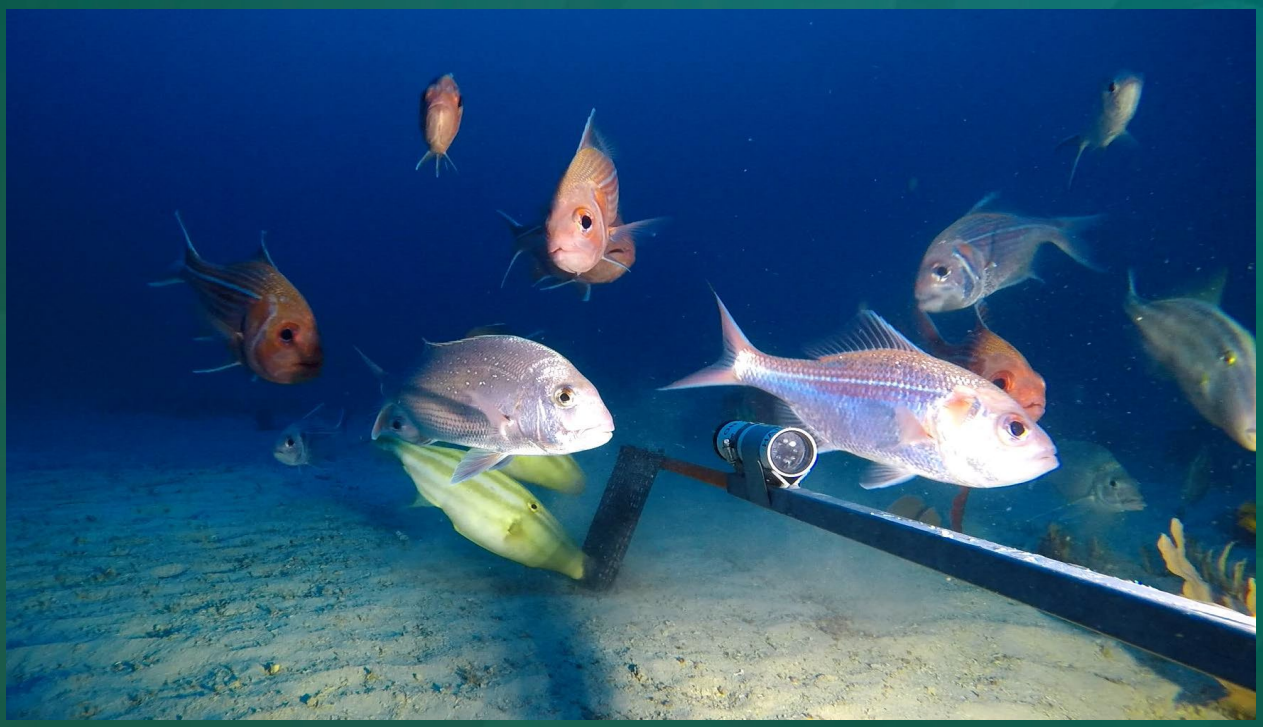
Fish assemblages and benthic habitats in the Western Kangaroo Island state and Commonwealth Marine Parks recorded using baited remote underwater video systems (BRUVS)



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Foreword

The Department for Environment and Water (DEW) is responsible for the management of the State's natural resources, ranging from policy leadership to on-ground delivery in consultation with government, industry and communities.

High-quality science and effective monitoring provides the foundation for the successful management of our environment and natural resources. This is achieved through undertaking appropriate research, investigations, assessments, monitoring and evaluation.

DEW's strong partnerships with educational and research institutions, industries, government agencies, Natural Resources Management Boards and the community ensures that there is continual capacity building across the sector, and that the best skills and expertise are used to inform decision making.

John Schutz
CHIEF EXECUTIVE
DEPARTMENT FOR ENVIRONMENT AND WATER

Acknowledgements

We wish to acknowledge the traditional custodians of the Karta land and sea country on which this expedition was undertaken and pay respects to Elders past, present and emerging.

This work was undertaken for Parks Australia Marine Parks with a collaborative partnership between the Department for Environment and Water (DEW), Parks Australia and Primary Industries and Regions SA (PIRSA). We wish to thank Nicole Middleton, Matt Read, Steven Kempster, Shane Gassen, Tim Langlois and Anita Giraldo for their support and delivery of this project.

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1 Introduction

1.1 Background

One of the main goals of Australian (Commonwealth) and state marine park networks is to protect and conserve marine biodiversity and habitats. A critical step to achieving this goal is to document the biodiversity and habitats contained within these parks. Currently very little is known about the benthic habitats and marine life within marine parks located off the western coastline of Kangaroo Island (KI). These waters are deep and remote making research and monitoring both expensive and challenging. This location does, however, benefit from having both the Western Kangaroo Island state and Commonwealth marine parks adjacent to each other thus creating significant conservation benefit by affording protection over a large area of ocean and also an opportunity for collaborative work to be undertaken (Figure 1).

When designing marine parks, a complementary approach is often taken to align boundaries across state and Commonwealth waters where possible and the Western KI Marine Park is one of many examples in South Australia of this. The close proximity of the two marine parks facilitates collaborative arrangements between state and federal agencies to manage these parks including undertaking research and monitoring partnerships to better understand the marine biodiversity contained in them. The joint expedition to the Investigator state marine park and Western Eyre Commonwealth marine park in 2018 being a recent example (e.g. Pearson Expedition).

Mesophotic habitats (30 – 150m) are often referred to as "transitional" zones that are potentially important to both shallow and deep water species, however much about the connectivity and the species that utilise these zones remains unclear (Semmler et al 2017; Williams et all 2019). Characterising the species assemblages and collecting inventory data from these systems is therefore critical to better understanding how these marine environments function and the role marine parks might play in protecting these systems. As these habitats comprise a large proportion of the combined state and commonwealth marine park network, collaborative research expeditions between state and commonwealth agencies can provide a cost-effective and unique opportunity to survey these marine environments and collect baseline data.

A collaborative expedition was undertaken between DEW, Parks Australia and PIRSA to characterise the species assemblages and benthic habitats inside the adjacent state and Commonwealth Western Kangaroo Island Marine Parks. The expedition was undertaken from aboard the PIRSA-owned vessel *FPV Southern Ranger* in November 2020. The expedition targeted the two adjacent areas with the highest protection in each park, sanctuary zone (SZ-2) in state waters and the national park zone (swwkinpz01) in Commonwealth waters; both of which are no-take zones (Figure 1).

The results from the expedition will contribute to our understanding of the biodiversity contained within these marine parks and assist in effectively managing them. The objectives of the expedition were to:

- Collect inventory data on fish assemblages and benthic habitats from one of the deepest state marine park sanctuary zones (~100m)
- Establish baseline ecological data for long term monitoring of national park and sanctuary zones in Commonwealth and state marine parks.

The outcomes from this expedition are expected to improve our understanding of the connectivity between Commonwealth and state marine parks and the benthic and pelagic communities contained within them; as well as increase our knowledge of the mesophotic environments in SA which have been little studied to date.

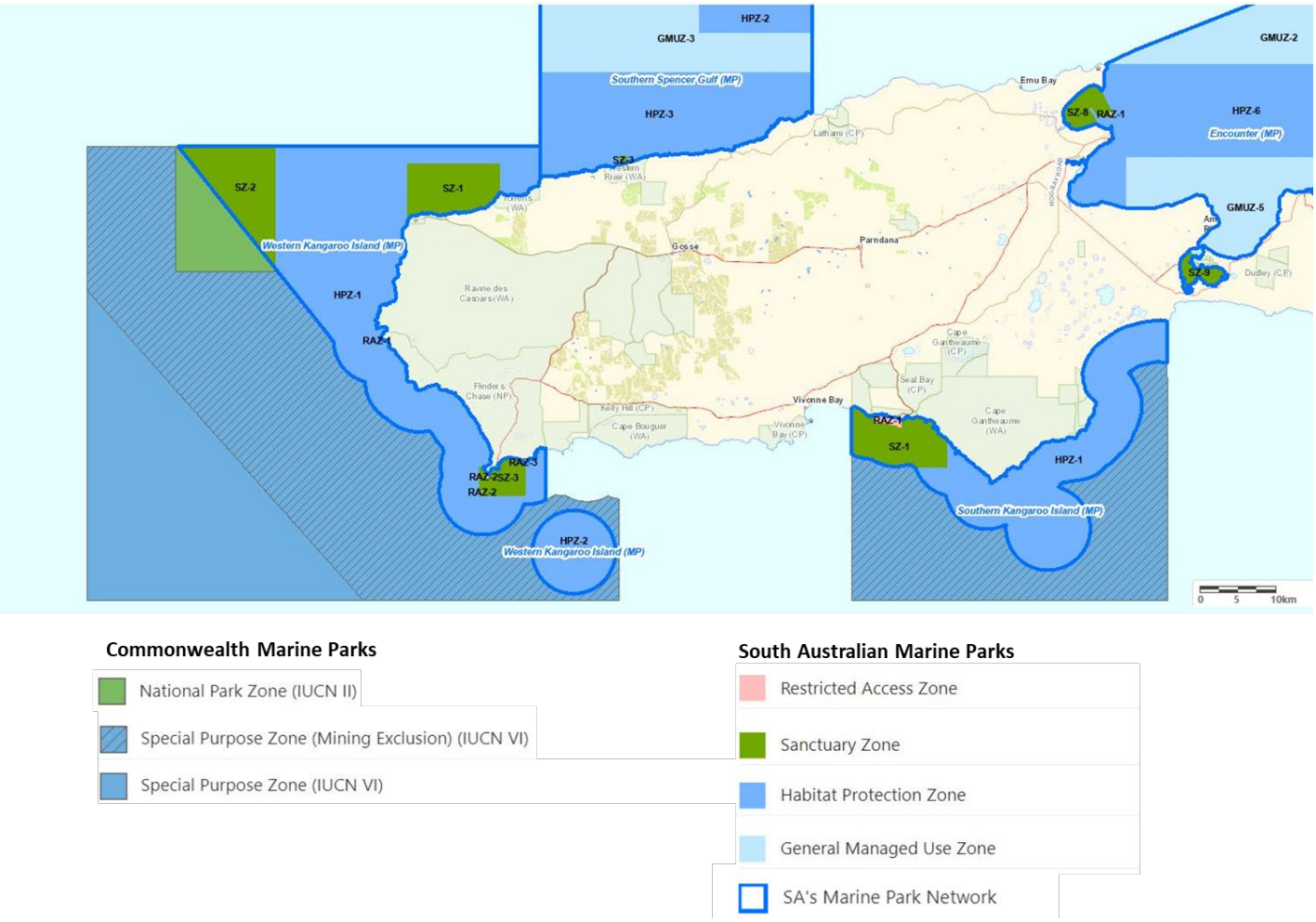


Figure 1. Map showing the location of the Commonwealth Kangaroo Island Marine Park and its proximity to the state Western Kangaroo Island Marine Park.

1.1.1 Park descriptions and significance

1.1.1.1 Commonwealth Western Kangaroo Island Marine Park

The Commonwealth Western Kangaroo Island Marine Park (CWKIMP) is located off Kangaroo Island, about 230 kilometres south-west of Adelaide and adjacent to the state South Australia Western Kangaroo Island Marine Park. It includes representative examples of habitats and ecosystems of the Spencer Gulf Shelf. The CWKIMP covers an area of 2,335 km^2 ranging from 15 to165 m (average 110m) deep and consists of three different zone types; Special Purpose Zone (IUCN VI) (~780 km^2), Special Purpose Zone (Mining Exclusion) (IUCN VI) (~1435km^2), and National Park Zone (IUCN II) (~120km^2, boating only). The CWKIMP includes an escarpment at depths of 90–120 m. The escarpment is part of an ancient coastline from when sea levels were lower than today. This park lies in an area where upwellings lift nutrient-rich waters from near the seafloor to the surface, helping marine life to flourish. The park is an important feeding ground for seabirds such as Caspian terns, pacific gulls and black-faced cormorants, Australian sea lions, white sharks and pygmy blue whales (Parks Australia, 2022 https://atlas.parksaustralia.gov.au)

1.1.1.2 State Western Kangaroo Island Marine Park

The State Western Kangaroo Island Marine Park (WKIMP) covers ~921km^2 and consists of three sanctuary zones including the Kangaroo Island Upwelling Sanctuary Zone (SZ-2 Figure 1). The WKIMP is located within the Eyre Bioregion. The southern and western coasts of the park are highly exposed to strong winds and large swells and experience seasonal nutrient-rich upwelling. The park's shoreline is dominated by rugged, exposed cliffs and headlands interspersed by pocket beaches. Reefs extend from intertidal wave-cut shore platforms along most of the coastline and transition to sandy seafloor habitats in deeper waters (Baker 2004). The coastline of this park is one of the longest management boundaries between marine and terrestrial protected areas in the State. The marine park includes the estuaries of rivers flowing from the adjacent Flinders Chase National Park. The catchments of two of these, the Breakneck and Rocky Rivers, are entirely contained within the terrestrial park and are listed as Wetlands of National Importance.

The WKIMP is used by a number of marine mammal species, including southern right whale, pygmy blue whale, sperm whale, pygmy sperm whale, dwarf sperm whale, pygmy right whale, beaked whale, short-finned pilot whale, false killer whale, Risso's dolphin, southern right whale dolphin, Australian sea lion, long-nosed fur seal, Australian fur seal, common dolphin and bottlenose dolphin. Some of these species are resident while others are more transient, visiting to rest, breed and/or feed (DENR 2010, Bryars et al 2016).

Three species of pinnipeds (seals and sea lions) are found within this park. Cape du Couedic has ten recorded breeding sites for long-nosed fur seals (LNFS) and another occurs on North Casuarina Islet. Together, these sites create the second largest concentration of LNFS on Kangaroo Island. North Casuarina Islet is also a site for Australian sea lions to haul-out, and occasionally breed, as well as a significant breeding site for Australian fur seals. Fish species of conservation concern found in the park include the long-lived and site-attached western blue groper, harlequin fish and southern blue devil (DENR 2010).

The WKIMP is used by a number of shark species, including blue shark, dusky whaler, smooth hammerhead, school shark, white shark, shortfin mako and porbeagle (DENR 2010).

The WKIMP is used by a number of seabird species, including white-bellied sea eagle, osprey, crested tern, fairy tern and Pacific gull (DENR 2010). Some of these species are resident while others are more transient, visiting the WKIMP to rest, breed and/or feed. Seabirds that breed in New Zealand or Antarctica, such as albatross, petrels and prions also occur in the WKIMP (Marchant and Higgins 1990).

2 Methods

2.1 Study area

The focus area of this study was the National Park Zone (IUCN II) of the CWKIMP and the Kangaroo Island Upwelling Sanctuary Zone (KIUSZ) which abuts the National Park Zone; together these zones form a large rectangular shape that lies offshore from the western coast of Kangaroo Island (Figure 1). The Commonwealth National Park Zones are equivalent to the state sanctuary zones in that fishing is excluded and therefore these zones are often the focus of monitoring as marine biodiversity is provided a high level of protection in these zones.

2.2 Baited Remote Underwater Video Systems (BRUVS)

Fish and mobile invertebrate assemblages were characterised using baited remote underwater video systems (BRUVS). BRUVS are frequently utilised to survey fish and large mobile invertebrates and monitor changes in assemblages (Langlois et al. 2006; Malcolm et al. 2007; Kleczkowski et al. 2008) and are currently used to monitor biodiversity of the South Australian Marine Parks Network (Miller et al 2017; Langlois et al 2020). BRUVS provide a non-destructive and repeatable method which can record fish abundance, size and species richness. BRUVS are an effective way to assess benthic and pelagic fish communities and is applicable for collecting baseline data in Australian Marine Parks (AMP's). For this study both benthic and pelagic BRUVS were utilised.

2.3 Benthic Stereo BRUVS

Thirty benthic stereo BRUVS drops were deployed in both state sanctuary zone (SZ) and Commonwealth national park zones (NPZ) within the Western Kangaroo Island Marine Parks, based on a spatially balanced design utilising Geoscience bathymetry layers (Figure 2) (Langlois et al 2020). Three sites were selected from the proposed spatially balanced design within each marine park with a clustered design (Figure 3). At each site a cluster of five replicate BRUVS drops were deployed which were separated by 500m to maintain independent sampling and reduce the likelihood of fish swimming between neighbouring deployments. One replicate deployment at two sites was aligned to previous benthic sampling locations undertaken by the Integrated Marine Observing System (IMOS) Autonomous Underwater Vehicle (AUV) during a previous expedition to Western Kangaroo Island (Squiddle+) (Figure 3).

The benthic BRUVS were deployed to depths ranging from 100-120 m based on where the spatially balanced model predicted there to be features in the system (Figure 2). Each stereo BRUVS unit consisted of a pair of GoPro Hero 7 cameras housed inside custom-made SeaGIS underwater housings mounted to a steel frame fitted with weights, ropes and floats (Figure 4). A plastic mesh bait bag filled with approximately 1kg of minced pilchards (*Sardinops* spp.) was mounted on a pole 1.5 m in front of the cameras to attract fish into the view of the cameras. Each BRUVS unit had a custom waterproof white light attached which was engaged for the duration of the deployment. The BRUVS were left on the seabed to record for 60 minutes before being retrieved and redeployed.

2.4 Pelagic Mono BRUVS

Thirty mono pelagic BRUVS drops were deployed in both state SZs and Commonwealth NPZs of the Western Kangaroo Island Marine Parks. Pelagic BRUVS were suspended in the water column above the benthic BRUVS on the same line at ~15m below the surface of the water (Clarke et al 2019). Each unit had 1 x Go Pro hero 4+ contained in custom underwater housing made by SeaGIS. To maintain upright orientation of the units in the water column, ballast weight and sub-surface floats were utilized with reflective tape to enhance visual attraction by pelagic species (Figure 4). All BRUVS were baited with approximately 1kg of minced pilchards placed in a bait basket approximately

1.5m from the camera. Each pelagic BRUVS unit was soaked for the same duration of the Benthic BRUVS (60 minutes) so that units could be collected simultaneously and then redeployed.

The video footage from the benthic and pelagic BRUVS was later interrogated to extract relative abundance (MaxN) and fish length data using EventMeasure software by SeaGIS. For a full description of BRUVS, use and data management, refer to Miller et al. (2017). Habitat data was classified for all benthic BRUVS drops by utilising definitions from 'Collaborative and Automated Tools for Analysis of Marine Imagery' (CATAMI) (Althaus et al. 2015; Langlois et al 2020).

2.5 Multivariate Analysis

Multivariate analysis was used to compare differences in community structure between the methods; SZs and habitats with community structure defined as the patterns in the distribution and abundance of species across monitoring sites. Examination of community structure is a powerful tool for examining changes through time; including recovery from disturbance and change in trophic status. Comparisons of community structure across different sites were conducted in PRIMER v7 (Clarke and Gorley 2015) and PERMANOVA + (Anderson et al. 2008). A total of 30 benthic drops were used for the analysis, with 5 replicate drops from each site within the Commonwealth NPZ and state SZ. A resemblance matrix was conducted using Bray-Curtis index of dissimilarity on dispersion weight transformed data. The data was transformed using dispersion weighting to reduce the impact of high abundance schooling fish which can introduce bias into the data (Clarke et. al 2006). A non-metric multidimensional scaling (nMDS) ordination was plotted to visualise the differences between the communities at each site. To test differences between assemblages at each site, comparisons using PERMANOVA + were conducted including random factors of habitat with pairwise tests conducted on significant factors.

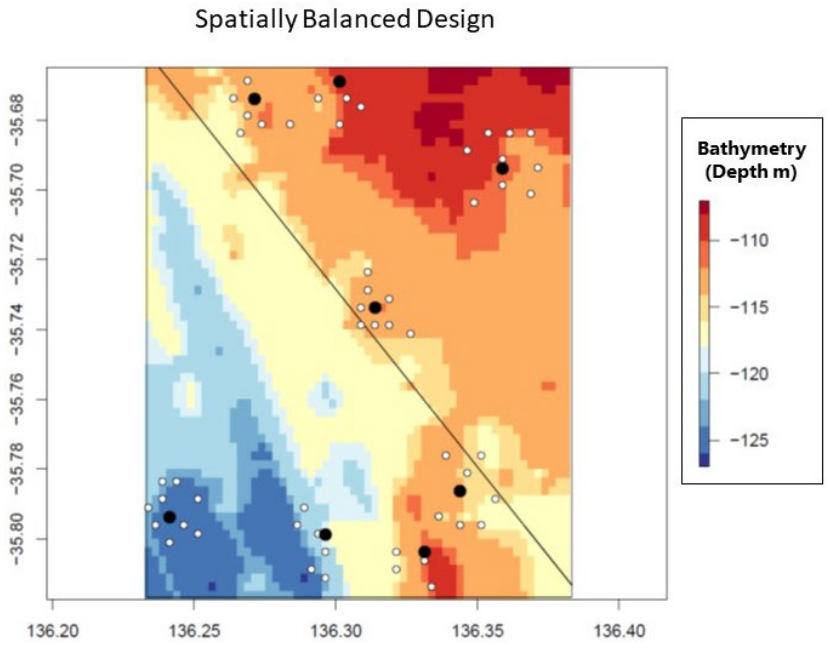


Figure 2. Spatially balanced design of proposed sampling locations for Commonwealth NPZ and state SZ in Western KI Marine Parks.

Figure 3. Map of location and sampling locations for BRUVS in the Commonwealth NPZ and state SZ in Western KI Marine Parks.

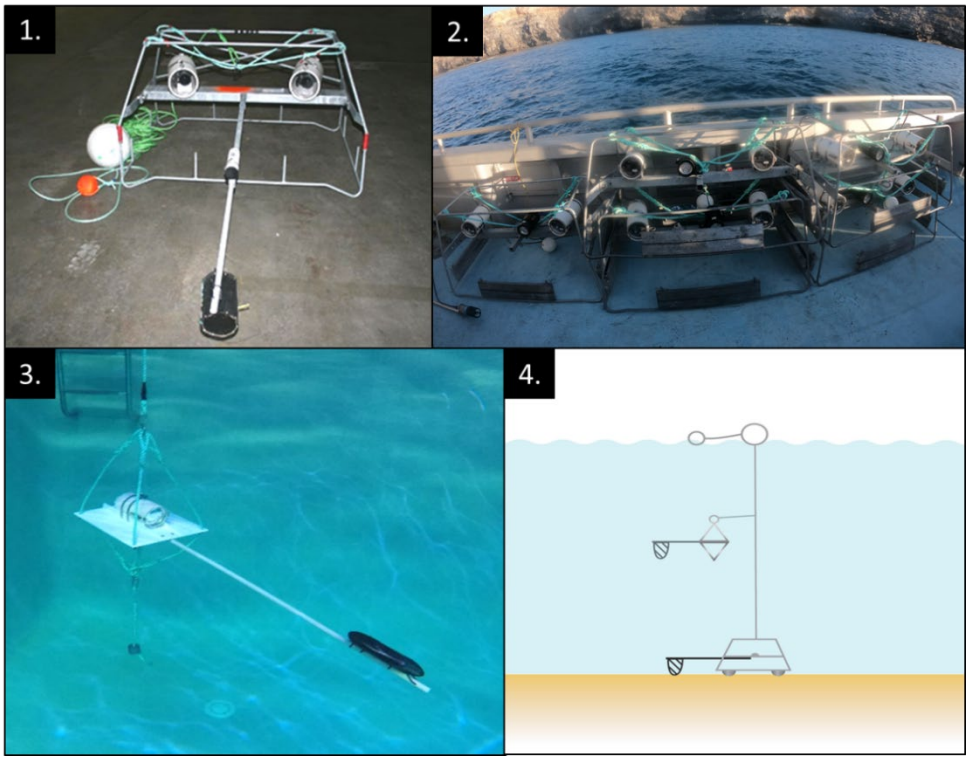


Figure 4. Images of the BRUVS utilised on the Western KI expedition; 1) Stereo Benthic BRUVS setup; 2) Stereo Benthic BRUVS on board the FV Southern Ranger; 3) Pelagic mono BRUVS set up; and 4) Schematic of deployed combined pelagic and benthic BRUVS set ups.

3 Results

3.1 Species richness and abundance captured on benthic BRUVS

3.1.1 Species Richness

In the Commonwealth NPZ, there were 14 species identified to species level and 1 identified to genus level. Ten (66.7%) belonged to ray finned fishes (Actinopterygii), 4 (26.7%) to sharks and rays (Elasmobranchii) and 1 (6.7%) to pinnipeds (Mammalia) (Table 1).

In the state SZ, there were 18 species identified to species level and 2 identified to genus level. Fourteen (70%) belonged to ray finned fishes (Actinopterygii), 5 (25%) to sharks and rays (Elasmobranchii) and 1 (5%) to crustaceans (Malacostraca) (Table 1).

Table 1. Number of species captured on benthic BRUVS classified by Class and % contribution to total species richness in Commonwealth NPZ and state SZ.

Class	No. Species	(%)
Commonwealth NPZ		
Actinopterygii	10	66.7
Elasmobranchii	4	26.7
Mammalia	1	6.7
	15	
State SZ		
Actinopterygii	14	70
Elasmobranchii	5	25
Malacostraca	1	5
	20	

Two species; Barracouta (*Thyrsites atun)* and Australian sea lion (*Neophoca cinerea*) were captured only on benthic BRUVS from the Commonwealth NPZ and not recorded in the state SZ (Figure 5).

Seven species; blue morwong (*Nemadactylus valenciennesi*); hermit crab (Diogenidae sp); samsonfish (*Seriola hippos*); Sergeant Baker (*Latropiscis purpurissatus*); smooth stingray (*Bathytoshia brevicaudata*); trevally (*Pseudocaranx* sp) and velvet leatherjacket (*Meuschenia scaber*) were captured only on benthic BRUVS from the state SZ and not recorded in the Commonwealth NPZ (Figure 5).

A total of 13 species were captured on benthic BRUVS from both Commonwealth NPZ and the state SZ; ocean leatherjacket (*Nelusetta ayraud)*; common jack mackerel (*Trachurus declivis*); swallowtail (*Centroberyx lineatus*); knifejaw (*Oplegnathus woodwardi)*; spikey dogfish (*Squalus megalops)*; bight redfish (*Centroberyx gerrardi*); common gurnard perch (*Neosebastes scorpaenoides*); jackass morwong (*Nemadactylus macropterus)*; snapper (*Chrysophrys auratus*); school shark (*Galeorhinus galeus*); whiskery shark (*Furgaleus macki*); gummy shark (*Mustelus antarcticus*) and gurnard species (*Neosebastes* sp)(Figure 5).

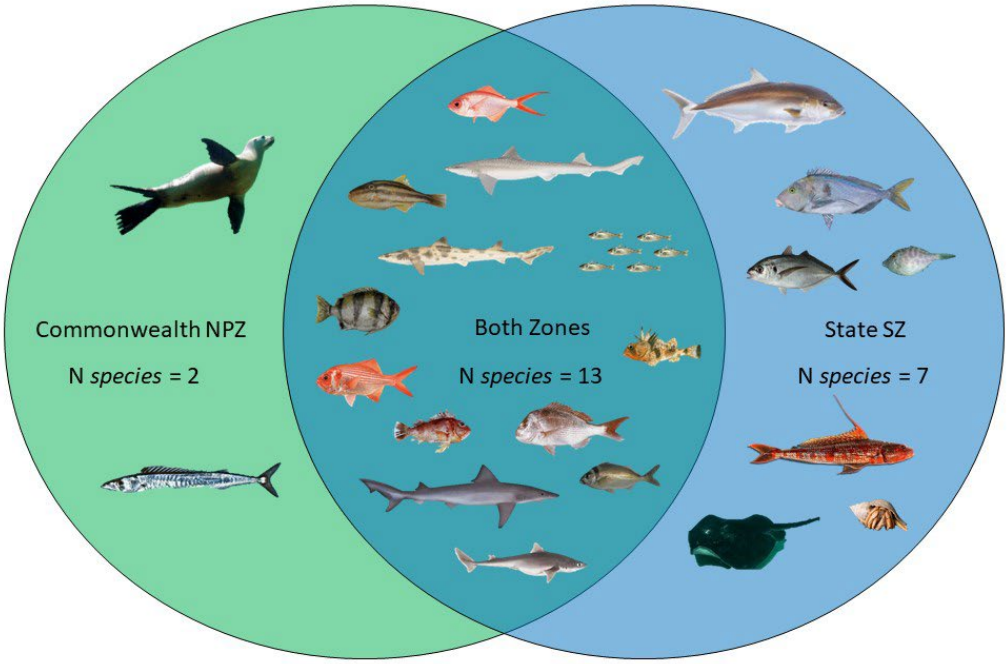


Figure 5. Venn diagram of unique species captured on benthic BRUVS in state SZ (n= 7 species), Commonwealth NPZ (n=2 species) and species captured in both zones (n = 13 species).

3.1.2 Relative Abundance (MaxN)

A total of 963 individuals were captured on benthic BRUVS from both Commonwealth NPZ and state SZ (n=473, n=490 respectively) (Appendix A). Ocean leatherjackets (*Nelusetta ayraud*) were the most abundant species in both the Commonwealth NPZ and state SZ (n = 356, n=326 respectively) comprising over 60% of the total abundance of all species captured (Appendix A).

The five most abundant species captured on benthic BRUVS in Commonwealth NPZ were; ocean leatherjacket (*Nelusetta ayraud)* accounting for 76% of total abundance; jack mackerel (*Trachurus declivis*) accounting for 8%; knifejaw (*Oplegnathus woodwardi)* accounting for 5%; spikey dogfish (*Squalus megalops)* accounting for 4%; and jackass morwong (*Nemadactylus macropterus)* which accounted for 2.5% (Figure 6). Representative images of species observed on benthic BRUVS can be seen in Appendix 3.

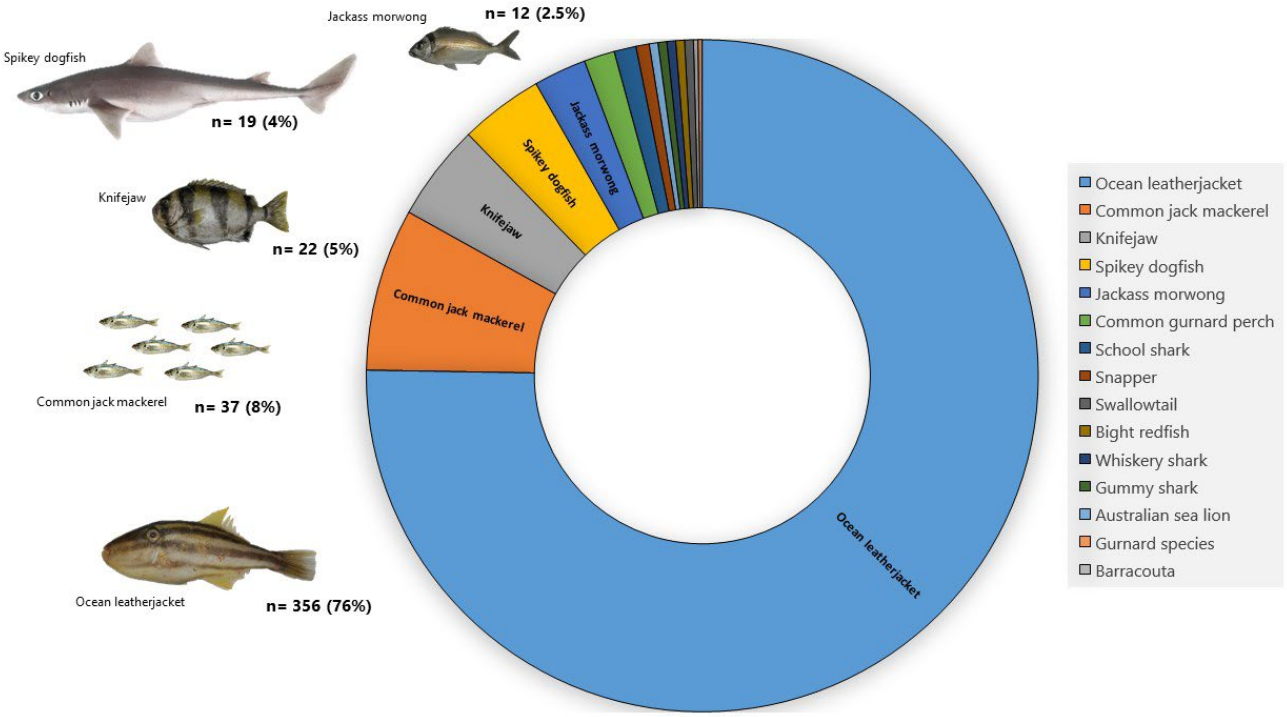


Figure 6. Species captured on benthic stereo BRUVS in the Western KI Commonwealth NPZ. The five most abundant species recorded were; ocean leatherjacket (*Nelusetta ayraud*); jack mackerel (*Trachurus declivis*); knifejaw (*Oplegnathus woodwardi*); spikey dogfish (*Squalus megalops*) and jackass morwong (*Nemadactylus macropterus*).

The five most abundant species captured on benthic BRUVS in state SZ were; ocean leatherjacket (*Nelusetta ayraud)* accounting for 67% of total abundance; swallowtail (*Centroberyx lineatus*) accounting for 11%; jack mackerel (*Trachurus declivis*) accounting for 7%; bight redfish (*Centroberyx gerrardi*) accounting for 3%; and knifejaw (*Oplegnathus woodwardi)* accounting for 3% (Figure 7).

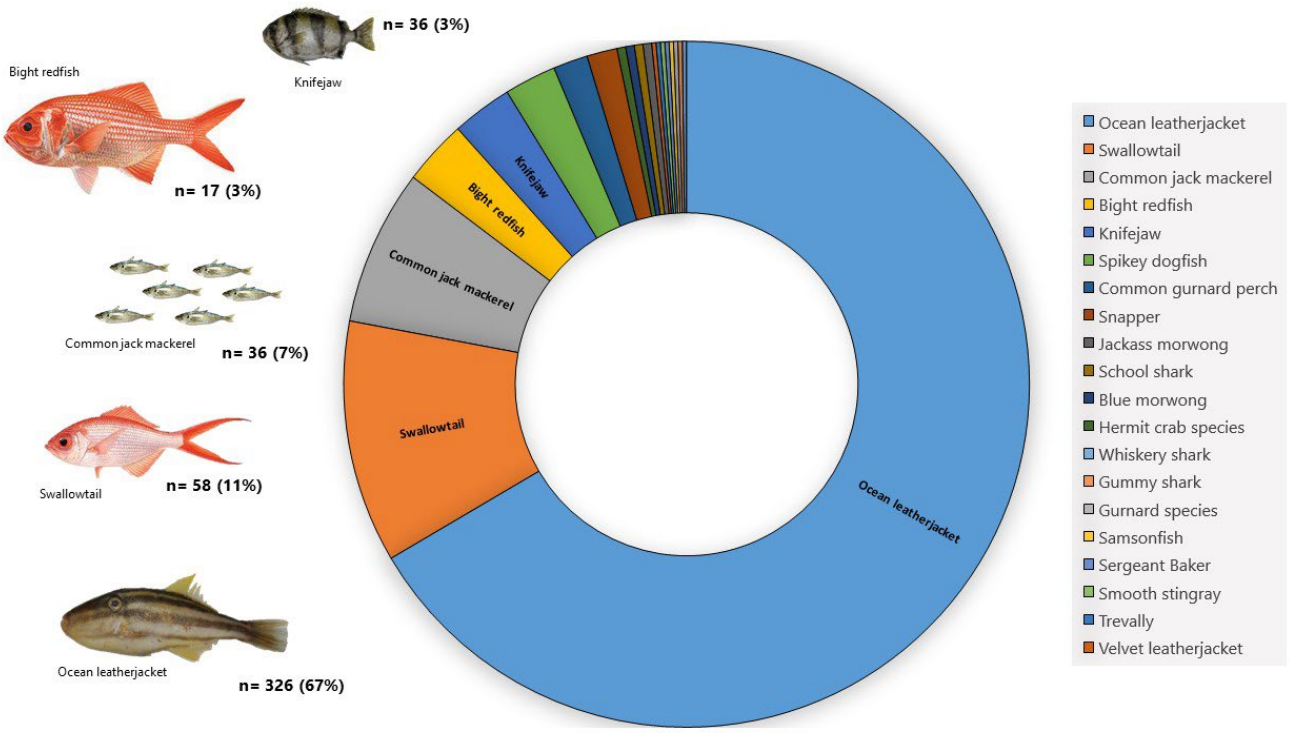


Figure 7. Species captured on benthic stereo BRUVS in the Western KI state SZ. The five most abundant species recorded were; ocean leatherjacket (*Nelusetta ayraud*); swallowtail (*Centroberyx lineatus*); common jack mackerel (*Trachurus declivis*); bight redfish (*Centroberyx gerradi*) and knifejaw (*Oplegnathus woodwardi*).

3.1.3 Abundance of large fish >200mm

The top five large fish species >200mm captured on benthic BRUVS at both the Commonwealth NPZ and state SZ were: ocean leatherjacket (*Nelusetta ayraud*) with a mean size of 329mm; knifejaw (*Oplegnathus woodwardi*) with a mean size of 288mm; swallowtail (*Centroberyx lineatus*) with a mean size of 263mm; Bight redfish (*Centroberyx gerrardi*) with a mean size of 352mm and common gurnard (*Neosebastes scorpaenoides)* with a mean size of 304mm (Figure 8). There was little difference in the abundance of these species between the two different zones with the state SZ having slightly more large fish >200mm than what were present in the Commonwealth NPZ (Figure 8).

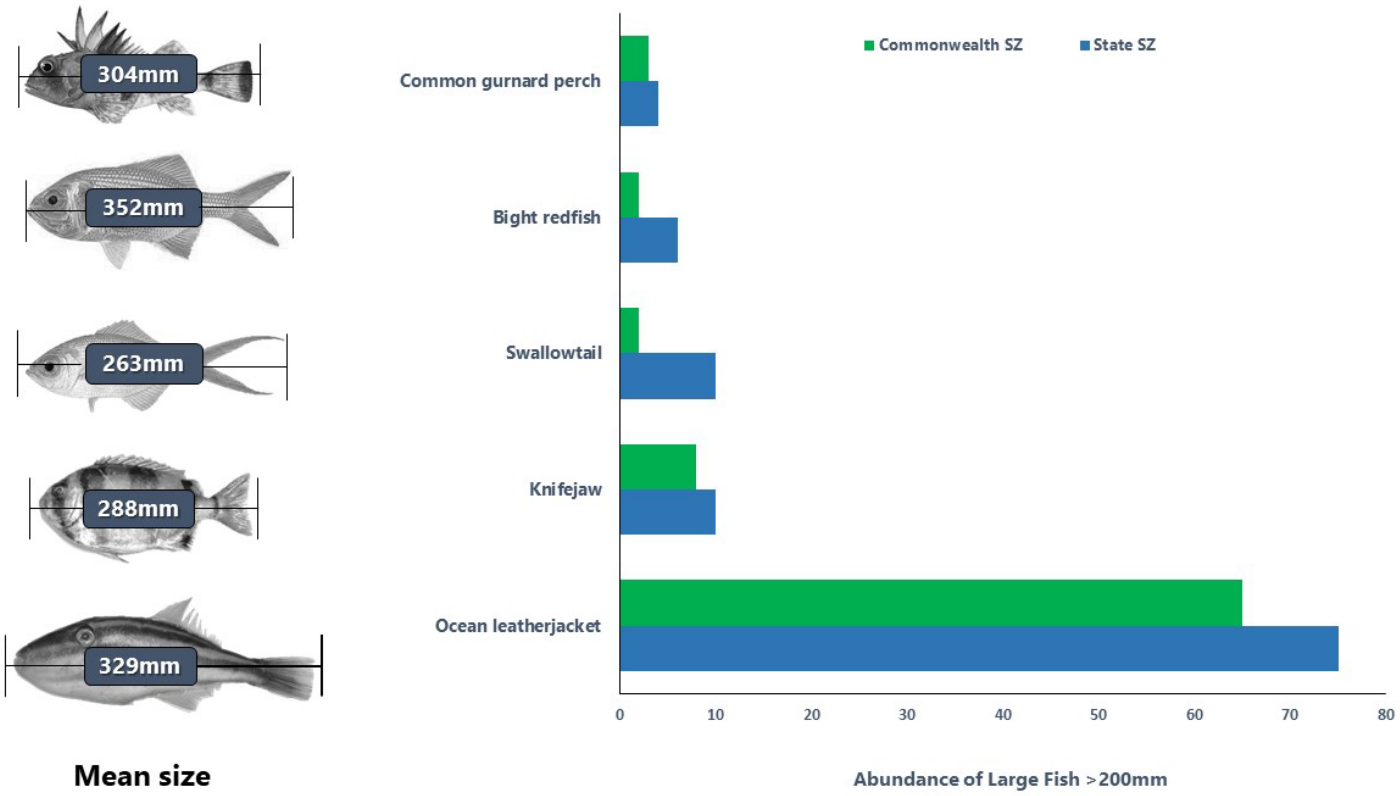


Figure 8. Abundance and mean size of large fish >200mm captured on benthic BRUVs inside the Commonwealth NPZ and state SZ of the Western KI Marine Parks.

3.1.4 Abundance of sharks and rays

There were a total of five different species of sharks and rays (elasmobranchs) captured on benthic BRUVS from both Commonwealth NPZ and state SZ which included; spikey dogfish (*Squalus megalops*) with a mean size of 466mm; school shark (*Galeorhinus galeus*) with a mean size of 923mm; whiskery shark (*Furgaleus macki*) with a mean size of 1181mm; gummy shark (*Mustelus antarcticus*) with a mean size of 619mm and smooth stingray (*Bathytoshia brevicaudata*) where no size data could be collected (Figure 9). Overall there was a higher abundance of sharks and rays captured inside the Commonwealth NPZ than the state SZ with the exception of the smooth stingray which was only recorded in the state SZ (Figure 9).

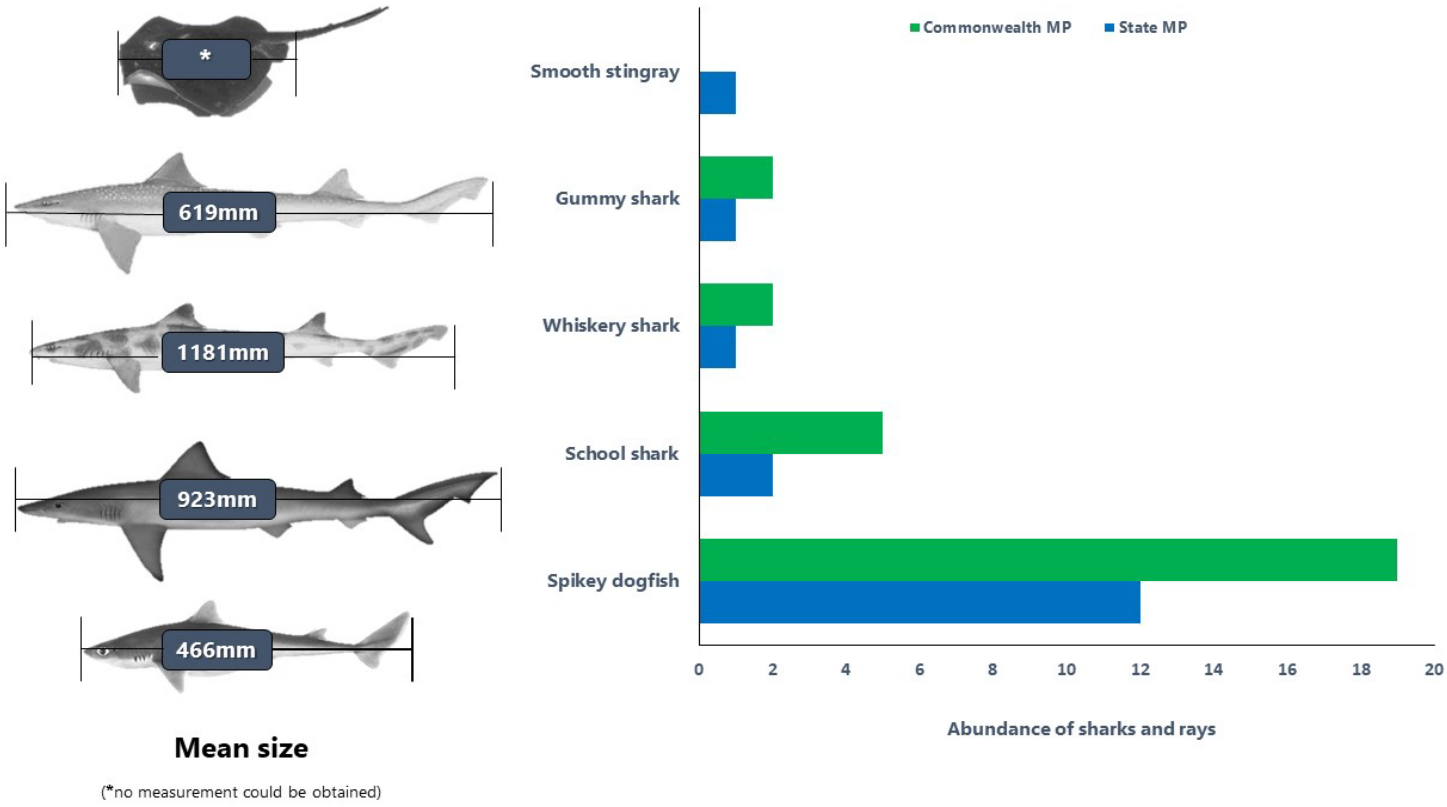


Figure 9. Abundance and mean size of sharks and rays captured on benthic BRUVS inside the Commonwealth NPZ and state SZ of the Western KI Marine Parks.

3.1.5 Benthic habitat

There were five different habitat types captured by benthic BRUVS in the Commonwealth NPZ and state SZ which were: 1) Sponge and Bryozoan; sparse; 2) Sponge and Bryozoan; medium; 3) Sand/mud (<2mm): Course sand with shell fragments; 4) Sand (<2mm); and 5) Soft coral; sponge; bryozoans; sparse (Figure 10). The most common habitat captured was Sponge and Bryozoan; sparse, which was recorded at 70% of all BRUVS sites. Sponges were collected for classification opportunistically from benthic BRUVS (Figure 11).

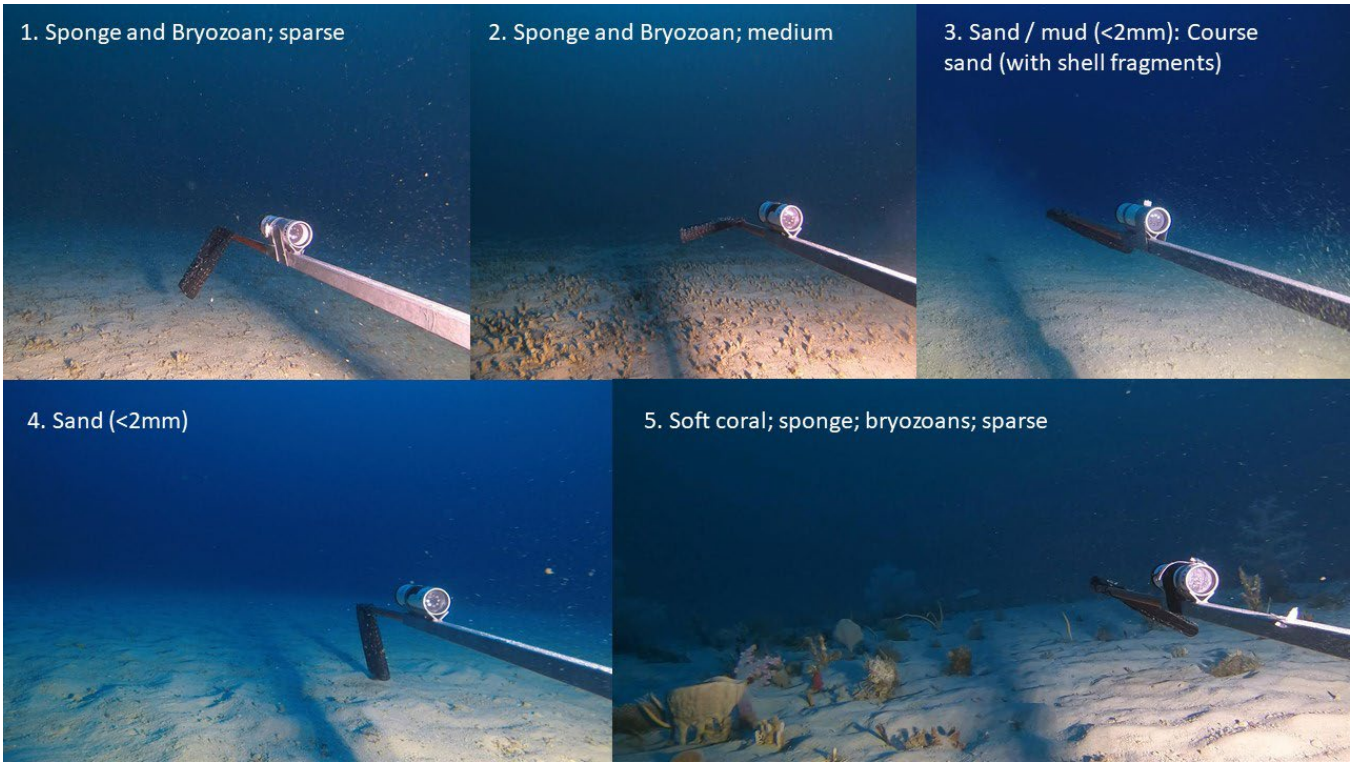


Figure 10. CATAMI classification of habitats captured by benthic BRUVS at Commonwealth NPZ and state SZ within the Western Kangaroo Island marine parks.

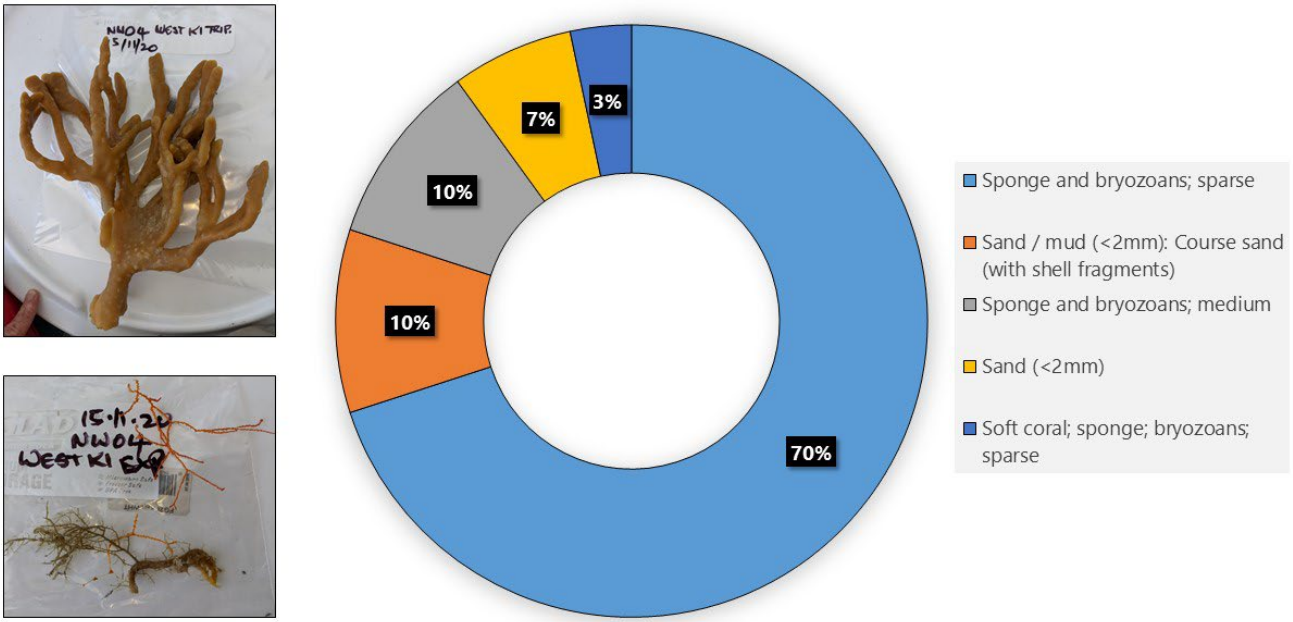


Figure 11. Habitats (%) captured by benthic BRUVS at Commonwealth NPZ and state SZ within the Western Kangaroo Island marine parks. Images: Sponge fragments which were collected opportunistically by the benthic BRUVS for classification.

3.2 Species richness and abundance captured on pelagic BRUVS

3.2.1 Species Richness

There was a total of 10 species captured on pelagic BRUVS in both Western KI marine parks (Appendix B). In the Commonwealth NPZ, there were 4 species identified to species level and 2 identified to genus level. Three species (50%) belonged to ray finned fishes (Actinopterygii); 2 (33%) belonged to pinniped and cetacean (Mammalia) and 1 (17%) belonged to Cnidaria (Table 2).

In the state SZ, there were 5 species identified to species level and 2 identified to genus level. Four species (58%) belonged to ray finned fishes (Actinopterygii); 1 (14%) belonged to Cnidaria; 1 (14%) belonged to cetacean (Mammalia) and 1 (14%) belonged to Argonauta (Mollusca) (Table 2).

Representative images of species observed on pelagic BRUVS can be seen in Appendix 4.

Table 2. Number of species captured on pelagic BRUVS classified by Class and % contribution to total species richness in Commonwealth NPZ and state SZ.

Class	No. Species	(%)
Commonwealth NPZ		
Actinopterygii	3	50
Mammalia	2	33
Cnidarian	1	17
	6	
State SZ		
Actinopterygii	4	58
Cnidarian	1	14
Mammalia	1	14
Mollusca	1	14
	7	

Three species; long-nosed fur seal (*Arctocephalus forsteri*), silver warehou (*Seriolella brama*) and leatherjacket species (Monocanthidae spp) were captured only on pelagic BRUVS from the Commonwealth NPZ and not recorded in the state SZ (Figure 12).

Four species; Ocean leatherjacket (*Nelusetta ayraud*); blue warehou (*Seriolella punctata*); Australian anchovy (*Engraulis australis)* and paper nautilus (*Argonauta* sp) were captured only on pelagic BRUVS from the state SZ and not recorded in the Commonwealth NPZ (Figure 12).

Three species were captured across both Commonwealth and state zones; Cnidaria; short-beaked common dolphin (*Delphinus delphinus);* and common jack mackerel (*Trachurus declivis*) (Figure 12).

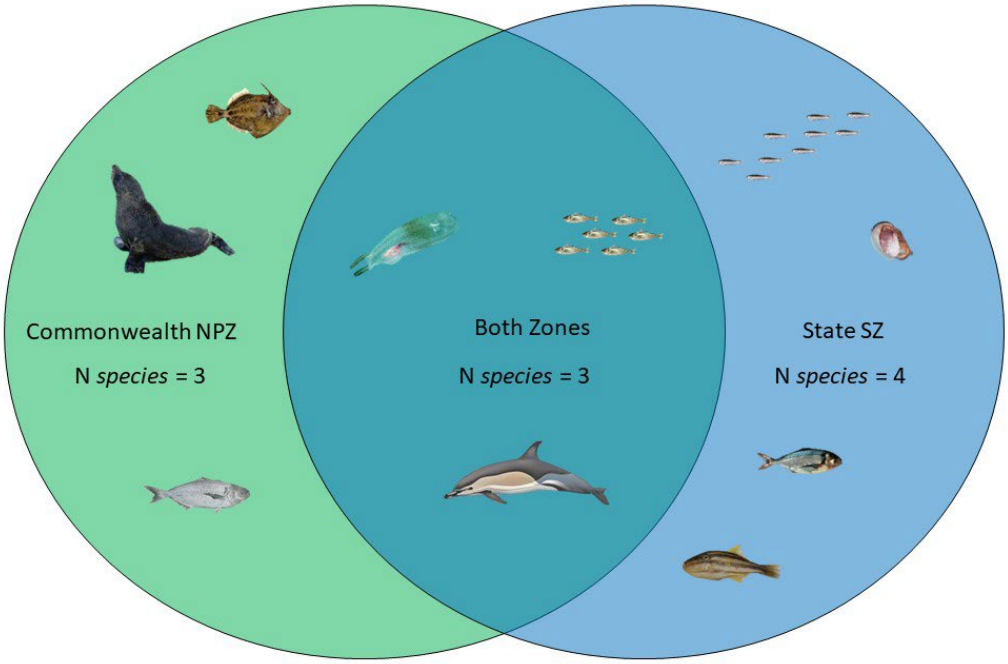


Figure 12. Venn diagram of unique species captured on pelagic BRUVS in state SZ (n= 4 species), Commonwealth NPZ (n=3 species) and same species captured in both zones (n = 3 species).

3.2.2 Relative Abundance (MaxN)

A total of 50 individuals was captured on pelagic BRUVS from both Commonwealth NPZ and state SZ (n=18, n=32 respectively) (Appendix B).

Cnidarians were the most abundant species in the Commonwealth NPZ (n=10) contributing 56% to the total abundance followed by silver warehou (*Seriolella brama*) (n= 3) contributing 17%; short-beaked common dolphin (*Delphinus delphis*) (n=2) contributing 11%; long-nosed fur seal (*Arctocephalus forsteri*) (n=1) contributing 6%; leatherjacket species (Monacanthidae sp) (n=1) contributing 6% and jack mackerel (*Trachurus declivis*) (n=1) contributing 6%, Figure 13).

Ocean leatherjackets (*Nelusetta ayraud*) were the most abundant species in the state SZ (n = 17) contributing 53% to the total relative abundance, followed by cnidarians (n=5) contributing 17%; blue warehou (*Seriolella punctata*) (n=3) contributing 9%; common jack mackerel (*Trachurus declivis*) (n=3) contributing 9%; short-beaked common dolphin (*Delphinus delphis*) (n=2) contributing 6%; paper nautilus species (*Argonauta* sp) (n=1) contributing 3% and Australian anchovy (*Engraulis australis)* (n=1) contributing 3% (Figure 14).

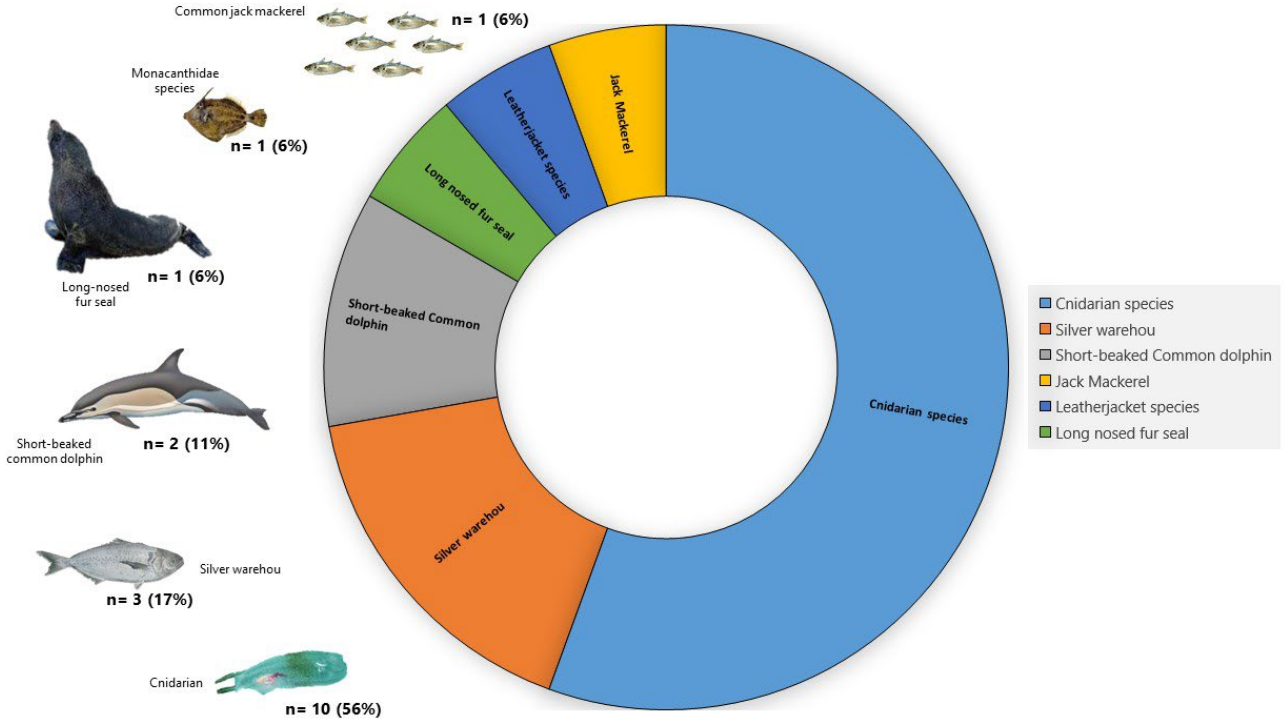


Figure 13. Abundance of species captured on pelagic mono BRUVS in the Western KI Commonwealth NPZ and their % contribution to total abundance.

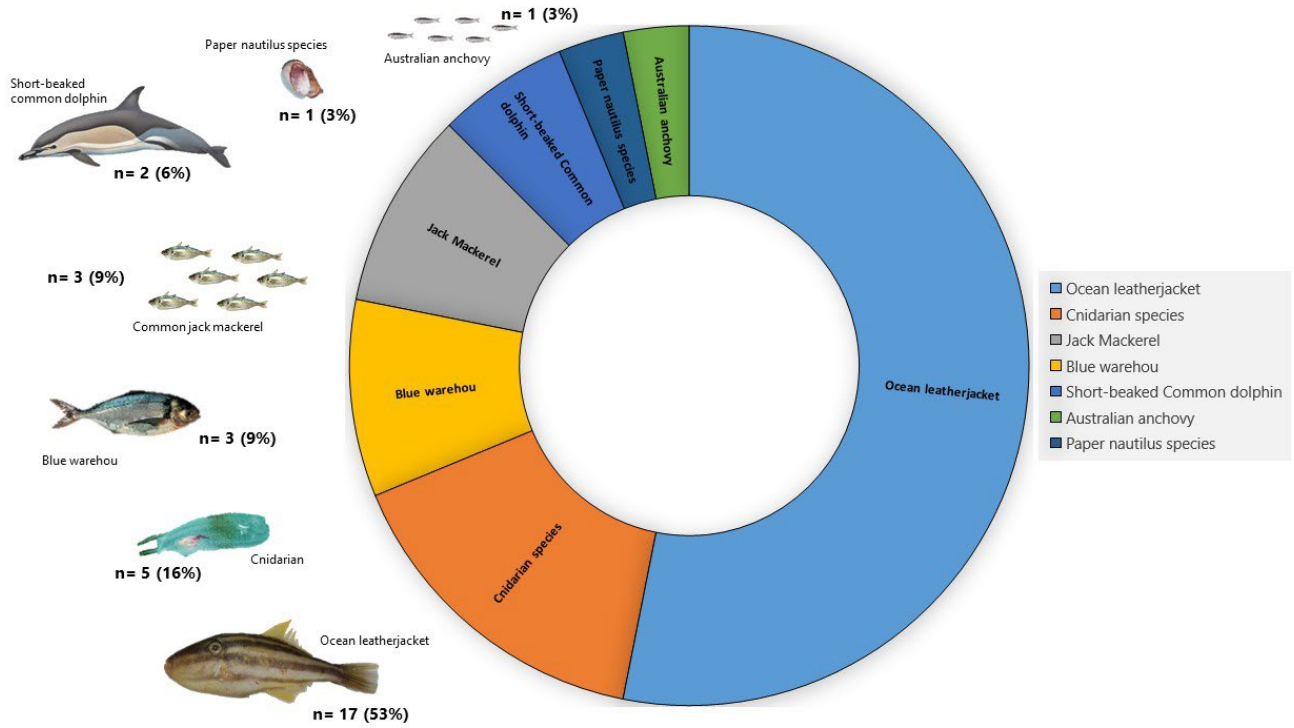


Figure 14. Abundance of species captured on pelagic mono BRUVS in the Western KI state SZ and their % contribution to total abundance.

3.3 Comparison of Benthic and Pelagic BRUVS

There were a total of 30 species captured on pelagic (n=8) and benthic (n=20) BRUVS and two species; ocean leatherjacket (*Nelusetta ayraud*) and jack mackerel *(Trachurus declivis*) which were captured on both pelagic and benthic BRUVS (Figure 15).

The species that were captured on pelagic and benthic BRUVS were typically representative of that marine environment, with salps (Cnidarians) and pelagic schooling fish such as Australian anchovy (*Engraulis australis)* being recorded in the pelagic zone compared to demersal species such as smooth stingray (*Bathytoshia brevicaudata)*, gummy shark (*Mustelus antarcticus),* bight redfish (*Centroberyx gerrardi)* and knifejaw (*Oplegnathus woodwardi)* recorded on benthic BRUVS (Figure 15).

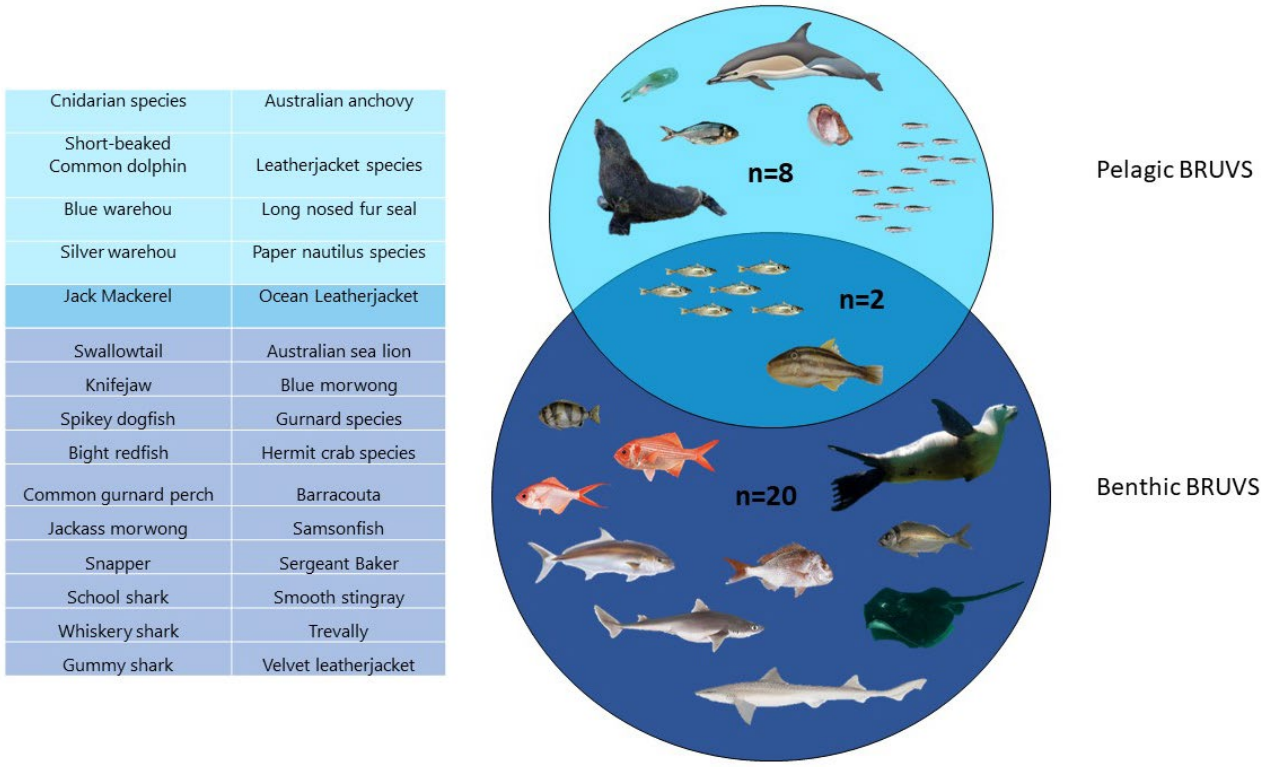


Figure 15. Venn diagram showing number of species captured on pelagic (n=2) and benthic (n=20) BRUVS, inclusive of species found on both (n=2).

3.4 Multivariate Analysis

A multivariate analysis of variance (PERMANOVA) indicated that there was a significant difference in community assemblages between the two methods utilized (i.e. benthic versus pelagic) (p=<0.001) (Table 3). A non-metric multidimensional scaling (nMDS) ordination of the data showed this significant difference between the two different methods (Fig 16).

The PERMANOVA showed there was no significant differences between the two different zones (Commonwealth and state) for both pelagic and benthic BRUVS and no significant difference between the different benthic habitats (Table 3). A non-metric multidimensional scaling (nMDS) ordination of the data showed no significant groupings of the species associated with those habitats (**Error! Reference source not found.**).

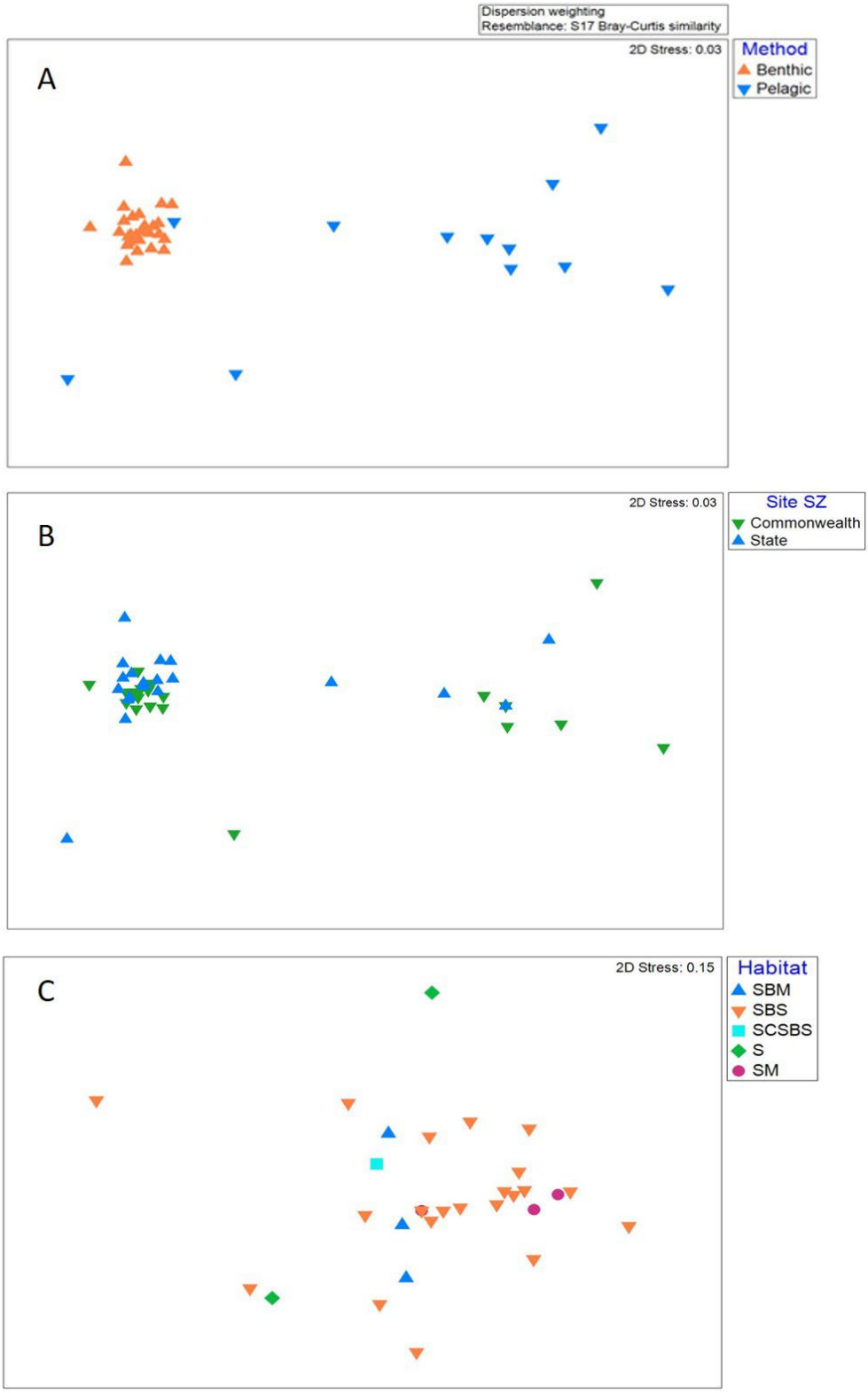


Figure 16. Non-metric MDS ordination of dispersion weighted Bray-Curtis similarity assemblage data from; A) Method (benthic and pelagic BRUVS); B) Site SZ (State and Commonwealth); and C) Benthic Habitats; SBM = Sponge and Bryozoans; medium; SBS = Sponge and Bryozoans; sparse; SCSBCS = Soft coral; sponge; bryozoans; sparse; S = Sand <2mm and SM = Sand, Mud <2mm.

Table 3. A permutational multivariate analysis of variance (PERMANOVA) based on Bray-Curtis dissimilarities of dispersion weight transformed abundances of community assemblages recorded on benthic and pelagic BRUVS from Western KI. Factors are; Methods (Benthic and pelagic BRUVS); SZ (Commonwealth and state) and benthic habitat.

Factor	df	SS	MS	Pseudo-F	P(perm)	Unique perms
Method (Benthic and Pelagic)	1	65469	65469	36.919	0.0001	9935
SZ (Commonwealth and state)	1	960.91	960.91	1.467	0.1887	9952
Benthic Habitat	4	2810.9	702.72	1.0653	0.3736	9915

4 Discussion

This study documents for the first time fish assemblages found in the Western KI National Park Zone and adjacent state sanctuary zone and also represents the deepest BRUVS drops to date in South Australia at 120m. The species richness, abundance and habitats captured between the two zones showed no significant differences which was expected given their proximity and similar bathymetric features, indicating that the two zones can be considered as one larger sanctuary zone.

Ray finned fish (Actinopterygii) were most common in terms of species and abundance in both pelagic and benthic habitats. The species captured on BRUVS during this expedition show that these marine sanctuaries are providing areas of protection for a mix of commercially targeted species and some species of conservation concern. As an example, the Bight redfish (*Centroberyx gerrardi*) is fished (demersal bottom trawl) in areas to the west of Kangaroo Island. This species is found on the continental shelf and upper slope in depths between 30 and 500 metres. They often form large schools around rocky reefs and mud substrates. They are slow growing reaching sexual maturity at between five and fourteen years and can live in excess of 80 years (AFMA 2021, SAFS 2020). This type of life history is similar to many other deep water species and makes them particularly vulnerable to fishing. A number of other species recorded during this expedition are also commercially targeted, including swallowtail (*Centroberyx lineatus*), snapper (*Chrysophrys auratus*), ocean leatherjacket (*Nelusetta ayraud*) and knifejaw (*Oplegnathus woodwardi*). The knifejaw, which was a commonly seen species on the benthic BRUVS, is a deep water fish found between 50 and 400 metres and is often caught in benthic commercial trawls. However, little is known about the biology of this species.

While ray finned fish were most abundant, sharks and rays (Elasmobranchii) made up a significant component of the benthic diversity contributing 25% of the total species observed on the benthic BRUVS. Sharks play an important ecological role as one of the top predators and exert considerable influence on the diversity and function of the ecosystems in which they live (Heupel et al 2014). The elasmobranchs observed on BRUVS were gummy shark (*Mustelus antarcticus*), school shark (*Galeorhinus galeus*), whiskery shark (*Furgaleus macki*), spikey dogfish (*Squalus megalops*), as well as the smooth ray (*Bathytoshia brevicaudata)*. The presence of sharks, rays and marine mammals provides insight into the use of remote and offshore zones being utilised by highly mobile species. The decline of shark and ray populations has been well documented globally (Pacoureau et al 2021) hence it is important to have areas that provide some protection for these key species.

Three species of marine mammal were captured on BRUVS; Australian sea lion (*Neophoca cinerea)*, short-beaked common dolphin (*Delphinus delphis)* and long-nosed fur seal (*Arctocephalus forsteri)*. The most interesting recordings were those associated with the Australian sea lion which was recently up listed to "endangered" status under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). This species breeds in coastal and offshore islands throughout South Australia and Western Australia and has not recovered from extensive harvesting from the 18th century. When analysing the footage from the benthic stereo BRUVS Australian sea lions were witnessed swimming at depths of ~112m. Long-nosed fur seals were also witnessed on the pelagic mono BRUVS. Both of these observations could signify that these areas are more important to the foraging ecology of these species than was previously thought and may warrant further investigation.

Apart from the occasional small patches of ribbon reef, the dominant habitats recorded during this study were soft sediment habitats featuring sand with sparse sponge and bryozoan communities. The lack of differentiation in habitats is a function of the bathymetry where changes in depth are minimal with typically a slope of less than 0.1 %. Recent studies in other Australian marine parks (AMP's) also found that the habitat beyond 120m was predominantly sand and mud silt (Langlois et al 2021 in prep). This study also found a decline in species richness in such habitats likely attributed to the lack of reef habitat available for fish species.

The combination of benthic and pelagic BRUVS resulted in a higher number of species recorded than if only one method was used. The benthic BRUVS captured the most unique species compared to the pelagic BRUVS method. In general there was very little overlap of species captured on pelagic and benthic BRUVS with only two species being captured on both. The two species (ocean leatherjacket and jack mackerel) captured on both methods are

highly mobile and active predators, however it is also possible that the pelagic BRUVS slipped down the line closer towards the benthic BRUVS which facilitated the overlap in species. The addition of pelagic BRUVS was useful for assisting with characterizing the entire ecosystem, particularly in deeper SZs. It should be noted that the recommended pelagic BRUVS soak time is 120 minutes compared to the 60 minutes (Langlois et al 2020) used here and additional species may have been recorded had this method been adopted. In this study pelagic BRUVS were tethered to the same line as the benthic BRUVS for logistical reasons to maximize the sampling undertaken on the expedition. The use of longer soak times for the pelagic BRUVS would have significantly decreased the number of benthic drops possible hence the decision to align the pelagic BRUVS soak times to the benthic BRUVS soak times (60 minutes) was made.

In conclusion, this study has significantly improved our knowledge of the species and habitats associated with the Western KI marine parks and at a broader national level, the South-West marine park network. To date these deep water soft sediment habitats have been little studied in the Australian marine park network despite the fact that they make up a significant component of national park zones in the South-West Marine Park network (e.g. Pearson Expedition). The data collected will also provide context and be comparable to other AMP's where benthic stereo BRUVS have been utilised to characterise community assemblages in the deeper mesophotic habitats between 80 – 150m (Monk et al 2017). The bathymetry of these parks is restricted in heterogeneity and overall depth variation resulting in large expanses of sand with sparse sponge and bryozoan communities as the major habitats. Despite the conformity of the seafloor there still exists a range of mobile animals including multiple fish species, several species of sharks and the endangered Australian sea lion. Several of these species are commercially fished or susceptible to capture as bycatch from trawling or long lining, particularly the shark species and therefore the Western KI state and Commonwealth marine parks afford some protection for these species and ecosystems in which they live.

5 Appendices

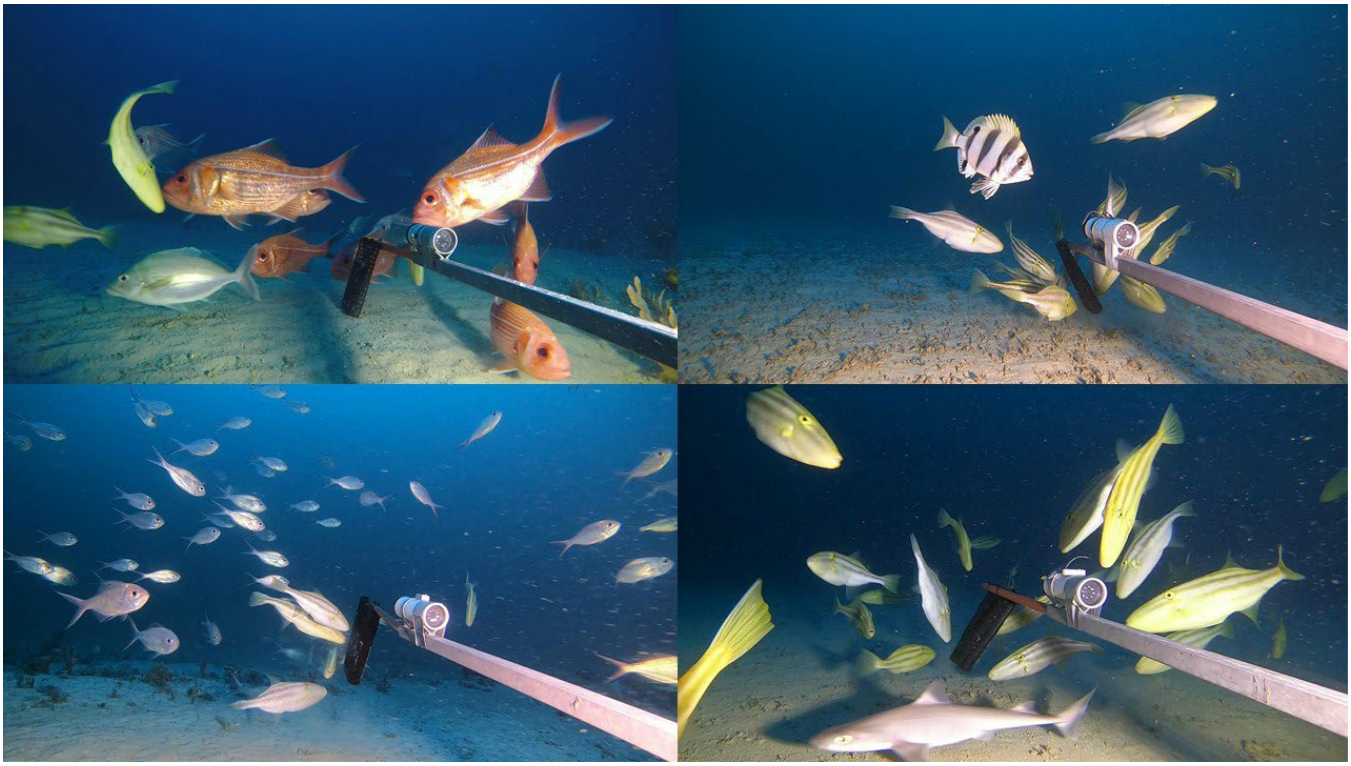
A. Relative abundance (MaxN) of species captured on benthic BRUVS in state and commonwealth SZ of Western KI Marine Parks.

Common Name	Species Name	Commonwealth SZ	State SZ	Total MaxN
Ocean leatherjacket	*Nelusetta ayraud*	356	326	682
Common jack mackerel	*Trachurus declivis*	37	36	73
Swallowtail	*Centroberyx lineatus*	2	56	58
Knifejaw	*Oplegnathus woodwardi*	22	14	36
Spikey dogfish	*Squalus megalops*	19	12	31
Bight redfish	*Centroberyx gerrardi*	2	15	17
Common gurnard perch	*Neosebastes scorpaenoides*	7	8	15
Jackass morwong	*Nemadactylus macropterus*	12	2	14
Snapper	*Chrysophrys auratus*	3	7	10
School shark	*Galeorhinus galeus*	5	2	7
Whiskery shark	*Furgaleus macki*	2	1	3
Gummy shark	*Mustelus antarcticus*	2	1	3
Australian sea lion	*Neophoca cinerea*	2	0	2
Blue morwong	*Nemadactylus valenciennesi*	0	2	2
Gurnard species	*Neosebastes sp*	1	1	2
Hermit crab species	*Diogenidae sp*	0	2	2
Barracouta	*Thyrsites atun*	1	0	1
Samsonfish	*Seriola hippos*	0	1	1
Sergeant Baker	*Latropiscis purpurissatus*	0	1	1
Smooth stingray	*Bathytoshia brevicaudata*	0	1	1
Trevally	*Pseudocaranx sp*	0	1	1
Velvet leatherjacket	*Meuschenia scaber*	0	1	1
		473	490	**963**

B. Relative Abundance (MaxN) of species captured on pelagic BRUVS in state and Commonwealth SZ of Western KI Marine Parks.

Common Name	Species	Commonwealth SZ	State SZ	Total MaxN
Ocean leatherjacket	*Nelusetta ayraud*	0	17	17
Cnidarian species	*Cnidaria sp*	10	5	15
Short-beaked Common dolphin	*Delphinus delphis*	2	2	4
Jack Mackerel	*Trachurus declivis*	1	3	4
Blue warehou	*Seriolella punctata*	0	3	3
Silver warehou	*Seriolella brama*	3	0	3
Australian anchovy	*Engraulis australis*	0	1	1
Leatherjacket species	*Monacanthidae sp*	1	0	1
Long nosed fur seal	*Arctocephalus forsteri*	1	0	1
Paper nautilus species	*Argonauta sp*	0	1	1
		18	32	**50**

C. Multiple screen grabs from the benthic stereo BRUVS footage showing the community assemblages in 100 – 125m in the Commonwealth NPZ and state SZ



D. Multiple screen grabs from the pelagic mono BRUVS footage showing the community assemblages in the Commonwealth NPZ and State SZ.

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