.2.2 Description of biological assemblages

Video surveys at the Cod Grounds AMP showed that in physical terms, high-profile continuous bedrock reef and boulders were the most common habitat on the reef (Figure 5; Jordan et al. 2011). Biologically, sponges, particularly encrusting and massive sponges were abundant in reef areas at depths between 30 and 55 m (Figure 5). Erect and branching sponges were generally found at depths greater than 35 m. Sea urchin barrens, typified by the presence of the long-spined sea urchin (*Centrostephanus rodgersii*) were relatively common at depths between 25 and 30 m. Ascidians (likely *Pyura spinifera* and *Sigillina* sp.) were observed at depths between 30 and 40 m (Figure 6). Assemblages of mixed brown algae were common on reef areas, particularly in areas of low-profile reef shallower than 40 m (Figure 6). Kelp (*Ecklonia radiata*) was not recorded in any video transects at the Cod Grounds AMP.

Figure 5. Reef habitat at Cod Grounds AMP showing boulder reef with some encrusting sponge and mixed algal assemblages.

Figure 6. Unconsolidated habitat at Cod Grounds AMP consisting of mixed cobbles and sand. Note the ascidian (*Sigillina* sp.) in (a) and algal assemblages in (a) – (c) (images from Jordan et al. 2011).

The sessile assemblages were sampled by Reef Life Survey (RLS) in 2009 and 2016 using photo quadrats at 10 sites (Edgar & Stuart-Smith 2014, 2017c). Crustose coralline algae was the dominant assemblage in the photo quadrats with over 50 % cover. Turfing algae had an average cover of 10 %, and other assemblages such as sponges, anemones, ascidians, bryozoan, hydroids and polychaetes made up the mosaic of assemblages.

In additional the photo quadrats taken by RLS, fish assemblages have also been sample in 2009 and 2016 within the Cod Grounds AMP using SCUBA-based underwater visual census at 10 sites (Edgar & Stuart-Smith 2014, 2017a, 2017b). A total of 69 and 68 species was recorded in 2009 and 2016 respectively, with 42 species being recorded both years. The three most abundant species were the mado (*Atypichthys strigatus*), silver sweep (*Scorpis lineolata*) and one-spot puller (*Chromis hypsilepsis*) (Table 5). Four and 12 grey nurse shark (*Carcharias taurus*) were recorded in 2009 and 2016 respectively (Table 5). Two black rock cod (*Epinephelus daemelii*) were recorded in 2009 (Table 5).

Diver transects counting mobile invertebrate recorded 39 species of invertebrates in 2009 (34 species) and 2016 (19 species) (Edgar & Stuart-Smith 2014, 2017a). The long-spined sea urchin (*Centrostephanus rodgersii*) was the most numerically abundant invertebrate with 3,511 animals counted in 2009 and 1,845 animals in 2016. The next most abundant species was the pencil urchin (*Phyllacanthus* parvispinus; 715 and 100 animals in 2009 and 2016, respectively) and the basket star (*Comanthus trichoptera*; 803 and 98 animals in 2009 and 2016, respectively).

The Cod Grounds AMP is known as a significant aggregation site for the grey nurse shark (Otway et al. 2003). This area offers prime habitat for the sharks, which are often observed in unusually large numbers in or near the deep, sandy-bottomed gutters between the Pinnacles. The Cod Grounds AMP support a large proportion of female sharks compared to other aggregation sites surveyed off the New South Wales coast and provides habitat for prey species preferred by the grey nurse shark.

Table 5. A summary of species recorded by Reef Life Survey SCUBA divers during 2009 and 2016 surveys at 10 sites within the Cod Grounds AMP. The count is the total number of animals recorded at the 10 sites, while rank orders the site from most to least abundant.

		2009		2016	
Family	**Species**	**Count**	**Rank**	**Count**	**Rank**
Acanthuridae	*Acanthurus nigrofuscus*			1	56
	Prionurus maculatus	2	47	4	46
	Prionurus microlepidotus	10	34	53	15
Aplodactylidae	*Aplodactylus lophodon*			1	57
Apogonidae	*Apogon limenus*			2	53
Aulopidae	*Aulopus purpurissatus*	3	44	1	55
Aulostomidae	*Aulostomus chinensis*			1	58
Berycidae	*Centroberyx affinis*	12	33		
Blenniidae	*Plagiotremus tapeinosoma*	2	48	5	42
Brachaeluridae	*Brachaelurus waddi*			1	59
Carangidae	*Carangid spp.*	2	49		
	Carangoides orthogrammus			1	60
	Elagatis bipinnulata	5	39		
	Pseudocaranx georgianus	9	35		
	Seriola dumerili			27	21
	Seriola hippos	18	28		
	Seriola lalandi	35	24	36	19
	Seriola rivoliana	4	41		
	Trachurus novaezelandiae	24	26		
Chaetodontidae	*Chaetodon guentheri*	1	57	8	31
	Chelmonops truncates	1	58		
Cheilodactylidae	*Cheilodactylus fuscus*	572	6	178	9
	Cheilodactylus vestitus	1	59	2	50
	Nemadactylus douglasii	83	15	7	33
Cirrhitidae	*Cyprinocirrhites polyactis*			5	43
Dinolestidae	*Dinolestes lewini*	395	9	40	18
Diodontidae	*Dicotylichthys punctulatus*	1	60		
Enoplosidae	*Enoplosus armatus*	65	18	44	16
Fistulariidae	*Fistularia commersonii*	2	51		
	Fistularia petimba	1	61		
Glaucosomatidae	*Glaucosoma scapulare*	29	25		
Heterodontidae	*Heterodontus portusjacksoni*	1	62	2	51
Kyphosidae	*Atypichthys strigatus*	24884	1	5957	3
	Microcanthus strigatus			15	26
	Scorpis lineolate	8538	2	44285	1
Labridae	*Achoerodus viridis*	14	31	5	40
	Bodianus axillaris			1	61

Family	Species	2009 Count	2009 Rank	2016 Count	2016 Rank
	Bodianus frenchii	2	52	4	47
	Bodianus unimaculatus			1	62
	Coris dorsomacula	5	40	5	41
	Coris picta	104	13	90	11
	Labrid spp.	1	63		
	Labroides dimidiatus			5	44
	Notolabrus gymnogenis	52	20	61	14
	Ophthalmolepis lineolatus	108	12	213	6
	Pseudocoris yamashiroi	1	64		
	Pseudolabrus luculentus			1	63
	Suezichthys arquatus	2	53		
Latridae	*Latridopsis forsteri*			5	45
Lutjanidae	*Lutjanus russellii*			7	35
	Paracaesio xanthura	100	14	5	39
Monacanthidae	*Eubalichthys bucephalus*	1	65		
	Eubalichthys mosaicus	1	66	2	52
	Meuschenia freycineti	6	38		
	Meuschenia scaber	22	27		
	Meuschenia trachylepis	1	67		
	Nelusetta ayraudi	1	68		
Moridae	*Lotella rhacina*	13	32	7	34
Mullidae	*Parupeneus spilurus*	78	16	71	12
	Upeneichthys lineatus	4	42	1	54
Muraenidae	*Gymnothorax prasinus*			1	64
	Gymnothorax thrysoideus			1	65
Odontaspididae	*Carcharias taurus*	4	43	12	28
Orectolobidae	*Orectolobus halei*	8	37	12	27
	Orectolobus maculatus	3	45	2	49
Ostraciidae	*Anoplocapros inermis*	2	54		
Pempherididae	*Pempheris affinis*	16	30	42	17
	Pempheris compressa	489	8	34	20
	Pempheris multiradiata			8	32
Pinguipedidae	*Parapercis stricticeps*			1	66
Plesiopidae	*Paraplesiops bleekeri*			1	67
	Trachinops taeniatus	1181	4	1083	4
Pomacentridae	*Chromis hypsilepis*	2056	3	7790	2
	Chromis margaritifer			1	68
	Mecaenichthys immaculatus	18	29	20	24
	Parma microlepis	57	19	10	29
	Parma unifasciata	264	10	313	5

		2009		2016	
Family	**Species**	**Count**	**Rank**	**Count**	**Rank**
Sciaenidae	*Argyrosomus japonicus*	40	23		
	Atractoscion aequidens	570	7	200	7
Scombridae	*Sarda australis*			100	10
Scorpaenidae	*Pterois volitans*			1	69
	Scorpaena cardinalis	9	36		
	Scorpaena jacksoniensis			6	37
Serranidae	*Acanthistius ocellatus*	2	55	6	36
	Caesioperca lepidoptera	1	69		
	Epinephelus daemelii	2	56		
	Epinephelus undulatostriatus	3	46	3	48
	Hypoplectrodes annulatus	1	70		
	Hypoplectrodes maccullochi	148	11	66	13
	Pseudanthias squamipinnis			6	38
Sparidae	*Acanthopagrus australis*	42	21	16	25
	Pagrus auratus	77	17	23	23
	Rhabdosargus sarba	41	22	25	22
Synodontidae	*Synodus variegatus*			1	70
Trachichthyidae	*Trachichthys australis*	1	71		

2.3 Hunter AMP

2.3.1 Description of physical habitat

Maps of the Hunter AMP were generated from data from the Australian Bathymetry and Topography Grid produced by Geoscience Australia in 2009. Targeted fine-scale MBES surveys were completed by CSIRO in the form of transits by RV Southern Surveyor/Investigator. The NSW Office of Environment and Heritage as part of NESP Theme D3 mapping of reef assests project conducted additional targeted surveys (Davies et al. 2016; Lucieer et al. 2016; Figure 7).

Fine-scale mapping of the Hunter AMP covers an area of 177 km^2 (19 %) on the continental shelf (<200 m water depth) compiled from RV Southern Surveyor/Investigator transit data (Figure 7). All bathymetric data for the Hunter AMP was collated and reported in Davies et al. (2016) as a part of Hub research to improve our understanding of the distribution of shelf rocky reefs within the AMP. Overall, it was found that rocky reef habitat was not extensive within the shelf region of the Hunter AMP (Figure 122 in Appendix A). However, Davies et al. (2016) identified three areas of reef, totalling 80 km^2, which were mapped using multibeam sonar. The reefs occur in water depths of 75 m to 120 m and are low relief, rising up to 7 m above the surrounding soft sediment (top insert in Figure 7, Figure 8 and Figure 9). Davies et al. (2016) were unable to sample the reefs to determine geological provenance. However, the orientation of the reef and general blocky appearance of the reefs suggests they are outcrops of bedrock (top insert in Figure 7).

It should be noted that the above-mentioned study was a preliminary investigation only and does not provide a comprehensive understanding of the extent of the reef systems in the Hunter AMP. It is almost certain that there are other areas of reef of the shelf that are yet to be mapped. Relatively extensive datasets of seafloor mapping from within state waters (< 3 nm from land) have previously been completed as part of the planning process for the Port Stephens Great Lakes Marine Park. Defined Sanctuary zones and Habitat Protection Zones around Broughton Island and Seal Rocks lie in close proximity to the current survey area. The range and distribution of seabed habitat types within these zones are described in detail in Jordan et al. (2010).

The Outer Gibber Reef is a small but complex high relief reef system that is immediately north of Broughton Island and is well know to recreational anglers. However, there are has been no mapping of this reef to date. The reef is within the Hunter AMP and is used as a reference site for the Port Stephens Great Lakes Marine Park monitoring programme using baited remote underwater stereo video (stereo BRUVs). Our current knowledge of this reef system is based on the video footage from stereo BRUVs (Figure 10, Figure 11). It is known that the reef varies in depth from 30 to 50 m.

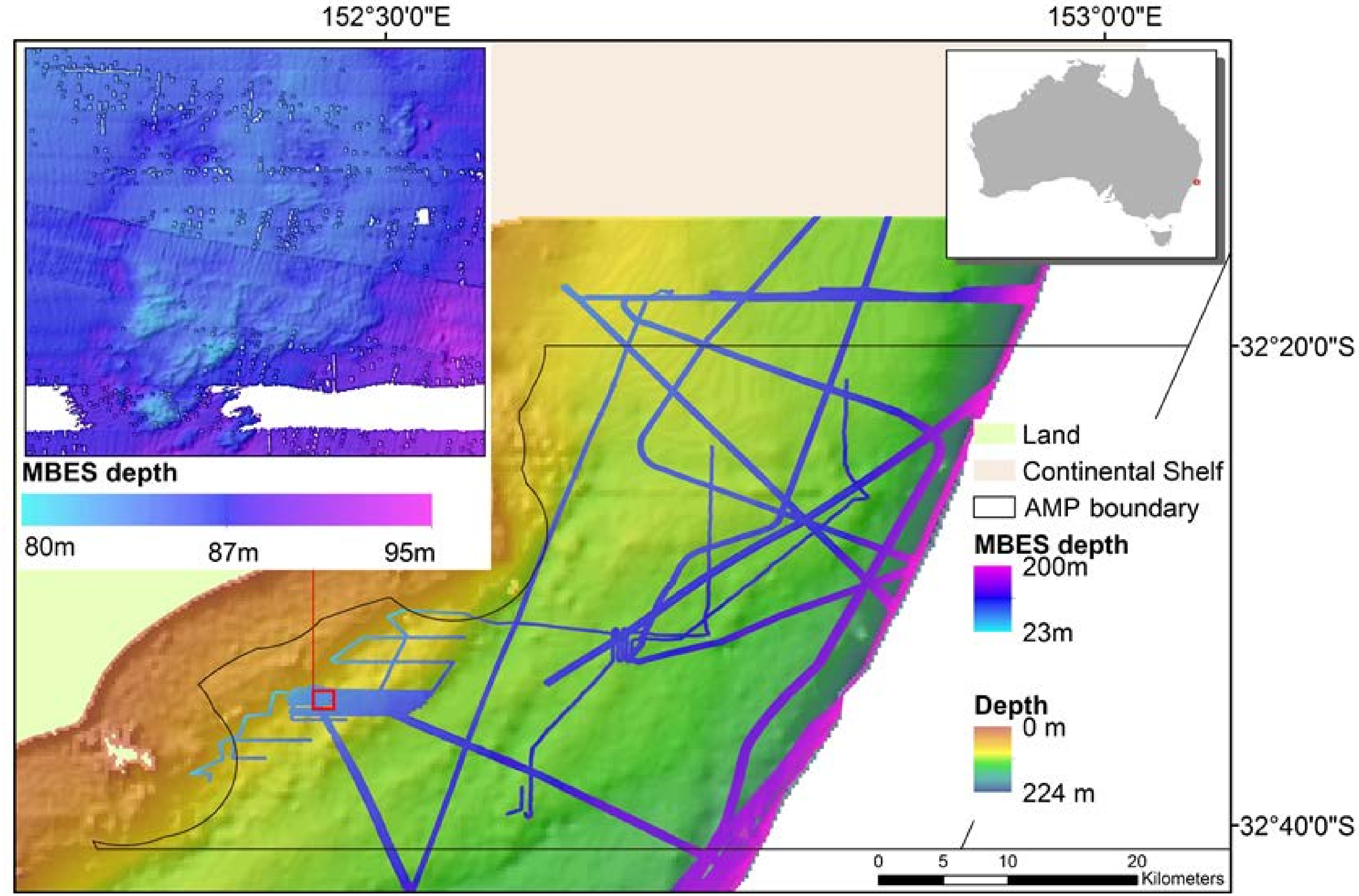


Figure 7. Mapping of the Hunter AMP based on the Australian Bathymetry and Topography Grid, produced by Geoscience in June 2009 and fine-scale 5-m resolution multibeam sonar (MBES depth) collected by the CSIRO Southern Surveyor/Investigator transits and NSW Office of Environment and Heritage.

Figure 8. An example of the low relief reef complex in the Hunter AMP northeast of Broughton Island. This same reef was mapped in Davies *et al.* (2016).

Figure 9. An example of a reef wall and cave in 102 m of water northeast of Broughton Island in the Hunter AMP. This same reef was mapped in Davies et al. (2016).

Figure 10. Outer Gibber Reef in 35 m of water. Note the high-profile reef in background.

Figure 11. Outer Gibber Reef in 35 m of water. Note the large boulders in the foreground.

2.3.2 Description of biological assemblages

The sessile seafloor assemblages of the Hunter AMP have not been well studied. The most recent information comes from stereo BRUVs that were used to sample the fish assemblages in the region. The stereo BRUVs provides qualitative information on the sessile seafloor assemblages that was previously undescribed (Figure 12-Figure 16). The stereo BRUV surveys were completed in 80-105 m water depth at two locations including offshore of Seal Rocks (immediately inside NSW state waters) and an area northeast of Broughton Island (Hunter AMP). Davies et al. (2016) have mapped both of these areas. It should be noted that this study did not intend to describe the sessile assemblages and that further research is needed to provide quantitative data and higher quality images to identify animals to a lower taxonomic level.

The rocky reef that was observed by the stereo BRUVs consisted of fragmented areas of bedrock reef and boulders. A mosaic of sponges and octocorals was commonly observed on the reef (Figure 12-Figure 16). Reef offshore from Seal Rocks appeared to have the greatest diversity and density of sponges and branched or fanned octocorals. One stereo BRUV drop recorded a large area blanketed by white soft corals (Figure 16). The greater coverage and diversity of sessile assemblages is most likely due to the area being more exposed to currents. In contrast, the sessile assemblages on the reef located to the northeast of Broughton Island were sparse and interspersing with rock covered in silt.

Figure 12. A screen grab from the stereo BRUV footage demonstrating the diversity of sponges and Octocorals on the rocky reefs in 90 m of water in the Hunter AMP. This same reef was mapped in Davies et al. (2016).

Figure 13. A screen grab from the stereo BRUV footage demonstrating the erect sessile assemblages that were indicative of the area sampled in the Hunter AMP.

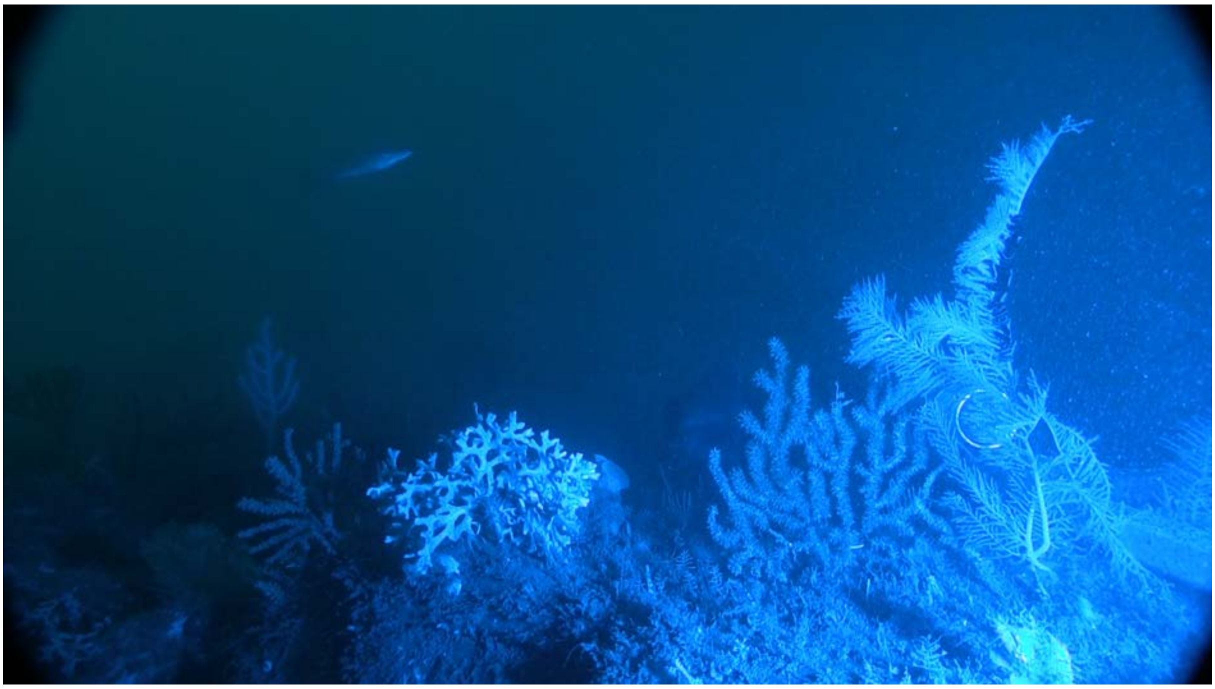


Figure 14. A screen grab from the stereo BRUV footage demonstrating the diversity of sponges and octocorals on the rocky reefs in 90 m of water in the Hunter AMP.

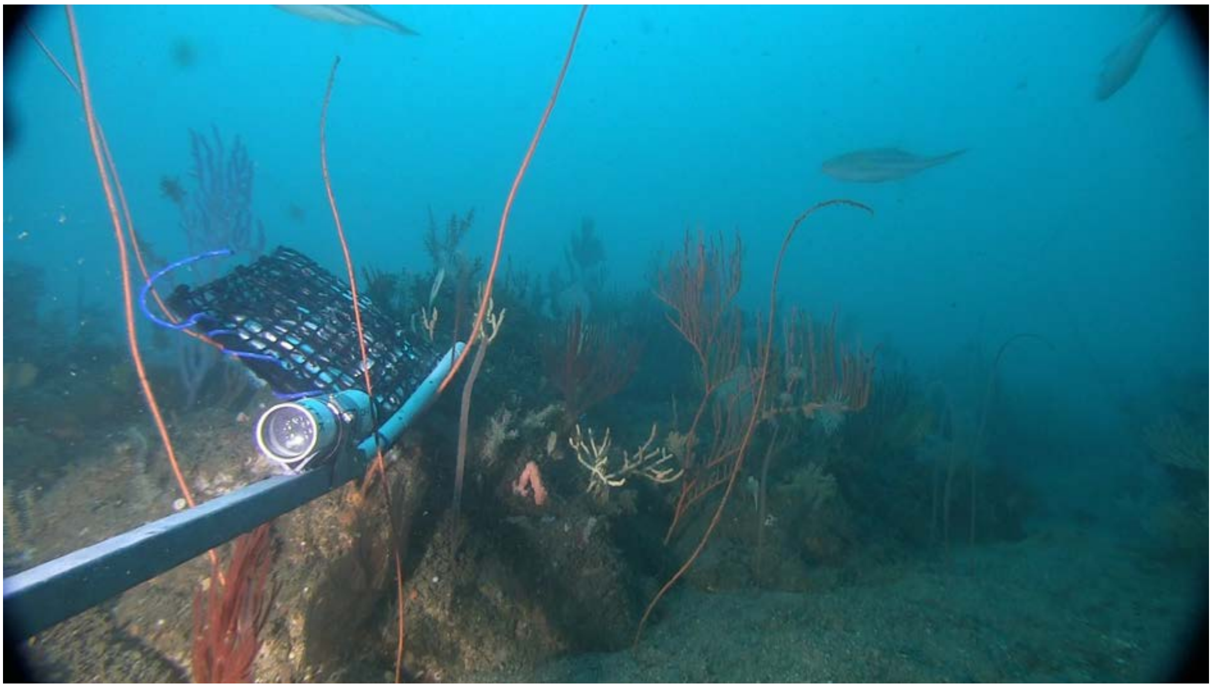


Figure 15. A screen grab from the stereo BRUV footage with an example of the sessile assemblages in 90 m of water adjacent to Seal Rocks on the boundary of the Port Stephens Great Lakes Marine Parks and the Hunter AMP.

Figure 16. A screen grab from the stereo BRUV footage showing an expansive area of white soft corals that were observed offshore from Seal Rocks in 90 m of water on the boundary of the Port Stephens Great Lakes Marine Parks and the Hunter AMP.

In spring of 2016, 35 stereo BRUV deployments were undertaken on outer shelf reef in 80-110 m of water from Seal Rocks to north east of Broughton Island as part of an exploratory investigation (Williams et al. unpublished data). Twelve of these BRUV deployments were on the reef that was described in Davies et al. (2016). A further 58 stereo BRUV deployments were done in autumn 2017, however, these videos are yet to be analysed. In 2016, 11 elasmobranch species representing 10 families and 37 teleost species representing 23 families were recorded (Figure 17 and Table 6). Approximately 17 % of fish species were observed once and these were mostly reef-affiliated species (Table 6).

The species richness (total number of species) observed offshore of Seal Rocks was 47. The three species that represented a combined 58 % of the fish assemblage were the schooling species mado (*Atypichthys strigatus*; 22 %), yellowtail scad (*Trachurus novaezelandiae*; 21 %) and nannygai (*Centroberyx affinis*; 14 %). Larger bodied fish species that were commonly observed were the pink snapper (*Chrysophrys auratus*; 5 %) and blue morwong (*Nemadactylus douglasii;* 3 %). The ocean perch (*Helicolenus percoides*; 2 %) was also commonly observed on most stereo BRUV deployments (Table 6).

The species richness (total number of species) observed at Broughton Island Offshore was 29. The two species that represented a combined 62 % of the fish assemblage at Broughton Island offshore were the nannygai (*Centroberyx affinis*; 38 %) and yellowtail scad (*Trachurus novaezelandiae*; 24 %). One species of crustacean, eastern rock lobster (*Sagmariasus verreauxi*) was identified at multiple locations. Larger bodied species that were commonly observed were the blue morwong (*Nemadactylus douglasii;* 4 %) and pink snapper (*Chrysophrys auratus*; 2 %). The ocean perch (*Helicolenus percoides*; 3 %) was also commonly observed on most stereo BRUV deployments.

The Outer Gibber Reef is a well know reef with recreational anglers, located northeast of Broughton Island and half way to Seal Rocks. The reef complex varies in depth from ~30-50 m. Although the Outer Gibber Reef has been used as a reference site for the Port Stephens Great Lakes Marine Park (NSW) monitoring programme using stereo BRUVs from 2011 to 2016 it is within the Hunter AMP. To date, 65 fish species representing 32 families have been recorded, including many sub-tropical and tropical fish species (Table 7).

The critically endangered grey nurse shark (*Charcharias taurus*) has been regularly sighted on the Outer Gibber Reef in 30-50 m (Figure 18) and on the deeper reefs in 100 m (unprocessed stereo BRUVs data; Figure 19). The sighting of grey nurse shark at 100 m is unique throughout its documented depth range.

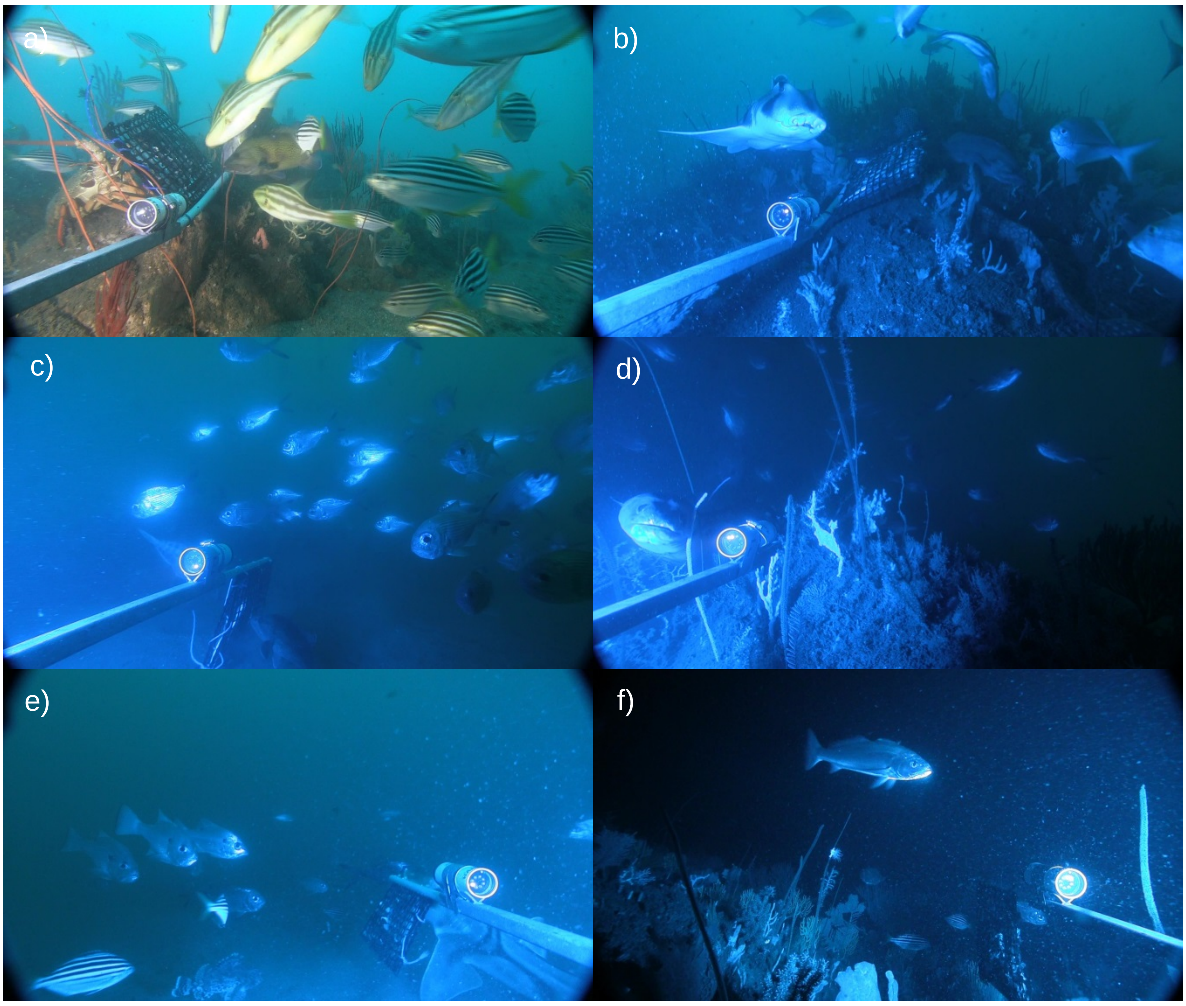


Figure 17. Examples of the fish assemblages recorded using stereo BRUVs on reef habitats in 80-100 m of water in the Hunter AMP. a) An example of mado (*Atypichthys strigatus*) and ocean leatherjacket (*Nelusetta ayraudi*). b) An example of Port Jackson shark (*Heterodontus portusjacksoni*) and silver sweep (*Scorpis lineolata)*. c) An example of a school of nannygai (*Centroberyx affinis*) and an eastern wirrah (*Acanthistius ocellatus*). d) A conger eel (*Conger verreauxi*) and a school of nannygai (*Centroberyx affinis*). e) An example of a school of pearl perch (*Glaucosoma scapulare*), mado (*Atypichthys strigatus*), and Port Jackson shark (*Heterodontus portusjacksoni*). f) An example of a teraglin (*Atractoscion aequidens*).

Figure 18. A grey nurse shark (*Carcharias taurus*) at Outer Gibber Reef in 35 m of water.

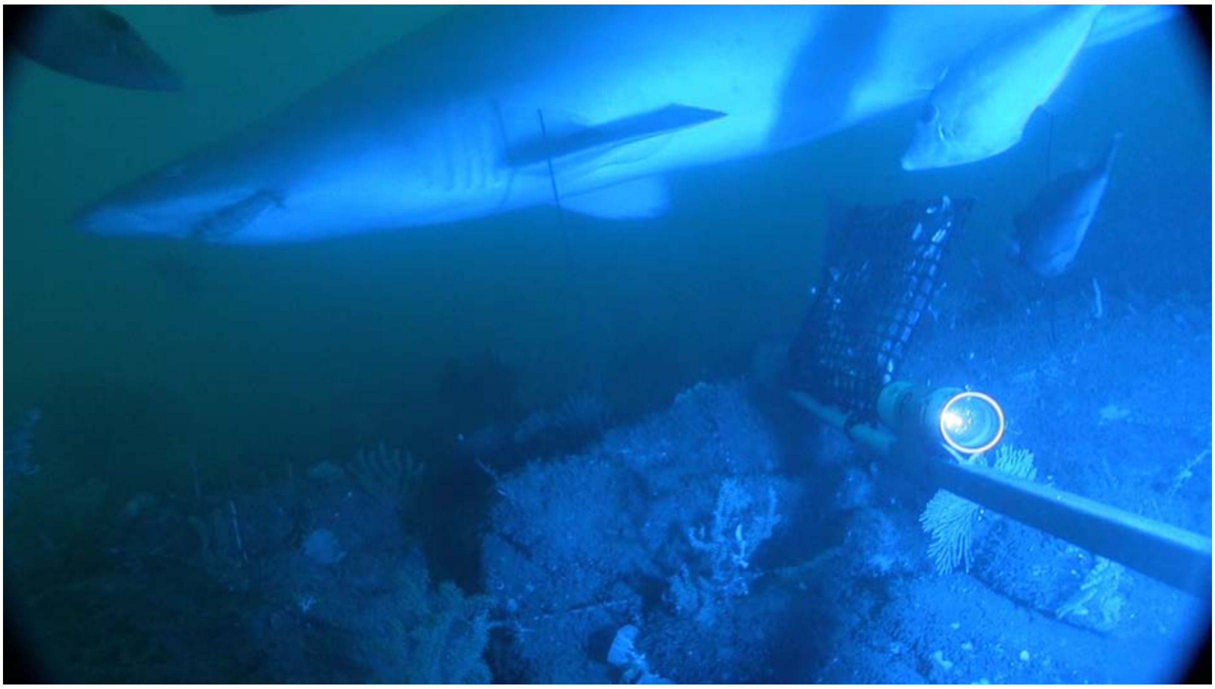


Figure 19. A grey nurse shark (*Carcharias taurus*) on reef northeast of Broughton Island in 105 m of water (unprocessed stereo BRUVs data from April 2017).

Table 6. A summary of species observed using stereo BRUVs to sample rocky reefs in 80-110 m of water at the two locations: northeast of Broughton Island (n=13), and immediately offshore of Seal Rocks (n=22). Mean MaxN refers to the relative abundance of the species and is calculated by taking the mean of the maximum number of a particular species observed on a single video frame per a BRUV deployment. Percent prevalence (Prev.) is the overall contribution of that species to that location.

			Broughton Is. Offshore			Seal Rocks Offshore		
Family	**Species**	**Common Name**	**Mean MaxN**	**Prev. (%)**	**Rank**	**Mean MaxN**	**Prev. (%)**	**Rank**
Aulopidae	*Aulopus purpurissatus*	Sergeant baker	0.69	1.44	11	0.18	0.37	27
Berycidae	*Centroberyx affinis*	Nannygai	18.46	38.40	1	7.23	14.53	3
Callanthiidae	*Callanthias australis*	Splendid perch	0.00	0.00	45	0.05	0.09	47
Carangidae	*Pseudocaranx dentex*	Silver trevally	0.38	0.80	13	3.59	7.22	4
	Trachurus novaezelandiae	Yellowtail scad	11.69	24.32	2	10.55	21.21	2
Carcharhinidae	*Galeocerdo cuvier*	Tiger shark	0.00	0.00	29	0.05	0.09	41
Cheilodactylidae	*Cheilodactylus fuscus*	Red morwong	0.00	0.00	30	0.09	0.18	34
	Nemadactylus douglasii	Blue morwong	1.69	3.52	6	1.41	2.83	7
Congridae	*Conger verreauxi*	Conger eel	0.08	0.16	27	0.00	0.00	48
Dasyatidae	*Dasyatis brevicaudata*	Smooth stingray	0.08	0.16	25	0.09	0.18	33
Dinolestidae	*Dinolestes lewini*	Longfin pike	3.00	6.24	3	0.18	0.37	26
Enoplosidae	*Enoplosus armatus*	Old wife	0.15	0.32	20	0.09	0.18	32
Glaucosomatidae	*Glaucosoma scapulare*	Pearl perch	0.31	0.64	16	0.45	0.91	15
Heterodontidae	*Heterodontus portusjacksoni*	Port Jackson shark	0.31	0.64	17	0.36	0.73	17
Kyphosidae	*Atypichthys strigatus*	Mado	0.00	0.00	42	10.68	21.48	1
Labridae	*Bodianus unimaculatus*	Pigfish	0.92	1.92	8	0.64	1.28	12
Latridae	*Latridopsis forsteri*	Bastard trumpeter	0.00	0.00	31	0.05	0.09	42
Monacanthidae	*Meuschenia freycineti*	Sixspine leatherjacket	0.00	0.00	32	0.05	0.09	43
	Meuschenia scaber	Velvet leatherjacket	2.62	5.44	4	1.18	2.38	8
	Nelusetta ayraudi	Ocean leatherjacket	0.00	0.00	33	2.18	4.39	6

Family	Species	Common Name	Broughton Is. Offshore Mean MaxN	Broughton Is. Offshore Prev. (%)	Broughton Is. Offshore Rank	Seal Rocks Offshore Mean MaxN	Seal Rocks Offshore Prev. (%)	Seal Rocks Offshore Rank
Moridae	*Lotella rhacina*	Bearded rock cod	0.38	0.80	14	0.27	0.55	21
Mullidae	*Parupeneus spilurus*	Black-spot goatfish	0.15	0.32	21	0.05	0.09	39
	Upeneichthys lineatus	Blue-lined goatfish	0.00	0.00	34	0.05	0.09	44
Muraenidae	*Gymnothorax prasinus*	Green moray	0.23	0.48	18	0.36	0.73	18
	Gymnothorax prionodon	Saw-tooth moray	2.23	4.64	5	0.27	0.55	20
Orectolobidae	*Orectolobus maculatus*	Ornate wobbegong	0.08	0.16	26	0.27	0.55	23
Palinuridae	*Sagmariasus verreauxi*	Eastern rock lobster	0.62	1.28	12	0.64	1.28	13
Parascylliidae	*Parascyllium collare*	Collared carpetshark	0.00	0.00	35	0.09	0.18	35
Platycephalidae	*Platycephalus caeruleopunctatus*	Bluespot flathead	0.15	0.32	22	0.86	1.74	11
	Platycephalus longispinis	Longspine flathead	0.00	0.00	36	0.05	0.09	45
Pomacentridae	*Mecaenichthys immaculatus*	Immaculate damsel	0.00	0.00	37	0.05	0.09	46
Pristiophoridae	*Pristiophorus cirratus*	Common sawshark	0.00	0.00	38	0.14	0.27	31
Rhinobatidae	*Aptychotrema rostrata*	Eastern shovelnose ray	0.00	0.00	39	0.27	0.55	24
	Trygonorrhina fasciata	Eastern fiddler ray	0.15	0.32	23	0.23	0.46	25
Sciaenidae	*Atractoscion aequidens*	Teraglin	0.00	0.00	40	0.32	0.64	19
Scombridae	*Scomber australasicus*	Blue mackerel	0.00	0.00	41	0.41	0.82	16
Scorpaenidae	*Scorpaena cardinalis*	Eastern red scorpionfish	0.23	0.48	19	0.14	0.27	30
Scorpididae	*Scorpis lineolata*	Silver sweep	0.00	0.00	43	1.05	2.10	10
Scyliorhinidae	*Asymbolus analis*	Australian spotted catshark	0.08	0.16	28	0.05	0.09	40
Sebastidae	*Helicolenus percoides*	Reef ocean perch	1.23	2.56	7	1.09	2.19	9
Serranidae	*Acanthistius ocellatus*	Eastern wirrah	0.77	1.60	10	0.55	1.10	14

Family	Species	Common Name	Broughton Is. Offshore Mean MaxN	Prev. (%)	Rank	Seal Rocks Offshore Mean MaxN	Prev. (%)	Rank
	Caesioperca lepidoptera	Butterfly perch	0.00	0.00	44	0.18	0.37	29
	Epinephelus ergastularius	Banded rockcod	0.00	0.00	46	0.09	0.18	36
	Hypoplectrodes maccullochi	Halfbanded seaperch	0.15	0.32	24	0.18	0.37	28
Sparidae	*Chrysophrys auratus*	Pink Snapper	0.85	1.76	9	2.55	5.12	5
Triakidae	*Mustelus antarcticus*	Gummy shark	0.38	0.80	15	0.27	0.55	22
Triglidae	*Pterygotrigla polyommata*	Latchet	0.00	0.00	47	0.09	0.18	37
Urolophidae	*Urolophus kapalensis*	Kapala ray	0.00	0.00	48	0.09	0.18	38

Table 7. A summary of the relative abundance (mean MaxN) of fishes recorded on stereo BRUV deployments from 2011 to 2016 out Outer Gibber, a reference site for the Port Stephen Great Lakes Marine Park monitoring programme that is located within the Hunter AMP as undertaken by the Department of Primary Industries NSW.

			Mean MaxN			
Family	**Species name**	**Common name**	**2011**	**2013**	**2015**	**2016**
Acanthuridae	*Prionurus microlepidotus*	Australian sawtail	0.5	2.0	0.4	0.7
Aplodactylidae	*Aplodactylus lophodon*	Rock cale	0.2	0.1	0.1	0.0
Aulopidae	*Aulopus purpurissatus*	Sergeant baker	0.3	0.5	0.5	0.3
Berycidae	*Centroberyx affinis*	Nannygai	5.3	0.1	0.0	0.7
Brachaeluridae	*Brachaelurus waddi*	Blind shark	0.2	0.0	0.0	0.0
Callanthiidae	*Callanthias australis*	Splendid perch	0.5	0.0	0.3	0.7
Carangidae	*Caranx sexfasciatus*	Bigeye trevally	0.0	1.0	0.0	0.0
	Pseudocaranx dentex	Silver trevally	1.0	8.4	4.3	8.2
	Seriola hippos	Samsonfish	0.0	0.3	0.0	0.0
	Seriola rivoliana	Amberjack	0.2	0.0	0.0	1.2
	Trachurus novaezelandiae	Yellowtail scad	32.8	5.8	2.3	8.8
Chaetodontidae	*Amphichaetodon howensis*	Lord Howe Isd. Butterflyfish	0.0	0.4	0.0	0.0
	Chaetodon guentheri	Gunthers butterflyfish	0.0	0.1	0.3	0.0
	Chelmonops truncatus	Eastern Talma	0.3	0.3	0.3	0.3
Cheilodactylidae	*Cheilodactylus fuscus*	Red morwong	1.5	4.8	6.6	0.8
	Nemadactylus douglasii	Blue morwong	1.3	0.6	0.9	0.8
Dasyatidae	*Dasyatis brevicaudata*	Smooth stingray	0.2	0.0	0.3	0.3
Dinolestidae	*Dinolestes lewini*	Longfin pike	0.7	0.3	2.0	1.0
Enoplosidae	*Enoplosus armatus*	Old wife	1.3	1.6	0.5	0.7
Glaucosomatidae	*Glaucosoma scapulare*	Pearl perch	0.0	0.0	0.1	0.0
Heterodontidae	*Heterodontus portusjacksoni*	Port Jackson shark	2.0	1.0	0.5	1.2
Kyphosidae	*Atypichthys strigatus*	Mado	55.0	33.1	37.6	35.3

Family	Species name	Common name	Mean MaxN 2011	2013	2015	2016
	Girella elevata	Rock blackfish	0.0	0.0	0.1	0.0
	Kyphosus sydneyanus	Silver drummer	0.2	0.1	0.0	0.0
Labridae	*Labridae sp*	Wrasse	0.2	0.0	0.0	0.0
	Achoerodus viridis	Eastern blue groper	0.8	0.9	0.9	0.7
	Bodianus unimaculatus	Pugfish	0.0	0.1	0.0	0.0
	Coris picta	Comb wrasse	1.3	0.6	1.4	1.8
	Coris sandeyeri	Sandager's wrasse	0.0	0.0	0.0	0.2
	Notolabrus gymnogenis	Crimsonband wrasse	0.8	0.8	0.9	0.8
	Ophthalmolepis lineolatus	Southern maori wrasse	3.0	3.4	2.9	3.8
	Pseudolabrus luculentus	Orange wrasse	0.3	0.4	0.0	0.5
Latridae	*Latridopsis forsteri*	Bastard trumpeter	0.0	0.0	0.1	0.0
Monacanthidae	*Eubalichthys bucephalus*	Black reef leatherjacket	0.3	0.0	0.0	0.0
	Eubalichthys mosaicus	Mosaic leatherjacket	0.3	0.1	0.4	0.0
	Meuschenia freycineti	Sixspine leatherjacket	1.5	1.6	0.8	0.8
	Meuschenia scaber	Velvet leatherjacket	13.3	13.1	6.8	5.8
	Meuschenia trachylepis	Yellowfin leatherjacket	0.2	0.4	0.3	0.5
	Meuschenia venusta	Stars-and-stripes leatherjacket	0.3	0.1	0.0	0.0
	Nelusetta ayraudi	Ocean leatherjacket	0.5	1.3	0.0	0.5
Moridae	*Lotella rhacina*	Largetooth Beardie	0.3	0.0	0.3	0.0
Mullidae	*Parupeneus spilurus*	Black-spot goatfish	2.2	1.9	5.0	3.5
	Upeneichthys lineatus	Bluestriped goatfish	0.5	0.3	0.4	0.2
Muraenidae	*Gymnothorax prasinus*	Green moray	1.5	0.9	0.8	1.3
	Gymnothorax prionodon	Saw-tooth moray	0.2	0.0	0.0	0.0
Myliobatidae	*Myliobatis australis*	Southern eagle ray	0.0	0.0	0.0	0.2
Odontaspididae	*Carcharias taurus*	Grey nurse shark	0.0	0.1	0.0	0.0

Family	Species name	Common name	Mean MaxN 2011	2013	2015	2016
Orectolobidae	*Orectolobus halei*	Banded carpet shark	0.0	0.1	0.1	0.0
	Orectolobus maculatus	Spotted wobbegong	0.2	0.1	0.3	1.3
	Orectolobus sp	Wobbegong	0.0	0.0	0.1	0.0
Ostraciidae	*Anoplocapros inermis*	Eastern smooth boxfish	0.3	0.0	0.0	0.0
Pomacentridae	*Chromis hypsilepis*	One-spot puller	0.7	2.8	0.5	3.5
	Mecaenichthys immaculatus	Immaculate damsel	0.2	0.4	0.0	0.5
	Parma microlepis	White ear	1.2	0.6	1.0	0.7
Pomatomidae	*Pomatomus saltatrix*	Tailor	0.0	1.3	0.0	0.0
Scorpaenidae	*Scorpaena cardinalis*	Eastern red scorpionfish	1.3	1.3	0.5	1.0
Scorpididae	*Scorpis lineolata*	Silver sweep	5.2	5.4	7.8	3.8
Serranidae	*Acanthistius ocellatus*	Eastern wirrah	0.8	0.5	0.3	0.2
	Hypoplectrodes annulatus	Blackbanded seaperch	0.0	0.0	0.0	0.2
	Hypoplectrodes maccullochi	Halfbanded seaperch	0.2	0.4	0.1	0.7
	Hypoplectrodes nigroruber	Banded seaperch	0.2	0.0	0.0	0.0
Sparidae	*Chrysophrys auratus*	Pink snapper	1.8	5.8	7.4	6.3
	Rhabdosargus sarba	Tarwhine	0.7	3.5	3.0	1.8
Sphyraenidae	*Sphyraena sp*	Barracuda	0.0	0.0	0.0	1.7
Tetraodontidae	*Torquigener pleurogramma*	Weeping toadfish	0.0	0.0	0.1	0.0

2.4 Jervis AMP

2.4.1 Description of physical habitat

Maps in the Jervis AMP were generated from a combination of the Australian Bathymetry and Topography Grid produced by Geoscience in June 2009 and finescale MBES data from CSIROs Southern Surveyer/Investigator transits (Figure 20). The continental shelf region of the Jervis AMP represents ~ 4 % of its total area (Figure 20). The coarse scale mapping of the AMP suggests that there is potential reef habitat along the the continental shelf break (Figure 123 in appendix A).

2.4.2 Description of biological assemblages

To date there are no known data or knowledge of surveys of reef-affiliated biota in the shelf region of the Jervis AMP.

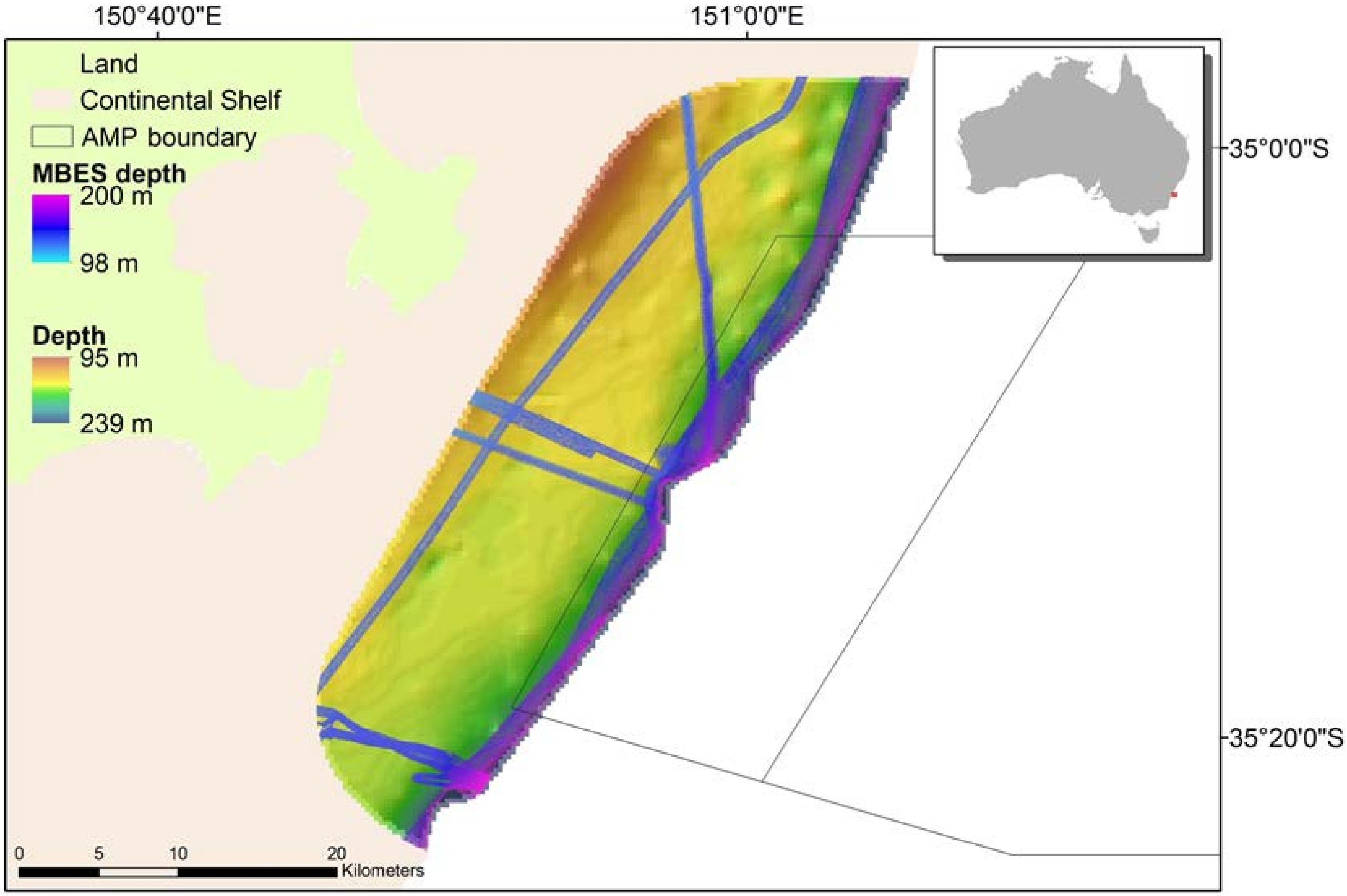


Figure 20. Mapping of the Jervis AMP is based on the Australian Bathymetry and Topography Grid, produced by Geoscience in June 2009 and fine-scale 5-m resolution multibeam sonar (MBES depth) collected by the CSIRO Southern Surveyor/Investigator transits.

2.5 Lord Howe Island AMP

2.5.1 Description of physical habitat

Fine-scale bathymetry is available for most of the shelf area surrounding Lord Howe Island, derived from a combination of multibeam and single beam acoustics and satellite imagery (Mleczko et al. 2010, Linklater et al. 2015, Linklater 2016, Linklater et al. 2016; Figure 21). The Lord Howe Island shelf consisted of depths of 30-60 m (68 %), with around 14 % in 60-90 m and 6-8 % > 90 m. It also contains a shallow lagoon area that is between 0-9 m deep. Overall, the shelf surrounding Lord Howe Island is characterised by a mix of reef and soft sediment benthic habitats that have been categorised into inner-, mid- and outer shelf areas (Linklater 2016; Figure 22). The AMP extends around all of the Lord Howe Island shelf area. It is restricted by the State water limit to an area of the outer shelf mostly in depths > 35 m and it is dominated by an outer-shelf platform. This is widest on the south western (11.3 km) and northeastern (7.8 km) section of the shelf, and narrowest (<50 m) on the western side where the mid-shelf reefs extend close to the shelf break.

Reefs are present on the outer shelf covering an area of 17 km^2, and are more prominent on the shelf in the northeast as patch platform reefs and in the south as sub-parallel linear ridge reefs. The southwestern part of the AMP also includes an area of mid-shelf relict fossil reefs that extend to depths up to around 50 m (Woodroffe et al. 2010). A series of terraces extend to the shelf break on the seaward edge of the outer shelf. Terraces are evident along the edge of the outer shelf (average depth of 87±18 m), and are most distinct on the northwest shelf region. The shelf break occurs at the average depth of 133 m.

Fine-scale bathymetry is available for almost the entire shelf area surrounding Balls Pyramid, derived from a combination of multibeam acoustics (272 km^2) and satellite imagery (11.7 km^2) (Linklater 2016). The shelf is predominantly 30-60 m deep (77 % of the shelf), with little shallow (<30 m) substrata, and a distinct outer-shelf platform that is mostly between 48-60 m deep. On the seaward edge of the outer shelf, a series of terraces extend to the shelf break, and are spread across a wide depth interval (with a mode at 75 m). Beyond the shelf break are steep flanks surrounded by abyssal plains > 3000 m depth.

The shelf surrounding Balls Pyramid is characterised by a mix of reef and soft sediment benthic habitats (Linklater et al. 2016). The Lord Howe Island AMP incorporates some of the Balls Pyramid shelf although it is restricted to the outer shelf mostly in depths > 45 m, with the width of the shelf within the AMP ranging from several hundred metres on the western edge to 4.5 km in the south. The majority of the Balls Pyramid outer shelf consists of a sediment-covered platform that is relatively flat and extends across the northern, southern and northwestern sections of the shelf. There are a number of patch reefs, primarily in 45-56 m depth, intersected by basins and channels. The largest outer-shelf reef occurs on the northern shelf, although only the most northern section of this reef is within the AMP. On the southern outer shelf, there are a number of narrow, mounded ridges (typically < 1 m height), including the longest reef at 8300 m and 40-90 m in width. These elongate, sub-parallel outer-shelf reefs appear to represent accretionary paleo-shoreline features, with possible origins as dunes or coral reefs (Linklater et al. 2016).

Seaward of the outer shelf platform to the shelf break the AMP characteristed by outer shelf terraces that occur in 65-100 m depth (average 92 m). A series of terraces and terrace steps are evident on the northern, southern and southeast shelves toward the shelf break. The terrace step is characterised by fore-reef buttresses on the western and eastern shelf, and these rise up to 1-2 m in height and are around 400 m in length. Based on their depth distribution and morphology the terrace steps are likely to be relict shoreline features, formed during periods of low sea level (Linklater et al. 2016).

The area formally known as Elizabeth and Middleton Reefs Marine National Reserve is now encompassed in the Lord Howe Island AMP (Oxley et al. 2003, Choat et al. 2006). Elizabeth and Middleton Reefs are located 600 km east of Coffs Harbour and 200 km north of Lord Howe Island. Elizabeth Reef (~5100 ha) and Middleton Reef (~3700 ha) formed on volcanic seamounts that rise abruptly from 2000 m and are close to the boundary of the Coral and Tasman seas. The reefs consist of an extensive lagoon surrounded by a well-defined reef crest with characteristic spur and groove formations.

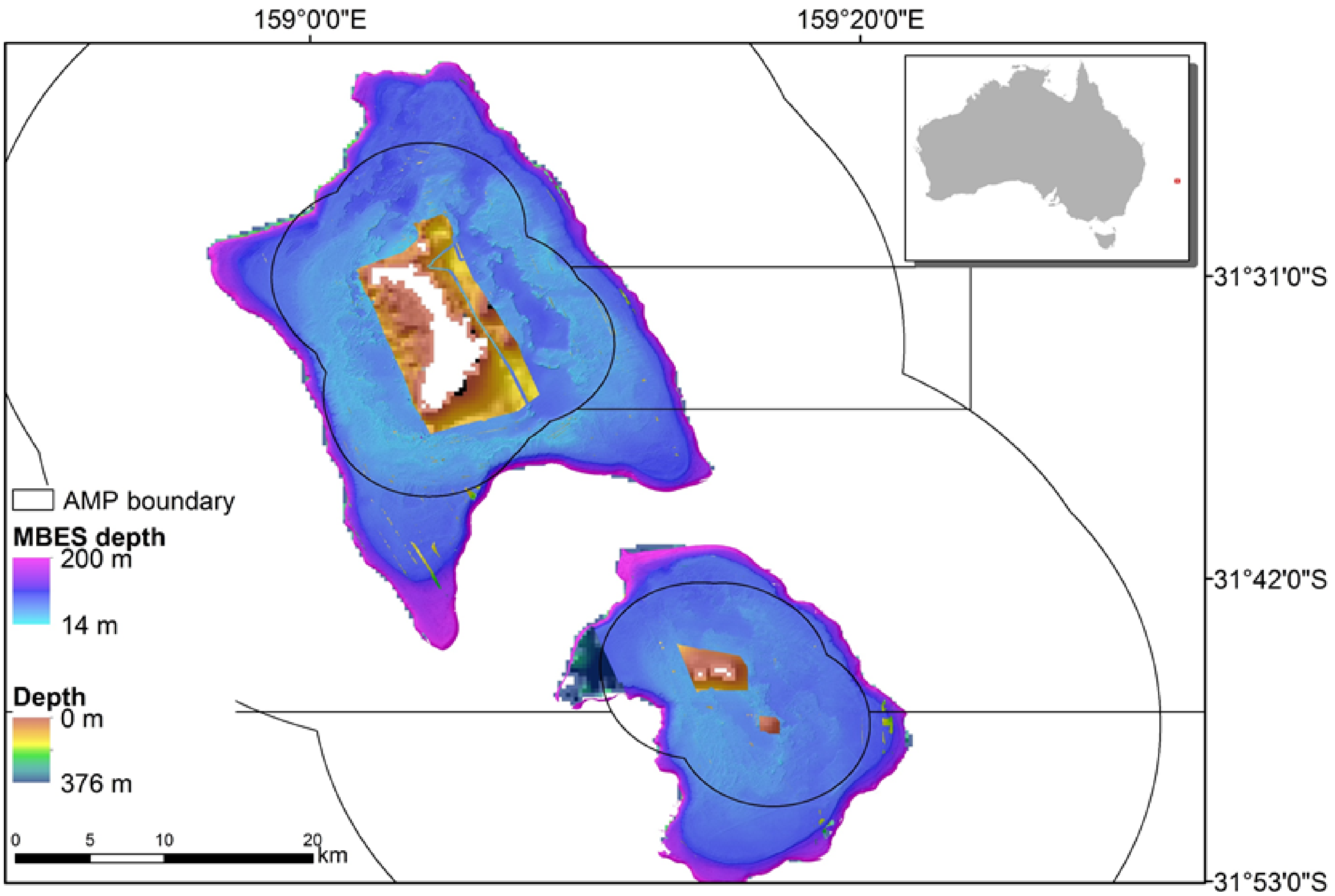


Figure 21. Mapping of the Lord Howe AMP based on the Australian Bathymetry and Topography Grid, produced by Geoscience in June 2009 with fine-scale 5-m resolution multibeam sonar (MBES depth) collected by Linklater (2016) and CSIRO Southern Survey/Investigator cruises. Note additional quickbird derived depth data has been identified for shallow lagoons from Linklater (2016) that is not included in this figure.

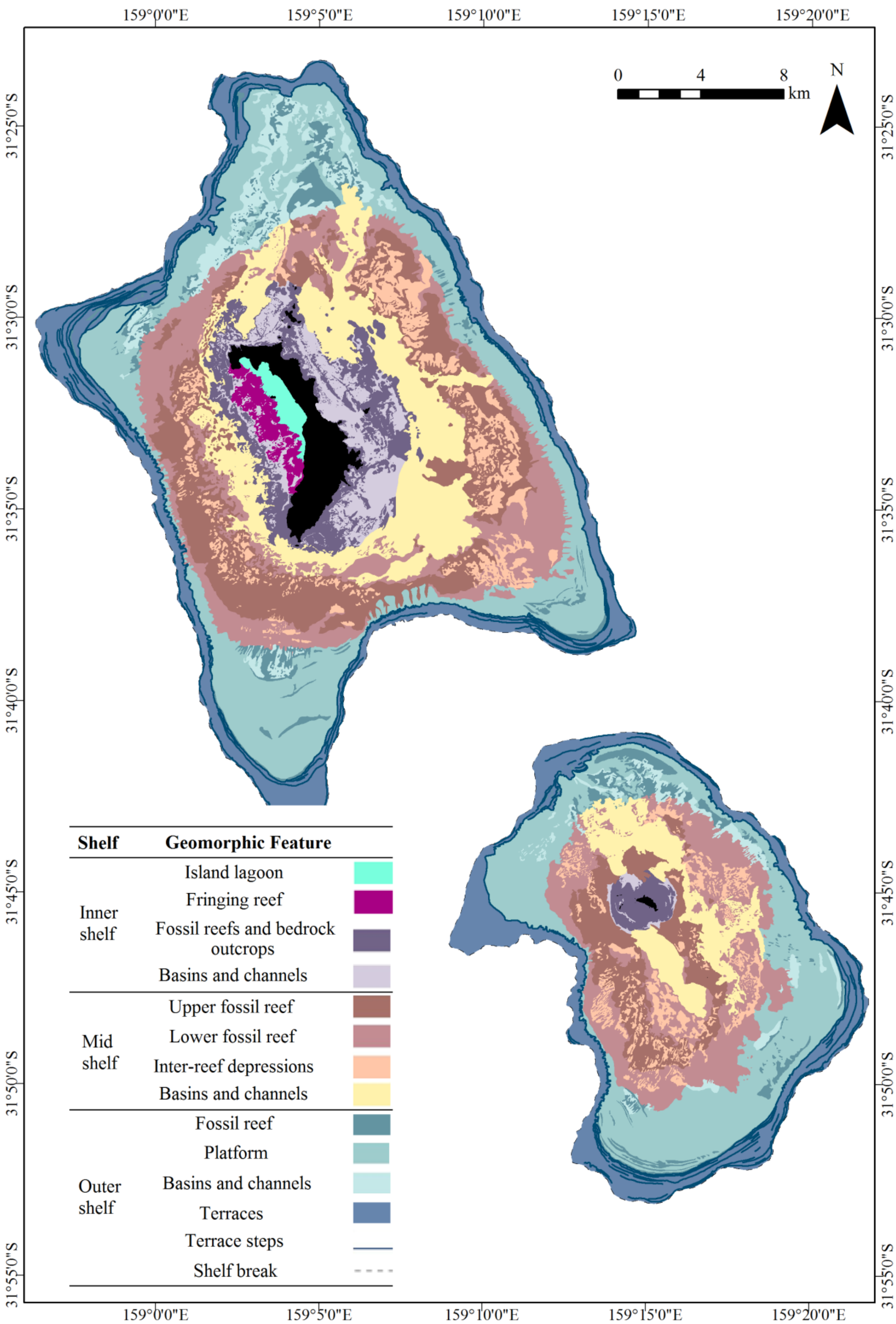


Figure 22. Fine-scale habitat map of the Lord Howe Island showing each geomorphic features as presented in Linklater (2016).

2.5.2 Description of biological assemblages

There have been limited surveys of sessile seafloor assemblages in AMP waters of the Lord Howe Island and Balls Pyramid shelf, particularly in the areas of outer shelf reef and terrace habitat. Towed video surveys indicate that the outer shelf reefs contain mixed macroalgae and unidentified biogenic material, as well as low abundances of stony corals, sponges and gorgonians (Linklater 2016; Speare et al. 2004), with a high degree of variation in community composition between sites. Coralline algae are often present over the reef surface and are associated with calcareous green macroalgae such as *Halimeda* (Woodroffe et al. 2005). Analysis of biota taken from stereo BRUV images also found macroalgae and stony corals to be present at most outer shelf sites, with soft corals and sea urchins also identified.

Marine invertebrates recorded from the Lord Howe Island shelf habitats consist of approximately 200 mollusc species as well as small numbers of annelids, echinoderms, brachiopods, crustaceans, sipunculids and bryozoans (Ponder et al. 2000), although these may include some non-reef and deeper water species. Pencil urchins (*Phyllacanthus* sp.) have been recorded in highest numbers on the northeast shelf of Lord Howe Island (Speare et al 2004), while the urchins, *Pseudoboletia Indiana* and *Prionocidaris callista*, are also noted as being common on the shelf (Ponder et al. 2000). Further targeted surveys of areas of reef habitat are required to confirm the spatial variations in community composition, and examine the difference to adjacent platform and basin geomorphic features.

The reefs at Elizabeth and Middleton Reefs have been regularly surveyed by researchers from James Cook University and the Australian Institute of Marine Science for the Commonwealth Government (Oxley et al. 2003, Choat et al. 2006, Pratchett et al. 2011, Hoey et al. 2014). The most recent report (Hoey et al. 2014) is the most comprehensive study documenting coral and macroalgae cover, coral replenishment and coral health. Hoey et al. (2014) reported that the mean hard coral cover was 29 % at Elizabeth Reef and 19 % at Middleton Reef and that this figure was slightly lower than the previous survey in 2011. Hoey et al. (2014) did note that coral cover at Elizabeth and Middleton Reefs was lower than the Great Barrier Reef and Lord Howe Island, suggesting that this was due to historical events damaging coral or low rates of coral replenishment. Despite this, it was reported that the health of the coral was generally high with low levels of coral bleaching or disease. A total of four crown of thorns starfish were recorded is this latest survey which was considerably lower than the 400 recorded in the 1980-90’s (Australian Museum 1992).

Elizabeth and Middleton Reefs are unique being the southernmost coral atolls in the world. Few other places in the world support such an assemblage of tropical, temperate and cosmopolitan species. In 2003, 111 species of coral were recorded (Oxley et al. 2004), slightly lower than the 122 species of coral recorded by Veron and Done during 1979 surveys. The four most dominant coral families included Faviidae, Acroporidae, Poritidae and Pocilloporidae. For a full list of species, refer to Oxley et al. (2004).

Cover of macroalgae was generally low at Elizabeth and Middleton Reefs (i.e. ~10 %; Hoey et al. 2014). The exception to this was the back reef on Middleton Reef where macroalgae cover (mostly *Codium* spp) extends to over two thirds of the shallow habitat.

There have been a number of studies on the fish assemblages on shelf habitats surrounding Lord Howe Island and Balls Pyramid, and more than 500 species of fishes have been recorded, with approximately 440 documented in coastal inshore habitats (Allen and Paxton, 1974, Allen et al. 1976; Francis 1991; Francis 1993; Francis & Randall, 1993; Speare et al. 2004; Marine Parks Authority 2010). In addition, a number of RLS UVC transects have been conducted in shallow depths. Of the inshore species, approximately 4 % are endemic to the Lord Howe Island/Norfolk Island region, while new endemic and non-endemic fish continue to be described (e.g. Hensley & Randall, 1993, Kuiter 2003). High conservation value species include endemic taxa as well as protected and threatened species, while fishers value many others. While shallow water fish assemblages at Lord Howe Island are well described, less information is available for depths > 30 m, particularly on outer shelf habitats in the AMP.

The limited surveys of fish assemblages in AMP shelf waters were conducted with stereo BRUVs deployed in depths of around 30–65 m (Speare et al. 2004). Overall, these surveys recorded a total of 79 species of sharks, rays, and fishes recorded on mid and outer-shelf habitats, with the fish assemblages consisting predominantly of Galapagos sharks (*Carcharhinus galapagensis*), carangids (Carangidae), wrasses (Labridae) and damselfish (Pomacentridae), with white spot chromis (*Chromis hypsilepsis*) and painted ladies (*Paracaesio xanthura*) locally abundant in large schools. In deeper waters of the mid-shelf, a small range of fish species typically characterise reef habitats, including the silver trevally (*Pseudocaranx georgianus*), southern pigfish (*Bodianus unimaculatus*) and comb wrasse (*Coris picta*). There was no evidence of differences in the community composition of fishes between Lord Howe and Balls Pyramid shelves, and similarly between the AMP and LHIMP areas, although the sites in depths >40 m were distinct primarily due to higher abundance of southern pigfish and Ballina angelfish (*Chaetodontoplus ballinae*). A total of 59 species were identified at shelf sites in the AMP. The shelf community includes some fish species of high conservation value, such as black cod (*Epinephelus daemelii*; Figure 23).

Pelagic and mid-water fish assemblages on the Lord Howe Island continental shelf were assessed using mid-water baited video (Heagney et al. 2007). Of eleven pelagic fish species recorded, seven were abundant and widespread, with the Galapagos shark being most numerous, and yellowtail kingfish (*Seriola lalandi*), amberjack (*Seriola rivoliana*), silver drummer (*Kyphosus sydneyanus*), silver trevally (*Pseudocaranx georgianus*), southern fusilier and blue mackerel (*Scomber australasicus*) also common.

The most abundant species, Galapagos sharks (*Carcharhinus galapagensis*), are a circum-global species found in temperate and warm waters, generally abundant in inshore waters around oceanic islands and occur in depths from the surface to around 300 m. In Australia, Galapagos sharks are only found around Lord Howe Island, and Middleton and Elizabeth Reef (Last & Stevens 2009, van Herwerden et al. 2008). The population on the Lord Howe Island shelf consists entirely of juveniles (van Herwerden et al. 2008).

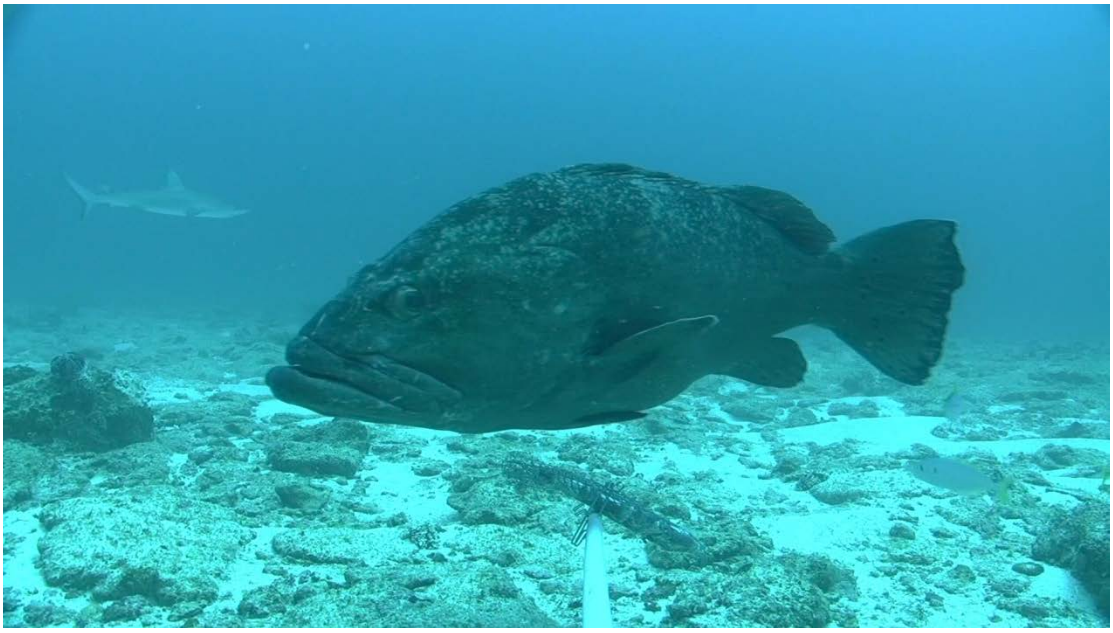


Figure 23. Adult black cod showing distinctive colouring and a black saddle.

The fish assemblages of Elizabeth and Middleton Reefs have been well documented over the past 30 years with surveys completed by the Australian Museum in 1987, James Cook University and Australian Institute of Marine Science for the Commonwealth Government in 1994, 2003, 2006, 2011 and 2014 and RLS in 2013 (Australian Museum 1992, Choat et al. unpublished data, Oxley et al. 2004, Choat et al. 2006, Pratchett et al. 2011, Hoey et al. 2014, Edgar et al. unpublished data). Fish surveys of Elizabeth and Middleton Reefs indicate that these reefs have a unique and unusual fish assemblage (Australian Museum 1992, Oxley et al. 2004, Hobbs et al. 2008, Hoey et al. 2014). The uniqueness of these two reefs led to their protection in 1987 when they formed the Elizabeth and Middleton Reefs Marine National Nature Reserve by the Australian Government. The uniqueness of the fish assemblage is due to geographic location, isolation and the convergence of tropical and temperate waters (Hobbs et al. 2008). Therefore, the fish assemblage comprises of tropical, temperate and endemic species (Hobbs et al. 2008).

In 2014, 270 species were recorded, including 10 species that had not been previously identified within the area. These new records take the total numbers of fish species recorded at Elizabeth and Middleton Reef to 356 (a full list of species can be found at Hoey et al. 2014). It should be noted that these data are created by diver surveys and are limited to depth less than 40 m. Therefore, species that inhabit deep reef habitats would not have been sampled or recorded. Hoey et al. (2014), and previous reports to the Commonwealth Government, divide the reporting of fish species into three categories, 1) herbivorous fishes, 2) endemic fishes and 3) apex predators. The density and biomass of herbivorous fishes remained generally stable between the 2011 and 2014 surveys. The three endemic species of interest are McCulloch's anemonefish (*Amphiron mccullochi*), threeband butterfly fish (*Chaetodon tricinctus*), doubleheader (*Coris bulbifrons*) varied greatly among study sites but overall densities were similar between the 2011 and 2014 surveys.

A notable characteristic of Elizabeth and Middleton Reefs is the high prevalence of two large predatory species, black cod (*Epinephelus daemelii*) and Galapagos shark (*Carcharhinus galapagensis*). Densities of the Galapagos shark were extremely high in 2014, double the number recorded in 2011 and 36 times higher than what was recorded in 2006. The average density across all habitats was 12.75 sharks per hectare. All observed sharks were small immature individuals suggesting that shallow habitat of Elizabeth and Middleton Reefs are important nursery habitats for this species.

Black cod (*Epinephelus daemelii*) were recorded at all sites at Elizabeth and Middleton Reefs (Hoey et al. 2014). The average density of black cod across all sites was 2.34 cod per hectare. This was a small but statistically insignificant increase in densities from the 2011 survey. Densities of cod were generally higher at Elizabeth Reef when compared to Middleton Reef (Hoey et al. 2014).

The RLS visited Elizabeth and Middleton Reefs in 2013 and surveyed the fish assemblage at 16 sites using diver transect methods (Edgar & Stuart-Smith 2014, 2017b). This survey recorded 236 species with one spot puller (*Chromis hypsilepis*) and black damselfish (*Chrysiptera notialis*) being the most commonly observed fishes. RLS also recorded in reasonable densities the three endemic species, McCulloch's anemonefish (*Amphiron mccullochi*), threeband butterfly fish (*Chaetodon tricinctus*), doubleheader (*Coris bulbifrons*) as well as the threatened black cod (*Epinephelus daemelii*).

2.6 Norfolk AMP

2.6.1 Description of physical habitat

The Norfolk Island group consists of three islands, Norfolk, Nepean and Phillip Island, and is situated on a 100 km long plateau on the Norfolk Ridge. Commonwealth waters extend right to the shore here. The Norfolk Ridge extends from New Caledonia in the north to New Zealand in the south. The islands coastlines are mostly volcanic and there are no true coral reefs. However, ~3 km of the Norfolk Island coastline is protected by fringing reefs formed by the accumulations of calcareous sands during the late Pleistocene. Patches of coral reef can be found inside lagoon and locally elsewhere.

Norfolk Island is influenced by the south limit of the Tropical Convergence. In fact, water temperatures are almost the same as those at Lord Howe Island.

Mapping data for the Norfolk AMP is coarse and completed by the Australian Bathymetry and Topography Grid (Figure 24). This mapping suggests the depth range of the continental shelf is 0 – 200 m, with the protected by fringing reefs are clearly visible from this mapping (top left insert in Figure 24).

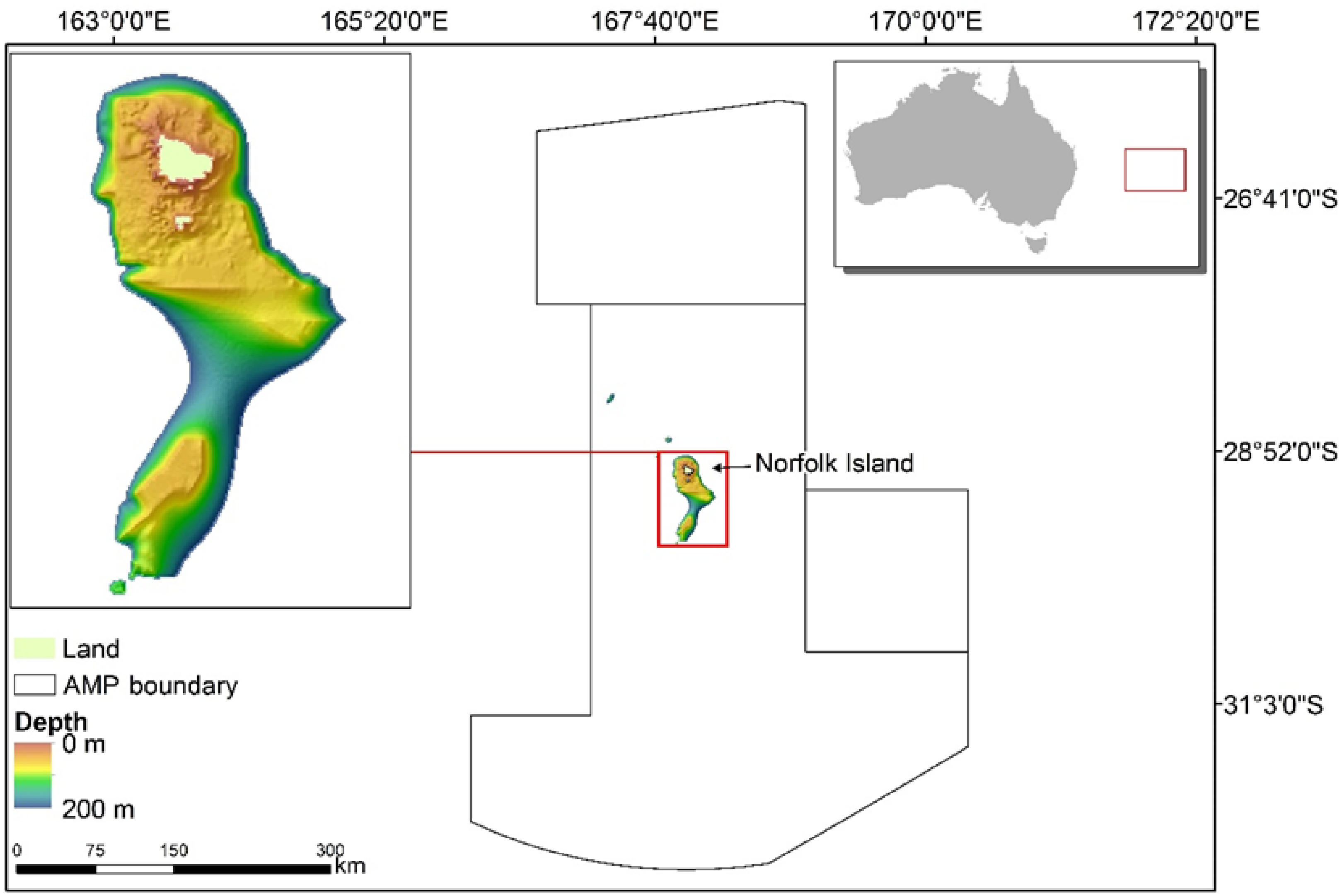


Figure 24. Mapping of the Norfolk AMP based on the Australian Bathymetry and Topography Grid, produced by Geoscience in June 2009.

2.6.2 Description of biological assemblages

There is very limited information and data on the sessile seafloor assemblages in the Norfolk AMP. The majority of data comes from the Leigh Marine Laboratory at Auckland University and from RLS. Thirty-nine species of hermatypic corals were recorded in the 1980s around Norfolk Island with many species being highly abundant (Brook 1990 see Francis 1993).

The RLS visited Norfolk Island in 2013 where diver surveys recorded habitat and invertebrates (Edgar & Stuart-Smith 2014, 2017c). The sessile habitat consisted of turfing algae (17 % mean cover), small to medium foliose brown algae (12 % mean cover) and tabular coral (9 %). At least 50 species of invertebrates were recorded during this survey. Five species of Arthropoda were recorded with the crab (*Thalamita* spp) being the most abundant, 19 species of Echinoderms were recorded with the urchin (*Heliocidaris tuberculate*) being the most abundant, 22 species of Mollusc were recorded with the sea slug (*Elysia* spp) being the most abundant and two species of Platyhelminthes were recorded with (*Pseudoceros bifurcus*) being the most abundant.

Data on the fish assemblages of the Norfolk AMP is limited with the majority of information again coming from the Leigh Marine Laboratory at Auckland University, RLS and the self-reporting Norfolk Island Inshore Fishery. Bleeker (1855) was the first to publish a list of fish species for Norfolk Island but this only contained eight species. A more recent list of 254 species recorded for Norfolk Island is presented in Francis (1993). The species diversity of Norfolk Island is less than Lord Howe Island, consisting of tropical (56 % of species) and sub-tropical species. Ten species of fish (3.9 %) are endemic to Norfolk Island (Francis 1993). Yet, Francis (1993) state that small cryptic and deep reef species are underrepresented and that there may be many more species to discover. Furthermore, 14 species of fish were recorded at both Lord Howe and Kermadec Island, which bracket Norfolk Island, thus it may be expected that they would probably be found at Norfolk Island with further investigations.

The demersal fishery of Norfolk Island is quite distinct in that they have more affinities with New Caledonia than with eastern Australia. The Norfolk Island Inshore Fishery (NIIF) was designed to encompass all shelf-water around Norfolk Island. The fishery is defined by a box 67 by 40 nautical miles, and is open to recreational and charter fishing only. Data on the fishery is collected through catch cards that are collated by the Norfolk Island Government before being provided to AFMA who then reports the data in a Data Summary (Norfolk Island Inshore Fishery Data Summary 2006-2009).

The latest report to be published by AFMA reported that 12 species were recorded on the catch cards (Norfolk Island Inshore Fishery Data Summary 2006-2009):

- Bar bod (*Epinephelus octofasciatus*);
- Cook's scorpionfish (*Scorpaena cookie*);
- Coral rockcod (*Cephalopholis miniata*);
- Hapuka (*Polyprion oxygeneios*);
- Queensland grouper (*Promicrops lanceolatus*);

- Yellowtail kingfish (*Seriola lalandi*);
- Red cod (*Epinephelus rivulatus*);
- Salmon (*Arripis* spp);
- Snapper (*Chrysophrys auratus*);
- Ophie / Silver trevally (*Pseudocaranx georgianus*);
- Trumpeter emperor (*Lethrinus miniatus*); and
- Yellowfin tuna (*Thunnus albacares*).

The Norfolk Island shelf region provides habitat for the black cod (*Epinephelus daemelii*), which is currently list as threatened under the Environment Protection and Biodiversity Conservation Act 1999. Fishers targeted black cod until Norfolk Island protected the species in 2012 (Francis et al. 2016). The stock relationships are unknown, there have been no detailed studies looking at the movement, and populations structure of this species at Norfolk Island. Due to the remoteness of Norfolk Island, and the large distance from other breeding populations, it is likely this population is sustained by self-recruitment (Francis et al. 2016). It is even hypothesised the larvae from Norfolk Island may provide the recruitment stock for the New Zealand population of black cod (Francis et al 2016).

The RLS visited Norfolk Island in 2013 surveying 13 sites (Edgar & Stuart-Smith 2014, 2017a, 2017b). A total of 103 species representing 34 families were recorded during this survey. A clupeid species was the most abundant representing 37 % of all fish recorded. The one-spot puller (*Chromis hypsilepis*) was the next most abundant, represented 22 % of all fish recorded. Five individuals of the apex predator, Galapagos shark (*Carcharhinus galapagensis*), were recorded and two individuals of the threatened and protected black cod (*Epinephelus daemelii*) were also recorded.

2.7 Solitary Islands AMP

2.7.1 Description of physical habitat

Mapping of the Solitary Islands AMP has been conducted by both the Australian Bathymetry and Topography Grid and targeted fine-scale MBES surveys from the NSW Department of Primary Industries as reported in Jordan et al. (2011) (Figure 25). The continental shelf region of the Solitary Islands AMP represents 100 % of its total area

Fine-scale bathymetry and habitat data have been collected by the NSW Department of Primary Industries and presented in Jordan et al. (2001; Figure 25). A large area of reef located on the mid-shelf south-west of Sandon Bluffs covers an area of 50 km^2 and contains shallow and intermediate reefs. The area includes at least four individual continuous reefs and numerous patchy reefs generally less than 200 m long. The reef system extends east into Commonwealth waters and joins up with the large reef system surrounding Pimpernel Rock. A minimum depth of 11 m was detected at Pimpernel Rock, and a maximum of 57 m at a point 1 km south-east of Pimpernel Rock. Reef surrounding Pimpernel Rock forms linear ridges oriented in a NE-SW direction bounded to the NW and SE by sediment covered seabed. Additional reef would appear to extend beyond the limits of the survey area. The reefs that have been mapped in high resolution are generally patchy and form low relief platforms and ridges (100 - 600 m wide and 100’s – 1000’s m long), rising 5-8 m from the surrounding seabed (Figure 25). The only area where the reef is steeper with a greater relief is due east of Minnie Water, where the reef rises 13 m from the surrounding area, forming a 2 km long ridge.

The rest of the seabed in this area consists of unconsolidated sediments of varying sediment size and bedform morphology, which is reflected in the variation in the backscatter intensity (bottom insert in Figure 25). A distinct area with lighter backscatter is evident offshore of Minnie Waters, which is likely to consist mostly of fine to coarse sands. In contrast, unconsolidated sediments within the area of patchy reef to the north have much higher backscatter intensity, and are therefore likely to be coarser and contain varying amounts of pebbles and cobbles. Underwater video ground truthing is yet to be conducted over the reef and unconsolidated habitats in this area. The central zone of reefs is bounded by and continuous parallel zone of high backscatter material. Sediment here is likely to consist of continuous gravel, pebble, cobble and boulder sized material as indicated by its backscatter intensity and texture. Zones of sand and unconsolidated sediments are interspersed with one another either side of the reef zone. The most extensive area of sand is to the northwest where sand appears to form a series of dunes or lobes, the edges of which are defined by curved narrow (<10 - 20 m) linear zones of coarser material.

It is likely that more extensive reef habitat exists in this region, as many of the reefs identified in multibeam acoustic surveys had not previously been identified in maps of broad-scale bathymetry (Figure 124 in Appendix A). This is particularly the case offshore of the prominent headlands where only small isolated reefs have previously been identified. Generally, the morphology of the reef complex appears to suggest an underlying geological feature.

Headlands and islands within the vicinity of the survey area form part of a group of Palaeozoic age marine clastic sediments known as the Coramba beds (Leitch et al. 1971).

Within the southern survey area, reef habitat covers a ~ 4.7 km^2 of seafloor surveyed in 2006. Sand and unconsolidated habitats cover 2.9 km^2, 1.4 km^2 and 3.0 km^2 of seafloor surveyed in 2006, respectively.

The general zone of reef and high backscatter response from unconsolidated material from the northern area continues in a southwesterly direction into the Solitary Islands Marine Park (SIMP) and across the northern section of the southern survey area. Broad continuous reef forms almost one single complex stretching 1500 m north-south and 650 m east-west at the widest point. Linear ridge reefs also feature in the west of the survey area and extend across into areas surveyed for SIMP, and some limited area of relict reef occurs in the southern area of the Solitary Islands AMP. This occurs adjacent to complex bedrock reef that occurs more broadly within the AMP.

Another large broad area of reef can be observed along the western edge of the survey area further to the south bounded by the latitudes 29◦ 44.00’ S and 29◦ 44.45’ S. This forms the shallowest reef complex of the southern survey area, the majority of which is at depths of less than 30-35 m.

The material classified as unconsolidated sediment generally lies between reefs and separates the reef from the other classes (sand). The largest expanse of sand in this area is located close to the eastern boundary of the survey area away from the main reef complexes. Some evidence of sand wave bedforms is apparent but less obvious than in the northern survey area. This indicates localised sediment transport within this area and may be associated with the disruption of near-bed currents moving around the reef complexes to the north, south and west.

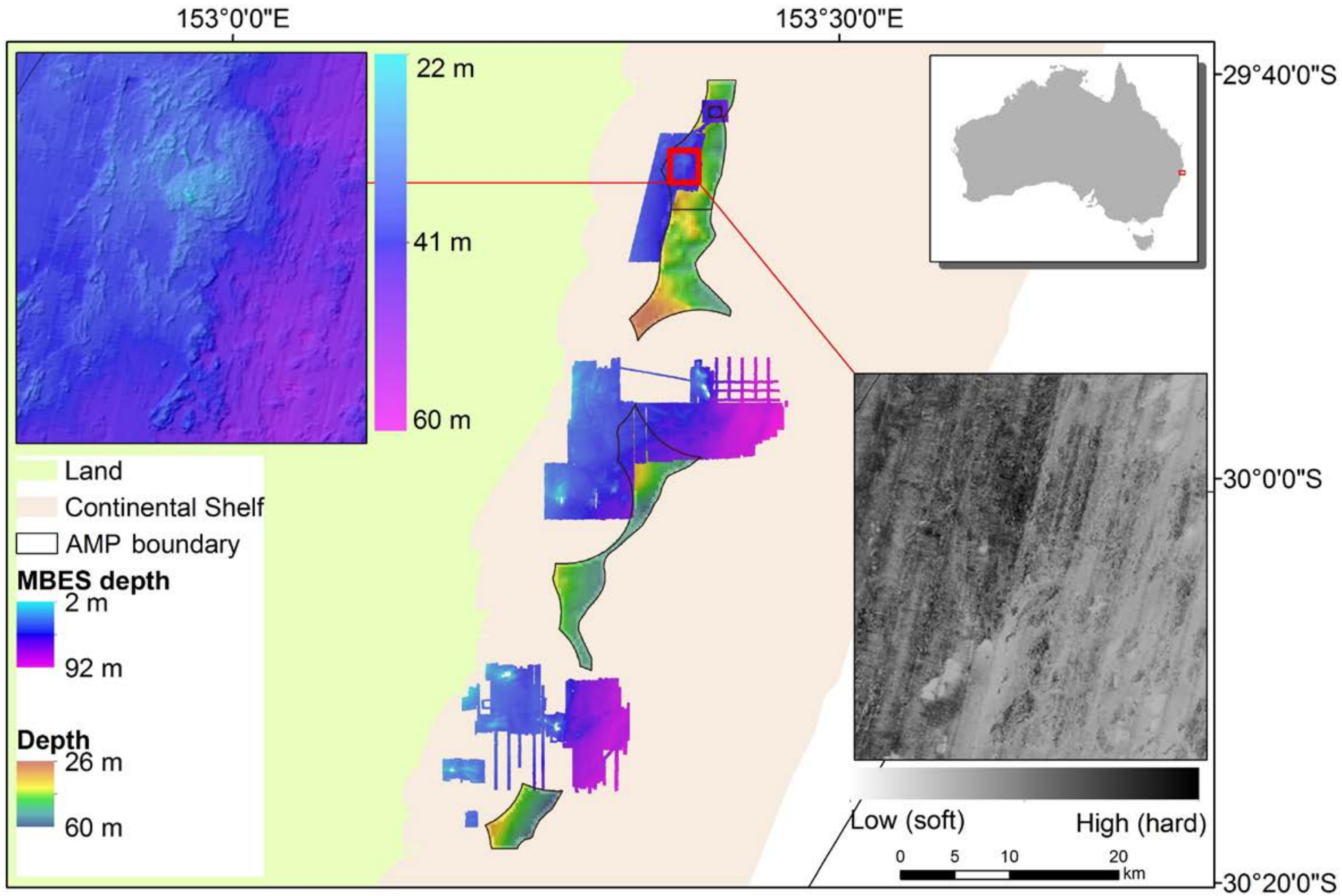


Figure 25. Mapping coverage of the Solitary Island AMP based on the Australian Bathymetry and Topography Grid, produced by Geoscience Australia in June 2009 and fine-scale 5-m resolution multibeam sonar (MBES depth) collected by the CSIRO Southern Surveyor/Investigator transits and NSW Office of Environment and Heritage (Jordan et al. 2011). Left insert shows reef structure in the proposed Mulitple use zone in the north of the AMP. Right insert shows backscatter returns showing soft (light grey) and hard substrata (black) of the same region.

2.7.2 Description of biological assemblages

A cross-shelf comparison of reef fish assemblages extended from Solitary Island Marine Park (NSW) into the Solitary Islands AMP (Malcolm et al. 2011). Nine of the 56 sites, surveyed during this study occurred within the AMP in 30-44 m water depth. Stereo BRUVs were deployed in the winter/spring period of 2007 and 2008. A total of 55 species of fish were observed with mado (*Atypichthys strigatus*) and silver sweep (*Scorpis lineolata*) being the most abundant species (Table 8). The average species richness was 15 with a maximum numbers of species recorded on a single drop being 23. The biodiversity of fishes within the Solitary Island Marine Park and Solitary Islands AMP is enriched by the presence of rocky reef to depth of 75 m (Malcolm et al. 2011). Malcolm et al. (2011) reported that there were cross-shelf patterns in species richness. However, it was not clear with some of the richest sites occurring at intermediate depths (some sites within the AMP) and there was considerable between site variation in species abundance and species richness (Malcolm et al. 2011).

Figure 26. Screen grabs stereo BRUVs footage showing examples of the sessile reef assemblages at Pimpernel Rock within the Solitary Island AMP.

Table 8. A list of species recorded, in order of relative abundance (Mean MaxN refers to the mean maximum number of fish of that species seen in a single video frame), using a single stereo BRUV deployment at nine sites located within the Solitary Islands SMR in 2007 and 2008 as reported in Malcolm et al. (2011).

Family	Species name	Common Name	Mean MaxN
Kyphosidae	*Atypichthys strigatus*	Mado	19.74
Scorpididae	*Scorpis lineolata*	Silver Sweep	10.11
Pomacentridae	*Chromis hypsilepis*	One-spot puller	2.52
Labridae	*Ophthalmolepis lineolatus*	Southern Maori wrasse	1.78
Sparidae	*Chrysophrys auratus*	Pink Snapper	1.78
Labridae	*Notolabrus gymnogenis*	Crimsonband wrasse	1.30
Serranidae	*Hypoplectrodes maccullochi*	Halfbanded seaperch	1.22
Plesiopidae	*Trachinops taeniatus*	Eastern hulafish	1.00
Labridae	*Bodianus frenchii*	Foxfish	0.96
Cheilodactylidae	*Nemadactylus douglasii*	Blue morwong	0.85
Mullidae	*Parupeneus spilurus*	Blackspot goatfish	0.85
Scorpaenidae	*Scorpaena cardinalis*	Eastern Red Scorpionfish	0.85
Labridae	*Choerodon venustus*	Venus tuskfish	0.74
Muraenidae	*Gymnothorax prasinus*	Green moray	0.74
Pomacentridae	*Parma unifasciata*	Girdled scalyfin	0.70
Sciaenidae	*Atractoscion aequidens*	Teraglin	0.67
Labridae	*Coris picta*	Comb wrasse	0.67
Aulopidae	*Aulopus purpurissatus*	Sergeant baker	0.59
Acanthuridae	*Prionurus microlepidotus*	Australian sawtail	0.48
Enoplosidae	*Enoplosus armatus*	Old wife	0.44
Pomacentridae	*Mecaenichthys immaculatus*	Immaculate damsel	0.37
Cheilodactylidae	*Cheilodactylus fuscus*	Red morwong	0.30
Mullidae	*Upeneichthys lineatus*	Bluestriped goatfish	0.30
Pomacentridae	*Parma microlepis*	White-ear	0.26
Muraenidae	*Gymnothorax prionodon*	Saw-tooth moray	0.22
Serranidae	*Hypoplectrodes annulatus*	Blackbanded seaperch	0.19
Lutjanidae	*Lutjanus adetii*	Yellow-banded snapper	0.19
Orectolobidae	*Orectolobus ornatus*	Ornate wobbegong	0.19
Lutjanidae	*Paracaesio xanthura*	Yellowtail snapper	0.19
Serranidae	*Acanthistius ocellatus*	Eastern Wirrah	0.15
Labridae	*Achoerodus viridis*	Eastern blue groper	0.15
Labridae	*Austrolabrus maculatus*	Black-spotted parrotfish	0.15
Labridae	*Bodianus unimaculatus*	Pigfish	0.15
Serranidae	*Caesioperca lepidoptera*	Butterfly perch	0.15
Chaetodontidae	*Chelmonops truncatus*	Eastern Talma	0.15
Monacanthidae	*Meuschenia* sp	Leatherjacket	0.15
Monodactylidae	*Schuettea scalaripinnis*	Eastern pomfred	0.15

Family	Species name	Common Name	Mean MaxN
Carangidae	*Seriola hippos*	Samson fish	0.15
Brachaeluridae	*Brachaelurus waddi*	Blind shark	0.11
Monacanthidae	*Eubalichthys mosaicus*	Mosaic leatherjacket	0.11
Glaucosomatidae	*Glaucosoma scapulare*	Pearl perch	0.11
Labridae	*Labroides dimidiatus*	Bluestreak cleaner wrasse	0.11
Myctophidae	*Meuschenia trachylepis*	Yellowfin leatherjacket	0.11
Pempherididae	*Pempheris affinis*	Blacktip bullseye	0.11
Carangidae	*Pseudocaranx dentex*	Silver trevally	0.11
Labridae	*Bodianus perditio*	Golden-spot hogfish	0.07
Heterodontidae	*Heterodontus galeatus*	Crested hornshark	0.07
Balistidae	*Abalistes stellatus*	Starry triggerfish	0.04
Lutjanidae	*Lutjanus russelli*	Moses' snapper	0.04
Scorpididae	*Microcanthus strigatus*	Stripey	0.04
Orectolobidae	*Orectolobus halei*	Banded carpet shark	0.04
Scombridae	*Sarda australis*	Australian bonito	0.04
Scorpaenidae	*Scorpaena cookii*	Eastern red scorpionfish	0.04
Carangidae	*Trachurus* sp	Mackerel	0.04

The Pimpernel Rock Marine National Park Zone, situated in northern extent of the Solitary Island AMP, is a popular site with recreational divers and has been well studied. This is due to its diverse fish life and the fact this area has important habitat for the critically endangered (under the EPBC Act 1999) grey nurse shark (*Carcharias taurus*). The NSW Department of Primary Industries has collated a list of 103 species of fish through the collection of diver observation and BRUV data at Pimpernel Rock (Table 9).

Pimpernel Rock Marine National Park Zone was sampled as a part a Commonwealth Government's monitoring programme using stereo BRUVs. Four sites were sampled in 2007 and 2015. Over the two sampling dates, 33 species representing 20 families were recorded (Table 10).

A number of commercially and recreationally target species were recorded in this area, including; yellowtail kingfish (*Seriola lalandi*; Figure 27), pink snapper (*Chrysophrys auratus),* Venus tuskfish (*Choerodon venustus*)*,* blue morwong (*Nemadactylus douglasii)*, pigfish (*Bodianus unimaculatus*)*,* foxfish (*Bodianus frenchii*)*,* and Maori wrasse (*Opthalmolepsis lineolatus*). Many of these species were recorded on multiple stereo BRUV drops.

Figure 27. Yellow-tail kingfish (*Seriola lalandi*) observed on the stereo BRUV footage at Pimpernel Rock in the Solitary Islands AMP.

Table 9. A complete list of fish species observed at Pimpernel Rock by the Department of Primary Industries NSW from diver timed counts (Timed count), incidental diving observations (Inc.) and stereo BRUVs.

Family Name	Species Name	Common Name	Timed count	Inc.	BRUV
Carcharhinidae	*Carcharinus* sp	Whaler shark			x
Odontaspididae	*Carcharias taurus*	Grey nurse shark	x		
Dasyatididae	*Dasyatis thetidis*	Black stingray	x		
Heterodontidae	*Heterodontus galeatus*	Crested Port Jackson			x
Orectolobidae	*Orectolobus maculatus*	Spotted wobbegong	x		
	Orectolobus halei	Gulf wobbegong	x		x
Muraenidae	*Gymnothorax prasinus*	Green moray	x		x
Aulopidae	*Aulopos purpurissatus*	Sergeant baker	x		x
Belonidae	*Tylosurus sp*	Longtom	x		
Holocentridae	*Myripristis murdjan*	Crimson squirrelfish	x		
Acanthuridae	*Naso unicornis*	Unicorn fish	x		
	Prionurus maculatas	Spotted sawtail	x		
	Prionurus microlepidotus	Sawtail	x		x
Apogonidae	*Rhabdamia gracilis*	Slender cardinalfish	x		
Blennidae	*Plagiotremis rhinorhyncos*	Tube-worm fang-blenny	x		
Caesionidae	*Caesio caerulaurea*	Gold banded fusilier	x		
	Pterocaesio digramma	Blacktip fusilier	x		
Carangidae	*Caranx melampygus*	Blue-fin trevally	x		
	Caranx sexfaciatus	Big-eye trevally	x		
	Elagatis bipinnulata	Rainbow runner	x		
	Pseudocaranx dentex	White trevally	x		x
	Seriola dumerili	Amberjack	x		
	Seriola hippos	Samsonfish	x		
	Seriola lalandi	Yellowtail kingfish	x		x
Chaetodontidae	*Chaetodon flavirostris*	Dusky butterflyfish	x		
	Chaetodon guentheri	Gunthers butterflyfish	x		
	Chaetodon kleinii	Brown butterflyfish	x		
	Coradion altivelus	Highfin coralfish	x		
	Heniochus acuminatus	Reef bannerfish	x		
Cheilodactylidae	*Cheilodactylus fuscus*	Red morwong	x		x
	Nemadactylus douglasii	Grey morwong			x
Cirrhitidae	*Cirrhitichthys aprinus*	Threadfin hawkfish	x		
Enoplosidae	*Enoplosus armatus*	Old wife	x		x
Ephippidae	*Platax teira*	Teira batfish	x		
Glaucosomidae	*Glaucosoma scapulare*	Pearl perch			x
Kyphosidae	*Kyphosus sydneyanus*	Southern silver drummer	x		
Labridae	*Achoerodus viridus*	Eastern blue groper	x		
	Anampses meleagrides	Spotted wrasse	x		
	Anampses neoguinaicus	New guinea wrasse	x		

Family Name	Species Name	Common Name	Timed count	Inc.	BRUV
	Bodianus diana	Dianas hogfish	x		
	Bodianus frenchii	Foxfish	x		x
	Bodianus perditio	Goldspot hogfish	x		
	Bodianus unimaculatus	Pigfish			x
	Choerodon venustus	Venus tuskfish			x
	Coris picta	Comb coris	x		x
	Coris sandayeri	King or sandaggers wrasse	x		
	Gomphosus varius	Birdnose wrasse	x		
	Labriodes bicolor	Bicolour cleaner wrasse	x		
	Labroides dimidiatus	Cleaner wrasse	x		
	Notolabrus gymnogenis	Crimson-banded wrasse	x		x
	Opthalmolepsis lineolata	Maori wrasse	x		x
	Pseudolabrus guentheri	Gunthers wrasse	x		
	Thalassoma amblycephalum	Two-tone wrasse	x		
	Thalassoma lunare	Moon wrasse	x		
	Thalassoma lutescens	Yellow moon wrasse	x		
	Thalassoma janseni	Jansens wrasse	x		
Lutjanidae	*Lutjanus argentimaculatus*	Mangrove jack	x		
	Lutjanus russelli	Moses perch	x		
	Paracaesio xanthura	Southern fusilier	x		
Mullidae	*Parupeneus spilurus*	Blackspot goatfish	x		x
	Upeneichthys lineatus	Blue lined goatfish			
Pempherididae	*Pempheris affinis*	Black-tipped bullseye	x		
Plesiopidae	*Trachinops taeniatus*	Eastern hulafish	x		
Pomacentridae	*Abudefduf bengalensis*	Bengel sergeant	x		
	Abudefduf vaigiensis	Sergeant major	x		
	Chromis hypsilepis	One-spot puller	x		
	Chrysiptera flavipinnis	Yellow-finned damsel	x		
	Chrysiptera notialis	Southern damsel	x		
	Mecaenichthys immaculatus	Immaculate damsel			
	Parma microlepis	White ear parma			
	Parma oligolepis	Big scale parma	x		
	Parma unifasciata	Girdled parma	x		x
	Pomacentrus coelestis	Blue damsel	x		
	Stegastes gasgoynei	Gold belly gregory	x		
Scaridae	*Scarus ghobban*	Blue-barred parrotfish	x		
Scianidae	*Argyrosomus hololepidotus*	Jewfish, mulloway	x		

Family Name	Species Name	Common Name	Timed count	Inc.	BRUV
Scianidae	*Atractoscion aequidens*	Teraglin			x
Scombridae	*Sarda australis*	Australian bonito	x		x
	Atypichthys strigatus	Mado	x		x
	Microcanthus strigatus	Stripey	x		
	Scorpis lineolata	Silver sweep	x		x
Serranidae	*Acanthistius ocellatus*	Wirrah	x		
	Cephalopholis miniata	Coral cod	x		
	Epinephelus daemelii	Black cod	x		
	Epinephelus fasciatus	Red-barred cod	x		
	Epinephelus lanceolatus	Queensland groper	x		
	Epinephelus undulatostriatus	Maori cod/ scribbled rockcod		x	
	Hypoplectrodes macullochi	Half-banded sea-perch	x		x
	Pseudanthias cooperi	Red seaperch		x	
	Pseudanthias fasciatus	Red-stripe seaperch	x		x
	Pseudanthias rubrizonatus	Redbar anthias	x		
	Pseudanthias squamipinnis	Orange seaperch	x		
	Pseudanthias sp			x	
Sparidae	*Chrysophrys auratus*	Pink snapper	x		x
Sphyraenidae	*Shyraena jello*	Pickhandle barracuda	x		
Scorpaenidae	*Pterois volitans*	Lionfish	x		
	Scorpaena cardinalis	Red rockcod	x		x
Aulostomidae	*Aulostomus chinensis*	Trumpetfish		x	
	Fistularia sp	Flutemouth	x		
Diodontidae	*Dicotylichthys punctulatus*	Three bar porcupinefish	x		
Monacanthidae	*Cantherinus pardalis*	Honeycomb leatherjacket	x		
	Meuschenia sp	Leatherjacket			x
Tetradontidae	*Canthigaster callisterna*	Clown toby	x		

Table 10. A list of species and their mean relative abundance (MaxN) recorded on four stereo BRUV drops per year in the Pimpernel Rock Sanctuary Zone.

Family	Species name	Common Name	Mean MaxN 2007	Mean MaxN 2015
Carcharhinidae	*Carcharinus* sp	Whaler shark		0.3
Heterodontidae	*Heterodontus galeatus*	Crested Port Jackson	0.3	
Orectolobidae	*Orectolobus halei*	Gulf wobbegong	0.3	
Muraenidae	*Gymnothorax prasinus*	Green moray	0.7	1.3
Aulopidae	*Aulopos purpurissatus*	Sergeant baker	0.7	0.3
Acanthuridae	*Prionurus microlepidotus*	Sawtail		0.3
Carangidae	*Pseudocaranx dentex*	Silver trevally	0.3	
Carangidae	*Seriola lalandi*	Yellowtail kingfish		3.7
Cheilodactylidae	*Cheilodactylus fuscus*	Red morwong	0.3	0.3
Cheilodactylidae	*Nemadactylus douglasii*	Grey morwong	0.3	0.7
Enoplosidae	*Enoplosus armatus*	Old wife	1.0	
Glaucosomidae	*Glaucosoma scapulare*	Pearl perch	0.3	
Labridae	*Bodianus frenchii*	Foxfish	1	0.3
Labridae	*Bodianus unimaculatus*	Pigfish		0.7
Labridae	*Choerodon venustus*	Venus tuskfish	1	1.0
Labridae	*Coris picta*	Comb coris	0.3	
Labridae	*Notolabrus gymnogenis*	Crimson-banded wrasse	1	1.3
Labridae	*Opthalmolepis lineolata*	Maori wrasse	1.7	1.7
Mullidae	*Parupeneus spilurus*	Blackspot goatfish	2.0	2.0
Mullidae	*Upeneichthys lineatus*	Blue lined goatfish	0.7	0.3
Pomacentridae	*Mecaenichthys immaculatus*	Immaculate damsel	0.3	
Pomacentridae	*Parma microlepis*	White ear parma	0.3	
Pomacentridae	*Parma unifasciata*	Banded parma		0.3
Scianidae	*Atractoscion aequidens*	Teraglin	0.3	
Scombridae	*Sarda australis*	Bonito		0.3
Scorpididae	*Atypichthys strigatus*	Mado	33.7	
Scorpididae	*Scorpis lineolata*	Sweep	20.3	0.3
Serranidae	*Hypoplectrodes maccullochi*	Half banded seaperch	0.7	1.0
Serranidae	*Pseudanthias fasciatus*	Red-stripe seaperch		0.3
Sparidae	*Chrysophrys auratus*	Snapper	5	3.7
Scorpaenidae	*Scorpaena cardinalis*	Red rockcod	1.0	
Monacanthidae	*Meuschenia* sp	Leatherjacket sp	0.3	
Species richness			25	20

The Pimpernel Rock is also known as a significant aggregation site for the grey nurse shark *Carcharias taurus* (Figure 28; Otway et al. 2003). Acoustic monitoring with Vemco acoustic tags and VR2 listening stages was used to track the movements of 31 Grey nurse Sharks along the NSW coast. Nine (29 % of the total number of tagged sharks) tagged sharks were recorded on the listening stations positioned on Pimpernel Rock. Further acoustic tracking studies are ongoing.

Figure 28. Photos from diver video work of the critically endangered grey nurse shark (*Carcharias taurus*) at Pimpernel Rock, Solitary Island AMP. Photos courtesy of Hamish Malcolm.

3. SOUTH-EAST MARINE PLANNING REGION

3.1 Overview

Australia's South-east AMP network extends from the south coast of New South Wales, encompassing all of Tasmania and Victoria, and extending west to Kangaroo Island off South Australia (Figure 29). It also includes the Macquarie Island AMP (Figure 29).

The AMPs cover an area of 388,355 km^2 with depth ranging from approximately 40 - 6000 m. Of the 14 AMPs within the South-east marine planning region, there are 10 (not including Macquarie Island AMP) with that cover 15,240 km^2 of the continental shelf (Table 12). There are four zonings within the AMPs on the continental shelf in the South-east marine planning region, including Marine National Park, Multiple Use, Recreational Use and Sanctuary Zones. Most of the AMPs in this marine planning region are classified entirely as Multiple Use. However, Freycinet and Tasman Fracture AMPs have Marine National Park, Recreational and Sanctuary zones (Table 12). Unlike in the Temperate east and South-west marine planning regions, AMPs in the South-east have finalised management plans.

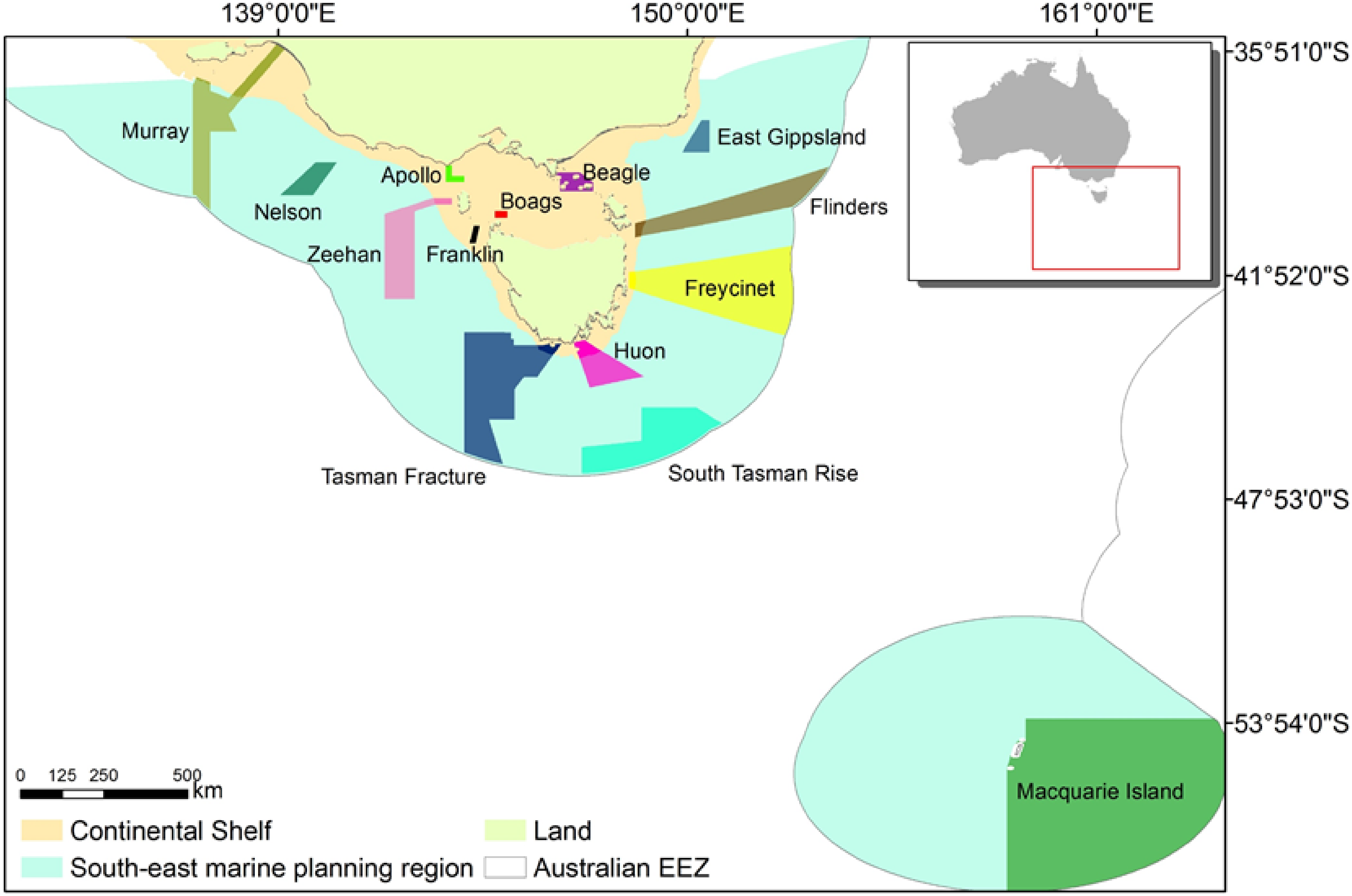


Figure 29. Location of the AMPs within the South-east marine planning region.

Table 11. Total coverage (km^2) for each AMP and area represented on the continental shelf in the South-east marine planning region.

AMP	Total area (km^2)	Area on shelf (km^2)	Percentage (%)
Apollo	1,184	1,184	100
Beagle	2,928	2,928	100
Boags	537	537	100
East Gippsland	4,137	0	0
Flinders	27,043	798	3
Franklin	671	671	100
Freycinet	57,942	735	1
Huon	9,991	1,783	18
Macquarie Island	161,895	35	0.02
Murray	25,803	4,803	19
Nelson	6,123	0	0
South Tasman Rise	27,704	0	0
Tasman Fracture	42,501	917	2
Zeehan	19,897	733	4
Total area (km^2)	*388,355*	*15,124*	*4*

Table 12: Summary of areas (km^2) of each protection zone within the continental shelf regions of each AMP in the South-east marine planning region.

AMP	Multiple Use Zone (km^2)	Recreational Use Zone (km^2)	Sanctuary Zone (km^2)	Marine National Park Zone
Apollo	1,184	0	0	0
Beagle	2,928	0	0	0
Boags	537	0	0	0
East Gippsland	0	0	0	0
Flinders	798	0	0	0
Franklin	671	0	0	0
Freycinet	550	185	0	0
Huon	1,783	0	0	0
Macquarie Island	0	0	35	0
Murray	4,803	0	0	0
Nelson	0	0	0	0
South Tasman Rise	0	0	0	0
Tasman Fracture	252	0	0	666
Zeehan	733	0	0	0
Total area (km^2)	*14,239*	*185*	*35*	*666*

3.2 List of publications for AMPs in the South-east marine planning region

A total of 15 publications were identified that pertain to at least one of the continential shelf regions within the AMPs in the South-east marine planning region. Bibliographic details and web links are provided in Table 13.

Table 13: List of publications containing biological sampling of continental shelf reef-habitats in AMPs for South-east marine planning region.

AMP	Date	Authors	Title	URL/Link
Apollo	1987	Wilson RS, Poore GCB	The Bass Strait Survey: biological sampling stations, 1979-1984.	Occasional Papers from the Museum of Victoria, 3: 1-14
	2002	O'Hara T	Benthic assemblages of Bass Strait.	Museum Victoria (Report)
Beagle	2000	Butler A, Gowlett-Holmes K, Barker B	Tasmanian Natural Gas Pipeline Project Pipeline Route Survey Aug-Sept 2000 Biological Data Report	https://publications.csiro.au/rpr/pub?pid=changeme:4401
Flinders	2016	Monk J, Barrett NS, Hill NA, Lucieer VL, Nichol SL, Siwabessy JPW, Williams SB	Outcropping reef ledges drive patterns of epibenthic assemblage diversity on cross-shelf habitats.	http://link.springer.com/article/10.1007/s10531-016-1058-1
	2016	Monk J, Barrett NS, Hulls J, James L, Hosack G, Oh E, Martin T, Edwards S, Nau A, Heaney B, Foster S	Seafloor biota, rock lobster and demersal fish assemblages of the Tasman Fracture Commonwealth Marine Reserve Region: Determining the influence of the shelf sanctuary zone on population demographics	http://www.nespmarine.edu.au/document/seafloor-biota-rock-lobster-and-demersal-fishes-assemblages-tasman-fracture-commonwealth
	2016	Althaus F, Barrett NS, Dambacher JM, Davies P, Ferrari R, Ford J, Hayes KR, Hill N, Hosack GR, Hovey R, Huang Z, Hulls J, Ingleton T, Jordan A, Kendrick GA, Kool J, Lawrence E, Leeming R, Lucieer VL, Malcolm H, Meyer L, Monk J, Nichol SL, Peel D, Perkins NR, Siwabessy JPW, Sherlock M, Martin T,	Analysis of approaches for monitoring biodiversity in Commonwealth waters: Field work report	http://www.nespmarine.edu.au/document/analysis-approaches-monitoring-biodiversity-commonwealth-waters-field-work-report

AMP	Date	Authors	Title	URL/Link
		Tran M, Walsh A, Williams A		
	2015	Lawrence E, Hayes KR, Lucieer VL, Nichol SL, Dambacher JM, Hil, NA, Barrett N, Kool J, Siwabessy J	Mapping habitats and developing baselines in offshore marine reserves with little prior knowledge: a critical evaluation of a new approach.	http://journals.plos.org/plosone/article?id=10.1371%2Fjournal.pone.0141051
	2014	Hill NA, Barrett N, Lawrence E, Hulls J, Dambacher JM, Nichol S, Williams A, Hayes KR	Quantifying fish assemblages in large, offshore marine protected areas: an Australian case study.	http://journals.plos.org/plosone/article?id=10.1371%2Fjournal.pone.0110831
	2002	O'Hara T	Benthic assemblages of Bass Strait.	Museum Victoria (Report)
	1987	Wilson RS, Poore GCB	The Bass Strait Survey: biological sampling stations, 1979-1984.	Occasional Papers from the Museum of Victoria, 3: 1-14
Franklin	2007	Williams AF, Althaus B, Barker R, Kloser, G Keith	Using data from the proposed Zeehan MPA to provide an inventory of benthic habitats and biodiversity, and evaluate prospective indicators for monitoring and performance assessment: research and monitoring for benthic ecosystems in marine protected areas of the South East Marine Region (SEMR). Final Report to the Department of the Environment and Water Resources	https://www.researchgate.net/publication/311066458_Using_data_from_the_proposed_Zeehan_MPA_to_provide_an_inventory_of_benthic_habitats_and_biodiversity_and_evaluate_prospective_indicators_for_monitoring_and_performance_assessment_research_and_monitori
	2002	O'Hara T	Benthic assemblages of Bass Strait.	Museum Victoria (Report)
	1987	Wilson RS, Poore GCB	The Bass Strait Survey: biological sampling stations, 1979-1984.	Occasional Papers from the Museum of Victoria, 3: 1-14
Freycinet	2009	Nichol SL, Anderson TJ, McArthur M, Barrett N, Heap AD, Siwabessy PJW, Brooke B	Southeast Tasmania Temperate Reef Survey, Post-Survey Report	Geoscience Australia, Record 2009/43, 73pp.
Huon	2009	Nichol SL, Anderson TJ, McArthur M, Barrett N, Heap AD, Siwabessy PJW, Brooke B	Southeast Tasmania Temperate Reef Survey, Post-Survey Report	Geoscience Australia, Record 2009/43, 73pp.
Tasman Fracture	2016	Monk, J, Barrett NS, Hulls J, James L, Hosack G, Oh E, Martin T, Edwards S, Nau A, Heaney B, Foster S	Seafloor biota, rock lobster and demersal fish assemblages of the Tasman Fracture Commonwealth Marine	http://www.nespmarine.edu.au/document/seafloor-biota-rock-lobster-and-demersal-fishes-

AMP	Date	Authors	Title	URL/Link
			Reserve Region: Determining the influence of the shelf sanctuary zone on population demographics	assemblages-tasman-fracture-commonwealth
Zeehan	2007	Williams A, Althaus F, Barker B, Kloser R, Keith G	Using data from the proposed Zeehan MPA to provide an inventory of benthic habitats and biodiversity, and evaluate prospective indicators for monitoring and performance assessment: research and monitoring for benthic ecosystems in marine protected areas of the South East Marine Region (SEMR). Final Report to the Department of the Environment and Water Resources	https://www.researchgate.net/publication/311066458_Using_data_from_the_proposed_Zeehan_MPA_to_provide_an_inventory_of_benthic_habitats_and_biodiversity_and_evaluate_prospective_indicators_for_monitoring_and_performance_assessment_research_and_monitori
All AMPS in SE region	2006	Williams A, Daley R, Fuller M, Knuckey I	Integrating fishing industry knowledge of fishing grounds with scientific data on seabed habitats for informed spatial management and ESD evaluation in the SESSF. FRDC Final Report: FRDC 2000/153	http://frdc.com.au/research/final-reports/Pages/2000-153-DLD.aspx
	2003	Hayes D, Furlani D, Condie S, Althaus F, Butler A	Data layers and metadata to assist in the selection of candidate MPAs in the SEMR (Draft). In. Department of the Environment and Heritage	http://www.environment.gov.au/coasts/mpa/publications/pubs/southeast-data.pdf

3.3 List of biological datasets for AMPs in the South-east marine planning region

Five sampling platforms provide the basis of the biological descriptions provided in the subsequent sections relating to the continential shelf regions of AMPs within the South-east marine planning region. A summary of these identified datasets that related to each AMP in the South-east marine planning region is provided in Table 14.

Importantly, no biological sampling was found in the Boags or Murray AMP and therefore no biological reporting could be undertaken.

Table 14. Available biological data records within the shelf regions of the AMPs in South-east marine planning region. BSS: Broad scale scoring (dominant substrata and biota at image level). FSS: fine scale scoring (superimposed random points scored to CATAMI morphotype class).

AMP	Survey Method	Biological resolution	Number of Samples/ Transects/ Images	Proportion of data records scored	Number of time series	Contact for data
Apollo	Epibenthic sampling	Full taxonomy on selected taxa	18 (4 on rocky bottom)	100%	1	Tim, O'Hara, Museum Victoria
Beagle	CritterCam	full taxonomy (Fish) Biotope (Sessile benthos)		100%	1	John Arnould, Deakin University
	Drop Camera	CSIRO - SGF	13	100%	1	CSIRO
	AUV		3 transects	0	1	Neville Barrett, IMAS-Utas
	BRUV		4 drops	0	1	Neville Barrett, IMAS-Utas
Flinders	AUV	CATAMI BSS	17 transects	240 images	3	Neville Barrett, IMAS-Utas
		CATAMI FSS	17 transects	1240 images	3	Neville Barrett, IMAS-Utas

AMP	Survey Method	Biological resolution	Number of Samples/ Transects/ Images	Proportion of data records scored	Number of time series	Contact for data
		IMAS-Utas Morphospecies	17 transects	240 images	3	Neville Barrett, IMAS-Utas
		Targeted for mobile invertebrates, fish and black corals	17 transects	100%	3	Neville Barrett, IMAS-Utas
	STV	CATAMI	11 transects	100%	1	Franzis Althaus, CSIRO
	BRUV	full taxonomy	51	100%	1	Neville Barrett, IMAS-Utas
Freycinet	AUV	IMAS-Utas Morphospecies	16 transects	408 images		Neville Barrett, IMAS-Utas
		Targeted for lobster, seastars and *Centrostephanus urchins*	1 Bicheno offshore/Joes Reef	100%	2	Neville Barrett, IMAS-Utas
	BRUV	full taxonomy	21	100%	1	Neville Barrett, IMAS-Utas
	TV	GA – Broad Biota type	8	100%	1	Neville Barrett, IMAS-Utas
Franklin	STV	CSIRO - SGF	1	100%	1	Franzis Althaus, CSIRO
	Epibenthic sled	OTU / full taxonomy	1	100%	1	Franzis Althaus, CSIRO
	Epibenthic sampling	Full taxonomy on selected taxa	3 (all coarse sand)	100%	1	Tim O'Hara, Museum Victoria

AMP	Survey Method	Biological resolution	Number of Samples/ Transects/ Images	Proportion of data records scored	Number of time series	Contact for data
Huon	AUV	Morphospecies	7	263 images	3	Neville Barrett, IMAS-Utas
	STV	CSIRO - SGF	2	100%	1	Franzis Althaus, CSIRO
	TV	GA – Broad Biota type	2	100%	1	Neville Barrett, IMAS-Utas
	Epibenthic sled	OTU / full taxonomy	2	100%	1	Franzis Althaus, CSIRO
Tasman Fracture	Lobster potting	full taxonomy	200	100%	1	Neville Barrett, IMAS-Utas
	AUV	Morphospecies	2	246 images		Neville Barrett, IMAS-Utas
		Targeted	2	100%	1	Neville Barrett, IMAS-Utas
	BRUV	full taxonomy	46	100%	1	Neville Barrett, IMAS-Utas
	STV	CSIRO - SGF	2	100%	1	Franzis Althaus, CSIRO
	Epibenthic sled	OTU / full taxonomy	3	100%	1	Franzis Althaus, CSIRO
Zeehan	STV	CSIRO - SGF	4 (part)	100%	1	Franzis Althaus, CSIRO
	Epibenthic sled	OTU / full taxonomy	1	100%	1	Franzis Althaus, CSIRO

3.4 Apollo AMP

3.4.1 Description of physical habitat

Mapping data for the Apollo AMP is coarse and completed by the Australian Bathymetry and Topography Grid produced by Geoscience in June 2009 (Figure 30). The continental shelf region of the Apollo AMP represents 100 % of its total area. This mapping suggests the depth range is *c* 50 – 100 m, with most reef-habitat confined to the shallow northern section (Figure 30 and Figure 142 in Appendix A).

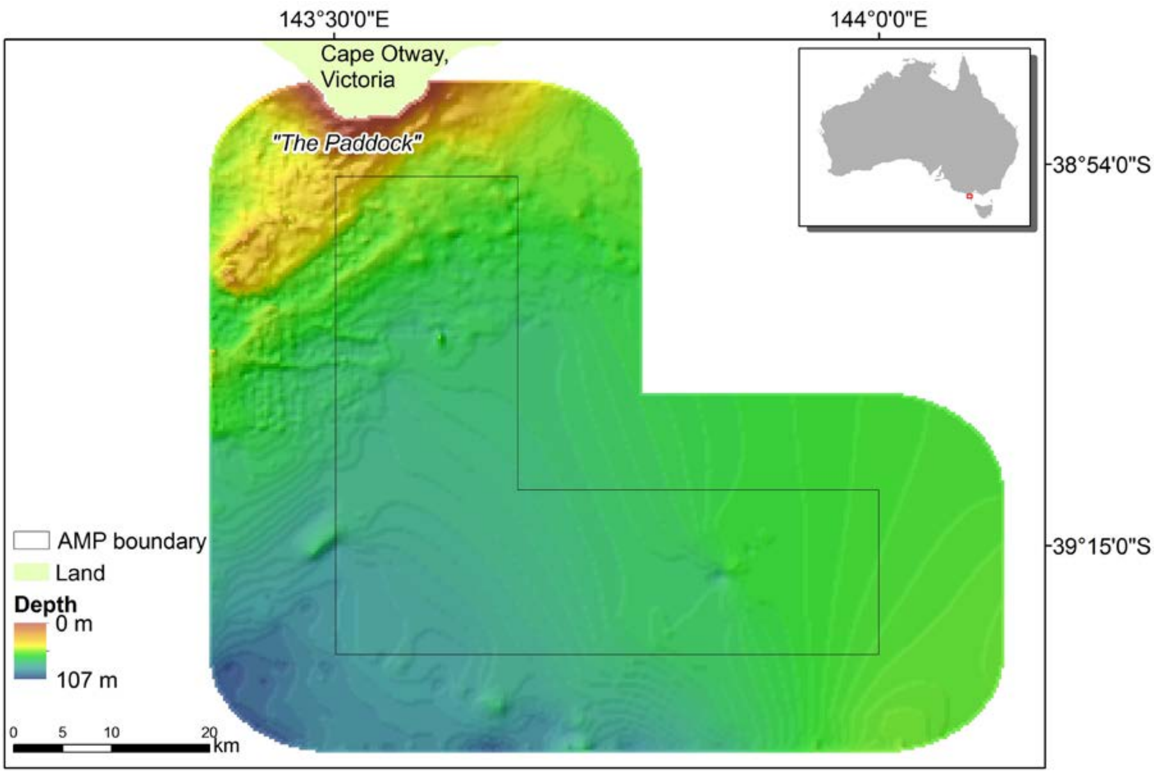


Figure 30. Mapping coverage of the Apollo AMP based on the Australian Bathymetry and Topography Grid, produced by Geoscience in June 2009. Note the location of “The Paddock”, known by commercial fishing sector for the high southern rock lobster biomass.

3.4.2 Description of biological assemblages

Only limited biological sampling has been undertaken on reef habitats within the Apollo AMP. O’Hara (2002) undertook an analysis of epibenthic sled collections conducted by Museum Victoria during the 1979-1983 throughout Bass Strait, with coverage in the Apollo AMP region. In total 18-epibenthic sleds sample were undertaken in the Apollo AMP region, with four targeting rocky reef habitats. Using a non-metric multidimensional scaling plot, they found that the macrofauna associated with the seabed in the western region of Bass Strait appeared to be distinctly different to the central and eastern sites surveyed as a part of the study. It is important to note that most of the sampling took place predominantly on soft sediments. O'Hara (2002) did suggest some of the differences in the recorded assemblages were due to comparably fewer sponges being collected in the Apollo AMP region. However, they do suggest that the region was not comprehensively surveyed for sponges and large sponge beds are likely to exist within the AMP.

Another key observation for the Apollo AMP relates to southern rock lobster (*Jasus edwardsii*). Directly to the north of the Apollo AMP in the shallower Victorian State waters is a region of reef known as the "Paddock" by commercial rock lobster fishing sector in recognition for its' ability to support a large biomass of southern rock lobster. From the limited resolution mapping, based on the Australian Bathymetry and Topography Grid, produced by Geoscience in June 2009 it appears these highly productive shallow reefs extend in a southwestern direction from Cape Otway and into the northwestern region of the Apollo AMP (Figure 30). While there are obvious, depth differences between the reefs between the Paddock region (*c.* 10-50m) and north western region of Apollo AMP (*c.* 50-90m), the southern rock lobster with in this region are thought to migrate to and from deeper water throughout the year, suggesting a possible link with these deeper reefs within the Apollo AMP.

There have been no targeted surveys of reef-affiliated fishes within or nearby the Apollo AMP.

3.6 Beagle AMP

3.6.1 Description of physical habitat

Mapping data within the Beagle AMP consists of the Australian Bathymetry and Topography Grid and target fine-scale MBES surveys from the Australian Hydrographic office (Figure 31 and Figure 126 in Appendix A). The continental shelf region of the Beagle AMP represents 100 % of its total area.The fine-scale MBES mapping covers ~ 34 % of the Beagle AMP, spanning the width of the AMP between the Hogan Group of islands and Deal Island (Figure 31). Additional MBES mapping was also undertaken by the navy onboard the RV Investigator in 2017. The extent of this mapping is shown in Figure 31 as we are unable to present this data until it has been released by the Department of Defence.

The area with older MBES data shows that the mid shelf is largely covered in sediment, with reefs restricted to narrow (*c.* <100 m width) and short (100’s m) ridges up to 5 m high. Examples of these localised features are mapped in the area to the southeast of Hogan Island in water depths of 30-70 m (top left insert in Figure 31). There also appears to be large sediment features northeast of Devils Tower in water depths around 60 m (top right insert in Figure 31). The origin of these ridges is unclear. An area of potential hard substrata is also mapped to the southwest of Hogan Island where a ledge feature defines a bathymetric step from 45 to 60 m (Figure 31). An autononmous underwater vehicle (AUV) mission to the area in 2017 confirmed that these features to the southeast of the Hogan Island were low profile reef.

3.6.2 Description of biological assemblages

There are a limited number of animal-borne video camera (CritterCam, National Geographic Society) deployments from the Australian fur seal colony on nearby Kanowna Island (Volpov et al. 2015). These geo-located, animal-borne video cameras were used to record the foraging event locations of Australian fur seal. Since these seals are benthic foragers throughout Bass Strait, foraging events document the prey type as well as the composition of the seabed habitats. Based on this tracking data associated with the animal-borne video deployments, two of the eight seals tracked foraged within the Beagle AMP.

The footage revealed that foraging events occurred in depths of between 43 to 78 m, on low-profile sand-inundated reef covered in sparse to medium densities of sessile invertebrates, including branching, cup and massive sponges as well as the commonly observed CATAMI class, bryozoan/cnidarian/hydroid matrix.

These animal-borne observations are similar to those from Bulter et al. (2000) who undertook 13 camera drops in the AMP as a part of a gas pipeline impact assessment study. From these images, it is clear that there is low-profile reefs southeast of the Hogan Group (sites 23-25 in Figure 31) that support moderate cover of sessile sponges and ascidians (Figure 32).

In 2017, NESP researchers from Institute of Marine and Antarctic Studies undertook a more targeted plot study of the Beagle AMP using an AUV and stereo BRUVs. While this data is yet to be annotated, imagery confirmed the low profile reef features seen in the MBES data to the southeast of Hogan Island (Figure 31). These reef features appear to be densily covered by sponges and hard bryozoans (Figure 33). Of particular interest is the unsually high prevalence of hard orange bryozoans (left column in Figure 33). However, detailed annotation and further surveys are required to determine how robust these initial observations are.

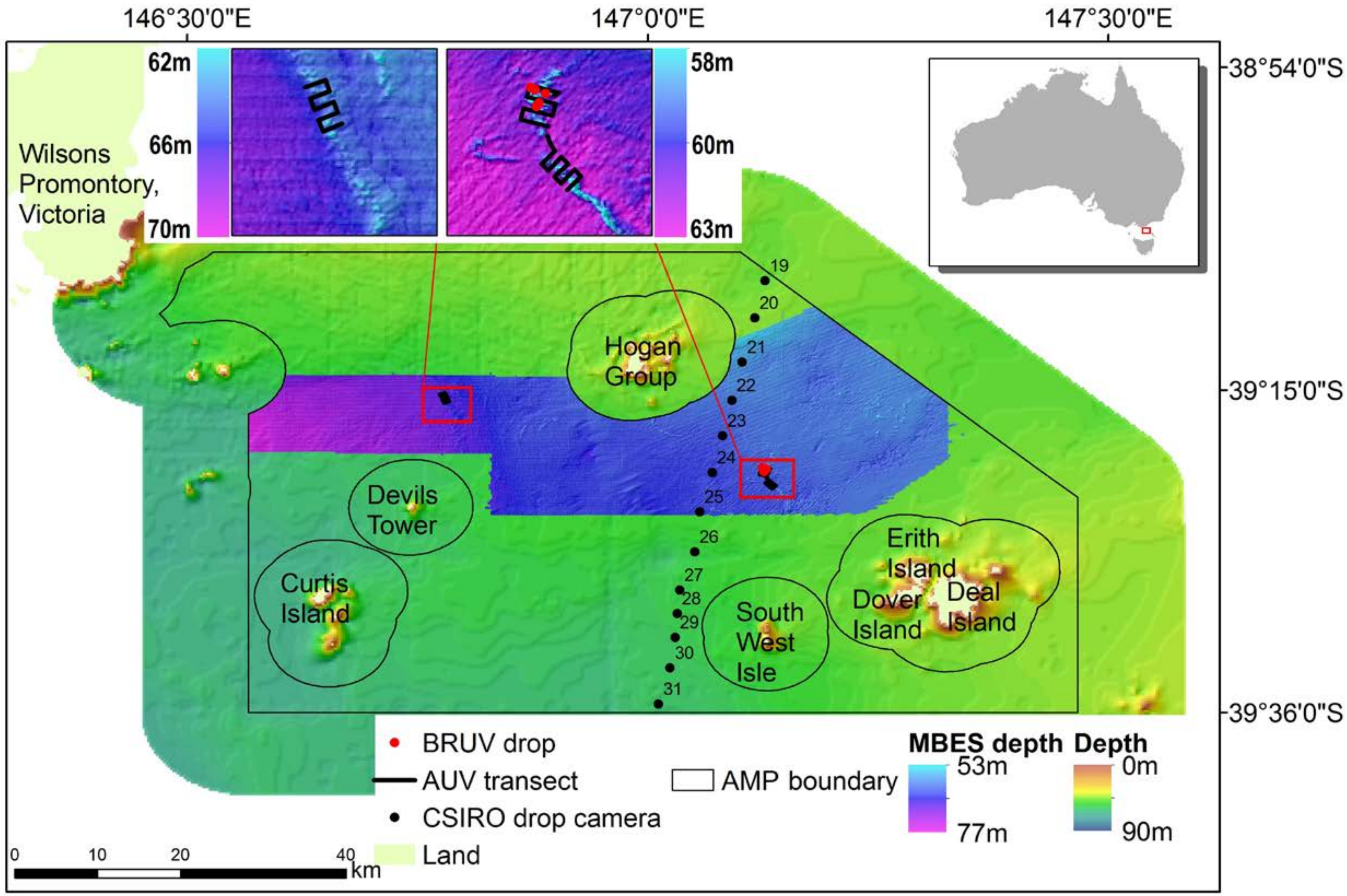


Figure 31. Mapping coverage of the Beagle AMP based on the Australian Bathymetry and Topography Grid, produced by Geoscience Australia in June 2009. Note the multibeam sonar (MBES depth) is at 40-m resolution as it was collected by the Australian Hydrographic Office. Inserts show potential reef features identified but yet to be visually confirmed. Numbered points relate to CSIRO survey by Butler et al. (2000).

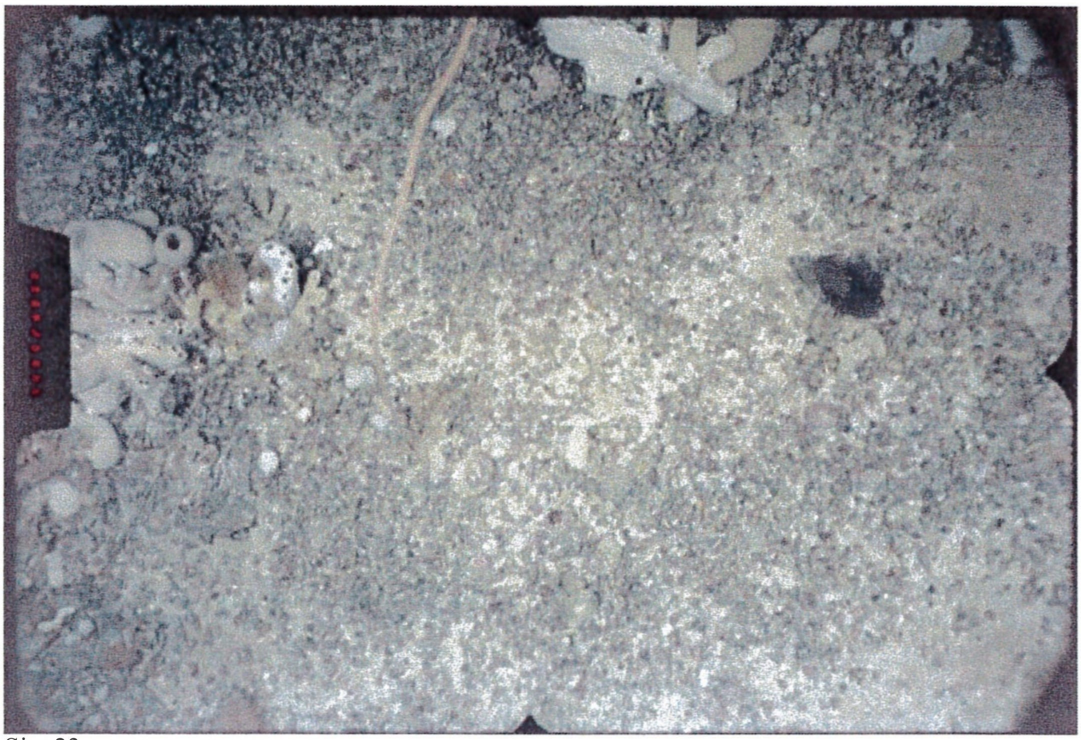
The animal-born video imagery also provides an insight into the fish present within the AMP. A total of 10 different prey species were recorded, with 32 individuals of unidentifiable fish (due to low quality black and white camera footage), 29 individuals of Scorpionfish (most likely a combination of *Helicolenus percoides* and *Neosebastes scorpaenoides*), and 10 individuals of leatherjackets (most probably *Meuschenia scaber).* Other prey species encountered on the footage included a small number of butterfly perch (*Caesioperca* spp.), scad (*Trachurus* spp.), octopus and elasmobranchs (catshark, stingaree and stringray) (Table 15).

The prey items and seabed habitats appear to be typical of fish assemblages and seabed biota surveyed in other low profile, sand inundated reefs in similar depth ranges within the South-east marine planning region (e.g. Flinders AMP).

Table 15. Fish species recorded using animal-born video deployments within the Beagle AMP.

Common name	Species name	Abundance
Butterfly perch	*Caesioperca* spp	2
Catshark	Elasmobranch (catshark)	1
Stingray	Elasmobranch (stingray)	2
Leatherjacket	Monacanthidae	10
Octopus	Octopoda	1
Scorpionfish	Scorpaenidae	29
Scad	*Trachurus* spp	1
Stingaree	Urolophidae	6
	Unidentifiable benthic fish spp	32
	Unidentifiable fish spp	1

Site 22



Site 23

Figure 32. Two images from Butler et al. (2000) showing stalked ascidians, branching sponges (top image), and laminar and small massive sponges (bottom image).

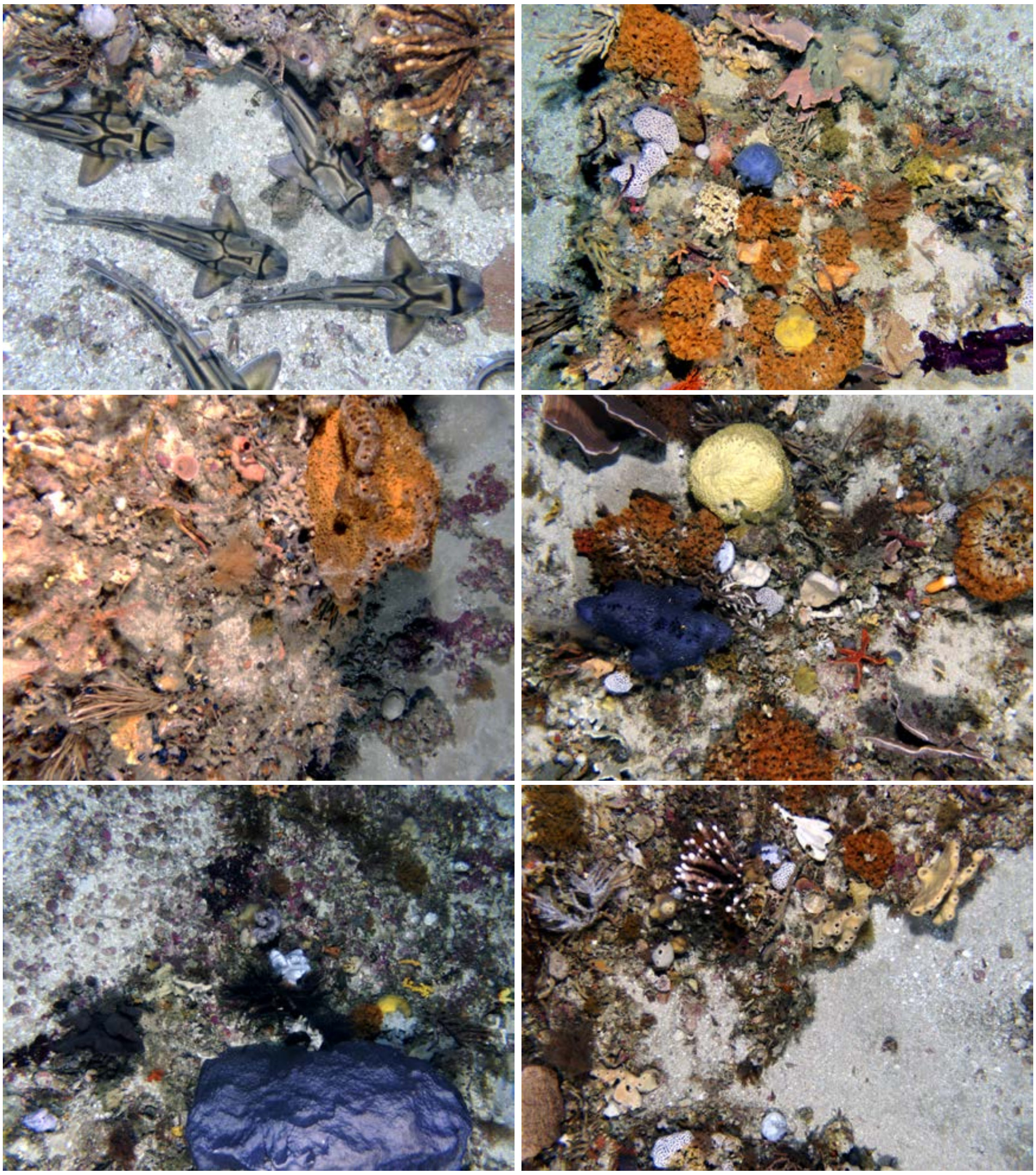


Figure 33. Examples of the sessile biota captured in the 2017 AUV survey of the Beagle AMP showing schools of Port Jackson Shark, massive sponges, branching sponges, cup sponges, bryozoans and cnidarians. Note the unusally high prevalence of the orange hard bryozoan in the left hand images.

3.7 Boags AMP

3.7.1 Description of physical habitat

Mapping data within the Boags AMP is of limited resolution and is represented by the very coarse (250 m cell resolution) Australian Bathymetry and Topography Grid. The continental shelf region of the Boags AMP represents 100 % of its total area. The broad-scale mapping data indicates the potential for the presence of hard seabed structures in the southeastern section of the AMP (Figure 34). The numerous small peaks which appear in the bathymetric record are likely artifacts (errors) in the data and do not reflect real, crest or peak structures (Figure 34 and Figure 127 in Appendix A). However, the smooth boundaries to the north and west of the image are likely to indicate steps in consolidated soft substrata known to be characteristic of the region.

3.7.2 Description of biological assemblages

There has not been any documented targeted sampling of reef-habitat within the continental shelf region of the Boags AMP.

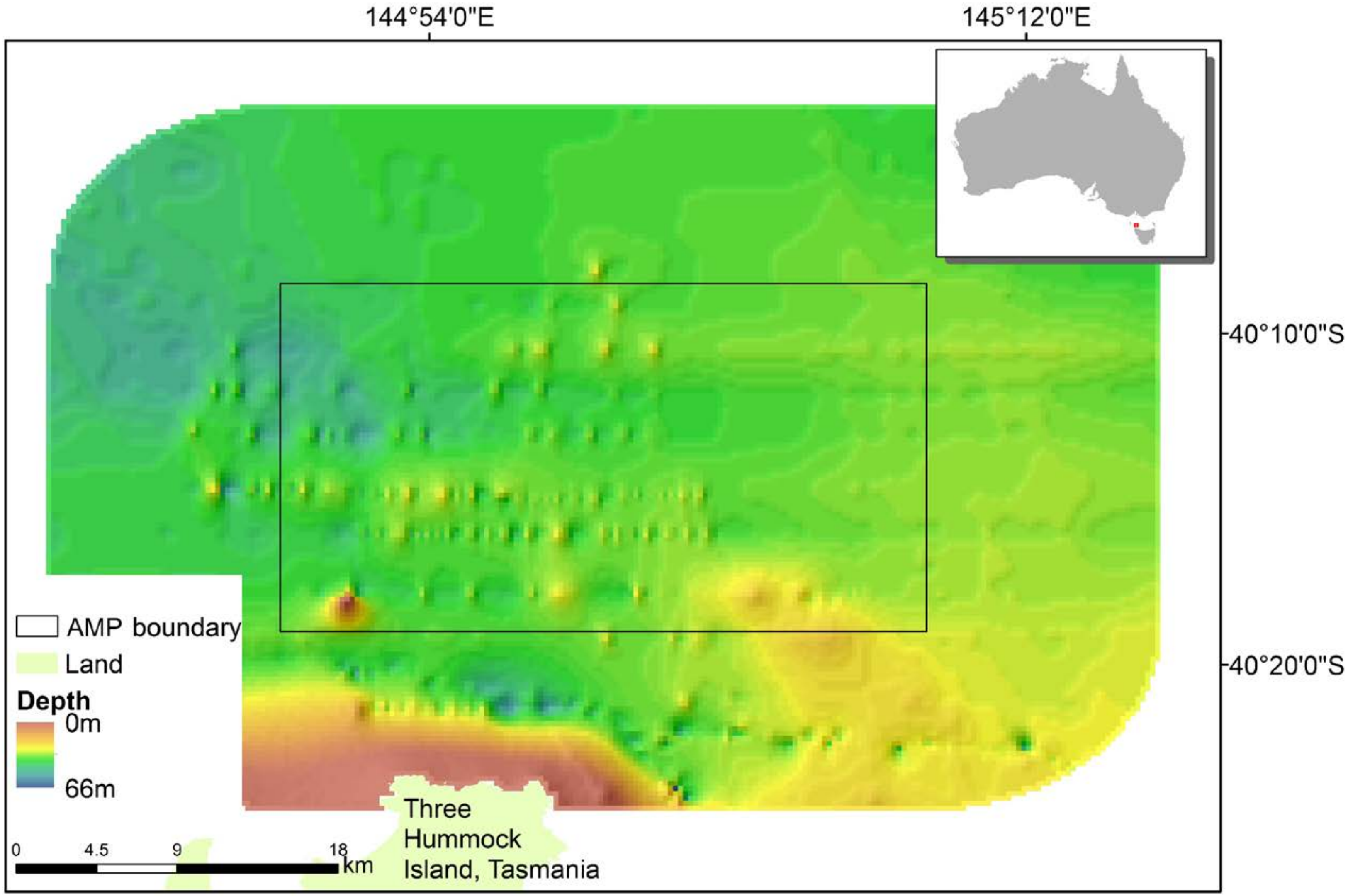


Figure 34. Mapping coverage of the Boags AMP based on the Australian Bathymetry and Topography Grid, produced by Geoscience Australia in June 2009. Note the numerous small peaks are likely error in the data and do not reflect real small crest-like structures.

3.8 Flinders AMP

3.8.1 Description of physical habitat

Mapping data for of the Flinders AMP can be compiled from a number of sources including the Australian Bathymetry and Topography Grid and targeted fine-scale MBES surveys from the CSIROs Southern Surveyor and Geoscience Australia as a part of the NERP science agenda in 2011 and 2012 (Figure 35). The continental shelf region of the Flinders AMP represents ~3% of its total area.

The majority of the fine-scale MBES seabed mapping of the continental shelf in Flinders AMP has focused along the shelf break with an area of ~ 30 km^2 on the outer shelf that was acquired in 2011 and 2012 under the NERP Marine Biodiversity Hub programme (Lawrence et al. 2015) (Figure 35b; hereafter referred to as the "continuous patch"). Additional mapping acquired during transits provides a further 13 km^2 of coverage across the mid shelf but in narrow (~700 m) swaths. Reef geoform featuresin the mapped area on the outer shelf include low relief platforms that rise 2-5 m above adjacent sandy seabed in ~ 60-90 m (Figure 36 and Figure 128 in Appendix A). These platforms are semi-continuous features, extending up to 5 km along the shelf in a northeast-southwest direction. Smaller platforms also occur as isolated features covering areas of ~0.05 km^2. A distinctive characteristic of the platforms is a ledge geofeature that defines the seaward (eastern) edge of the larger platforms. This ledge is up to 2 m high and formed in exposed rock (possibly sandstone) that provides hard substrata for sessile fauna. In contrast, the AUV and stereo towed video (STV) observations show that the platforms are partly covered by a thin sand veneer forming mixed (hard and soft) substrata. The distribution of reef platforms elsewhere on the shelf of Flinders AMP is likely to be patchy and discontinuous, with bathymetry collected on transit lines indicating a similar irregular flat platform and ledge reef structure and adjacent sand-dominated seabed.

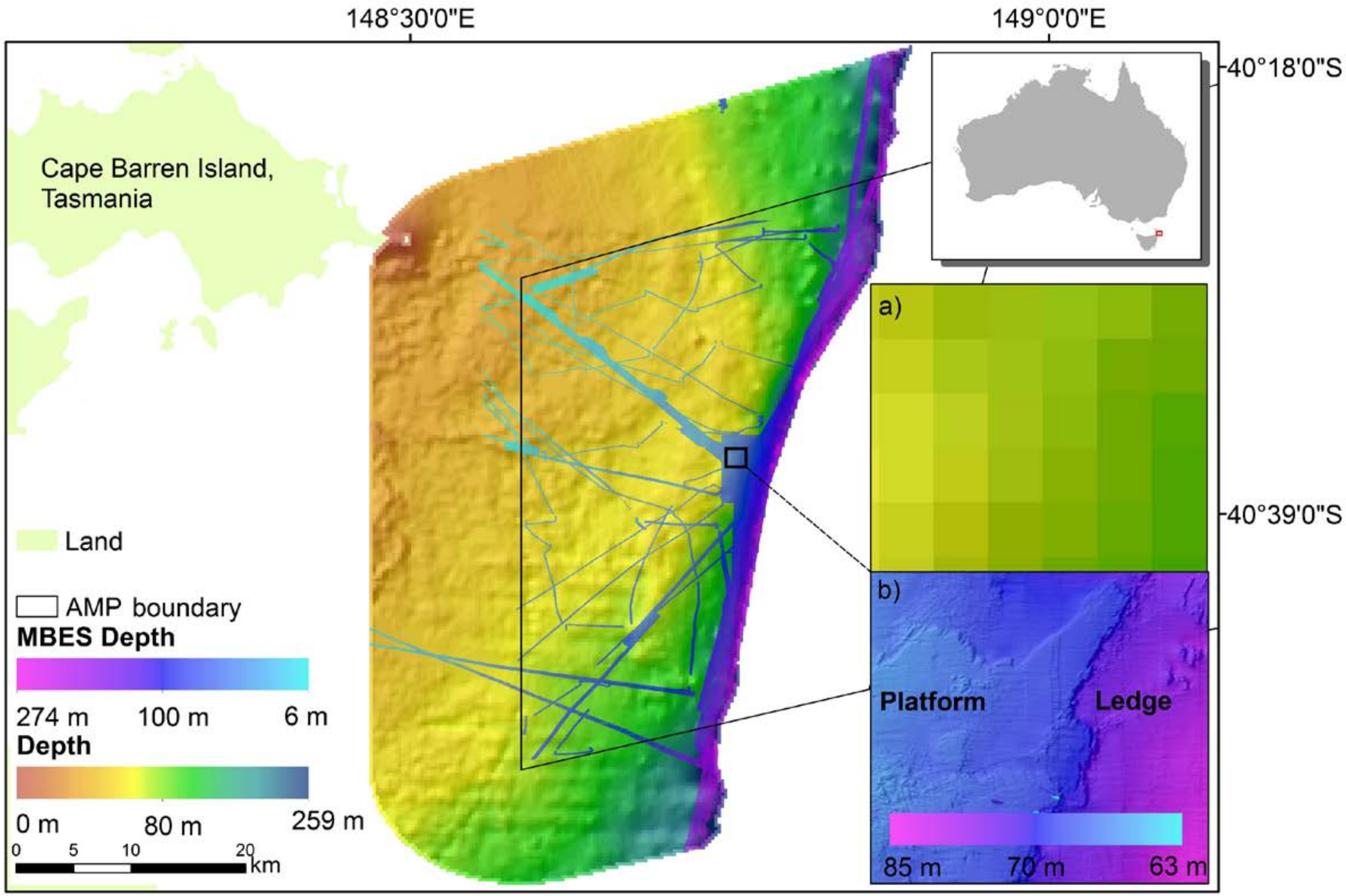


Figure 35. Mapping coverage of the Flinders AMP based on the Australian Bathymetry and Topography Grid, produced by Geoscience Australia in June 2009. Note the fine-scale 5-m resolution multibeam sonar (MBES depth) collected by the CSIRO and Geoscience Australia as a part of NERP. a-b) show a comparison in the detail between the Australian Bathymetry and Topography Grid and fine-scale MBES for a zoomed region surveyed in detail by the IMOS AUV. b) Platform and ledge reef geoform features have been identified from the MBES on the outer shelf of Flinders AMP..

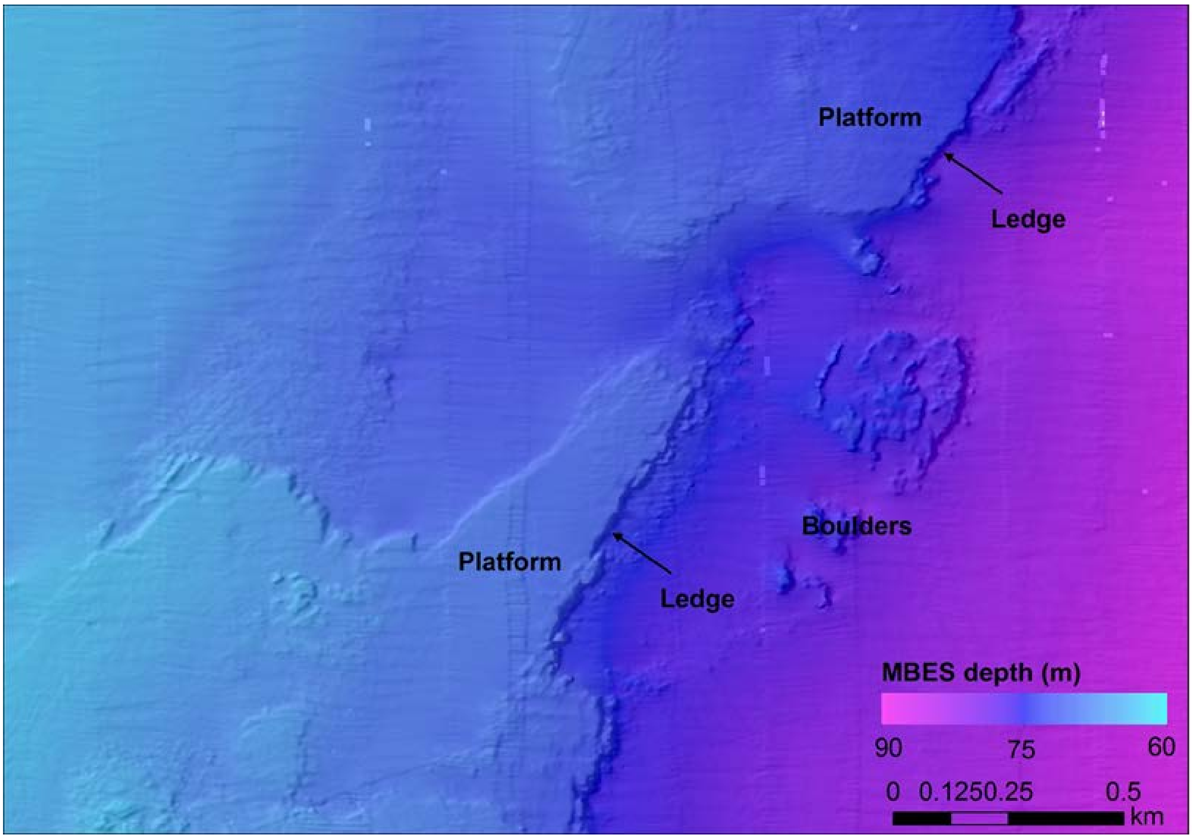


Figure 36. Close-up of the geoform features of Continuous patch in the Flinders AMP.

3.8.2 Description of biological assemblages

A total of 51 stereo BRUV deployments were undertaken in 2012 as a part of NERP (Althaus et al*.* 2016). A total of 2397 individual fishes were recorded represented by 52 species from 31 families (Table 16). Of the predominantly benthic-feeding, reef-resident species, the degens leatherjacket (*Thamnaconus degeni*; 491 individuals; Figure 37), jackass morwong (*Nemadactylus macropterus*; 404 individuals; Figure 38), species striped trumpeter (*Latris lineata*; 116 individuals; Figure 39) and cosmopolitan leatherjacket (*Meuschenia scaber*; 101 individuals) were the were most abundant (Table 16). Interestingly, while high abundances were recorded for these species only the cosmopolitan leatherjacket and jackass morwong were observed on > 50% of the deployments (Table 16) suggesting the remaining species have limited distributions within the AMP.

The only other species that was found in high relative abundances was the pelagic species, jack mackerel (*Trachurus declivis*; 359 individuals), which are likely to be transient residents of the area (Table 16).

Approximately, 35 % of fish species were observed once or twice (Table 16) which is reasonably consistent with fish assemblages recorded elsewhere in Tasmania.

Southern rock lobster (*Jasus edwardsii*), arrow squid (*Nototodarus* sp), octopus (unidentifiable) and southern calamari (*Sepia australis*) were recorded in low abundances on the stereo BRUVs (Table 16).

It should be noted that the sampling was targeted towards reef habitats, thus potentially biasing fish assemblages and abundances towards fish species with strong preference of reef habitats.

These data were collected as a part of the NERP work within the Flinders AMP to trial generating overall estimates of the average relative abundance (mean MaxN) of some potential indicator fish species within the AMP (Table 17). These estimates represent the overall average MaxN that you would expect to observe if sampling in the Flinders AMP. They take into account the relative proportions of the different substrata types expected across the entire AMP (Table 17).

Jackass morwong (*Nemadactylus macropterus*) had the highest average abundance (MaxN) across the entire reserve (5.37 individuals per sample in the design-based estimate; Table 17), followed by sand flathead (*Platycephalus bassensis*; 1.96 individuals; Table 17). The overall average abundance (MaxN) of striped trumpeter (*Latris lineata*), tiger flathead (*Platycephalus richardsoni*), ocean reef perch (*Helicolenus percoides*), and gummy shark (*Mustelus antarcticus*) were similar, ranging from 0.80 to 0.50 individuals, respectively (Table 17). Uncertainty increased with larger values of average abundance (MaxN), indicating the patchiness and habitat preferences of the species (Figure 40). For example, the overall average abundance (MaxN) for ocean reef perch (*Helicolenus percoides*) was 0.69 individuals per sample, but higher for mixed reef/sediment habitats (i.e. 1.98 individuals; Table 17), and considerably lower for sediment only habitats (0.1 individuals; Table 17).

Table 16. Fish species recorded using stereo BRUVs in the Flinders AMP based on 51 deployments. Abundance was measured using MaxN.

Family	Species	Abundance (MaxN)	Prevalence	Min Length (mm)	Max Length (mm)	Mean Length (mm)	Number measured	Percent Measured
Callanthiidae	*Callanthias australis*	4	2%				0	0%
Callorhinchidae	*Callorhinchus milii*	2	4%	-	-	807	1	50%
Carangidae	*Trachurus declivis*	359	6%				0	0%
	Trachurus sp	34	10%	85	105	94	12	35%
Cheilodactylidae	*Nemadactylus douglasii*	8	12%	145	244	190	7	88%
	Nemadactylus macropterus	404	65%	141	375	276	268	66%
Cyttidae	*Cyttus australis*	6	12%	146	289	213	5	83%
Dasyatidae	*Dasyatis brevicaudata*	1	2%				0	0%
Diodontidae	*Diodon nicthemerus*	1	2%				0	0%
Fishes (multi-family groups)	Blenniidae, Gobiidae, Tripterygiidae	7	10%				0	0%
	Skates & rays	1	2%	-	-	905	1	100%
Gempylidae	*Thyrsites atun*	17	24%	443	620	481	9	53%
Gerreidae	*Parequula melbournensis*	84	33%	-	-	163	1	1%
Heterodontidae	*Heterodontus portusjacksoni*	4	8%	754	933	847	4	100%
Labridae	*Ophthalmolepis lineolatus*	1	2%				0	0%
	Pseudolabrus rubicundus	81	29%				0	0%
Lamnidae	*Isurus oxyrinchus*	1	2%	-	-	1484	1	100%
Latridae	*Latris lineata*	116	27%	426	870	536	72	62%
Loliginidae	*Sepioteuthis australis*	22	31%	178	392	256	18	82%
Monacanthidae	*Acanthaluteres vittiger*	16	20%	246	262	254	2	13%

Family	Species	Abundance (MaxN)	Prevalence	Min Length (mm)	Max Length (mm)	Mean Length (mm)	Number measured	Percent Measured
	Meuschenia freycineti	3	6%				0	0%
	Meuschenia scaber	101	57%	97	221	178	12	12%
	Meuschenia venusta	1	2%				0	0%
	Nelusetta ayraud	1	2%				0	0%
	Thamnaconus degeni	491	43%	214	239	230	3	1%
Moridae	*Pseudophycis barbata*	9	14%	333	430	404	7	78%
Mullidae	*Upeneichthys vlamingii*	18	18%	89	270	227	6	33%
Neosebastidae	*Neosebastes scorpaenoides*	50	47%	213	349	301	40	80%
Octopodidae	Octopodidae	1	2%				0	0%
Ommastrephidae	*Nototodarus* sp	2	2%	216	371	294	2	100%
	Ommastrephidae	7	10%				0	0%
Ostraciidae	*Aracana aurita*	7	12%				0	0%
	Aracana ornata	1	2%				0	0%
	Aracana sp	1	2%				0	0%
Palinuridae	*Jasus edwardsii*	2	4%	104	128	116	2	100%
Paraulopidae	*Paraulopus nigripinnis*	55	29%	118	159	139	3	5%
Pinguipedidae	*Parapercis allporti*	39	41%				0	0%
Platycephalidae	*Platycephalus bassensis*	36	27%	274	519	379	25	69%
	Platycephalus richardsoni	23	27%	263	559	423	18	78%
	Platycephalus sp	1	2%				0	0%
Pristiophoridae	*Pristiophorus cirratus*	2	4%	833	969	901	2	100%
Rajidae	*Dentiraja lemprieri*	2	4%	488	580	534	2	100%
	Dipturus sp	1	2%				0	0%

Family	Species	Abundance (MaxN)	Prevalence	Min Length (mm)	Max Length (mm)	Mean Length (mm)	Number measured	Percent Measured
	Spiniraja whitleyi	9	18%	369	1677	1139	10	111%
Scyliorhinidae	*Cephaloscyllium laticeps*	71	67%	279	884	678	50	70%
Sebastidae	*Helicolenus percoides*	69	37%	67	308	223	50	72%
Serranidae	*Caesioperca lepidoptera*	102	12%				0	0%
	Caesioperca rasor	2	4%				0	0%
	Caesioperca sp	45	6%				0	0%
	Lepidoperca tasmanica	18	12%				0	0%
Squalidae	*Squalus acanthias*	1	2%	482	482	482	1	100%
	Squalus megalops	16	16%	277	388	321	15	94%
	Squalus sp	2	2%				0	0%
Superclass Pisces - undifferentiated	Unidentifiable fish	5	10%				0	0%
Triakidae	*Mustelus antarcticus*	21	39%	358	1054	589	17	81%
Triglidae	*Lepidotrigla* sp	3	6%				0	0%
Urolophidae	*Urolophus cruciatus*	2	4%				0	0%
	Urolophus paucimaculatus	4	8%	320	459	408	3	75%
	Urolophus sp	4	8%	281	281	281	1	25%

Table 17. Design-based estimates of the mean abundance (MaxN) of each potential indicator fish species derived during NERP work in the Flinders AMP.

Species	Entire area					On mixed reef and sediment substrata					On sediment substrata				
	n	Mean	SE	L95	U95	n	Mean	SE	L95	U95	n	Mean	SE	L95	U95
Helicolenus percoides	46	0.69	0.19	0.32	1.06	34	1.98	0.55	0.91	3.05	12	0.10	0.12	-0.13	0.33
Latris lineata	46	0.80	NA	NA	NA	34	2.53	1.08	0.40	4.66	12	0.00	NA	NA	NA
Mustelus antarcticus	46	0.50	0.14	0.22	0.78	34	0.17	0.06	0.05	0.29	12	0.65	0.21	0.24	1.06
Nemadactylus macropterus	46	5.37	1.84	1.78	8.97	34	11.11	2.14	6.91	15.30	12	2.74	2.49	-2.14	7.62
Platycephalus bassensis	46	1.96	0.74	0.52	3.40	34	0.09	0.06	-0.03	0.21	12	2.82	1.07	0.71	4.92
Platycephalus richardsoni	46	0.72	0.26	0.21	1.22	34	0.30	0.15	0.02	0.59	12	0.90	0.37	0.18	1.63

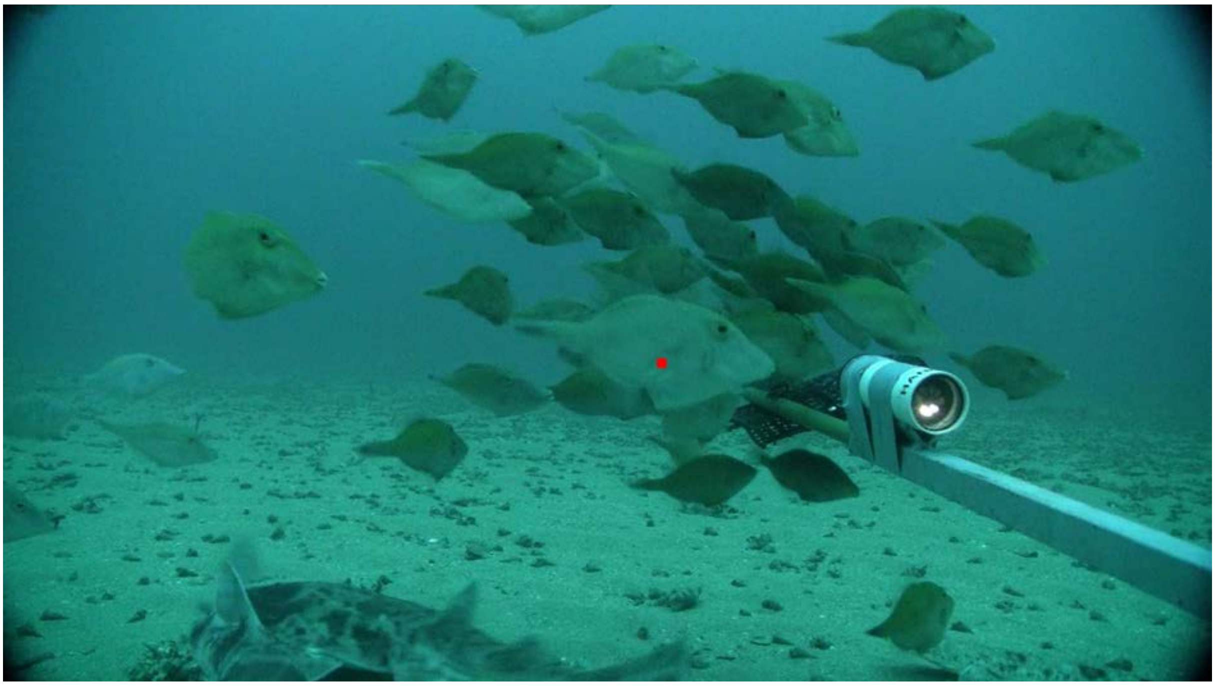


Figure 37. An example of a large school of degens leatherjackets recorded in the Flinders AMP. Note the draughtboard shark at bottom left of image.

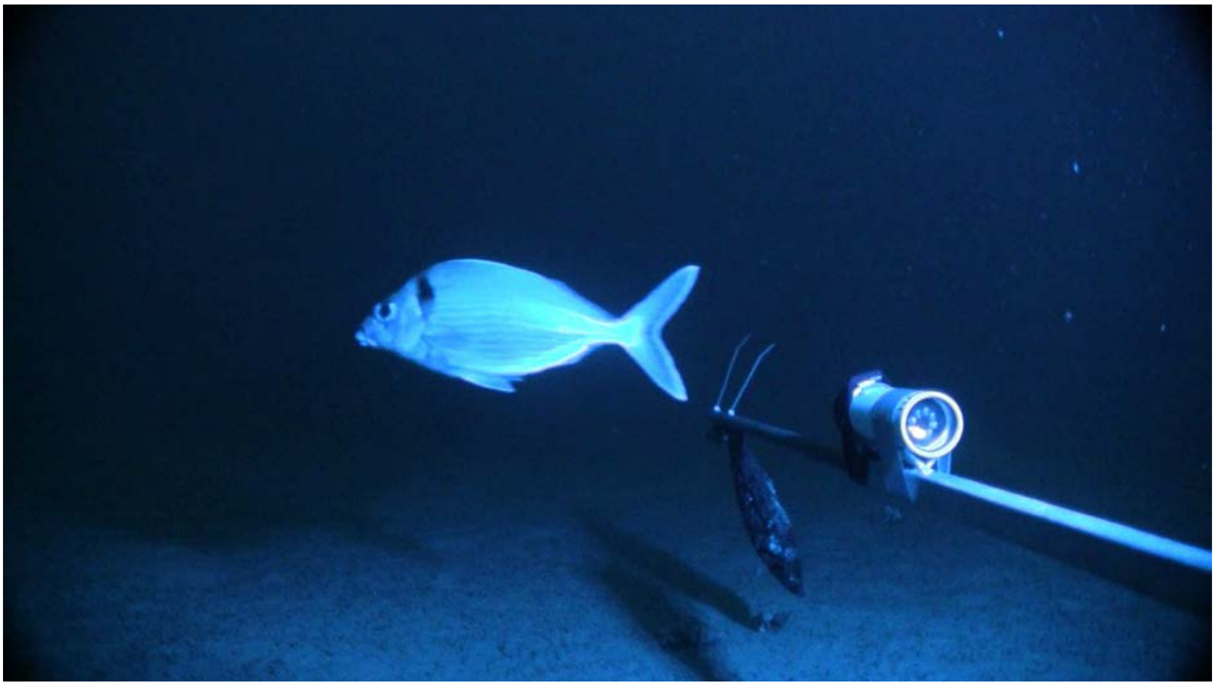


Figure 38. An example of a solitary jackass morwong. Schools large of 44 individuals were recorded in Flinders AMP.

Figure 39. Example of typical school of striped trumpeter from Flinders AMP. Note blue colouration is from blue lights used for illumination.

The STV and the AUV have been used to survey the seabed biota within the Flinders AMP. Imagery from both these platforms has primarily been scored to two biological schemes: CATAMI and IMAS morphospecies. Additional targeted scoring was undertaken to map the distribution of mobile organisms captured within the AUV imagery.

Based on the STV imagery collected at 11 sites within the broader Flinders AMP shelf region suggests that the proportion coverage of component seabed biota for most sites was quite low for most CATAMI level 1 classes, ranging from 0 to 0.84 (Figure 41). Bryozoans appeared to have higher coverage around the shelf break, while macroalgae appeared to be constrained to the shallow regions in the northwest of the Flinders AMP (Figure 41). Sponges, cnidarians and ascidians appeared to be evenly distributed (Figure 41).

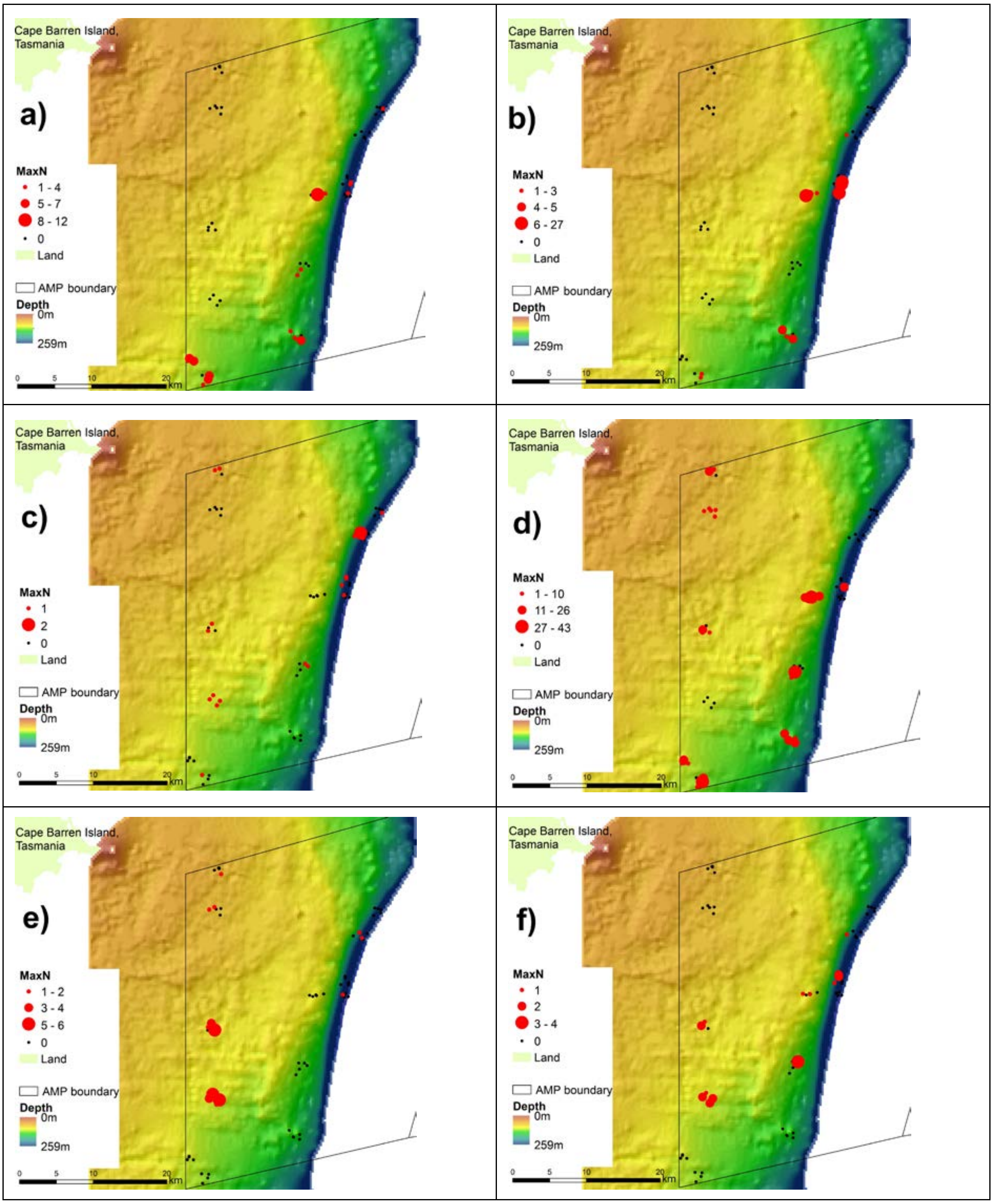


Figure 40. Distribution in the relative abundance of six potential indicator fish species with the shelf region of the Flinders AMP. a) ocean reef perch (*Helicolenus percoides*), b) striped trumpeter (*Latris lineata*), c) gummy shark (*Mustelus antarcticus*), d) jackass morwong (*Nemadactylus macropterus*), e) sand flathead (*Platycephalus bassensis*), f) tiger flathead (*Platycephalus richardsoni*)

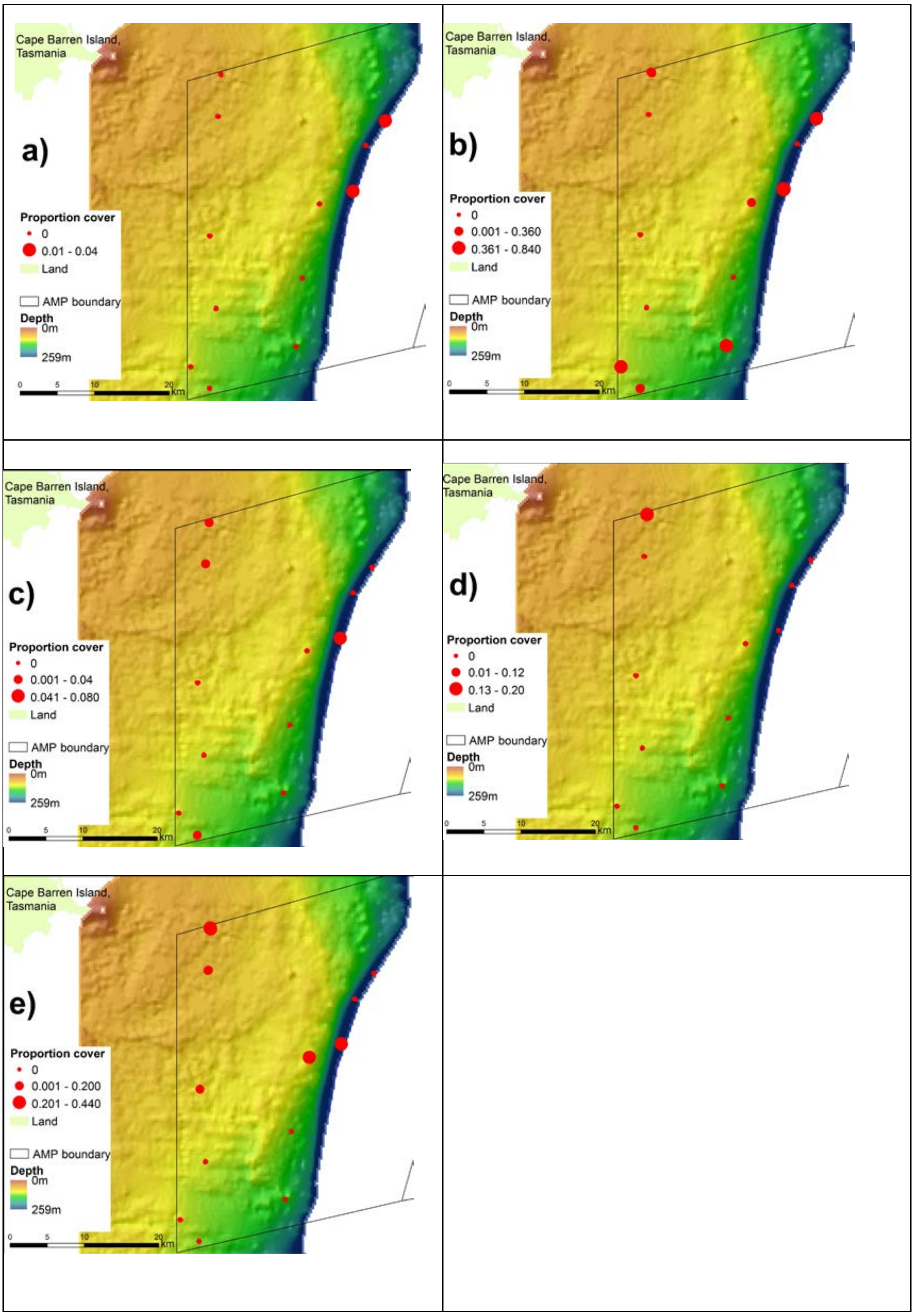


Figure 41. Distribution of proportion cover of sessile biological communities (grouped to CATAMI level 1) at each of the 11 GRTS cells across the broader Flinders AMP shelf region. a) Ascidians, b) Bryozoans, c) Cnidarians, d) Macroalgae, e) Sponges.

A total of 17 AUV transects have been completed within the Flinders AMP. Nine were conducted in 2011 and the remaining eight in 2013, with five being repeats of the same transects for yet to be done temporal comparison analysis (Figure 42).

Most of the scoring of the AUV imagery from Flinders AMP has focused on the continuous patch. From the AUV missions in 2013 a total 240 AUV images, representing 10 samples per transect, were scored for benthic invertebrate cover (Table 18). From these images a highly diverse assemblage was recorded, with 129 biological morphospecies being identified and four substratum types (Table 18). Sponges were commonly observed with 88 morphospecies, followed by Cnidarians (14 morphospecies), Ascidians and Bryozoans (eight morphospecies each). The mixed class of Bryozoan/Cnidaria/Hydroid matrix was most commonly observed (Table 18). The morphospecies “Lumpy 5 Yellow” was the most common sponge, representing 0.21 % of the total assemblage, followed by “Repent 2 Brown” (Table 18; Figure 43; Figure 44). Overall, the remaining biota was typical of that found in deep reef assemblages, with very few species approaching cover of 2 %, and with the vast majority significantly less than that.

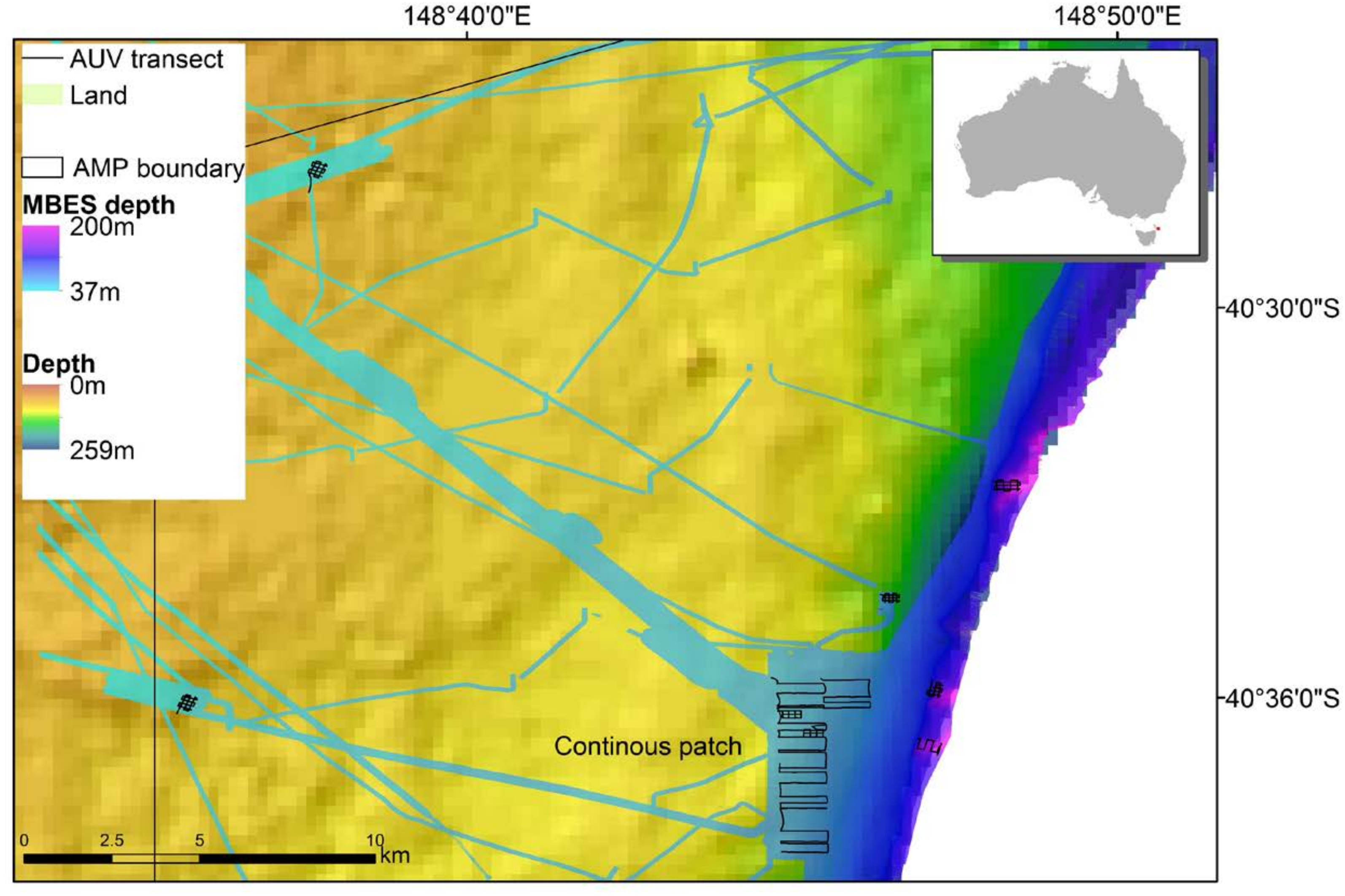


Figure 42. Overview in the coverage of AUV transects completed in Flinders AMP.

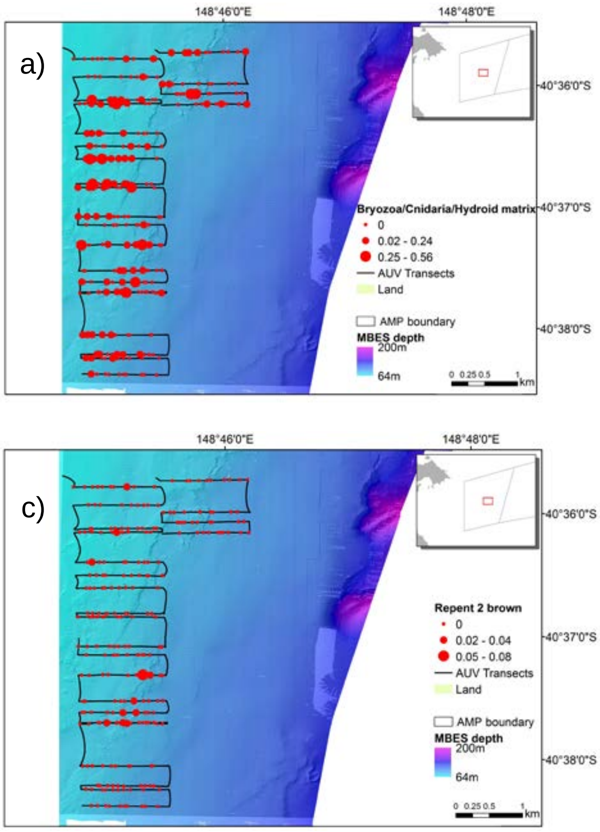


Figure 43. AUV transects and the distribution of proportion cover for three of the most commonly observed morphospecies. a) Bryozoan/Cnidaria/Hydroid matrix. b) Lumpy 5 Yellow. c) Repent 2 Brown.

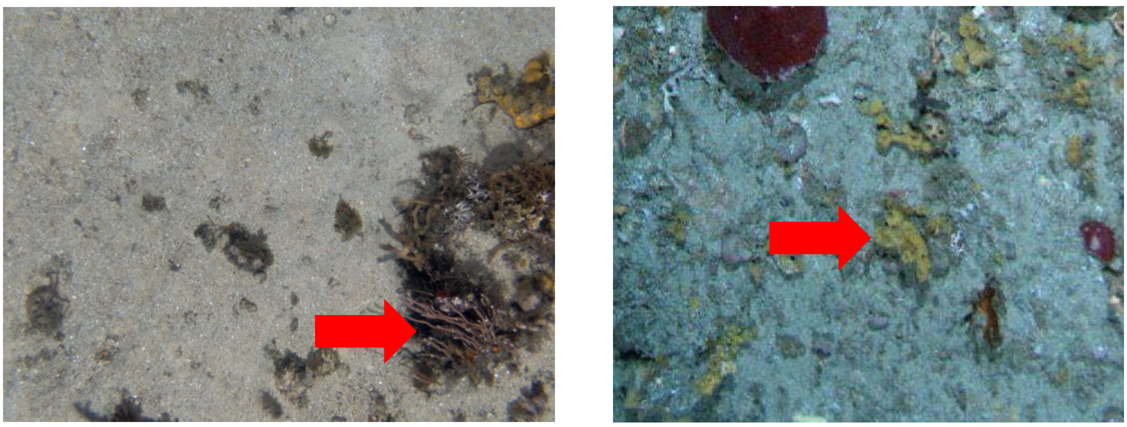


Figure 44. Examples of Repent 2 Brown (left) and Lumpy 5 Yellow (Right).

Table 18. Total observations and percentage contribution of morphospecies and bare substrate type observed in the Flinders AMP using the AUV.

CATAMI class	Morphospecies	Total observations	Percentage contribution
Ascidians	Ascidian 10 Colonial Purple	2	0.02
	Ascidian 11 Colonial	2	0.02
	Ascidian 12 Colonial Red	1	0.01
	Ascidian 2 Clavelina Like	1	0.01
	Ascidian 6 Red Throated	1	0.01
	Ascidian 9 Colonial	1	0.01
	Ascidian Red Throated	1	0.01
	Ascidian Unknown Solitary	4	0.03
Ascidians total			0.11
Biota	Unknown Biology	1	0.01
Bioturbation	Bioturbation	30	0.25
Bryozoa	Bryozoa Hard Sparse	3	0.03
	Bryozoan 1 Steginoprella Like	1	0.01
	Bryozoan 3 Cantinicella Like	17	0.14
	Bryozoan 4 Hard Celleporaria Like	1	0.01
	Bryozoan 5 Lace	1	0.01
	Bryozoan 6 Dark Red	1	0.01
	Bryozoan 7 Hard	2	0.02
	Bryozoan Unknown Soft	6	0.05
Bryozoa total			0.27
Bryozoa/Cnidaria/Hydroid matrix	Bryozoa/Cnidaria/Hydroid matrix	524	4.37
Cnidaria	Anemone sp1	3	0.03
	Bramble Acabaria sp	4	0.03
	Bramble *Asperaxis bareni*	1	0.01
	Coral Orange Solitary	2	0.02
	Gorgonian Pink 1	1	0.01
	Gorgonian Red 2	5	0.04
	Hydriod Orange 2D	1	0.01
	Hydroid 1	1	0.01
	Hydroid 2	1	0.01
	Hydroid Brown Feathers	2	0.02
	Hydroid White	1	0.01
	Sea Whip 1	6	0.05
	Soft Coral 3 Dark Red	1	0.01
	Zooanthid 1 Cf Epizooanthus	1	0.01
Cnidaria total			0.25

CATAMI class	Morphospecies	Total observations	Percentage contribution
Fishes	*Caesioperca lepidoptera*	1	0.01
	Unknown Fish	1	0.01
	Unknown Teleost	1	0.01
	Urolophus paucimaculatus	2	0.02
Molluscs	Spindle Shell	1	0.01
	Volute	3	0.03
Sponges	Arborescent 10 Orange/Brown Fingers	2	0.02
	Arborescent 13 Orange	1	0.01
	Arborescent 17 Stumpy Grey	13	0.11
	Arborescent 2 Grey	1	0.01
	Arborescent 3 Purple Thin	2	0.02
	Arborescent 6 Yellow	5	0.04
	Arborescent 8 Tan	2	0.02
	Arborescent 9 Orange Thin	6	0.05
	Barrel Red Thick Wall	1	0.01
	Branching 1 Orange	2	0.02
	Branching 2 Brown	8	0.07
	Branching 3 Purple	3	0.03
	Branching 4 Brown	1	0.01
	Branching Beige Spindles	12	0.10
	Branching Beige Stumpy	1	0.01
	Branching Grey Fine Repent Like	2	0.02
	Branching Grey Repent Like	1	0.01
	Branching Grey Thorny	1	0.01
	Branching Orange Frilly	3	0.03
	Branching Orange Long Fine	5	0.04
	Branching Purple Ramose Like	2	0.02
	Branching White Pointed	1	0.01
	Chimney Grey Single	3	0.03
	Cryptic 1 Red	3	0.03
	Cup 7 Light Pink Flat Thick	1	0.01
	Cup 8 Yellow	7	0.06
	Cup Red Smooth	1	0.01
	Cup Stalked Purple	5	0.04
	Encrusting 1 Orange	2	0.02
	Encrusting 4 Blue	1	0.01
	Encrusting 6 White	2	0.02
	Encrusting Beige Oscula	1	0.01

CATAMI class	Morphospecies	Total observations	Percentage contribution
	Encrusting Black Lumpy	1	0.01
	Encrusting Purple Lumpy	1	0.01
	Encrusting White Granular	1	0.01
	Encrusting White Lumpy	3	0.03
	Encrusting Yellow Orange Thick	1	0.01
	Fan 11 Thick Pink	1	0.01
	Fan 12 Brown Thin	1	0.01
	Fan 13 Orange Frilly	2	0.02
	Fan 4 Pink	3	0.03
	Fan 9 Orange Thick	6	0.05
	Fan White Thick	1	0.01
	Globular 5 Grey	1	0.01
	Laminar Grey Fungi	2	0.02
	Laminar White Small	2	0.02
	Lumpy 2 Orange	6	0.05
	Lumpy 5 Yellow	25	0.21
	Lumpy 6 Opaque Yellow	1	0.01
	Lumpy Shapeless Grey	2	0.02
	Massive 18 Orange Holey	1	0.01
	Massive 19 Yellow Shapeless	2	0.02
	Massive 20 Pink	2	0.02
	Massive 21	1	0.01
	Massive 22 Yellow Holey	2	0.02
	Massive 23 Orange Ribbon	4	0.03
	Massive 24 Blue Lumpy	1	0.01
	Massive 3 Orange	1	0.01
	Massive 4 Donut	1	0.01
	Massive Beige Shapeless	2	0.02
	Massive Grey Laminar Like	4	0.03
	Massive Peach Shapeless Oscula	2	0.02
	Massive Yellow Irregular Ball	2	0.02
	Orange Massive Ball 1	1	0.01
	Palmate Grey Fingers	1	0.01
	Papillate 5 Black Ball	2	0.02
	Ramose Single Cream	8	0.07
	Repent 1 Brown	1	0.01
	Repent 2 Brown	20	0.17
	Simple Beige Irregular Oscula	4	0.03

CATAMI class	Morphospecies	Total observations	Percentage contribution
	Simple Beige Laminar Like	1	0.01
	Simple Blue Shapeless	1	0.01
	Simple Erect 1 Cream	11	0.09
	Simple Erect 2 Pink	1	0.01
	Simple Grey Creep	1	0.01
	Simple Grey Doughnut	4	0.03
	Simple Orange Confused	1	0.01
	Simple Orange Smooth	2	0.02
	Simple Purple Furrowed	1	0.01
	Simple Purple Shapeless	1	0.01
	Simple Red Ball Like	1	0.01
	Simple Red Globes	2	0.02
	Simple Yellow Lumpy	2	0.02
	Tube Beige Irregular	1	0.01
	Tubes Beige Prostrate	2	0.02
	Tubular 15 Fuzzy	1	0.01
	Yellow French Fires 1	1	0.01
	Yellow Shapeless Smooth 1	1	0.01
Sponges total			2.15
Worms	Tube Worm sp1	2	0.02
Substrata	Biological Rubble	59	0.49
	Pebble/Gravel	45	0.38
	Rock	16	0.13
	Sand	10,933	91.11
Unscorable	Unscorable	48	0.40

The biological importance of the geoform ledge features were explored by Monk et al. (2016a). Using 1420 CATAMI level scored AUV imagery for the continuous patch; they found a distinct pattern in the biological assemblage with the 55 CATAMI classes identified (Figure 45). The proportion cover of Cnidaria/Bryozoa/Hydroid matrix, branching erect sponges, encrusting sponges and presence of infaunal bioturbation were identified as responsible for biodiversity patterns in relation to the mapped ledge features (Figure 45b-e). Both α and β diversity declined sharply with distance from nearest ledge feature. Patterns of the CATAMI classes were characterized by (1) class turnover at scales of 5 to 10's of metres from nearest ledge feature (Figure 45a), (2) 30 % of CATAMI classes were recorded only once (i.e. singletons), and (3) generally low levels of proportion cover of the component CATAMI classes. This suggests that the assemblages in this region contain a considerable number of locally rare CATAMI classes.

In light of these findings, Monk et al. (2016a) proposed a conceptual diagram to describe the faunal assemblages typical of the cross shelf, ledge reefs in Flinders AMP region. Shallow dipping rocks of sedimentary origin outcrop across the shelf and are preferentially eroded at bedding planes, producing an elongated sawtooth profile (Figure 46). The near vertical structures (*c* 1 - 3 m in height) at the eroded bedding planes (ledge reef features) can be linear and extend for many hundreds of metres where reef is exposed from the surrounding sediments (Figure 46). The steep surfaces and nearby boulders that are related to them are generally sediment free and covered with abundant, diverse and highly structured CATAMI classes. At distances of as little as 5 m from this, on the low profile expanse of bedrock between consecutive steps, sediment inundation begins, restricting the ability of sessile CATAMI classes to attach and be supported as they grow.

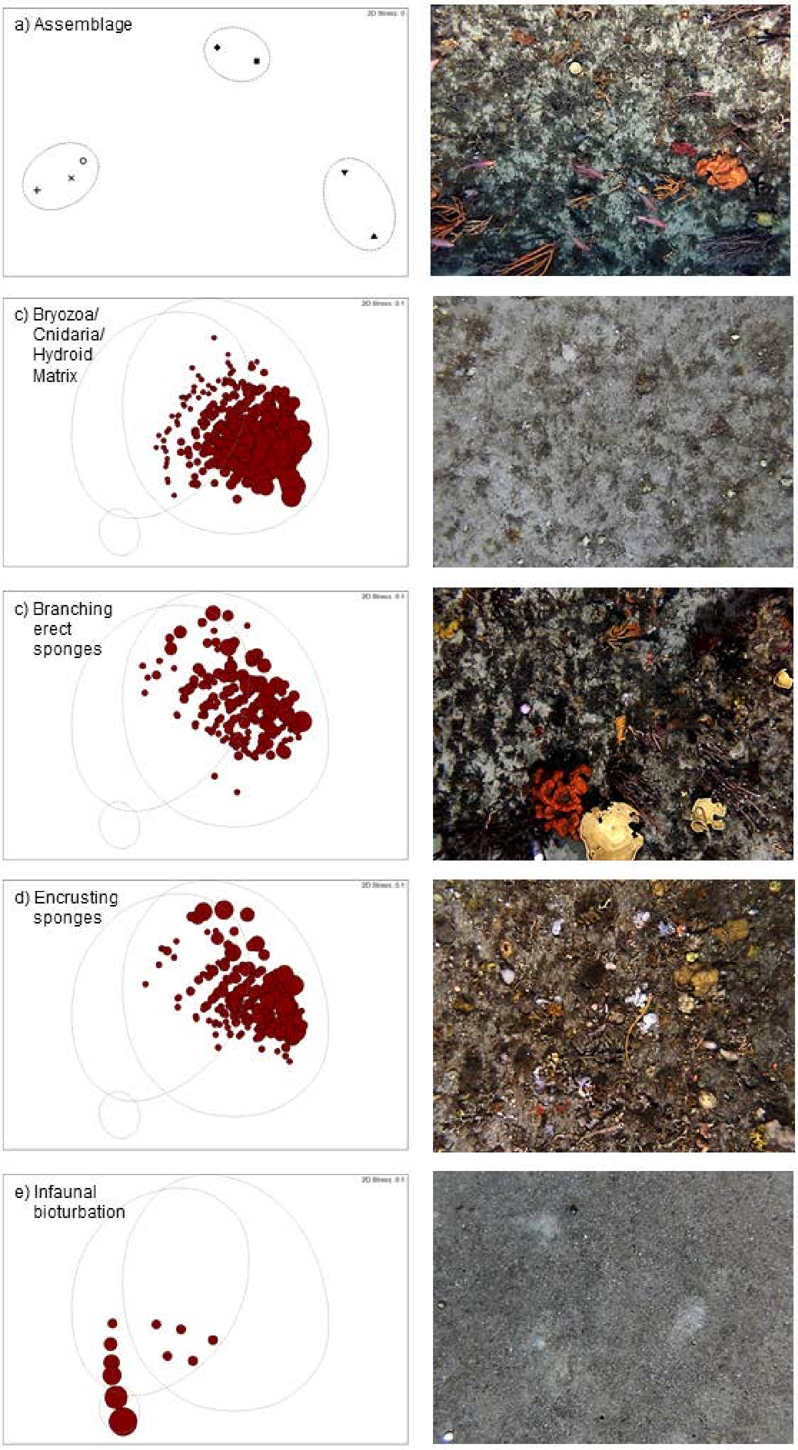


Figure 45**.** Non-metric multidimensional scaling ordinations for CATAMI-level assemblages between distance categories. Hashed lines indicate 20 % similarity. A) Centroids of the total assemblage for each distance category: 1) 0 m (▲), 2) 1 - 5 m (▼), 3) 5 - 10 m (■), 4) 10 - 20 m (♦), 5) 20 - 40 m (○), 6) 40 - 80 m (×) and 7) > 80 m (+). B-E) Important CATAMI classes identified in SIMPER analysis: bubble size indicates relative mean proportion cover (i.e. larger bubble = higher proportion cover). Example images of the CATAMI classes are given in right column (Source: Monk et al. 2016a).

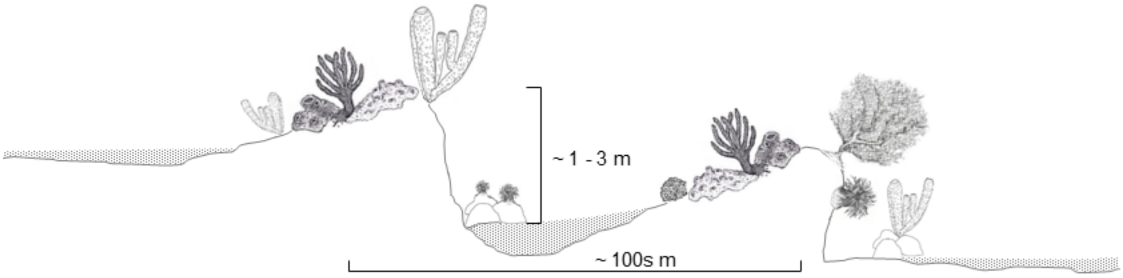


Figure 46. Conceptual diagram of the typical cross-shelf reef systems contained within the Flinders AMP. Ledge features with complex and highly structured CATAMI-level classes adjacent to, and on features, with sand inundation (grey shading) covering reef between ledge features, limiting growth of associated taxa (Source: Monk et al. 2016a).

3.9 Franklin AMP

3.9.1 Description of physical habitat

Mapping data for the Franklin AMP consists of the Australian Bathymetry and Topography Grid and target fine-scale MBES surveys from the CSIRO Southern Survey/Investigator vessel transits. This mapping indicates that the Franklin AMP ranges in depth from 50 to 115 m (Figure 47). Based on the coarse Australian Bathymetry and Topography Grid there appears to be reef-like structures extending southeast from Black Pyramid Rock, which is located 6 km north of the Franklin AMP (Figure 47). There also appears to be some isolated reef-like structure patches in the southeastern region of the AMP (Figure 47and Figure 129 in Appendix A). These structures remain unverified as the fine scale MBES data only covers the sediment-dominated habitats along the western boundary of the Franklin AMP (Figure 47). The continental shelf region of the Franklin AMP represents 100 % of its total area.

3.9.2 Description of biological assemblages

Three previous surveys of sessile seabed biota were identified within the Franklin AMP region (Table 13). The most recent, undertaken by Williams et al. (2007), used sled tows and towed camera to sample seabed biota within the Franklin AMP. From the sled tows, they found that sponge species richness in Franklin AMP area was low with only seven sponge species being identified (Table 19). The only successful video transect in the Franklin AMP area covered a region on the western boundary with a depth range of 75 m to 95 m. From the 1112 one-second video frames captured, it appears this area of the AMP was uniform with no reef being observed; rather rippled fine sediments and rippled coarse sediments dominated the images (Figure 48). Typically, fauna was very sparse on these sandy habitats, with only seven seapens, a dory, starfish, urchin and five hermit crabs being observed.

There have been no targeted surveys of reef-affiliated fishes within or nearby the Franklin AMP.

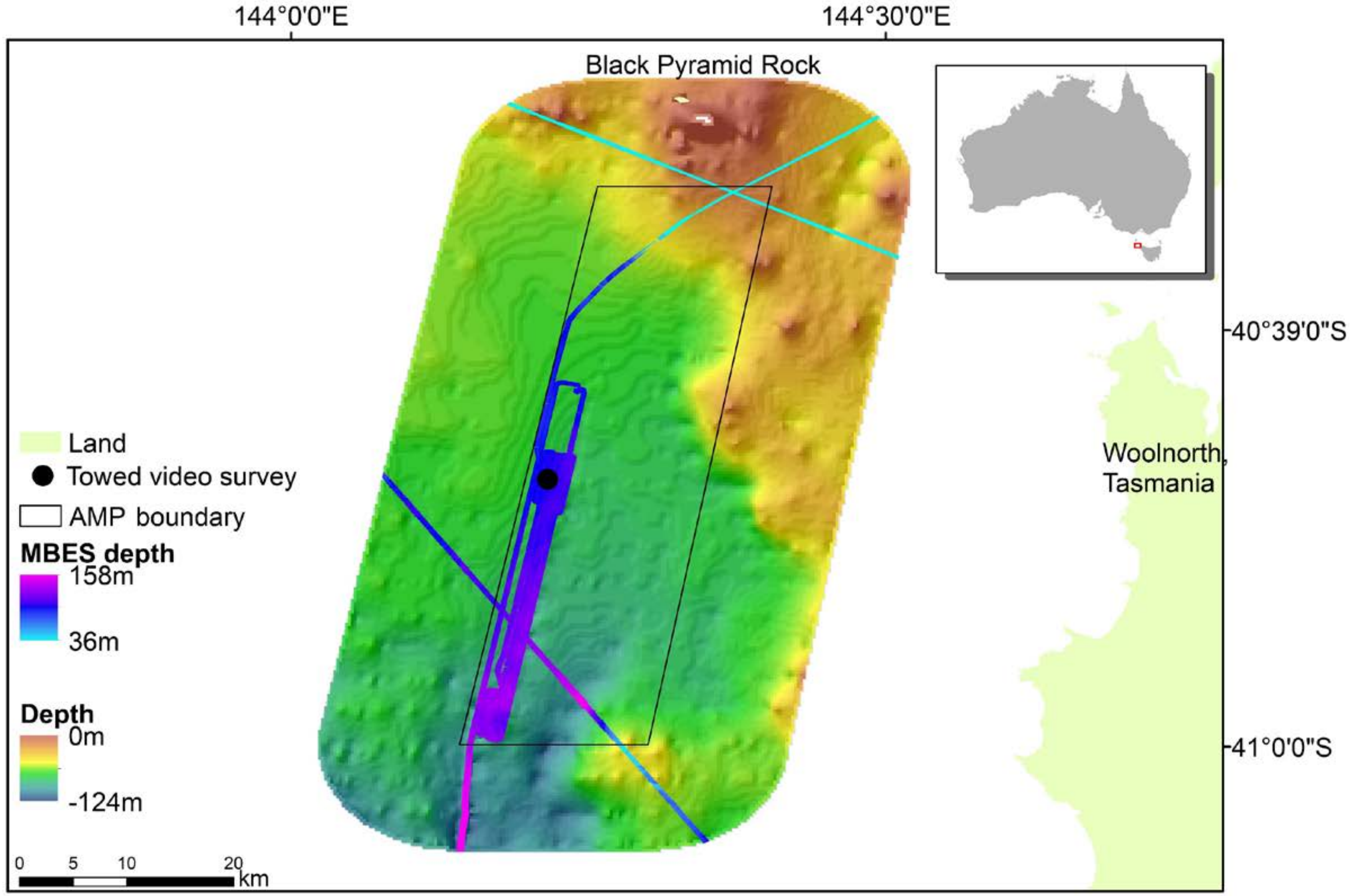


Figure 47. Mapping coverage of the Franklin AMP based on the Australian Bathymetry and Topography Grid, produced by Geoscience in June 2009. Note the fine-scale 5-m resolution multibeam sonar (MBES depth) collected by the CSIRO Southern Survey/Investigator.

Table 19. Species list from Williams et al. 2007 documenting sessile organisms sampled from the Franklin AMP using the sled tows.

CATAMI class	Species
Ascidian	*Sycozoa murrayi*
Cnidarian	*Pteronisis* sp.1
Crustacean	Paguridae sp.1
Crustacean	*Actaea peronii peronii*
Crustacean	Pilumnidae sp.1
Echinoderm	*Bollonaster pectinatus*
Echinoderm	*Ophionereis terba*
Echinoderm	*Ophiomyxa australis*
Echinoderm	*Conocladus australis*
Echinoderm	*Goniocidaris tubaria*
Mollusc	Sphaeromatidae sp.1
Sponge	Spongia (Spongia) 1
Sponge	Crella (Pytheas) 1
Sponge	Thorecta 6
Sponge	Trachycladus 2
Sponge	Cymbastella 1
Sponge	*Clathria (Wilsonella) australiensis* Lithoplacamia 1
Sponge	Crella (Pytheas) 1

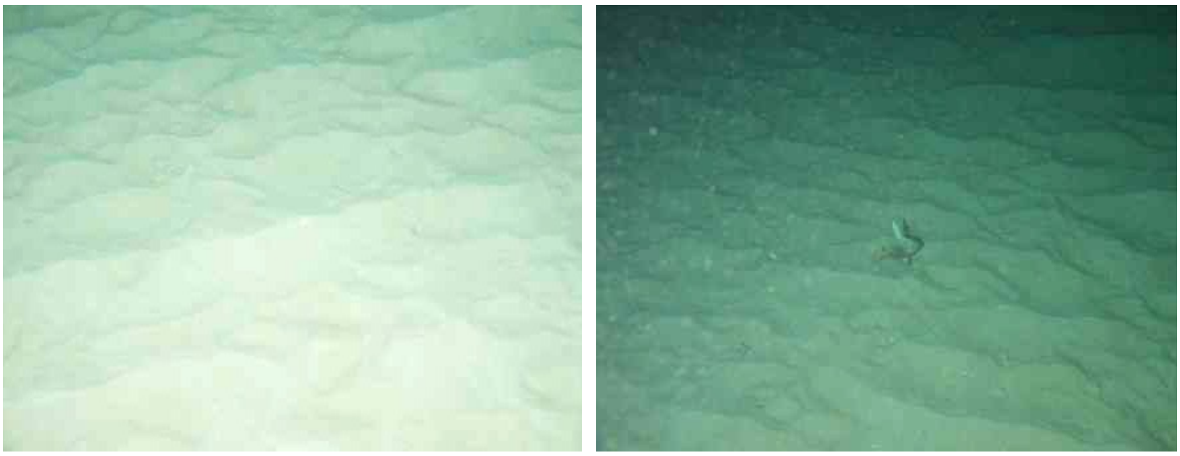


Figure 48. Example images from Franklin AMP showing the two most common bottom types identified by Williams et al. (2007). a) Rippled fine sediments with no epifauna (90 m). b) Rippled fine sediments with solitary a seapen and a Dory (93 m).

3.10 Freycinet AMP

3.10.1 Description of physical habitat

Mapping data within the Freycinet AMP consists of the Australian Bathymetry and Topography Grid and targeted fine-scale MBES surveys from the Geoscience Australia surveys and CSIRO Southern Survey/Investigator vessel transits. The contiential shelf region represents 1.3 % of the Freycient AMP. This MBES data was acquired in part in 2009 under the CERF Marine Biodiversity Hub programme (Nichol et al., 2009) and extended in 2015 as part of the geoscience sea trials for the RV *Investigator* (Nichol et al., 2016). This fine-scale mapping indicates that the shelf zone of the Freycinet AMP ranges in depth from 70 to 200 m (Figure 49). Based on this mapping, two key reef features have been identified in the Multiple Use Zone of the AMP. The first of these features, known by locals as Joe's Reef, is an isolated high-profile reef consisting of ridge, channel and platform geoform features (top insert in Figure 49 and Figure 50). The second feature was revealed in the MBES mapping on the 85-110 m bathome and consists of a number of low profile (3-5 m high) reef ridges that are aligned in a north-south direction and extend 3-5 km along the shelf (Figure 50). The ridges are considered to be formed in hard substrata, most likely comprising cemented carbonate sediment that was deposited in beach ridges during a period of lower sea level. In addition, there are a number of platforms that are covered by a veneer of carbonate sand and gravel, with limited exposed hard reef substrata (bottom insert in Figure 49 and Figure 51). These low profile ridge geoform features have been mapped in both the multiple use zone and recreational use zone of Freycinet AMP.

According to local fishers, these features are thought to support good abundances of striped trumpeter, *Latris lineata*. However, targeted sampling using stereo BRUVs on these features are needed to quantify this observation.

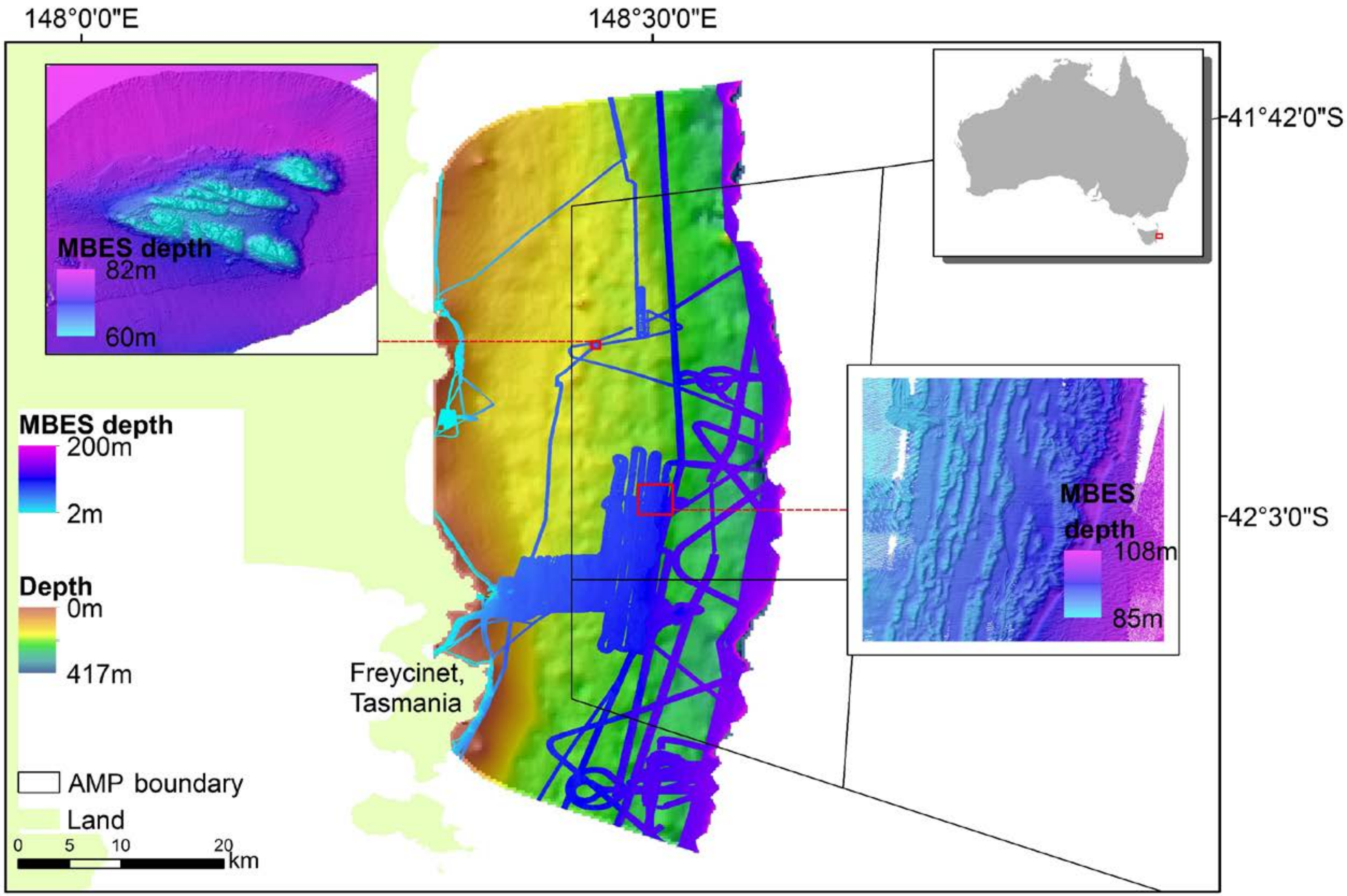


Figure 49. Mapping coverage of the Freycinet AMP based on the Australian Bathymetry and Topography Grid, produced by Geoscience in June 2009. Note the fine-scale 5-m resolution multibeam sonar (MBES depth) collected by the Geoscience Australia and CSIRO Southern Survey/Investigator in 2016. Top left insert showing close-up of Joe's Reef. Bottom right insert showing ridge and platform geoform features. Larger annotated maps are provided in Figure 50 and Figure 51.

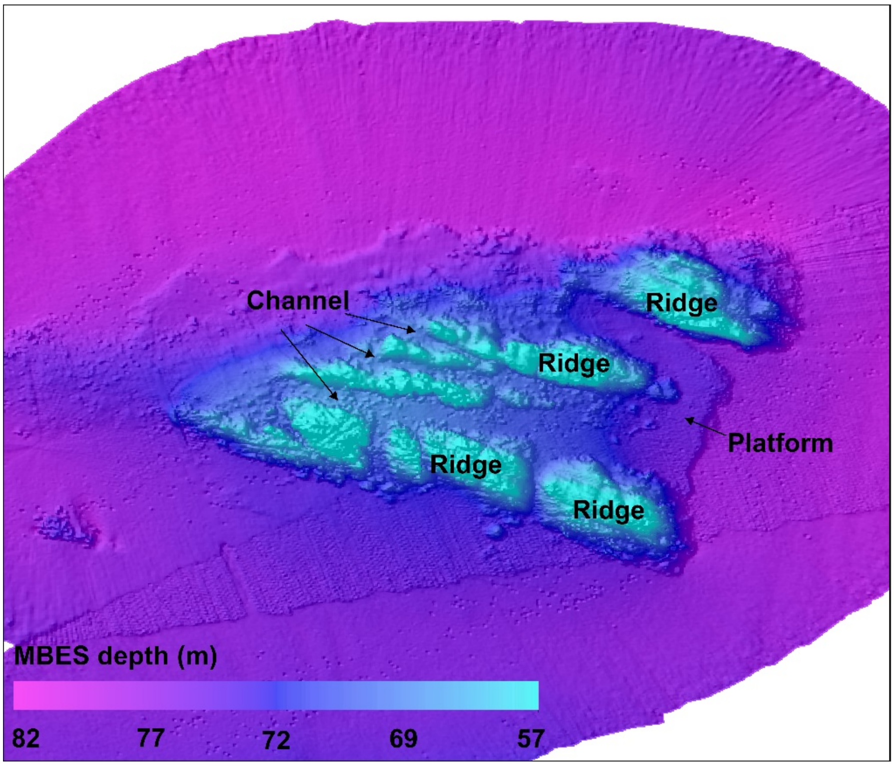


Figure 50. Close-up of the complex geoform features of Joe's Reef in the Freycinet AMP.

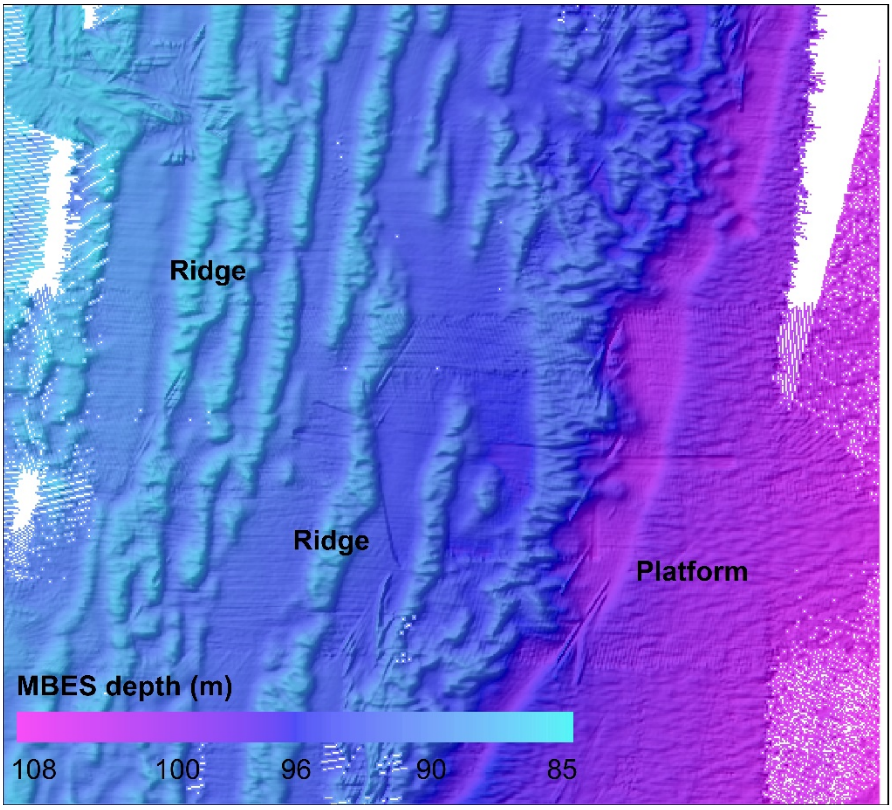


Figure 51. Close-up of the low profile geoform features mapped in the 85-110m bathome on the outer shelf region of the Freycinet AMP.

3.10.2 Description of biological assemblages

A stereo BRUV survey was carried out in 2016, with 18 deployments undertaken alongside an AUV survey of the Freycinet AMP (Figure 52). A total of 29 fish species and three Octopoda species were identified (Table 20). Common gurnard perch (*Neosebastes scorpaenoides*), draughtboard shark (*Cephaloscyllium laticeps*) and jackass morwong (*Nemadactylus macropterus*) were the most abundant species encountered with relative abundances of 48, 24 and 17 being recorded, respectively (Table 20; Figure 53; Figure 54; Figure 55). Of note was the observation of post paperfish stage juvenile blue morwong (*Nemadactylus douglasii*) and jackass morwong (*Nemadactylus macropterus*). Another interesting observation was the low abundances of ocean reef perch (*Helicolenus percoides*) and lack of striped trumpeter (*Latris lineata*). This perhaps more reflective of the habitat where the stereo BRUVs were deployed being not supporting these fishes rather than an absence of these organism as there is anecdotal reports of good abundances of striped trumpeter (*Latris lineata*) on reef systems east of Joe's reef (slightly north of where stereo BRUV sampling was undertaken).

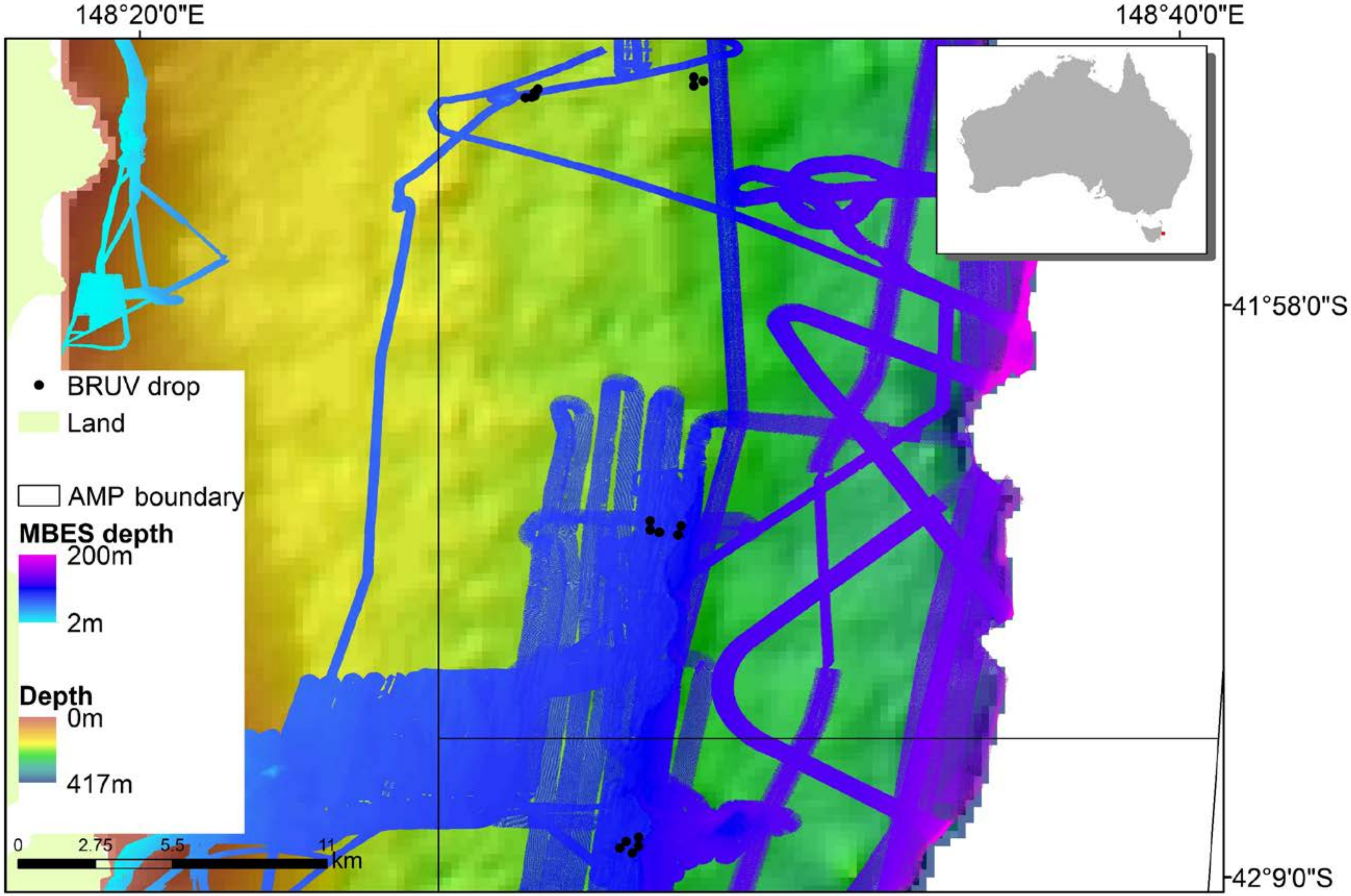


Figure 52. Location of exploratory stereo BRUV deployments undertaken as part of the 2016 survey of the Freycinet AMP.

Table 20. Fish species recorded using stereo BRUVs in the Freycinet AMP based on 18 deployments. Abundance was measured using MaxN.

Family	Scientific Name	Abundance (MaxN)
Carangidae	*Trachurus* sp	12
Cheilodactylidae	*Nemadactylus douglasii*	2
	Nemadactylus macropterus	17
Fishes (multi-family groups)	Blenniidae, Gobiidae, Tripterygiidae	2
	Fish oceanic/marine - unspecified	1
Hexanchidae	*Notorynchus cepedianus*	3
Macroramphosidae	*Macroramphosus scolopax*	1
Monacanthidae	*Meuschenia scaber*	11
	Thamnaconus degeni	1
Moridae	*Pseudophycis barbata*	1
Neosebastidae	*Neosebastes scorpaenoides*	48
Octopodidae	Octopodidae	1
	Pinnoctopus cordiformis	7
Ommastrephidae	*Nototodarus gouldi*	2
Ostraciidae	*Aracana aurita*	1
Otaridae	*Arctocephalus pusilus doriferus*	1
Paraulopidae	*Paraulopus nigripinnis*	20
Pinguipedidae	*Parapercis allporti*	15
Platycephalidae	*Platycephalus richardsoni*	9
	Platycephalus sp	1
Rajidae	*Dentiraja lemprieri*	2
	Spiniraja whitleyi	2
Scyliorhinidae	*Asymbolus rubiginosus*	10
	Cephaloscyllium laticeps	24
Sebastidae	*Helicolenus percoides*	1
Squalidae	*Squalus megalops*	3
Triakidae	*Mustelus antarcticus*	4
Triglidae	*Chelidonichthys kumu*	1
	Lepidotrigla modesta	2
	Lepidotrigla sp	2
	Pterygotrigla polyommata	6
	Triglidae	1

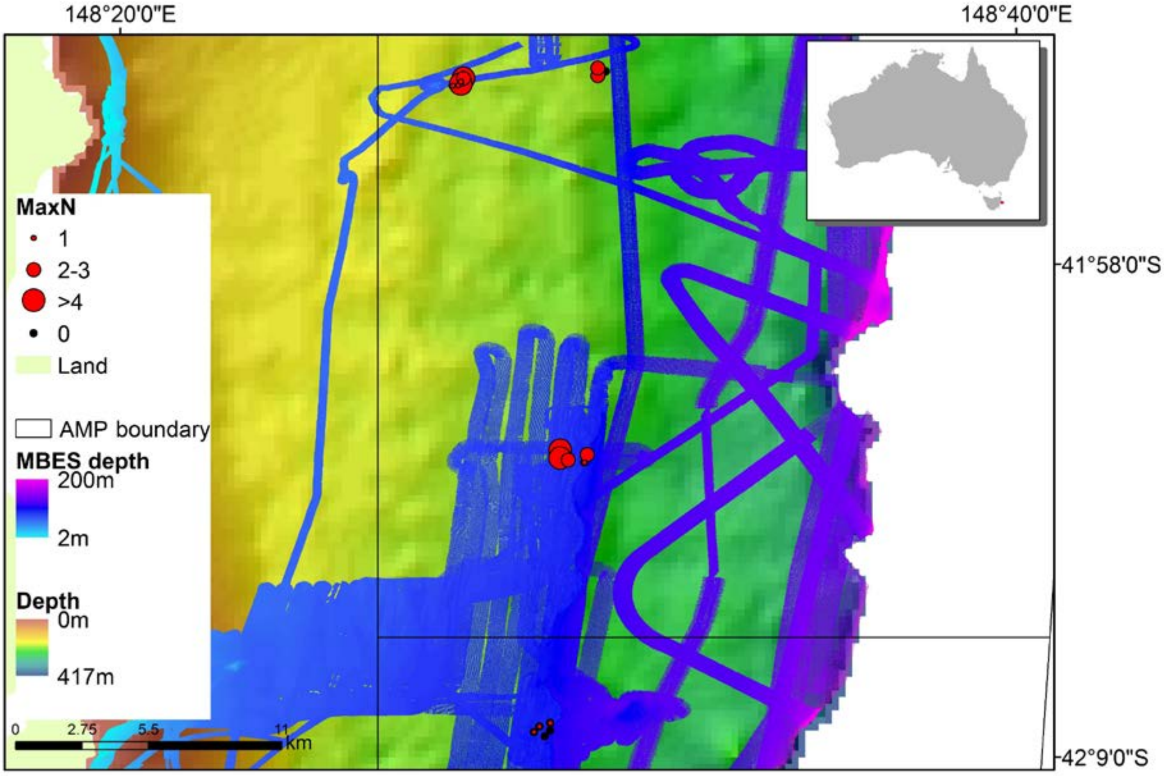


Figure 53. Abundance distribution of common gurnard perch (Neosebastes scorpaenoides) in Freycinet AMP.

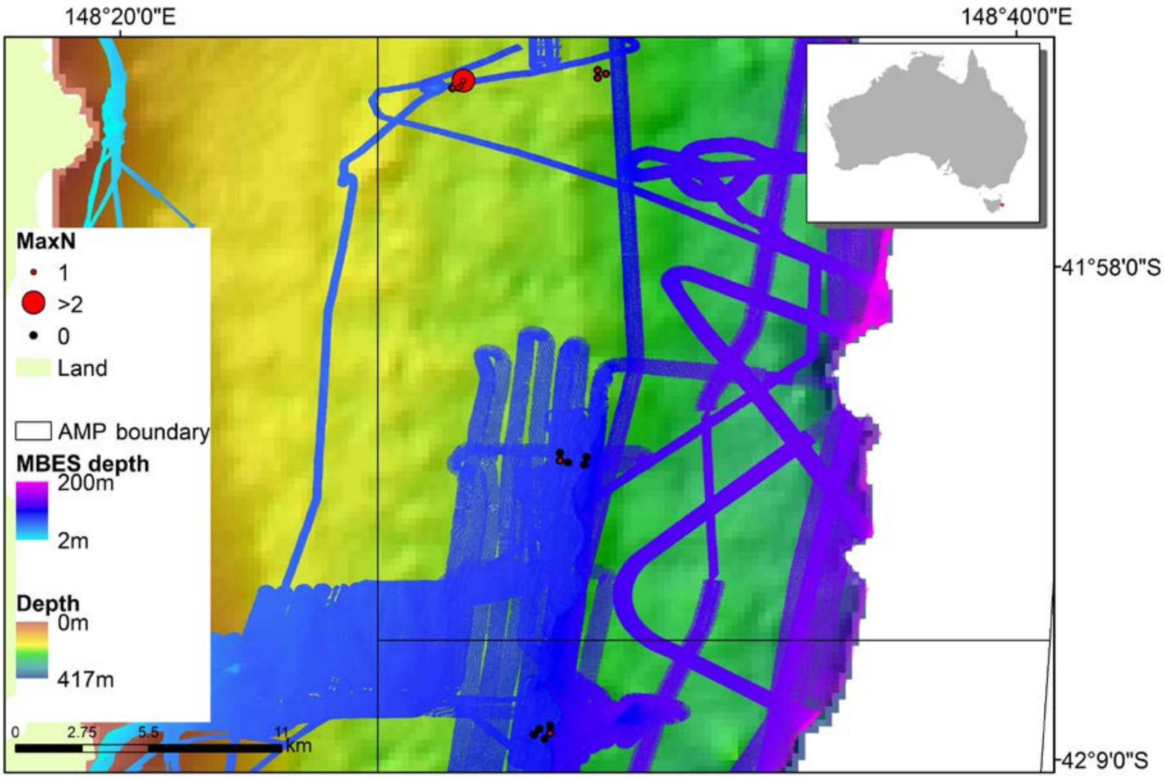


Figure 54. Abundance distribution of draughtboard shark (Cephaloscyllium laticeps) in Freycinet AMP.

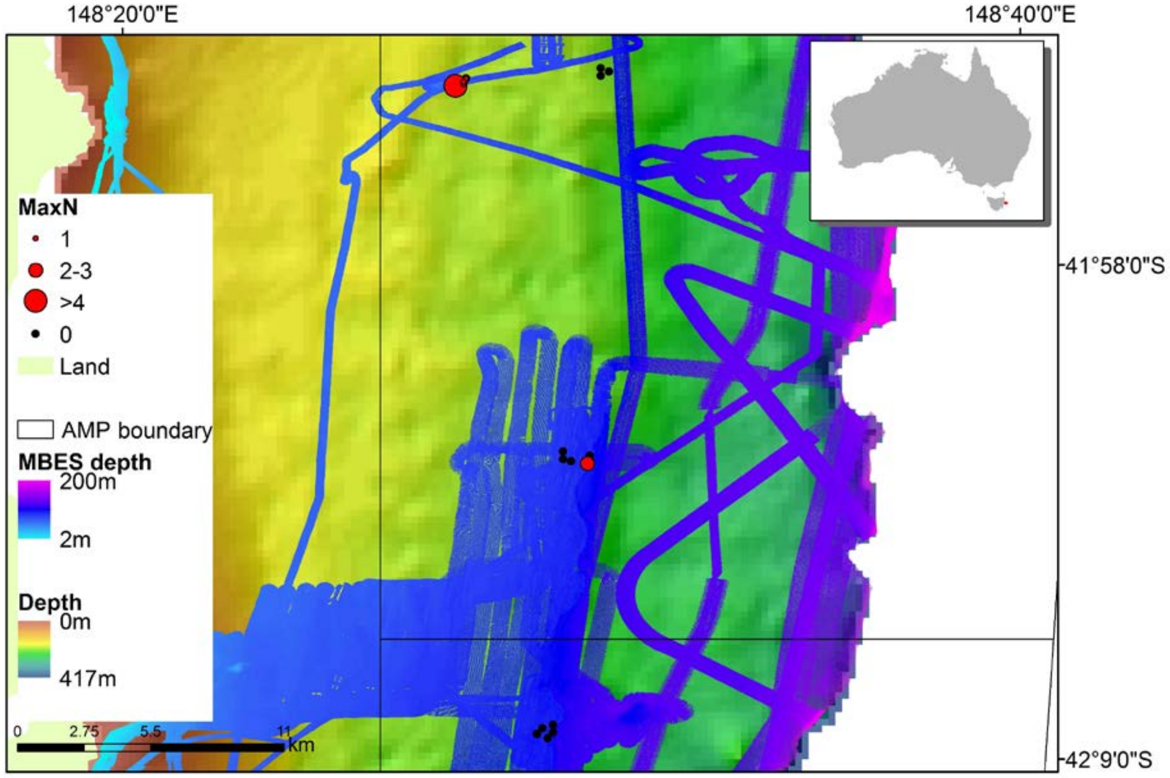


Figure 55. Relative abundance distribution of jackass morwong (*Nemadactylus macropterus*) in Freycinet AMP.

Some of the AUV transects within the Freycinet AMP have been sampled five times since 2009, with the most recent sampling in 2016 (Figure 56). To date, however, the assemblage level scoring of this imagery focussed only on the data collected in 2009 (i.e. the four most southern transects; Figure 56). A total of 408 images were scored from the 2009 sampling, which represents approximately every 100th image, or one image every 50 m along transect. Scoring was done using a count of cover below each of 50 randomly placed points per image. Scoring of the transects collected post-2009 remains a priority as it would illucidate how these assemblages have changed over time, and further inform long-term monitoring programme design within the region.

Sand was scored in every image and was therefore mapped as the most common substrata type (Table 21). Unsurprisingly, there was a low level of complexity in the morphospecies recorded with only 29 morphospecies being identified (Table 21). Bryozoa/Cnidaria/Hydroid matrix was the most commonly observed class contributing nearly 9 % to the overall assemblage. The remaining biological components of the assemblage contributed < 1 % each. In fact, a third of morphospecies recorded in the Freycinet AMP were singletons (i.e. only seen once) (Table 21). This suggests that the diversity in the benthic assemblage in the Freycinet AMP is comparatively lower in morphospecies diversity when compared to other AMPs around Tasmania. It should be acknowledged that this sampling took place largely over very low profile sand inundated reef systems on the mid-shelf regions of the AMP and is perhaps the reason for the low diversity and cover recorded (Table 21).

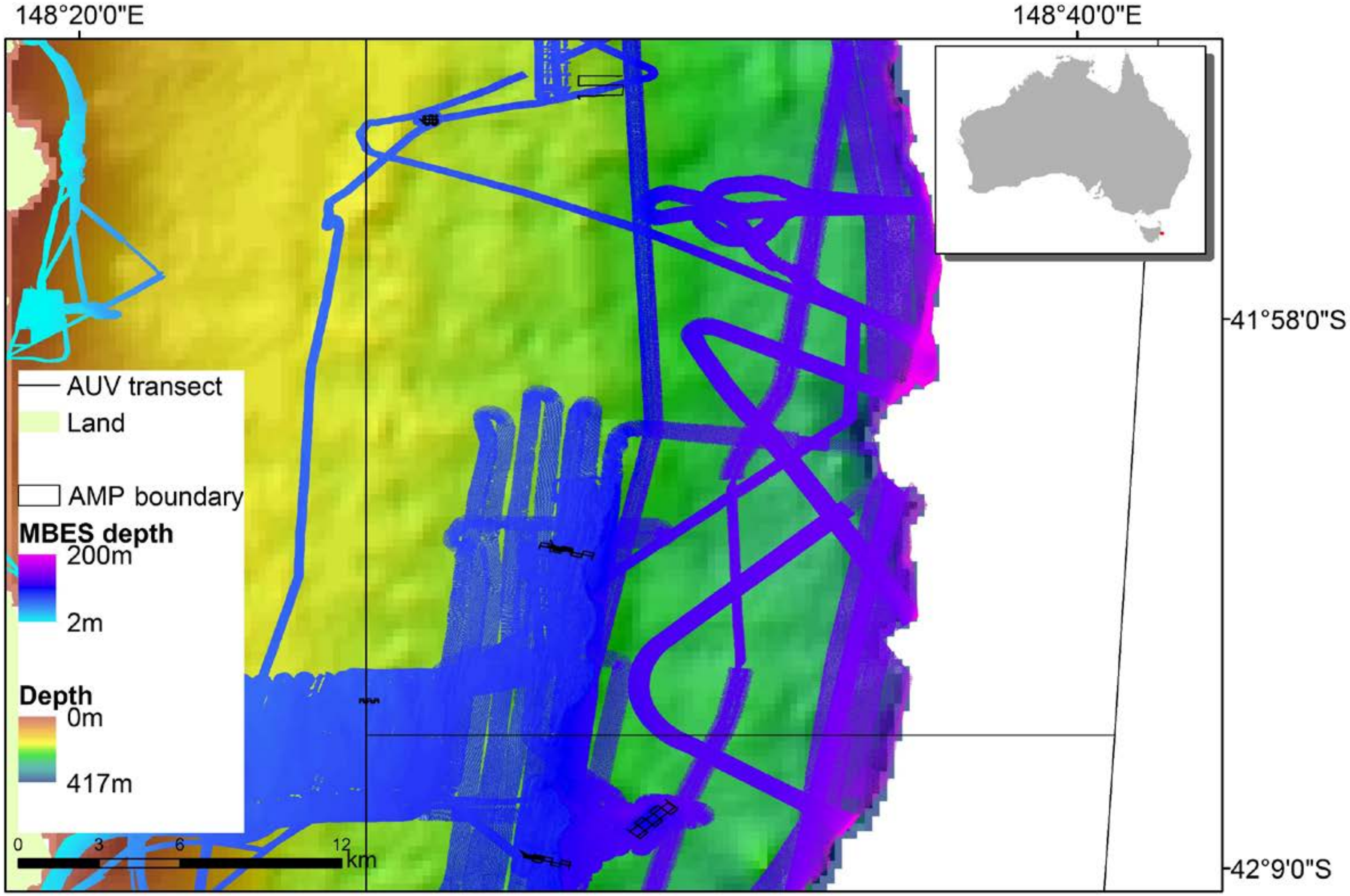


Figure 56. Location of the six AUV transects within the Freycinet AMP. Note only the most southern AUV transects have been scored for morphospecies.

Table 21. Total observations and percentage contribution of morphospecies and bare substrate type observed in the Freycinet AMP using the AUV deployed in 2009.

CATAMI class	Morphospecies	Total observations	Percentage contribution
Bioturbation	Bioturbation	204	1.000
Bryozoa	Bryozoan 3 *Cantinicella* like	4	0.020
Bryozoa/Cnidaria/Hydroid matrix	Bryozoa/Cnidaria/Hydroid matrix	1,824	8.941
Cnidaria	Coral 2 soft *Capnella* like	6	0.029
	Gorgonian red 2	2	0.010
	Hydroid 1	4	0.020
	Sea pen	7	0.034
	Anthomastus like coral	1	0.005
Cnidaria total			*0.098*
Echinoderms	Urchins	9	0.044
	Brittle star	5	0.025
Fishes	Unknown fish	2	0.010
Macroalgae	Drift algae	4	0.020
Molluscs	Mollusc	12	0.059
	New Zealand screw shell	11	0.054
Sponges	Arborescent 10 orange/brown fingers	1	0.005
	Cup 7 light pink flat thick	19	0.093
	Cup 8 yellow	16	0.078
	Fan 1 orange	1	0.005
	Globular 4 orange	3	0.015
	Lumpy 3 white	1	0.005
	Massive peach shapeless oscula	2	0.010
	Massive 18 orange holey	1	0.005
	Tubular 14 solitary	1	0.005
	Tubular 2 apricot	1	0.005
	Cryptic purple brain	2	0.010
	Cryptic black wrinkly	1	0.005
Sponges total			*0.240*
Worms	Tube worm sp1	1	0.005
	Flatworm white sp1	1	0.005
	Fanworm *Sabella* like	2	0.010
Substrata	Biological rubble	55	0.270
	Sand	18,127	88.858
Unscorable	Unscorable	1	0.005

Further north of these initial AUV transects is the unique reef feature of Joe's Reef (Figure 50). This reef has been the focus of three repeat AUV surveys, with two of them (i.e. surveys in 2011 and 2014) being scored for mobile invertebrates. Very few mobile invertebrates were observed in the AUV imagery on Joe's reef, with the seastar, Asteroidea, being recorded on the low-profile platform geoform features that surround the higher profile reef (Figure 57).

While complete morphospecies scoring is yet to be completed at Joe's reef, initial assessment of the AUV imagery suggests that the high-profile reefs support high diversity of branching sponges and more importantly- black corals (Figure 59). The AUV imagery also identified large schools of butterfly (*Caesioperca lepidoptera*) and splendid perch (*Callanthias australis*) were a common feature of Joe's reef. However, further targeted stereo BRUV surveys are required to better document the diversity of fishes on Joe's reef.

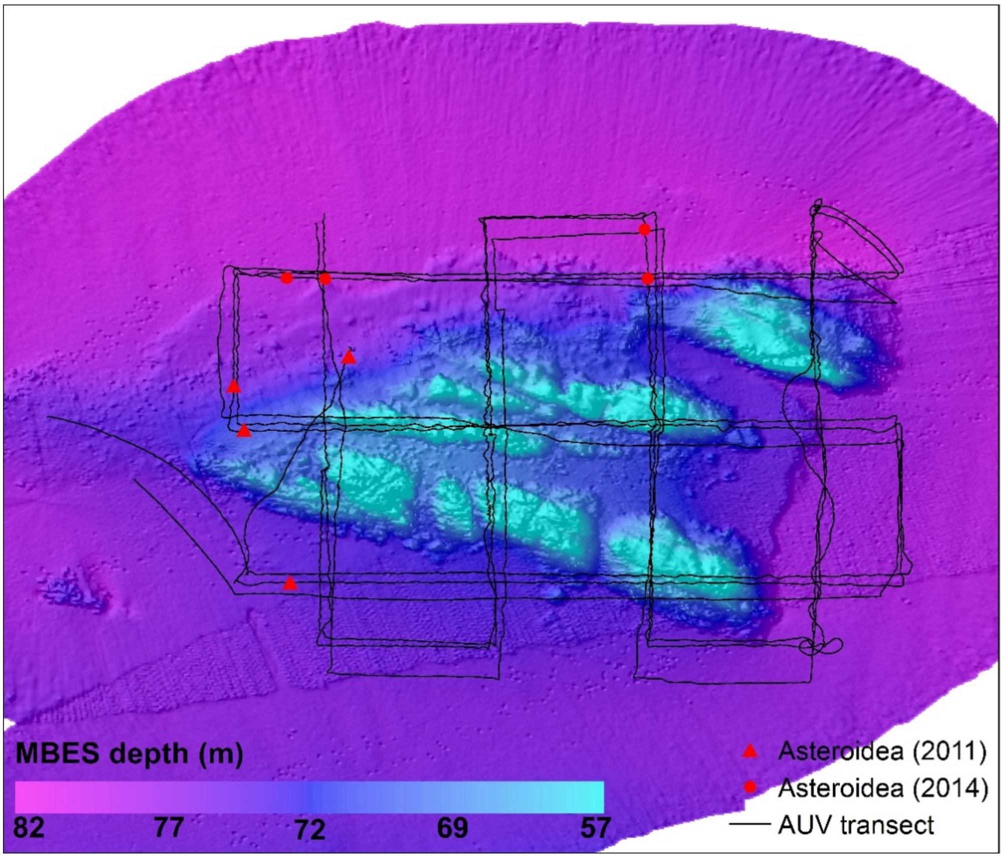


Figure 57. Location of Asteroidea seastars on Joe's reef.

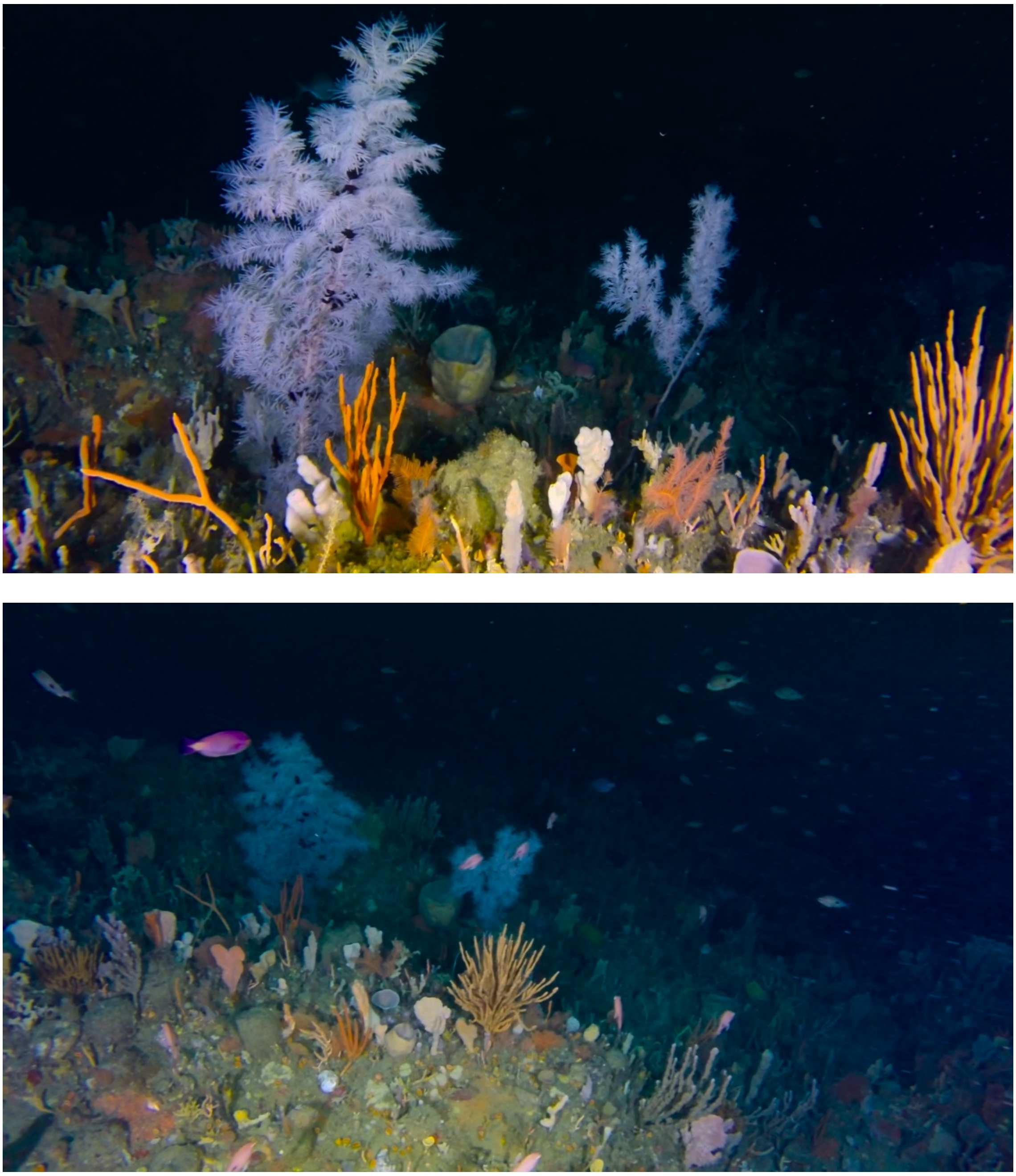


Figure 58. Examples of the seabed biota present on Joe's reef in the Freycinet AMP. Images are from deep citizen SCUBA diver who captured the images because of NESP citizen science collaboration (https://www.nespmarine.edu.au/news/extreme-citizen-scientists-film-black-corals-spectacular-unexplored-reef-tasmania%E2%80%99s-east-coast). Top image shows two large black corals. Bottom image illustrates the variety of seabed biota inhabiting Joe's reef (note the schools of butterfly perch (*Caesioperca lepidoptera*) in background and splendid perch (*Callanthias australis*)).

In addition to the AUV and BRUV, datasets for Freycinet AMP, IMAS and Geoscience Australia undertook a towed video survey of the region prior to the start of CERF in 2007. This towed video survey of the Freycinet AMP consisted of eight towed video transects (Figure 59). While the biological resolution of this data is limited, soft sandy sediments appear to most common along these transects, with branching and cup sponges often observed.

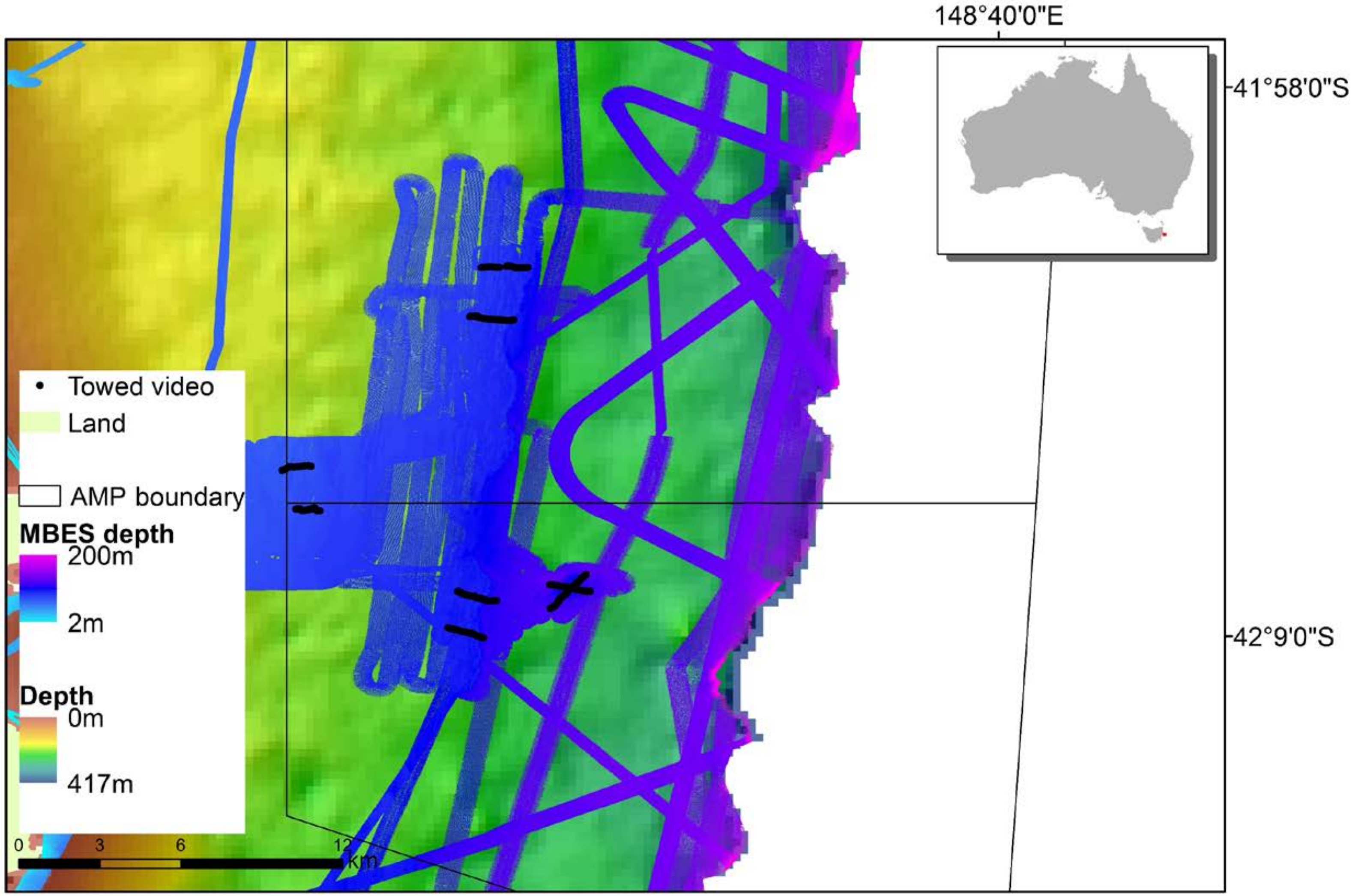


Figure 59. Location of the eight towed video transects undertaken by researchers from IMAS and Geoscience Australia prior to 2007.

3.11 Huon AMP

3.11.1 Description of physical habitat

Fine-scale mapping of the seabed on the continental shelf within the Huon AMP consists of a targeted mid shelf MBES survey that was acquired in 2009 under the CERF Marine Biodiversity Hub programme (Nichol et al. 2009) and includes numerous transits from CSIRO's Southern Surveyor/Investigator voyages over the area. The continental shelf region represents ~ 18 % of the Huon AMP.

The mapped area extends outside the AMP boundary to the north and is characterised by platform reef formed in dolerite rock that sits in water depths of 25 – 100 m. Relief of the platform is classified as medium (up to 5 m) but locally the reef is highly dissected by linear fractures that change the relief up to 12 m over a linear length of 500 m (Figure 56). The Australian Bathymetry and Topography Grid and targeted fine-scale MBES surveys from the CSIRO transits suggests this reef feature extends in a south-westerly direction into the AMP, potentially covering 30 km^2 of the reserve. However, this requires confirmation with additional fine-scale MEBS mapping.

3.11.2 Description of biological assemblages

There were three AUV transects undertaken in 2009, with repeats of two of these transects in 2014. Scoring of 263 images from the 2009 surveys found identified 129 morphospecies (Table 22). A total of 109 sponge morphospecies identified, followed by nine macroalgae morphospecies (Table 22). The invasive New Zealand screw shell was occasionally observed on sandy habitats (Table 22). In the shallow regions of the AMP kelp (*Ecklonia radiata*) with an understory of thallose and encrusting red algae, were the most commonly recorded organisms. Deeper, red gorgonian 2 and Bryozoa/Cnidaria/Hydroid matrix were the most commonly observed morphospecies. In these deeper depths, combined sponge morphospecies contribute nearly 4 % of the assemblage (Table 22).

Nearly 10 % of morphospecies were singletons (i.e. only seen once) (Table 22). Interestingly, the number of singletons observed within the Huon AMP is considerably lower when compared to other Tasmanian AMPs conducted from AUV surveys. This suggests that the benthic assemblage in the Huon AMP consists of a morphospecies that are highly diverse and spatially common.

There has not been any document targeted sampling of reef-affiliated fishes within the shelf region of the Huon AMP.

.

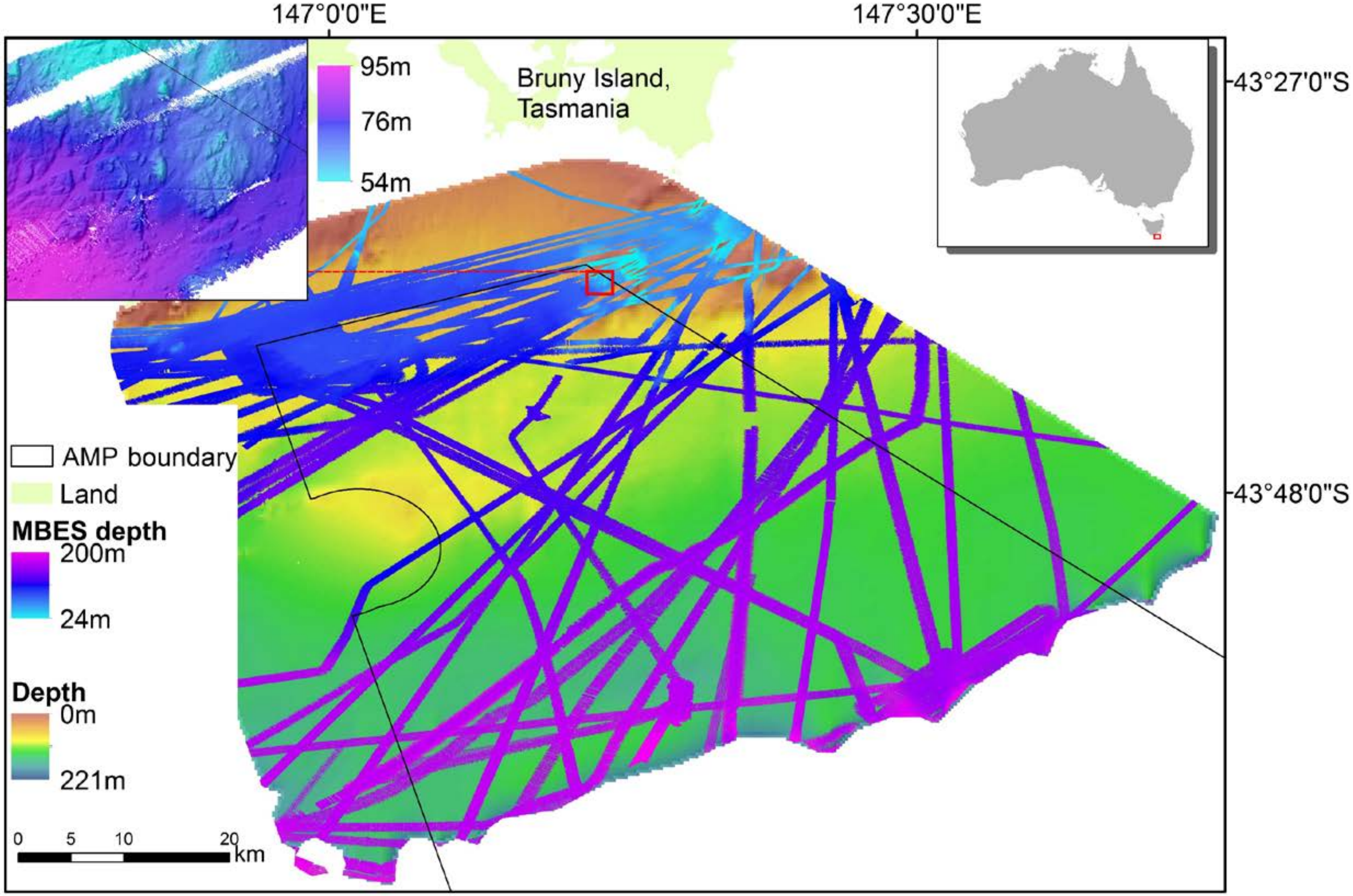


Figure 60. Mapping coverage of the Huon AMP based on the Australian Bathymetry and Topography Grid, produced by Geoscience in June 2009. Note the fine-scale 5-m resolution multibeam sonar (MBES depth) collected by the CSIRO Southern Survey/Investigator. Insert showing platform dolerite reef features extending across AMP boundary towards Bruny Island.

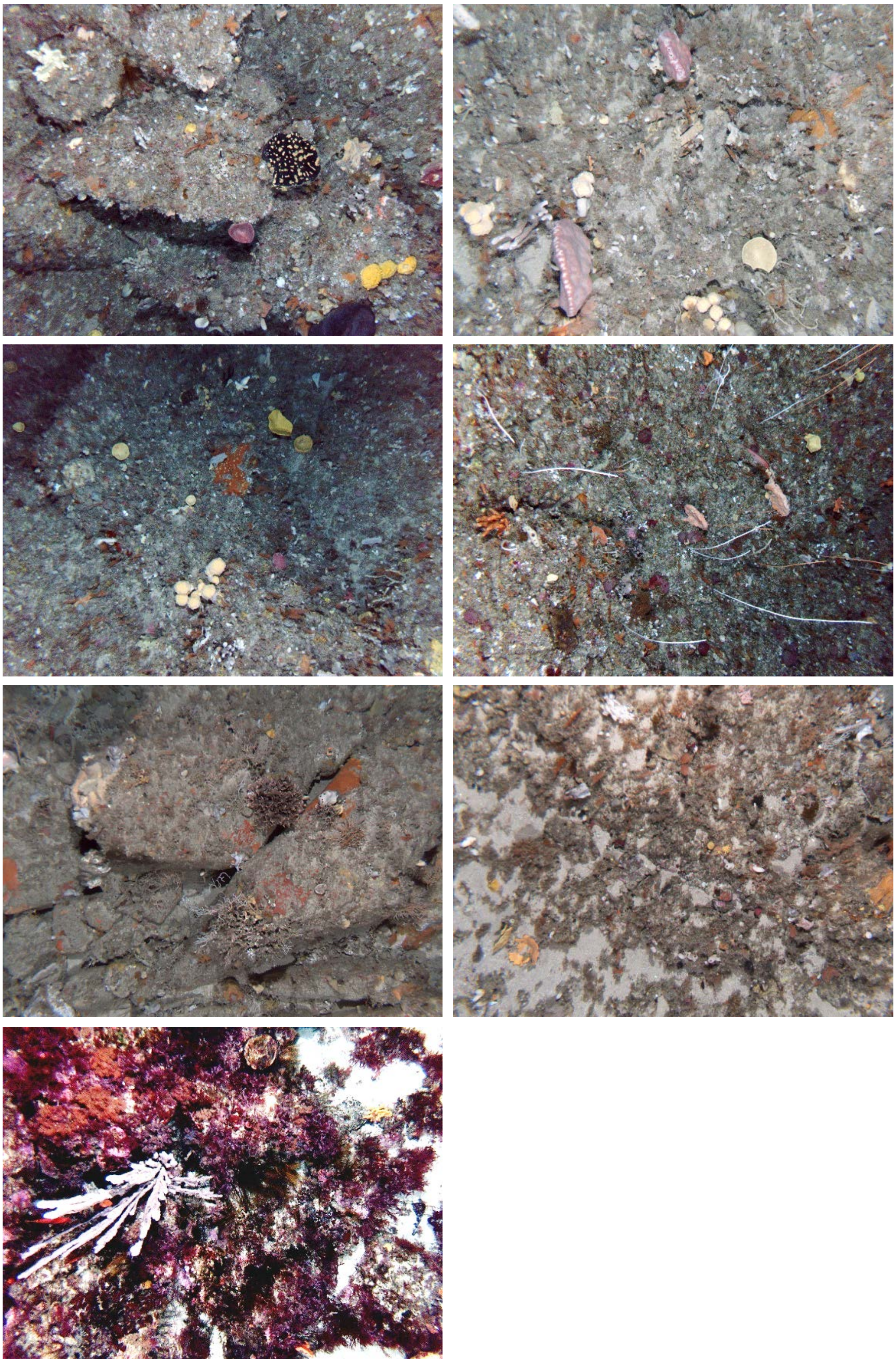


Figure 61. Example images from the 2009 AUV sampling of the Huon AMP showing a variety of morphospecies, including: branching sponges, massive sponges, cup sponges seawhips and red algae

Table 22. Total observations and percentage contribution of morphospecies and bare substrate type observed in the Huon AMP using the AUV.

CATAMI class	Morphospecies	Total observations	Percentage contribution
Ascidian	Ascidian 2 *Clavelina* like	3	0.035
	Ascidian 3 orange	1	0.012
	Ascidian solitary grey	1	0.012
Ascidian total			*0.058*
Bryozoa	Bryozoan 2 soft *Amathia* like	25	0.291
	Bryozoan 3 *Cantinicella* like	104	1.210
	Bryozoan 5 soft *Orthoscuticella* like	2	0.023
	Bryozoan soft pinky white	6	0.070
Bryozoa total			*1.595*
Bryozoa/Cnidaria/Hydroid Matrix	Bryozoa/Cnidaria/Hydroid Matrix	7,337	85.393
Cnidaria	Bramble Acabaria sp	1	0.012
	Cenolia sp	5	0.058
	Coral 2 soft *Capnella* like	5	0.058
	Coral 6 soft blue	8	0.093
	Coral orange solitary	3	0.035
	Gorgonian red 2	182	2.118
	Parazoanthus sp 1	6	0.070
	Sea whip 1	4	0.047
	Hydroid 1	1	0.012
Cnidaria total		*215*	*2.502*
Mollusc	NZ screw shell	5	0.058
Macroalgae	Encrusting algae red dark	132	1.536
	Encrusting coralline	286	3.329
	Red foliose	4	0.047
Macroalgae total		422	4.911
Sponge	Arborescent 1 white flat	6	0.070
	Arborescent 11 orange fan	1	0.012
	Arborescent 13 orange	2	0.023
	Arborescent 15 white short	4	0.047
	Arborescent 2 grey	8	0.093
	Arborescent 4 orange flat	3	0.035
	Arborescent 5 white	2	0.023
	Arborescent 8 tan	3	0.035
	Arborescent 9 orange thin	1	0.012
	Barrel red thick wall	3	0.035
	Branching beige frilly	2	0.023
	Branching beige stumpy	2	0.023

CATAMI class	Morphospecies	Total observations	Percentage contribution
	Branching grey fine repent like	1	0.012
	Branching grey thorny	4	0.047
	Branching orange long fine	2	0.023
	Branching orange lumpy	4	0.047
	Branching white stubby	1	0.012
	Cryptic purple brain	1	0.012
	Cup 1 white	3	0.035
	Cup 4 blue thick	13	0.151
	Cup 5 red	5	0.058
	Cup 6 pink thick	2	0.023
	Cup 8 yellow	21	0.244
	Cup beige shallow irregular	2	0.023
	Cup black smooth	7	0.081
	Cup brown irregular	12	0.140
	Cup red smooth	29	0.338
	Cup red thick	3	0.035
	Encrusting papillate pink white	2	0.023
	Encrusting 1 orange	114	1.327
	Encrusting 2 light orange	16	0.186
	Encrusting 3 yellow	24	0.279
	Encrusting 4 blue	1	0.012
	Encrusting 5 brown	7	0.081
	Encrusting 6 white	47	0.547
	Encrusting beige oscula	11	0.128
	Encrusting black lumpy	1	0.012
	Encrusting white lumpy	2	0.023
	Encrusting yellow rough	11	0.128
	Fan 1 orange	1	0.012
	Fan 10 thick large oscules	1	0.012
	Fan 14 white thin	7	0.081
	Fan 15 orange thorny	1	0.012
	Fan 2 brown	1	0.012
	Fan 3 orange flat	4	0.047
	Fan 4 pink	6	0.070
	Fan 5 peach	3	0.035
	Fan 6 yellow	8	0.093
	Fan 8 blue thick	1	0.012
	Fan 9 orange thick	17	0.198
	Fan peach thick	3	0.035
	Fan white thick	11	0.128

CATAMI class	Morphospecies	Total observations	Percentage contribution
	Fan white thin	1	0.012
	Globular 1 orange *Tethya* like	2	0.023
	Globular 3 blue	4	0.047
	Globular 4 orange	2	0.023
	Laminar apricot stalked	3	0.035
	Laminar grey fungi	11	0.128
	Laminar grey round stalk	2	0.023
	Laminar white small	8	0.093
	Lumpy 2 orange	13	0.151
	Lumpy 3 white	53	0.617
	Lumpy 4 pink	5	0.058
	Lumpy 5 yellow	4	0.047
	Massive 11 white holey	3	0.035
	Massive 12 yellow papillate	4	0.047
	Massive 13 white papillate	9	0.105
	Massive 16 purple	22	0.256
	Massive 17 white lumpy	1	0.012
	Massive 18 orange holey	2	0.023
	Massive 19 yellow shapeless	7	0.081
	Massive 20 pink	6	0.070
	Massive 3 orange	4	0.047
	Massive 6 velet	4	0.047
	Massive 8	1	0.012
	Massive 9 white	2	0.023
	Massive blue shapeless	10	0.116
	Massive peach shapeless oscula	23	0.268
	Massive red white shapeless	8	0.093
	Massive yellow irregular ball	7	0.081
	Palmate beige flat	1	0.012
	Palmate grey	18	0.209
	Papillate 1 *Suberites* like	2	0.023
	Ramose single cream	2	0.023
	Simple beige labyrinth	3	0.035
	Simple beige shapeless	1	0.012
	Simple beige tube like	2	0.023
	Simple grey creep	6	0.070
	Simple grey doughnut	15	0.175
	Simple orange smooth	10	0.116
	Simple pink irregular	3	0.035
	Simple yellow lumpy	1	0.012

CATAMI class	Morphospecies	Total observations	Percentage contribution
	Simple yellow rough	10	0.116
	Tube white lumpy	1	0.012
	Tubes beige prostrate	11	0.128
	Tubes white fan	2	0.023
	Tubes white large osculum	1	0.012
	Tubular 10 orange thorny	11	0.128
	Tubular 13 sycon	3	0.035
	Tubular 14 solitary	4	0.047
	Tubular 3 white colony	3	0.035
	Tubular 4 tan	1	0.012
	Tubular 8 orange	1	0.012
Sponge total			*9.078*
Worms	Fanworm *Sabella* like	2	0.023
	Tube Worm sp1	1	0.012
Unknown	Unknown biology	166	1.932
Fish	Unknown fish	8	0.093
Substrata	Biological rubble	7	0.081
	Pebble/Gravel	72	0.838
	Rock	29	0.338
	Sand	3,955	46.031
Unscorable	Unscorable	9	0.105

3.12 Murray AMP

3.12.1 Description of physical habitat

Mapping data within the Murray AMP consists of the Australian Bathymetry and Topography Grid and limited fine-scale MBES surveys from CSIRO Southern Survey/Investigator vessel transits. The continental shelf zone of the Murray AMP ranges from ~18 to 200 m based on this MEBS data, and represents ~ 19 % of the Murray AMP.

There is little fine-scale MBES data available for the continental shelf zone of the Murray AMP and what exists only covers only 1 % of the area (Figure 62). From the mapping, we can see that there is potentially reef habitat in *c* 65 m water depth near the shelf break in the eastern Multiple Use zone (Figure 62 and Figure 132 in Append A). However, targeted MBES surveys are needed validate this observation.

3.12.2 Description of biological assemblages

No sampling data for reef-affiliated fishes or seabed biota could be identified for the shelf region of the Murray AMP.

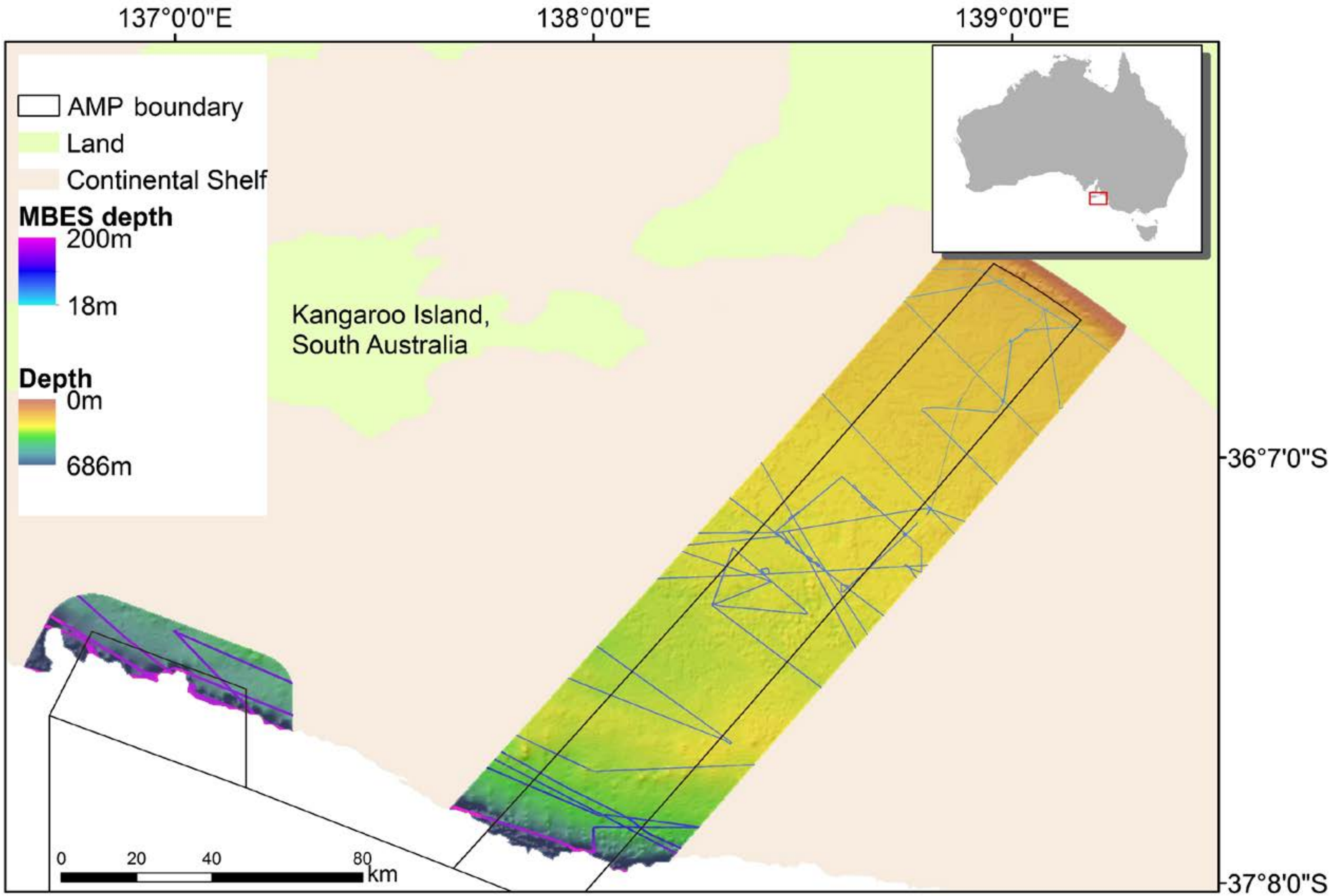


Figure 62. Mapping coverage of the Murray AMP based on the Australian Bathymetry and Topography Grid, produced by Geoscience in June 2009. Note the fine-scale 5-m resolution multibeam sonar (MBES depth) collected by the CSIRO Southern Survey/Investigator.

3.13 Tasman Fracture AMP

3.13.1 Description of physical habitat

Fine-scale seabed mapping of the continental shelf in the Tasman Fracture AMP covers an area of approximately 560 km^2 on the mid to outer shelf within the Marine National Park Zone, with additional mapping of 230 km^2 outside the AMP boundary to the north (Figure 63). The contiential shelf region covers ~ 2% of the Tasman Fracture AMP. Fine-scale MBES data was collected in Bluefin by CSIRO. Reefs that are are located within the northwestern part of the AMP are small, isolated features rising from water depths of 150 m. Some reefs straddle the northern AMP boundary into state waters (top insert Figure 63). Reef geoform features include platforms, ridges and mounds that range in area from 0.01 km^2 to 1 km^2, but with two reefs extending a further 1-2 km^2 outside the reserve (Figure 63). Potentially dolorite in origin, these platforms that form the larger reef system are dissected by linear fractures (top insert of Figure 63). An isolated reef feature was also mapped in the east of the AMP, consisting of ridges and channel geofeatures (Figure 64). The local relief of reefs is characterised as medium to high with platforms rising up to 70 m above the surrounding seabed (Figure 63). The remainder of the seafloor data within the AMP is characterised by flat to gently sloping domindated by sediment cover (Figure 63 and Figure 133 in Appendix A).

3.13.2 Description of biological assemblages

A total 46 stereo BRUV deployments were collected inside the Tasman Fracture AMP (Figure 65). A total of 11621 individual fishes were recorded represented by 33 species from 20 families (Table 23). The most abundant species where clupid baitfish (9564 individuals), butterfly perch (*Caesioperca lepidoptera*; 737 individuals; Figure 68), jack mackerel (*Trachurus declivis*; 430 individuals; Figure 71), jackass morwong (*Nemadactylus macropterus*; 214 individuals; Figure 69) and ocean reef perch (*Helicolenus percoides*; 205 individuals; Figure 67) (Table 23).

While some species were present in high numbers, many of these were pelagic species that are likely to be transient residents of the area. These included the *Trachurus* species (jack mackerel), species in the order clupeiformis (small baitfish), and even yellowfin or bluefin tuna (*Thunnus* sp). The latter could not be differentiated from each other in the imagery.

Of the reef resident species, schooling planktivore species were most abundant, including the splendid perch and butterfly perch. Common and generally widespread species included the ocean perch, jackass morwong, rosy wrasse, cosmopolitan leatherjacket and red cod (*Pseudophycis bachus*), all predominantly benthic feeding species ranging from piscivores to micro-carnivores. Striped trumpeter (*Latris lineata*; Figure 70) were less common, with only 13 individuals encountered (based on MaxN) across the 46 BRUV deployments, despite these deployments being in optimal depth ranges and habitat for this species. Interestingly, draughtboard sharks (*Cephaloscyllium laticeps;* Figure 71) were not commonly encountered either, despite being well represented in lobster potting bycatch data.

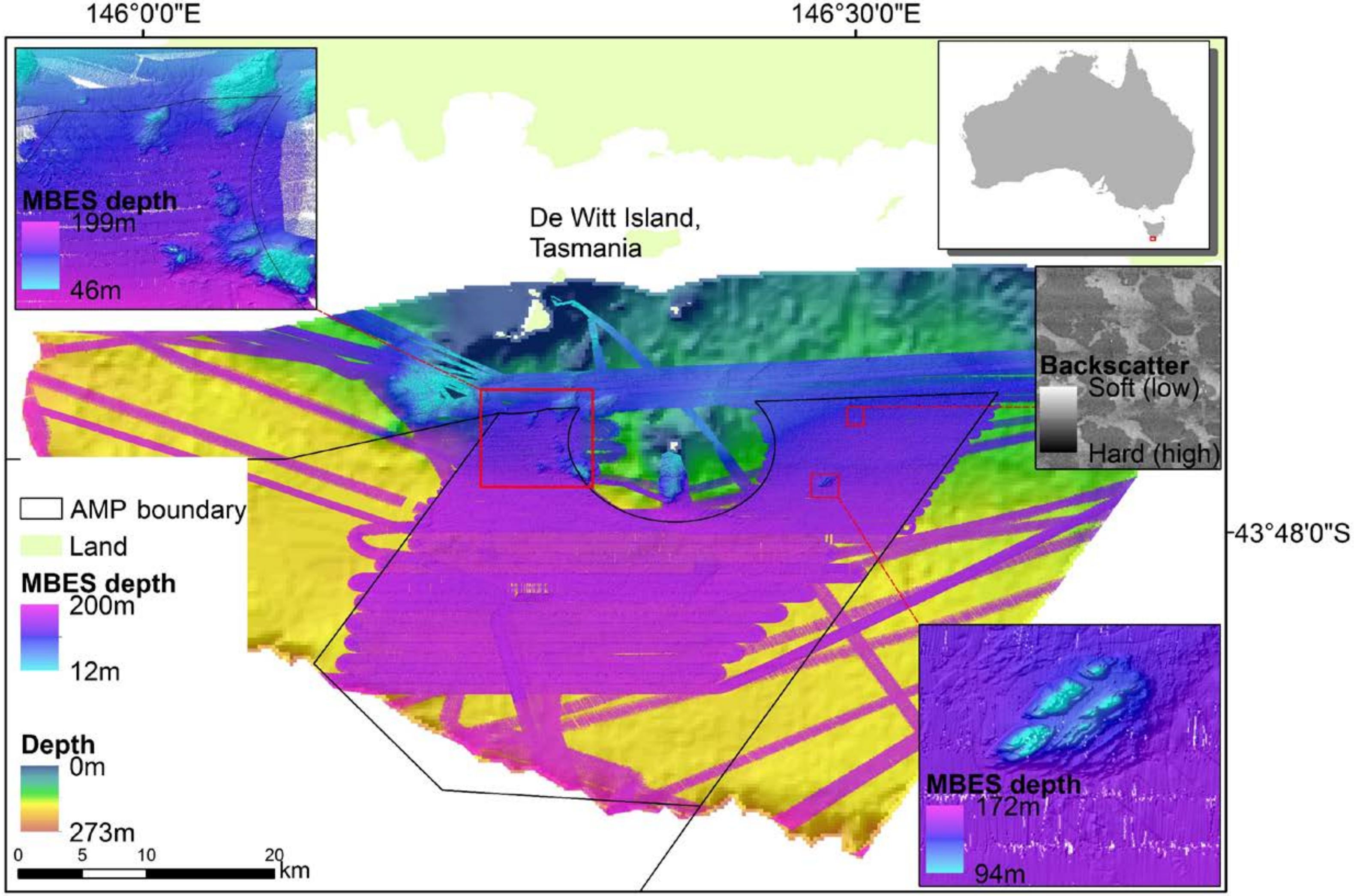


Figure 63. Mapped coverage of the Tasman Fracture AMP based on the Australian Bathymetry and Topography Grid, produced by Geoscience in June 2009. Note the fine-scale 5-m resolution multibeam sonar (MBES depth) collected by CSIRO Southern Survey/Investigator. Top insert showing closeup of high-profile reef features in the northwest of the AMP. Bottom left insert showing an isolated high-profile reef feature.

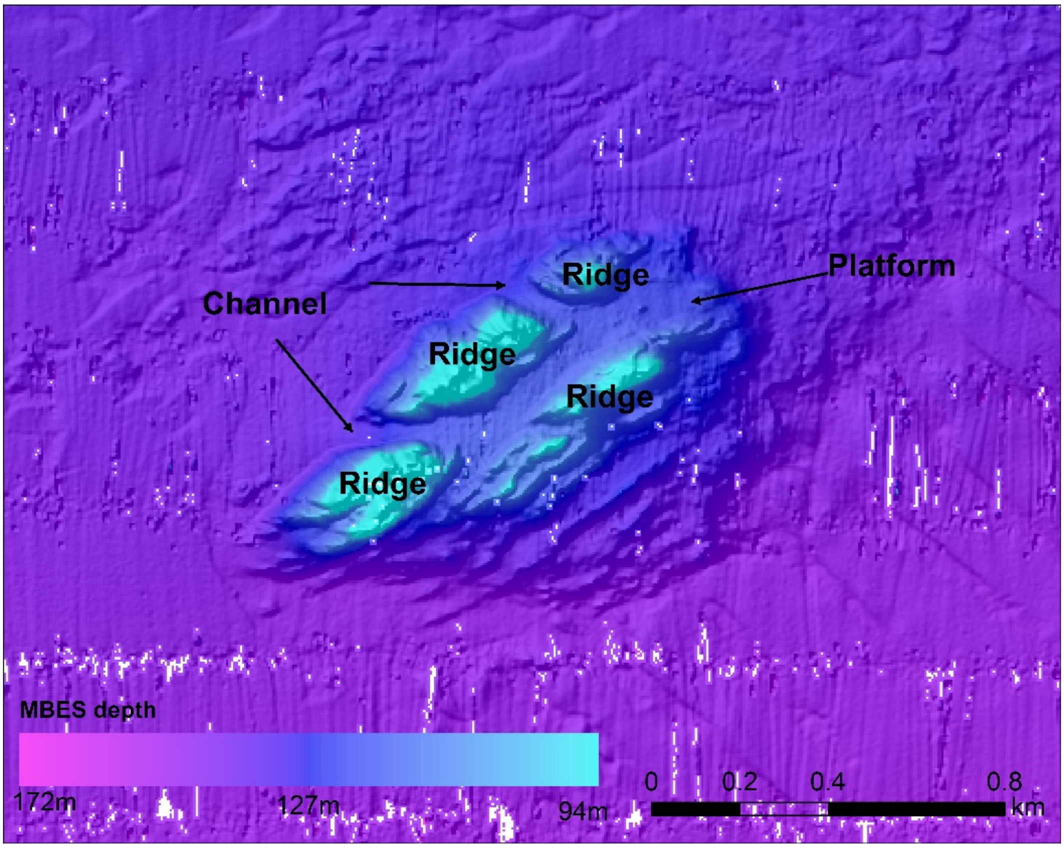


Figure 64. Geoform feature annotated reef located east of the Mewstone inside the Tasman Fracture AMP.

The observation of large schools of juvenile jackass morwong were unique (*c* 100-150 mm length; Figure 69) as juveniles of this species are usually associated with estuaries and other shallow-water coastal regions.

Monk et al. (2016b) undertook additional analysis contrasting the AMP with adjacent fished zones. They found that some fishery targeted species were more abundant within the AMP, including striped trumpeter, jackass morwong, Morid cods and ocean reef perch. This increase in abundance also applied to large (legal sized) size class for striped trumpeter and jackass morwong. The overall abundance and the abundance of large-sized fish varied over depth, with depths *c* 60 – 90 m and >120 m being important. Interestingly, the analysis of overall mean fish size indicated that fish were generally smaller inside the AMP.

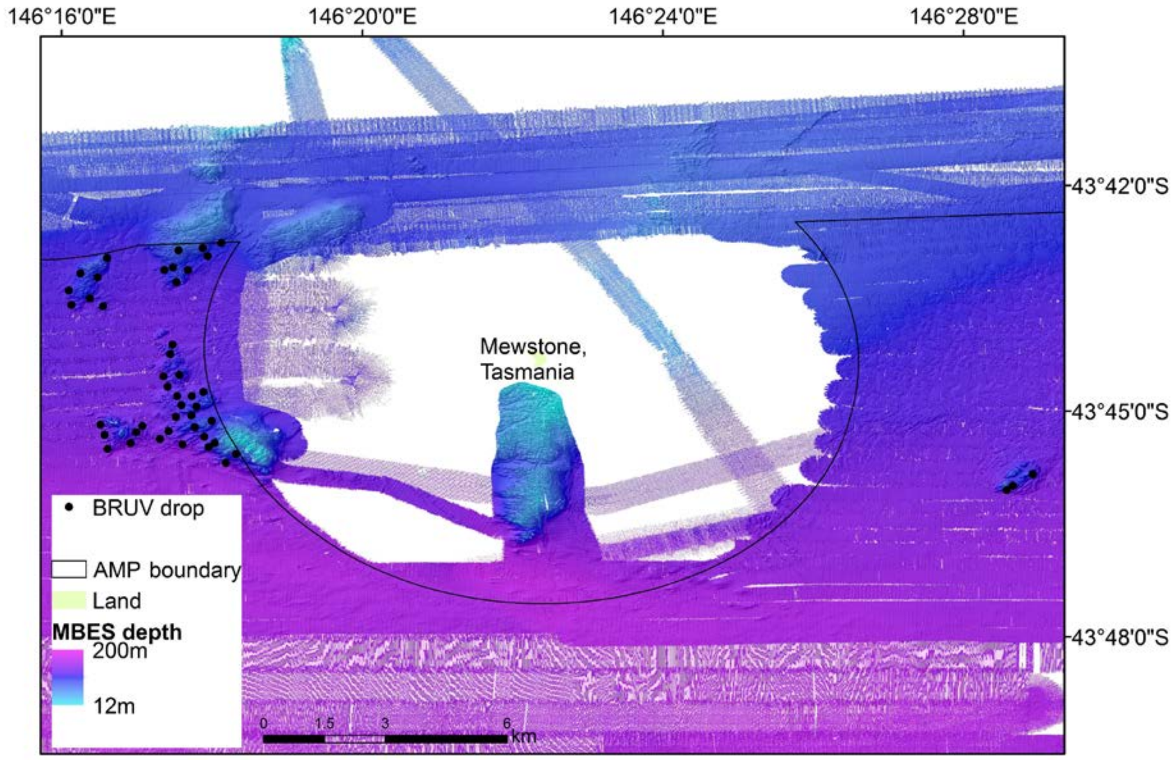


Figure 65. Location of 46 stereo BRUV drops within the Tasman Fracture AMP undertaken by Monk et al. (2016b).

Table 23. Fish species recorded using stereo BRUVs in the Tasman Fracture AMP based on 46 deployments. Abundance was measured using MaxN.

Family	Species name	Common name	Abundance	Habitat preference	Trophic group
Callanthiidae	*Callanthias australis*	Splendid perch	61	Reef/Pelagic	Demersal planktivore
Carangidae	*Trachurus declivis*	Jack mackerel	430	Pelagic	Pelagic carnivore
	Trachurus sp	Mackerel	66	Pelagic	Pelagic carnivore
Cheilodactylidae	*Nemadactylus macropterus*	Jackass morwong	214	Soft sediment	Demersal invertivore
Congridae	*Conger verreauxi*	Conger eel	2	Reef/Soft sediment	Demersal carnivore
Cyttidae	*Cyttus australis*	Silver dory	74	Reef/Soft	Demersal
Fishes (multi-family)	Blenniidae, Gobiidae,	Blenny	1	Soft sediment	Demersal
	Order Clupeiformes -	Baitfish	9,564	Pelagic	Pelagic planktivore
	Pseudolabrus rubicundus	Rosy wrasse	26	Reef	Demersal
Latridae	*Latris lineata*	Striped trumpeter	13	Reef/Soft	Demersal
Macroramphosidae	*Notopogon lilliei*	Crested bellowsfish	5	Reef	Demersal invertivore
	Meuschenia scaber	Cosmopolitan	11	Reef	Demersal
	Pseudophycis bachus	Red cod	66	Reef	Demersal carnivore
	Pseudophycis barbata	Southern codling	8	Reef	Demersal carnivore
	Pseudophycis sp	Morid cod	2	Reef	Demersal carnivore
Narcinidae	*Narcine tasmaniensis*	Tasmanian numbfish	1	Soft sediment	Demersal invertivore

Family	Species name	Common name	Abundance	Habitat preference	Trophic group
Neosebastidae	*Neosebastes scorpaenoides*	Common gurnard perch	1	Reef/Soft sediment	Demersal invertivore
Ophidiidae	*Genypterus tigerinus*	Rock ling	1	Reef/Soft	Demersal
Paraulopidae	*Paraulopus nigripinnis*	Blacktip cucumberfish	1	Soft sediment	Benthic invertivore
Pinguipedidae	*Parapercis allporti*	Barred grubfish	76	Soft sediment	Benthic invertivore
Rajidae	*Dentiraja lemprieri*	Thornback skate	1	Soft sediment	Benthic carnivore
	Spiniraja whitleyi	Melbourne skate	2	Soft sediment	Benthic carnivore
Scombridae	*Thunnus* sp	Tuna	1	Pelagic	Pelagic carnivore
Scorpaenidae	*Scorpaena papillosa*	Southern red	3	Reef	Benthic invertivore
Scyliorhinidae	*Asymbolus rubiginosus*	Orange spotted	7	Reef	Benthic carnivore
	Cephaloscyllium laticeps	Draught board	11	Reef/Pelagic	Demersal carnivore
Sebastidae	*Helicolenus percoides*	Ocean perch	205	Reef	Benthic carnivore
Serranidae	*Caesioperca lepidoptera*	butterfly perch	737	Reef/Pelagic	Pelagic planktivore
	Caesioperca rasor	barber perch	5	Reef/Pelagic	Pelagic planktivore
	Caesioperca sp	perch	4	Reef/Pelagic	Pelagic planktivore
	Lepidoperca pulchella	Eastern orange	8	Reef/Pelagic	Pelagic planktivore
Trachichthyidae	*Paratrachichthys macleayi*	Sandpaper fish	11	Reef	Benthic carnivore
Urolophidae	*Urolophus cruciatus*	Banded stingaree	3	Soft sediment	Benthic invertivore
Total			*11,621*		

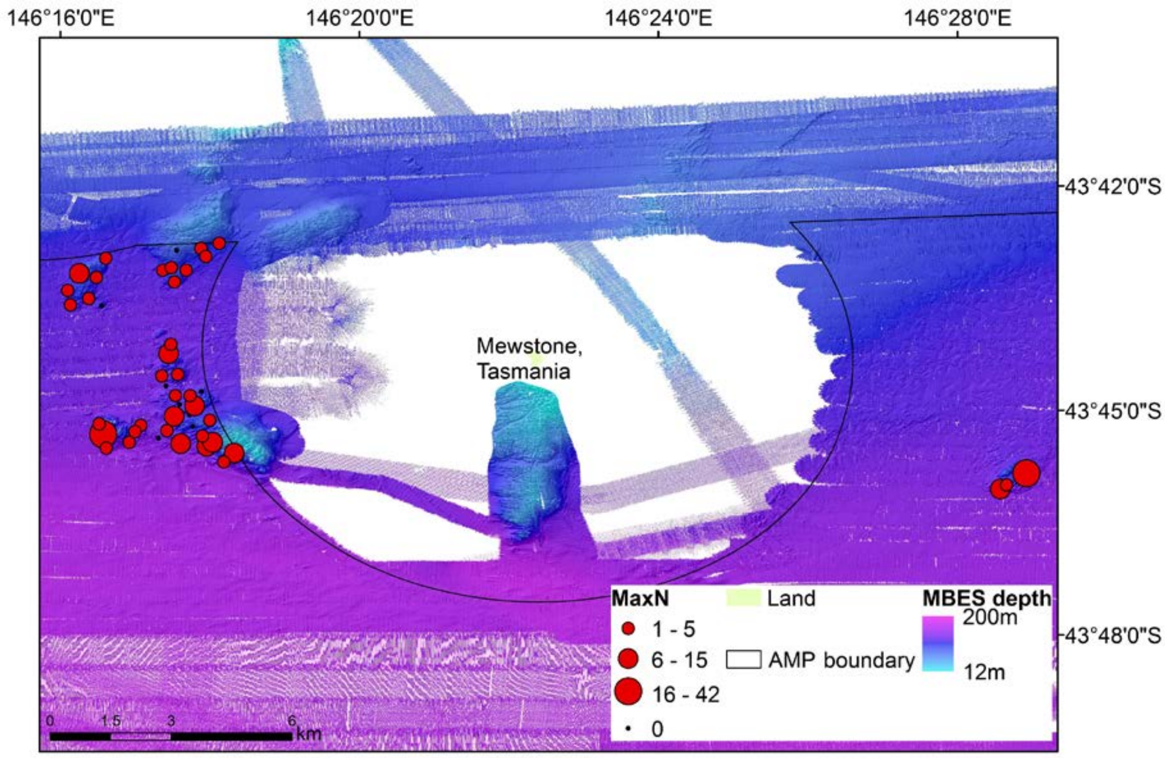


Figure 66. Abundance distribution of jackass morwong (*Nemadactylus macropterus*) in Tasman Fracture AMP.

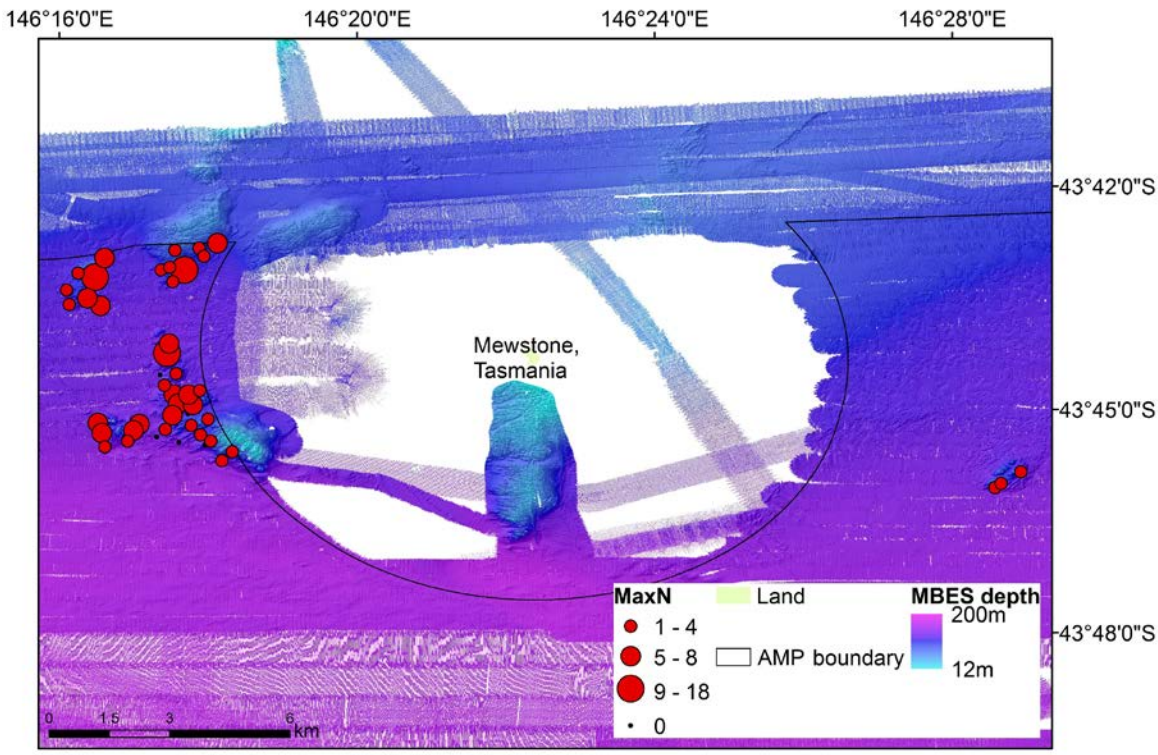


Figure 67. Abundance distribution of ocean reef perch (Helicolenus percoides) in Tasman Fracture AMP.

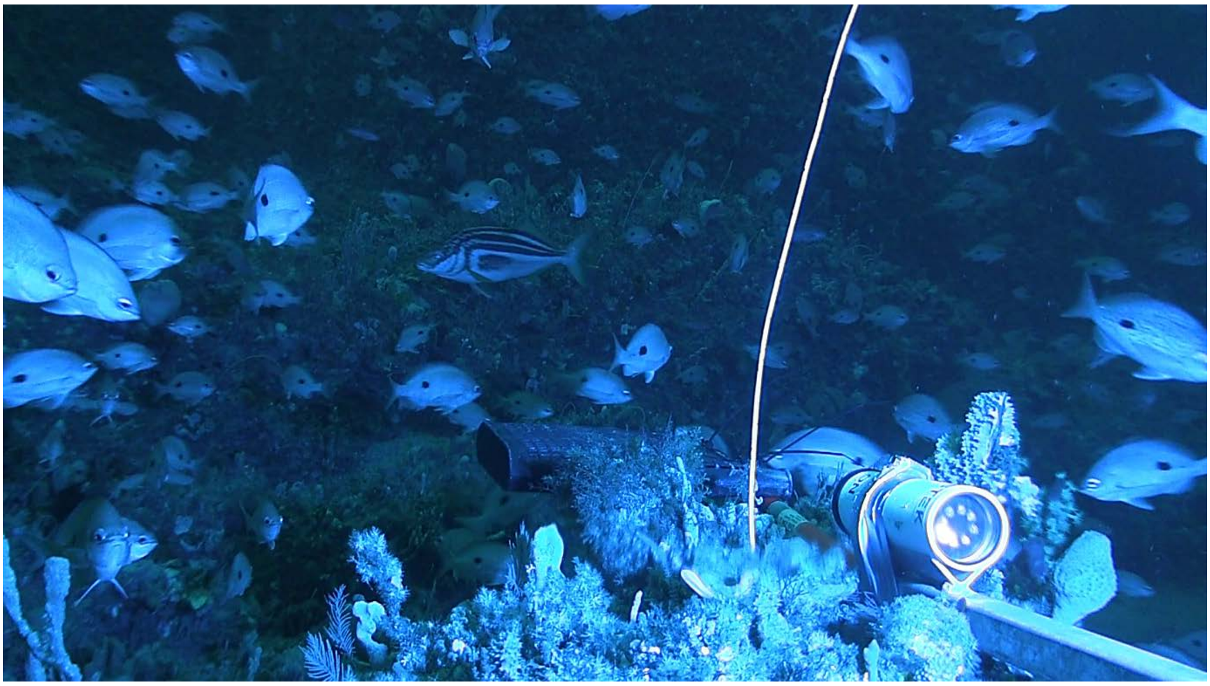


Figure 68. An example of one of the large schools of butterfly perch observed within the Tasman Facture AMP. Note the striped trumpeter (*Latris lineata*).

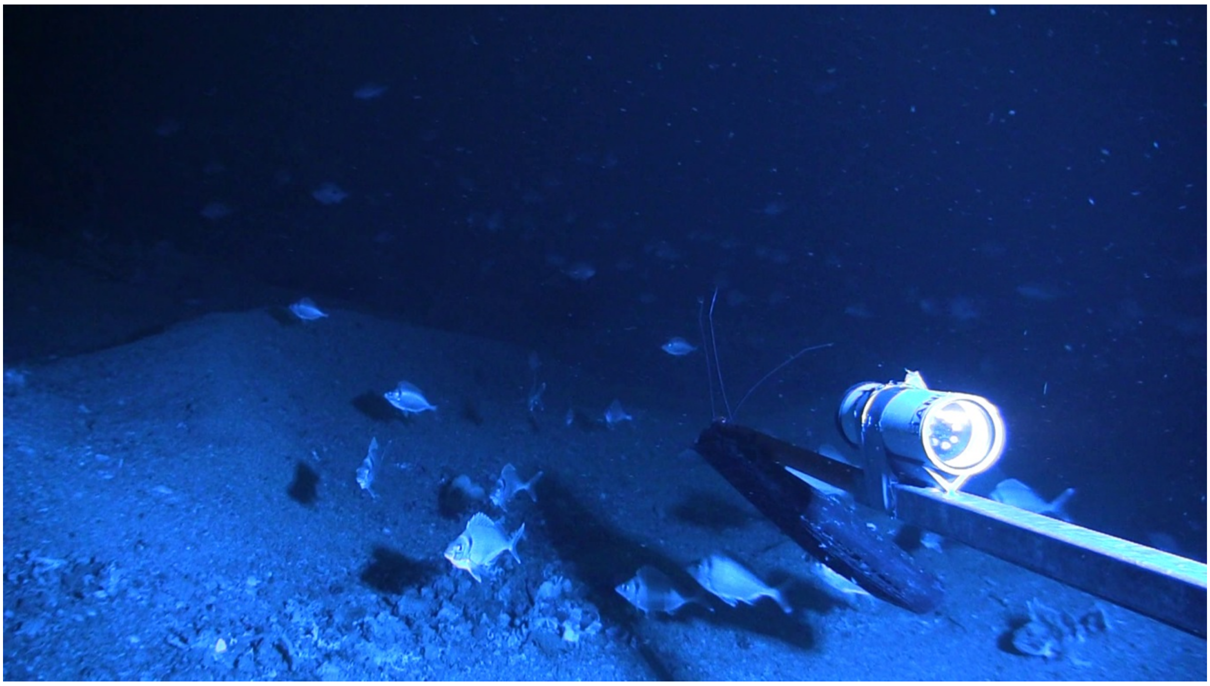


Figure 69. An example of one of the large schools of juvenile jackass morwong observed within the Tasman Facture AMP. This is an interesting finding as juvenile jackass morwong (*Nemadactylus macropterus*) are thought to be usually associated with estuaries and other sheltered shallow-water regions.

Figure 70. An example of one of the large striped trumpeter (*Latris lineata*) observed within the Tasman Facture AMP.

Figure 71. Large seven gill shark (*Notorynchus cepedianus*), Morid cods (Moridae) and jack mackerel (*Trachurus declivis*) attracted to the stereo BRUVs.

Two AUV transects have been undertaken in the Tasman Fracture AMP located ~ 6 km west of the Mewstone during a survey in 2015 (Figure 72). From these two AUV missions 261 images, representing a subsample of approximately every 50th image, or one image every 25 m along transect, were scored for percentage cover of benthic invertebrate and substrata cover using a count of cover below each of 25 randomly placed points per image.

A highly diverse assemblage was recorded, with 149 biological morphospecies being identified and three substratum types (Table 24). Similar to other deep-water environments around Tasmania (such as the Flinders AMP), a matrix of low profile, finely-structured invertebrate cover was the most common biogenic substrata feature (CATAMI class Bryozoan/Cnidaria/Hydroid matrix; Figure 73 and Table 24) comprising 16% of the assemblage. For the larger, more visible invertebrates, sponges formed the most significant identifiable component of the fauna (17.6 %). Of these, the morphospecies “encrusting white 6” (Figure 74), was the most common sponge, representing 4.8 % of the total cover. Overall, the remaining biota was typical of that found in deep reef assemblages on previous studies in the region, with very few species approaching cover of 2 %, and with the vast majority significantly less than that. A large number of sponge morphospecies were encountered (110 morphospecies), including a number of structure forming species such as “cup 1 white” (Figure 75).

Two quite notable features of the overall invertebrate cover were (1) the abundance of mobile brittle stars (Figure 76; 1.9% assemblage), and (2) the abundance of octocoral species which at 5.7% overall was markedly higher than encountered on similar surveys in the south east region of Australia, and may prove to be a unique feature of this region. The soft coral morphospecies “soft *Capnella* like” (Figure 77) was the more abundant of these contributing 1.9% to the overall assemblage. Likewise, the broad scale abundance of brittle stars throughout the imagery (1.9% of the assemblage) is a feature not yet seen elsewhere in AUV-based surveys although they are a conspicuous component of trawl catch in some soft sediment locations. Their abundance potentially indicates this environment is rich in detrital food sources.

Similar to the Huon AMP, nearly 29 % of morphospecies within the Tasman Fracture AMP were singletons (i.e. only seen once) and nearly half the morphospecies in the assemblage were not often seen more than once (Table 24). This suggests that the benthic assemblage in the Tasman Fracture consists of a morphospecies that are highly diverse and spatially rare.

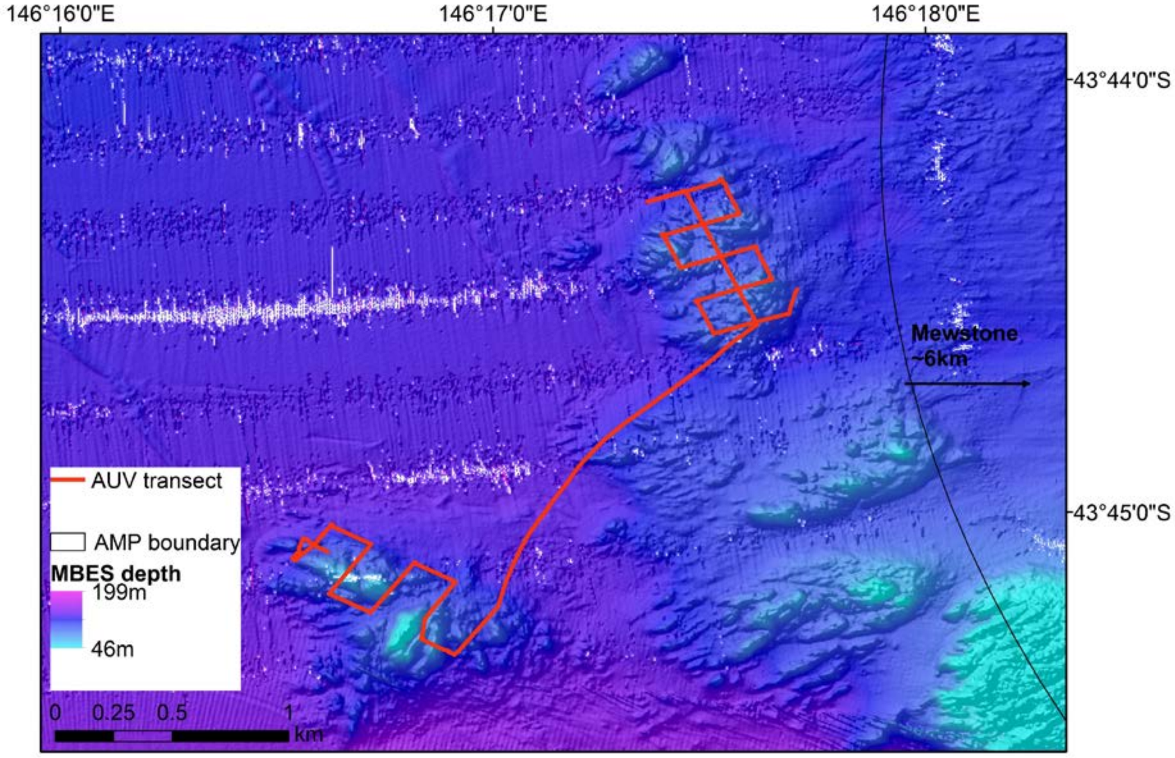


Figure 72. Location of the two AUV transections undertaken inside Tasman Fracture AMP in 2015.

Table 24. Total observations and percentage contribution of morphospecies and bare substrate type observed in the Tasman Facture AMP using the AUV.

CATAMI class	Morphospecies	Total observations	Percentage contribution
Ascidians	Ascidian 12 Colonial Red	1	0.02
	Ascidian 2 *Clavelina* like	2	0.03
	Ascidian Solitary Grey	1	0.02
	Ascidian Unstalked Colonial Encrusting	3	0.05
	Ascidian Unknown Solitary	7	0.11
Total ascidian			0.21
Biota	Biogenic Matrix	33	0.50
	Unknown Biology	65	0.98
Bryozoa	Bryozoan 3 *Cantinicella* like	70	1.06
	Bryozoan 5 Lace	16	0.24
	Bryozoan 7 Hard	8	0.12
	Bryozoan Unknown Soft	43	0.65
Total Bryozoa			2.08
Bryozoa/Cnidaria/Hydroid matrix	Bryozoa/Cnidaria/Hydroid matrix	1,045	15.83
Bryozoa/Sponge matrix	Bryozoa/Sponge matrix	240	3.64
Cnidaria	bramble *Acabaria* sp	46	0.70
	bramble *Asperaxis kareni*	9	0.14
	Coral 2 soft *Capnella* like	123	1.86
	Coral 6 soft blue	6	0.09
	Coral orange solitary	6	0.09
	Gorgonian pink 1	7	0.11
	Gorgonian red 2	55	0.83
	Hydroid 1	73	1.11
	Hydroid 2	3	0.05
	Hydroid White	7	0.11
	Sea whip 1	21	0.32
	Hydroid Brown Feathers	6	0.09
	Hydroid Yellowish	4	0.06
	Branching grey Octocoral	1	0.02
	Hydriod Orange 2D	4	0.06
	Zooanthid 1 Cf *Epizooanthus*	1	0.02
Total Cnidaria			5.64
Crustacea	*Jasus edwardsii*	1	0.02
Echinoderms	Brittle star	124	1.88
	Holothuroidea	2	0.03
Fishes	*Caesioperca lepidoptera*	1	0.02
Fishes	*Helicolenus percoides*	3	0.05
Jellies	Salps	8	0.12

CATAMI class	Morphospecies	Total observations	Percentage contribution
Macroalgae	Drift	1	0.02
Molluscs	Scallop	4	0.06
Sponges	Arborescent 10 orange/brown fingers	1	0.02
	Arborescent 12 brown thorny	2	0.03
	Arborescent 13 orange	2	0.03
	Arborescent 14 black	2	0.03
	Arborescent 15 white short	15	0.23
	Arborescent 17 stumpy grey	5	0.08
	Arborescent 5 white	5	0.08
	Arborescent 6 yellow	10	0.15
	Arborescent 8 tan	1	0.02
	Branching 1 Orange	2	0.03
	Branching 3 Purple	1	0.02
	Branching 4 Brown	2	0.03
	Cup 1 white	13	0.20
	Cup 2 white frilly	1	0.02
	Cup 6 pink thick	2	0.03
	Cup 7 light pink flat thick	9	0.14
	Cup 8 yellow	7	0.11
	Encrusting 1 orange	77	1.17
	Encrusting 2 light orange	13	0.20
	Encrusting 3 yellow	76	1.15
	Encrusting 4 blue	35	0.53
	Encrusting 5 brown	119	1.80
	Encrusting 6 white	313	4.74
	Fan 10 thick large oscules	2	0.03
	Fan 12 brown thin	2	0.03
	Fan 14 white thin	1	0.02
	Fan 3 orange flat	5	0.08
	Fan 4 pink	2	0.03
	Fan 6 yellow	3	0.05
	Fan 7 orange thin blade	2	0.03
	Fan 9 orange thick	1	0.02
	Globular 2 white *Tethya* like	1	0.02
	Massive 11 white holey	3	0.05
	Massive 12 yellow papillate	3	0.05
	Massive 17 White Lumpy	1	0.02
	Massive 18 orange holey	4	0.06
	Massive 20 pink	1	0.02
	Massive 22 Yellow holey	4	0.06
	Laminar Grey Fungi	1	0.02
	Orange Massive Ball 1	2	0.03

CATAMI class	Morphospecies	Total observations	Percentage contribution
	Papillate 2 yellow	2	0.03
	Tubular 7 pink thorny	1	0.02
	Tubular 3 white colony	6	0.09
	Tubular 4 tan	1	0.02
	Tubular 6 white thorny	3	0.05
	Tubular 9 pink small oscules	3	0.05
	Ramose Single Cream	12	0.18
	Cup Beige Shallow Irregular	6	0.09
	Simple Orange Rough	1	0.02
	Simple Beige Honeycomb	1	0.02
	Cup Beige Thick	1	0.02
	Tube White Lumpy	2	0.03
	Stalked White Lumpy	1	0.02
	Encrusting Orange Lumpy	2	0.03
	Laminar Grey Rough	1	0.02
	Simple Grey Brain	1	0.02
	Encrusting Yellow Thick	3	0.05
	Simple Beige Laminar Like	1	0.02
	Encrusting White Granular	9	0.14
	Encrusting Black Thick	61	0.92
	Palmate Orange Flat	1	0.02
	Massive Beige Shapeless	9	0.14
	Encrusting Brown	2	0.03
	Encrusting Orange Fluffy	1	0.02
	Encrusting White Granular	16	0.24
	Encrusting Black	6	0.09
	Simple Purple Shapeless	3	0.05
	Massive Grey Laminar Like	9	0.14
	Branching Beige Spindles	1	0.02
	Tubes Beige Prostrate	1	0.02
	Tube Beige Irregular	1	0.02
	Encrusting Black Papillate	1	0.02
	Encrusting Beige Smooth	12	0.18
	Palmate Grey Fingers	2	0.03
	Branching White Thorny Lumps	2	0.03
	Laminar White Irregular	3	0.05
	Ball Yellow Papillate Irregular	2	0.03
	Chimney White Tall	1	0.02
	Simple Yellow Lumpy	12	0.18
	Simple Beige Irregular Oscula	1	0.02
	Encrusting White Lumpy	13	0.20
	Branching Grey Fine Repent Like	13	0.20
	Chimney White Round	6	0.09

CATAMI class	Morphospecies	Total observations	Percentage contribution
	Cryptic Black Wrinkly	1	0.02
	Cup Red Smooth	3	0.05
	Simple Beige Lumpy	2	0.03
	Tubes Beige Prostrate	8	0.12
	Encrusting Black Lumpy	8	0.12
	Simple Orange Smooth	1	0.02
	Branching Beige Stumpy	2	0.03
	Simple Pink Irregular	1	0.02
	Laminar White Small	1	0.02
	Fan White Thin	1	0.02
	Simple Beige Shapeless	1	0.02
	Cup Brown Irregular	2	0.03
	Repent Orange	2	0.03
	Massive Blue Shapeless	2	0.03
	Encrusting Beige Oscula	4	0.06
	Fan Peach Thick	1	0.02
	Palmate Grey	4	0.06
	Simple Grey Doughnut	1	0.02
	Simple Beige Tube Like	1	0.02
	Palmate Beige Flat	1	0.02
	Encrusting Yellow Rough	3	0.05
	Branching Black Fingers	2	0.03
	Simple Grey Creep	2	0.03
	Lumpy Shapeless Grey	15	0.23
	Encrusting Yellow 2	83	1.26
	Yellow French Fires 1	4	0.06
	Yellow Shapeless Smooth 1	2	0.03
Total Sponge			17.35
Worms	Tube Worm sp1	4	0.06
	Fanworm *sabella* like.	2	0.03
Substrata	Biological Rubble	1,123	17.02
	Rock	492	7.45
	Sand	1,781	26.98
Unscorable	Unscorable	3	0.05

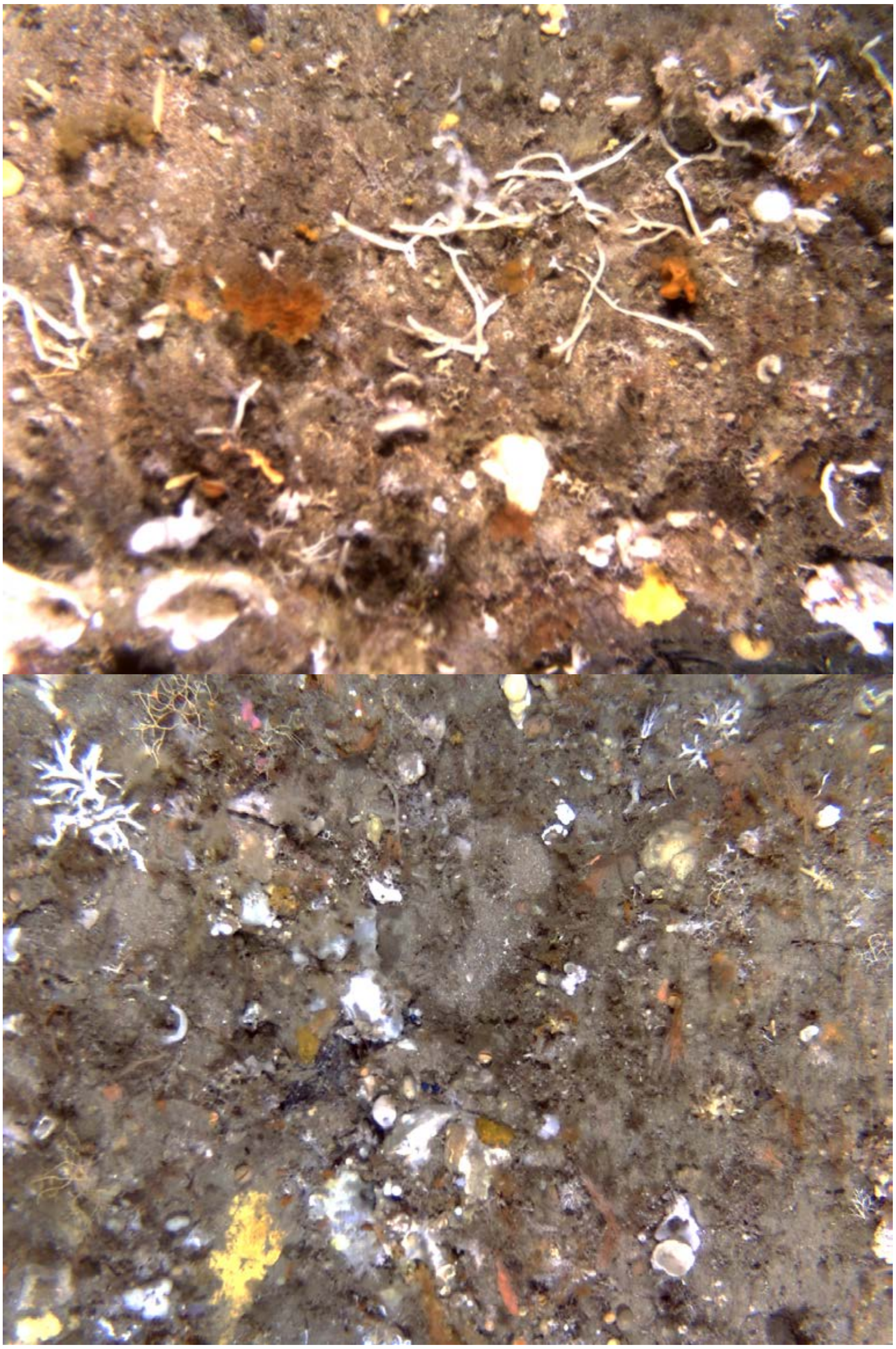


Figure 73. Example of the Bryozoa/Cnidaria/Hydroid matrix class (non-descript brown turf) that were the most commonly observed portion of the assemblage in the Tasman Fracture AMP.

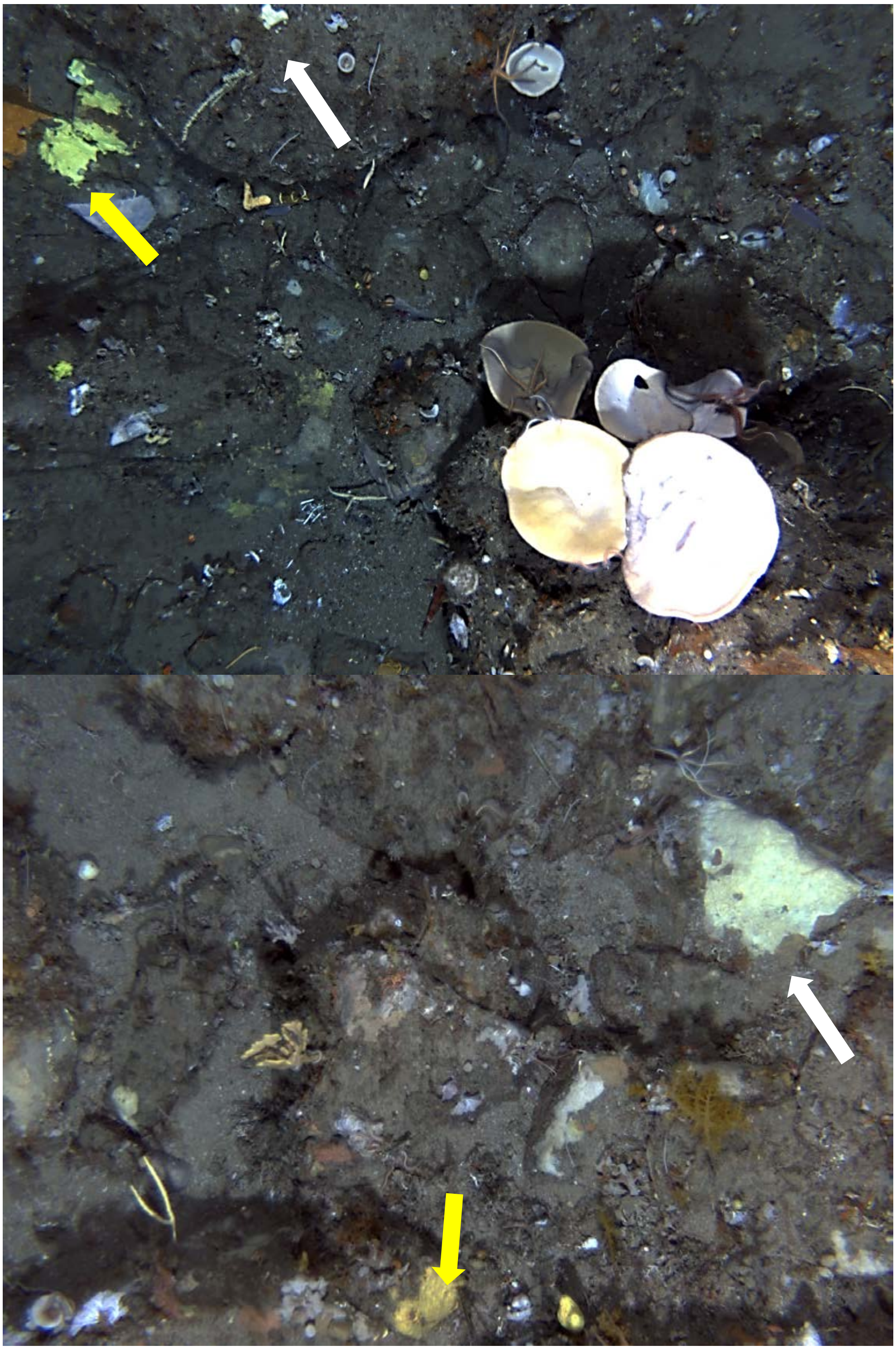


Figure 74. Boulder reefs supporting encrusting yellow and white sponges (colour coded arrows). White encrusting sponges are morphospecies “Encrusting white 6”. Note also the large cup-like (“cup 1 white”) in top image.

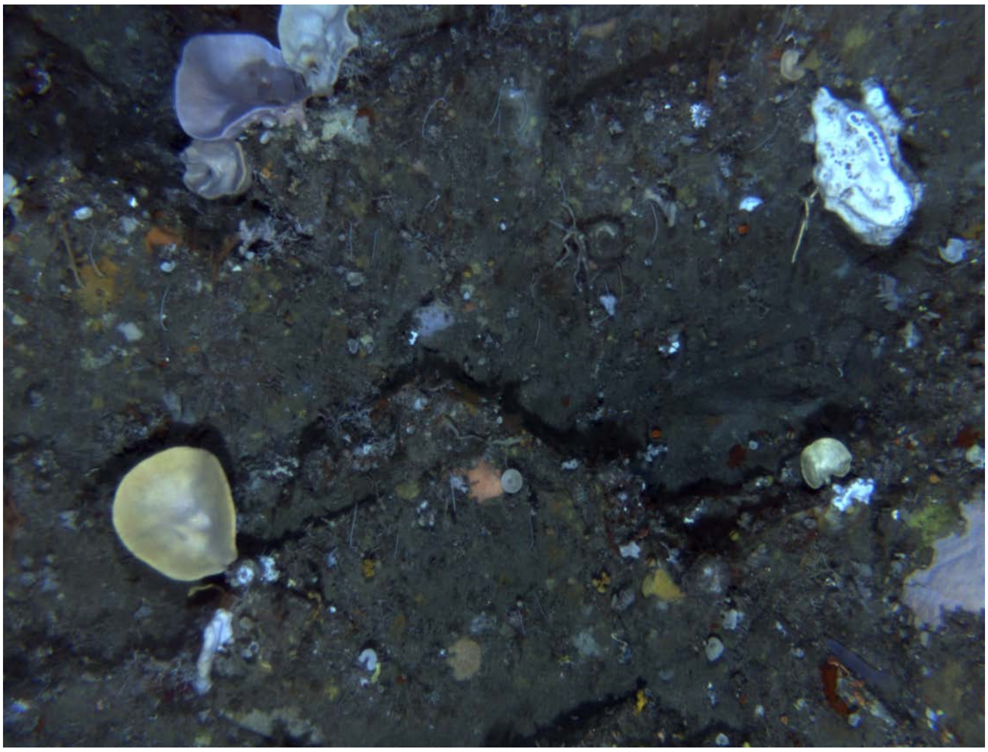


Figure 75. Examples of the variety in cup-like sponges from small (centre of image) to large top left image (“cup 1 white” morphospecies).

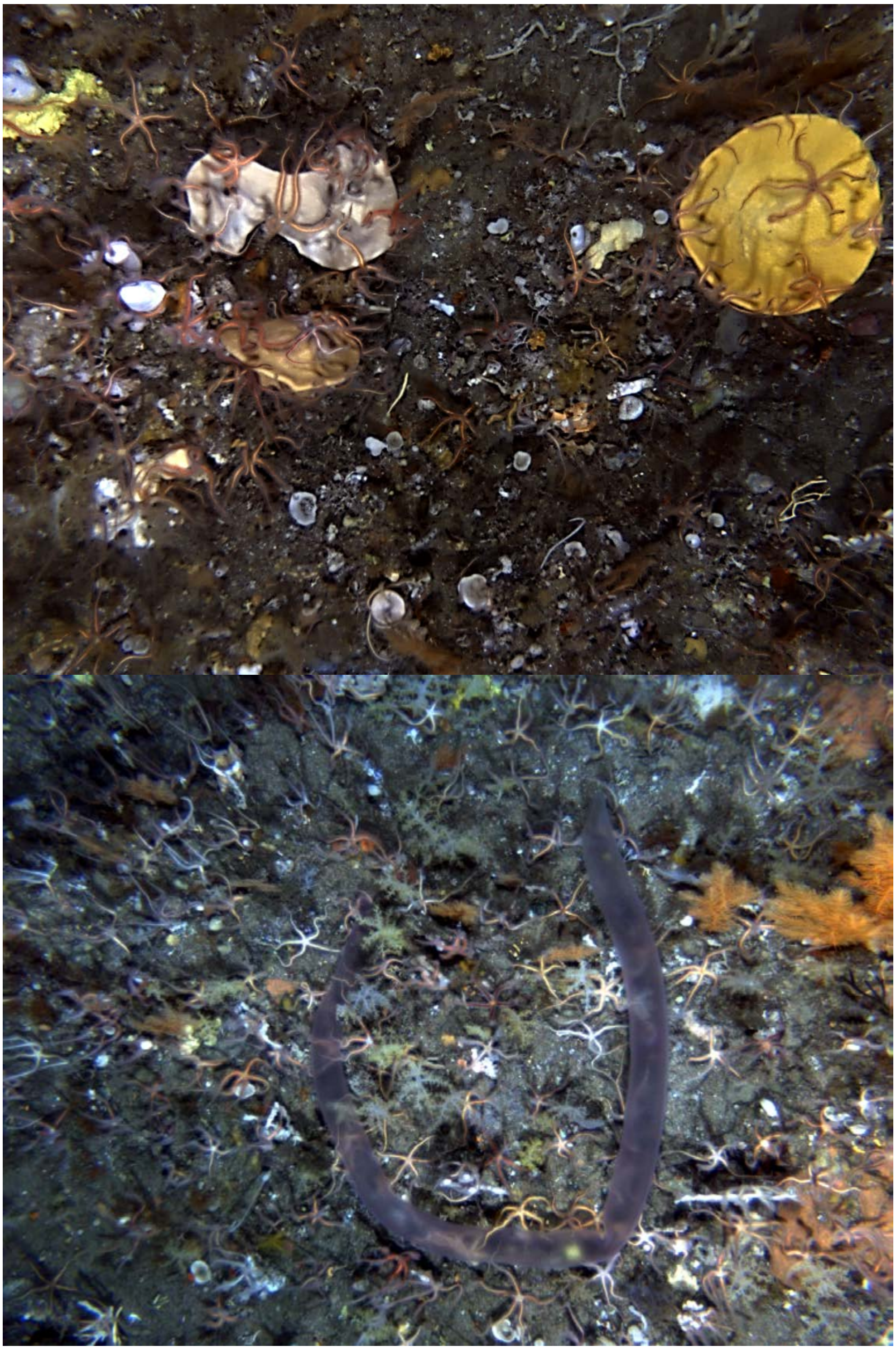


Figure 76. An example image highlighting the high abundance in the brittle star community. Note the large salp in bottom image. Salps were also a common occurrence in the lobster pots.

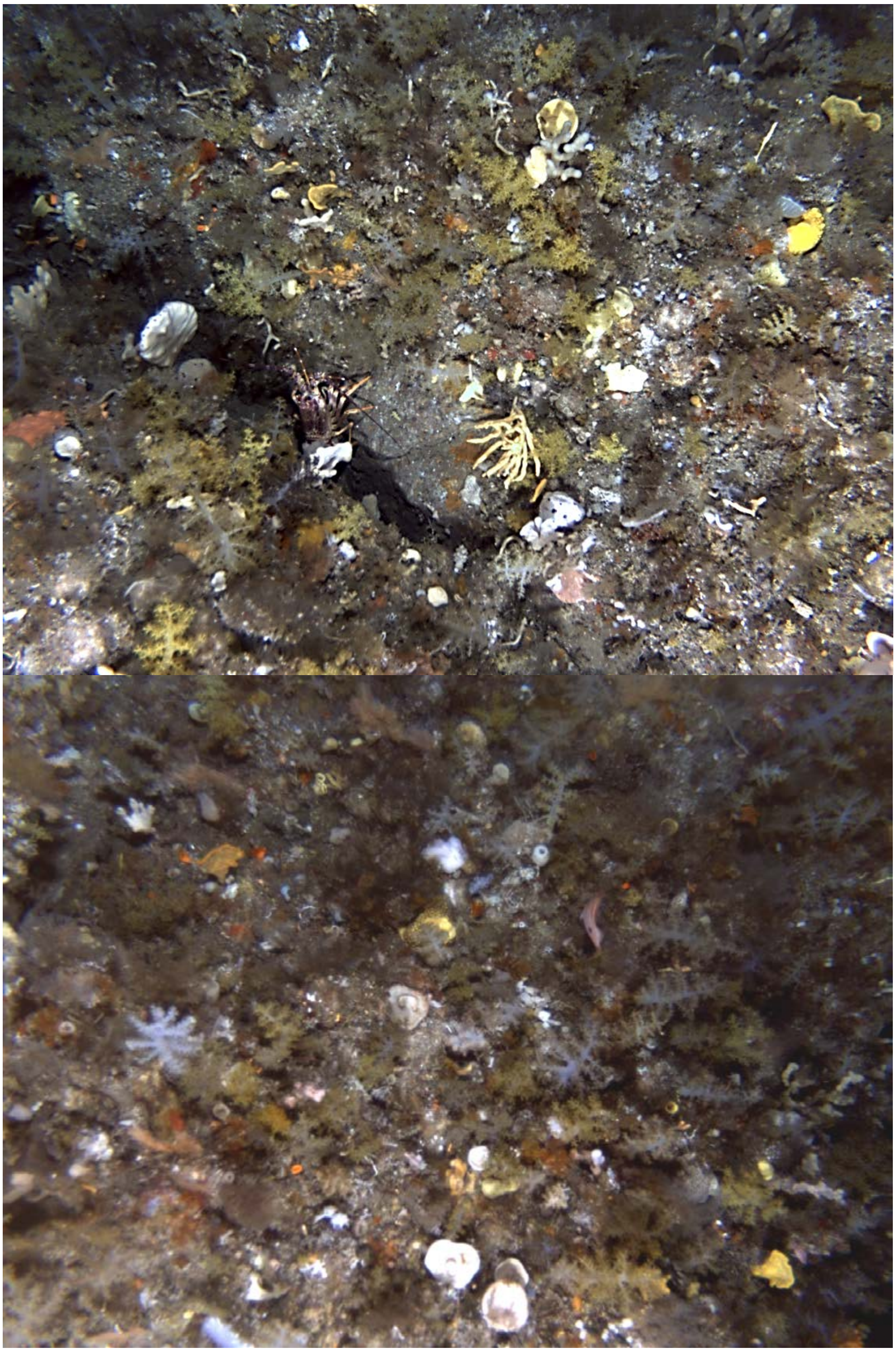


Figure 77. An example of the complex invertebrate assemblages including sponges, *Capnella*-like soft corals (Coral 2 soft *Capnella* like) and ascidians. Note the lobster (*Jasus edwardsii*) in the centre of the top image.

Mobile organisms within the AUV imagery were also scored (Table 25). A total of 26 mobile organisms, comprising of 12226 individuals were identified within the imagery. The doughboy scallop (*Mimachlamys asperrima*), salps (*Thaliaceans*), squat lobster (*Galathea australiensis*; Figure 78), ocean reef perch (*Helicolenus percoides*; Figure 79) and butterfly perch (*Caesioperca lepidoptera*) were the most commonly recorded species (Table 25).

Table 25. Summary of mobile organisms with the AUV imagery collected in the Tasman Fracture AMP.

Common name	Species	Abundance
Southern rock lobster	*Jasus edwardsii*	28
Sea cucumber	*Australostichopus mollis*	115
Salp	Thaliaceans	2140
Doughboy scallop	*Mimachlamys asperrima*	8628
Squat lobster	*Galathea australiensis*	418
Volutes/Cowries	Prosobranchs	55
Grubfish	*Parapercis allporti*	44
Ocean reef perch	*Helicolenus percoides*	381
Butterfly perch	*Caesioperca lepidoptera*	210
Spiny pipehorse	*Solegnathus spinosissimus*	11
Draughtboard shark	*Cephaloscyllium laticeps*	5
Butterfly gurnard	*Lepidotrigla vanessa*	2
Red/Rock cod	*Pseudophycis* spp	22
Rosy wrasse	*Pseudolabrus rubicundus*	5
Banded stingaree	*Urolophus cruciatus*	15
Hermit crab	Diogenids	52
Feather star	Crinoids	10
Sea star	Asteroides	4
Pencil sea urchin	Cidarids	20
Bivalve	Mollusc	14
Velvet leatherjacket	*Meuschenia scaber*	2
Spotted dragonet	*Repomucenus calcaratus*	3
Rusty carpet shark	*Parascyllium ferrugineum*	6
Sandpaper fish	*Paratrachichthys richardsoni*	34
Tiger flathead	*Neoplatycephalus*	1
Thornback skate	*Dentiraja lemprieri*	1

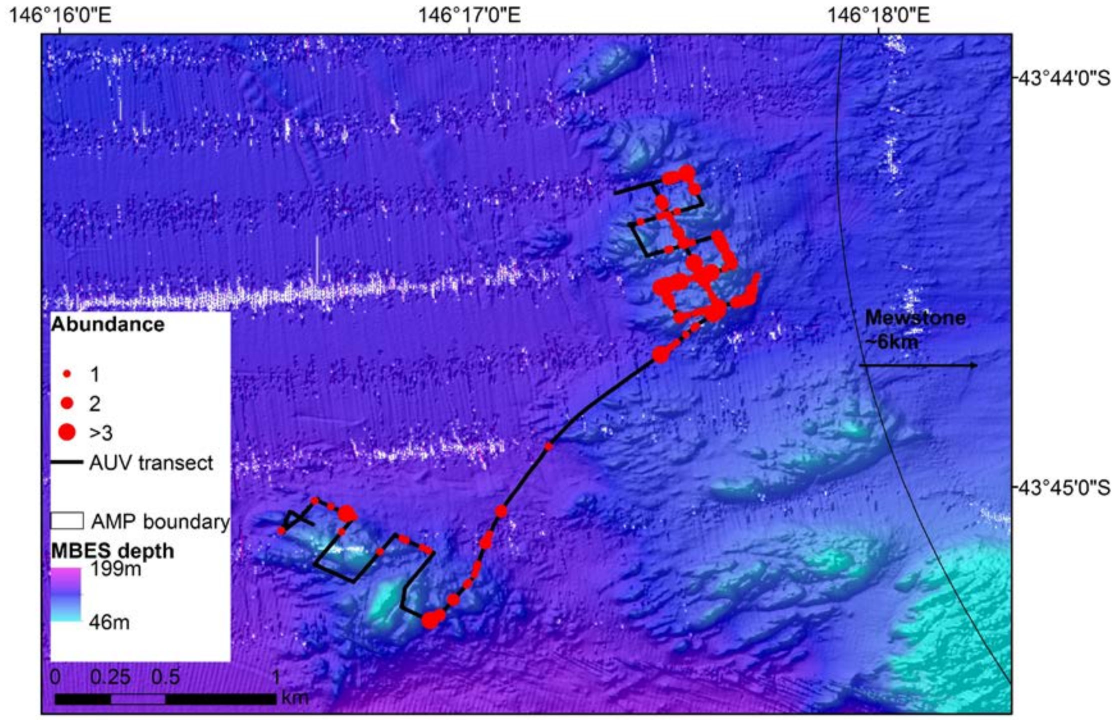


Figure 78. Abundance distribution of squat lobster (*Galathea australiensis*) within the AUV imagery from Tasman Fracture AMP.

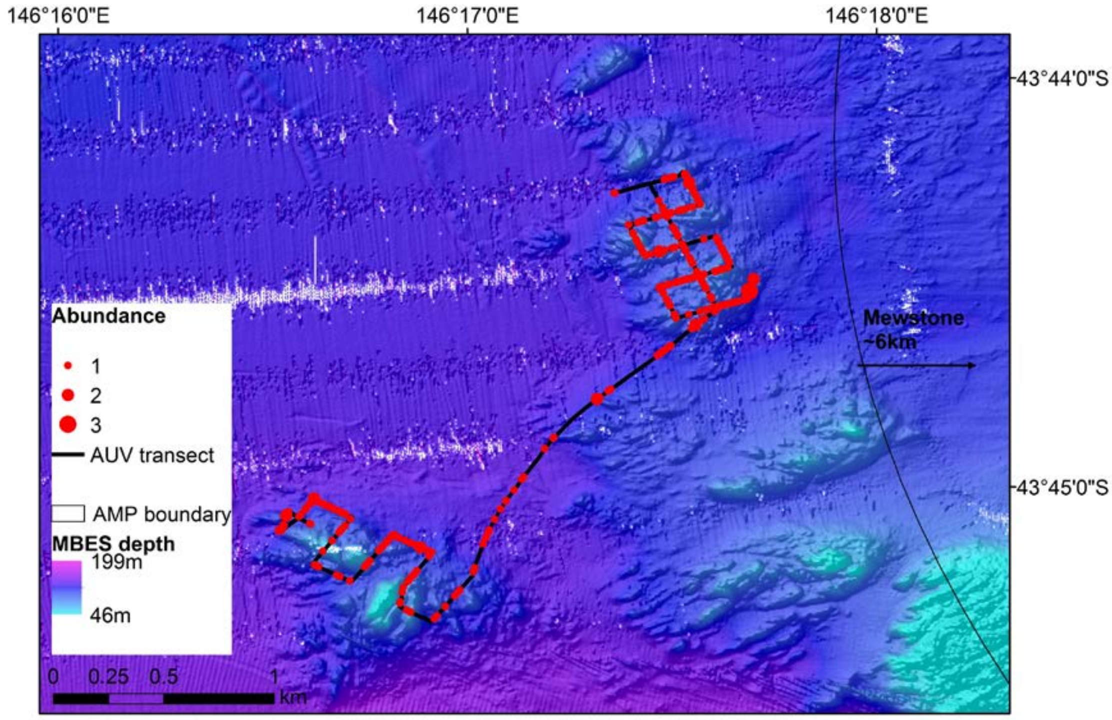


Figure 79. Abundance distribution of ocean reef perch (*Helicolenus percoides*) within the AUV imagery from Tasman Fracture AMP.

Monk et al. (2016b) investigated the protection effects on lobster populations inside the Tasman Fracture AMP. They found a marked discrepancy between capture rates within the AMP and the adjacent fished reefs (Figure 80). On average 3.5 lobsters were caught per pot in the AMP compared to 9.2 lobsters per pot within the fished locations, with a total of 1277 lobsters captured overall from 200 pots (Figure 80).

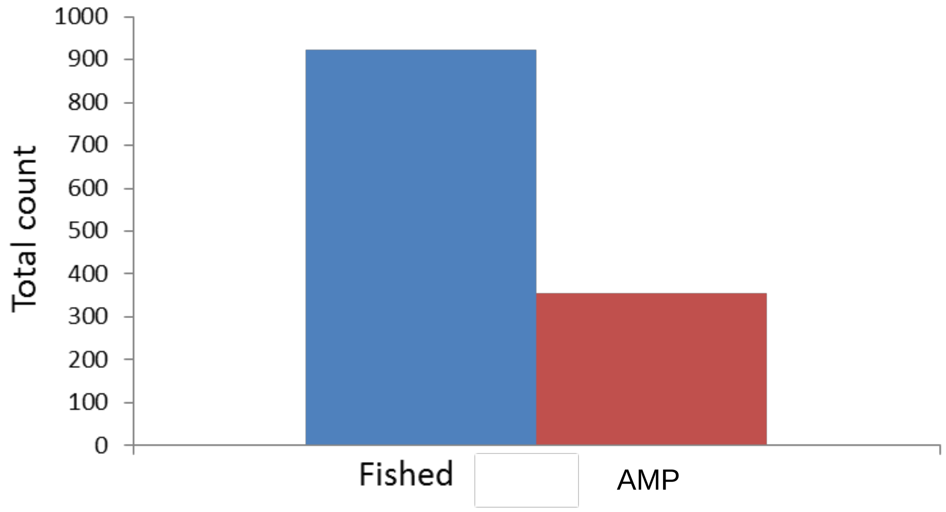


Figure 80. Total lobster counts from potting surveys within the Tasman Fracture AMP.

Monk et al. (2016b) also found a marked difference in the ratio of legal size v's undersize male lobsters between the fished areas and the AMP (Figure 81), with legal sized males (> 110 mm carapace length) representing 45 % of the catch in the AMP compared with 18 % in the fished reference areas. For females, however, the story was very different. Irrespective of location very, few females were legal size (7 % of the captured females within the AMP and only 2 % of the captured females within the fished reference locations; Figure 81). The growth rates of female lobster in this region are known to be extremely low. Therefore, the AMP offers no additional protection other than reduced capture-related mortality if potting effort is high within the fishery.

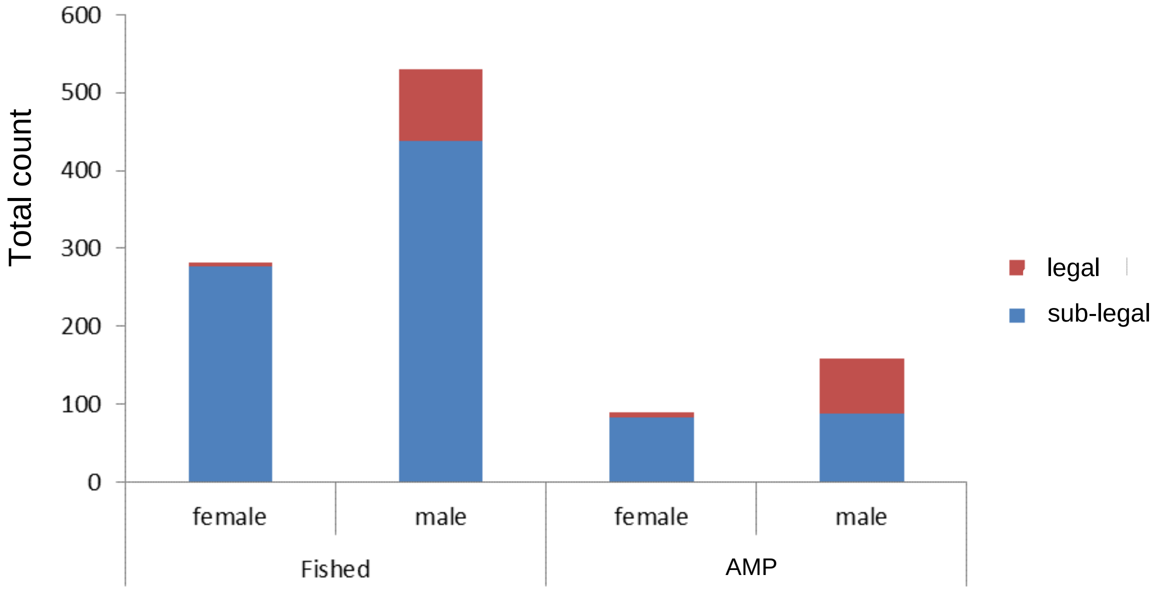


Figure 81. Abundance of legal sized vs sub-legal sized lobsters within fished and AMP reefs.

Monk et al. (2016b) also modelled this data (based on the initial statistical sampling design) to account for the combined variations in depth, day of pot set and the influence of protection. The model results suggested that there was a strong positive protection effect for catch per pot, weaker yet positive average male lobster size, average legal-sized male abundance, proportion of females caught, and the proportion of legal males caught.

3.14 Zeehan AMP

3.14.1 Description of physical Habitat

Mapping data within theZeehan AMP consists of the Australian Bathymetry and Topography Grid and fine-scale MBES surveys from CSIRO Southern Survey/Investigator vessel transits. The continental shelf region covers ~ 4 % of the Zeehan AMP. The fine-scale MBES data covers ~ 14 % of the continental shelf region of the AMP and indicates that the depth range is from *c* 97 to 200 m (Figure 82 and Figure 134 in Appendix A). From the mapping data, it appears that there is an isolated reef mound near the 130-150m bathome on the north western boundary of the AMP (Figure 82).

3.14.2 Description of biological assemblages

No sampling data for reef-affiliated fishes or biota could be identified for the continental shelf region of the Zeehan AMP.

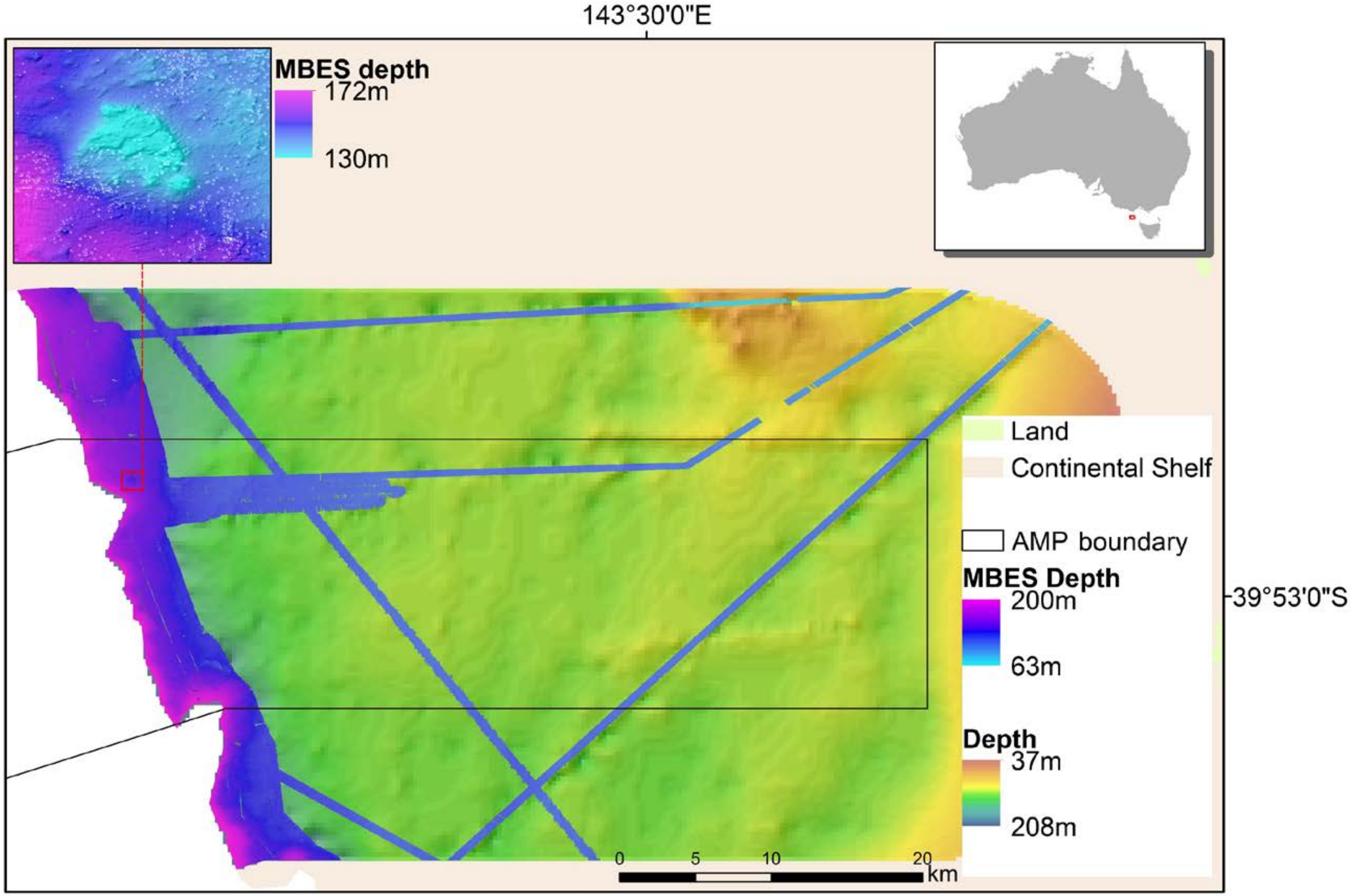


Figure 82. Mapping coverage of the Zeehan AMP based on the Australian Bathymetry and Topography Grid, produced by Geoscience Australia in June 2009. Note the fine-scale 5-m resolution multibeam sonar (MBES depth) collected by CSIRO Southern Survey/Investigator.

4. SOUTH-WEST MARINE PLANNING REGION

4.1 Overview

Australia's South-west marine planning region extends from the eastern end of Kangaroo Island in South Australia to Shark Bay in Western Australia (Figure 83). This region covers approximately 1.3 million km^2 of temperate and sub-tropical waters. There are 14 AMPs within this region, covering 506,171 km^2, with all AMPs having partial coverage over the continental shelf to a total of 90,655 km^2 (Table 26).

There are five proposed zones within the South-west AMP network, including Marine National Park Zone, Habitat Protection Zone, Multiple Use Zone, Special Purpose Zone, Special Purpose Zone (Oil and Gas Exclusion) (Table 27). Marine National Park and Special purpose Zones are the largest zonings within the South-west marine planning region. Marine National Park Zones cover 23% of the continental shelf regions within the South-west AMP Network and Special Purpose Zones cover 76%. The AMP management plans are yet to be finalised for these AMPs, and thus the zoning currently proposed may be subject to change.

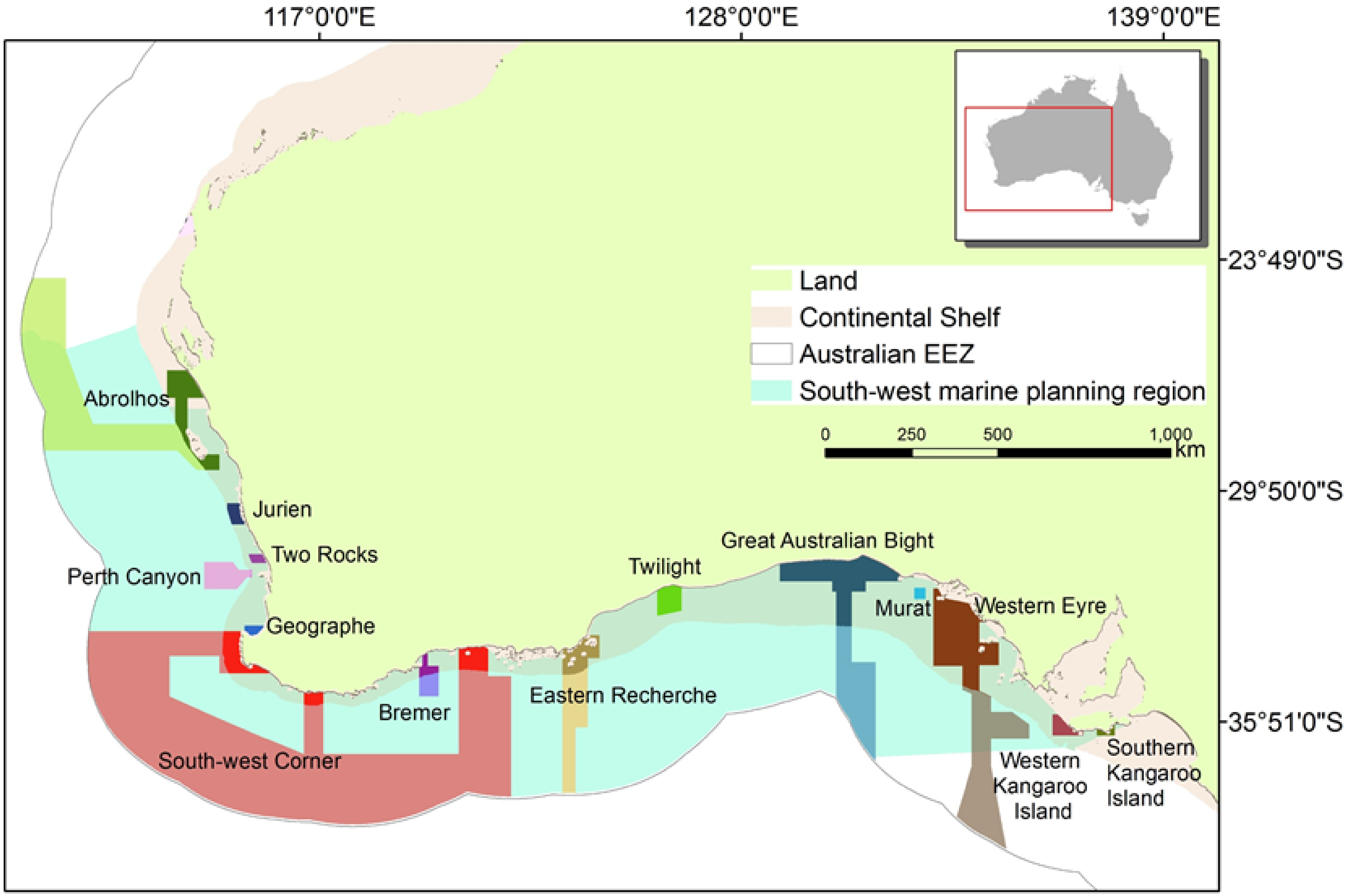


Figure 83. Location of the AMPs within the South-west marine planning region.

Table 26. Summary of total area, and continental shelf area, encapsulated by each AMP within the South-west marine planning region.

AMP	Total area (km^2)	Area on shelf (km^2)	Percentage (%)
Abrolhos	86,026	11,097	13
Bremer	4,443	1,561	35
Eastern Recherche	20,518	5,289	26
Geographe	965	965	100
Great Australian Bight	45,426	22,705	50
Jurien	1,812	1,810	100
Murat	923	923	100
Perth Canyon	7283	72	1
Southern Kangaroo Island	630	630	100
South-west Corner	272,505	11,940	4
Twilight	4572	4,572	100
Two Rocks	866	866	100
Western Eyre	57,866	25,890	45
Western Kangaroo Island	2,335	2,335	100
Total	*506,171*	*97,927*	*19*

Table 27: Summary of areas of each proposed protection zone within the continental shelf regions of each AMP in the South-west marine planning region.

Name of AMP	Marine National Park Zone	Multiple Use Zone	Special Purpose Zone	Special Purpose Zone (Oil and Gas Exclusion)
Abrolhos	417	5595	5,085	-
Bremer	281	<1	1,279	-
Eastern Recherche	1,320	-	3,968	-
Geographe	36	287	642	-
Great Australian Bight	7,596	-	15,108	-
Jurien	28	-	1,781	-
Murat	923	-		-
Perth Canyon	-	72		-
Southern Kangaroo Island	-	-	630	-
South-west Corner	2,206	-	4,590	5,144
Twilight	4,572	-		-
Two Rocks	7	859		-
Western Eyre	1,742	116	24,032	-
Western Kangaroo Island	119	-	2,215	-
Total	*19,249*	*6,929*	*59,332*	*5,144*

4.2 List of publications for AMPs in the South-west marine planning region.

A total of 10 publications were identified that reference the continental shelf regions of the AMPs in the South-west marine planning region. Bibliographic details and web links are provided in Table 28.

Table 28: List of publications containing biological sampling of reef-habitats on the continental shelf regions of AMPs in the South-west marine planning region.

AMP	Date	Authors	Title	URL
Geographe	2016	Lawrence E, Hovey R, Harvey E, Kendrick G, Hayes KR, Williams S	Application of NERP Biodiversity Hub survey methodology to Geographe Commonwealth Marine Reserve	https://www.nespmarine.edu.au/document/application-nerp-biodiversity-hub-survey-methodology-geographe-commonwealth-marine-reserve
	2007	Westera MB, Barnes PB, Kendrick GA, Cambridge ML	Establishing benchmarks of seagrass communities and water quality in Geographe Bay, Western Australia	http://www.web.uwa.edu.au/__data/assets/pdf_file/0006/199869/Seagrass_communities_in_Geographe_Bay.pdf
Great Australian Bight	2007	Currie D, Sorokin SJ, Ward TM	Infaunal assemblages of the eastern Great Australian Bight: effectiveness of a Benthic Protection Zone in representing regional biodiversity. Final report for the South Australian Department for Environment and Heritage and the Commonwealth Department of the Environment and Water Resources.	SARDI Publication No. F2007/001079-1
	2008	Currie D, Sorokin SJ, Ward TM	Performance assessment of the Benthic Protection Zone of the Great Australian Bight Marine Park: Epifauna.	SARDI Publication No. F2008/000647-1
Twilight			No known publically available publications	
Two Rocks			No known publically available publications	
Western Eyre	2007	Currie D, Sorokin SJ, Ward TM	Infaunal assemblages of the eastern Great	SARDI Publication No. F2007/001079-1

AMP	Date	Authors	Title	URL
			Australian Bight: effectiveness of a benthic protection zone in representing regional biodiversity. Final report for the South Australian Department for Environment and Heritage and the Commonwealth Department of the Environment and Water Resources	
VARIOUS AMPs	2013	McCallum, A.W., Poore, G.C.B., Williams, A., Althaus, F. & O'Hara, T.	Environmental predictors of decapod species richness and turnover along an extensive Australian continental margin (13-35^{o}S).	*Marine Ecology*, **34**, 298-312. DOI: DOI 10.1111/maec.12016
	2012	Dunstan PK, Bax NJ, Foster SD, Williams A, Althaus F	Identifying hotspots for biodiversity management using Rank Abundance Distributions	http://onlinelibrary.wiley.com/doi/10.1111/j.1472-4642.2011.00838.x/abstract
	2012	Fromont, J., Althaus, F., McEnnulty, F.R., Williams, A., Salotti, M., Gomez, O. & Gowlett-Holmes, K.	Living on the edge: the sponge fauna of Australia's southwestern and north western deep continental margin	https://link.springer.com/article/10.1007/s10750-011-0845-7
	2011	McEnnulty FR, Gowlett-Holmes KL, Williams A, Althaus F, Fromont J, Poore GCB, O'Hara TD, Marsh L, Kott P, Slack-Smith S, Alderslade P, Kitahara MV	The deepwater megabenthic invertebrates on the western continental margin of Australia (100–1500 m depths): composition, distribution and novelty.	http://museum.wa.gov.au/research/records-supplements/records/deepwater-megabenthic-invertebrates-on-western-continental-marg
	2011	Williams A, Daley R, Fuller M, Knuckey I	Supporting sustainable fishery development in the GAB with interpreted multi-scale seabed maps based on fishing industry knowledge and scientific survey data	http://frdc.com.au/research/final-reports/Pages/2006-036-DLD.aspx
	2010	Williams A, Althaus F, Dunstan PK, Poore GCB, Bax NJ, Kloser RJ, McEnnulty F	Scales of habitat heterogeneity and megabenthos biodiversity on an extensive Australian continental margin (100-1100 m depths).	http://dx.doi.org/10.1111/j.1439-0485.2009.00355.x

4.3 List of biological datasets for AMPs in the South-east marine planning region

Six sampling platforms provide the basis of the biological descriptions provided in the subsequent sections relating to the continental shelf regions of AMPs within the South-west marine planning region. A summary of these identified datasets that related to each AMP in the South-west marine planning region is summarised in Table 29.

Table 29. Available biological data records within the continental shelf regions of the AMPs in South-west marine planning region.

AMP	Survey Method	Biological resolution	Number of Samples/ Transects/ Images	Proportion of data records scored	Number of time series	Contact for data
Abrolhos	STV	CSIRO - SGF	1 transect N: SS200507_082 1 transect near S: SS200507_121	100 %	1	Franzis Althaus CSIRO
	Sled	full taxonomy	1 sample N: SS200510_104 2 samples near S: SS200510_092/093	100 %	1	Franzis Althaus CSIRO
	Beam TW	full taxonomy	1 sample N: SS200510_110	100 %	1	Franzis Althaus CSIRO
	BRUV	Species	27	Unk.	1	Dianne McLean, GlobalArchive

AMP	Survey Method	Biological resolution	Number of Samples/ Transects/ Images	Proportion of data records scored	Number of time series	Contact for data
	BRUV	Species	60	100 %	1	Corey Wakefield, Department of Fisheries
Bremer	BRUV	Species	50	100 %	1	Euan Harvey, GlobalArchive
Eastern Recherche	BRUV	Species	83	Unk.	1	Euan Harvey, GlobalArchive
Geographe	BRUV	Species	160	100 %	1	Euan Harvey, GlobalArchive
	AUV	Broad taxonomy	15	100 %	1	Emma Lawrence, AODN
	SCUBA	Order/Family	Unk	100 %	1	Westera, BMT Oceanica
	BRUV	Species	5	100 %	1	Westera, BMT Oceanica
	TV	Species (Fishes)	Unk	100 %	1	Ronen Galaiduk/Euan Harvey, Curtin
Great Australian Bight	STV	CSIRO - SGF	1 transects: LS200801_26	100 %		CSIRO
	CSIRO-TACOS (video)	CSIRO - SGF (basic)	7 transects: SS200001_338/343/346/365/366/379/382	100 %		CSIRO
	Epibenthic sled with mounted Camera	OTU				Dave Curry SARDI
Jurien	BRUV		140	Unk.	1	Euan Harvey, GlobalArchive

AMP	Survey Method	Biological resolution	Number of Samples/ Transects/ Images	Proportion of data records scored	Number of time series	Contact for data
Murat	STV	CSIRO - SGF	4 transects: LS200801_011/013/014/034	100 %	1	Franzis Althaus, CSIRO
Perth Canyon	STV	CSIRO - SGF	2 transects (shelf-break): SS200507_216/218	100 %	1	Franzis Althaus, CSIRO
	Sled	full taxonomy	1 sample (shelf-break): SS200510_069	100 %	1	Franzis Althaus, CSIRO
	BRUV	Species	190	100 %	1	Euan Harvey, GlobalArchive
South-west Corner	STV	CSIRO - SGF	2 transects SE: SS200507_210/211	100 %	1	Franzis Althaus, CSIRO
	Sled	full taxonomy	1 sample NW: SS200510_015 3 samples near SE: SS200510_021/055/056		1	Franzis Althaus, CSIRO
	BRUV	Species	14	100 %	2	Euan Harvey, GlobalArchive
	BRUV	Species	71	100 %	1	Corey Wakefield, Department of Fisheries
Two Rocks	STV	CSIRO - SGF	1 transect: SS200507_219	100 %	1	Franzis Althaus CSIRO

AMP	Survey Method	Biological resolution	Number of Samples/ Transects/ Images	Proportion of data records scored	Number of time series	Contact for data
	Beam TW	full taxonomy	1 sample SS200510_002	100 %	1	Franzis Althaus CSIRO
	Sled	full taxonomy	1 sample (shelf-break): SS200510_011	100 %	1	Franzis Althaus CSIRO
	BRUV	Species	72	100 %.	1	GlobalArchive
Western Eyre	STV	CSIRO - SGF	5 transects: LS200801_002/033/036/037/038	100 %	1	Franzis Althaus, CSIRO

4.4 Abrolhos AMP

4.4.1 Description of physical habitat

Mapping data within the Abrolhos AMP consists of Australian Bathymetry and Topography Grid and fine-scale MBES surveys from CSIRO Southern Survey/Investigator vessel transits. The continental shelf region of the Abrolhos AMP represents ~ 13 % of its total area. The fine-scale MBES data cover ~ 5 % of the continental shelf region of the AMP and reveals that the depth range extends from ~ 100 to 200 m (Figure 84). From the mapping data, it appears that there are extensive reefs extending from the north to the south at depths of ~50-100m (Figure 84 and Figure 135 in Appendix A). There also appears to be significant reef surrounding the western edge of the Abrolhos Islands in water depths < 50 m (Figure 84).

Data from two of the latitudinal sites of the joint CSIRO and The Western Australian Museum "Voyage of Discovery" project were collected within or near the Abrolhos AMP: the 'Zytdorp' site to the north of the Abrolhos Islands, and the 'Abrolhos' site to the south, where samples were taken just outside the AMP boundary. The outer shelf to the south ('Abrolhos') showed a patchwork of mostly large rocky outcrops, interspersed with rippled and bioturbated soft substrates, while to the north ('Zuytdorp') the rippled and bioturbated soft sediments were more abundant, although still interspersed with sub-crops of hard rocky substrates.

4.4.2 Description of biological assemblages

Biological data from two of the latitudinal sites of the Voyage of Discovery were collected within or near the Abrolhos AMP: the 'Zytdorp' site to the north of the Abrolhos Islands, and the 'Abrolhos' site to the south, where samples were taken just outside the AMP boundary. A rich fauna consisting of low lumpy and large cup sponges, but also including bryozoans, hydroids, ascidians and octocorals covered the out- and sub-cropping reefs (Figure 85 and Figure 86). The physical samples at both locations were highly diverse with > 60 species in 10 phyla. The most specious groups in the south and north were sponges, with also highly specious decapods and echinoderms, particularly in the north. The sediment patches either were devoid of emergent fauna or showed sparse cover by soft bryozoans and hydroids.

The fish assemblages of the Abrolhos AMP were sampled using baited remote underwater stereo video by the University of Western Australia. In 2005, approximately 27 deployments were made in the northern proposed Multiple Use Zone (McLean et al. unpublished data; GlobalArchive). An additional 50 stereo Stereo BRUVswere deployed in November 2010 as part of a scientific research project conducted by the Department of Fisheries in collaboration with the University of Western Australia and CSIRO. In this project, approximately 453 individual fishes from 51 different species were recorded (Mike Travers, pers. comm.). However, for both of these surveys we have not been able to obtain this data within the timeframe of this project. It is invisaged that this data will be available through GlobalArchieve before the end of 2017.

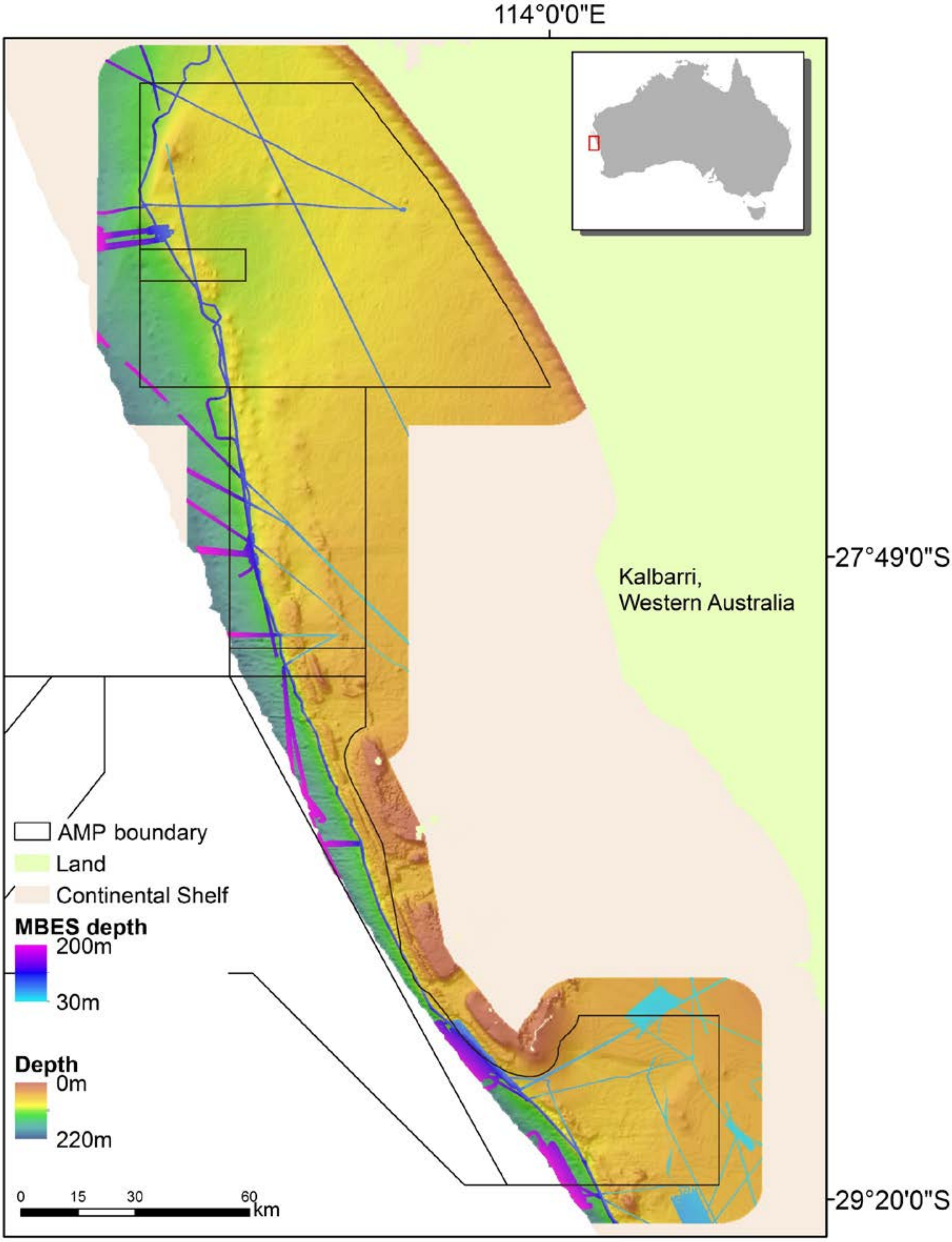


Figure 84. Mapping coverage of the Abrolhos AMP based on the Australian Bathymetry and Topography Grid, produced by Geoscience Australia in June 2009. Note the fine-scale 5-m resolution multibeam sonar (MBES depth) collected by the CSIRO Southern Survey/Investigator.

Figure 85. The sessile invertebrate assemblage as captured on towed video in the Abrolhos AMP during the Voyage of Discovery.

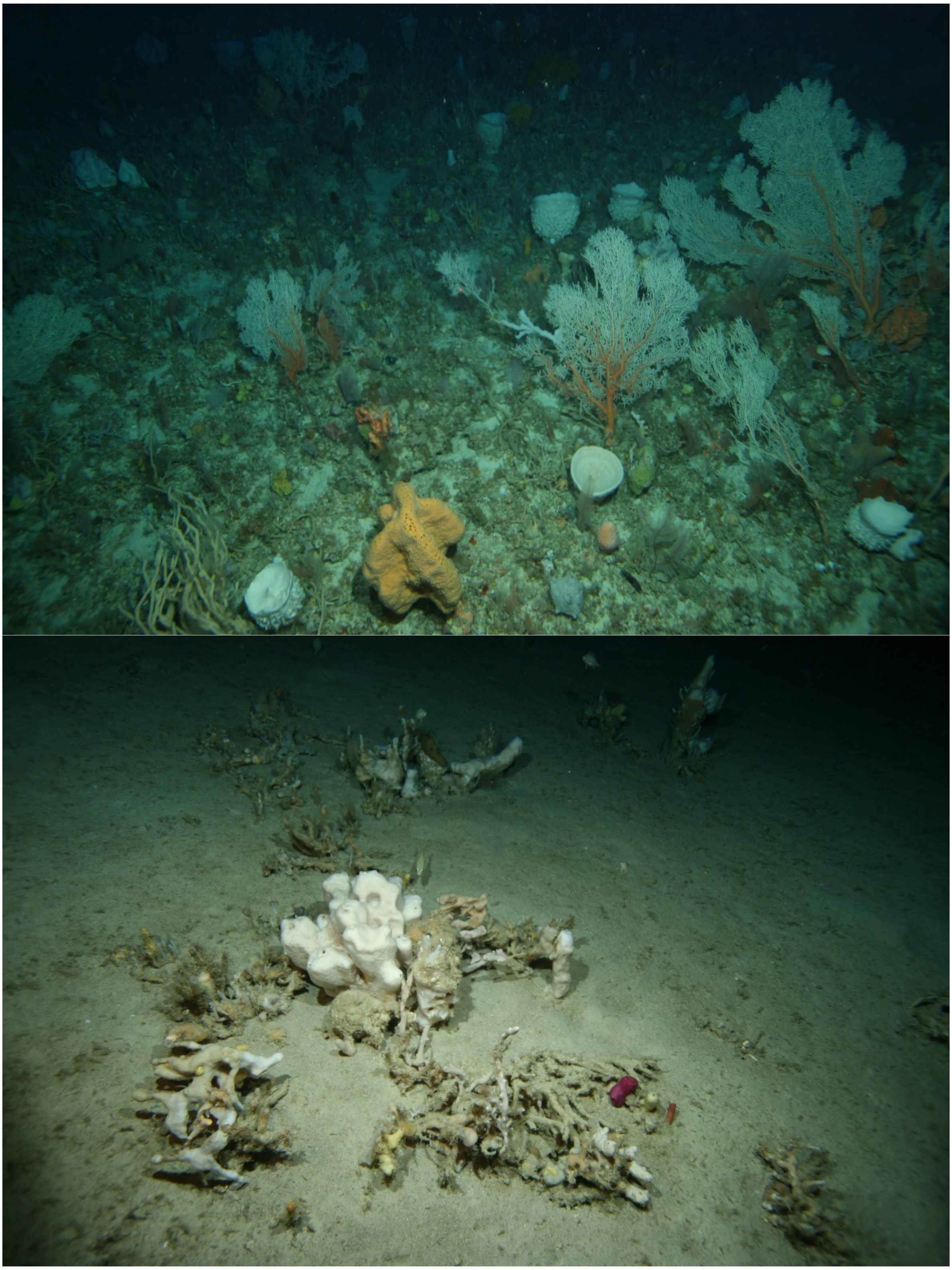


Figure 86. The sessile invertebrate assemblage as captured on towed video in the Abrolhos AMP during the Voyage of Discovery.

4.5 Bremer AMP

4.5.1 Description of physical habitat

Mapping data within the Bremer AMP consists of Australian Bathymetry and Topography Grid and fine-scale MBES surveys from CSIRO Southern Survey/Investigator vessel transits, as well as fine-scale mapping from the Marine Futures programme. The continental shelf region of the Bremer AMP represents ~ 35 % of its total area. The fine-scale MBES data cover ~ 4 % of the continental shelf region of the AMP and indicates that depth ranges from ~50 to 200 m (Figure 87). From the mapping, it appears that there are large ridge reef geoform features in the northwestern corner of the proposed Marine National Park Zne (top insert in Figure 87, Figure 88 and Figure 136 in Appendix A).

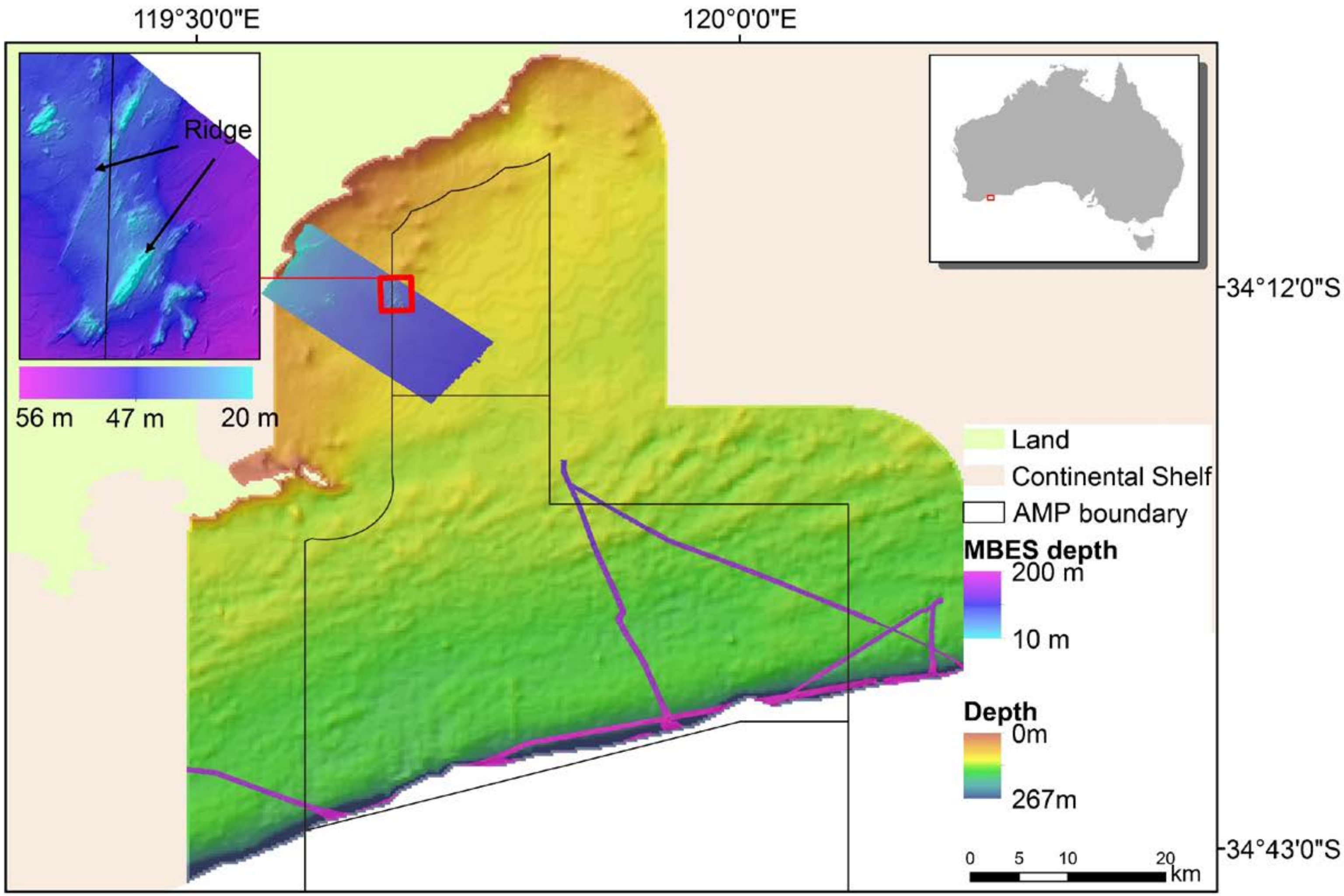


Figure 87. Mapping coverage of the Bremer AMP based on the Australian Bathymetry and Topography Grid, produced by Geoscience Australia in June 2009. Note the fine-scale 5-m resolution multibeam sonar (MBES depth) collected by the CSIRO Southern Survey/Investigator and the Marine Futures programme. Top insert shows the reef ridge geoform features that straddle the northwestern boundary of the AMP.

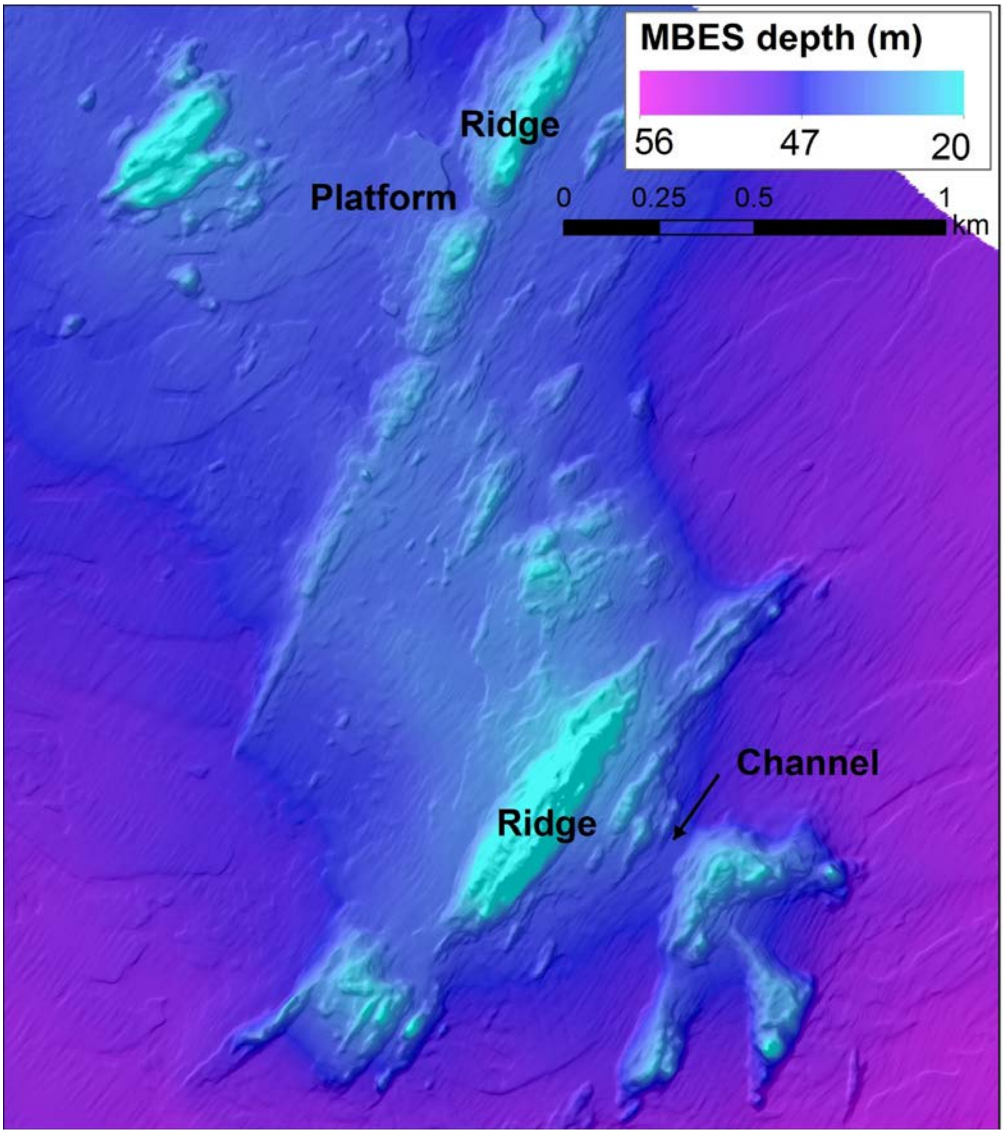


Figure 88. Close-up of the complex geoform features that straddle the northwestern boundary of the Bremer AMP.

4.5.2 Description of biological assemblages

The fish assemblages of the Bremer AMP were sampled using stereo BRUVs by the University of Western Australia. In 2007, 50 deployments were made with 48 in a proposed Marine National Park Zone and two in a proposed Special Purpose Zone (Figure 89).

A total of 16 fish species from 12 families were identified from the 50 BRUV deployments (Table 30). Larbids and Monacanthids were the most speciose, with three and two species, respectively (Table 30). Abundances (MaxN) were quite low for most species with ocean leatherjacket (*Nelusetta ayraudi;* Figure 90), perch (*Caesioperca* spp.) and eagle rays (*Myliobatis australis*) being the most abundant (Table 30).

Table 30. Fish species recorded using stereo BRUVs in the Bremer AMP based on 50 deployments. Abundance was measured using MaxN.

Family	Scientific Name	Common Name	Abundance
Aulopodidae	*Aulopus purpurissatus*	Sergent baker	2
Dasyatidae	*Dasyatis brevicaudata*	Smooth stingray	1
Diodontidae	*Allomycterus pilatus*	Deepwater burrfish	6
Heterodontidae	*Heterodontus portusjacksoni*	Port Jackson shark	3
Labridae	*Achoerodus gouldii*	Western blue grouper	2
	Coris auricularis	Western king wrasse	4
	Eupetrichthys angustipes	Snakeskin wrasse	1
Monacanthidae	*Acanthaluteres spilomelanurus*	Bridled leatherjacket	1
	Nelusetta ayraudi	Ocean leatherjacket	960
Myliobatidae	*Myliobatis australis*	Eagle ray	16
Ostraciidae	*Anoplocapros lenticularis*	Whitebarred boxfish	1
Rhinobatidae	*Aptychotrema vincentiana*	Southern shovelnosed ray	1
Serranidae	*Caesioperca* spp.	Perch	30
Triakidae	*Mustelus antarcticus*	Gummy shark	2
Triglidae	*Chelidonichthys kumu*	Red gurnard	1

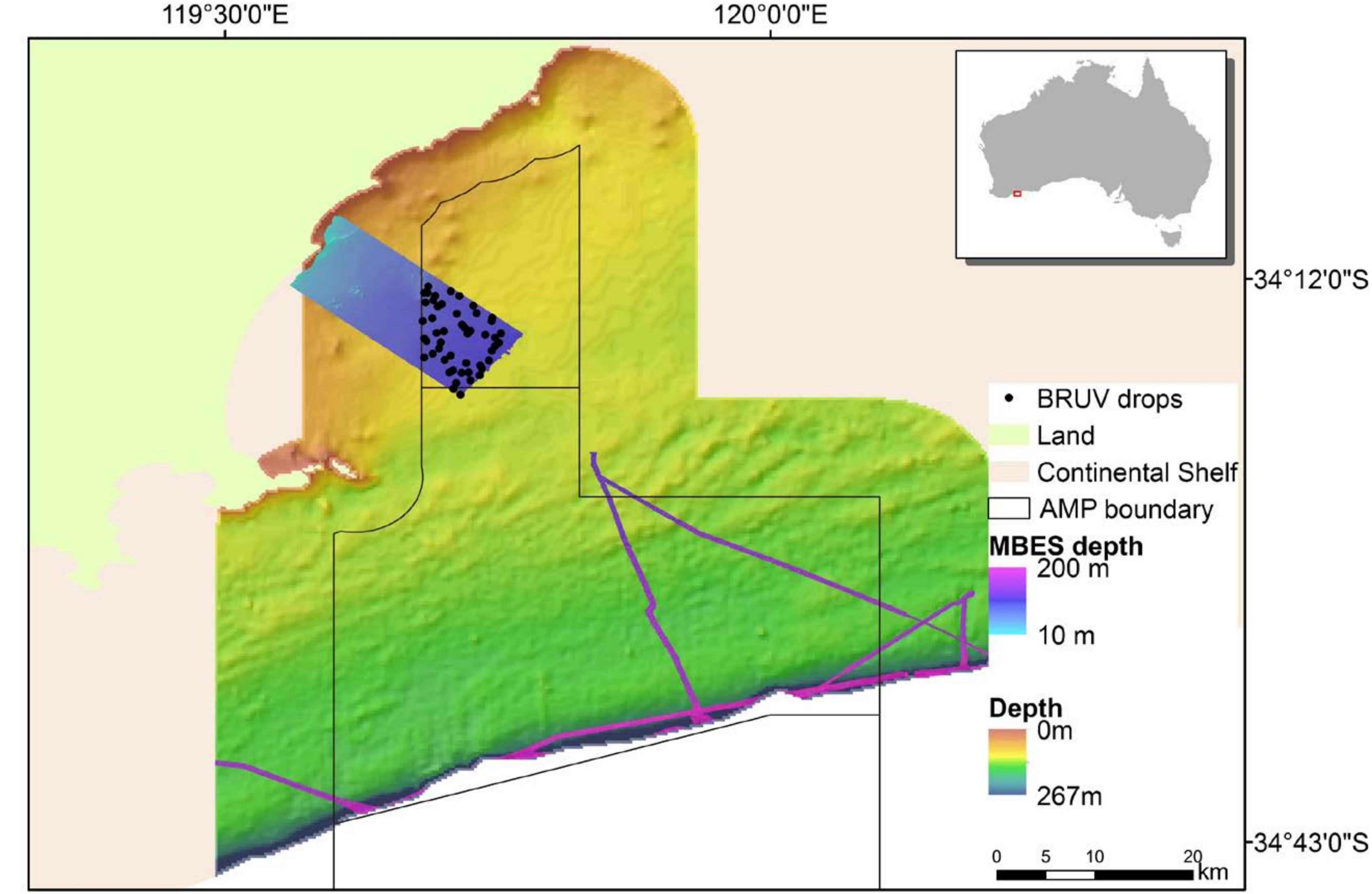


Figure 89. Location of the stereo BRUV sampling undertaken in 2007 within the Bremer AMP.

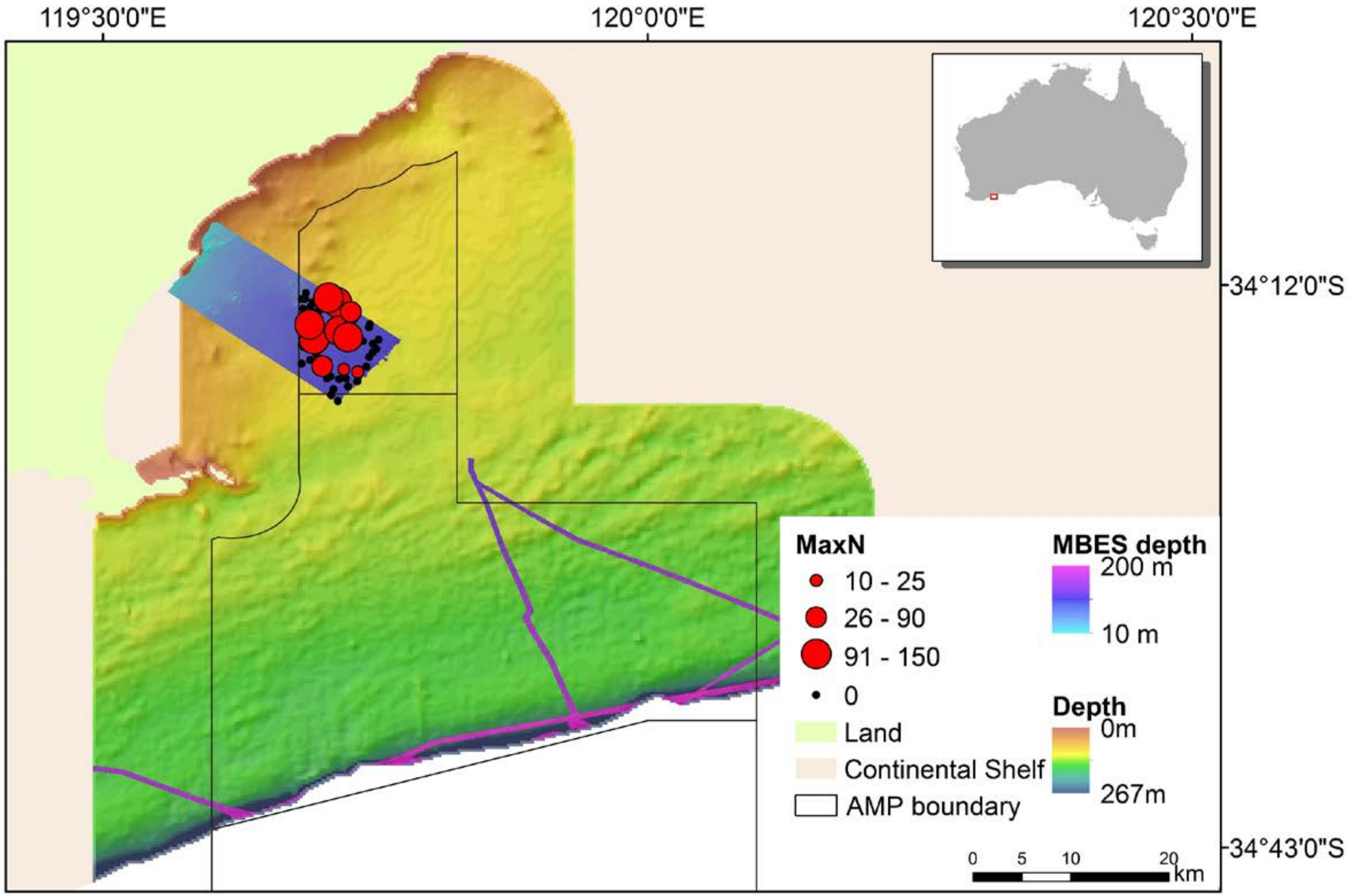


Figure 90. Abundance distribution of ocean leather jacket from stereo BRUV sampling within the Bremer AMP.

4.6 Eastern Recherche AMP

4.6.1 Description of physical habitat

The Recherche Archipelago is a chain of islands and islets extending over 470 km of the coastline near Esperance in Western Australia. The Eastern Recherche AMP is located on the eastern half of the Archipelago.

Mapping data with the Eastern Recherche AMP consists of the Australian Bathymetry and Topography Grid and fine-scale MBES surveys from CSIRO Southern Survey/Investigator vessel transits, as well as fine-scale mapping from the Marine Futures programme. The continental shelf region of the Eastern Recherche AMP represents ~ 26 % of its total area. The fine-scale MBES data covers ~ 2 % of the continental shelf region of the AMP and indicates that depth ranges from ~ 100 to 200 m (Figure 91). From the mapping it appears that there areas of reef in < 100 m water along the Western Australian state marine boundary (3 nautical miles) (which also includes the offshore islands (Figure 91)).

The fine-scale MBES mapping data in the northwest of the AMP has revealed a number of isolated reef ridge, mound and channelized reef geoform features that extend into State waters (Figure 91 , Figure 92 and Figure 137 in Appendix A).

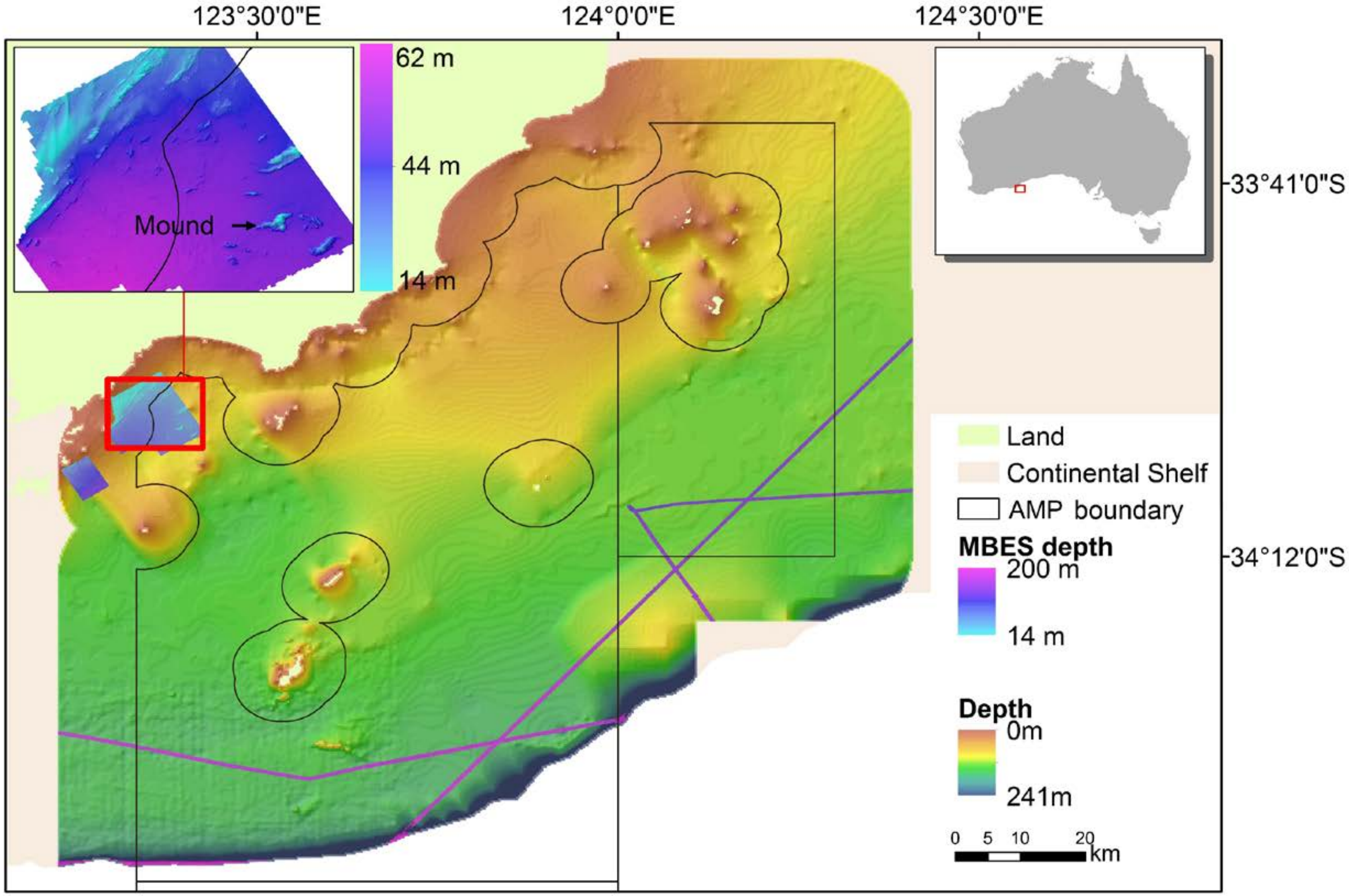


Figure 91. Seabed mapping data coverage of the Eastern Recherche AMP based on the Australian Bathymetry and Topography Grid, produced by Geoscience Australia in June 2009. Note the fine-scale 5-m resolution multibeam sonar (MBES depth) collected by the CSIRO Southern Survey/Investigator and the Marine Futures programme.

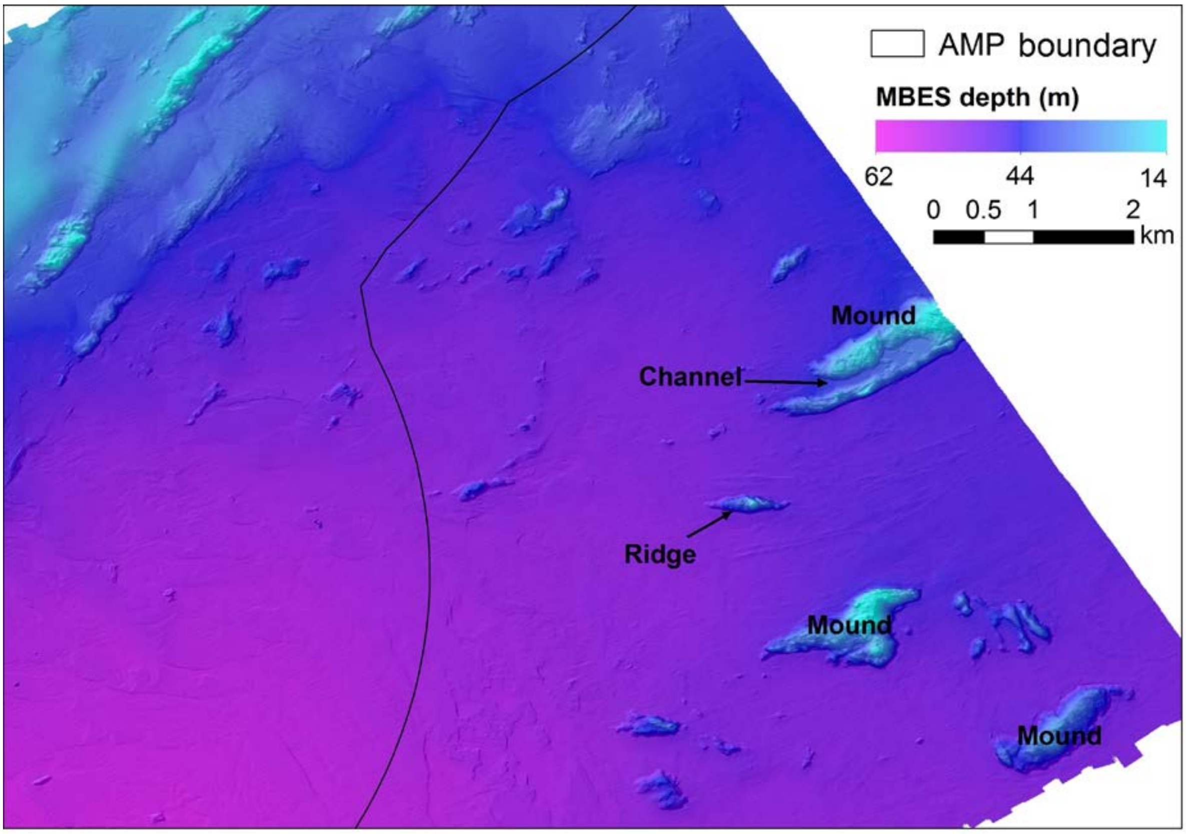


Figure 92. Close-up of the isolated geoform features along the northwestern boundary of the Eastern Recherche AMP.

4.6.2 Description of biological assemblages

The broader Recherche region is known to have a high biodiversity, endemism and aggregations of marine life (Kendrick et al. 2005). In general, there is little biological information and data for the area of shelf encompassed by the AMP. A comprehensive study of the fish and invertebrate faunas in three regions within Western Australia state boundaries (Esperance Bay, Duke of Orleans and Cape Arid) to the east of the AMP can be found at Kendrick et al. (2005).

The University of Western Australia sampled the fish assemblages of the Eastern Recherche AMP using stereo BRUVs. In 2007, 85 BRUV deployments were made in the northwestern corner of the proposed Special Purpose Zone (Figure 93). A total of 25 fish species from 15 families were identified, with Larbids and Monacanthids being the most speciose, with five and three species, respectively (Table 31). Abundances (MaxN) were quite low for most species with velvet leatherjacket (*Meuschenia scaber;* Figure 94), barber perch (*Caesioperca rasor*) and eagle rays (*Myliobatis australis*) being the most abundant (Table 31).

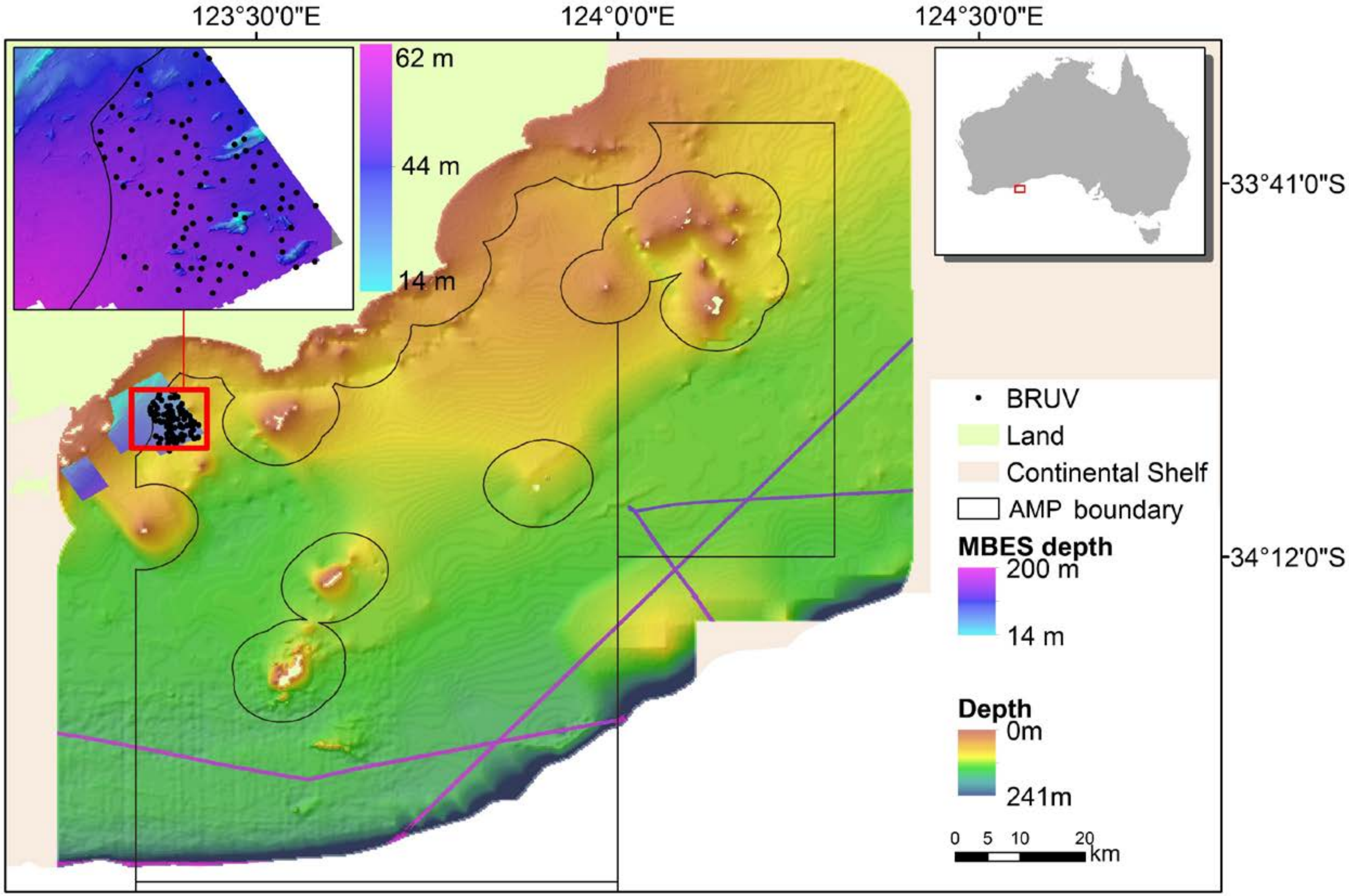


Figure 93. Location of stereo BRUV sampling undertaken in 2007 within the Eastern Recherche AMP.

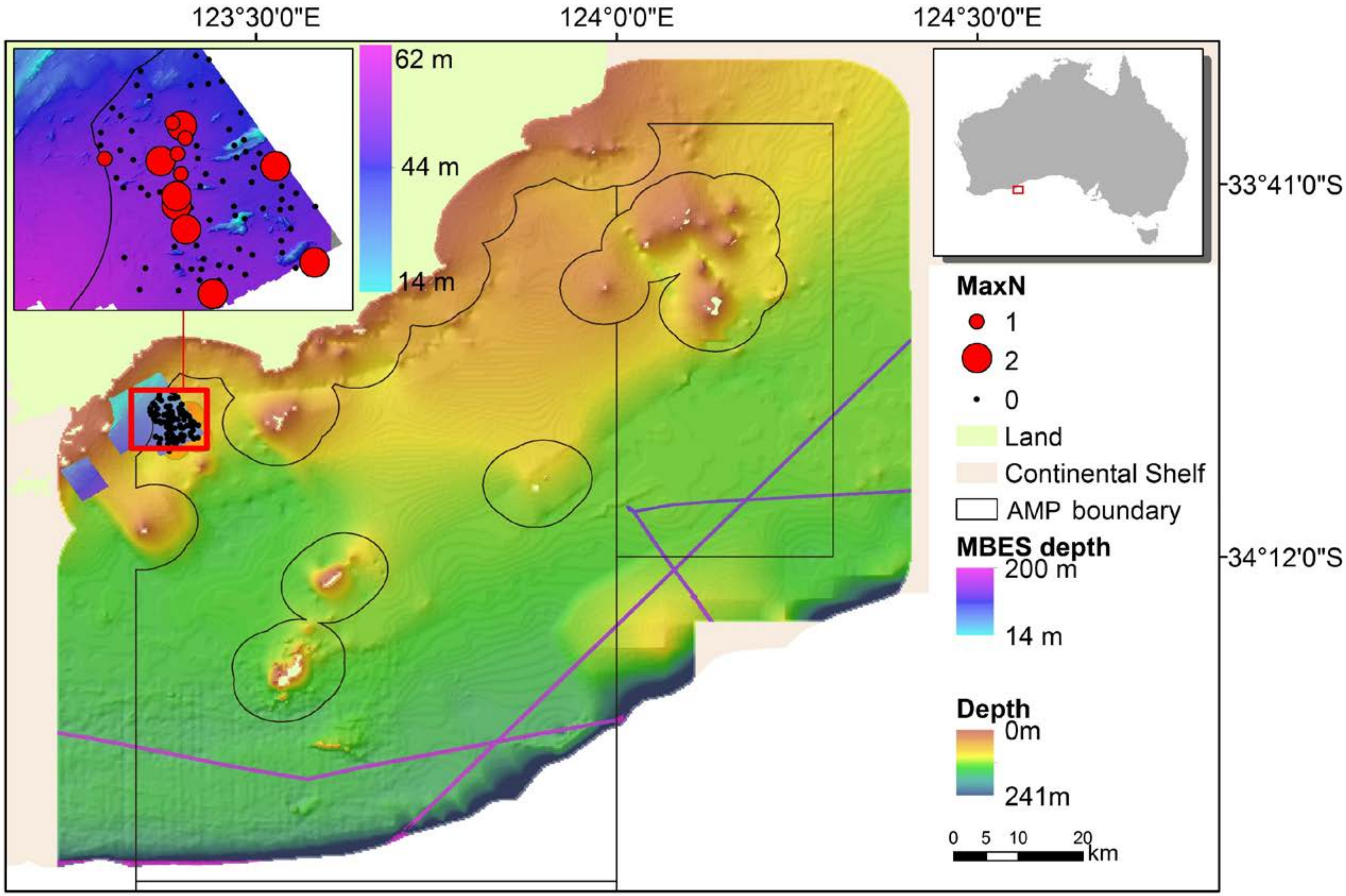


Figure 94. Abundance distribution of velvet leatherjackets from BRUV sampling undertaken in 2007 within the Eastern Recherche AMP.

Table 31. Fish species recorded using stereo BRUVs in the Eastern Recherche AMP based on 85 deployments. Aundance was measured using MaxN.

Family	Scientific name	Common name	Abundance
Aulopodidae	*Aulopus purpurissatus*	Sergent baker	4
Berycidae	*Centroberyx gerrardi*	Bight redfish	1
Cheilodactylidae	*Dactylophora nigricans*	Dusky morwong	1
Dasyatidae	*Dasyatis brevicaudata*	Smooth ray	3
Gerreidae	*Parequula melbournensis*	Silverbelly	4
Heterodontidae	*Heterodontus portusjacksoni*	Port jackson shark	5
Labridae	*Achoerodus gouldii*	Western blue grouper	3
	Austrolabrus maculatus	Black spotted parrotfish	6
	Bodianus frenchii	Foxfish	1
	Eupetrichthys angustipes	Snakeskin wrasse	2
	Ophthalmolepis lineolatus	Southern maori wrasse	3
Monacanthidae	*Acanthaluteres vittiger*	Toothbrush leatherjacket	2
	Meuschenia freycineti	Six spine leatherjacket	1
	Meuschenia scaber	Velvet leatherjacket	21
	Meuschenia venusta	Stars-and-stripes leatherjacket	1
Myliobatidae	*Myliobatis australis*	Eagle ray	17
Ostraciidae	*Anoplocapros amygdaloides*	Western smooth boxfish	1
	Anoplocapros lenticularis	Whitebarred boxfish	2
Parascylliidae	*Parascyllium variolatum*	Varied catshark	1
Platycephalidae	*Platycephalus* spp	Flathead	5
Rhinobatidae	*Trygonorrhina fasciata*	Eastern fiddler ray	1
Serranidae	*Caesioperca rasor*	Barber perch	21
	Caesioperca sp	Perch	16
	Callanthias australis	Splendid perch	1
Tetraodontidae	*Contusus brevicaudus*	Prickly toadfish	1

4.7 Geographe AMP

4.7.1 Description of physical habitat

Mapping data within the Geographe AMP consists of the Australian Bathymetry and Topography Grid, fine-scale MBES surveys from CSIRO Southern Survey/Investigator vessel transits, and LiDAR from the Department of Transport WA (Figure 95). The continental shelf region of the Geographe AMP represents 100 % of its total area. Fine-scale MBES bathymetry data are only available for ~ 4 % of the continental shelf region of the Geographe AMP (Figure 95). Additional fine-scale data has been identified from the 2009 Fugro LADS LiDAR seabed survey from Two Rocks to Cape Naturaliste out to approximately 20 m water depth (Lawrence et al. 2016). This LiDAR data cover some of the eastern Marine National Park Zone and the southern and eastern portions of the Multiple Use Zone and the eastern proportion of the Special Use Zone to a depth of x (Lawrence et al. 2016). The LiDAR data are available from Department of Transport in WA upon request.

The majority of the Geographe AMP seafloor consisted of unconsolidated sediments that are deposited over older clay layers and limestone formations (Lawrence et al. 2016). These limestone formations tend to be long and narrow, grating bands of hard substrate surrounded by unconsolidated sediments (Lawrence et al. 2016 and Figure 138 in Appendix A). Approximately 40 % of the benthos inside the Marine National Park Zones consists of reef or mixed reef/sand matrix. In comparison to the Multiple and Special Use Zone where there was only 20 % reef or mixed reef/sand matrix. Linear reef ridge and platform geoform features appear to prevail near shore in the proposed National Park Zone, potentially reflecting ancient coastlines (Figure 95, Figure 96).

4.7.2 Description of biological assemblages

A review of previous biological data and a collection of contemporary biological data from within the Geographe AMP can be found in Lawrence et al. (2016). Lawrence et al. (2016) reports on data from all habitat types including rocky reefs. Small pockets of reef were identified from Westera et al. (2007) at the southern extent of the AMP. An in depth description of the invertebrate assemblages can be found in this report. In summary these SCUBA surveys reported five species of coral and one zoanthid, seven species of sea star, one species of sea urchin, one species sea cucumber, two species of mollusc, 12 species of ascidians and 72 sponge specimens were collected. The preliminary analysis of this data suggested that species distribution was highly patchy, with few species widespread.

Lawrence et al. (2016) used an AUV to survey the benthic habitat over the vast extent of the AMP. Fifteen sites targeting reef were sampled with the AUV (Figure 97). However, due to time constraints the scoring of images was limited to a broad scale-scoring classification with the intention of using a finer scaled classification scheme in the future. The greatest area of reef that was imaged occurred to the east of the proposed Sanctuary zone. Otherwise, a seagrass and algae biota made up the majority of images from other zones with the exception of the offshore deep regions were algae and sponges were commonly observed (Figure 98). A key observation from this study was the discovery of Amphibolis, Heterozosteracae and Posidonia seagrasses in unchacteristic waters depths of 20-50 m (Figure 98).

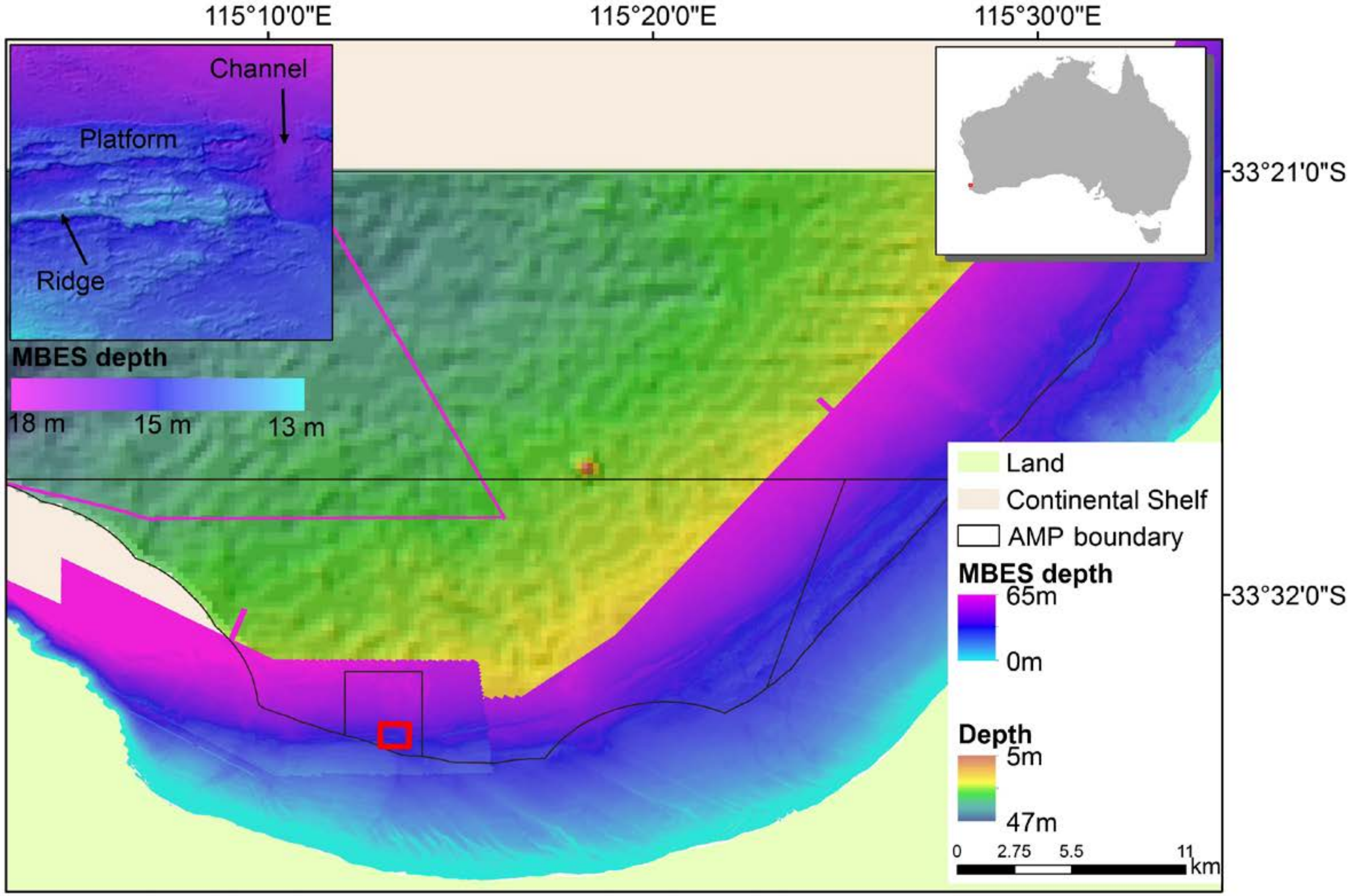


Figure 95. Mapping data coverage of the Geographe AMP based on the Australian Bathymetry and Topography Grid, produced by Geoscience Australia in June 2009. Note the fine-scale 5-m resolution multibeam sonar (MBES depth) collected by the Marine Futures while LiDAR (10-m resolution) was collect by the Western Australian State Goverment. Top box shows the ridge, platform and channel geoform features within the proposed Marine National Park Zone covered by the MBES data.

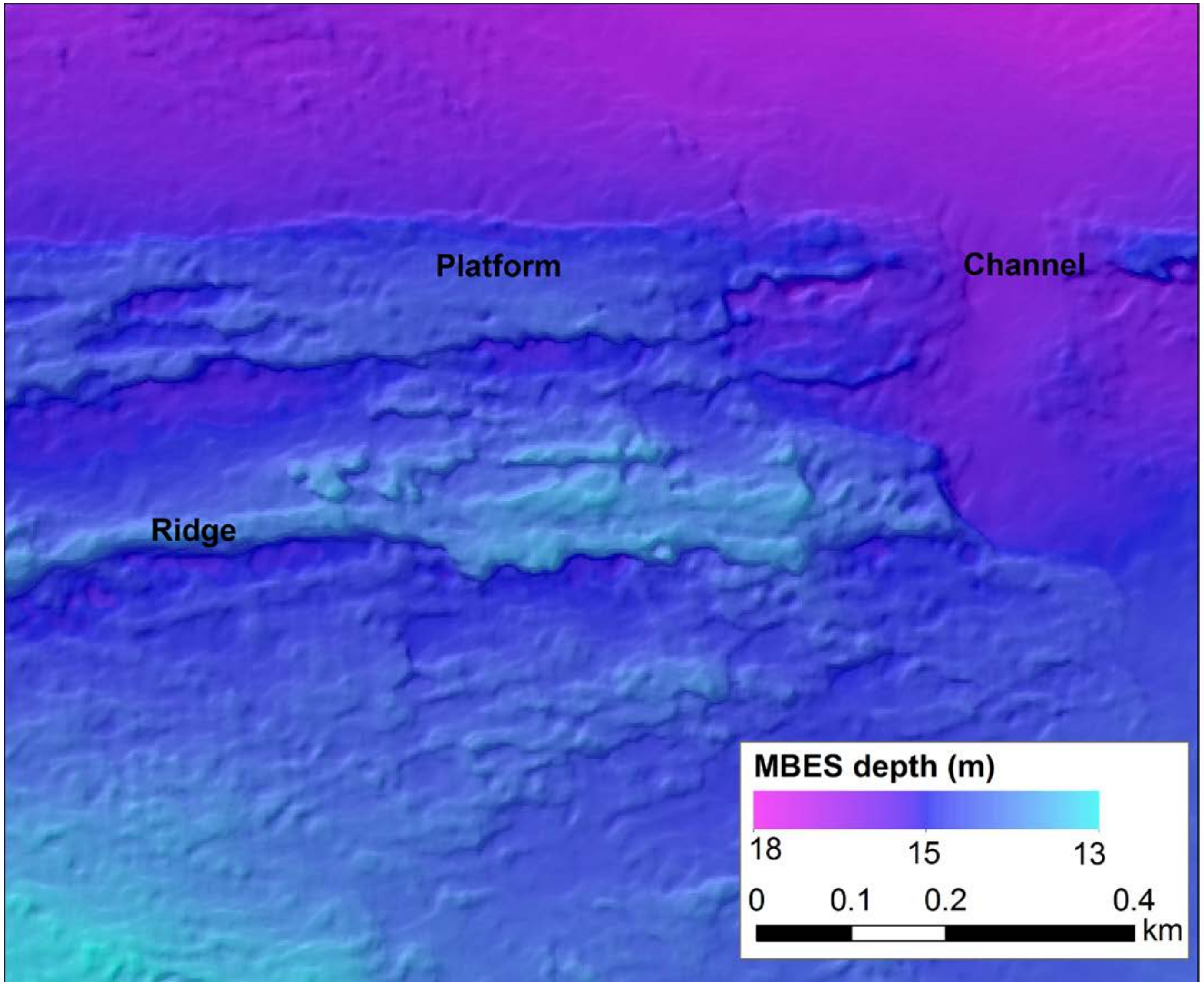


Figure 96. Close-up of the geoform features that prevail near shore in the proposed National Park Zone of the Geographe AMP.

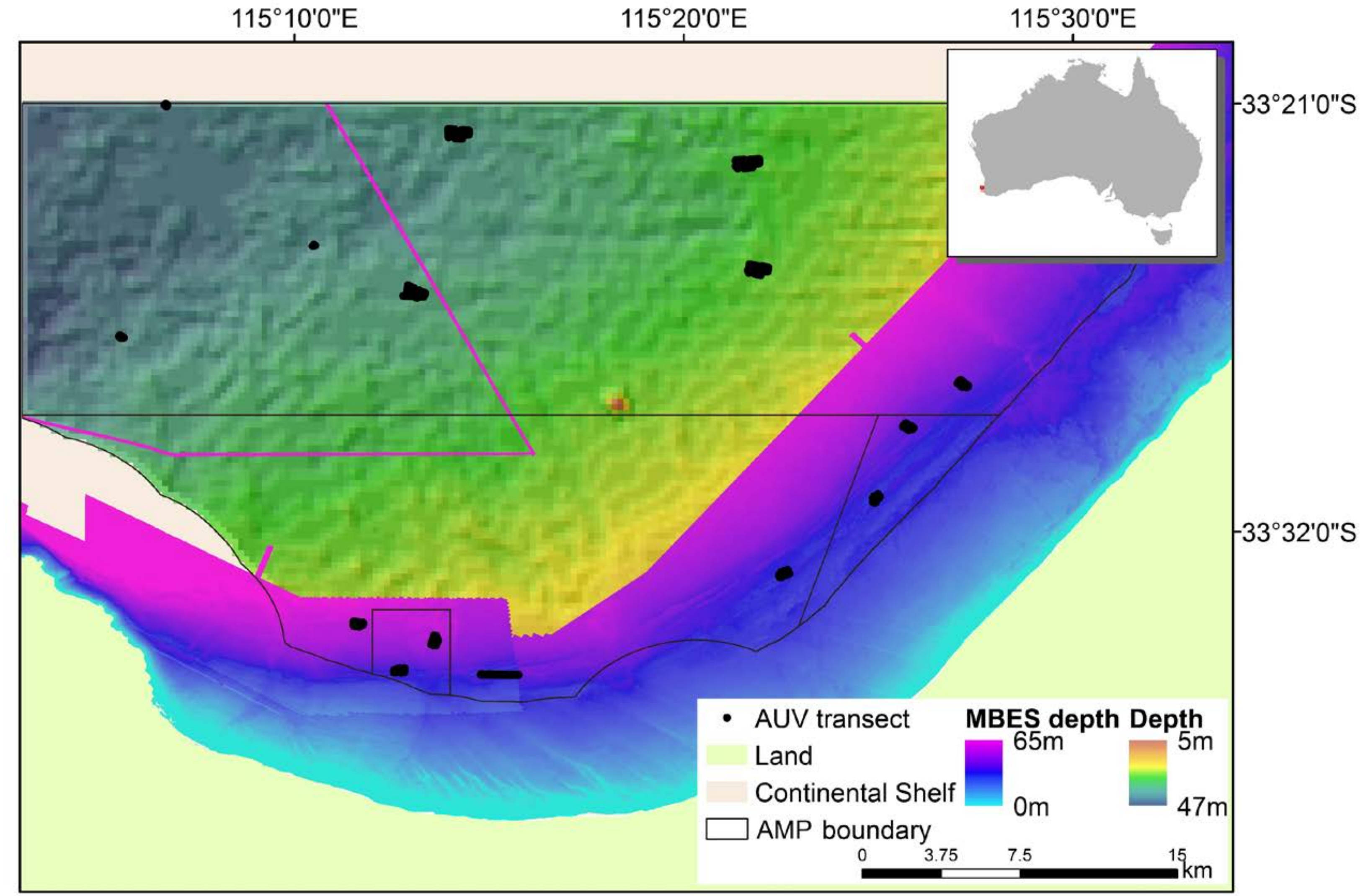


Figure 97. Location of the 15 AUV transects in Geographe AMP.

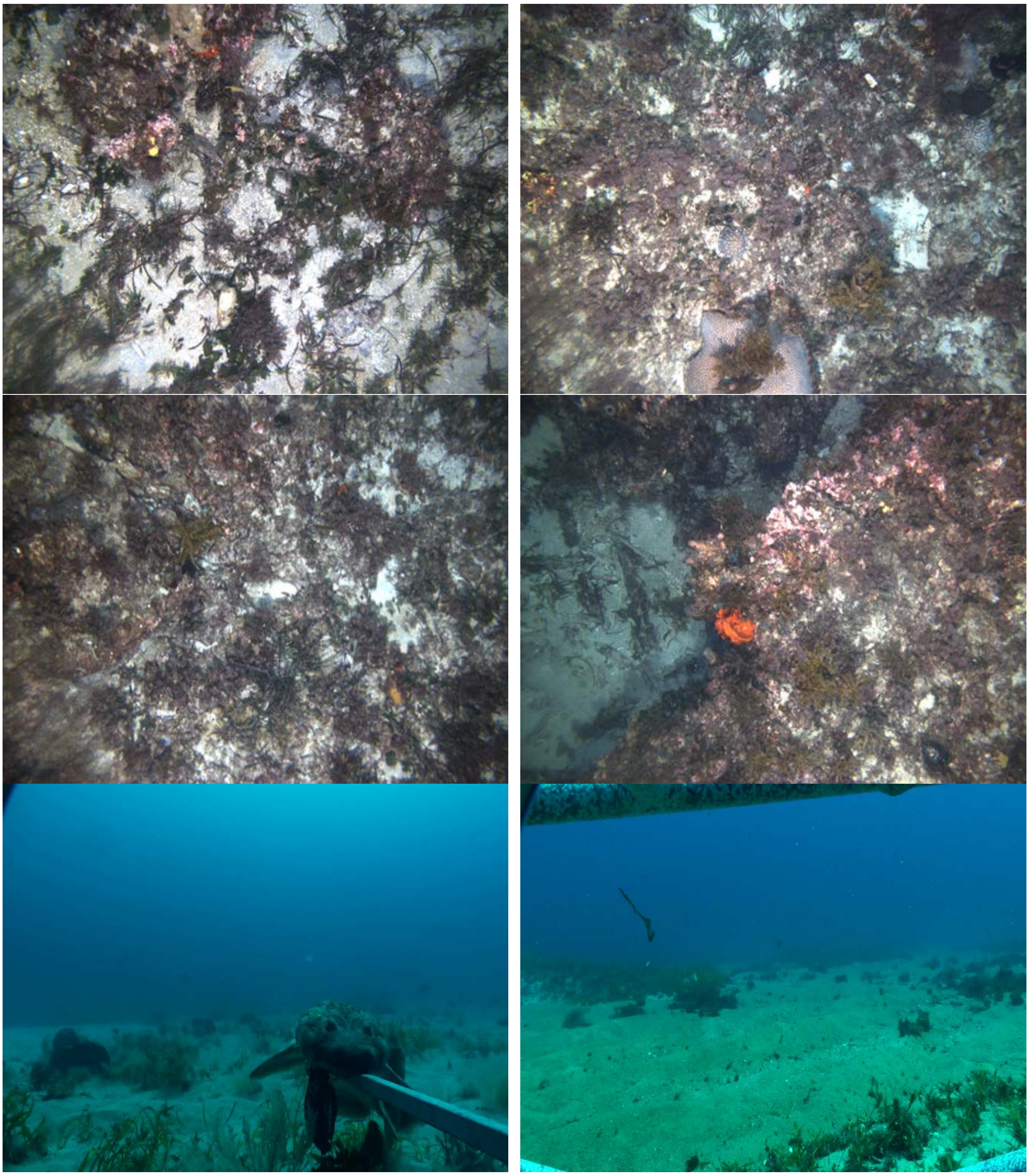


Figure 98. Top two rows show examples of seagrass, red algae and sponges captured from the AUV transects inside the proposed Marine National Park zone in Geographe AMP. Bottom left image is of *Posidonia* seagrass found in 37m observed in BRUV footage. Bottom right shows the *Amphibolis* seagrass in 27m from BRUV footage.

The fish assemblages of Geographe Bay have been sample on two separate occasions. The first in 2007 by Westera et al. (2007) using stereo BRUVs. While the study focussed on inshore sites that were outside the AMP, there were five ‘off-shore’ sites of which four (one site within the proposed Marine National Park Zone) were within the southern extent of the AMP. A total of 45 species of fish were recorded from ‘off-shore’ sites, with the most abundant species being striped trumpeter (*Pelates sexlineatus*), yellowtail scad (*Trachurus novaezelandiae*) and sand trevally (*Pseudocaranx wrightii*).

The second study was undertaken in 2014/15 by Lawrence et al. (2016) who sampled 160 stereo BRUV sites (Figure 100). Although not included in this report, an additional ~60 stereo BRUV drops and 10 stereo towed video transects were collected as a part of a PhD project running in parallel with Lawrence et al. (2016) study. These data will become available via Global Archive by the end of 2017 (Euan Harvey pers.comm).

Based on the work by Lawrence et al. (2016) the majority of stereo BRUV drops occurred on sand with 6 % sites within the proposed Marine National Park Zone landing on reef and 1 % of sites outside the proposed Marine National Park Zone landing on reef (a detailed description of the habitat types recorded using stereo BRUV scan be found in Lawrence et al. (2016)). A total of 8046 individual fish from 123 species were recorded during the study (Table 32). Labrids and Monacanthids were the most speciose fishes with 13 species each. It was noted that there are significantly more species of fish and a greater number of individuals on reef habitats compared to sand and a mixed reef/sand habitats. The most abundant species included the western king wrasse (*Coris auricularis*; Figure 101), western footballer (*Neatypus obliquus*; Figure 102), silverbelly (*Parequula melbournensis*), rough bullseye (*Pempheris klunzingeri*) and trevally (*Pseudocaranx* spp; Figure 103) (Figure 99).

Figure 99. Example of the abundance and diversity of fishes within Geographe AMP recorded fromt the 2014/15 BRUV deployments, including the highly abundant western footballer (*Neatypus obliquus*), western king wrasse (*Coris auricularis*) and trevally (*Pseudocaranx* spp). Also, note the pink snapper (*Chrysophrys auratus*).

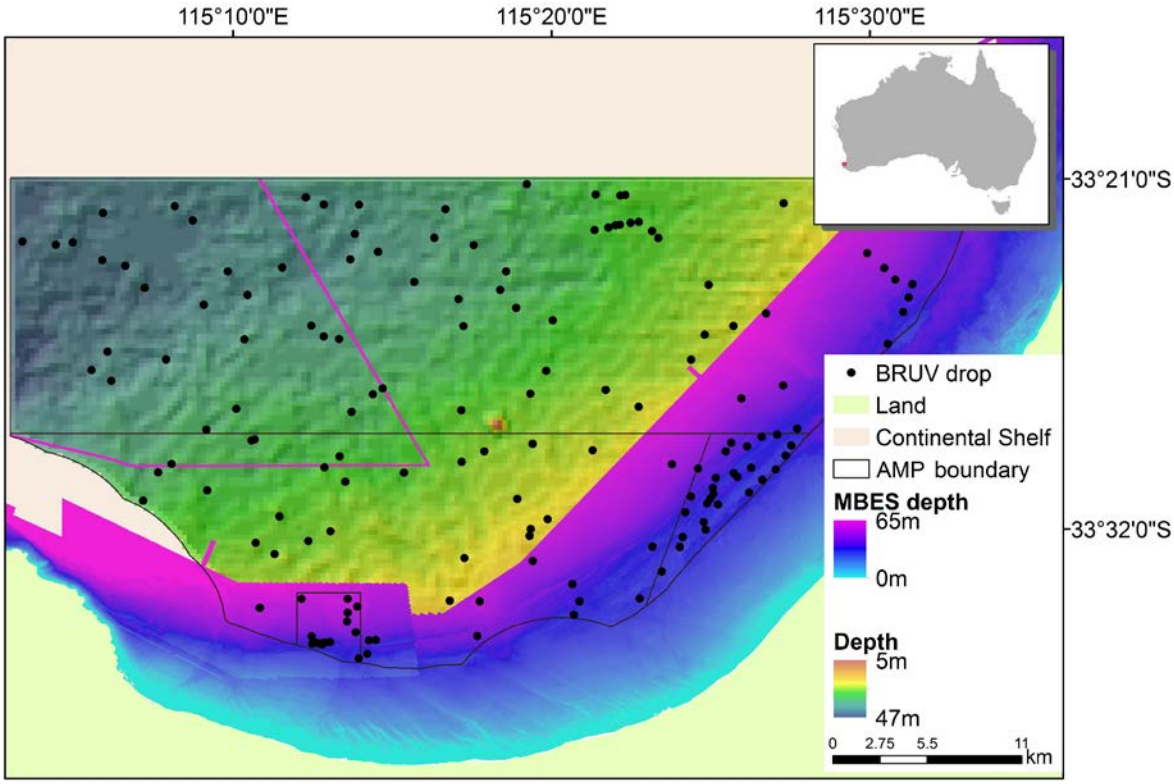


Figure 100. Location of BRUV samples undertaken by Lawerence et al. (2016) within Geographe AMP.

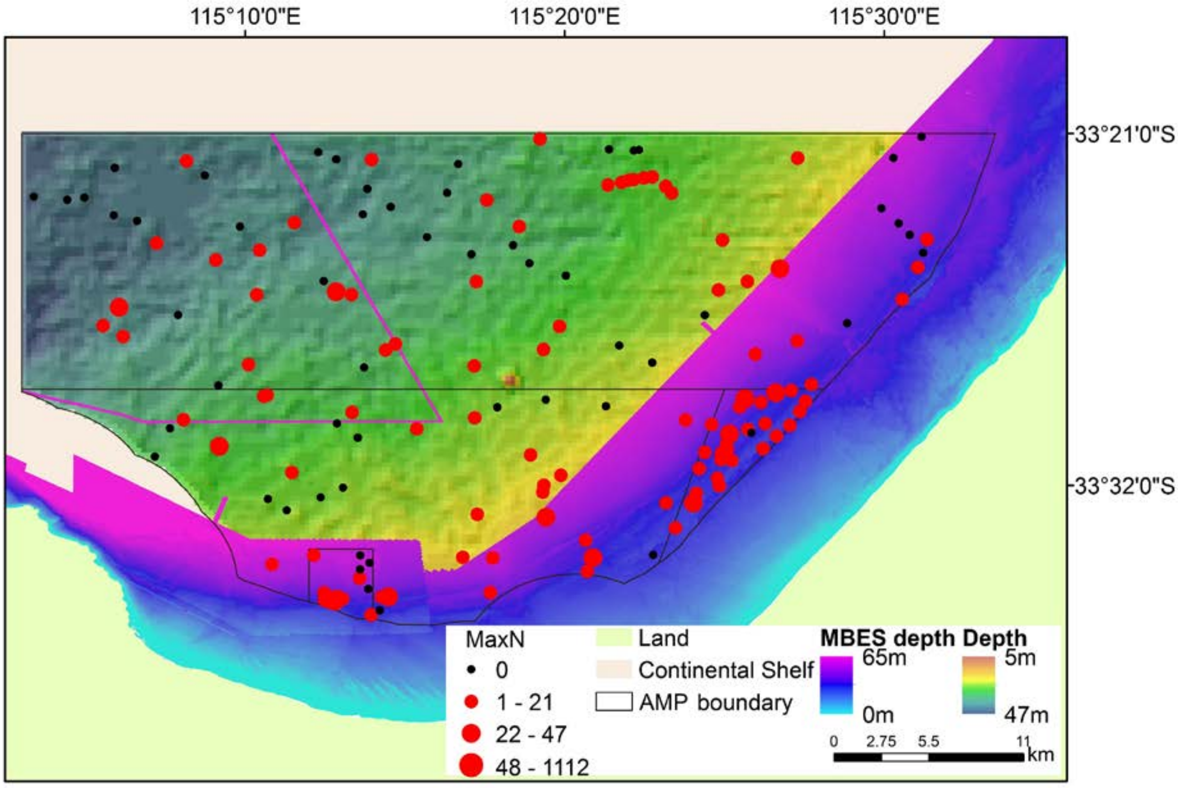


Figure 101. Abundance distribution of western king wrasse from BRUV sampling undertaken by Lawerence et al. (2016) within Geographe AMP.

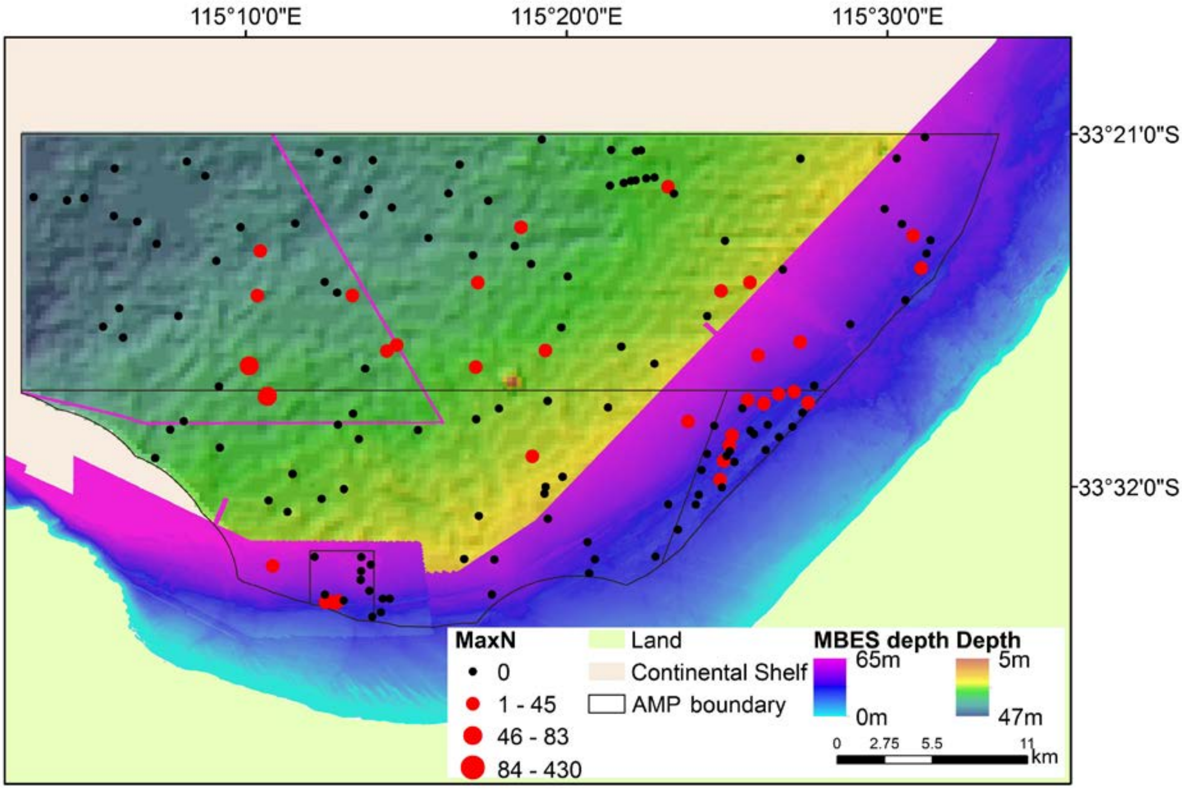


Figure 102. Abundance distribution of footballer sweep from BRUV sampling undertaken by Lawerence et al. (2016) within Geographe AMP.

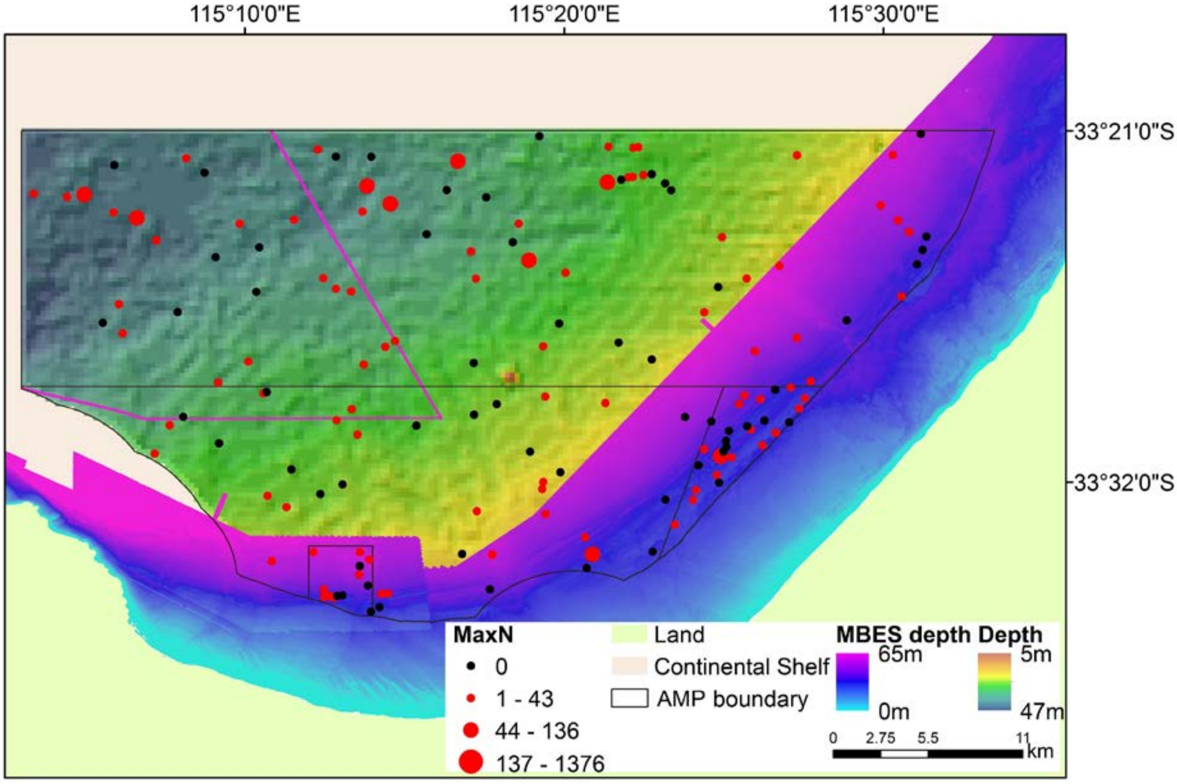


Figure 103. Abundance distribution of trevally from BRUV sampling undertaken by Lawerence et al. (2016) within Geographe AMP.

Table 32. Fish species recorded using stereo BRUVs in the Geographe AMP based on 160 deployments. Abundance was measured using MaxN.

Family	Scientific Name	Common Name	Abundance
Apogonidae	*Ostorhinchus victoriae*	Western Striped Cardinalfish	3
Aulopidae	*Aulopus purpurissatus*	Sergeant Baker	4
Berycidae	*Centroberyx lineatus*	Swallow-tail	13
Blenniidae	*Petroscirtes breviceps*	Short-headed Sabre-tooth	2
Bothidae	Bothidae spp	Flounder	1
Carangidae	*Decapterus* spp	Mackerel scad	1
	Pseudocaranx spp	Trevally	1376
	Seriola hippos	Sampsonfish	42
	Seriola lalandi	Yellowtail kingfish	1
	Seriolina nigrofasciata	Blackbanded trevally	1
	Trachurus novaezelandiae	Yellowtail scad	791
Carcharhinidae	*Carcharhinus brevipinna*	Spinner shark	2
Chaetodontidae	*Chelmonops curiosus*	Western Talma	38
	Cheilodactylus gibbosus	Magpie Morwong	6
	Dactylophora nigricans	Dusky Morwong	5
	Nemadactylus valenciennesi	Queen Snapper	11
Dasyatidae	*Dasyatis brevicaudata*	Smooth Stingray	23
Dinolestidae	*Dinolestes lewini*	Long-fin Pike	2
Diodontidae	*Diodon nicthemerus*	Globe Fish	7
Echeneidae	*Echeneis naucrates*	Live sharksucker	1
Enoplosidae	*Enoplosus armatus*	Old Wife	12
Gerreidae	*Parequula melbournensis*	Silverbelly	868
Glaucosomatidae	*Glaucosoma hebraicum*	West Australian Jewfish	34
Haemulidae	*Plectorhinchus flavomaculatus*	Gold-spotted Sweetlips	1
Heterodontidae	*Heterodontus portusjacksoni*	Port Jackson Shark	31
Hypnidae	*Hypnos monopterygius*	Australian numbfish	1
Kyphosidae	*Girella tephraeops*	Western Rock Blackfish	1
	Girella zebra	Zebra Fish	6
	Kyphosus spp	Sea chubs	8
Labridae	*Achoerodus gouldii*	Western Blue Groper	1

Family	Scientific Name	Common Name	Abundance
	Austrolabrus maculatus	Black-spotted Wrasse	104
	Bodianus frenchii	Foxfish	25
	Choerodon rubescens	Baldchin Groper	26
	Coris auricularis	Western King Wrasse	1112
	Dotalabrus aurantiacus	Castelnaus Wrasse	1
	Eupetrichthys angustipes	Snake-skin Wrasse	37
	Halichoeres brownfieldi	Brownfields Wrasse	9
	Notolabrus parilus	Brown-spotted Wrasse	97
	Ophthalmolepis lineolatus	Maori Wrasse	322
	Pictilabrus laticlavius	Senator Wrasse	6
	Pseudolabrus biserialis	Red-banded Wrasse	83
	Suezichthys cyanolaemus	Blue-throated Rainbow Wrasse	1
Lamnidae	*Isurus oxyrinchus*	Shortfin mako shark	1
Monacanthidae	*Acanthaluteres brownii*	Spiny Tailed Leatherjacket	7
	Acanthaluteres vittiger	Toothbrush Leatherjacket	105
	Brachaluteres jacksonianus	Pygmy Leatherjacket	2
	Chaetodermis penicilligera	Tasselled Leatherjacket	3
	Eubalichthys mosaicus	Mosaic Leatherjacket	1
	Meuschenia australis	Brown-stripe Leatherjacket	3
	Meuschenia flavolineata	Yellow-stripe Leatherjacket	32
	Meuschenia freycineti	Six-spine Leatherjacket	18
	Meuschenia galii	Blue-lined Leatherjacket	30
	Meuschenia hippocrepis	Horseshoe Leatherjacket	13
	Nelusetta ayraud	Chinaman Leatherjacket	3
	Scobinichthys granulatus	Rough Leatherjacket	74
	Thamnaconus degeni	Degens Leatherjacket	1
Mullidae	*Parupeneus chrysopleuron*	Yellow-striped Goatfish	17
	Upeneichthys lineatus	Blue-lined Goatfish	1
	Upeneichthys vlamingii	Southern Goatfish	96
Muraenidae	*Gymnothorax prasinus*	Green Moray	5
	Gymnothorax undulatus	Undulated moray	1
	Gymnothorax woodwardi	Western Moray	11
Myliobatidae	*Myliobatis australis*	Eagle Ray	115

Family	Scientific Name	Common Name	Abundance
Nemipteridae	*Pentapodus vitta*	Western Australian Butterfish	5
Neosebastidae	*Neosebastes pandus*	Big-head Gurnard Perch	58
Odacidae	*Neoodax balteatus*	Little Rock Whiting	1
	Siphonognathus caninis	Sharp-nosed Weed Whiting	2
Ophidiidae	*Genypterus tigerinus*	Rock Ling	1
Oplegnathidae	*Oplegnathus woodwardi*	Knifejaw	2
Orectolobidae	*Orectolobus hutchinsi*	Western Wobbegong	2
Ostraciidae	*Anoplocapros amygdaloides*	Western Smooth Boxfish	43
	Anoplocapros lenticularis	White-barred Boxfish	4
	Aracana aurita	Shaws Cowfish	3
	Aracana ornata	Ornate Cowfish	11
	Caprichthys gymnura	Rigid boxfish	2
Paralichthyidae	*Pseudorhombus jenynsii*	Smalltooth flounder	1
Parascylliidae	*Parascyllium ferrugineum*	Rusty Catshark	3
	Parascyllium variolatum	Varied Catshark	6
Pempherididae	*Pempheris klunzingeri*	Rough Bullseye	616
Pinguipedidae	*Parapercis haackei*	Wavy Grubfish	12
	Parapercis ramsayi	Spotted grubfish	7
Platycephalidae	*Platycephalus spp*	Flathead	191
Plesiopidae	*Paraplesiops meleagris*	Western Blue Devil	4
	Trachinops noarlungae	Yellow-headed Hulafish	9
Pleuronectidae	Pleuronectidae spp	Righteye flounder	4
Plotosidae	*Cnidoglanis macrocephalus*	Estuary Catfish	1
Pomacentridae	*Chromis klunzingeri*	Black-headed Puller	186
	Chromis westaustralis	West Australian Puller	1
	Parma mccullochi	McCullochs Scalyfin	6
	Parma victoriae	Victorian Scalyfin	14
Rhinobatidae	*Aptychotrema vincentiana*	Southern Shovelnose Ray	13
	Trygonorrhina dumerilii	Southern Fiddler Ray	156
Scorpaenidae	*Scorpaena sumptuosa*	Western Red Rock Cod	1
	Neatypus obliquus	Footballer Sweep	430
	Scorpis georgiana	Banded Sweep	2
	Tilodon sexfasciatus	Moonlighter	3

Family	Scientific Name	Common Name	Abundance
Scyliorhinidae	*Aulohalaelurus labiosus*	Black-spotted Catshark	3
Sebastidae	*Helicolenus barathri*	Bigeye Ocean Perch	1
Serranidae	*Caesioperca rasor*	Barber Perch	1
	Caesioperca sp	Perch	13
	Epinephelides armatus	Breaksea Cod	18
	Hypoplectrodes nigroruber	Banded Seaperch	6
	Othos dentex	Harlequin Fish	4
Sillaginidae	*Sillaginodes punctata*	King George Whiting	65
	Sillago schomburgkii	Yellowfin sillago	6
	Sillago spp	Whiting	267
Sparidae	*Chrysophrys auratus*	Pink Snapper	125
	Rhabdosargus sarba	Tarwhine	1
Sphyraenidae	*Sphyraena novaehollandiae*	Snook	1
	Sphyraena obtusata	Striped Seapike	22
Sphyrnidae	*Sphyrna zygaena*	Smooth hammerhead	1
Synodontidae	Synodontidae spp	Lizardfish	2
Terapontidae	*Pelates sexlineatus*	Eastern Striped Grunter	1
	Pelsartia humeralis	Sea Trumpeter	2
Tetraodontidae	*Lagocephalus sceleratus*	Silver-cheeked toadfish	2
	Torquigener pallimaculatus	Rusty-spotted toadfish	2
Triakidae	*Galeorhinus galeus*	School shark	2
	Mustelus antarcticus	Gummy shark	5
	Chelidonichthys kumu	Bluefin gurnard	1
Urolophidae	*Trygonoptera ovalis*	Striped Stingaree	29
	Trygonoptera personata	Masked Stingaree	7
	Urolophus circularis	Circular Stingaree	3
Zeidae	*Zeus faber*	John Dory	1

4.8 Great Australian Bight AMP

4.8.1 Description of physical habitat

Mapping data within the Great Australian Bight AMP consists of the Australian Bathymetry and Topography Grid and fine-scale MBES surveys from CSIRO Southern Survey/Investigator vessel transits (Figure 104). The continental shelf region of the Great Australian Bight AMP represents ~ 50 % of its total area.The fine-scale MBES data cover ~ 1 % of the continental shelf region of the AMP and indicates that depth ranges from ~50 to 200 m (Figure 104). From the mapping data it appears that there areas of reef features in <100 m water in the eastern extent of the AMP at the state water boundary and surrounding the Nuyts Reef Conservation Park (Figure 104 and Figure 139 in Appendix A).

4.8.2 Description of biological assemblages

The central section of the Great Australian Bight AMP that encompasses the pre-existing GAB Marine Benthic Protection Zone has been sampled by SARDI and CSIRO during the National Oceans Office survey SS200001. More recently, CSIROs GAB mapping project has undertaken a limited number of video tows in the east of the AMP. However, we have not been able access this data or reports as most are not publically available.

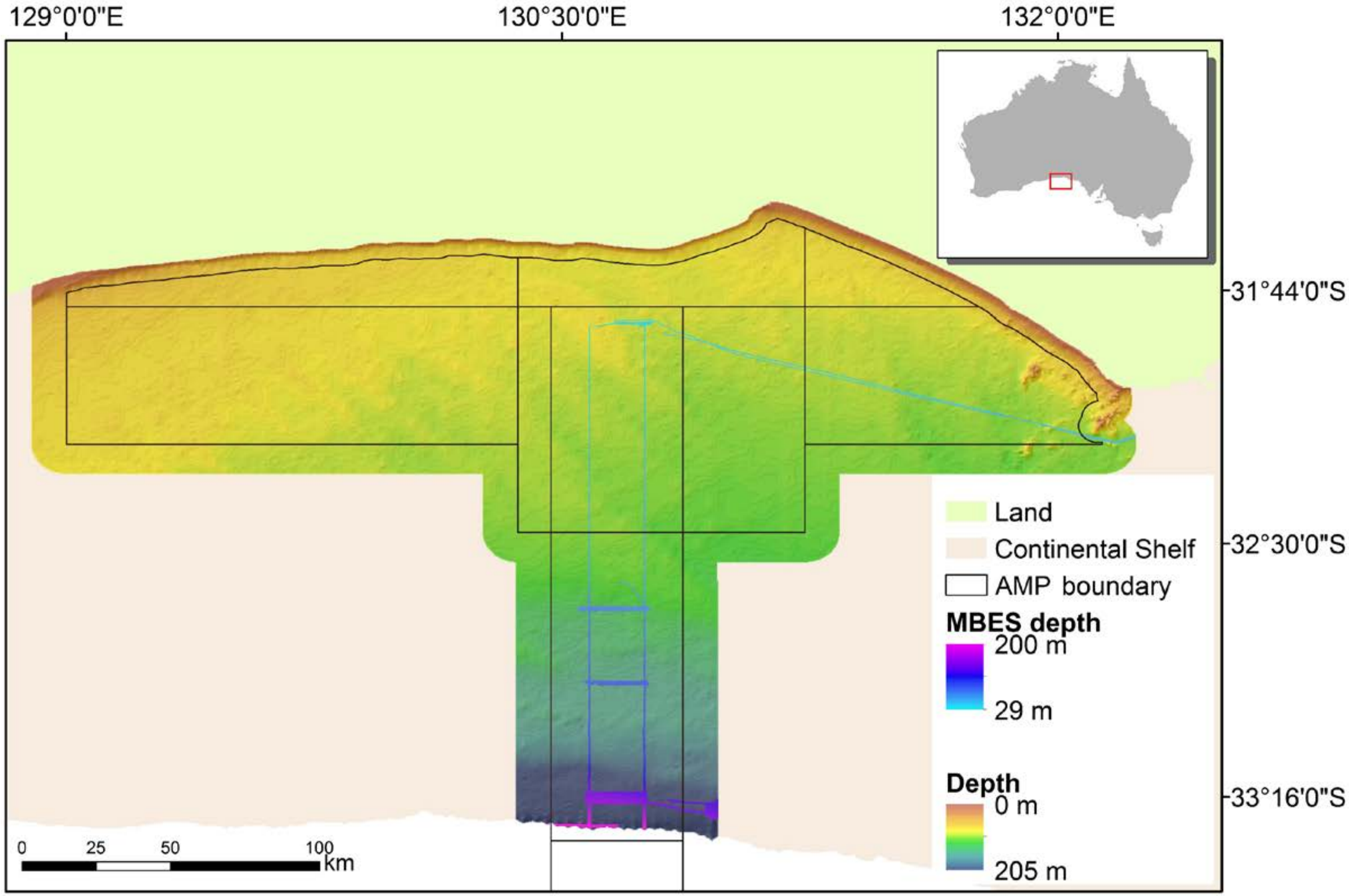


Figure 104. Mapping coverage of the Great Australian Bight AMP based on the Australian Bathymetry and Topography Grid, produced by Geoscience Australia in June 2009. Note the fine-scale 5-m resolution multibeam sonar (MBES depth) collected by the CSIRO Southern Survey/Investigator.

4.9 Jurien AMP

4.9.1 Description of physical habitat

Mapping data within the Jurien AMP consists of the Australian Bathymetry and Topography Grid and fine-scale MBES surveys from CSIRO Southern Survey/Investigator vessel transits and the Marine Futures Programme (Figure 105). The continental shelf region of the Jurien AMP represents 100 % of its total area. The fine-scale MBES data cover ~ 16 % of the continental shelf region of the AMP and indicates that depth ranges from ~ 50 to 200 m (Figure 105). From the fine-scaling mapping, it is clear that there a number of significant areas of reef in the centre of the AMP mapped by the Marine Futures programme (Figure 140 in Appendix A). There also appears to be some extensive reef platforms and ridge geoform features in *c* 36 – 80 m near shelf break (insert in Figure 105).

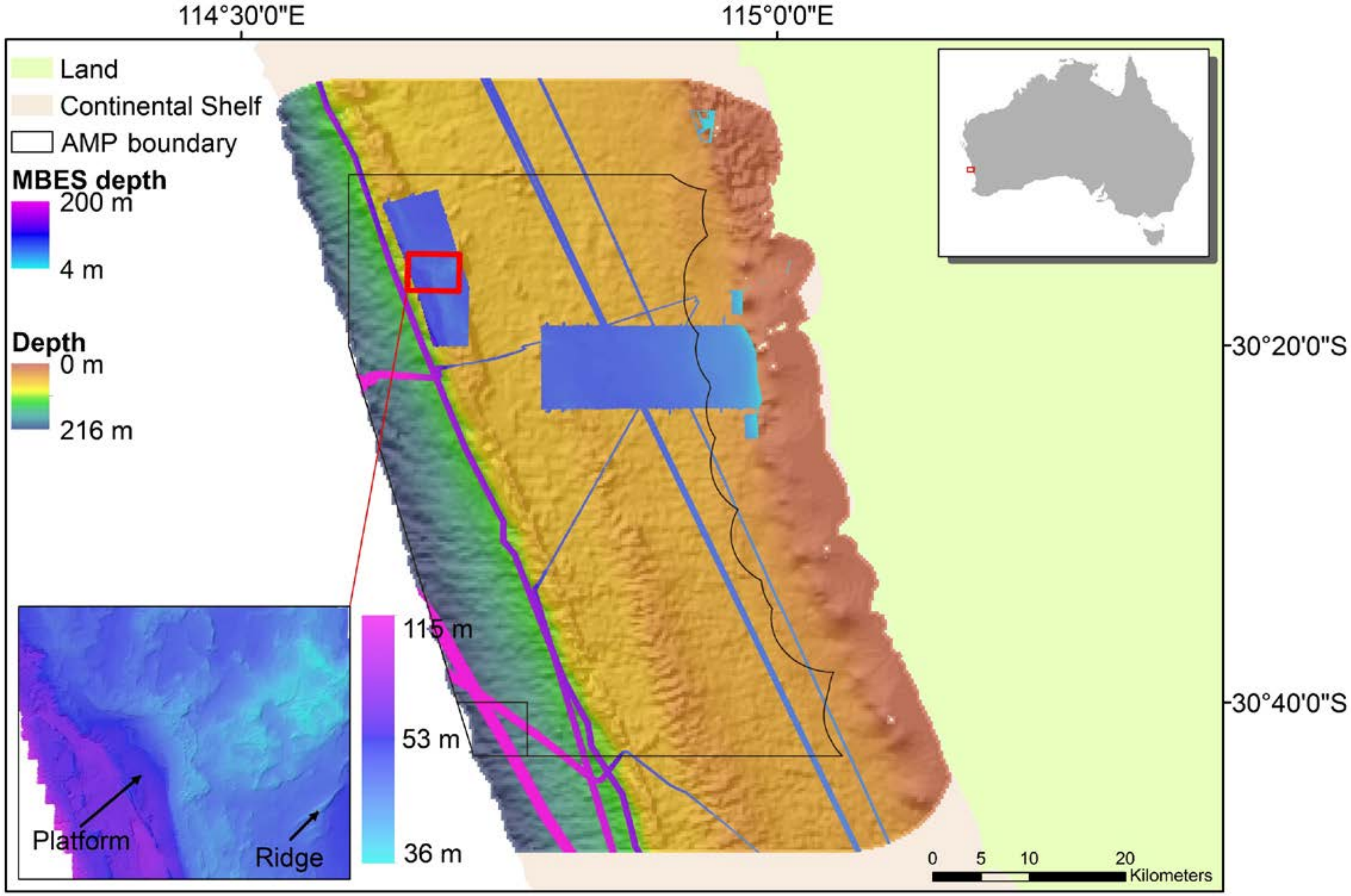


Figure 105. Mapping data coverage within the Jurien AMP is based on the Australian Bathymetry and Topography Grid, produced by Geoscience Australia in June 2009. Note the fine-scale 5-m resolution multibeam sonar (MBES depth) collected by the CSIRO Southern Survey/Investigator and the Marine Futures programme.

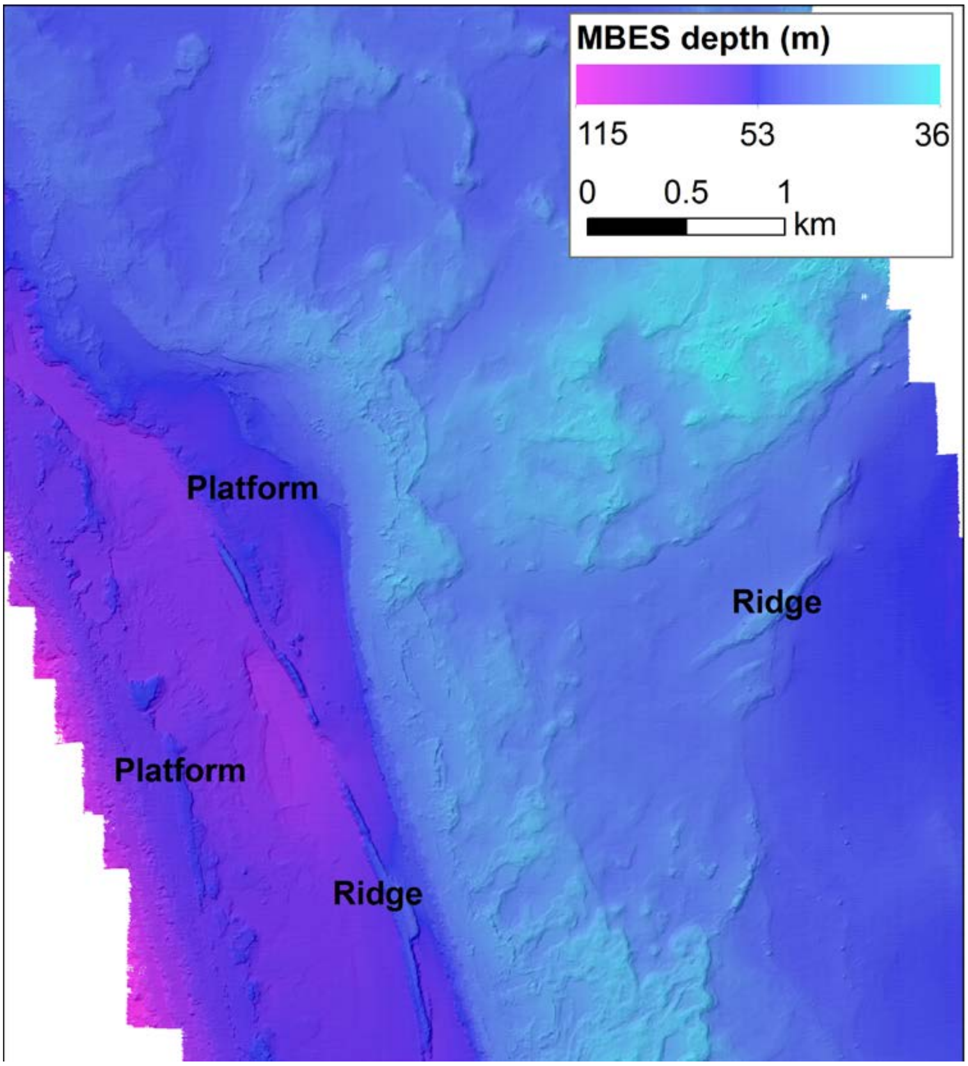


Figure 106. Close-up of the geoform features located in the northwest of the Jurien AMP.

4.9.2 Description of biological assemblages

In 2007, the University of Western Australia sampled fishes within the Jurien AMP using 138 stereo BRUV deployments within the proposed Special Purpose Zone (Figure 107). A total of 28 fish species from 17 families were idenitified. Carangids and Labrids were the most speciose, with seven and five species, respectively (Table 33). Abundances (MaxN) were generally low for most species with pelagic schooling species such as yellowtail scad (*Trachurus novaezelandiae*), trevally (*Pseudocaranx* spp) and amberstipe scad (*Decapterus muroadsi*) being most abundant (Table 33). Western king wrasse (*Coris auricularis*) were the most abundance reef-affiliated fish species (Table 33).

No sampling of sessile seabed biota has been collated for Jurien AMP. However, it is likely that there is towed video data available from the Marine Futures programme. We have not been able to attain this data.

Table 33. Fish species recorded using stereo BRUVs in the Jurien AMP based on 138 deployments. Abundance was measured using MaxN.

Family	Scientific name	Common name	Abundance
Apogonidae	*Apogon rueppellii*	Western gobbleguts	8
Aulopodidae	*Aulopus purpurissatus*	Sergen baker	7
Blenniidae	*Aspidontus taeniatus*	False cleanerfish	3
Carangidae	*Decapterus muroadsi*	Amberstripe scad	143
	Decapterus russelli	Indian scad	5
	Elagatis bipinnulata	Rainbow runner	2
	Pseudocaranx spp	Trevally	171
	Seriola hippos	Sampsonfish	27
	Seriola lalandi	Yellowtail kingfish	25
	Trachurus novaezelandiae	Yellowtail scad	230
Carcharhinidae	*Carcharhinus obscurus*	Dusky shark	2
	Carcharhinus plumbeus	Sandbar shark	3
Cheilodactylidae	*Dactylophora nigricans*	Dusky morwong	1
Dasyatidae	*Dasyatis brevicaudata*	Smooth ray	9
Dinolestidae	*Dinolestes lewini*	Pike	10
Gerreidae	*Parequula melbournensis*	Silverbelly	3
Glaucosomatidae	*Glaucosoma hebraicum*	Western jewfish	8
Haemulidae	*Plectorhinchus flavomaculatus*	Goldspotted sweetlip	3
Heterodontidae	*Heterodontus portusjacksoni*	Port jackson shark	7
Kyphosidae	*Kyphosus sydneyanus*	Silver drummer	1
Labridae	*Achoerodus gouldii*	Western blue grouper	1
	Austrolabrus maculatus	Black spotted parrotfish	2
	Choerodon rubescens	Baldchin grouper	16

Family	Scientific name	Common name	Abundance
	Cirrhilabrus temminckii	Bluestripe fairy wrasse	2
	Coris auricularis	Western king wrasse	93
Monacanthidae	*Nelusetta ayraudi*	Ocean leatherjacket	1
Platycephalidae	*Platycephalus* spp	Flathead	6
Tetraodontidae	*Lagocephalus sceleratus*	Silver cheeked toadfish	1

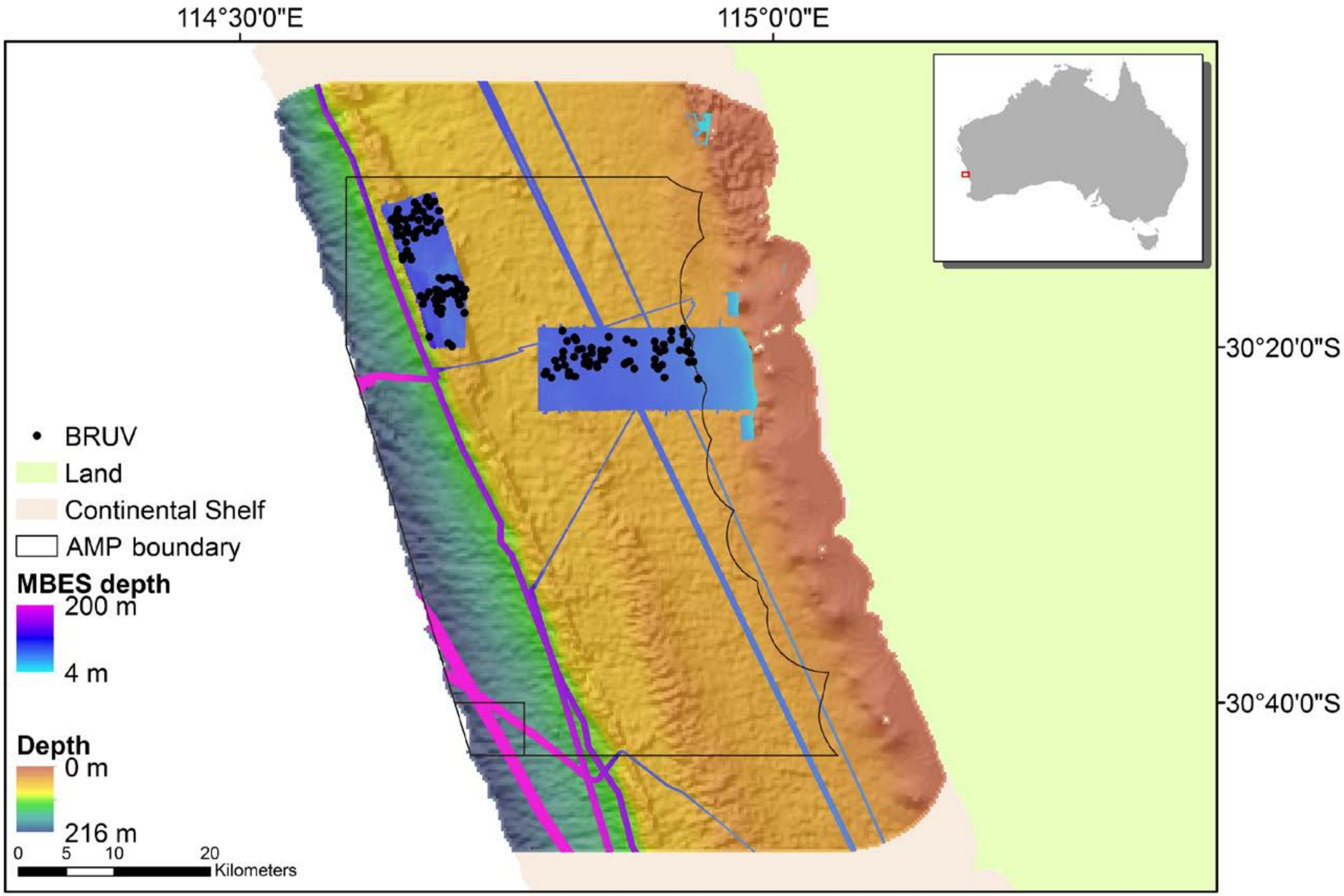


Figure 107. Location of BRUV sampling undertaken in 2007 within the proposed Special Purpose Zone in Jurien AMP.

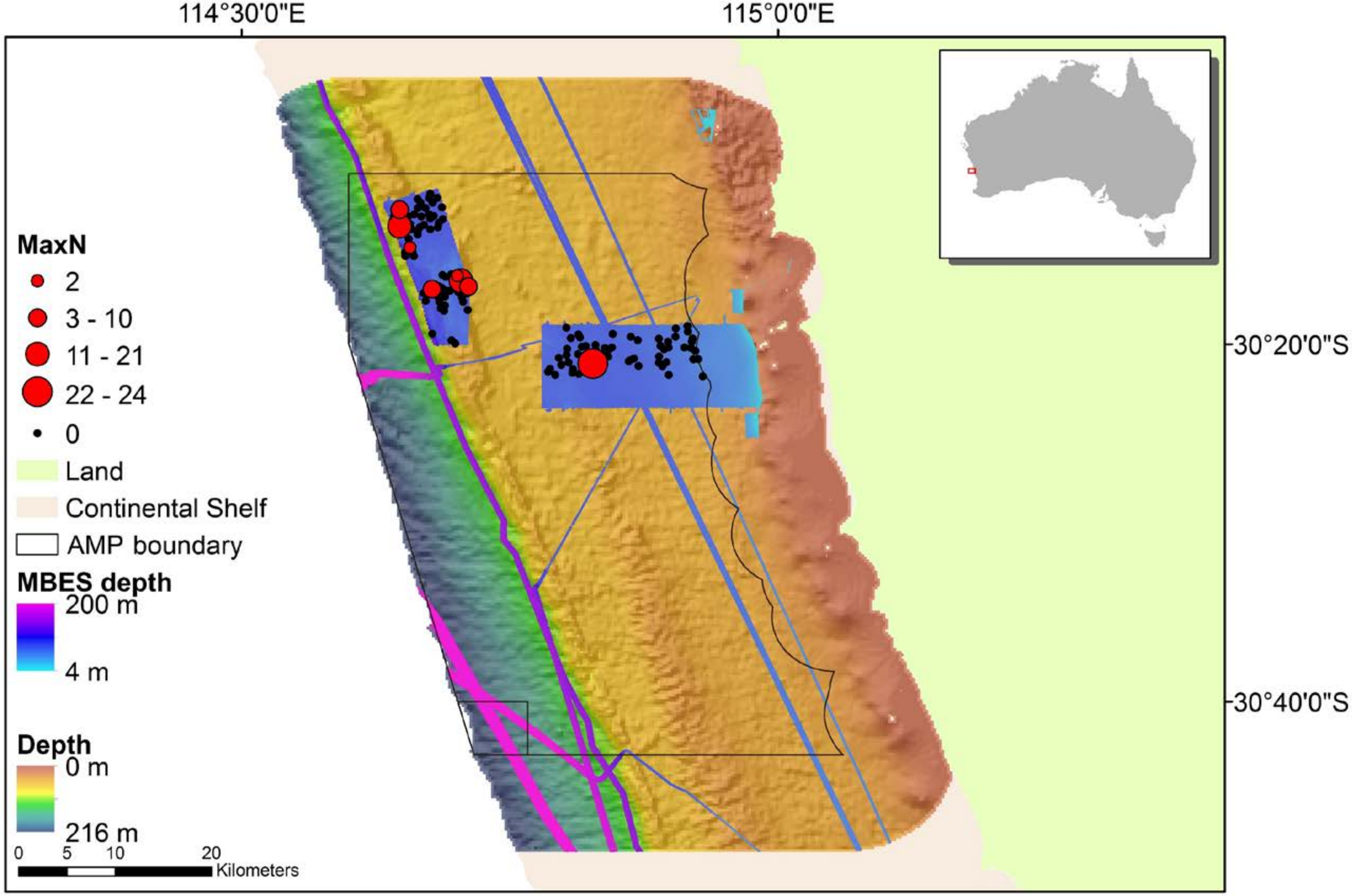


Figure 108. Abundance distribution of western king wrasse from BRUV sampling undertaken in 2007 within Jurien AMP.

4.10 Murat AMP

4.10.1 Description of physical habitat

Mapping data within the Murat AMP consists of the Australian Bathymetry and Topography Grid (Figure 109). There are no fine-scale MBES data for the Murat AMP. The continental shelf region of the Murat AMP represents 100 % of its total area. The mapping data indicates that the depth ranges from ~10 to 70 m (Figure 109). From the available mapping data there appears to be a large feature with high relief that could be reef on the southern boundary of the AMP, and has been noted by the Australian Hydrographic Office (Figure 141 in Appendix A).

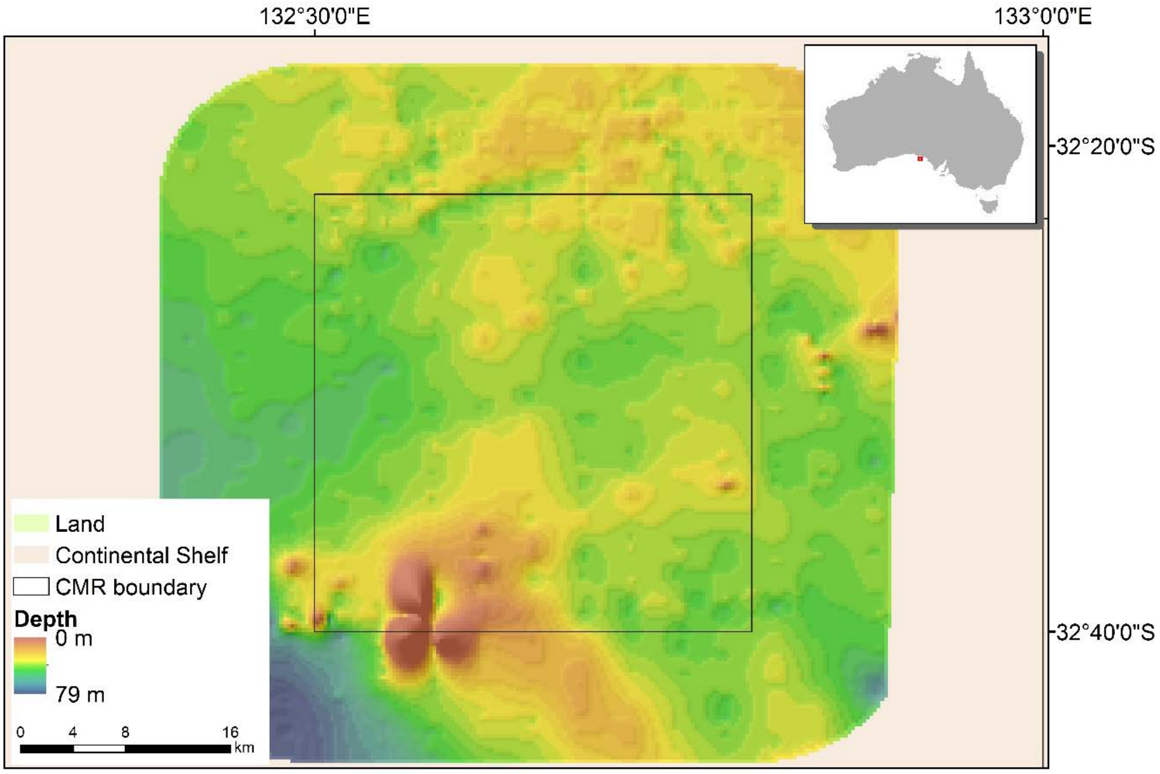


Figure 109. Mapping coverage of the Murat AMP based on the Australian Bathymetry and Topography Grid, produced by Geoscience Australia in June 2009. Note no fine-scale MBES data is available for the Murat AMP.

4.10.2 Description of biological assemblages

The only biological dataset that was identified for the Murat AMP is associated with CSIROs GAB mapping project, with four-towed video transects being completed. As this data is restricted access, we are yet to provide a summary of the biology associated with the survey.

4.11 Perth Canyon AMP

4.11.1 Description of physical habitat

Mapping data within the Perth Canyon AMP consists of the Australian Bathymetry and Topography Grid and fine-scale MBES surveys from CSIRO Southern Survey/Investigator vessel transits (Figure 110). The continental shelf region of the Perth Canyon AMP represents ~ 1 % of its total area. The fine-scale MBES data cover ~ 65 % of the continental shelf region of the AMP and indicates that depth ranges from ~57 to 200 m (Figure 110). From the mapping data, it is difficult to determine, but there appears to be some reef-like features at the shelf break in ~200 m of water (Figure 142 in Appendix A). However, targeted MBES mapping is needed to confirm this observation.

4.11.2 Description of biological assemblages

The Perth Canyon was also a focus site for the Voyage of Discovery. However, sampling was concentrated on the shelf break at ~ 200 m depth and below. The shelf-break did not show any clear reef features, being predominatly soft substrata, probably littered with sub-cropping harder fragments. The emergent fauna consisted mostly of moderately densely distributed small stalked or finger sponges. The Voyage collected 19 species and 56 nominal species of benthic invertebrates in 5 phyla; the most speciose group were the sponges.

The University of Western Australia sampled the fish assemblages of the Perth Canyon AMP using stereo BRUVs. In 2010, ~ 190 deployments were made in the Multiple Purpose Zone in the east of the AMP (Langlois et al. unpublished data; GlobalArchive). We are yet to access this data to provide summaries. This data is likely to be available via GlobalArchive by the end of 2017.

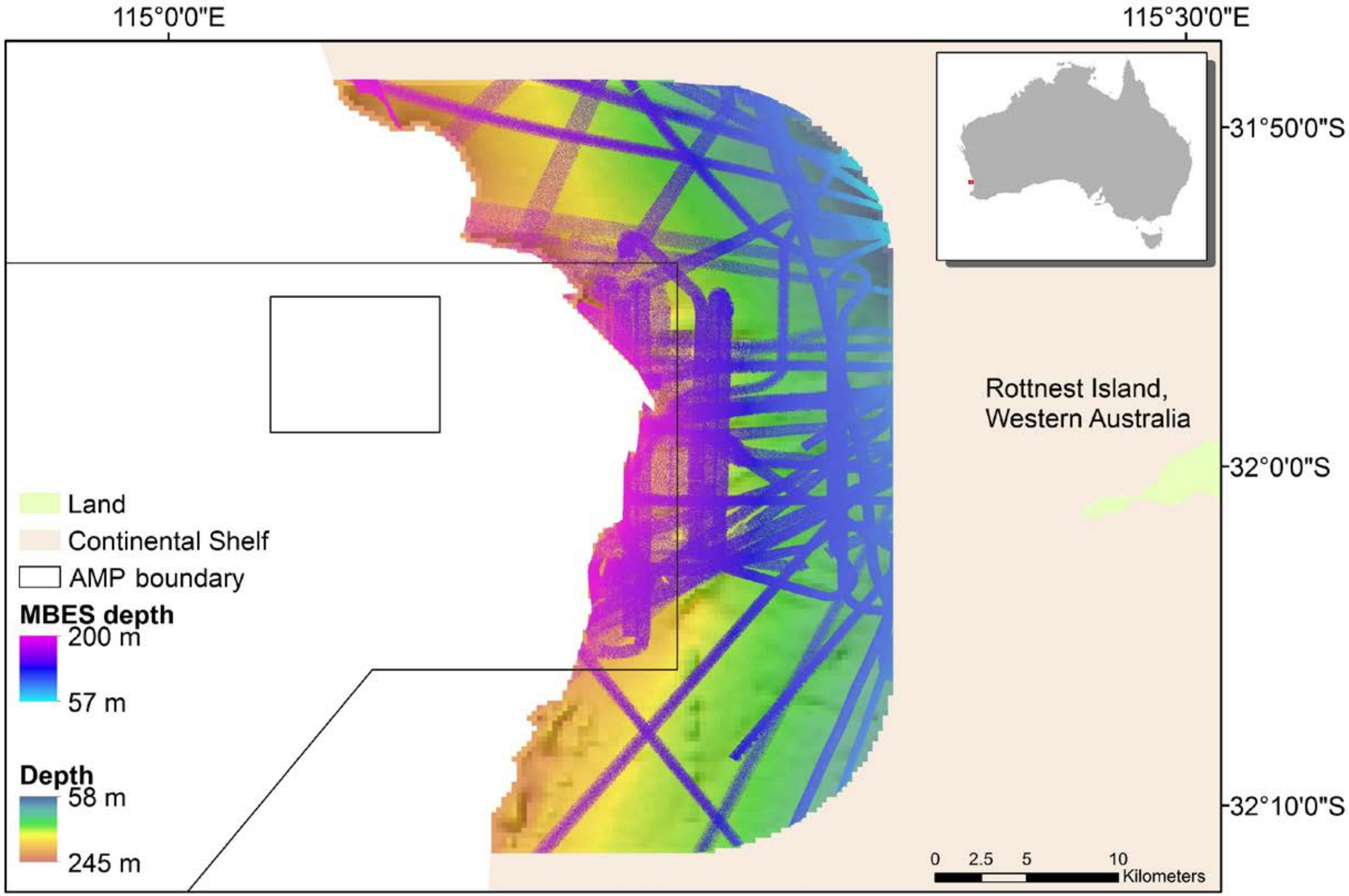


Figure 110. Mapping coverage of the Perth Canyon AMP based on the Australian Bathymetry and Topography Grid, produced by Geoscience Australia in June 2009. Note the fine-scale 5-m resolution multibeam sonar (MBES depth) collected by the CSIRO Southern Survey/Investigator. The salt and pepper appearance of the fine-scale MBES data inside the AMP is because of decreased sounding densities at those deeper depths.

4.12 Southern Kangaroo Island AMP

4.12.1 Description of physical habitat

Mapping data of the Southern Kangaroo Island AMP consists of the Australian Bathymetry and Topography Grid (Figure 111). The continental shelf region of the Southern Kangaroo Island AMP represents 100 % of its total area. There is no fine-scale MBES data for the continental shelf region of the AMP. From the coarse scale mapping, it appears there are numerous reef features as either pinnacles or mounds throughout the entire AMP that are around 1 km in size (Figure 111 and Figure 143 in Appendix A).

4.12.2 Description of biological assemblages

There is currently no biological data available for the Southern Kangaroo Island AMP.

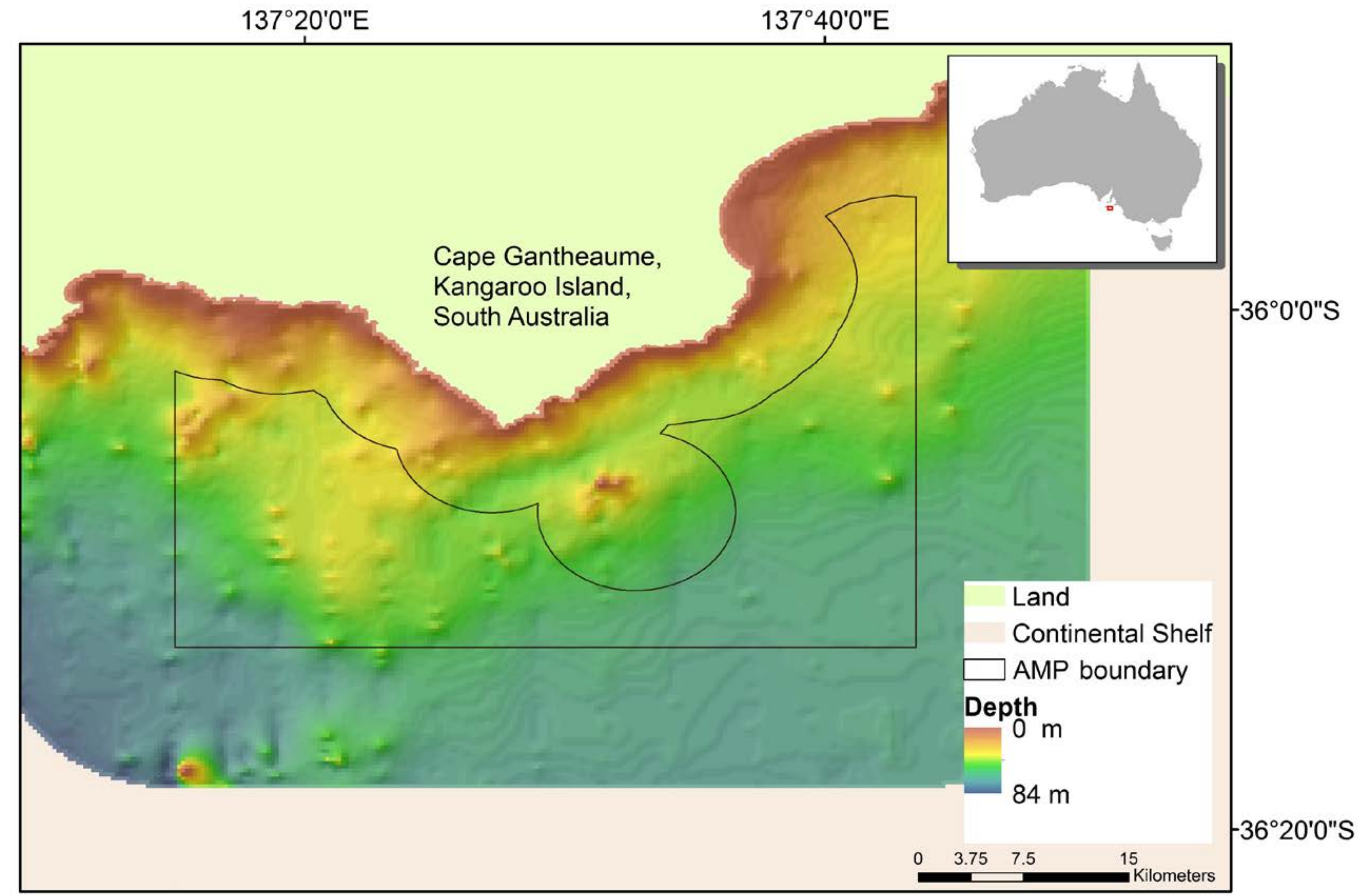


Figure 111. Mapping coverage of the Southern Kangaroo Island AMP based on the Australian Bathymetry and Topography Grid, produced by Geoscience Australia in June 2009. Note no fine-scale MBES data is available for the Southern Kangaroo Island AMP.

4.13 Southwest Corner AMP

4.13.1 Description of physical habitat

Mapping data for the Southwest Corner AMP consists of the Australian Bathymetry and Topography Grid and fine-scale MBES surveys from CSIRO Southern Survey/Investigator vessel transits (Figure 112). The continental shelf region of the Southwest Corner AMP represents ~4 % of its total area. The fine-scale MBES data cover ~ 6 % of the continental shelf region of the AMP and indicates that depth ranges from ~33 to 200 m (Figure 112). From the mapping, it appears there are reef features throughout the AMP, but it difficult to determine their extents without more comprehensive MBES mapping (Figure 144 in Appendix A).

4.13.2 Description of biological assemblages

The Southwest Corner AMP overlaps the continental shelf off the Southwest cape in the northwest and near Pt. Hillier to the southeast. The former overlaps with the 'Mentelle' site from the Voyage of Discovery, the latter is just west of the 'Pt. Hillier' site.

The outer shelf in the northwest, at 'Mentelle' was not sampled with towed cameras; however, samples consisted predominantly of sponges suggest hard substrata at this site. At the 'Pt Hillier' site in the southeast rippled sediments were common, however where sub- or outcropping rock was observed it was rich with sponges, bryozoans and some octocorals. Sponges and decapods were the most specious taxa collected.

The University of Western Australia sampled the fish assemblages of the Southwest Corner AMP using stereo BRUVs in 2010. A total of 7 deployments were made in the northern proposed Special Purpose Zone (Figure 113).

A total of four fish species from four families were recorded in these stereo BRUV deployments, with swallowtail (*Centroberyx lineatus*) and trevally (*Pseudocaranx* spp) being most abundance (Table 34).

An additional ~71 stereo BRUV deployments, collected by Western Australia Department of Fisheries on a FRDC funded project, have been identified but not summarised. These drops are located on the outershelf in the most northern part of the proposed Special Purpose Zone.

Table 34. Fish species recorded using stereo BRUVs in the Southwest Corner AMP based on seven deployments. Abundance was measured using MaxN.

Family	Scientific name	Common name	Abundance
Berycidae	*Centroberyx lineatus*	Swallowtail	11
Carangidae	*Pseudocaranx* spp	Trevally	8
Carcharhinidae	*Carcharhinus* spp	Shark	1
Gerreidae	*Parequula melbournensis*	Silverbelly	2

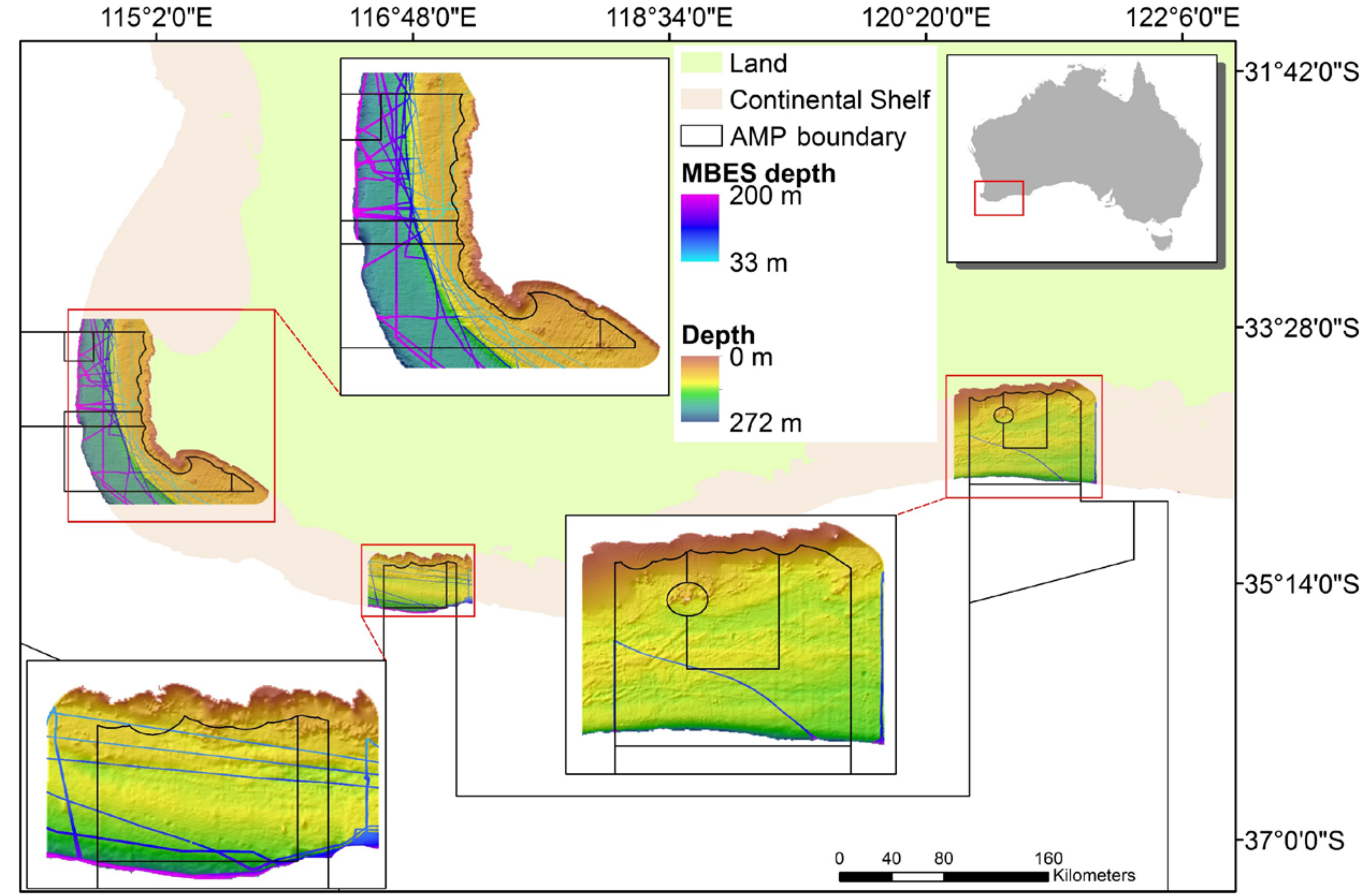


Figure 112. Mapping coverage of the Southwest Corner AMP based on the Australian Bathymetry and Topography Grid, produced by Geoscience Australia in June 2009. Note the fine-scale 5-m resolution multibeam sonar (MBES depth) collected by the CSIRO Southern Survey/Investigator.

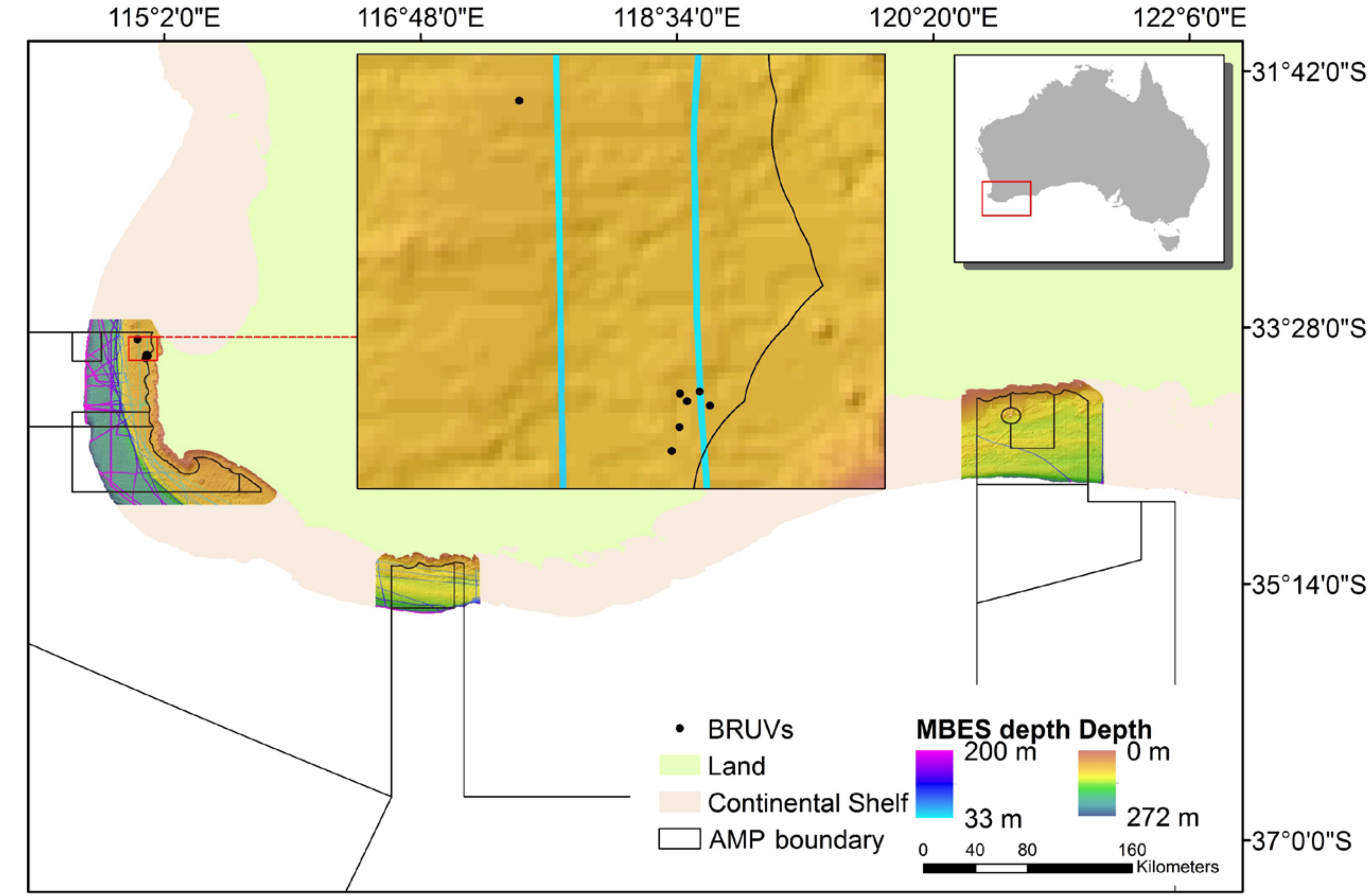


Figure 113. Location of stereo BRUV sampling undertaken in 2007 within the proposed Special Purpose Zone in Southwest Corner AMP.

4.14 Twilight AMP

4.14.1 Description of physical habitat

Mapping data within the Twilight AMP consists of the Australian Bathymetry and Topography Grid and fine-scale MBES surveys from CSIRO Southern Survey/Investigator vessel transits (Figure 114). The continental shelf region of the Twilight AMP represents 100 % of its total area. The fine-scale MBES data cover < 1 % of the continental shelf region of the AMP and indicates that depth ranges from ~ 25 to 81 m (Figure 114). It is difficult to distinguish reef features from the current mapping data but it does appear that there could be reef-like features in the *c* 50-80 m bathome (Figure 145 in Appendix A).

4.14.2 Description of biological assemblages

There is currently no biological data available for the Twilight AMP.

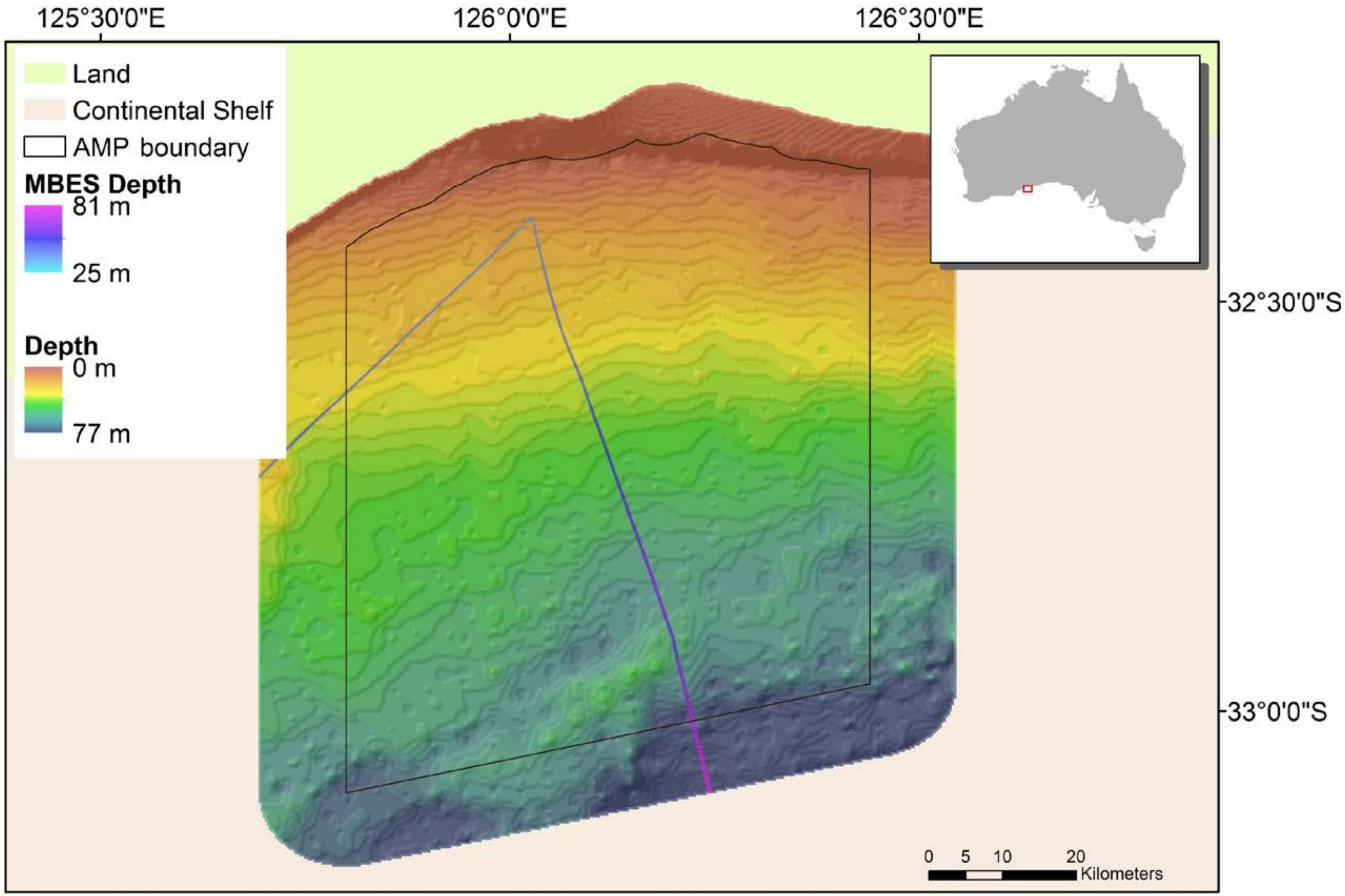


Figure 114. Mapping coverage of the Twilight AMP based on the Australian Bathymetry and Topography Grid, produced by Geoscience Australia in June 2009. Note the fine-scale 5-m resolution multibeam sonar (MBES depth) collected by the CSIRO Southern Survey/Investigator.

4.15 Two Rocks AMP

4.15.1 Description of physical habitat

Mapping data within the Two Rocks AMP consists of the Australian Bathymetry and Topography Grid and fine-scale MBES surveys from CSIRO Southern Survey/Investigator vessel transits (Figure 115). The continental shelf region of the Two Rocks AMP represents 100 % of its total area. The fine-scale MBES data cover ~9 % of the continental shelf region of the AMP and indicates that depth ranges from ~10 to 200 m (Figure 115). The fine-scale MBES mapping shows some reef ridges throughout the AMP (Figure 115 and Figure 146 in Appendix A). While there is good coverage on the southern boundary of the AMP showing these reef ridges (bottom insert in Figure 115), a more comprehensive MBES survey is required to determine the spatial extent of these reef-like systems.

4.15.2 Description of biological assemblages

The outer shelf (~100 m) sample at the 'Two Rocks' site of the Voyage of Discovery sits on the south-western edge of the AMP reserve boundary. The towed camera imagery did not show any clearly defined reefs; instead, the seafloor consisted of soft, rippled substrata with patches of consolidated, harder substrata covered by a veneer of fine to muddy sediments. The fauna consisted of sparsely distributed patches of hydroids and soft bryozoans with sparse sponges (Figure 116). A total of 45 species and 30 nominal species of benthic invertebrates in 9 phyla; the most speciose groups were the decapod crustaceans, followed by sponges and echinoderms.

The University of Western Australia sampled the fish assemblages of the Two Rocks AMP using stereo BRUVs in 2008 with a repeat of most of the in 2010. A total of 71 and 61 BRUV deployments were made in the proposed Multiple Use Zone in 2008 and 2010, respectively (Figure 117).

In 2008, 26 fish species from 20 families were observed in the stereo BRUV footage (Table 35). In 2010, a slightly less diverse fish assemblage was recorded, with 21 fish species from 14 families (Table 35). Carangids and Labrids were most speciose families (Table 35). Fish abundances across the two sampling periods was generally low with exception to trevally (*Pseudocaranx* spp), pike (*Dinolestes lewini*), western king wrasse (*Coris auricularis*), western Australian chromis (*Chromis westaustralis*) and perch (*Caesioperca* spp) which were found in moderate abundances (Table 35). Interestingly, most of these abundant species where observed on a select number of BRUV deployments. For example, western king wrasse was only observed on two deployments on each sampling period, with higher abundances in the deeper waters of the AMP (Figure 118).

Table 35. Fish species recorded using stereo BRUVs in the two rocks AMP based on deployments undertaken in 2008 and 2010. Abundance was measured using MaxN.

Family	Scientific name	Common name	Abundance (2008)	Abundance (2010)	Abundance (Total)
Antennariidae	*Histiophryne bougainvilli*	Smooth Anglerfish		1	1
Aplodactylidae	*Aplodactylus westralis*	Western seacarp	1		1
Aulopidae	*Aulopus purpurissatus*	Sergent baker	7	6	13
Berycidae	*Centroberyx lineatus*	Swallowtail	2		2
Carangidae	*Decapterus muroadsi*	Amberstripe scad	1		1
	Pseudocaranx spp	Trevally	154	91	245
	Seriola hippos	Samson fish	7	8	15
	Seriola lalandi	Yellowtail kingfish		1	1
	Trachurus novaezelandiae	Yellowtail scad	1	7	8
Carcharhinidae	*Carcharhinus plumbeus*	Sandbar shark		1	1
	Carcharhinus spp	Shark		1	1
	Galeocerdo cuvier	Tiger shark		1	1
Chaetodontidae	*Chelmonops curiosus*	Western talma	6	4	10
Cheilodactylidae	*Nemadactylus valenciennesi*	Blue morwong	1	3	4
Dasyatidae	*Dasyatis brevicaudata*	Smooth ray	2	7	9
Dinolestidae	*Dinolestes lewini*	Pike	60		60
Enoplosidae	*Enoplosus armatus*	Old wife	1		1
Gerreidae	*Parequula melbournensis*	Silverbelly		3	3
Glaucosomatidae	*Glaucosoma hebraicum*	Western jewfish	3	5	8
Haemulidae	*Plectorhinchus flavomaculatus*	Goldspotted sweetlip		1	1
Heterodontidae	*Heterodontus portusjacksoni*	Port jackson shark	1	5	6
Labridae	*Austrolabrus maculatus*	Black spotted wrasse	7		7
	Bodianus frenchii	Foxfish		1	1
	Choerodon rubescens	Baldchin grouper	1	1	2
	Coris auricularis	Western king wrasse	36	21	57

Family	Scientific name	Common name	Abundance (2008)	Abundance (2010)	Abundance (Total)
	Ophthalmolepis lineolatus	Southern maori wrasse	3		3
	Pseudolabrus biserialis	Redband wrasse	2		2
Mullidae	*Upeneichthys vlamingii*	Goatfish	2		2
Myliobatidae	*Myliobatis australis*	Eagle ray	1		1
Pomacentridae	*Chromis westaustralis*	Western australian chromis	23		23
Scorpididae	*Scorpis georgiana*	Banded sweep	1		1
Serranidae	*Caesioperca* sp	Perch	31		31
	Epinephelides armatus	Black-arse cod		2	2
Sparidae	*Chrysophrys auratus*	Snapper	1	10	11
Tetraodontidae	*Lagocephalus sceleratus*	Silver-cheeked toadfish	1		1

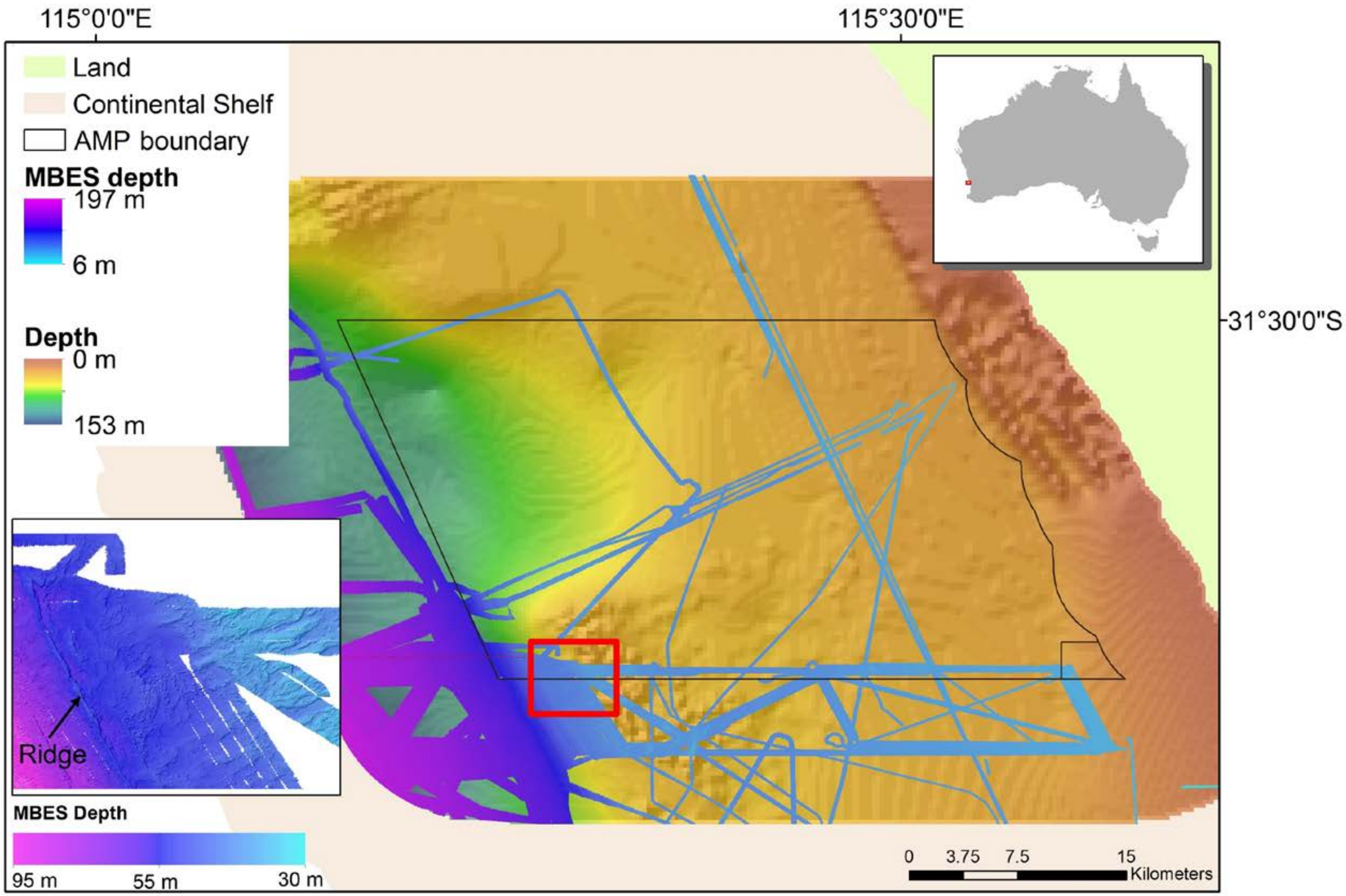


Figure 115. Mapping coverage of the Two Rocks AMP based on the Australian Bathymetry and Topography Grid, produced by Geoscience Australia in June 2009. Note the fine-scale 5-m resolution multibeam sonar (MBES depth) collected by the CSIRO Southern Survey/Investigator.

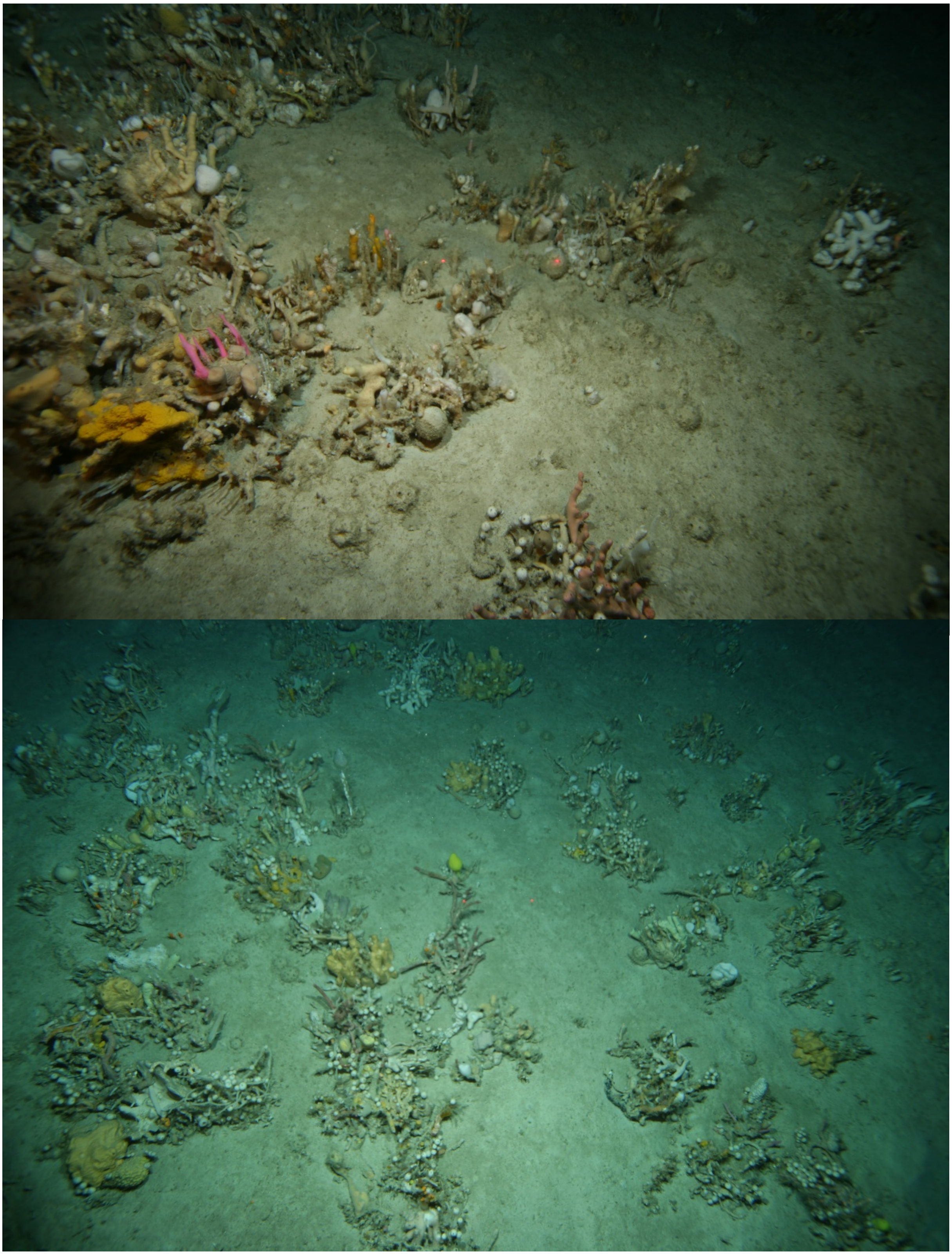


Figure 116. The sessile invertebrate assemblage as captured on towed video in the Two Rocks AMP during the Voyage of Discovery.

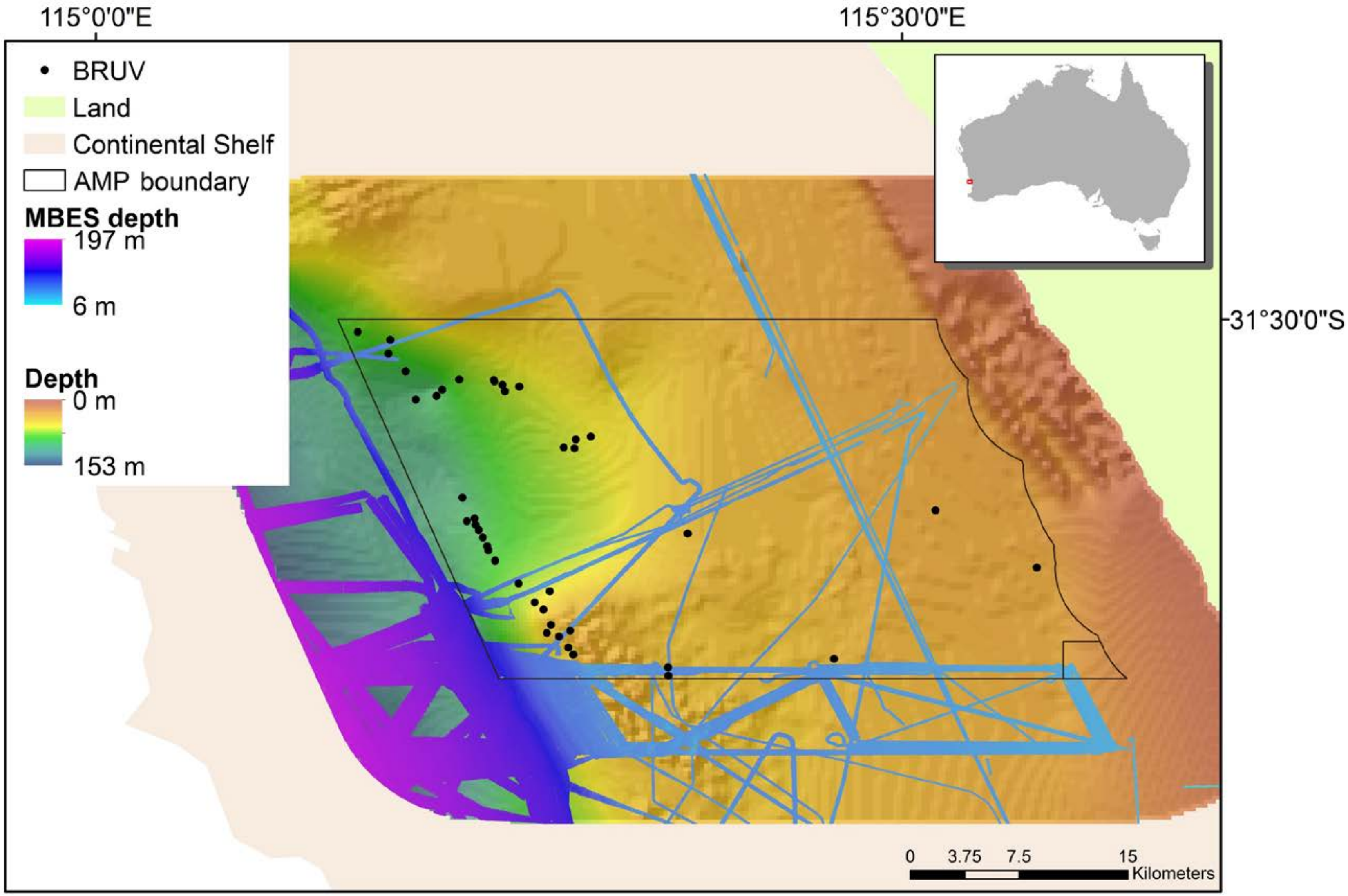


Figure 117. Location of repeated stereo BRUV sampling undertaken in 2008 and 2010 in two rocks AMP.

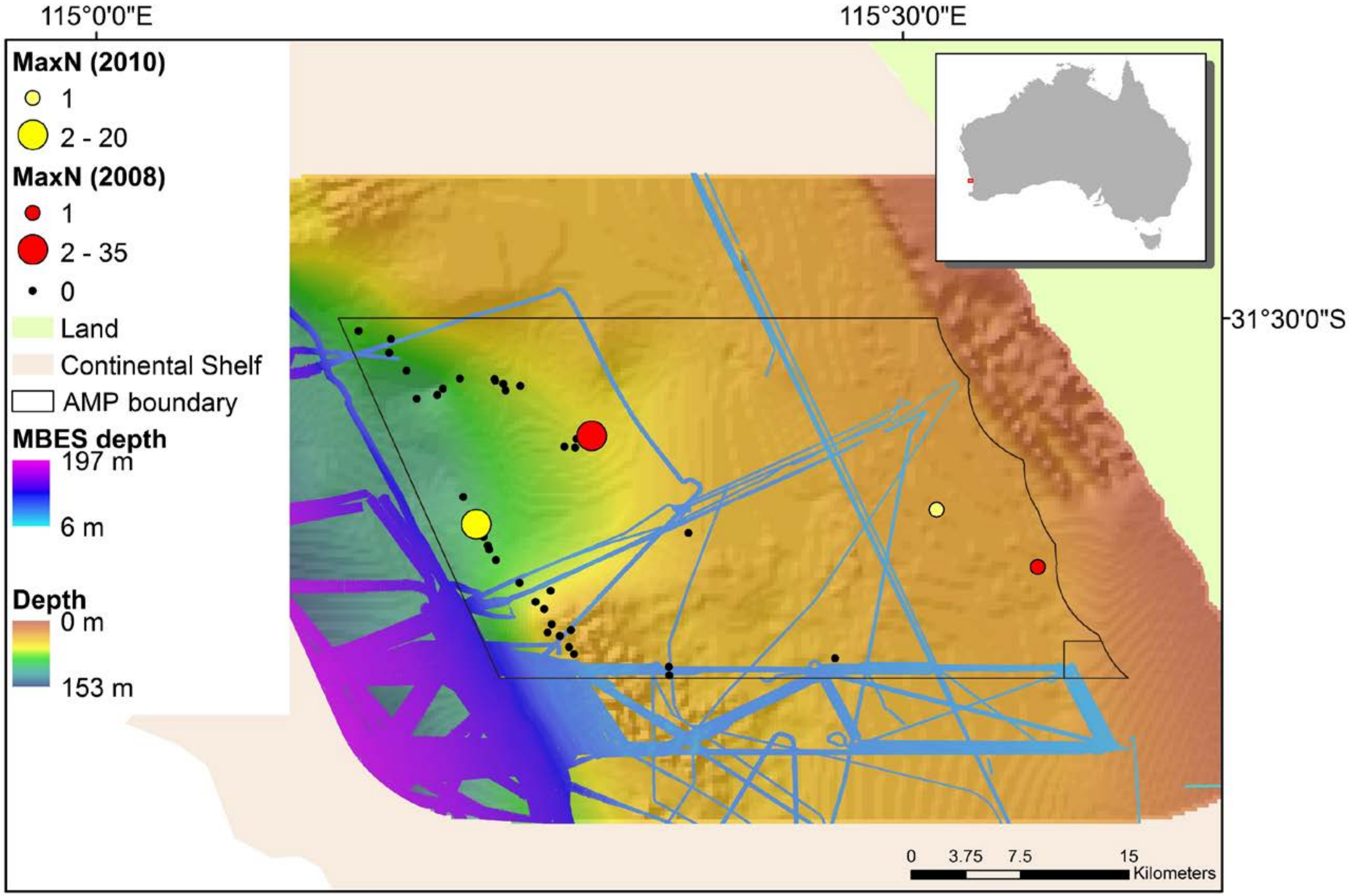


Figure 118. Abundance distribution of western king wrasse in the BRUV deployments in the two rocks AMP.

4.16 Western Eyre AMP

4.16.1 Description of physical habitat

Mapping data for the the Western Eyre AMP consists of the Australian Bathymetry and Topography Grid and fine-scale MBES surveys from CSIRO Southern Survey/Investigator vessel transits (Figure 119). Mapping data show a number of potential reef features in < 100 m of water along the state waters boundary and in particular around Saint Francis Island, between Streaky Bay and Venus Bay, and around the Investigator Group Conservation Park islands (Figure 119 and Figure 147 in Appendix A).

4.16.2 Description of biological assemblages

The only biological dataset that was identified for the Western Eyre AMP is associated with CSIROs Great Australian Bight mapping project, with five-towed video transects being completed. As this data is restricted access, we are yet to provide a summary of the biology associated with the survey.

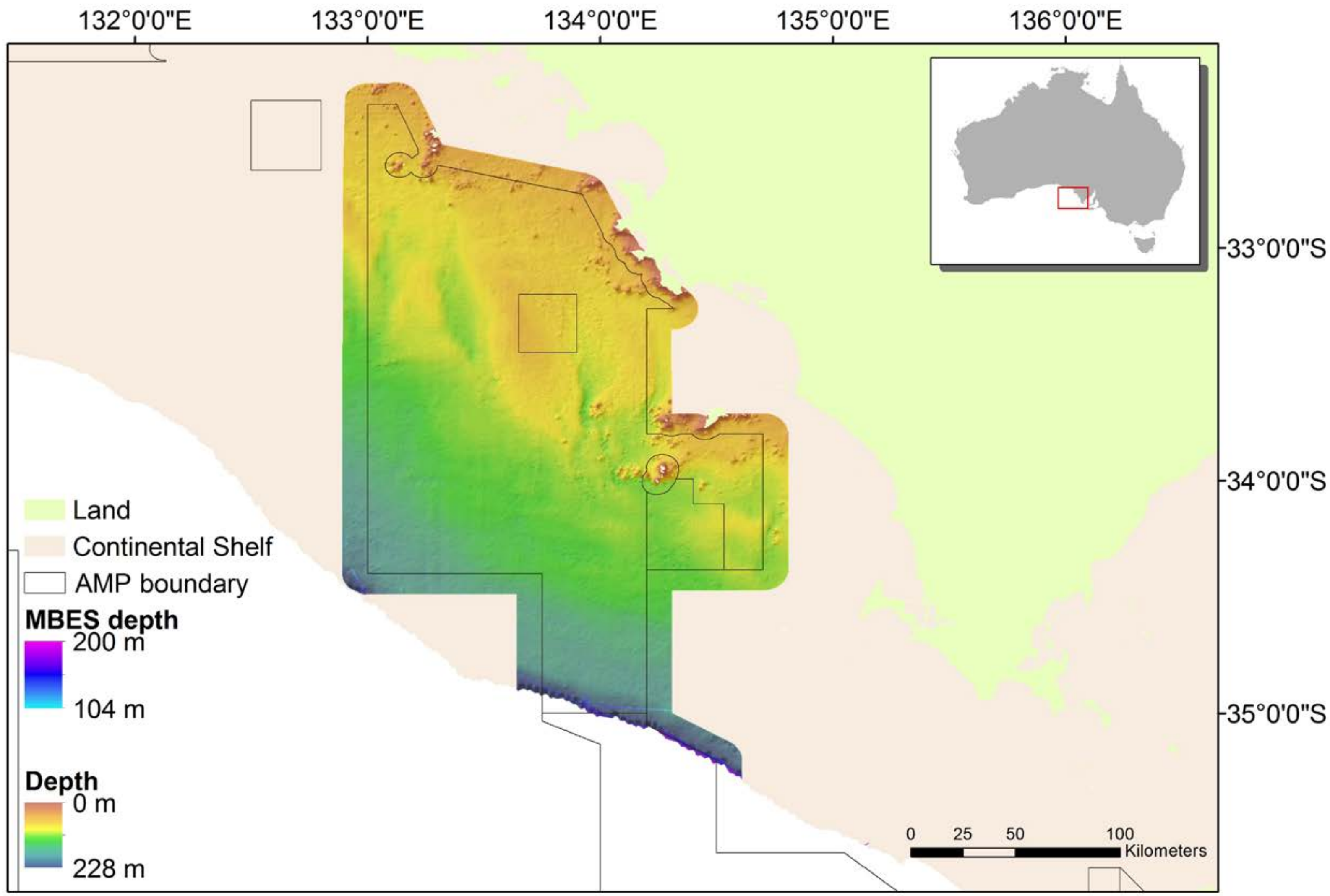


Figure 119. Mapping coverage of the Western Eyre AMP based on the Australian Bathymetry and Topography Grid, produced by Geoscience Australia in June 2009. Note no fine-scale 5-m resolution multibeam sonar (MBES depth) is available for Western Eyre AMP.

4.17 Western Kangaroo Island AMP

4.17.1 Description of physical habitat

Mapping data for the the Western Kangaroo Island AMP consists of the Australian Bathymetry and Topography Grid and fine-scale MBES surveys from CSIRO Southern Survey/Investigator vessel transits (Figure 120). The continental shelf region of the Western Kangaroo Island AMP represents 100 % of its total area. The fine-scale MBES data covers only 4 % of the continental shelf region of the AMP and indicates that depth ranges from ~ 36 to 200 m (Figure 120). Mapping data show a number of potential reef features in < 100 m, including a ridge of peaks running north to south in the centre of the AMP (Figure 120 and Figure 148 in Appendix A).

4.17.2 Description of biological assemblages

There are currently no biological data available for the Western Kangaroo Island AMP.

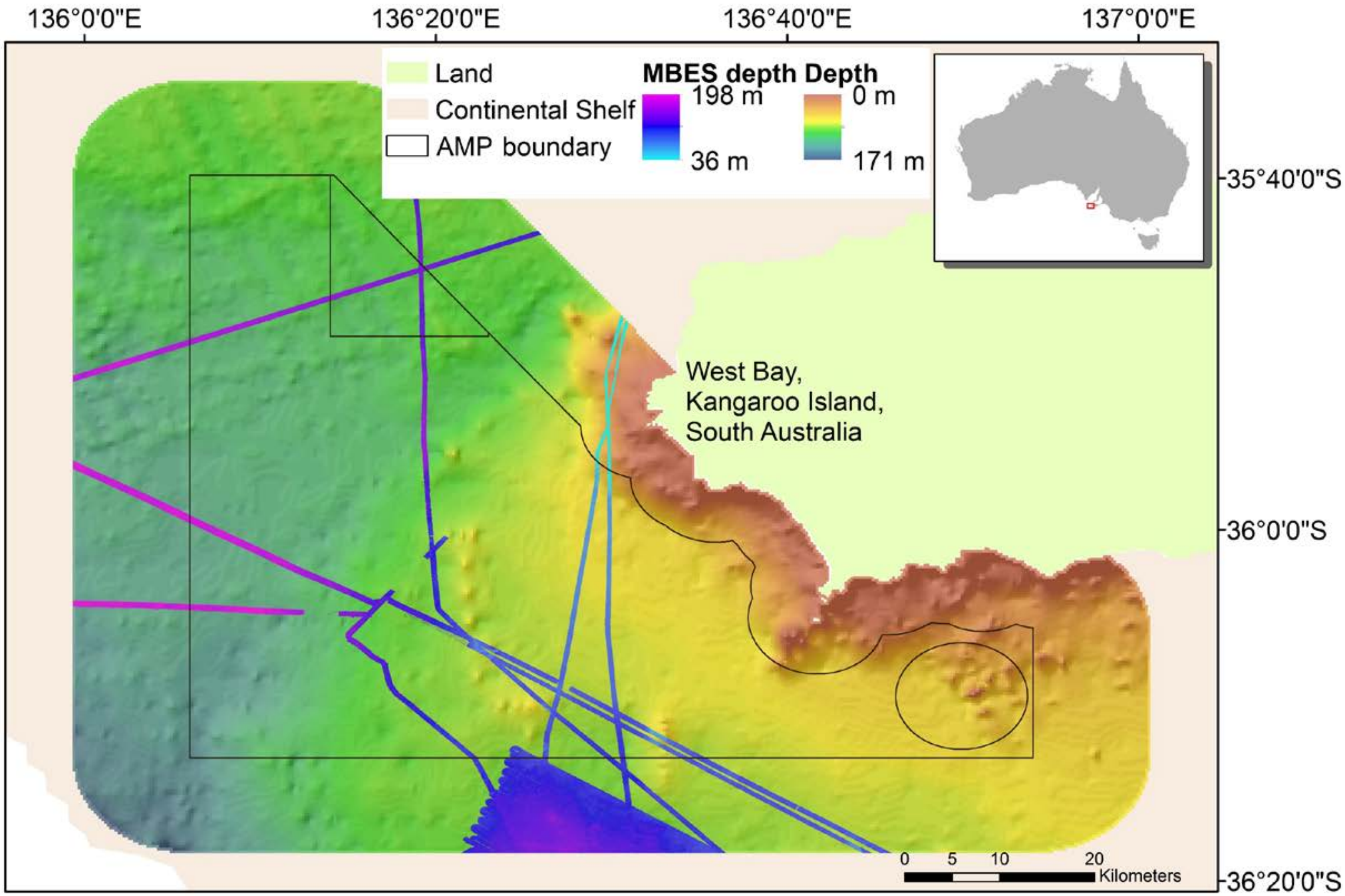


Figure 120. Mapping coverage of the Western Kangaroo Island AMP based on the Australian Bathymetry and Topography Grid, produced by Geoscience Australia in June 2009. Note the fine-scale 5-m resolution multibeam sonar (MBES depth) collected by the CSIRO Southern Survey/Investigator.

5. CONCLUDING SUMMARY OF MAJOR DATA GAPS WITHIN THE TEMPERATE WATER AMP NETWORKS

With a particular focus on the AMPs within the Temperate east, South-east and South-west marine planning regions this project has made a considerable step forward in the collation, synthesis and access to a wide range of datasets describing the distribution of reef habitats and associated sessile and mobile biota. A key outcome of this compilation project was to provide an updated synthesis of our current understanding of the physical reef habitats and associated biota within the continental shelf regions of the AMPs.

The synthesis of seafloor mapping data suggests that the continental shelf regions within the AMPs in the Temperate east and South-east marine planning regions are the most comprehensively mapped, with 16 % and 17 % being mapped with MBES, respectively (Table 36). Considerably less mapping has been undertaken on the continental shelf regions within the AMPs in the South-west marine planning region, with 3 % of the shelf habitats being mapped with MBES. At an individual AMP level, Lord Howe, Cod Grounds, Perth Canyon and Tasman Fracture are the most comprehensively mapped (Table 36). While the continental shelf regions within Apollo, Great Australian Bight, Murat, Murray, Southern Kangaroo Island, Twilight, and Western Eyre are the least mapped with < 1 % coverage (Table 36). Importantly, Boags, Carter Island and Central Eastern have no fine-scale MBES seafloor mapping data (Table 36).

We have also identified publications and associated datasets that have facilitated an updated description of reef-affiliated seabed biota in 68 % of the continental shelf regions of the AMPs within the Temperate east, South-east and South-west marine planning regions (Table 36). Through this process we found that six seabed biota sampling gear types have been used within the continental shelf regions of the AMPs, with towed video being the most commonly deployed sampling gear (used in 58 % of temperate water AMPs), followed by sleds (35 % of temperate water AMPs), AUV and SCUBA (19 % of temperwater AMPs each). Beam trawls and animal-borne cameras were the remaining gear types identified, being deployed in one AMP each. It should be noted that 42 % of temperate water AMPs are beyond safe diving depths; hence, the limited number datasets associated with traditionally more commonly used SCUBA diver-based underwater visual census transects (Table 36).

We identified 11 AMPs with no scientific sampling of seabed reef-affiliated biota, including: Boags, Bremer, Central Eastern, Eastern Recherche, Hunter, Jervis, Jurien, Murray, Southern Kangaroo Island, Twilight and Western Kangaroo Island (Table 36). Most of our understanding of reef-affiliated sessile seabed biota comes from, often limited, towed video transects undertaken by CSIRO and others, which were done for a different purpose prior to AMP boundaries being established. While this data may form a valuable source of “before” data, the lack of contempory sampling within AMPs should be noted.

Only six AMPs were identified as having AUV transects, with five in the South-east marine planning region (i.e. Beagle, Huon, Flinders, Freycinet and Tasman Fracture AMPs) and one in the South-west marine planning region (i.e. Geographe AMP). However, it should be noted that an AUV survey is proposed for the Hunter AMP later in the 2017/18 supported by the Integrated Marine Observing Facility (IMOS). Importantly, there is a lack of AUV transects in the AMPs along most of the AMPs (in particular along the southern coastline west of Bass Strait) represents a significant gap in Australia's AUV monitoring programme.

An opportunity exists to annotate current BRUV footage to provide an initial description of seafloor habitats within AMPs where there is an absence of AUV or towed video transects. Four such AMPs include Bremer, Hunter, Eastern Recherche and Jurien. Additionally, the annotation of BRUV footage for seabed biota could provide an important dataset for prioritising further sampling efforts. Some of this annotation is currently underway through Hub partners and key other BRUV stake-holders (T. Langlois pers. comm.).

The project also identified datasets for reef-affiliated demersal fishes (and in some instances mobile invertebrate fauna such as southern rock lobster) (Table 36). From the data compilation, we were able to provide a revised description of reef-affiliated demersal fishes for 78 % of the continental shelf zones within the AMPs in the Temperate east. In the South-east marine planning region, we were able to identify datasets on reef-affiliated demersal fish for 50 % of the AMPs. This process highlighted that the AMPs in Bass Strait were generally the least sampled. Similarly, in the South-west marine planning region there are BRUV datasets describing the reef-affiliated fish assemblages for 57 % of the AMPs. For some of the reef-fish dataset identified in the South-west marine planning region we have been unable to access these data in the timeframe of this project. In addition, we may have inadvertently missed datasets held, mostly by the oil and gas industry and consulancies, particularly in the GAB region. Importantly, however, we have identified a number of AMPs with no sampling for reef-affiliated fishes, these include; Apollo, Boags, Central Eastern, Great Australian Bight, Huon, Jervis, Jurien, Murat, Murray, Southern Kangaroo Island, Two Rocks, Western Kangaroo Island, Zeehan (Table 36). It should also be noted that there is limited fish data available for the Beagle AMP, with our current knowledge generated from four BRUV deployments and animal-borne cameras, the latter representing a non-traditional form of surveying fishes.

The collation process undertaken by this project has drawn attention for the need of improved data curation and cataloguing onto public databases. The Hub has recognised this and through the instruction of Standard Operating Procedural documents, which will be drafted by the end of 2017 for all physical and biological data collected by the Hub, this bottleneck for data access will be thoroughly addressed. Further to this, we have been able to evaluate and improve the comprehensiveness of online data portals such as CSIROs Australian Region MArine Data Aggregation (ARMADA; http://www.cmar.csiro.au/data/armada/region_summary_by_gear.cfm?set=2&region_set=Commonwealth%20Marine%20Reserves). For example, the ARMADA platform now contains the ability to summarise physical and biological datasets from geoservers around Australia by AMP and proposed zones. In addition, the data collected is assisting in the develop of new interactive data portals such SeaMap Australia (www.seamapaustralia.org), GlobalArchive (www.globalarchive.org) and Squidle + (http://squidle.greybits.com.au) that are currently in beta testing phase, with the latter two providing a mechanism to lodge, explore and download unprocessed and processed BRUV and AUV imagery, respectively. Squidle + also facilitates image annotation for imagery. These online data portals will improve the discovery of these datasets via links to the AODN.

Finally, managers now have a comprehensive document (as well as links to databases containing datasets) describing the key biological and geological features for the reef-habitats found on the continental shelf regions of each temperate-water AMP. Further, mapping data provides valuable resource from which monitoring designs can be based (e.g. Foster et al. 2017), while identified biological datasets provide the basis for contrasts with future monitoring studies.

Table 36. Gap analysis of available data for continental shelf regions of the temperate water AMP network. # No coverage on continental shelf. * Including quickbird satellite derived depth data. MBES coverage is based in 5-m resolution data. ** Does not include MBES data collected in 2017 as this data requires access clearance from Department of Defence. ## Not assessed. NA Beyond safe diving limits.

					Seabed reef biota data				Demersal reef fish data			
Marine planning region	**AMP**	**Area on shelf (km²)**	**Habitat Map Coverage (%)**	**MBES Coverage (%)**	**AUV**	**TV**	**Sled/Grab**	**Other**	**SCUBA**	**BRUV**	**TV**	**Other**
Temperate east	Central Eastern	346	0	0					NA			
	Cod Grounds	4	97.65	97.65		Y			Y	Y	Y	
	Gifford	0	#									
	Hunter	1,307	8.7	13.43					Y	Y		
	Jervis	103	1.93	34.44					NA			
	Lord Howe	447	100	100*		Y			Y	Y		
	Norfolk	161	#			Y			Y			
	Solitary Islands	152	34.55	34.55		Y			Y	Y		Acoustic tags
South-east	Apollo	1,184	0.05	0			Y		NA			
	Beagle	2,928	0.06	30.48**	Y			Animal-borne	NA	Y		Animal-borne
	Boags	537	0	0					NA			
	East Gippsland	0	#									
	Flinders	798	3.88	20.59	Y	Y			NA	Y		
	Franklin	671	1.15	12.28		Y	Y		NA	Y		
	Freycinet	735	8.31	35.61	Y	Y	Y		NA	Y		
	Huon	1,783	1.96	26.76	Y	Y	Y		NA			

					Seabed reef biota data				Demersal reef fish data			
Marine planning region	AMP	Area on shelf (km^2)	Habitat Map Coverage (%)	MBES Coverage (%)	AUV	TV	Sled/Grab	Other	SCUBA	BRUV	TV	Other
	Macquarie Island	0	#									
	Murray	4,803	0.91	2.19					NA			
	Nelson	0	#									
	South Tasman Rise	0	#									
	Tasman Fracture	917	2.72	57.61	Y	Y	Y		NA	Y		
	Zeehan	733	7.3	14.07		Y	Y					
South-west	Abrolhos	11,097	1.49	5.37		Y	Y			Y		
	Bremer	1,561	4.46	3.98						Y		
	Eastern Recherche	5,289	1.45	2.21						Y		
	Geographe	965	4.08	25.40	Y				Y	Y	Y	
	Great Australian Bight	22,705	0.53	1.42		Y	Y		NA			
	Jurien	1,810	13.27	15.8						Y		
	Murat	923	0.24	0		Y						
	Perth Canyon	72	1.58	65.48		Y	Y		NA	Y		
	Southern Kangaroo Island	630	0.94	0.29								

Marine planning region	AMP	Area on shelf (km²)	Habitat Map Coverage (%)	MBES Coverage (%)	Seabed reef biota data				Demersal reef fish data			
					AUV	TV	Sled/Grab	Other	SCUBA	BRUV	TV	Other
	South-west Corner	11,940	1.37	6.43		Y	Y			Y		
	Twilight	4,572	0.31	0.69								
	Two Rocks	866	3.01	9.22		Y	Y	Beam Trawl		Y		
	Western Eyre	25,890	0.53	0		Y						
	Western Kangaroo Island	2,335	1.51	4.44								
North-west	Cartier Island	3	0	##		##			##			
	Dampier	1,238	2.86	##		##			##			
	Eighty Mile Beach	10,707	4.74	##		##			##			
	Gascoyne	2,561	7.66	##		##			##			
	Kimberley	72,170	3.61	##		##			##			
	Montebello	3,377	1.54	##		##			##			
	Ningaloo	1,574	7.69	##		##			##			
	Roebuck	304	0.75	##		##			##			
North	Arafura	23,047	0.38	##		##			##			
	Arnhem	7,476	2.7	##		##			##			
	Gulf of Carpentaria	24,077	1.83	##		##			##			
	Joseph Bonaparte Gulf	8,806	2.71	##		##			##			

					Seabed reef biota data				Demersal reef fish data			
Marine planning region	**AMP**	**Area on shelf (km^2)**	**Habitat Map Coverage (%)**	**MBES Coverage (%)**	**AUV**	**TV**	**Sled/Grab**	**Other**	**SCUBA**	**BRUV**	**TV**	**Other**
	Limmen	1,424	0.96	##		##			##			
	Oceanic shoals	75,235	5.97	##		##			##			
	Shark Bay	7,272	0.72	##		##			##			
	Wessel	6,196	0.76	##		##			##			
	Western Cape York	16,853	0.59	##		##			##			
Coral Sea	Coral Sea	187	2.59	##		##			##			

REFERENCES

Allen GR, Hoese DF, Paxton JR, Randall JE, Russell BC, Starck WA, Talbot FH, Whitley GP (1976) Annotated checklist of the fishes of Lord Howe Island. Records of the Australian Museum 30, pp 365–454

Allen GR, Paxton JR (1974) A tropical outpost in the Pacific. Australian Natural History 18, pp 50–55

Althaus F, Barrett NS, Dambacher JM, Davies P, Ferrari R, Ford J, Hayes KR, Hill N, Hosack GR, Hovey R, Huang Z, Hulls J, Ingleton T, Jordan A, Kendrick GA, Kool J, Lawrence E, Leeming R, Lucieer VL, Malcolm H, Meyer L, Monk J, Nichol SL, Peel D, Perkins NR, Siwabessy JPW, Sherlock M, Martin T, Tran M, Walsh A, Williams A (2016) Analysis of approaches for monitoring biodiversity in Commonwealth waters: Field work report. Report to the Department of the Environment. Marine Biodiversity Hub. 112 pp

Australian Museum Business Services (1998) Proposed Lord Howe Island Marine Park marine fish and invertebrate data investigation Report by Australian Museum Business Services for Environment Australia, Canberra

Australian Museum (1992) Reef Biology - A survey of Elizabeth and Middleton Reefs, South Pacific. Kowari 3. The Australian Museum, Sydney. An Australian National Parks and Wildlife Service publication

Bleeker P (1855) Over eenige visschen van Diemensland. Amsterdam: C. G. Van der

Barbier EB, Hacker SD, Kennedy C, Koch EW, Stier AC, Silliman BR (2011) The value of estuarine and coastal ecosystem services. Ecological Monographs 81: 169-193.

Butler A, Gowlett-Holmes K, Barker B (2000) Tasmanian Natural Gas Pipeline Project Pipeline Route Survey Aug-Sept 2000 Biological Data Report. CSIRO

Ceccarelli DM (2011) Australia's Coral Sea: A Biophysical Profile. Report for the Protect our Coral Sea Coalition 128 pp

Choat JH, Herwerden L, Robbins WD, Hobbs JP (2006) A report on the ecological surveys undertaken at Middleton and Elizabeth Reefs, February 2006. Report to Department of the Environment and Heritage. James Cook University 71 pp

Davies P, Ingleton T, Jordan A, Barrett N (2016) Mapping shelf rocky reef habitats in the Hunter Commonwealth Marine Reserve. Report to the National Environmental Science Programme, Marine Biodiversity Hub. NSW Office of Environment and Heritage 22 pp

Edgar GJ, Davey A, Kelly G, Mawbey R, Parsons K (2009) Biogeographical and ecological context for managing threats to coral and rocky reef communities in the Lord Howe Island

Marine Park, south-western Pacific. Aquatic Conservation: Marine and Freshwater Ecosystems. DOI: 10.1002/aqc.1075

Edgar GJ, Stuart-Smith RD 2014 Systematic global assessment of reef fish communities by the Reef Life Survey programme, Scientific Data, 1 Article 140007. doi:10.1038/sdata.2014.7 ISSN 2052-4463

Edgar GJ, Stuart-Smith RD (2017a) Reef Life Survey (RLS): Cryptic Fish. Institute for Marine and Antarctic Studies (IMAS). Data accessed at http://www.reeflifesurvey.com on 11 April 2017

Edgar GJ, Stuart-Smith RD (2017b) Reef Life Survey (RLS): Global Reef Fish Dataset. Institute for Marine and Antarctic Studies (IMAS). Data accessed at http://www.reeflifesurvey.com on 11 April 2017

Edgar GJ, Stuart-Smith RD (2017c) Reef Life Survey (RLS): Habitat Quadrats. Institute for Marine and Antarctic Studies (IMAS). Data accessed at http://www.reeflifesurvey.com on 11 April 2017

Edgar GJ, Stuart-Smith RD (2017d) Reef Life Survey (RLS): Invertebrates. Institute for Marine and Antarctic Studies (IMAS). Data accessed at http://www.reeflifesurvey.com on 11 April 2017

Foster SD, Hosack GR, Lawrence E, Przeslawski R, Hedge P, Caley MJ, Barrett NS, Williams A, Li J, Lynch T, Dambacher JM, Sweatman HPA, Hayes KR (2017) Spatially balanced designs that incorporate legacy sites. Methods in Ecology and Evolution 8:1433-1442

Francis MP (1991) Additions to the fish faunas of Lord Howe, Norfolk, and Kermadec islands, south-west Pacific Ocean. Pacific Science 45:204–220

Francis MP (1993) Checklist of the coastal fishes of Lord Howe, Norfolk, and Kermadec islands, south-west Pacific Ocean. Pacific Science 47:136–170

Francis MP, Harasti D, Malcolm HA (2016) Sureving under pressure and protection: a review of the biology, ecology and population status of the highly vulnerable grouper *Epinephelus daemelii*. Marine and Freshwater Research 67:1215-1228

Francis MP and Randall JE (1993) Further additions to the fish faunas of Lord Howe and Norfolk islands, south-west Pacific Ocean. Pacific Science 47:118–135

Gray JS (1997) Marine biodiversity: patterns, threats and conservation needs. Biodiversity and Conservation 6: 153-175.

Halpern BS, Walbridge S, Selkoe KA, Kappel CV, Micheli F, D'Agrosa C, Bruno JF, Casey KS, Ebert C, Fox HE, Fujita R, Heinemann D, Lenihan HS, Maden EM, Perry MT, Selig ER, Spalding M, Steneck R, Watson R (2008) A Global Map of Human Impact on Marine Ecosystems. Science 319:948–52.

Heagney E, Lynch TP, Babcock RC, Suthers I (2007) Pelagic fish assemblages assessed using mid-water baited video: standardising fish counts using bait plume size. Marine Ecology Progress Series 350:255-266

Hensley DA, Randall JE (1993) Description of a new flatfish of the Indo-Pacific genus *Crossorhombus* (Teleostei: Bothidae), with comments on congeners. Copeia 4:1119-1126

Hoey AS, Pratchett MS, Johansen J, Hoey J (2014) 2014 Marine ecological survey of Elizabeth and Middleton reefs, Lord Howe Commonwealth Marine Reserve. Report to the Department of the Environment. James Cook University 101 pp.

Hobbs JPA, Choat JH, Robbins WD, van Herwerden L, Feary DA (2008) Unique fish assemblages at world's southernmost oceanic coral reefs, Elizabeth and Middleton Reefs, Tasman Sea, Australia. Coral Reefs 27:15

Jordan A, Davies P, Ingleton T, Foulsham E, Neilson J, Pritchard T (2011) Seabed habitat mapping of the continental shelf of NSW. Department of Environment, Climate Change and Water NSW 206 pp

Kendrick G, Harvey E, McDonald J, Pattiaratchi C, Cappo M, Fromont J, Shortis M, Grove S, Bickers A, Baxter K, Goldberg N, Kletczkowski M, Butler J (2005) Characterising the fish habitats of the Recherche Archipelago. Report to the FRDC 2001/060

Kuiter RH (1993) A new pygmy seahorse (Pisces: Syngnathidae: *Hippocampus*) from Lord Hower Island. Record of the Australian Museum 55:113-116

Last PR, Stevens JD (2009) Sharks and rays of Australia. CSIRO Publishing, Collingwood, Australia

Lawrence E, Hovey R, Harvey E, Kendrick G, Hayes KR, Williams S (2016) Application of NERP Biodiversity Hub survey methodology to Geographe Commonwealth Marine Reserve. CSIRO report to Department of Environment

Leitch EC, Neilson MJ, Hobson E (1971) Dorrigo - Coffs Harbour 1:250 000 Geological Sheet SH/56-10 & part SH/56-11, 2nd edition, Geological Survey of New South Wales, Sydney

Linklater M (2016) Past and present coral distribution at the latitudinal limit of reef development, southwest Pacific Ocean. PhD Thesis, University of Wollongong

Linklater M, Brooke BP, Hamylton SM, Nichol SL, Woodroffe CD (2015) Submerged fossil reefs discovered beyond the limit of modern reef growth in the Pacific Ocean. Geomorphology 246:579-588

Linklater M, Carroll AG, Hamylton SM, Jordan AR, Brooke BP, Nichol SL, Woodroffe CD (2016) High coral cover on a mesophotic, subtropical island platform at the limits of coral reef growth. Continental Shelf Research 130:34-36

Lucieer V, Porter-Smith R, Nichol S, Monk J, Barrett N (2016) Collation of existing shelf reef mapping data and gap identification. Phase 1 Final Report - Shelf reef key ecological features. Report to the National Environmental Science Programme. Marine Biodiversity Hub, University of Tasmania.

Malcolm HA, Jordan A, Smith DA (2011) Testing a depth-based habitat classification system against reef fish assemblage patterns in a subtropical marine park. Aquatic Conservation 21:173-185

Marine Parks Authority (2010) Benthic fish assemblages in deep water habitats around Lord Howe Island. NSW Marine Parks Authority

Mleczko R, Sagar S, Spinoccia M, Brooke B (2010) The creation of high resolution bathymetry grids for the Lord Howe Island Region. Geoscience Australia Record 2010/36. 58pp

Monk J, Barrett NS, Hill NA, Lucieer VL, Nichol SL, Siwabessy JPW, Williams SB (2016a) Outcropping reef ledges drive patterns of epibenthic assemblage diversity on cross-shelf habitats. Biodiversity and Conservation 25:485-502

Monk J, Barrett NS, Hulls J, James L, Hosack G, Oh E, Martin T, Edwards S, Nau A, Heaney B, Foster S (2016b) Seafloor biota, rock lobster and demersal fish assemblages of the Tasman Fracture Commonwealth Marine Reserve Region: Determining the influence of the shelf sanctuary zone on population demographics. A report to the National Environmental Research Program, Marine Biodiversity Hub. Published by the University of Tasmania. 97 pp.

Nichol SL, Anderson TJ, McArthur M, Barrett N, Heap AD, Siwabessy PJW, Brooke B (2009) Southeast Tasmania Temperate Reef Survey, Post Survey Report. Geoscience Australia Record 2009/43, 73 pp

Nichol S, Huang Z, Howard F, Porter-Smith R, Lucieer V, Barrett, N (2016) Geomorphological classification of reefs - Draft Framework for an Australian Standard. Report to the National Environmental Science Program, Marine Biodiversity Hub. Geoscience Australia. 27 pp.

Australian Fisheries Management Authority (2010) Norfolk Island inshore fishery data summary 2006-2009. Australian Fisheries Management Authority, Canberra

O’Hara TD (2002) Benthic assemblages of Bass Strait. Museum Victoria, Melbourne

Otway NM, Burke AL, Morrison NS, Parker PC (2003) Monitoring and identification of NSW critical habitat sites for conservation of grey nurse sharks. New South Wales Fisheries Final Report Series No. 47. NSW Fisheries Office of Conservation, Nelson Bay, NSW. 62 pp

Oxley WG, Ayling AM, Cheal AJ, Osborne K (2004) Marine surveys undertaken in the Elizabeth and Middleton Marine National Nature Reserve, December 2003. Report for Deparment of the Environment and Heritage. Australian Institute of Marine Science 77pp

Volpov BL, Hoskins AJ, Battaile BC, Viviant M, Wheatley KE, Marshall G, Abernathy K, Arnould JPY (2015) Identification of prey captures in Australian fur seals (*Arctocephalus pusillus doriferus*) using head-mounted accelerometers: Field validation with animal-borne video cameras. PLoS ONE, 10, e0128789.

Ponder WF (1981) Marine mollusca, in HF Recher and WF Ponder (eds) Lord Howe Island: a summary of current and projected scientific and environmental activities, Occasional Reports of the Australian Museum No. 1, p 10

Ponder WF, Loch I Berents P (2000) An assessment of the marine invertebrate fauna of the Lord Howe Island shelf. Report prepared by the Australian Museum, Sydney for Environment Australia

Pratchett MS, Hobbs J A, Hoey AS, Baird AH, Ayling AM, Gudge S, Choat HJ (2011) Elizabeth and Middleton Reefs Marine National Nature Reserve, Marine Survey 2011. Report to the Department of Sustainability, Environmnet, Water, Population and Communities. James Cook University 89 pp

Speare P, Cappo M, Rees M, Brownlie J, Oxley W (2004) Deeper water fish and benthic surveys in the Lord Howe Island Marine Park (Commonwealth Waters): February 2004, report prepared by the Australian Institute of Marine Science, Townsville, for the Department of the Environment and Heritage, Canberra

van Herwerden L, Almojil D, Choat H (2008) Population genetic structure of Australian Galapagos reef sharks *Carcharhinus galapagensis* at Elizabeth and Middleton Reefs Marine National Nature Reserve and Lord Howe Island Marine Park. Final report to the Department of the Environment, Water, Heritage and the Arts. Prepared by the Molecular Ecology and Evolution Laboratory, School of Marine and Tropical Biology, James Cook University

Westera MB, Barnes PB, Kendrick GA, Cambridge ML (2007) Establishing benchmarks of seagrass communities and water quality in Geographe Bay, Western Australia. University of Western Australia.

Williams A, Althaus F, Barker B, Kloser R, Keith G (2007) Using data from the proposed Zeehan MPA to provide an inventory of benthic habitats and biodiversity, and evaluate prospective indicators for monitoring and performance assessment: research and monitoring for benthic ecosystems in marine protected areas of the South East Marine Region (SEMR). Final Report to the Department of the Environment and Water Resources

Woodroffe CD, Dickson ME, Brooke BP, Kennedy DM (2005) Episodes of reef growth at Lord Howe Island, the southernmost reef in the south-west Pacific. Global and Planetary Change 49;222–237

Woodroffe CD, Kennedy DM, Brooke BP, Dickson ME (2006) Geomorphological evolution of Lord Howe Island and carbonate production at the latitudinal limit to reef growth. Journal of Coastal Research 22:188–201

Woodroffe CD, Brooke BP, Linklater M, Kennedy DM, Jones BG, Buchanan C, Mleczko R, Hua Q, Zhao J (2010) Response of coral reefs to climate change: expansion and demise of the southernmost Pacific coral reef. Geophysical Research Letters 37

APPENDIX A – MAPS OF REEF COVERAGE ON THE CONTINENTAL SHELF WITHIN TEMPERATE WATER AMPS

The following maps show mapped reef extents within the continental shelf of each AMP. Specific details of this mapping can be found in Lucieer et al. (2016). Four tiers of data were generated by Lucieer et al. (2016) including:

1. TIER 1 data has been sourced from seafloor mapping programs completed around the nation by, predominantly, State-based/funded agencies. This mapped reef data represents the highest quality mapping data, with reef extents being field validated.

2. TIER 2 data was generated from the collation and reprocessing of CSIRO’s acoustic bathymetric data holdings on the continental shelf. A bathymetric analysis was used to identify high slope regions, which were interpreted as probable, but unvalidated, reef.

3. The creation of Tier 3 data involved the extraction reef features from the AHO S57 maps.

4. TIER 4 was created utilising the bathymetric data in the AHO S57 database. This TIER indicates the probability of a reef being present based on a bathymetric analysis of the AHO S57 data layers on the continental shelf.

Appendix A: Reef mapping of the Temperate east marine planning region

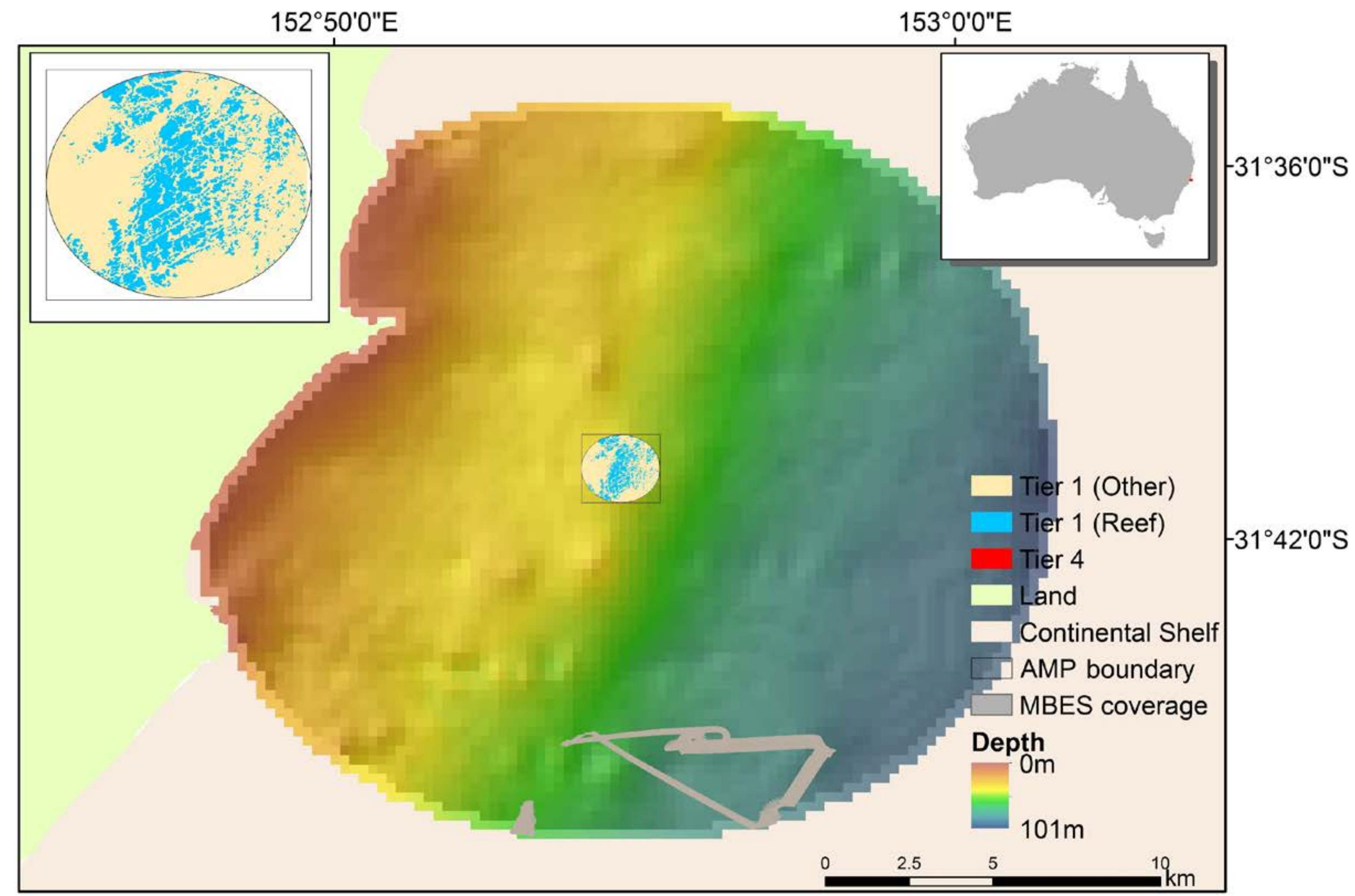


Figure 121. Reef mapping extents within the continental shelf zone of the Cod Grounds AMP.

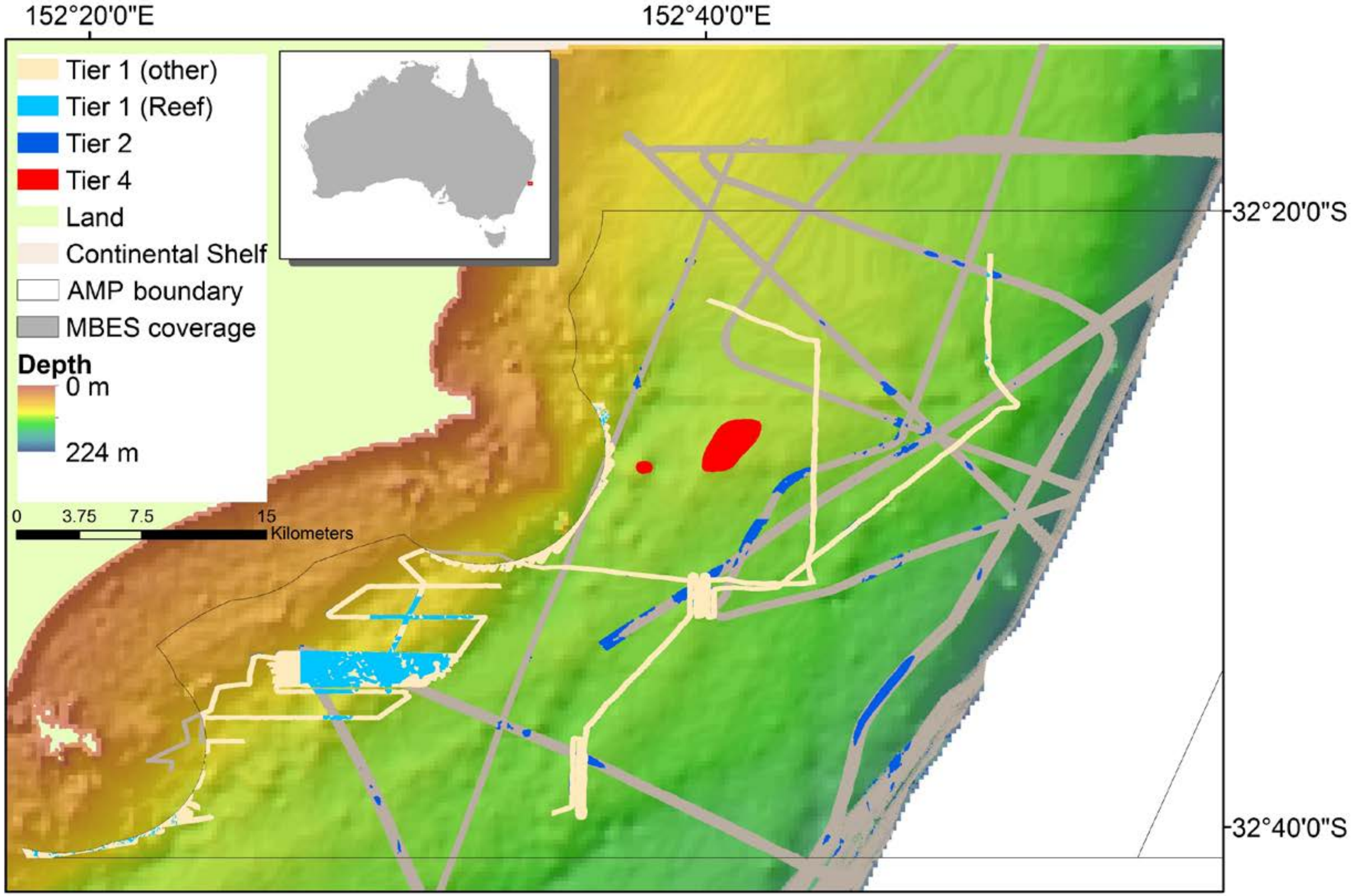


Figure 122. Reef mapping extents within the continental shelf zone of the Hunter AMP.

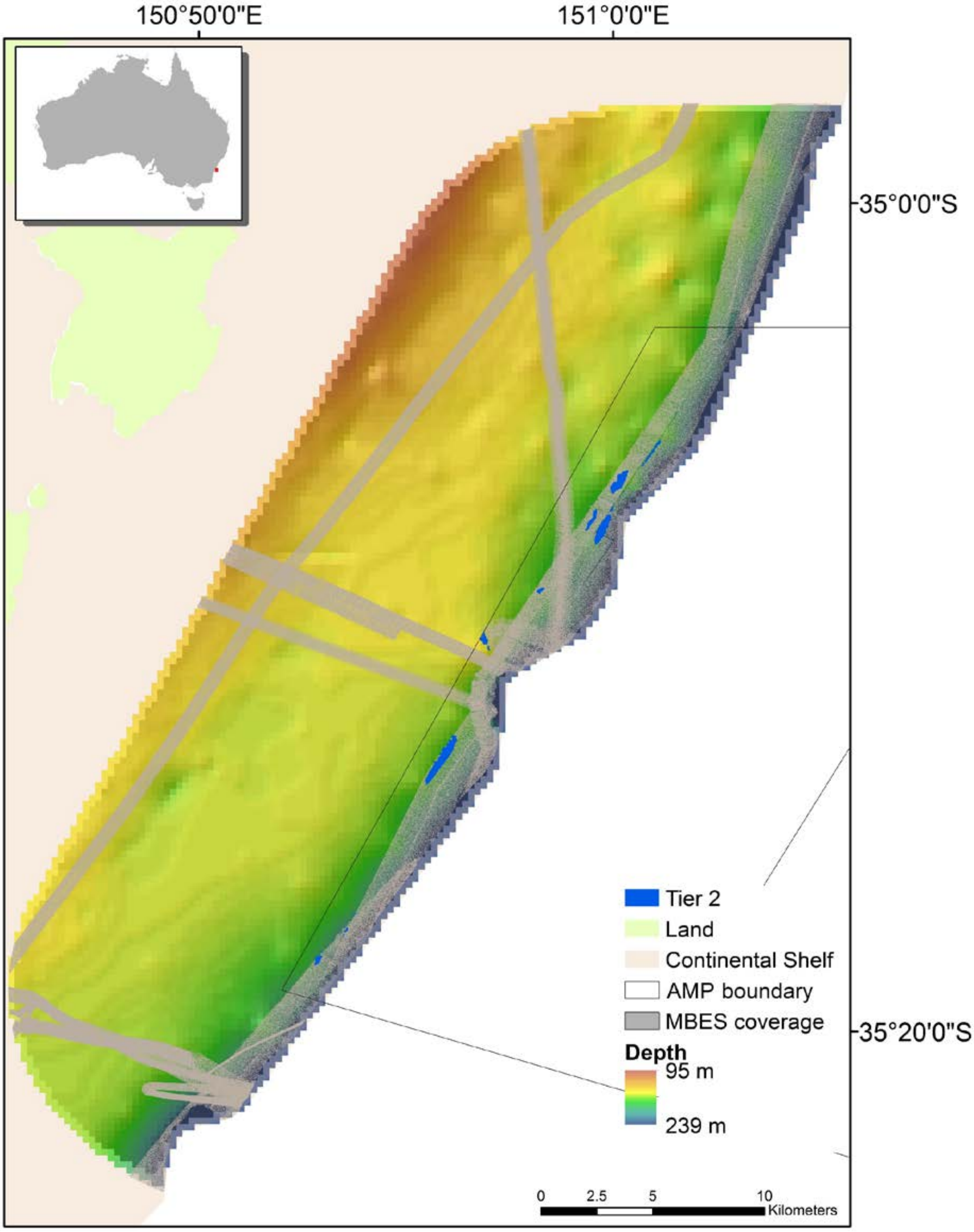


Figure 123. Reef mapping extents within the continental shelf zone of the Jervis AMP.

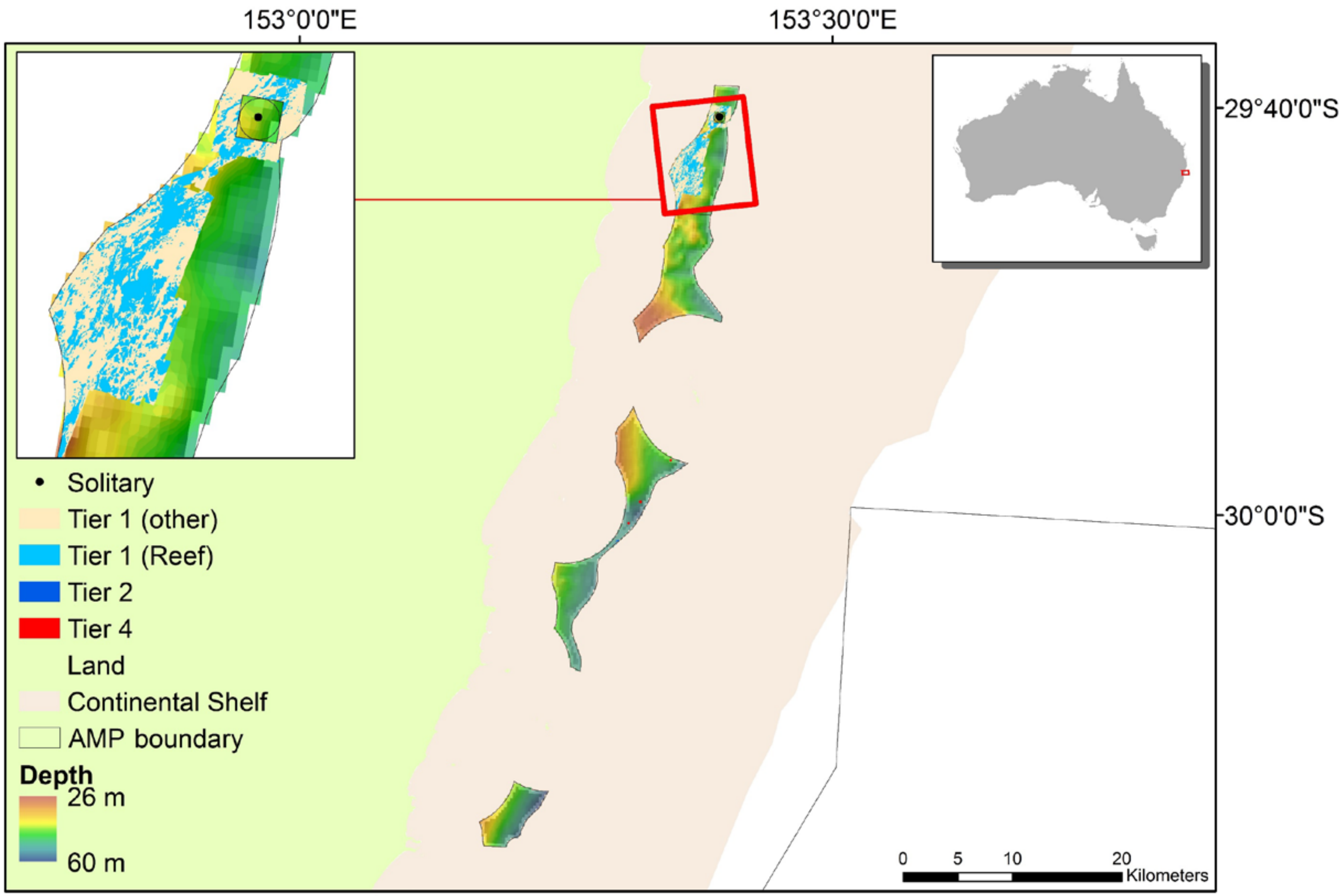


Figure 124. Reef mapping extents within the continental shelf zone of the Solitary Islands AMP.

Appendix A: Reef mapping of the South-east marine planning region

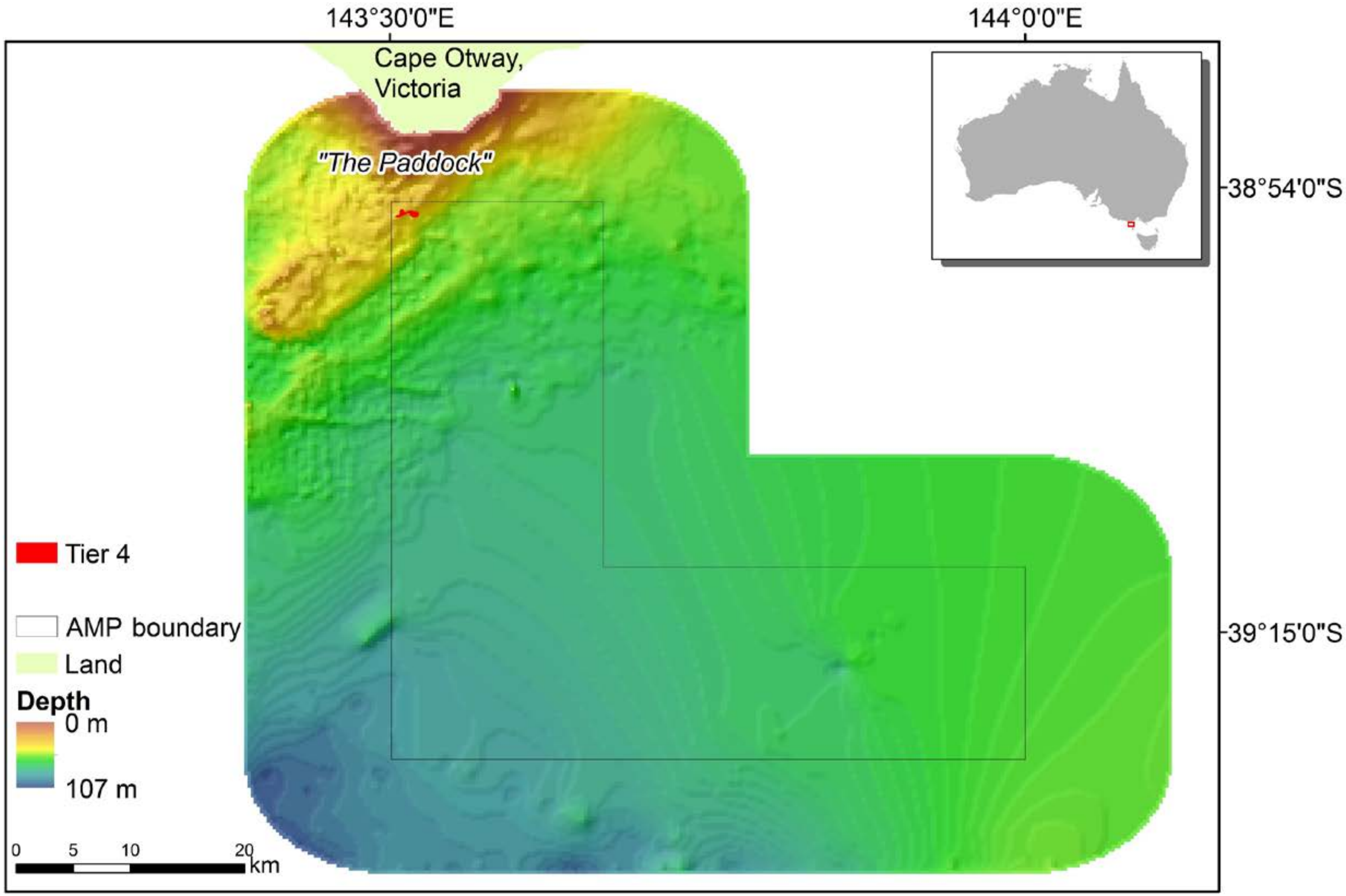


Figure 125. Reef mapping extents within the continental shelf zone of the Apollo AMP.

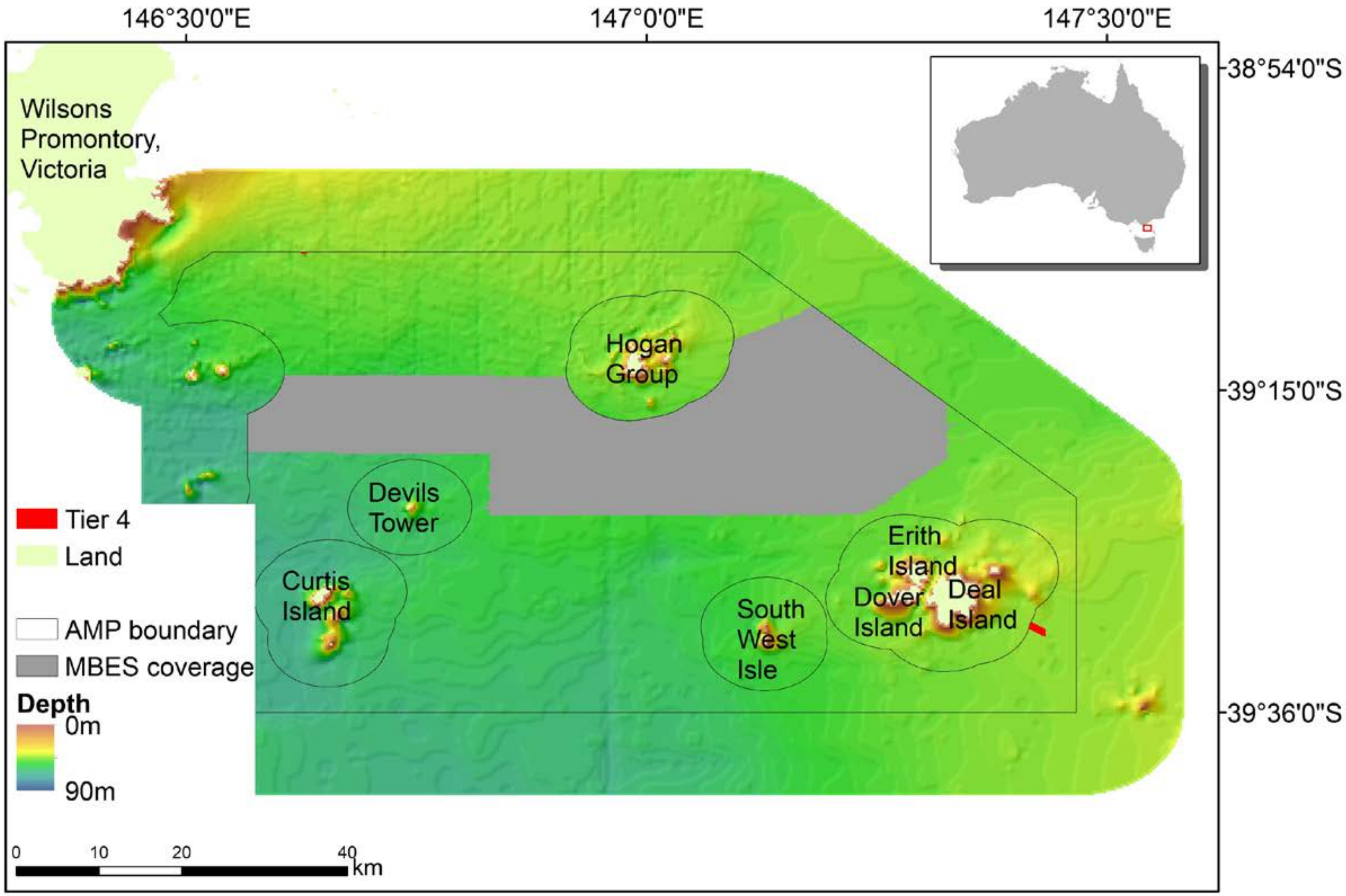


Figure 126. Reef mapping extents within the continental shelf zone of the Beagle AMP.

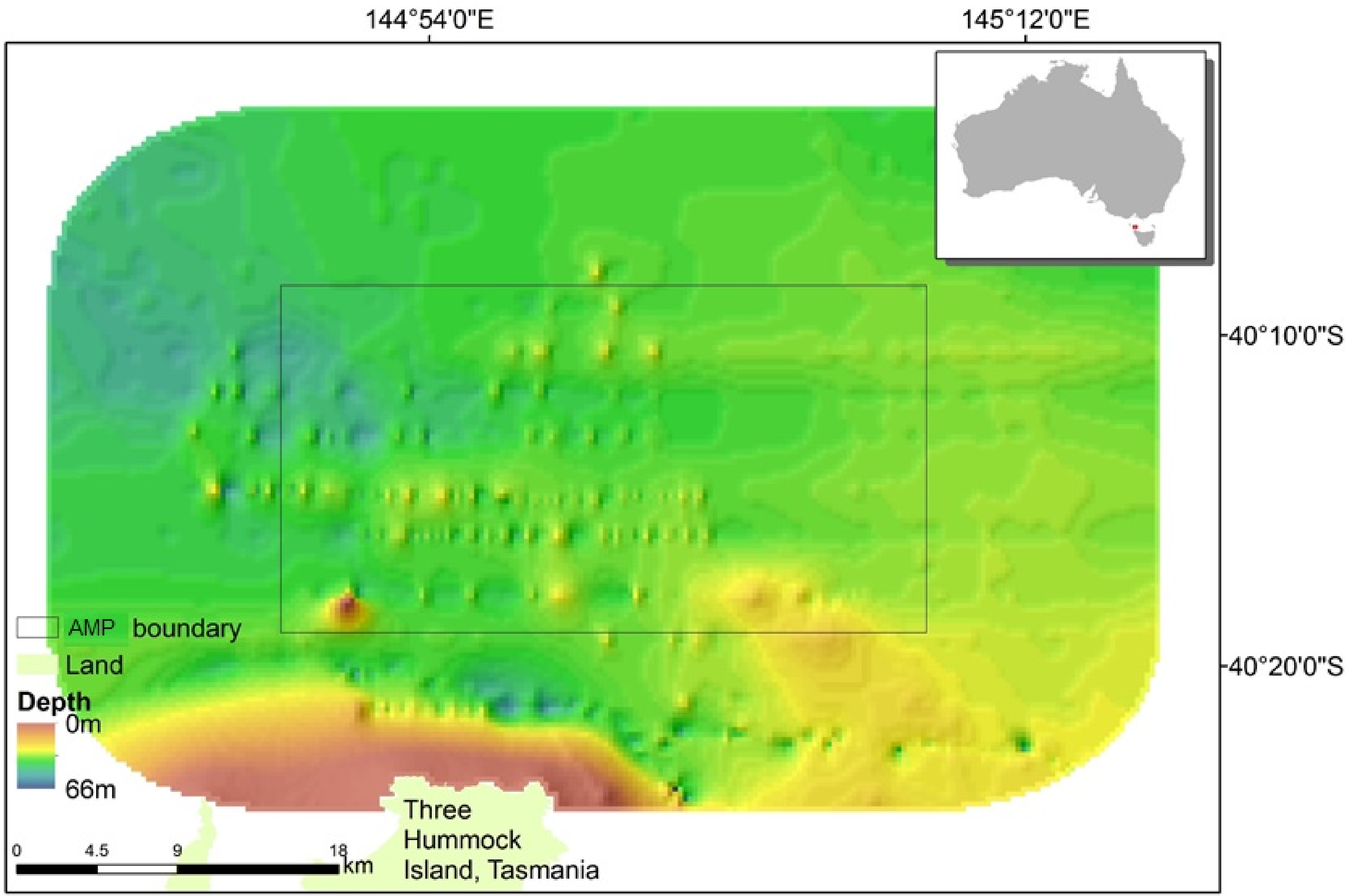


Figure 127. Reef mapping extents within the continental shelf zone of the Boags AMP.

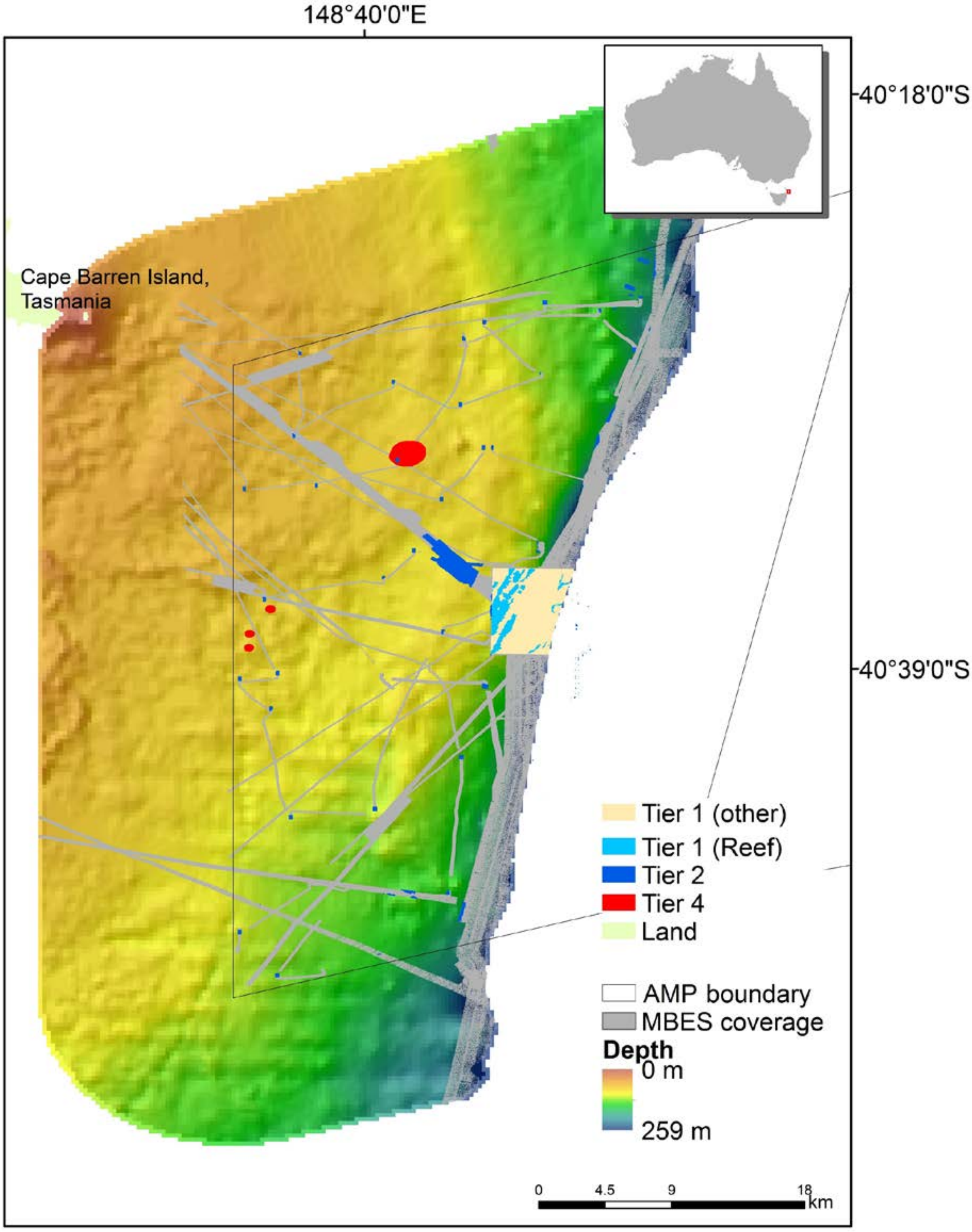


Figure 128. Reef mapping extents within the continental shelf zone of the Flinders AMP.

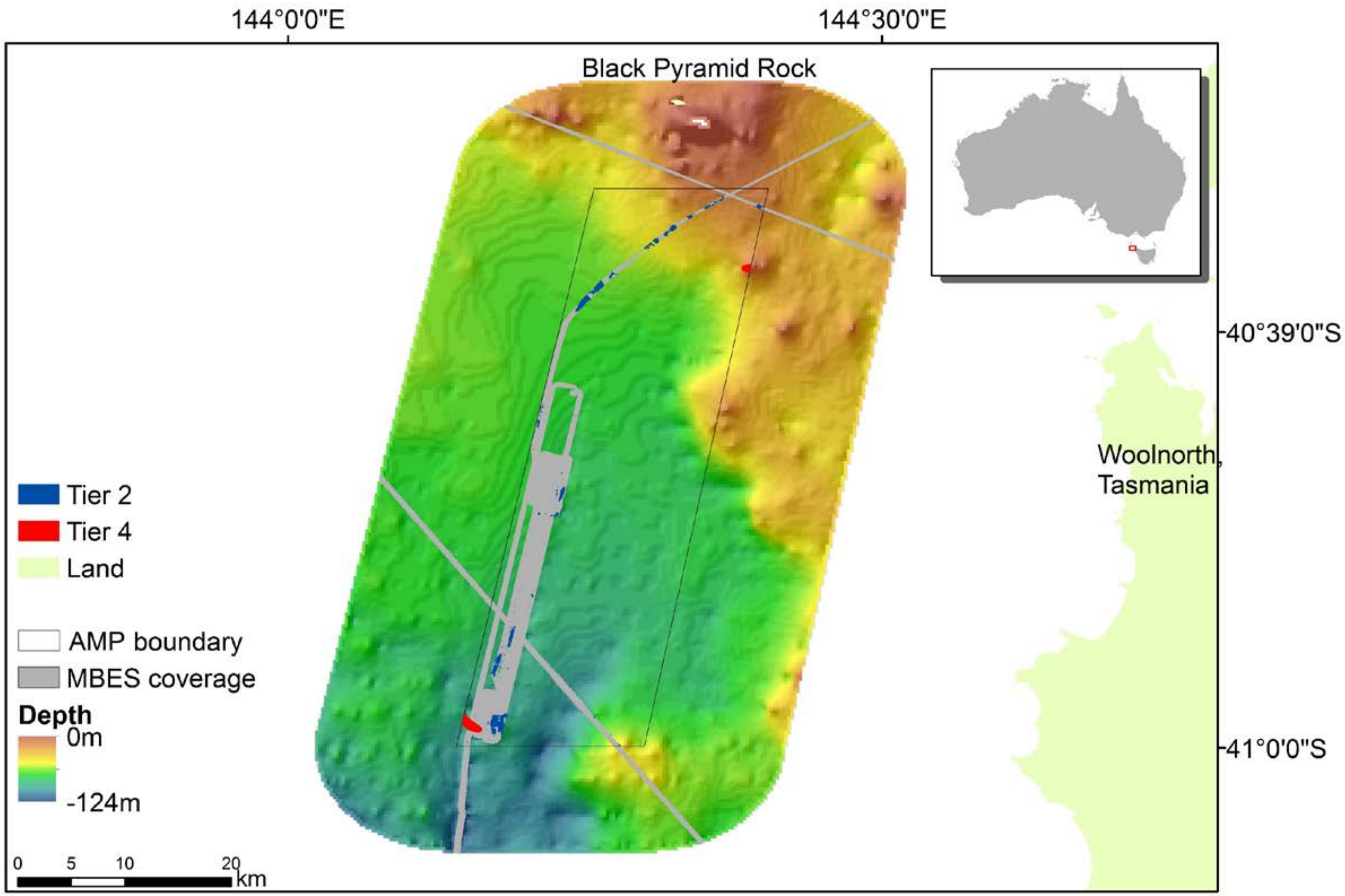


Figure 129. Reef mapping extents within the continental shelf zone of the Franklin AMP.

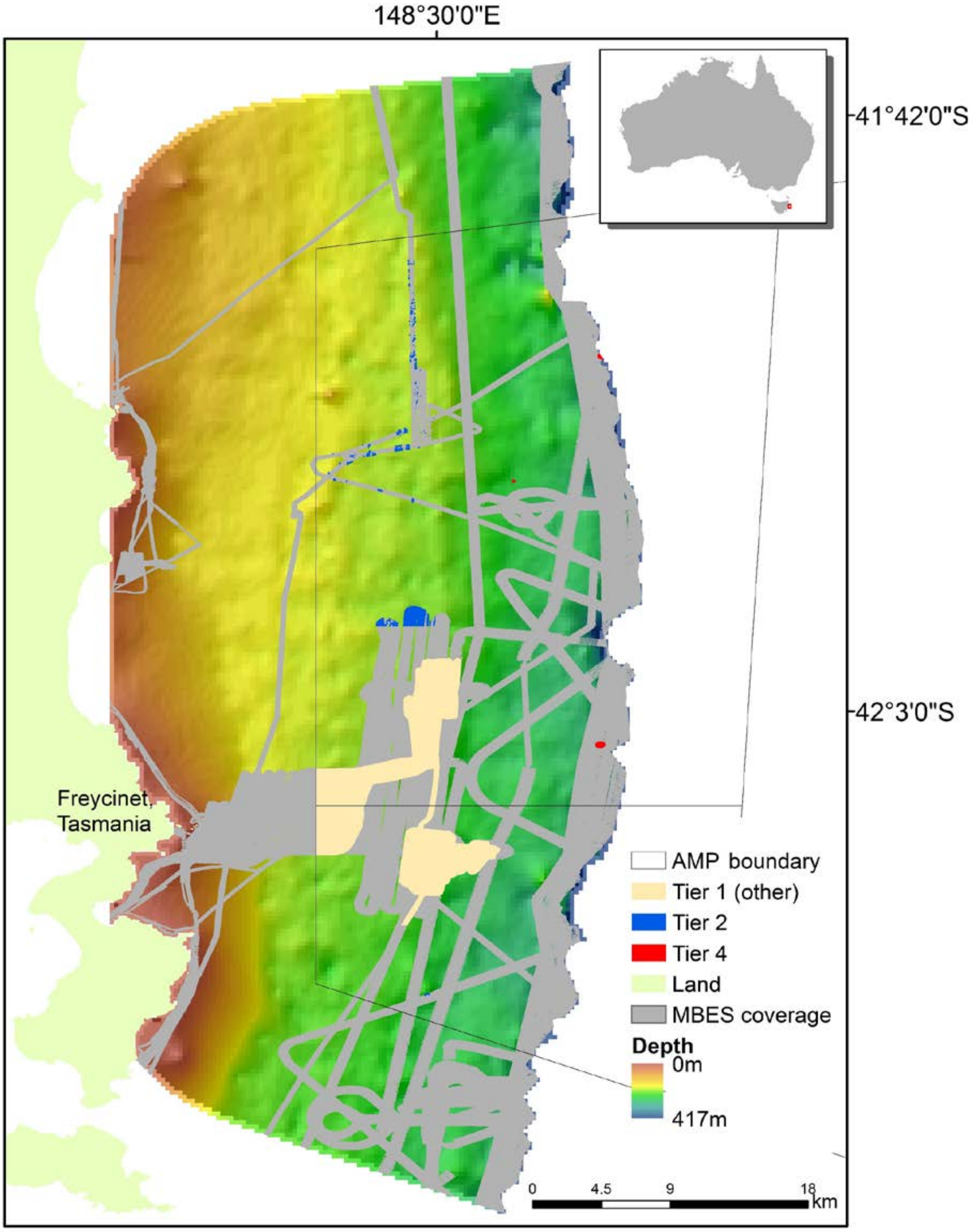


Figure 130. Reef mapping extents within the continental shelf zone of the Freycinet AMP.

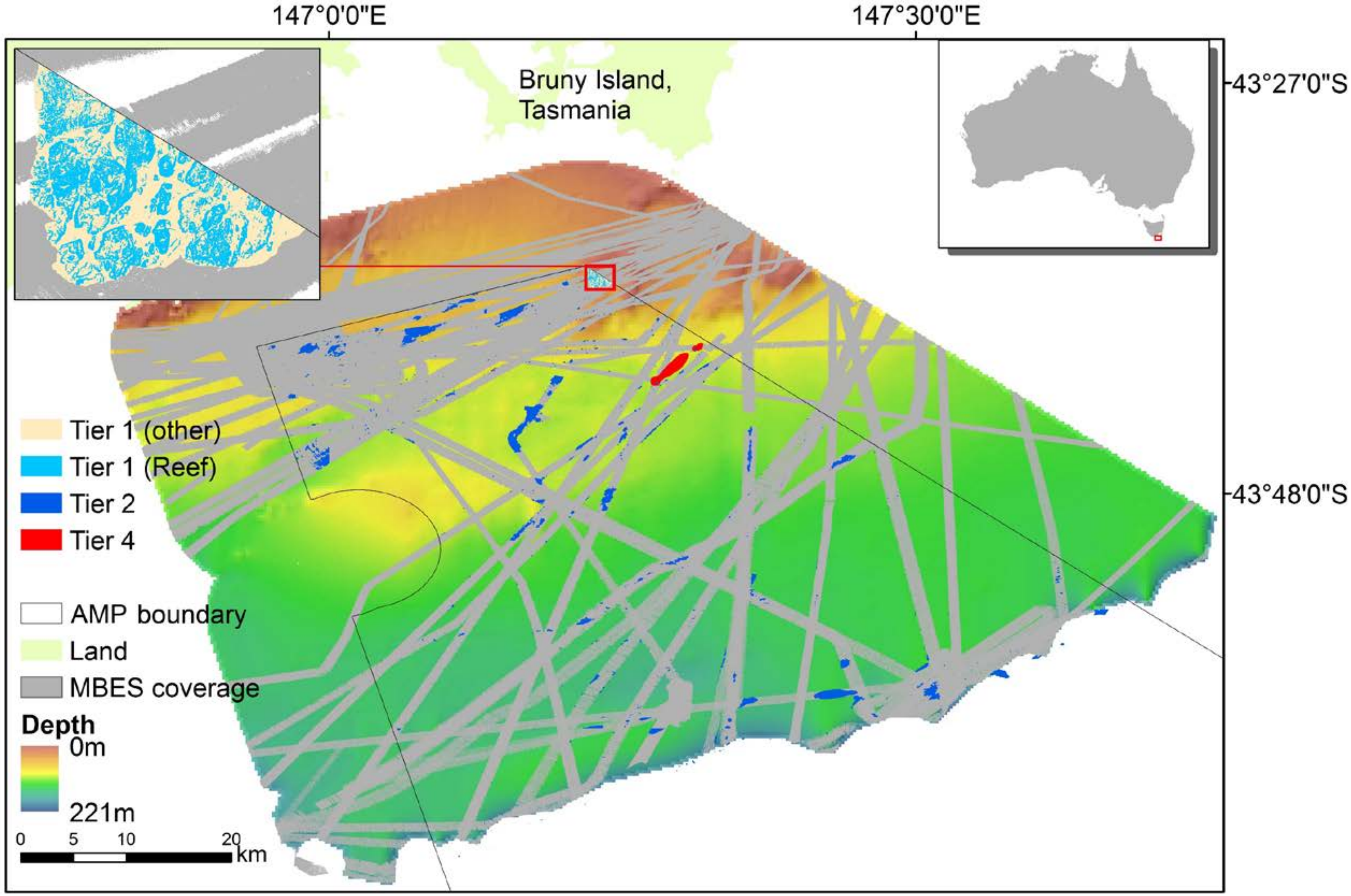


Figure 131. Reef mapping extents within the continental shelf zone of the Huon AMP.

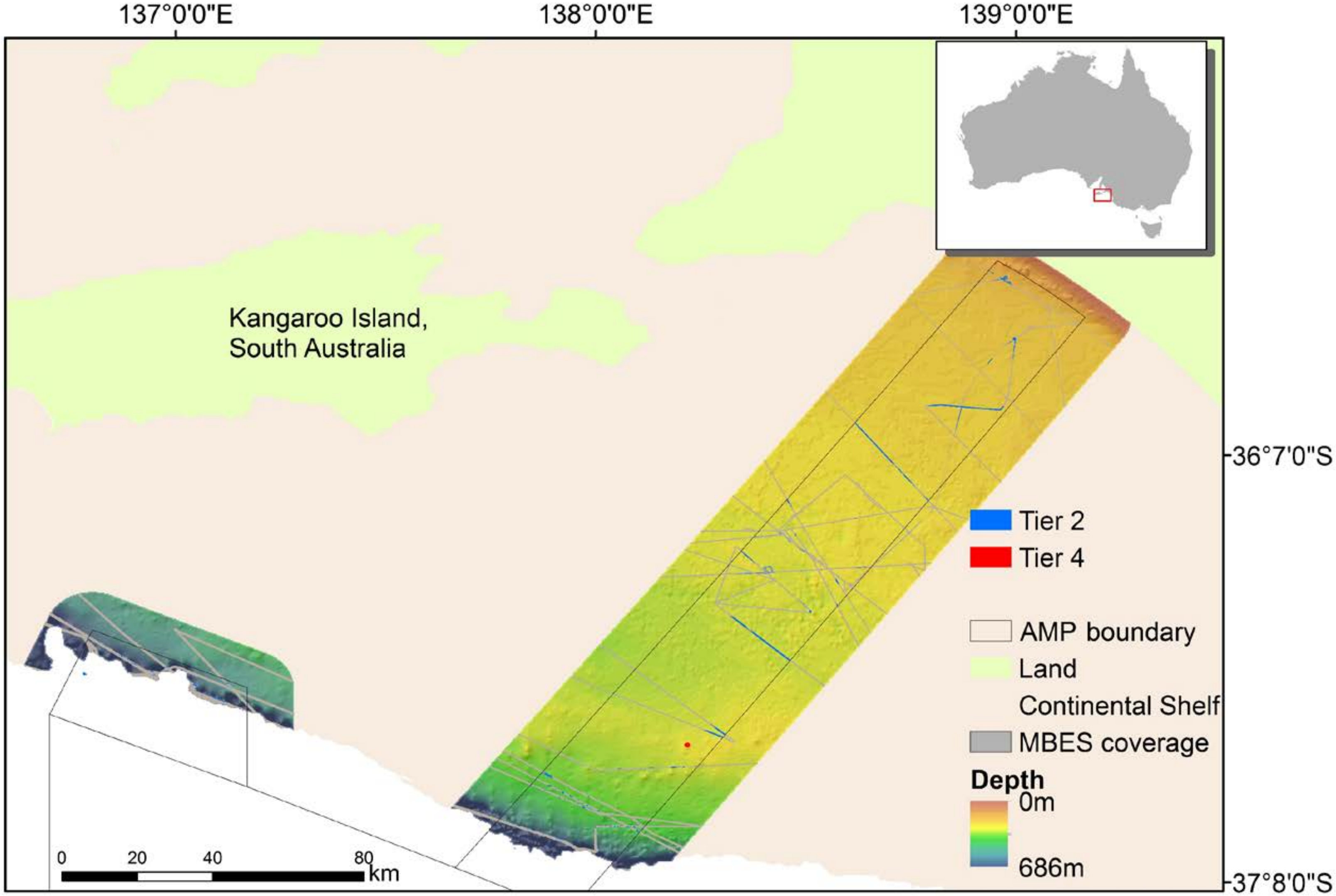


Figure 132. Reef mapping extents within the continental shelf zone of the Murray AMP.

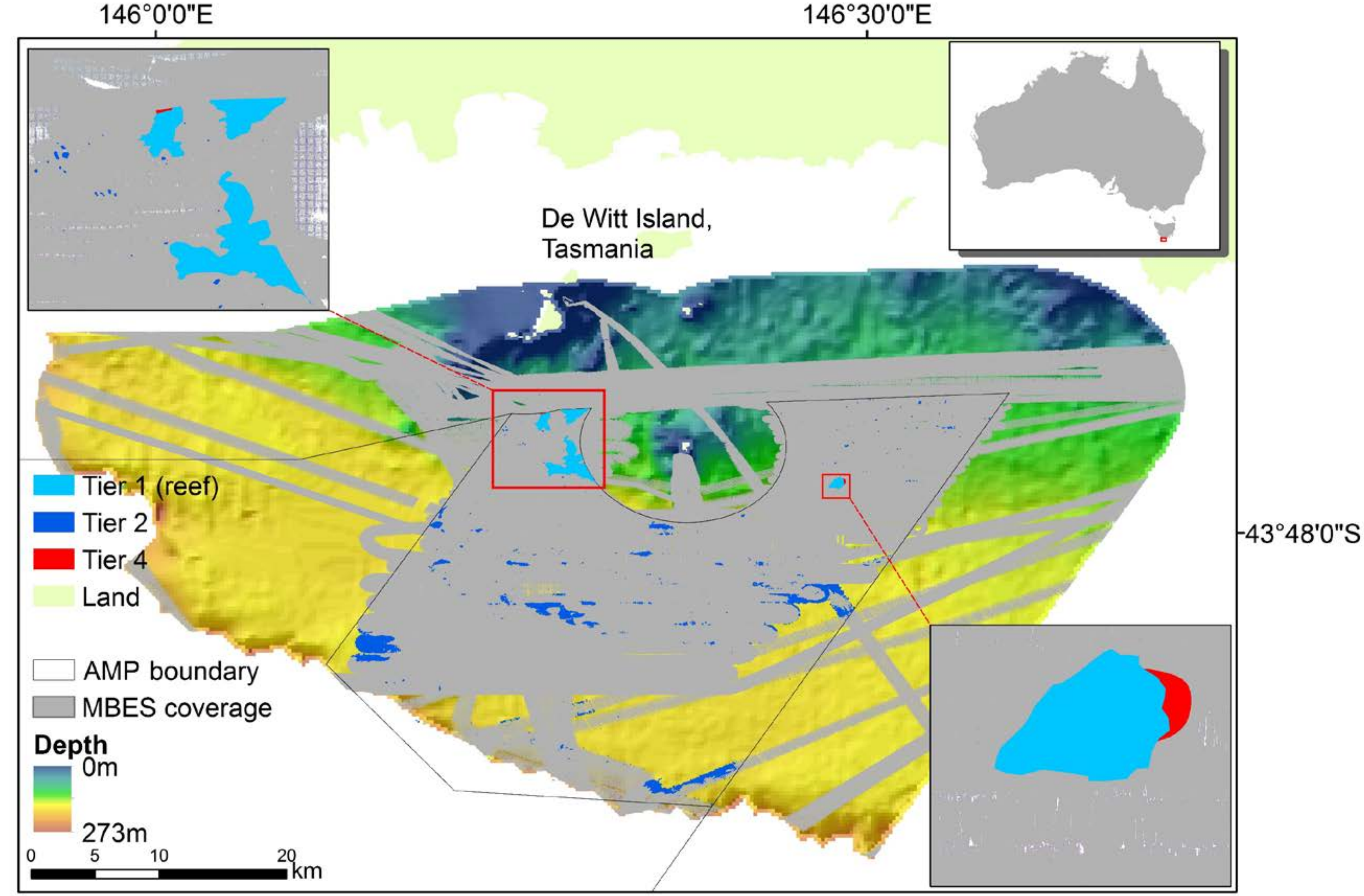


Figure 133. Reef mapping extents within the continental shelf zone of the Tasman Fracture AMP.

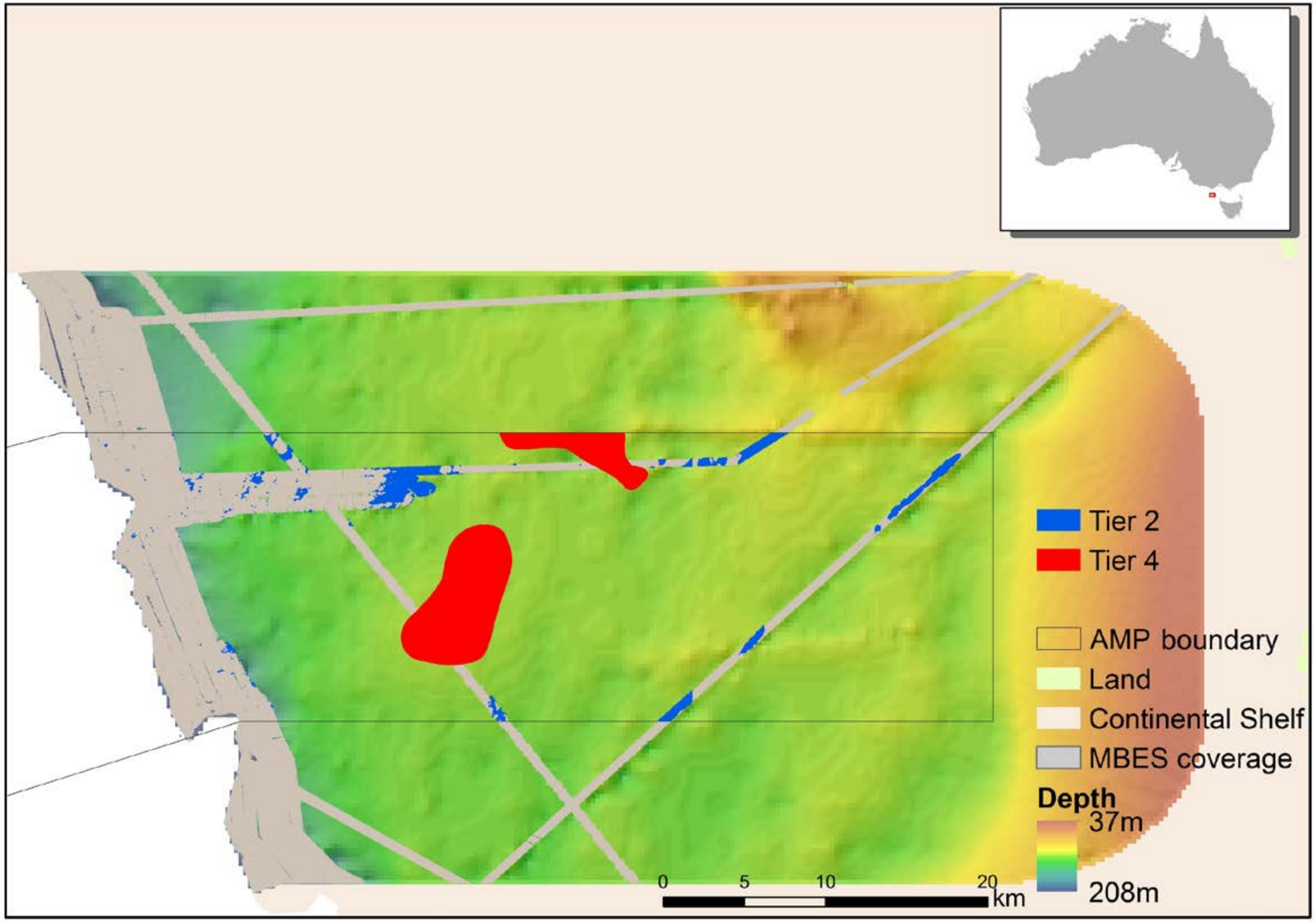


Figure 134. Reef mapping extents within the continental shelf zone of the Zeehan AMP.

Appendix A: Reef mapping of the South-west marine planning region

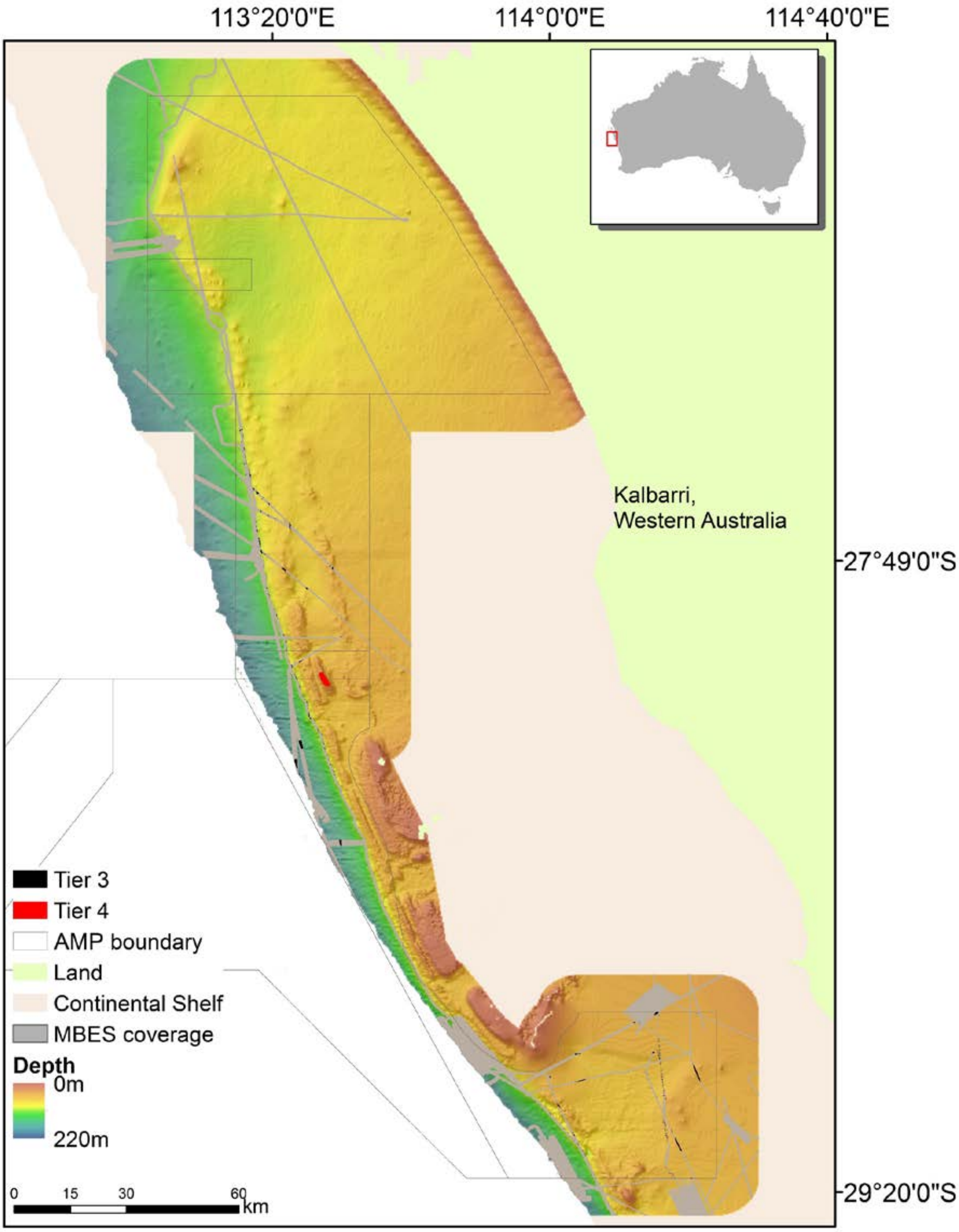


Figure 135. Reef mapping extents within the continental shelf zone of the Abrolhos AMP.

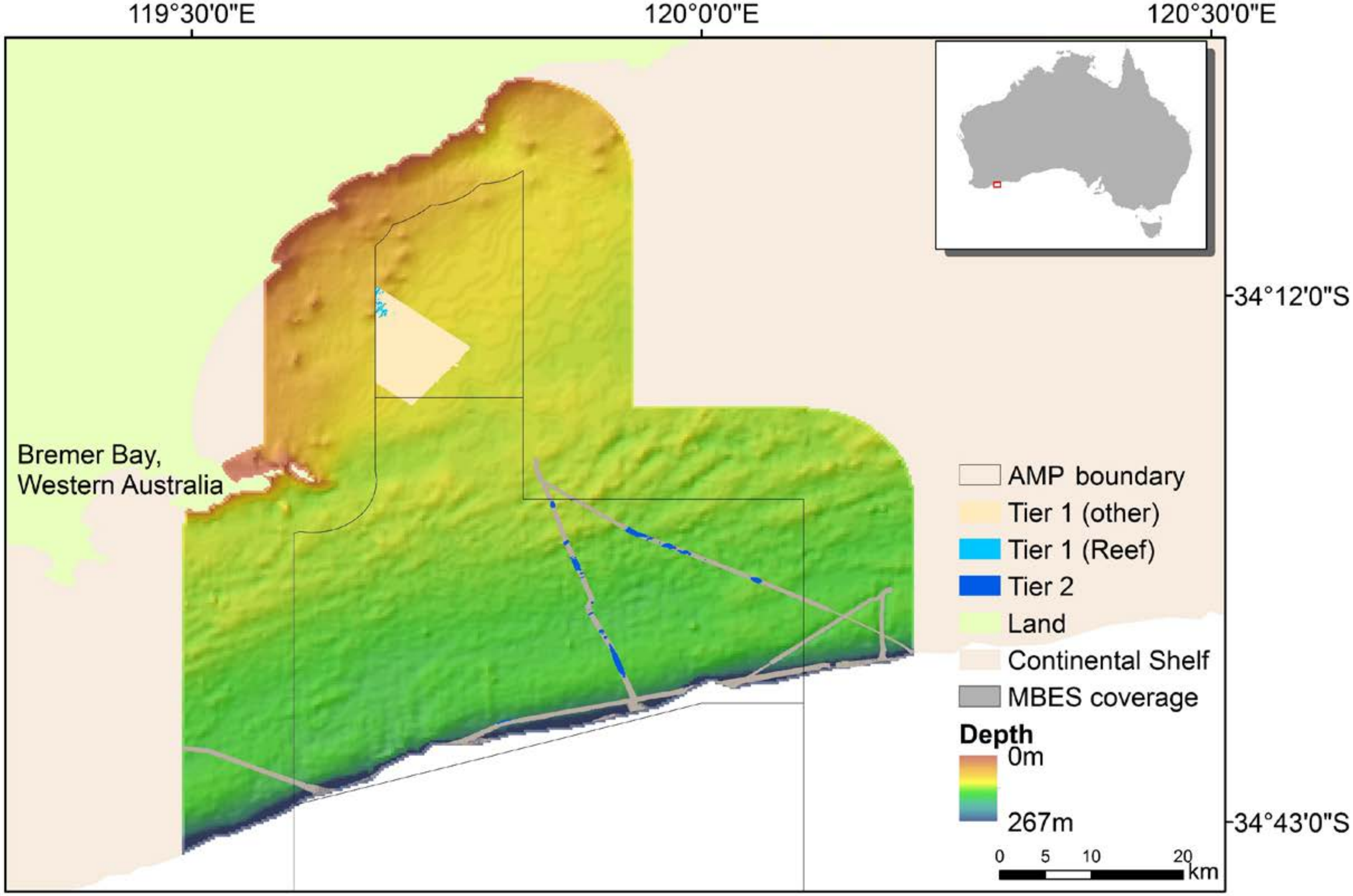


Figure 136. Reef mapping extents within the continental shelf zone of the Bremer AMP.

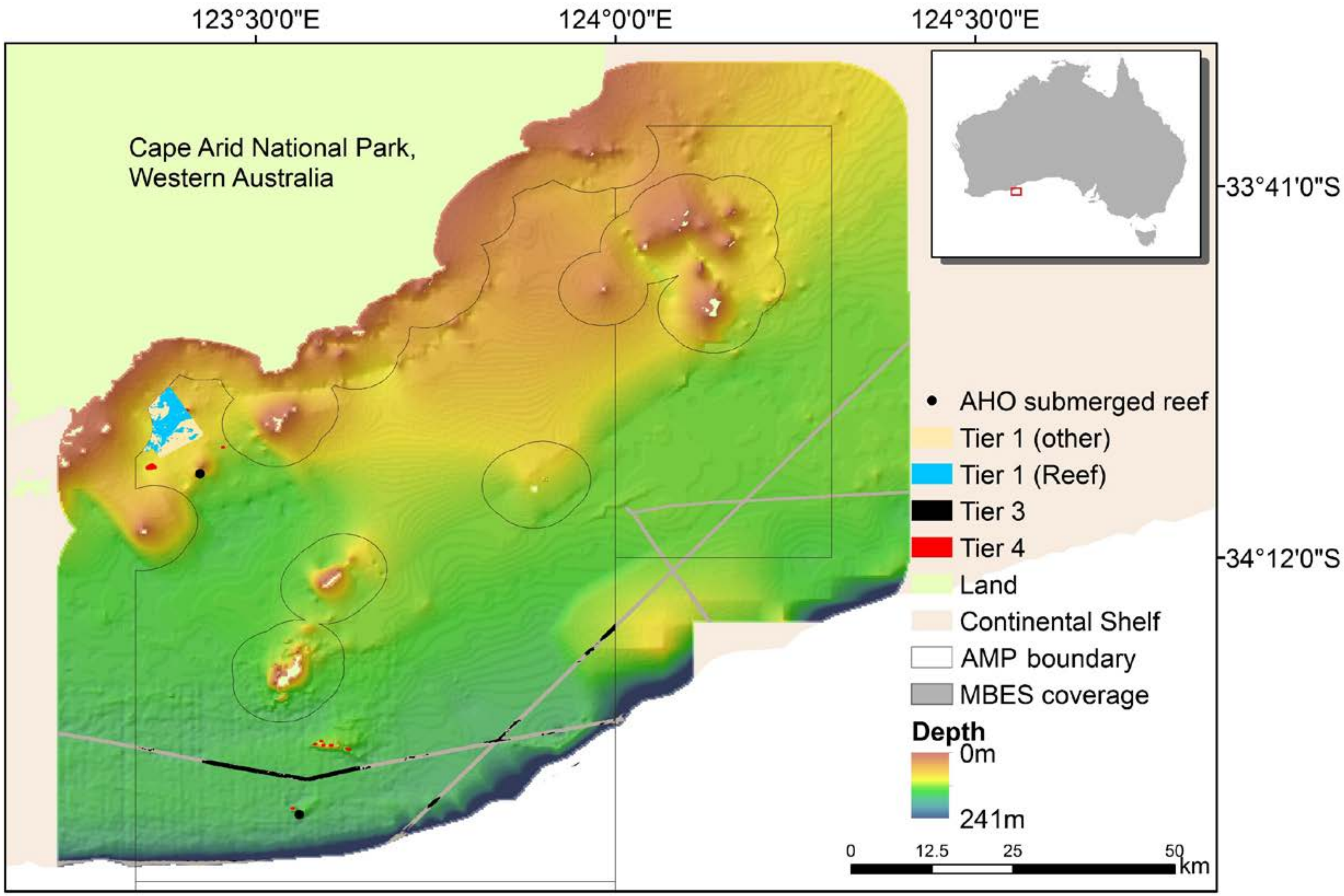


Figure 137. Reef mapping extents within the continental shelf zone of the Eastern Recherche AMP.

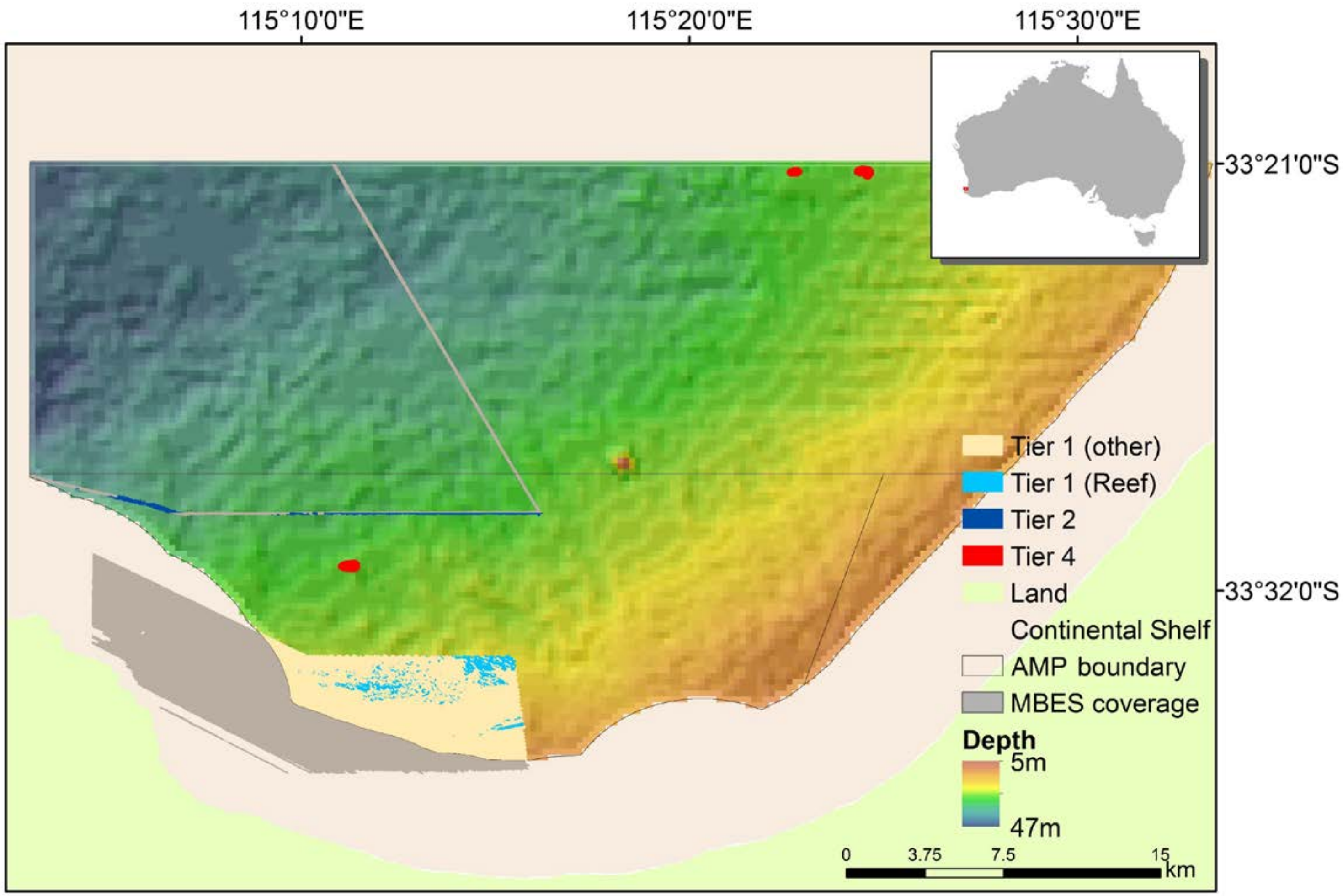


Figure 138. Reef mapping extents within the continental shelf zone of the Geographe AMP.

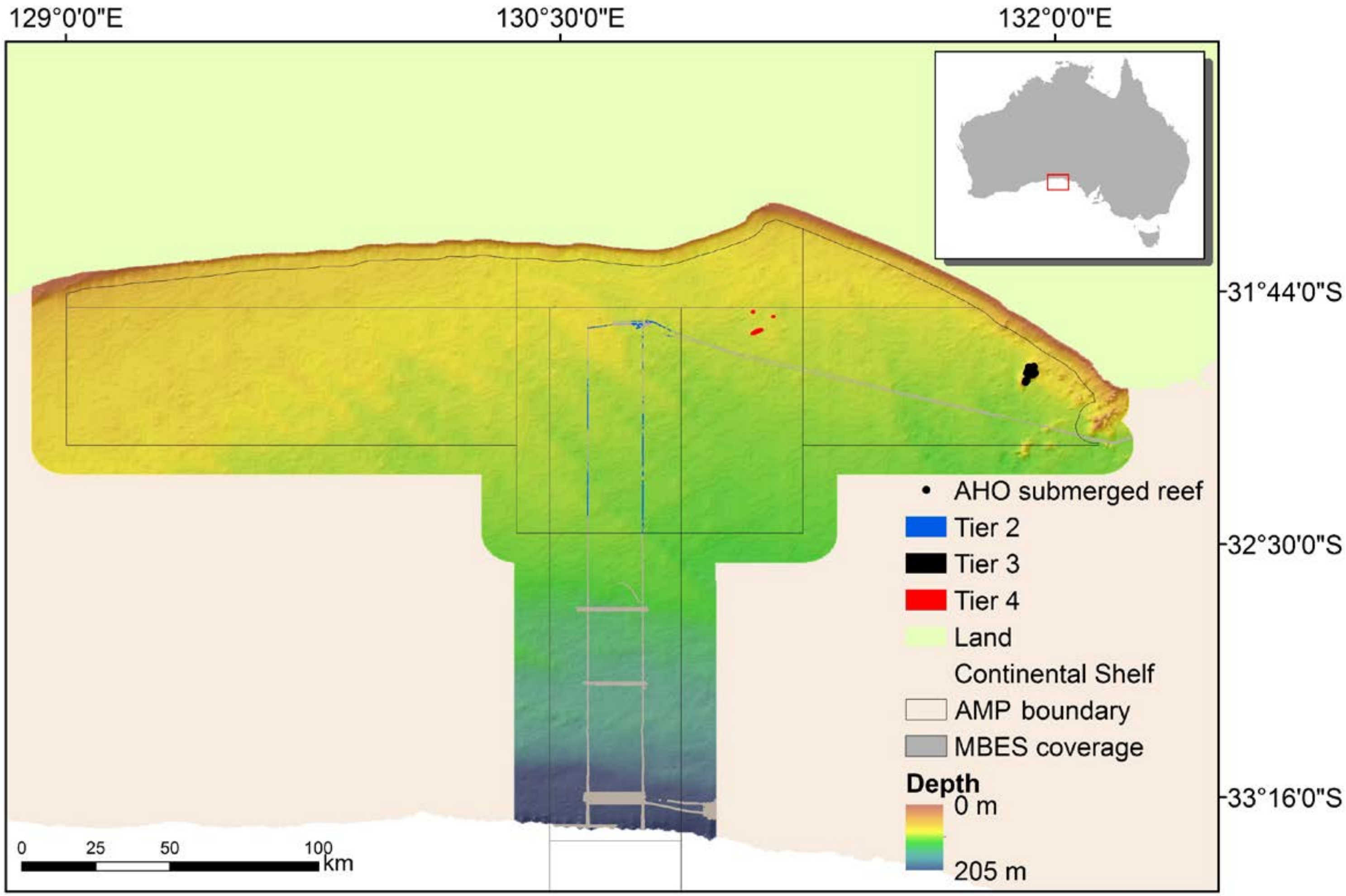


Figure 139. Reef mapping extents within the continental shelf zone of the Great Australian Bight AMP.

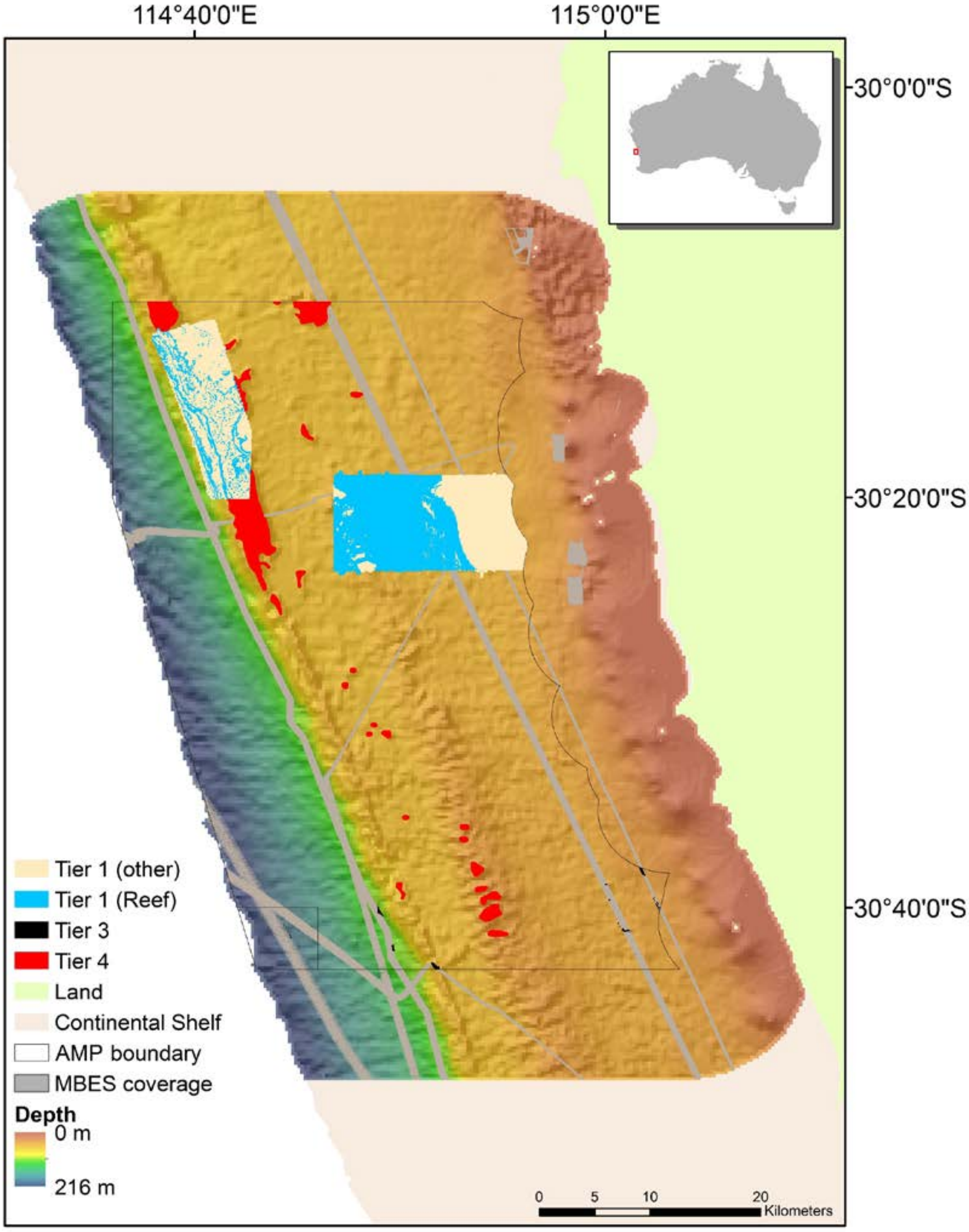


Figure 140. Reef mapping extents within the continental shelf zone of the Jurien AMP.

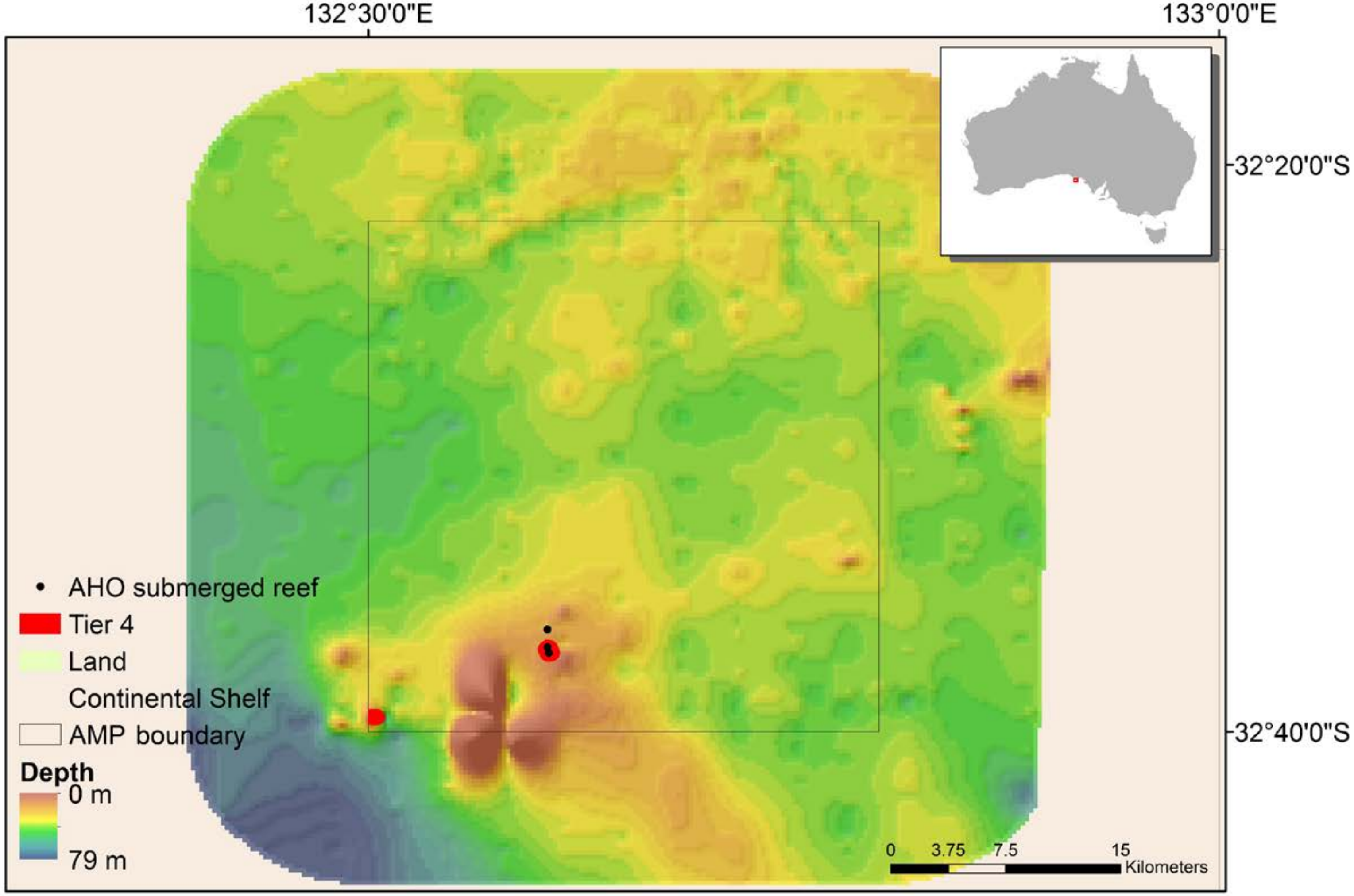


Figure 141. Reef mapping extents within the continental shelf zone of the Murat AMP.

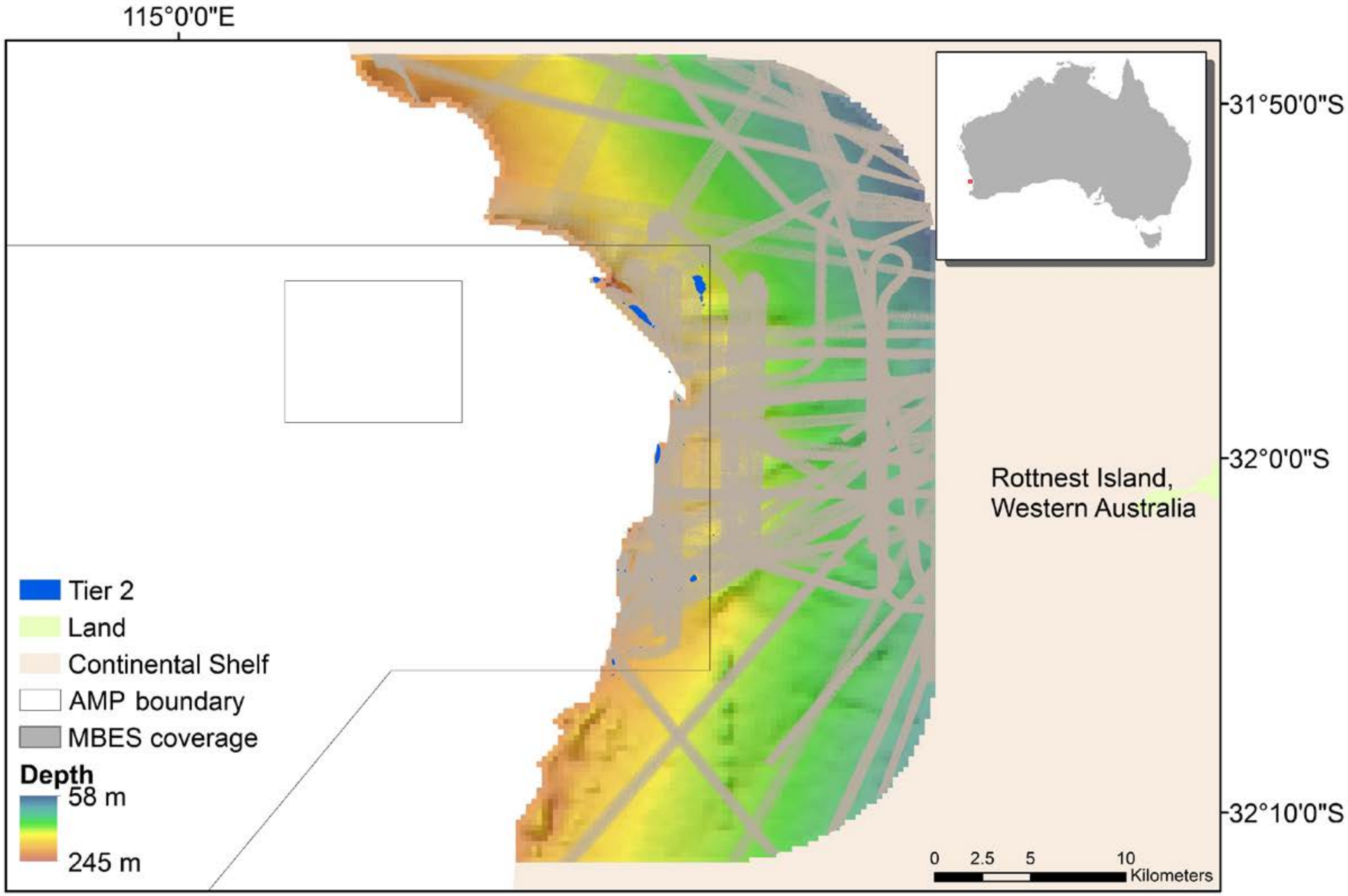


Figure 142. Reef mapping extents within the continental shelf zone of the Perth Canyon AMP.

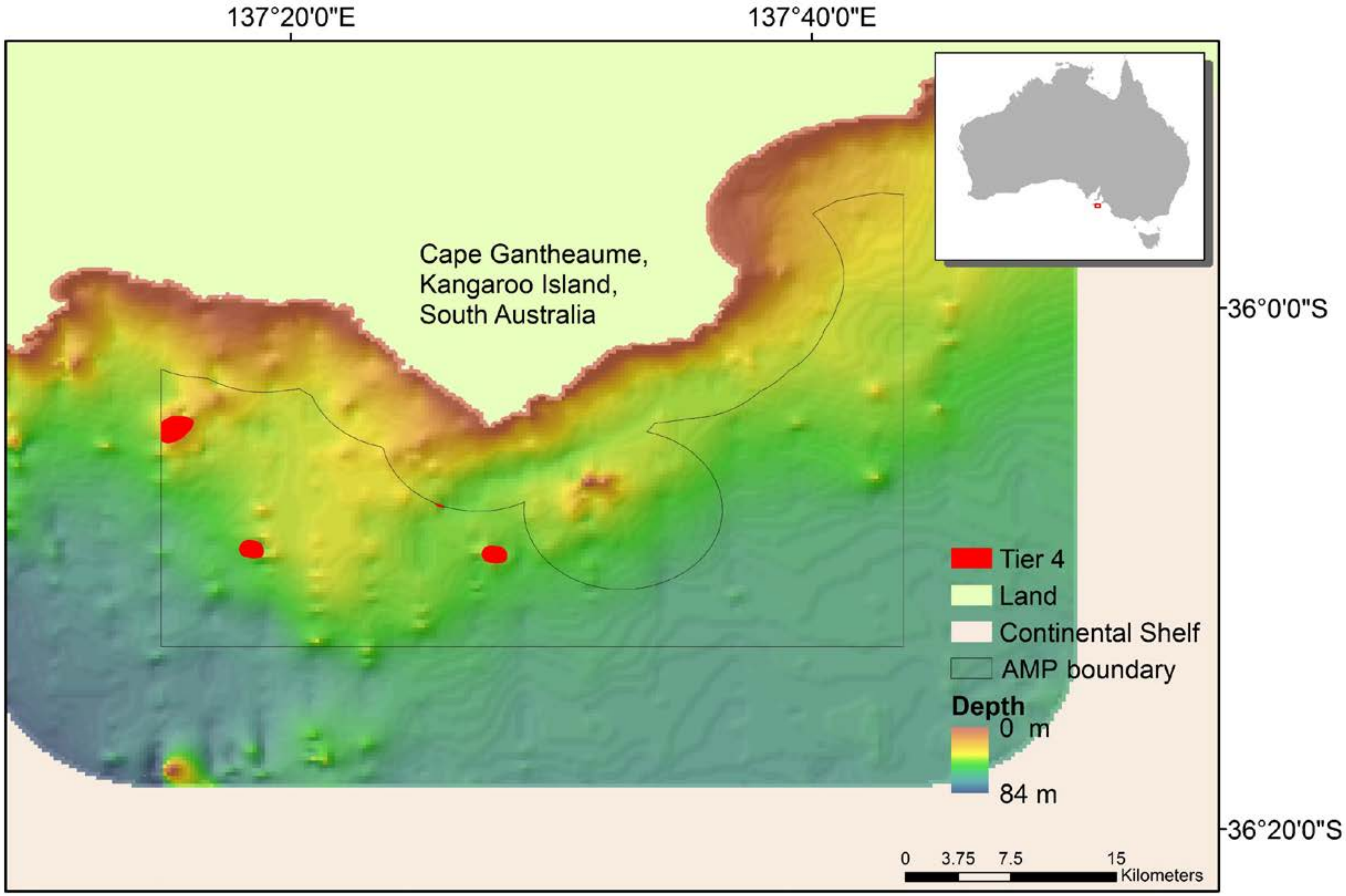


Figure 143. Reef mapping extents within the continental shelf zone of the Southern Kangaroo Island AMP.

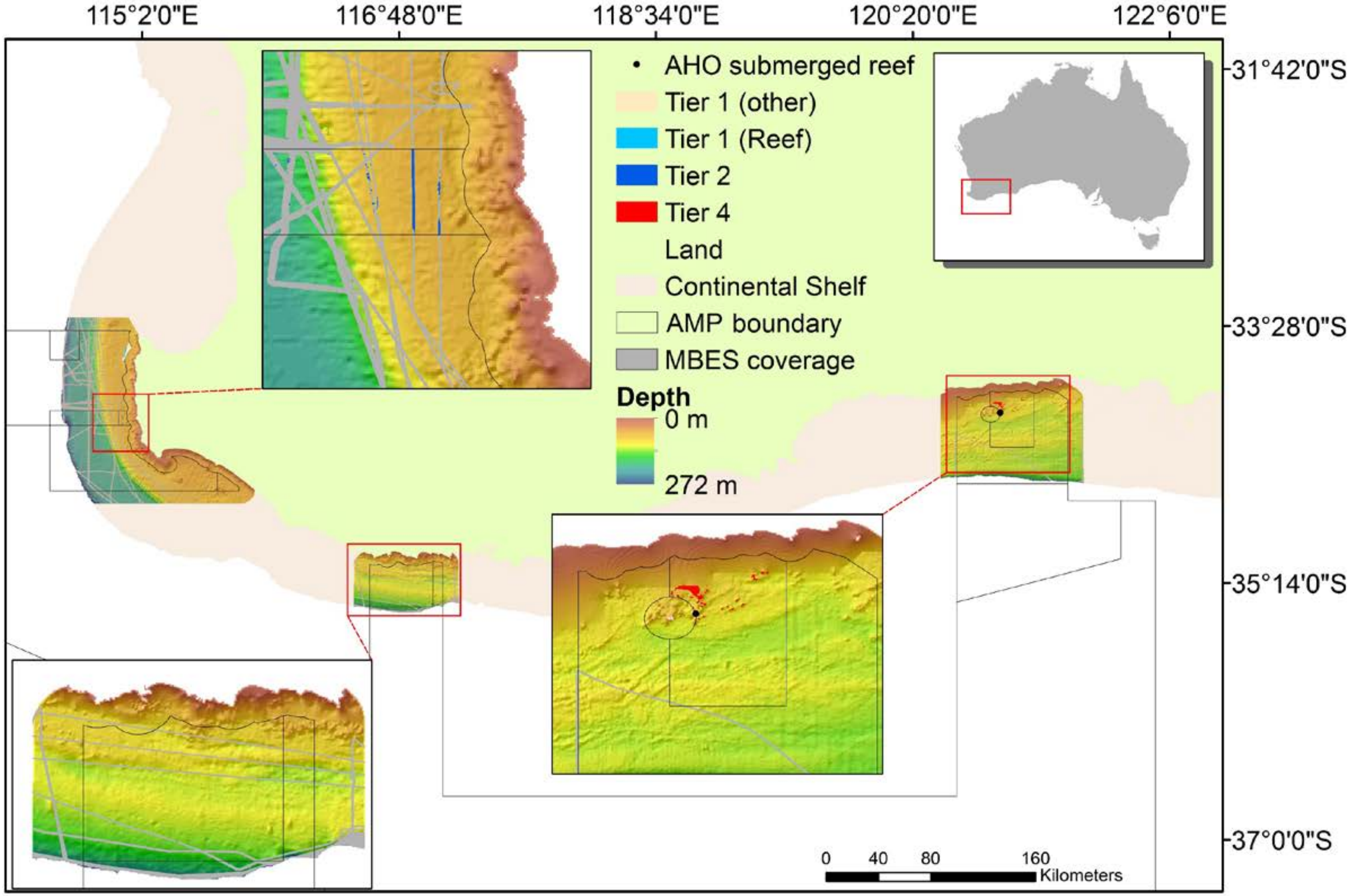


Figure 144. Reef mapping extents within the continental shelf zone of the South-west Corner AMP.

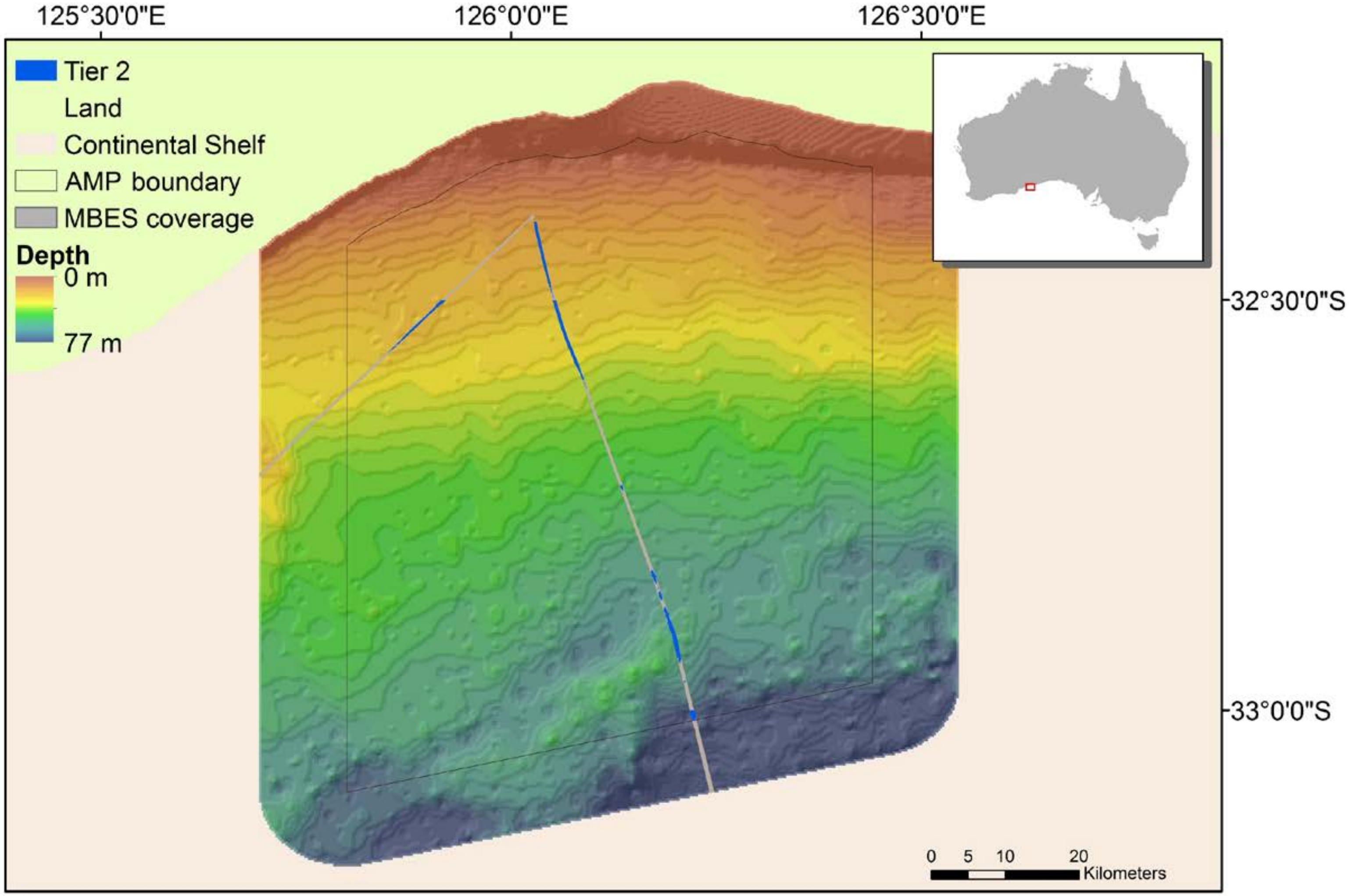


Figure 145. Reef mapping extents within the continental shelf zone of the Twilight AMP.

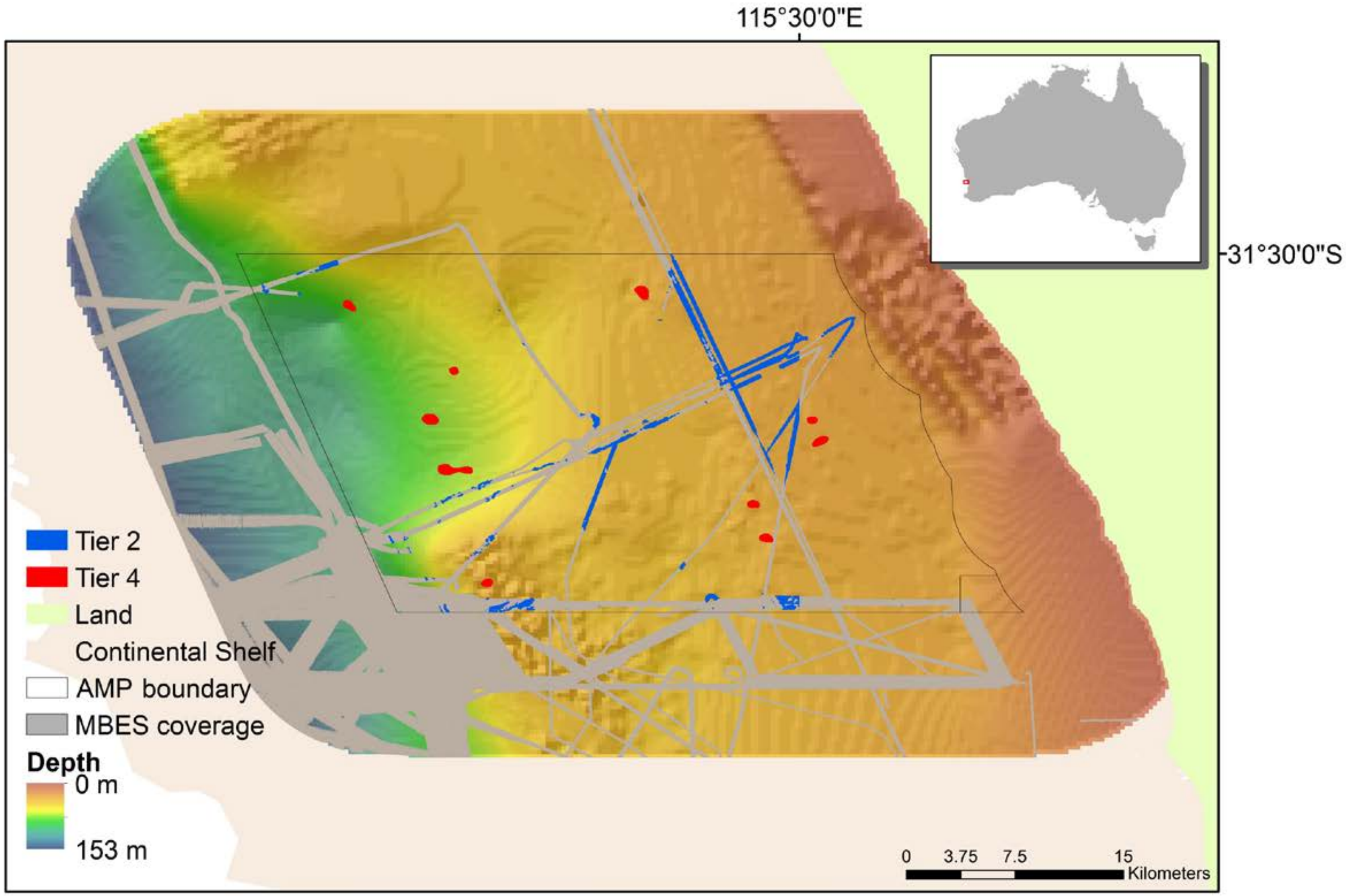


Figure 146. Reef mapping extents within the continental shelf zone of the Two Rocks AMP.

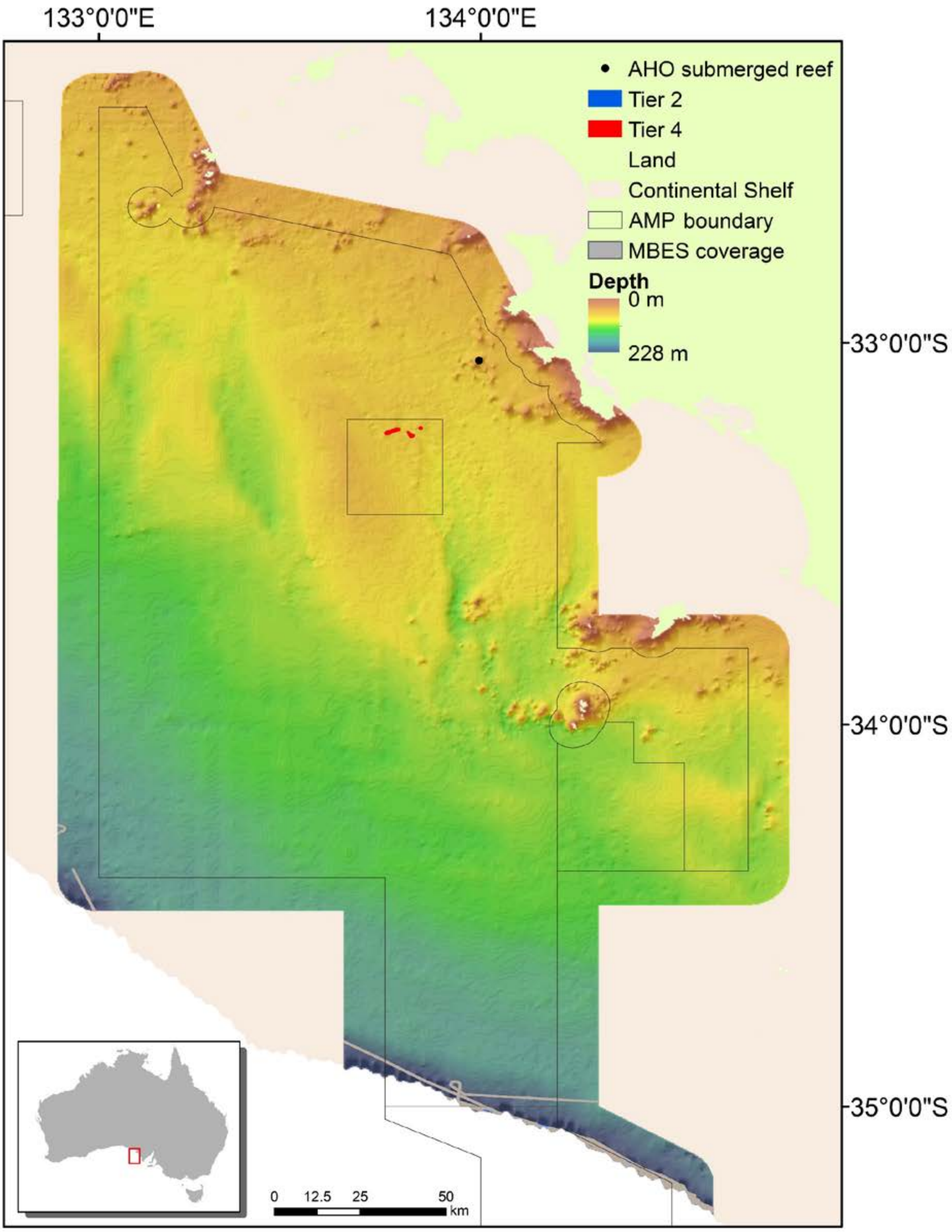


Figure 147. Reef mapping extents within the continental shelf zone of the Western Eyre AMP.

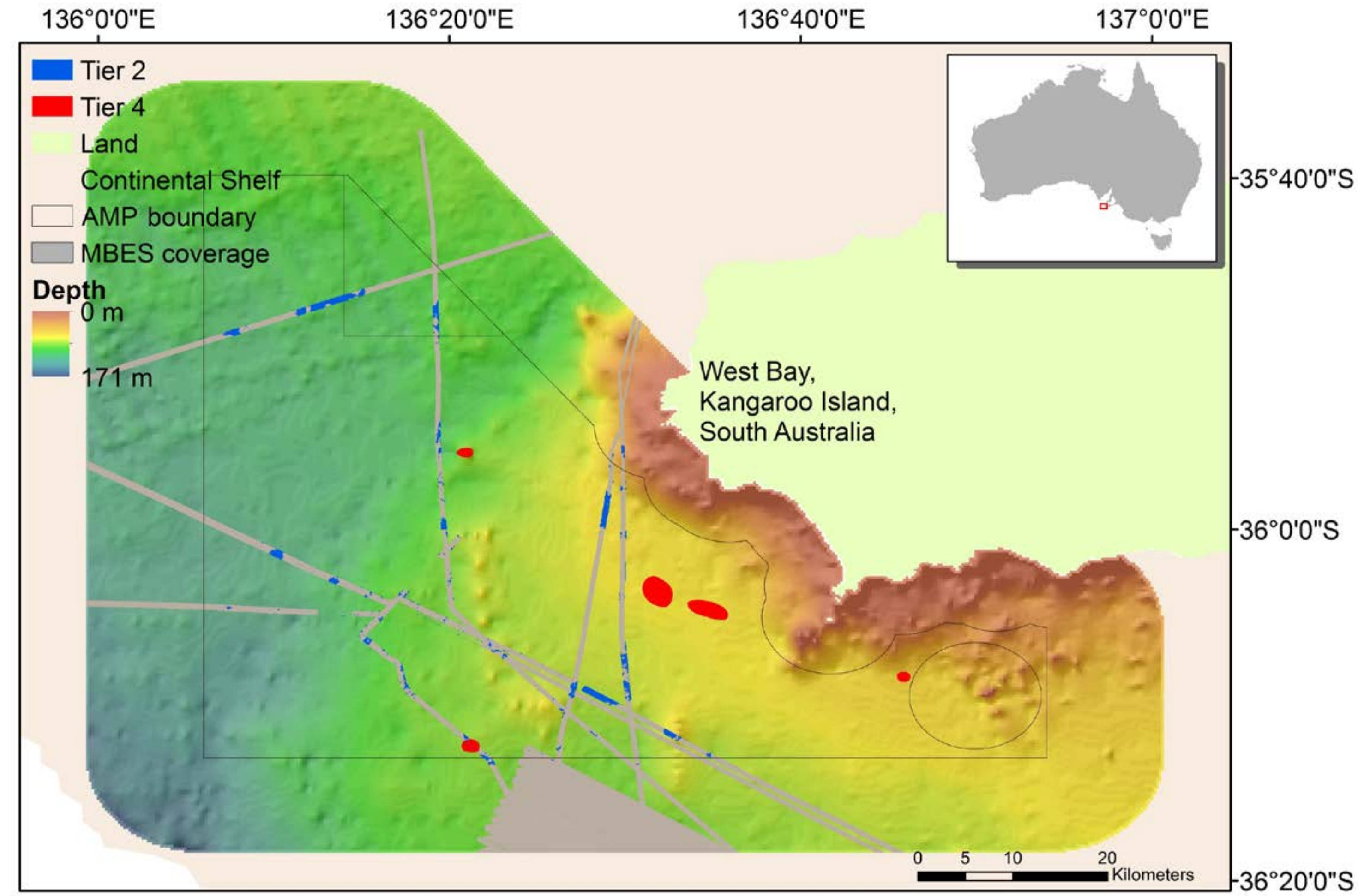


Figure 148. Reef mapping extents within the continental shelf zone of the West Kangaroo Island AMP.

APPENDIX B – MAPS OF REEF COVERAGE ON THE CONTINENTAL SHELF WITHIN TROPICAL WATER AMPS

The following maps show mapped reef extents within the continental shelf of each AMP. Specific details of this mapping can be found in Lucieer et al. (2016). Four tiers of data were generated by Lucieer et al. (2016) including:

1. TIER 1 data has been sourced from seafloor mapping programs completed around the nation by, predominantly, State-based/funded agencies. This mapped reef data represents the highest quality mapping data, with reef extents being field validated.

2. TIER 2 data was generated from the collation and reprocessing of CSIRO’s acoustic bathymetric data holdings on the continental shelf. A bathymetric analysis was used to identify high slope regions, which were interpreted as probable, but unvalidated, reef.

3. The creation of Tier 3 data involved the extraction reef features from the AHO S57 maps.

4. TIER 4 was created utilising the bathymetric data in the AHO S57 database. This TIER indicates the probability of a reef being present based on a bathymetric analysis of the AHO S57 data layers on the continental shelf.

Appendix B: Reef mapping of the northwest marine planning region.

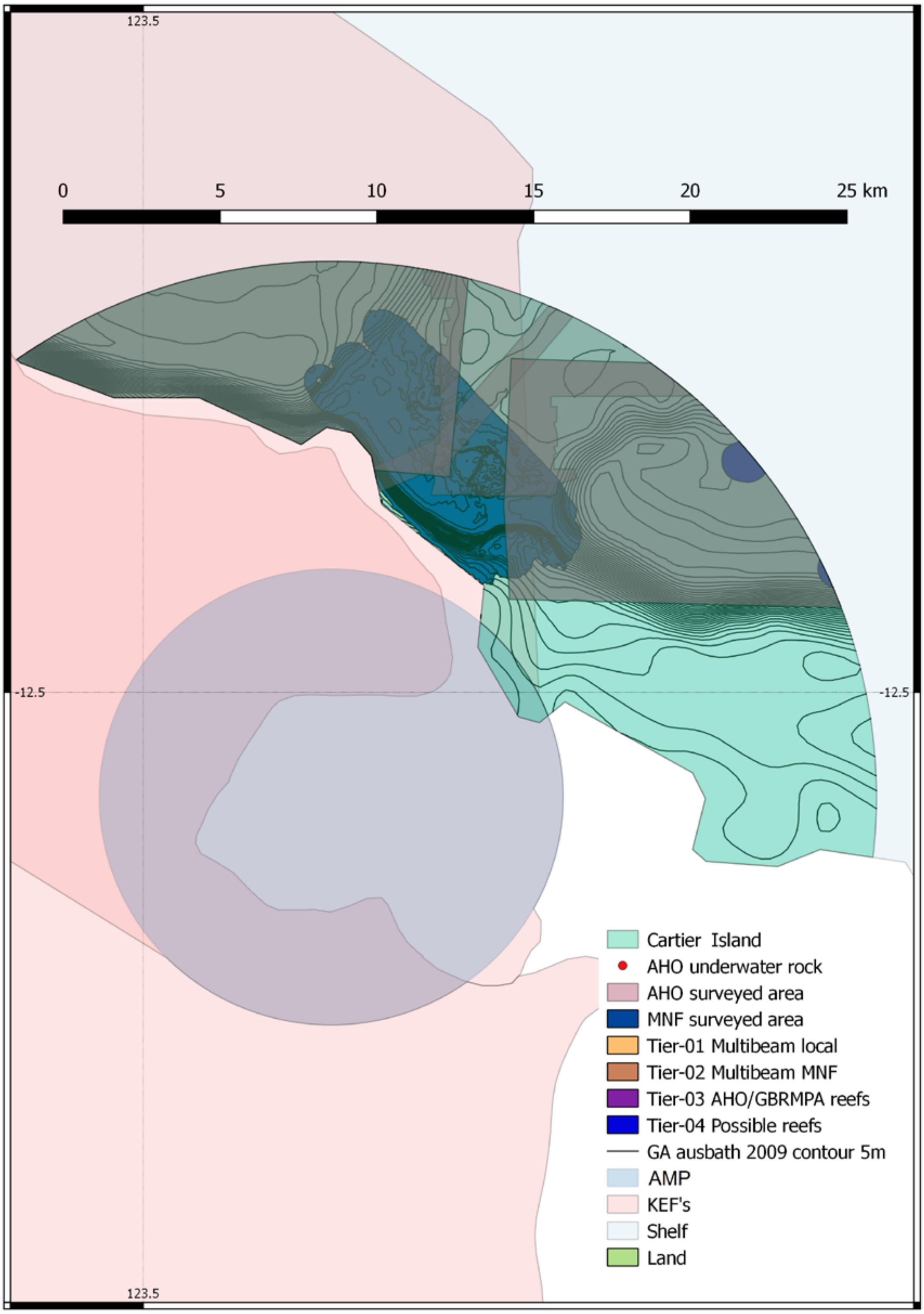


Figure 149. Reef mapping extents within the continental shelf zone of the Carter Island AMP.

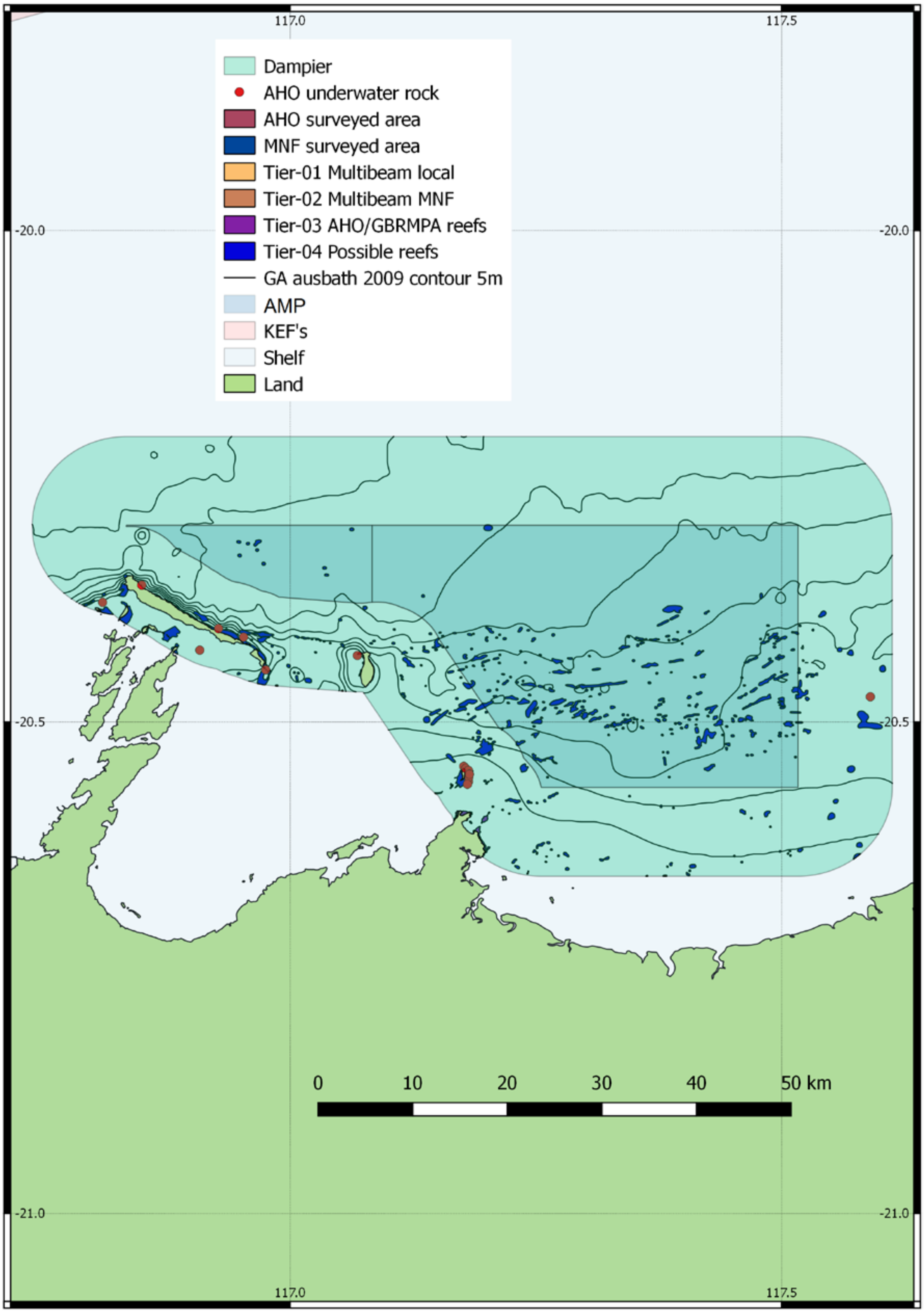


Figure 150. Reef mapping extents within the continental shelf zone of the Dampier AMP.

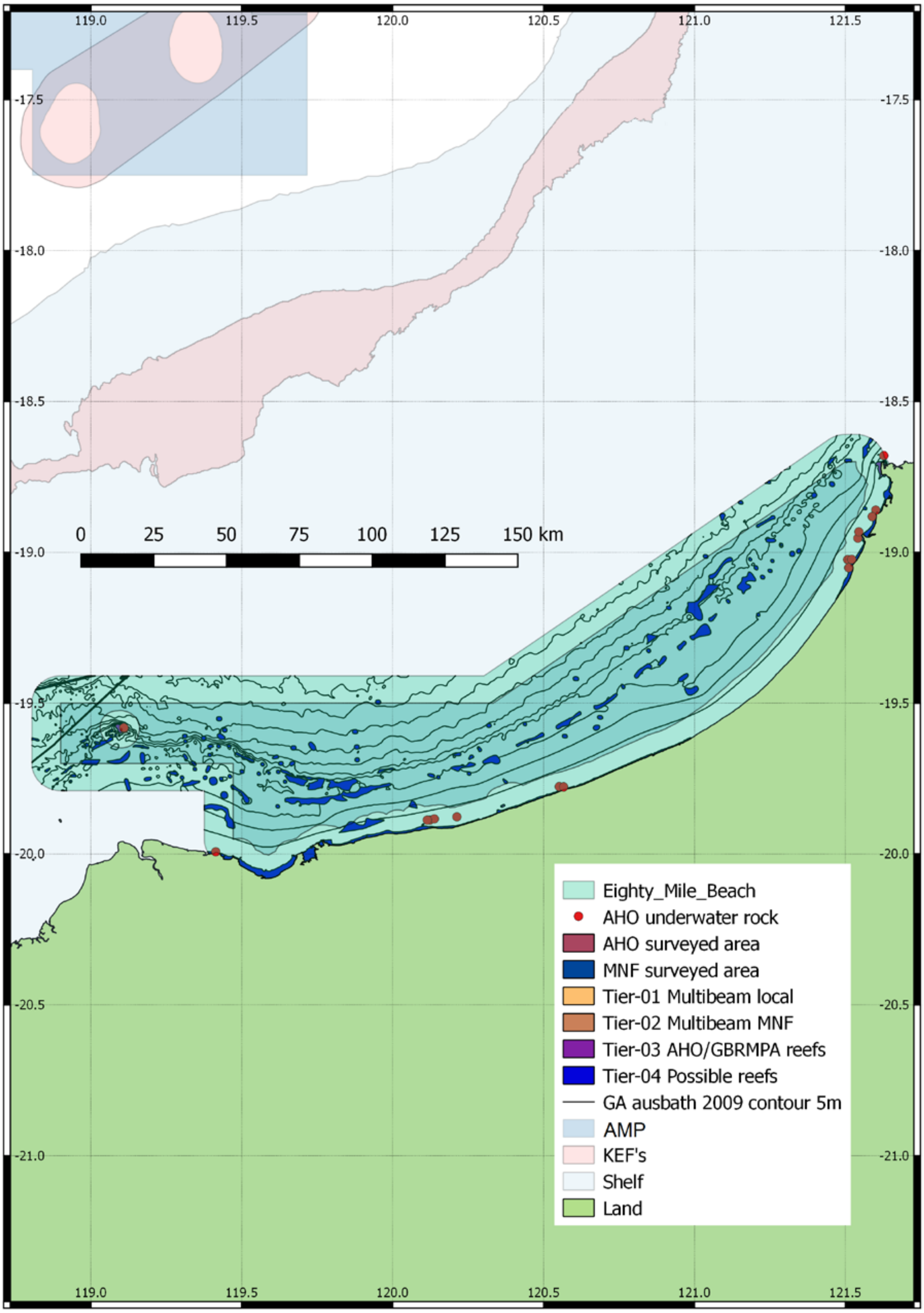


Figure 151. Reef mapping extents within the continental shelf zone of the Eighty Mile Beach AMP.

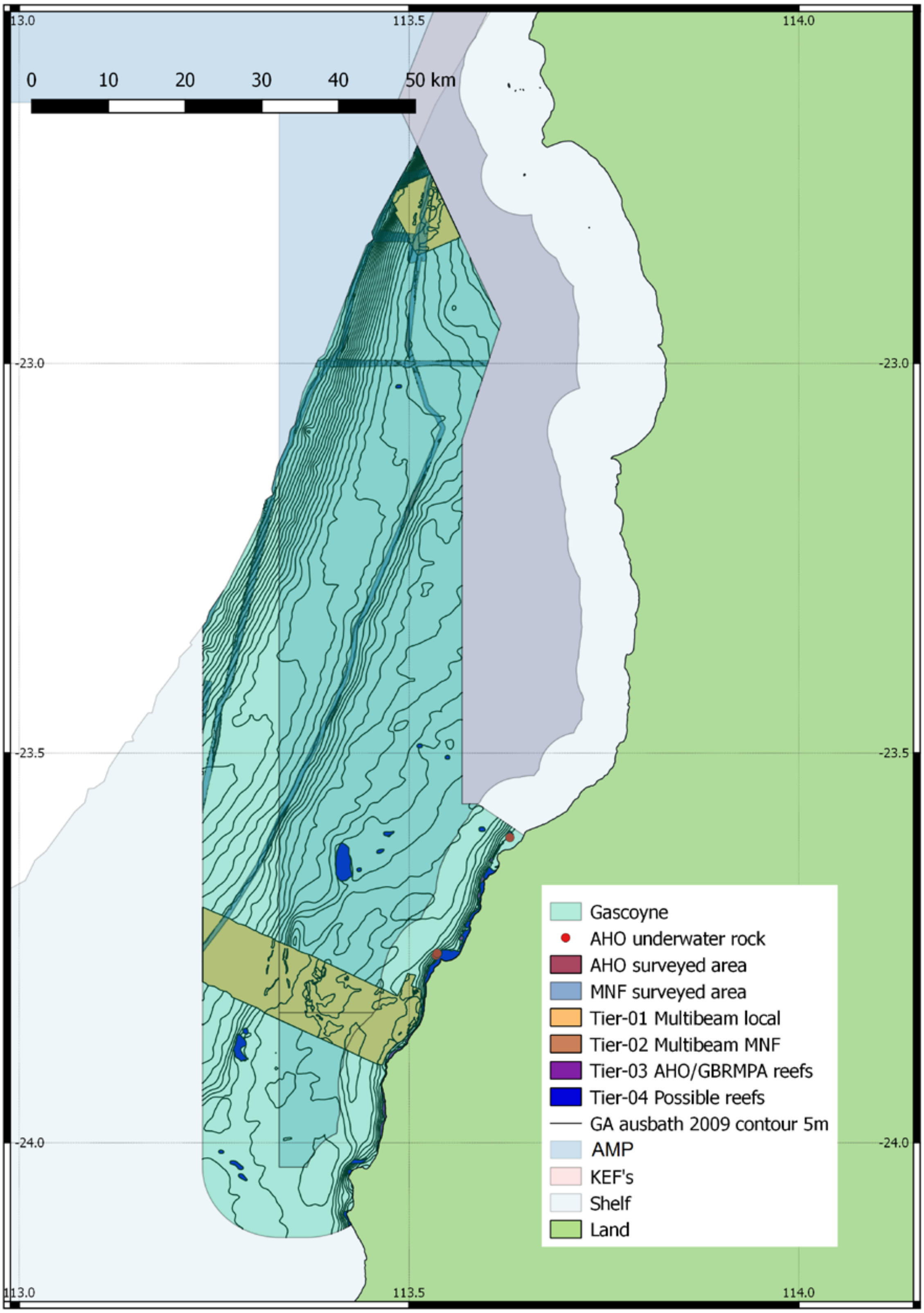


Figure 152. Reef mapping extents within the continental shelf zone of the Gascoyne AMP.

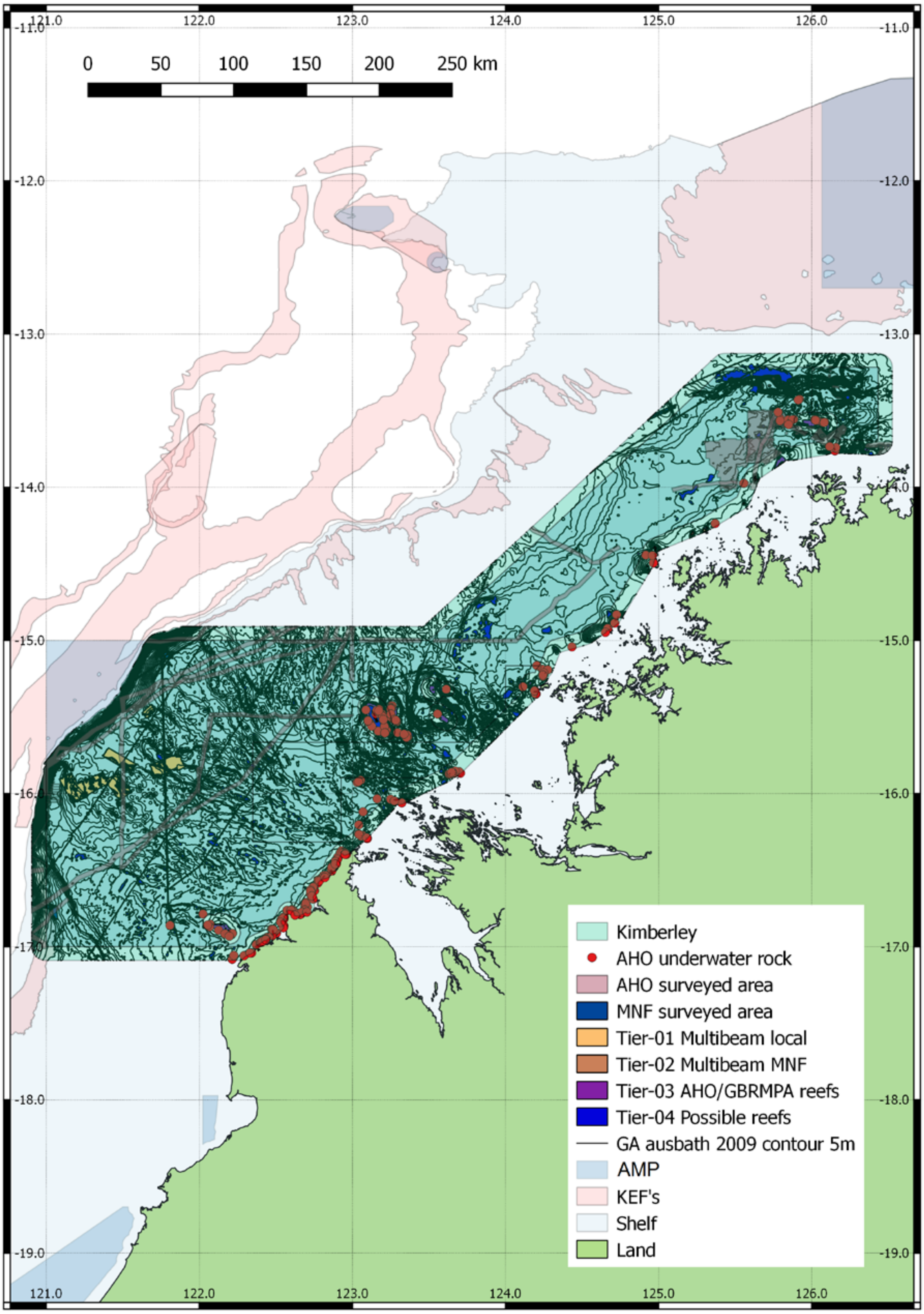


Figure 153. Reef mapping extents within the continental shelf zone of the Kimberley AMP.

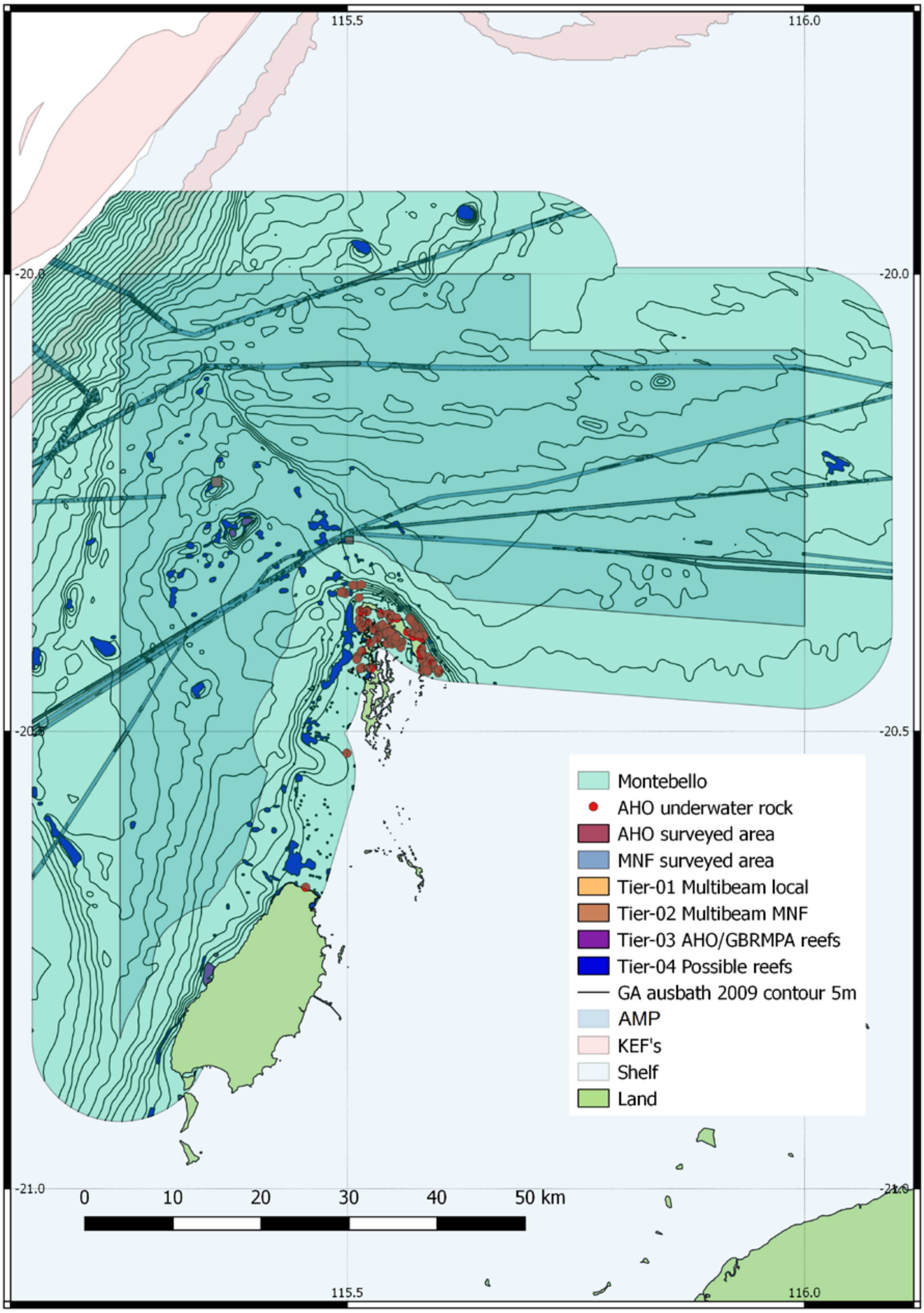


Figure 154. Reef mapping extents within the continental shelf zone of the Montebello AMP.

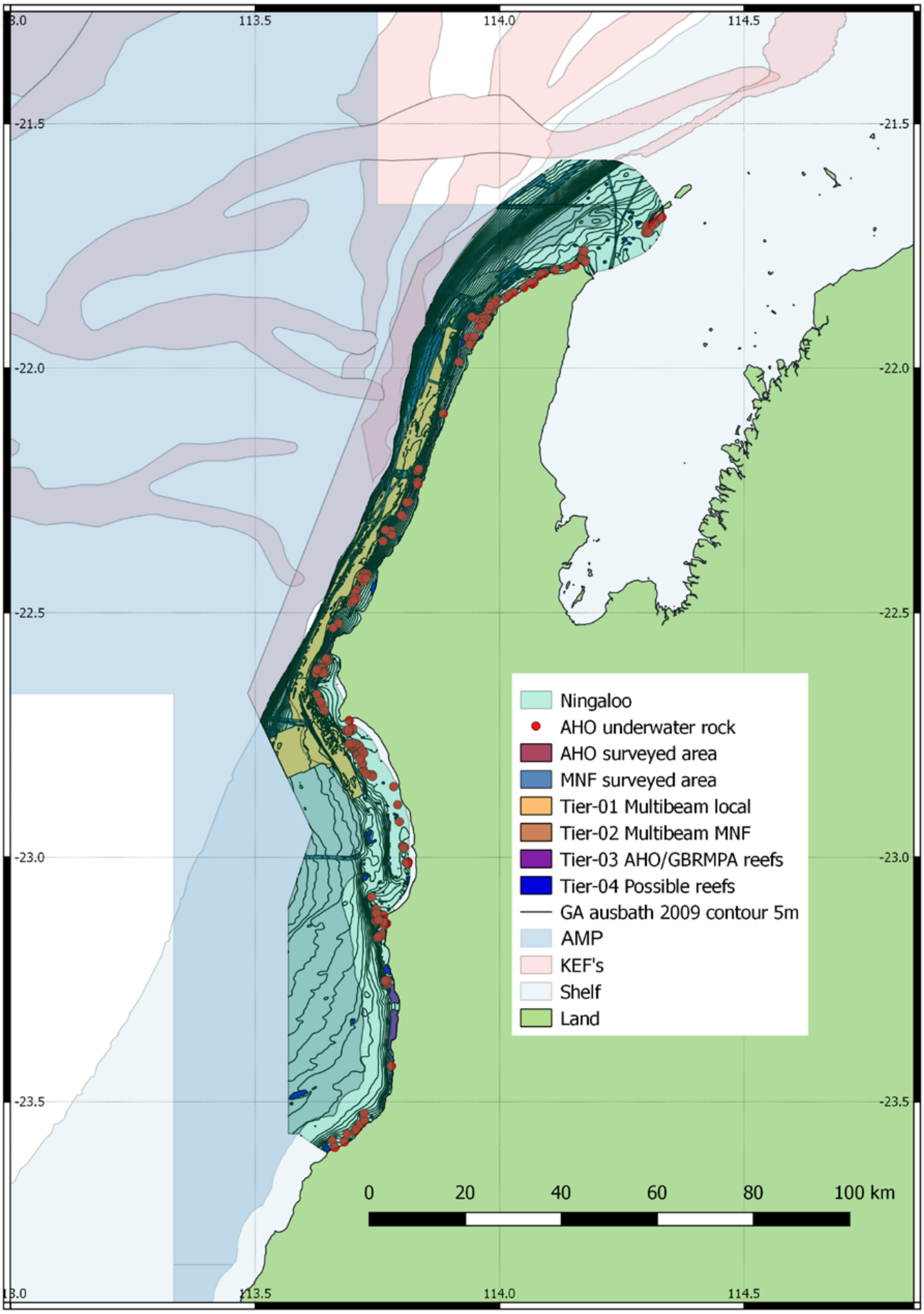


Figure 155. Reef mapping extents within the continental shelf zone of the Ningaloo AMP.

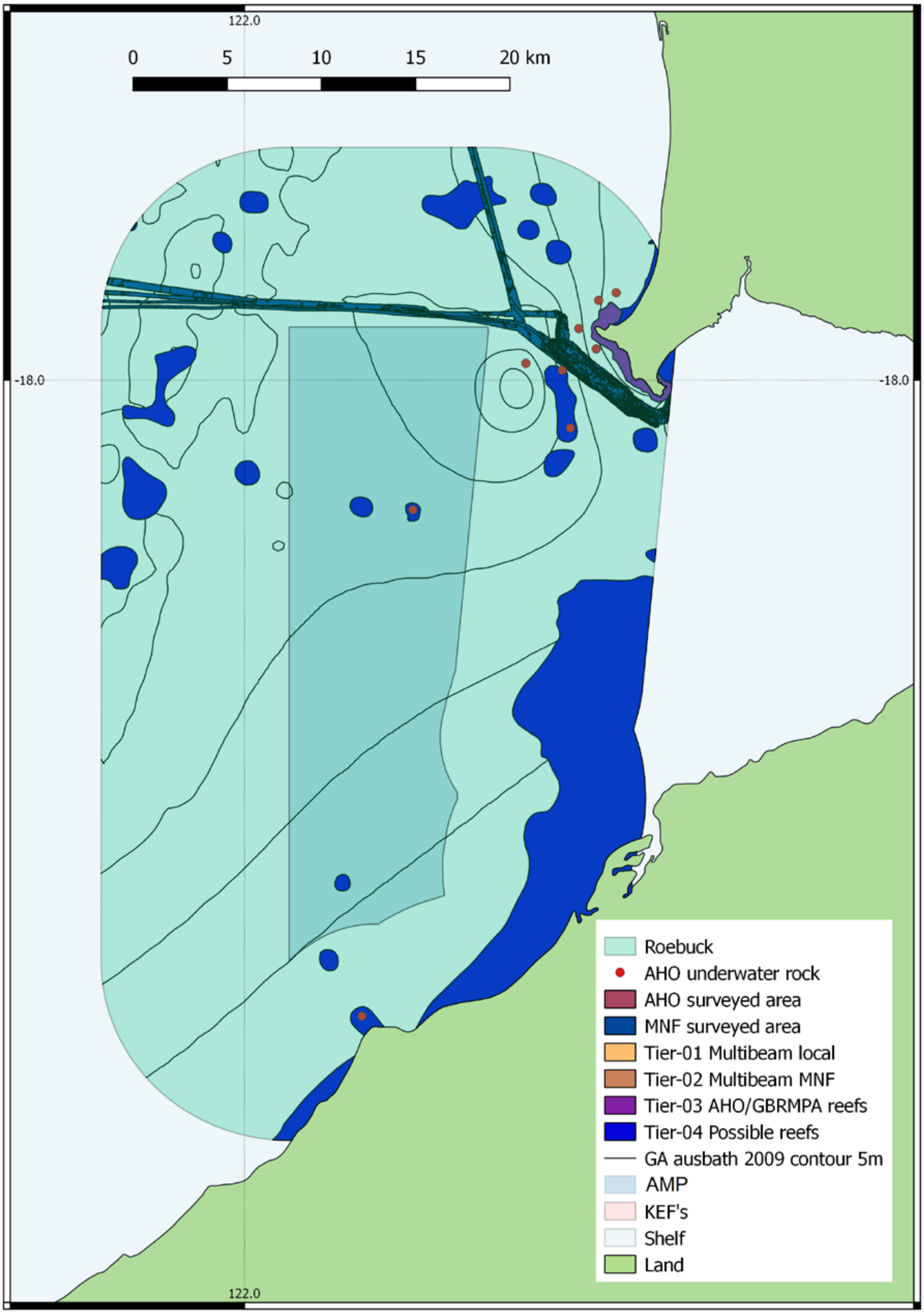


Figure 156. Reef mapping extents within the continental shelf zone of the Roebuck AMP.

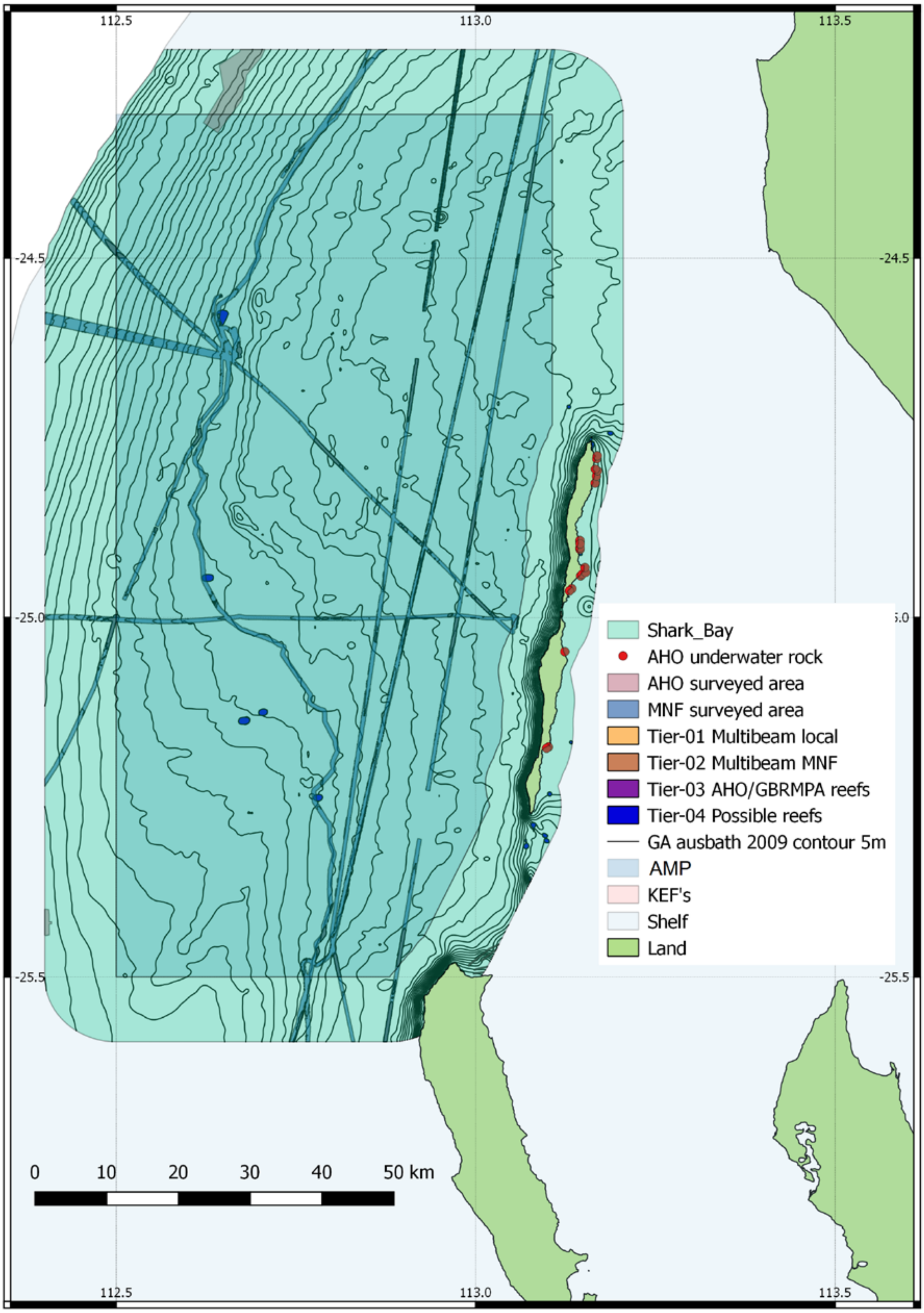


Figure 157. Reef mapping extents within the continental shelf zone of the Shark Bay AMP.

Appendix B: Reef mapping of the north marine planning region.

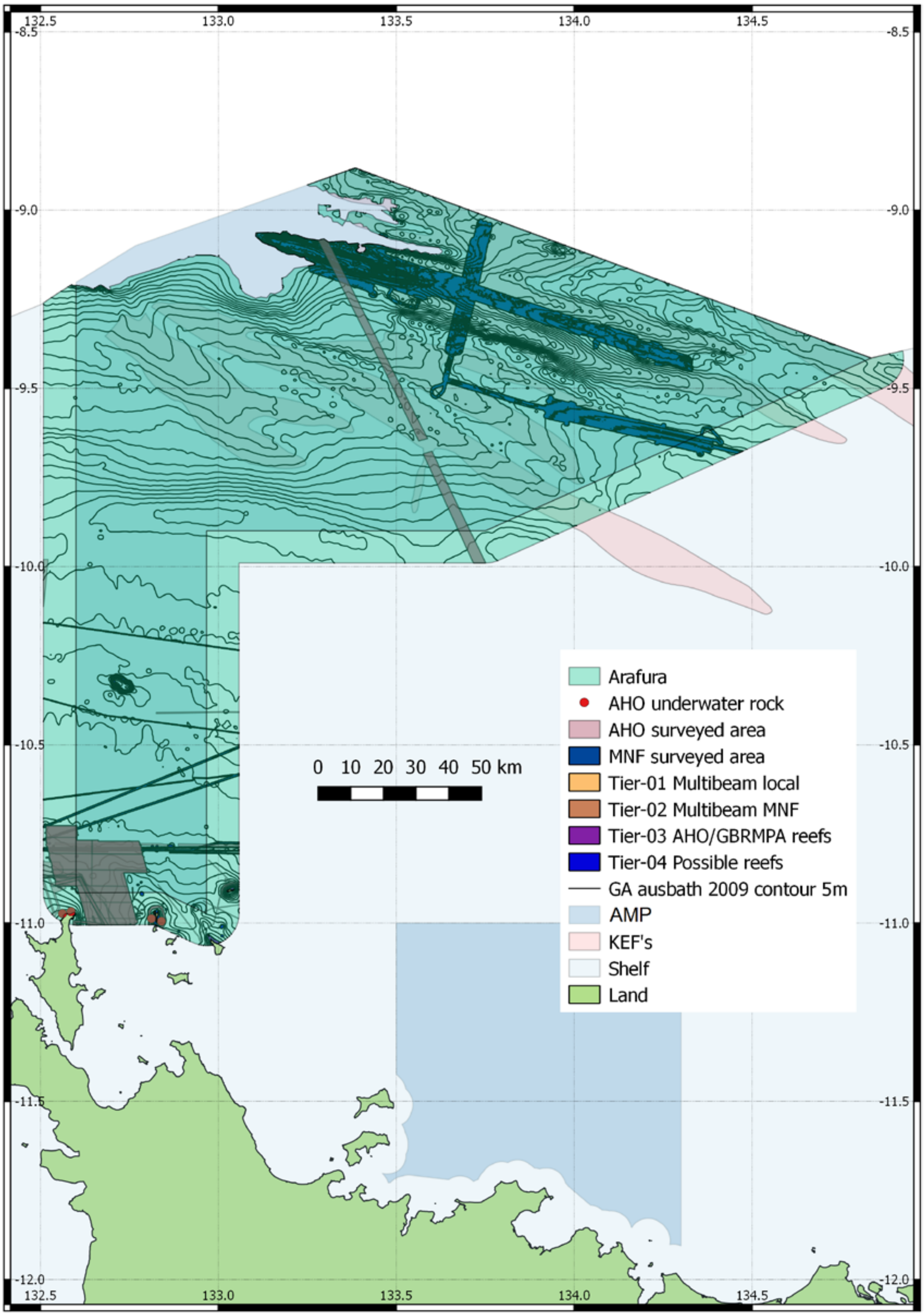


Figure 158. Reef mapping extents within the continental shelf zone of the Arafura AMP.

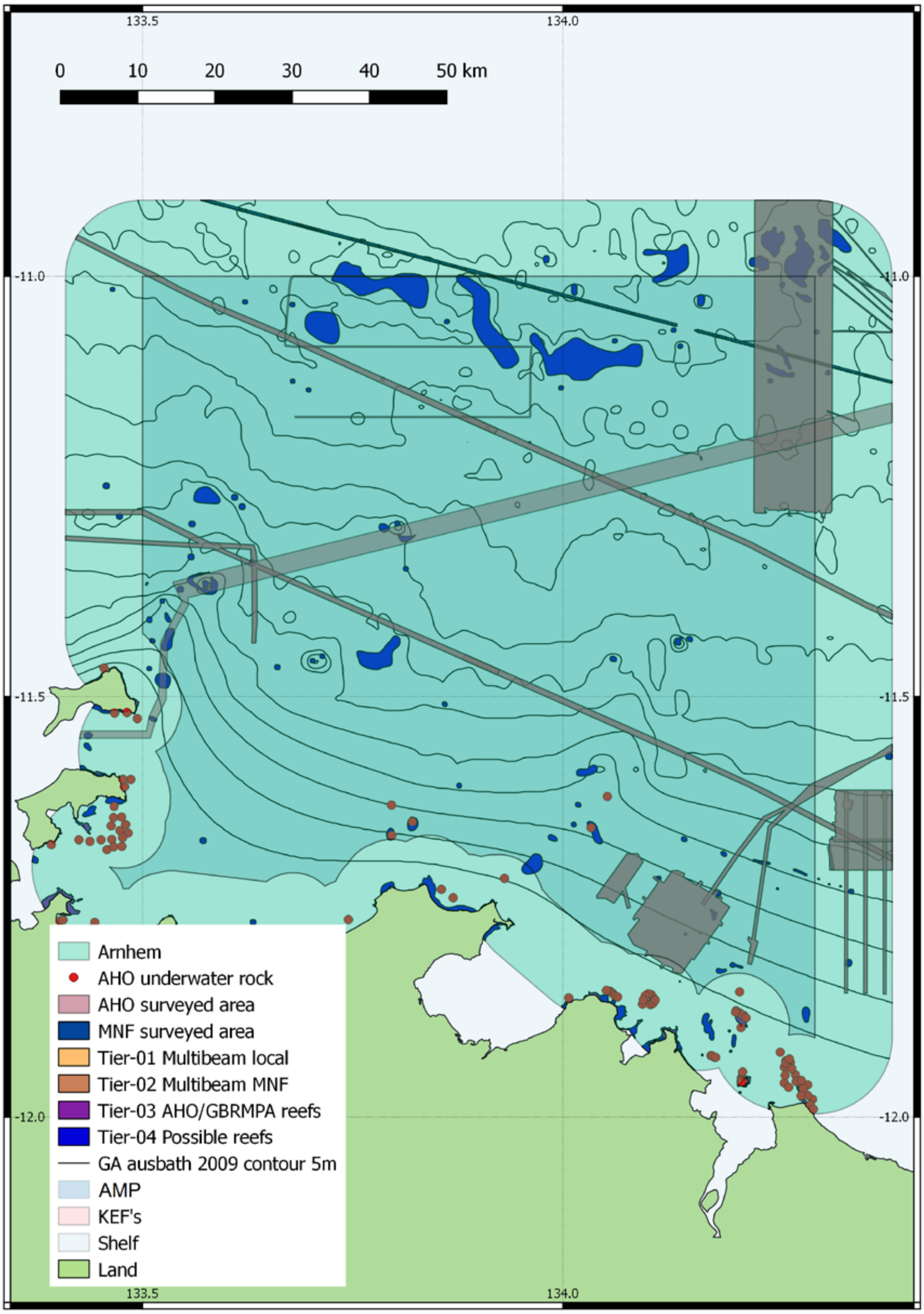


Figure 159. Reef mapping extents within the continental shelf zone of the Arnhem AMP.

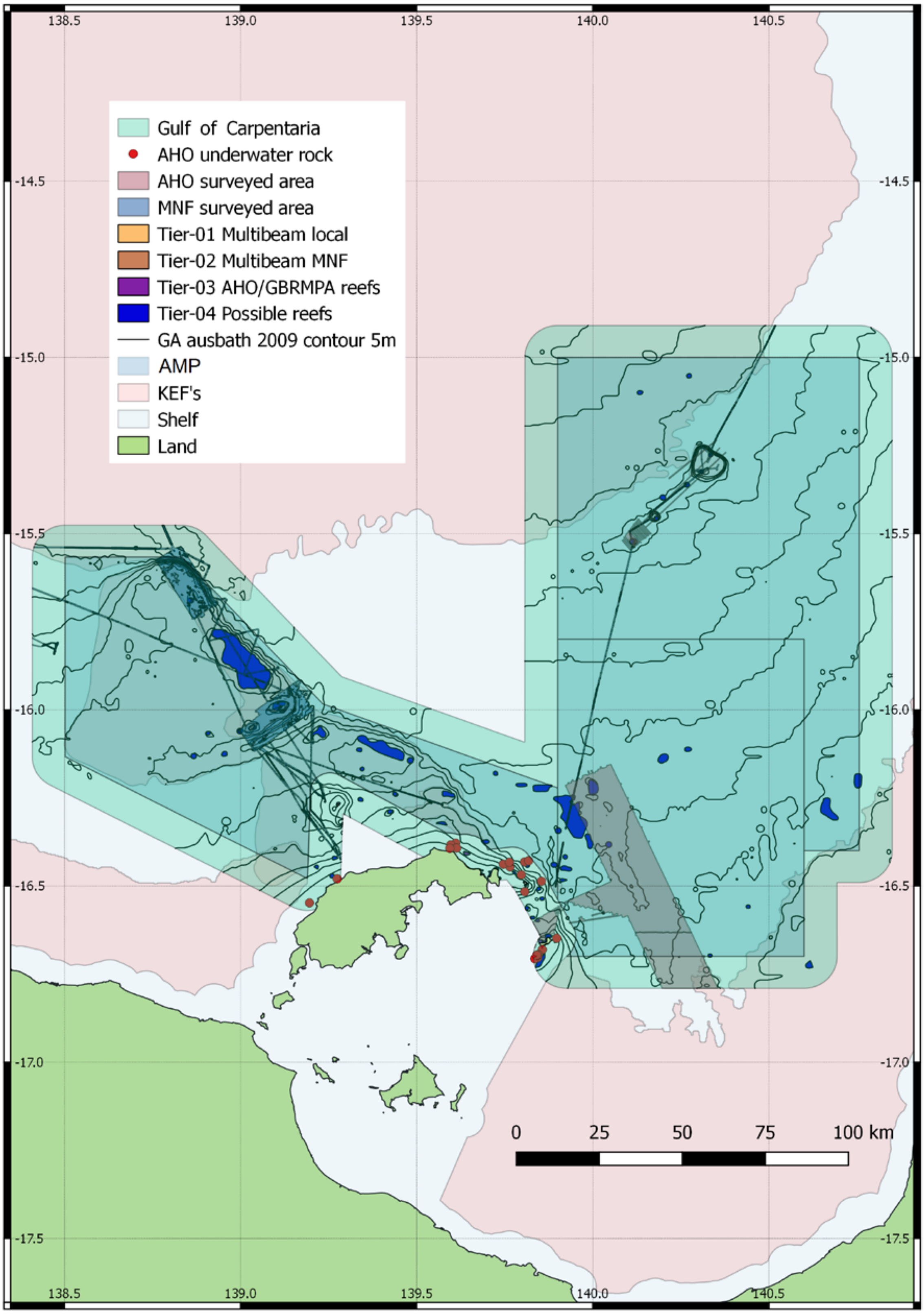


Figure 160. Reef mapping extents within the continental shelf zone of the Gulf of Carpentaria AMP.

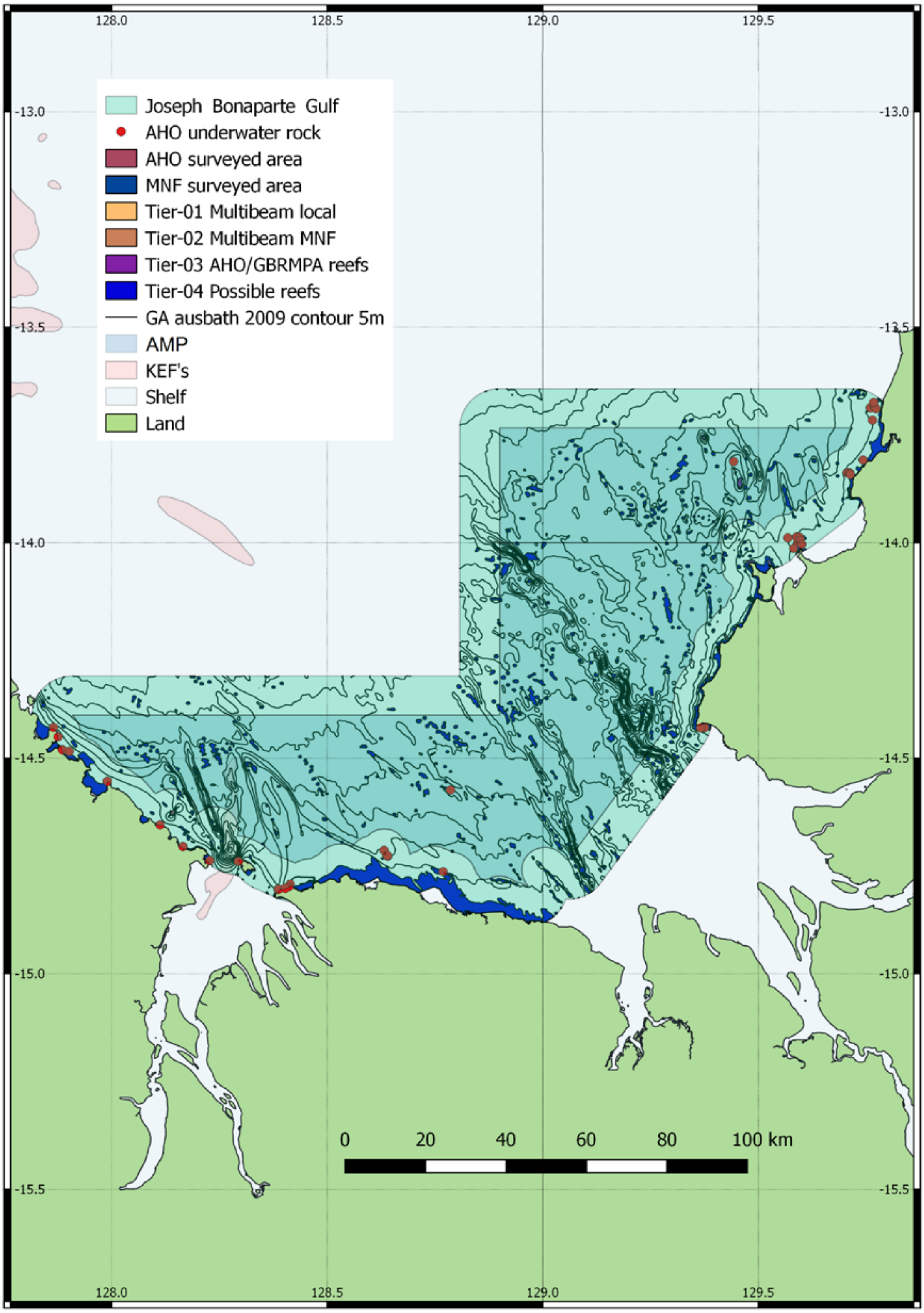


Figure 161. Reef mapping extents within the continental shelf zone of the Joseph Bonaparte Gulf AMP.

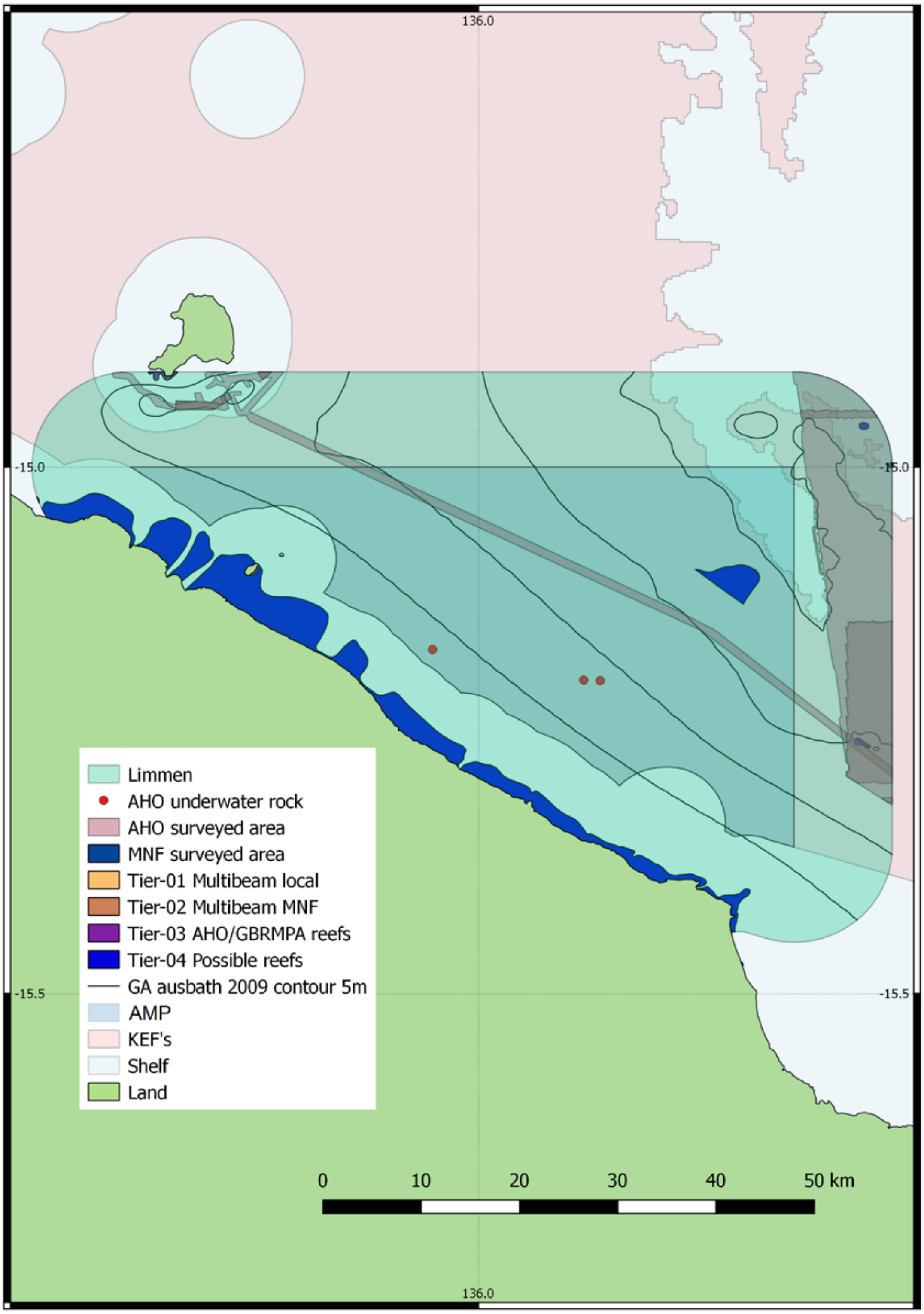


Figure 162. Reef mapping extents within the continental shelf zone of the Limmen AMP.

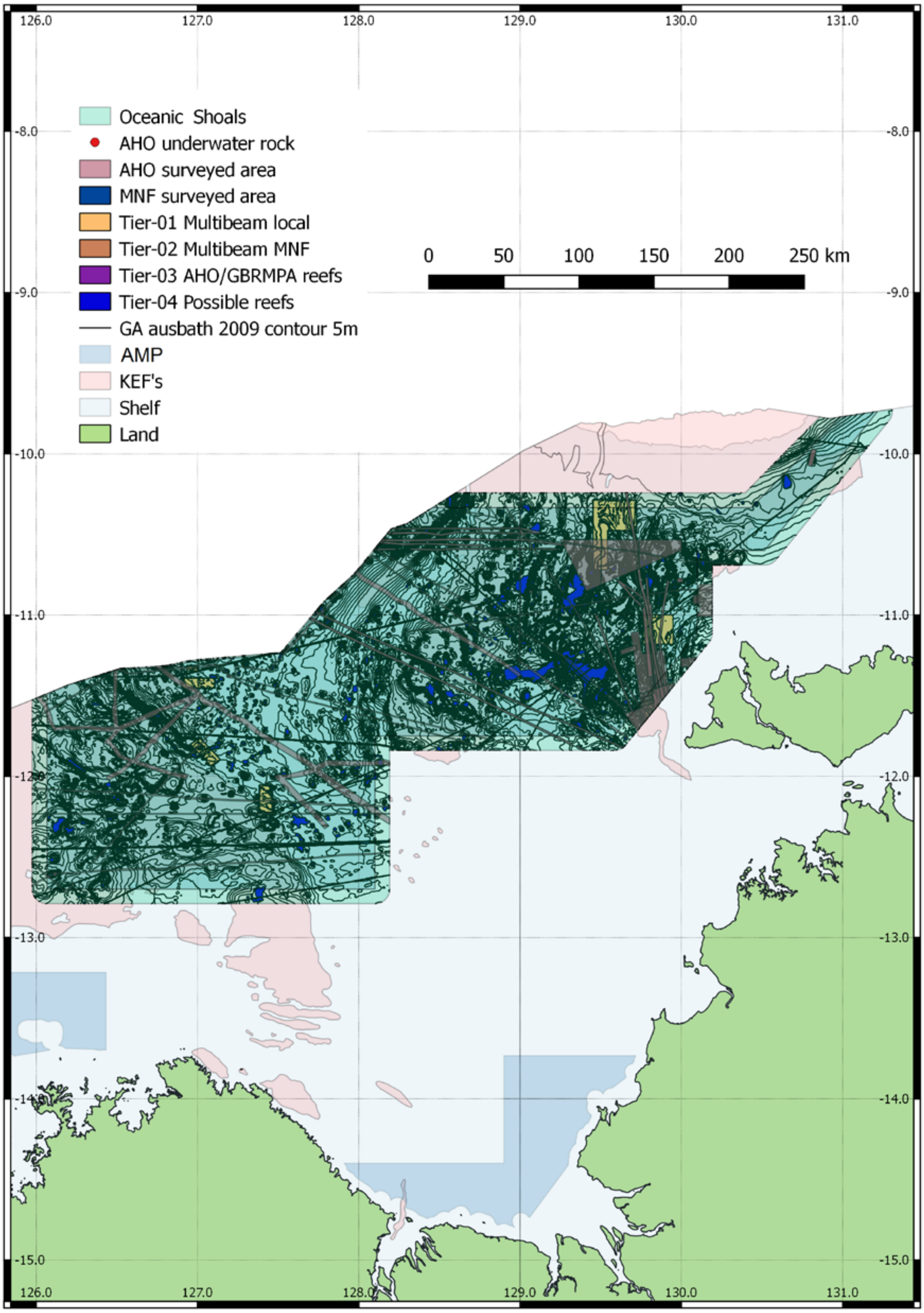


Figure 163. Reef mapping extents within the continental shelf zone of the Oceanic Shoals AMP.

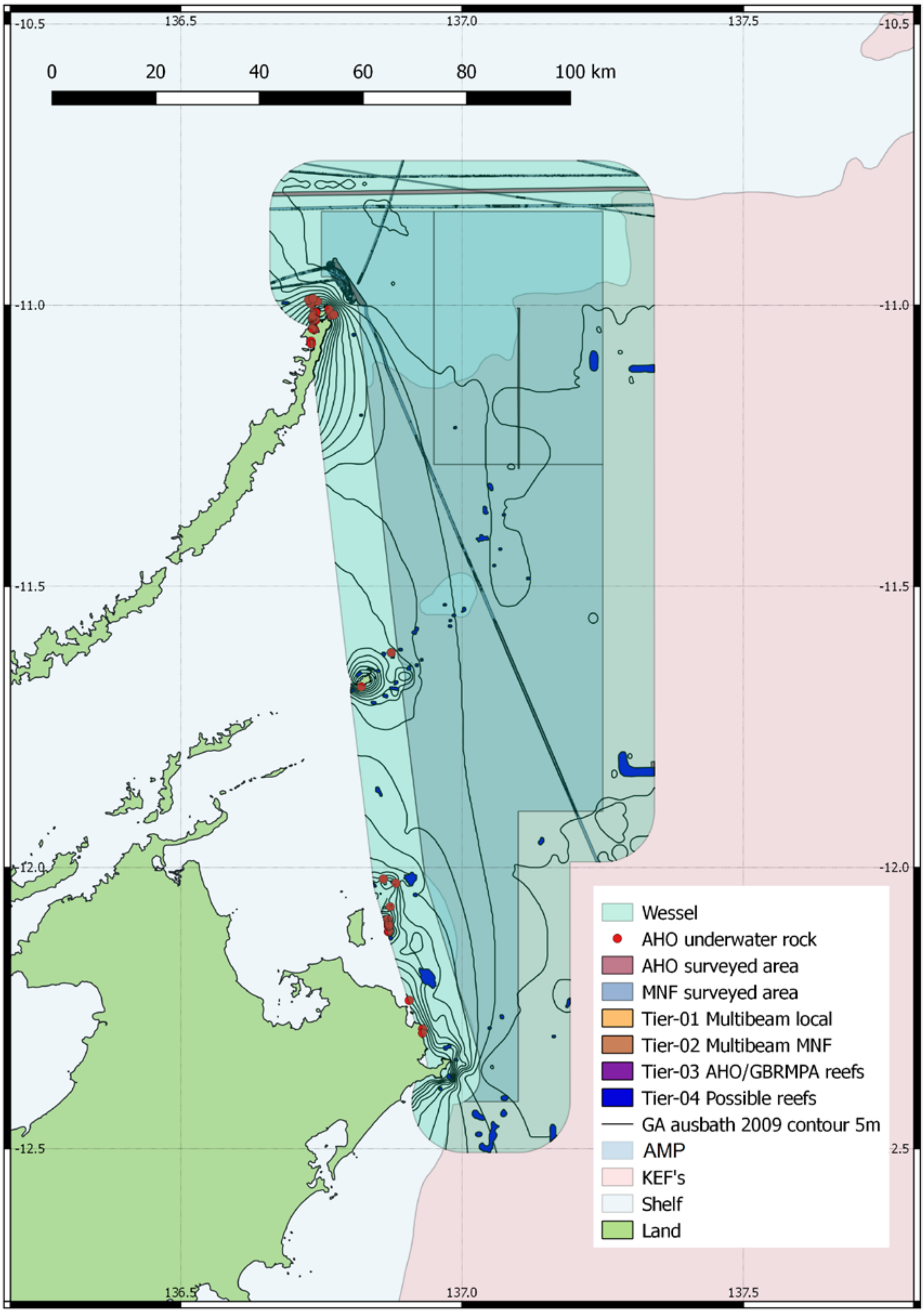


Figure 164. Reef mapping extents within the continental shelf zone of the Wessel AMP.

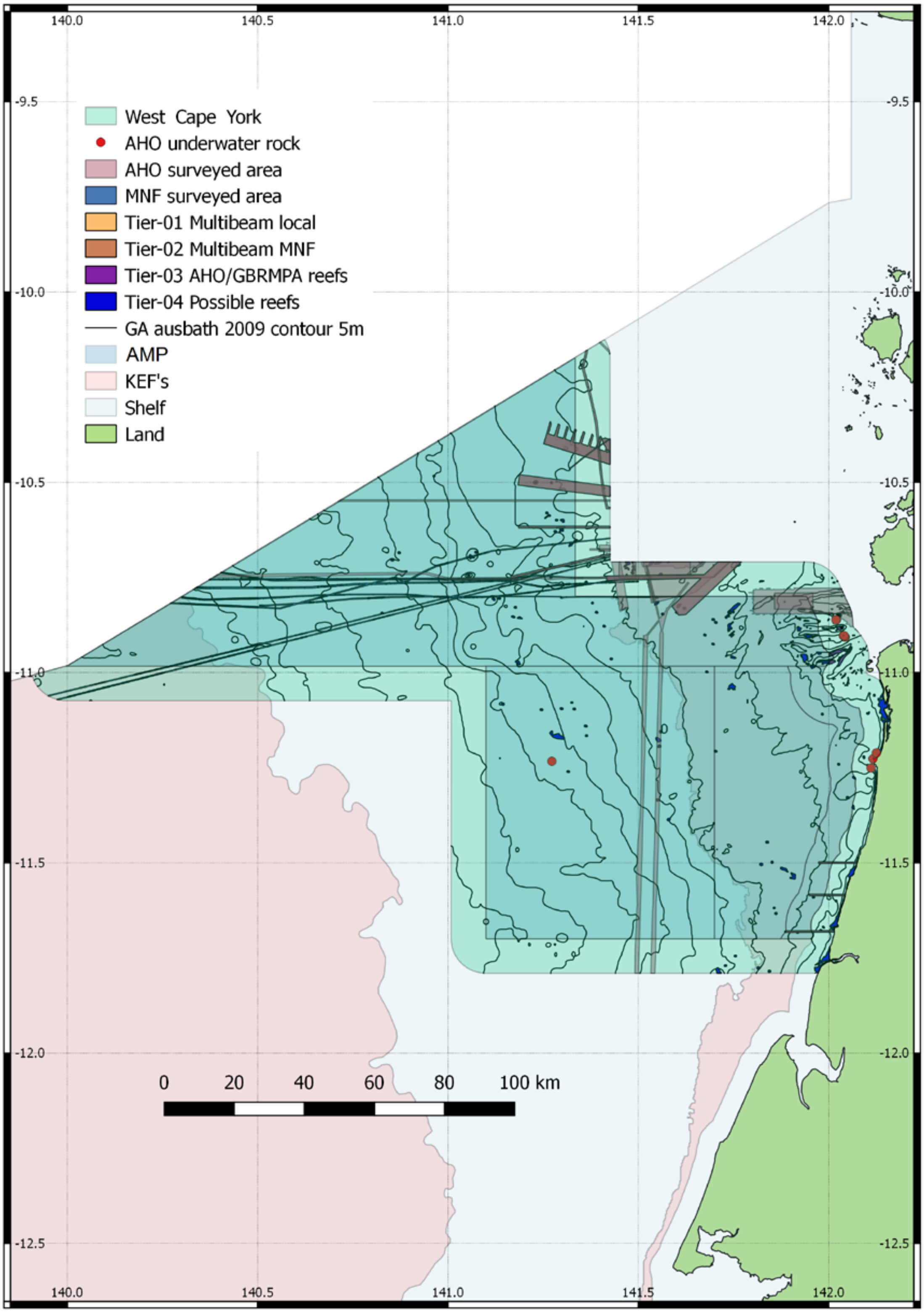


Figure 165.Reef mapping extents within the continental shelf zone of the West Cape York AMP.

www.nespmarine.edu.au

Contact:
Dr Jacquomo Monk
Dr Neville Barrett
Institute of Marine and Antarctic Studies, University of Tasmania

IMAS, Private Bag 49, Hobart, Tasmania, 7001
Jacquomo.monk@utas.edu.au | tel +61 3 6226 8385
neville.barrett@utas.edu.au | tel +61 3 6226 8210